U.S. Army Corps of Engineers

New England District
Concord, Massachusetts

STUDY AREAS - GRANT, LOCUST, AND CAVITE HOUSING AREAS
FORMER FORT DEVENS ARMY INSTALLATION
DEVENS, MASSACHUSETTS

Contract No. DACA31-00-D-0023
Task Order No. 0046
DCN: DVNPASI-052008-AAWM

FINAL
PRELIMINARY ASSESSMENT SITE INSPECTION
SUPPLEMENTAL SITE INVESTIGATION
COMPREHENSIVE REPORT

MAY 2008

01M-0007

WESTON SOLUTIONS

FINAL
PRELIMINARY ASSESSMENT SITE INSPECTION/SUPPLEMENTAL SITE INVESTIGATION COMPREHENSIVE REPORT STUDY AREA – GRANT, LOCUST AND CAVITE HOUSING AREAS FORMER FORT DEVENS ARMY INSTALLATION DEVENS, MASSACHUSETTS

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May 2008

Work Order No. 03886.518.045

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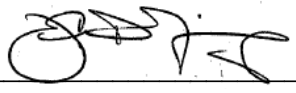

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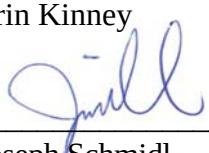

Joseph Schmidl

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LIST OF ACRONYMS

µg/kg	micrograms per kilogram
ACEC	Areas of Critical Environmental Concern
ACM	asbestos-containing materials
Alpha	Alpha Analytical Laboratory
Army	U.S. Army
ASR	Archive Search Report
AST	aboveground storage tank
BCT	Base Closure Team
bgs	below ground surface
BRAC	Base Realignment and Closure
BW	base-wide
CDD	chlorodibenzodioxins
CDF	chlorodibenzofurans
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CMR	Code of Massachusetts Regulations
COC	constituents of concern
COMM-97	Reuse and Disposal of Contaminated Soil at Massachusetts Landfills
CSM	Conceptual Site Model
4,4'-DDE	Dichlorodiphenyldichloroethylene
4.4'-DDT	Dichlorodiphenyltrichloroethane
DGM	Digital Geophysical Mapping
DQO	Data Quality Objectives
ECSM	*Expanded Conceptual Site Model*
EPA	U.S. Environmental Protection Agency
EPC	Exposure Point Concentration
EPH	extractable petroleum hydrocarbons
FFA	Federal Facilities Agreement
ft	foot/feet
ft^2	square feet
HA	Housing Area
HFA	Human Factors Applications, Inc.
HpCDD	heptachlorodibenzodioxin
HpCDF	heptachlorodibenzofuran
HSA	hollow stem auger
HVAC	heating, ventilation, and air conditioning

LIST OF ACRONYMS (Continued)

HxCDD	Hexachlorodibenzodioxin
HxCDF	Hexachlorodibenzofuran
IA	Investigation Areas
lf	linear feet
LDR	Land Disposal Regulations
LUC	Land Use Controls
MassDEP	Massachusetts Department of Environmental Protection
MassDevelopment	Massachusetts Development and Finance Agency
MCP	Massachusetts Contingency Plan
MEC	Munitions and Explosives of Concern
mg/kg	milligrams per kilogram
Mitkem	Mitkem Corporation
mm	millimeter
MS	matrix spike
NHESP	National Heritage and Endangered Species Program
Nobis	Nobis Engineering, Inc.
NPL	National Priorities List
NSR	No Significant Risk
OCDD	octachlorodibenzodioxin
OCDF	octachlorodibenzofuran
OER	Ordnance & Explosives Remediation, Inc.
PAH	polycyclic aromatic hydrocarbons
PAL	Project Action Level
PASI	Preliminary Assessment Site Investigation
PCB	polychlorinated biphenyls
PRG	Preliminary Remediation Goals
QAPP	Quality Analysis Project Plan
QC	quality control
RFTA	Reserve Forces Training Area
RPD	relative percent difference
SA	Study Area
SCR	Screening Cancer Risk
SCS	Soil Conservation Service
SHQ	Screening Hazard Quotient

LIST OF ACRONYMS
(Concluded)

SIM	secondary ion-mass spectrometry
SMA	Stockpile Management Area
SSI	Supplemental Site Investigation
STL	Severn-Trent Laboratories
SVOC	semi-volatile organic compounds
TAL	Target Analyte List
TCG	Target Cleanup Goal
TCL	Target Compound List
TCRA	Time Critical Removal Action
TEF	Toxicity Equivalency Factors
TEQ	Toxicity Equivalency Quotient
TPH	total petroleum hydrocarbons
TSCA	Toxic Substances Control Act
TSCR	Total Screening Cancer Risk
TSHI	Total Screening Hazard Index
UCL	Upper Confident Limit
U.S.	United States
USACE	U.S. Army Corps of Engineers
USDA	U.S. Department of Agriculture
USGS	U.S. Geological Survey
UXO	unexploded ordnance
VOC	volatile organic compounds
WESTON®	Weston Solutions, Inc.
WP	Work Plan
WWI	World War I
WWII	World War II

EXECUTIVE SUMMARY

EXECUTIVE SUMMARY

Weston Solutions, Inc. (WESTON®) performed a Preliminary Assessment Site Inspection (PASI) and a subsequent Supplemental Site Investigation (SSI) of the former Grant, Locust, and Cavite Housing Areas (HA), otherwise referred to as the Study Area (SA), at the request of the United States (U.S.) Army Corps of Engineers (USACE), New England District, in cooperation with the U.S. Army (Army) Base Realignment and Closure (BRAC) Office.

The former Fort Devens Army Installation is located in the towns of Ayer, Shirley, Harvard, and Lancaster, Massachusetts. Fort Devens was established as a temporary training area for soldiers during World War I. The installation occupied approximately 9,300 acres and was used for a variety of training missions between 1917 and 1990. Fort Devens was officially closed in March 1996. The SA comprises the former Grant, Locust, and Cavite HAs, three separate HAs that are located on the central portion of the former installation. The SA was substantially undeveloped until the late 1950s, with the exception of a facility designated as the "Base Laundry" during the 1940s and 1950s. A total of 150 multi-family housing units were constructed in the SA during the late 1950s and early 1960s. The buildings were razed in the fall 2001 and spring 2002. The current property owners, Massachusetts Development and Finance Agency, plans to redevelop the SA for a mixture of residential and commercial uses.

Extensive Massachusetts Contingency Plan (MCP)-lead soil remediation for pesticides was performed at the Grant, Locust, and Cavite HAs in 2002. Sample analysis performed throughout the MCP-Lead Pesticide Soil Remedial Action indicated that, in addition to pesticides, the soil within the HAs had elevated concentrations of arsenic and/or polychlorinated biphenyls (PCB). The PASI/SSI was initiated in response to a letter from U.S. Environmental Protection Agency (EPA) to the Army's BRAC program dated 13 March 2003 (as modified in an e-mail message dated 17 September 2003). The letter directed that the former Grant, Locust, and Cavite HAs become an SA of the former Fort Devens National Priorities List site in accordance with the Army-EPA Federal Facilities Agreement.

Preliminary Assessment/Site Inspection

Based on the identification of elevated levels of arsenic and PCBs during a previous MCP-Lead Pesticide Soil Remedial Action, the former Grant, Locust, and Cavite HAs became an SA. The original objective of the PASI was to determine whether a release or potential release of Comprehensive Environmental Response, Compensation, and Liability Act-regulated contaminants (specifically arsenic and/or PCBs) existed, and the nature of the associated threats to human health and the environment. The scope of the PASI was subsequently expanded to include the investigation of lead, explosives, and perchlorate based on a review of historical information for this SA.

From the historical review and existing data provided in previous investigations, the PASI sampling effort was devised to provide additional information to evaluate releases or potential releases within the SA. During the PASI, 422 soil samples were collected from test pits and soil borings, with 255 samples analyzed for PCBs, 65 samples analyzed for lead, 82 samples analyzed for arsenic, and 20 samples analyzed for explosives. Samples were collected throughout the SA to determine whether PCB releases extended beyond the existing known release locations, arsenic concentrations in soil within the SA resulted from site-related waste handling activities or are consistent with background arsenic concentrations, and whether former military training and range activities have resulted in the release of lead or explosives to soil.

Supplemental Site Investigation

Based on the results of samples collected during the PASI, review of the past historical uses, and small arms training in the SA, indicated the potential presence of impacts at several Investigation Areas (IA). The Base Cleanup Team, comprising of BRAC, EPA, the Massachusetts Department of Environmental Protection (MassDEP), and USACE agreed that additional data was required to fully characterize the potential for releases that may have occurred within the SA. The additional data needs requirement resulted in the SSI.

In order to assist in the identification of past potential small arms training and range activities within and surrounding the SA, additional site reconnaissance was conducted to identify site features over the approximately 282 acres that may be indicative of historic training activities, areas of significant alteration of surface topography, subgrade utility structures, old foundations, old roads, and walls. The reconnaissance effort did not identify any features inconsistent with the known uses of the SA as general Training Areas and/or Firing Ranges between 1917 and approximately 1960.

During the SSI, 505 soil samples were collected from 73 locations (including soil borings, test pits, and shallow soil sample locations), with 46 samples analyzed for volatile organic compounds, 39 samples analyzed for semi-volatile organic compounds, 22 samples analyzed for extractable petroleum hydrocarbons, 44 samples analyzed for pesticides, 24 samples analyzed for chlorinated dibenzodioxins/chlorinated dibenzofurans, 40 samples analyzed for PCBs, 187 samples analyzed for Target Analyte List Metals, 36 samples analyzed for perchlorate, and 67 samples analyzed for explosives. In addition to the collection of soil samples, a total of six piezometers and four groundwater monitoring wells were installed in two of the IAs. Four groundwater samples were collected from selected monitoring wells and piezometers to characterize groundwater quality beneath the former Grant HA of the SA. The ultimate density of sampling performed during the PASI/SSI (not including pre-existing data) resulted in approximately seven soil samples collected per acre. The majority of the samples collected were biased toward areas where releases were suspected, such as impact and firing areas of ranges, rather than intermediate areas.

The available data provide sufficient information regarding the SA to reach the following conclusions regarding potential risks to human health and the environment. Human health risk screening calculations demonstrate that the relatively limited detections of hazardous substances, above their respective Project Action Levels that may be associated with the former military use of the SA, do not pose a significant risk. Ecological risk screening performed for IA-6 following the Time Critical Removal Action (TCRA) indicated No Significant Risk. Finally, based on review of existing records involving prior munitions and explosives of concern (MEC) investigations and removal actions and data presented in the PASI/SSI, including the Expanded

Conceptual Site Model, there is no evidence that additional MEC are present within the SA. However, given the former use of this SA as part of an active military installation and training area, there is a possibility that MEC may exist within the SA. In order to address any potential MEC within areas impacted by the former IA-2 training/range area, the Army has recommended that a Focused Feasibility Study be conducted. In addition, based on concerns that the IA-2 training/range activities may have impacted the adjacent former Oak and Maple HAs, a follow-on remedial investigation is recommended to address any potential remnant MEC in these areas and any related explosive safety hazards. The following table summarizes the findings of the PASI/SSI.

Investigation Area	Area Type	Hazardous Substance(s) Detected above PALs	Conclusions
IA-1	Former Training Area (circa 1922)	PAHs, Metals	Soil concentrations are consistent with background and pose NSR; no further action.
IA-2	Former 37-mm Anti-Tank Range	PAHs, Pesticides, Metals	Soil concentrations of PAHs and metals are consistent with background; and pesticides pose NSR; no further action for chemical constituents. Groundwater concentrations are below PALs; no further action. MEC requires further action. Conduct Focused Feasibility Study to evaluate the need for Land Use Controls in former impact area and Grant HA. Conduct remedial MEC investigation at the former Oak and Maple HAs.
IA-3	Possible Rifle Range	PAHs, Metals	Soil concentrations of PAHs and metals consistent with background; pesticides pose NSR; no further action.
IA-5	Former Sub-Caliber Anti-Tank Range	PCBs, Metals	Soil concentrations of metals consistent with background; PCBs were previously removed to achieve NSR; no further action.
IA-6	Former Machine Gun Range (Bryant Range)	PAHs, Metals	Numerous soil samples exceeded antimony and lead PALs; TCRA for antimony- and lead-contaminated soil conducted; remnant concentrations of metals, and PAHs pose NSR; no further action.
IA-7	Former Sub-Caliber Anti-Tank Range	Metals	3 of 14 soil samples exceed antimony and lead PALs; the localized area of lead impacted soils will be removed by MassDevlopment under an MCP RAM prior to commercial site development; risk screening calculations based on this pending soil removal indicate NSR from antimony and lead; no further action.

Investigation Area	Area Type	Hazardous Substance(s) Detected above PALs	Conclusions
IA-8	Former Base Laundry Buildings	PAHs, PCBs, Metals	Soil and groundwater concentrations of metals consistent with background; Groundwater not above PALs; PAHs above PALs at one location, likely associated with asphalt; PCBs previously removed to achieve NSR; no further action.
IA-9	Former Cavite HA	Pesticides, Metals	Soil concentrations of metals consistent with background except for arsenic, pesticides were previously removed to achieve NSR; no further action. Based on risk screening, arsenic poses NSR.
IA-10	Former Grant HA	PAHs, Pesticides, PCBs, Metals	Pesticides and PCBs were previously removed to achieve NSR. Soil concentrations of metals and PAHs consistent with background, except for PAHs at location IA10-SB02, where benzo(a)pyrene results slightly exceed risk screening criteria; however, no further action recommended.
IA-11	Former Locust HA	PAHs, Pesticides, Metals	Pesticides were previously removed to achieve NSR; Soil concentrations of metals are consistent with background; elevated PAHs at one location, likely associated with asphalt; no further action.

Notes:
PAL = Project Action Limits
PAH = polycyclic aromatic hydrocarbons
TCRA = Time Critical Removal Action
NSR = No Significant Risk
MCP = Massachusetts Contingency Plan
PCB = polychlorinated biphenyls
RAM = Release Abatement Measure
mm = millimeter
HA = Housing Area
MEC = Munitions and Explosives of Concern

SECTION 1

INTRODUCTION

1. INTRODUCTION

This document summarizes the findings of a Preliminary Assessment Site Inspection (PASI) and subsequent Supplemental Site Inspection (SSI) of the former Grant, Locust, and Cavite Housing Areas (HA), otherwise referred to as the Study Area (SA). The investigations were conducted in accordance with the United States (U.S.) Environmental Protection Agency (EPA) Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) as amended by the Superfund Amendments and Reauthorization Act, and EPA PASI guidance, as amended by site assessment guidance; U.S. Army (Army)-EPA Federal Facilities Agreement (FFA) dated 11 May 1991, and modification dated 26 March 1996; and the Army-Massachusetts Development and Finance Agency (MassDevelopment) Environmental Services Cooperative Agreement dated 28 September 2001. Weston Solutions, Inc. (WESTON®) performed this work under contracts DACA31-00-D-0023, Delivery Order No. 0046 and W912DR-05-D-00-22, Delivery Order No. 0020 to the U.S. Army Corps of Engineers (USACE), New England District on behalf of the Army Base Realignment and Closure (BRAC) Office.

SECTION 2

SITE BACKGROUND AND DESCRIPTION

2. SITE BACKGROUND AND DESCRIPTION

2.1 BACKGROUND

Former Fort Devens Army Installation, hereafter referred to as former Fort Devens, is located in the towns of Ayer and Shirley (Middlesex County) and Harvard and Lancaster (Worcester County), Massachusetts, approximately 35 miles west of Boston, Massachusetts.

According to local officials, residences and farmland occupied the site prior to the establishment of Fort Devens in 1917. Fort Devens was established as a temporary training area for soldiers during World War I (WWI). In 1931, Fort Devens became a permanent installation with the primary mission of commanding, training, and providing logistical support for non-divisional troop units. The installation occupied approximately 9,300 acres and was used for a variety of training missions between 1917 and 1990. The installation also supported the Army Readiness Regional Reserve and National Guard units in the New England area.

On 21 November 1989, Fort Devens was placed on the National Priorities List (NPL) pursuant to CERCLA and was identified for cessation of operations and closure under Public Law 101-510, the Defense BRAC Act of 1990. Fort Devens was officially closed in March 1996. Portions of the property formerly occupied by Fort Devens were retained by the Army for reserve forces training and renamed the Devens Reserve Forces Training Area (RFTA). Areas not retained as part of the Devens RFTA were, or are in the process of being, transferred to new owners for reuse and redevelopment.

The SA comprises the former Grant, Locust, and Cavite HAs, three separate HAs that are located on the central portion of the former installation. Figure 2-1 depicts the location of the SA on a U.S. Geological Survey (USGS) topographic base map. A total of 150 buildings formerly occupied the HAs. The buildings were razed in the fall 2001 and spring 2002, including their foundations, paved walkways, driveways, and utilities to the main road. The supporting infrastructure, such as roadways and utilities, remain in place. Ground cover is limited to bare soil, un-maintained lawns, and wooded areas.

A review of the historical aerial photographs, historical USGS maps, facility base maps, and facility plans indicates that within 5 years after the base was established, most of the north-central base area was developed with facilities and infrastructure (i.e., buildings and roads). The SA appeared substantially undeveloped prior to the construction of the existing HAs during the late 1950s and early 1960s.

The only buildings present within the HAs prior to the construction of the Grant, Locust, and Cavite housing units include several buildings of unknown use in the Cavite HA, several small buildings of unknown use in the far northern portion of the Grant HA, and a facility designated as the "Base Laundry", in the southeastern portion of the Grant HA. Following search of the historical records, very limited information was found that detailed the historical use or activities conducted at any of these former structures. No structures were identified in the Locust HA prior to the construction of the housing units.

Since the transfer of certain portions of the installation, redevelopment of areas outside the SA has begun. According to the current Devens Reuse Plan, the former Grant HA will be redeveloped for new residential housing, Locust HA will be redeveloped as an Innovative and Technology Business Area, and Cavite HA will be reused as a residential and recreational area. Redevelopment is planned for 2006 through 2007.

Extensive Massachusetts Contingency Plan (MCP)-lead soil remediation for pesticides was performed at the Grant, Locust, and Cavite HAs in 2002 (WESTON, 2003b; 2003c; 2003d). Sample analysis performed throughout the MCP-Lead Pesticide Remedial Action indicated that in addition to pesticides, the soil within the HAs had elevated concentrations of arsenic and/or polychlorinated biphenyls (PCB). The PASI was initiated in response to a letter from EPA to the Army's BRAC program dated 13 March 2003 (as modified in an e-mail message dated 17 September 2003). The letter directed that the former Grant, Locust, and Cavite HAs become an SA of the former Fort Devens NPL site in accordance with the FFA.

2.1.1 Grant Housing Area

The Grant HA is approximately 137 acres, located along the northwestern boundary of the former Fort Devens and between the Nashua River to the west, Hospital Road to the south, and El Caney Street to the east. The Grant HA included 130 former multi-family housing units located on Plum Street, Beech Street, Spruce Street, Poplar Street, Hospital Road, El Caney Street, Antietam Street, Birch Circle, and Grant Road that were constructed in the late 1950s or early 1960s. Figure 2-2 depicts the layout of the former Grant HA.

Based on reviewed historical documents, the former Grant HA, prior to the construction of the earliest housing units, was used for a variety of military training purposes from 1917 through the early 1950s. The former Base Laundry facility was constructed in the 1940s. After the early 1960s, the area was used solely as a HA.

The earliest available map, "Base Map-1919", indicated the presence of buildings/structures at the northern end of the former Grant HA near Grant Housing Unit No. 830. These buildings are visible on aerial photographs until 1938. By 1938, cleared/excavated areas were present in much of the former Grant HA and the area was crisscrossed with trails and roads. Some of the cleared areas appear to be associated with localized "high spots" on the historic USGS topographical quadrangle maps and are most likely related to excavation of sands and gravels (USGS, 1939; 1945; 1951). Figure 2-3 summarizes the locations of significant sand and gravel mining within the SA. Other cleared areas (e.g., linear areas cleared of trees, smaller cleared or excavated areas) may be associated with some military training. Notes on several of the aerial photographs in the *Archive Search Reports* (*ASR*) (USACE, 1995a; 1995b; 1995c), specify use(s) of several areas within the SA as training areas and ranges including a rifle range, two sub-caliber anti-tank ranges, and multiple general training areas. Neither the aerial photographs, nor the report specify the duration of use or intensity of use of these training areas or ranges.

A removal action identified significant amounts of unexploded ordnance (UXO) and UXO scrap in the Oak HA, located to the southwest of the Grant HA [Human Factors Applications, Inc. (HFA), 1996a], in an area beyond the ranges identified in the *ASRs* (USACE, 1995a; 1995b; 1995c). Further research indicated that this area was part of a 37-millimeter (mm) anti-tank range

that operated in the WWI to pre-World War II (WWII) era. This information was not previously included in available documentation, including the 1995 *ASRs*. Figure 2-3 summarizes the locations of established former training areas and former ranges within the SA.

The former Base Laundry facility was constructed in the 1940s at the present day location of the Poplar Street loop. The duration of the former Base Laundry facility operation at this location has not been established, but it was demolished prior to 1963 and the construction of the former HA. A *General Plan of Fort Devens* (1941) indicates the presence of the former Base Laundry facility in the vicinity of Poplar Street by 1941. A 1943 aerial photograph of this area indicates that some clearing and soil disturbance has occurred; however, the resolution of the photograph is sufficient to confirm the presence of the building. A 1951 aerial photograph clearly depicts the existence of the former Base Laundry facility and that construction of the housing units had not commenced. A 1952 *Topographic Survey of Fort Devens* map indicates that several of the housing units in the northern portion of the former Grant HA along Grant Avenue had been built and identifies planned locations for the remaining housing units throughout the former Grant HA. A 1963 aerial photograph clearly shows that the former Base Laundry facility no longer exists and that construction of all the housing units had been completed.

Due to the size of the Grant HA and the quantity of ranges and former training areas, investigation activities were conducted independently in smaller Investigation Areas (IA). Grant HA was divided into six separate IAs which are listed below.

- IA-1: Former Training Area and/or Rifle Range
- IA-2: Former 37-mm Anti-Tank Range
- IA-3: Possible Rifle Range
- IA-5: Sub-Caliber Anti-Tank Range
- IA-7: Sub-Caliber Anti-Tank Range
- IA-8: Former Base Laundry/Dry Cleaner Facility

Further details are included in Section 5.

2.1.2 Locust Housing Area

The Locust HA (also known as IA-11) comprises approximately 11 acres, located south of Hospital Road and the Grant HA near the western boundary of former Fort Devens

approximately 1,000 feet (ft) east of the Nashua River. The Locust HA formerly contained 14 housing units, which were constructed sometime between 1959 and 1965 (Figure 2-4).

Based on aerial photographs, the Locust HA was not developed until the construction of the housing units some time between 1959 and 1965. Prior to the housing construction, no known facilities existed in the area. No other special features or past uses of the HA prior to the housing construction have been identified. Based on the *ASRs (*USACE, 1995a; 1995b; 1995c), three suspect training areas and/or ranges (IA-3 and IA-6 Pistol, Rifle and Machine Gun Ranges, and IA-7, Sub-Caliber Anti-Tank Range) are located adjacent to the HA; however, neither the aerial photographs, nor the report specify the duration of use or intensity of use of these suspect ranges.

2.1.3 Cavite Housing Area

The Cavite HA (also known as IA-9) comprises approximately 6 acres, located adjacent to Bates Service Road in the northeastern portion of former Fort Devens. The Cavite HA (part of the larger Buena Vista HA) formerly contained six multi-family housing units (see Figure 2-5). Based on aerial photographs, the former housing units were built sometime after 1952. A more specific date of construction of the former Cavite HA could not be determined from available records, plans, or aerial photographs, but it is believed that the construction timeframe likely coincides with the construction effort at Grant and Locust HAs.

Various buildings and structures of unknown use are visible on portions of the Cavite HA in photographs from 1922 to the present. What appear to be trails, paths, and trenches are visible in several of the photographs. According to the aerial photographs and base maps, the former buildings in the Cavite HA were present until at least 1952. The area approximately 0.5 miles to the south of the former Cavite HA, identified as IA-4, was utilized as a trench-warfare training area and/or general training area from 1922 until at least 1961 (Figure 2-3) (IA-4 is not shown on Figure 2-3). Investigation Area 4 has been identified as a former military training area; however, the area has been determined to be outside of the Grant, Locust, and Cavite HA and will not be included in this PASI/SSI. Investigation Area 4 has been addressed during previous investigations, specifically, the *U.S. Department of Defense BRAC, Ordnance, Ammunition and Explosives – Archives Search Report Findings*, May 1995; *U.S. Dept. of Defense BRAC,*

Ordnance, Ammunition and Explosives – Archives Search Report Conclusions and Recommendations, May 1995; and the *Final Expanded CSM Report*, June 2004. Training activities may have also occurred along the southern portion of the HA prior to the construction of the housing units. Due to the close proximity of neighboring facilities, training activities that occurred in this area were likely limited to physical training activities.

SECTION 3

PHYSICAL SETTING

3. PHYSICAL SETTING

3.1 REGIONAL GEOLOGY

The former Fort Devens encompasses a variety of glacial landforms and materials, as well as recent riverine (fluvial) features, deposited upon bedrock of varying composition. These are described below.

The landforms are the result of unconsolidated materials being deposited by ice and/or water in various environments below, within, and beyond the glacial margin, which was influenced, in part, by the pre-existing bedrock geology. The regional topography is depicted in the Physical Setting Map (Figure 3-1). Regional bedrock geologic mapping, identifying distinct bedrock lithofacies, is depicted in the Bedrock Geology Map (Figure 3-2). Regional surficial geologic mapping, identifying sand and gravel, till or bedrock, and floodplain alluvial deposits, is depicted in the Surficial Geology Map (Figure 3-3).

To supplement publicly-available sources of geological data, field activities conducted during the PASI and SSI included 20 test pits and 76 soil borings. Observations from a number of the test pits and soil borings have been used to further define the understanding of the geology within the SA. WESTON Test Pit Logs are included in Appendix A, and Soil Boring Logs are included in Appendix B. Details regarding the specific number of test pits and soil borings by IA, their locations, and the rationale for each, are included in Section 5 of this report.

3.2 BEDROCK GEOLOGY

According to the USGS, the SA is located along the western side of the Clinton-Newbury Fault Zone, a regional zone of westward-dipping thrust faults that crosses Massachusetts from northeast to southwest (USGS, 1983). Bedrock beneath the former Grant and Locust HAs is mapped as Silurian-age Oakdale Formation, comprising metamorphosed, thin-bedded, pelitic and calcareous siltstone and muscovite schist (USGS, 1983). The depth to bedrock beneath the former Grant HA is approximately 45 to 50 ft below ground surface (bgs), based on the depth to auger refusal during the SSI. There are no known bedrock outcrops in the former Grant and

Locust HAs. The bedrock observed in the former Grant HA, based on cuttings from the depth of auger refusal, is gray siltstone, consistent with the USGS description of the Oakdale Formation.

Bedrock between the former Grant and Locust HAs and the former Cavite HA is separated by one of the Clinton-Newbury thrust faults. Bedrock beneath the former Cavite HA is mapped as Siluro-Ordovician-age Devens-Long Pond facies of the Ayer Granite, an equiangular to porphyritic, gneissic, biotite granite, and granodiorite (USGS, 1983). The bedrock surface in the former Cavite HA is very irregular, forming steep ridges and valleys with over 15 ft of vertical relief over similar horizontal distances. Bedrock outcrops are located in the northern portion of the former Cavite HA (WESTON, 2003a). The bedrock observed in the former Cavite HA is pale gray, porphyritic gneiss, consistent with the USGS description of the Devens-Long Pond facies of the Ayer Granite (USGS, 1983). The test pit TP-01 excavated in the former Cavite HA encountered the top of bedrock at depths between 5 and 6 ft bgs.

3.2.1 Bedrock Metals Concentrations

Due to concerns regarding elevated arsenic concentrations in drinking water wells in eastern New England, a number of studies have been conducted to determine the source(s) of the arsenic detected. These studies have produced a data set that provides insight regarding the natural variability of metals concentrations in various bedrock units in eastern New England. As these bedrock units are the source of the unconsolidated materials present at the SA, the variability of metals concentrations in these rocks has a direct impact on the concentrations of metals naturally-occurring in soils throughout the SA.

USGS has determined that drinking water wells completed in clastic metasedimentary rocks, derived primarily from moderately calcareous sedimentary protoliths, containing 5% to 45% carbonate minerals at lower metamorphic grades and larger percentages of calc-silicate minerals at higher metamorphic grades, which may also include locally non-calcareous, sulfidic or metavolcanic rocks, have the highest percentages of elevated concentrations of arsenic (USGS, 1999). Arsenic concentrations from whole-rock samples of the suspect rock formations have concentrations of arsenic from 3 to 40 milligrams per kilogram (mg/kg) (Ayotte, et al., 2003). Carbonate and sulfide minerals are distinguished because these highly

reactive minerals can have a disproportionately large effect on groundwater chemistry, compared to other minerals commonly found in rocks of this region (USGS, 1999). It is presumed that a similar effect will be noted in soil chemistry, where chemical weathering occurs naturally during the soil formation process. USGS has identified specific rock formations that meet this definition, and these include the Oakdale and Berwick Formations of Massachusetts (USGS, 1999). As noted above, the Oakdale Formation underlies the former Grant and Locust HAs, and also extends northwestward of the SA, the source direction for the glacial deposits present at the SA. Exposures of the Berwick Formation lie east of the SA.

3.2.2 Glacial Geology

The SA is located on a former glacial outwash plain. The glacial outwash sediments have been reworked by the Nashua River along the northwestern edge of the former Grant HA, which is part of the Nashua River floodplain [U.S. Department of Agriculture (USDA) Soil Conservation Service (SCS), 1985; MassGIS, 1999]. The three HAs of the SA are located along the east side of the Nashua River Valley, where the topography slopes gently northwestward toward the river (USGS, 1988).

Glacial materials deposited in contact with the glacier (ground moraine) are generally dense and very poorly sorted. Particles are angular to subangular, as they have not been re-worked by water. Till deposited beneath the glacier can be present as a thin mantle across the bedrock and also as smooth, elongate oval hills known as drumlins and is referred to as lodgment till. Material entrained in the glacial ice that melts out, but is not subsequently re-worked or sorted, resembles lodgment till in its angular to subangular particles and very poor sorting, but is less dense and is known as ablation till. Lodgment till is the oldest deposit in the glacial sequence, overlain by ablation till. Interbeds of fluvioglacial sands that originate in the same glacial advance may also be present amongst glacial till deposits.

The next oldest features are those deposited by the sub-glacial river systems. Eskers are positive relief features deposited by sub-glacial drainage systems beneath stagnant glacial ice. These sub-glacial rivers carried high-energy sediment loads. When the glacial ice melted, these features were left as irregular, sinuous hummocky ridges. Eskers have also been described as ice channel

fillings on historical geology maps. They often contain rounded cobbles and have very low silt contents. Esker deposits can be similar in appearance to fluvial deposits, as both are deposited in stream environments. The topographically-elevated nature of esker deposits and their lack of fine particles distinguish them from fluvial deposits, which are generally limited to river valley bottomlands.

Later glacial materials deposited at/beyond the ice margin include a variety of glacial outwash deposits related to the drainage systems below, along, and beyond the glacier. Melt waters within the glacier carried sediment from the glacier and deposited them in deltas (kames) near the ice margin, and in large sheets beyond the glacier (kame plains). Previously deposited till and outwash can also be subsequently re-worked by melt water. Glacial Lake Nashua extended across the area following the retreat of the ice, which led to the formation of kame deltas and beach deposits along the margins of the glacial lake. Outwash deposits display a range of sorting and are often stratified. There is generally low silt content, and particles tend to be subrounded, and not angular, due to being carried and placed by water.

Glacial till is mapped at the surface at very few locations in the SA, but is typically present at depth below the outwash deposits. Notable locations where glacial till is mapped at the surface include a drumlin at the north end of the Grant HA and where glacial till mantles Shepley's Hill, and a bedrock hill south of the Cavite HA and north of Robbins Pond. There are other small, isolated glacial till locations between and west of these two hills and south of the Grant HA, near Route 2 and Jackson Road (MassGIS, 1999).

Sand and gravel deposits, consistent with the materials included in esker and kame glacial outwash deposits, are mapped as comprising all of the former Grant and Locust HAs (MassGIS, 1999). Minor inclusions of well-sorted sand are interpreted as beach deposits of the Harvard stage of glacial Lake Nashua (USGS, 1953). Eskers are observed as irregular ridges at the following locations: Grant HA (trend northeast-southwest), northwest of Mirror Lake (trend northwest-southeast), and between Mirror Lake and Little Mirror Lake (trend northeast-southwest). Kame deposits likely filled in areas between eskers in the Grant HA and between Robbins Pond and Mirror Lake. Kame plains are also observed as large, flat-topped plateaus just

south of Robbins Pond, west of Mirror Lake, and southeast of Little Mirror Lake. Former Moore Army Airfield is built on a kame plain in the northern portion of the former Fort Devens.

3.2.3 Fluvial Deposits

The till and outwash deposits which underlie the SA have been subsequently eroded or incised by rivers and streams. One example of this is the drumlin at the north end of the Grant HA that appears to be bisected by the Nashua River. That is, half of the drumlin is on each side of the river. Typically, a river would have flowed around such a feature. However in this case, it is possible that the course of the present-day Nashua River is the result of a supra-glacial drainage system incising itself into the underlying landscape formed by the sub-glacial system.

The Nashua River flows northerly within a relatively wide, flat valley northeast of the drumlin, while the valley is much narrower where it crosses the drumlin. Floodplain deposits generally consist of well-sorted, often stratified, sands and silts.

3.2.4 Soil Deposits

The soils in the former Grant and Locust HA are mapped by the USDA SCS as somewhat excessively drained Quonset loamy sands, with inliers of Sudbury fine sandy loam, formed on glacial outwash stratified drift deposits. The soils in the southern portion of the former Cavite HA are mapped by SCS as somewhat excessively drained Quonset loamy sands, while soils in the northern portion of the area are mapped as somewhat excessively drained Chatfield-Hollis complex soils, formed on either bedrock outcrops or Quonset loamy sands (SCS, 1985).

3.2.5 Site-Specific Observations

Site-specific observations of unconsolidated materials at the SA are summarized in test pit logs and soil boring logs, which are included in Appendices A and B, respectively. In several areas, it was apparent that the soils extending as much as 3 to 4 ft bgs had been reworked during the construction of the former housing units, although the material encountered was generally consistent with nearby natural deposits, in some cases making it difficult to differentiate fill from native material. In a few cases, fill was discovered that contained metal, asphalt or concrete

fragments at depths up to 9 ft bgs. In some areas, buried topsoil "A" horizons, comprised of dark brown loam with trace rootlets, were noted at depths of 2 to 5 ft bgs. These buried "A" horizons were interpreted to be the original ground surface in areas that had been filled prior to construction activities.

In the former Cavite HA, excavations to remove the containment cell were advanced to depths of 12 ft bgs. Native overburden in this area was described as dense, green-brown sandy material. During the SSI, one test pit was excavated to a depth of 6 ft bgs in the Cavite HA. Beneath a thin topsoil layer, 2.0 to 3.5 ft of fill was noted, underlain by 1.5 to 3.0 ft of well-sorted sand, which was underlain by pale olive brown, dense, gravelly clay, which is interpreted as glacial lodgment till. The glacial till lies directly on top of granitic bedrock. Limited sample recovery in the soil boring advanced in the Cavite HA is attributed to the presence of gravelly glacial lodgment till.

In the former Grant HA, unconsolidated materials observed from depths of 0 to 6 ft bgs during the PASI sampling effort were consistent with the soils mapped by SCS, comprised of primarily fine sand with varying amounts of silt (loamy sand in the SCS classification system) and fine to medium subrounded gravel. Local, natural variations, to be expected in glacial outwash deposits, were also noted in the subsurface materials, such as medium to coarse sand 3 to 6 ft beneath a portion of the Building 877 area (interpreted as a kame bar deposit) and dense, fine sand, and silt, with faceted gravel at depths of 3 to 4 ft beneath portions of the Building 863 area (interpreted as glacial lodgment till).

In the former Grant HA, unconsolidated materials observed to depths of 49 ft bgs during the SSI sampling effort were also consistent with the soils mapped by SCS. Two test pits were excavated to a depth of 6 ft bgs at the northern end of IA-1. Beneath 0.5 ft of soil, Test Pit TP-01 showed 3.0 ft of well-sorted fine sand, underlain by well-sorted sandy gravel, interpreted as a kame deposit underlain by an esker deposit. Beneath 0.5 ft of soil, Test Pit TP-02 showed 1.5 ft of well-sorted fine sand, underlain by well-sorted gravelly sand which showed strong cross-bedding, with the majority of beds dipping approximately 40º to the southeast, interpreted as a kame delta deposit.

Subsurface soil borings advanced during the SSI sampling effort in the former Grant HA provided additional stratigraphic information. In most of the IAs, the 10-foot (ft) soil borings identified topsoil, fill (if present), and glacial outwash deposits. In IA-2, soil borings encountered ablation and/or lodgment till deposits beneath glacial outwash kame deposits, at depths ranging from 1 to 44 ft bgs. Glacial till deposits were shallowest (1 to 8 ft bgs) in the area of three soil borings, IA02-SB07, IA02-SB12, and IA02-SB16, located east of Oak Hill. Shallow glacial till deposits were also noted at three soil borings, IA02-SB24, IA02-SB25, and IA02-SB27, located along the northern edge of the hilltop at the northern end of IA-2. These observations suggest that Oak Hill and the unnamed hill at the northern end of IA-2 are till-cored drumlins, draped with glacial outwash deposits.

In IA-8, the depth to glacial till deposits ranged from 10 to 14 ft bgs, overlain by glacial outwash deposits comprising both well- and poorly-sorted sands. Both glacial till and glacial outwash deposits were found to contain beds of relatively better sorted sands, which in some cases provide avenues for the migration of groundwater.

In the former Locust HA, six shallow soil borings and four test pits located in the vicinity provided additional stratigraphic information. Subsurface explorations in IA-6 revealed that the former range was leveled by cutting material from the western face of Locust Hill and spreading it westward. This process had the added advantage of raising the relative height of the Impact Berm. The fill material and the native surficial soils exhibit little to no difference in lithology. Both consist of poorly graded fine gravelly sands interpreted as reworked glacial outwash, possibly a beach terrace associated with former glacial Lake Nashua. Soil borings advanced in the former Locust HA proper indicated soils characteristic of kame deposits.

The gravel fractions of the unconsolidated materials in the former Grant and Locust HAs comprised mainly gray siltstone (noted in the logs as shale), with a few granitic members.

No fluvial sediments were observed in subsurface materials beneath the Grant and Locust HAs, except for locations adjacent to the Nashua River, in the IA-2 Impact Area. It appears that the Nashua River channel is erosional along its eastern side in this area, resulting in the steep slope which bounds the Grant and Locust HAs along the river to the west.

3.2.6 Background Concentrations of Hazardous Substances in Native Soils

An objective of the PASI/SSI was to determine whether former military activities performed in the various parts of the SA resulted in contamination of native soils. This condition can be as difficult to establish for naturally-occurring elements as it is for anthropogenic substances. The background concentrations of many anthropogenic substances, such as polycyclic aromatic hydrocarbons (PAH) cannot be presumed to be zero, due to their widespread distribution as air particulates from both natural (i.e., forest fires) and anthropogenic sources. Naturally-occurring inorganic elements may be found at various concentrations in native materials. For this reason, it is necessary to establish background concentrations for hazardous substances before determining whether the concentrations of these substances are the results of on-site or natural processes or the result of former military activities. It should be noted that, for the purposes of risk screening, pesticides and lead were not screened against background concentrations. In light of the background information and analytical results which provide documentation of the attribution of pesticides and lead to former military uses of the SA, these hazardous substances were automatically included in potential risk assessment calculations for IAs in which they were detected.

3.2.6.1 Background Concentrations of Polycyclic Aromatic Hydrocarbons

According to the Massachusetts Department of Environmental Protection (MassDEP) guidance documents, “PAHs are ubiquitous and consistently present in the environment and are typically formed during the incomplete burning of organic material, including wood, coal, oil, gasoline, and garbage. Polycyclic aromatic hydrocarbons are also found in crude oil, coal tar, creosote, and asphalt. Historically, PAHs have been associated with human activities such as cooking, heating homes and industries, and fuel for operating automobiles, although low levels of PAHs are also present in the environment from natural sources, such as forest fires. Their presence in the environment at higher concentrations is an artifact of habitation and is due to the widespread practice of emptying fireplaces, stoves, boilers, garbage, etc. in rural and urban areas over the past several hundred years. As a result, it is very common to detect “background” levels of PAHs in soils (MassDEP, 2002).”

"MassDEP has obtained background data from various sources documenting the concentrations of PAHs and metals in soil affected by human activities, particularly soil associated with wood ash and coal ash. These levels are representative of typical concentrations found in areas with fill material, *not* pristine conditions. MassDEP has also compiled background soil data for metals that are representative of undisturbed, natural conditions (MassDEP, 2002)."

For the purposes of screening for risk at the SA, the MassDEP-established background concentrations of PAHs representative of undisturbed, natural conditions have been used. These concentrations are listed as Secondary Regulatory Criteria in data summary tables discussed in Sections 5 and 6 of this report. The application of the PAH background concentrations is discussed in detail in Subsection 6.2.

3.2.6.2 Background Concentrations of Inorganic Elements

Although MassDEP has also determined that "metals are both naturally occurring and found in man-made materials (such as paint, fuel, fertilizers, and pesticides) widely distributed in the environment", the MassDEP-established background concentrations of metals representative of undisturbed, natural conditions are considered inappropriate for screening for potential risk in the SA due to the particular bedrock geology present beneath and in the vicinity of the SA. As described in Subsection 3.2.1, the parent material for unconsolidated materials at the SA includes bedrock of the Oakdale Formation, which is a member of a group of metasedimentary rocks that are known for above-normal percentages of calc-silicate and sulfidic minerals (USGS, 1999). These highly reactive minerals have been found to yield unusually high concentrations of certain elements, including arsenic, following chemical weathering (USGS, 1999).

In order to resolve the issue of the appropriate background concentration of arsenic in soil in the SA, a detailed statistical analysis was performed on arsenic concentrations derived from four recent data sets associated with the SA in order to ascertain if apparent elevated arsenic concentrations were naturally occurring or anthropogenic in origin. The data sets included the base-wide (BW) background data set derived by the USACE (USACE, 2004b) and three data subsets from the SA. The detailed statistical analysis is included in Appendix C.

The analysis utilized the comparison of the central tendencies of the arsenic data (rather than the use of extreme value statistics) that allowed for robust statistical comparison of various data set distributions. The use of central tendencies also facilitated the quantitative analysis of potential correlations between arsenic and other collocated metals. Despite initial statistical test results that indicated the arsenic data from the BW and SA data sets were from two different populations, a closer inspection of the relationship between arsenic and other naturally occurring collocated metals determined that no difference could be resolved between the arsenic concentrations in the BW and SA data sets. Consequently, the SA data set is presumed to represent naturally occurring arsenic within this SA at the former Fort Devens.

These results were further confirmed by review of the arsenic analytical results in a number of locations in the SA, which showed that arsenic concentrations tend (in 65% of cases) to increase with depth. Further, arsenic concentrations observed in soil and underlying overburden deposits throughout the SA tended to cluster in groups based on their depositional environment, i.e., glacial till, glacio-fluvial deposits, etc. Therefore, the arsenic concentrations observed in soil and underlying overburden deposits throughout the SA appear to be more closely related to depositional environment than to past uses of the SA, and are interpreted as naturally occurring, rather than anthropogenic in origin.

However, two arsenic concentrations (130 and 70 mg/kg) from the former Cavite HA are considered statistical outliers of the naturally-occurring arsenic concentrations, possibly due to an anthropogenic source. The remaining arsenic concentrations, including a 68 mg/kg result, detected in a Nobis Engineering, Inc. (Nobis) background sample collected in the Locust HA, are considered “consistent with the arsenic background data set.” Thus, with the exception of the two Cavite HA soil samples noted above, all arsenic concentrations detected during the PASI and SSI investigations are “consistent with the arsenic background data set.” The former Cavite HA samples noted above are considered not consistent with background and may be either natural anomalies or from an anthropogenic contribution of arsenic within the former Cavite HA.

3.3 GROUNDWATER

Depth to groundwater beneath the SA was documented during the SSI. The depth to groundwater, measured in four monitoring wells and six piezometers installed in the former Grant HA during the SSI, is approximately 40 ft bgs, except adjacent to the Nashua River, where the ground elevation is approximately 25 ft lower, and groundwater is present at approximately 12 to 16 ft bgs. Table 3-1 summarizes the groundwater depths measured during and following SSI field activities.

Based upon groundwater elevations measured in the four monitoring wells and six piezometers installed in the former Grant HA during the SSI, groundwater flow beneath the former Grant HA portion of the SA is southwesterly to westerly beneath IA-2 and northeasterly to northerly beneath IA-8. It appears that groundwater flow directions are quite variable beneath the former Grant HA, likely the result of the presence of buried esker or other deposits that provide preferential pathways for groundwater flow. Evidence for a buried esker or other highly-conductive deposits include coarse material encountered in soil borings and test pits in the area and the USGS Surficial Geology map, which shows an ice channel filling deposit oriented north-south and located immediately east of the former Base Laundry (USGS, 1953). It is presumed that regionally, groundwater flow is northwesterly, toward the Nashua River, where groundwater is presumed to ultimately discharge (see Figures 3-4 and 3-5). Consistent with groundwater flow directions, horizontal hydraulic gradients appear to be variable over relatively short distances, which is indicative of variability of overburden materials. Comparing values in the downgradient direction, in IA-2, the hydraulic gradient between monitoring well MW-3 and PZ-4 is 0.004, while the hydraulic gradient between PZ-5 and MW-4 is 0.03, a difference of almost an order of magnitude. In IA-8, the hydraulic gradient between monitoring well MW-1 and PZ-1 is 0.02, while the hydraulic gradient between MW-1 and MW-2 is 0.005, a factor of four. Both of these changes occur over distances of only a few hundred feet, and yet both high and low ranges are similar in value, reflecting the similarity of the properties of these unconsolidated materials across the SA.

Based on the observed groundwater elevations and interpretation of groundwater flow directions, it appears that more conductive units, such as esker deposits within kame or ground moraine

deposits, result in preferential pathways for groundwater flow. This is particularly evident in IA-8, where there appears to be a buried esker deposit that directs groundwater flow northwestward from monitoring well MW-1 in a linear fashion toward monitoring well MW-2, with higher groundwater elevations to both the east and the west. Further, it appears that portions of the saturated overburden comprise partially confined aquifers, due to the presence of relatively low-permeability aquitard units that overlie more conductive units at depth. Examples of this are seen at piezometers PZ-1 and PZ-2, where relatively thin sandy units within glacial till produce significant amounts of water.

The depth to groundwater beneath the former Locust HA was not documented, but is likely similar to that observed at the former Grant HA, based on the similarity of the surficial geology observed. The depth to groundwater beneath IA-6, located immediately west and downhill of the former Locust HA, is approximately 5 ft bgs. The depth to groundwater beneath the former Cavite HA portion of the SA is not documented. The area is located along the groundwater divide between Cold Spring Brook to the east and Robbins Pond Brook to the west (MassDevelopment, 1997). Groundwater was not observed in the excavations in the former Cavite HA, which reached more than 12 ft bgs (WESTON, 2003a). Groundwater beneath the former Cavite HA is presumed to be present only in bedrock fractures, as it was not noted in test pit TP-01 excavated in the former Cavite HA.

The former Grant and Locust HAs, in the western portion of the SA, are underlain by a stratified drift aquifer with a transmissivity estimated at up to 1,400 square feet (ft^2) per day (MassDevelopment, 1997). The former Fort Devens installation is served by a public water supply that is operated and maintained by MassDevelopment. The water supply obtains water from four sources: the Patterson and Shebokin overburden wells (south of the SA), the Grove Pond overburden well field (east of the SA), and the MacPherson overburden/bedrock well (north of the SA). The locations of the wells are depicted on the Physical Setting Map (Figure 3-1). The closest well is the Grove Pond wellfield, which is located approximately 4,800 ft north-northeast of the former Cavite HA. The areas of contribution of the four groundwater sources are outside of the SA, with the exception of the extreme northeastern portion of the former Grant HA, which is within the Zone II Contribution Area of the

MacPherson well (MassDevelopment, 1997). The wells are part of an interconnected system that has approximately 287 commercial and residential connections (Schmidl, 2004).

The towns of Ayer and Shirley also operate and maintain public drinking water supplies. The Town of Ayer obtains water from two groundwater sources, which are located cross-gradient of the SA. The two Town of Ayer Grove Pond overburden wells are located immediately east of the MassDevelopment Grove Pond overburden well field (MassDevelopment, 1997; MassDEP, 2004a). The Town of Shirley obtains water from three groundwater sources, only one of which is located down gradient of the SA. The Town of Shirley Patterson overburden well is located approximately 2,300 ft north of the northern portion of the former Grant HA, and is the closest drinking water well to the SA, with the interim (not formally calculated) area of contribution to the well extending into the northern portion of the former Grant HA (MassDevelopment, 1997; MassDEP 2004a). No known private drinking water wells are located on the former Fort Devens installation or near the SA.

3.4 SURFACE WATER

Runoff from the former Grant and Locust HAs drains westward to the Nashua River, via storm drains and overland flow. The Nashua River is located approximately 100 to 1,000 ft to the west of the western boundary of the former Grant and Locust HAs, respectively. Runoff from the former Cavite HA drains westward, via storm drains and overland flow, to Willow Brook, which drains northward approximately 1 mile to Nonacaicus Brook, which flows west approximately 0.5 mile to the Nashua River. Willow Brook is located approximately 900 ft to the west of the former Cavite HA (USGS, 1988). Willow Brook is a minimal stream, Nonacaicus Brook is a small to moderate stream, and the Nashua River is a moderate to large stream (MassDEP, 2004c; USGS, 1988, 2002). The SA is located above the 500-year flood elevation of the Nashua River and its tributaries (Federal Emergency Management Agency, 1983).

3.5 EXPOSURE PATHWAYS

Potential exposure pathways at the site include groundwater, surface water, soil, and air and each has associated receptors. The following paragraphs identify the potential sources and receptors

for each of the pathways and serve as a Conceptual Site Model (CSM) for potential contaminant exposure and migration.

3.5.1 Groundwater

As indicated in Subsection 3.3, the individual HAs are served by public water supply. The nearest supply wells are approximately 4,800 ft to the north-northeast of the Cavite HA and approximately 2,300 ft to the north of the Grant and Locust HAs. Most of the SA, except for the extreme northeastern portion of Grant HA, is outside a Zone II Contribution Area. There are no Wellhead Protection Areas within the SA. There are no known private water supply or drinking water wells in the vicinity of the SA. The depth to groundwater is 30 to 40 ft bgs within the HAs.

The potential constituents of concern (COC) that may impact groundwater would be pesticides in the three HAs, volatile organic compounds (VOC), PAHs, pesticides, PCBs, explosives, antimony, and lead within the Grant HA, and lead in IA-6. Typically, PAHs, pesticides, and PCBs tend to adhere to the individual soil particles rather than dissolve into groundwater, and as a result, are not typically considered groundwater contaminants. Volatile organic compounds, explosives, antimony, and lead have higher potential groundwater mobility. Although a few of the COCs were detected at trace concentrations in groundwater samples collected during the SSI, none of the potential COCs were detected at concentrations that indicate any potential risk. The details regarding the SSI groundwater analytical results are included in Section 5 of this report. However, due to the proximity of public water supply wells and the trace concentrations of potential COCs in groundwater samples collected during the SSI, the groundwater pathway must be considered a complete, albeit unlikely, pathway.

3.5.2 Surface Water

As indicated in Subsection 3.4, the predominant transport route for surface water is via overland flow and storm drains. The predominant receptor of surface water runoff for the SA is the Nashua River. There are no direct discharges from the SA to the Nashua River and any surface water would be mixed/diluted with flow from neighboring properties before being released to the river. Stormwater from the Cavite HA would have to drain through overland flow from the site

to Willow Brook, which is located approximately 900 ft south, then flow nearly a mile to Nonacaicus Brook which flows approximately 0.5 mile before being released to the Nashua River.

There are no freshwater wetlands, Surface Water Supply Zone A areas, certified vernal pools, protected open spaces, National Heritage and Endangered Species Program (NHESP) Priority Habitats of Rare Species, NHESP Estimated Habitats of Rare Wildlife, or Areas of Critical Environmental Concern (ACEC) within the SA (MassGIS, 2003a, 2003b, 2003c, 2003d, 2004b, 2004c, 2005). Freshwater wetlands, NHESP Habitats of Rare Species, NHESP Estimated Habitats of Rare Wildlife, ACECs, and protected open spaces associated with the Nashua River are located immediately west of the former Grant and Locust HAs. Figure 4-2 depicts available wetland and other environmental data for the SA.

Suspected releases to surface water would again be VOCs, PAHs, pesticides, PCBs, explosives, antimony, and lead. However, these releases would be associated with the movement of impacted soils through overland flow and storm drains. The likelihood that sufficient quantities of PAH-, pesticide-, and PCB-impacted soil have been released to surface water is unlikely, due to the impacted areas being covered by roadway or lawns. According to base history, any antimony, lead, and explosives releases would be to open surfaces in the identified ranges. Any release from the ranges would be through overland flow and would likely have occurred near the time of range activities. Additionally, if overland flow released COCs or impacted soils from the effected areas, the flow would be combined and diluted with stormwater from areas surrounding the SA, thus reducing the overall impact upon release to the river. Since releases of pesticides and PCBs have been limited due to the pavement or grass coverage, it is unlikely that stormwater impacts would present a condition of unacceptable risk to human health or the environment. Since releases of lead and explosives would have occurred pre-1960 and the areas are now overgrown, it is unlikely that releases to surface water from the soil are occurring. Therefore, surface water will not be addressed as a potential exposure pathway as part of this investigation.

3.5.3 Soil

Human and ecological receptors to COCs in soil are likely, both now and in the future. Certain limited PAH, pesticide, antimony, and lead impacts have been documented in soils in certain portions of the SA. The details regarding the SSI soil analytical results are included in Section 5 of this report. Currently, the SA is unoccupied. However, redevelopment is planned as residential in the Grant HA, innovative and technology business in the Locust HA, and residential and open/recreation in the Cavite HA. Therefore, soil will be assessed as a potential exposure pathway as part of this investigation.

3.5.4 Air

Air exposure to COCs is unlikely due to present and future site conditions. Currently, there are no problems related to the release of dust from the SA and odor-related complaints. Dust levels which would be released for short durations during construction activities would be low primarily due to the low clay and silt content of the SA soils. Construction management practices will mitigate potential dust generation during construction activities. Most of the SA is grass-covered or will be covered by new homes, businesses, pavement, and lawns following development further reducing the potential for airborne exposures. The available soil analytical results do not indicate that VOCs are present in soil in any part of the SA, so there is no reason to consider soil vapor migration of contaminants. Therefore, air will not be assessed as a potential exposure pathway as part of this investigation.

SECTION 4

PREVIOUS ACTIVITIES AND INVESTIGATIONS

4. PREVIOUS ACTIVITIES AND INVESTIGATIONS

4.1 MASSACHUSETTS CONTINGENCY PLAN-LEAD PESTICIDE SOIL REMEDIAL ACTION - GRANT, LOCUST, AND CAVITE HOUSING AREAS

4.1.1 Scope

An MCP-Lead Pesticide Soil Remedial Action was initiated by WESTON in February 2002. The remedial effort was initially performed to address COCs associated with pesticide application under and around the buildings. Asbestos-containing materials (ACM) associated with the heating, ventilation, and air conditioning (HVAC) ductwork, vapor barrier, and mastic waterproof coating on the foundation walls below the slabs of the former base housing units was also abated. During and following the removal of pesticide-contaminated soil, PCB-contaminated soils exceeding EPA cleanup criteria for residential use (1 mg/kg) were identified. A removal action was initiated within the Grant HA to address excavation of PCB-impacted soil. The HAs and units addressed by the MCP-Lead Pesticide Soil Remedial Action were:

- **Grant Housing Area** - 130 former building locations (Buildings 308 through 319, Buildings 328 through 333, Buildings 343 through 367, Buildings 384 through 392 (excluding Building 388), and Buildings 822 through 899.
- **Locust Housing Area** - 14 former building locations (Buildings 547 through 560).
- **Cavite Housing Area** - 6 former building locations (Buildings 137, 138, 144, 145, 146, and 147).

The remedial activities at the former Grant, Locust, and Cavite HAs were performed in accordance with the MCP (MCP–310 Code of Massachusetts Regulations (CMR) 40.0000). Massachusetts Contingency Plan Method 1 Risk Characterization was used as the clean-up criteria. The primary objectives of the MCP-Lead Pesticide Soil Remedial Action included: the removal and reuse of non-pesticide-contaminated concrete foundations; removal and off-site disposal of pesticide-contaminated concrete; abatement and disposal of ACM; and excavation and off-site disposal of pesticide-impacted soil to the extents necessary to meet established

project clean-up goals as presented in the *Pesticide Soil Remedial Action – Revised-Final Sampling and Analysis Plan* (WESTON, 2002). All excavation areas were backfilled to existing grade with crushed uncontaminated concrete and/or clean and suitable soils.

Prior to the commencement of remedial activities, characterization samples were collected from each of the 150 buildings for disposal profiling. Asbestos-containing material samples were collected from each suspect material within each housing unit and submitted for polarized light microscopy analysis. Soil characterization samples were collected at a rate of one sample per 3,000 ft^2 of foundation. Five discrete samples were collected from 0 to 4 ft below the base of each slab and composited into one sample. Between 14 February and 17 April 2002, a total of 163 samples were submitted to an off-site laboratory for Resource Conservation and Recovery Act metals, PAHs, VOCs, semi-volatile organic compounds (SVOC), total petroleum hydrocarbons (TPH), PCBs, and pesticides analysis.

4.1.2 Results

Characterization results for ACM indicated the presence of asbestos-containing HVAC ductwork (as transite pipe) under 88 slabs, waterproofing mastic on the foundation walls of 6 buildings, and a vapor barrier below 3 of the building slabs (Table 4-1).

Characterization results of soils from below the building slabs indicated the presence of pesticides, metals, SVOCs/PAHs, VOCs, and TPH. The results also identified arsenic, chloroform, PAHs, and TPHs as potential COCs based on exceedances of Project Action Levels (PAL). Further evaluation of the potential COCs was conducted with the following results:

- **Chloroform:** Re-evaluation of chloroform reporting limits by the analytical laboratory reduced the limit to below the clean-up criteria resulting in the elimination of chloroform as a potential COC (WESTON, 2003d).
- **Total Petroleum Hydrocarbons:** Further sampling and analysis conducted at the five locations with TPH exceedances by speciation of the samples into extractable petroleum hydrocarbons (EPH) and volatile petroleum hydrocarbons analysis eliminated TPH as a potential COC. The results indicated no exceedances of the MCP standard for the listed carbon range at these buildings (see Table 4-2). No further action was required (WESTON, 2003d).

- **Polycyclic Aromatic Hydrocarbons:** Polycyclic Aromatic Hydrocarbons were detected at low concentrations in 12 buildings, their presence was not widespread, and a source was not present. The sample data was compared to background concentrations presented in the document *Background Levels of Polycyclic Aromatic Hydrocarbons and Metals in Soil* (MassDEP, 2002). In addition, re-evaluation of the PAH reporting limits was performed by the analytical laboratory. The result of these actions was the elimination of nine buildings from further assessment. To address the remaining PAH exceedances, PAH sample analyses was added to the list of confirmatory sample analyses that were conducted as part of post-excavation sample analysis. Results of post-excavation sample analysis (see Table 4-3) met the MCP criteria and no further action was required at these locations (WESTON, 2003d).

- **Arsenic:** Arsenic concentrations exceeded MCP RCS-1 standard (30 mg/kg) in 30 samples (see Table 4-4). Further evaluation of arsenic was performed as part of this PASI and SSI effort, and is included in Subsection 3.2.6 of this report.

4.1.3 Conclusions

Remedial activities at the site consisted of the following activities: existing ACM was abated and disposed at an off-site landfill in accordance with MassDEP asbestos abatement guidance; concrete was removed, stockpiled, sampled, and used as backfill or disposed; pesticide-contaminated soils were excavated to a level of No Significant Risk (NSR) and disposed off-site; post-excavation confirmatory sampling and analysis was conducted; and the excavations were backfilled with clean and suitable materials in accordance with BRAC Cleanup Team -approved Work Plans (WP).

The MCP-Lead Pesticide Soil Remedial Action resulted in the collection of over 7,000 samples and the removal of the following materials:

- **Grant Housing Area** - A total of 30,912 linear feet (lf) of transite pipe ACM, 2,082 ft^2 of waterproof mastic ACM, 2,079 ft^2 of vapor barrier ACM, 169,052 tons of pesticide-contaminated soil, and 16,689 tons of pesticide-contaminated concrete excavated or removed and transported to the on-site Devens Consolidated Landfill or to off-site landfills for proper disposal. A total of 3,707 tons of clean concrete was pulverized and blended with clean soils obtained from an approved off-site source.

- **Locust Housing Area** - A total of 5,491 lf of transite pipe ACM, 20,035 tons of pesticide-contaminated soil, and 2,081 tons of pesticide-contaminated concrete were abated, excavated or removed and transported to off-site landfills for proper disposal.

- **Cavite Housing Area** - A total of 1,950 lf of transite pipe ACM, 4,000 ft^2 of waterproof mastic ACM, 1,350 ft^2 of vapor barrier ACM, 6,866 tons of pesticide-contaminated soil, and 1,236 tons of pesticide-contaminated concrete were abated, excavated or removed and transported to off-site landfills for proper disposal.

The report concluded that all site remedial activities had been completed and applicable MassDEP project clean-up goals were met at each building within the three former HAs for each potential COC, excluding PCBs (see Subsection 4.1.4). With the exception of PCBs, the Licensed Site Professional determined that NSR of harm to health, safety, and public welfare remained. A Class A-2 Response Action Outcome can be filed for the site in accordance with the MCP.

4.1.4 Polychlorinated Biphenyls

During the course of MCP-Lead Pesticide Soil Removal Actions, PCBs were detected at concentrations above EPA clean-up standard (1 mg/kg) in 12 buildings in the Grant HA (Buildings 838, 842, 857, 861 to 866, 869, 874, and 877) and one Stockpile Management Area (SMA) (SMA - Poplar Street). At two buildings (Buildings 863 and 877), PCBs were detected at concentrations above 50 mg/kg. Polychlorinated biphenyls were not detected at concentrations above 1 mg/kg in samples collected in the Locust and Cavite HAs. The detection of PCBs above EPA clean-up standards promulgated an EPA-lead PCB Soil Removal Action in the Grant HA in accordance with Toxic Substances Control Act (TSCA), described in Subsection 4.2.

4.2 TIME CRITICAL REMOVAL ACTION - GRANT HOUSING AREA

During remedial activities performed in 2002 by WESTON for USACE to address pesticide contamination associated with housing units in the former Grant HA, PCB contamination was detected at concentrations above the MassDEP standard of 2 mg/kg.

During post-excavation sampling associated with Release Abatement Measures being performed to address pesticide contamination around housing unit foundations within the site, PCB signatures were observed by the on-site laboratory in samples associated with several buildings within the former HA. Off-site analysis initially indicated that the PCB concentrations were below 50 mg/kg, which did not meet TSCA regulatory requirements and could be managed

under MassDEP authority. However, during preliminary remedial activities, that included excavation and transport and disposal with co-located pesticide-contaminated soil, several samples yielded PCB results in excess of 50 mg/kg.

Based on subsequent discussions held between the Army, USACE, MassDevelopment, MassDEP, and EPA regarding elevated detections of PCBs and a due diligence investigation performed to determine the time of spill-release, a TSCA-regulated remediation was implemented to address the elevated detections of PCBs. Per EPA guidance, a Time-Critical Removal Action (TCRA) was implemented by the Army to remediate the PCB-impacted soil according to the established clean-up goal of 1 mg/kg.

Remedial activities conducted during the TCRA consisted of delineation, excavation, confirmatory sampling, waste characterization, transportation and disposal as documented in this Closure Report. During TCRA activities, approximately 1,170 soil samples have been collected to evaluate the extent of PCB-impacted soils. Ten separate rounds of remediation were performed in the Grant HA between 2002 and 2005. A total of approximately 13,400 tons of soil was excavated and disposed from the site as either TSCA-regulated (greater than or equal to 50 mg/kg), low PCB concentration soil (less than 50 mg/kg but greater than or equal to 15 mg/kg) and/or *Reuse and Disposal of Contaminated Soil at Massachusetts Landfills* (COMM-97) daily landfill cover material (less than 15 mg/kg), depending on the concentration of PCBs in the soil. Remedial and site restoration activities were completed in accordance with all applicable state and federal regulations and in accordance with specifications provided by MassDevelopment for construction activities. No further actions are anticipated at the site as all remaining PCB concentrations in soil are currently below the EPA-established remedial criteria (WESTON, 2006a; 2006e).

4.3 USACE ARSENIC BACKGROUND STUDY

This report describes the attributes of a set of soil data collected from 40 soil borings that were analyzed for arsenic and four other indicator metals (iron, manganese, aluminum, and nickel) throughout Main and North Posts at former Fort Devens. The attributes of the soil that were of most interest for this analysis were the concentrations of the various metals, geologic unit

(i.e., lacustrine, till, etc), and soil type (sand, silt, gravel, etc.). A total of 124 soil samples from three different depths at each soil boring were proposed. The locations for the soil borings were carefully chosen in areas without any prior known human activity associated with the base (i.e., representative of background conditions). The data set provided a broader assessment of arsenic concentrations across former Fort Devens and was intended to supersede the Group 1B study and establish a BW background distribution for arsenic (USACE, 2004b).

Samples were collected from the 0 to 3, 3 to 6, and 6 to 10 ft bgs intervals at each boring location. However, some borings encountered refusal before the depth of 10 ft bgs, thereby limiting the total number of samples. A total of 124 samples were submitted and analyzed for arsenic, iron, manganese, aluminum, and nickel including; 40 primary and six duplicate samples from 0 to 3 ft bgs, 39 primary and 7 duplicate samples from 3 to 6 ft bgs, and 31 primary and 1 duplicate sample from 6 to 10 ft bgs. Metals other than arsenic were also chosen for analysis based on an expected geochemical association and previously observed correlations with arsenic in studies by Hon, et al. (Hon, 2002).

In addition to the samples discussed above, Nobis also collected 42 soil samples from 15 soil boring locations throughout the former Grant and Locust HAs (hereafter referred to as the Nobis data set). These data were collected from within the SA, but from locations that did not appear to have been significantly disturbed by the construction of the former housing units. These data are summarized in Table 4 of the *Metals in Soil Investigation in Support of Arsenic Background Study – Former Fort Devens* (USACE, 2003a; 2004a). Samples were not collected within the Cavite HA.

The *Metals in Soil Investigation in Support of Arsenic Background Study – Former Fort Devens* (USACE, 2003) was used in compliance with the MCP, such that the results were used to evaluate background samples for arsenic, with background numbers developed for the SA as a whole. Background arsenic concentrations have not been developed on a IA-specific basis.

4.4 REMEDIAL INVESTIGATION REPORT FOR FUNCTIONAL AREA I – APPENDIX L

An evaluation of background arsenic at the former Fort Devens was conducted as part of the *Functional Area 1 (Group 1B) Remedial Investigation Report* (U.S. Army Environmental Center, 1994). The Group 1B report established a background concentration of 19 mg/kg for arsenic in soil. This background concentration has been used for guidance on past and ongoing soil remediation efforts at former Fort Devens. However, both site investigations and remediation activities since 1994 and regional investigations have led to questions and concerns about the representativeness of this background. There is also considerable uncertainty regarding the variability of naturally occurring arsenic at former Fort Devens and in the New England region. A subsequent report by Ecology & Environment, Inc., included as Appendix L of the *Remedial Investigation Report for Functional Area I* (USACE, 1994), utilized data from several sources to establish background concentrations of several inorganic analytes for the former Fort Devens (hereafter referred to as the Group 1B data set). After eliminating 4 of the 33 data points as outliers, the study estimated a background concentration for arsenic (19 mg/kg). This value corresponded to the highest concentration within the remaining data set. No further information was provided in the report to indicate why this method was used to derive an arsenic background concentration, nor was any detailed or rigorous statistical analysis apparently performed on the background data (USACE, 1994). A background concentration for lead (48 mg/kg) was established using the same methodology. As indicated in Subsection 4.3, the USACE Background Study supersedes this study.

4.5 ARCHIVES SEARCH REPORT AND ORDNANCE & EXPLOSIVES REMOVAL REPORT

The *ASR* (USACE, 1995a; 1995b; 1995c) documents the locations of all known training areas and ranges within the SA. These locations have been summarized in Figures 2-3 and 4-1. Based on the findings of *ASRs* (USACE, 1995a; 1995b; 1995c), portions of the Grant and Oak HAs were identified for a removal action of UXO. This removal action identified significant amounts of UXO and UXO scrap in the Oak HA, located to the southwest of the Grant HA (HFA, 1996). A removal action in this area was undertaken and the results summarized in the *Final Ordnance,*

Ammunition and Explosives Removal Action Report (HFA, 1996). Sampling for explosives, lead, or perchlorate was not conducted as part of this removal action.

4.6 EXPANDED CONCEPTUAL SITE MODEL

The *Expanded Conceptual Site Model* (*ECSM*) (USACE, 2006) documents the findings of the previous munitions and explosives of concern (MEC) investigations in the Grant, Locust, and Cavite HAs, including the PASI. The *ECSM* concluded that the characterization of the UXO survey is fully developed and sufficient to identify the areas of concern that have a potential for UXO.

Firing-range activities were presumed to have occurred within each of the identified investigation areas. Over time the range feature have become less defined. Therefore, samples were collected within each of the ranges in areas identified in the field to be the likely areas impacted by range activities and/or were identified from aerial photographs as the likely impacted areas. Analytical results collected from samples collected within IAs-1, 3, and 5 did not indicate the presence of potential COCs that would present unacceptable risk to human health or the environment. Consequently, no further investigation of potential COCs was recommended for IA-1, 3, and -5.

Investigation Areas 6 and IA-7 are not located within any of the former HAs. At IA-6, the analytical results indicated the presence of lead that is above the MCP RCS-1 standard of 300 mg/kg that was associated with the former range activities. Initial research indicated that IA-7 was an indoor small arms range. No sampling action was recommended in the *ECSM* for IA-7. However, in 2004 (after the *Final Draft ECSM* was produced), it was determined that the IA-7 range area was actually located outdoors, slightly south of the original estimated location. This issue was addressed in the 2006 revision of the *ECSM*. A time-critical removal action was performed at IA-6 to address the elevated antimony and lead concentrations in soil at this former range (see Subsection 4.8). Although not recommended for the same remedy in the *ECSM*, subsequent discussions between the Army, MassDEP, and MassDevelopment have concluded that a limited soil removal action will be performed by MassDevelopment following the

MassDEP regulation 310 CMR 40.0440 in order to address a localized area of elevated antimony and lead concentrations in soil at the former range at IA-7.

The only identified area of concern with potential residual UXO presence was the 37-mm range associated with IA-2. The characteristics of the 37-mm range were considered clearly defined, with the Impact Area located on the hillside between the Grant and Oak (Oak Circle) HA and the Firing Point located to the northeast at IA-2 within Grant HA. The effective range of the 37-mm falls within the target area, given IA-2 as the firing point. There is a low potential for finding 37-mm UXO remaining on the site and the potential is higher in the former Impact Area with the potential decreasing outside of it as the distance increases from the target area. It was concluded that any additional investigation was not going to alter the characterization of the range features and the perception of residual UXO presence.

The *ECSM* concluded there was a potential for a complete UXO-related pathway within the former IA-2 range. There was a higher potential within the former Impact Area. The former Impact Area was determined to be located on the hillside between the Grant and Oak HA, and not within Grant HA. The recommendations provided in the *ESCM* were utilized in making the recommendation that Land Use Controls (LUCs) should be evaluated in a Focused Feasibility Study for the Impact Area. The specific LUCs will be developed based on the results of this study.

The *ECSM* concluded there was a lower potential for a complete UXO-related pathway on the former range within Grant HA, excluding the impact area. Safety training and notification of the construction workers, residents, and surrounding community were recommended. The recommendations provided in the *ESCM* were utilized in making the recommendation that LUCs should be evaluated in a Focused Feasibility Study for the Grant HA. The specific LUCs will be developed based on the results of this study.

Further development and assessment is required to fully develop and implement the recommended actions. The final determination will be based on (1) the Record of Decision and LUC that will be produced for the Impact Area and the Grant HA, and (2) the results of an

additional MEC investigation within the Oak, and Maple HAs (see recommendation specified in Sections 7 and 8 of this report).

It should be noted that, with the exception of the change in location of IA-7, the conclusions of the *ECSM* did not change substantially in light of subsequent data collection in the Grant HA (see Subsection 4.7). The *ECSM* is included as Appendix D of this report.

4.7 MUNITIONS AND EXPLOSIVES OF CONCERN SURVEY

MassDevelopment retained Ordnance & Explosives Remediation, Inc. (OER) to perform a Digital Geophysical Mapping (DGM) investigation and MEC removal from the former Grant HA. The DGM was performed using a Geonics EM-61 unit to identify subsurface electromagnetic anomalies that could be MEC-related items. Following the DGM, OER and its subcontractors reaquired and marked the anomalies, and excavated, identified, and removed those items. Trees and severe slopes prevented OER from achieving 100% coverage with the DGM, but OER believes that these issues did not affect the overall goal of demonstrating that the site is suitable for residential end land use (OER, 2006).

Approximately 20 pieces of 37-mm UXO and 1,870 pounds of MEC scrap were recovered from the site, mostly located on the north side of Oak Hill, the presumed impact area. In addition, six 3-inch-diameter Stokes mortars and 30 other miscellaneous ordnance items were recovered from the area. These items were distributed evenly across the site in a way that suggests that the ordnance were not associated with specific training areas. The ordnance recovered was detonated in place, and all MEC-related scrap was removed from the site (OER, 2006). The *Site Specific Final Report DGM & UXO* is included in Appendix E of this report.

4.8 TIME CRITICAL REMOVAL ACTION - FORMER BRYANT RANGE

The PASI activities conducted within former Bryant Range (IA-6) Small Arms Firing Range clearly indicated the presence of bullets, bullet fragments, and elevated antimony and lead concentrations in the soil. Based on this information, additional investigation activities were conducted at Bryant Range as part of the SSI to further define the extent of the constituents of concern impacts at the site.

In fall 2005, WESTON was tasked by USACE to conduct the TCRA activities under the direction of the Army. The TCRA was designed to ensure reduction of soil antimony and lead to concentrations below the Target Cleanup Goals (TGG) and that remaining lead concentrations will be protective of human health and the environment. Analytical results indicated that antimony and lead contamination was entirely co-located, such that removal of lead-contaminated soils would also result in the removal of antimony-impacted soils (WESTON, 2006b).

The TCRA Scope of Work included the following field activities:

- Mobilization
- Tree, Stump, and Brush Removal
- Removal of Antimony- and Lead-Impacted Soil
- Post-Excavation Field Screening
- Treatment of Excavated Soil
- Disposal of Waste
- Demobilization

Approximately 1,655 tons of soil were removed and disposed of off-site following excavation, treatment, sampling, and disposal characterization as summarized below.

- 267 tons of excavated soil meeting Land Disposal Regulations (LDR) and COMM-97 criteria (total lead concentrations less than 2,000 mg/kg) were transported to Fitchburg Landfill, in Westminster, Massachusetts.

- 910 tons of excavated and treated soil meeting LDRs and COMM-97 criteria (total lead concentrations less than 2,000 mg/kg, lead toxicity less then 5.0 milligrams per liter) were transported to Fitchburg Landfill, in Westminster, Massachusetts.

- 478 tons of bullet-laden excavated soil were transported to an off-site, hazardous waste disposal facility, Stablex Canada, Inc., in Blainville, Quebec, Canada (WESTON, 2006d).

Figure 4-3 depicts the areas where soil was removed from IA-6, and the confirmatory soil analytical results (WESTON, 2006d). Site restoration activities included grading or backfilling and compaction of excavations, general site grading for drainage, upland restoration, and wetland restoration (WESTON, 2006c; 2006d).

SECTION 5

PRELIMINARY ASSESSMENT/SITE INSPECTION AND SUPPLEMENTAL SITE INVESTIGATION SAMPLING ACTIVITIES

5. PRELIMINARY ASSESSMENT/SITE INSPECTION AND SUPPLEMENTAL SITE INVESTIGATION SAMPLING ACTIVITIES

5.1 PRELIMINARY ASSESSMENT SITE INVESTIGATION

Based on the identification of elevated levels of arsenic and PCBs during the MCP-Lead Pesticide Soil Remedial Action [EPA letter, 13 March 2003 (as modified in an e-mail message dated 17 September 2003)], the former Grant, Locust, and Cavite HAs became an SA. The original objective of the PASI was to determine whether a release or potential release of CERCLA-regulated contaminants, arsenic and/or PCBs exists and the nature of the associated threats to human health and the environment. The scope of the PASI was subsequently expanded to include the investigation of lead, explosives, and perchlorate based on a review of historical information for this SA.

The following subsections describe the objectives of the PASI in more detail, including sample rationale.

5.1.1 Scope

On 16 October 2003, a *Draft PASI WP* was completed and submitted to the Base Closure Team (BCT). The *Draft PASI WP* (WESTON, 2003e), which included the Preliminary Assessment, provided a summary of:

- Historical site information and existing analytical databases to assess the likelihood that a release or potential release of arsenic and/or PCBs had occurred.
- Data gaps in the analytical database regarding the presence of arsenic in the HAs.
- Assessed potential PCB sources, extent of PCB-contaminated soils, and the status of the completed and on-going removal actions to remediate PCBs to the CERCLA standard.
- Locations of several training areas and firing ranges within the SA.

Several modifications and expansions were made to the sampling approach that was outlined in the *Draft PASI WP* (WESTON, 2003e). USACE proposed a *Revised Sampling Approach* for

arsenic which was approved on 13 November 2003, by the BCT that realigned the proposed arsenic sampling to correspond closely to the procedures used in the previously conducted arsenic background sampling effort. The *Revised Sampling Approach* also stated that 45 samples would be collected randomly within areas planned for redevelopment and that the SA arsenic data set would be evaluated against the BW arsenic data set.

On 26 November 2003, EPA provided comments on the *Draft PASI WP* (WESTON, 2003e) and requested that assessments be considered for explosives, lead, and perchlorate releases as part of the PASI effort. Results of the subsequent evaluation for the potential of explosives, lead, and perchlorate releases were presented in the *Explosive, Lead, and Perchlorate –Conceptual Site Model* (WESTON, 2004a). Based on the *CSM*, investigations of lead and explosives at several locations within the Grant and Locust HAs were added. Perchlorate was not identified as a COC for several reasons, but primarily due to the fact that perchlorate came into wide-scale use in the military with the development of solid rocket fuels during and after WWII. Most of the training and range activities, which could have resulted in the use of rockets, would not have occurred in the SA due to the establishment of infrastructure in and around these areas in the 1930s. Also, given the high solubility of perchlorate, it is highly unlikely that any residual perchlorate would remain in the soil after it had been used 70 to 85 years earlier.

Addenda to the previously prepared MCP-Lead Pesticide Soil Remedial Action plans were prepared and samples were collected in accordance with the *Quality Assurance Project Plan* (see Appendix F), *Sampling and Analysis Plan* (see Appendix G), and *Health and Safety Plan* addenda.

Maps of each IA detailing PASI (as well as SSI) sample locations are included as follows:

- Figure 5-1: Sample Location Index Map
- Figure 5-2: IA-1 & IA-2 Firing Points Sample Location Map
- Figure 5-3: IA-1 Impact Area Sample Location Map
- Figure 5-4: IA-2 Intermediate Area Sample Location Map
- Figure 5-5: IA-8 Sample Location Map
- Figure 5-6: IA-2 Impact Area Sample Location Map
- Figure 5-7: IA-5 Sample Location Map
- Figure 5-8: IA-6 Sample Location Map
- Figure 5-9: IA-3 & IA-11 Sample Location Map

- Figure 5-10: IA-7 Sample Location Map
- Figure 5-11: IA-9 Sample Location Map

The PASI sample analytical results are discussed in Subsection 5.1.2, and SSI sample analytical results are discussed in Subsection 5.2.

5.1.2 Preliminary Assessment Site Investigation Methodology

5.1.2.1 Arsenic Investigation

Metals samples were collected from 18 test pit locations throughout the SA in an effort to obtain representative samples from all areas of the SA that were likely to be redeveloped. The samples were collected as grab samples from a minimum of two sample intervals (0 to 3 and 3 to 6 ft bgs). Each test pit was excavated utilizing a backhoe to allow for visual assessment of the stratigraphy. The sample was then collected directly from the excavation sidewall using a sampling trowel. Each sample was homogenized and placed in a 4-ounce glass jar for submittal to the off-site laboratory. The samples were analyzed for aluminum, arsenic, iron, lead, manganese, and nickel by EPA Method 6010.

Forty (40) randomly located samples were collected by WESTON from the test pits in accordance with the *Revised Sampling Approach*. Of the 18 test pits, 12 were located in the former Grant HA, 3 were located in the former Locust HA, and 3 were located in the former Cavite HA. Initially, additional samples were collected from the test pits in the Cavite HA. While a minimum of two samples were collected from each test pit (e.g., 0 to 3 ft and 3 to 6 ft bgs), additional samples were collected from stratigraphic units within these sample depths. Test pit logs are presented in Appendix A.

The metals analytical results for the PASI soil samples are summarized in Table 5-1a. The arsenic data set of 40 samples was combined with an additional 42 samples that were previously collected by Nobis from the Grant and Locust HAs. Collectively, the 82 samples from the two separate investigations form the “SA data set” which allowed for a more robust comparison between the SA data set and the BW background arsenic data set. The determination that it is appropriate to combine the two data subsets was made using the non-parametric Kruskal-Wallis

test to establish, at the 95% confidence level, that these two data sets are drawn from the same population (USACE, 2004). A more complete discussion of the Kruskal-Wallis test is presented beginning on Page 5 of Appendix C.

5.1.2.2 Polychlorinated Biphenyl Investigation

Sample locations were chosen throughout the SA to assess potential releases or known releases within each HA. Sampling was conducted in accordance with the WPs. Grab sampling was utilized to assess PCB releases in shallow soil (typically 0.5 to 2 ft) beneath the HA roadways. Samples were collected utilizing a Geoprobe to minimize disturbance to the roadway. Sample spacing was approximately 200 to 250 ft along the roadways. A total of 55 roadway samples were collected from the Grant (51) and Locust (4) HAs. The roadways in the vicinity of Cavite HA were not sampled as no known sources of PCBs could be found in the historical record, and no transformers were located in or near this HA.

Composite soil sampling was utilized to assess the shallow soil (0 to 2 ft) in areas off the road. Within HAs, either "5-point" or "polygon" composites were utilized to assess arsenic and PCB impacts. Each composite sample represents an approximate area of 10,000 ft^2 and was collected utilizing a backhoe in order to visually assess the vertical stratigraphy. All samples were collected directly from the excavation sidewall. The 5-point composite samples were composited from the four corners and center of each polygon sampled. An aliquot from each test pit within a composite sample area was placed into a sampling bowl and homogenized. The composite sample along with a discrete sample from each test pit was submitted to the off-site laboratory of PCB analysis via Method 8082. Initially, only the composite sample was analyzed. However, if a PCB Aroclor was detected above the laboratory reporting limit in any composite sample, then all five discrete samples associated with that composite sample were analyzed for PCBs.

Five hundred and eighty-nine (589) samples were collected from the Grant (501), Locust (40), and Cavite (48) HAs as part of the PASI sampling effort. From the samples collected, 255 (197 from Grant, 10 from Locust, and 48 from Cavite) were analyzed by the off-site laboratory for PCBs via Method 8082. A total of 105 discrete samples were submitted for analysis from the Grant (65) and Cavite (40) HAs based on composite sample analytical results. Polychlorinated

biphenyls were not detected in the composite samples submitted from the Locust HA. All the discrete samples from the Cavite HA, regardless of the composite result, were submitted to evaluate the effectiveness of the sampling approach. The PCB analytical results for the PASI soil samples are summarized in Table 5-1b.

5.1.2.3 Lead Investigation

Three suspect ranges were identified for the further evaluation including IA's-3, -5, and -6, (see Figure 2-3). Sample locations were chosen to represent the area with the highest probability of lead impact, based on the most likely layout of the range, the types of weapons used, and the location of targets. Earthen berms are located on the north and south borders of IA-3. Because information is not available on which of these areas was the most likely impact area, both areas were sampled.

Soil samples were collected in groups of five, with each group centered approximately every 100 lf along earthen berms in the identified IAs. Each group of grab samples was collected in a horizontal line, approximately 2.5 ft apart (Figures 5-7 through 5-9).

Each soil sample was collected from the side of the earthen berms/hills. The sampling technicians either used hand tools, such as pick axes or shovels, or a backhoe to reach the appropriate sample depth interval in a 3-ft swath from 3 to 6 ft above the presumed firing grade level. Soil samples were collected from each sample location at a depth interval of 0 to 0.5 ft bgs into the side of the berm/hill, perpendicular to the slope. The intent of sampling was to screen for the presence of potential lead releases. Therefore, shallow soil sampling was initiated because projectiles and projectile fragments are found in shallow soils of impact zones and the soil type present in the IAs would limit penetration of a projectile. If lead was released to the area, elevated concentrations of lead would be detected in the shallow soils. The sampling technician used a disposable, stainless steel trowel and bowl to collect each discrete sample. The sample was homogenized and placed in a 4-ounce glass jar for submittal to the off-site lab. If the sample technician was unable to collect a sample at a given location due to site/terrain restrictions (i.e., large trees), the sample location was moved laterally and collection reattempted. The samples were analyzed for lead by EPA Method 6010.

The metals analytical results for the PASI soil samples are summarized in Table 5-1a. In the absence of a site-specific lead background concentration, lead concentrations in soil have been evaluated by comparing the lead concentrations in soil to the lead PAL. The lead analytical results for each IA were compared to PAL (which is based on the MCP Reportable Concentration S-1 Standard of 300 mg/kg, the lowest of all applicable standards) to screen for potential lead impacts within each IA (see Table 5-1a).

5.1.2.4 Explosives Investigation

Investigation for explosives use was initially presumed to be limited to IA-2 due to its former use as a 37-mm range. Sample locations in the Firing Area location of IA-2 were chosen to best cover the area in which weapons were most likely fired. Because the exact location of the Firing Areas was not known, sample locations were located throughout the area believed to be the highest probability of fallout from the fired weapons.

Sample locations in the Impact Area were chosen based on the typical range and accuracy of the equipment tested in the area and the identification of UXO and ordnance scrap during previous removal actions. The WESTON *Explosives, Lead and Perchlorate – Conceptual Site Model Investigation Areas – Grant, Locust, and Cavite HAs, Former Fort Devens, Devens, Massachusetts* provides details regarding range and weapon specifics (WESTON, 2004a). The highest concentration of UXO and ordnance scrap discovered in the 1996 remediation was the northern side of the hill in the suspected Impact Area. Samples were biased towards this area to ensure that the areas of greatest potential contamination were adequately sampled.

For the firing point and Impact Area of IA-2, 20 grab soil samples were collected at a total of 10 locations in both areas (see Figures 5-2 and 5-6). Prior to any excavation to collect the discrete soil samples, a UXO technician screened the sampling areas with a magnetometer to confirm that the area is free of buried metallic objects. If the magnetometer survey indicated potential subsurface metallic objects, the area was flagged and a new sample location was chosen. No excavation or disturbance of flagged locations was performed. Further evaluation of UXO was not addressed as part of the PASI effort.

The grab soil samples were collected using hand tools, such as shovel or pick axe, to reach to the appropriate sample depth interval. Soil samples were collected from each sample location from two depth intervals: 0 to 1 and 1 to 2 ft bgs. Disposable stainless steel spoons and bowls were used to collect each sample. Samples for explosives analysis were placed in 4-ounce amber glass jars. The samples were analyzed for explosives by EPA Method 8330.

No explosive samples were collected in the Cavite or Locust HAs, due to the lack of historical or other evidence that explosives were ever used in these areas. The explosives analytical results for the PASI soil samples are summarized in Table 5-1c.

5.2 SUPPLEMENTAL SITE INVESTIGATION

Based on the results of samples collected during the PASI, and review of the past historical uses and small arms training in the SA that indicated the potential presence of impacts at several IAs, BRAC, EPA, MassDEP, and USACE agreed that additional data were required to fully characterize the potential for releases that may have occurred within the SA.

The following subsections describe the objectives of the SSI in more detail, including sample rationale.

5.2.1 Scope

Based on the available information, USACE requested that WESTON prepare a supplemental WP to address outstanding issues at the SA. On 20 July 2004, a *Draft Final SSI WP* (WESTON, 2004b) was completed and submitted to the BCT. The *Draft Final SSI WP* (WESTON, 2004b) provided a summary of:

- Arsenic, lead, PCBs, and explosives analytical results of the PASI.
- Remaining data gaps in the analytical database regarding the presence of arsenic in the HAs.

- Assessed potential PCB sources, extent of PCB-contaminated soils, and updates to the status of the on-going removal actions to remediate PCBs to the CERCLA standard.

- Further information regarding the locations of the training areas and firing ranges within the SA.

The scope of the *Draft Final SSI WP* (WESTON, 2004b) included three primary tasks:

- Field Reconnaissance and Mapping
- Soil Sampling
- Groundwater Monitoring and Well Installation
- Risk Assessment

Several modifications and expansions were made to the sampling approach that was outlined in the *Draft Final SSI WP* (WESTON, 2004b), between July 2004 and January 2005. The Risk Assessment task of the *Draft Final SSI WP* (WESTON, 2004b) was dropped, and revisions to the sampling plan were made in response to BCT comments.

On 11 August 2004, WESTON submitted a revised *Draft Final SSI WP* (WESTON, 2004b) to BCT. During the review process, an on-site BCT meeting was held on 1 November 2004, at which time, proposed sample locations were reviewed in the field, and a number of changes made. Additional changes to the suites of analytes were also made. These changes were incorporated into another revision of the *Draft Final SSI WP* (WESTON, 2004b), which was submitted to BCT on 24 November 2004. Following additional minor changes, the *Final SSI WP* (WESTON, 2005a) was submitted on 24 January 2005.

5.2.2 Field Reconnaissance and Mapping

In order to assist in the identification of past potential small arms training and range activities within and surrounding the SA, additional site reconnaissance was conducted. The objective of the site reconnaissance was to identify site features over the approximately 282 acres that may be indicative of historic training activities (i.e., former foxholes, trenches, or impact craters), areas of significant alteration of surface topography (i.e., areas of cut and fill), monuments, subgrade utility structures, old foundations, old roads, and walls.

Site reconnaissance efforts utilized a digital camera and a Trimble XRS global positioning system unit to record images and identify the locations of site features, respectively. The global positioning system unit has an accuracy that ranges from ± 3 ft up to ± 20 ft, depending on the over-story cover.

The reconnaissance effort identified the following types of features:

- Fill: Three different types of fill were identified during this field effort: berms, piles, and mounds. Berms were characterized as generally linear areas of fill. Piles were typically small, comprised of debris, rock or earth, and appeared to have been discarded or dumped. Mounds were typically larger than piles and were comprised of primarily earthen materials.

- Depressions: Three different types of depressions were identified during this field effort: trenches, borrow pits, and excavations. Trenches were generally narrow, linear features ranging up to a few feet in depth. Borrow pits were located against a hill slope and were constructed with at least one side designed to allow easy egress into the pit. Excavations ranged in size from a few feet up to several tens of feet in diameter and typically had either a sharp acute edge (as opposed to the more convex curvature of a depression's natural margin).

- Structures: Three different structures were identified within the SA: foundations, concrete features, and various miscellaneous structures collectively categorized as "Other". Features identified as foundations contained either a wall or footing of a former above-grade building or structure. Concrete features included pads, blocks, vaults or other type of small, ground level structures made out of concrete. "Other" structures included obstacle course components, anchors/tie rods and stone, metal, concrete, or wooden monuments or markers.

The reconnaissance effort did not identify any features inconsistent with the known uses of the SA as general Training Areas and/or Firing Ranges between 1917 and approximately 1960. The identified features are depicted on Figures 5-12 and 5-13. Evidence collected during the reconnaissance was supported by sampling conducted as part of the SSI by co-locating sample locations with site features. The photographs and records of the field reconnaissance are included in Appendix H.

5.2.3 Soil Sampling

All soil sampling was conducted in accordance with the procedures outlined in the *Final SSI WP* (WESTON, 2005a) included in Appendix I. Additional investigative activities at IA-6 were requested by USACE, New England District, and are detailed in the *Final Investigation Area 6 (IA-6) Workplan Addendum to the Supplemental Site Investigation WP* (WESTON, 2005b). Sample requirements and rationale is discussed by IA in the following subsections.

The sampling tasks in the *Final SSI WP* (WESTON, 2005a) were not organized according to COC, as they were in the *Draft PASI WP* (WESTON, 2003e) but rather, by IA. The discussion of the SSI field activities and results that follows in Subsections 5.2.3.1 through 5.2.3.10 is organized in the same way. Results of the PASI and SSI sampling efforts have been included into the evaluation of potential historical impacts in each IA, to provide the most thorough possible assessment. Tables summarizing SSI soil analytical results, sorted by each IA, are included as follows:

- Table 5-2a: Summary of Volatile Organic Compounds Soil Analytical Results
- Table 5-2b: Summary of Semi-Volatile Organic Compounds Soil Analytical Results
- Table 5-2c: Summary of Extractable Petroleum Hydrocarbons Soil Analytical Results
- Table 5-2d: Summary of Polychlorinated Biphenyls Soil Analytical Results
- Table 5-2e: Summary of Pesticides Soil Analytical Results
- Table 5-2f: Summary of Target Analyte List (TAL) Metals Soil Analytical Results
- Table 5-2g: Summary of Dioxin/Furan Soil Analytical Results
- Table 5-2h: Summary of Perchlorate Soil Analytical Results
- Table 5-2i: Summary of Explosives Soil Analytical Results

Project Action Levels for soil and groundwater are summarized in Tables 5-5a and 5-5b, respectively. Conclusions regarding the potential risk to human health and the environment are summarized in Section 6 of this report.

5.2.3.1 Investigation Area-1 – Former Training Area (circa 1922)

Investigation Area 1 is located in the northern portion of the Grant HA along Grant Road and centered at the Chance Street intersection (Figures 5-2 and 5-3). This area was identified as a former Training Area based on a 1922 map contained in the *ASRs* (USACE, 1995a; 1995b; 1995c). Although no specific activities have been identified for this area, the possibility exists that the area was used as a former small arms firing range and that past uses may have impacted the area. The IA is located in the area of significant overburden soils mining (Figure 2-3) and remnant features such as the Impact Berm no longer exist. Based on historical documentation, it is presumed that the Impact Berm would have been located to the southwestern end of the IA and the firing point(s) would have been located to the northeast of the Impact Berm.

SSI Sampling Methodology

Previous soil sampling conducted as a result of the MCP-Lead Pesticide Soil Remedial Action in the area focused on investigating potential pesticide releases, as well as arsenic and PCB releases, in the vicinity of the disturbed soils surrounding the former housing units, and under the roadways. During the PASI, a total of five composite PCB samples, three discrete PCB samples, and three discrete arsenic samples were collected and analyzed at an off-site laboratory. Investigation results indicated that neither arsenic nor PCB releases were detected in this area.

During the SSI, a metal detector survey was conducted over the presumed Impact Berm of IA-1. Results of the survey did not locate the presence of metals associated with past use as a firing range. Sample locations were chosen based on the presumed orientation of the potential range. Three soil borings (IA01-SB02, -SB03, and -SB04) were completed within the presumed Impact Berm and vicinity, and one soil boring (IA01-SB01) was completed at the presumed firing point. Composite soil samples were collected from 0 to 3 ft and 3 to 10 ft bgs at each boring location. Samples were collected from 3-inch steel split-spoons which were used in conjunction with hollow stem auger (HSA) drilling techniques. Once the split-spoon was collected, sample recovery was recorded and soil classification activities were completed. Soil boring logs are included in Appendix B. Sample aliquots were placed into clean sampling bowls

using stainless steel spoons and homogenized. The sample aliquot was then placed into the appropriate pre-labeled sample container(s).

At one location within the Impact Berm area (IA01-SB02), samples were submitted to the off-site laboratory for Target Compound List (TCL)/TAL full suite analysis (VOCs, SVOCs, PCBs, pesticides, TAL metals, and EPH). Samples collected from the remaining three soil borings were submitted to the off-site laboratory for TAL metals analysis.

PASI/SSI Results/Data Evaluation

Samples were collected for PCBs and arsenic analyses from this IA during PASI activities. Polychlorinated biphenyls were not detected in any soil samples, and concentrations of arsenic were consistent with background concentrations for the site, with a maximum value of 28.2 mg/kg. In addition, the following metals were detected in one or more PASI samples at concentrations above their PALs: aluminum (all four samples), iron (all four samples), manganese (all four samples) and nickel (three samples). Summary tables of PASI analytical results are included as Tables 5-1a through 5-1c.

The SSI samples submitted for TCL/TAL full suite analysis indicated concentrations of benzo(a)pyrene and dibenz(a,h)anthracene at the 0 to 3 ft depth, and benzo(a)pyrene at the 3 to 10 ft depth above their respective PALs in sample IA01-SB01. No other compounds were detected at concentrations above the PALs for VOC, PCB, pesticide, and EPH analyses. Results of the samples submitted for TAL metals analysis indicated arsenic concentrations above its PAL in each sample analyzed; however, arsenic concentrations were consistent with background concentrations, with a maximum value of 46 mg/kg. In addition, the following metals were detected in one or more SSI samples at concentrations above their PALs: aluminum (one sample), iron (all nine samples), manganese (seven samples) and nickel (five samples). Summary tables of SSI analytical results are included as Tables 5-2a through 5-2i.

5.2.3.2 Investigation Area-2 – Training Area and/or Range (circa 1922)

Investigation Area 2 is located in the northernmost portion of the Grant HA along Birch Circle (see Figures 5-2, 5-4, and 5-6). This area has been identified as a former Training Area and/or Range and is one of three areas where PCBs have been previously detected. Although several small buildings of unknown use were identified in the vicinity of the presumed firing point before 1934, no specific training or range activities were identified for this area in the *ASRs* (USACE, 1995a; 1995b; 1995c). The *Draft Final Expanded CSM Report* (USACE, 2004b) identifies this area as a 37-mm range based on historical aerial photographs and the discovery of 37-mm munitions. In addition to the 37-mm rounds, more than 2,700 pounds of ordnance scrap was removed from the Impact Area during previous removal actions (USACE, 1995a).

SSI Sampling Methodology

The northern portion of the area contains the localized PCB detections that were previously remediated by WESTON as part of the MCP-Lead Pesticide Soil Remedial Action. Although the area of PCB-impacted soil was removed and the resulting verification soil samples of this removal action did not detect any further PCB-impacted soils, additional soil samples were collected in this area to confirm that the extent and source of the previously detected PCBs had been identified and to screen the remainder of the area for arsenic and PCBs.

In the fall of 2003, as part of the PASI, a total of nine composite samples were collected and analyzed for PCBs, and six composite samples were analyzed for arsenic and PCBs. The results indicated no levels above background for arsenic and no levels above the CERCLA action level for PCBs. In addition, since IA-2 is the location of a presumed 37-mm direct fire range, a total of 20 discrete soil samples were collected to assess this area for residual explosives. Explosive samples were collected from ten test pits, five of which were located at the firing point, and the other five located at the Impact Area.

To further assess IA-2, an additional 29 soil borings were completed in this IA as shown on Figures 5-2, 5-4, and 5-6. Munitions and Explosives of Concern avoidance measures were conducted prior to the initiation of soil boring activities. Soil borings were located and sampled

within the area which was separated into three zones; the Impact Area, the Intermediate Area, and the firing point as described below.

Impact Area

A total of 12 soil borings, (IA02-SB02 through IA02-SB11, and IA02-MW03 and IA02-MW-4) were advanced throughout the Impact Area. Locations were chosen based upon where historical impacts are likely to have occurred, including potential remnant range features (i.e., demolition or impact craters); areas where pockets of fragmentation or MEC were encountered during the UXO removal actions completed in the mid-1990s; and areas that appear to be undisturbed (and therefore, may contain MEC as yet undiscovered). Representative soil samples were collected from 0 to 3 ft and 3 to 10 ft bgs at the soil boring and monitoring well boring locations. Samples collected from one boring placed within a UXO removal action area (IA02-SB02) and each of the monitoring well borings were submitted for TCL/TAL full suite, perchlorate, and explosives analyses. Soil samples collected from each of the monitoring well soil borings (IA02-MW03 and IA02-MW04) were submitted for TCL/TAL full suite, perchlorate, and explosives analyses. The samples from the nine remaining boring locations were collected from the same intervals and submitted for TAL metals, perchlorate, and explosives analyses.

An additional soil boring (IA02-SB29) was added near MW-03 after preliminary soil analytical results from sample IA02-MW03 were received that indicated trace concentrations of SVOCs. The soil boring was completed to a depth of 10 ft bgs, the soils were classified, and a soil sample was collected. This soil sample was not submitted to the laboratory for analysis, as further review of the preliminary soil analytical results indicated that the detection of SVOCs was eliminated following laboratory quality control (QC) review.

Intermediate Area

A total of 10 soil borings (IA02-SB12 through IA02-SB21) were completed throughout the intermediate area east of the Impact Area and along Beech Street. Sample locations were chosen based upon areas of potential remnant range features identified during the site reconnaissance and also in areas thought to be the most likely location for “short shots” (i.e., along line of flight

between firing point and pockets of fragmentation/UXO removal during the 1996 UXO removal action). Representative soil samples were collected from 0 to 3 ft and 3 to 10 ft bgs at each soil boring location. Samples collected from two randomly selected borings (IA02-SB13 and IA02-SB20) were submitted for TCL/TAL full suite, perchlorate, and explosives analyses. Samples from the remaining eight boring locations were collected from the same intervals and submitted for TAL metals and explosives analyses.

Firing Point

A total of six soil borings (IA02-SB23 through IA02-SB28) and one shallow soil sample (IA02-SS01) were completed in the area of the firing point. One boring was placed in the center of the Birch Circle cul-de-sac, and the remaining borings were placed in the vicinity and downrange of the cul-de-sac. The shallow soil sample was collected from a remnant training feature (foxhole or defensive training position) located north of the cul-de-sac. This sampling approach assumes that the cul-de-sac was the primary firing point for 37-mm artillery. Representative soil samples were collected from 0 to 3 ft and 3 to 10 ft bgs at each soil boring location and from 0 to 1.5 ft bgs at the shallow soil location. The samples collected from the soil boring to the southwest of the cul-de-sac (IA02-SB23) were submitted for TCL/TAL full suite and explosives analyses. Samples collected from the five remaining boring locations and the shallow soil sample were submitted for TAL metals and explosives analyses.

All soil boring samples were collected from 3-inch steel split-spoons which were used in conjunction with HSA drilling techniques. Once the split-spoon was collected, sample recovery was recorded and soil classification activities were completed. Soil boring logs are included in Appendix B. The description of the shallow soil sample is included in Table 5-4a. Sample aliquots were placed into clean sampling bowls using stainless steel spoons and homogenized. The sample aliquot was then placed into the appropriate pre-labeled sample container(s) and submitted to an off-site laboratory for analysis.

PASI/SSI Results/Data Evaluation

Samples collected for explosives during the PASI indicated no detectable residual explosives in samples collected in the Impact Area and firing position. Polychlorinated biphenyls were detected in two soil samples, which were subsequently addressed as part of the PCB removal action described in Subsection 4.1.4. Concentrations of arsenic were consistent with background concentrations for the site, with a maximum value of 40.9 mg/kg. In addition, the following metals were detected in one or more PASI samples at concentrations above their PALs: aluminum (12 samples), iron (all 23 samples), manganese (13 samples), and nickel (11 samples). Summary tables of PASI analytical results are included Tables 5-1a through 5-1c.

The SSI soil samples from six boring locations (IA02-SB02, -SB13, -SB20, -SB23, -MW03, and -MW04) were submitted for TCL/TAL full suite analysis. Elevated concentrations of the pesticides Aldrin and dieldrin were detected exceeding their PALs in the 0 to 3 ft sample collected from IA02-SB23 located southwest of the Birch Circle cul-de-sac. Dieldrin was also detected above its PAL in the 0 to 3 ft sample from IA02-SB20, the 3 to 10 ft sample from IA02-SB23, and the 0 to 3 ft sample from IA10-SB03. 4,4'-Dichlorodiphenyldichloroethylene (4,4'-DDE) and 4,4'-Dichlorodiphenyltrichloroethane (4,4'-DDT) were detected exceeding their PALs in the 0 to 3 ft sample collected from IA02-SB30. Benzo(a)pyrene was detected in the 0 to 3 ft sample from IA02-SB23 at concentrations exceeding the PAL, although well below the MCP background concentration. No other compounds were detected in soils at concentrations above the respective PALs for VOC, PCB, EPH, perchlorate, and explosives analyses.

The SSI soil samples submitted for TAL metals analysis indicated concentrations above their PALs for aluminum (30 samples), arsenic (all 47 samples), chromium (three samples), iron (all 47 samples), manganese (40 samples) nickel (24 samples), and thallium (one sample); however, no results were above MCP background concentrations. Arsenic concentrations ranged from 5.3 mg/kg to 45 mg/kg in this area, which is consistent with background concentrations for the site. Summary tables of SSI soil analytical results are included as Tables 5-2a through 5-2i.

5.2.3.3 Investigation Area-3 – Possible Rifle Range

Investigation Area 3 is located along Hospital Road north of the Locust HA (Figure 5-9). A 1922 map in the *ASRs* (USACE, 1995a; 1995b; 1995c) indicated the past use of this IA as a possible rifle range. The physical features of this area suggest at least two possible locations of firing and target situations. Earthen berms are located to the north and south of Hospital Road. Since information concerning which of these areas was the most likely impact area was not available, both berms were included in the scope of investigation activities.

SSI Sampling Methodology

In the fall of 2003, a total of 30 discrete lead samples were collected and analyzed at an off-site laboratory as part of PASI activities. Sample locations were chosen to represent the area with the highest probability of lead impact, based on the most likely layout of the range, the types of weapons used, and the location of targets. The locations were evenly divided between the northern and southern potential Impact Berms.

To further evaluate IA-3, an additional four soil borings and 22 shallow soil samples were completed during the SSI as shown on Figure 5-9. Two soil borings and 11 shallow soil locations were collected from each of the northern and southern Impact Berms. Locations were chosen based on the presumed orientation of the potential range, and concentrated areas of metal objects determined from an all-metal survey conducted on the hill slopes to the north and south of the berms. Munitions casings and metals associated with past use as a firing range were uncovered during the metals survey.

Composite soil samples were collected from 0 to 3 and 3 to 10 ft bgs at each boring location. Samples were collected from 3-inch steel split-spoons which were used in conjunction with HSA drilling techniques. Once the split-spoon was opened, sample recovery was recorded, and soil classification activities were completed. Soil boring logs are included as Appendix B. Sample aliquots were placed into clean sampling bowls using stainless steel spoons and homogenized. The sample aliquot was then placed into the appropriate pre-labeled sample container(s).

The samples collected from one boring location at each of the northern and southern Impact Berms (IA03-SB02 and IA03-SB04) were submitted to the off-site laboratory for full suite analysis (VOCs, SVOCs, PCBs, pesticides, TAL metals, and EPH). Samples collected from the remaining soil borings were submitted to the off-site laboratory for TAL metals analysis. Representative shallow soil samples were collected from 0 to 1.5 ft bgs at each location and were submitted to the off-site laboratory for TAL metals analysis. Descriptions of shallow soil samples are included as Table 5-3b.

PASI/SSI Results/Data Evaluation

During the PASI, 37 shallow soil samples were submitted for lead analysis. Analytical results indicated lead concentrations ranging from 6.7 mg/kg to 59.4 mg/kg which was well below the PAL of 300 mg/kg. Summary tables of PASI analytical results are included as Table 5-1a.

During SSI activities, 26 soil samples were submitted for TAL metals analysis and four soil samples were submitted for TCL/TAL full suite analysis. No pesticide, VOC, PCB, EPH, perchlorate, and explosives compounds were detected at concentrations above their respective PALs in this area during the SSI investigation. The SSI soil samples submitted for SVOC analysis indicated concentrations of benzo(a)pyrene and dibenz(a,h)anthracene above their respective PALs, but well below their MCP background concentrations) at the 0 to 3 ft depth at location IA03-SB04. Arsenic concentrations ranged between 10 mg/kg and 31 mg/kg which are consistent with background levels for the site. In addition, the following metals were detected in one or more SSI soil samples at concentrations above their PALs: aluminum (13 samples), iron (all 32 samples), manganese (12 samples) and nickel (5 samples). Summary tables of SSI analytical results are included as Tables 5-2a through 5-2i.

5.2.3.4 Investigation Area-5 – Sub-Caliber Anti-Tank Range

Investigation Area 5 is located in the eastern portion of the Grant HA, west of Grant Road (see Figure 5-7). This area has been identified as a possible former Sub-Caliber Anti-Tank Range in aerial photographs of the base from 1943 and 1955. Investigation Area 5 is one of three areas

where PCB impacts have been detected in the SA and is an area where significant quantities of fill material were identified during the PCB removal action.

SSI Sampling Methodology

Polychlorinated biphenyls were originally detected in IA-5 during the MCP-Lead Pesticide Soil Remedial Action in areas adjacent to two former housing units (Buildings 874 and 877) with concentrations ranging to greater than 50 mg/kg. Polychlorinated biphenyls delineation sampling was conducted to investigate the extent of contamination, and PCB-impacted soil was excavated surrounding the building footprints.

In the fall of 2003, PASI soil investigation activities conducted in this area focused on known PCB releases and potential lead and arsenic impacts identified during a review of historical information. As part of the PASI, 19 composite and 2 discrete PCB samples were collected from areas surrounding the footprints of the former buildings and from along the roadways. Discrete soil samples were also collected and analyzed for arsenic (3 samples) and lead (25 samples). Arsenic samples were collected randomly throughout the Grant HA from test pits, and the results were combined with previous arsenic results to establish a data set for the SA. Soil samples for lead were collected to determine if the former use of the IA as a Sub-Caliber Anti-Tank Range caused a release.

To further evaluate IA-5, an additional nine soil borings (IA05-SB01 through IA05-SB09) and six shallow soil samples (IA05-SS01 through IA05-SS06) were completed as shown on Figure 5-7. Sample locations were chosen based on the presumed orientation of the potential range, and concentrated areas of buried metal objects identified during an all-metal survey conducted on the Impact Berm. The all-metals survey of the Impact Berm indicated several areas of concentrated metal objects in the berm; however, the few metal objects uncovered were not associated with munitions.

Representative shallow soil samples were collected from 0 to 1.5 ft bgs at six locations and were submitted to the off-site laboratory for TAL metals analysis. Descriptions of shallow soil samples are included in Table 5-3c. Composite soil samples were collected from 0 to 3 ft and

3 to 10 ft bgs at each boring location. Soil boring samples were collected from 3-inch steel split-spoons which were used in conjunction with HSA drilling techniques. Once the split-spoon was opened, sample recovery was recorded and soil classification activities were completed. Soil boring logs are included as Appendix B. Sample aliquots were placed into clean sampling bowls using stainless steel spoons and homogenized. Sample aliquots were then placed into the appropriate pre-labeled sample container(s), and were submitted to the off-site laboratory for TAL metals analysis. Samples collected from one of the soil borings (IA05-SB07) were submitted for TCL/TAL full suite analysis (VOC, SVOC, pesticides, PCB, EPH, and TAL metals analysis).

PASI/SSI Results/Data Evaluation

Twenty-five soil samples were collected for lead analysis from IA-5 during PASI activities. Lead concentrations ranged from 7.0 mg/kg to 203 mg/kg with a mean of 47.7 mg/kg and a standard deviation of 52.4 mg/kg. No sample results were reported above the PAL for lead. Results of the arsenic sampling survey indicated that the concentrations of arsenic detected within the Grant HA (which includes IA-5) are consistent with background levels for the site.

Results of the PCB samples collected during the PASI indicated that two of the "5-point" composite samples exceeded the EPA remedial criteria of 1.0 mg/kg. The five discrete samples associated with each of the two composite samples were subsequently analyzed for PCBs to accurately define the extent of PCB contamination. Six of the ten discrete samples detected concentrations of PCBs above the laboratory reporting limit, which were subsequently addressed as part of the PCB removal action described in Subsection 4.1.4. Summary tables of PASI analytical results are included as Tables 5-1a and 5-1b.

A total of 28 samples were collected from this area for TAL metals analysis as part of SSI activities. Two of the samples were additionally analyzed for TCL/TAL full suite (VOC, SVOC, pesticide, PCB, and EPH) analyses. The following metals were detected in one or more SSI soil samples analyzed for TAL metals, at concentrations above their PALs: aluminum (14 samples), arsenic (all 28 samples), chromium (one sample), iron (all 28 samples), manganese (17 samples), and nickel (13 samples). None of the metals concentrations were above MCP background, with

the exception of arsenic. Arsenic concentrations ranged between 20 mg/kg and 35 mg/kg, which were consistent with background levels for the site. Lead concentrations ranged from 6.6 mg/kg to 180 mg/kg, well below the lead PAL. No other compounds were detected at concentrations above their PALs for the samples analyzed for TCL/TAL full suite analysis. Summary tables of the SSI analytical results are included as Tables 5-2a through 5-2i.

5.2.3.5 Investigation Area-6 – Former Machine Gun Range (Bryant Range)

This area has been identified as Bryant Range, a former pistol and machine gun range, used from before 1943 to after 1957. It is presumed that use of the range ceased by the early 1960s, when the Locust HA was constructed. The range is located west of IA-3 along the southern side of Hospital Road (see Figure 5-8). The range was constructed by a combination of cut and fill on the existing slope, apparently using local sand. A buried soil horizon is present beneath the western, filled portion of the range floor, and no buried soil horizon was noted beneath the eastern, cut portion of the range floor and berm. An earthen Impact Berm is located along the eastern boundary of the area, adjacent to the Locust HA. The firing point and remaining portions of the area are relatively flat.

SSI Sampling Methodology

In the fall of 2003, PASI soil investigation activities conducted in this area focused on potential lead impacts identified during a review of historical information. Excavation by hand within the Impact Berm demonstrated that bullets are common within the sand fill used to construct the berm. As part of the PASI, 10 discrete soil samples were collected and analyzed for and lead. Lead analytical results were used to determine if the former use of the IA as a Pistol, Rifle, and Machine Gun Range resulted in a release.

Sampling in this IA was not included in the Scope of Work for the SSI, as the results of the PASI soil sampling clearly indicated that remedial activities would need to be performed in the IA to address soil lead concentrations. However, shortly following the completion of SSI field activities, USACE, New England District requested additional investigation of IA-6, via an addendum to the Scope of Work.

In April 2005, WESTON personnel mobilized to IA-6 with a drilling subcontractor equipped with a track mounted Geoprobe Model 6610 DT. During a 3-day field effort, shallow soil borings were advanced at 66 locations in IA-6 with the Geoprobe, and four test pits were excavated in the Impact Berm using an excavator. Investigation Area 6 was segregated into nine assessment areas, depicted on Figure 5-14, and sampling was performed in each area in order to confirm the assumptions in the conceptual model developed to describe the former Bryant Range. The six assessment areas that comprise the former range are the Firing Line, Impact Berm, "Short Shot" Area, "High Shot" Area, Hill Slope and Range Floor. Three additional assessment areas were established to characterize areas peripheral to the former range: the Southern Depression, Northern Swale, and Airborne Dispersion areas. Sample locations are depicted on Figure 5-8.

Subsurface explorations in IA-6 revealed that, prior to use as a range, the former range was leveled by cutting material from the western face of Locust Hill and spreading it westward. This process had the added advantage of raising the relative height of the Impact Berm. The fill material and the native surficial soils exhibit little to no difference in lithology. Both consist of poorly graded fine gravelly sands interpreted as reworked glacial outwash. Buried, former soil surfaces were noted beneath the fill at the western edge of IA-6, approximately 5 ft bgs. Similar conditions were observed at the southeastern side of the range where buried, former soil surfaces were observed at approximately 0.5 ft bgs. In addition, a wooden retaining wall was observed at the southwest corner of the range, which was constructed to hold back the approximately 4 ft of fill located above the native ground surface in this area. Along the northwestern corner of the range, fill material was observed sloped up to approximately up to 12 ft above the native northern drainage depression where the thickest quantity of native surficial loam was encountered.

The following subsections describe the sampling activities performed in each of the nine assessment areas.

Firing Line

The former Firing Line area was assessed by collecting 5-point composite samples from 25-ft by 25-ft grids along the length of the firing line. The samples (IA06-SS04 through IA06-SS11) were collected from eight alternating grids. The 5-point composite sampling was performed by advancing soil borings extending from 0 to 1.5 ft bgs at five locations within each grid, one location near each corner of the grid, and the fifth location in the center of the grid. Following description by the WESTON geologist, the soil from the 0 to 0.5 ft and the 0.5 to 1.5 ft bgs intervals from each of the five soil cores was divided into two disposable pans for sample homogenization. Any VOC sample fraction required was collected prior to sample homogenization. Each composite sample was thoroughly homogenized with disposable stainless steel spoons prior to sample collection. Samples were collected for TAL metals analysis from each depth interval. Although two samples were collected from each location along the firing line and sent to the off-site laboratory, only the 0 to 0.5 ft bgs samples were analyzed initially. The corresponding 0.5 to 1.5 ft bgs interval sample was held by the laboratory pending results for the 0 to 0.5 ft bgs sample. When results for the 0 to 0.5 ft interval sample exceeded the PAL for any of the TAL metals, the laboratory analyzed the 0.5 to 1.5 ft bgs interval sample collected from the same location. In addition to the TAL metals samples described above, a separate sample was collected from 0 to 1.5 ft bgs at location IA06-SS08 and submitted for TCL VOCs, SVOCs, explosives, EPH, PCBs, pesticides, and TAL metals analyses.

In addition to the shallow soil samples, two 10-ft deep soil borings (IA06-SB03 and IA06-SB04) were advanced along the firing line. The soil boring locations were determined by surveying the firing line with a Scheibel all-metal detector, selecting the areas of most significant metal detection. Following description by the WESTON geologist, soil from these soil borings was composited by two depth intervals: 0 to 3 ft and 3 to 10 ft bgs, and submitted to the laboratory for analysis for SVOCs, explosives, and TAL metals. Soil samples collected from IA06-SB04 was also analyzed for VOCs, PCBs, pesticides, EPH, and chlorodibenzodioxins (CDD)/chlorodibenzofurans (CDF).

Impact Berm

The former Impact Berm area was assessed by advancing two soil borings (IA06-SB05 and IA06-SB06) to a depth of 10 ft bgs at the toe of the Impact Berm. Following description by the WESTON geologist, soil from these soil borings was composited by two depth intervals: 0 to 3 ft and 3 to 10 ft bgs, and submitted to the laboratory for analysis for SVOCs, explosives, and TAL metals. Soil samples collected from IA06-SB06 was also analyzed for VOCs, PCBs, pesticides, EPH, and CDDs/CDFs.

In addition to the two soil borings, four test pits (TP-1 through TP-4) were excavated into the Impact Berm. Each test pit was excavated to sufficient depth that native material was identified beneath the Impact Berm fill. The test pits were logged by a WESTON geologist. A grab soil sample (IA06-TP-01 through IA06-TP-04) for TAL metals analysis was collected from the native material immediately beneath the Impact Berm at each test pit.

"Short Shot" Area

The former "Short Shot" area was assessed by collecting 5-point composite samples from 15 ft by 25 ft grids along the length of the firing line. The 5-point composite samples (IA06-SS21 through IA06-SS28) were collected from eight alternating grids, from two depth intervals, and analyzed iteratively based on shallow soil sample results, as described above. In addition to the TAL metals samples, a separate sample was collected from 0 to 1.5 ft bgs at location IA06-SS25 and submitted for TCL VOCs, SVOCs, explosives, EPH, PCBs, pesticides and TAL metals analyses.

"High Shot" Area

The former "High Shot" area was assessed by collecting 5-point composite samples from 15 ft by 25 ft grids along the length of the firing line. Samples (IA06-SS31 through IA06-SS38) were collected from eight alternating grids, from two depth intervals, and analyzed iteratively based on shallow soil sample results, as described above. In addition to the TAL metals samples,

a separate sample was collected from 0 to 1.5 ft bgs at location IA06-SS35 and submitted for TCL VOCs, SVOCs, explosives, EPH, PCBs, pesticides, and TAL metals analyses.

Hill Slope

The Hill Slope area was assessed by collecting 5-point composite samples from 25 ft wide grids that extended from the top of the "High Shot" area to the crest of the slope. Samples (IA06-SS39 and IA06-SS40) were collected from two randomly selected grids, from two depth intervals, and analyzed iteratively based on shallow soil sample results, as described above. In addition to TAL metals samples, a separate sample was collected from 0 to 1.5 ft bgs at location IA06-SS40 and submitted for TCL VOCs, SVOCs, explosives, EPH, PCBs, pesticides, and TAL metals analyses.

Range Floor

The former Range Floor area was assessed by collecting 5-point composite samples from 25 ft by 25 ft grids along the length of the firing line. Samples (IA06-SS03 and IA06-SS12 through IA06-SS20) were collected from nine randomly selected grids, from two depth intervals, and analyzed iteratively based on shallow soil sample results, as described above. In addition to the TAL metals samples, a separate sample was collected from 0 to 1.5 ft bgs at location IA06-SS16 and submitted for TCL VOCs, SVOCs, explosives, EPH, PCBs, pesticides and TAL metals analyses.

Southern Depression

Low lying areas and a stormwater drainage pipe located in a depression south of the Range Floor were investigated by collecting shallow sediment/soil samples to a depth of 1.5 ft bgs. Following a metal survey to identify the inlet and outfall of the stormwater drainage pipe, grab sediment/soil samples of the sediment accumulated at the inlet, outfall and five other locations (IA06-SD01 through IA06-SD07, respectively) were collected. The samples were collected from two depth intervals and analyzed iteratively based on shallow sediment/soil

sample results, as described above. In addition to the TAL metals samples, a separate sample was collected from 0 to 1.5 ft bgs at location IA06-SD06 and submitted for TCL VOCs, SVOCs, explosives, EPH, PCBs, pesticides, and TAL metals analyses.

Northern Swale

A drainage system, comprising a swale that diverts stormwater to a drainage basin north of the Range Floor, was investigated by collecting shallow sediment/soil samples to a depth of 1.5 ft bgs. Grab sediment/soil samples of the sediment accumulated in the swale (IA06-SD08 through IA06-SD10) and seven locations within the depression (IA06-SD11 through IA06-SD17) were collected. Location IA06-SD17 was identified as the lowest lying point in the basin. The samples were collected from two depth intervals and analyzed iteratively based on shallow sediment/soil sample results, as described above. In addition to the TAL metals samples, a separate sample was collected from 0 to 1.5 ft bgs at location IA06-SD17 and submitted for TCL VOCs, SVOCs, explosives, EPH, PCBs, pesticides, and TAL metals analyses.

Airborne Dispersion

To assess the possibility of airborne dispersion of contaminants into soil surrounding the former range, grab soil samples were collected from five locations arranged in a crescent in the downwind direction around the perimeter of the former Bryant Range. The samples were collected from two depth intervals and analyzed for TAL metals iteratively, based on shallow soil sample results, as described above.

PASI/SSI Results/Data Evaluation

The PASI analytical results of the sampling indicated that lead concentrations ranged from 2.3 mg/kg to 2,600 mg/kg with a mean of 818 mg/kg and a standard deviation of 716 mg/kg. Summaries of PASI analytical results for metals are included in Table 5-1a. Eight of the ten sample results were reported above the lead PAL, which indicated that the lead release is associated with the former range activities.

The supplemental investigation of IA-6 generally confirmed the predictions of the CSM. Elevated concentrations of the pesticide Dieldrin were detected exceeding its PALs in the 0 to 1.5 ft sample collected from IA06-SS40. 4,4'-DDE and 4,4'-DDT were detected exceeding their PALs in the 0 to 1.5 ft sample collected from IA06-SS08 and the 0 to 1.5 ft sample from IA06-SD06. Benzo(a)pyrene, benzo(b)fluoranthene and dibenz(a,h)anthracene were detected in the 0 to 1.5 ft sample from IA06-SD06 and benzo(a)pyrene and dibenz(a,h)anthracene were detected in the 0 to 1.5 ft sample from IA06-SD17 at concentrations exceeding their respective PALs, although well below their MCP background concentrations. In addition, the analytical laboratory was unable to achieve detection limits below two or more of the carcinogenic PAH PALs in 16 of the samples analyzed, including the two where PAHs were detected above their PALs, as noted above. No other compounds were detected in soils at concentrations above the respective PALs for VOC, PCB, EPH, perchlorate, and explosives analyses.

Supplemental soil TAL metals analytical results indicated that lead concentrations ranged from 3 mg/kg to 21,800 mg/kg, with a mean of 114 mg/kg and a standard deviation of 147 mg/kg. Antimony concentrations ranged from 0.37 mg/kg to 10 mg/kg, with a mean of 1.25 mg/kg and a standard deviation of 1.49 mg/kg. The results also defined the extent of antimony and lead concentrations that exceed their respective PALs as limited to the Impact Berm, High Shot, and Northern Swale areas. Arsenic concentrations ranged between 7.8 mg/kg and 47.1 mg/kg which are consistent with background levels for the site. In addition, the following metals were detected in one or more SSI soil samples at concentrations above their PALs: aluminum (90 samples), beryllium (6 samples), chromium (34 samples), copper (1 sample), iron (all 101 samples), manganese (49 samples), nickel (45 samples), and thallium (6 samples).

5.2.3.6 Investigation Area-7 – Sub-Caliber Anti-Tank Range

Investigation Area 7 is located to the south of the former Sports Arena and to the west of the Grant Road and Sherman Avenue Intersection (see Figure 5-10). This area has been identified as a former Sub-Caliber Anti-Tank Range on historical Target Range Area Maps (1942 and 1948). Earthen berms are located on the western and south/southwestern boundaries of the area. The firing point area is relatively flat. The range appears to have been constructed by the mining of

overburden from a former hill. Access to the area is from the east side of the site via Sherman Avenue.

SSI Sampling Methodology

Investigation Area 7 was identified as a former Sub-Caliber Anti-Tank Range and sampling activities were designed to determine if an impact from lead or other CERCLA-regulated contaminants exists. No samples were collected from this IA during the PASI. During the SSI, four soil borings (IA07-SB01 through IA07-SB04) and six shallow soil samples (IA07-SS01 through IA07-SS06) were completed in this area as shown on Figure 5-10. Sample locations were chosen based on the presumed orientation of the potential range, and concentrated areas of buried metal objects identified during an all-metal survey conducted on the Impact Berm. Representative shallow soil samples were collected from 0 to 1.5 ft bgs at six locations along the Impact Berm and were submitted to the off-site laboratory for TAL metals analysis. Descriptions of shallow soil samples are presented in Table 5-3d. Composite soil samples were collected from 0 to 3 ft and 3 to 10 ft bgs at two boring locations within the Impact Berm and two boring locations within the firing point. Samples were collected from 3-inch steel split-spoons which were used in conjunction with HSA drilling techniques. Once the split-spoon was opened, sample recovery was recorded, and soil classification activities were completed. Soil boring logs are included as Appendix B. Sample aliquots were placed into clean sampling bowls using stainless steel spoons and homogenized. The sample aliquot was then placed into the appropriate pre-labeled sample container(s). The samples collected from the boring locations were submitted to the off-site laboratory for TAL metals analysis.

PASI/SSI Results/Data Evaluation

During SSI activities 14 soil samples were submitted for TAL metals analysis. Lead and antimony were detected at concentrations exceeding PALS in three of the samples. Antimony concentrations ranged from non-detect to 24 mg/kg and lead concentrations ranged from 7.5 mg/kg to 1,400 mg/kg. Antimony and lead concentrations exceeded their PALs in the same three samples: GR-IA07-SB01, GR-IA07-SB02, and GR-IA07-SS03. The following other metals

were detected in one or more SSI soil samples analyzed for TAL metals, at concentrations above their PALs: aluminum (2 samples), antimony (3 samples), arsenic (all 14 samples), iron (all 14 samples), lead (3 samples), manganese (11 samples), and nickel (9 samples). None of the metals concentrations were above MCP background, with the exception of arsenic. Arsenic concentrations ranged from 20 mg/kg to 52 mg/kg, which are consistent with background levels for the site.

5.2.3.7 Investigation Area 8 – Former Base Laundry Buildings

Investigation Area 8 is located in the eastern portion of the Grant HA, east of Grant Road and just north of the Poplar Circle loop (see Figure 5-5). This area has been identified as a former Base Laundry and is located within one of three areas of known PCB impact. Figure 5-15 provides an overlay of the former Grant HA features on a 1953 aerial photograph of the site when the Base Laundry and associated Dry Cleaning facility were present at the IA.

SSI Sampling Methodology

Polychlorinated biphenyls were originally detected in IA-8 during the MCP-Lead Pesticide Soil Remedial Action in areas adjacent to two former housing units (Buildings 858 and 859, 861 through 864, and 866) with concentrations ranging to greater than 50 mg/kg. Polychlorinated biphenyls delineation sampling was conducted to investigate the extent of contamination, and PCB-impacted soil was excavated surrounding the building footprints.

As part of PASI activities, a total of 6 discrete and 17 5-point composite PCB samples were collected from the vicinity of IA-8 and analyzed at an off-site laboratory. Sample locations were chosen to represent the entire area of the IA, excluding areas of clean fill emplaced following the pesticide removal program. Discrete samples were collected from beneath areas of pavement, while 5-point composite samples were used to characterize areas surrounding the former housing buildings. Polychlorinated biphenyls concentrations ranged from non-detect to 4.1 mg/kg, which is above the Project Cleanup Goal of 1 mg/kg. Polychlorinated biphenyls are being addressed separately.

To further evaluate IA-8, an additional 12 soil borings were completed during the SSI as shown on Figure 5-5. Seven of the soil borings were advanced below the water table beneath the IA, and four of these soil borings were further advanced to auger refusal, which was interpreted to be the top of bedrock. Three of the soil borings were completed as piezometers (IA08-PZ01 through IA08-PZ03) and two of the soil borings (IA08-MW01 and IA08-MW02) were completed as groundwater monitoring wells. Locations were chosen based on the known location of the former Dry Cleaning facility. Composite soil samples were collected from 0 to 3 ft and 3 to 10 ft bgs at the seven soil boring locations that were not completed as piezometers. Samples were collected from 3-inch steel split-spoons which were used in conjunction with HSA drilling techniques. Once the split-spoon was opened, sample recovery was recorded and soil classification activities were completed. Soil boring logs are presented in Appendix B. Sample aliquots were placed into clean sampling bowls using stainless steel spoons and homogenized. The sample aliquot was then placed into the appropriate pre-labeled sample container(s).

The samples collected from soil borings from locations IA08-SB01 and IA08-MW02 were submitted to the off-site laboratory for TCL/TAL full suite analysis (VOCs, SVOCs, PCBs, pesticides, TAL metals, and EPH), as well as perchlorate and explosives. The soil samples from the 2-ft interval with the highest soil headspace measurement from each of the six soil borings that were located in the footprint of the former Dry Cleaning facility (IA08-SB02 through IA08-SB07) were submitted to the off-site laboratory for TCL VOC analysis only.

PASI/SSI Results/Data Evaluation

During the PASI, 59 shallow soil samples were submitted for PCB analysis. Polychlorinated biphenyls were detected in 23 of the 59 samples collected during the PASI, but at concentrations above their respective PALs in only 17 of the 59 soil samples. Concentrations of PCBs ranged up to 13 mg/kg. Summary tables of PASI analytical results are included as Tables 5-1b. None of the samples collected during the SSI contained PCBs at detectable concentrations. Through prior decision, PCBs in the vicinity of IA-8 have been addressed through a TCRA (see Subsection 4.2), which has resulted in a condition of NSR for PCBs within the IA.

During SSI activities, four soil boring samples were submitted for full suite TCL/TAL analysis, including EPH analysis, and six soil samples were submitted for TCL VOCs analysis only. No VOCs, pesticides, PCBs or EPH were detected at concentrations above their respective PALs.

Five SVOCs, (benzo(a)anthracene, benzo(a)pyrene, benzo(b)fluoranthene, dibenz(a,h)anthracene, and indeno(1,2,3-c,d)pyrene), were detected at concentrations slightly above their respective PALs in the 0 to 3 ft depth interval at location IA08-SB01, and benzo(a)pyrene was detected at concentrations slightly above its PAL in the deep soil sample from this location. In addition, the SVOC benzo(a)pyrene was detected at concentrations slightly above its PAL in the shallow and deep soil samples from location IA08-SB09. Finally, five SVOCs (benzo(a)anthracene, benzo(a)pyrene, benzo(b)fluoranthene, dibenz(a,h)anthracene, and indeno(1,2,3-c,d)pyrene) were detected at concentrations slightly above their respective PALs in the 0 to 3 ft depth interval at location IA10-SB02. Since the soil sample was collected directly beneath asphalt paving, the asphalt paving may have been the source of the SVOCs detected.

The following metals were detected in one or more of the eight SSI soil samples analyzed for TAL metals, at concentrations above their PALs: aluminum (one sample), arsenic (all eight samples), iron (all eight samples), manganese (all eight samples), nickel (all eight samples), and sodium (six samples). Arsenic concentrations in the SSI soil samples collected from IA-8 ranged between 25 and 36 mg/kg, which are consistent with background levels for the site. Summary tables of SSI soil analytical results are included as Tables 5-2a through 5-2i.

5.2.3.8 Investigation Area-9 – Cavite Housing Area

Investigation Area 9 includes the entire Cavite HA, which has been historically identified as a Former Training Area (see Figure 5-11). The former Cavite HA is located on the eastern portion of the Main Base on Cavite Street and includes six housing units on Cavite Street and Bates Service Road, between MacArthur Avenue and Saratoga Road. Investigation Area 4, which was identified as a Possible Trench Warfare Training Area, was previously thought to be located within and adjacent to the southern boundary of IA-9. However, after a comprehensive review of aerial photographs and supporting data, it was determined that IA-4 is located approximately 0.5-mile south of IA-9, beyond the limits of the former Cavite HA.

SSI Sampling Methodology

Previous soil sampling, conducted as a result of the MCP-Lead Pesticide Soil Remedial Action in the area, focused on investigating potential arsenic and PCB releases in the vicinity of the disturbed soils surrounding the former housing units and under the roadways. During the PASI, a total of 48 PCB samples and 10 discrete arsenic samples were collected and analyzed at an off-site laboratory. Arsenic samples were collected randomly from test pits.

To further evaluate IA-9, one soil boring (IA09-SB01) and one test pit (IA09-TP01) were completed during the SSI (see Figure 5-11). Soil boring IA09-SB01 was completed between the footprints of former Buildings 145 and 147, near where a previous soil sample indicated elevated arsenic concentrations. The soil boring was located within an area of fill material not assessed as part of previous investigation activities. Representative soil samples were collected from 0 to 3 ft and 3 to 10 ft bgs at the boring location and were submitted to an off-site laboratory for TCL/TAL full suite analysis (including VOCs, SVOCs, PCBs, pesticides, TAL metals, and EPH) and dioxin/furan analysis. The soil samples collected from the boring location were collected utilizing HSA drilling and split-spoon sample collection techniques.

Test pit IA09-TP01 was excavated to a depth of 6 ft bgs using a backhoe and representative soil samples were collected from each sidewall at 0 to 2 ft, 2 to 4 ft, and 4 to 6 ft depth intervals using stainless steel spoons. The 12 soil samples collected from the test pit were submitted to an off-site laboratory for TAL metals analysis.

During sample collection activities, soils from the boring location and the test pit were classified. Test pit and soil boring logs are presented in Appendices A and B, respectively. Sample aliquots were placed into clean sampling bowls using stainless steel spoons and homogenized. The sample aliquot was then placed into the appropriate pre-labeled sample container(s) and submitted to the off-site laboratory for analysis.

PASI/SSI Results/Data Evaluation

Analytical results from the PASI indicated that each of the 10 samples submitted for metals analysis contained arsenic and iron at concentrations greater than their PAL, one contained aluminum above its PAL, three contained lead above its PAL three contained manganese above its PAL, two contained magnesium above its PAL, one contained nickel above its PAL, one contained potassium above its PAL, and one contained vanadium above its PAL. The arsenic concentration reported for sample CT-GB-502-2 was 130 mg/kg, which may be an outlier from the background concentration dataset, due to either anomalously high natural concentrations or a non-natural source.

In addition, 2 of the 48 PASI samples submitted for PCB analysis detected trace concentrations of PCBs above the laboratory reporting limit, but well below the EPA remedial criteria of 1.0 mg/kg. Since adjacent or surrounding samples to each of the detections were below the laboratory report limit, it was concluded that there were no PCB impacts in this area. Summary tables of PASI PCB analytical results are included in Table 5-1c.

During SSI activities, two samples collected from one soil boring were submitted for full suite TCL/TAL analysis, including EPH analysis, and 12 soil samples collected from a test pit were submitted for TAL metals analysis only. The soil boring samples submitted for TCL/TAL full suite analysis indicated no levels of contaminants above their respective laboratory reporting limits for VOC, SVOC, PCB, pesticides, CDDs/CDFs, and EPH analyses. Results of samples collected during the SSI are presented in Tables 5-2a through 5-2i.

Results of the SSI soil boring and test pit samples submitted for TAL metals analysis indicated arsenic levels generally consistent with background levels for the SA, with the exception of the result from sample CA-IA09-TP01-C3, which was 70 mg/kg, and may also be an outlier from the background concentration dataset, due to either anomalously high natural concentrations or a non-natural source. The arsenic data set for IA-9 is not normally-distributed at the 5% significance level, and the data are non-parametric. In addition, following metals were detected in one or more of the 14 SSI soil samples analyzed for TAL metals, at concentrations above their

PALs: aluminum (1 sample), arsenic (all 14 samples), iron (all 14 samples), manganese (3 samples), nickel (2 samples), potassium (1 sample), and vanadium (1 sample).

5.2.3.9 Investigation Area-10 – Grant Housing Area

Investigation Area 10 includes the entire Grant HA, which has been historically identified as a Former Training Area (Figures 5-2 through 5-10). The Grant HA is approximately 400 acres, located along the northwestern boundary of the former Fort Devens and between Nashua River located to the west, Hospital Road to the south and El Caney Street to the east. The Grant HA included 130 former housing units located on Plum Street, Beech Street, Spruce Street, Poplar Street, Hospital Road, El Caney Street, Antietam Street, Birch Circle, and Grant Road that were constructed in the late 1950s or early 1960s. The former Grant HA was used for a variety of military training purposes from 1917 through the early 1950s prior to the construction of the earliest housing units. After the early 1960s, the area was used solely as a HA.

SSI Sampling Methodology

Previous soil sampling, conducted as a result of the MCP-Lead Pesticide Soil Remedial Action in the area, focused on investigating potential arsenic and PCB releases in the vicinity of the disturbed soils surrounding the former housing units and under the roadways. During the PASI, 34 of 197 samples submitted for analysis detected the presence of PCBs above the laboratory reporting limit. Polychlorinated biphenyls were detected in samples collected from 11 composited areas and 3 samples. Discrete samples associated with the composite samples where PCBs were detected above the laboratory detection limit were subsequently analyzed for PCBs as well. Analytical results of the discrete samples indicated that only 6 of the 11 composite areas (as certain samples that contained PCBs exceeding the remedial criteria were located adjacent to one another, resulting in a single, common composite area that exceeded the remedial criteria) detected the presence of PCBs at concentrations in exceedance of the EPA remedial criteria of 1.0 mg/kg.

Results of the removal action and PASI arsenic samples indicated that a potential arsenic impact may have existed. However, a comparison to more statistically-robust arsenic background data

set was required to confirm that the observed arsenic concentrations were associated with natural conditions versus a release. To further evaluate IA-10, during the SSI, an additional four soil borings (IA10-SB01 through IA10-SB04) and two test pits (IA10-TP01 and IA10-TP02) were completed, as shown in Figures 5-2 through 5-10. The locations of three soil borings (IA10-SB01, IASB-SB03, and IASB-SB04) were set in fill areas that had not been assessed as part of previous investigation activities or former range investigation activities. The final boring (IA10-SB02) was placed in the location of the former Base Laundry facility to evaluate potential releases associated with the laundry operations. Historical aerial photographs and site plans indicate the laundry facility operations included the former boiler house and an aboveground storage tank (AST). It is unclear at this time if the AST contained water, fuel, or another liquid.

Representative soil samples were collected from 0 to 3 ft and 3 to 10 ft bgs at each boring location. A total of eight soil samples were submitted to an off-site laboratory for TCL/TAL full suite (including VOCs, SVOCs, PCBs, pesticides, TAL metals, and EPH) and dioxin/furan analysis. The soil samples collected from the boring locations were collected utilizing HSA drilling and split spoon sampling techniques. Two test pits, IA10-TP01 and -TP02, were completed to assess a potential arsenic impact associated with previous soil samples GR-3-01 and GR-3-09, respectively. The test pits were excavated to a depth of 6 ft bgs using a backhoe. Representative soil samples were collected from each sidewall of the pit at 0 to 2 ft, 2 to 4 ft, and 4 to 6 ft bgs intervals using stainless steel spoons. The 24 samples collected from the test pits were submitted to an off-site laboratory for TAL metals analysis.

During sample collection activities, soils from the boring locations and the test pits were classified. Test pit and soil boring logs are presented in Appendices A and B, respectively. Sample aliquots were placed into clean sampling bowls using stainless steel spoons and homogenized. The sample aliquot was then placed into the appropriate pre-labeled sample container(s) and submitted to the off-site laboratory for analysis.

PASI/SSI Results/Data Evaluation

During the PASI, PCBs were detected at 14 locations (11 composited areas and 3 roadway samples) within the Grant HA. Subsequent analysis of the discrete samples associated with each

of the 11 composite samples indicated the presence of PCBs in exceedance of the EPA remedial criteria of 1.0 mg/kg in only 6 composite areas, since some of the areas were adjacent to one another. The PCBs within IA-10 have been addressed through a TCRA (see Subsection 4.2), which has resulted in a condition of NSR for PCBs within the IA. Summary tables of PASI analytical results are included as Tables 5-1a through 5-1c.

Although the SSI investigation of IA-10 was focused on the possible impacts of the former Grant HA, the analytical results collected from IA-1, IA-2, IA-5, and IA-8, while focused on impacts from actual or potential former ranges or other facilities, are still applicable for assessing possible impacts from the former HA, especially since no impacts were noted due to the former ranges, and only a limited impact was noted, apparently due to the former laundry facility. The SSI soil boring samples submitted for TCL/TAL full suite and dioxin/furan analysis indicated no levels of contaminants above the PALs for VOC, PCB, and TAL metals, and dioxin/furan analyses. Results for SVOCs and EPH indicated elevated levels of various compounds, including benzo(a)pyrene, benzo(b)fluroanthene, dibenzo(a,h)anthracene, benzo(a)anthracene, and indeno(1,2,3-c,d)pyrene in the samples from locations IA02-SB23 (0 to 3 ft), IA08-SB01 (0 to 3 and 3 to 10 ft), IA08-SB09 (0 to 3 and 3 to 10 ft), IA10-SB01 (0 to 3 and 3 to 10 ft), IA10-SB02 (0 to 3 and 3 to 10 ft) and IA10-SB03 (0 to 3 and 3 to 10 ft) at levels exceeding their PALs. Concentrations of the pesticides Aldrin and/or Dieldrin that exceeded their PALs were detected in samples collected from locations IA02-SB20 (0 to 3 ft), IA02-SB23 (0 to 3 and 3 to 10 ft), and IA10-SB03 (0 to 3 ft). Concentrations of the pesticides 4,4'-DDE and 4,4'-DDT that exceeded their PALs were detected in the 0 to 3 ft depth interval at sample location IA02-SB30.

As noted in association with IA-2, benzo(a)pyrene was detected in the 0 to 3 ft sample from IA02-SB23 at concentrations exceeding the PAL, although well below the MCP background concentration. As noted in association with IA-8, five SVOCs, (benzo(a)anthracene, benzo(a)pyrene, benzo(b)fluoranthene, dibenz(a,h)anthracene, and indeno(1,2,3-c,d)pyrene), were detected at concentrations slightly above their respective PALs in the 0 to 3 ft depth interval at location IA08-SB01, and benzo(a)pyrene was detected at concentrations slightly above its PAL in the deep soil sample from this location. In addition, the SVOC benzo(a)pyrene was detected at concentrations slightly above its PAL in the shallow and deep soil samples from

location IA08-SB09. Finally, seven SVOCs (anthracene, benzo(a)anthracene, benzo(a)pyrene, benzo(b)fluoranthene, benzo(g,h,i)perylene, dibenz(a,h)anthracene, and indeno(1,2,3-c,d)pyrene) were detected at concentrations slightly above their respective PALs in the 0 to 3 ft depth interval at location IA10-SB02.

The following metals were detected in one or more of the 101 SSI soil samples analyzed for TAL metals, at concentrations above their PALs: aluminum (43 samples), arsenic (all 101 samples), chromium (3 samples); iron (all 101 samples), lead (5 samples), manganese (65 samples), nickel (53 samples), and thallium (3 samples). Arsenic concentrations in the SSI soil samples collected from IA-10 ranged between 6.3 mg/kg and 68 mg/kg, which are consistent with background levels for the site. Summary tables of SSI soil analytical results are included as Tables 5-2a through 5-2i.

Results of the test pit samples submitted for TAL metals analysis indicated arsenic concentrations ranged from 4.9 mg/kg to 58 mg/kg. The arsenic results were consistent with background levels for the SA. Results of samples collected during the SSI are presented in Tables 5-2a through 5-2i.

5.2.3.10 Investigation Area-11 – Locust Housing Area

Investigation Area 11 includes the entire Locust HA, which has been historically identified as a Former Training Area (Figure 5-9). The former Locust HA is located within the southern portion of the SA and comprises the entirety of Locust Street which formerly contained 14 houses. The Locust HA is adjacent to three former Training Areas and/or Ranges (IA-3 and IA-6, Rifle and Machine Gun Ranges, and IA-7, Sub-Caliber Anti-Tank Range). No specific features or past use for the area prior to its development as base housing was identified. Based on aerial photographs, the houses appear to have been built sometime between 1952 and 1965.

SSI Sampling Methodology

Previous soil sampling, conducted as a result of the MCP-Lead Pesticide Soil Remedial Action in the area, focused on investigating potential arsenic and PCB releases in the vicinity of the

disturbed soils surrounding the former housing units and under the roadways. During the PASI, a total of six composite PCB samples, four discrete PCB samples, and seven discrete arsenic samples were collected and analyzed at an off-site laboratory.

To further evaluate IA-11, six soil borings were completed during the SSI (see Figure 5-9). The soil borings were completed to the southeast of the HA in an area with a high concentration of apparent man-made features. Initially, only one soil boring (IA11-SB01) was planned for this IA. The remaining five soil borings were added after the preliminary results of the initial soil boring indicated concentrations of pesticides and SVOCs above the laboratory reporting limits. Representative soil samples were collected from 0 to 3 ft and 3 to 10 ft bgs at boring locations (IA11-SB01 and IA11-SB02). Samples collected from the soil boring IA11-SB01 were submitted to an off-site laboratory for full suite (including VOCs, SVOCs, PCBs, pesticides, TAL metals, and EPH) and dioxin/furan analysis. Samples collected from soil boring IA11-SB02 were submitted to an off-site laboratory for SVOC analysis only. The remaining four borings were completed to a depth of 3 ft bgs. Samples IA11-SB03 through IA11-SB06 were located approximately 10 ft to the east, south, west, and north of the soil boring IA11-SB01 and were submitted to an off-site laboratory for pesticides analysis. The two 10-ft soil boring samples were collected utilizing HSA drilling and split-spoon sample collection techniques. The four 3-ft soil borings were collected using a Geoprobe unit. Once the split-spoon/polyvinyl chloride sleeve was opened, sample recovery was recorded and soil classification activities were completed. Soil boring logs are included as Appendix B. Sample aliquots were placed into clean sampling bowls using stainless steel spoons and homogenized. The sample aliquot was then placed into the appropriate pre-labeled sample container(s).

PASI/SSI Results/Data Evaluation

The PASI results indicated a trace level of PCBs present below the roadway. The concentration detected (0.042 mg/kg) was slightly above the laboratory reporting limit (0.041 mg/kg) and is well below the EPA remedial criteria of 1.0 mg/kg. Results of the arsenic samples collected during the PASI indicated concentrations consistent with background levels for the SA. Results of the samples collected during the PASI are presented in Tables 5-1a through 5-1c.

Although the SSI investigation of IA-11 was focused on the possible impacts of the former Locust HA, the analytical results collected from IA-3 south of Hospital Road, while focused on impacts from a potential former range, are still applicable for assessing possible impacts from the former HA, especially since no impacts were noted due to the former range. The SSI results indicated no VOCs, PCBs or dioxins/furans that exceeded their PALs. Five SVOCs, (benzo(a)anthracene, benzo(a)pyrene, benzo(b)fluoranthene, dibenz(a,h)anthracene and indeno(1,2,3-c,d)pyrene) and two pesticides (Aldrin and Dieldrin) were detected at concentrations above their respective PALs in the 0 to 3 ft depth interval at location IA11-SB01. Sample IA11-SB02 was located approximately 30 ft west/southwest of IA11-SB01 and was submitted for SVOC analysis. No SVOCs were detected above the laboratory reporting limits, which were all below the PALs. Results of the additional four soil borings surrounding I A11-SB01 (IA11-03 through IA11-SB06) submitted for pesticides indicated Aldrin and Dieldrin were present, but at much lower concentrations, with Aldrin detected above its PAL in the sample from location IA11-SB06 and Dieldrin detected above its PAL in the sample from locations IA11-05 and IA11-SB06. In addition, five metals, aluminum, arsenic, iron, manganese, nickel, were detected in one or more samples above their respective PALs. Results of samples collected during the SSI are presented in Tables 5-2a through 5-2i

5.2.4 Groundwater Monitoring and Well Installation

All groundwater sampling was conducted in accordance with the procedures outlined in the *Final SSI WP* (WESTON, 2005a) included in Appendix I. Tables summarizing SSI groundwater analytical results, sorted by each IA, are included as follows:

- Table 5-4a: Summary of Volatile Organic Compounds Groundwater Analytical Results
- Table 5-4b: Summary of Semi-Volatile Organic Compounds Groundwater Analytical Results
- Table 5-4c: Summary of Extractable Petroleum Hydrocarbons Groundwater Analytical Results
- Table 5-4d: Summary of Polychlorinated Biphenyls Groundwater Analytical Results

- Table 5-4e: Summary of Pesticides Groundwater Analytical Results
- Table 5-4f: Summary of TAL Metals Groundwater Analytical Results
- Table 5-4g: Summary of Dioxin/Furan Groundwater Analytical Results
- Table 5-4h: Summary of Perchlorate Groundwater Analytical Results
- Table 5-4i: Summary of Explosives Groundwater Analytical Results

Sample requirements and rationale is discussed by IA in the following subsections.

5.2.4.1 Investigation Area-2 – Training Area and/or Range (circa 1922)

The Impact Area of IA-2 was further investigated for potential impacts to groundwater associated with its former use as a former Training Area and/or 37-mm range (see Figure 5-6).

SSI Sampling Methodology

To further assess IA-2, two monitoring wells and three piezometers were completed in this IA as shown on Figure 5-6. Munitions and Explosives of Concern avoidance measures were conducted prior to the initiation of soil boring activities. Soil borings, monitoring wells, and piezometers were located and sampled within the Impact Area.

Impact Area

Three piezometers (IA02-PZ04, -PZ05, and -PZ06) and two soil borings (IA02-SB01 and IA02-SB30) were completed to estimate the direction of groundwater flow in the area. The initial assumption was that groundwater flow was northwesterly, toward the Nashua River. The initial results from locations PZ-04, PZ-05, and MW-03 indicated a southwesterly groundwater flow direction. Attempts were made to install piezometers southwest of PZ-04 and northwest of PZ-05, with no success due to overhead utilities and auger refusal above the water table, respectively. An additional piezometer was installed at PZ-06, which further indicated that groundwater flow was southwesterly. At this time, monitoring well MW-04 was installed between PZ-04 and PZ-05, to better define groundwater flow direction. Subsequent groundwater

elevation measurements indicated that PZ-04 was in a position downgradient of MW-03. Since the piezometer and monitoring well installations were the same, downgradient groundwater sampling was shifted from MW-04 to PZ-04. Based on the estimated direction of groundwater flow, two monitoring well borings were installed. The first monitoring well, IA02-MW03, was placed at the toe-of-slope of the Impact Area. The second monitoring well, IA02-MW04, was installed in the downgradient groundwater flow direction from monitoring well MW-03 (see Figure 3-4). Soil samples for laboratory analysis were not collected from the piezometer soil borings. Soil samples collected from each of the monitoring well soil borings (IA02-MW03 and -MW04) were submitted for TCL/TAL full suite, perchlorate, and explosives analyses.

Following monitoring well development and equilibration, groundwater samples were collected from monitoring wells MW-03 and PZ-04. The groundwater samples were analyzed for TCL/TAL full suite analysis (VOCs, SVOCs, PCBs, pesticides, TAL metals, and EPH), as well as perchlorate, explosives, and dioxin/furan analyses. In addition, groundwater elevation measurements were collected from the IA-2 monitoring wells and piezometers on a number of occasions. These measurements were made within a 15-minute period, prior to any groundwater sample collection in the area.

PASI/SSI Results/Data Evaluation

During the SSI, two groundwater samples were submitted for TCL/TAL full suite analysis, plus explosives, dioxins/furans, and perchlorate. None of the analytes were detected above their respective PALs in the groundwater samples. Summary tables of SSI groundwater analytical results are included as Tables 5-4a through 5-4i.

5.2.4.2 Investigation Area 8 – Former Base Laundry Buildings

Investigation Area 8 was further investigated for potential impacts to groundwater associated with its former use as a former Base Laundry and associated Dry Cleaning facility (see Figure 5-5). The possible release to groundwater of chlorinated solvents commonly used in the dry cleaning process was the primary focus of the groundwater investigation.

SSI Sampling Methodology

To further evaluate IA-8, an additional 12 soil borings were completed during the SSI as shown on Figure 5-5. Seven of the soil borings were advanced below the water table beneath the IA, and four of these soil borings were further advanced to auger refusal, which was interpreted to be the top of bedrock. Three of the soil borings were completed as piezometers (IA08-PZ01 through IA08-PZ03), and two of the soil borings (IA08-MW01 and IA08-MW02) were completed as groundwater monitoring wells. Locations were chosen based on the known location of the former Dry Cleaning facility.

The piezometers and monitoring wells were installed in the following sequence. The initial assumption was that groundwater flow was northwesterly, toward the Nashua River. Initially, piezometers PZ01 through PZ03 were installed approximately 200 ft in likely downgradient directions (southwest, northwest, and northeast, respectively) from the presumed source area, the former Dry Cleaning facility. In addition, two deep soil borings, IA08-SB01 and IA08-SB05, were advanced to the top of bedrock in the source area. During the drilling program, these five locations were surveyed for location/elevation relative to each other by a WESTON geologist using an autolevel. Based on the groundwater elevations measured, or, in the case of soil borings, estimated based on soil boring logs, the direction of groundwater flow was estimated. Using the estimated direction of groundwater flow, the two monitoring wells, MW-01 and MW-02, were sited. Monitoring well MW-01 was sited at the downgradient edge of the presumed source area, while monitoring well MW-02 was sited approximately 200 ft downgradient of the presumed source area. Post-installation water level measurements confirm that MW-01 and MW-02 are located slightly and further downgradient of the presumed source area.

Following monitoring well development and equilibration, groundwater samples were collected from monitoring wells MW-01 and MW-02. The groundwater samples were analyzed for TCL/TAL full suite analysis (VOCs, SVOCs, PCBs, pesticides, TAL metals, and EPH), as well as perchlorate, explosives, and dioxin/furan analyses. In addition, groundwater elevation measurements were collected from the IA-8 monitoring wells and piezometers on a number of occasions. These measurements were made within a 15-minute period, prior to any groundwater sample collection in the area.

PASI/SSI Results/Data Evaluation

During the SSI, two groundwater samples were submitted for full suite analysis TCL/TAL analysis, plus EPH, dioxins/furans, and perchlorate. Summary tables of PASI groundwater analytical results are included as Tables 5-4a through 5-4i. None of the analytes were detected above their respective PALs in the groundwater samples.

5.3 DATA REVIEW/LABORATORY PERFORMANCE

5.3.1 Preliminary Assessment Site Investigation Data

Soil samples were submitted to Mitkem Corporation (Mitkem) for analysis for PCBs by SW-846 Method 8082, and metals by SW-846 Method 6010. Soil samples were submitted to Severn-Trent Laboratories (STL) of Burlington, Vermont for analysis for explosives by SW-846 Method 8330. Soil analytical results were reviewed in accordance with the *U.S. EPA New England Region I Data Validation Functional Guidelines for Evaluating Environmental Analyses* (December 1996), MassDEP MCP Data Quality Enhancement Program criteria for Presumptive Certainty, and the QC limits stated in the project specific *Quality Assurance Project Plan* (*QAPP*). The following QC indicators were reviewed; holding time, method blanks, equipment blanks, surrogate recoveries (2,4,5,6-Tetrachloro-m-xylene and decachlorobiphenyl), matrix spike (MS) recoveries, field duplicate results, laboratory control spike recoveries, and calibration.

Twenty samples were analyzed for explosives and 255 samples were analyzed for PCBs. All data that were reviewed met the QC guidelines stated in the MCP and the *QAPP* for method blanks, surrogate recoveries (at least one surrogate in each sample recovered within the 30 to 150 QC range), and laboratory control spike recoveries. In laboratory package, B1774, ten samples were extracted 1 day out of holding time and all results should be considered estimated. However, PCBs are known to be very stable and a 1-day exceedence should not impact data quality. Also in this data package, an MS/MS duplicate had Aroclor 1016 above QC recovery limits. Since 1016 was not reported in the unspiked sample, no action was taken.

In several instances, PCB results are flagged with a "P" since the results between the two columns did not meet the MCP percent difference criteria (i.e., percent difference less than 40%). These values should be considered estimated according to the *U.S. EPA New England Region I Data Validation Functional Guidelines for Evaluating Environmental Analyses* (December 1996). The laboratory chose to report the lower of the two results which met the EPA guidelines, but did not meet the MCP guidelines. In cases where all QC criteria were met on the column from which the result was reported, the lower result is acceptable; since, in most cases, both results were below the cleanup goal of 1,000 micrograms per kilogram (µg/kg). However, in several instances, the laboratory reported the result from the column which did not pass all QC criteria (continuing calibrations had percent differences above 15%). WESTON requested that Mitkem resubmit the results from the passing column. There were two instances where the original reported result was below the project's cleanup goal of 1,000 µg/kg and the resubmitted result was above the cleanup goal. In sample PASI-GR-GB-019B-1, Mitkem originally reported a result of 870 µg/kg. Second column analysis had a result of 1,100 µg/kg. Since the original result came off a column which did not meet calibration criteria, the result has been changed to 1,100 µg/kg. In sample PASI-GR-GB-020E-1, the laboratory originally reported 750 µg/kg, which came from the column that did not meet calibration criteria. Therefore, the second column result of 1,200 µg/kg was reported. There were no discrepancies noted in the explosive data submitted by STL. The consistent use of the higher of the two results when calibration criteria were exceeded is a bias toward overestimation.

Sixty-five samples were analyzed for lead and 82 samples were analyzed for arsenic by Mitkem. The data were evaluated under the same guidelines listed above and the following QC indicators were reviewed: holding time, method blanks, equipment blanks, laboratory control spikes, MSs, laboratory duplicates, field duplicates, serial dilutions, and calibration. A total of seven qualifiers were applied in five of the laboratory data packages. These qualifiers were based on MS, laboratory duplicate, field duplicate or serial dilution criteria not meeting and did not affect the overall quality of the data results that were reported by the laboratory.

5.3.2 SSI Data

Soil and groundwater samples were submitted to Alpha Analytical Laboratory (Alpha) for analyses for VOCs by SW-846 Method 8260B, SVOCs by SW846 Method 8270C and secondary ion-mass spectrometry (SIM) for benzo(a)pyrene and dibenzo(a,h)anthracene, pesticides/PCBs by SW-846 Methods 8081/8082, metals by SW-846 Methods 6010B/7471 and EPH. Soil and groundwater samples were submitted to Lionville Laboratory and Columbia Analytical Laboratory, under contract to Alpha, for analyses for explosives by SW-846 Method 8330 and CDD/CDFs by SW-846 Method 8290, respectively.

A modified Tier II data review and validation was performed on all data packages in accordance with the *U.S. EPA New England Region I Data Validation Functional Guidelines for Evaluating Environmental Analyses* (December 1996), MassDEP MCP Data Quality Enhancement Program criteria for Presumptive Certainty, and the QC limits stated in the project specific *QAPP*. Additionally, the following QC indicators were reviewed; method blanks, field blanks, surrogate recoveries, MS recoveries, field duplicate results, laboratory control spike recoveries, reporting limits, and calibration. The data validation qualifiers listed below contain superscripts, which refer to footnotes in the data validation memoranda, which are included in Appendix G.

Volatile organic compounds, SVOCs, EPH, and pesticide/PCB data submitted by Alpha for approximately 40 samples were reviewed and were found to meet the quality objectives of this project, with the following qualifications. Toluene was qualified as undetected (U^3) in samples GR-IA03-SB04-1 and GR-IA10-SB03-1 (lab data package L0414049) and in samples GR-IA02-SB23-1 and GR-IA10-SB01-1 (lab data package L0413910), since it was detected in the trip blank. Two qualifiers were applied due to field duplicate criteria not meeting relative percent difference (RPD) criteria for soils, which must be less than or equal to 50%; J^2/UJ^2 was applied to compounds naphthalene, benzene, toluene, p/m-xylene, and o-xylene in samples GR-IA10-SB02-1 and GR-IA10-SB02-1-D (3-10 ft) in lab package L0413820, and J^4/UJ^4 was applied to naphthalene and m/p-xylenes in samples GR-IA08-SB02-1 and GR-IA08-SB02-1-D (8 to 10 ft) in the same lab package. In cases where field duplicate RPD criteria were exceeded, the higher of the two values should be utilized.

Metals results for 187 samples was found to meet the quality objectives of this project except for three instances, where data were qualified as estimated due to field duplicates not meeting the RPD criteria of less than or equal to 50%; J[1]/UJ[1] was applied to barium, calcium, and potassium in samples GR-IA05-SB02-1 and GR-IA05-SB02-1D, J[5]/UJ[5] was applied to calcium in samples GR-IA02-SB08-1 and GR-IA02-SB08-1-D (0-3ft), J[6]/UJ[6] was applied to potassium in samples CA-IA09-TP01-D1-1/-1D and GR-IA10-TP02-B1-1/-1D. In cases where field duplicate RPD criteria did not meet, the higher of the two values should be utilized. Several metal equipment blanks contained target analytes above the reporting limits. However, since sample results were much higher, no qualifications were necessary. The equipment blank contamination has been attributed to sub-freezing weather conditions during sampling, which necessitated the Geoprobe contractor not completely dismantling split spoons during the steam-cleaning decontamination, to avoid blasting the smaller components about.

Explosives results for 63 samples were reviewed and found to meet the quality objectives of this project. However, the laboratory did not perform the MCP 8330 Method; therefore, some of the criteria for MCP Presumptive Certainty were not met. For example, the QC limits listed in the MCP 8330 Method for spike and surrogate recoveries is 70 to 110 whereas the laboratory's QC limits were 60 to 140. Also, all explosives results were reported on a wet weight basis. The MCP method and the laboratory's methods for explosives analysis were compared, and it was determined that both methods were similar enough such that the analytical results were not greatly impacted. Since the percent solids determined for these samples in other analytical fractions were above 80%, results would not have changed significantly if reported on a dry weight basis.

Chlorinated dibenzodioxins/chlorinated dibenzofurans results for 16 samples were reviewed. In several instances, the laboratory method blank contained target compounds at concentrations greater than the detection limits. Since these compounds were detected in the associated samples at concentrations less than five times those of the laboratory method blank, their detections in the following samples must be qualified as undetected (U[7])**:**

- 1,2,3,4,6,7,8-heptachlorodibenzofuran (HpCDF) and octachlorodibenzofuran (OCDF) in GR-IA10-SB01-1 (0-3).

- Octachlorodibenzodioxin (OCDD) in sample GR-IA10-SB01-1 (3-10).
- 1,2,3,4,6,7,8-heptachlorodibenzodioxin (HpCDD) and OCDF in sample GR-IA10-SB02-1 (0-3).
- 1,2,3,4,6,7,8-HpCDD, OCDD, and OCDF in sample GR-IA10-SB02-1 (3-10).
- 1,2,3,4,6,7,8-HpCDD, OCDD, and OCDF in sample GA-IA10-SB02-1-D (3-10).
- 1,2,3,4,6,7,8-HpCDD, OCDD, and 1,2,3,4,7,8-Hexachlorodibenzofuran (HxCDF), 1,2,3,4,6,7,8-HpCDF in sample GR-PZ04S-1.
- 1,2,3,4,6,7,8-HpCDD and OCDD in sample GR-MW-02S-1.
- 1,2,3,4,6,7,8-HpCDD, OCDD, 1,2,3,4,6,7,8-HpCDF, and OCDF in samples GR-IA10-SB03-1 (3-10) and GR-IA10-SB03-1-D (3-10).
- OCDD and OCDF in sample GR-IA10-SB04-1 (0-3).
- 1,2,3,4,6,7,8-HpCDD, OCDD, 1,2,3,4,6,7,8-HpCDF, and OCDF in sample GR-IA10-SB04-1 (3-10).
- 1,2,3,4,6,7,8-HpCDD, OCDD, 1,2,3,4,7,8-HxCDF, and 1,2,3,4,6,7,8-HpCDF in samples GR-MW01S-1, GR-MW01S-1-D, and GR-MW03S-1.
- OCDD in sample LO-IA11-SB01 (3-10).
- 1,2,3,4,6,7,8-HpCDD, OCDD, 1,2,3,4,6,7,8-HpCDF, and OCDF in sample CA-IA09-SB01-1 (0-3).
- OCDD and 1,2,3,4,6,7,8-HpCDF in sample CA-IA-9-SB01-1 (3-10).

For sample GR-MW02S-1, all nine internal standard recoveries were less than the control limits. All results should be qualified as estimated (J^8) with the exceptions of 1,2,3,7,8-Pentachlorodibenzofuran and 2,3,4,7,8-PeCDF which should be rejected (R^8) due to their ^{13}Carbon-labeled internal standard recovery being less than 25%. The recovery of ^{13}C-OCDD was less than the control limit of 40% for sample LO-IA11-SB01-1(0-3). As a result, the OCDD and OCDF results reported for this sample were qualified as estimates (J^9)**.**

The following qualifications were made due to the responses of recovery standards not meeting QC criteria:

- Reject (R^{10}) 1,2,3,4,7,8- Hexachlorodibenzo-P-Dioxin (HxCDD), 1,2,3,7,8,9-HxCDF and 1,2,3,7,8,9-HpCDF results and estimate **(**J^{10}**)** 1,2,3,4,6,7,8-HpCDD, OCDD, 1,2,3,4,6,7,8-HpCDF, and OCDF results in LO-IA11-SB02-1 (0-3).
- Reject (R^{11}) all HxCDD, all HxCDF, 1,2,3,4,7,8,9-HpCDF and OCDF results in CA-IA09-SB01-1 (3-10).
- Estimate (UJ^{12}) all results except OCDD and 1,2,3,4,7,8-HxCDF in sample LO-IA09-SB01-1(3-10).
- Estimate (UJ^{13}) all results except 1,2,3,4,6,7,8-HpCDD, OCDD, 1,2,3,4,6,7,8-HpCDF, and OCDF in CA-IA09-SB01-1(0-3).

All validated CDD/CDF results were adjusted by EPA Toxicity Equivalency Factors (TEF) and World Health Organization TEFs, substituting half-detection limit for analytes that were not detected, to generate a 2,3,7,8-tetrachlorodibenzodioxin Toxicity Equivalency Quotient (TEQ). All CDD/CDF TEQs were found to be less than the MCP Method 1 S-1 soil standard.

Except for the 13 qualifications noted above, all other data generated for the SSI effort have been determined to be useable as reported by the laboratories.

SECTION 6

CONTAMINATION ASSESSMENT AND PRELIMINARY RISK EVALUATION

6. CONTAMINATION ASSESSMENT AND PRELIMINARY RISK EVALUATION

6.1 PASI AND SSI DATA SUMMARY

To date, as part of the PASI/SSI efforts, the history of activities presented in available documents has been reviewed. Historical documentation indicates that military training had occurred within each of the HAs from the time the property was established as a military installation through the construction of the housing units. The documentation is not detailed on the extents and types of training; however, sufficient detail is available to determine that several types of training would have been limited to the pre-WWII timeframe due to logistics. Historical documentation indicates that eight specific areas were formerly used as training areas (small arms or 37-mm ranges) or service areas (Base Laundry facility). Based on these findings, these areas were designated IAs (IA-1 through IA-8). In addition, in order to account for potential undiscovered former uses of the three former HAs, the former Grant, Locust, and Cavite HAs were also designated as IAs (IA-9 through IA-11), and subjected to further characterization beyond the boundaries of the eight IAs located within these areas.

From the historical review and existing data provided in previous investigations, the PASI sampling effort was devised to provide additional information to evaluate releases or potential releases within the SA. During the PASI, 357 samples were collected and analyzed for PCBs (255 samples), lead (65 samples), arsenic (82 samples), and/or explosives (20 samples). Samples were collected throughout the SA to determine whether PCB releases extended beyond the existing known release locations, arsenic concentrations in soil within the SA were naturally-occurring or anthropogenic, and whether former military training and range activities have resulted in the release of lead or explosives to soil.

During the SSI, 505 samples were collected from 112 locations and analyzed for VOCs (46 samples), SVOCs (39 samples), EPH (22 samples), pesticides (44 samples), CDDs/CDFs (24 samples), PCBs (40 samples), TAL metals (187 samples), perchlorate (36 samples), and/or explosives (67 samples). An additional 148 samples were collected from 70 locations at IA-6 and analyzed for VOCs (11 samples), SVOCs (15 samples), EPH (11 samples), pesticides

(11 samples), CDDs/CDFs (4 samples), PCBs (11 samples), TAL metals (149 samples), and/or explosives (4 samples).

The ultimate density of sampling performed during the PASI and SSI resulted in approximately seven (7) samples collected per acre. The majority of the samples collected were biased toward areas where contamination was suspected, such as impact and firing areas of ranges, rather than intermediate areas or areas with no known historic use. Table 6-1 summarizes the number and type of soil and groundwater samples collected during the PASI and SSI investigations.

6.1.1 Data Quality Objectives

The Data Quality Objectives (DQO) of this SSI (as well as the previous PASI, where applicable) are to:

- Collect and analyze soil and groundwater samples from the IAs for use in determination of the presence of COCs in a given IA and to facilitate risk screening of each IA.
- Produce legally-defensible analytical results, with accompanying field documentation of a sufficient level of detail and accuracy, to be used to support a determination of no further action or remediation decisions under CERCLA at each IA.
- Produce data of sufficient quality, including appropriate quantitation limits, to ensure compliance with CERCLA and other applicable and/or relevant and appropriate requirements and regulations/policies which have been used to develop the PALs for the SA.

Efforts to characterize the SA have been undertaken by numerous parties. The results of the previous investigations, in addition to the data from the SSI, will be used to support remediation decisions under CERCLA, in so far as the data meet the DQOs for the SSI.

In some cases, the analytical laboratory was unable to reach detection limits that were below the PAL for carcinogenic PAHs, including benzo(a)anthracene, benzo(a)pyrene, benzo(b)fluoranthene, dibenz(a,h)anthracene, and indeno(1,2,3-c,d)pyrene. However, in all but a few of these cases, the detection limits were well below the MassDEP-established background concentrations for these substances, which allowed these substances to be screened out of further risk screening. In the cases where the detection limits were above the MassDEP-established

background concentrations, one-half the detection limit was used in subsequent risk screening calculations. Therefore, the analytical results remain usable for risk screening purposes, although they may result in conservative estimates of potential risk.

Both "discrete" or "grab" soil samples and "composite" soil samples were collected during the PASI and SSI, to satisfy different data needs. Table 6-1 summarizes the number and type of soil and groundwater samples collected during the PASI and SSI investigations. Discrete samples were collected from a single location or depth interval, and were used for comparison with risk screening criteria, to determine compliance with cleanup goals. Composite samples (limited to PASI soil sampling for PCB analysis) were collected from multiple locations, and were used to determine whether hazardous substances were present in an area. Composite sampling allowed areas to be more thoroughly surveyed for hazardous substances at reasonable cost. Where composite soil samples were collected, discrete samples of the aliquots collected for compositing were retained for possible future analysis. In 31 cases, the discrete soil samples were analyzed when it was found that the PCB concentration in the composite soil sample exceeded the 1 mg/kg PCB cleanup goal. In two additional cases, the discrete soil samples were analyzed when it was found that the detection limit in the composite soil sample exceeded the 1 mg/kg PCB cleanup goal. In these 33 cases, in order to avoid skewing the calculations in favor of these samples, the analytical results from the five discrete samples used to create the composite sample were used in place of the composite results. Of the 977 soil samples collected during the PASI and SSI, 33 composite sample results, approximately 3% of the total, were not used for comparison against risk screening criteria, as component discrete sample analytical results were available.

6.2 INVESTIGATION AREA RISK SCREENING

Risk screening for human health and ecological targets was performed where required in the SA. In order to determine the types of risk screening required, a pathway assessment was performed for each IA. A pathway assessment of ecological risk screening is consistent with human health risk assessment and indicated that the air, groundwater, and surface water pathways are incomplete for the IAs. Soil exposure is the predominant pathway, however, the currently proposed residential and commercial reuse and landscaped open space of the IAs finds no excess

potential human health risks. Based on the planned reuse, it is the opinion of the Army that it was unnecessary to further evaluate potential ecological risks at the IAs, except for IA-6. The results of the pathway assessment were that each HA required human health risk screening, but that only IA-6, due to its location within the Oxbow National Wildlife Refuge, required ecological risk screening. The exposure pathway assessments are included in Subsection 3.5 of this report. The following subsections provide details of the human health and ecological risk screening performed in each HA.

6.2.1 Human Health Risk Screening

The human health risk screening summarized in Subsections 6.2.1 through 6.2.10 is a multi-step process, prescribed by the EPA and was conducted following the guidance provided in *EPA Risk Updates Newsletters #3* and *#5* (EPA, 1995c; 1999). The following paragraphs describe the process used to screen each area for potential human health risk.

Step 1 – Update Project Action Levels: The screening step of the risk screening process relies on PALs, which are a set of soil concentrations based on the lower of the following regulatory standards: MCP Method 1 S-1/GW-3 Soil Standards, EPA Region III Risk Based Concentrations, and EPA Region IX Preliminary Remediation Goals (PRG). In order to perform the Investigation Area Risk Screening, the PALs included in the *Final SSI WP* (WESTON, 2005a) were updated to meet two conditions. First, in January 2006, MassDEP released updated Method 1 S-1/GW-3 Soil Standards (WAVE-2) and second, the risk screening process requires the use of $1/10^{th}$ of the EPA Region IX PRG as a potential value for the PAL for non-carcinogenic substances. Table 5-5a summarizes the revised PALs used to perform the risk screening.

Step 2 – Summarize Analytical Results by Investigation Area: The second step was to compile a list of all substances that were detected above their laboratory detection limit in at least one sample within each IA. Tables 6-2a through 6-11a provide a list of substances detected within each IA and the concentration of that substance at each sample location within the IA. If the substance was analyzed for but not detected in a sample, the detection limited is posted. If the

sample was not analyzed for the substance, the cell is left blank. Concentrations of substances that exceed the PAL are highlighted.

Step 3 – Reduce Analytical Results for Calculations: In order to develop a representative data set for all substances detected at least once, several data reduction steps were required to address duplicate results, results from multiple analysis, and non-detects. Where duplicate samples exist, the higher result or lower detection limit was retained and the other result was removed from the data set, so as not to bias the data. Where PAH substances were listed up to three, different analytical methods may have been used to assess the substance (i.e., Method 8270 results, MassDEP EPH Method results, and MassDEP EPH Method SIM results); in each case the highest value or detection limit was retained. Where substances were not detected, half the detection limit for those samples was used as the value for that substance. Finally, for certain analytes, such as PCBs and CDDs/CDFs (which have PALs applicable only to totals or equivalency factors, respectively), individual analyte data were rolled up to the appropriate format (summed for total PCBs and processed into the 2,4,7,8-tetrachlorodibenzodioxin TEQ for CDDs/CDFs).

Step 4 – Screen Analytical Results Against Project Action Levels: When the representative data set was reduced (conclusion of Step #3), the maximum analytical result for each substance was compared to its PAL. If the maximum detected concentration was less than the PAL, the substance was eliminated from further evaluation. Tables 6-2b through 6-11b summarize the substances that were retained following Step #4, and include the minimum, maximum, and average concentrations for each substance.

Step 5 – Calculate Maximum and 95% Upper Confident Limit for each Substance: Following Step #4, the 95% Upper Confident Limit (UCL) was calculated for each remaining substance (see Tables 6-2b through 6-11b). The UCL calculations were performed using EPA's ProUCL software, Version 3.0. ProUCL output tables are provided for each substance (see Appendix J). The output tables provide the program recommended UCL value (value was used in the risk screening calculations) as well as raw statistics.

Step 6 – Assign Exposure Point Concentration: The Exposure Point Concentration (EPC) for each substance was assigned as the lower of the maximum or 95% UCL values.

Step 7 – Calculate Screening Cancer Risk: Using assigned EPCs, risk screening was performed for carcinogens detected in each IA by calculating the Screening Cancer Risk (SCR). The results of these risk screening calculations are summarized in Tables 6-2b through 6-11b. The SCR was calculated by dividing the EPC for each carcinogen by its unadjusted EPA Region IX residential soil PRG, and multiplying the result by 10^{-6}. The SCRs were then summed to calculate the Total Screening Cancer Risk (TSCR).

Step 8 – Calculate Screening Hazard Quotient: Using these data sets, risk screening was performed for non-carcinogens detected in each IA by calculating the Screening Hazard Quotient (SHQ). The results of these risk screening calculations are also summarized in Tables 6-2b through 6-11b. The SHQ was calculated by dividing the EPC for each non-carcinogen by its unadjusted EPA Region IX residential soil PRG. The SHQs were then summed to calculate the Total Screening Hazard Index (TSHI).

Step 9 – Evaluate Total Screening Cancer Risk and Total Screening Hazard Index Results: If the TSCR was less than 10^{-4} and TSHI was less than 1, it was concluded that no excess risk exists at the IA. If either the TSCR was greater than or equal to 10^{-4} or the TSHI was greater than or equal to 1, it was concluded that excess risk may exist at the IA, and additional factors should be evaluated to determine whether significant risk actually exists.

Step 10 – Compare Total Screening Cancer Risk with and without Arsenic Values: If arsenic (a carcinogen) was included in the TSCR screening, the concentrations of arsenic detected in the IA were reviewed against the arsenic background data set, which is discussed in further detail in Subsection 3.2.6.2 and Appendix C. The comparison consisted of comparing the highest arsenic result from the IA against 68 mg/kg, which is the third highest arsenic result that has been detected in the SA, and was considered the high end of the background concentration range, being from a sample (GRB-03-09X) collected by Nobis as part of the Arsenic Background Study. The more problematic 70 and 130 mg/kg results noted in the Cavite HA were not used for comparison, for obvious reasons. If the arsenic concentrations were found to be consistent with

the arsenic background data set, the arsenic SCR value was reviewed to determine the level of risk associated with arsenic. If arsenic was found to be the primary driver of a TSCR greater than 10^{-4}, then no further action was proposed in response to the excess TSCR. Tables 6-2b through 6-11b summarize the results of these calculations, where applicable.

Step 11 – Compare Total Screening Cancer Risk and Total Screening Hazard Index with and without Polycyclic Aromatic Hydrocarbon Values: In cases where TSCR is greater than 10^{-4} even after the elimination of the arsenic component of the TSCR and carcinogenic PAH concentrations were included in the TSCR calculations, or if TSHI is greater than 1, the concentrations of PAH(s) detected in the IA were reviewed against the MassDEP background PAH concentrations for undisturbed, natural conditions soils data set (MassDEP, 2002). Where the PAHs concentrations were found to be consistent with undisturbed, natural conditions, the TSCR was recalculated using only the PAH SCRs. If PAHs were found to be the driver of a TSCR greater than 10^{-4} and TSHI greater than 1, then no soil remediation was proposed in response to the excess TSCR and/or TSHI. Tables 6-2b through 6-11b summarize the results of these calculations, where applicable.

Step 12 – Compare Screening Cancer Risk with and without Polychlorinated Biphenyls Values: In cases where TSCR is greater than 10^{-4} even after the elimination of the arsenic and PAHs components of the TSCR and carcinogenic PCBs concentrations were included in the TSCR calculations, the concentrations of PCBs detected in the IA were reviewed against the 1 mg/kg site action level for PCBs previously agreed to by all stakeholders. Where the total PCBs concentrations in the IA were less than 1 mg/kg, the TSCR was recalculated using only the total PCBs SCRs. If PCBs were found to be the sole remaining drivers of a TSCR less than 10^{-4}, then no soil remediation was proposed in response to the excess TSCR. Tables 6-2b through 6-11b summarize the results of these calculations, where applicable.

Step 13 – Estimate Hypothetical Soil Removal Needs to Reduce Total Screening Cancer Risk to $<10^{-4}$: Where arsenic or PAHs concentrations were not consistent with established background concentrations or where PCB concentrations exceeded 1 mg/kg, several options are available to confirm or address the risk associated with these substances. For the benefit of this risk management evaluation, an estimate of soil removal is being provided as part of the risk

management process; however, the final risk management decision will not be based solely on comparison with a removal action. The removal action is based on an estimate of the volume of soil that would need to be removed to result in a TSCR $<10^{-4}$. These estimates were made by recalculating the TSCR after eliminating the elevated result or results that represent the highest percentage of excess SCR from the data set. Depending on the location(s) of the soil that drives the theoretical remediation, the soil volume required was estimated. These comparisons are contained within Subsections 6.2.1.1 through 6.2.1.10, where applicable.

Step 14 – Compare Cost and Feasibility Against Total Screening Cancer Risk Reduction: Costs and feasibility of these targeted, hypothetical removals were then calculated and compared against the degree of risk reduction hypothetically obtained. These comparisons are contained within Subsections 6.2.1.1 through 6.2.1.10, where applicable.

Step 15 – Make Risk Management Decisions based on Risk Screening Results: Risk management decisions are presented regarding whether soil remediation, the hypothetical removal, should be implemented. These decisions conclude each of Subsections 6.2.1.1 through 6.2.1.10, where applicable.

Based on the successful outcome of the risk screening described above, the data collected during the PASI and SSI should provide sufficient information for each IA to reach conclusions regarding potential risks to human health and the environment, including past, present, and reasonably foreseeable future land uses and conditions. The following subsections describe conclusions and potential risks to human health and the environment due to the presence of hazardous materials in each IA (IA-1 through IA-8) and evaluate the risks associated with any hazardous substances that resulted from previous military use of the IA, such as, explosives, lead, or chlorinated solvents. For IA-9 through IA-11, the former Cavite, Grant, and Locust HAs, respectively, data were used to evaluate the risks associated with any hazardous substances that result from the former use as military housing, such as pesticides; or hazardous substances with no known use, such as arsenic and PCBs. Since IA-1 through IA-8 are within or adjacent to the former HAs, the risk evaluations performed for IA-9 through IA-11 utilize all available data for the HA (excluding the post-excavation confirmatory sample results).

6.2.1.1 Investigation Area 1 – Former Training Area

A total of 28 substances were detected at least once in the 13 samples collected from IA-1 during the PASI and SSI (see Table 6-2a). Of these 28 substances, only 7 (aluminum, arsenic, iron, manganese, nickel, benzo(a)pyrene, and dibenz(a,h)anthracene) were detected at least once above their respective PAL. The risk screening calculations performed with these data (see Table 6-2b) indicate that the TSCR is less than 10^{-4} ($9x10^{-5}$) and the TSHI rounds to less than or equal to 1 (0.78). Further, for all of the substances (excluding arsenic) detected in soil at IA-1 their concentrations that are consistent with their concentrations in "Natural Soils" (MassDEP, 2002). Arsenic soil concentrations appear to be consistent with SA naturally occurring levels (CENAE, 2004). Therefore, the analytical results from the samples collected during PASI and SSI sampling activities from areas surrounding the former housing units and from the presumed Impact Berm and firing point(s) in this IA do not indicate the presence of contaminants indicative of past military use that would present unacceptable risks to human health or the environment. Based on the risk screening results, no further action is recommended within IA-1.

Investigation Area 1 was also evaluated for potential explosive safety risks related to MEC. This evaluation included a review existing records included in the *ASR* (see Subsection 4.5). In addition to this review, the Army prepared an *ECSM* that evaluated the risk and exposure pathways relating to potential presence of MEC at the IA (see Subsection 4.6). Subsequent to the development of the *ECSM*, the property owner, MassDevelopment, performed a MEC survey as described in Subsection 4.7. This information was also included in the evaluation of MEC at the site. The conclusions related to the MEC evaluation of IA-1 are as presented in Section 6 of the *ECSM* (see Appendix D).

6.2.1.2 Investigation Area 2 – Training Area and/or 37-mm Range

A total of 31 substances were detected at least once in the 209 samples collected from IA 02 during the PASI and SSI (see Table 6-3a). Of these 31 substances, only 13 (aluminum, arsenic, chromium, iron, lead, manganese, nickel, thallium, benzo(a)pyrene, 4,4-DDE, 4,4-DDT, aldrin, and dieldrin) were detected at least once above their respective PAL. The risk screening

calculations performed with these data (see Table 6-3b) indicate that the TSCR is less than less than 10^{-4} ($6x10^{-5}$) and the TSHI rounds to less than or equal to 1 (0.87). Further, all of the metals and PAHs concentrations in soil at IA-2 are consistent with concentrations in "Natural Soils" (MassDEP, 2002). Therefore, the analytical results from the samples collected from the Impact Area, Range Area, and Firing Point(s) in this IA do not indicate the presence of contaminants indicative of past military use that would present unacceptable risks to human health or the environment. Based on the risk screening results, no further action is recommended within IA-2.

No hazardous substances were detected in groundwater in IA-2 at concentrations above their PALs. Consequently, no further investigation of potential groundwater contamination is warranted within IA-2.

Investigation Area 2 was also evaluated for potential explosive safety hazards related to MEC. This evaluation included a review existing records included in the *ASR* and the Ordnance & Explosives Removal Report (see Subsection 4.5). In addition to this review, the Army prepared an *ECSM* that evaluated the risk and exposure pathways relating to potential presence of MEC at the IA (see Subsection 4.6). Subsequent to the development of the *ECSM*, the property owner, MassDevelopment, performed a MEC survey and removal as described in Subsection 4.7. This information was also included in the evaluation of MEC at the site and was incorporated into the *ECSM* (see Appendix D). The *ECSM* concluded that there is a potential for finding 37-mm MEC remaining on the site with a higher potential associated with the former target area with the potential decreasing outside of this area as the distance increases form the target area. The *ESCM* concluded that MEC related construction support would be necessary for future redevelopment within the former target area. In addition, safety training and notification of construction workers, residents, and the surrounding community was also recommended for the target area. Since there is a lower potential for a completed MEC pathway on the former range within the Grant HA, excluding the target area, the *ECSM* recommended safety training and notification of construction workers, residents, and the surrounding community as part of redevelopment within this area. These recommendations and conclusions within the *ECSM* were further evaluated and modified by the Army, EPA, MassDEP, and MassDevelopment with the final recommendations for the site as specified in Sections 7 and 8 of this report.

6.2.1.3 Investigation Area 3 – Possible Rifle Range

A total of 34 substances were detected at least once in the 70 samples collected from IA-3 during the PASI and SSI (see Table 6-4a). Of these 34 substances, only seven (aluminum, arsenic, iron, manganese, nickel, benzo(a)pyrene, and dibenz(a,h)anthracene) were detected at least once above their respective PAL. The risk screening calculations performed with these data (see Table 6-4b) indicate that the TSCR is less than less than 10^{-4} ($7x10^{-5}$) and the TSHI rounds to less than or equal to 1 (1.05). All substance concentrations in soil at IA-3 are consistent with concentrations in "Natural Soils" (MassDEP, 2002). Therefore, the analytical results from the soil samples collected during the PASI and SSI from this IA do not indicate the presence of hazardous materials associated with past military use that would present unacceptable risks to human health or the environment. Based on the risk screening results, no further action is recommended within IA-3.

Investigation Area 3 was also evaluated for potential explosive safety risks related to MEC. This evaluation included a review existing records included in the *ASR* (see Subsection 4.5). In addition to this review, the Army prepared an *ECSM* that evaluated the risk and exposure pathways relating to potential presence of MEC at the IA (see Subsection 4.6). Subsequent to the development of the *ECSM*, the property owner, MassDevelopment, performed a MEC survey as described in Subsection 4.7. This information was also included in the evaluation of MEC at the site. The conclusions related to the MEC evaluation of IA-3 are as presented in Section 6 of the *ECSM* (see Appendix D).

6.2.1.4 Investigation Area 5 – Sub-Caliber Anti-Tank Range

A total of 19 substances were detected at least once in the 65 samples collected from IA-5 during the PASI and SSI (see Table 6-5a). Of these 19 substances, only 8 (aluminum, arsenic, chromium, iron, manganese, nickel and PCBs) were detected at least once above their respective PAL. The risk screening calculations performed with these data (see Table 6-5b) indicate that the TSCR is less than less than 10^{-4} ($7x10^{-5}$) and the TSHI rounds to less than or equal to 1 (0.97). Further, all of the substances (excluding PCBs) detected in soil in IA-5 are at concentrations that are consistent with concentrations in "Natural Soils" (MassDEP, 2002). The PCBs issues have

been addressed by the EPA-Lead PCB Soil Remedial Action and all remaining concentrations are below 1 mg/kg. Therefore, the analytical results from the samples collected during the PASI and the SSI from this IA do not indicate the existence of contaminants resulting from the historical use of the area as a range. Based on the risk screening results, no further action is recommended within IA-5.

Investigation Area 5 was also evaluated for potential explosive safety risks related to MEC. This evaluation included a review existing records included in the *ASR* (see Subsection 4.5). In addition to this review, the Army prepared an *ECSM* that evaluated the risk and exposure pathways relating to potential presence of MEC at the IA (see Subsection 4.6). Subsequent to the development of the *ECSM*, the property owner, MassDevelopment, performed a MEC survey as described in Subsection 4.7. This information was also included in the evaluation of MEC at the site. The conclusions related to the MEC evaluation of IA-5 are as presented in Section 6 of the *ECSM* (see Appendix D).

6.2.1.5 Investigation Area-6 – Former Machine Gun Range (Bryant Range)

A total of 56 substances were detected at least once in the 145 samples collected from IA-6 during the PASI and SSI and Supplemental Sampling activities (see Table 6-5a). Of these 56 substances, 17 (aluminum, antimony, arsenic, beryllium, chromium, copper, iron, lead, manganese, nickel, thallium, benzo(a)pyrene, benzo(b)fluoranthene and dibenz(a,h)anthracene. dieldrin, 4,4'-DDD and 4,4'-DDT) were detected at least once above their respective PALs. Antimony was detected in one sample, IA06-SS06 (0-0.5) at its PAL of 10 mg/kg. Lead concentrations exceeded their PAL of 300 mg/kg in the 0 to 0.5 ft depth interval at 11 sample locations in the Impact Berm and the High Shot areas, and six locations in the Northern Swale area.

The supplemental investigation confirmed the assumptions of the *CSM*, that lead concentrations in the Impact Berm and the High Shot areas significantly exceed their PALs. In addition, the supplemental investigation found that lead concentrations significantly exceed their PALs in much of the Northern Swale area. In December 2005, USACE began a TCRA to address the impacted soils from the Impact Berm, High Shot, and Northern Swale areas. Approximately

1,655 tons of soil were removed and disposed of off-site following excavation, treatment, sampling, and disposal characterization confirmatory samples were collected to confirm achievement of the 300 mg/kg lead TCG and reduction of human health risk to acceptable levels. Site remedial activities achieved the following project goals:

- The average lead concentration for the site is 105 mg/kg, which is below the human health criterion of 300 mg/kg.
- More than 75% of individual confirmatory sample results are less than 300 mg/kg (162 of 165, or 98.2%).
- No individual result exceeds twice the TCG of 300 mg/kg.
- Site restoration has been completed in accordance with the *WP* (WESTON, 2006b).

Based on remedial actions conducted during the TCRA and results of post-excavation sampling and particle analysis, the remediation has achieved the project goals and provides protection of human health.

Following the TCRA, post-remedial risk screening was performed for IA-6, by eliminating the data from sample locations/depths that were removed during the TCRA. The 43 analytical results that were removed for post-remedial risk screening include samples IA-001-A through -E, IA-002-A through -E, LO-IA06-SB05 (0-3), LO-IA06-SB06 (0-3), LO-IA06-SD08 (0-0.5), LO-IA06-SD09 (0-0.5), LO-IA06-SD10 (0-0.5), LO-IA06-SD11 (0-0.5) and (0.5-1.5), LO-IA06-SD13 (0-0.5) and (0.5-1.5), LO-IA06-SD15 (0-0.5), LO-IA06-SS14 (0-0.5), LO-IA06-SS15 (0-0.5), LO-IA06-SS17 (0-0.5), LO-IA06-SS22 (0-0.5), LO-IA06-SS24 (0-0.5), LO-IA06-SS25 (0-0.5) and (0-1.5), LO-IA06-SS27 (0-0.5) and (0.5-1.5), LO-IA06-SS32 (0-0.5) and (0.5-1.5), LO-IA06-SS34 (0-0.5) and (0.5-1.5), LO-IA06-SS35 (0-0.5), (0.5-1.5) and (0-1.5), LO-IA06-SS36 (0-0.5) and (0.5-1.5), LO-IA06-SS37 (0-0.5) and (0.5-1.5), LO-IA06-SS46 (0-0.5), LO-IA06-SS47 (0-0.5), and LO-IA06-SS48 (0-0.5). Consistent with the procedures followed during risk screening in IA-2, where a TCRA was performed for PCBs, confirmatory sample analytical results were not included in the post-remedial screening calculations.

Among the remaining 102 samples used to screen for post-remedial risk, 13 substances (aluminum, antimony, arsenic, beryllium, chromium, iron, lead, manganese, nickel, thallium,

benzo(a)pyrene, benzo(b)fluoranthene and dibenz(a,h)anthracene) were detected at least once above their respective PAL. The risk screening calculations performed with these data (see Table 6-6b) indicate that the TSCR is less than less than 10^{-4} (7×10^{-5}) and the TSHI rounds to less than or equal to 1 (1.22). Further, all of the substances detected in post-remedial soil in IA-6 are at concentrations that are consistent with concentrations in "Natural Soils" (MassDEP, 2002). Based on the risk screening results, no further action is recommended within IA-6.

Investigation Area 6 was also evaluated for potential explosive safety risks related to MEC. This evaluation included a review existing records included in the *ASR* (see Subsection 4.5). In addition to this review, the Army prepared an *ECSM* that evaluated the risk and exposure pathways relating to potential presence of MEC at the IA (see Subsection 4.6). This information was also included in the evaluation of MEC at the site. The conclusions related to the MEC evaluation of IA-6 are as presented in Section 6 of the *ECSM* (see Appendix D).

6.2.1.6 Investigation Area 7 – Sub-Caliber Anti-Tank Range

A total of 17 substances were detected at least once in the 14 samples collected from IA-7 during the PASI and SSI (see Table 6-7a). Of these 17 substances, only 7 (aluminum, antimony, arsenic, iron, lead, manganese, and nickel) were detected at least once above their respective PAL. The risk screening calculations performed with these data (see Table 6-7b) indicate that the TSCR is less than less than 10^{-4} (8×10^{-5}) but the TSHI is greater than 1 (3.10). All of the substances detected in soil in IA-7 are at concentrations that are consistent with concentrations in "Natural Soils" (MassDEP, 2002), with the exception of antimony and lead.

Antimony and lead are both associated with former use as a range, as demonstrated in the analytical results from IA-6. Antimony and lead concentrations from the 0 to 3 ft depth interval at locations IA07-SS03, IA07-SB01 and IA07-SB02 are clustered together in the center of the presumed Impact Berm for the former range. Antimony and lead arithmetic average concentrations for all samples (4.9 mg/kg and 279 mg/kg, respectively) are near their respective PALs (3.1 mg/kg and 300 mg/kg, respectively), This disparity in concentrations potentially constitutes a "hot spot" where the difference in sample concentrations or average concentrations range greater than 10 to 100 times. At IA-7, the average of the highest lead results

(three locations) is 1,130 mg/kg. The average of the remaining samples is 70 mg/kg. The difference in concentrations between the highest concentration in the area of elevated lead and surrounding soils is 1,400 mg/kg vs. 120 mg/kg. In either case, the disparity does not exceed 16 times difference. The analytical results from the soil samples collected during the PASI and SSI from this IA indicate the presence of hazardous materials associated with past military use that may present an unacceptable risks to human health or the environment; however, there is no supporting evidence that this discrete area is associated with a greater exposure potential for the IA (i.e., elevated lead levels throughout the former range, remnant bullets). Based on the risk screening calculations, a level of risk is present at the IA and further evaluation may be warranted for IA-7.

Subsequent discussions between the Army, EPA, MassDEP, and MassDevelopment have decided upon a remedial action to address the elevated antimony and lead soil concentrations (which is consistent with the former use of the area as a range). MassDevelopment will implement a limited soil removal action following the MassDEP regulation 310 CMR 40.0440 in order to address a localized area of elevated antimony and lead concentrations in soil at the former range at IA-7. The limited soil removal from the 0 to 3 ft depth interval of approximately 200 cubic yards could be conducted in the approximately 80 ft by 20 ft area surrounding sample locations IA07-SS03, IA07-SB01 and IA07-SB02. The extents of the elevated concentrations are bounded to the sides by samples (IA07-SS02 and IA07-SS06) which have lower antimony and lead concentrations. Table 6-7c summarizes the risk reduction that would be accomplished through such a soil removal. It should be noted that the alternative risk calculation does not account for the replacement of the antimony- and lead-impacted soils with clean backfill, which would further reduce the alternative TSHI. The results of the proposed soil removal would result the reduction of TSHI from 3.10 to less than 1.25, with the contribution of TSHI risk from antimony and lead reduced from 75% to 35%. In the alternative risk scenario, iron contributes 47% of the TSHI. This remedy is planned for implementation as a cooperative effort between the Army and MassDevelopment, and will allow reuse of the IA without LUCs.

Consistent with the TCRA performed at IA-6, the proposed soil removal would address a lead remedial goal of 300 mg/kg, and would include removal confirmation sampling. The cost of a

200 cubic yard soil removal and disposal at a Massachusetts lined landfill is estimated as $25,000 to $40,000.

Investigation Area 7 was also evaluated for potential explosive safety risks related to MEC. This evaluation included a review existing records included in the *ASR* (see Subsection 4.5). In addition to this review, the Army prepared an *ECSM* that evaluated the risk and exposure pathways relating to potential presence of MEC at the IA (see Subsection 4.6). Subsequent to the development of the *ECSM*, the location of IA-7 changed, and this was accounted for during the SSI. This information was also included in the evaluation of MEC at the site. The conclusions related to the MEC evaluation of IA-7 are as presented in Section 6 of the *ECSM* (see Appendix D), and have been modified based on additional information.

6.2.1.7 Investigation Area 8 – Former Base Laundry Area

A total of 39 substances were detected at least once in the 75 samples collected from IA-8 during the PASI and SSI (see Table 6-8a). Of these 39 substances, only 12 (aluminum, arsenic, iron, manganese, nickel, sodium, benzo(a)anthracene, benzo(a)pyrene, benzo(b)fluoranthene, dibenz(a,h)anthracene, indeno(1,2,3-c,d)pyrene, and total PCBs) were detected at least once above their respective PALs. The risk screening calculations performed with these data (see Table 6-8b) indicate that the TSCR is greater than 10^{-4} (2×10^{-4}) and the TSHI is less than 1 (0.83). Note: The PAH risk is compounded through the data reduction process (Step #2). The use of the higher concentrations from duplicate analyses and half of adjusted laboratory detection limits results in a more conservative evaluation of risk for these PAHs.

The analytical results from the samples collected during the SSI do not indicate the presence of chlorinated solvents commonly associated with dry cleaning that were suspected in soils in IA-8. Concentrations of metals are below site or natural soil background levels. Concentrations of five PAHs (benzo(a)anthracene, benzo(a)pyrene, benzo(b)fluoranthene, dibenz(a,h)anthracene, and indeno(1,2,3-c,d)pyrene) exceed their PALs at one location (IA10-SB02). This sample location is in the vicinity of the former boiler house that served the former Base Laundry. The concentrations of the PAHs in the remaining samples are below their MCP background concentrations for native materials. The analytical results from the samples collected during the

PASI and SSI support the lack of overall risk associated with the past dry cleaner and laundry operation, excluding the area of sample IA10-SB02.

A potential exists for a limited release of PAH compounds through boiler house operations. Review of the boring log associated with IA10-SB02 shows that there were no observable presence of a petroleum release (i.e., stained soil or elevated headspace results). Although the location and former use suggests that a release of PAHs to soil may have occurred, ancillary data does not support the conclusion. The fact that the risk associated with the PAHs may be excessively conservative due to the screening process, the levels are not excessive in comparison to MassDEP Natural Soil standards, and a potential that the PAHs may be remnant contaminants of a former asphalt driveway for a housing unit all support a conclusion of minimal risk. The PCBs have been addressed, per Subsection 4.2. Therefore, based on the risk screening process and an evaluation of additional factors, no further action is recommended for IA-8.

No hazardous substances were detected in groundwater in IA-8 at concentrations above their PALs. Consequently, no further investigation of potential groundwater contamination is warranted within IA-8.

Investigation Area 8 was also evaluated for potential explosive safety risks related to MEC. This evaluation included a review existing records included in the *ASR* (see Subsection 4.5). In addition to this review, the Army prepared an *ECSM* that evaluated the risk and exposure pathways relating to potential presence of MEC at the IA (see Subsection 4.6). Subsequent to the development of the *ECSM*, the property owner, MassDevelopment, performed a MEC survey as described in Subsection 4.7. This information was also included in the evaluation of MEC at the site. The conclusions related to the MEC evaluation of IA-8 are as presented in Section 6 of the *ECSM* (see Appendix D).

6.2.1.8 Investigation Area 9 – Cavite Housing Area

A total of 20 substances were detected at least once in the 24 samples collected from IA-9 during the PASI and SSI (see Table 6-9a). Of these 20 substances, only 9 (aluminum, arsenic, iron, lead, manganese, magnesium, nickel, potassium and vanadium) were detected at least once above their

respective PALs. The risk screening calculations performed with these data (see Table 6-9b) indicate that the TSCR is $1x10^{-4}$, and the TSHI is less than 1 (0.69). The TSCR is based solely on the SCR for arsenic.

The elevated arsenic soil concentrations (130 and 70 mg/kg) do not represent "hot spots", as they do not exceed the surrounding soil concentrations by at least 10 times. Further, there remains no documentation, based on review of historical documents, of attribution of arsenic in soil to former military activities conducted in IA-9, especially as the elevated arsenic concentrations are not linked to fill material or a release. Unlike the clearly elevated concentrations of pesticides, PCBs, or antimony and lead concentrations that have directly resulted from past military activities, the detection of the elevated concentrations of arsenic may be either natural anomalies or may be from an anthropogenic contribution of arsenic. Table 6-9c depicts the distribution of arsenic concentrations with depth and soil type within IA-9.

Based on the risk screening results, that indicates a TSCR equal to $1x10^{-4}$ for IA-9, a conclusion of no excess risk can be justified. Therefore, no further action is recommended within IA-9. In October 2005, IA-9 was administratively separated from the remainder of the SA, and a Release Abatement Measure and Partial Response Action Outcome Statement for IA-9 was approved by MassDEP.

Investigation Area 9 was also evaluated for potential explosive safety risks related to MEC. This evaluation included a review existing records included in the *ASR* (see Subsection 4.5). In addition to this review, the Army prepared an *ECSM* that evaluated the risk and exposure pathways relating to potential presence of MEC at the IA (see Subsection 4.6). This information was also included in the evaluation of MEC at the site. The conclusions related to the MEC evaluation of IA-9 are as presented in Section 6 of the *ECSM* (see Appendix D).

6.2.1.9 Investigation Area 10 – Grant Housing Area

A number of smaller IAs (IA-1, IA-2, IA-5, and IA-8) lie partially or wholly within IA-10. As such, the analytical results for IA-1, IA-5, IA-8, and part of IA-2 (sample locations IA02-SS01, IA02-SB04, IA02-SB05, and IA02-SB16 through IA02-SB28) are equally applicable to the

assessment of IA-10, and were used to screen for potential risk at IA-10. A total of 42 substances were detected at least once in the 385 samples collected from IA-10 during the PASI and SSI (see Table 6-10a). Of these 42 substances, only 20 (aluminum, arsenic, chromium, iron, lead, manganese, nickel, thallium, anthracene, benzo(a)anthracene, benzo(a)pyrene, benzo(b)fluoranthene, benzo(g,h,i)perylene, dibenz(a,h)anthracene, indeno(1,2,3-c,d)pyrene, total PCBs, 4,4-DDE, 4,4-DDT, aldrin, and dieldrin) were detected at least once above their respective PALs. The risk screening calculations performed with these data (see Table 6-10b) indicate that the TSCR is less than less than 10^{-4} ($8x10^{-5}$), but the TSHI rounds to greater than 1 (1.58).

No hazardous substances were detected in soil in IA-10 at concentrations that are not consistent with their respective "Natural Soil" concentrations, with the exception of PAHs in sample IA10-SB02. The PCBs have been addressed, per Subsection 4.2. As noted during the discussion of the results for IA-8 in Subsection 6.2.1.8, no further action is recommended to address IA10-SB02. This conclusion was based on the fact that the risk associated with the PAHs may be excessively conservative due to the screening process, the levels are not excessive in comparison to MassDEP Natural Soil standards, and a potential that the PAHs may be remnant contaminants of a former asphalt driveway for a housing unit all support a conclusion of minimal risk. Therefore, based on the risk screening and the background study, no further action is recommended within IA-10.

Investigation Area 10 was also evaluated for potential explosive safety risks related to MEC. This evaluation included a review existing records included in the *ASR* and the Ordnance & Explosives Removal Report (see Subsection 4.5). In addition to this review, the Army prepared an *ECSM* that evaluated the risk and exposure pathways relating to potential presence of MEC at the IA (see Subsection 4.6). Subsequent to the development of the *ECSM*, the property owner, MassDevelopment, performed a MEC survey as described in Subsection 4.7. This information was also included in the evaluation of MEC at the site. The conclusions related to the MEC evaluation of IA-10 are as presented in Section 6 of the *ECSM* (see Appendix D).

6.2.1.10 Investigation Area 11 – Locust Housing Area

Portions of IA-3 and IA-6 lie within IA-11. As such, the analytical results for sample locations IA03-SS06, IA03-SS06, IA03-SS15 through IA03-SS22, IA03-SB01, IA03-SB02, IA06-SS39, IA06-SS40, and IA06-SS43 through IA06-SS45 are equally applicable to the assessment of IA-11, and were used to screen for potential risk at IA-11. A total of 43 substances were detected at least once in the 39 samples collected from IA-11 during PASI and SSI sampling activities (see Table 6-11a). Of these 17 substances, only 13 (aluminum, arsenic, iron, manganese, nickel, benzo(a)anthracene, benzo(a)pyrene, benzo(b)fluoranthene, dibenz(a,h)anthracene, indeno(1,2,3-c,d)pyrene, aldrin, and dieldrin) were detected at least once above their respective PAL. The risk screening calculations performed with these data (see Table 6-11b) indicate that the TSCR is greater than $1x10^{-4}$, and the TSHI is lower than 1 (0.97).

Unlike the analytical results for the previously described IAs, no single group of analytes, (i.e., arsenic, PAHs or pesticides) acts as a driver for the TSCR. No single analyte group contributes an SCR of $1x10^{-4}$. The arsenic concentrations are consistent with the background concentrations. The pesticide and PAH risk is based on a location of the elevated PAHs and pesticide soil concentrations, at sample location IA11-SB01. Additionally, the location was under a former housing unit asphalt driveway which may have impacted the original sample result. The subsequent bounding sample analyses also support this conclusion, as all pesticide concentrations were lower in the bounding samples. The elevated pesticides are likely associated with spot application of pesticides outside the building foundations. The former pesticides soil removals conducted at Locust HA addressed the risk associated with pesticide applications. The average remnant concentrations of pesticides within the excavation areas are less than 0.030 mg/kg in accordance with the remedial goals. The inclusion of the average pesticide risk into the risk screening process would eliminate the pesticide risk and reduce the TSCR to $1x10^{-4}$. Therefore, according to the potential risk screening criteria and an evaluation of factors that address the elevated risk, no further action is warranted within IA-11.

Investigation Area 11 was also evaluated for potential explosive safety risks related to MEC. This evaluation included a review existing records included in the *ASR* (see Subsection 4.5). In addition to this review, the Army prepared an *ECSM* that evaluated the risk and exposure

pathways relating to potential presence of MEC at the IA (see Subsection 4.6). This information was also included in the evaluation of MEC at the site. The conclusions related to the MEC evaluation of IA-11 are as presented in Section 6 of the *ECSM* (see Appendix D).

6.2.2 Ecological Risk Screening

No specific ecological receptors were identified in the MassDEP GIS system, with the exception of IA-6, where ecological risks were evaluated. For the remaining IAs, no environmental receptors (defined under 310 CMR 40.0922), such as Areas of Critical Environmental Concern, surface water, fisheries, wetlands, Species of Concern, or Threatened or Endangered Species have been identified. The pathway assessment of ecological risk screening, consistent with the human health risk assessment, indicated that the air, groundwater, and surface water pathways are incomplete for the IAs. Regarding potential soil exposure, the currently proposed residential and commercial reuse of the IAs finds no excess potential human health risks. Based on the planned reuse for the IAs, it is the opinion of the Army that it is unnecessary to further evaluate potential ecological risks at the other IAs. Only IA-6, Former Bryant Range, which is partly located within the Oxbow National Wildlife Refuge, was found to have current or foreseeable land use as ecological habitat. Ecological risk screening in IA-6 was performed as part of the TCRA performed between November 2005 and April 2006. For protection of the environment, two separate TCGs were established. The first was to achieve a site-wide average lead concentration of 118 mg/kg. The second goal was to limit the number of lead particles in soils to no more than three per square foot (as determined through sampling) to protect avian species that ingest grit.

Following completion of excavation and confirmatory sampling, site restoration work was completed, including backfilling, seeding, installation of erosion control mats, and plant installation. A wildlife friendly slope stabilization geotextile matting was installed to the top of the regraded slope. The slope and Range Floor were reseeded and vegetated with red maple, white pine, gray birch, and northern red oak trees. An ongoing habitat monitoring program will

be required to monitoring growth of invasive species and survival of trees and shrubs planted as part of restoration. Site remedial activities achieved the following project goals:

- The average lead concentration for the site is 105 mg/kg, which is below the environmental criterion of 118 mg/kg.
- No individual sample had three or more lead particles (particles with lead concentrations greater than 1,000 mg/kg).
- Site restoration has been completed in accordance with the *WP* (WESTON, 2006b).

Based on remedial actions conducted during the TCRA and results of post-excavation sampling and particle analysis, the remediation has achieved the project goals and provides protection the environment.

SECTION 7

CONCLUSIONS AND RECOMMENDATIONS

7. CONCLUSIONS AND RECOMMENDATIONS

7.1 INVESTIGATION AREA 1 – FORMER TRAINING AREA (CIRCA 1922)

The objective of the PASI/SSI field investigations at IA-1 was to determine if historical activities associated with former Training Area had adversely impacted the soil and groundwater at the site. Based on the information presented in Sections 5 and 6 of this report, the analytical results from the samples collected from the Range Area in this IA do not indicate the presence of contaminants indicative of past military use that would present unacceptable risks to human health or the environment. Therefore, based on the risk screening results, no further action is recommended within IA-1.

On the basis of *ECSM* for IA-1, prior MEC historical reviews and investigations associated with the former Training Area located within IA-1, it is recommended that Land Use Controls (LUC) are unnecessary. Note: The property is currently zoned for residential redevelopment per the 1996 Devens Reuse Plan.

7.2 INVESTIGATION AREA 2 – FORMER TRAINING AREA AND 37-MM RANGE

The objective of the PASI/SSI field investigations at IA-2 was to determine if historical activities associated with former Training Areas and/or 37-mm Range had adversely impacted the soil and groundwater at the site. Based on the data and contamination assessment presented in Sections 5 and 6 of this report, the analytical results from the samples collected from the Impact Area, Range Area, and Firing Point(s) in this IA do not indicate the presence of contaminants indicative of past military use that would present unacceptable risks to human health or the environment. Therefore, based on the risk screening results, no further action is recommended with respect to soil and groundwater contamination within IA-2.

Further action is recommended to address the potential explosive safety hazards within IA-2. This recommendation is made on the basis of the *ECSM* for MEC at the former Grant, Locust, and Cavite HAs, and all prior MEC historical reviews, investigations, and removal actions associated with the former 37-mm Anti-tank Range located within IA-2. This MEC evaluation

also considered potential MEC impacts to the surrounding Oak and Maple HAs which are substantially within the IA-2 boundary. Specifically, it is recommended that a Focused Feasibility Study be prepared to evaluate response alternatives involving LUCs that will reduce the explosive safety hazards associated with IA-2. The Focused Feasibility Study will address the former Impact Area (hillside between Oak and Grant HA) and the former Grant HA (Range Area, and Firing Point(s)). In addition, to more fully characterize the potential MEC hazards at the former Oak and Maple HAs, it is recommended that a MEC remedial investigation be performed in order to characterize the potential MEC safety hazard and determine the need for additional MEC removals and/or LUCs within these areas.

7.3 INVESTIGATION AREA 3 – POSSIBLE RIFLE RANGE

The objective of the PASI/SSI field investigations at IA-3 was to determine if historical activities associated with former possible Rifle Range had adversely impacted the soil and groundwater at the site. Based on the information presented in Sections 5 and 6 of this report, the analytical results from the samples collected from the range area in this IA do not indicate the presence of contaminants indicative of past military use that would present unacceptable risks to human health or the environment. Based on the risk screening results, no further action is recommended within IA-3.

On the basis of *ECSM* for IA-3, prior MEC historical reviews and investigations associated with the former possible Rifle Range located within IA-3, it is recommended that LUCs are unnecessary. Note: The property is currently zoned for commercial redevelopment per the 1996 Devens Reuse Plan.

7.4 INVESTIGATION AREA 5 – SUB-CALIBER ANTI-TANK RANGE

The objective of the PASI/SSI field investigations at IA-5 was to determine if historical activities associated with former Sub-Caliber Anti-Tank Range had adversely impacted the soil and groundwater at the site. Based on the information presented in Sections 5 and 6 of this report, the analytical results from the samples collected from the range area in this IA do not indicate the presence of contaminants indicative of past military use that would present unacceptable risks to

human health or the environment. Based on the risk screening results, no further action is recommended within IA-5.

On the basis of *ECSM* for IA-5, prior MEC historical reviews and investigations associated with the former Sub-Caliber Anti-Tank Range located within IA-5, it is recommended that LUCs are unnecessary. Note: The property is currently zoned for residential redevelopment per the 1996 Devens Reuse Plan.

7.5 INVESTIGATION AREA 6 – FORMER MACHINE GUN RANGE (BRYANT RANGE)

The objective of the PASI/SSI field investigations at IA-6 was to determine if historical activities associated with former Machine Gun Range (Bryant Range) had adversely impacted the soil and groundwater at the site. Based on the information presented in Sections 5 and 6 of this report, the analytical results from the samples collected from the range area in this IA, following the TCRA completed in 2006, do not indicate the presence of contaminants indicative of past military use that would present unacceptable risks to human health or the environment. Based on the risk screening results, no further action is recommended within IA-6.

On the basis of *ECSM* for IA-6, prior MEC historical reviews, investigations, and/or removal actions associated with the former Machine Gun Range located within IA-6, it is recommended that LUCs are unnecessary. Note: The property is currently zoned for recreational use per the 1996 Devens Reuse Plan.

7.6 INVESTIGATION AREA 7 – SUB-CALIBER ANTI-TANK RANGE

The objective of the PASI/SSI field investigations at IA-7 was to determine if historical activities associated with former Sub-Caliber Anti-Tank Range had adversely impacted the soil and groundwater at the site. Based on the information presented in Sections 5 and 6 of this report, the analytical results from the samples collected from the range area in this IA indicate the presence of contaminants indicative of past military use that may present unacceptable risks to human health or the environment. Therefore, based on discussions between the stakeholders, MassDevelopment will implement this limited soil removal action following the MassDEP

regulation 310 CMR 40.0440 in order to address a localized area of elevated antimony and lead concentrations in soil at the former range at IA-7. The area comprises a limited soil removal from the 0 to 3 ft depth interval of approximately 200 cubic yards in the approximately 80-ft by 20-ft area surrounding sample locations IA07-SS03, IA07-SB01, and IA07-SB02. This remedy is planned for implementation as a cooperative effort between the Army and MassDevelopment and will meet a lead remedial goal of 300 mg/kg.

Therefore, based on the revised risk screening results which accounts for the planned soil removal to address the limited area impacted by elevated antimony and lead soil concentrations, no further action is recommended within IA-7.

On the basis of *ECSM* for IA-7, prior MEC historical reviews, investigations, and/or removal actions associated with the former Sub-Caliber Anti-Tank Range located within IA-7, it is recommended that LUCs are unnecessary. Note: The property is currently zoned for commercial redevelopment per the 1996 Devens Reuse Plan.

7.7 INVESTIGATION AREA 8 – FORMER BASE LAUNDRY BUILDINGS

The objective of the PASI/SSI field investigations at IA-8 was to determine if historical activities associated with former Base Laundry Buildings had adversely impacted the soil and groundwater at the site. Based on the information presented in Sections 5 and 6 of this report, the analytical results from the samples collected from the range area in this IA do not indicate the presence of contaminants indicative of past military use that would present unacceptable risks to human health or the environment. Based on the PASI/SSI field investigations, historical reviews and risk screening results, no further action is recommended within IA-8. Note: The property is currently zoned for residential redevelopment per the 1996 Devens Reuse Plan.

7.8 INVESTIGATION AREA 9 – FORMER CAVITE HOUSING AREA

The objective of the PASI/SSI field investigations at IA-9 was to determine if historical activities associated with former Cavite HA had adversely impacted the soil and groundwater at the site. Based on the information presented in Sections 5 and 6 of this report, the analytical results from the samples collected from the HA in this IA do not indicate the presence of contaminants

indicative of past military use that would present unacceptable risks to human health or the environment. Based on the risk screening results, no further action is recommended within IA-9.

On the basis of *ECSM* for IA-9, prior MEC historical reviews and investigations associated with the former HA located within IA-9, it is recommended that LUCs are unnecessary. Note: The property is currently zoned for commercial redevelopment per the 1996 Devens Reuse Plan.

7.9 INVESTIGATION AREA 10 – FORMER GRANT HOUSING AREA

The objective of the PASI/SSI field investigations at IA-10 was to determine if historical activities associated with former Grant HA had adversely impacted the soil and groundwater at the site. Based on the information presented in Sections 5 and 6 of this report, the analytical results from the samples collected from the HA in this IA do not indicate the presence of contaminants indicative of past military use that would present unacceptable risks to human health or the environment. Based on the risk screening results, no further action is recommended within IA-10.

On the basis of *ECSM* for IA-10 prior MEC historical reviews, investigations, and/or removal actions associated with areas within IA-10, including the conclusions/recommendations provided under IA-2 (see Subsections 6.2.1.2 and 7.2), it is recommended that LUCs be evaluated as per the recommendation associated with IA-2. Note: The property is currently zoned for residential redevelopment per the 1996 Devens Reuse Plan.

7.10 INVESTIGATION AREA 11 – FORMER LOCUST HOUSING AREA

The objective of the PASI/SSI field investigations at IA-11 was to determine if historical activities associated with former Locust HA had adversely impacted the soil and groundwater at the site. Based on the information presented in Sections 5 and 6 of this report, the analytical results from the samples collected from the HA in this IA do not indicate the presence of contaminants indicative of past military use that would present unacceptable risks to human health or the environment. Based on the risk screening results, no further action is recommended within IA-11.

On the basis of *ECSM* for IA-11, prior MEC historical reviews, investigations, and/or removal actions associated with the former HA located within IA-11, it is recommended that LUCs are unnecessary. Note: The property is currently zoned for commercial redevelopment per the 1996 Devens Reuse Plan.

SECTION 8

DECISIONS

8. DECISIONS

8.1 INVESTIGATION AREA 1 – FORMER TRAINING AREA

On the basis of findings at IA-1, there is no evidence or reason to conclude that contaminants detected at this IA pose a threat to human health or the environment. The decision has been made to remove IA-1 from further consideration in the Army's Installation Restoration Program process.

On the basis of the Expanded Conceptual Site Model for IA-1, prior Munitions and Explosives of Concern historical reviews and investigations associated with the former Training Area located within IA-1, the decision has been made to propose No Further Action, as specified in Subsection 7.1.

In accordance with Comprehensive Environmental Response, Compensation, and Liability Act 120(h) (3), all remedial actions necessary have taken place and the U.S. States Environmental Protection Agency and the Massachusetts Department of Environmental Protection signatures constitute concurrence in accordance with the same.

_____ _____

Robert J Simeone Date
BRAC Environmental Coordinator

U.S. ENVIRONMENTAL PROTECTION AGENCY

_____ _____

Ginny Lombardo Date
Devens Remedial Project Manager

[ ] Concur

[ ] Non-concur (Provide reasons for non-concurrence)

MASSACHUSETTS DEPARTMENT OF ENVIRONMENTAL PROTECTION

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D. Lynne Welsh Date
Section Chief, Federal Facilities - CERO

[ ] Concur

[ ] Non-concur (Provide reasons for non-concurrence)

8.2 INVESTIGATION AREA 2 – FORMER TRAINING AREA AND 37-MM RANGE

On the basis of findings at IA-2 related to chemical contamination, there is no evidence or reason to conclude that contaminants detected in soil and groundwater at this IA pose a threat to human health or the environment. Therefore, the decision has been made to remove IA-2 from further consideration in the Army's Installation Restoration Program process.

On the basis of the findings at IA-2 related to residual Munitions and Explosives of Concern and potential explosive safety hazards at IA-2, the decision has been made to implement the recommendation specified in Subsection 7.2 in order to fully address the remaining explosive safety hazards associated with IA-2.

In accordance with Comprehensive Environmental Response, Compensation, and Liability Act and the National Contingency Plan, all remedial actions with respect to chemical contamination in soil and groundwater have taken place at IA-2. The U.S. States Environmental Protection Agency and the Massachusetts Department of Environmental Protection signatures constitute concurrence in accordance with the same.

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Robert J Simeone Date
BRAC Environmental Coordinator

U.S. ENVIRONMENTAL PROTECTION AGENCY

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Ginny Lombardo Date
Devens Remedial Project Manager

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MASSACHUSETTS DEPARTMENT OF ENVIRONMENTAL PROTECTION

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D. Lynne Welsh Date
Section Chief, Federal Facilities - CERO

[ ] Concur

[ ] Non-concur (Provide reasons for non-concurrence)

8.3 INVESTIGATION AREA 3 – POSSIBLE RIFLE RANGE

On the basis of findings at IA-3, there is no evidence or reason to conclude that contaminants detected at this IA pose a threat to human health or the environment. The decision has been made to remove IA-3 from further consideration in the Army's Installation Restoration Program process.

On the basis of the Expanded Conceptual Site Model for IA-3, prior Munitions and Explosives of Concern historical reviews and investigations associated with the former possible Rifle Range located within IA-3, the decision has been made to propose No Further Action, as specified in Subsection 7.3.

In accordance with Comprehensive Environmental Response, Compensation, and Liability Act 120(h) (3), all remedial actions necessary have taken place and the U.S. States Environmental Protection Agency and the Massachusetts Department of Environmental Protection signatures constitute concurrence in accordance with the same.

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Robert J Simeone Date
BRAC Environmental Coordinator

U.S. ENVIRONMENTAL PROTECTION AGENCY

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Ginny Lombardo Date
Devens Remedial Project Manager

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MASSACHUSETTS DEPARTMENT OF ENVIRONMENTAL PROTECTION

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D. Lynne Welsh Date
Section Chief, Federal Facilities - CERO

[ ] Concur

[ ] Non-concur (Provide reasons for non-concurrence)

8.4 INVESTIGATION AREA 5 – FORMER SUB-CALIBER ANTI-TANK RANGE

On the basis of findings at IA-5, there is no evidence or reason to conclude that contaminants detected at this IA pose a threat to human health or the environment. The decision has been made to remove IA-5 from further consideration in the Army's Installation Restoration Program process.

On the basis of the Expanded Conceptual Site Model for IA-5, prior Munitions and Explosives of Concern historical reviews and investigations associated with the former Sub-caliber Anti-tank Range located within IA-5, the decision has been made to propose No Further Action, as specified in Subsection 7.4.

In accordance with Comprehensive Environmental Response, Compensation, and Liability Act 120(h) (3), all remedial actions necessary have taken place and the U.S. States Environmental Protection Agency and the Massachusetts Department of Environmental Protection signatures constitute concurrence in accordance with the same.

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Robert J Simeone Date
BRAC Environmental Coordinator

U.S. ENVIRONMENTAL PROTECTION AGENCY

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Ginny Lombardo Date
Devens Remedial Project Manager

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MASSACHUSETTS DEPARTMENT OF ENVIRONMENTAL PROTECTION

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D. Lynne Welsh Date
Section Chief, Federal Facilities - CERO

[ ] Concur

[ ] Non-concur (Provide reasons for non-concurrence)

8.5 INVESTIGATION AREA 6 – FORMER MACHINE GUN RANGE

On the basis of findings at IA-6, there is no evidence or reason to conclude that contaminants detected at this IA pose a threat to human health or the environment. The decision has been made to remove IA-6 from further consideration in the Army's Installation Restoration Program process.

On the basis of the Expanded Conceptual Site Model for IA-6, prior Munitions and Explosives of Concern historical reviews, investigations, and removal actions associated with the former Machine Gun Range located within IA-6, the decision has been made to propose No Further Action, as specified in Subsection 7.5.

In accordance with Comprehensive Environmental Response, Compensation, and Liability Act 120(h) (3), all remedial actions necessary have taken place and the U.S. States Environmental Protection Agency and the Massachusetts Department of Environmental Protection signatures constitute concurrence in accordance with the same.

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Robert J Simeone Date
BRAC Environmental Coordinator

U.S. ENVIRONMENTAL PROTECTION AGENCY

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Ginny Lombardo Date
Devens Remedial Project Manager

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MASSACHUSETTS DEPARTMENT OF ENVIRONMENTAL PROTECTION

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D. Lynne Welsh Date
Section Chief, Federal Facilities - CERO

[ ] Concur

[ ] Non-concur (Provide reasons for non-concurrence)

8.6 INVESTIGATION AREA 7 – FORMER SUB-CALIBER ANTI-TANK RANGE

On the basis of findings at IA-7, there is no evidence or reason to conclude that, once the proposed soil removal is accomplished, contaminants detected at this IA pose a threat to human health or the environment. It is noted that the soil removal action is being performed by MassDevelopment under CMR 310 40.0440 and therefore the decision has been made to remove IA-7 from further consideration in the Army's Installation Restoration Program process.

On the basis of the Expanded Conceptual Site Model for IA-7, prior Munitions and Explosives of Concern historical reviews and investigations associated with the former Sub-caliber Anti-tank Range located within IA-7, the decision has been made to propose No Further Action, as specified in Subsection 7.6.

In accordance with Comprehensive Environmental Response, Compensation, and Liability Act 120(h) (3), all remedial actions necessary have taken place and the U.S. States Environmental Protection Agency and the Massachusetts Department of Environmental Protection signatures constitute concurrence in accordance with the same.

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Robert J Simeone Date
BRAC Environmental Coordinator

U.S. ENVIRONMENTAL PROTECTION AGENCY

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Ginny Lombardo Date
Devens Remedial Project Manager

[ ] Concur

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MASSACHUSETTS DEPARTMENT OF ENVIRONMENTAL PROTECTION

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D. Lynne Welsh Date
Section Chief, Federal Facilities - CERO

[ ] Concur

[ ] Non-concur (Provide reasons for non-concurrence)

8.7 INVESTIGATION AREA 8 – FORMER BASE LAUNDRY BUILDINGS

On the basis of findings at IA-8, there is no evidence or reason to conclude that contaminants detected at this IA pose a threat to human health or the environment. The decision has been made to remove IA-8 from further consideration in the Army's Installation Restoration Program process.

In accordance with Comprehensive Environmental Response, Compensation, and Liability Act 120(h) (3), all remedial actions necessary have taken place and the U.S. States Environmental Protection Agency and the Massachusetts Department of Environmental Protection signatures constitute concurrence in accordance with the same.

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Robert J Simeone Date
BRAC Environmental Coordinator

U.S. ENVIRONMENTAL PROTECTION AGENCY

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Ginny Lombardo Date
Devens Remedial Project Manager

[ ] Concur

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MASSACHUSETTS DEPARTMENT OF ENVIRONMENTAL PROTECTION

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D. Lynne Welsh Date
Section Chief, Federal Facilities - CERO

[ ] Concur

[ ] Non-concur (Provide reasons for non-concurrence)

8.8 INVESTIGATION AREA 9 – FORMER CAVITE HOUSING AREA

On the basis of findings at IA-9, there is no evidence or reason to conclude that contaminants detected at this IA pose a threat to human health or the environment. The decision has been made to remove IA-9 from further consideration in the Army's Installation Restoration Program process.

On the basis of the Expanded Conceptual Site Model for IA-9, prior Munitions and Explosives of Concern historical reviews and investigations associated with the former Housing Area located within IA-9, the decision has been made to propose No Further Action, as specified in Subsection 7.8.

In accordance with Comprehensive Environmental Response, Compensation, and Liability Act 120(h) (3), all remedial actions necessary have taken place and the U.S. States Environmental Protection Agency and the Massachusetts Department of Environmental Protection signatures constitute concurrence in accordance with the same.

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Robert J Simeone Date
BRAC Environmental Coordinator

U.S. ENVIRONMENTAL PROTECTION AGENCY

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Ginny Lombardo Date
Devens Remedial Project Manager

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MASSACHUSETTS DEPARTMENT OF ENVIRONMENTAL PROTECTION

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D. Lynne Welsh Date
Section Chief, Federal Facilities - CERO

[ ] Concur

[ ] Non-concur (Provide reasons for non-concurrence)

8.9 INVESTIGATION AREA 10 – FORMER GRANT HOUSING AREA

On the basis of findings at IA-10, there is no evidence or reason to conclude that contaminants detected at this IA pose a threat to human health or the environment. The decision has been made to remove IA-10 from further consideration in the Army's Installation Restoration Program process.

On the basis of the findings at IA-10 related to residual Munitions and Explosives of Concern and potential explosive safety hazards associated with IA-2 (i.e., IA-2 is a former range area that fall within the boundary of IA-10), the decision has been made to implement the recommendation specified in Subsection 7.2 in order to fully address the remaining explosive safety hazards associated with IA-2.

In accordance with Comprehensive Environmental Response, Compensation, and Liability Act and the National Contingency Plan, all remedial actions with respect to chemical contamination in soil and groundwater have taken place at IA-10. The U.S. States Environmental Protection Agency and the Massachusetts Department of Environmental Protection signatures constitute concurrence in accordance with the same.

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Robert J Simeone Date
BRAC Environmental Coordinator

U.S. ENVIRONMENTAL PROTECTION AGENCY

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Ginny Lombardo Date
Devens Remedial Project Manager

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MASSACHUSETTS DEPARTMENT OF ENVIRONMENTAL PROTECTION

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D. Lynne Welsh Date
Section Chief, Federal Facilities - CERO

[ ] Concur

[ ] Non-concur (Provide reasons for non-concurrence)

8.10 INVESTIGATION AREA 11 – FORMER LOCUST HOUSING AREA

On the basis of findings at IA-11, there is no evidence or reason to conclude that contaminants detected at this IA pose a threat to human health or the environment. The decision has been made to remove IA-11 from further consideration in the Army's Installation Restoration Program process.

On the basis of the Expanded Conceptual Site Model for IA-11, prior Munitions and Explosives of Concern historical reviews, investigations, and removal actions associated with the former Housing Area located within IA-11, the decision has been made to propose No Further Action, as specified in Subsection 7.10.

In accordance with Comprehensive Environmental Response, Compensation, and Liability Act 120(h) (3), all remedial actions necessary have taken place and the U.S. States Environmental Protection Agency and the Massachusetts Department of Environmental Protection signatures constitute concurrence in accordance with the same.

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Robert J Simeone Date
BRAC Environmental Coordinator

U.S. ENVIRONMENTAL PROTECTION AGENCY

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Ginny Lombardo Date
Devens Remedial Project Manager

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D. Lynne Welsh Date
Section Chief, Federal Facilities - CERO

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SECTION 9

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Weston Solutions, Inc., *Final Supplemental Site Investigation Work Plan – Study Area – Grant, Locust, and Cavite Housing Areas, Former Fort Devens, Devens, Massachusetts, RTN: 2-0662.* Prepared for U.S. Army Corps of Engineers, New England District, January, 2005a.

Weston Solutions, Inc., *Final Investigation Area 6 (IA-6) Workplan Addendum to the Supplemental Site Investigation Work Plan Investigation – Study Area – Grant, Locust, and Cavite Housing Areas, Former Fort Devens, Devens, Massachusetts, RTN: 2-0662.* Prepared for U.S. Army Corps of Engineers, New England District, February, 2005b.

Weston Solutions, Inc., *Final Polychlorinated Biphenyls Time Critical Removal Action Closure Report, Former Grant Housing Area, Fort Devens, Devens, Massachusetts.* Prepared for U.S. Army Corps of Engineers, New England District, August, 2006a.

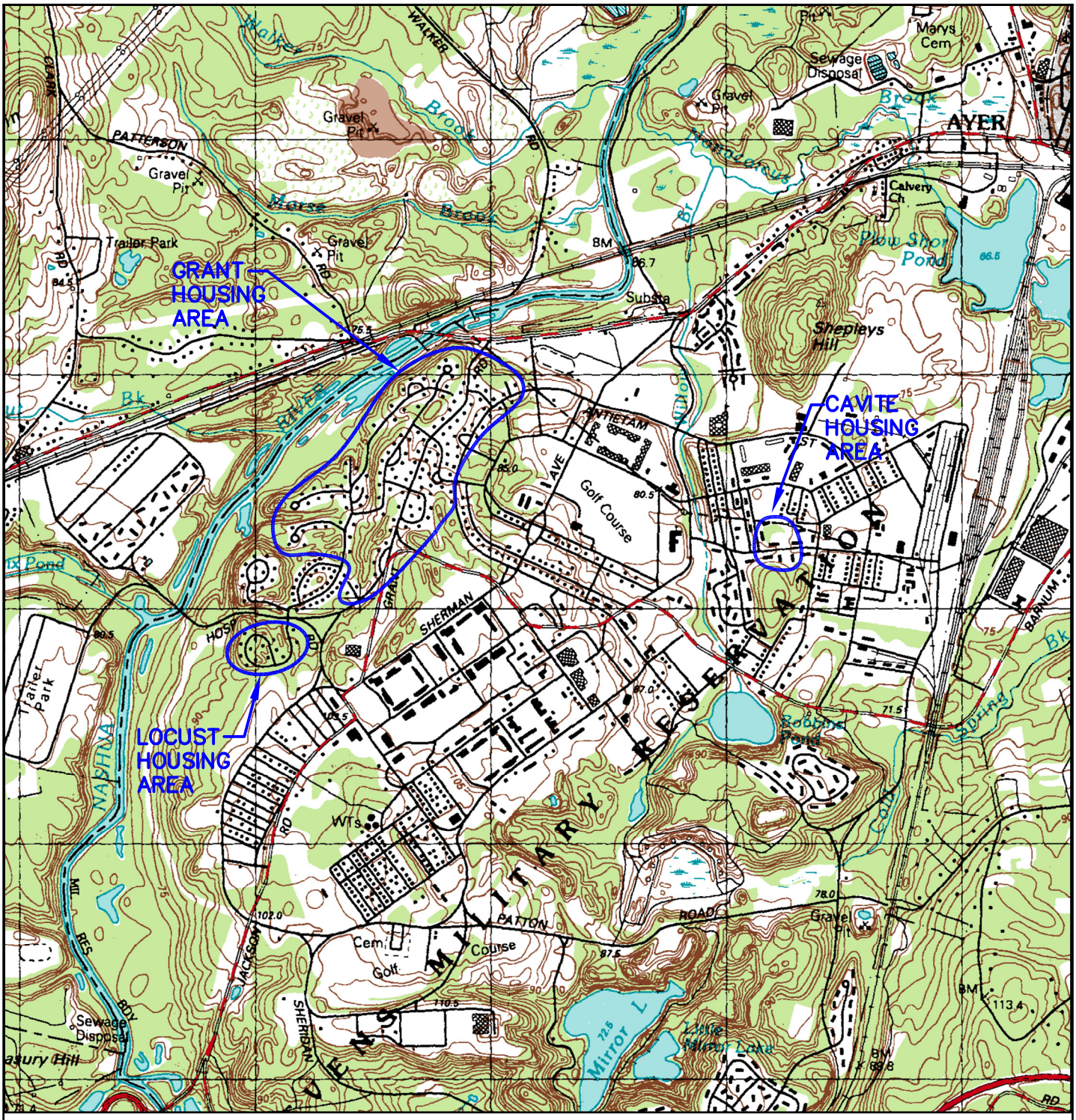
Weston Solutions, Inc., *Final Action Memorandum, Bryant Range (IA-6) Small Arms Firing Range, Fort Devens, Devens, Massachusetts.* Prepared for U.S. Army Corps of Engineers, New England District, 5 April, 2006b.

Weston Solutions, Inc., *Draft Final Work Plan, Time Critical Removal Action, Bryant Range (IA-6) Small Arms Firing Range, Fort Devens, Devens, Massachusetts.* Prepared for U.S. Army Corps of Engineers, New England District, April, 2006c.

Weston Solutions, Inc., *Final Time Critical Removal Action Closure Report, Bryant Range (IA-6) Small Arms Firing Range, Fort Devens, Devens, Massachusetts.* Prepared for U.S. Army Corps of Engineers, New England District, August, 2006d.

Weston Solutions, Inc., *Final Action Memorandum, Removal of Polychlorinated Biphenyls - Former Grant Housing Area, Fort Devens, Devens, Massachusetts.* Prepared for U.S. Army Corps of Engineers,New England District, 5 August, 2006e.

FIGURES



SOURCE
US DEPT. OF THE INTERIOR, GEOLOGICAL SURVEY
7.5 x 15 MINUTE SERIES (TOPOGRAPHIC)
AYER, MA., 1988

GRAPHIC SCALE
2000 1000 0 1000 2000
APPROXIMATE SCALE IN FEET

PASI/SSI COMPREHENSIVE REPORT
STUDY AREA – GRANT, LOCUST, AND CAVITE HOUSING AREAS
DEVENS, MASSACHUSETTS

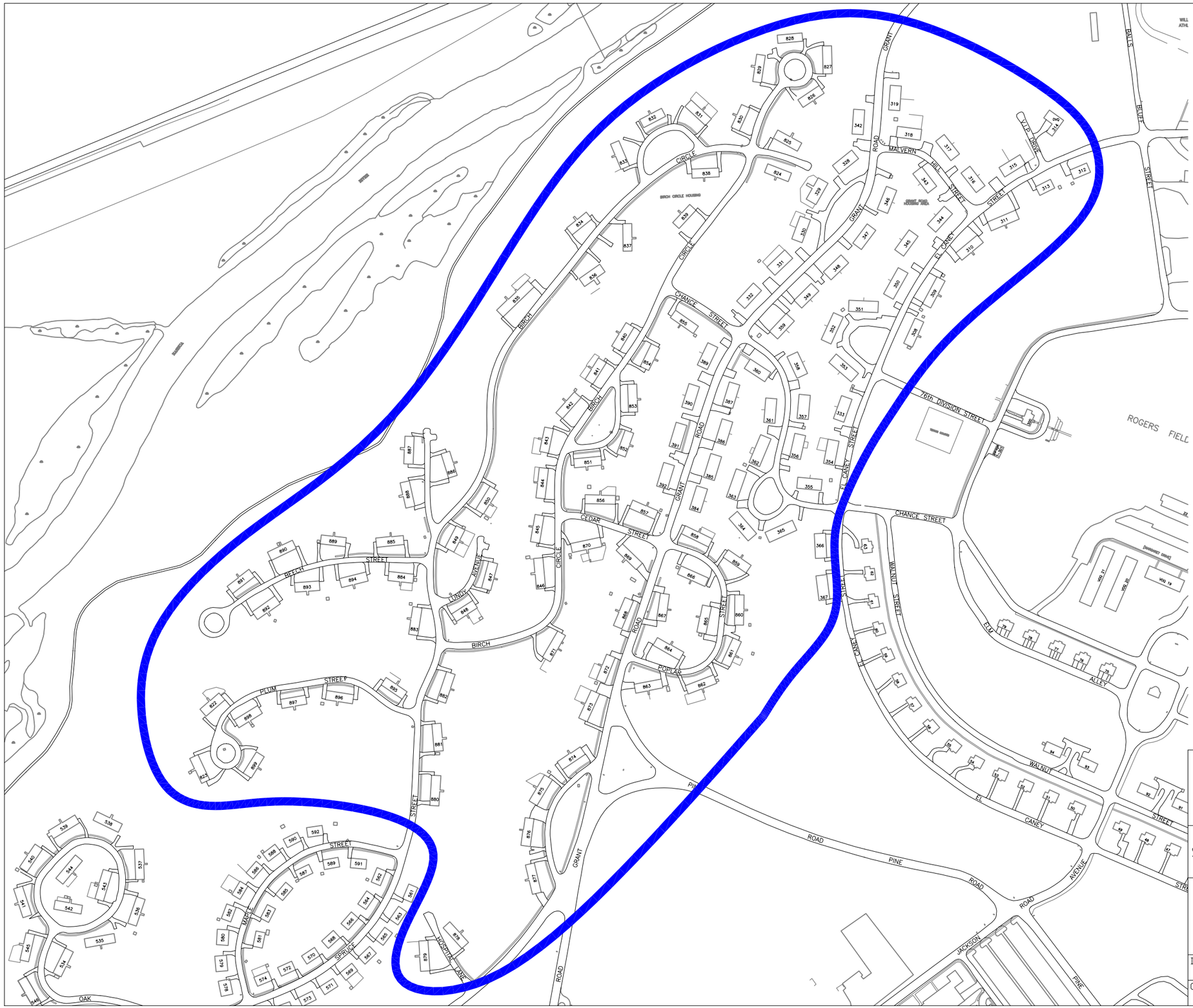
DEPARTMENT OF THE ARMY
NEW ENGLAND DISTRICT
CORPS OF ENGINEERS
CONCORD, MASSACHUSETTS

SITE LOCATION MAP

WESTON SOLUTIONS
MANCHESTER NEW HAMPSHIRE

DRAWN	BEG
DATE	MAR 2005
FIGURE NO.	2–1

M:\Design\DWG\ACOE\FTDEVENS\PASI-SSI FINAL REPORT\rev 2\FIG 2-1.dwg, Layout 1, 3/4/2005 8:39:42 AM, girardeb, 1:1



WESTON SOLUTIONS
MANCHESTER NEW HAMPSHIRE

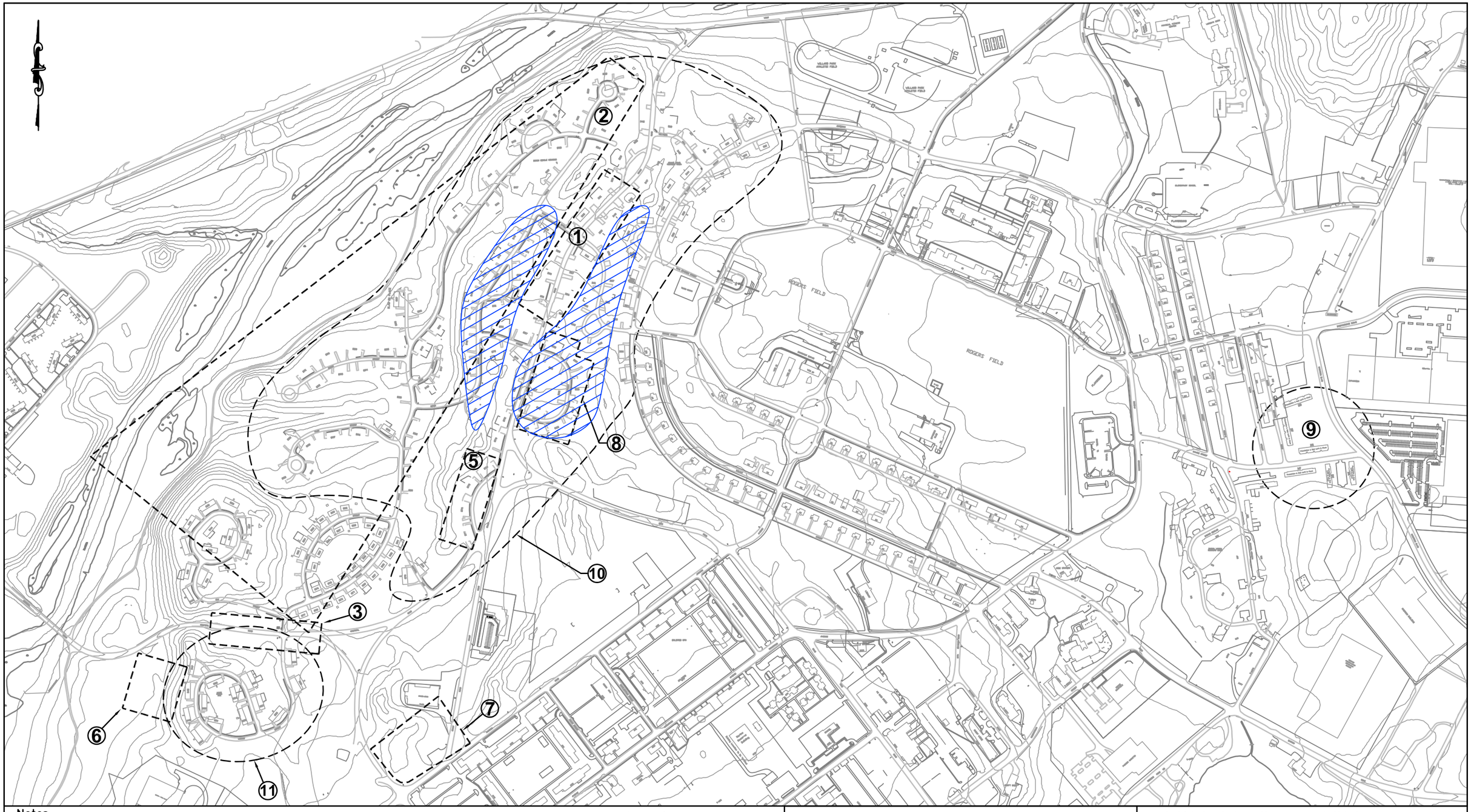
DEPARTMENT OF THE ARMY
NEW ENGLAND DISTRICT
CORPS OF ENGINEERS
CONCORD, MASSACHUSETTS

PASI/SSI COMPREHENSIVE REPORT
STUDY AREA – GRANT, LOCUST, AND CAVITE HOUSING AREAS
DEVENS, MASSACHUSETTS

FORMER GRANT HOUSING AREA MAP

DRAWN	DATE	FIGURE NO.
BEG	MAY 2006	2–2
CHECKED	W.O. NO.	

M:\Design\DWG\ACOE\FTDEVENS\PASI-SSI FINAL REPORT\rev 3\FIG 2-2.dwg, Layout1, 4/26/2006 3:01:44 PM, GIRARDEB, 1:1



Notes

** Based on information gathered from the Archives Search Report – (Findings, Maps, Conclusions and Recommendations), Fort Devens, U.S. Army Corps of Engineers, St. Louis District, US Dept. of Defense BRAC, Ordnance, Ammunition and Explosives, May 1995.

1. 1922 – Possible Training Area
2. 1922 – Possible Training Area and/or Range
3. 1922 – Possible Rifle Range
5. 1943 & 1951 – Anti-tank Range
6. 1943 & 1957 – Former Pistol and Machine Gun Range (Bryant Range)
7. 1943 & 1951 – Anti-tank Range
8. Former Laundry Facility
9. Entire Cavite Housing Area referred to as a Training Area – 1954, 1957, 1961.
10. Entire Grant Housing Area west of Grant Road is referred to as a Training Area – 1954, 1957.
11. Entire Locust Housing Area is referred to as a Training Area – 1954, 1957, 1961.

Legend

Investigation Area (IA) Boundary

Area of Significant Mining of Sand and Gravel

GRAPHIC SCALE

600 300 0 300 600

APPROXIMATE SCALE IN FEET

INVESTIGATION AREAS WITHIN THE GRANT, LOCUST, AND CAVITE HOUSING AREAS MAP

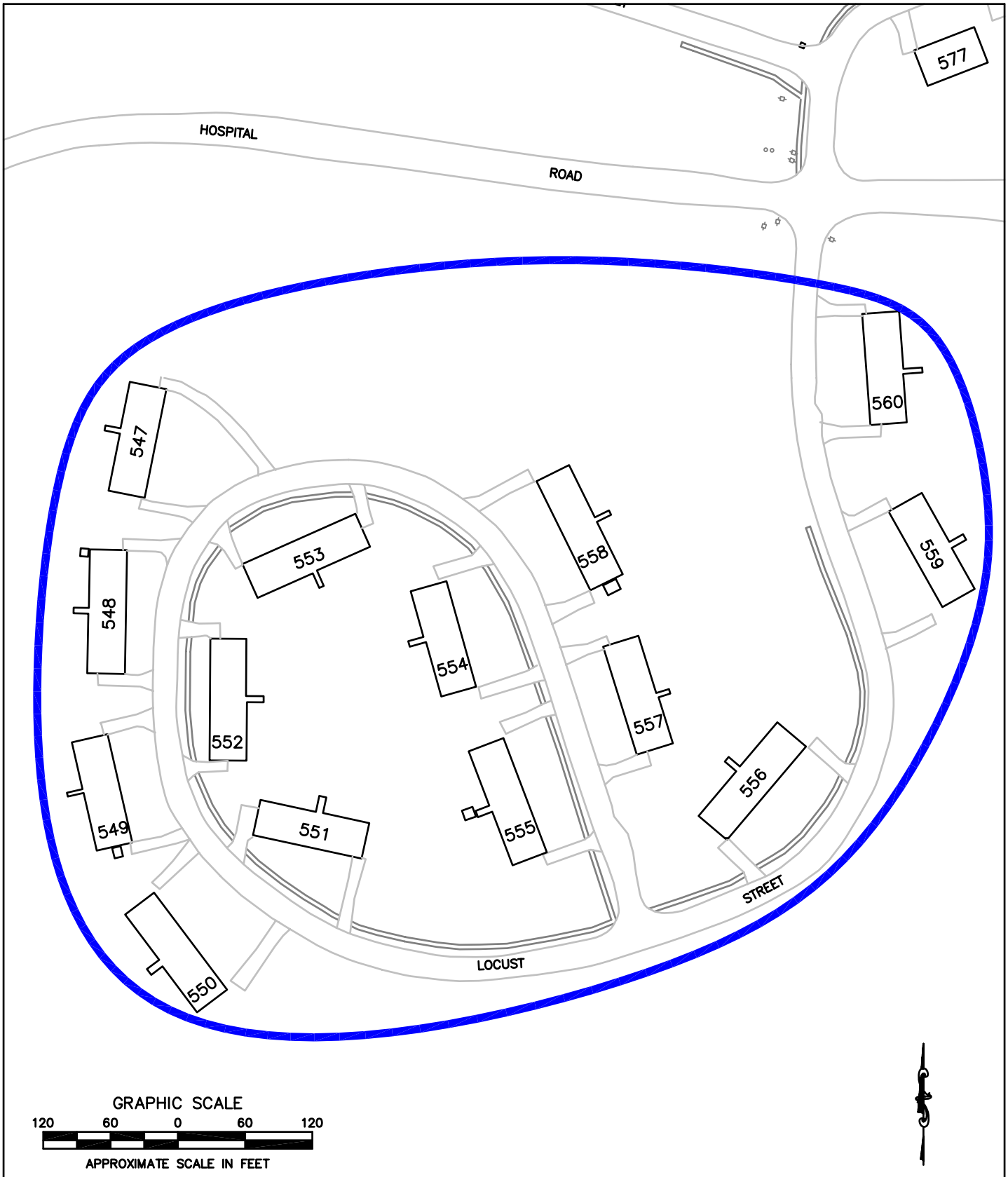
PASI/SSI COMPREHENSIVE REPORT
STUDY AREA – GRANT, LOCUST, AND CAVITE HOUSING AREAS
DEVENS, MASSACHUSETTS

DEPARTMENT OF THE ARMY
NEW ENGLAND DISTRICT
CORPS OF ENGINEERS
CONCORD, MASSACHUSETTS

WESTON SOLUTIONS
MANCHESTER NEW HAMPSHIRE

DRAWN BEG
DATE MAY 2006
FIGURE NO. 2-3

M:\Design\DWG\ACOE\FTDEVENS\PASI-SSI FINAL REPORT\rev 3\FIG 2-3.dwg, Layout 1, 4/25/2006 4:27:16 PM, GIRARDEB, 1:1



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STUDY AREA – GRANT, LOCUST, AND CAVITE HOUSING AREAS
DEVENS, MASSACHUSETTS

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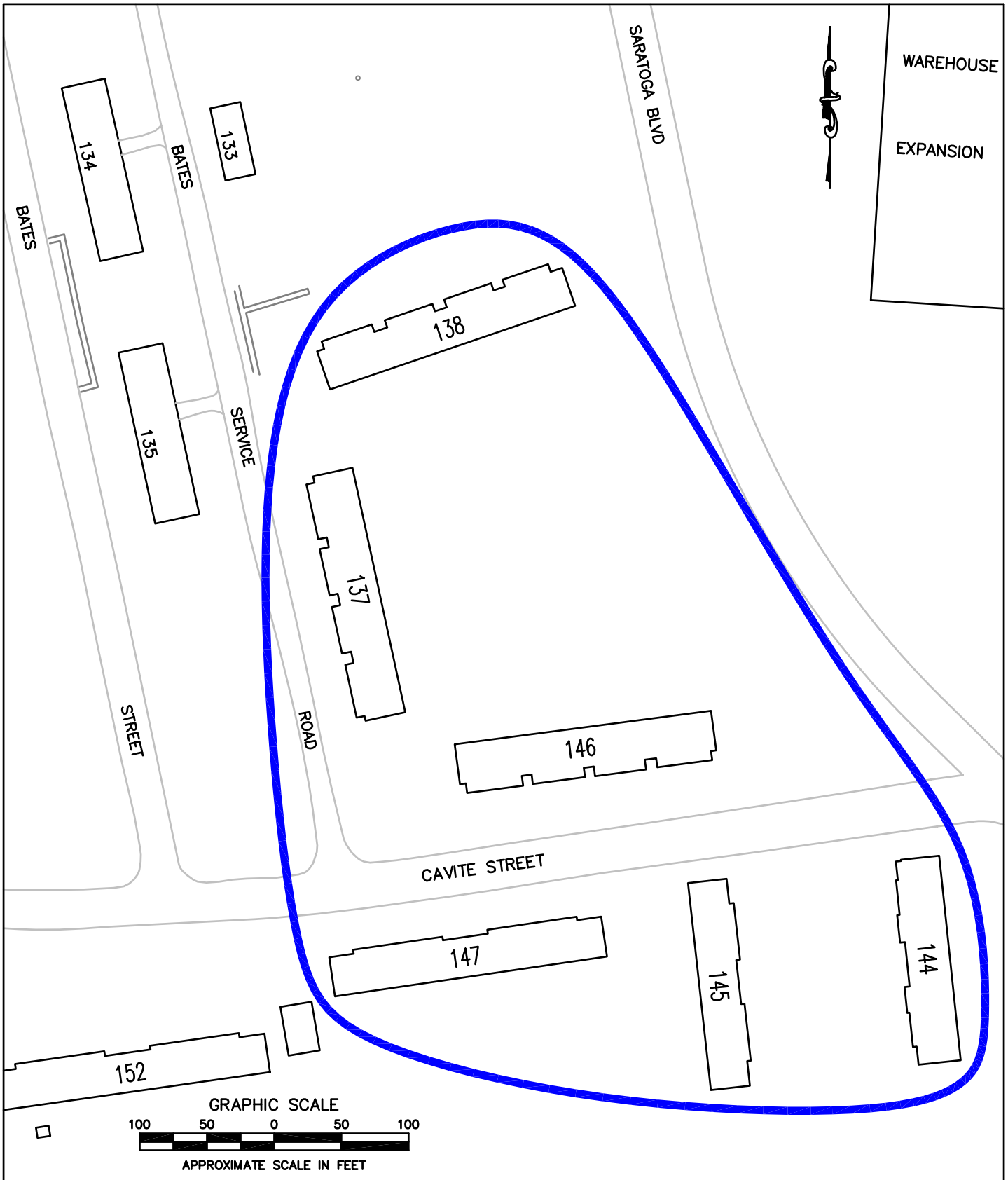
FORMER LOCUST HOUSING AREA MAP

WESTON SOLUTIONS
MANCHESTER NEW HAMPSHIRE

DRAWN: BEG
DATE: MAR 2005
FIGURE NO.: 2-4

M:\Design\DWG\ACOE\FTDEVENS\PASI-SSI FINAL REPORT\rev 2\FIG 2-4.dwg, Layout 1, 3/4/2005 8:41:32 AM, girardeb, 1:1



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STUDY AREA – GRANT, LOCUST, AND CAVITE HOUSING AREAS
DEVENS, MASSACHUSETTS

DEPARTMENT OF THE ARMY
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FORMER CAVITE HOUSING AREA MAP

WESTON SOLUTIONS
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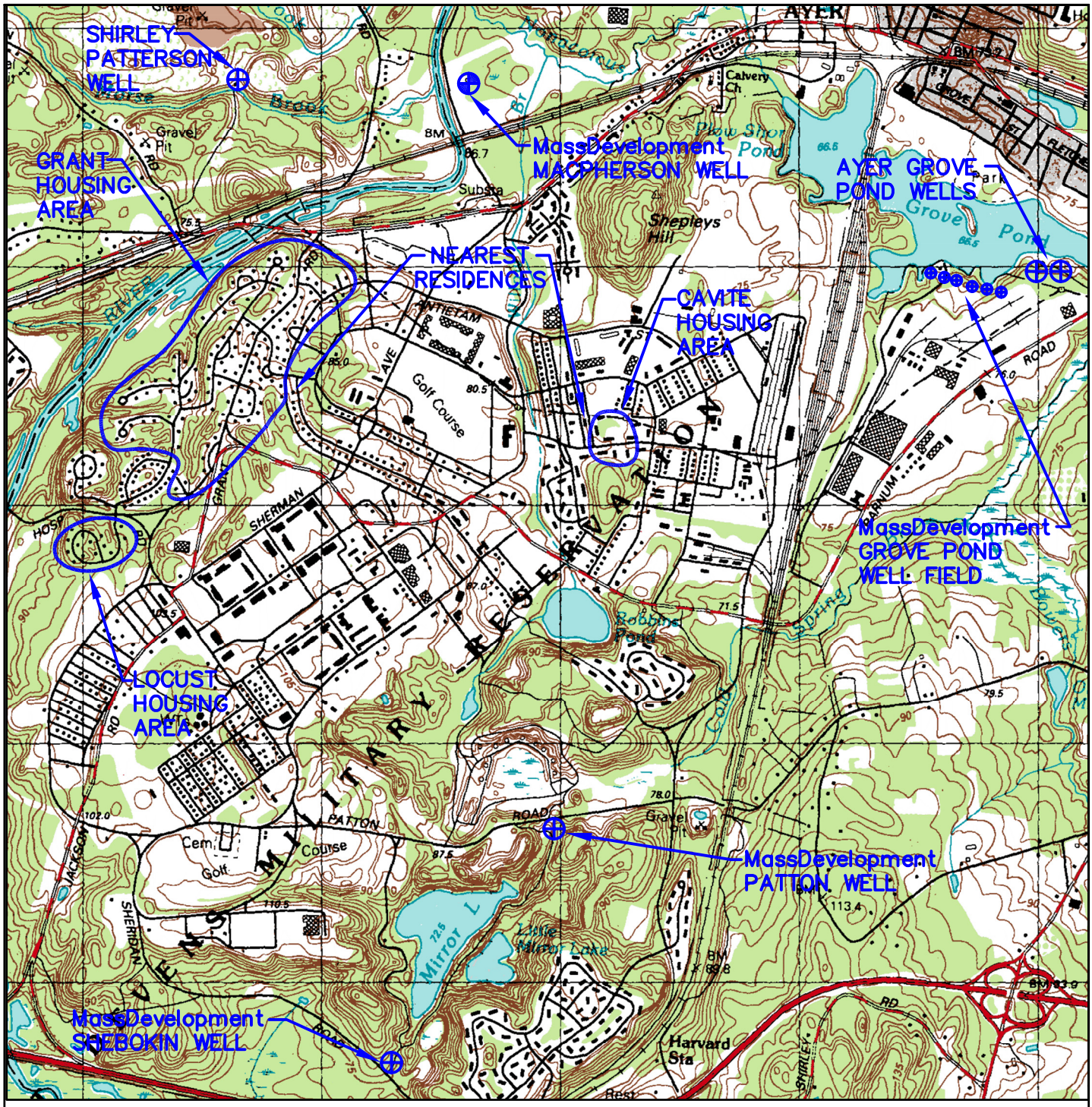
DRAWN	BEG
DATE	MAR 2005
FIGURE NO.	2–5

M:\Design\DWG\ACOE\FTDEVENS\PASI-SSI FINAL REPORT\rev 2\FIG 2-5.dwg, Layout 1, 3/4/2005 8:58:28 AM, girardeb, 1:1



SOURCE
US DEPT. OF THE INTERIOR, GEOLOGICAL SURVEY 7.5 x 15 MINUTE SERIES (TOPOGRAPHIC) AYER, MA., 1988

GRAPHIC SCALE
2000 1000 0 1000 2000
APPROXIMATE SCALE IN FEET

LEGEND
- OVERBURDEN DRINKING WATER WELL
- OVERBURDEN/ BEDROCK DRINKING WATER WELL

PASI/SSI COMPREHENSIVE REPORT
STUDY AREA – GRANT, LOCUST, AND CAVITE HOUSING AREAS
DEVENS, MASSACHUSETTS

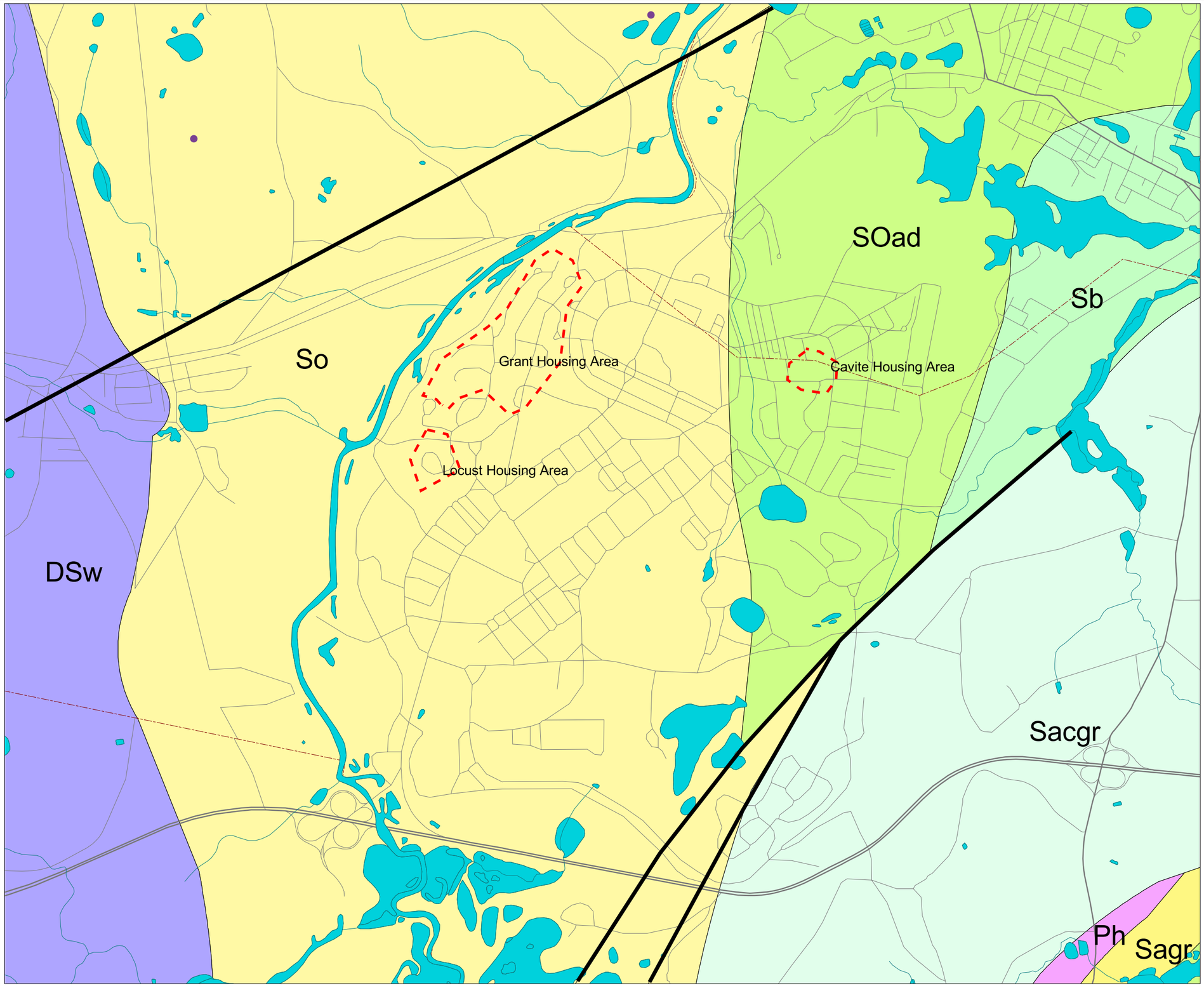
DEPARTMENT OF THE ARMY
NEW ENGLAND DISTRICT
CORPS OF ENGINEERS
CONCORD, MASSACHUSETTS

PHYSICAL SETTING MAP

WESTON SOLUTIONS
MANCHESTER NEW HAMPSHIRE

DRAWN BEG
DATE MAR 2005
FIGURE NO. 3–1

M:\Design\DWG\ACOE\FTDEVENS\PASI-SSI FINAL REPORT\rev 2\FIG 3-1.dwg, Physical Setting Map, 3/4/2005 9:04:12 AM, girardeb, 1:1



LEGEND

- Surface Water
- Roads
- Town Boundary

Bedrock Geology

- DSw-Worcester Formation
- Ph-Harvard Conclomerate
- SOad-Ayer Granite, Devens-Long Pond Facies
- Sacgr-Ayer Granite, Clinton Facies
- Sagr-Ayer Granite
- Sb-Berwick Formation
- So-Oakdale Formation
- Thrust Fault

N
W E
S

1000 0 1000 2000 3000 4000 Feet

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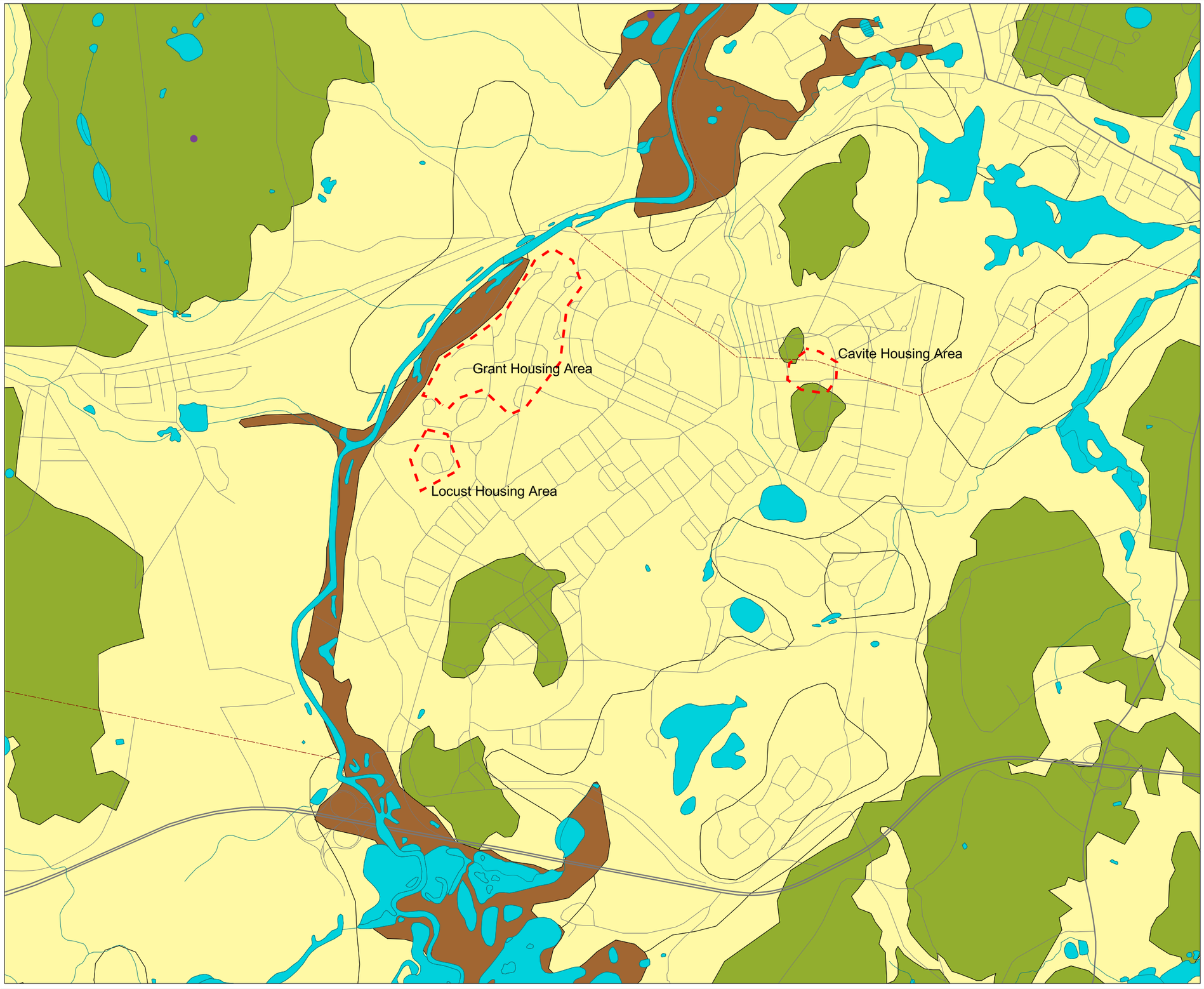
STUDY AREA - GRANT, LOCUST, AND CAVITE HOUSING AREAS
DEVENS, MASSACHUSETTS

Bedrock Geology Map

DRAWN	DATE	
JS	FEB 2005	Figure 3-2
CHECKED	W.O. NO.	
EK	03886.518.045	

G:/PROJECTS/03886518/045/Devens SSI/Figure 3-2.pdf



LEGEND

- Surface Water
- Roads
- Town Boundary

Surficial Geology

- Sand and Gravel
- Glacial Till or Bedrock
- Floodplain Alluvium

N
W E
S

1000 0 1000 2000 3000 4000 Feet

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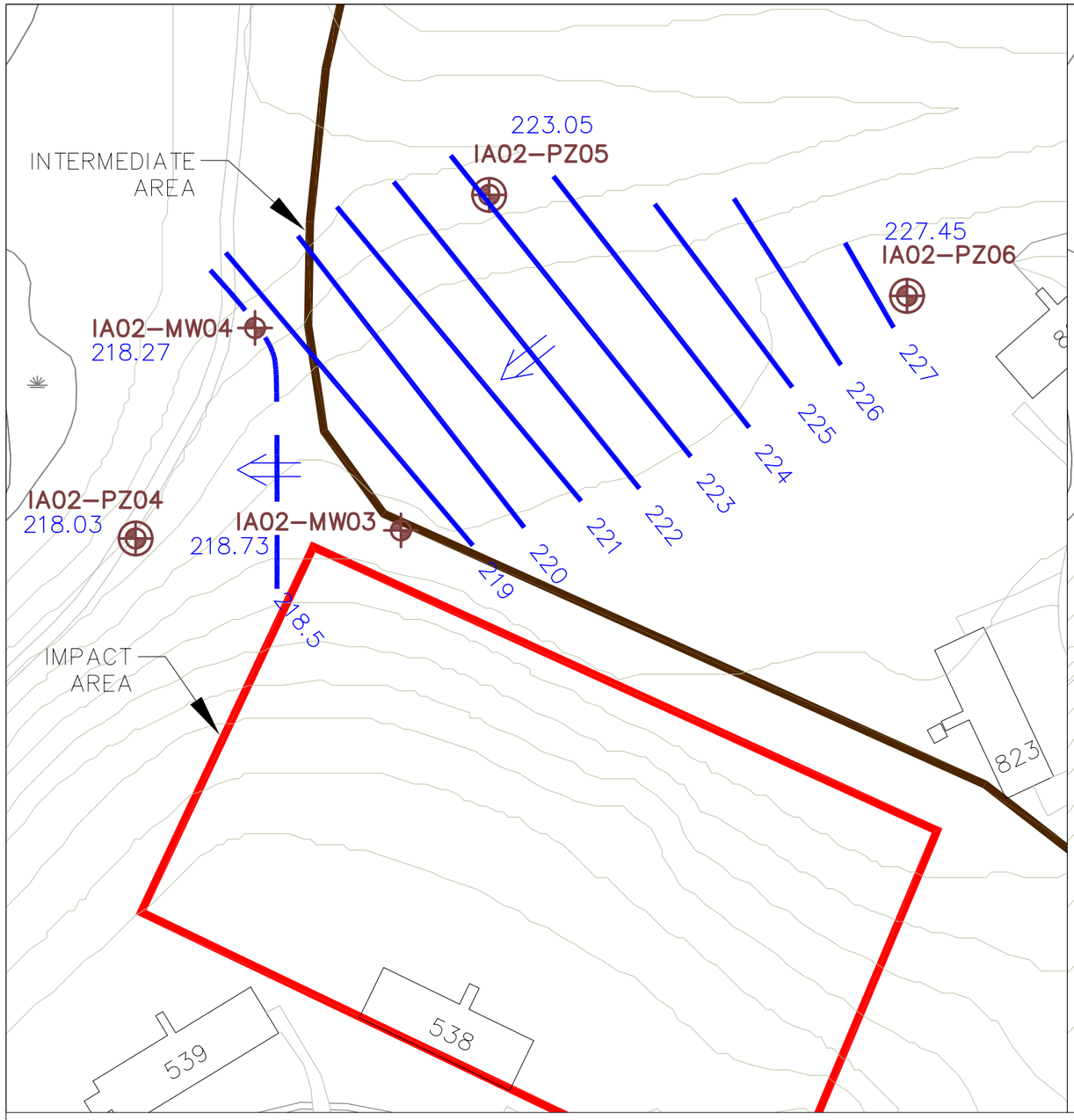
PASI/SSI COMPREHENSIVE REPORT
STUDY AREA - GRANT, LOCUST, AND CAVITE HOUSING AREAS
DEVENS, MASSACHUSETTS

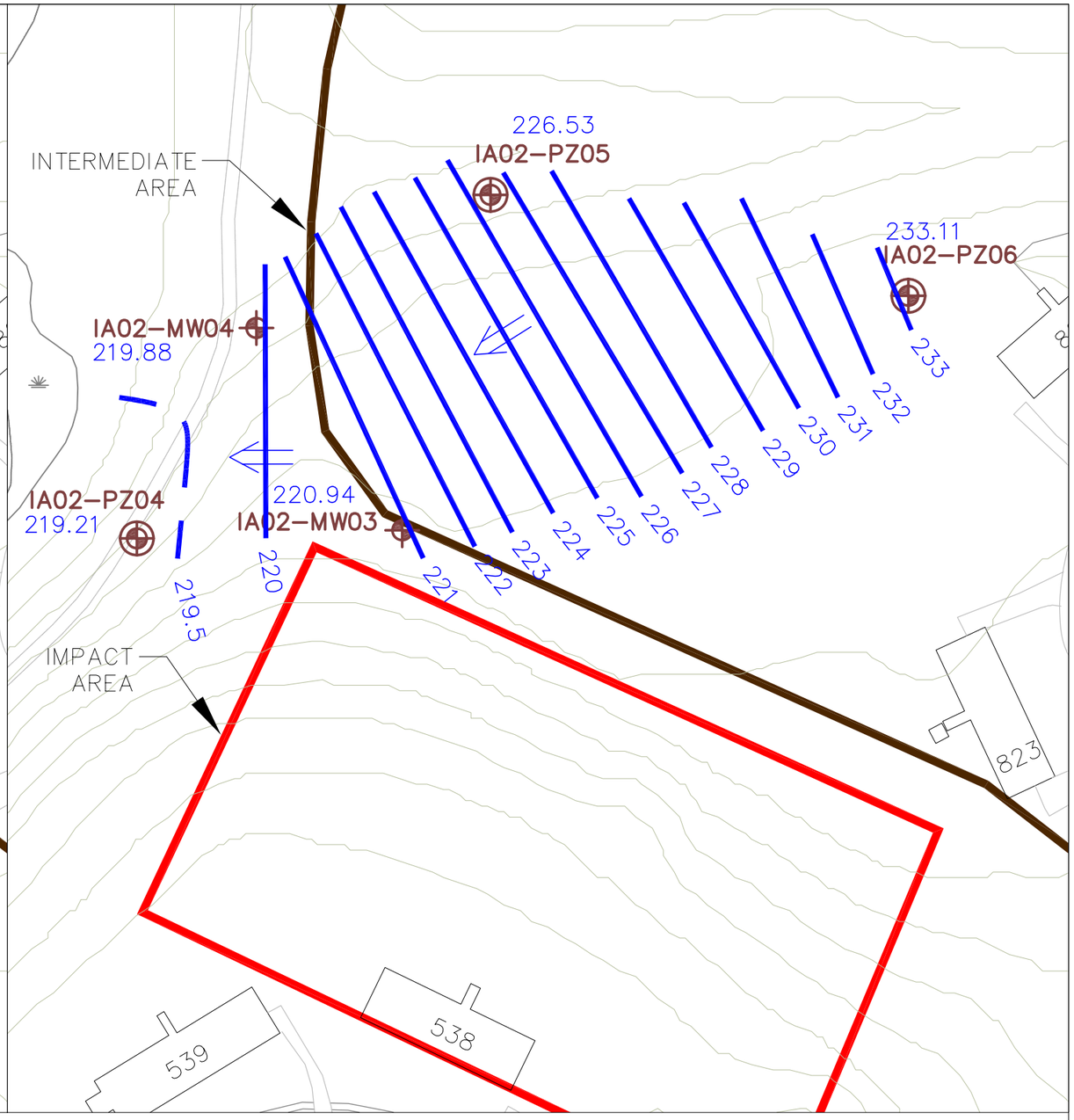
Surficial Geology Map

Devens PA/SI SSI: JS	DATE: FEB 2005	Figure 3-3
CHECKED: EK	W.O. NO.: 03886.518.045	

G:/PROJECTS/03886518/045/Devens SSI/Draft SSI Report/Figure 3-3.pdf



DECEMBER 28, 2004



MAY 20, 2005

LEGEND

- MONITORING WELL LOCATION
- PIEZOMETER LOCATION
- 227 — GROUNDWATER CONTOUR AND ELEVATION (AMSL)
- 218.73 — WELL MEASURING POINT ELEVATION (AMSL)
- GROUNDWATER FLOW DIRECTION

GRAPHIC SCALE

80 40 0 40 80

APPROXIMATE SCALE IN FEET

IA–2 GROUNDWATER CONTOUR MAP

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PASI/SSI COMPREHENSIVE REPORT
STUDY AREA – GRANT, LOCUST, AND CAVITE HOUSING AREAS
DEVENS, MASSACHUSETTS

WESTON SOLUTIONS
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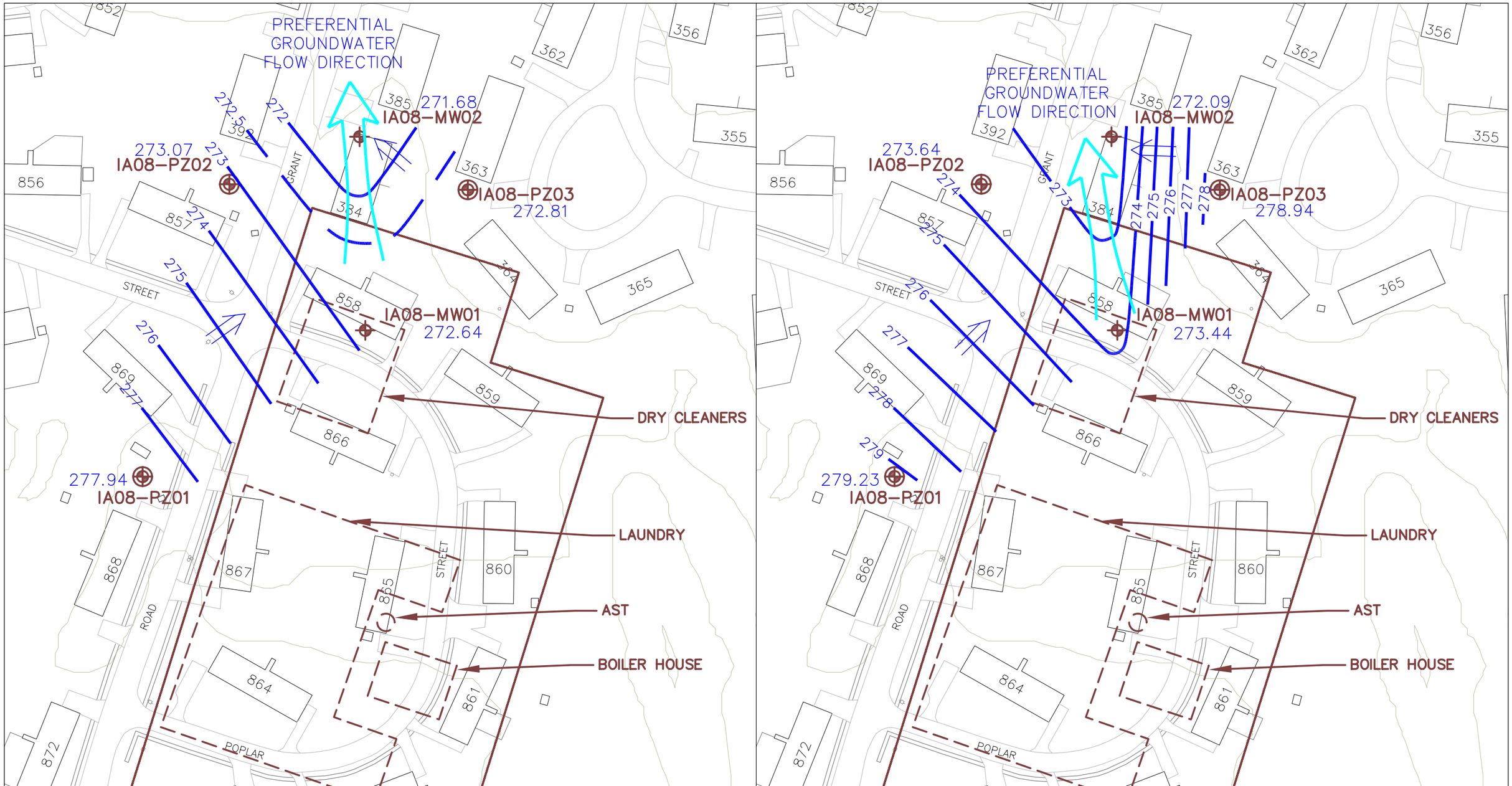
DRAWN BEG
DATE JUN 2005
FIGURE NO. 3–4

M:\Design\DWG\ACOE\FTDEVENS\PASI-SSI FINAL REPORT\rev 2\FIG 3-4.dwg, Layout 1, 9/13/2006 8:09:51 AM, MURROT, 1:1



DECEMBER 28, 2004

MAY 20, 2005

LEGEND

- IA BOUNDARY
- MONITORING WELL LOCATION
- PIEZOMETER LOCATION
- 272 GROUNDWATER CONTOUR AND ELEVATION (AMSL)
- 277.94 WELL MEASURING POINT ELEVATION (AMSL)
- GROUNDWATER FLOW DIRECTION

GRAPHIC SCALE

100 50 0 50 100

APPROXIMATE SCALE IN FEET

IA-8 GROUNDWATER CONTOUR MAP

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PASI/SSI COMPREHENSIVE REPORT
STUDY AREA - GRANT, LOCUST, AND CAVITE HOUSING AREAS
DEVENS, MASSACHUSETTS

WESTON SOLUTIONS
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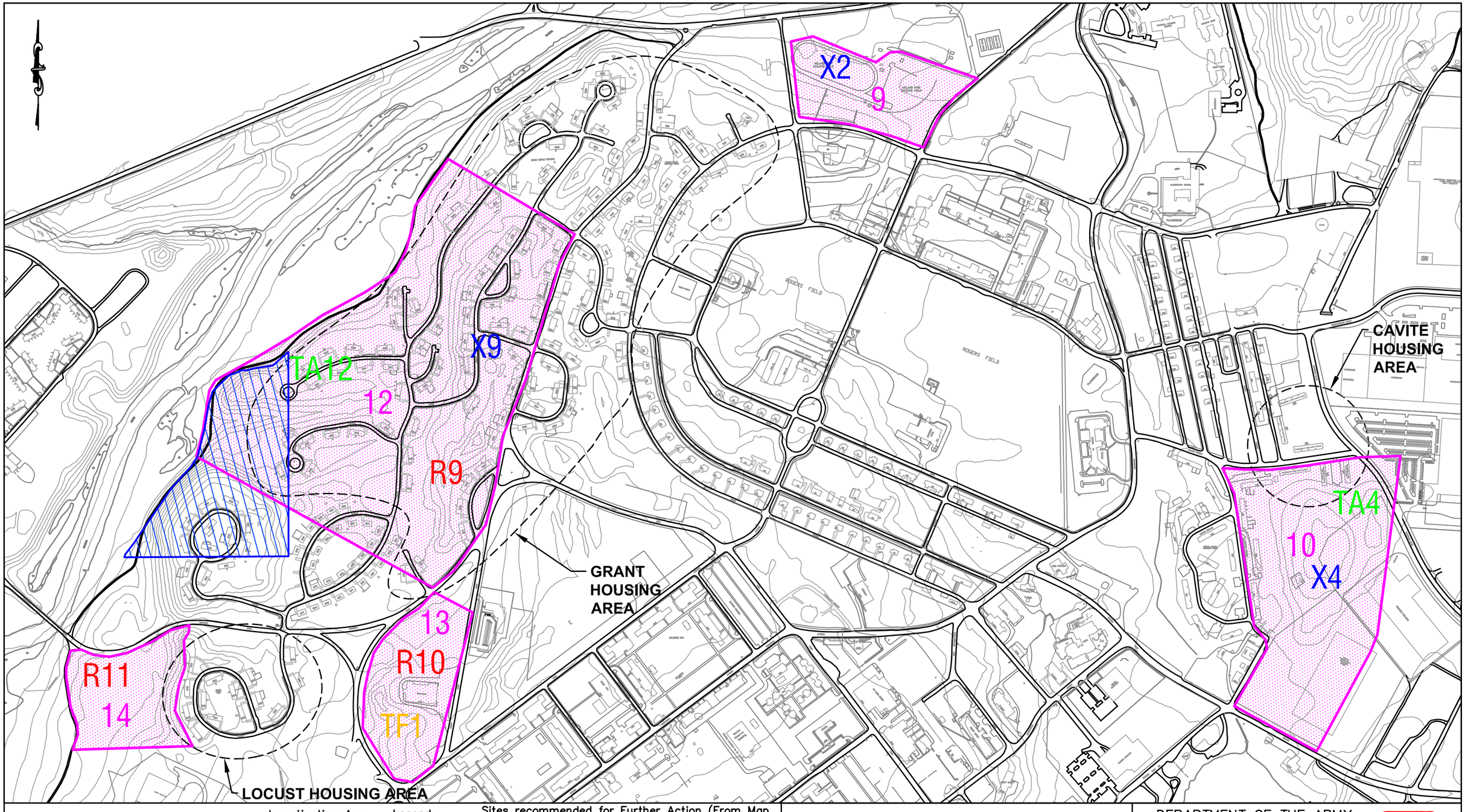
DRAWN BEG
DATE JUN 2005
FIGURE NO. 3-5

M:\Design\DWG\ACOE\FTDEVENS\PASI-SSI FINAL REPORT\rev 2\FIG 3-5.dwg, Layout 1, 6/9/2005 9:19:33 AM, girardeb, 1:1



Legend

- Investigation Area (IA) Boundary
- R RANGE
- TA TRAINING AREA
- TF TRAINING FACILITY
- X FOUND ORDNANCE

GRAPHIC SCALE
600 300 0 300 600
APPROXIMATE SCALE IN FEET

Sites recommended for Further Action (From Map M–15, Archives Search Report – Maps, Fort Devens, U.S. Army Corp of Engineers, St. Louis District, US Dept. of Defense BRAC, Ordnance, Ammunition, and Explosives, May 1995)

HFA Site 12 (From the Human Factors Applications, Inc.(HFA), Final Removal Action Report, Ordnance, Ammunition, and Explosives Removal Action, Devens RFTA, Fort Devens, Massachusetts, dated 10 October 1996)

UXO SITES AS IDENTIFIED IN ARMY DOCUMENTATION MAP

PASI/SSI COMPREHENSIVE REPORT
STUDY AREA – GRANT, LOCUST, AND CAVITE HOUSING AREAS
DEVENS, MASSACHUSETTS

DEPARTMENT OF THE ARMY
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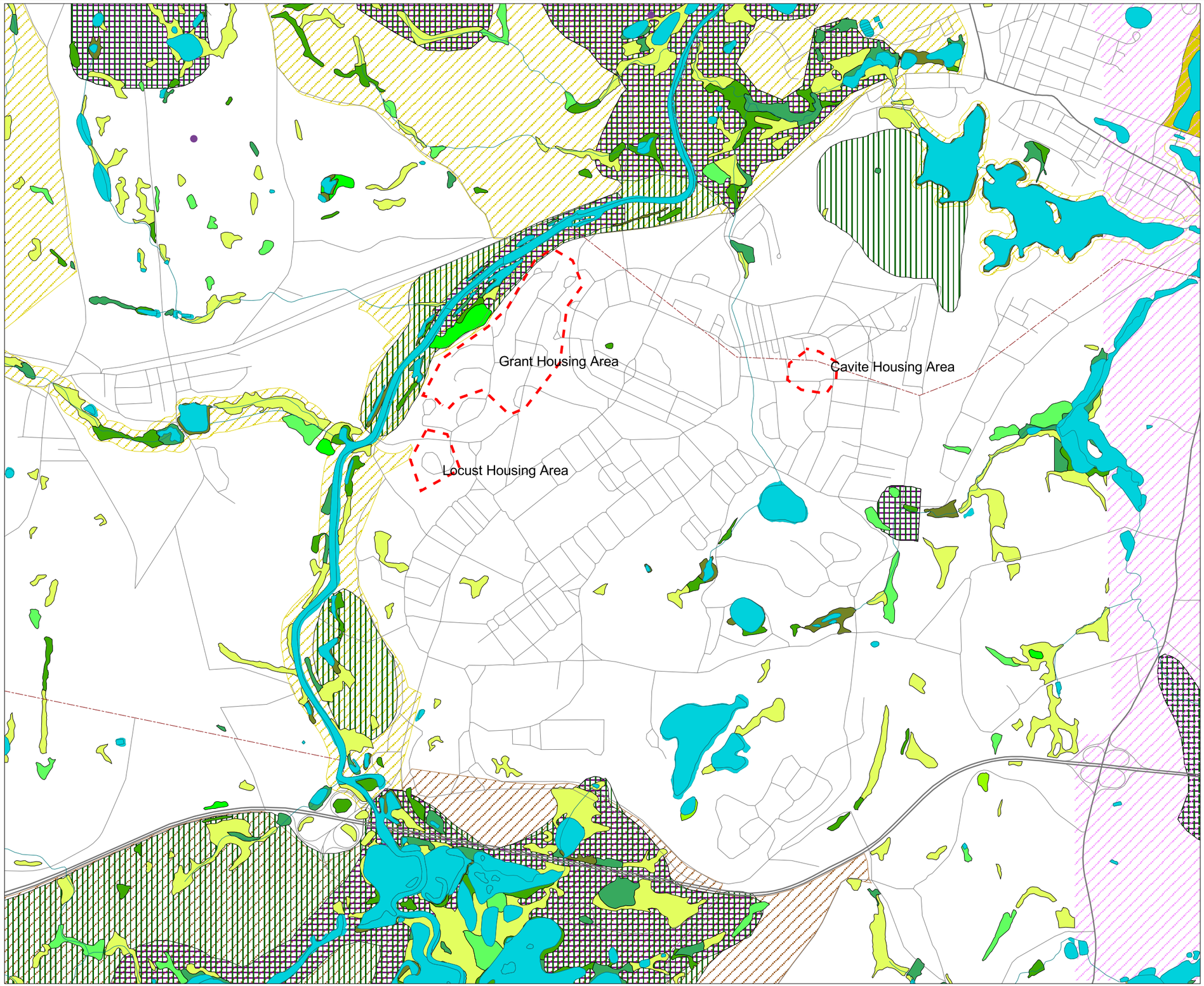
WESTON SOLUTIONS
MANCHESTER NEW HAMPSHIRE

DRAWN BEG
DATE APR 2005
FIGURE NO. 4–1

M:\Design\DWG\ACOE\FTDEVENS\PASI-SSI FINAL REPORT\rev 2\FIG 4-1.dwg, Layout 1, 4/28/2005 2:40:06 PM, girardeb, 1:1



LEGEND

- Surface Water
- Roads
- Town Boundary
- NHESP Priority Habitats of Rare Species
- NHESP Estimated Habitats of Rare Wildlife

MDEP Wetlands

- Bog
- Deep Marsh
- Not Interpreted
- Open Water
- Shallow Marsh Meadow or Fen
- Shrub Swamp
- Wooded Swamp, Coniferous
- Wooded Swamp, Deciduous
- Wooded Swamp, Mixed Trees

Areas of Critical Environmental Concern

- Central Nashua River Valley
- Squannassit

N
W E
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1000 0 1000 2000 3000 4000 Feet

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PASI/SSI COMPREHENSIVE REPORT
STUDY AREA - GRANT, LOCUST, AND CAVITE HOUSING AREAS
DEVENS, MASSACHUSETTS

Wetlands and Wildlife Habitats Map

DRAWN	DATE	
JS	FEB 2005	Figure 4-2
CHECKED	W.O. NO.	
EK	03886.518.045	

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HOSPITAL ROAD

LOCUST STREET

EXCAVATION LOCATION

- HIGH SHOT AREA
- IMPACT BERM AREA
- SHORT SHOT AREA
- NORTHERN SWALE AREA
- RANGE FLOOR AREA
- HILL SLOPE AREA
- 68 SAMPLE LOCATION WITH LEAD CONCENTRATION IN PPM

4 5 6 X Y Z A B C D E F G H I J K L M N O

1 2 3 4 5 6 7 8 9 10

188 190 149 81 175 144 150 270 75 38 220 168 250 110 63 11 74 100 193 17 135 280 64 10 158 260 141 140 72 300 225 25 120 190 57 10 95 69 51 52 153 58 94 13 210 130 38 9 191 168 174 81 72 140 36 29 143 93 190 240 150 124 99 68 150 200 74 35 160 185 68 125 80 34 17 44 36 28 58 15 18 17 69 44 49 32 29 71 50 35 14 57 46 38 49 51 31 19 29

GRAPHIC SCALE

60 30 0 30 60

APPROXIMATE SCALE IN FEET

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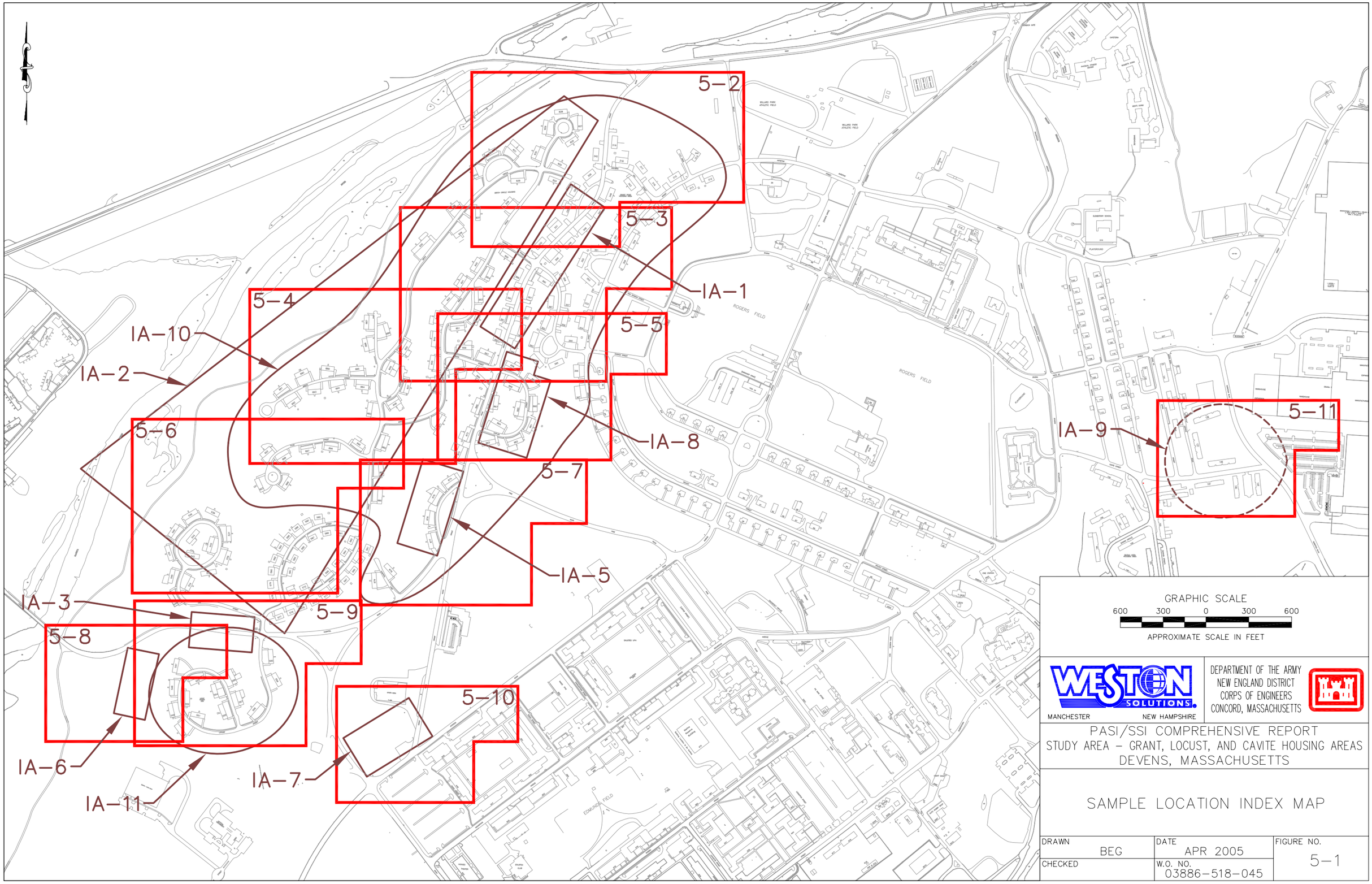
STUDY AREA – GRANT, LOCUST, AND CAVITE HOUSING AREAS
DEVENS, MASSACHUSETTS

EXCAVATED AREAS AND FINAL CONFIRMATORY SAMPLING CONCENTRATIONS

DRAWN	DATE	FIGURE NO.
BEG	JUN 2006	4–3
CHECKED	W.O. NO. 03886.110.020	

M:\Design\DWG\ACOE\FTDEVENS\PASI-SSI FINAL REPORT\rev 3\FIG 4-3.dwg, layout 1, 6/12/2006 9:16:21 AM, GIRARDEB, 1:1



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PASI/SSI COMPREHENSIVE REPORT
STUDY AREA – GRANT, LOCUST, AND CAVITE HOUSING AREAS
DEVENS, MASSACHUSETTS

SAMPLE LOCATION INDEX MAP

DRAWN	DATE	FIGURE NO.
BEG	APR 2005	5–1
CHECKED	W.O. NO. 03886–518–045	

M:\Design\DWG\ACOE\FTDEVENS\PASI-SSI FINAL REPORT\rev 2\FIG 5-1.dwg, Layout 1, 4/5/2007 1:00:13 PM, GIRARDEB, 1:1

M:\Design\DWG\ACOE\FTDEVENS\PASI-SSI FINAL REPORT\rev 2\FIG 5-2.dwg, Layout 1, 3/4/2005 9:33:07 AM, girardeb, 1:1

IA-2 FIRING POINT

IA-1

IA-2

IA-10

BOUNDARY BY GALE ASSOC. 5/6/98

NASHUA ROAD

GRANT ROAD

MALVERN HILL STREET

BIRCH CIRCLE HOUSING

GRANT ROAD HOUSING AREA

CHANCE CIRCLE

V.I.P. DRIVE

BALLS BLUFF STREET

GR-IA02-SS01

GR-IA02-SB24

GR-IA02-SB25

GR-IA02-SB26

GR-IA02-SB27

GR-IA02-SB23

GR-IA02-SB28

GR-IA01-SB01

GR-IA10-TP01

GR-IA10-TP02

BGB-03-10X

BGB-03-09X

GRB-03-01X

GRB-03-02X

IA2-006

IA2-007

IA2-008

IA2-009

IA2-010

GR 243

GR 244

GR 245

GR 246

GR 247

GR 248

GR 204

GR 205

GR 206

GR 207

GR 208

GR 305

GR 306

GR 307

GR 045A

GR 045B

GR 045C

GR 045D

GR 045E

GR 046A

GR 046B

GR 046C

GR 046D

GR 046E

GR 047A

GR 047B

GR 047C

GR 047D

GR 047E

GR 048A

GR 048B

GR 048C

GR 048D

GR 048E

GR 049A

GR 049B

GR 049C

GR 049D

GR 049E

GR 050A

GR 050B

GR 050C

GR 050D

GR 050E

GR 051A

GR 051B

GR 051C

GR 051D

GR 051E

GR 052A

GR 052B

GR 052C

GR 052D

GR 052E

GR 053A

GR 053B

GR 053C

GR 053D

GR 053E

GR 054A

GR 054B

GR 054C

GR 054D

GR 054E

GR 055A

GR 055B

GR 055C

GR 055D

GR 055E

GR 056A

GR 056B

GR 056C

GR 056D

GR 056E

GR 057A

GR 057B

GR 057C

GR 057D

GR 057E

GR 058A

GR 058B

GR 058C

GR 058D

GR 058E

GR 059A

GR 059B

GR 059C

GR 059D

GR 059E

GR 061A

GR 061B

GR 061C

GR 061D

GR 061E

GR 062A

GR 062B

GR 062C

GR 062D

GR 062E

824 825 826 827 828 829 830 831 832 833 837 838 839 312 313 314 315 316 317 318 319 328 329 330 331 332 342 343 346 347 348 349 350

DVQ

GRAPHIC SCALE

120 60 0 60 120

APPROXIMATE SCALE IN FEET

LEGEND

- PASI: COMPOSITE PCB AND/OR ARSENIC SAMPLES
- PASI: DISCRETE WESTON & NOBIS ARSENIC SAMPLES
- PASI: DISCRETE PCB SAMPLES
- PASI: LEAD OR EXPLOSIVES
- SSI: SOIL BORING LOCATION
- SSI: TEST PIT LOCATION
- SSI: SHALLOW SOIL SAMPLE LOCATION
- PESTICIDE REMEDIAL ACTION
- PCB EXCAVATION
- IA BOUNDARY

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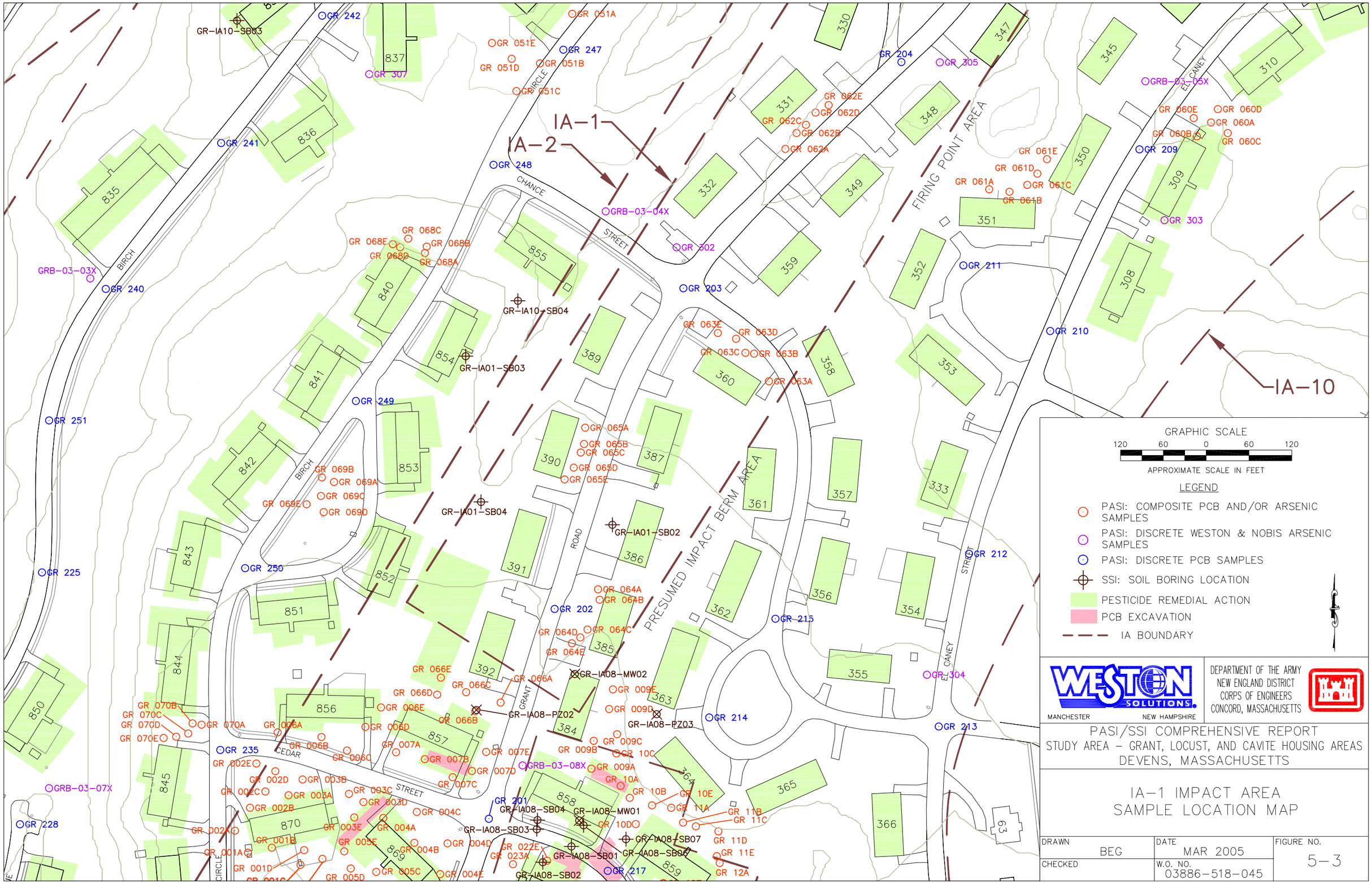
PASI/SSI COMPREHENSIVE REPORT
STUDY AREA - GRANT, LOCUST, AND CAVITE HOUSING AREAS
DEVENS, MASSACHUSETTS

IA-1 & IA-2 FIRING POINTS SAMPLE LOCATION MAP

DRAWN	DATE	FIGURE NO.
BEG	MAR 2005	5-2
CHECKED	W.O. NO. 03886.518.045	



GRAPHIC SCALE

120 60 0 60 120

APPROXIMATE SCALE IN FEET

LEGEND

- PASI: COMPOSITE PCB AND/OR ARSENIC SAMPLES
- PASI: DISCRETE WESTON & NOBIS ARSENIC SAMPLES
- PASI: DISCRETE PCB SAMPLES
- SSI: SOIL BORING LOCATION
- PESTICIDE REMEDIAL ACTION
- PCB EXCAVATION
- IA BOUNDARY

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IA-1 IMPACT AREA
SAMPLE LOCATION MAP

DRAWN	DATE	FIGURE NO.
BEG	MAR 2005	5-3
CHECKED	W.O. NO. 03886-518-045	

M:\Design\DWG\ACOE\FTDEVENS\PASI-SSI FINAL REPORT\rev 2\FIG 5-3.dwg, Layout 1, 3/4/2005 9:32:30 AM, girardeb, 1:1

IA–2

IA–10

INTERMEDIATE AREA

IA–1

IA–8

IA–2

IA–5

GR 251
GR 227
GR 308
GR 225
GR 250
GR 202
GR 226
GR 228
GR 235
GR 230
GR 231
GR 229
GR 234
GR 232
GR 233
GR 310
GR 237
GR 238
GR 236
GR 344
GR 309
GR 201

GR–IA01–SB04
GR–IA02–SB15
GR–IA02–SB14
GR–IA02–SB13
GR–IA10–SB01
GR–IA02–SB20
GR–IA02–SB21
GR–IA02–SB19
GR–IA02–SB17
GR–IA02–SB18
GR–IA08–PZ02
GR–IA08–SB04
GR–IA08
GR–IA02–PZ06

GRB–03–06X
GRB–03–07X
GRB–03–08X
GRB–03–09X

GR 069A
GR 069B
GR 069C
GR 069D
GR 069E
GR 065D
GR 065E
GR 064D
GR 064E
GR 066A
GR 066B
GR 066C
GR 066D
GR 066E
GR 070A
GR 070B
GR 070C
GR 070D
GR 070E
GR 006A
GR 006B
GR 006C
GR 006D
GR 006E
GR 007A
GR 007B
GR 007C
GR 007D
GR 007E
GR 009B
GR 002A
GR 002B
GR 002C
GR 002D
GR 002E
GR 003A
GR 003B
GR 003C
GR 003D
GR 004C
GR 001A
GR 001C
GR 001D
GR 071A
GR 071B
GR 071C
GR 071D
GR 071E
GR 072A
GR 072B
GR 072C
GR 072D
GR 072E
GR 073A
GR 073B
GR 073C
GR 073D
GR 073E
GR 074A
GR 074B
GR 074C
GR 074D
GR 074E
GR 075A
GR 075B
GR 075C
GR 075D
GR 075E
GR 037B

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845
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822
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392
384
385
858

BIRCH
ROAD
GRANT
CEDAR
STREET
CIRCLE
LUNDY
AVENUE
BEECH
PLUM

GRAPHIC SCALE
120 60 0 60 120
APPROXIMATE SCALE IN FEET

LEGEND

- PASI: COMPOSITE PCB AND/OR ARSENIC SAMPLES
- PASI: DISCRETE WESTON & NOBIS ARSENIC SAMPLES
- PASI: DISCRETE PCB SAMPLES
- SSI: SOIL BORING LOCATION
- SSI: PIEZOMETER LOCATION
- PESTICIDE REMEDIAL ACTION
- PCB EXCAVATION
- IA BOUNDARY

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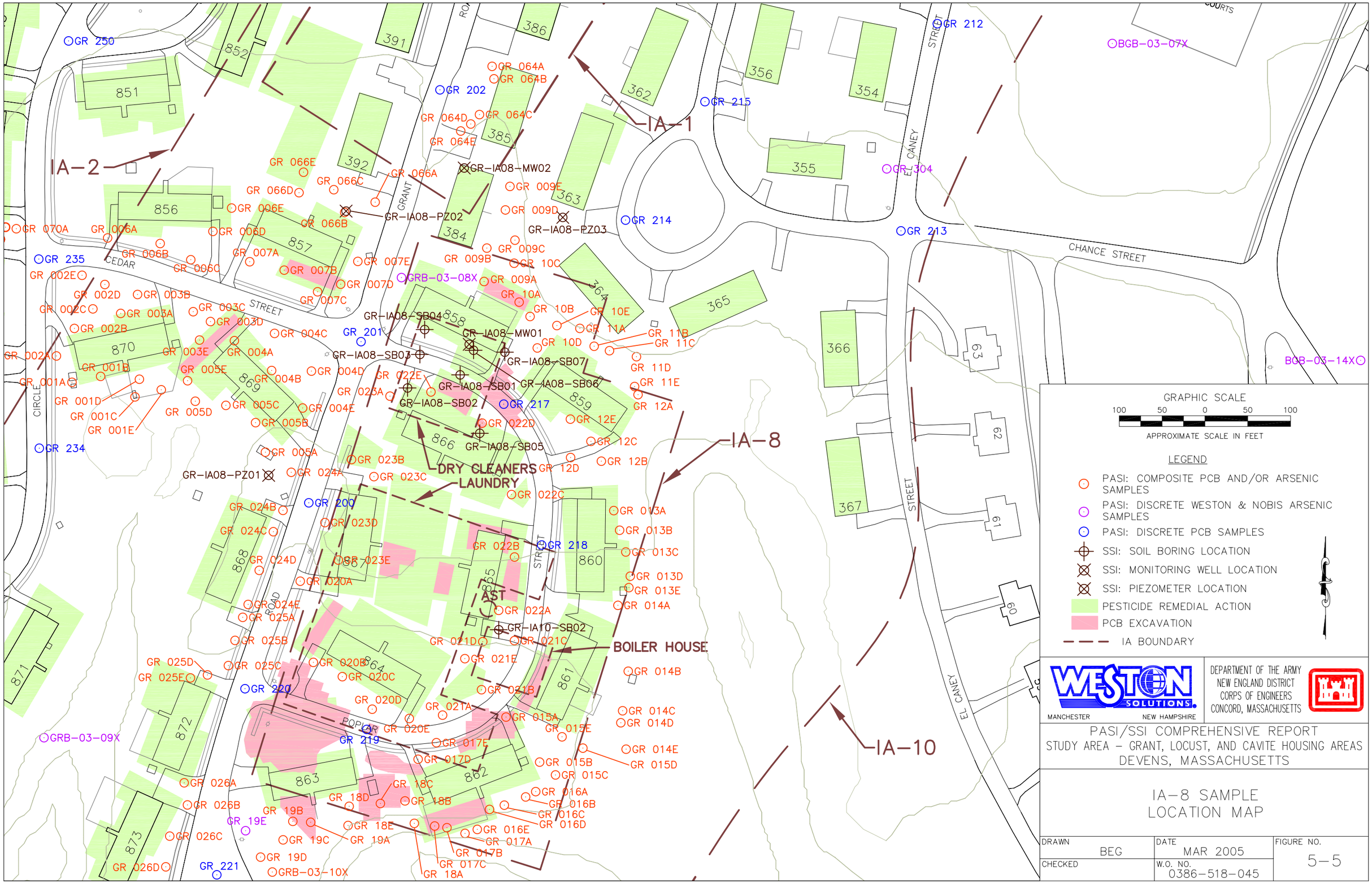
IA–2 INTERMEDIATE AREA SAMPLE LOCATION MAP

DRAWN	DATE	FIGURE NO.
BEG	MAR 2005	5–4
CHECKED	W.O. NO. 03886.518.045	

M:\Design\DWG\ACOE\FTDEVENS\PASI-SSI FINAL REPORT\rev 2\FIG 5-4.dwg, Layout 1, 3/4/2005 9:32:03 AM, girardeb, 1:1



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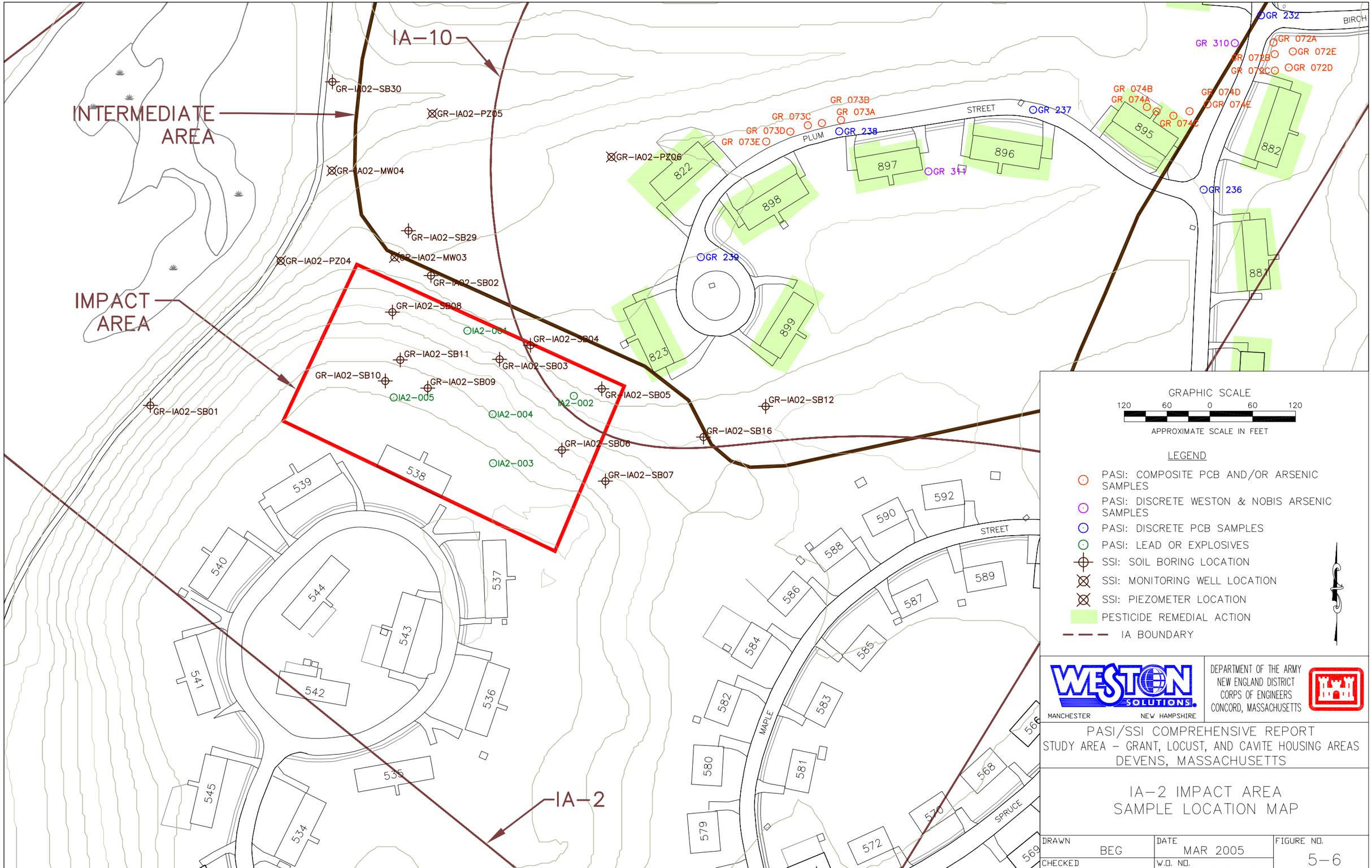
IA-8 SAMPLE LOCATION MAP

DRAWN	DATE	FIGURE NO.
BEG	MAR 2005	5-5
CHECKED	W.O. NO. 0386-518-045	

M:\Design\DWG\ACOE\FTDEVENS\PASI-SSI FINAL REPORT\rev 2\FIG 5-5.dwg, Layout 1, 4/21/2005 9:55:21 AM, girarderb, 1:1



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IA-2 IMPACT AREA
SAMPLE LOCATION MAP

DRAWN	DATE	FIGURE NO.
BEG	MAR 2005	5-6
CHECKED	W.O. NO. 03886.518.045	

M:\Design\DWG\ACOE\FTDEVENS\PASI-SSI FINAL REPORT\rev 2\FIG 5-6.dwg, Layout 1, 9/13/2006 8:12:48 AM, MURROT, 1:1

IA-2

IA-5

IA-10

STREET

PINE ROAD

GRANT ROAD

HOSPITAL LANE

881 880 874 873 876 561 563 878 879

GR 037B GR 038D IA5-001A IA5-001B IA5-001C IA5-001E GR-IA05-SS01 IA5-002A IA5-002B IA5-002C IA5-002D IA5-002E GR-IA05-SB06 GR 037D GR 038A GR-IA05-SS03 GR-IA05-SB07 IA5-003B IA5-003A IA5-003C GR-IA05-SB01 IA5-003E GR-IA05-SS04 IA5-003D GR-IA05-SB09 GR-IA05-SB02 IA5-004B IA5-004A IA5-004C IA5-004D IA5-004E GR-IA05-SB05 GR-IA05-SS05 GR-IA05-SB03 GR-IA05-SB04 GR 039D GR 300 GRB-03-11X IA5-005A GR-IA05-SS06 IA5-005C IA5-005B IA5-005D IA5-005E GR 041A

GR 026E GR 027B GR 027A GR 038E GR 037A GR 027C GR 027D GR 027E IA5-001D GR 038C GR 037C GR-IA05-SS02 GR 043D GR 038B GR 043C GR-IA05-SB08 GR 043B GR 037E GR 039A GR 039E GR 039B GR 044E GR 039C GR 044C GR 044B GR 044A GR 040A GR 040B GR 040E GR 040C GR 040D GR 041B GR 041C GR 041D GR 041E

GR 30E GR 30D GR 30A GR 30B GR 30C GR 028B GR 043E GR 28A GR 222 GR 029A GR 028C GR 301 GR 028E GR 29D GR 028D GR 29C GR 29B GR 031C GR 29E GR 031A GR 031B GR 031D GR 031E GR 032A GR 032B GR 032C GR 032D GR 032E GR 033A GR 033B GR 033C GR 033D GR 033E GR 223 GR 042C GR 042D GR 042E GR 042A GR 042B GR 224

GR 34A GR 34B GR 34C GR 043A GR 34E GR 34D GR 35B GR 44D GR 35A GR 35C GR 35D GR 36E GR 35E GR 36D GR 36C GR 36B GR 36A

GR 067C GR 067B GR 067A GR 067D GR 067E

M:\Design\DWG\ACOE\FTDEVENS\PASI-SSI FINAL REPORT\rev 2\FIG 5-7.dwg, Layout 1, 3/4/2005 9:15:15 AM, girardeb, 1:1

GRAPHIC SCALE

80 40 0 40 80

APPROXIMATE SCALE IN FEET

LEGEND

- PASI: COMPOSITE PCB AND/OR ARSENIC SAMPLES
- PASI: DISCRETE WESTON & NOBIS ARSENIC SAMPLES
- PASI: DISCRETE PCB SAMPLES
- PASI: LEAD OR EXPLOSIVES
- SSI: SOIL BORING LOCATION
- SSI: SHALLOW SOIL SAMPLE LOCATION
- PESTICIDE REMEDIAL ACTION
- PCB EXCAVATION
- IA BOUNDARY

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IA-5 SAMPLE LOCATION MAP

DRAWN	DATE	FIGURE NO.
BEG	MAR 2005	5-7
CHECKED	W.O. NO. 03886.518.045	

M:\Design\DWG\ACOE\FTDEVENS\PASI-SSI FINAL REPORT\rev 2\FIG 5-8.dwg, Layout1, 4/25/2006 3:29:59 PM, GIRARDEB, 1:1

ROAD

HOSPITAL

IA-3

IA-11

IA-6

IA3-006C
GR-IA03-SS03
GR-IA03-SB04
IA3-002D
GR-IA03-SS05
IA3-003D
IA3-003A
GR-IA03-SS04
IA3-003E
IA3-003C
IA3-003B
IA3-002E
GR-IA03-SB01
GR-IA03-SS20
GR-IA03-S
GR-IA03-SS21

IA06-SS41
IA06-SD15
IA06-SD13
IA06-SD14
IA06-SD12
IA06-SD17
IA06-SD16
IA06-SD11
IA06-SS11
IA06-SS21
IA06-SS30
IA06-SS31
IA06-SS10
IA06-SD10
IA06-SD09
IA06-SD08
IA06-SS16
IA06-SS09
IA06-SS20
IA06-SS22
IA06-SS43
IA06-SS32
IA06-TP01
IA06-SS46
IA06-SS33
IA06-SS23
IA06-SB06
IA06-SS08
IA6-001E
IA06-SS39
IA6-001D
IA06-SS15
IA06-TP02
IA6-001C
IA06-SS24
IA06-SS07
IA6-001B
IA06-SS34
IA06-SS19
IA6-001A
IA06-SS47
IA06-SS44
IA06-SS12
IA06-SS25
IA6-002E
IA06-SS14
IA6-002D
IA06-TP03
IA06-SB03
IA06-SS35
IA06-SS06
IA06-SS17
IA6-002C
IA06-SS48
IA6-002B
IA06-SS40
IA06-SB04
IA6-002A
IA06-SS13
IA06-SS26
IA06-SS36
IA06-SB05
IA06-SS05
IA06-TP04
IA06-SD07
IA06-SD06
IA06-SS27
IA06-SS03
IA06-SS18
IA06-SS37
IA06-SD05
IA06-SS45
IA06-SD04
IA06-SS04
IA06-SD03
IA06-SD01
IA06-SD02
IA06-SS28
IA06-SS42
IA06-SS29
IA06-SS38

LOB-03-01X
LO 003B
LO 003E
LO 003D
LOB-03-02X
LO 003C
LO 003A

547
548
549

1 2 3 4 5 6 7 8 9 10 11 12 13 14 15

GRAPHIC SCALE
80 40 0 40 80
APPROXIMATE SCALE IN FEET

LEGEND

- PASI: COMPOSITE PCB AND/OR ARSENIC SAMPLES
- PASI: DISCRETE WESTON & NOBIS ARSENIC SAMPLES
- PASI: DISCRETE PCB SAMPLES
- PASI: LEAD OR EXPLOSIVES
- SSI: SOIL BORING LOCATION
- SSI: SHALLOW SOIL SAMPLE LOCATION
- IA-6: COMPOSITE SOIL SAMPLE LOCATION
- IA-6: DISCRETE SOIL SAMPLE LOCATION
- IA-6: DISCRETE SOIL SAMPLE LOCATION WITHIN TEST PIT
- IA-6: SOIL BORING
- PESTICIDE REMEDIAL ACTION
- IA BOUNDARY

SOURCE INFO:
– 2 FOOT CONTOUR DATA WAS COLLECTED IN 2002

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IA-6 SAMPLE LOCATION MAP

DRAWN	DATE	FIGURE NO.
BEG	MAR 2005	5-8
CHECKED	W.O. NO. 03886.518.045	

M:\Design\DWG\ACOE\FTDEVENS\PASI-SSI FINAL REPORT\rev 2\FIG 5-9.dwg, Layout 1, 3/4/2005 9:33:31 AM, girardeb, 1:1

OAK STREET
HOSPITAL
HOSPITAL
ROAD
LOCUST
STREET
LOCUST HOUSING AREA

IA-2
IA-3
IA-4
IA-6
IA-11

GR-IA03-SS13
GR-IA03-SS12
GR-IA03-SS14
GR-IA03-SS11
GR-IA03-SS08
GR-IA03-SS10
GR-IA03-SS09
GR-IA03-SS07
GR-IA03-SS02
GR-IA03-SB03
GR-IA03-SS01
GR-IA03-SS03
GR-IA03-SB04
GR-IA03-SB02
GR-IA03-SS06
GR-IA03-SS05
GR-IA03-SS04
GR-IA03-SB01
GR-IA03-SS20
GR-IA03-SS22
GR-IA03-SS21
GR-IA03-SS15
GR-IA03-SS19
GR-IA03-SS16
GR-IA03-SS17
GR-IA03-SS18

IA3-006B
IA3-006E
IA3-006A
IA3-006D
IA3-006C
IA3-005C
IA3-005A
IA3-005B
IA3-005D
IA3-005E
IA3-004E
IA3-004C
IA3-004A
IA3-004B
IA3-004D
IA3-002D
IA3-002C
IA3-002A
IA3-003D
IA3-003A
IA3-003E
IA3-003C
IA3-003B
IA3-002E
IA3-002B
IA3-001D
IA3-001C
IA3-001E
IA3-001A
IA3-001B

LO 001B
LO 001C
LO 001A
LO 001D
LO 001E
LO 300
LO 002A
LO 002B
LO 002E
LO 002D
LO 002C
LO 200
LO 203
LO 004B
LO 004A
LO 004C
LO 004D
LO 004E
LO 005C
LO 005D
LO 005A
LO 005E
LO 005B
LO 003B
LO 003E
LO 003D
LO 003A
LO 003C
LO 302
LO 301
LO 202
LO 201
LO 006A
LO 006E
LO 006B
LO 006D
LO 006C

LOB-03-01X
LOB-03-02X
LOB-03-03X
LOB-03-04X
BGB-03-18X
LO-IA11-SB01
LO-IA11-SB02

IA6-001E
IA6-001D
IA6-001C
IA6-001B
IA6-001A
IA6-002E
IA6-002D
IA6-002C
IA6-002B
IA6-002A

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GRAPHIC SCALE
100 50 0 50 100
APPROXIMATE SCALE IN FEET

LEGEND
- PASI: COMPOSITE PCB AND/OR ARSENIC SAMPLES
- PASI: DISCRETE WESTON & NOBIS ARSENIC SAMPLES
- PASI: DISCRETE PCB SAMPLES
- PASI: LEAD OR EXPLOSIVES
- SSI: SOIL BORING LOCATION
- SSI: SHALLOW SOIL SAMPLE LOCATION
- PESTICIDE REMEDIAL ACTION
- IA BOUNDARY

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IA-11 & IA-3
SAMPLE LOCATION MAP

DRAWN	DATE	FIGURE NO.
BEG	MAR 2005	5-9
CHECKED	W.O. NO. 03886.518.045	

SPORTS ARENA

T-620

ROAD

GRANT

JACKSON

IA-7

GR-IA07-SS01

GR-IA07-SS02

GR-IA07-SB02

GR-IA07-SS03

GR-IA07-SB01

GR-IA07-SS06

GR-IA07-SS04

GR-IA07-SS05

119

GR-IA07-SB03

GR-IA07-SB04

650

655

649

648

PATSY STREET

GRAPHIC SCALE

80 40 0 40 80

APPROXIMATE SCALE IN FEET

LEGEND

- PASI: DISCRETE PCB SAMPLES
- SSI: SOIL BORING LOCATION
- SSI: SHALLOW SOIL SAMPLE LOCATION
- IA BOUNDARY

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IA-7 SAMPLE LOCATION MAP

DRAWN	DATE	FIGURE NO.
BEG	MAR 2005	5-10
CHECKED	W.O. NO. 03886-518-045	

M:\Design\DWG\ACOE\FTDEVENS\PASI-SSI FINAL REPORT\rev 2\FIG 5-10.dwg, Layout 1, 3/4/2005 4:21:40 PM, baronal, 1:1

M:\Design\DWG\ACOE\FTDEVENS\PASI-SSI FINAL REPORT\rev 2\FIG 5-11.dwg, Layout 1, 4/28/2005 2:51:32 PM, girardeb, 1:1

BATES

STREET

SERVICE

ROAD

135

137

138

146

147

145

144

152

IA-9

CA 002B
CA 002A
CA 002E
CA 002C
CA 002D
CT-500

CA 001E
CA 001D
CA 001A
CA 001C
CA 001B
CT-501

CA 003C
CA 003D
CA 003A
CA 003B
CA 003E

CA 004E
CA 004A
CA 004D
CA 004C
CA 004B

CA 005D
CA 005C
CA 005E
CA 005A
CA 005B
CA-IA09-TP01

CA 007E
CA-IA09-SB01
CA 007D
CA 007A
CA 007C
CA 007B

CA 008D
CA 008B
CA 008A
CA 008C
CA 008E

CA 006D
CA 006A
CA 006E
CA 006C
CA 006B
CT-502

GRAPHIC SCALE

80 40 0 40 80

APPROXIMATE SCALE IN FEET

LEGEND

- PASI: COMPOSITE PCB AND/OR ARSENIC SAMPLES
- PASI: DISCRETE WESTON & NOBIS ARSENIC SAMPLES
- SSI: SOIL BORING LOCATION
- SSI: TEST PIT LOCATION
- PESTICIDE REMEDIAL ACTION
- IA BOUNDARY

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IA-9 SAMPLE LOCATION MAP
CAVITE HOUSING AREA

DRAWN	DATE	FIGURE NO.
BEG	APR 2005	5-11
CHECKED	W.O. NO. 03886-518-045	

BIRCH CR.
BEECH ST.
PLUM ST.
OAK ST.
HOSPITAL RD.
LOCUST ST.
GRANT RD.
POPLAR ST.

Legend

- STREAM
- TOPO LINE (3m/10ft)
- OLD ROAD
- INSTALLATION BOUNDARY
- FILL AREA
- CUT AREA
- OPEN WATER
- WETLAND

EXCAVATIONS

- PESTICIDE REMEDIAL ACTION
- PCB EXCAVATION
- RECON BOUNDARIES

STRUCTURE

- CONCRETE
- FOUNDATION
- OTHER

FILL

- BERM
- MOUND
- PILE

DEPRESSION

- BORROW PIT
- EXCAVATION
- TRENCH

N

0 400 800 Feet

CULTURAL FEATURES WITHIN THE FORMER GRANT AND LOCUST HOUSING AREAS

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FIGURE 5-12

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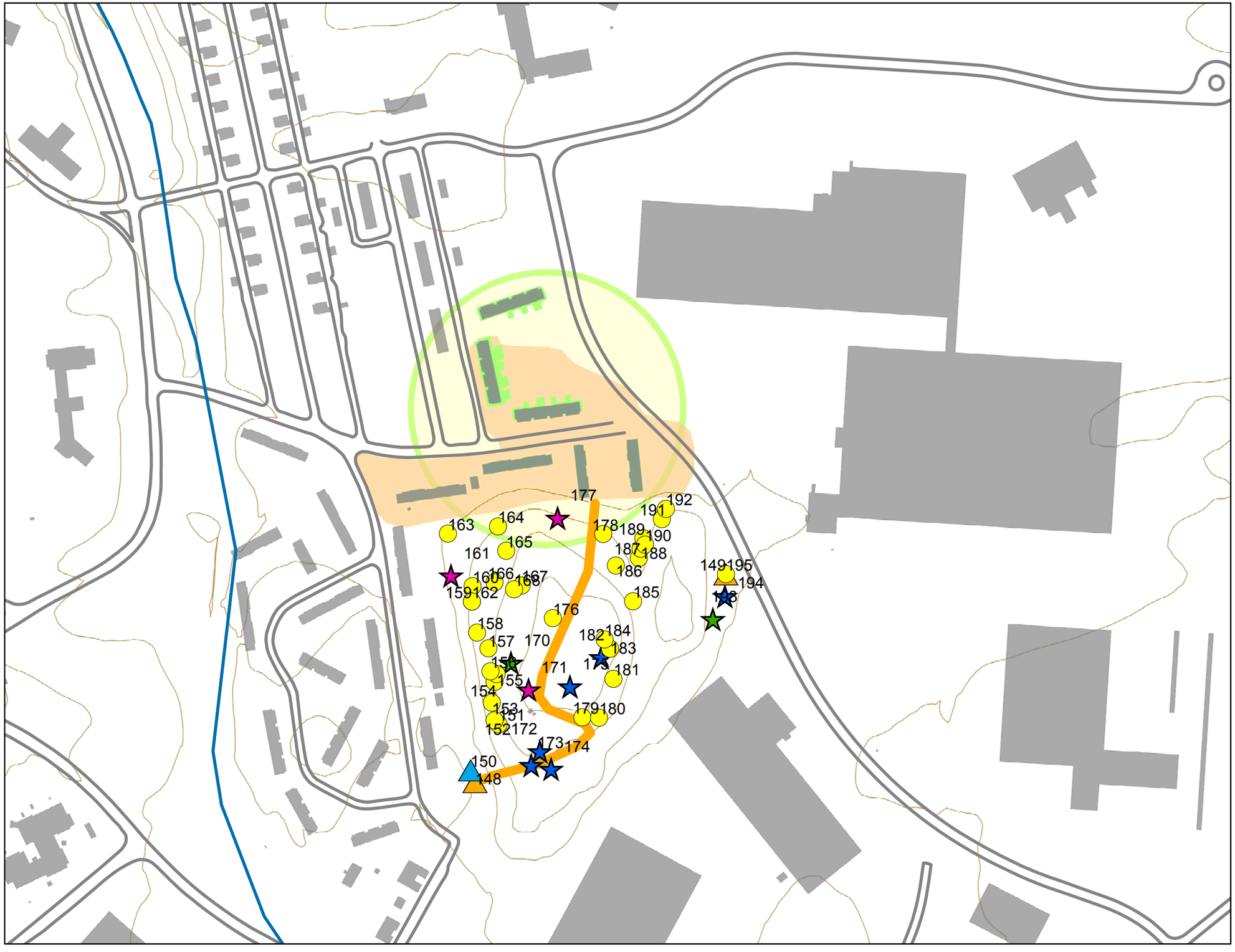
MARCH 2005



Legend

- STREAM
- TOPO LINE (3m/10ft)
- OLD ROAD
- INSTALLATION BOUNDARY
- FILL AREA
- CUT AREA
- OPEN WATER
- WETLAND

EXCAVATIONS

- PESTICIDE REMEDIAL ACTION
- PCB EXCAVATION
- RECON BOUNDARIES

STRUCTURE

- CONCRETE
- FOUNDATION
- OTHER

FILL

- BERM
- MOUND
- PILE

DEPRESSION

- BORROW PIT
- EXCAVATION
- TRENCH

N

0 200 400 Feet

CULTURAL FEATURES WITHIN THE FORMER CAVITE HOUSING AREA

PASI/SSI COMPREHENSIVE REPORT
STUDY AREA - GRANT, LOCUST, & CAVITE HOUSING AREAS
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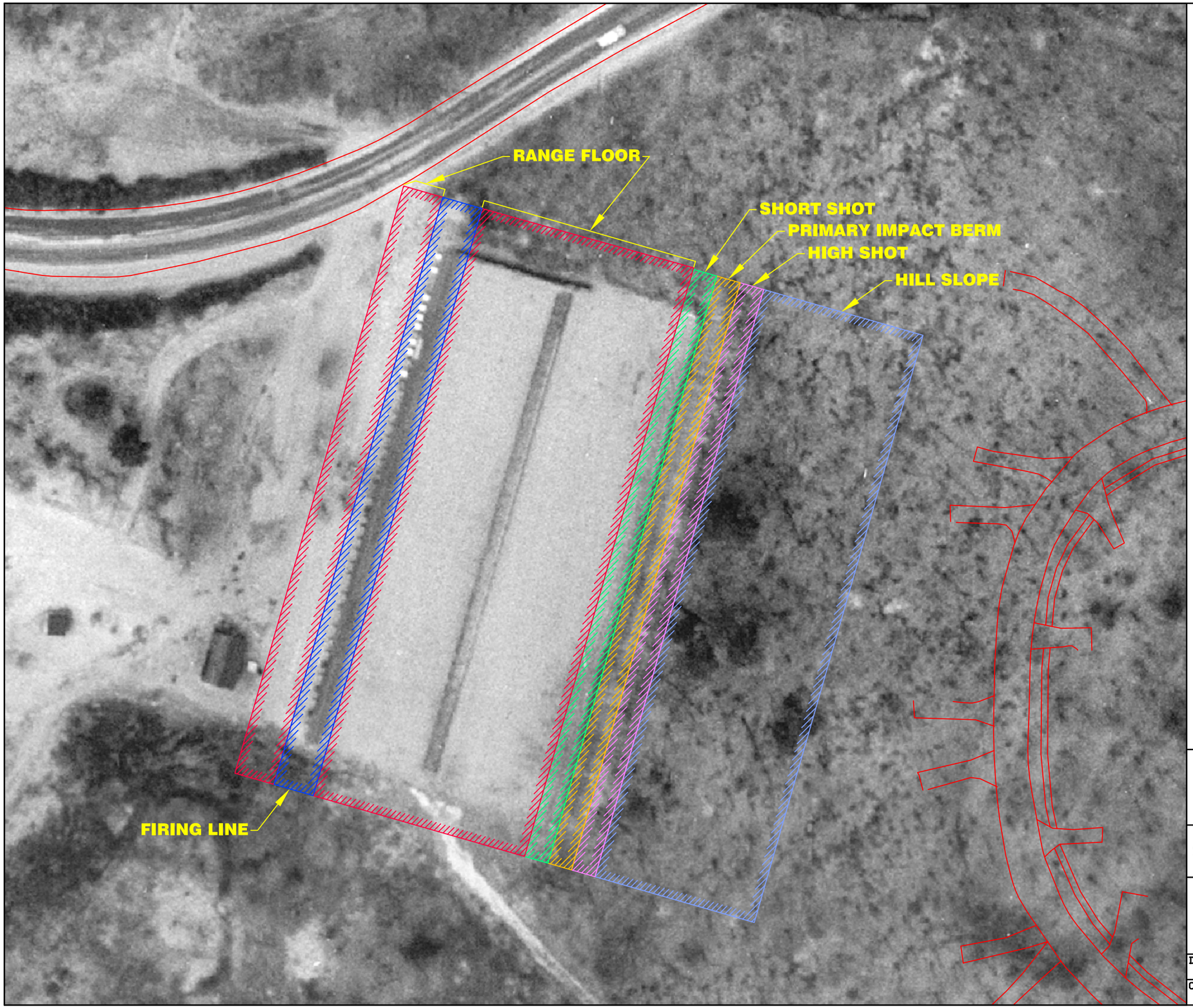
FIGURE 5-13

US Army Corps of Engineers®

MARCH 2005



GRAPHIC SCALE

60 30 0 30 60

APPROXIMATE SCALE IN FEET

SOURCE INFO:
– AERIAL PHOTO WAS TAKEN ON APRIL 28, 1959

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STUDY AREA – GRANT, LOCUST, AND CAVITE HOUSING AREAS
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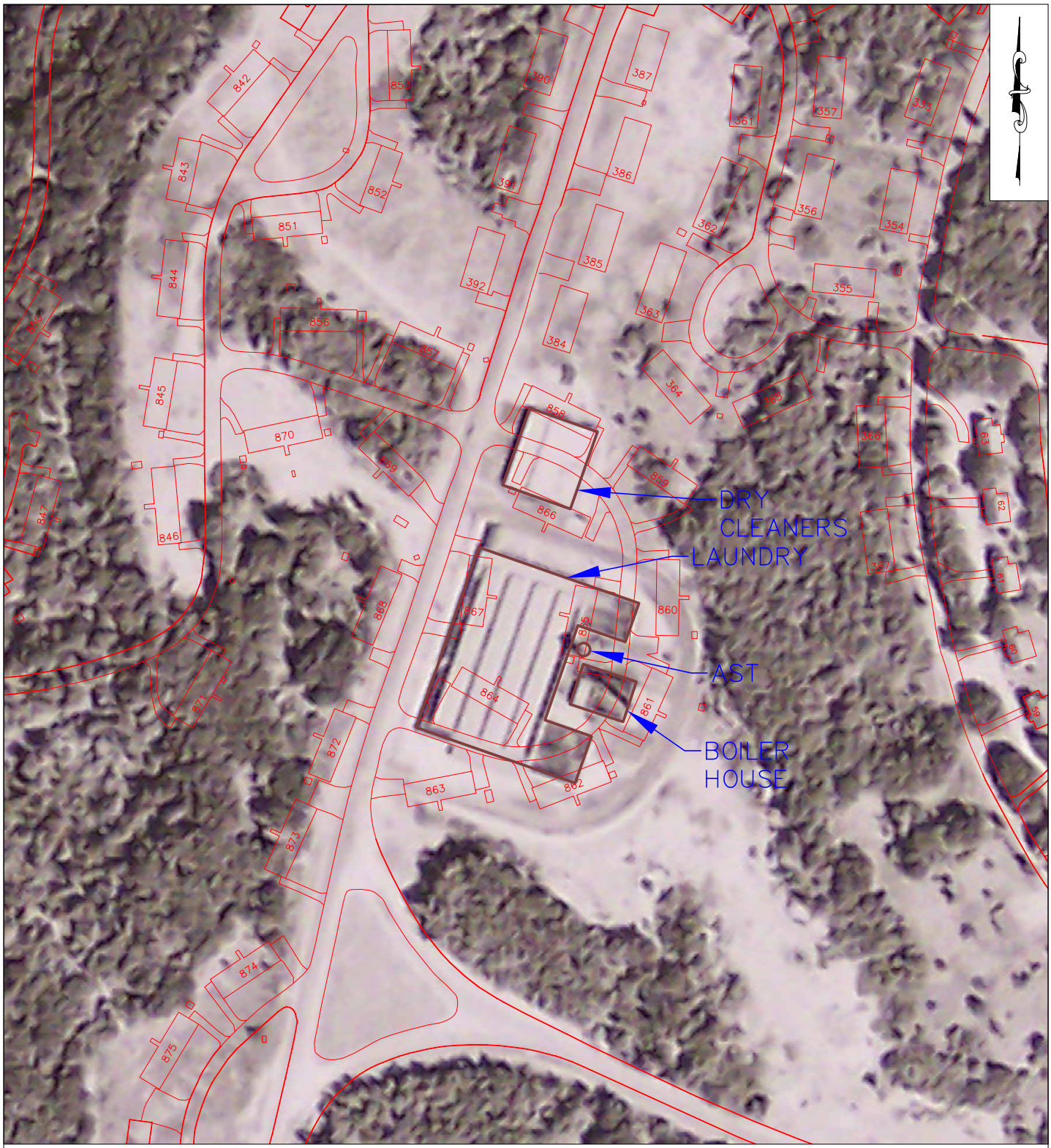
IA–6 OVERLAY MAP

DRAWN	DATE	FIGURE NO.
BEG	MAR 2005	5–14
CHECKED	W.O. NO. 03886.518.045	

M:\Design\DWG\ACOE\FTDEVENS\PASI-SSI FINAL REPORT\rev 2\FIG 5-14.dwg, Layout1, 4/21/2005 2:03:42 PM, girardeb, 1:1



AERIAL PHOTO DATE: 1952

PASI/SSI COMPREHENSIVE REPORT
STUDY AREA – GRANT, LOCUST, AND CAVITE HOUSING AREAS
DEVENS, MASSACHUSETTS

DEPARTMENT OF THE ARMY
NEW ENGLAND DISTRICT
CORPS OF ENGINEERS
CONCORD, MASSACHUSETTS

IA–8 OVERLAY MAP

WESTON SOLUTIONS
MANCHESTER NEW HAMPSHIRE

DRAWN BEG
DATE MAR 2005
FIGURE NO. 5–15

M:\Design\DWG\ACOE\FTDEVENS\PASI-SSI FINAL REPORT\rev 2\FIG 5-15.dwg, poplar circle, 4/21/2005 9:23:52 AM, girardeb, 1:1

TABLES

Table 3-1

Study Area Groundwater Elevations

Location	Top of Inner Casing Elevation (ft amsl)	Depth to Water (12/7/04)	Water Elevation (12/7/04)	Depth to Water (12/16/04)	Water Elevation (12/16/04)	Depth to Water (12/21/04)	Water Elevation (12/21/04)	Depth to Water (12/28/04)	Water Elevation (12/28/04)	Depth to Water (1/28/05)	Water Elevation (1/28/05)	Depth to Water (5/20/05)	Water Elevation (5/20/05)
MW-1	309.80			36.89	272.91	37.11	272.69	37.16	272.64	36.25	273.55	36.36	273.44
MW-2	306.41					34.64	271.77	34.73	271.68	34.17	272.24	34.32	272.09
MW-3	262.29	43.64	218.65			43.68	218.61	43.56	218.73	43.34	218.95	41.35	220.94
MW-4	233.88					16.24	217.64	15.61	218.27			14.00	219.88
PZ-1	311.15			33.83	277.32	33.34	277.81	33.21	277.94	32.18	278.97	31.92	279.23
PZ-2	306.24			33.78	272.46	33.15	273.09	33.17	273.07	32.46	273.78	32.60	273.64
PZ-3	299.82			26.63	273.19	26.80	273.02	27.01	272.81	27.39	272.43	20.88	278.94
PZ-4	238.25	20.29	217.96			20.35	217.90	20.22	218.03	21.13	217.12	19.04	219.21
PZ-5	234.16	11.49	222.67			11.24	222.92	11.11	223.05	12.74	221.42	7.63	226.53
PZ-6	274.65					47.33	227.32	47.20	227.45	46.01	228.64	41.54	233.11

Notes:
ft amsl = Feet above mean sea level. Elevations from survey by Guerriere and Halnon, Inc., Franklin, Massachusetts.

Table 4-1
Disposal Characterization Results-
Asbestos Containing Material (ACM)
Grant, Locust and Cavite Housing Areas
Devens, Massachusetts

Building Number	ACM Detected
137	Transite Pipe and Mastic
138	Transite Pipe and Mastic
144	None Detected
145	None Detected
146	Transite Pipe and Mastic
147	Mastic
308	Transite Pipe
309	Transite Pipe
310	Transite Pipe
311	Transite Pipe
312	Vapor Barrier
313	Vapor Barrier
314	None Detected
315	None Detected
316	None Detected
317	None Detected
318	None Detected
319	None Detected
328	None Detected
329	None Detected
330	None Detected
331	None Detected
332	None Detected
333	Vapor Barrier
342	None Detected
343	None Detected
344	None Detected
345	None Detected
346	None Detected
347	None Detected
348	None Detected
349	None Detected
350	None Detected
351	None Detected
352	None Detected
353	None Detected
354	None Detected
355	None Detected
356	None Detected
357	None Detected
358	None Detected
359	None Detected
360	None Detected
361	None Detected
362	None Detected

Building Number	ACM Detected
826	Transite Pipe
827	Transite Pipe
828	Transite Pipe
829	Transite Pipe
830	Transite Pipe
831	Transite Pipe
832	Transite Pipe
833	Transite Pipe
834	Transite Pipe
835	Transite Pipe
836	Transite Pipe
837	Transite Pipe
838	Transite Pipe
839	Transite Pipe
840	Transite Pipe
841	Transite Pipe
842	Transite Pipe
843	Transite Pipe
844	Transite Pipe
845	Transite Pipe
846	Transite Pipe
847	Transite Pipe
848	Transite Pipe
849	Transite Pipe
850	Transite Pipe
851	Transite Pipe
852	Transite Pipe
853	Transite Pipe
854	Transite Pipe
855	Transite Pipe
856	Transite Pipe and Mastic
857	Transite Pipe and Mastic
858	Transite Pipe
859	Transite Pipe
860	Transite Pipe
861	Transite Pipe
862	Transite Pipe
863	Transite Pipe
864	Transite Pipe
865	Transite Pipe
866	Transite Pipe
867	Transite Pipe
868	Transite Pipe
869	Transite Pipe
870	Transite Pipe

Table 4-1
Disposal Characterization Results-
Asbestos Containing Material (ACM)
Grant, Locust and Cavite Housing Areas
Devens, Massachusetts

363	None Detected
364	None Detected
365	None Detected
366	None Detected
367	None Detected
384	None Detected
385	None Detected
386	None Detected
387	None Detected
389	None Detected
390	None Detected
391	None Detected
392	None Detected
547	Transite Pipe
548	Transite Pipe
549	Transite Pipe
550	Transite Pipe
551	Transite Pipe
552	Transite Pipe
553	Transite Pipe
554	Transite Pipe
555	Transite Pipe
556	Transite Pipe
557	Transite Pipe
558	Transite Pipe
559	Transite Pipe
560	Transite Pipe
824	Transite Pipe
825	Transite Pipe

871	Transite Pipe
872	Transite Pipe
873	Transite Pipe
874	Transite Pipe
875	Transite Pipe
876	Transite Pipe
877	Transite Pipe
878	Transite Pipe
879	Transite Pipe
880	Transite Pipe
881	Transite Pipe
882	Transite Pipe
883	Transite Pipe
884	Transite Pipe
885	Transite Pipe
886	Transite Pipe
887	Transite Pipe
888	Transite Pipe
889	Transite Pipe
890	Transite Pipe
891	Transite Pipe
892	Transite Pipe
893	Transite Pipe
894	Transite Pipe
895	Transite Pipe
896	Transite Pipe
897	Transite Pipe
898	Transite Pipe
899	Transite Pipe

Table 4-2
Confirmatory Results Exceedence Report
Total Petroleum Hydrocarbons (TPH)
Comparison of Confirmatory Sampling Analytical Data to Project Clean-Up Goals

			Aliphatic C5 to C8	Aliphatic C9 to C12	Aliphatic C9 to C18	Aliphatic C19 to C36	Aromatic C9 to C10	Aromatic C11 to C22
Project Clean-up Goals (S-1):			*100*	*1000*	*1000*	*2500*	*100*	*200*
Building 387								
Offsite Laboratory Results								
Sample ID	**Depth**	**Date**						
PS-016A	(0-4)	10/15/2002	<0.0018	<0.0018	<0.0106	<0.0106	<0.0018	<0.0106
PS-016B	(0-4)	10/15/2002	<0.0021	<0.0021	<0.0106	<0.0106	<0.0021	<0.0106
PS-016C	(0-4)	10/15/2002	<0.0018	<0.0018	<0.0106	<0.0106	<0.0018	<0.0106
PS-016D	(0-4)	10/15/2002	<0.0015	<0.0015	<0.0106	0.0111	<0.0015	<0.0106
PS-016E	(0-4)	10/15/2002	<0.0017	<0.0017	<0.0106	<0.0106	<0.0017	<0.0106
Building 389								
Offsite Laboratory Results								
Sample ID	**Depth**	**Date**						
PS-020A	(0-4)	10/15/2002	<0.0019	<0.0019	<0.0105	<0.0105	<0.0019	<0.0105
PS-020B	(0-4)	10/15/2002	<0.0019	<0.0019	<0.0106	<0.0106	<0.0019	<0.0106
PS-020C	(0-4)	10/15/2002	<0.002	<0.002	<0.0106	<0.0106	<0.002	<0.0106
PS-020D	(0-4)	10/15/2002	<0.0019	<0.0019	<0.0106	<0.0106	<0.0019	<0.0106
PS-020E	(0-4)	10/15/2002	<0.0017	<0.0017	<0.0106	0.0135	<0.0017	0.0282
Building 392								
Offsite Laboratory Results								
Sample ID	**Depth**	**Date**						
PS-019A	(0-4)	10/11/2002	<0.0015	<0.0015	<0.0104	<0.0104	<0.0015	<0.0104
PS-019B	(0-4)	10/11/2002	<0.0018	<0.0018	<0.0104	<0.0104	<0.0018	<0.0104
PS-019C	(0-4)	10/11/2002	<0.002	<0.002	<0.0104	<0.0104	<0.002	<0.0104
PS-019D	(0-4)	10/11/2002	<0.0019	<0.0019	<0.0105	<0.0105	<0.0019	<0.0105
PS-019E	(0-4)	10/11/2002	<0.0019	<0.0019	<0.0105	<0.0105	<0.0019	<0.0105

***** All values reported in milligrams per kilogram (mg/kg) *****

Table 4-3

Disposal Characterization Results

Polycyclic Aromatic Hydrocarbons (PAHs)

Grant, Locust and Cavite Housing Area Devens
Massachusetts

					2-Chloronaphthalene	2-Methylnaphthalene	Acenaphthene	Acenaphthylene	Anthracene	Benzo(a)anthracene	Benzo(a)pyrene	Benzo(b)fluoranthene	Benzo(g,h,i)perylene	Benzo(k)fluoranthene	Chrysene	Dibenz(a,h)Anthracene	Fluoranthene	Fluorene	Indeno(1,2,3-c,d)Pyrene	Naphthalene	Phenanthrene	Pyrene
Project Clean-up Goals					*1000*	*4*	*20*	*1000*	*1000*	*0.7*	*0.7*	*0.7*	*1000*	*7*	*7*	*0.7*	*1000*	*400*	*0.7*	*4*	*700*	*700*
Date	**Bldg**	**Sample ID**	**Depth**	**Lab**																		
2/14/2002	867	PS-001	(0-4)	ALPHA	<0.64	<0.64	<0.64	<0.64	<0.64	**1.4**	**1.3**	**1.3**	0.69	1.1	1.3	<0.64	2.5	<0.64	**0.8**	<0.64	1.9	2.3
2/14/2002	866	PS-002	(0-4)	ALPHA	<0.63	<0.63	<0.63	<0.63	<0.63	<0.63	<0.63	<0.63	<0.63	<0.63	<0.63	<0.63	<0.63	<0.63	<0.63	<0.63	<0.63	<0.63
2/14/2002	865	PS-003	(0-4)	ALPHA	<0.64	<0.64	<0.64	<0.64	<0.64	<0.64	<0.64	<0.64	<0.64	<0.64	<0.64	<0.64	<0.64	<0.64	<0.64	<0.64	<0.64	<0.64
2/14/2002	861	PS-004	(0-4)	ALPHA	<0.63	<0.63	<0.63	<0.63	<0.63	<0.63	<0.63	<0.63	<0.63	<0.63	<0.63	<0.63	0.74	<0.63	<0.63	<0.63	<0.63	0.72
2/14/2002	860	PS-005	(0-4)	ALPHA	<0.62	<0.62	<0.62	<0.62	<0.62	<0.62	<0.62	<0.62	<0.62	<0.62	<0.62	<0.62	<0.62	<0.62	<0.62	<0.62	<0.62	<0.62
2/14/2002	859	PS-006	(0-4)	ALPHA	<0.62	<0.62	<0.62	<0.62	<0.62	<0.62	<0.62	<0.62	<0.62	<0.62	<0.62	<0.62	0.82	<0.62	<0.62	<0.62	0.76	0.66
2/14/2002	858	PS-007	(0-4)	ALPHA	<0.64	<0.64	<0.64	<0.64	<0.64	**0.74**	<0.64	**0.73**	<0.64	<0.64	0.74	<0.64	1.2	<0.64	<0.64	<0.64	<0.64	1.2
2/14/2002	864	PS-008	(0-4)	ALPHA	<0.64	<0.64	<0.64	<0.64	<0.64	<0.64	<0.64	<0.64	<0.64	<0.64	<0.64	<0.64	<0.64	<0.64	<0.64	<0.64	<0.64	<0.64
2/14/2002	863	PS-009	(0-4)	ALPHA	<0.62	<0.62	<0.62	<0.62	<0.62	<0.62	<0.62	<0.62	<0.62	<0.62	<0.62	<0.62	0.69	<0.62	<0.62	<0.62	<0.62	0.77
2/14/2002	862	PS-010	(0-4)	ALPHA	<0.63	<0.63	<0.63	<0.63	<0.63	**1.7**	**1.4**	**1.4**	0.81	1.2	1.5	<0.63	3	<0.63	**0.86**	<0.63	2.1	2.7
2/15/2002	869	PS-011	(0-4)	ALPHA	<0.62	<0.62	<0.62	<0.62	<0.62	<0.62	<0.62	<0.62	<0.62	<0.62	<0.62	<0.62	<0.62	<0.62	<0.62	<0.62	<0.62	<0.62
2/15/2002	868	PS-012	(0-4)	ALPHA	<0.62	<0.62	<0.62	<0.62	<0.62	<0.62	<0.62	<0.62	<0.62	<0.62	<0.62	<0.62	<0.62	<0.62	<0.62	<0.62	<0.62	<0.62
2/15/2002	384	PS-013	(0-4)	ALPHA	<1.3	<1.3	<1.3	<1.3	<1.3	<1.3	<1.3	<1.3	<1.3	<1.3	<1.3	<1.3	<1.3	<1.3	<1.3	<1.3	<1.3	<1.3
2/15/2002	385	PS-014	(0-4)	ALPHA	<3.2	<3.2	<3.2	<3.2	<3.2	<3.2	<3.2	<3.2	<3.2	<3.2	<3.2	<3.2	<3.2	<3.2	<3.2	<3.2	<3.2	<3.2
2/15/2002	386	PS-015	(0-4)	ALPHA	<0.63	<0.63	<0.63	<0.63	<0.63	<0.63	<0.63	<0.63	<0.63	<0.63	<0.63	<0.63	<0.63	<0.63	<0.63	<0.63	<0.63	<0.63
2/15/2002	387	PS-016	(0-4)	ALPHA	<0.64	<0.64	<0.64	<0.64	<0.64	<0.64	<0.64	<0.64	<0.64	<0.64	<0.64	<0.64	<0.64	<0.64	<0.64	<0.64	<0.64	<0.64
2/15/2002	390	PS-017	(0-4)	ALPHA	<0.64	<0.64	<0.64	<0.64	<0.64	<0.64	<0.64	<0.64	<0.64	<0.64	<0.64	<0.64	<0.64	<0.64	<0.64	<0.64	<0.64	<0.64
2/15/2002	391	PS-018	(0-4)	ALPHA	<0.64	<0.64	<0.64	<0.64	<0.64	<0.64	<0.64	<0.64	<0.64	<0.64	<0.64	<0.64	<0.64	<0.64	<0.64	<0.64	<0.64	<0.64
2/15/2002	392	PS-019	(0-4)	ALPHA	<1.3	<1.3	<1.3	<1.3	<1.3	<1.3	<1.3	<1.3	<1.3	<1.3	<1.3	<1.3	<1.3	<1.3	<1.3	<1.3	<1.3	<1.3

***** All values reported in milligrams per kilogram (mg/kg) *****

Table 4-3

Disposal Characterization Results

Polycyclic Aromatic Hydrocarbons (PAHs)

Grant, Locust and Cavite Housing Area Devens Massachusetts

					2-Chloronaphthalene	2-Methylnaphthalene	Acenaphthene	Acenaphthylene	Anthracene	Benzo(a)anthracene	Benzo(a)pyrene	Benzo(b)fluoranthene	Benzo(g,h,i)perylene	Benzo(k)fluoranthene	Chrysene	Dibenz(a,h)Anthracene	Fluoranthene	Fluorene	Indeno(1,2,3-c,d)Pyrene	Naphthalene	Phenanthrene	Pyrene
Project Clean-up Goals					*1000*	*4*	*20*	*1000*	*1000*	*0.7*	*0.7*	*0.7*	*1000*	*7*	*7*	*0.7*	*1000*	*400*	*0.7*	*4*	*700*	*700*
Date	**Bldg**	**Sample ID**	**Depth**	**Lab**																		
2/15/2002	389	PS-020	(0-4)	ALPHA	<1.3	<1.3	<1.3	<1.3	<1.3	<1.3	<1.3	<1.3	<1.3	<1.3	<1.3	<1.3	<1.3	<1.3	<1.3	<1.3	<1.3	<1.3
2/15/2002	857	PS-021	(0-4)	ALPHA	<0.62	<0.62	<0.62	<0.62	<0.62	<0.62	<0.62	<0.62	<0.62	<0.62	<0.62	<0.62	<0.62	<0.62	<0.62	<0.62	<0.62	<0.62
2/15/2002	856	PS-022	(0-4)	ALPHA	<0.61	<0.61	<0.61	<0.61	<0.61	<0.61	<0.61	<0.61	<0.61	<0.61	<0.61	<0.61	<0.61	<0.61	<0.61	<0.61	<0.61	<0.61
2/20/2002	147	PS-023	(0-4)	ALPHA	<0.65	<0.65	<0.65	<0.65	<0.65	<0.65	<0.65	<0.65	<0.65	<0.65	<0.65	<0.65	<0.65	<0.65	<0.65	<0.65	<0.65	<0.65
2/20/2002	147	PS-024	(0-4)	ALPHA	<0.64	<0.64	<0.64	<0.64	<0.64	<0.64	<0.64	<0.64	<0.64	<0.64	<0.64	<0.64	<0.64	<0.64	<0.64	<0.64	<0.64	<0.64
2/20/2002	145	PS-025	(0-4)	ALPHA	<0.64	<0.64	<0.64	<0.64	<0.64	<0.64	<0.64	<0.64	<0.64	<0.64	<0.64	<0.64	<0.64	<0.64	<0.64	<0.64	<0.64	<0.64
2/20/2002	145	PS-026	(0-4)	ALPHA	<0.67	<0.67	<0.67	<0.67	<0.67	<0.67	<0.67	<0.67	<0.67	<0.67	<0.67	<0.67	<0.67	<0.67	<0.67	<0.67	<0.67	<0.67
2/20/2002	144	PS-027	(0-4)	ALPHA	<0.64	<0.64	<0.64	<0.64	<0.64	<0.64	<0.64	<0.64	<0.64	<0.64	<0.64	<0.64	<0.64	<0.64	<0.64	<0.64	<0.64	<0.64
2/20/2002	144	PS-028	(0-4)	ALPHA	<0.64	<0.64	<0.64	<0.64	<0.64	<0.64	<0.64	<0.64	<0.64	<0.64	<0.64	<0.64	<0.64	<0.64	<0.64	<0.64	<0.64	<0.64
2/21/2002	146	PS-029	(0-4)	ALPHA	<0.62	<0.62	<0.62	<0.62	<0.62	<0.62	<0.62	<0.62	<0.62	<0.62	<0.62	<0.62	<0.62	<0.62	<0.62	<0.62	<0.62	<0.62
2/21/2002	146	PS-030	(0-4)	ALPHA	<0.63	<0.63	<0.63	<0.63	<0.63	<0.63	<0.63	<0.63	<0.63	<0.63	<0.63	<0.63	<0.63	<0.63	<0.63	<0.63	<0.63	<0.63
2/21/2002	137	PS-031	(0-4)	ALPHA	<0.64	<0.64	<0.64	<0.64	<0.64	<0.64	<0.64	<0.64	<0.64	<0.64	<0.64	<0.64	<0.64	<0.64	<0.64	<0.64	<0.64	<0.64
2/21/2002	137	PS-032	(0-4)	ALPHA	<0.63	<0.63	<0.63	<0.63	<0.63	<0.63	<0.63	<0.63	<0.63	<0.63	<0.63	<0.63	<0.63	<0.63	<0.63	<0.63	<0.63	<0.63
2/21/2002	138	PS-033	(0-4)	ALPHA	<0.63	<0.63	<0.63	<0.63	<0.63	<0.63	<0.63	<0.63	<0.63	<0.63	<0.63	<0.63	<0.63	<0.63	<0.63	<0.63	<0.63	<0.63
2/21/2002	138	PS-034	(0-4)	ALPHA	<0.62	<0.62	<0.62	<0.62	<0.62	<0.62	<0.62	<0.62	<0.62	<0.62	<0.62	<0.62	<0.62	<0.62	<0.62	<0.62	<0.62	<0.62
2/22/2002	851	PS-035	(0-4)	ALPHA	<0.63	<0.63	<0.63	<0.63	<0.63	<0.63	<0.63	<0.63	<0.63	<0.63	<0.63	<0.63	<0.63	<0.63	<0.63	<0.63	<0.63	<0.63
2/22/2002	852	PS-036	(0-4)	ALPHA	<0.63	<0.63	<0.63	<0.63	<0.63	<0.63	<0.63	<0.63	<0.63	<0.63	<0.63	<0.63	<0.63	<0.63	<0.63	<0.63	<0.63	<0.63
2/22/2002	853	PS-037	(0-4)	ALPHA	<0.64	<0.64	<0.64	<0.64	<0.64	<0.64	<0.64	<0.64	<0.64	<0.64	<0.64	<0.64	<0.64	<0.64	<0.64	<0.64	<0.64	<0.64
2/22/2002	854	PS-038	(0-4)	ALPHA	<0.63	<0.63	<0.63	<0.63	<0.63	<0.63	<0.63	<0.63	<0.63	<0.63	<0.63	<0.63	<0.63	<0.63	<0.63	<0.63	<0.63	<0.63

***** All values reported in milligrams per kilogram (mg/kg) *****

Table 4-3

Disposal Characterization Results

Polycyclic Aromatic Hydrocarbons (PAHs)

Grant, Locust and Cavite Housing Area Devens Massachusetts

					2-Chloronaphthalene	2-Methylnaphthalene	Acenaphthene	Acenaphthylene	Anthracene	Benzo(a)anthracene	Benzo(a)pyrene	Benzo(b)fluoranthene	Benzo(g,h,i)perylene	Benzo(k)fluoranthene	Chrysene	Dibenz(a,h)Anthracene	Fluoranthene	Fluorene	Indeno(1,2,3-c,d)Pyrene	Naphthalene	Phenanthrene	Pyrene
Project Clean-up Goals					*1000*	*4*	*20*	*1000*	*1000*	*0.7*	*0.7*	*0.7*	*1000*	*7*	*7*	*0.7*	*1000*	*400*	*0.7*	*4*	*700*	*700*
Date	**Bldg**	**Sample ID**	**Depth**	**Lab**																		
2/22/2002	855	PS-039	(0-4)	ALPHA	<0.64	<0.64	<0.64	<0.64	<0.64	<0.64	<0.64	<0.64	<0.64	<0.64	<0.64	<0.64	<0.64	<0.64	<0.64	<0.64	<0.64	<0.64
2/22/2002	840	PS-040	(0-4)	ALPHA	<0.62	<0.62	<0.62	<0.62	<0.62	<0.62	<0.62	<0.62	<0.62	<0.62	<0.62	<0.62	<0.62	<0.62	<0.62	<0.62	<0.62	<0.62
2/25/2002	841	PS-041	(0-4)	ALPHA	<0.63	<0.63	<0.63	<0.63	<0.63	<0.63	<0.63	<0.63	<0.63	<0.63	<0.63	<0.63	<0.63	<0.63	<0.63	<0.63	<0.63	<0.63
2/25/2002	842	PS-042	(0-4)	ALPHA	<0.64	<0.64	<0.64	<0.64	<0.64	<0.64	<0.64	<0.64	<0.64	<0.64	<0.64	<0.64	<0.64	<0.64	<0.64	<0.64	<0.64	<0.64
2/25/2002	843	PS-043	(0-4)	ALPHA	<0.63	<0.63	<0.63	<0.63	<0.63	<0.63	<0.63	<0.63	<0.63	<0.63	<0.63	<0.63	<0.63	<0.63	<0.63	<0.63	<0.63	<0.63
2/25/2002	844	PS-044	(0-4)	ALPHA	<0.62	<0.62	<0.62	<0.62	<0.62	<0.62	<0.62	<0.62	<0.62	<0.62	<0.62	<0.62	<0.62	<0.62	<0.62	<0.62	<0.62	<0.62
2/25/2002	845	PS-045	(0-4)	ALPHA	<0.62	<0.62	<0.62	<0.62	<0.62	<0.62	<0.62	<0.62	<0.62	<0.62	<0.62	<0.62	<0.62	<0.62	<0.62	<0.62	<0.62	<0.62
2/25/2002	870	PS-046	(0-4)	ALPHA	<0.62	<0.62	<0.62	<0.62	<0.62	<0.62	<0.62	<0.62	<0.62	<0.62	<0.62	<0.62	<0.62	<0.62	<0.62	<0.62	<0.62	<0.62
2/26/2002	875	PS-047	(0-4)	ALPHA	<0.64	<0.64	<0.64	<0.64	<0.64	<0.64	<0.64	<0.64	<0.64	<0.64	<0.64	<0.64	<0.64	<0.64	<0.64	<0.64	<0.64	<0.64
2/26/2002	874	PS-048	(0-4)	ALPHA	<0.62	<0.62	<0.62	<0.62	<0.62	<0.62	<0.62	<0.62	<0.62	<0.62	<0.62	<0.62	<0.62	<0.62	<0.62	<0.62	<0.62	<0.62
2/26/2002	873	PS-049	(0-4)	ALPHA	<0.64	<0.64	<0.64	<0.64	<0.64	<0.64	<0.64	<0.64	<0.64	<0.64	<0.64	<0.64	<0.64	<0.64	<0.64	<0.64	<0.64	<0.64
2/26/2002	872	PS-050	(0-4)	ALPHA	<0.63	<0.63	<0.63	<0.63	<0.63	<0.63	<0.63	<0.63	<0.63	<0.63	<0.63	<0.63	<0.63	<0.63	**0.87**	<0.63	<0.63	<0.63
2/26/2002	846	PS-051	(0-4)	ALPHA	<0.62	<0.62	<0.62	<0.62	<0.62	<0.62	<0.62	<0.62	<0.62	<0.62	<0.62	<0.62	<0.62	<0.62	<0.62	<0.62	<0.62	<0.62
2/26/2002	871	PS-052	(0-4)	ALPHA	<0.62	<0.62	<0.62	<0.62	<0.62	<0.62	<0.62	<0.62	<0.62	<0.62	<0.62	<0.62	<0.62	<0.62	<0.62	<0.62	<0.62	<0.62
2/27/2002	879	PS-053	(0-4)	ALPHA	<0.64	<0.64	<0.64	<0.64	<0.64	<0.64	<0.64	<0.64	<0.64	<0.64	<0.64	<0.64	<0.64	<0.64	<0.64	<0.64	<0.64	<0.64
2/27/2002	878	PS-054	(0-4)	ALPHA	<0.64	<0.64	<0.64	<0.64	<0.64	<0.64	<0.64	<0.64	<0.64	<0.64	<0.64	<0.64	<0.64	<0.64	<0.64	<0.64	<0.64	<0.64
2/27/2002	877	PS-055	(0-4)	ALPHA	<0.64	<0.64	<0.64	<0.64	<0.64	<0.64	<0.64	<0.64	<0.64	<0.64	<0.64	0.7	<0.64	<0.64	**0.95**	<0.64	<0.64	<0.64
2/27/2002	876	PS-056	(0-4)	ALPHA	<0.64	<0.64	<0.64	<0.64	<0.64	<0.64	<0.64	<0.64	<0.64	<0.64	<0.64	<0.64	<0.64	<0.64	<0.64	<0.64	<0.64	<0.64
2/28/2002	839	PS-057	(0-4)	ALPHA	<0.65	<0.65	<0.65	<0.65	<0.65	<0.65	<0.65	<0.65	<0.65	<0.65	<0.65	<0.65	<0.65	<0.65	<0.65	<0.65	<0.65	<0.65

***** All values reported in milligrams per kilogram (mg/kg) *****

Table 4-3

Disposal Characterization Results

Polycyclic Aromatic Hydrocarbons (PAHs)

Grant, Locust and Cavite Housing Area Devens Massachusetts

					2-Chloronaphthalene	2-Methylnaphthalene	Acenaphthene	Acenaphthylene	Anthracene	Benzo(a)anthracene	Benzo(a)pyrene	Benzo(b)fluoranthene	Benzo(g,h,i)perylene	Benzo(k)fluoranthene	Chrysene	Dibenz(a,h)Anthracene	Fluoranthene	Fluorene	Indeno(1,2,3-c,d)Pyrene	Naphthalene	Phenanthrene	Pyrene
Project Clean-up Goals					*1000*	*4*	*20*	*1000*	*1000*	*0.7*	*0.7*	*0.7*	*1000*	*7*	*7*	*0.7*	*1000*	*400*	*0.7*	*4*	*700*	*700*
Date	**Bldg**	**Sample ID**	**Depth**	**Lab**																		
2/28/2002	838	PS-058	(0-4)	ALPHA	<0.64	<0.64	<0.64	<0.64	<0.64	<0.64	<0.64	<0.64	<0.64	<0.64	<0.64	<0.64	<0.64	<0.64	<0.64	<0.64	<0.64	<0.64
2/28/2002	831	PS-059	(0-4)	ALPHA	<0.64	<0.64	<0.64	<0.64	<0.64	<0.64	<0.64	<0.64	<0.64	<0.64	<0.64	<0.64	<0.64	<0.64	<0.64	<0.64	<0.64	<0.64
2/28/2002	832	PS-060	(0-4)	ALPHA	<0.64	<0.64	<0.64	<0.64	<0.64	<0.64	<0.64	<0.64	<0.64	<0.64	<0.64	<0.64	<0.64	<0.64	<0.64	<0.64	<0.64	<0.64
2/28/2002	833	PS-061	(0-4)	ALPHA	<0.63	<0.63	<0.63	<0.63	<0.63	<0.63	<0.63	<0.63	<0.63	<0.63	<0.63	<0.63	<0.63	<0.63	<0.63	<0.63	<0.63	<0.63
2/28/2002	830	PS-062	(0-4)	ALPHA	<0.63	<0.63	<0.63	<0.63	<0.63	<0.63	<0.63	<0.63	<0.63	<0.63	<0.63	<0.63	<0.63	<0.63	<0.63	<0.63	<0.63	<0.63
2/28/2002	825	PS-063	(0-4)	ALPHA	<0.64	<0.64	<0.64	<0.64	<0.64	<0.64	<0.64	<0.64	<0.64	<0.64	<0.64	<0.64	<0.64	<0.64	<0.64	<0.64	<0.64	<0.64
2/28/2002	824	PS-064	(0-4)	ALPHA	<0.64	<0.64	<0.64	<0.64	<0.64	<0.64	<0.64	<0.64	<0.64	<0.64	<0.64	<0.64	<0.64	<0.64	<0.64	<0.64	<0.64	<0.64
3/1/2002	826	PS-065	(0-4)	ALPHA	<0.63	<0.63	<0.63	<0.63	<0.63	<0.63	<0.63	<0.63	<0.63	<0.63	<0.63	<0.63	<0.63	<0.63	<0.63	<0.63	<0.63	<0.63
3/1/2002	827	PS-066	(0-4)	ALPHA	<0.65	<0.65	<0.65	<0.65	<0.65	<0.65	<0.65	<0.65	<0.65	<0.65	<0.65	<0.65	<0.65	<0.65	<0.65	<0.65	<0.65	<0.65
3/1/2002	828	PS-067	(0-4)	ALPHA	<0.64	<0.64	<0.64	<0.64	<0.64	<0.64	<0.64	<0.64	<0.64	<0.64	<0.64	<0.64	<0.64	<0.64	<0.64	<0.64	<0.64	<0.64
3/1/2002	829	PS-068	(0-4)	ALPHA	<0.65	<0.65	<0.65	<0.65	<0.65	<0.65	<0.65	<0.65	<0.65	<0.65	<0.65	<0.65	<0.65	<0.65	<0.65	<0.65	<0.65	<0.65
3/1/2002	837	PS-069	(0-4)	ALPHA	<0.64	<0.64	<0.64	<0.64	<0.64	<0.64	<0.64	<0.64	<0.64	<0.64	<0.64	<0.64	<0.64	<0.64	<0.64	<0.64	<0.64	<0.64
3/1/2002	834	PS-070	(0-4)	ALPHA	<0.64	<0.64	<0.64	<0.64	<0.64	<0.64	<0.64	<0.64	<0.64	<0.64	<0.64	<0.64	<0.64	<0.64	<0.64	<0.64	<0.64	<0.64
3/1/2002	836	PS-071	(0-4)	ALPHA	<0.64	<0.64	<0.64	<0.64	<0.64	<0.64	<0.64	<0.64	<0.64	<0.64	<0.64	<0.64	<0.64	<0.64	<0.64	<0.64	<0.64	<0.64
3/5/2002	865	PS-072	(0-4)	ALPHA	<0.63	<0.63	<0.63	<0.63	<0.63	<0.63	<0.63	<0.63	<0.63	<0.63	<0.63	<0.63	<0.63	<0.63	<0.63	<0.63	<0.63	<0.63
3/5/2002	866	PS-073	(0-4)	ALPHA	<1.3	<1.3	<1.3	<1.3	<1.3	**1.8**	**1.9**	**1.5**	1.3	1.7	2	<1.3	2.5	<1.3	<1.3	<1.3	<1.3	2.9
3/6/2002	864	PS-074	(0-4)	ALPHA	<0.63	<0.63	<0.63	<0.63	<0.63	**1.3**	**1.2**	**0.97**	0.8	1.2	1.4	<0.63	2.8	<0.63	**0.88**	<0.63	1.8	2.4
3/6/2002	560	PS-075	(0-4)	ALPHA	<0.63	<0.63	<0.63	<0.63	<0.63	<0.63	<0.63	<0.63	<0.63	<0.63	<0.63	<0.63	<0.63	<0.63	<0.63	<0.63	<0.63	<0.63
3/6/2002	559	PS-076	(0-4)	ALPHA	<0.62	<0.62	<0.62	<0.62	<0.62	<0.62	<0.62	<0.62	<0.62	<0.62	<0.62	<0.62	<0.62	<0.62	<0.62	<0.62	<0.62	<0.62

***** All values reported in milligrams per kilogram (mg/kg) *****

Table 4-3

Disposal Characterization Results

Polycyclic Aromatic Hydrocarbons (PAHs)

Grant, Locust and Cavite Housing Area Devens Massachusetts

					2-Chloronaphthalene	2-Methylnaphthalene	Acenaphthene	Acenaphthylene	Anthracene	Benzo(a)anthracene	Benzo(a)pyrene	Benzo(b)fluoranthene	Benzo(g,h,i)perylene	Benzo(k)fluoranthene	Chrysene	Dibenz(a,h)Anthracene	Fluoranthene	Fluorene	Indeno(1,2,3-c,d)Pyrene	Naphthalene	Phenanthrene	Pyrene
Project Clean-up Goals					*1000*	*4*	*20*	*1000*	*1000*	*0.7*	*0.7*	*0.7*	*1000*	*7*	*7*	*0.7*	*1000*	*400*	*0.7*	*4*	*700*	*700*
Date	**Bldg**	**Sample ID**	**Depth**	**Lab**																		
3/6/2002	556	PS-077	(0-4)	ALPHA	<0.62	<0.62	<0.62	<0.62	<0.62	<0.62	<0.62	<0.62	<0.62	<0.62	<0.62	<0.62	<0.62	<0.62	<0.62	<0.62	<0.62	<0.62
3/6/2002	557	PS-078	(0-4)	ALPHA	<0.62	<0.62	<0.62	<0.62	<0.62	<0.62	<0.62	<0.62	<0.62	<0.62	<0.62	<0.62	<0.62	<0.62	<0.62	<0.62	<0.62	<0.62
3/6/2002	863	PS-079	(0-4)	ALPHA	<0.63	<0.63	<0.63	<0.63	<0.63	<0.63	<0.63	<0.63	<0.63	<0.63	<0.63	<0.63	<0.63	<0.63	<0.63	<0.63	<0.63	<0.63
3/11/2002	555	PS-080	(0-4)	ALPHA	<0.64	<0.64	<0.64	<0.64	<0.64	<0.64	<0.64	<0.64	<0.64	<0.64	<0.64	<0.64	<0.64	<0.64	<0.64	<0.64	<0.64	<0.64
3/11/2002	554	PS-081	(0-4)	ALPHA	<0.62	<0.62	<0.62	<0.62	<0.62	<0.62	<0.62	<0.62	<0.62	<0.62	<0.62	<0.62	<0.62	<0.62	<0.62	<0.62	<0.62	<0.62
3/11/2002	553	PS-082	(0-4)	ALPHA	<0.62	<0.62	<0.62	<0.62	<0.62	<0.62	<0.62	<0.62	<0.62	<0.62	<0.62	<0.62	<0.62	<0.62	<0.62	<0.62	<0.62	<0.62
3/12/2002	558	PS-083	(0-4)	ALPHA	<0.64	<0.64	<0.64	<0.64	<0.64	<0.64	<0.64	<0.64	<0.64	<0.64	<0.64	<0.64	<0.64	<0.64	<0.64	<0.64	<0.64	<0.64
3/12/2002	547	PS-084	(0-4)	ALPHA	<0.62	<0.62	<0.62	<0.62	<0.62	<0.62	<0.62	<0.62	<0.62	<0.62	<0.62	<0.62	<0.62	<0.62	<0.62	<0.62	<0.62	<0.62
3/12/2002	552	PS-085	(0-4)	ALPHA	<0.62	<0.62	<0.62	<0.62	<0.62	<0.62	<0.62	<0.62	<0.62	<0.62	<0.62	<0.62	<0.62	<0.62	<0.62	<0.62	<0.62	<0.62
3/12/2002	548	PS-086	(0-4)	ALPHA	<0.63	<0.63	<0.63	<0.63	<0.63	<0.63	<0.63	<0.63	<0.63	<0.63	<0.63	<0.63	<0.63	<0.63	<0.63	<0.63	<0.63	<0.63
3/12/2002	549	PS-087	(0-4)	ALPHA	<0.62	<0.62	<0.62	<0.62	<0.62	<0.62	<0.62	<0.62	<0.62	<0.62	<0.62	<0.62	<0.62	<0.62	<0.62	<0.62	<0.62	<0.62
3/13/2002	550	PS-088	(0-4)	ALPHA	<0.61	<0.61	<0.61	<0.61	<0.61	<0.61	<0.61	<0.61	<0.61	<0.61	<0.61	<0.61	<0.61	<0.61	<0.61	<0.61	<0.61	<0.61
3/13/2002	551	PS-089	(0-4)	ALPHA	<0.61	<0.61	<0.61	<0.61	<0.61	<0.61	<0.61	<0.61	<0.61	<0.61	<0.61	<0.61	<0.61	<0.61	<0.61	<0.61	<0.61	<0.61
3/13/2002	308	PS-090	(0-4)	ALPHA	<0.62	<0.62	<0.62	<0.62	<0.62	<0.62	<0.62	<0.62	<0.62	<0.62	<0.62	<0.62	<0.62	<0.62	<0.62	<0.62	<0.62	<0.62
3/14/2002	309	PS-091	(0-4)	ALPHA	<0.63	<0.63	<0.63	<0.63	<0.63	<0.63	<0.63	<0.63	<0.63	<0.63	<0.63	<0.63	<0.63	<0.63	<0.63	<0.63	<0.63	<0.63
3/14/2002	310	PS-092	(0-4)	ALPHA	<0.62	<0.62	<0.62	<0.62	<0.62	<0.62	<0.62	<0.62	<0.62	<0.62	<0.62	<0.62	<0.62	<0.62	<0.62	<0.62	<0.62	<0.62
3/14/2002	311	PS-093	(0-4)	ALPHA	<0.62	<0.62	<0.62	<0.62	<0.62	<0.62	<0.62	<0.62	<0.62	<0.62	<0.62	<0.62	<0.62	<0.62	<0.62	<0.62	<0.62	<0.62
3/15/2002	313	PS-094	(0-4)	ALPHA	<0.65	<0.65	1.5	<0.65	2.6	**3.6**	**3.1**	**2.5**	1.9	2.6	3.3	<0.65	9	1.3	**2.1**	<0.65	9.7	7.4
3/15/2002	312	PS-095	(0-4)	ALPHA	<0.64	<0.64	<0.64	<0.64	<0.64	<0.64	<0.64	<0.64	<0.64	<0.64	<0.64	<0.64	<0.64	<0.64	<0.64	<0.64	<0.64	<0.64

***** All values reported in milligrams per kilogram (mg/kg) *****

Table 4-3

Disposal Characterization Results

Polycyclic Aromatic Hydrocarbons (PAHs)

Grant, Locust and Cavite Housing Area Devens
Massachusetts

					2-Chloronaphthalene	2-Methylnaphthalene	Acenaphthene	Acenaphthylene	Anthracene	Benzo(a)anthracene	Benzo(a)pyrene	Benzo(b)fluoranthene	Benzo(g,h,i)perylene	Benzo(k)fluoranthene	Chrysene	Dibenz(a,h)Anthracene	Fluoranthene	Fluorene	Indeno(1,2,3-c,d)Pyrene	Naphthalene	Phenanthrene	Pyrene
Project Clean-up Goals					*1000*	*4*	*20*	*1000*	*1000*	*0.7*	*0.7*	*0.7*	*1000*	*7*	*7*	*0.7*	*1000*	*400*	*0.7*	*4*	*700*	*700*
Date	**Bldg**	**Sample ID**	**Depth**	**Lab**																		
3/15/2002	314	PS-096	(0-4)	ALPHA	<0.65	<0.65	<0.65	<0.65	<0.65	<0.65	<0.65	<0.65	<0.65	<0.65	<0.65	<0.65	<0.65	<0.65	<0.65	<0.65	<0.65	<0.65
3/15/2002	315	PS-097	(0-4)	ALPHA	<0.64	<0.64	<0.64	<0.64	<0.64	<0.64	<0.64	<0.64	<0.64	<0.64	<0.64	<0.64	<0.64	<0.64	<0.64	<0.64	<0.64	<0.64
3/18/2002	316	PS-098	(0-4)	ALPHA	<0.64	<0.64	<0.64	<0.64	<0.64	<0.64	<0.64	<0.64	<0.64	<0.64	<0.64	<0.64	<0.64	<0.64	<0.64	<0.64	<0.64	<0.64
3/18/2002	344	PS-099	(0-4)	ALPHA	<0.65	<0.65	<0.65	<0.65	<0.65	<0.65	<0.65	<0.65	<0.65	<0.65	<0.65	<0.65	<0.65	<0.65	<0.65	<0.65	<0.65	<0.65
3/18/2002	345	PS-100	(0-4)	ALPHA	<0.64	<0.64	<0.64	<0.64	<0.64	<0.64	<0.64	<0.64	<0.64	<0.64	<0.64	<0.64	<0.64	<0.64	<0.64	<0.64	<0.64	<0.64
3/18/2002	350	PS-101	(0-4)	ALPHA	<0.64	<0.64	<0.64	<0.64	<0.64	<0.64	<0.64	<0.64	<0.64	<0.64	<0.64	<0.64	<0.64	<0.64	<0.64	<0.64	<0.64	<0.64
3/18/2002	351	PS-102	(0-4)	ALPHA	<0.64	<0.64	<0.64	<0.64	<0.64	<0.64	<0.64	<0.64	<0.64	<0.64	<0.64	<0.64	<0.64	<0.64	<0.64	<0.64	<0.64	<0.64
3/18/2002	352	PS-103	(0-4)	ALPHA	<0.64	<0.64	<0.64	<0.64	<0.64	<0.64	<0.64	<0.64	<0.64	<0.64	<0.64	<0.64	<0.64	<0.64	<0.64	<0.64	<0.64	<0.64
3/19/2002	353	PS-104	(0-4)	ALPHA	<0.64	<0.64	<0.64	<0.64	<0.64	<0.64	<0.64	<0.64	<0.64	<0.64	<0.64	<0.64	<0.64	<0.64	<0.64	<0.64	<0.64	<0.64
3/19/2002	333	PS-105	(0-4)	ALPHA	<0.64	<0.64	<0.64	<0.64	<0.64	<0.64	<0.64	<0.64	<0.64	<0.64	<0.64	<0.64	<0.64	<0.64	<0.64	<0.64	<0.64	<0.64
3/19/2002	354	PS-106	(0-4)	ALPHA	<0.64	<0.64	<0.64	<0.64	<0.64	<0.64	<0.64	<0.64	<0.64	<0.64	<0.64	<0.64	<0.64	<0.64	<0.64	<0.64	<0.64	<0.64
3/19/2002	366	PS-107	(0-4)	ALPHA	<0.65	<0.65	<0.65	<0.65	<0.65	<0.65	<0.65	<0.65	<0.65	<0.65	<0.65	<0.65	<0.65	<0.65	<0.65	<0.65	<0.65	<0.65
3/19/2002	367	PS-108	(0-4)	ALPHA	<0.67	<0.67	<0.67	<0.67	<0.67	<0.67	<0.67	<0.67	<0.67	<0.67	<0.67	<0.67	<0.67	<0.67	<0.67	<0.67	<0.67	<0.67
3/19/2002	355	PS-109	(0-4)	ALPHA	<0.64	<0.64	<0.64	<0.64	<0.64	<0.64	<0.64	<0.64	<0.64	<0.64	<0.64	<0.64	<0.64	<0.64	<0.64	<0.64	<0.64	<0.64
3/20/2002	318	PS-110	(0-4)	ALPHA	<0.64	<0.64	<0.64	<0.64	<0.64	<0.64	<0.64	<0.64	<0.64	<0.64	<0.64	<0.64	<0.64	<0.64	<0.64	<0.64	<0.64	<0.64
3/20/2002	317	PS-111	(0-4)	ALPHA	<0.64	<0.64	<0.64	<0.64	<0.64	<0.64	<0.64	<0.64	<0.64	<0.64	<0.64	<0.64	<0.64	<0.64	<0.64	<0.64	<0.64	<0.64
3/20/2002	343	PS-112	(0-4)	ALPHA	<0.64	<0.64	<0.64	<0.64	<0.64	<0.64	<0.64	<0.64	<0.64	<0.64	<0.64	<0.64	<0.64	<0.64	<0.64	<0.64	<0.64	<0.64
3/20/2002	319	PS-113	(0-4)	ALPHA	<0.64	<0.64	<0.64	<0.64	<0.64	<0.64	<0.64	<0.64	<0.64	<0.64	<0.64	<0.64	<0.64	<0.64	<0.64	<0.64	<0.64	<0.64
3/20/2002	346	PS-114	(0-4)	ALPHA	<0.64	<0.64	<0.64	<0.64	<0.64	<0.64	<0.64	<0.64	<0.64	<0.64	<0.64	<0.64	<0.64	<0.64	<0.64	<0.64	<0.64	<0.64

***** All values reported in milligrams per kilogram (mg/kg) *****

Table 4-3

Disposal Characterization Results

Polycyclic Aromatic Hydrocarbons (PAHs)

Grant, Locust and Cavite Housing Area Devens
Massachusetts

					2-Chloronaphthalene	2-Methylnaphthalene	Acenaphthene	Acenaphthylene	Anthracene	Benzo(a)anthracene	Benzo(a)pyrene	Benzo(b)fluoranthene	Benzo(g,h,i)perylene	Benzo(k)fluoranthene	Chrysene	Dibenz(a,h)Anthracene	Fluoranthene	Fluorene	Indeno(1,2,3-c,d)Pyrene	Naphthalene	Phenanthrene	Pyrene
Project Clean-up Goals					*1000*	*4*	*20*	*1000*	*1000*	*0.7*	*0.7*	*0.7*	*1000*	*7*	*7*	*0.7*	*1000*	*400*	*0.7*	*4*	*700*	*700*
Date	**Bldg**	**Sample ID**	**Depth**	**Lab**																		
3/20/2002	347	PS-115	(0-4)	ALPHA	<0.64	<0.64	<0.64	<0.64	<0.64	<0.64	<0.64	<0.64	<0.64	<0.64	<0.64	<0.64	<0.64	<0.64	<0.64	<0.64	<0.64	<0.64
3/21/2002	348	PS-116	(0-4)	ALPHA	<0.64	<0.64	<0.64	<0.64	<0.64	<0.64	<0.64	<0.64	<0.64	<0.64	<0.64	<0.64	<0.64	<0.64	<0.64	<0.64	<0.64	<0.64
3/21/2002	349	PS-117	(0-4)	ALPHA	<0.64	<0.64	<0.64	<0.64	<0.64	<0.64	<0.64	<0.64	<0.64	<0.64	<0.64	<0.64	<0.64	<0.64	<0.64	<0.64	<0.64	<0.64
3/21/2002	359	PS-118	(0-4)	ALPHA	<0.64	<0.64	<0.64	<0.64	<0.64	<0.64	<0.64	<0.64	<0.64	<0.64	<0.64	<0.64	<0.64	<0.64	<0.64	<0.64	<0.64	<0.64
3/21/2002	358	PS-119	(0-4)	ALPHA	<0.65	<0.65	<0.65	<0.65	<0.65	<0.65	<0.65	<0.65	<0.65	<0.65	<0.65	<0.65	<0.65	<0.65	<0.65	<0.65	<0.65	<0.65
3/21/2002	357	PS-120	(0-4)	ALPHA	<0.64	<0.64	<0.64	<0.64	<0.64	<0.64	<0.64	<0.64	<0.64	<0.64	<0.64	<0.64	<0.64	<0.64	<0.64	<0.64	<0.64	<0.64
3/21/2002	356	PS-121	(0-4)	ALPHA	<0.64	<0.64	<0.64	<0.64	<0.64	<0.64	<0.64	<0.64	<0.64	<0.64	<0.64	<0.64	<0.64	<0.64	<0.64	<0.64	<0.64	<0.64
3/21/2002	146	PS-122	(0-4)	ALPHA	<0.64	<0.64	<0.64	<0.64	<0.64	<0.64	<0.64	<0.64	<0.64	<0.64	<0.64	<0.64	<0.64	<0.64	<0.64	<0.64	<0.64	<0.64
3/21/2002	146	PS-123	(0-4)	ALPHA	<0.64	<0.64	<0.64	<0.64	<0.64	<0.64	<0.64	<0.64	<0.64	<0.64	<0.64	<0.64	<0.64	<0.64	<0.64	<0.64	<0.64	<0.64
3/22/2002	365	PS-124	(0-4)	ALPHA	<0.66	<0.66	<0.66	<0.66	<0.66	<0.66	<0.66	<0.66	<0.66	<0.66	<0.66	<0.66	<0.66	<0.66	<0.66	<0.66	<0.66	<0.66
3/22/2002	364	PS-125	(0-4)	ALPHA	<0.68	<0.68	<0.68	<0.68	<0.68	<0.68	<0.68	<0.68	<0.68	<0.68	<0.68	<0.68	<0.68	<0.68	<0.68	<0.68	<0.68	<0.68
3/22/2002	363	PS-126	(0-4)	ALPHA	<0.65	<0.65	<0.65	<0.65	<0.65	<0.65	<0.65	<0.65	<0.65	<0.65	<0.65	<0.65	<0.65	<0.65	<0.65	<0.65	<0.65	<0.65
3/22/2002	362	PS-127	(0-4)	ALPHA	<0.64	<0.64	<0.64	<0.64	<0.64	<0.64	<0.64	<0.64	<0.64	<0.64	<0.64	<0.64	<0.64	<0.64	<0.64	<0.64	<0.64	<0.64
3/22/2002	361	PS-128	(0-4)	ALPHA	<0.64	<0.64	<0.64	<0.64	<0.64	<0.64	<0.64	<0.64	<0.64	<0.64	<0.64	<0.64	<0.64	<0.64	<0.64	<0.64	<0.64	<0.64
3/22/2002	360	PS-129	(0-4)	ALPHA	<0.64	<0.64	<0.64	<0.64	<0.64	<0.64	<0.64	<0.64	<0.64	<0.64	<0.64	<0.64	<0.64	<0.64	<0.64	<0.64	<0.64	<0.64
3/22/2002	N/A	PS-130	(0-4)	GPL	<0.037	<0.034	<0.043	<0.12	<0.052	<0.034	<0.03	<0.074	<0.074	<0.057	<0.045	<0.059	<0.077	<0.054	<0.055	<0.046	<0.043	<0.072
3/22/2002	N/A	PS-131	(0-4)	GPL	<0.037	<0.033	<0.043	<0.11	<0.051	<0.033	<0.029	<0.073	<0.073	<0.056	<0.045	<0.058	<0.076	<0.053	<0.054	<0.046	<0.043	<0.071
3/25/2002	332	PS-132	(0-4)	GPL	<0.037	<0.034	<0.043	<0.12	<0.052	0.087	0.12	0.14	0.11	<0.057	0.09	<0.059	0.11	<0.054	0.073	<0.047	<0.043	0.11
3/25/2002	331	PS-133	(0-4)	GPL	<0.04	<0.037	<0.047	<0.13	<0.056	0.043	0.04	<0.08	<0.08	<0.062	<0.049	<0.064	<0.083	<0.058	<0.059	<0.05	<0.047	<0.078

***** All values reported in milligrams per kilogram (mg/kg) *****

Table 4-3

Disposal Characterization Results

Polycyclic Aromatic Hydrocarbons (PAHs)

Grant, Locust and Cavite Housing Area Devens Massachusetts

					2-Chloronaphthalene	2-Methylnaphthalene	Acenaphthene	Acenaphthylene	Anthracene	Benzo(a)anthracene	Benzo(a)pyrene	Benzo(b)fluoranthene	Benzo(g,h,i)perylene	Benzo(k)fluoranthene	Chrysene	Dibenz(a,h)Anthracene	Fluoranthene	Fluorene	Indeno(1,2,3-c,d)Pyrene	Naphthalene	Phenanthrene	Pyrene
Project Clean-up Goals					*1000*	*4*	*20*	*1000*	*1000*	*0.7*	*0.7*	*0.7*	*1000*	*7*	*7*	*0.7*	*1000*	*400*	*0.7*	*4*	*700*	*700*
Date	**Bldg**	**Sample ID**	**Depth**	**Lab**																		
3/25/2002	330	PS-134	(0-4)	GPL	<0.038	<0.034	<0.044	<0.12	<0.053	<0.034	<0.03	<0.075	<0.075	<0.058	<0.046	<0.06	<0.078	<0.055	<0.056	<0.047	<0.044	<0.073
3/25/2002	329	PS-135	(0-4)	GPL	<0.037	<0.034	<0.043	<0.12	<0.052	<0.034	<0.03	<0.074	<0.074	<0.057	<0.045	<0.059	<0.077	<0.054	<0.055	<0.046	<0.043	<0.072
3/25/2002	328	PS-136	(0-4)	GPL	<0.037	<0.034	<0.044	<0.12	<0.052	<0.034	<0.03	<0.074	<0.074	<0.057	<0.046	<0.06	<0.078	<0.054	<0.055	<0.047	<0.044	<0.072
3/25/2002	342	PS-137	(0-4)	GPL	<0.037	<0.034	<0.044	<0.12	<0.052	0.044	0.051	<0.074	<0.074	<0.057	0.046	<0.06	<0.078	<0.054	<0.055	<0.047	<0.044	0.073
3/26/2002	835	PS-138	(0-4)	GPL	<0.036	<0.033	<0.042	<0.11	<0.05	<0.033	<0.029	<0.072	<0.072	<0.055	<0.044	<0.057	<0.075	<0.052	<0.053	<0.045	<0.042	<0.07
3/26/2002	835	PS-139	(0-4)	GPL	<0.036	<0.033	<0.043	<0.11	<0.051	<0.033	<0.029	<0.073	<0.073	<0.056	<0.045	<0.058	<0.076	<0.053	<0.054	<0.046	<0.043	<0.071
3/26/2002	850	PS-140	(0-4)	GPL	<0.037	<0.034	<0.043	<0.12	<0.051	<0.034	<0.029	<0.073	<0.073	<0.057	<0.045	<0.059	<0.076	<0.053	<0.054	<0.046	<0.043	<0.071
4/3/2002	849	PS-141	(0-4)	GPL	<0.037	<0.033	<0.043	<0.12	<0.051	<0.033	<0.029	<0.073	<0.073	<0.057	<0.045	<0.059	<0.076	<0.053	<0.054	<0.046	<0.043	<0.071
4/3/2002	888	PS-142	(0-4)	GPL	<0.036	<0.033	<0.043	<0.11	<0.051	<0.033	<0.029	<0.073	<0.073	<0.056	<0.045	<0.058	<0.076	<0.053	<0.054	<0.046	<0.043	<0.071
4/3/2002	887	PS-143	(0-4)	GPL	<0.037	<0.034	<0.043	<0.12	<0.051	<0.034	<0.029	<0.073	<0.073	<0.057	<0.045	<0.059	<0.077	<0.054	<0.055	<0.046	<0.043	<0.071
4/3/2002	886	PS-144	(0-4)	GPL	<0.037	<0.034	<0.043	<0.12	<0.052	<0.034	<0.03	<0.074	<0.074	<0.057	<0.045	<0.059	<0.077	<0.054	<0.055	<0.046	<0.043	<0.072
4/3/2002	848	PS-145	(0-4)	GPL	<0.036	<0.033	<0.042	<0.11	<0.051	<0.033	<0.029	<0.072	<0.072	<0.056	<0.044	<0.058	<0.075	<0.053	<0.054	<0.045	<0.042	<0.07
4/3/2002	847	PS-146	(0-4)	GPL	<0.037	<0.034	<0.043	<0.12	<0.051	0.043	0.03	<0.073	<0.073	<0.057	<0.045	<0.059	0.11	<0.054	<0.055	<0.046	0.076	<0.071
4/10/2002	882	PS-147	(0-4)	GPL	<0.037	<0.034	<0.044	<0.12	<0.052	<0.034	<0.03	<0.075	<0.075	<0.058	<0.046	<0.06	<0.078	<0.054	<0.056	<0.047	<0.044	<0.073
4/10/2002	883	PS-148	(0-4)	GPL	<0.037	<0.034	<0.043	<0.12	<0.052	<0.034	<0.03	<0.074	<0.074	<0.057	<0.045	<0.059	<0.077	<0.054	<0.055	<0.046	<0.043	<0.072
4/10/2002	884	PS-149	(0-4)	GPL	<0.036	<0.033	<0.042	<0.11	<0.051	<0.033	<0.029	<0.072	<0.072	<0.056	<0.044	<0.058	<0.076	<0.053	<0.054	<0.046	<0.042	<0.07
4/10/2002	894	PS-150	(0-4)	GPL	<0.037	<0.034	<0.043	<0.12	<0.051	<0.034	<0.029	<0.073	<0.073	<0.057	<0.045	<0.059	<0.077	<0.053	<0.054	<0.046	<0.043	<0.071
4/10/2002	893	PS-151	(0-4)	GPL	<0.037	<0.034	<0.043	<0.12	<0.051	<0.034	<0.029	<0.073	<0.073	<0.057	<0.045	<0.059	<0.077	<0.053	<0.055	<0.046	<0.043	<0.071
4/10/2002	892	PS-152	(0-4)	GPL	<0.037	<0.034	<0.043	<0.12	<0.051	<0.034	<0.029	<0.073	<0.073	<0.057	<0.045	<0.059	<0.077	<0.054	<0.055	<0.046	<0.043	<0.071

***** All values reported in milligrams per kilogram (mg/kg) *****

Table 4-3

Disposal Characterization Results

Polycyclic Aromatic Hydrocarbons (PAHs)

Grant, Locust and Cavite Housing Area Devens
Massachusetts

					2-Chloronaphthalene	2-Methylnaphthalene	Acenaphthene	Acenaphthylene	Anthracene	Benzo(a)anthracene	Benzo(a)pyrene	Benzo(b)fluoranthene	Benzo(g,h,i)perylene	Benzo(k)fluoranthene	Chrysene	Dibenz(a,h)Anthracene	Fluoranthene	Fluorene	Indeno(1,2,3-c,d)Pyrene	Naphthalene	Phenanthrene	Pyrene
Project Clean-up Goals					*1000*	*4*	*20*	*1000*	*1000*	*0.7*	*0.7*	*0.7*	*1000*	*7*	*7*	*0.7*	*1000*	*400*	*0.7*	*4*	*700*	*700*
Date	**Bldg**	**Sample ID**	**Depth**	**Lab**																		
4/11/2002	891	PS-153	(0-4)	GPL	<0.037	<0.033	<0.043	<0.12	<0.051	<0.033	<0.029	<0.073	<0.073	<0.056	<0.045	<0.058	<0.076	<0.053	<0.054	<0.046	<0.043	<0.071
4/11/2002	890	PS-154	(0-4)	GPL	<0.036	<0.033	<0.043	<0.11	<0.051	<0.033	<0.029	<0.073	<0.073	<0.056	<0.045	<0.058	<0.076	<0.053	<0.054	<0.046	<0.043	<0.071
4/11/2002	889	PS-155	(0-4)	GPL	<0.036	<0.033	<0.042	<0.11	<0.051	<0.033	<0.029	<0.072	<0.072	<0.056	<0.044	<0.058	<0.075	<0.053	<0.054	<0.045	<0.042	<0.07
4/11/2002	885	PS-156	(0-4)	GPL	<0.037	<0.034	<0.044	<0.12	<0.052	<0.034	<0.03	<0.075	<0.075	<0.058	<0.046	<0.06	<0.078	<0.054	<0.055	<0.047	<0.044	<0.073
4/17/2002	895	PS-157	(0-4)	GPL	<0.037	<0.034	<0.044	<0.12	<0.052	<0.034	<0.03	<0.075	<0.075	<0.058	<0.046	<0.06	<0.078	<0.054	<0.055	<0.047	<0.044	<0.072
4/17/2002	896	PS-158	(0-4)	GPL	<0.037	<0.034	<0.043	<0.12	<0.052	<0.034	<0.029	<0.074	<0.074	<0.057	<0.045	<0.059	<0.077	<0.054	<0.055	<0.046	<0.043	<0.072
4/17/2002	897	PS-159	(0-4)	GPL	<0.037	<0.034	<0.044	<0.12	<0.052	<0.034	<0.03	<0.075	<0.075	<0.058	<0.046	<0.06	<0.078	<0.055	<0.056	<0.047	<0.044	<0.073
4/17/2002	898	PS-160	(0-4)	GPL	<0.037	<0.034	<0.044	<0.12	<0.052	<0.034	<0.03	<0.075	<0.075	<0.058	<0.046	<0.06	<0.078	<0.054	<0.056	<0.047	<0.044	<0.073
4/17/2002	899	PS-161	(0-4)	GPL	<0.038	<0.034	<0.044	<0.12	<0.053	<0.034	<0.03	<0.075	<0.075	<0.058	<0.046	<0.06	<0.079	<0.055	<0.056	<0.047	<0.044	<0.073
4/17/2002	822	PS-162	(0-4)	GPL	<0.036	<0.033	<0.043	<0.11	<0.051	<0.033	<0.029	<0.073	<0.073	<0.056	<0.045	<0.058	<0.076	<0.053	<0.054	<0.046	<0.043	<0.071
4/17/2002	823	PS-163	(0-4)	GPL	<0.037	<0.034	<0.043	<0.12	<0.052	<0.034	<0.03	<0.074	<0.074	<0.057	<0.045	<0.059	<0.077	<0.054	<0.055	<0.046	<0.043	<0.072
4/17/2002	880	PS-164	(0-4)	GPL	<0.037	<0.034	<0.043	<0.12	<0.052	<0.034	<0.03	<0.074	<0.074	<0.057	<0.046	<0.059	<0.077	<0.054	<0.055	<0.047	<0.043	<0.072
4/17/2002	881	PS-165	(0-4)	GPL	<0.037	<0.034	<0.043	<0.12	<0.052	<0.034	<0.03	<0.074	<0.074	<0.057	<0.045	<0.059	<0.077	<0.054	<0.055	<0.046	<0.043	<0.072

Notes:
Bold/Highlighted = Exceeds Project Clean-up Goals

***** All values reported in milligrams per kilogram (mg/kg) *****

Table 4-4 Disposal Characterization Results - Arsenic

Waste Characterization

Analytic Method: Multiple
Sample Matrix: Soil
Reporting Units: mg/kg
Sample Dates: 14-Feb-2002 to 15-Nov-2004

		Arsenic
SSI Project Action Limit (PAL)		NC
Secondary Regulatory Criteria Not Selected		
Location	**Date**	**Sample ID**	**Depth**	**Method**	**DF**	
PS-002	14-Feb-02	PS-002	0-4'	6010B	1	23
PS-003	14-Feb-02	PS-003	0-4'	6010B	1	18
PS-004	14-Feb-02	PS-004	0-4'	6010B	1	25
PS-005	14-Feb-02	PS-005	0-4'	6010B	1	26
PS-006	14-Feb-02	PS-006	0-4'	6010B	1	21
PS-007	14-Feb-02	PS-007	0-4'	6010B	1	28
PS-008	14-Feb-02	PS-008	0-4'	6010B	1	27
PS-009	14-Feb-02	PS-009	0-4'	6010B	1	28
PS-010	14-Feb-02	PS-010	0-4'	6010B	1	28
PS-011	15-Feb-02	PS-011	0-4'	6010B	1	24
PS-012	15-Feb-02	PS-012	0-4'	6010B	1	30
PS-013	15-Feb-02	PS-013	0-4'	6010B	1	17
PS-014	15-Feb-02	PS-014	0-4'	6010B	1	28
PS-015	15-Feb-02	PS-015	0-4'	6010B	1	31
PS-016	15-Feb-02	PS-016	0-4'	6010B	1	18
PS-017	15-Feb-02	PS-017	0-4'	6010B	1	25
PS-018	15-Feb-02	PS-018	0-4'	6010B	1	19
PS-019	15-Feb-02	PS-019	0-4'	6010B	1	26
PS-020	15-Feb-02	PS-020	0-4'	6010B	1	20
PS-021	15-Feb-02	PS-021	0-4'	6010B	1	27
PS-022	15-Feb-02	PS-022	0-4'	6010B	1	22
PS-023	20-Feb-02	PS-023	0-4'	6010B	1	26
PS-024	20-Feb-02	PS-024	0-4'	6010B	1	27
PS-025	20-Feb-02	PS-025	0-4'	6010B	1	29
PS-026	20-Feb-02	PS-026	0-4'	6010B	1	24
PS-027	20-Feb-02	PS-027	0-4'	6010B	1	26
PS-028	20-Feb-02	PS-028	0-4'	6010B	1	31
PS-029	21-Feb-02	PS-029	0-4'	6010B	1	19
PS-030	21-Feb-02	PS-030	0-4'	6010B	1	17
PS-031	21-Feb-02	PS-031	0-4'	6010B	1	23
PS-032	21-Feb-02	PS-032	0-4'	6010B	1	20
PS-033	21-Feb-02	PS-033	0-4'	6010B	1	18
PS-034	21-Feb-02	PS-034	0-4'	6010B	1	12
PS-035	22-Feb-02	PS-035	0-4'	6010B	1	26

Notes:

NC No criteria listed under the regulation cited
ND Non-detect result (Original data unavailable)
- Parameter not analyzed

Analytic Flags:

j Estimated value - parameter not detected above laboratory quantitation limits
e Value exceeds analytical calibration limits
b Parameter detected in quality control blank and sample

Highlighting:

Value or Detection Limit exceeds Criteria 1 only
Value or Detection Limit exceeds Criteria 2 only
Value or Detection Limit exceeds both criteria

Table 4-4 Disposal Characterization Results - Arsenic

Waste Characterization

Analytic Method: Multiple
Sample Matrix: Soil
Reporting Units: mg/kg
Sample Dates: 14-Feb-2002 to 15-Nov-2004

	Arsenic
SSI Project Action Limit (PAL)	NC
Secondary Regulatory Criteria Not Selected	

Location	Date	Sample ID	Depth	Method	DF	
PS-036	22-Feb-02	PS-036	0-4'	6010B	1	28
PS-037	22-Feb-02	PS-037	0-4'	6010B	1	28
PS-038	22-Feb-02	PS-038	0-4'	6010B	1	22
PS-039	22-Feb-02	PS-039	0-4'	6010B	1	27
PS-040	22-Feb-02	PS-040	0-4'	6010B	1	29
PS-041	25-Feb-02	PS-041	0-4'	6010B	1	22
PS-042	25-Feb-02	PS-042	0-4'	6010B	1	32
PS-043	25-Feb-02	PS-043	0-4'	6010B	1	27
PS-044	25-Feb-02	PS-044	0-4'	6010B	1	25
PS-045	25-Feb-02	PS-045	0-4'	6010B	1	34
PS-046	25-Feb-02	PS-046	0-4'	6010B	1	27
PS-047	26-Feb-02	PS-047	0-4'	6010B	1	24
PS-048	26-Feb-02	PS-048	0-4'	6010B	1	32
PS-049	26-Feb-02	PS-049	0-4'	6010B	1	28
PS-050	26-Feb-02	PS-050	0-4'	6010B	1	26
PS-051	26-Feb-02	PS-051	0-4'	6010B	1	25
PS-052	26-Feb-02	PS-052	0-4'	6010B	1	27
PS-053	27-Feb-02	PS-053	0-4'	6010B	1	27
PS-054	27-Feb-02	PS-054	0-4'	6010B	1	24
PS-055	27-Feb-02	PS-055	0-4'	6010B	1	36
PS-056	27-Feb-02	PS-056	0-4'	6010B	1	34
PS-057	28-Feb-02	PS-057	0-4'	6010B	1	32
PS-058	28-Feb-02	PS-058	0-4'	6010B	1	26
PS-059	28-Feb-02	PS-059	0-4'	6010B	1	30
PS-060	28-Feb-02	PS-060	0-4'	6010B	1	37
PS-061	28-Feb-02	PS-061	0-4'	6010B	1	27
PS-062	28-Feb-02	PS-062	0-4'	6010B	1	32
PS-063	28-Feb-02	PS-063	0-4'	6010B	1	28
PS-064	28-Feb-02	PS-064	0-4'	6010B	1	30
PS-065	01-Mar-02	PS-065	0-4'	6010B	1	21
PS-066	01-Mar-02	PS-066	0-4'	6010B	1	24
PS-067	01-Mar-02	PS-067	0-4'	6010B	1	34
PS-068	01-Mar-02	PS-068	0-4'	6010B	1	38
PS-069	01-Mar-02	PS-069	0-4'	6010B	1	25

Notes:

NC No criteria listed under the regulation cited
ND Non-detect result (Original data unavailable)
- Parameter not analyzed

Analytic Flags:

j Estimated value - parameter not detected above laboratory quantitation limits
e Value exceeds analytical calibration limits
b Parameter detected in quality control blank and sample

Highlighting:

Value or Detection Limit exceeds Criteria 1 only
Value or Detection Limit exceeds Criteria 2 only
Value or Detection Limit exceeds both criteria

Table 4-4 Disposal Characterization Results - Arsenic

Waste Characterization

Analytic Method: Multiple
Sample Matrix: Soil
Reporting Units: mg/kg
Sample Dates: 14-Feb-2002 to 15-Nov-2004

	Arsenic
SSI Project Action Limit (PAL)	NC
Secondary Regulatory Criteria Not Selected	

Location	Date	Sample ID	Depth	Method	DF	
PS-070	01-Mar-02	PS-070	0-4'	6010B	1	26
PS-071	01-Mar-02	PS-071	0-4'	6010B	1	26
PS-072	05-Mar-02	PS-072	0-4'	6010B	1	21
PS-073	05-Mar-02	PS-073	0-4'	6010B	1	23
PS-074	06-Mar-02	PS-074	0-4'	6010B	1	28
PS-075	06-Mar-02	PS-075	0-4'	6010B	1	30
PS-076	06-Mar-02	PS-076	0-4'	6010B	1	25
PS-077	06-Mar-02	PS-077	0-4'	6010B	1	21
PS-078	06-Mar-02	PS-078	0-4'	6010B	1	23
PS-079	06-Mar-02	PS-079	0-4'	6010B	1	30
PS-080	11-Mar-02	PS-080	0-4'	6010B	1	20
PS-081	11-Mar-02	PS-081	0-4'	6010B	1	22
PS-082	11-Mar-02	PS-082	0-4'	6010B	1	24
PS-083	12-Mar-02	PS-083	0-4'	6010B	1	27
PS-084	12-Mar-02	PS-084	0-4'	6010B	1	33
PS-085	12-Mar-02	PS-085	0-4'	6010B	1	26
PS-086	12-Mar-02	PS-086	0-4'	6010B	1	28
PS-087	12-Mar-02	PS-087	0-4'	6010B	1	24
PS-088	13-Mar-02	PS-088	0-4'	6010B	1	28
PS-089	13-Mar-02	PS-089	0-4'	6010B	1	20
PS-090	13-Mar-02	PS-090	0-4'	6010B	1	27
PS-091	14-Mar-02	PS-091	0-4'	6010B	1	23
PS-092	14-Mar-02	PS-092	0-4'	6010B	1	25
PS-093	14-Mar-02	PS-093	0-4'	6010B	1	18
PS-094	15-Mar-02	PS-094	0-4'	6010B	1	28
PS-095	15-Mar-02	PS-095	0-4'	6010B	1	32
PS-096	15-Mar-02	PS-096	0-4'	6010B	1	28
PS-097	15-Mar-02	PS-097	0-4'	6010B	1	34
PS-098	18-Mar-02	PS-098	0-4'	6010B	1	31
PS-099	18-Mar-02	PS-099	0-4'	6010B	1	23
PS-100	18-Mar-02	PS-100	0-4'	6010B	1	28
PS-101	18-Mar-02	PS-101	0-4'	6010B	1	28
PS-102	18-Mar-02	PS-102	0-4'	6010B	1	29
PS-103	18-Mar-02	PS-103	0-4'	6010B	1	27

Notes:

NC No criteria listed under the regulation cited
ND Non-detect result (Original data unavailable)
- Parameter not analyzed

Analytic Flags:

j Estimated value - parameter not detected above laboratory quantitation limits
e Value exceeds analytical calibration limits
b Parameter detected in quality control blank and sample

Highlighting:

Value or Detection Limit exceeds Criteria 1 only
Value or Detection Limit exceeds Criteria 2 only
Value or Detection Limit exceeds both criteria

Table 4-4 Disposal Characterization Results - Arsenic

Waste Characterization

Analytic Method: Multiple
Sample Matrix: Soil
Reporting Units: mg/kg
Sample Dates: 14-Feb-2002 to 15-Nov-2004

		Arsenic
SSI Project Action Limit (PAL)		NC
Secondary Regulatory Criteria Not Selected		
Location	**Date**	**Sample ID**	**Depth**	**Method**	**DF**	
PS-104	19-Mar-02	PS-104	0-4'	6010B	1	32
PS-105	19-Mar-02	PS-105	0-4'	6010B	1	33
PS-106	19-Mar-02	PS-106	0-4'	6010B	1	27
PS-107	19-Mar-02	PS-107	0-4'	6010B	1	34
PS-108	19-Mar-02	PS-108	0-4'	6010B	1	45
PS-108A	23-Dec-02	PS-108A	0-1'	6010B	1	38
PS-108B	23-Dec-02	PS-108B	0-1'	6010B	1	31
PS-108C	23-Dec-02	PS-108C	0-1'	6010B	1	37
PS-108E	23-Dec-02	PS-108E	0-1'	6010B	1	39
PS-109	19-Mar-02	PS-109	0-4'	6010B	1	39
PS-110	20-Mar-02	PS-110	0-4'	6010B	1	29
PS-111	20-Mar-02	PS-111	0-4'	6010B	1	33
PS-112	20-Mar-02	PS-112	0-4'	6010B	1	30
PS-113	20-Mar-02	PS-113	0-4'	6010B	1	26
PS-114	20-Mar-02	PS-114	0-4'	6010B	1	26
PS-115	20-Mar-02	PS-115	0-4'	6010B	1	29
PS-116	21-Mar-02	PS-116	0-4'	6010B	1	26
PS-117	21-Mar-02	PS-117	0-4'	6010B	1	29
PS-118	21-Mar-02	PS-118	0-4'	6010B	1	26
PS-119	21-Mar-02	PS-119	0-4'	6010B	1	33
PS-120	21-Mar-02	PS-120	0-4'	6010B	1	29
PS-121	21-Mar-02	PS-121	0-4'	6010B	1	24
PS-122	21-Mar-02	PS-122	0-4'	6010B	1	16
PS-123	21-Mar-02	PS-123	0-4'	6010B	1	11
PS-124	22-Mar-02	PS-124	0-4'	6010B	1	44
PS-124A	23-Dec-02	PS-124A	0-1'	6010B	1	31
PS-124B	23-Dec-02	PS-124B	0-1'	6010B	1	34
PS-124C	23-Dec-02	PS-124C	0-1'	6010B	1	33
PS-124E	23-Dec-02	PS-124E	0-1'	6010B	1	34
PS-124F	23-Dec-02	PS-124F	0-1'	6010B	1	65
PS-125	22-Mar-02	PS-125	0-4'	6010B	1	24
PS-126	22-Mar-02	PS-126	0-4'	6010B	1	35
PS-127	22-Mar-02	PS-127	0-4'	6010B	1	27
PS-128	22-Mar-02	PS-128	0-4'	6010B	1	46

Notes:

NC No criteria listed under the regulation cited
ND Non-detect result (Original data unavailable)
- Parameter not analyzed

Analytic Flags:

j Estimated value - parameter not detected above laboratory quantitation limits
e Value exceeds analytical calibration limits
b Parameter detected in quality control blank and sample

Highlighting:

Value or Detection Limit exceeds Criteria 1 only
Value or Detection Limit exceeds Criteria 2 only
Value or Detection Limit exceeds both criteria

Table 4-4 Disposal Characterization Results - Arsenic

Waste Characterization

Analytic Method: Multiple
Sample Matrix: Soil
Reporting Units: mg/kg
Sample Dates: 14-Feb-2002 to 15-Nov-2004

						Arsenic
SSI Project Action Limit (PAL)						NC
Secondary Regulatory Criteria Not Selected						
Location	**Date**	**Sample ID**	**Depth**	**Method**	**DF**	
PS-128A	23-Dec-02	PS-128A	0-1'	6010B	1	30
PS-128B	23-Dec-02	PS-128B	0-1'	6010B	1	45
PS-128C	23-Dec-02	PS-128C	0-1'	6010B	1	31
PS-128E	23-Dec-02	PS-128E	0-1'	6010B	1	38
PS-129	22-Mar-02	PS-129	0-4'	6010B	1	33
PS-130	22-Mar-02	PS-130	0-4'	6010B	1	9.5 n
PS-131	22-Mar-02	PS-131	0-4'	6010B	1	9.8 n
PS-132	25-Mar-02	PS-132	0-4'	6010B	1	28.3 n
PS-133	25-Mar-02	PS-133	0-4'	6010B	1	23.6 n
PS-134	25-Mar-02	PS-134	0-4'	6010B	1	21.7 n
PS-135	25-Mar-02	PS-135	0-4'	6010B	1	31.8 n
PS-136	25-Mar-02	PS-136	0-4'	6010B	1	38 n
PS-137	25-Mar-02	PS-137	0-4'	6010B	1	28.7 n
PS-138	26-Mar-02	PS-138	0-4'	6010B	1	16.2 n
PS-139	26-Mar-02	PS-139	0-4'	6010B	1	11.1 n
PS-140	26-Mar-02	PS-140	0-4'	6010B	1	19.3 n
PS-141	03-Apr-02	PS-141	0-4'	6010B	1	23.6 n
PS-142	03-Apr-02	PS-142	0-4'	6010B	1	20.8 n
PS-143	03-Apr-02	PS-143	0-4'	6010B	1	17.9 n
PS-144	03-Apr-02	PS-144	0-4'	6010B	1	31.7 n
PS-145	03-Apr-02	PS-145	0-4'	6010B	1	19.8 n
PS-146	03-Apr-02	PS-146	0-4'	6010B	1	22.7 n
PS-147	10-Apr-02	PS-147	0-4'	6010B	1	19.3
PS-148	10-Apr-02	PS-148	0-4'	6010B	1	17.1
PS-149	10-Apr-02	PS-149	0-4'	6010B	1	17
PS-150	10-Apr-02	PS-150	0-4'	6010B	1	22.1
PS-151	10-Apr-02	PS-151	0-4'	6010B	1	28.8
PS-152	10-Apr-02	PS-152	0-4'	6010B	1	19.2
PS-153	11-Apr-02	PS-153	0-4'	6010B	1	18.5 n
PS-154	11-Apr-02	PS-154	0-4'	6010B	1	15.8 n
PS-155	11-Apr-02	PS-155	0-4'	6010B	1	20.6 n
PS-156	11-Apr-02	PS-156	0-4'	6010B	1	11.9 n
PS-157	17-Apr-02	PS-157	0-4'	6010B	1	29.8
PS-158	17-Apr-02	PS-158	0-4'	6010B	1	14

Notes:

NC No criteria listed under the regulation cited
ND Non-detect result (Original data unavailable)
- Parameter not analyzed

Analytic Flags:

j Estimated value - parameter not detected above laboratory quantitation limits
e Value exceeds analytical calibration limits
b Parameter detected in quality control blank and sample

Highlighting:

Value or Detection Limit exceeds Criteria 1 only
Value or Detection Limit exceeds Criteria 2 only
Value or Detection Limit exceeds both criteria

Table 4-4 Disposal Characterization Results - Arsenic

Waste Characterization

Analytic Method: Multiple
Sample Matrix: Soil
Reporting Units: mg/kg
Sample Dates: 14-Feb-2002 to 15-Nov-2004

	Arsenic
SSI Project Action Limit (PAL)	NC
Secondary Regulatory Criteria Not Selected	

Location	Date	Sample ID	Depth	Method	DF	
PS-159	17-Apr-02	PS-159	0-4'	6010B	1	36.2
PS-160	17-Apr-02	PS-160	0-4'	6010B	1	22.7
PS-161	17-Apr-02	PS-161	0-4'	6010B	1	45.6
PS-161B	23-Dec-02	PS-161B	0-1'	6010B	1	17
PS-161C	23-Dec-02	PS-161C	0-1'	6010B	1	14
PS-161E	23-Dec-02	PS-161E	0-1'	6010B	1	17
PS-161F	23-Dec-02	PS-161F	0-1'	6010B	1	27
PS-161G	23-Dec-02	PS-161G	0-1'	6010B	1	18
PS-162	17-Apr-02	PS-162	0-4'	6010B	1	16.3
PS-163	17-Apr-02	PS-163	0-4'	6010B	1	56.6
PS-164	17-Apr-02	PS-164	0-4'	6010B	1	24.7
PS-165	17-Apr-02	PS-165	0-4'	6010B	1	27.8
PS-169	01-Oct-02	PS-169	0-4'	6010B	1	23
PS-170	01-Oct-02	PS-170	0-4'	6010B	1	20
PS-171	03-Oct-02	PS-171	0-4'	6010B	1	22
PS-172	03-Oct-02	PS-172	0-4'	6010B	1	21
PS-173	25-Aug-03	PS-173	--	6010/E200.7	1	16.9
PS-176	23-Dec-03	PS-176	0-4'	6010B	1	31
PS-177	10-Dec-03	PS-177	0-4'	6010/E200.7	1	16.6
	23-Dec-03	PS-177	0-4'	6010B	1	24
PS-178	11-Dec-03	PS-178	0-4'	6010/E200.7	1	23.8
	23-Dec-03	PS-178	0-4'	6010B	1	6.3
PS-179	23-Dec-03	PS-179	0-4'	6010B	1	35
PS-180	23-Dec-03	PS-180	0-4'	6010B	1	28
PS-181	25-Mar-04	PS-181	--	6010B	1	32
PS-182	25-Mar-04	PS-182	--	6010B	1	24
PS-183	25-Mar-04	PS-183	--	6010B	1	23
PS-184	25-Mar-04	PS-184	--	6010B	1	210
PS-185	25-Mar-04	PS-185	--	6010B	1	22
PS-186	25-Mar-04	PS-186	--	6010B	1	19
PS-187	15-Nov-04	PS-187	--	6010B	1	28

Notes:
NC No criteria listed under the regulation cited
ND Non-detect result (Original data unavailable)
- Parameter not analyzed

Analytic Flags:
j Estimated value - parameter not detected above laboratory quantitation limits
e Value exceeds analytical calibration limits
b Parameter detected in quality control blank and sample

Highlighting:
Value or Detection Limit exceeds Criteria 1 only
Value or Detection Limit exceeds Criteria 2 only
Value or Detection Limit exceeds both criteria

Table 5-1a PASI Sampling Results - Metals

Nobis Background Study

Analytic Method: Multiple
Sample Matrix: Soil
Reporting Units: mg/kg
Sample Dates: 20-May-2003 to 21-May-2003

						Aluminum	Arsenic	Iron	Lead	Manganese	Nickel
SSI Project Action Limit (PAL) - Wave 2 (Metals)						7600	0.39	2300	300	180	20
Secondary Regulatory Criteria Not Selected											
Location	**Date**	**Sample ID**	**Depth**	**Method**	**DF**						
GRB-03-01X	20-May-03	GRB-03-01X (0-3)	0-3'	6010	1	7400	**11**	**7700**	-	82	8.6
	20-May-03	GRB-03-01X (0-3)	0-3'	7060	1	-	**ND**	-	-	-	-
	20-May-03	GRB-03-01X (3-6)	3-6'	6010	1	**9200**	**52**	**15000**	-	**270**	**34**
	20-May-03	GRB-03-01X (3-6)	3-6'	7060	1	-	**ND**	-	-	-	-
	20-May-03	GRB-03-01X (6-10)	6-10'	6010	1	**10000**	**32**	**19000**	-	**380**	**46**
	20-May-03	GRB-03-01X (6-10)	6-10'	7060	1	-	**ND**	-	-	-	-
GRB-03-02X	21-May-03	GRB-03-02X (0-3)	0-3'	6010	1	**10000**	**47**	**22000**	-	**420**	**50**
	21-May-03	GRB-03-02X (0-3)	0-3'	7060	1	-	**ND**	-	-	-	-
	21-May-03	GRB-03-02X (3-6)	3-6'	6010	1	**11000**	**38**	**21000**	-	**470**	**48**
	21-May-03	GRB-03-02X (3-6)	3-6'	7060	1	-	**ND**	-	-	-	-
	21-May-03	GRB-03-02X (3-6)_	3-6'	6010	1	**13000**	**38**	**23000**	-	**430**	**48**
	21-May-03	GRB-03-02X (3-6)_	3-6'	7060	1	-	**ND**	-	-	-	-
GRB-03-03X	20-May-03	GRB-03-03X (0-3)	0-3'	6010	1	7500	**24**	**12000**	-	**250**	**25**
	20-May-03	GRB-03-03X (0-3)	0-3'	7060	1	-	**ND**	-	-	-	-
	20-May-03	GRB-03-03X (3-6)	3-6'	6010	1	7200	**14**	**8700**	-	95	16
	20-May-03	GRB-03-03X (3-6)	3-6'	7060	1	-	**ND**	-	-	-	-
	20-May-03	GRB-03-03X (6-10)	6-10'	6010	1	7500	**12**	**9000**	-	170	11
	20-May-03	GRB-03-03X (6-10)	6-10'	7060	1	-	**ND**	-	-	-	-
GRB-03-04X	21-May-03	GRB-03-04X (0-3)	0-3'	6010	1	**8100**	**12**	**10000**	-	**320**	12
	21-May-03	GRB-03-04X (0-3)	0-3'	7060	1	-	**ND**	-	-	-	-
	21-May-03	GRB-03-04X (3-6)	3-6'	6010	1	**7700**	**18**	**10000**	-	**300**	17
	21-May-03	GRB-03-04X (3-6)	3-6'	7060	1	-	**ND**	-	-	-	-
	21-May-03	GRB-03-04X (6-10)	6-10'	6010	1	3700	**18**	**21000**	-	**640**	**57**
	21-May-03	GRB-03-04X (6-10)	6-10'	7060	1	-	**ND**	-	-	-	-
GRB-03-05X	21-May-03	GRB-03-05X (0-3)	0-3'	6010	1	5800	**20**	**10000**	-	**240**	**23**
	21-May-03	GRB-03-05X (0-3)	0-3'	7060	1	-	**ND**	-	-	-	-
	21-May-03	GRB-03-05X (3-6)	3-6'	6010	1	**13000**	**26**	**16000**	-	**280**	**29**
	21-May-03	GRB-03-05X (3-6)	3-6'	7060	1	-	**ND**	-	-	-	-
GRB-03-06X	20-May-03	GRB-03-06X (0-3)	0-3'	6010	1	6500	**12**	**8100**	-	91	9.9
	20-May-03	GRB-03-06X (0-3)	0-3'	7060	1	-	**ND**	-	-	-	-
	20-May-03	GRB-03-06X (3-6)	3-6'	6010	1	4200	**10**	**7300**	-	120	11
	20-May-03	GRB-03-06X (3-6)	3-6'	7060	1	-	**ND**	-	-	-	-
	20-May-03	GRB-03-06X (6-10)	6-10'	6010	1	3000	**9**	**5300**	-	99	7.6
	20-May-03	GRB-03-06X (6-10)	6-10'	7060	1	-	**ND**	-	-	-	-

Notes:

- **NC** No criteria listed under the regulation cited
- **ND** Non-detect result (Original data unavailabl)
- **-** Parameter not analyzed

Analytic Flags:

- **u** Not detected above laboratory detection limits
- **j** Estimated value - parameter not detected above laboratory quantitation limits
- **e** Value exceeds analytical calibration limits
- **b** Parameter detected in quality control blank and sample

Highlighting:

- Value or Detection Limit exceeds Criteria 1 only
- Value or Detection Limit exceeds Criteria 2 only
- Value or Detection Limit exceeds both criteria

Table 5-1a PASI Sampling Results - Metals

Nobis Background Study

Analytic Method: Multiple
Sample Matrix: Soil
Reporting Units: mg/kg
Sample Dates: 20-May-2003 to 21-May-2003

						Aluminum	Arsenic	Iron	Lead	Manganese	Nickel
SSI Project Action Limit (PAL) - Wave 2 (Metals)						7600	0.39	2300	300	180	20
Secondary Regulatory Criteria Not Selected											
Location	**Date**	**Sample ID**	**Depth**	**Method**	**DF**						
GRB-03-07X	20-May-03	GRB-03-07X (0-3)	0-3'	6010	1	5200	**34**	**12000**	-	**220**	**32**
	20-May-03	GRB-03-07X (0-3)	0-3'	7060	1	-	**ND**	-	-	-	-
	20-May-03	GRB-03-07X (3-6)	3-6'	6010	1	2900	**17**	**6700**	-	110	14
	20-May-03	GRB-03-07X (3-6)	3-6'	7060	1	-	**ND**	-	-	-	-
	20-May-03	GRB-03-07X (6-10)	6-10'	6010	1	5000	**32**	**12000**	-	**230**	**27**
	20-May-03	GRB-03-07X (6-10)	6-10'	7060	1	-	**ND**	-	-	-	-
GRB-03-08X	20-May-03	GRB-03-08X (0-3)	0-3'	6010	1	**9600**	**27**	**16000**	-	**270**	**32**
	20-May-03	GRB-03-08X (0-3)	0-3'	7060	1	-	**ND**	-	-	-	-
	20-May-03	GRB-03-08X (3-6)	3-6'	6010	1	**9200**	**22**	**14000**	-	**270**	**30**
	20-May-03	GRB-03-08X (3-6)	3-6'	7060	1	-	**ND**	-	-	-	-
	20-May-03	GRB-03-08X (6-10)	6-10'	6010	1	**8500**	**19**	**14000**	-	**260**	**28**
	20-May-03	GRB-03-08X (6-10)	6-10'	7060	1	-	**ND**	-	-	-	-
GRB-03-09X	20-May-03	GRB-03-09X (0-3)	0-3'	6010	1	**8200**	**68**	**23000**	-	**280**	**73**
	20-May-03	GRB-03-09X (0-3)	0-3'	7060	1	-	**ND**	-	-	-	-
	20-May-03	GRB-03-09X (3-6)	3-6'	6010	1	5100	**28**	**13000**	-	**320**	**29**
	20-May-03	GRB-03-09X (3-6)	3-6'	7060	1	-	**ND**	-	-	-	-
	20-May-03	GRB-03-09X (6-10)	6-10'	6010	1	2000	**15**	**5000**	-	83	8.4
	20-May-03	GRB-03-09X (6-10)	6-10'	7060	1	-	**ND**	-	-	-	-
LOB-03-01X	20-May-03	LOB-03-01X (0-3)	0-3'	6010	1	5400	**22**	**12000**	-	**230**	**25**
	20-May-03	LOB-03-01X (0-3)	0-3'	7060	1	-	**ND**	-	-	-	-
	20-May-03	LOB-03-01X (3-6)	3-6'	6010	1	2500	**23**	**6100**	-	100	11
	20-May-03	LOB-03-01X (3-6)	3-6'	7060	1	-	**ND**	-	-	-	-
	20-May-03	LOB-03-01X (6-10)	6-10'	6010	1	2100	**14**	**5500**	-	120	9.3
	20-May-03	LOB-03-01X (6-10)	6-10'	7060	1	-	**ND**	-	-	-	-
LOB-03-02X	20-May-03	LOB-03-02X (0-3)	0-3'	6010	1	**11000**	**52**	**19000**	-	**330**	**36**
	20-May-03	LOB-03-02X (0-3)	0-3'	7060	1	-	**ND**	-	-	-	-
	20-May-03	LOB-03-02X (3-6)	3-6'	6010	1	7300	**22**	**10000**	-	**260**	**20**
	20-May-03	LOB-03-02X (3-6)	3-6'	7060	1	-	**ND**	-	-	-	-
	20-May-03	LOB-03-02X (3-6)_D	3-6'	6010	1	4500	**21**	**6900**	-	140	16
	20-May-03	LOB-03-02X (3-6)_D	3-6'	7060	1	-	**ND**	-	-	-	-
	20-May-03	LOB-03-02X (6-10)	6-10'	6010	1	3600	**19**	**8000**	-	170	16
	20-May-03	LOB-03-02X (6-10)	6-10'	7060	1	-	**ND**	-	-	-	-
LOB-03-03X	20-May-03	LOB-03-03X (0-3)	0-3'	6010	1	**8400**	**21**	**11000**	-	120	16
	20-May-03	LOB-03-03X (0-3)	0-3'	7060	1	-	**ND**	-	-	-	-
	20-May-03	LOB-03-03X (3-6)	3-6'	6010	1	**8200**	**21**	**14000**	-	**350**	**25**
	20-May-03	LOB-03-03X (3-6)	3-6'	7060	1	-	**ND**	-	-	-	-

Notes:

- **NC** No criteria listed under the regulation cited
- **ND** Non-detect result (Original data unavailabl)
- **-** Parameter not analyzed

Analytic Flags:

- **u** Not detected above laboratory detection limits
- **j** Estimated value - parameter not detected above laboratory quantitation limits
- **e** Value exceeds analytical calibration limits
- **b** Parameter detected in quality control blank and sample

Highlighting:

- Value or Detection Limit exceeds Criteria 1 only
- Value or Detection Limit exceeds Criteria 2 only
- Value or Detection Limit exceeds both criteria

Table 5-1a PASI Sampling Results - Metals

Nobis Background Study

Analytic Method: Multiple
Sample Matrix: Soil
Reporting Units: mg/kg
Sample Dates: 20-May-2003 to 21-May-2003

							Aluminum	Arsenic	Iron	Lead	Manganese	Nickel	
SSI Project Action Limit (PAL) - Wave 2 (Metals)							7600	0.39	2300	300	180	20	
Secondary Regulatory Criteria Not Selected													
Location	**Date**	**Sample ID**	**Depth**	**Method**	**DF**								
LOB-03-04X	20-May-03	LOB-03-04X (0-3)	0-3'	6010	1		7100	**20**	**15000**	-	**350**	**24**	
	20-May-03	LOB-03-04X (0-3)	0-3'	7060	1		-	**ND**	-	-	-	-	
	20-May-03	LOB-03-04X (3-6)	3-6'	6010	1		**8100**	**17**	**22000**	-	**430**	**31**	
	20-May-03	LOB-03-04X (3-6)	3-6'	7060	1		-	**ND**	-	-	-	-	
	20-May-03	LOB-03-04X (6-10)	6-10'	6010	1		**13000**	**22**	**29000**	-	**690**	**48**	
	20-May-03	LOB-03-04X (6-10)	6-10'	7060	1		-	**ND**	-	-	-	-	

Notes:

- **NC** No criteria listed under the regulation cited
- **ND** Non-detect result (Original data unavailabl)
- **-** Parameter not analyzed

Analytic Flags:

- **u** Not detected above laboratory detection limits
- **j** Estimated value - parameter not detected above laboratory quantitation limits
- **e** Value exceeds analytical calibration limits
- **b** Parameter detected in quality control blank and sample

Highlighting:

- Value or Detection Limit exceeds Criteria 1 only
- Value or Detection Limit exceeds Criteria 2 only
- Value or Detection Limit exceeds both criteria

Table 5-1a PASI Sampling Results - Metals

PASI - Cavite

Analytic Method: 6010B
Sample Matrix: Soil
Reporting Units: mg/kg
Sample Dates: 07-Nov-2003 to 07-Nov-2003

						Aluminum	Arsenic	Iron	Lead	Manganese	Nickel	
SSI Project Action Limit (PAL) - Wave 2 (Metals)						7600	0.39	2300	300	180	20	
Secondary Regulatory Criteria Not Selected												
Location	**Date**	**Sample ID**	**Depth**	**Method**	**DF**							
CT-500	07-Nov-03	PASI-CT-GB-500-1	0-1.5'	6010B	1	6200	**8.3**	**6400**	-	130	6.9	
	07-Nov-03	PASI-CT-GB-500-2	1.5-3'	6010B	1	4700	**5.6**	**4500**	-	42	4.3	
	07-Nov-03	PASI-CT-GB-500-3	3-6'	6010B	1	4800	**8.7**	**6800**	-	110	8.4	
CT-501	07-Nov-03	PASI-CT-GB-501-1	0-1.25'	6010B	1	6200	**22**	**16000**	-	140	11	
	07-Nov-03	PASI-CT-GB-501-2	1.25-2.25	6010B	1	7000	**20**	**12000**	-	**220**	18	
	07-Nov-03	PASI-CT-GB-501-3	2.25-3'	6010B	1	6200	**4.3**	**4900**	-	51	4.8	
	07-Nov-03	PASI-CT-GB-501-4	3-6'	6010B	1	3900	**8.2**	**6000**	-	100	6.2	
CT-502	07-Nov-03	PASI-CT-GB-502-1	0-1'	6010B	1	7300	**15**	**8500**	-	**280**	12	
	07-Nov-03	PASI-CT-GB-502-2	1-3'	6010B	1	4000	**130**	**14000**	-	**350**	**24**	
	07-Nov-03	PASI-CT-GB-502-3	3-6'	6010B	1	**7700**	**15**	**8000**	-	**260**	11	
	07-Nov-03	PASI-CT-GB-502-3D	3-6'	6010B	1	**7700**	**13**	**9500**	-	**240**	17 r	

Notes:

- **NC** No criteria listed under the regulation cited
- **ND** Non-detect result (Original data unavailabl)
- **-** Parameter not analyzed

Analytic Flags:

- **u** Not detected above laboratory detection limits
- **j** Estimated value - parameter not detected above laboratory quantitation limits
- **e** Value exceeds analytical calibration limits
- **b** Parameter detected in quality control blank and sample

Highlighting:

- Value or Detection Limit exceeds Criteria 1 only
- Value or Detection Limit exceeds Criteria 2 only
- Value or Detection Limit exceeds both criteria

Table 5-1a PASI Sampling Results - Metals

PASI - Grant

Analytic Method: 6010B
Sample Matrix: Soil
Reporting Units: mg/kg
Sample Dates: 19-Nov-2003 to 19-Dec-2003

						Aluminum	Arsenic	Iron	Lead	Manganese	Nickel
SSI Project Action Limit (PAL) - Wave 2 (Metals)						7600	0.39	2300	300	180	20
Secondary Regulatory Criteria Not Selected											
Location	**Date**	**Sample ID**	**Depth**	**Method**	**DF**						
GR-301	19-Nov-03	PASI-GR-GB-301-1	--	6010B	1	4760	**13.1**	**7200**	-	127	13.3
	19-Nov-03	PASI-GR-GB-301-2	--	6010B	1	**8840**	**66.4**	-	-	**384**	**33.3**
	19-Nov-03	PASI-GR-GB-301-2	--	6010B	2	-	-	**18800**	-	-	-
GR-302	19-Nov-03	PASI-GR-GB-302-1	--	6010B	1	**8270**	**27.3**	**11500**	-	**196**	**23.7**
	19-Nov-03	PASI-GR-GB-302-2	--	6010B	1	**9700**	**25.3**	**11800**	-	**185**	**21.5**
GR-303	19-Nov-03	PASI-GR-GB-303-1	--	6010B	1	**9830**	**29.8**	**14600**	-	**252**	**27.4**
	19-Nov-03	PASI-GR-GB-303-2	--	6010B	1	**8980**	**35.9**	**14400**	-	**365**	**28.1**
GR-304	19-Nov-03	PASI-GR-GB-304-1	--	6010B	1	**9270**	**44.7**	-	-	**247**	**34.6**
	19-Nov-03	PASI-GR-GB-304-1	--	6010B	2	-	-	**17400**	-	-	-
	19-Nov-03	PASI-GR-GB-304-2	--	6010B	1	**8350**	**25.7**	-	-	**256**	**30.8**
	19-Nov-03	PASI-GR-GB-304-2	--	6010B	2	-	-	**16300**	-	-	-
GR-305	19-Nov-03	PASI-GR-GB-305-1	--	6010B	1	**7690**	**17.9**	**10400**	-	**215**	12.8
	19-Nov-03	PASI-GR-GB-305-2	--	6010B	1	**10500**	**28.2**	**14500**	-	**288**	**26.3**
GR-306	19-Nov-03	PASI-GR-GB-306-1	--	6010B	1	**10300**	**21.4**	-	-	**355**	**27**
	19-Nov-03	PASI-GR-GB-306-1	--	6010B	2	-	-	**16700**	-	-	-
	19-Nov-03	PASI-GR-GB-306-2	--	6010B	1	**12000**	**19.8**	-	-	**315**	**28.3**
	19-Nov-03	PASI-GR-GB-306-2	--	6010B	2	-	-	**17800**	-	-	-
GR-307	19-Nov-03	PASI-GR-GB-307-1	--	6010B	1	**9820**	**34**	**13400**	-	173	**30.9**
	19-Nov-03	PASI-GR-GB-307-2	--	6010B	1	**10900**	**33**	**15400**	-	**202**	**35.4**
GR-308	19-Nov-03	PASI-GR-GB-308-1	--	6010B	1	**8170**	**26.1**	**12900**	-	**239**	**26.3**
	19-Nov-03	PASI-GR-GB-308-2	--	6010B	1	7150	**36.1**	**12300**	-	**239**	**25.8**
GR-309	19-Nov-03	PASI-GR-GB-309-1	--	6010B	1	**10900**	**11.1**	**8440**	-	55.2	6.3
	19-Nov-03	PASI-GR-GB-309-2	--	6010B	1	7160	**13.9**	**6560**	-	88	8.4
GR-310	19-Nov-03	PASI-GR-GB-310-1	--	6010B	1	6810	**20.3**	**9410**	-	176	17.5
	19-Nov-03	PASI-GR-GB-310-2	--	6010B	1	**8600**	**24.1**	**12800**	-	**259**	**28.6**
GR-311	19-Nov-03	PASI-GR-GB-311-1	--	6010B	1	**11800**	**25.7**	**15200**	-	**276**	16.7
	19-Nov-03	PASI-GR-GB-311-1	--	6010B	1	**9240**	**15.8**	**9130**	-	136	14.4
	19-Nov-03	PASI-GR-GB-311-2	--	6010B	1	**9990**	**40.9**	**15200**	-	**365**	**36.6**
	19-Nov-03	PASI-GR-GB-311-2	--	6010B	2	-	-	17.2	-	-	-
	19-Nov-03	PASI-GR-GB-311-2	--	6010B	1	4.2	**10.2**	3	-	30.4 r	12.9
IA5-001	18-Dec-03	IA5-001-A	0-0.5'	6010B	1	-	-	-	51.3	-	-
	18-Dec-03	IA5-001-A-D	0-0.5'	6010B	1	-	-	-	43.5658	-	-
	18-Dec-03	IA5-001-B	0-0.5'	6010B	1	-	-	-	48.9	-	-
	18-Dec-03	IA5-001-C	0-0.5'	6010B	1	-	-	-	34.1	-	-
	18-Dec-03	IA5-001-D	0-0.5'	6010B	1	-	-	-	26.8	-	-
	18-Dec-03	IA5-001-E	0-0.5'	6010B	1	-	-	-	7	-	-

Notes:

- **NC** No criteria listed under the regulation cited
- **ND** Non-detect result (Original data unavailabl)
- **-** Parameter not analyzed

Analytic Flags:

- **u** Not detected above laboratory detection limits
- **j** Estimated value - parameter not detected above laboratory quantitation limits
- **e** Value exceeds analytical calibration limits
- **b** Parameter detected in quality control blank and sample

Highlighting:

- Value or Detection Limit exceeds Criteria 1 only
- Value or Detection Limit exceeds Criteria 2 only
- Value or Detection Limit exceeds both criteria

Table 5-1a PASI Sampling Results - Metals

PASI - Grant

Analytic Method: 6010B
Sample Matrix: Soil
Reporting Units: mg/kg
Sample Dates: 19-Nov-2003 to 19-Dec-2003

						Aluminum	Arsenic	Iron	Lead	Manganese	Nickel	
SSI Project Action Limit (PAL) - Wave 2 (Metals)						7600	0.39	2300	300	180	20	
Secondary Regulatory Criteria Not Selected												
Location	**Date**	**Sample ID**	**Depth**	**Method**	**DF**							
IA5-002	18-Dec-03	IA5-002-A	0-0.5'	6010B	1	-	-	-	7	-	-	
	18-Dec-03	IA5-002-B	0-0.5'	6010B	1	-	-	-	7.2	-	-	
	18-Dec-03	IA5-002-C	0-0.5'	6010B	1	-	-	-	89.7	-	-	
	18-Dec-03	IA5-002-D	0-0.5'	6010B	1	-	-	-	31.7	-	-	
	18-Dec-03	IA5-002-E	0-0.5'	6010B	1	-	-	-	203	-	-	
IA5-003	18-Dec-03	IA5-003-A	0-0.5'	6010B	1	-	-	-	203	-	-	
	18-Dec-03	IA5-003-B	0-0.5'	6010B	1	-	-	-	45	-	-	
	18-Dec-03	IA5-003-C	0-0.5'	6010B	1	-	-	-	15	-	-	
	18-Dec-03	IA5-003-D	0-0.5'	6010B	1	-	-	-	44	-	-	
	18-Dec-03	IA5-003-D-D	0-0.5'	6010B	1	-	-	-	8.1	-	-	
	18-Dec-03	IA5-003-E	0-0.5'	6010B	1	-	-	-	14.1	-	-	
IA5-004	18-Dec-03	IA5-004-A	0-0.5'	6010B	1	-	-	-	86.1	-	-	
	18-Dec-03	IA5-004-B	0-0.5'	6010B	1	-	-	-	83.2	-	-	
	18-Dec-03	IA5-004-C	0-0.5'	6010B	1	-	-	-	45.4	-	-	
	18-Dec-03	IA5-004-D	0-0.5'	6010B	1	-	-	-	21.4	-	-	
	18-Dec-03	IA5-004-E	0-0.5'	6010B	1	-	-	-	12.5	-	-	
	18-Dec-03	IA5-004-E-D	0-0.5'	6010B	1	-	-	-	11.6483	-	-	
IA5-005	19-Dec-03	IA5-005-A	0-0.5'	6010B	1	-	-	-	19.8	-	-	
	19-Dec-03	IA5-005-A-D	0-0.5'	6010B	1	-	-	-	16.1	-	-	
	19-Dec-03	IA5-005-B	0-0.5'	6010B	1	-	-	-	26.1	-	-	
	19-Dec-03	IA5-005-C	0-0.5'	6010B	1	-	-	-	15.2	-	-	
	19-Dec-03	IA5-005-D	0-0.5'	6010B	1	-	-	-	27.2	-	-	
	19-Dec-03	IA5-005-E	0-0.5'	6010B	1	-	-	-	26.5	-	-	

Notes:

- **NC** No criteria listed under the regulation cited
- **ND** Non-detect result (Original data unavailabl)
- **-** Parameter not analyzed

Analytic Flags:

- **u** Not detected above laboratory detection limits
- **j** Estimated value - parameter not detected above laboratory quantitation limits
- **e** Value exceeds analytical calibration limits
- **b** Parameter detected in quality control blank and sample

Highlighting:

- Value or Detection Limit exceeds Criteria 1 only
- Value or Detection Limit exceeds Criteria 2 only
- Value or Detection Limit exceeds both criteria

Table 5-1b PASI Sampling Results - PCBs

PASI - Cavite

Analytic Method: 8082_S
Sample Matrix: Soil
Reporting Units: mg/kg
Sample Dates: 07-Nov-2003 to 07-Nov-2003

	Arochlor 1016	Arochlor 1221	Arochlor 1232	Arochlor 1242	Arochlor 1248	Arochlor 1254	Arochlor 1260
SSI Project Action Limit (PAL) - Wave 2 (PCBs)	2	0.22	0.22	0.22	0.22	0.22	0.22
Secondary Regulatory Criteria Not Selected							

Location	Date	Sample ID	Depth	Method	DF							
CT-001	07-Nov-03	PASI-CT-CO-001-1	0-3'	8082_S	1	0.0021 u	0.0066 u	0.004 u	0.004 u	0.0094 u	0.0094 u	0.0085 u
	07-Nov-03	PASI-CT-GB-001A-1	0-3'	8082_S	1	0.0021 u	0.0066 u	0.004 u	0.004 u	0.11	0.0093 u	0.0084 u
	07-Nov-03	PASI-CT-GB-001B-1	0-3'	8082_S	1	0.0022 u	0.0067 u	0.0041 u	0.0041 u	0.0095 u	0.0095 u	0.0086 u
	07-Nov-03	PASI-CT-GB-001C-1	0-3'	8082_S	1	0.0021 u	0.0066 u	0.004 u	0.004 u	0.0094 u	0.0094 u	0.0085 u
	07-Nov-03	PASI-CT-GB-001D-1	0-3'	8082_S	1	0.0022 u	0.0067 u	0.0041 u	0.0041 u	0.0095 u	0.0095 u	0.0086 u
	07-Nov-03	PASI-CT-GB-001E-1	0-3'	8082_S	1	0.0022 u	0.0067 u	0.0041 u	0.0041 u	0.0095 u	0.0095 u	0.0086 u
CT-002	07-Nov-03	PASI-CT-CO-002-1	0-3'	8082_S	1	0.0021 u	0.0066 u	0.0041 u	0.0041 u	0.0094 u	0.0094 u	0.0086 u
	07-Nov-03	PASI-CT-GB-002A-1	0-3'	8082_S	1	0.0022 u	0.0067 u	0.0041 u	0.0041 u	0.0096 u	0.0096 u	0.0087 u
	07-Nov-03	PASI-CT-GB-002B-1	0-3'	8082_S	1	0.0022 u	0.0067 u	0.0041 u	0.0041 u	0.0096 u	0.0096 u	0.0087 u
	07-Nov-03	PASI-CT-GB-002C-1	0-3'	8082_S	1	0.0022 u	0.0067 u	0.0041 u	0.0041 u	0.0094 u	0.0094 u	0.0085 u
	07-Nov-03	PASI-CT-GB-002D-1	0-3'	8082_S	1	0.0022 u	0.0067 u	0.0041 u	0.0041 u	0.0096 u	0.0096 u	0.0087 u
	07-Nov-03	PASI-CT-GB-002E-1	0-3'	8082_S	1	0.0022 u	0.0068 u	0.0042 u	0.0042 u	0.0097 u	0.0097 u	0.0088 u
CT-003	07-Nov-03	PASI-CT-CO-003-1	0-3'	8082_S	1	0.0021 u	0.0065 u	0.004 u	0.004 u	0.0092 u	0.0092 u	0.0083 u
	07-Nov-03	PASI-CT-GB-003A-1	0-3'	8082_S	1	0.0021 u	0.0066 u	0.004 u	0.004 u	0.0094 u	0.0094 u	0.0085 u
	07-Nov-03	PASI-CT-GB-003B-1	0-3'	8082_S	1	0.0022 u	0.0068 u	0.0042 u	0.0042 u	0.0097 u	0.0097 u	0.0088 u
	07-Nov-03	PASI-CT-GB-003C-1	0-3'	8082_S	1	0.0021 u	0.0065 u	0.004 u	0.004 u	0.0092 u	0.0092 u	0.0083 u
	07-Nov-03	PASI-CT-GB-003D-1	0-3'	8082_S	1	0.0021 u	0.0065 u	0.004 u	0.004 u	0.0093 u	0.0093 u	0.0084 u
	07-Nov-03	PASI-CT-GB-003E-1	0-3'	8082_S	1	0.0021 u	0.0066 u	0.004 u	0.004 u	0.0094 u	0.0094 u	0.0085 u
CT-004	07-Nov-03	PASI-CT-CO-004-1	0-3'	8082_S	1	0.0021 u	0.0066 u	0.004 u	0.004 u	0.0093 u	0.0093 u	0.0085 u
	07-Nov-03	PASI-CT-GB-004A-1	0-3'	8082_S	1	0.0022 u	0.0067 u	0.0041 u	0.0041 u	0.0095 u	0.0095 u	0.0086 u
	07-Nov-03	PASI-CT-GB-004B-1	0-3'	8082_S	1	0.0021 u	0.0066 u	0.004 u	0.004 u	0.0093 u	0.0093 u	0.0084 u
	07-Nov-03	PASI-CT-GB-004C-1	0-3'	8082_S	1	0.0022 u	0.0068 u	0.0042 u	0.0042 u	0.0097 u	0.0097 u	0.0088 u
	07-Nov-03	PASI-CT-GB-004D-1	0-3'	8082_S	1	0.0022 u	0.0068 u	0.0042 u	0.0042 u	0.0097 u	0.0097 u	0.076
	07-Nov-03	PASI-CT-GB-004E-1	0-3'	8082_S	1	0.0022 u	0.0067 u	0.0041 u	0.0041 u	0.0095 u	0.0095 u	0.0086 u
CT-005	07-Nov-03	PASI-CT-CO-005-1	0-3'	8082_S	1	0.0021 u	0.0066 u	0.004 u	0.004 u	0.0093 u	0.0093 u	0.0085 u
	07-Nov-03	PASI-CT-GB-005A-1	0-2.5'	8082_S	1	0.0021 u	0.0066 u	0.004 u	0.004 u	0.0093 u	0.0093 u	0.0084 u
	07-Nov-03	PASI-CT-GB-005B-1	0-3'	8082_S	1	0.0021 u	0.0066 u	0.004 u	0.004 u	0.0094 u	0.0094 u	0.0085 u
	07-Nov-03	PASI-CT-GB-005C-1	0-2.5'	8082_S	1	0.0022 u	0.007 u	0.0043 u	0.0043 u	0.0098 u	0.0098 u	0.0089 u
	07-Nov-03	PASI-CT-GB-005D-1	0-3'	8082_S	1	0.0021 u	0.0065 u	0.004 u	0.004 u	0.0092 u	0.0092 u	0.0083 u
	07-Nov-03	PASI-CT-GB-005E-1	0-3'	8082_S	1	0.0022 u	0.0067 u	0.0041 u	0.0041 u	0.0095 u	0.0095 u	0.0086 u
CT-006	07-Nov-03	PASI-CT-CO-006-1	0-3'	8082_S	1	0.0022 u	0.0068 u	0.0041 u	0.0041 u	0.0096 u	0.0096 u	0.0087 u
	07-Nov-03	PASI-CT-GB-006A-1	0-3'	8082_S	1	0.0021 u	0.0066 u	0.0041 u	0.0041 u	0.0094 u	0.0094 u	0.0086 u
	07-Nov-03	PASI-CT-GB-006B-1	0-3'	8082_S	1	0.0021 u	0.0066 u	0.0041 u	0.0041 u	0.0094 u	0.0094 u	0.0086 u
	07-Nov-03	PASI-CT-GB-006C-1	0-3'	8082_S	1	0.0022 u	0.0067 u	0.0041 u	0.0041 u	0.0095 u	0.0095 u	0.0086 u
	07-Nov-03	PASI-CT-GB-006D-1	0-3'	8082_S	1	0.0022 u	0.0067 u	0.0041 u	0.0041 u	0.0095 u	0.0095 u	0.0086 u
	07-Nov-03	PASI-CT-GB-006E-1	0-3'	8082_S	1	0.0022 u	0.0067 u	0.0041 u	0.0041 u	0.0095 u	0.0095 u	0.0086 u

Notes:

- **NC** No criteria listed under the regulation cited
- **ND** Non-detect result (Original data unavailabl)
- **-** Parameter not analyzed

Analytic Flags:

- **u** Not detected above laboratory detection limits
- **j** Estimated value - parameter not detected above laboratory quantitation limits
- **e** Value exceeds analytical calibration limits
- **b** Parameter detected in quality control blank and sample

Highlighting:

- Value or Detection Limit exceeds Criteria 1 only
- Value or Detection Limit exceeds Criteria 2 only
- Value or Detection Limit exceeds both criteria

Table 5-1b PASI Sampling Results - PCBs

PASI - Cavite

Analytic Method: 8082_S
Sample Matrix: Soil
Reporting Units: mg/kg
Sample Dates: 07-Nov-2003 to 07-Nov-2003

	Arochlor 1016	Arochlor 1221	Arochlor 1232	Arochlor 1242	Arochlor 1248	Arochlor 1254	Arochlor 1260
SSI Project Action Limit (PAL) - Wave 2 (PCBs)	2	0.22	0.22	0.22	0.22	0.22	0.22
Secondary Regulatory Criteria Not Selected							
Location / **Date** / **Sample ID** / **Depth** / **Method** / **DF**							
CT-007 07-Nov-03 PASI-CT-CO-007-1 0-3' 8082_S 1	0.002 u	0.0063 u	0.0039 u	0.0039 u	0.0089 u	0.0089 u	0.0081 u
07-Nov-03 PASI-CT-GB-007A-1 0-3' 8082_S 1	0.0022 u	0.0068 u	0.0041 u	0.0041 u	0.0096 u	0.0096 u	0.0087 u
07-Nov-03 PASI-CT-GB-007B-1 0-3' 8082_S 1	0.0023 u	0.0072 u	0.0044 u	0.0044 u	0.01 u	0.01 u	0.0092 u
07-Nov-03 PASI-CT-GB-007C-1 0-3' 8082_S 1	0.002 u	0.0063 u	0.0039 u	0.0039 u	0.0089 u	0.0089 u	0.0081 u
07-Nov-03 PASI-CT-GB-007D-1 0-3' 8082_S 1	0.0022 u	0.0069 u	0.0042 u	0.0042 u	0.0098 u	0.0098 u	0.0089 u
07-Nov-03 PASI-CT-GB-007E-1 0-3' 8082_S 1	0.0022 u	0.0067 u	0.0041 u	0.0041 u	0.0096 u	0.0096 u	0.0087 u
CT-008 07-Nov-03 PASI-CT-CO-008-1 0-3' 8082_S 1	0.0021 u	0.0065 u	0.004 u	0.004 u	0.0093 u	0.0093 u	0.0084 u
07-Nov-03 PASI-CT-GB-008A-1 0-3' 8082_S 1	0.0021 u	0.0064 u	0.0039 u	0.0039 u	0.0091 u	0.0091 u	0.0083 u
07-Nov-03 PASI-CT-GB-008B-1 0-3' 8082_S 1	0.0021 u	0.0064 u	0.0039 u	0.0039 u	0.0091 u	0.0091 u	0.0083 u
07-Nov-03 PASI-CT-GB-008C-1 0-3' 8082_S 1	0.002 u	0.0063 u	0.0038 u	0.0038 u	0.0089 u	0.0089 u	0.0081 u
07-Nov-03 PASI-CT-GB-008D-1 0-3' 8082_S 1	0.0021 u	0.0065 u	0.004 u	0.004 u	0.0092 u	0.0092 u	0.0084 u
07-Nov-03 PASI-CT-GB-008E-1 0-3' 8082_S 1	0.0021 u	0.0064 u	0.0039 u	0.0039 u	0.0091 u	0.0091 u	0.0083 u

Notes:

- **NC** No criteria listed under the regulation cited
- **ND** Non-detect result (Original data unavailabl)
- **-** Parameter not analyzed

Analytic Flags:

- **u** Not detected above laboratory detection limits
- **j** Estimated value - parameter not detected above laboratory quantitation limits
- **e** Value exceeds analytical calibration limits
- **b** Parameter detected in quality control blank and sample

Highlighting:

- Value or Detection Limit exceeds Criteria 1 only
- Value or Detection Limit exceeds Criteria 2 only
- Value or Detection Limit exceeds both criteria

Table 5-1b PASI Sampling Results - PCBs

PASI - Grant

Analytic Method: 8082_S
Sample Matrix: Soil
Reporting Units: mg/kg
Sample Dates: 06-Nov-2003 to 18-Nov-2003

						Arochlor 1016	Arochlor 1221	Arochlor 1232	Arochlor 1242	Arochlor 1248	Arochlor 1254	Arochlor 1260
SSI Project Action Limit (PAL) - Wave 2 (PCBs)						2	0.22	0.22	0.22	0.22	0.22	0.22
Secondary Regulatory Criteria Not Selected												
Location	**Date**	**Sample ID**	**Depth**	**Method**	**DF**							
GR-001	06-Nov-03	PASI-GR-CO-001-1	0-3'	8082_S	1	0.0022 u	0.0067 u	0.0041 u	0.0041 u	0.0095 u	0.0095 u	0.0086 u
GR-002	06-Nov-03	PASI-GR-CO-002-1	0-3'	8082_S	1	0.0023 u	0.0071 u	0.0044 u	0.0044 u	0.01 u	0.01 u	0.0092 u
GR-003	06-Nov-03	PASI-GR-CO-003-1	0-3'	8082_S	1	0.0021 u	0.0066 u	0.004 u	0.004 u	0.0094 u	0.0094 u	0.0085 u
GR-004	06-Nov-03	PASI-GR-CO-004-1	0-3'	8082_S	1	0.0022 u	0.0067 u	0.0041 u	0.0041 u	0.0094 u	0.0094 u	0.0085 u
GR-005	06-Nov-03	PASI-GR-CO-005-1	0-3'	8082_S	1	0.0022 u	0.0068 u	0.0042 u	0.0042 u	0.0097 u	0.0097 u	0.0088 u
GR-006	06-Nov-03	PASI-GR-CO-006-1	0-3'	8082_S	1	0.002 u	0.0062 u	0.0038 u	0.0038 u	**0.27**	0.0088 u	0.008 u
	06-Nov-03	PASI-GR-GB-006A-	0-3'	8082_S	1	0.0071 u	0.022 u	0.013 u	0.013 u	0.031 u	0.031 u	0.028 u
	06-Nov-03	PASI-GR-GB-006B-	0-3'	8082_S	1	0.0067 u	0.021 u	0.013 u	0.013 u	0.029 u	0.029 u	0.027 u
	06-Nov-03	PASI-GR-GB-006C-	0-3'	8082_S	1	0.0065 u	0.02 u	0.012 u	0.012 u	0.028 u	0.13	0.026 u
	06-Nov-03	PASI-GR-GB-006D-	0-3'	8082_S	1	0.007 u	0.022 u	0.013 u	0.013 u	**0.51**	0.031 u	0.028 u
	06-Nov-03	PASI-GR-GB-006E-	0-3'	8082_S	1	0.0065 u	0.02 u	0.012 u	0.012 u	0.029 u	0.029 u	0.026 u
GR-007	06-Nov-03	PASI-GR-CO-007-1	0-3'	8082_S	1	0.0024 u	0.0074 u	0.0045 u	0.0045 u	0.01 u	0.01 u	0.0095 u
GR-008	06-Nov-03	PASI-GR-CO-008-1	0-3'	8082_S	10	0.029 u	0.089 u	0.054 u	0.054 u	**13**	0.12 u	0.11 u
	06-Nov-03	PASI-GR-GB-008A-	0-3'	8082_S	1	0.0065 u	0.02 u	0.012 u	0.012 u	0.028 u	0.028 u	0.026 u
	06-Nov-03	PASI-GR-GB-008B-	0-3'	8082_S	1	0.0065 u	0.02 u	0.012 u	0.012 u	0.029 u	0.029 u	0.026 u
	06-Nov-03	PASI-GR-GB-008C-	0-3'	8082_S	1	0.0067 u	0.021 u	0.013 u	0.013 u	0.03 u	0.03 u	0.027 u
	06-Nov-03	PASI-GR-GB-008D-	0-3'	8082_S	1	0.0065 u	0.02 u	0.012 u	0.012 u	0.029 u	0.029 u	0.026 u
	06-Nov-03	PASI-GR-GB-008E-	0-3'	8082_S	1	0.0065 u	0.02 u	0.012 u	0.012 u	0.028 u	0.028 u	0.026 u
GR-009	06-Nov-03	PASI-GR-CO-009-1	0-3'	8082_S	1	0.0022 u	0.007 u	0.0043 u	0.0043 u	0.0099 u	0.0099 u	0.009 u
GR-010	10-Nov-03	PASI-GR-CO-010-1	0-3'	8082_S	1	0.0024 u	0.0075 u	0.0046 u	0.0046 u	0.011 u	0.011 u	0.0097 u
	10-Nov-03	PASI-GR-CO-010-1	0-3'	8082_S	1	0.0024 u	0.0073 u	0.0045 u	0.0045 u	0.01 u	0.01 u	0.0095 u
GR-011	10-Nov-03	PASI-GR-CO-011-1	0-3'	8082_S	1	0.0024 u	0.0075 u	0.0046 u	0.0046 u	0.011 u	0.011 u	0.0097 u
	10-Nov-03	PASI-GR-CO-011-1	0-3'	8082_S	1	0.0021 u	0.0064 u	0.0039 u	0.0039 u	0.0091 u	0.0091 u	0.0083 u
GR-012	10-Nov-03	PASI-GR-CO-012-1	0-3'	8082_S	1	0.0022 u	0.0067 u	0.0041 u	0.0041 u	0.0095 u	0.0095 u	0.0086 u
GR-013	10-Nov-03	PASI-GR-CO-013-1	0-3'	8082_S	1	0.0024 u	0.0075 u	0.0046 u	0.0046 u	0.011 u	0.011 u	0.0096 u
GR-014	10-Nov-03	PASI-GR-CO-014-1	0-3'	8082_S	1	0.0024 u	0.0073 u	0.0045 u	0.0045 u	0.01 u	0.01 u	0.0094 u
GR-015	10-Nov-03	PASI-GR-CO-015-1	0-3'	8082_S	1	0.0023 u	0.007 u	0.0043 u	0.0043 u	**0.56**	0.01 u	0.0091 u
	10-Nov-03	PASI-GR-GB-015A-	0-3'	8082_S	5	0.01 u	0.033 u	0.02 u	0.02 u	**2.6**	0.046 u	0.042 u
	10-Nov-03	PASI-GR-GB-015B-	0-3'	8082_S	1	0.0021 u	0.0066 u	0.004 u	0.004 u	0.0093 u	0.0093 u	0.0085 u
	10-Nov-03	PASI-GR-GB-015C-	0-3'	8082_S	1	0.002 u	0.0063 u	0.0039 u	0.0039 u	0.009 u	0.009 u	0.0082 u
	10-Nov-03	PASI-GR-GB-015D-	0-3'	8082_S	1	0.0022 u	0.0067 u	0.0041 u	0.0041 u	0.0095 u	0.0095 u	0.0086 u
	10-Nov-03	PASI-GR-GB-015E-	0-3'	8082_S	1	0.0021 u	0.0065 u	0.004 u	0.004 u	0.0092 u	0.0092 u	0.0083 u
GR-016	10-Nov-03	PASI-GR-CO-016-1	0-3'	8082_S	1	0.0022 u	0.0069 u	0.0042 u	0.0042 u	0.0097 u	0.0097 u	0.0088 u

Notes:

- **NC** No criteria listed under the regulation cited
- **ND** Non-detect result (Original data unavailabl)
- **-** Parameter not analyzed

Analytic Flags:

- **u** Not detected above laboratory detection limits
- **j** Estimated value - parameter not detected above laboratory quantitation limits
- **e** Value exceeds analytical calibration limits
- **b** Parameter detected in quality control blank and sample

Highlighting:

- Value or Detection Limit exceeds Criteria 1 only
- Value or Detection Limit exceeds Criteria 2 only
- Value or Detection Limit exceeds both criteria

Table 5-1b PASI Sampling Results - PCBs

PASI - Grant

Analytic Method: 8082_S
Sample Matrix: Soil
Reporting Units: mg/kg
Sample Dates: 06-Nov-2003 to 18-Nov-2003

						Arochlor 1016	Arochlor 1221	Arochlor 1232	Arochlor 1242	Arochlor 1248	Arochlor 1254	Arochlor 1260	
SSI Project Action Limit (PAL) - Wave 2 (PCBs)						2	0.22	0.22	0.22	0.22	0.22	0.22	
Secondary Regulatory Criteria Not Selected													
Location	**Date**	**Sample ID**	**Depth**	**Method**	**DF**								
GR-017	10-Nov-03	PASI-GR-CO-017-1	0-3'	8082_S	1	0.0023 u	0.0073 u	0.0045 u	0.0045 u	**0.39**	0.01 u	0.0094	u
	10-Nov-03	PASI-GR-GB-017A-	0-3'	8082_S	1	0.0021 u	0.0065 u	0.004 u	0.004 u	**0.46**	0.0093 u	0.0084	u
	10-Nov-03	PASI-GR-GB-017B-	0-3'	8082_S	1	0.002 u	0.0063 u	0.0039 u	0.0039 u	0.009 u	0.009 u	0.0081	u
	10-Nov-03	PASI-GR-GB-017C-	0-3'	8082_S	1	0.0021 u	0.0066 u	0.0041 u	0.0041 u	0.041	0.0094 u	0.0086	u
	10-Nov-03	PASI-GR-GB-017D-	0-3'	8082_S	1	0.0021 u	0.0066 u	0.004 u	0.004 u	0.0094 u	0.0094 u	0.0085	u
	10-Nov-03	PASI-GR-GB-017E-	0-3'	8082_S	1	0.0022 u	0.0068 u	0.0042 u	0.0042 u	0.0096 u	0.0096 u	0.0088	u
GR-018	12-Nov-03	PASI-GR-CO-018-1	0-3'	8082_S	1	0.0068 u	0.021 u	0.013 u	0.013 u	**1.8**	0.03 u	0.027	u
	12-Nov-03	PASI-GR-GB-018A-	0-3'	8082_S	1	0.0062 u	0.019 u	0.012 u	0.012 u	0.027 u	0.027 u	0.025	u
	12-Nov-03	PASI-GR-GB-018B-	0-3'	8082_S	1	0.0063 u	0.02 u	0.012 u	0.012 u	0.12	0.028 u	0.025	u
	12-Nov-03	PASI-GR-GB-018C-	0-3'	8082_S	1	0.0062 u	0.019 u	0.012 u	0.012 u	**4.1**	0.027 u	0.025	u
	12-Nov-03	PASI-GR-GB-018D-	0-3'	8082_S	1	0.0062 u	0.019 u	0.012 u	0.012 u	**0.53**	0.027 u	0.025	u
	12-Nov-03	PASI-GR-GB-018E-	0-3'	8082_S	1	0.006 u	0.018 u	0.011 u	0.011 u	0.026 u	0.026 u	0.024	u
GR-019	12-Nov-03	PASI-GR-CO-019-1	0-3'	8082_S	1	0.0061 u	0.019 u	0.012 u	0.012 u	0.16	0.027 u	0.024	u
	12-Nov-03	PASI-GR-GB-019A-	0-3'	8082_S	1	0.0065 u	0.02 u	0.012 u	0.012 u	**1.1**	0.028 u	0.026	u
	12-Nov-03	PASI-GR-GB-019B-	0-3'	8082_S	1	0.0061 u	0.019 u	0.012 u	0.012 u	**0.87**	0.027 u	0.024	u
	12-Nov-03	PASI-GR-GB-019C-	0-3'	8082_S	1	0.0059 u	0.018 u	0.011 u	0.011 u	0.026 u	0.026 u	0.024	u
	12-Nov-03	PASI-GR-GB-019D-	0-3'	8082_S	1	0.0062 u	0.019 u	0.012 u	0.012 u	0.027 u	0.027 u	0.025	u
	12-Nov-03	PASI-GR-GB-019E-	0-3'	8082_S	1	0.0061 u	0.019 u	0.012 u	0.012 u	0.027 u	0.027 u	0.024	u
GR-020	11-Nov-03	PASI-GR-CO-020-1	0-3'	8082_S	1	0.0023 u	0.0072 u	0.0044 u	0.0044 u	0.063	0.01 u	0.0093	u
	11-Nov-03	PASI-GR-GB-020A-	0-3'	8082_S	1	0.002 u	0.0062 u	0.0038 u	0.0038 u	0.0088 u	0.0088 u	0.008	u
	11-Nov-03	PASI-GR-GB-020B-	0-3'	8082_S	1	0.0021 u	0.0065 u	0.004 u	0.004 u	0.0092 u	0.0092 u	0.0084	u
	11-Nov-03	PASI-GR-GB-020C-	0-3'	8082_S	1	0.0021 u	0.0065 u	0.004 u	0.004 u	0.0092 u	0.0092 u	0.0084	u
	11-Nov-03	PASI-GR-GB-020D-	0-3'	8082_S	1	0.0021 u	0.0064 u	0.0039 u	0.0039 u	0.0091 u	0.039	0.0083	u
	11-Nov-03	PASI-GR-GB-020E-	0-3'	8082_S	1	0.0021 u	0.0064 u	0.0039 u	0.0039 u	**0.75**	0.0091 u	0.0083	u
GR-021	11-Nov-03	PASI-GR-CO-021-1	0-3'	8082_S	1	0.0024 u	0.0074 u	0.0045 u	0.0045 u	**0.24**	0.01 u	0.0095	u
	11-Nov-03	PASI-GR-GB-021A-	0-3'	8082_S	1	0.0021 u	0.0066 u	0.004 u	0.004 u	**0.3**	0.0093 u	0.0085	u
	11-Nov-03	PASI-GR-GB-021B-	0-3'	8082_S	1	0.0022 u	0.0067 u	0.0041 u	0.0041 u	0.19	0.0095 u	0.0087	u
	11-Nov-03	PASI-GR-GB-021C-	0-3'	8082_S	1	0.0021 u	0.0064 u	0.004 u	0.004 u	**0.61**	0.0091 u	0.0083	u
	11-Nov-03	PASI-GR-GB-021D-	0-3'	8082_S	1	0.0021 u	0.0067 u	0.0041 u	0.0041 u	0.0094 u	0.0094 u	0.0086	u
	11-Nov-03	PASI-GR-GB-021E-	0-3'	8082_S	1	0.0021 u	0.0066 u	0.004 u	0.004 u	0.0094 u	0.0094 u	0.0085	u
GR-022	11-Nov-03	PASI-GR-CO-022-1	0-3'	8082_S	1	0.0022 u	0.007 u	0.0043 u	0.0043 u	**0.31**	0.0099 u	0.009	u
	11-Nov-03	PASI-GR-GB-022A-	0-3'	8082_S	1	0.0061 u	0.019 u	0.012 u	0.012 u	0.027 u	0.027 u	0.024	u
	11-Nov-03	PASI-GR-GB-022B-	0-3'	8082_S	1	0.006 u	0.019 u	0.011 u	0.011 u	0.026 u	0.026 u	0.024	u
	11-Nov-03	PASI-GR-GB-022C-	0-3'	8082_S	1	0.0061 u	0.019 u	0.012 u	0.012 u	0.027 u	0.027 u	0.024	u
	11-Nov-03	PASI-GR-GB-022D-	0-3'	8082_S	1	0.0063 u	0.02 u	0.012 u	0.012 u	**1.5**	0.028 u	0.025	u
	11-Nov-03	PASI-GR-GB-022E-	0-3'	8082_S	1	0.006 u	0.019 u	0.011 u	0.011 u	0.026 u	0.026 u	0.024	u
GR-023	11-Nov-03	PASI-GR-CO-023-1	0-3'	8082_S	1	0.0025 u	0.0077 u	0.0047 u	0.0047 u	0.011 u	0.011 u	0.0099	u

Notes:

- **NC** No criteria listed under the regulation cited
- **ND** Non-detect result (Original data unavailabl)
- **-** Parameter not analyzed

Analytic Flags:

- **u** Not detected above laboratory detection limits
- **j** Estimated value - parameter not detected above laboratory quantitation limits
- **e** Value exceeds analytical calibration limits
- **b** Parameter detected in quality control blank and sample

Highlighting:

- Value or Detection Limit exceeds Criteria 1 only
- Value or Detection Limit exceeds Criteria 2 only
- Value or Detection Limit exceeds both criteria

Table 5-1b PASI Sampling Results - PCBs

PASI - Grant

Analytic Method: 8082_S
Sample Matrix: Soil
Reporting Units: mg/kg
Sample Dates: 06-Nov-2003 to 18-Nov-2003

						Arochlor 1016	Arochlor 1221	Arochlor 1232	Arochlor 1242	Arochlor 1248	Arochlor 1254	Arochlor 1260	
SSI Project Action Limit (PAL) - Wave 2 (PCBs)						2	0.22	0.22	0.22	0.22	0.22	0.22	
Secondary Regulatory Criteria Not Selected													
Location	**Date**	**Sample ID**	**Depth**	**Method**	**DF**								
GR-024	11-Nov-03	PASI-GR-CO-024-1	0-3'	8082_S	1	0.0024 u	0.0075 u	0.0046 u	0.0046 u	0.011 u	0.011 u	0.0096	u
	11-Nov-03	PASI-GR-GB-024A-	0-3'	8082_S	1	0.0023 u	0.0071 u	0.0044 u	0.0044 u	0.01 u	0.01 u	0.0092	u
	11-Nov-03	PASI-GR-GB-024B-	0-3'	8082_S	1	0.0023 u	0.0073 u	0.0045 u	0.0045 u	0.01 u	0.01 u	0.0094	u
	11-Nov-03	PASI-GR-GB-024C-	0-3'	8082_S	1	0.0024 u	0.0074 u	0.0045 u	0.0045 u	0.011 u	0.011 u	0.0096	u
	11-Nov-03	PASI-GR-GB-024D-	0-3'	8082_S	1	0.0027 u	0.0084 u	0.0052 u	0.0052 u	0.012 u	0.012 u	0.011	u
	11-Nov-03	PASI-GR-GB-024E-	0-3'	8082_S	1	0.0024 u	0.0074 u	0.0045 u	0.0045 u	0.01 u	0.01 u	0.0095	u
GR-025	11-Nov-03	PASI-GR-CO-025-1	0-3'	8082_S	1	0.0021 u	0.0065 u	0.004 u	0.004 u	0.0092 u	0.0092 u	0.0084	u
	11-Nov-03	PASI-GR-GB-025A-	0-3'	8082_S	1	0.0021 u	0.0065 u	0.004 u	0.004 u	0.0093 u	0.0093 u	0.0084	u
	11-Nov-03	PASI-GR-GB-025B-	0-3'	8082_S	1	0.0022 u	0.0069 u	0.0042 u	0.0042 u	0.0098 u	0.0098 u	0.0089	u
	11-Nov-03	PASI-GR-GB-025C-	0-3'	8082_S	1	0.0023 u	0.0071 u	0.0043 u	0.0043 u	0.01 u	0.01 u	0.0091	u
	11-Nov-03	PASI-GR-GB-025D-	0-3'	8082_S	1	0.0023 u	0.007 u	0.0043 u	0.0043 u	0.01 u	0.01 u	0.0091	u
	11-Nov-03	PASI-GR-GB-025E-	0-3'	8082_S	1	0.0022 u	0.0069 u	0.0042 u	0.0042 u	0.0098 u	0.0098 u	0.0089	u
GR-026	12-Nov-03	PASI-GR-CO-026-1	0-3'	8082_S	1	0.0025 u	0.0076 u	0.0047 u	0.0047 u	0.011 u	0.011 u	0.0098	u
GR-027	12-Nov-03	PASI-GR-CO-027-1	0-3'	8082_S	1	0.0022 u	0.0069 u	0.0042 u	0.0042 u	0.0098 u	0.0098 u	0.0089	u
GR-028	12-Nov-03	PASI-GR-CO-028-1	0-3'	8082_S	1	0.0024 u	0.0075 u	0.0046 u	0.0046 u	0.011 u	0.011 u	0.0097	u
GR-029	12-Nov-03	PASI-GR-CO-029-1	0-3'	8082_S	1	0.0024 u	0.0075 u	0.0046 u	0.0046 u	0.011 u	0.011 u	0.0097	u
GR-030	12-Nov-03	PASI-GR-CO-030-1	0-3'	8082_S	1	0.0069 u	0.021 u	0.013 u	0.013 u	0.03 u	0.03 u	0.028	u
GR-031	12-Nov-03	PASI-GR-CO-031-1	0-3'	8082_S	1	0.0075 u	0.023 u	0.014 u	0.014 u	0.033 u	0.033 u	0.03	u
GR-032	12-Nov-03	PASI-GR-CO-032-1	0-3'	8082_S	1	0.0075 u	0.023 u	0.014 u	0.014 u	0.033 u	0.033 u	0.03	u
GR-033	12-Nov-03	PASI-GR-CO-033-1	0-3'	8082_S	1	0.0072 u	0.022 u	0.014 u	0.014 u	0.032 u	0.032 u	0.029	u
GR-034	13-Nov-03	PASI-GR-CO-034-1	0-3'	8082_S	1	0.006 u	0.019 u	0.011 u	0.011 u	0.026 u	0.026 u	0.024	u
GR-035	13-Nov-03	PASI-GR-CO-035-1	0-3'	8082_S	1	0.0061 u	0.019 u	0.012 u	0.012 u	0.027 u	0.027 u	0.024	u
GR-036	13-Nov-03	PASI-GR-CO-036-1	0-3'	8082_S	1	0.0083 u	0.026 u	0.016 u	0.016 u	**4.7**	0.037 u	0.033	u
	13-Nov-03	PASI-GR-GB-036A-	0-3'	8082_S	1	0.006 u	0.019 u	0.011 u	0.011 u	0.18	0.026 u	0.024	u
	13-Nov-03	PASI-GR-GB-036B-	0-3'	8082_S	1	0.006 u	0.019 u	0.011 u	0.011 u	**0.83**	0.027 u	0.024	u
	13-Nov-03	PASI-GR-GB-036C-	0-3'	8082_S	1	0.0066 u	0.02 u	0.013 u	0.013 u	**0.33**	0.029 u	0.026	u
	13-Nov-03	PASI-GR-GB-036D-	0-3'	8082_S	1	0.0061 u	0.019 u	0.012 u	0.012 u	**1.3**	0.027 u	0.024	u
	13-Nov-03	PASI-GR-GB-036E-	0-3'	8082_S	1	0.0064 u	0.02 u	0.012 u	0.012 u	0.028 u	0.028 u	0.026	u
GR-037	13-Nov-03	PASI-GR-CO-037-1	0-3'	8082_S	1	0.0062 u	0.019 u	0.012 u	0.012 u	0.027 u	0.027 u	0.025	u
GR-038	13-Nov-03	PASI-GR-CO-038-1	0-3'	8082_S	1	0.0069 u	0.021 u	0.013 u	0.013 u	0.03 u	0.03 u	0.028	u
GR-039	13-Nov-03	PASI-GR-CO-039-1	0-3'	8082_S	1	0.007 u	0.022 u	0.013 u	0.013 u	0.031 u	0.031 u	0.028	u
GR-040	13-Nov-03	PASI-GR-CO-040-1	0-3'	8082_S	1	0.0075 u	0.023 u	0.014 u	0.014 u	0.033 u	0.033 u	0.03	u
GR-041	13-Nov-03	PASI-GR-CO-041-1	0-3'	8082_S	1	0.0072 u	0.022 u	0.014 u	0.014 u	0.032 u	0.032 u	0.029	u
GR-042	13-Nov-03	PASI-GR-CO-042-1	0-3'	8082_S	1	0.0066 u	0.02 u	0.013 u	0.013 u	0.029 u	0.029 u	0.026	u

Notes:

- **NC** No criteria listed under the regulation cited
- **ND** Non-detect result (Original data unavailabl)
- **-** Parameter not analyzed

Analytic Flags:

- **u** Not detected above laboratory detection limits
- **j** Estimated value - parameter not detected above laboratory quantitation limits
- **e** Value exceeds analytical calibration limits
- **b** Parameter detected in quality control blank and sample

Highlighting:

- Value or Detection Limit exceeds Criteria 1 only
- Value or Detection Limit exceeds Criteria 2 only
- Value or Detection Limit exceeds both criteria

Table 5-1b PASI Sampling Results - PCBs

PASI - Grant

Analytic Method: 8082_S
Sample Matrix: Soil
Reporting Units: mg/kg
Sample Dates: 06-Nov-2003 to 18-Nov-2003

						Arochlor 1016	Arochlor 1221	Arochlor 1232	Arochlor 1242	Arochlor 1248	Arochlor 1254	Arochlor 1260	
SSI Project Action Limit (PAL) - Wave 2 (PCBs)						2	0.22	0.22	0.22	0.22	0.22	0.22	
Secondary Regulatory Criteria Not Selected													
Location	**Date**	**Sample ID**	**Depth**	**Method**	**DF**								
GR-043	13-Nov-03	PASI-GR-CO-043-1	0-3'	8082_S	1	0.0065 u	0.02 u	0.012 u	0.012 u	**1.1**	0.028 u	0.026	u
	13-Nov-03	PASI-GR-GB-043A-	0-3'	8082_S	1	0.0021 u	0.0066 u	0.0041 u	0.0041 u	0.0094 u	0.0094 u	0.0086	u
	13-Nov-03	PASI-GR-GB-043B-	0-3'	8082_S	1	0.002 u	0.0063 u	0.0039 u	0.0039 u	0.009 u	0.009 u	0.0082	u
	13-Nov-03	PASI-GR-GB-043C-	0-3'	8082_S	1	0.0022 u	0.0067 u	0.0041 u	0.0041 u	**1.7**	0.0095 u	0.0086	u
	13-Nov-03	PASI-GR-GB-043D-	0-3'	8082_S	1	0.0021 u	0.0066 u	0.004 u	0.004 u	0.15	0.0093 u	0.0085	u
	13-Nov-03	PASI-GR-GB-043E-	0-3'	8082_S	1	0.0021 u	0.0066 u	0.004 u	0.004 u	0.0093 u	0.0093 u	0.0085	u
GR-044	17-Nov-03	PASI-GR-CO-044-1	0-3'	8082_S	1	0.0065 u	0.02 u	0.012 u	0.012 u	0.029 u	0.029 u	0.026	u
GR-045	13-Nov-03	PASI-GR-CO-045-1	0-3'	8082_S	1	0.0064 u	0.02 u	0.012 u	0.012 u	0.028 u	0.028 u	0.026	u
GR-046	14-Nov-03	PASI-GR-CO-046-1	0-3'	8082_S	1	0.0069 u	0.021 u	0.013 u	0.013 u	0.03 u	0.03 u	0.028	u
GR-047	14-Nov-03	PASI-GR-CO-047-1	0-3'	8082_S	1	0.007 u	0.022 u	0.013 u	0.013 u	0.031 u	0.031 u	0.028	u
GR-048	14-Nov-03	PASI-GR-CO-048-1	0-3'	8082_S	1	0.0068 u	0.021 u	0.013 u	0.013 u	0.03 u	0.03 u	0.027	u
GR-049	14-Nov-03	PASI-GR-CO-049-1	0-3'	8082_S	1	0.0066 u	0.02 u	0.013 u	0.013 u	0.029 u	0.029 u	0.026	u
GR-050	14-Nov-03	PASI-GR-CO-050-1	0-3'	8082_S	1	0.0066 u	0.02 u	0.013 u	0.013 u	0.029 u	0.029 u	0.026	u
GR-051	14-Nov-03	PASI-GR-CO-051-1	0-3'	8082_S	1	0.0065 u	0.02 u	0.012 u	0.012 u	0.029 u	0.029 u	0.026	u
GR-052	14-Nov-03	PASI-GR-CO-052-1	0-3'	8082_S	1	0.0067 u	0.021 u	0.013 u	0.013 u	0.029 u	0.029 u	0.027	u
GR-053	14-Nov-03	PASI-GR-CO-053-1	0-3'	8082_S	1	0.0064 u	0.02 u	0.012 u	0.012 u	0.028 u	0.028 u	0.026	u
GR-054	14-Nov-03	PASI-GR-CO-054-1	0-3'	8082_S	1	0.0067 u	0.021 u	0.012 u	0.012 u	0.029 u	0.029 u	0.027	u
GR-055	14-Nov-03	PASI-GR-CO-055-1	0-3'	8082_S	1	0.0067 u	0.02 u	0.013 u	0.013 u	0.03 u	0.03 u	0.027	u
GR-056	14-Nov-03	PASI-GR-CO-056-1	0-3'	8082_S	1	0.0065 u	0.02 u	0.012 u	0.012 u	0.029 u	0.029 u	0.026	u
GR-057	17-Nov-03	PASI-GR-CO-057-1	0-3'	8082_S	1	0.007 u	0.022 u	0.013 u	0.013 u	0.03 u	0.03 u	0.028	u
GR-058	17-Nov-03	PASI-GR-CO-058-1	0-3'	8082_S	1	0.0065 u	0.02 u	0.012 u	0.012 u	0.029 u	0.029 u	0.026	u
GR-059	14-Nov-03	PASI-GR-CO-059-1	0-3'	8082_S	1	0.0066 u	0.021 u	0.012 u	0.012 u	0.029 u	0.029 u	0.026	u
GR-060	14-Nov-03	PASI-GR-CO-060-1	0-3'	8082_S	1	0.0065 u	0.021 u	0.012 u	0.012 u	0.028 u	0.028 u	0.026	u
GR-061	17-Nov-03	PASI-GR-CO-061-1	0-3'	8082_S	1	0.0068 u	0.022 u	0.013 u	0.013 u	0.03 u	0.03 u	0.027	u
GR-062	17-Nov-03	PASI-GR-CO-062-1	0-3'	8082_S	1	0.0064 u	0.02 u	0.012 u	0.012 u	0.029 u	0.029 u	0.025	u
GR-063	17-Nov-03	PASI-GR-CO-063-1	0-3'	8082_S	1	0.0063 u	0.02 u	0.012 u	0.012 u	0.027 u	0.027 u	0.025	u
	17-Nov-03	PASI-GR-CO-063-1	0-3'	8082_S	1	0.0063 u	0.019 u	0.012 u	0.012 u	0.028 u	0.028 u	0.026	u
GR-064	17-Nov-03	PASI-GR-CO-064-1	0-3'	8082_S	1	0.0063 u	0.019 u	0.012 u	0.012 u	0.028 u	0.028 u	0.026	u
GR-065	17-Nov-03	PASI-GR-CO-065-1	0-3'	8082_S	1	0.0065 u	0.02 u	0.012 u	0.012 u	0.028 u	0.028 u	0.026	u
GR-066	17-Nov-03	PASI-GR-CO-066-1	0-3'	8082_S	1	0.0061 u	0.019 u	0.011 u	0.011 u	0.027 u	0.027 u	0.025	u
GR-067	18-Nov-03	PASI-GR-CO-067-1	0-3'	8082_S	1	0.0063 u	0.019 u	0.012 u	0.012 u	0.028 u	0.028 u	0.026	u
GR-068	18-Nov-03	PASI-GR-CO-068-1	0-3'	8082_S	1	0.007 u	0.022 u	0.013 u	0.013 u	0.03 u	0.03 u	0.028	u
GR-069	18-Nov-03	PASI-GR-CO-069-1	0-3'	8082_S	1	0.0063 u	0.019 u	0.012 u	0.012 u	0.028 u	0.028 u	0.026	u
GR-070	18-Nov-03	PASI-GR-CO-070-1	0-3'	8082_S	1	0.0062 u	0.019 u	0.012 u	0.012 u	0.027 u	0.027 u	0.024	u

Notes:

- **NC** No criteria listed under the regulation cited
- **ND** Non-detect result (Original data unavailabl)
- **-** Parameter not analyzed

Analytic Flags:

- **u** Not detected above laboratory detection limits
- **j** Estimated value - parameter not detected above laboratory quantitation limits
- **e** Value exceeds analytical calibration limits
- **b** Parameter detected in quality control blank and sample

Highlighting:

- Value or Detection Limit exceeds Criteria 1 only
- Value or Detection Limit exceeds Criteria 2 only
- Value or Detection Limit exceeds both criteria

Table 5-1b PASI Sampling Results - PCBs

PASI - Grant

Analytic Method: 8082_S
Sample Matrix: Soil
Reporting Units: mg/kg
Sample Dates: 06-Nov-2003 to 18-Nov-2003

	Arochlor 1016	Arochlor 1221	Arochlor 1232	Arochlor 1242	Arochlor 1248	Arochlor 1254	Arochlor 1260
SSI Project Action Limit (PAL) - Wave 2 (PCBs)	2	0.22	0.22	0.22	0.22	0.22	0.22
Secondary Regulatory Criteria Not Selected							

Location	Date	Sample ID	Depth	Method	DF							
GR-071	18-Nov-03	PASI-GR-CO-071-1	0-3'	8082_S	1	0.0064 u	0.02 u	0.012 u	0.012 u	0.028 u	0.028 u	0.026 u
	18-Nov-03	PASI-GR-CO-071-1	0-3'	8082_S	1	0.0065 u	0.02 u	0.012 u	0.012 u	0.028 u	0.028 u	0.026 u
GR-072	18-Nov-03	PASI-GR-CO-072-1	0-3'	8082_S	1	0.0061 u	0.019 u	0.012 u	0.012 u	0.027 u	0.027 u	0.025 u
GR-073	18-Nov-03	PASI-GR-CO-073-1	0-3'	8082_S	1	0.0064 u	0.02 u	0.012 u	0.012 u	0.028 u	0.028 u	0.026 u
GR-074	18-Nov-03	PASI-GR-CO-074-1	0-3'	8082_S	1	0.0063 u	0.02 u	0.012 u	0.012 u	0.028 u	0.028 u	0.025 u
GR-075	18-Nov-03	PASI-GR-CO-075-1	0-3'	8082_S	1	0.0063 u	0.019 u	0.012 u	0.012 u	0.028 u	0.028 u	0.025 u
GR-200	10-Nov-03	PASI-GR-GB-200-1	1.75-4.75	8082_S	1	0.0021 u	0.0066 u	0.004 u	0.004 u	0.0094 u	0.0094 u	0.0085 u
GR-201	10-Nov-03	PASI-GR-GB-201-1	1.33-4.33	8082_S	1	0.0023 u	0.0073 u	0.0045 u	0.0045 u	0.01 u	0.01 u	0.0094 u
GR-202	10-Nov-03	PASI-GR-GB-202-1	1-4'	8082_S	1	0.0024 u	0.0073 u	0.0045 u	0.0045 u	0.01 u	0.01 u	0.0095 u
GR-203	10-Nov-03	PASI-GR-GB-203-1	1.33-4.33	8082_S	1	0.0024 u	0.0074 u	0.0045 u	0.0045 u	0.01 u	0.01 u	0.0095 u
GR-204	10-Nov-03	PASI-GR-GB-204-1	1.33-4.33	8082_S	1	0.0025 u	0.0076 u	0.0047 u	0.0047 u	0.011 u	0.011 u	0.0099 u
GR-205	10-Nov-03	PASI-GR-GB-205-1	1.33-4.33	8082_S	1	0.0026 u	0.008 u	0.0049 u	0.0049 u	0.011 u	0.011 u	0.01 u
GR-206	10-Nov-03	PASI-GR-GB-206-1	1.33-4.33	8082_S	1	0.0026 u	0.008 u	0.0049 u	0.0049 u	0.011 u	0.011 u	0.01 u
GR-207	10-Nov-03	PASI-GR-GB-207-1	1-4'	8082_S	1	0.0028 u	0.0086 u	0.0053 u	0.0053 u	0.012 u	0.012 u	0.011 u
GR-208	10-Nov-03	PASI-GR-GB-208-1	1.33-4.33	8082_S	1	0.0026 u	0.0081 u	0.0049 u	0.0049 u	0.011 u	0.011 u	0.01 u
GR-209	10-Nov-03	PASI-GR-GB-209-1	1-4'	8082_S	1	0.0026 u	0.008 u	0.0049 u	0.0049 u	0.011 u	0.011 u	0.01 u
GR-210	10-Nov-03	PASI-GR-GB-210-1	1.17-4.17	8082_S	1	0.0025 u	0.0077 u	0.0047 u	0.0047 u	0.011 u	0.011 u	0.01 u
GR-211	10-Nov-03	PASI-GR-GB-211-1	1-4'	8082_S	1	0.0027 u	0.0084 u	0.0052 u	0.0052 u	0.012 u	0.012 u	0.011 u
GR-212	10-Nov-03	PASI-GR-GB-212-1	1.17-4.17	8082_S	1	0.0032 u	0.01 u	0.0061 u	0.0061 u	0.014 u	0.014 u	0.013 u
GR-213	10-Nov-03	PASI-GR-GB-213-1	1.33-4.33	8082_S	1	0.0023 u	0.0072 u	0.0044 u	0.0044 u	0.01 u	0.01 u	0.0092 u
GR-214	10-Nov-03	PASI-GR-GB-214-1	3.66-3.66	8082_S	1	0.0022 u	0.007 u	0.0043 u	0.0043 u	0.0099 u	0.0099 u	0.009 u
GR-215	10-Nov-03	PASI-GR-GB-215-1	3.75-3.75	8082_S	1	0.0023 u	0.0071 u	0.0043 u	0.0043 u	0.01 u	0.01 u	0.0091 u
GR-216	10-Nov-03	PASI-GR-GB-216-1	0-3'	8082_S	1	0.0022 u	0.0069 u	0.0042 u	0.0042 u	0.0098 u	0.0098 u	0.0089 u
GR-217	10-Nov-03	PASI-GR-GB-217-1	1-4'	8082_S	10	0.023 u	0.071 u	0.043 u	0.043 u	**13**	0.1 u	0.091 u
GR-218	10-Nov-03	PASI-GR-GB-218-1	1-4'	8082_S	1	0.0022 u	0.0068 u	0.0042 u	0.0042 u	0.037	0.0097 u	0.0088 u
GR-219	10-Nov-03	PASI-GR-GB-219-1	1-4'	8082_S	10	0.022 u	0.067 u	0.041 u	0.041 u	**6.1**	0.095 u	0.087 u
GR-220	10-Nov-03	PASI-GR-GB-220-1	1.33-4.33	8082_S	1	0.0027 u	0.0082 u	0.005 u	0.005 u	0.012 u	0.012 u	0.011 u
	10-Nov-03	PASI-GR-GB-220-1-	1.33-4.33	8082_S	1	0.0026 u	0.008 u	0.0049 u	0.0049 u	0.011 u	0.011 u	0.01 u
GR-221	10-Nov-03	PASI-GR-GB-221-1	1.17-4.17	8082_S	1	0.0024 u	0.0076 u	0.0046 u	0.0046 u	0.011 u	0.011 u	0.0098 u
GR-222	10-Nov-03	PASI-GR-GB-222-1	1.58-4.58	8082_S	1	0.0023 u	0.0071 u	0.0044 u	0.0044 u	0.01 u	0.01 u	0.0092 u
GR-223	10-Nov-03	PASI-GR-GB-223-1	1.5-4.5'	8082_S	1	0.0023 u	0.0071 u	0.0043 u	0.0043 u	0.01 u	0.01 u	0.0091 u
GR-224	10-Nov-03	PASI-GR-GB-224-1	1-4'	8082_S	1	0.0021 u	0.0065 u	0.004 u	0.004 u	0.0092 u	0.0092 u	0.0084 u
GR-225	10-Nov-03	PASI-GR-GB-225-1	1-4'	8082_S	1	0.0027 u	0.0083 u	0.0051 u	0.0051 u	0.012 u	0.012 u	0.011 u
GR-226	10-Nov-03	PASI-GR-GB-226-1	0.5-3.5'	8082_S	1	0.0071 u	0.022 u	0.013 u	0.013 u	0.031 u	0.031 u	0.028 u

Notes:

- **NC** No criteria listed under the regulation cited
- **ND** Non-detect result (Original data unavailabl)
- **-** Parameter not analyzed

Analytic Flags:

- **u** Not detected above laboratory detection limits
- **j** Estimated value - parameter not detected above laboratory quantitation limits
- **e** Value exceeds analytical calibration limits
- **b** Parameter detected in quality control blank and sample

Highlighting:

- Value or Detection Limit exceeds Criteria 1 only
- Value or Detection Limit exceeds Criteria 2 only
- Value or Detection Limit exceeds both criteria

Table 5-1b PASI Sampling Results - PCBs

PASI - Grant

Analytic Method: 8082_S
Sample Matrix: Soil
Reporting Units: mg/kg
Sample Dates: 06-Nov-2003 to 18-Nov-2003

	Arochlor 1016	Arochlor 1221	Arochlor 1232	Arochlor 1242	Arochlor 1248	Arochlor 1254	Arochlor 1260
SSI Project Action Limit (PAL) - Wave 2 (PCBs)	2	0.22	0.22	0.22	0.22	0.22	0.22
Secondary Regulatory Criteria Not Selected							

Location	Date	Sample ID	Depth	Method	DF							
GR-227	10-Nov-03	PASI-GR-GB-227-1	3.66-3.66	8082_S	1	0.0025 u	0.0077 u	0.0047 u	0.0047 u	0.011 u	0.011 u	0.01 u
GR-228	10-Nov-03	PASI-GR-GB-228-1	3.75-3.75	8082_S	1	0.0021 u	0.0064 u	0.0039 u	0.0039 u	0.0091 u	0.0091 u	0.0083 u
GR-229	10-Nov-03	PASI-GR-GB-229-1	3.66-3.66	8082_S	1	0.0021 u	0.0066 u	0.004 u	0.004 u	0.0093 u	0.0093 u	0.0085 u
GR-230	10-Nov-03	PASI-GR-GB-230-1	3.66-3.66	8082_S	1	0.0021 u	0.0065 u	0.004 u	0.004 u	0.0092 u	0.0092 u	0.0084 u
GR-231	10-Nov-03	PASI-GR-GB-231-1	1-4'	8082_S	1	0.0023 u	0.007 u	0.0043 u	0.0043 u	0.01 u	0.01 u	0.0091 u
GR-232	10-Nov-03	PASI-GR-GB-232-1	3.83-3.83	8082_S	1	0.0023 u	0.0071 u	0.0043 u	0.0043 u	0.01 u	0.01 u	0.042
GR-233	10-Nov-03	PASI-GR-GB-233-1	0.5-3.5'	8082_S	1	0.0067 u	0.021 u	0.013 u	0.013 u	0.029 u	0.029 u	0.027 u
GR-234	11-Nov-03	PASI-GR-GB-234-1	3.75-3.75	8082_S	1	0.0073 u	0.023 u	0.014 u	0.014 u	0.032 u	0.032 u	0.029 u
GR-235	10-Nov-03	PASI-GR-GB-235-1	3.66-3.66	8082_S	1	0.0026 u	0.0082 u	0.005 u	0.005 u	0.012 u	0.012 u	0.011 u
GR-236	11-Nov-03	PASI-GR-GB-236-1	3.83-3.83	8082_S	1	0.0075 u	0.023 u	0.014 u	0.014 u	0.033 u	0.033 u	0.03 u
GR-237	11-Nov-03	PASI-GR-GB-237-1	3.66-3.66	8082_S	1	0.0068 u	0.021 u	0.013 u	0.013 u	0.03 u	0.03 u	0.027 u
GR-238	11-Nov-03	PASI-GR-GB-238-1	3.75-3.75	8082_S	1	0.0071 u	0.022 u	0.014 u	0.014 u	0.031 u	0.031 u	0.029 u
GR-239	11-Nov-03	PASI-GR-GB-239-1	3.66-3.66	8082_S	1	0.0065 u	0.02 u	0.012 u	0.012 u	0.029 u	0.029 u	0.026 u
GR-240	11-Nov-03	PASI-GR-GB-240-1	3.33-3.33	8082_S	1	0.007 u	0.022 u	0.013 u	0.013 u	0.031 u	0.031 u	0.028 u
	11-Nov-03	PASI-GR-GB-240-1	3.33-3.33	8082_S	1	0.0069 u	0.021 u	0.013 u	0.013 u	0.03 u	0.03 u	0.027 u
GR-241	11-Nov-03	PASI-GR-GB-241-1	0.5-3.5'	8082_S	1	0.0065 u	0.02 u	0.012 u	0.012 u	0.029 u	0.029 u	0.026 u
GR-242	11-Nov-03	PASI-GR-GB-242-1	3.42-3.42	8082_S	1	0.0061 u	0.019 u	0.012 u	0.012 u	0.027 u	0.027 u	0.025 u
GR-243	11-Nov-03	PASI-GR-GB-243-1	3.83-3.83	8082_S	1	0.0066 u	0.02 u	0.013 u	0.013 u	0.029 u	0.029 u	0.026 u
GR-244	11-Nov-03	PASI-GR-GB-244-1	3.42-3.42	8082_S	1	0.0063 u	0.019 u	0.012 u	0.012 u	0.028 u	0.028 u	0.025 u
GR-245	11-Nov-03	PASI-GR-GB-245-1	0.5-3.5'	8082_S	1	0.0066 u	0.021 u	0.013 u	0.013 u	0.029 u	0.029 u	0.026 u
GR-246	11-Nov-03	PASI-GR-GB-246-1	3.66-3.66	8082_S	1	0.0063 u	0.019 u	0.012 u	0.012 u	0.028 u	0.028 u	0.025 u
GR-247	11-Nov-03	PASI-GR-GB-247-1	0.5-3.5'	8082_S	1	0.0063 u	0.02 u	0.012 u	0.012 u	0.028 u	0.028 u	0.025 u
GR-248	11-Nov-03	PASI-GR-GB-248-1	3.83-3.83	8082_S	1	0.0066 u	0.02 u	0.013 u	0.013 u	0.029 u	0.029 u	0.026 u
GR-249	11-Nov-03	PASI-GR-GB-249-1	3.66-3.66	8082_S	1	0.0063 u	0.02 u	0.012 u	0.012 u	0.028 u	0.028 u	0.025 u
GR-250	11-Nov-03	PASI-GR-GB-250-1	0.5-3.5'	8082_S	1	0.007 u	0.022 u	0.013 u	0.013 u	0.031 u	0.031 u	0.028 u
GR-251	11-Nov-03	PASI-GR-GB-251-1	0.5-3.5'	8082_S	1	0.007 u	0.022 u	0.013 u	0.013 u	0.031 u	0.031 u	0.028 u

Notes:

- **NC** No criteria listed under the regulation cited
- **ND** Non-detect result (Original data unavailabl)
- **-** Parameter not analyzed

Analytic Flags:

- **u** Not detected above laboratory detection limits
- **j** Estimated value - parameter not detected above laboratory quantitation limits
- **e** Value exceeds analytical calibration limits
- **b** Parameter detected in quality control blank and sample

Highlighting:

- Value or Detection Limit exceeds Criteria 1 only
- Value or Detection Limit exceeds Criteria 2 only
- Value or Detection Limit exceeds both criteria

Table 5-1b PASI Sampling Results - PCBs

PASI - Locust

Analytic Method: 8082_S
Sample Matrix: Soil
Reporting Units: mg/kg
Sample Dates: 11-Nov-2003 to 18-Nov-2003

	Arochlor 1016	Arochlor 1221	Arochlor 1232	Arochlor 1242	Arochlor 1248	Arochlor 1254	Arochlor 1260
SSI Project Action Limit (PAL) - Wave 2 (PCBs)	2	0.22	0.22	0.22	0.22	0.22	0.22
Secondary Regulatory Criteria Not Selected							

Location	Date	Sample ID	Depth	Method	DF							
LO-001	18-Nov-03	PASI-LO-CO-001-1	0-3'	8082_S	1	0.0066 u	0.02 u	0.012 u	0.012 u	0.029 u	0.029 u	0.027 u
LO-002	18-Nov-03	PASI-LO-CO-002-1	0-3'	8082_S	1	0.0067 u	0.02 u	0.013 u	0.013 u	0.03 u	0.03 u	0.027 u
LO-003	18-Nov-03	PASI-LO-CO-003-1	0-3'	8082_S	1	0.0066 u	0.02 u	0.012 u	0.012 u	0.029 u	0.029 u	0.027 u
LO-004	18-Nov-03	PASI-LO-CO-004-1	0-3'	8082_S	1	0.0066 u	0.021 u	0.012 u	0.012 u	0.029 u	0.029 u	0.026 u
LO-005	18-Nov-03	PASI-LO-CO-005-1	0-3'	8082_S	1	0.0063 u	0.02 u	0.012 u	0.012 u	0.028 u	0.028 u	0.025 u
LO-006	18-Nov-03	PASI-LO-CO-006-1	0-3'	8082_S	1	0.0063 u	0.019 u	0.012 u	0.012 u	0.028 u	0.028 u	0.026 u
LO-200	11-Nov-03	PASI-LO-GB-200-1	0.33-3.33	8082_S	1	0.0024 u	0.0074 u	0.0046 u	0.0046 u	0.011 u	0.011 u	0.0096 u
LO-201	11-Nov-03	PASI-LO-GB-201-1	0.5-3.5'	8082_S	1	0.0025 u	0.0077 u	0.0047 u	0.0047 u	0.011 u	0.011 u	0.042
LO-202	11-Nov-03	PASI-LO-GB-202-1	0.66-3.66	8082_S	1	0.0021 u	0.0065 u	0.004 u	0.004 u	0.0092 u	0.0092 u	0.0084 u
LO-203	11-Nov-03	PASI-LO-GB-203-1	0.5-3.5'	8082_S	1	0.0023 u	0.007 u	0.0043 u	0.0043 u	0.01 u	0.01 u	0.0091 u

Notes:

- **NC** No criteria listed under the regulation cited
- **ND** Non-detect result (Original data unavailabl)
- **-** Parameter not analyzed

Analytic Flags:

- **u** Not detected above laboratory detection limits
- **j** Estimated value - parameter not detected above laboratory quantitation limits
- **e** Value exceeds analytical calibration limits
- **b** Parameter detected in quality control blank and sample

Highlighting:

- Value or Detection Limit exceeds Criteria 1 only
- Value or Detection Limit exceeds Criteria 2 only
- Value or Detection Limit exceeds both criteria

Table 5-1c PASI Sampling Results - Explosives

PASI - Grant

Analytic Method: 8330
Sample Matrix: Soil
Reporting Units: mg/kg
Sample Dates: 18-Dec-2003 to 18-Dec-2003

	1,3,5-Trinitrobenzene	1,3-Dinitrobenzene	2,4,6-Trinitrotoluene	2,4-Dinitrotoluene	2,6-Dinitrotoluene	2-AminoDNT	2-Nitrotoluene	3-Nitrotoluene	4-AminoDNT	4-Nitrotoluene	HMX	Nitrobenzene
SSI Project Action Limit (PAL) - Wave 2 (Explosives)	1800	0.61	16	12	6.1	NC	2.8	370	NC	38	0	2
Secondary Regulatory Criteria Not Selected												

Location	Date	Sample ID	Depth	Method	DF											
IA2-001	18-Dec-03	IA2-001-A-1	0-1'	8330	1	0.12 u	0.12 u	0.12 u	0.12 u	0.12 u	0.12 u	0.12 u	0.12 u	0.12 u	0.12 u	**0.12 u**	0.12 u
	18-Dec-03	IA2-001-A-2	1-2'	8330	1	0.12 u	0.12 u	0.12 u	0.12 u	0.12 u	0.12 u	0.12 u	0.12 u	0.12 u	0.12 u	**0.12 u**	0.12 u
IA2-002	18-Dec-03	IA2-002-A-1	0-1'	8330	1	0.12 u	0.12 u	0.12 u	0.12 u	0.12 u	0.12 u	0.12 u	0.12 u	0.12 u	0.12 u	**0.12 u**	0.12 u
	18-Dec-03	IA2-002-A-2	1-2'	8330	1	0.12 u	0.12 u	0.12 u	0.12 u	0.12 u	0.12 u	0.12 u	0.12 u	0.12 u	0.12 u	**0.12 u**	0.12 u
IA2-003	18-Dec-03	IA2-003-A-1	0-1'	8330	1	0.12 u	0.12 u	0.12 u	0.12 u	0.12 u	0.12 u	0.12 u	0.12 u	0.12 u	0.12 u	**0.12 u**	0.12 u
	18-Dec-03	IA2-003-A-2	1-2'	8330	1	0.12 u	0.12 u	0.12 u	0.12 u	0.12 u	0.12 u	0.12 u	0.12 u	0.12 u	0.12 u	**0.12 u**	0.12 u
IA2-004	18-Dec-03	IA2-004-A-1	0-1'	8330	1	0.12 u	0.12 u	0.12 u	0.12 u	0.12 u	0.12 u	0.12 u	0.12 u	0.12 u	0.12 u	**0.12 u**	0.12 u
	18-Dec-03	IA2-004-A-2	1-2'	8330	1	0.12 u	0.12 u	0.12 u	0.12 u	0.12 u	0.12 u	0.12 u	0.12 u	0.12 u	0.12 u	**0.12 u**	0.12 u
IA2-005	18-Dec-03	IA2-005-A-1	0-1'	8330	1	0.12 u	0.12 u	0.12 u	0.12 u	0.12 u	0.12 u	0.12 u	0.12 u	0.12 u	0.12 u	**0.12 u**	0.12 u
	18-Dec-03	IA2-005-A-2	1-2'	8330	1	0.12 u	0.12 u	0.12 u	0.12 u	0.12 u	0.12 u	0.12 u	0.12 u	0.12 u	0.12 u	**0.12 u**	0.12 u
IA2-006	18-Dec-03	IA2-006-A-1	0-1'	8330	1	0.12 u	0.12 u	0.12 u	0.12 u	0.12 u	0.12 u	0.12 u	0.12 u	0.12 u	0.12 u	**0.12 u**	0.12 u
	18-Dec-03	IA2-006-A-2	1-2'	8330	1	0.12 u	0.12 u	0.12 u	0.12 u	0.12 u	0.12 u	0.12 u	0.12 u	0.12 u	0.12 u	**0.12 u**	0.12 u
	18-Dec-03	IA2-006-A-2-D	1-2'	8330	1	0.12 u	0.12 u	0.12 u	0.12 u	0.12 u	0.12 u	0.12 u	0.12 u	0.12 u	0.12 u	**0.12 u**	0.12 u
IA2-007	18-Dec-03	IA2-007-A-1	0-1'	8330	1	0.12 u	0.12 u	0.12 u	0.12 u	0.12 u	0.12 u	0.12 u	0.12 u	0.12 u	0.12 u	**0.12 u**	0.12 u
	18-Dec-03	IA2-007-A-2	1-2'	8330	1	0.12 u	0.12 u	0.12 u	0.12 u	0.12 u	0.12 u	0.12 u	0.12 u	0.12 u	0.12 u	**0.12 u**	0.12 u
IA2-008	18-Dec-03	IA2-008-A-1	0-1'	8330	1	0.12 u	0.12 u	0.12 u	0.12 u	0.12 u	0.12 u	0.12 u	0.12 u	0.12 u	0.12 u	**0.12 u**	0.12 u
	18-Dec-03	IA2-008-A-1-D	0-1'	8330	1	0.12 u	0.12 u	0.12 u	0.12 u	0.12 u	0.12 u	0.12 u	0.12 u	0.12 u	0.12 u	**0.12 u**	0.12 u
	18-Dec-03	IA2-008-A-2	1-2'	8330	1	0.12 u	0.12 u	0.12 u	0.12 u	0.12 u	0.12 u	0.12 u	0.12 u	0.12 u	0.12 u	**0.12 u**	0.12 u
IA2-009	18-Dec-03	IA2-009-A-1	0-1'	8330	1	0.12 u	0.12 u	0.12 u	0.12 u	0.12 u	0.12 u	0.12 u	0.12 u	0.12 u	0.12 u	**0.12 u**	0.12 u
	18-Dec-03	IA2-009-A-2	1-2'	8330	1	0.12 u	0.12 u	0.12 u	0.12 u	0.12 u	0.12 u	0.12 u	0.12 u	0.12 u	0.12 u	**0.12 u**	0.12 u
IA2-010	18-Dec-03	IA2-010-A-1	0-1'	8330	1	0.12 u	0.12 u	0.12 u	0.12 u	0.12 u	0.12 u	0.12 u	0.12 u	0.12 u	0.12 u	**0.12 u**	0.12 u
	18-Dec-03	IA2-010-A-2	1-2'	8330	1	0.12 u	0.12 u	0.12 u	0.12 u	0.12 u	0.12 u	0.12 u	0.12 u	0.12 u	0.12 u	**0.12 u**	0.12 u

Notes:

- **NC** No criteria listed under the regulation cited
- **ND** Non-detect result (Original data unavailabl)
- **-** Parameter not analyzed

Analytic Flags:

- **u** Not detected above laboratory detection limits
- **j** Estimated value - parameter not detected above laboratory quantitation limits
- **e** Value exceeds analytical calibration limits
- **b** Parameter detected in quality control blank and sample

Highlighting:

- Value or Detection Limit exceeds Criteria 1 only
- Value or Detection Limit exceeds Criteria 2 only
- Value or Detection Limit exceeds both criteria

Table 5-1c PASI Sampling Results - Explosives

PASI - Grant

Analytic Method: 8330
Sample Matrix: Soil
Reporting Units: mg/kg
Sample Dates: 18-Dec-2003 to 18-Dec-2003

	RDX	Tetryl
SSI Project Action Limit (PAL) - Wave 2 (Explosives)	4.4	780
Secondary Regulatory Criteria Not Selected		

Location	Date	Sample ID	Depth	Method	DF	RDX	Tetryl
IA2-001	18-Dec-03	IA2-001-A-1	0-1'	8330	1	0.12 u	0.12 u
	18-Dec-03	IA2-001-A-2	1-2'	8330	1	0.12 u	0.12 u
IA2-002	18-Dec-03	IA2-002-A-1	0-1'	8330	1	0.12 u	0.12 u
	18-Dec-03	IA2-002-A-2	1-2'	8330	1	0.12 u	0.12 u
IA2-003	18-Dec-03	IA2-003-A-1	0-1'	8330	1	0.12 u	0.12 u
	18-Dec-03	IA2-003-A-2	1-2'	8330	1	0.12 u	0.12 u
IA2-004	18-Dec-03	IA2-004-A-1	0-1'	8330	1	0.12 u	0.12 u
	18-Dec-03	IA2-004-A-2	1-2'	8330	1	0.12 u	0.12 u
IA2-005	18-Dec-03	IA2-005-A-1	0-1'	8330	1	0.12 u	0.12 u
	18-Dec-03	IA2-005-A-2	1-2'	8330	1	0.12 u	0.12 u
IA2-006	18-Dec-03	IA2-006-A-1	0-1'	8330	1	0.12 u	0.12 u
	18-Dec-03	IA2-006-A-2	1-2'	8330	1	0.12 u	0.12 u
	18-Dec-03	IA2-006-A-2-D	1-2'	8330	1	0.12 u	0.12 u
IA2-007	18-Dec-03	IA2-007-A-1	0-1'	8330	1	0.12 u	0.12 u
	18-Dec-03	IA2-007-A-2	1-2'	8330	1	0.12 u	0.12 u
IA2-008	18-Dec-03	IA2-008-A-1	0-1'	8330	1	0.12 u	0.12 u
	18-Dec-03	IA2-008-A-1-D	0-1'	8330	1	0.12 u	0.12 u
	18-Dec-03	IA2-008-A-2	1-2'	8330	1	0.12 u	0.12 u
IA2-009	18-Dec-03	IA2-009-A-1	0-1'	8330	1	0.12 u	0.12 u
	18-Dec-03	IA2-009-A-2	1-2'	8330	1	0.12 u	0.12 u
IA2-010	18-Dec-03	IA2-010-A-1	0-1'	8330	1	0.12 u	0.12 u
	18-Dec-03	IA2-010-A-2	1-2'	8330	1	0.12 u	0.12 u

Notes:

NC No criteria listed under the regulation cited
ND Non-detect result (Original data unavailabl)
- Parameter not analyzed

Analytic Flags:

u Not detected above laboratory detection limits
j Estimated value - parameter not detected above laboratory quantitation limits
e Value exceeds analytical calibration limits
b Parameter detected in quality control blank and sample

Highlighting:

Value or Detection Limit exceeds Criteria 1 only
Value or Detection Limit exceeds Criteria 2 only
Value or Detection Limit exceeds both criteria

SSI -Summary of Volatile Organic Compounds Soil Analytical Results

Table 5-2a

Supplemental Site Investigation

Analytic Method: 8260B
Sample Matrix: Soil
Reporting Units: mg/kg
Sample Dates: 29-Nov-2004 to 13-Apr-2005

						1,1,1,2-Tetrachloroethane	1,1,1-Trichloroethane	1,1,2,2-Tetrachloroethane	1,1,2-Trichloroethane	1,1-Dichloroethane	1,1-Dichloroethene	1,1-Dichloropropene	1,2,3-Trichlorobenzene	1,2,3-Trichloropropane	1,2,4-Trichlorobenzene	1,2,4-Trimethylbenzene	1,2-Dibromo-3-chloropropane	1,2-Dichlorobenzene	1,2-Dichloroethane	1,2-Dichloroethene	1,2-Dichloropropane	1,3,5-Trimethylbenzene	1,3-Dichlorobenzene	1,3-Dichloropropane	1,4-Dichlorobenzene	1,4-Dioxane	2,2-Dichloropropane	2-Butanone
SSI Project Action Limit (PAL) - Wave 2 (VOCs)						3.2	500	0.41	0.73	51	120	NC	NC	0.01	65	5.2	0.45	300	0.28	NC	0.34	2.1	1.6	10	3.4	0.5	NC	NC
Secondary Regulatory Criteria Not Selected																												
	Date	Sample ID	Depth	Method	Dilution																							
IA01-SB02	10-Dec-04	GR-IA01-SB02-1	0-3'	8260B	1	0.0007 u	0.0007 u	0.0007 u	0.001 u	0.001 u	0.0007 u	0.0035 u	0.0035 u	0.007 u	0.0035 u	0.0035 u	0.0035 u	0.0035 u	0.0007 u	-	0.0024 u	0.0035 u	0.0035 u	0.0035 u	0.0035 u	0.35 u	0.0035 u	0.007 u
	10-Dec-04	GR-IA01-SB02-1	3-10'	8260B	1	0.00092 u	0.00092 u	0.00092 u	0.0014 u	0.0014 u	0.00092 u	0.0046 u	0.0046 u	0.0092 u	0.0046 u	0.0046 u	0.0046 u	0.0046 u	0.00092 u	-	0.0032 u	0.0046 u	0.0046 u	0.0046 u	0.0046 u	0.46 u	0.0046 u	0.0092 u
IA02-SB01	30-Nov-04	GR-IA02-SB01-1	0-3'	8260B	1	0.00081 u	0.00081 u	0.00081 u	0.0012 u	0.0012 u	0.00081 u	0.004 u	0.004 u	0.0081 u	0.004 u	0.004 u	0.004 u	0.004 u	0.00081 u	-	0.0028 u	0.004 u	0.004 u	0.004 u	0.004 u	0.4 u	0.004 u	0.0081 u
	30-Nov-04	GR-IA02-SB01-1	3-10'	8260B	1	0.0007 u	0.0007 u	0.0007 u	0.001 u	0.001 u	0.0007 u	0.0035 u	0.0035 u	0.007 u	0.0035 u	0.0035 u	0.0035 u	0.0035 u	0.0007 u	-	0.0024 u	0.0035 u	0.0035 u	0.0035 u	0.0035 u	0.35 u	0.0035 u	0.007 u
IA02-SB02	02-Dec-04	GR-IA02-SB02-1	0-3'	8260B	1	0.00069 u	0.00069 u	0.00069 u	0.001 u	0.001 u	0.00069 u	0.0035 u	0.0035 u	0.0069 u	0.0035 u	0.0035 u	0.0035 u	0.0035 u	0.00069 u	-	0.0024 u	0.0035 u	0.0035 u	0.0035 u	0.0035 u	0.35 u	0.0035 u	0.0069 u
	02-Dec-04	GR-IA02-SB02-1-M	3-10'	8260B	1	0.00072 u	0.00072 u	0.00072 u	0.0011 u	0.0011 u	0.00072 u	0.0036 u	0.0036 u	0.0072 u	0.0036 u	0.0036 u	0.0036 u	0.0036 u	0.00072 u	-	0.0025 u	0.0036 u	0.0036 u	0.0036 u	0.0036 u	0.36 u	0.0036 u	0.0072 u
IA02-SB13	13-Dec-04	GR-IA02-SB13-1	0-3'	8260B	1	0.00075 u	0.00075 u	0.00075 u	0.0011 u	0.0011 u	0.00075 u	0.0038 u	0.0038 u	0.0075 u	0.0038 u	0.0038 u	0.0038 u	0.0038 u	0.00075 u	-	0.0026 u	0.0038 u	0.0038 u	0.0038 u	0.0038 u	0.38 u	0.0038 u	0.0075 u
	13-Dec-04	GR-IA02-SB13-1	3-10'	8260B	1	0.001 u	0.001 u	0.001 u	0.0016 u	0.0016 u	0.001 u	0.0053 u	0.0053 u	**0.01 u**	0.0053 u	0.0053 u	0.0053 u	0.0053 u	0.001 u	-	0.0037 u	0.0053 u	0.0053 u	0.0053 u	0.0053 u	**0.53 u**	0.0053 u	0.01 u
	13-Dec-04	GR-IA02-SB13-1-D	3-10'	8260B	1	0.00092 u	0.00092 u	0.00092 u	0.0014 u	0.0014 u	0.00092 u	0.0046 u	0.0046 u	0.0092 u	0.0046 u	0.0046 u	0.0046 u	0.0046 u	0.00092 u	-	0.0032 u	0.0046 u	0.0046 u	0.0046 u	0.0046 u	0.46 u	0.0046 u	0.0092 u
IA02-SB20	08-Dec-04	GR-IA02-SB20-1	0-3'	8260B	1	0.0011 u	0.0011 u	0.0011 u	0.0016 u	0.0016 u	0.0011 u	0.0054 u	0.0054 u	**0.011 u**	0.0054 u	0.0054 u	0.0054 u	0.0054 u	0.0011 u	-	0.0038 u	0.0054 u	0.0054 u	0.0054 u	0.0054 u	**0.54 u**	0.0054 u	0.011 u
	08-Dec-04	GR-IA02-SB20-1-M	3-10'	8260B	1	0.00084 u	0.00084 u	0.00084 u	0.0012 u	0.0012 u	0.00084 u	0.0042 u	0.0042 u	0.0084 u	0.0042 u	0.0042 u	0.0042 u	0.0042 u	0.00084 u	-	0.0029 u	0.0042 u	0.0042 u	0.0042 u	0.0042 u	0.42 u	0.0042 u	0.0084 u
IA02-SB23	13-Dec-04	GR-IA02-SB23-1	0-3'	8260B	1	0.00097 u	0.00097 u	0.00097 u	0.0014 u	0.0014 u	0.00097 u	0.0048 u	0.0048 u	0.0097 u	0.0048 u	0.0048 u	0.0048 u	0.0048 u	0.00097 u	-	0.0034 u	0.0048 u	0.0048 u	0.0048 u	0.0048 u	0.48 u	0.0048 u	0.0097 u
	13-Dec-04	GR-IA02-SB23-1	3-10'	8260B	1	0.00088 u	0.00088 u	0.00088 u	0.0013 u	0.0013 u	0.00088 u	0.0044 u	0.0044 u	0.0088 u	0.0044 u	0.0044 u	0.0044 u	0.0044 u	0.00088 u	-	0.0031 u	0.0044 u	0.0044 u	0.0044 u	0.0044 u	0.44 u	0.0044 u	0.0088 u
	13-Dec-04	GR-IA02-SB23-1-D	3-10'	8260B	1	0.0011 u	0.0011 u	0.0011 u	0.0017 u	0.0017 u	0.0011 u	0.0056 u	0.0056 u	**0.011 u**	0.0056 u	0.0056 u	0.0056 u	0.0056 u	0.0011 u	-	0.0039 u	0.0056 u	0.0056 u	0.0056 u	0.0056 u	**0.56 u**	0.0056 u	0.011 u
IA02-SB30	15-Dec-04	GR-IA02-SB30-1	0-3'	8260B	1	0.0011 u	0.0011 u	0.0011 u	0.0017 u	0.0017 u	0.0011 u	0.0056 u	0.0056 u	**0.011 u**	0.0056 u	0.0056 u	0.0056 u	0.0056 u	0.0011 u	-	0.0039 u	0.0056 u	0.0056 u	0.0056 u	0.0056 u	**0.56 u**	0.0056 u	0.011 u
	15-Dec-04	GR-IA02-SB30-1-M	3-10'	8260B	1	0.00074 u	0.00074 u	0.00074 u	0.0011 u	0.0011 u	0.00074 u	0.0037 u	0.0037 u	0.0074 u	0.0037 u	0.0037 u	0.0037 u	0.0037 u	0.00074 u	-	0.0026 u	0.0037 u	0.0037 u	0.0037 u	0.0037 u	0.37 u	0.0037 u	0.0074 u
IA03-SB02	13-Dec-04	GR-IA03-SB02-1	0-3'	8260B	1	0.00082 u	0.00082 u	0.00082 u	0.0012 u	0.0012 u	0.00082 u	0.0041 u	0.0041 u	0.0082 u	0.0041 u	0.0041 u	0.0041 u	0.0041 u	0.00082 u	-	0.0028 u	0.0041 u	0.0041 u	0.0041 u	0.0041 u	0.41 u	0.0041 u	0.0082 u
	13-Dec-04	GR-IA03-SB02-1	3-10'	8260B	1	0.00069 u	0.00069 u	0.00069 u	0.001 u	0.001 u	0.00069 u	0.0035 u	0.0035 u	0.0069 u	0.0035 u	0.0035 u	0.0035 u	0.0035 u	0.00069 u	-	0.0024 u	0.0035 u	0.0035 u	0.0035 u	0.0035 u	0.35 u	0.0035 u	0.0069 u
IA03-SB04	15-Dec-04	GR-IA03-SB04-1	0-3'	8260B	1	0.0011 u	0.0011 u	0.0011 u	0.0017 u	0.0017 u	0.0011 u	0.0056 u	0.0056 u	**0.011 u**	0.0056 u	0.0056 u	0.0056 u	0.0056 u	0.0011 u	-	0.0039 u	0.0056 u	0.0056 u	0.0056 u	0.0056 u	**0.56 u**	0.0056 u	0.011 u
	15-Dec-04	GR-IA03-SB04-1	3-10'	8260B	1	0.00074 u	0.00074 u	0.00074 u	0.0011 u	0.0011 u	0.00074 u	0.0037 u	0.0037 u	0.0074 u	0.0037 u	0.0037 u	0.0037 u	0.0037 u	0.00074 u	-	0.0026 u	0.0037 u	0.0037 u	0.0037 u	0.0037 u	0.37 u	0.0037 u	0.0074 u
IA05-SB07	10-Dec-04	GR-IA05-SB07-1	0-3'	8260B	1	0.0012 u	0.0012 u	0.0012 u	0.0018 u	0.0018 u	0.0012 u	0.0059 u	0.0059 u	**0.012 u**	0.0059 u	0.0059 u	0.0059 u	0.0059 u	0.0012 u	-	0.0041 u	0.0059 u	0.0059 u	0.0059 u	0.0059 u	**0.59 u**	0.0059 u	0.012 u
	10-Dec-04	GR-IA05-SB07-1	3-10'	8260B	1	0.0016 u	0.0016 u	0.0016 u	0.0023 u	0.0023 u	0.0016 u	0.0078 u	0.0078 u	**0.016 u**	0.0078 u	0.0078 u	0.0078 u	0.0078 u	0.0016 u	-	0.0054 u	0.0078 u	0.0078 u	0.0078 u	0.0078 u	**0.78 u**	0.0078 u	0.016 u
IA06-SB04	11-Apr-05	LO-IA06-SB04-1	3-10'	8260B	1	0.0056 u	0.0056 u	0.0056 u	0.0056 u	0.0056 u	0.0056 u	0.0056 u	0.0056 u	-	0.0056 u	0.0056 u	0.0056 u	0.0056 u	0.0056 u	0.0056 u	0.0056 u	0.0056 u	0.0056 u	0.0056 u	0.0056 u	0.28 u	0.0056 u	0.003 j
	11-Apr-05	LO-IA06-SB04-1	0-3'	8260B	1	0.0046 u	0.0046 u	0.0046 u	0.0046 u	0.0046 u	0.0046 u	0.0046 u	0.0046 u	-	0.0046 u	0.0046 u	0.0046 u	0.0046 u	0.0046 u	0.0046 u	0.0046 u	0.0046 u	0.0046 u	0.0046 u	0.0046 u	0.23 u	0.0046 u	0.0037 j
IA06-SB06	11-Apr-05	LO-IA06-SB06-1	3-10'	8260B	1	0.0056 u	0.0056 u	0.0056 u	0.0056 u	0.0056 u	0.0056 u	0.0056 u	0.0056 u	-	0.0056 u	0.0056 u	0.0056 u	0.0056 u	0.0056 u	0.0056 u	0.0056 u	0.0056 u	0.0056 u	0.0056 u	0.0056 u	0.28 u	0.0056 u	0.0056 u
	11-Apr-05	LO-IA06-SB06-1	0-3'	8260B	1	0.005 u	0.005 u	0.005 u	0.005 u	0.005 u	0.005 u	0.005 u	0.005 u	-	0.005 u	0.005 u	0.005 u	0.005 u	0.005 u	0.005 u	0.005 u	0.005 u	0.005 u	0.005 u	0.005 u	0.25 u	0.005 u	0.0024 j
IA06-SD06	13-Apr-05	LO-IA06-SD06-1	0-1.5'	8260B	1	0.0075 u	0.0075 u	0.0075 u	0.0075 u	0.0075 u	0.0073 u	0.0075 u	0.0075 u	-	0.0075 u	0.0075 u	0.0075 u	0.0075 u	0.0075 u	0.0075 u	0.0075 u	0.0075 u	0.0075 u	0.0075 u	0.0075 u	0.38 u	0.0075 u	0.0075 u
IA06-SD17	13-Apr-05	LO-IA06-SD17-1	0-1.5'	8260B	1	0.007 u	0.007 u	0.007 u	0.007 u	0.007 u	0.007 u	0.007 u	0.007 u	-	0.007 u	0.007 u	0.007 u	0.007 u	0.007 u	0.007 u	0.007 u	0.007 u	0.007 u	0.007 u	0.007 u	0.35 u	0.007 u	0.007 u
IA06-SS08	11-Apr-05	LO-IA06-SS08-1	0-1.5'	8260B	1	0.005 u	0.005 u	0.005 u	0.005 u	0.005 u	0.005 u	0.005 u	0.005 u	-	0.005 u	0.005 u	0.005 u	0.005 u	0.005 u	0.005 u	0.005 u	0.005 u	0.005 u	0.005 u	0.005 u	0.25 u	0.005 u	0.0066
IA06-SS16	11-Apr-05	LO-IA06-SS16-1	0-1.5'	8260B	1	0.0055 u	0.0055 u	0.0055 u	0.0055 u	0.0055 u	0.0055 u	0.0055 u	0.0055 u	-	0.0055 u	0.0055 u	0.0055 u	0.0055 u	0.0055 u	0.0055 u	0.0055 u	0.0055 u	0.0055 u	0.0055 u	0.0055 u	0.27 u	0.0055 u	0.0055 u
	11-Apr-05	LO-IA06-SS16-1-D	0-1.5'	8260B	1	0.0058 u	0.0058 u	0.0058 u	0.0058 u	0.0058 u	0.0058 u	0.0058 u	0.0058 u	-	0.0058 u	0.0058 u	0.0058 u	0.0058 u	0.0058 u	0.0058 u	0.0058 u	0.0058 u	0.0058 u	0.0058 u	0.0058 u	0.29 u	0.0058 u	0.0058 u
IA06-SS35	12-Apr-05	LO-IA06-SS35-1	0-1.5'	8260B	1	0.0051 u	0.0051 u	0.0051 u	0.0051 u	0.0051 u	0.0051 u	0.0051 u	0.0051 u	-	0.0051 u	0.0051 u	0.0051 u	0.0051 u	0.0051 u	0.0051 u	0.0051 u	0.0051 u	0.0051 u	0.0051 u	0.0051 u	0.25 u	0.0051 u	0.0096
IA06-SS40	12-Apr-05	LO-IA06-SS40-1	0-1.5'	8260B	1	0.007 u	0.007 u	0.007 u	0.007 u	0.007 u	0.007 u	0.007 u	0.007 u	-	0.007 u	0.007 u	0.007 u	0.007 u	0.007 u	0.007 u	0.007 u	0.007 u	0.007 u	0.007 u	0.007 u	0.35 u	0.007 u	0.0046 j
IA06-SS45	13-Apr-05	LO-IA06-SS25-1	0-1.5'	8260B	1	0.0045 u	0.0045 u	0.0047 u	0.0045 u	0.0045 u	0.0045 u	0.0047 u	0.0047 u	-	0.0047 u	0.0047 u	0.0047 u	0.0047 u	0.0045 u	0.0045 u	0.0045 u	0.0047 u	0.0047 u	0.0047 u	0.0047 u	0.22 u	0.0047 u	0.0029 j

Location

Notes:

NC No criteria listed under the regulation cited
ND Non-detect result (Original data unavailable - neither value nor detection limit provided)
- Parameter not analyzed

Analytic Flags:

u Not detected above laboratory reporting limits
j Estimated value - parameter detected between laboratory reporting limit and half of the laboratory reporting limit.
e Value exceeds analytical calibration limits
b Parameter detected in quality control blank and sample

Highlighting:

Value or Detection Limit exceeds Criteria 1 only
Value or Detection Limit exceeds Criteria 2 only
Value or Detection Limit exceeds both criteria

SSI -Summary of Volatile Organic Compounds Soil Analytical Results

Table 5-2a

Supplemental Site Investigation

Analytic Method: 8260B
Sample Matrix: Soil
Reporting Units: mg/kg
Sample Dates: 29-Nov-2004 to 13-Apr-2005

						1,1,1,2-Tetrachloroethane	1,1,1-Trichloroethane	1,1,2,2-Tetrachloroethane	1,1,2-Trichloroethane	1,1-Dichloroethane	1,1-Dichloroethene	1,1-Dichloropropene	1,2,3-Trichlorobenzene	1,2,3-Trichloropropane	1,2,4-Trichlorobenzene	1,2,4-Trimethylbenzene	1,2-Dibromo-3-chloropropane	1,2-Dichlorobenzene	1,2-Dichloroethane	1,2-Dichloroethene	1,2-Dichloropropane	1,3,5-Trimethylbenzene	1,3-Dichlorobenzene	1,3-Dichloropropane	1,4-Dichlorobenzene	1,4-Dioxane	2,2-Dichloropropane	2-Butanone
SSI Project Action Limit (PAL) - Wave 2 (VOCs)						3.2	500	0.41	0.73	51	120	NC	NC	0.01	65	5.2	0.45	300	0.28	NC	0.34	2.1	1.6	10	3.4	0.5	NC	NC
Secondary Regulatory Criteria Not Selected																												
	Date	Sample ID	Depth	Method	Dilution																							
IA08-SB01	30-Nov-04	GR-IA08-SB01-1	0-3'	8260B	1	0.0009 u	0.0009 u	0.0009 u	0.0014 u	0.0014 u	0.0009 u	0.0045 u	0.0045 u	0.009 u	0.0045 u	0.0045 u	0.0045 u	0.0045 u	0.0009 u	-	0.0032 u	0.0045 u	0.0045 u	0.0045 u	0.0045 u	0.45 u	0.0045 u	0.009 u
	30-Nov-04	GR-IA08-SB01-1	3-10'	8260B	1	0.0015 u	0.0015 u	0.0015 u	0.0023 u	0.0023 u	0.0015 u	0.0077 u	0.0077 u	**0.015 u**	0.0077 u	0.0077 u	0.0077 u	0.0077 u	0.0015 u	-	0.0054 u	0.0077 u	0.0077 u	0.0077 u	0.0077 u	**0.77 u**	0.0077 u	0.015 u
	30-Nov-04	GR-IA08-SB01-1-D	3-10'	8260B	1	0.0019 u	0.0019 u	0.0019 u	0.0028 u	0.0028 u	0.0019 u	0.0094 u	0.0094 u	**0.019 u**	0.0094 u	0.0094 u	0.0094 u	0.0094 u	0.0019 u	-	0.0066 u	0.0094 u	0.0094 u	0.0094 u	0.0094 u	**0.94 u**	0.0094 u	0.019 u
IA08-SB02	03-Dec-04	GR-IA08-SB02-1	8-10'	8260B	1	0.00064 u	0.00064 u	0.00064 u	0.00097 u	0.00097 u	0.00064 u	0.0032 u	0.0032 u	0.0064 u	0.0032 u	0.0032 u	0.0032 u	0.0032 u	0.00064 u	-	0.0023 u	0.0032 u	0.0032 u	0.0032 u	0.0032 u	0.32 u	0.0032 u	0.0064 u
	03-Dec-04	GR-IA08-SB02-1-D	8-10'	8260B	1	0.00056 u	0.00056 u	0.00056 u	0.00084 u	0.00084 u	0.00056 u	0.0028 u	0.0028 u	0.0056 u	0.0028 u	0.0028 u	0.0028 u	0.0028 u	0.00056 u	-	0.002 u	0.0028 u	0.0028 u	0.0028 u	0.0028 u	0.28 u	0.0028 u	0.0056 u
IA08-SB03	09-Dec-04	GR-IA08-SB03-1	0-2'	8260B	1	0.001 u	0.001 u	0.001 u	0.0015 u	0.0015 u	0.001 u	0.005 u	0.005 u	**0.01 u**	0.005 u	0.005 u	0.005 u	0.005 u	0.001 u	-	0.0035 u	0.005 u	0.005 u	0.005 u	0.005 u	**0.5 u**	0.005 u	0.01 u
IA08-SB04	03-Dec-04	GR-IA08-SB04-1	2-4'	8260B	1	0.0011 u	0.0011 u	0.0011 u	0.0016 u	0.0016 u	0.0011 u	0.0054 u	0.0054 u	**0.011 u**	0.0054 u	0.0054 u	0.0054 u	0.0054 u	0.0011 u	-	0.0038 u	0.0054 u	0.0054 u	0.0054 u	0.0054 u	**0.54 u**	0.0054 u	0.011 u
IA08-SB05	08-Dec-04	GR-IA08-SB05-1	40-42'	8260B	1	0.0014 u	0.0014 u	0.0014 u	0.002 u	0.002 u	0.0014 u	0.0068 u	0.0068 u	**0.014 u**	0.0068 u	0.0068 u	0.0068 u	0.0068 u	0.0014 u	-	0.0047 u	0.0068 u	0.0068 u	0.0068 u	0.0068 u	**0.68 u**	0.0068 u	0.014 u
	03-Dec-04	GR-IA08-SB05-1	6-8'	8260B	1	0.00077 u	0.00077 u	0.00077 u	0.0012 u	0.0012 u	0.00077 u	0.0038 u	0.0038 u	0.0077 u	0.0038 u	0.0038 u	0.0038 u	0.0038 u	0.00077 u	-	0.0027 u	0.0038 u	0.0038 u	0.0038 u	0.0038 u	0.38 u	0.0038 u	0.0077 u
IA08-SB06	09-Dec-04	GR-IA08-SB06-1	0-2'	8260B	1	0.00096 u	0.00096 u	0.00096 u	0.0014 u	0.0014 u	0.00096 u	0.0048 u	0.0048 u	0.0096 u	0.0048 u	0.0048 u	0.0048 u	0.0048 u	0.00096 u	-	0.0034 u	0.0048 u	0.0048 u	0.0048 u	0.0048 u	0.48 u	0.0048 u	0.0096 u
IA08-SB07	06-Dec-04	GR-IA08-SB07-1	4-6'	8260B	1	0.0013 u	0.0013 u	0.0013 u	0.002 u	0.002 u	0.0013 u	0.0066 u	0.0066 u	**0.013 u**	0.0066 u	0.0066 u	0.0066 u	0.0066 u	0.0013 u	-	0.0046 u	0.0066 u	0.0066 u	0.0066 u	0.0066 u	**0.66 u**	0.0066 u	0.013 u
IA08-SB09	16-Dec-04	GR-IA08-SB09-1	0-3'	8260B	1	0.00066 u	0.00066 u	0.00066 u	0.00098 u	0.00098 u	0.00066 u	0.0033 u	0.0033 u	0.0066 u	0.0033 u	0.0033 u	0.0033 u	0.0033 u	0.00066 u	-	0.0023 u	0.0033 u	0.0033 u	0.0033 u	0.0033 u	0.33 u	0.0033 u	0.0066 u
	16-Dec-04	GR-IA08-SB09-1	3-10'	8260B	1	0.00078 u	0.00078 u	0.00078 u	0.0012 u	0.0012 u	0.00078 u	0.0039 u	0.0039 u	0.0078 u	0.0039 u	0.0039 u	0.0039 u	0.0039 u	0.00078 u	-	0.0027 u	0.0039 u	0.0039 u	0.0039 u	0.0039 u	0.39 u	0.0039 u	0.0078 u
IA09-SB01	29-Nov-04	CA-IA09-SB01-1	0-3'	8260B	1	0.028 u	0.028 u	0.028 u	0.043 u	0.043 u	0.028 u	0.14 u	0.14 u	**0.28 u**	0.14 u	0.14 u	0.14 u	0.14 u	0.028 u	-	0.1 u	0.14 u	0.14 u	0.14 u	0.14 u	**14 u**	0.14 u	0.28 u
	29-Nov-04	CA-IA09-SB01-1	3-10'	8260B	1	0.044 u	0.044 u	0.044 u	0.066 u	0.066 u	0.044 u	0.22 u	0.22 u	**0.44 u**	0.22 u	0.22 u	0.22 u	0.22 u	0.044 u	-	0.15 u	0.22 u	0.22 u	0.22 u	0.22 u	**22 u**	0.22 u	0.44 u
IA10-SB01	13-Dec-04	GR-IA10-SB01-1	0-3'	8260B	1	0.00095 u	0.00095 u	0.00095 u	0.0014 u	0.0014 u	0.00095 u	0.0047 u	0.0047 u	0.0095 u	0.0047 u	0.0047 u	0.0047 u	0.0047 u	0.00095 u	-	0.0033 u	0.0047 u	0.0047 u	0.0047 u	0.0047 u	0.47 u	0.0047 u	0.0095 u
	13-Dec-04	GR-IA10-SB01-1	3-10'	8260B	1	0.0008 u	0.0008 u	0.0008 u	0.0012 u	0.0012 u	0.0008 u	0.004 u	0.004 u	0.008 u	0.004 u	0.004 u	0.004 u	0.004 u	0.0008 u	-	0.0028 u	0.004 u	0.004 u	0.004 u	0.004 u	0.4 u	0.004 u	0.008 u
IA10-SB02	10-Dec-04	GR-IA10-SB02-1	0-3'	8260B	1	0.00065 u	0.00065 u	0.00065 u	0.00097 u	0.00097 u	0.00065 u	0.0032 u	0.0032 u	0.0065 u	0.0032 u	0.0032 u	0.0032 u	0.0032 u	0.00065 u	-	0.0023 u	0.0032 u	0.0032 u	0.0032 u	0.0032 u	0.32 u	0.0032 u	0.0065 u
	10-Dec-04	GR-IA10-SB02-1	3-10'	8260B	1	0.00092 u	0.00092 u	0.00092 u	0.0014 u	0.0014 u	0.00092 u	0.0046 u	0.0046 u	0.0092 u	0.0046 u	0.0046 u	0.0046 u	0.0046 u	0.00092 u	-	0.0032 u	0.0046 u	0.0046 u	0.0046 u	0.0046 u	0.46 u	0.0046 u	0.0092 u
	10-Dec-04	GR-IA10-SB02-1-D	3-10'	8260B	1	0.00067 u	0.00067 u	0.00067 u	0.001 u	0.001 u	0.00067 u	0.0033 u	0.0033 u	0.0067 u	0.0033 u	0.0033 u	0.0033 u	0.0033 u	0.00067 u	-	0.0023 u	0.0033 u	0.0033 u	0.0033 u	0.0033 u	0.33 u	0.0033 u	0.0067 u
IA10-SB03	15-Dec-04	GR-IA10-SB03-1	0-3'	8260B	1	0.00077 u	0.00077 u	0.00077 u	0.0012 u	0.0012 u	0.00077 u	0.0038 u	0.0038 u	0.0077 u	0.0038 u	0.0038 u	0.0038 u	0.0038 u	0.00077 u	-	0.0027 u	0.0038 u	0.0038 u	0.0038 u	0.0038 u	0.38 u	0.0038 u	0.0077 u
	15-Dec-04	GR-IA10-SB03-1	3-10'	8260B	1	0.00092 u	0.00092 u	0.00092 u	0.0014 u	0.0014 u	0.00092 u	0.0046 u	0.0046 u	0.0092 u	0.0046 u	0.0046 u	0.0046 u	0.0046 u	0.00092 u	-	0.0032 u	0.0046 u	0.0046 u	0.0046 u	0.0046 u	0.46 u	0.0046 u	0.0092 u
IA10-SB04	16-Dec-04	GR-IA10-SB04-1	0-3'	8260B	1	0.00076 u	0.00076 u	0.00076 u	0.0011 u	0.0011 u	0.00076 u	0.0038 u	0.0038 u	0.0076 u	0.0038 u	0.0038 u	0.0038 u	0.0038 u	0.00076 u	-	0.0027 u	0.0038 u	0.0038 u	0.0038 u	0.0038 u	0.38 u	0.0038 u	0.0076 u
	16-Dec-04	GR-IA10-SB04-1	3-10'	8260B	1	0.00099 u	0.00099 u	0.00099 u	0.0015 u	0.0015 u	0.00099 u	0.005 u	0.005 u	0.0099 u	0.005 u	0.005 u	0.005 u	0.005 u	0.00099 u	-	0.0035 u	0.005 u	0.005 u	0.005 u	0.005 u	**0.5 u**	0.005 u	0.0099 u
IA11-SB01	29-Nov-04	LO-IA11-SB01-1	0-3'	8260B	1	0.045 u	0.045 u	0.045 u	0.067 u	0.067 u	0.045 u	0.22 u	0.22 u	**0.45 u**	0.22 u	0.22 u	0.22 u	0.22 u	0.045 u	-	0.16 u	0.22 u	0.22 u	0.22 u	0.22 u	**22 u**	0.22 u	0.45 u
	29-Nov-04	LO-IA11-SB01-1	3-10'	8260B	1	0.00076 u	0.00076 u	0.00076 u	0.0011 u	0.0011 u	0.00076 u	0.0038 u	0.0038 u	0.0076 u	0.0038 u	0.0038 u	0.0038 u	0.0038 u	0.00076 u	-	0.0026 u	0.0038 u	0.0038 u	0.0038 u	0.0038 u	0.38 u	0.0038 u	0.0076 u

Location

Notes:

- **NC** No criteria listed under the regulation cited
- **ND** Non-detect result (Original data unavailable - neither value nor detection limit provided)
- **-** Parameter not analyzed

Analytic Flags:

- **u** Not detected above laboratory reporting limits
- **j** Estimated value - parameter detected between laboratory reporting limit and half of the laboratory reporting limit.
- **e** Value exceeds analytical calibration limits
- **b** Parameter detected in quality control blank and sample

Highlighting:

- Value or Detection Limit exceeds Criteria 1 only
- Value or Detection Limit exceeds Criteria 2 only
- Value or Detection Limit exceeds both criteria

Supplemental Site Investigation

Analytic Method: 8260B
Sample Matrix: Soil
Reporting Units: mg/kg
Sample Dates: 29-Nov-2004 to 13-Apr-2005

						2-Chlorotoluene	2-Hexanone	4-Chlorotoluene	4-Isopropyltoluene	4-Methyl-2-pentanone	Acetone	Benzene	Bromobenzene	Bromochloromethane	Bromodichloromethane	Bromoform	Bromomethane	Carbon Disulfide	Carbon Tetrachloride	Chlorobenzene	Chloroethane	Chloroform	Chloromethane	cis-1,2-Dichloroethene	cis-1,3-Dichloropropene	Dibromochloromethane	Dibromomethane	Dichlorodifluoromethane
	SSI Project Action Limit (PAL) - Wave 2 (VOCs)					160	NC	NC	NC	79	60	0.64	2.8	NC	0.82	62	0.39	36	0.25	15	3	3.6	0.12	4.3	3	7.6	67	9.4
	Secondary Regulatory Criteria Not Selected																											
	Date	Sample ID	Depth	Method	Dilution																							
IA01-SB02	10-Dec-04	GR-IA01-SB02-1	0-3'	8260B	1	0.0035 u	0.007 u	0.0035 u	-	0.007 u	0.014	0.0007 u	0.0035 u	0.0035 u	0.0007 u	0.0028 u	0.0014 u	0.007 u	0.0007 u	0.0007 u	0.0014 u	0.001 u	0.0035 u	0.0007 u	0.0007 u	0.0007 u	0.007 u	0.007 u
	10-Dec-04	GR-IA01-SB02-1	3-10'	8260B	1	0.0046 u	0.0092 u	0.0046 u	-	0.0092 u	0.019	0.00092 u	0.0046 u	0.0046 u	0.00092 u	0.0037 u	0.0018 u	0.0092 u	0.00092 u	0.00092 u	0.0018 u	0.0014 u	0.0046 u	0.00092 u	0.00092 u	0.00092 u	0.0092 u	0.0092 u
IA02-SB01	30-Nov-04	GR-IA02-SB01-1	0-3'	8260B	1	0.004 u	0.0081 u	0.004 u	-	0.0081 u	0.028	0.00081 u	0.004 u	0.004 u	0.00081 u	0.0032 u	0.0016 u	0.0081 u	0.00081 u	0.00081 u	0.0016 u	0.0012 u	0.004 u	0.00081 u	0.00081 u	0.00081 u	0.0081 u	0.0081 u
	30-Nov-04	GR-IA02-SB01-1	3-10'	8260B	1	0.0035 u	0.007 u	0.0035 u	-	0.007 u	0.007 u	0.0007 u	0.0035 u	0.0035 u	0.0007 u	0.0028 u	0.0014 u	0.007 u	0.0007 u	0.0007 u	0.0014 u	0.001 u	0.0035 u	0.0007 u	0.0007 u	0.0007 u	0.007 u	0.007 u
IA02-SB02	02-Dec-04	GR-IA02-SB02-1	0-3'	8260B	1	0.0035 u	0.0069 u	0.0035 u	-	0.0069 u	0.0078	0.00069 u	0.0035 u	0.0035 u	0.00069 u	0.0028 u	0.0014 u	0.0069 u	0.00069 u	0.00069 u	0.0014 u	0.001 u	0.0035 u	0.00069 u	0.00069 u	0.00069 u	0.0069 u	0.0069 u
	02-Dec-04	GR-IA02-SB02-1-M	3-10'	8260B	1	0.0036 u	0.0072 u	0.0036 u	-	0.0072 u	0.017	0.00072 u	0.0036 u	0.0036 u	0.00072 u	0.0029 u	0.0014 u	0.0072 u	0.00072 u	0.00072 u	0.0014 u	0.0011 u	0.0036 u	0.00072 u	0.00072 u	0.00072 u	0.0072 u	0.0072 u
IA02-SB13	13-Dec-04	GR-IA02-SB13-1	0-3'	8260B	1	0.0038 u	0.0075 u	0.0038 u	-	0.0075 u	0.0075 u	0.00075 u	0.0038 u	0.0038 u	0.00075 u	0.003 u	0.0015 u	0.0075 u	0.00075 u	0.00075 u	0.0015 u	0.0011 u	0.0038 u	0.00075 u	0.00075 u	0.00075 u	0.0075 u	0.0075 u
	13-Dec-04	GR-IA02-SB13-1	3-10'	8260B	1	0.0053 u	0.01 u	0.0053 u	-	0.01 u	0.01 u	0.001 u	0.0053 u	0.0053 u	0.001 u	0.0042 u	0.0021 u	0.01 u	0.001 u	0.001 u	0.0021 u	0.0016 u	0.0053 u	0.001 u	0.001 u	0.001 u	0.01 u	0.01 u
	13-Dec-04	GR-IA02-SB13-1-D	3-10'	8260B	1	0.0046 u	0.0092 u	0.0046 u	-	0.0092 u	0.0092 u	0.00092 u	0.0046 u	0.0046 u	0.00092 u	0.0037 u	0.0018 u	0.0092 u	0.00092 u	0.00092 u	0.0018 u	0.0014 u	0.0046 u	0.00092 u	0.00092 u	0.00092 u	0.0092 u	0.0092 u
IA02-SB20	08-Dec-04	GR-IA02-SB20-1	0-3'	8260B	1	0.0054 u	0.011 u	0.0054 u	-	0.011 u	0.049	0.0011 u	0.0054 u	0.0054 u	0.0011 u	0.0043 u	0.0021 u	0.011 u	0.0011 u	0.0011 u	0.0026 u	0.0016 u	0.0054 u	0.0011 u	0.0011 u	0.0011 u	0.011 u	0.011 u
	08-Dec-04	GR-IA02-SB20-1-M	3-10'	8260B	1	0.0042 u	0.0084 u	0.0042 u	-	0.0084 u	0.0088	0.00084 u	0.0042 u	0.0042 u	0.00084 u	0.0033 u	0.0017 u	0.0084 u	0.00084 u	0.00084 u	0.0017 u	0.0012 u	0.0042 u	0.00084 u	0.00084 u	0.00084 u	0.0084 u	0.0084 u
IA02-SB23	13-Dec-04	GR-IA02-SB23-1	0-3'	8260B	1	0.0048 u	0.0097 u	0.0048 u	-	0.0097 u	0.036	0.00097 u	0.0048 u	0.0048 u	0.00097 u	0.0039 u	0.0019 u	0.0097 u	0.00097 u	0.00097 u	0.0019 u	0.0014 u	0.0048 u	0.00097 u	0.00097 u	0.00097 u	0.0097 u	0.0097 u
	13-Dec-04	GR-IA02-SB23-1	3-10'	8260B	1	0.0044 u	0.0088 u	0.0044 u	-	0.0088 u	0.032	0.00088 u	0.0044 u	0.0044 u	0.00088 u	0.0035 u	0.0018 u	0.0088 u	0.00088 u	0.00088 u	0.0018 u	0.0013 u	0.0044 u	0.00088 u	0.00088 u	0.00088 u	0.0088 u	0.0088 u
	13-Dec-04	GR-IA02-SB23-1-D	3-10'	8260B	1	0.0056 u	0.011 u	0.0056 u	-	0.011 u	0.031	0.0011 u	0.0056 u	0.0056 u	0.0011 u	0.0045 u	0.0022 u	0.011 u	0.0011 u	0.0011 u	0.0022 u	0.0017 u	0.0056 u	0.0011 u	0.0011 u	0.0011 u	0.011 u	0.011 u
IA02-SB30	15-Dec-04	GR-IA02-SB30-1	0-3'	8260B	1	0.0056 u	0.011 u	0.0056 u	-	0.011 u	0.033	0.0011 u	0.0056 u	0.0056 u	0.0011 u	0.0045 u	0.0022 u	0.011 u	0.0011 u	0.0011 u	0.0022 u	0.0017 u	0.0056 u	0.0011 u	0.0011 u	0.0011 u	0.011 u	0.011 u
	15-Dec-04	GR-IA02-SB30-1-M	3-10'	8260B	1	0.0037 u	0.0074 u	0.0037 u	-	0.0074 u	0.0074 u	0.00074 u	0.0037 u	0.0037 u	0.00074 u	0.003 u	0.0015 u	0.0074 u	0.00074 u	0.00074 u	0.0015 u	0.0011 u	0.0037 u	0.00074 u	0.00074 u	0.00074 u	0.0074 u	0.0074 u
IA03-SB02	13-Dec-04	GR-IA03-SB02-1	0-3'	8260B	1	0.0041 u	0.0082 u	0.0041 u	-	0.0082 u	0.033	0.00082 u	0.0041 u	0.0041 u	0.00082 u	0.0033 u	0.0016 u	0.0082 u	0.00082 u	0.00082 u	0.0016 u	0.0012 u	0.0041 u	0.00082 u	0.00082 u	0.00082 u	0.0082 u	0.0082 u
	13-Dec-04	GR-IA03-SB02-1	3-10'	8260B	1	0.0035 u	0.0069 u	0.0035 u	-	0.0069 u	0.0069 u	0.00069 u	0.0035 u	0.0035 u	0.00069 u	0.0028 u	0.0014 u	0.0069 u	0.00069 u	0.00069 u	0.0014 u	0.001 u	0.0035 u	0.00069 u	0.00069 u	0.00069 u	0.0069 u	0.0069 u
IA03-SB04	15-Dec-04	GR-IA03-SB04-1	0-3'	8260B	1	0.0056 u	0.011 u	0.0056 u	-	0.011 u	0.04	0.0011 u	0.0056 u	0.0056 u	0.0011 u	0.0045 u	0.0022 u	0.011 u	0.0011 u	0.0011 u	0.0022 u	0.0017 u	0.0056 u	0.0011 u	0.0011 u	0.0011 u	0.011 u	0.011 u
	15-Dec-04	GR-IA03-SB04-1	3-10'	8260B	1	0.0037 u	0.0074 u	0.0037 u	-	0.0074 u	0.0074 u	0.00074 u	0.0037 u	0.0037 u	0.00074 u	0.0029 u	0.0015 u	0.0074 u	0.00074 u	0.00074 u	0.0015 u	0.0011 u	0.0037 u	0.00074 u	0.00074 u	0.00074 u	0.0074 u	0.0074 u
IA05-SB07	10-Dec-04	GR-IA05-SB07-1	0-3'	8260B	1	0.0059 u	0.012 u	0.0059 u	-	0.012 u	0.057	0.0012 u	0.0059 u	0.0059 u	0.0012 u	0.0047 u	0.0024 u	0.012 u	0.0012 u	0.0012 u	0.0024 u	0.0018 u	0.0059 u	0.0012 u	0.0012 u	0.0012 u	0.012 u	0.012 u
	10-Dec-04	GR-IA05-SB07-1	3-10'	8260B	1	0.0078 u	0.016 u	0.0078 u	-	0.016 u	0.022	0.0016 u	0.0078 u	0.0078 u	0.0016 u	0.0062 u	0.0031 u	0.016 u	0.0016 u	0.0016 u	0.0031 u	0.0023 u	0.0078 u	0.0016 u	0.0016 u	0.0016 u	0.016 u	0.016 u
IA06-SB04	11-Apr-05	LO-IA06-SB04-1	3-10'	8260B	1	0.0056 u	0.0056 u	0.0056 u	0.0056 u	0.0056 u	0.02	0.0056 u	0.0056 u	0.0056 u	0.0056 u	0.0056 u	0.0056 u	0.0056 u	0.0056 u	0.0056 u	0.0056 u	0.0056 u	0.0056 u	0.0056 u	0.0056 u	0.0056 u	0.0056 u	0.0056 u
	11-Apr-05	LO-IA06-SB04-1	0-3'	8260B	1	0.0046 u	0.0046 u	0.0046 u	0.0046 u	0.0046 u	0.045	0.0046 u	0.0046 u	0.0046 u	0.0046 u	0.0046 u	0.0046 u	0.0046 u	0.0046 u	0.0046 u	0.0046 u	0.0046 u	0.0046 u	0.0046 u	0.0046 u	0.0046 u	0.0046 u	0.0046 u
IA06-SB06	11-Apr-05	LO-IA06-SB06-1	3-10'	8260B	1	0.0056 u	0.0056 u	0.0056 u	0.0056 u	0.0056 u	0.0095	0.0056 u	0.0056 u	0.0056 u	0.0056 u	0.0056 u	0.0056 u	0.0056 u	0.0056 u	0.0056 u	0.0056 u	0.0056 u	0.0056 u	0.0056 u	0.0056 u	0.0056 u	0.0056 u	0.0056 u
	11-Apr-05	LO-IA06-SB06-1	0-3'	8260B	1	0.005 u	0.005 u	0.005 u	0.005 u	0.005 u	0.023	0.005 u	0.005 u	0.005 u	0.005 u	0.005 u	0.005 u	0.005 u	0.005 u	0.005 u	0.005 u	0.005 u	0.005 u	0.005 u	0.005 u	0.005 u	0.005 u	0.005 u
IA06-SD06	13-Apr-05	LO-IA06-SD06-1	0-1.5'	8260B	1	0.0075 u	0.0075 u	0.0075 u	0.0075 u	0.0075 u	0.052	0.0075 u	0.0075 u	0.0075 u	0.0075 u	0.0075 u	0.0073 u	0.0073 u	0.0075 u	0.0075 u	0.0073 u	0.0075 u	0.0073 u	0.0075 u	0.0075 u	0.0075 u	0.0075 u	0.0073 u
IA06-SD17	13-Apr-05	LO-IA06-SD17-1	0-1.5'	8260B	1	0.007 u	0.007 u	0.007 u	0.007 u	0.007 u	0.051	0.007 u	0.007 u	0.007 u	0.007 u	0.007 u	0.007 u	0.007 u	0.007 u	0.007 u	0.007 u	0.007 u	0.007 u	0.007 u	0.007 u	0.007 u	0.007 u	0.007 u
IA06-SS08	11-Apr-05	LO-IA06-SS08-1	0-1.5'	8260B	1	0.005 u	0.005 u	0.005 u	0.005 j	0.005 u	0.11	0.005 u	0.005 u	0.005 u	0.005 u	0.005 u	0.005 u	0.005 u	0.005 u	0.005 u	0.005 u	0.005 u	0.005 u	0.005 u	0.005 u	0.005 u	0.005 u	0.005 u
IA06-SS16	11-Apr-05	LO-IA06-SS16-1	0-1.5'	8260B	1	0.0055 u	0.0055 u	0.0055 u	0.0055 u	0.0055 u	0.038	0.0055 u	0.0055 u	0.0055 u	0.0055 u	0.0055 u	0.0055 u	0.0055 u	0.0055 u	0.0055 u	0.0055 u	0.0055 u	0.0055 u	0.0055 u	0.0055 u	0.0055 u	0.0055 u	0.0055 u
	11-Apr-05	LO-IA06-SS16-1-D	0-1.5'	8260B	1	0.0058 u	0.0058 u	0.0058 u	0.0058 u	0.0058 u	0.054	0.0058 u	0.0058 u	0.0058 u	0.0058 u	0.0058 u	0.0058 u	0.0017 j	0.0058 u	0.0058 u	0.0058 u	0.0058 u	0.0058 u	0.0058 u	0.0058 u	0.0058 u	0.0058 u	0.0058 u
IA06-SS35	12-Apr-05	LO-IA06-SS35-1	0-1.5'	8260B	1	0.0051 u	0.0051 u	0.0051 u	0.0029 j	0.0051 u	0.13	0.0051 u	0.0051 u	0.0051 u	0.0051 u	0.0051 u	0.0051 u	0.0051 u	0.0051 u	0.0051 u	0.0051 u	0.0051 u	0.0051 u	0.0051 u	0.0051 u	0.0051 u	0.0051 u	0.0051 u
IA06-SS40	12-Apr-05	LO-IA06-SS40-1	0-1.5'	8260B	1	0.007 u	0.007 u	0.007 u	0.007 u	0.007 u	0.083	0.007 u	0.007 u	0.007 u	0.007 u	0.007 u	0.007 u	0.007 u	0.007 u	0.007 u	0.007 u	0.007 u	0.007 u	0.007 u	0.007 u	0.007 u	0.007 u	0.007 u
IA06-SS45	13-Apr-05	LO-IA06-SS25-1	0-1.5'	8260B	1	0.0047 u	0.0045 u	0.0047 u	0.0047 u	0.0045 u	0.026	0.0045 u	0.0047 u	0.0045 u	0.0045 u	0.0045 u	0.0045 u	0.0012 j	0.0045 u	0.0045 u	0.0045 u	0.0045 u	0.0045 u	0.0045 u	0.0045 u	0.0045 u	0.0045 u	0.0045 u

Location

Notes:

NC No criteria listed under the regulation cited
ND Non-detect result (Original data unavailable - neither value nor detection limit provided)
- Parameter not analyzed

Analytic Flags:

u Not detected above laboratory reporting limits
j Estimated value - parameter detected between laboratory reporting limit and half of the laboratory reporting limit.
e Value exceeds analytical calibration limits
b Parameter detected in quality control blank and sample

Highlighting:

Value or Detection Limit exceeds Criteria 1 only
Value or Detection Limit exceeds Criteria 2 only
Value or Detection Limit exceeds both criteria

Supplemental Site Investigation

Analytic Method: 8260B
Sample Matrix: Soil
Reporting Units: mg/kg
Sample Dates: 29-Nov-2004 to 13-Apr-2005

						2-Chlorotoluene	2-Hexanone	4-Chlorotoluene	4-Isopropyltoluene	4-Methyl-2-pentanone	Acetone	Benzene	Bromobenzene	Bromochloromethane	Bromodichloromethane	Bromoform	Bromomethane	Carbon Disulfide	Carbon Tetrachloride	Chlorobenzene	Chloroethane	Chloroform	Chloromethane	cis-1,2-Dichloroethene	cis-1,3-Dichloropropene	Dibromochloromethane	Dibromomethane	Dichlorodifluoromethane
	SSI Project Action Limit (PAL) - Wave 2 (VOCs)					160	NC	NC	NC	79	60	0.64	2.8	NC	0.82	62	0.39	36	0.25	15	3	3.6	0.12	4.3	3	7.6	67	9.4
	Secondary Regulatory Criteria Not Selected																											
	Date	Sample ID	Depth	Method	Dilution																							
IA08-SB01	30-Nov-04	GR-IA08-SB01-1	0-3'	8260B	1	0.0045 u	0.009 u	0.0045 u	-	0.009 u	0.009 u	0.0009 u	0.0045 u	0.0045 u	0.0009 u	0.0036 u	0.0018 u	0.009 u	0.0009 u	0.0009 u	0.0018 u	0.0014 u	0.0045 u	0.0009 u	0.0009 u	0.0009 u	0.009 u	0.009 u
	30-Nov-04	GR-IA08-SB01-1	3-10'	8260B	1	0.0077 u	0.015 u	0.0077 u	-	0.015 u	0.015 u	0.0015 u	0.0077 u	0.0077 u	0.0015 u	0.0062 u	0.0031 u	0.015 u	0.0015 u	0.0015 u	0.0031 u	0.0023 u	0.0077 u	0.0015 u	0.0015 u	0.0015 u	0.015 u	0.015 u
	30-Nov-04	GR-IA08-SB01-1-D	3-10'	8260B	1	0.0094 u	0.019 u	0.0094 u	-	0.019 u	0.019 u	0.0019 u	0.0094 u	0.0094 u	0.0019 u	0.0075 u	0.0038 u	0.019 u	0.0019 u	0.0019 u	0.0038 u	0.0028 u	0.0094 u	0.0019 u	0.0019 u	0.0019 u	0.019 u	0.019 u
IA08-SB02	03-Dec-04	GR-IA08-SB02-1	8-10'	8260B	1	0.0032 u	0.0064 u	0.0032 u	-	0.0064 u	0.0064 u	0.00064 u	0.0032 u	0.0032 u	0.00064 u	0.0026 u	0.0013 u	0.0064 u	0.00064 u	0.00064 u	0.0013 u	0.00097 u	0.0032 u	0.00064 u	0.00064 u	0.00064 u	0.0064 u	0.0064 u
	03-Dec-04	GR-IA08-SB02-1-D	8-10'	8260B	1	0.0028 u	0.0056 u	0.0028 u	-	0.0056 u	0.0061	0.00056 u	0.0028 u	0.0028 u	0.00056 u	0.0022 u	0.0011 u	0.0056 u	0.00056 u	0.00056 u	0.0011 u	0.00084 u	0.0028 u	0.00056 u	0.00056 u	0.00056 u	0.0056 u	0.0056 u
IA08-SB03	09-Dec-04	GR-IA08-SB03-1	0-2'	8260B	1	0.005 u	0.01 u	0.005 u	-	0.01 u	0.01 u	0.001 u	0.005 u	0.005 u	0.001 u	0.004 u	0.002 u	0.01 u	0.001 u	0.001 u	0.002 u	0.0015 u	0.005 u	0.001 u	0.001 u	0.001 u	0.01 u	0.01 u
IA08-SB04	03-Dec-04	GR-IA08-SB04-1	2-4'	8260B	1	0.0054 u	0.011 u	0.0054 u	-	0.011 u	0.011 u	0.0011 u	0.0054 u	0.0054 u	0.0011 u	0.0044 u	0.0022 u	0.011 u	0.0011 u	0.0011 u	0.0022 u	0.0016 u	0.0054 u	0.0011 u	0.0011 u	0.0011 u	0.011 u	0.011 u
IA08-SB05	08-Dec-04	GR-IA08-SB05-1	40-42'	8260B	1	0.0068 u	0.014 u	0.0068 u	-	0.014 u	0.014 u	0.0014 u	0.0068 u	0.0068 u	0.0014 u	0.0054 u	0.0027 u	0.014 u	0.0014 u	0.0014 u	0.0027 u	0.002 u	0.0068 u	0.0014 u	0.0014 u	0.0014 u	0.014 u	0.014 u
	03-Dec-04	GR-IA08-SB05-1	6-8'	8260B	1	0.0038 u	0.0077 u	0.0038 u	-	0.0077 u	0.0077 u	0.00077 u	0.0038 u	0.0038 u	0.00077 u	0.0031 u	0.0015 u	0.0077 u	0.00077 u	0.00077 u	0.0015 u	0.0012 u	0.0038 u	0.00077 u	0.00077 u	0.00077 u	0.0077 u	0.0077 u
IA08-SB06	09-Dec-04	GR-IA08-SB06-1	0-2'	8260B	1	0.0048 u	0.0096 u	0.0048 u	-	0.0096 u	0.016	0.00096 u	0.0048 u	0.0048 u	0.00096 u	0.0038 u	0.0019 u	0.0096 u	0.00096 u	0.00096 u	0.0019 u	0.0014 u	0.0048 u	0.00096 u	0.00096 u	0.00096 u	0.0096 u	0.0096 u
IA08-SB07	06-Dec-04	GR-IA08-SB07-1	4-6'	8260B	1	0.0066 u	0.013 u	0.0066 u	-	0.013 u	0.013 u	0.0013 u	0.0066 u	0.0066 u	0.0013 u	0.0053 u	0.0026 u	0.013 u	0.0013 u	0.0013 u	0.0026 u	0.002 u	0.0066 u	0.0013 u	0.0013 u	0.0013 u	0.013 u	0.013 u
IA08-SB09	16-Dec-04	GR-IA08-SB09-1	0-3'	8260B	1	0.0033 u	0.0066 u	0.0033 u	-	0.0066 u	0.011	0.00066 u	0.0033 u	0.0033 u	0.00066 u	0.0026 u	0.0013 u	0.0066 u	0.00066 u	0.00066 u	0.0013 u	0.00098 u	0.0033 u	0.00066 u	0.00066 u	0.00066 u	0.0066 u	0.0066 u
	16-Dec-04	GR-IA08-SB09-1	3-10'	8260B	1	0.0039 u	0.0078 u	0.0039 u	-	0.0078 u	0.015	0.00078 u	0.0039 u	0.0039 u	0.00078 u	0.0031 u	0.0016 u	0.0078 u	0.00078 u	0.00078 u	0.0016 u	0.0012 u	0.0039 u	0.00078 u	0.00078 u	0.00078 u	0.0078 u	0.0078 u
IA09-SB01	29-Nov-04	CA-IA09-SB01-1	0-3'	8260B	1	0.14 u	0.28 u	0.14 u	-	0.28 u	0.28 u	0.028 u	0.14 u	0.14 u	0.028 u	0.11 u	0.057 u	0.28 u	0.028 u	0.028 u	0.057 u	0.043 u	**0.14 u**	0.028 u	0.028 u	0.028 u	0.28 u	0.28 u
	29-Nov-04	CA-IA09-SB01-1	3-10'	8260B	1	0.22 u	0.44 u	0.22 u	-	0.44 u	0.44 u	0.044 u	0.22 u	0.22 u	0.044 u	0.18 u	0.088 u	0.44 u	0.044 u	0.044 u	0.088 u	0.066 u	**0.22 u**	0.044 u	0.044 u	0.044 u	0.44 u	0.44 u
IA10-SB01	13-Dec-04	GR-IA10-SB01-1	0-3'	8260B	1	0.0047 u	0.0095 u	0.0047 u	-	0.0095 u	0.0095	0.00095 u	0.0047 u	0.0047 u	0.00095 u	0.0038 u	0.0019 u	0.0095 u	0.00095 u	0.00095 u	0.0019 u	0.0014 u	0.0047 u	0.00095 u	0.00095 u	0.00095 u	0.0095 u	0.0095 u
	13-Dec-04	GR-IA10-SB01-1	3-10'	8260B	1	0.004 u	0.008 u	0.004 u	-	0.008 u	0.008 u	0.0008 u	0.004 u	0.004 u	0.0008 u	0.0032 u	0.0016 u	0.008 u	0.0008 u	0.0008 u	0.0016 u	0.0012 u	0.004 u	0.0008 u	0.0008 u	0.0008 u	0.008 u	0.008 u
IA10-SB02	10-Dec-04	GR-IA10-SB02-1	0-3'	8260B	1	0.0032 u	0.0065 u	0.0032 u	-	0.0065 u	0.0065 u	0.00065 u	0.0032 u	0.0032 u	0.00065 u	0.0026 u	0.0013 u	0.0065 u	0.00065 u	0.00065 u	0.0013 u	0.00097 u	0.0032 u	0.00065 u	0.00065 u	0.00065 u	0.0065 u	0.0065 u
	10-Dec-04	GR-IA10-SB02-1	3-10'	8260B	1	0.0046 u	0.0092 u	0.0046 u	-	0.0092 u	0.0092 u	0.0026	0.0046 u	0.0046 u	0.00092 u	0.0037 u	0.0018 u	0.0092 u	0.00092 u	0.00092 u	0.0018 u	0.0014 u	0.0046 u	0.00092 u	0.00092 u	0.00092 u	0.0092 u	0.0092 u
	10-Dec-04	GR-IA10-SB02-1-D	3-10'	8260B	1	0.0033 u	0.0067 u	0.0033 u	-	0.0067 u	0.0067 u	0.0012	0.0033 u	0.0033 u	0.00067 u	0.0027 u	0.0013 u	0.0067 u	0.00067 u	0.00067 u	0.0013 u	0.001 u	0.0033 u	0.00067 u	0.00067 u	0.00067 u	0.0067 u	0.0067 u
IA10-SB03	15-Dec-04	GR-IA10-SB03-1	0-3'	8260B	1	0.0038 u	0.0077 u	0.0038 u	-	0.0077 u	0.035	0.00077 u	0.0038 u	0.0038 u	0.00077 u	0.0031 u	0.0015 u	0.0077 u	0.00077 u	0.00077 u	0.0015 u	0.0012 u	0.0038 u	0.00077 u	0.00077 u	0.00077 u	0.0077 u	0.0077 u
	15-Dec-04	GR-IA10-SB03-1	3-10'	8260B	1	0.0046 u	0.0092 u	0.0046 u	-	0.0092 u	0.011	0.00092 u	0.0046 u	0.0046 u	0.00092 u	0.0037 u	0.0018 u	0.0092 u	0.00092 u	0.00092 u	0.0018 u	0.0014 u	0.0046 u	0.00092 u	0.00092 u	0.00092 u	0.0092 u	0.0092 u
IA10-SB04	16-Dec-04	GR-IA10-SB04-1	0-3'	8260B	1	0.0038 u	0.0076 u	0.0038 u	-	0.0076 u	0.086	0.00076 u	0.0038 u	0.0038 u	0.00076 u	0.003 u	0.0015 u	0.0076 u	0.00076 u	0.00076 u	0.0015 u	0.0011 u	0.0038 u	0.00076 u	0.00076 u	0.00076 u	0.0076 u	0.0076 u
	16-Dec-04	GR-IA10-SB04-1	3-10'	8260B	1	0.005 u	0.0099 u	0.005 u	-	0.0099 u	0.024	0.00099 u	0.005 u	0.005 u	0.00099 u	0.004 u	0.002 u	0.011	0.00099 u	0.00099 u	0.002 u	0.0015 u	0.005 u	0.00099 u	0.00099 u	0.00099 u	0.0099 u	0.0099 u
IA11-SB01	29-Nov-04	LO-IA11-SB01-1	0-3'	8260B	1	0.22 u	0.45 u	0.22 u	-	0.45 u	0.45 u	0.045 u	0.22 u	0.22 u	0.045 u	0.18 u	0.089 u	0.45 u	0.045 u	0.045 u	0.089 u	0.067 u	**0.22 u**	0.045 u	0.045 u	0.045 u	0.45 u	0.45 u
	29-Nov-04	LO-IA11-SB01-1	3-10'	8260B	1	0.0038 u	0.0076 u	0.0038 u	-	0.0076 u	0.018	0.00076 u	0.0038 u	0.0038 u	0.00076 u	0.003 u	0.0015 u	0.0076 u	0.00076 u	0.00076 u	0.0015 u	0.0011 u	0.0038 u	0.00076 u	0.00076 u	0.00076 u	0.0076 u	0.0076 u

Location

Notes:

- **NC** No criteria listed under the regulation cited
- **ND** Non-detect result (Original data unavailable - neither value nor detection limit provided)
- **-** Parameter not analyzed

Analytic Flags:

- **u** Not detected above laboratory reporting limits
- **j** Estimated value - parameter detected between laboratory reporting limit and half of the laboratory reporting limit.
- **e** Value exceeds analytical calibration limits
- **b** Parameter detected in quality control blank and sample

Highlighting:

- Value or Detection Limit exceeds Criteria 1 only
- Value or Detection Limit exceeds Criteria 2 only
- Value or Detection Limit exceeds both criteria

Supplemental Site Investigation

Analytic Method: 8260B
Sample Matrix: Soil
Reporting Units: mg/kg
Sample Dates: 29-Nov-2004 to 13-Apr-2005

							DIPE	Ethyl ether	Ethylbenzene	Ethylene Dibromide	Ethyl-Tert-Butyl-Ether	Hexachlorobutadiene	Isopropyl Ether	Isopropylbenzene	m,p-Xylenes	Methyl tert-butyl ether	Methylene Chloride	Naphthalene	n-Butylbenzene	n-Propylbenzene	o-Xylene	p-Isopropyltoluene	sec-Butylbenzene	Styrene	Tert-Amyl Methyl Ether	tert-Butylbenzene	Tetrachloroethene	Tetrahydrofuran	Toluene
SSI Project Action Limit (PAL) - Wave 2 (VOCs)							NC	16000	8.9	0.0069	NC	6	NC	57	NC	62	9.1	5.6	240	240	27	NC	220	30	NC	390	1.2	9.4	500
Secondary Regulatory Criteria Not Selected																													
	Date	Sample ID	Depth	Method	Dilution																								
IA01-SB02	10-Dec-04	GR-IA01-SB02-1	0-3'	8260B	1	-	0.0035 u	0.0007 u	0.0028 u	0.0028 u	0.0035 u	0.0028 u	0.0007 u	0.0007 u	0.0014 u	0.007 u	0.0035 u	0.0007 u	0.0007 u	0.0007 u	0.0007 u	0.0007 u	0.0007 u	0.0028 u	0.0035 u	0.0007 u	0.014 u	0.001 u
	10-Dec-04	GR-IA01-SB02-1	3-10'	8260B	1	-	0.0046 u	0.00092 u	0.0037 u	0.0037 u	0.0046 u	0.0037 u	0.00092 u	0.00092 u	0.0018 u	0.0092 u	0.0046 u	0.00092 u	0.00092 u	0.00092 u	0.00092 u	0.00092 u	0.00092 u	0.0037 u	0.0046 u	0.00092 u	0.018 u	0.0014 u
IA02-SB01	30-Nov-04	GR-IA02-SB01-1	0-3'	8260B	1	-	0.004 u	0.00081 u	0.0032 u	0.0032 u	0.004 u	0.0032 u	0.00081 u	0.00081 u	0.0016 u	0.0081 u	0.004 u	0.00081 u	0.00081 u	0.00081 u	0.00081 u	0.00081 u	0.00081 u	0.0032 u	0.004 u	0.00081 u	0.016 u	0.0012 u
	30-Nov-04	GR-IA02-SB01-1	3-10'	8260B	1	-	0.0035 u	0.0007 u	0.0028 u	0.0028 u	0.0035 u	0.0028 u	0.0007 u	0.0007 u	0.0014 u	0.007 u	0.0035 u	0.0007 u	0.0007 u	0.0007 u	0.0007 u	0.0007 u	0.0007 u	0.0028 u	0.0035 u	0.0007 u	0.014 u	0.001 u
IA02-SB02	02-Dec-04	GR-IA02-SB02-1	0-3'	8260B	1	-	0.0035 u	0.00069 u	0.0028 u	0.0028 u	0.0035 u	0.0028 u	0.00069 u	0.00069 u	0.0014 u	0.0069 u	0.0035 u	0.00069 u	0.00069 u	0.00069 u	0.00069 u	0.00069 u	0.00069 u	0.0028 u	0.0035 u	0.00069 u	0.014 u	0.001 u
	02-Dec-04	GR-IA02-SB02-1-M	3-10'	8260B	1	-	0.0036 u	0.00072 u	0.0029 u	0.0029 u	0.0036 u	0.0029 u	0.00072 u	0.00072 u	0.0014 u	0.0072 u	0.0036 u	0.00072 u	0.00072 u	0.00072 u	0.00072 u	0.00072 u	0.00072 u	0.0029 u	0.0036 u	0.00072 u	0.014 u	0.0011 u
IA02-SB13	13-Dec-04	GR-IA02-SB13-1	0-3'	8260B	1	-	0.0038 u	0.00075 u	0.003 u	0.003 u	0.0038 u	0.003 u	0.00075 u	0.00075 u	0.0015 u	0.0075 u	0.0038 u	0.00075 u	0.00075 u	0.00075 u	0.00075 u	0.00075 u	0.00075 u	0.003 u	0.0038 u	0.00075 u	0.015 u	0.0011 u
	13-Dec-04	GR-IA02-SB13-1	3-10'	8260B	1	-	0.0053 u	0.001 u	0.0042 u	0.0042 u	0.0053 u	0.0042 u	0.001 u	0.001 u	0.0021 u	0.01 u	0.0053 u	0.001 u	0.001 u	0.001 u	0.001 u	0.001 u	0.001 u	0.0042 u	0.0053 u	0.001 u	0.021 u	0.0016 u
	13-Dec-04	GR-IA02-SB13-1-D	3-10'	8260B	1	-	0.0046 u	0.00092 u	0.0037 u	0.0037 u	0.0046 u	0.0037 u	0.00092 u	0.00092 u	0.0018 u	0.0092 u	0.0046 u	0.00092 u	0.00092 u	0.00092 u	0.00092 u	0.00092 u	0.00092 u	0.0037 u	0.0046 u	0.00092 u	0.018 u	0.0014 u
IA02-SB20	08-Dec-04	GR-IA02-SB20-1	0-3'	8260B	1	-	0.0054 u	0.0011 u	0.0043 u	0.0043 u	0.0054 u	0.0043 u	0.0011 u	0.0011 u	0.0021 u	0.011 u	0.0054 u	0.0011 u	0.0011 u	0.0011 u	0.0011 u	0.0011 u	0.0011 u	0.0043 u	0.0054 u	0.0011 u	0.021 u	0.0016 u
	08-Dec-04	GR-IA02-SB20-1-M	3-10'	8260B	1	-	0.0042 u	0.00084 u	0.0033 u	0.0033 u	0.0042 u	0.0033 u	0.00084 u	0.00084 u	0.0017 u	0.0084 u	0.0042 u	0.00084 u	0.00084 u	0.00084 u	0.00084 u	0.00084 u	0.00084 u	0.0033 u	0.0042 u	0.00084 u	0.017 u	0.0012 u
IA02-SB23	13-Dec-04	GR-IA02-SB23-1	0-3'	8260B	1	-	0.0048 u	0.00097 u	0.0039 u	0.0039 u	0.0048 u	0.0039 u	0.00097 u	0.00097 u	0.0019 u	0.0097 u	0.0048 u	0.00097 u	0.00097 u	0.00097 u	0.00097 u	0.00097 u	0.00097 u	0.0039 u	0.0048 u	0.00097 u	0.019 u	0.0015
	13-Dec-04	GR-IA02-SB23-1	3-10'	8260B	1	-	0.0044 u	0.00088 u	0.0035 u	0.0035 u	0.0044 u	0.0035 u	0.00088 u	0.00088 u	0.0018 u	0.0088 u	0.0044 u	0.00088 u	0.00088 u	0.00088 u	0.00088 u	0.00088 u	0.00088 u	0.0035 u	0.0044 u	0.00088 u	0.018 u	0.0013 u
	13-Dec-04	GR-IA02-SB23-1-D	3-10'	8260B	1	-	0.0056 u	0.0011 u	0.0045 u	0.0045 u	0.0056 u	0.0045 u	0.0011 u	0.0011 u	0.0022 u	0.011 u	0.0056 u	0.0011 u	0.0011 u	0.0011 u	0.0011 u	0.0011 u	0.0011 u	0.0045 u	0.0056 u	0.0011 u	0.022 u	0.0017 u
IA02-SB30	15-Dec-04	GR-IA02-SB30-1	0-3'	8260B	1	-	0.0056 u	0.0011 u	0.0045 u	0.0045 u	0.0056 u	0.0045 u	0.0011 u	0.0011 u	0.0022 u	0.011 u	0.0056 u	0.0011 u	0.0011 u	0.0011 u	0.0011 u	0.0011 u	0.0011 u	0.0045 u	0.0056 u	0.0011 u	0.022 u	0.0017 u
	15-Dec-04	GR-IA02-SB30-1-M	3-10'	8260B	1	-	0.0037 u	0.00074 u	0.003 u	0.003 u	0.0037 u	0.003 u	0.00074 u	0.00074 u	0.0015 u	0.0074 u	0.0037 u	0.00074 u	0.00074 u	0.00074 u	0.00074 u	0.00074 u	0.00074 u	0.003 u	0.0037 u	0.00074 u	0.015 u	0.0011 u
IA03-SB02	13-Dec-04	GR-IA03-SB02-1	0-3'	8260B	1	-	0.0041 u	0.00082 u	0.0033 u	0.0033 u	0.0041 u	0.0033 u	0.00082 u	0.00082 u	0.0016 u	0.0082 u	0.0041 u	0.00082 u	0.00082 u	0.00082 u	0.00082 u	0.00082 u	0.00082 u	0.0033 u	0.0041 u	0.00082 u	0.016 u	0.0012 u
	13-Dec-04	GR-IA03-SB02-1	3-10'	8260B	1	-	0.0035 u	0.00069 u	0.0028 u	0.0028 u	0.0035 u	0.0028 u	0.00069 u	0.00069 u	0.0014 u	0.0069 u	0.0035 u	0.00069 u	0.00069 u	0.00069 u	0.00069 u	0.00069 u	0.00069 u	0.0028 u	0.0035 u	0.00069 u	0.014 u	0.001 u
IA03-SB04	15-Dec-04	GR-IA03-SB04-1	0-3'	8260B	1	-	0.0056 u	0.0011 u	0.0045 u	0.0045 u	0.0056 u	0.0045 u	0.0011 u	0.0011 u	0.0022 u	0.011 u	0.0056 u	0.0011 u	0.0011 u	0.0011 u	0.0011 u	0.0011 u	0.0011 u	0.0045 u	0.0056 u	0.0011 u	0.022 u	0.0017 u
	15-Dec-04	GR-IA03-SB04-1	3-10'	8260B	1	-	0.0037 u	0.00074 u	0.0029 u	0.0029 u	0.0037 u	0.0029 u	0.00074 u	0.00074 u	0.0015 u	0.0074 u	0.0037 u	0.00074 u	0.00074 u	0.00074 u	0.00074 u	0.00074 u	0.00074 u	0.0029 u	0.0037 u	0.00074 u	0.015 u	0.0011
IA05-SB07	10-Dec-04	GR-IA05-SB07-1	0-3'	8260B	1	-	0.0059 u	0.0012 u	0.0047 u	0.0047 u	0.0059 u	0.0047 u	0.0012 u	0.0012 u	0.0024 u	0.012 u	0.0059 u	0.0012 u	0.0012 u	0.0012 u	0.0012 u	0.0012 u	0.0012 u	0.0047 u	0.0059 u	0.0012 u	0.024 u	0.0018 u
	10-Dec-04	GR-IA05-SB07-1	3-10'	8260B	1	-	0.0078 u	0.0016 u	0.0062 u	0.0062 u	0.0078 u	0.0062 u	0.0016 u	0.0016 u	0.0031 u	0.016 u	0.0078 u	0.0016 u	0.0016 u	0.0016 u	0.0016 u	0.0016 u	0.0016 u	0.0062 u	0.0078 u	0.0016 u	0.031 u	0.0023 u
IA06-SB04	11-Apr-05	LO-IA06-SB04-1	3-10'	8260B	1	0.0056 u	0.0056 u	0.0056 u	0.0056 u	0.0056 u	0.0056 u	0.0056 u	-	0.0056 u	0.0056 u	0.0056 u	0.0056 u	0.0056 u	0.0056 u	0.0056 u	0.0056 u	-	0.0056 u	0.0056 u	0.0056 u	0.0056 u	0.0056 u	0.056 u	0.0056 u
	11-Apr-05	LO-IA06-SB04-1	0-3'	8260B	1	0.0046 u	0.0046 u	0.0046 u	0.0046 u	0.0046 u	0.0046 u	0.0046 u	-	0.0046 u	0.0046 u	0.0046 u	0.0046 u	0.0046 u	0.0046 u	0.0046 u	0.0046 u	-	0.0046 u	0.0046 u	0.0046 u	0.0046 u	0.0046 u	0.046 u	0.0046 u
IA06-SB06	11-Apr-05	LO-IA06-SB06-1	3-10'	8260B	1	0.0056 u	0.0056 u	0.0056 u	0.0056 u	0.0056 u	0.0056 u	0.0056 u	-	0.0056 u	0.0056 u	0.0056 u	0.0056 u	0.0056 u	0.0056 u	0.0056 u	0.0056 u	-	0.0056 u	0.0056 u	0.0056 u	0.0056 u	0.0056 u	0.056 u	0.0056 u
	11-Apr-05	LO-IA06-SB06-1	0-3'	8260B	1	0.005 u	0.005 u	0.005 u	0.005 u	0.005 u	0.005 u	0.005 u	-	0.005 u	0.005 u	0.005 u	0.005 u	0.005 u	0.005 u	0.005 u	0.005 u	-	0.005 u	0.005 u	0.005 u	0.005 u	0.005 u	0.05 u	0.005 u
IA06-SD06	13-Apr-05	LO-IA06-SD06-1	0-1.5'	8260B	1	0.0075 u	0.0073 u	0.0075 u	**0.0075 u**	0.0075 u	0.0075 u	0.0075 u	-	0.0075 u	0.0075 u	0.0075 u	0.0075 u	0.0075 u	0.0075 u	0.0075 u	0.0075 u	-	0.0075 u	0.0075 u	0.0075 u	0.0075 u	0.0075 u	0.075 u	0.0075 u
IA06-SD17	13-Apr-05	LO-IA06-SD17-1	0-1.5'	8260B	1	0.007 u	0.007 u	0.007 u	**0.007 u**	0.007 u	0.007 u	0.007 u	-	0.007 u	0.007 u	0.007 u	0.007 u	0.007 u	0.007 u	0.007 u	0.007 u	-	0.007 u	0.007 u	0.007 u	0.007 u	0.007 u	0.07 u	0.007 u
IA06-SS08	11-Apr-05	LO-IA06-SS08-1	0-1.5'	8260B	1	0.005 u	0.005 u	0.005 u	0.005 u	0.005 u	0.005 u	0.005 u	-	0.005 u	0.005 u	0.005 u	0.005 u	0.005 u	0.005 u	0.005 u	0.005 u	-	0.005 u	0.005 u	0.005 u	0.005 u	0.005 u	0.05 u	0.0013 j
IA06-SS16	11-Apr-05	LO-IA06-SS16-1	0-1.5'	8260B	1	0.0055 u	0.0055 u	0.0055 u	0.0055 u	0.0055 u	0.0055 u	0.0055 u	-	0.0055 u	0.0055 u	0.0055 u	0.0055 u	0.0055 u	0.0055 u	0.0055 u	0.0055 u	-	0.0055 u	0.0055 u	0.0055 u	0.0055 u	0.0055 u	0.055 u	0.0055 u
	11-Apr-05	LO-IA06-SS16-1-D	0-1.5'	8260B	1	0.0058 u	0.0058 u	0.0058 u	0.0058 u	0.0058 u	0.0058 u	0.0058 u	-	0.0058 u	0.0058 u	0.0058 u	0.0058 u	0.0058 u	0.0058 u	0.0058 u	0.0058 u	-	0.0058 u	0.0058 u	0.0058 u	0.0058 u	0.0058 u	0.058 u	0.0058 u
IA06-SS35	12-Apr-05	LO-IA06-SS35-1	0-1.5'	8260B	1	0.0051 u	0.0051 u	0.0051 u	0.0051 u	0.0051 u	0.0051 u	0.0051 u	-	0.0051 u	0.0051 u	0.0051 u	0.0051 u	0.0051 u	0.0051 u	0.0051 u	0.0051 u	-	0.0051 u	0.0051 u	0.0051 u	0.0051 u	0.0051 u	0.051 u	0.0012 j
IA06-SS40	12-Apr-05	LO-IA06-SS40-1	0-1.5'	8260B	1	0.007 u	0.007 u	0.007 u	**0.007 u**	0.007 u	0.007 u	0.007 u	-	0.007 u	0.007 u	0.007 u	0.007 u	0.007 u	0.007 u	0.007 u	0.007 u	-	0.007 u	0.007 u	0.007 u	0.007 u	0.007 u	0.07 u	0.007 u
IA06-SS45	13-Apr-05	LO-IA06-SS25-1	0-1.5'	8260B	1	0.0045 u	0.0045 u	0.0045 u	0.0045 u	0.0045 u	0.0047 u	-	0.0045 u	0.0045 u	0.0045 u	0.0045 u	0.0047 u	0.0047 u	0.0047 u	0.0045 u	-	0.0047 u	0.0045 u	0.0045 u	0.0047 u	0.0045 u	0.045 u	0.0045 u

Location

Notes:

NC No criteria listed under the regulation cited
ND Non-detect result (Original data unavailable - neither value nor detection limit provided)
- Parameter not analyzed

Analytic Flags:

u Not detected above laboratory reporting limits
j Estimated value - parameter detected between laboratory reporting limit and half of the laboratory reporting limit.
e Value exceeds analytical calibration limits
b Parameter detected in quality control blank and sample

Highlighting:

Value or Detection Limit exceeds Criteria 1 only
Value or Detection Limit exceeds Criteria 2 only
Value or Detection Limit exceeds both criteria

Supplemental Site Investigation

Analytic Method: 8260B
Sample Matrix: Soil
Reporting Units: mg/kg
Sample Dates: 29-Nov-2004 to 13-Apr-2005

							DIPE	Ethyl ether	Ethylbenzene	Ethylene Dibromide	Ethyl-Tert-Butyl-Ether	Hexachlorobutadiene	Isopropyl Ether	Isopropylbenzene	m,p-Xylenes	Methyl tert-butyl ether	Methylene Chloride	Naphthalene	n-Butylbenzene	n-Propylbenzene	o-Xylene	p-Isopropyltoluene	sec-Butylbenzene	Styrene	Tert-Amyl Methyl Ether	tert-Butylbenzene	Tetrachloroethene	Tetrahydrofuran	Toluene
SSI Project Action Limit (PAL) - Wave 2 (VOCs)							NC	16000	8.9	0.0069	NC	6	NC	57	NC	62	9.1	5.6	240	240	27	NC	220	30	NC	390	1.2	9.4	500
Secondary Regulatory Criteria Not Selected																													
	Date	Sample ID	Depth	Method	Dilution																								
IA08-SB01	30-Nov-04	GR-IA08-SB01-1	0-3'	8260B	1	-	0.0045 u	0.0009 u	0.0036 u	0.0036 u	0.0045 u	0.0036 u	0.0009 u	0.0009 u	0.0018 u	0.009 u	0.0045 u	0.0009 u	0.0009 u	0.0009 u	0.0009 u	0.0009 u	0.0009 u	0.0036 u	0.0045 u	0.0009 u	0.018 u	0.0023
	30-Nov-04	GR-IA08-SB01-1	3-10'	8260B	1	-	0.0077 u	0.0015 u	0.0062 u	0.0062 u	0.0077 u	0.0062 u	0.0015 u	0.0015 u	0.0031 u	0.015 u	0.0077 u	0.0015 u	0.0015 u	0.0015 u	0.0015 u	0.0015 u	0.0015 u	0.0062 u	0.0077 u	0.0015 u	0.031 u	0.0023 u
	30-Nov-04	GR-IA08-SB01-1-D	3-10'	8260B	1	-	0.0094 u	0.0019 u	**0.0075 u**	0.0075 u	0.0094 u	0.0075 u	0.0019 u	0.0019 u	0.0038 u	0.019 u	0.0094 u	0.0019 u	0.0019 u	0.0019 u	0.0019 u	0.0019 u	0.0019 u	0.0075 u	0.0094 u	0.0019 u	0.038 u	0.0028 u
IA08-SB02	03-Dec-04	GR-IA08-SB02-1	8-10'	8260B	1	-	0.0032 u	0.00064 u	0.0026 u	0.0026 u	0.0032 u	0.0026 u	0.00064 u	0.00064 u	0.0013 u	0.0064 u	0.0032 u	0.00064 u	0.00064 u	0.00064 u	0.00064 u	0.00064 u	0.00064 u	0.0026 u	0.0032 u	0.00064 u	0.013 u	0.00097 u
	03-Dec-04	GR-IA08-SB02-1-D	8-10'	8260B	1	-	0.0028 u	0.00056 u	0.0022 u	0.0022 u	0.0028 u	0.0022 u	0.00056 u	0.00076	0.0011 u	0.0056 u	0.0039	0.00056 u	0.00056 u	0.00056 u	0.00056 u	0.00056 u	0.00056 u	0.0022 u	0.0028 u	0.00056 u	0.011 u	0.00084 u
IA08-SB03	09-Dec-04	GR-IA08-SB03-1	0-2'	8260B	1	-	0.005 u	0.001 u	0.004 u	0.004 u	0.005 u	0.004 u	0.001 u	0.001 u	0.002 u	0.01 u	0.005 u	0.001 u	0.001 u	0.001 u	0.001 u	0.001 u	0.001 u	0.004 u	0.005 u	0.001 u	0.02 u	0.0015 u
IA08-SB04	03-Dec-04	GR-IA08-SB04-1	2-4'	8260B	1	-	0.0054 u	0.0011 u	0.0044 u	0.0044 u	0.0054 u	0.0044 u	0.0011 u	0.0011 u	0.0022 u	0.011 u	0.0054 u	0.0011 u	0.0011 u	0.0011 u	0.0011 u	0.0011 u	0.0011 u	0.0044 u	0.0054 u	0.0011 u	0.022 u	0.0016 u
IA08-SB05	08-Dec-04	GR-IA08-SB05-1	40-42'	8260B	1	-	0.0068 u	0.0014 u	0.0054 u	0.0054 u	0.0068 u	0.0054 u	0.0014 u	0.0014 u	0.0027 u	0.014 u	0.0068 u	0.0014 u	0.0014 u	0.0014 u	0.0014 u	0.0014 u	0.0014 u	0.0054 u	0.0068 u	0.0014 u	0.027 u	0.002 u
	03-Dec-04	GR-IA08-SB05-1	6-8'	8260B	1	-	0.0038 u	0.00077 u	0.0031 u	0.0031 u	0.0038 u	0.0031 u	0.00077 u	0.00077 u	0.0015 u	0.0077 u	0.0038 u	0.00077 u	0.00077 u	0.00077 u	0.00077 u	0.00077 u	0.00077 u	0.0031 u	0.0038 u	0.00077 u	0.015 u	0.0012 u
IA08-SB06	09-Dec-04	GR-IA08-SB06-1	0-2'	8260B	1	-	0.0048 u	0.00096 u	0.0038 u	0.0038 u	0.0048 u	0.0038 u	0.00096 u	0.00096 u	0.0019 u	0.0096 u	0.0048 u	0.00096 u	0.00096 u	0.00096 u	0.0053	0.00096 u	0.00096 u	0.0038 u	0.0048 u	0.00096 u	0.019 u	0.0022
IA08-SB07	06-Dec-04	GR-IA08-SB07-1	4-6'	8260B	1	-	0.0066 u	0.0013 u	0.0053 u	0.0053 u	0.0066 u	0.0053 u	0.0013 u	0.0013 u	0.0026 u	0.013 u	0.0066 u	0.0013 u	0.0013 u	0.0013 u	0.0013 u	0.0013 u	0.0013 u	0.0053 u	0.0066 u	0.0013 u	0.026 u	0.002 u
IA08-SB09	16-Dec-04	GR-IA08-SB09-1	0-3'	8260B	1	-	0.0033 u	0.00066 u	0.0026 u	0.0026 u	0.0033 u	0.0026 u	0.00066 u	0.00066 u	0.0013 u	0.0066 u	0.0033 u	0.00066 u	0.00066 u	0.00066 u	0.00066 u	0.00066 u	0.00066 u	0.0026 u	0.0033 u	0.00066 u	0.013 u	0.00098 u
	16-Dec-04	GR-IA08-SB09-1	3-10'	8260B	1	-	0.0039 u	0.00078 u	0.0031 u	0.0031 u	0.0039 u	0.0031 u	0.00078 u	0.00078 u	0.0016 u	0.0078 u	0.0039 u	0.00078 u	0.00078 u	0.00078 u	0.00078 u	0.00078 u	0.00078 u	0.0031 u	0.0039 u	0.00078 u	0.016 u	0.0012 u
IA09-SB01	29-Nov-04	CA-IA09-SB01-1	0-3'	8260B	1	-	0.14 u	0.028 u	**0.11 u**	0.11 u	0.14 u	0.11 u	0.028 u	0.028 u	0.057 u	0.28 u	0.14 u	0.028 u	0.028 u	0.028 u	0.028 u	0.028 u	0.028 u	0.11 u	0.14 u	0.028 u	0.57 u	0.043 u
	29-Nov-04	CA-IA09-SB01-1	3-10'	8260B	1	-	0.22 u	0.044 u	**0.18 u**	0.18 u	0.22 u	0.18 u	0.044 u	0.044 u	0.088 u	0.44 u	0.22 u	0.044 u	0.044 u	0.044 u	0.044 u	0.044 u	0.044 u	0.18 u	0.22 u	0.044 u	0.88 u	0.066 u
IA10-SB01	13-Dec-04	GR-IA10-SB01-1	0-3'	8260B	1	-	0.0047 u	0.00095 u	0.0038 u	0.0038 u	0.0047 u	0.0038 u	0.00095 u	0.00095 u	0.0019 u	0.0095 u	0.0047 u	0.00095 u	0.00095 u	0.00095 u	0.00095 u	0.00095 u	0.00095 u	0.0038 u	0.0047 u	0.00095 u	0.019 u	0.0014 u
	13-Dec-04	GR-IA10-SB01-1	3-10'	8260B	1	-	0.004 u	0.0008 u	0.0032 u	0.0032 u	0.004 u	0.0032 u	0.0008 u	0.0008 u	0.0016 u	0.008 u	0.004 u	0.0008 u	0.0008 u	0.0008 u	0.0008 u	0.0008 u	0.0008 u	0.0032 u	0.004 u	0.0008 u	0.016 u	0.0013
IA10-SB02	10-Dec-04	GR-IA10-SB02-1	0-3'	8260B	1	-	0.0032 u	0.00065 u	0.0026 u	0.0026 u	0.0032 u	0.0026 u	0.00065 u	0.00065 u	0.0013 u	0.0065 u	0.0051	0.00065 u	0.00065 u	0.00065 u	0.00065 u	0.00065 u	0.00065 u	0.0026 u	0.0032 u	0.00065 u	0.013 u	0.00097 u
	10-Dec-04	GR-IA10-SB02-1	3-10'	8260B	1	-	0.0046 u	0.00092 u	0.0037 u	0.0037 u	0.0046 u	0.0037 u	0.00092 u	0.0026	0.0018 u	0.0092 u	0.02	0.00092 u	0.00092 u	0.0022	0.00092 u	0.00092 u	0.00092 u	0.0037 u	0.0046 u	0.00092 u	0.018 u	0.0048
	10-Dec-04	GR-IA10-SB02-1-D	3-10'	8260B	1	-	0.0033 u	0.00067 u	0.0027 u	0.0027 u	0.0033 u	0.0027 u	0.00067 u	0.00067 u	0.0013 u	0.0067 u	0.006	0.00067 u	0.00067 u	0.00067 u	0.00067 u	0.00067 u	0.00067 u	0.0027 u	0.0033 u	0.00067 u	0.013 u	0.0017
IA10-SB03	15-Dec-04	GR-IA10-SB03-1	0-3'	8260B	1	-	0.0038 u	0.00077 u	0.0031 u	0.0031 u	0.0038 u	0.0031 u	0.00077 u	0.00077 u	0.0015 u	0.0077 u	0.0038 u	0.00077 u	0.00077 u	0.00077 u	0.00077 u	0.00077 u	0.00077 u	0.0031 u	0.0038 u	0.00077 u	0.015 u	0.0012 u
	15-Dec-04	GR-IA10-SB03-1	3-10'	8260B	1	-	0.0046 u	0.00092 u	0.0037 u	0.0037 u	0.0046 u	0.0037 u	0.00092 u	0.00092 u	0.0018 u	0.0092 u	0.0046 u	0.00092 u	0.00092 u	0.00092 u	0.00092 u	0.00092 u	0.00092 u	0.0037 u	0.0046 u	0.00092 u	0.018 u	0.0014
IA10-SB04	16-Dec-04	GR-IA10-SB04-1	0-3'	8260B	1	-	0.0038 u	0.00076 u	0.003 u	0.003 u	0.0038 u	0.003 u	0.00076 u	0.00076 u	0.0015 u	0.0076 u	0.0038 u	0.00076 u	0.00076 u	0.00076 u	0.00076 u	0.00076 u	0.00076 u	0.003 u	0.0038 u	0.00076 u	0.015 u	0.0011 u
	16-Dec-04	GR-IA10-SB04-1	3-10'	8260B	1	-	0.005 u	0.00099 u	0.004 u	0.004 u	0.005 u	0.004 u	0.00099 u	0.00099 u	0.002 u	0.0099 u	0.005 u	0.00099 u	0.00099 u	0.00099 u	0.00099 u	0.00099 u	0.00099 u	0.004 u	0.005 u	0.00099 u	0.02 u	0.0015 u
IA11-SB01	29-Nov-04	LO-IA11-SB01-1	0-3'	8260B	1	-	0.22 u	0.045 u	**0.18 u**	0.18 u	0.22 u	0.18 u	0.045 u	0.045 u	0.089 u	0.45 u	3.1	0.045 u	0.045 u	0.045 u	0.045 u	0.045 u	0.045 u	0.18 u	0.22 u	0.045 u	0.89 u	0.067 u
	29-Nov-04	LO-IA11-SB01-1	3-10'	8260B	1	-	0.0038 u	0.00076 u	0.003 u	0.003 u	0.0038 u	0.003 u	0.00076 u	0.00076 u	0.0015 u	0.0076 u	0.0038 u	0.00076 u	0.00076 u	0.00076 u	0.00076 u	0.00076 u	0.00076 u	0.003 u	0.0038 u	0.00076 u	0.015 u	0.0011 u

Location

Notes:

- **NC** No criteria listed under the regulation cited
- **ND** Non-detect result (Original data unavailable - neither value nor detection limit provided)
- **-** Parameter not analyzed

Analytic Flags:

- **u** Not detected above laboratory reporting limits
- **j** Estimated value - parameter detected between laboratory reporting limit and half of the laboratory reporting limit.
- **e** Value exceeds analytical calibration limits
- **b** Parameter detected in quality control blank and sample

Highlighting:

- Value or Detection Limit exceeds Criteria 1 only
- Value or Detection Limit exceeds Criteria 2 only
- Value or Detection Limit exceeds both criteria

Supplemental Site Investigation

Analytic Method: 8260B
Sample Matrix: Soil
Reporting Units: mg/kg
Sample Dates: 29-Nov-2004 to 13-Apr-2005

						trans-1,2-dichloroethene	trans-1,3-dichloropropene	Trichloroethene	Trichlorofluoromethane	Vinyl Chloride	Xylenes, Total
SSI Project Action Limit (PAL) - Wave 2 (VOCs)						6.9	3	0.053	39	0.079	NC
Secondary Regulatory Criteria Not Selected											
	Date	Sample ID	Depth	Method	Dilution						
IA01-SB02	10-Dec-04	GR-IA01-SB02-1	0-3'	8260B	1	0.001 u	0.0007 u	0.0007 u	0.0035 u	0.0014 u	-
	10-Dec-04	GR-IA01-SB02-1	3-10'	8260B	1	0.0014 u	0.00092 u	0.00092 u	0.0046 u	0.0018 u	-
IA02-SB01	30-Nov-04	GR-IA02-SB01-1	0-3'	8260B	1	0.0012 u	0.00081 u	0.00081 u	0.004 u	0.0016 u	-
	30-Nov-04	GR-IA02-SB01-1	3-10'	8260B	1	0.001 u	0.0007 u	0.0007 u	0.0035 u	0.0014 u	-
IA02-SB02	02-Dec-04	GR-IA02-SB02-1	0-3'	8260B	1	0.001 u	0.00069 u	0.00069 u	0.0035 u	0.0014 u	-
	02-Dec-04	GR-IA02-SB02-1-M	3-10'	8260B	1	0.0011 u	0.00072 u	0.00072 u	0.0036 u	0.0014 u	-
IA02-SB13	13-Dec-04	GR-IA02-SB13-1	0-3'	8260B	1	0.0011 u	0.00075 u	0.00075 u	0.0038 u	0.0015 u	-
	13-Dec-04	GR-IA02-SB13-1	3-10'	8260B	1	0.0016 u	0.001 u	0.001 u	0.0053 u	0.0021 u	-
	13-Dec-04	GR-IA02-SB13-1-D	3-10'	8260B	1	0.0014 u	0.00092 u	0.00092 u	0.0046 u	0.0018 u	-
IA02-SB20	08-Dec-04	GR-IA02-SB20-1	0-3'	8260B	1	0.0016 u	0.0011 u	0.0011 u	0.0054 u	0.0021 u	-
	08-Dec-04	GR-IA02-SB20-1-M	3-10'	8260B	1	0.0012 u	0.00084 u	0.00084 u	0.0042 u	0.0017 u	-
IA02-SB23	13-Dec-04	GR-IA02-SB23-1	0-3'	8260B	1	0.0014 u	0.00097 u	0.00097 u	0.0048 u	0.0019 u	-
	13-Dec-04	GR-IA02-SB23-1	3-10'	8260B	1	0.0013 u	0.00088 u	0.00088 u	0.0044 u	0.0018 u	-
	13-Dec-04	GR-IA02-SB23-1-D	3-10'	8260B	1	0.0017 u	0.0011 u	0.0011 u	0.0056 u	0.0022 u	-
IA02-SB30	15-Dec-04	GR-IA02-SB30-1	0-3'	8260B	1	0.0017 u	0.0011 u	0.0011 u	0.0056 u	0.0022 u	-
	15-Dec-04	GR-IA02-SB30-1-M	3-10'	8260B	1	0.0011 u	0.00074 u	0.00074 u	0.0037 u	0.0015 u	-
IA03-SB02	13-Dec-04	GR-IA03-SB02-1	0-3'	8260B	1	0.0012 u	0.00082 u	0.00082 u	0.0041 u	0.0016 u	-
	13-Dec-04	GR-IA03-SB02-1	3-10'	8260B	1	0.001 u	0.00069 u	0.00069 u	0.0035 u	0.0014 u	-
IA03-SB04	15-Dec-04	GR-IA03-SB04-1	0-3'	8260B	1	0.0017 u	0.0011 u	0.0011 u	0.0056 u	0.0022 u	-
	15-Dec-04	GR-IA03-SB04-1	3-10'	8260B	1	0.0011 u	0.00074 u	0.00074 u	0.0037 u	0.0015 u	-
IA05-SB07	10-Dec-04	GR-IA05-SB07-1	0-3'	8260B	1	0.0018 u	0.0012 u	0.0012 u	0.0059 u	0.0024 u	-
	10-Dec-04	GR-IA05-SB07-1	3-10'	8260B	1	0.0023 u	0.0016 u	0.0016 u	0.0078 u	0.0031 u	-
IA06-SB04	11-Apr-05	LO-IA06-SB04-1	3-10'	8260B	1	0.0056 u	0.0056 u	0.0056 u	0.0056 u	0.0056 u	0.0056 u
	11-Apr-05	LO-IA06-SB04-1	0-3'	8260B	1	0.0046 u	0.0046 u	0.0046 u	0.0046 u	0.0046 u	0.0046 u
IA06-SB06	11-Apr-05	LO-IA06-SB06-1	3-10'	8260B	1	0.0056 u	0.0056 u	0.0056 u	0.0056 u	0.0056 u	0.0056 u
	11-Apr-05	LO-IA06-SB06-1	0-3'	8260B	1	0.005 u	0.005 u	0.005 u	0.005 u	0.005 u	0.005 u
IA06-SD06	13-Apr-05	LO-IA06-SD06-1	0-1.5'	8260B	1	0.0075 u	0.0075 u	0.0075 u	0.0073 u	0.0073 u	0.0075 u
IA06-SD17	13-Apr-05	LO-IA06-SD17-1	0-1.5'	8260B	1	0.007 u	0.007 u	0.007 u	0.007 u	0.007 u	0.007 u
IA06-SS08	11-Apr-05	LO-IA06-SS08-1	0-1.5'	8260B	1	0.005 u	0.005 u	0.005 u	0.005 u	0.005 u	0.005 u
IA06-SS16	11-Apr-05	LO-IA06-SS16-1	0-1.5'	8260B	1	0.0055 u	0.0055 u	0.0055 u	0.0055 u	0.0055 u	0.0055 u
	11-Apr-05	LO-IA06-SS16-1-D	0-1.5'	8260B	1	0.0058 u	0.0058 u	0.0058 u	0.0058 u	0.0058 u	0.0058 u
IA06-SS35	12-Apr-05	LO-IA06-SS35-1	0-1.5'	8260B	1	0.0051 u	0.0051 u	0.0051 u	0.0051 u	0.0051 u	0.0051 u
IA06-SS40	12-Apr-05	LO-IA06-SS40-1	0-1.5'	8260B	1	0.007 u	0.007 u	0.007 u	0.007 u	0.007 u	0.007 u
IA06-SS45	13-Apr-05	LO-IA06-SS25-1	0-1.5'	8260B	1	0.0045 u	0.0045 u	0.0045 u	0.0045 u	0.0045 u	0.0045 u

Location

Notes:

NC No criteria listed under the regulation cited
ND Non-detect result (Original data unavailable - neither value nor detection limit provided)
- Parameter not analyzed

Analytic Flags:

u Not detected above laboratory reporting limits
j Estimated value - parameter detected between laboratory reporting limit and half of the laboratory reporting limit.
e Value exceeds analytical calibration limits
b Parameter detected in quality control blank and sample

Highlighting:

Value or Detection Limit exceeds Criteria 1 only
Value or Detection Limit exceeds Criteria 2 only
Value or Detection Limit exceeds both criteria

Supplemental Site Investigation

Analytic Method: 8260B
Sample Matrix: Soil
Reporting Units: mg/kg
Sample Dates: 29-Nov-2004 to 13-Apr-2005

						trans-1,2-dichloroethene	trans-1,3-dichloropropene	Trichloroethene	Trichlorofluoromethane	Vinyl Chloride	Xylenes, Total
SSI Project Action Limit (PAL) - Wave 2 (VOCs)						6.9	3	0.053	39	0.079	NC
Secondary Regulatory Criteria Not Selected											
	Date	Sample ID	Depth	Method	Dilution						
IA08-SB01	30-Nov-04	GR-IA08-SB01-1	0-3'	8260B	1	0.0014 u	0.0009 u	0.0009 u	0.0045 u	0.0018 u	-
	30-Nov-04	GR-IA08-SB01-1	3-10'	8260B	1	0.0023 u	0.0015 u	0.0015 u	0.0077 u	0.0031 u	-
	30-Nov-04	GR-IA08-SB01-1-D	3-10'	8260B	1	0.0028 u	0.0019 u	0.0019 u	0.0094 u	0.0038 u	-
IA08-SB02	03-Dec-04	GR-IA08-SB02-1	8-10'	8260B	1	0.00097 u	0.00064 u	0.00064 u	0.0032 u	0.0013 u	-
	03-Dec-04	GR-IA08-SB02-1-D	8-10'	8260B	1	0.00084 u	0.00056 u	0.00056 u	0.0028 u	0.0011 u	-
IA08-SB03	09-Dec-04	GR-IA08-SB03-1	0-2'	8260B	1	0.0015 u	0.001 u	0.001 u	0.005 u	0.002 u	-
IA08-SB04	03-Dec-04	GR-IA08-SB04-1	2-4'	8260B	1	0.0016 u	0.0011 u	0.0011 u	0.0054 u	0.0022 u	-
IA08-SB05	08-Dec-04	GR-IA08-SB05-1	40-42'	8260B	1	0.002 u	0.0014 u	0.0014 u	0.0068 u	0.0027 u	-
	03-Dec-04	GR-IA08-SB05-1	6-8'	8260B	1	0.0012 u	0.00077 u	0.00077 u	0.0038 u	0.0015 u	-
IA08-SB06	09-Dec-04	GR-IA08-SB06-1	0-2'	8260B	1	0.0014 u	0.00096 u	0.00096 u	0.0048 u	0.0019 u	-
IA08-SB07	06-Dec-04	GR-IA08-SB07-1	4-6'	8260B	1	0.002 u	0.0013 u	0.0013 u	0.0066 u	0.0026 u	-
IA08-SB09	16-Dec-04	GR-IA08-SB09-1	0-3'	8260B	1	0.00098 u	0.00066 u	0.00066 u	0.0033 u	0.0013 u	-
	16-Dec-04	GR-IA08-SB09-1	3-10'	8260B	1	0.0012 u	0.00078 u	0.00078 u	0.0039 u	0.0016 u	-
IA09-SB01	29-Nov-04	CA-IA09-SB01-1	0-3'	8260B	1	0.043 u	0.028 u	0.028 u	0.14 u	0.057 u	-
	29-Nov-04	CA-IA09-SB01-1	3-10'	8260B	1	0.066 u	0.044 u	0.044 u	0.22 u	**0.088 u**	-
IA10-SB01	13-Dec-04	GR-IA10-SB01-1	0-3'	8260B	1	0.0014 u	0.00095 u	0.00095 u	0.0047 u	0.0019 u	-
	13-Dec-04	GR-IA10-SB01-1	3-10'	8260B	1	0.0012 u	0.0008 u	0.0008 u	0.004 u	0.0016 u	-
IA10-SB02	10-Dec-04	GR-IA10-SB02-1	0-3'	8260B	1	0.00097 u	0.00065 u	0.00065 u	0.0032 u	0.0013 u	-
	10-Dec-04	GR-IA10-SB02-1	3-10'	8260B	1	0.0014 u	0.00092 u	0.00092 u	0.0046 u	0.0018 u	-
	10-Dec-04	GR-IA10-SB02-1-D	3-10'	8260B	1	0.001 u	0.00067 u	0.00067 u	0.0033 u	0.0013 u	-
IA10-SB03	15-Dec-04	GR-IA10-SB03-1	0-3'	8260B	1	0.0012 u	0.00077 u	0.00077 u	0.0038 u	0.0015 u	-
	15-Dec-04	GR-IA10-SB03-1	3-10'	8260B	1	0.0014 u	0.00092 u	0.00092 u	0.0046 u	0.0018 u	-
IA10-SB04	16-Dec-04	GR-IA10-SB04-1	0-3'	8260B	1	0.0011 u	0.00076 u	0.00076 u	0.0038 u	0.0015 u	-
	16-Dec-04	GR-IA10-SB04-1	3-10'	8260B	1	0.0015 u	0.00099 u	0.00099 u	0.005 u	0.002 u	-
IA11-SB01	29-Nov-04	LO-IA11-SB01-1	0-3'	8260B	1	0.067 u	0.045 u	0.045 u	0.22 u	**0.089 u**	-
	29-Nov-04	LO-IA11-SB01-1	3-10'	8260B	1	0.0011 u	0.00076 u	0.00076 u	0.0038 u	0.0015 u	-

Location

Notes:

NC No criteria listed under the regulation cited
ND Non-detect result (Original data unavailable - neither value nor detection limit provided)
- Parameter not analyzed

Analytic Flags:

u Not detected above laboratory reporting limits
j Estimated value - parameter detected between laboratory reporting limit and half of the laboratory reporting limit.
e Value exceeds analytical calibration limits
b Parameter detected in quality control blank and sample

Highlighting:

Value or Detection Limit exceeds Criteria 1 only
Value or Detection Limit exceeds Criteria 2 only
Value or Detection Limit exceeds both criteria

Supplemental Site Investigation

Analytic Method: 8270C and 8270C-SIM
Sample Matrix: Soil
Reporting Units: mg/kg
Sample Dates: 29-Nov-2004 to 13-Apr-2005

						1,2,4-Trichlorobenzene	1,2-Dichlorobenzene	1,3-Dichlorobenzene	1,4-Dichlorobenzene	2,2-Oxybis(1-Chloropropane)	2,4,5-Trichlorophenol	2,4,6-Trichlorophenol	2,4-Dichlorophenol	2,4-Dimethylphenol	2,4-Dinitrophenol	2,4-Dinitrotoluene	2,6-Dinitrotoluene	2-Chloronaphthalene	2-Chlorophenol	2-Methylnaphthalene	2-methylphenol	2-Nitrophenol	3 & 4-Methylphenol	3,3-Dichlorobenzidine	4-Bromophenyl phenyl ether	4-Bromophenyl-phenylether	4-Chloroaniline	4-Methylphenol
	SSI Project Action Limit (PAL) - Wave 2 (SVOCs)					65	300	1.6	3.4	NC	600	0.61	18	120	12	2	6.1	490	6.3	31	310	NC	310	1	NC	NC	3	31
	Secondary Regulatory Criteria Not Selected																											
	Date	Sample ID	Depth	Method	Dilution																							
IA01-SB02	10-Dec-04	GR-IA01-SB02-1	0-3'	8270C	1	0.37 u	0.37 u	0.37 u	0.37 u	-	0.37 u	0.37 u	0.73 u	0.37 u	1.5 u	0.37 u	0.37 u	0.37 u	0.44 u	0.37 u	0.44 u	1.5 u	-	0.73 u	0.37 u	-	0.37 u	-
	10-Dec-04	GR-IA01-SB02-1	0-3'	8270C-SIM	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	10-Dec-04	GR-IA01-SB02-1	3-10'	8270C	1	0.36 u	0.36 u	0.36 u	0.36 u	-	0.36 u	0.36 u	0.72 u	0.36 u	1.4 u	0.36 u	0.36 u	0.36 u	0.43 u	0.36 u	0.43 u	1.4 u	-	0.72 u	0.36 u	-	0.36 u	-
	10-Dec-04	GR-IA01-SB02-1	3-10'	8270C-SIM	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
IA02-SB01	30-Nov-04	GR-IA02-SB01-1	0-3'	8270C	1	0.39 u	0.39 u	0.39 u	0.39 u	-	0.39 u	0.39 u	0.78 u	0.39 u	1.6 u	0.39 u	0.39 u	0.39 u	0.46 u	0.39 u	0.46 u	1.6 u	0.46 u	0.78 u	0.39 u	-	0.39 u	-
	30-Nov-04	GR-IA02-SB01-1	0-3'	8270C-SIM	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	30-Nov-04	GR-IA02-SB01-1	3-10'	8270C	1	0.36 u	0.36 u	0.36 u	0.36 u	-	0.36 u	0.36 u	0.72 u	0.36 u	1.4 u	0.36 u	0.36 u	0.36 u	0.43 u	0.36 u	0.43 u	1.4 u	0.43 u	0.72 u	0.36 u	-	0.36 u	-
	30-Nov-04	GR-IA02-SB01-1	3-10'	8270C-SIM	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
IA02-SB02	02-Dec-04	GR-IA02-SB02-1	0-3'	8270C	1	0.38 u	0.38 u	0.38 u	0.38 u	-	0.38 u	0.38 u	0.76 u	0.38 u	1.5 u	0.38 u	0.38 u	0.38 u	0.45 u	0.38 u	0.45 u	1.5 u	0.45 u	0.76 u	0.38 u	-	0.38 u	-
	02-Dec-04	GR-IA02-SB02-1	0-3'	8270C-SIM	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	02-Dec-04	GR-IA02-SB02-1-M	3-10'	8270C	1	0.36 u	0.36 u	0.36 u	0.36 u	-	0.36 u	0.36 u	0.72 u	0.36 u	1.4 u	0.36 u	0.36 u	0.36 u	0.43 u	0.36 u	0.43 u	1.4 u	0.43 u	0.72 u	0.36 u	-	0.36 u	-
	02-Dec-04	GR-IA02-SB02-1-M	3-10'	8270C-SIM	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
IA02-SB13	13-Dec-04	GR-IA02-SB13-1	0-3'	8270C	1	0.37 u	0.37 u	0.37 u	0.37 u	-	0.37 u	0.37 u	0.73 u	0.37 u	1.5 u	0.37 u	0.37 u	0.37 u	0.44 u	0.37 u	0.44 u	1.5 u	0.44 u	0.73 u	0.37 u	-	0.37 u	-
	13-Dec-04	GR-IA02-SB13-1	0-3'	8270C-SIM	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	13-Dec-04	GR-IA02-SB13-1	3-10'	8270C	1	0.35 u	0.35 u	0.35 u	0.35 u	-	0.35 u	0.35 u	0.7 u	0.35 u	1.4 u	0.35 u	0.35 u	0.35 u	0.42 u	0.35 u	0.42 u	1.4 u	0.42 u	0.7 u	0.35 u	-	0.35 u	-
	13-Dec-04	GR-IA02-SB13-1	3-10'	8270C-SIM	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	13-Dec-04	GR-IA02-SB13-1-D	3-10'	8270C	1	0.35 u	0.35 u	0.35 u	0.35 u	-	0.35 u	0.35 u	0.7 u	0.35 u	1.4 u	0.35 u	0.35 u	0.35 u	0.42 u	0.35 u	0.42 u	1.4 u	0.42 u	0.7 u	0.35 u	-	0.35 u	-
	13-Dec-04	GR-IA02-SB13-1-D	3-10'	8270C-SIM	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
IA02-SB20	08-Dec-04	GR-IA02-SB20-1	0-3'	8270C	1	0.38 u	0.38 u	0.38 u	0.38 u	-	0.38 u	0.38 u	0.76 u	0.38 u	1.5 u	0.38 u	0.38 u	0.38 u	0.45 u	0.38 u	0.45 u	1.5 u	0.45 u	0.76 u	0.38 u	-	0.38 u	-
	08-Dec-04	GR-IA02-SB20-1	0-3'	8270C-SIM	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	08-Dec-04	GR-IA02-SB20-1-M	3-10'	8270C	1	0.36 u	0.36 u	0.36 u	0.36 u	-	0.36 u	0.36 u	0.72 u	0.36 u	1.4 u	0.36 u	0.36 u	0.36 u	0.43 u	0.36 u	0.43 u	1.4 u	0.43 u	0.72 u	0.36 u	-	0.36 u	-
	08-Dec-04	GR-IA02-SB20-1-M	3-10'	8270C-SIM	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
IA02-SB23	13-Dec-04	GR-IA02-SB23-1	0-3'	8270C	1	0.37 u	0.37 u	0.37 u	0.37 u	-	0.37 u	0.37 u	0.75 u	0.37 u	1.5 u	0.37 u	0.37 u	0.37 u	0.45 u	0.37 u	0.45 u	1.5 u	0.45 u	0.75 u	0.37 u	-	0.37 u	-
	13-Dec-04	GR-IA02-SB23-1	0-3'	8270C-SIM	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	13-Dec-04	GR-IA02-SB23-1	3-10'	8270C	1	0.4 u	0.4 u	0.4 u	0.4 u	-	0.4 u	0.4 u	0.8 u	0.4 u	1.6 u	0.4 u	0.4 u	0.4 u	0.48 u	0.4 u	0.48 u	1.6 u	0.48 u	0.8 u	0.4 u	-	0.4 u	-
	13-Dec-04	GR-IA02-SB23-1	3-10'	8270C-SIM	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	13-Dec-04	GR-IA02-SB23-1-D	3-10'	8270C	1	0.4 u	0.4 u	0.4 u	0.4 u	-	0.4 u	0.4 u	0.79 u	0.4 u	1.6 u	0.4 u	0.4 u	0.4 u	0.48 u	0.4 u	0.48 u	1.6 u	0.48 u	0.79 u	0.4 u	-	0.4 u	-
	13-Dec-04	GR-IA02-SB23-1-D	3-10'	8270C-SIM	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
IA02-SB30	15-Dec-04	GR-IA02-SB30-1	0-3'	8270C	1	0.37 u	0.37 u	0.37 u	0.37 u	-	0.37 u	0.37 u	0.75 u	0.37 u	1.5 u	0.37 u	0.37 u	0.37 u	0.45 u	0.37 u	0.45 u	1.5 u	0.45 u	0.75 u	0.37 u	-	0.37 u	-
	15-Dec-04	GR-IA02-SB30-1	0-3'	8270C-SIM	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	15-Dec-04	GR-IA02-SB30-1-M	3-10'	8270C	1	0.35 u	0.35 u	0.35 u	0.35 u	-	0.35 u	0.35 u	0.7 u	0.35 u	1.4 u	0.35 u	0.35 u	0.35 u	0.42 u	0.35 u	0.42 u	1.4 u	0.42 u	0.7 u	0.35 u	-	0.35 u	-
	15-Dec-04	GR-IA02-SB30-1-M	3-10'	8270C-SIM	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
IA03-SB02	13-Dec-04	GR-IA03-SB02-1	0-3'	8270C	1	0.37 u	0.37 u	0.37 u	0.37 u	-	0.37 u	0.37 u	0.74 u	0.37 u	1.5 u	0.37 u	0.37 u	0.37 u	0.44 u	0.37 u	0.44 u	1.5 u	0.44 u	0.74 u	0.37 u	-	0.37 u	-
	13-Dec-04	GR-IA03-SB02-1	0-3'	8270C-SIM	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	13-Dec-04	GR-IA03-SB02-1	3-10'	8270C	1	0.35 u	0.35 u	0.35 u	0.35 u	-	0.35 u	0.35 u	0.7 u	0.35 u	1.4 u	0.35 u	0.35 u	0.35 u	0.42 u	0.35 u	0.42 u	1.4 u	0.42 u	0.7 u	0.35 u	-	0.35 u	-
	13-Dec-04	GR-IA03-SB02-1	3-10'	8270C-SIM	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

Location

Notes:

NC No criteria listed under the regulation cited
ND Non-detect result (Original data unavailable - neither value nor detection limit provided)
- Parameter not analyzed

Analytic Flags:

u Not detected above laboratory reporting limits
j Estimated value - parameter detected between laboratory reporting limit and half of the laboratory reporting limit.
e Value exceeds analytical calibration limits
b Parameter detected in quality control blank and sample

Highlighting:

Value or Detection Limit exceeds Criteria 1 only
Value or Detection Limit exceeds Criteria 2 only
Value or Detection Limit exceeds both criteria

Supplemental Site Investigation

Analytic Method: 8270C and 8270C-SIM
Sample Matrix: Soil
Reporting Units: mg/kg
Sample Dates: 29-Nov-2004 to 13-Apr-2005

						1,2,4-Trichlorobenzene	1,2-Dichlorobenzene	1,3-Dichlorobenzene	1,4-Dichlorobenzene	2,2-Oxybis(1-Chloropropane)	2,4,5-Trichlorophenol	2,4,6-Trichlorophenol	2,4-Dichlorophenol	2,4-Dimethylphenol	2,4-Dinitrophenol	2,4-Dinitrotoluene	2,6-Dinitrotoluene	2-Chloronaphthalene	2-Chlorophenol	2-Methylnaphthalene	2-methylphenol	2-Nitrophenol	3 & 4-Methylphenol	3,3-Dichlorobenzidine	4-Bromophenyl phenyl ether	4-Bromophenyl-phenylether	4-Chloroaniline	4-Methylphenol
	SSI Project Action Limit (PAL) - Wave 2 (SVOCs)					65	300	1.6	3.4	NC	600	0.61	18	120	12	2	6.1	490	6.3	31	310	NC	310	1	NC	NC	3	31
	Secondary Regulatory Criteria Not Selected																											
	Date	Sample ID	Depth	Method	Dilution																							
IA03-SB04	15-Dec-04	GR-IA03-SB04-1	0-3'	8270C	1	0.37 u	0.37 u	0.37 u	0.37 u	-	0.37 u	0.37 u	0.73 u	0.37 u	1.5 u	0.37 u	0.37 u	0.37 u	0.44 u	0.37 u	0.44 u	1.5 u	0.44 u	0.73 u	0.37 u	-	0.37 u	-
	15-Dec-04	GR-IA03-SB04-1	0-3'	8270C-SIM	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	15-Dec-04	GR-IA03-SB04-1	3-10'	8270C	1	0.36 u	0.36 u	0.36 u	0.36 u	-	0.36 u	0.36 u	0.72 u	0.36 u	1.4 u	0.36 u	0.36 u	0.36 u	0.43 u	0.36 u	0.43 u	1.4 u	0.43 u	0.72 u	0.36 u	-	0.36 u	-
	15-Dec-04	GR-IA03-SB04-1	3-10'	8270C-SIM	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
IA05-SB07	10-Dec-04	GR-IA05-SB07-1	0-3'	8270C	1	0.39 u	0.39 u	0.39 u	0.39 u	-	0.39 u	0.39 u	0.78 u	0.39 u	1.6 u	0.39 u	0.39 u	0.39 u	0.47 u	0.39 u	0.47 u	1.6 u	-	0.78 u	0.39 u	-	0.39 u	-
	10-Dec-04	GR-IA05-SB07-1	0-3'	8270C-SIM	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	10-Dec-04	GR-IA05-SB07-1	3-10'	8270C	1	0.36 u	0.36 u	0.36 u	0.36 u	-	0.36 u	0.36 u	0.72 u	0.36 u	1.4 u	0.36 u	0.36 u	0.36 u	0.43 u	0.36 u	0.43 u	1.4 u	-	0.72 u	0.36 u	-	0.36 u	-
	10-Dec-04	GR-IA05-SB07-1	3-10'	8270C-SIM	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
IA06-SB03	11-Apr-05	LO-IA06-SB03-1	3-10'	8270C	1	0.38 u	0.38 u	0.38 u	0.38 u	0.38 u	1.9 u	0.38 u	0.38 u	0.38 u	1.9 u	0.38 u	0.38 u	0.38 u	0.38 u	0.38 u	0.38 u	0.38 u	-	0.38 u	-	0.38 u	0.38 u	0.38 u
	11-Apr-05	LO-IA06-SB03-1	0-3'	8270C	1	0.35 u	0.35 u	0.35 u	0.35 u	0.35 u	1.8 u	0.35 u	0.35 u	0.35 u	1.8 u	0.35 u	0.35 u	0.35 u	0.35 u	0.35 u	0.35 u	0.35 u	-	0.35 u	-	0.35 u	0.35 u	0.35 u
IA06-SB04	11-Apr-05	LO-IA06-SB04-1	3-10'	8270C	1	0.44 u	0.44 u	0.44 u	0.44 u	0.44 u	2.2 u	0.44 u	0.44 u	0.44 u	2.2 u	0.44 u	0.44 u	0.44 u	0.44 u	0.44 u	0.44 u	0.44 u	-	0.44 u	-	0.44 u	0.44 u	0.44 u
	11-Apr-05	LO-IA06-SB04-1	0-3'	8270C	1	0.37 u	0.37 u	0.37 u	0.37 u	0.37 u	1.8 u	0.37 u	0.37 u	0.37 u	1.8 u	0.37 u	0.37 u	0.37 u	0.37 u	0.37 u	0.37 u	0.37 u	-	0.37 u	-	0.37 u	0.37 u	0.37 u
IA06-SB05	11-Apr-05	LO-IA06-SB05-1	3-10'	8270C	1	0.38 u	0.38 u	0.38 u	0.38 u	0.38 u	1.9 u	0.38 u	0.38 u	0.38 u	1.9 u	0.38 u	0.38 u	0.38 u	0.38 u	0.38 u	0.38 u	0.38 u	-	0.38 u	-	0.38 u	0.38 u	0.38 u
	11-Apr-05	LO-IA06-SB05-1	0-3'	8270C	1	0.37 u	0.37 u	0.37 u	0.37 u	0.37 u	1.9 u	0.37 u	0.37 u	0.37 u	1.9 u	0.37 u	0.37 u	0.37 u	0.37 u	0.37 u	0.37 u	0.37 u	-	0.37 u	-	0.37 u	0.37 u	0.37 u
IA06-SB06	11-Apr-05	LO-IA06-SB06-1	3-10'	8270C	1	0.38 u	0.38 u	0.38 u	0.38 u	0.38 u	1.9 u	0.38 u	0.38 u	0.38 u	1.9 u	0.38 u	0.38 u	0.38 u	0.38 u	0.38 u	0.38 u	0.38 u	-	0.38 u	-	0.38 u	0.38 u	0.38 u
	11-Apr-05	LO-IA06-SB06-1	0-3'	8270C	1	0.39 u	0.39 u	0.39 u	0.39 u	0.39 u	2 u	0.39 u	0.39 u	0.39 u	2 u	0.39 u	0.39 u	0.39 u	0.39 u	0.39 u	0.39 u	0.39 u	-	0.39 u	-	0.39 u	0.39 u	0.39 u
IA06-SD06	13-Apr-05	LO-IA06-SD06-1	0-1.5'	8270C	1	1.1 u	1.1 u	1.1 u	1.1 u	1.1 u	2.7 u	**1.1 u**	1.1 u	1.1 u	2.7 u	1.1 u	1.1 u	1.1 u	1.1 u	1.1 u	1.1 u	1.1 u	-	**1.1 u**	-	1.1 u	1.1 u	1.1 u
IA06-SD17	13-Apr-05	LO-IA06-SD17-1	0-1.5'	8270C	1	1 u	1 u	1 u	1 u	1 u	2.5 u	**1 u**	1 u	1 u	2.5 u	1 u	1 u	1 u	1 u	1 u	1 u	1 u	-	**1 u**	-	1 u	1 u	1 u
IA06-SS08	11-Apr-05	LO-IA06-SS08-1	0-1.5'	8270C	1	0.36 u	0.36 u	0.36 u	0.36 u	0.36 u	1.8 u	0.36 u	0.36 u	0.36 u	1.8 u	0.36 u	0.36 u	0.36 u	0.36 u	0.36 u	0.36 u	0.36 u	-	0.36 u	-	0.36 u	0.36 u	0.36 u
IA06-SS16	11-Apr-05	LO-IA06-SS16-1	0-1.5'	8270C	1	0.35 u	0.35 u	0.35 u	0.35 u	0.35 u	1.8 u	0.35 u	0.35 u	0.35 u	1.8 u	0.35 u	0.35 u	0.35 u	0.35 u	0.35 u	0.35 u	0.35 u	-	0.35 u	-	0.35 u	0.35 u	0.35 u
	11-Apr-05	LO-IA06-SS16-1-D	0-1.5'	8270C	1	0.33 u	0.33 u	0.33 u	0.33 u	0.33 u	1.7 u	0.33 u	0.33 u	0.33 u	1.7 u	0.33 u	0.33 u	0.33 u	0.33 u	0.33 u	0.33 u	0.33 u	-	0.33 u	-	0.33 u	0.33 u	0.33 u
IA06-SS35	12-Apr-05	LO-IA06-SS35-1	0-1.5'	8270C	1	0.38 u	0.38 u	0.38 u	0.38 u	0.38 u	1.9 u	0.38 u	0.38 u	0.38 u	1.9 u	0.38 u	0.38 u	0.38 u	0.38 u	0.38 u	0.38 u	0.38 u	-	0.38 u	-	0.38 u	0.38 u	0.38 u
IA06-SS40	12-Apr-05	LO-IA06-SS40-1	0-1.5'	8270C	1	0.38 u	0.38 u	0.38 u	0.38 u	0.38 u	1.9 u	0.38 u	0.38 u	0.38 u	1.9 u	0.38 u	0.38 u	0.38 u	0.38 u	0.38 u	0.38 u	0.38 u	-	0.38 u	-	0.38 u	0.38 u	0.38 u
IA06-SS45	13-Apr-05	LO-IA06-SS25-1	0-1.5'	8270C	1	0.79 u	0.79 u	0.79 u	0.79 u	0.79 u	2 u	**0.79 u**	0.79 u	0.79 u	2 u	0.79 u	0.79 u	0.79 u	0.79 u	0.79 u	0.79 u	0.79 u	-	0.79 u	-	0.79 u	0.79 u	0.79 u
IA08-SB01	30-Nov-04	GR-IA08-SB01-1	0-3'	8270C	1	0.36 u	0.36 u	0.36 u	0.36 u	-	0.36 u	0.36 u	0.72 u	0.36 u	1.4 u	0.36 u	0.36 u	0.36 u	0.43 u	0.36 u	0.43 u	1.4 u	0.43 u	0.72 u	0.36 u	-	0.36 u	-
	30-Nov-04	GR-IA08-SB01-1	0-3'	8270C-SIM	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	30-Nov-04	GR-IA08-SB01-1	3-10'	8270C	1	0.35 u	0.35 u	0.35 u	0.35 u	-	0.35 u	0.35 u	0.7 u	0.35 u	1.4 u	0.35 u	0.35 u	0.35 u	0.42 u	0.35 u	0.42 u	1.4 u	0.42 u	0.7 u	0.35 u	-	0.35 u	-
	30-Nov-04	GR-IA08-SB01-1	3-10'	8270C-SIM	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	30-Nov-04	GR-IA08-SB01-1-D	3-10'	8270C	1	0.35 u	0.35 u	0.35 u	0.35 u	-	0.35 u	0.35 u	0.7 u	0.35 u	1.4 u	0.35 u	0.35 u	0.35 u	0.42 u	0.35 u	0.42 u	1.4 u	0.42 u	0.7 u	0.35 u	-	0.35 u	-
	30-Nov-04	GR-IA08-SB01-1-D	3-10'	8270C-SIM	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
IA08-SB09	16-Dec-04	GR-IA08-SB09-1	0-3'	8270C	1	0.36 u	0.36 u	0.36 u	0.36 u	-	0.36 u	0.36 u	0.72 u	0.36 u	1.4 u	0.36 u	0.36 u	0.36 u	0.43 u	0.36 u	0.43 u	1.4 u	0.43 u	0.72 u	0.36 u	-	0.36 u	-
	16-Dec-04	GR-IA08-SB09-1	0-3'	8270C-SIM	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	16-Dec-04	GR-IA08-SB09-1	3-10'	8270C	1	0.35 u	0.35 u	0.35 u	0.35 u	-	0.35 u	0.35 u	0.7 u	0.35 u	1.4 u	0.35 u	0.35 u	0.35 u	0.42 u	0.35 u	0.42 u	1.4 u	0.42 u	0.7 u	0.35 u	-	0.35 u	-
	16-Dec-04	GR-IA08-SB09-1	3-10'	8270C-SIM	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

Location

Notes:

NC No criteria listed under the regulation cited
ND Non-detect result (Original data unavailable - neither value nor detection limit provided)
- Parameter not analyzed

Analytic Flags:

u Not detected above laboratory reporting limits
j Estimated value - parameter detected between laboratory reporting limit and half of the laboratory reporting limit.
e Value exceeds analytical calibration limits
b Parameter detected in quality control blank and sample

Highlighting:

Value or Detection Limit exceeds Criteria 1 only
Value or Detection Limit exceeds Criteria 2 only
Value or Detection Limit exceeds both criteria

Supplemental Site Investigation

Analytic Method: 8270C and 8270C-SIM
Sample Matrix: Soil
Reporting Units: mg/kg
Sample Dates: 29-Nov-2004 to 13-Apr-2005

						1,2,4-Trichlorobenzene	1,2-Dichlorobenzene	1,3-Dichlorobenzene	1,4-Dichlorobenzene	2,2-Oxybis(1-Chloropropane)	2,4,5-Trichlorophenol	2,4,6-Trichlorophenol	2,4-Dichlorophenol	2,4-Dimethylphenol	2,4-Dinitrophenol	2,4-Dinitrotoluene	2,6-Dinitrotoluene	2-Chloronaphthalene	2-Chlorophenol	2-Methylnaphthalene	2-methylphenol	2-Nitrophenol	3 & 4-Methylphenol	3,3-Dichlorobenzidine	4-Bromophenyl phenyl ether	4-Bromophenyl-phenylether	4-Chloroaniline	4-Methylphenol
	SSI Project Action Limit (PAL) - Wave 2 (SVOCs)					65	300	1.6	3.4	NC	600	0.61	18	120	12	2	6.1	490	6.3	31	310	NC	310	1	NC	NC	3	31
	Secondary Regulatory Criteria Not Selected																											
	Date	Sample ID	Depth	Method	Dilution																							
IA09-SB01	29-Nov-04	CA-IA09-SB01-1	0-3'	8270C	1	0.37 u	0.37 u	0.37 u	0.37 u	-	0.37 u	0.37 u	0.73 u	0.37 u	1.5 u	0.37 u	0.37 u	0.37 u	0.44 u	0.37 u	0.44 u	1.5 u	0.44 u	0.73 u	0.37 u	-	0.37 u	-
	29-Nov-04	CA-IA09-SB01-1	0-3'	8270C-SIM	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	29-Nov-04	CA-IA09-SB01-1	3-10'	8270C	1	0.37 u	0.37 u	0.37 u	0.37 u	-	0.37 u	0.37 u	0.74 u	0.37 u	1.5 u	0.37 u	0.37 u	0.37 u	0.44 u	0.37 u	0.44 u	1.5 u	0.44 u	0.74 u	0.37 u	-	0.37 u	-
	29-Nov-04	CA-IA09-SB01-1	3-10'	8270C-SIM	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
IA10-SB01	13-Dec-04	GR-IA10-SB01-1	0-3'	8270C	1	0.38 u	0.38 u	0.38 u	0.38 u	-	0.38 u	0.38 u	0.76 u	0.38 u	1.5 u	0.38 u	0.38 u	0.38 u	0.45 u	0.38 u	0.45 u	1.5 u	0.45 u	0.76 u	0.38 u	-	0.38 u	-
	13-Dec-04	GR-IA10-SB01-1	0-3'	8270C-SIM	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	13-Dec-04	GR-IA10-SB01-1	3-10'	8270C	1	0.35 u	0.35 u	0.35 u	0.35 u	-	0.35 u	0.35 u	0.7 u	0.35 u	1.4 u	0.35 u	0.35 u	0.35 u	0.42 u	0.35 u	0.42 u	1.4 u	0.42 u	0.7 u	0.35 u	-	0.35 u	-
	13-Dec-04	GR-IA10-SB01-1	3-10'	8270C-SIM	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
IA10-SB02	10-Dec-04	GR-IA10-SB02-1	0-3'	8270C	5	1.8 u	1.8 u	**1.8 u**	1.8 u	-	1.8 u	**1.8 u**	3.6 u	1.8 u	7.2 u	1.8 u	1.8 u	1.8 u	2.2 u	1.8 u	2.2 u	7.2 u	-	**3.6 u**	1.8 u	-	1.8 u	-
	10-Dec-04	GR-IA10-SB02-1	0-3'	8270C-SIM	5	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	10-Dec-04	GR-IA10-SB02-1	3-10'	8270C	5	1.8 u	1.8 u	**1.8 u**	1.8 u	-	1.8 u	**1.8 u**	3.7 u	1.8 u	7.3 u	1.8 u	1.8 u	1.8 u	2.2 u	1.8 u	2.2 u	7.3 u	-	**3.7 u**	1.8 u	-	1.8 u	-
	10-Dec-04	GR-IA10-SB02-1	3-10'	8270C-SIM	5	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	10-Dec-04	GR-IA10-SB02-1-D	3-10'	8270C	5	1.8 u	1.8 u	**1.8 u**	1.8 u	-	1.8 u	**1.8 u**	3.7 u	1.8 u	7.4 u	1.8 u	1.8 u	1.8 u	2.2 u	1.8 u	2.2 u	7.4 u	-	**3.7 u**	1.8 u	-	1.8 u	-
	10-Dec-04	GR-IA10-SB02-1-D	3-10'	8270C-SIM	5	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
IA10-SB03	15-Dec-04	GR-IA10-SB03-1	0-3'	8270C	1	0.37 u	0.37 u	0.37 u	0.37 u	-	0.37 u	0.37 u	0.74 u	0.37 u	1.5 u	0.37 u	0.37 u	0.37 u	0.44 u	0.37 u	0.44 u	1.5 u	0.44 u	0.74 u	0.37 u	-	0.37 u	-
	15-Dec-04	GR-IA10-SB03-1	0-3'	8270C-SIM	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	15-Dec-04	GR-IA10-SB03-1	3-10'	8270C	1	0.37 u	0.37 u	0.37 u	0.37 u	-	0.37 u	0.37 u	0.73 u	0.37 u	1.5 u	0.37 u	0.37 u	0.37 u	0.44 u	0.37 u	0.44 u	1.5 u	0.44 u	0.73 u	0.37 u	-	0.37 u	-
	15-Dec-04	GR-IA10-SB03-1	3-10'	8270C-SIM	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
IA10-SB04	16-Dec-04	GR-IA10-SB04-1	0-3'	8270C	1	0.37 u	0.37 u	0.37 u	0.37 u	-	0.37 u	0.37 u	0.74 u	0.37 u	1.5 u	0.37 u	0.37 u	0.37 u	0.44 u	0.37 u	0.44 u	1.5 u	0.44 u	0.74 u	0.37 u	-	0.37 u	-
	16-Dec-04	GR-IA10-SB04-1	0-3'	8270C-SIM	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	16-Dec-04	GR-IA10-SB04-1	3-10'	8270C	1	0.35 u	0.35 u	0.35 u	0.35 u	-	0.35 u	0.35 u	0.7 u	0.35 u	1.4 u	0.35 u	0.35 u	0.35 u	0.42 u	0.35 u	0.42 u	1.4 u	0.42 u	0.7 u	0.35 u	-	0.35 u	-
	16-Dec-04	GR-IA10-SB04-1	3-10'	8270C-SIM	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
IA11-SB01	29-Nov-04	LO-IA11-SB01-1	0-3'	8270C	1	0.41 u	0.41 u	0.41 u	0.41 u	-	0.41 u	0.41 u	0.81 u	0.41 u	1.6 u	0.41 u	0.41 u	0.41 u	0.49 u	0.41	0.49 u	1.6 u	0.49 u	0.81 u	0.41 u	-	0.41 u	-
	29-Nov-04	LO-IA11-SB01-1	0-3'	8270C-SIM	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	29-Nov-04	LO-IA11-SB01-1	3-10'	8270C	1	0.35 u	0.35 u	0.35 u	0.35 u	-	0.35 u	0.35 u	0.71 u	0.35 u	1.4 u	0.35 u	0.35 u	0.35 u	0.42 u	0.35 u	0.42 u	1.4 u	0.42 u	0.71 u	0.35 u	-	0.35 u	-
	29-Nov-04	LO-IA11-SB01-1	3-10'	8270C-SIM	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
IA11-SB02	15-Dec-04	LO-IA11-SB02-1	0-3'	8270C	1	0.39 u	0.39 u	0.39 u	0.39 u	-	0.39 u	0.39 u	0.78 u	0.39 u	1.6 u	0.39 u	0.39 u	0.39 u	0.46 u	0.39 u	0.46 u	1.6 u	0.46 u	0.78 u	0.39 u	-	0.39 u	-
	15-Dec-04	LO-IA11-SB02-1	0-3'	8270C-SIM	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

Location

Notes:

NC No criteria listed under the regulation cited
ND Non-detect result (Original data unavailable - neither value nor detection limit provided)
- Parameter not analyzed

Analytic Flags:

u Not detected above laboratory reporting limits
j Estimated value - parameter detected between laboratory reporting limit and half of the laboratory reporting limit.
e Value exceeds analytical calibration limits
b Parameter detected in quality control blank and sample

Highlighting:

Value or Detection Limit exceeds Criteria 1 only
Value or Detection Limit exceeds Criteria 2 only
Value or Detection Limit exceeds both criteria

Supplemental Site Investigation

Analytic Method: 8270C and 8270C-SIM
Sample Matrix: Soil
Reporting Units: mg/kg
Sample Dates: 29-Nov-2004 to 13-Apr-2005

						4-Nitrophenol	Acenaphthene	Acenaphthylene	Acetophenone	Aniline (Phenylamine, aminobenzene)	Anthracene	Azobenzene	Benzo(a)anthracene	Benzo(a)pyrene	Benzo(b)fluoranthene	Benzo(g,h,i)perylene	Benzo(k)fluoranthene	Benzyl Butyl Phthalate	bis(2-chloroethoxy) methane	bis(2-chloroethyl) ether	Bis(2-chloroisopropyl)ether	bis(2-ethylhexyl) phthalate	Chrysene	Dibenz(a,h)Anthracene	Dibenzofuran	Diethyl Phthalate	Dimethyl Phthalate	di-n-Butyl Phthalate
SSI Project Action Limit (PAL) - Wave 2 (SVOCs)						NC	370	100	7800	11	1000	4.4	0.62	0.062	0.62	1000	6.2	1200	NC	0.58	2	35	7	0.062	29	300	600	610
Secondary Regulatory Criteria Not Selected																												
	Date	Sample ID	Depth	Method	Dilution																							
IA01-SB02	10-Dec-04	GR-IA01-SB02-1	0-3'	8270C	1	0.73 u	0.37 u	0.37 u	1.5 u	0.73 u	0.37 u	0.37 u	0.49	**0.66**	0.44	0.38	0.44	0.37 u	0.37 u	0.37 u	0.37 u	0.73 u	0.55	**0.37 u**	0.37 u	0.37 u	0.37 u	0.37 u
	10-Dec-04	GR-IA01-SB02-1	0-3'	8270C-SIM	1	-	-	-	-	-	-	-	-	**0.53**	-	-	-	-	-	-	-	-	-	**0.07**	-	-	-	-
	10-Dec-04	GR-IA01-SB02-1	3-10'	8270C	1	0.72 u	0.36 u	0.36 u	1.4 u	0.72 u	0.36 u	0.36 u	0.36 u	**0.36 u**	0.36 u	0.36 u	0.36 u	0.36 u	0.36 u	0.36 u	0.36 u	0.72 u	0.36 u	**0.36 u**	0.36 u	0.36 u	0.36 u	0.36 u
	10-Dec-04	GR-IA01-SB02-1	3-10'	8270C-SIM	1	-	-	-	-	-	-	-	-	**0.076**	-	-	-	-	-	-	-	-	-	0.014 u	-	-	-	-
IA02-SB01	30-Nov-04	GR-IA02-SB01-1	0-3'	8270C	1	0.78 u	0.39 u	0.39 u	1.6 u	0.78 u	0.39 u	0.39 u	0.39 u	**0.39 u**	0.39 u	0.39 u	0.39 u	0.39 u	0.39 u	0.39 u	0.39 u	0.78 u	0.39 u	**0.39 u**	0.39 u	0.39 u	0.39 u	0.39 u
	30-Nov-04	GR-IA02-SB01-1	0-3'	8270C-SIM	1	-	-	-	-	-	-	-	-	0.016 u	-	-	-	-	-	-	-	-	-	0.016 u	-	-	-	-
	30-Nov-04	GR-IA02-SB01-1	3-10'	8270C	1	0.72 u	0.36 u	0.36 u	1.4 u	0.72 u	0.36 u	0.36 u	0.36 u	**0.36 u**	0.36 u	0.36 u	0.36 u	0.36 u	0.36 u	0.36 u	0.36 u	0.72 u	0.36 u	**0.36 u**	0.36 u	0.36 u	0.36 u	0.36 u
	30-Nov-04	GR-IA02-SB01-1	3-10'	8270C-SIM	1	-	-	-	-	-	-	-	-	0.014 u	-	-	-	-	-	-	-	-	-	0.014 u	-	-	-	-
IA02-SB02	02-Dec-04	GR-IA02-SB02-1	0-3'	8270C	1	0.76 u	0.38 u	0.38 u	1.5 u	0.76 u	0.38 u	0.38 u	0.38 u	**0.38 u**	0.38 u	0.38 u	0.38 u	0.38 u	0.38 u	0.38 u	0.38 u	0.76 u	0.38 u	**0.38 u**	0.38 u	0.38 u	0.38 u	0.38 u
	02-Dec-04	GR-IA02-SB02-1	0-3'	8270C-SIM	1	-	-	-	-	-	-	-	-	0.015 u	-	-	-	-	-	-	-	-	-	0.015 u	-	-	-	-
	02-Dec-04	GR-IA02-SB02-1-M	3-10'	8270C	1	0.72 u	0.36 u	0.36 u	1.4 u	0.72 u	0.36 u	0.36 u	0.36 u	**0.36 u**	0.36 u	0.36 u	0.36 u	0.36 u	0.36 u	0.36 u	0.36 u	0.72 u	0.36 u	**0.36 u**	0.36 u	0.36 u	0.36 u	0.36 u
	02-Dec-04	GR-IA02-SB02-1-M	3-10'	8270C-SIM	1	-	-	-	-	-	-	-	-	0.014 u	-	-	-	-	-	-	-	-	-	0.014 u	-	-	-	-
IA02-SB13	13-Dec-04	GR-IA02-SB13-1	0-3'	8270C	1	0.73 u	0.37 u	0.37 u	1.5 u	0.73 u	0.37 u	0.37 u	0.37 u	**0.37 u**	0.37 u	0.37 u	0.37 u	0.37 u	0.37 u	0.37 u	0.37 u	0.73 u	0.37 u	**0.37 u**	0.37 u	0.37 u	0.37 u	0.37 u
	13-Dec-04	GR-IA02-SB13-1	0-3'	8270C-SIM	1	-	-	-	-	-	-	-	-	0.027	-	-	-	-	-	-	-	-	-	0.015 u	-	-	-	-
	13-Dec-04	GR-IA02-SB13-1	3-10'	8270C	1	0.7 u	0.35 u	0.35 u	1.4 u	0.7 u	0.35 u	0.35 u	0.35 u	**0.35 u**	0.35 u	0.35 u	0.35 u	0.35 u	0.35 u	0.35 u	0.35 u	0.7 u	0.35 u	**0.35 u**	0.35 u	0.35 u	0.35 u	0.35 u
	13-Dec-04	GR-IA02-SB13-1	3-10'	8270C-SIM	1	-	-	-	-	-	-	-	-	0.014 u	-	-	-	-	-	-	-	-	-	0.014 u	-	-	-	-
	13-Dec-04	GR-IA02-SB13-1-D	3-10'	8270C	1	0.7 u	0.35 u	0.35 u	1.4 u	0.7 u	0.35 u	0.35 u	0.35 u	**0.35 u**	0.35 u	0.35 u	0.35 u	0.35 u	0.35 u	0.35 u	0.35 u	0.7 u	0.35 u	**0.35 u**	0.35 u	0.35 u	0.35 u	0.35 u
	13-Dec-04	GR-IA02-SB13-1-D	3-10'	8270C-SIM	1	-	-	-	-	-	-	-	-	0.014 u	-	-	-	-	-	-	-	-	-	0.014 u	-	-	-	-
IA02-SB20	08-Dec-04	GR-IA02-SB20-1	0-3'	8270C	1	0.76 u	0.38 u	0.38 u	1.5 u	0.76 u	0.38 u	0.38 u	0.38 u	**0.38 u**	0.38 u	0.38 u	0.38 u	0.38 u	0.38 u	0.38 u	0.38 u	0.76 u	0.38 u	**0.38 u**	0.38 u	0.38 u	0.38 u	0.38 u
	08-Dec-04	GR-IA02-SB20-1	0-3'	8270C-SIM	1	-	-	-	-	-	-	-	-	0.015 u	-	-	-	-	-	-	-	-	-	0.015 u	-	-	-	-
	08-Dec-04	GR-IA02-SB20-1-M	3-10'	8270C	1	0.72 u	0.36 u	0.36 u	1.4 u	0.72 u	0.36 u	0.36 u	0.36 u	**0.36 u**	0.36 u	0.36 u	0.36 u	0.36 u	0.36 u	0.36 u	0.36 u	0.72 u	0.36 u	**0.36 u**	0.36 u	0.36 u	0.36 u	0.36 u
	08-Dec-04	GR-IA02-SB20-1-M	3-10'	8270C-SIM	1	-	-	-	-	-	-	-	-	0.014 u	-	-	-	-	-	-	-	-	-	0.014 u	-	-	-	-
IA02-SB23	13-Dec-04	GR-IA02-SB23-1	0-3'	8270C	1	0.75 u	0.37 u	0.37 u	1.5 u	0.75 u	0.37 u	0.37 u	0.37 u	**0.37 u**	0.37 u	0.37 u	0.37 u	0.37 u	0.37 u	0.37 u	0.37 u	0.75 u	0.37 u	**0.37 u**	0.37 u	0.37 u	0.37 u	0.37 u
	13-Dec-04	GR-IA02-SB23-1	0-3'	8270C-SIM	1	-	-	-	-	-	-	-	-	**0.081**	-	-	-	-	-	-	-	-	-	0.015 u	-	-	-	-
	13-Dec-04	GR-IA02-SB23-1	3-10'	8270C	1	0.8 u	0.4 u	0.4 u	1.6 u	0.8 u	0.4 u	0.4 u	0.4 u	**0.4 u**	0.4 u	0.4 u	0.4 u	0.4 u	0.4 u	0.4 u	0.4 u	0.8 u	0.4 u	**0.4 u**	0.4 u	0.4 u	0.4 u	0.4 u
	13-Dec-04	GR-IA02-SB23-1	3-10'	8270C-SIM	1	-	-	-	-	-	-	-	-	0.017	-	-	-	-	-	-	-	-	-	0.016 u	-	-	-	-
	13-Dec-04	GR-IA02-SB23-1-D	3-10'	8270C	1	0.79 u	0.4 u	0.4 u	1.6 u	0.79 u	0.4 u	0.4 u	0.4 u	**0.4 u**	0.4 u	0.4 u	0.4 u	0.4 u	0.4 u	0.4 u	0.4 u	0.79 u	0.4 u	**0.4 u**	0.4 u	0.4 u	0.4 u	0.4 u
	13-Dec-04	GR-IA02-SB23-1-D	3-10'	8270C-SIM	1	-	-	-	-	-	-	-	-	0.027	-	-	-	-	-	-	-	-	-	0.016 u	-	-	-	-
IA02-SB30	15-Dec-04	GR-IA02-SB30-1	0-3'	8270C	1	0.75 u	0.37 u	0.37 u	1.5 u	0.75 u	0.37 u	0.37 u	0.37 u	**0.37 u**	0.37 u	0.37 u	0.37 u	0.37 u	0.37 u	0.37 u	0.37 u	0.75 u	0.37 u	**0.37 u**	0.37 u	0.37 u	0.37 u	0.37 u
	15-Dec-04	GR-IA02-SB30-1	0-3'	8270C-SIM	1	-	-	-	-	-	-	-	-	0.015 u	-	-	-	-	-	-	-	-	-	0.015 u	-	-	-	-
	15-Dec-04	GR-IA02-SB30-1-M	3-10'	8270C	1	0.7 u	0.35 u	0.35 u	1.4 u	0.7 u	0.35 u	0.35 u	0.35 u	**0.35 u**	0.35 u	0.35 u	0.35 u	0.35 u	0.35 u	0.35 u	0.35 u	0.7 u	0.35 u	**0.35 u**	0.35 u	0.35 u	0.35 u	0.35 u
	15-Dec-04	GR-IA02-SB30-1-M	3-10'	8270C-SIM	1	-	-	-	-	-	-	-	-	0.014 u	-	-	-	-	-	-	-	-	-	0.014 u	-	-	-	-
IA03-SB02	13-Dec-04	GR-IA03-SB02-1	0-3'	8270C	1	0.74 u	0.37 u	0.37 u	1.5 u	0.74 u	0.37 u	0.37 u	0.37 u	**0.37 u**	0.37 u	0.37 u	0.37 u	0.37 u	0.37 u	0.37 u	0.37 u	0.74 u	0.37 u	**0.37 u**	0.37 u	0.37 u	0.37 u	0.37 u
	13-Dec-04	GR-IA03-SB02-1	0-3'	8270C-SIM	1	-	-	-	-	-	-	-	-	0.039	-	-	-	-	-	-	-	-	-	0.015 u	-	-	-	-
	13-Dec-04	GR-IA03-SB02-1	3-10'	8270C	1	0.7 u	0.35 u	0.35 u	1.4 u	0.7 u	0.35 u	0.35 u	0.35 u	**0.35 u**	0.35 u	0.35 u	0.35 u	0.35 u	0.35 u	0.35 u	0.35 u	0.7 u	0.35 u	**0.35 u**	0.35 u	0.35 u	0.35 u	0.35 u
	13-Dec-04	GR-IA03-SB02-1	3-10'	8270C-SIM	1	-	-	-	-	-	-	-	-	0.014 u	-	-	-	-	-	-	-	-	-	0.014 u	-	-	-	-

Location

Notes:

NC No criteria listed under the regulation cited
ND Non-detect result (Original data unavailable - neither value nor detection limit provided)
- Parameter not analyzed

Analytic Flags:

u Not detected above laboratory reporting limits
j Estimated value - parameter detected between laboratory reporting limit and half of the laboratory reporting limit.
e Value exceeds analytical calibration limits
b Parameter detected in quality control blank and sample

Highlighting:

Value or Detection Limit exceeds Criteria 1 only
Value or Detection Limit exceeds Criteria 2 only
Value or Detection Limit exceeds both criteria

Supplemental Site Investigation

Analytic Method: 8270C and 8270C-SIM
Sample Matrix: Soil
Reporting Units: mg/kg
Sample Dates: 29-Nov-2004 to 13-Apr-2005

						4-Nitrophenol	Acenaphthene	Acenaphthylene	Acetophenone	Aniline (Phenylamine, aminobenzene)	Anthracene	Azobenzene	Benzo(a)anthracene	Benzo(a)pyrene	Benzo(b)fluoranthene	Benzo(g,h,i)perylene	Benzo(k)fluoranthene	Benzyl Butyl Phthalate	bis(2-chloroethoxy) methane	bis(2-chloroethyl) ether	Bis(2-chloroisopropyl)ether	bis(2-ethylhexyl) phthalate	Chrysene	Dibenz(a,h)Anthracene	Dibenzofuran	Diethyl Phthalate	Dimethyl Phthalate	di-n-Butyl Phthalate
SSI Project Action Limit (PAL) - Wave 2 (SVOCs)						NC	370	100	7800	11	1000	4.4	0.62	0.062	0.62	1000	6.2	1200	NC	0.58	2	35	7	0.062	29	300	600	610
Secondary Regulatory Criteria Not Selected																												
	Date	Sample ID	Depth	Method	Dilution																							
IA03-SB04	15-Dec-04	GR-IA03-SB04-1	0-3'	8270C	1	0.73 u	0.37 u	0.37 u	1.5 u	0.73 u	0.37 u	0.37 u	0.38	**0.62**	0.45	0.36 j	0.44	0.37 u	0.37 u	0.37 u	0.37 u	0.73 u	0.55	**0.37 u**	0.37 u	0.37 u	0.37 u	0.37 u
	15-Dec-04	GR-IA03-SB04-1	0-3'	8270C-SIM	1	-	-	-	-	-	-	-	-	**0.55**	-	-	-	-	-	-	-	-	-	**0.082**	-	-	-	-
	15-Dec-04	GR-IA03-SB04-1	3-10'	8270C	1	0.72 u	0.36 u	0.36 u	1.4 u	0.72 u	0.36 u	0.36 u	0.36 u	**0.36 u**	0.36 u	0.36 u	0.36 u	0.36 u	0.36 u	0.36 u	0.36 u	0.72 u	0.36 u	**0.36 u**	0.36 u	0.36 u	0.36 u	0.36 u
	15-Dec-04	GR-IA03-SB04-1	3-10'	8270C-SIM	1	-	-	-	-	-	-	-	-	0.024	-	-	-	-	-	-	-	-	-	0.014 u	-	-	-	-
IA05-SB07	10-Dec-04	GR-IA05-SB07-1	0-3'	8270C	1	0.78 u	0.39 u	0.39 u	1.6 u	0.78 u	0.39 u	0.39 u	0.39 u	**0.39 u**	0.39 u	0.39 u	0.39 u	0.39 u	0.39 u	0.39 u	0.39 u	0.78 u	0.39 u	**0.39 u**	0.39 u	0.39 u	0.39 u	0.39 u
	10-Dec-04	GR-IA05-SB07-1	0-3'	8270C-SIM	1	-	-	-	-	-	-	-	-	0.017	-	-	-	-	-	-	-	-	-	0.016 u	-	-	-	-
	10-Dec-04	GR-IA05-SB07-1	3-10'	8270C	1	0.72 u	0.36 u	0.36 u	1.4 u	0.72 u	0.36 u	0.36 u	0.36 u	**0.36 u**	0.36 u	0.36 u	0.36 u	0.36 u	0.36 u	0.36 u	0.36 u	0.72 u	0.36 u	**0.36 u**	0.36 u	0.36 u	0.36 u	0.36 u
	10-Dec-04	GR-IA05-SB07-1	3-10'	8270C-SIM	1	-	-	-	-	-	-	-	-	0.014 u	-	-	-	-	-	-	-	-	-	0.014 u	-	-	-	-
IA06-SB03	11-Apr-05	LO-IA06-SB03-1	3-10'	8270C	1	1.9 u	0.38 u	0.38 u	0.38 u	1.9 u	0.38 u	0.38 u	0.38 u	**0.38 u**	0.38 u	0.38 u	0.38 u	0.38 u	0.38 u	0.38 u	-	0.38 u	0.38 u	**0.38 u**	0.38 u	0.38 u	0.38 u	0.38 u
	11-Apr-05	LO-IA06-SB03-1	0-3'	8270C	1	1.8 u	0.35 u	0.35 u	0.35 u	1.8 u	0.35 u	0.35 u	0.35 u	**0.35 u**	0.35 u	0.35 u	0.35 u	0.35 u	0.35 u	0.35 u	-	0.35 u	0.35 u	**0.35 u**	0.35 u	0.35 u	0.35 u	0.35 u
IA06-SB04	11-Apr-05	LO-IA06-SB04-1	3-10'	8270C	1	2.2 u	0.44 u	0.44 u	0.44 u	2.2 u	0.44 u	0.44 u	0.44 u	**0.44 u**	0.44 u	0.44 u	0.44 u	0.44 u	0.44 u	0.44 u	-	0.44 u	0.44 u	**0.44 u**	0.44 u	0.44 u	0.44 u	0.44 u
	11-Apr-05	LO-IA06-SB04-1	0-3'	8270C	1	1.8 u	0.37 u	0.37 u	0.37 u	1.8 u	0.37 u	0.37 u	0.37 u	**0.37 u**	0.37 u	0.37 u	0.37 u	0.37 u	0.37 u	0.37 u	-	0.37 u	0.37 u	**0.37 u**	0.37 u	0.37 u	0.37 u	0.37 u
IA06-SB05	11-Apr-05	LO-IA06-SB05-1	3-10'	8270C	1	1.9 u	0.38 u	0.38 u	0.38 u	1.9 u	0.38 u	0.38 u	0.38 u	**0.38 u**	0.38 u	0.38 u	0.38 u	0.38 u	0.38 u	0.38 u	-	0.38 u	0.38 u	**0.38 u**	0.38 u	0.38 u	0.38 u	0.38 u
	11-Apr-05	LO-IA06-SB05-1	0-3'	8270C	1	1.9 u	0.37 u	0.37 u	0.37 u	1.9 u	0.37 u	0.37 u	0.37 u	**0.37 u**	0.37 u	0.37 u	0.37 u	0.37 u	0.37 u	0.37 u	-	0.37 u	0.37 u	**0.37 u**	0.37 u	0.37 u	0.37 u	0.37 u
IA06-SB06	11-Apr-05	LO-IA06-SB06-1	3-10'	8270C	1	1.9 u	0.38 u	0.38 u	0.38 u	1.9 u	0.38 u	0.38 u	0.38 u	**0.38 u**	0.38 u	0.38 u	0.38 u	0.38 u	0.38 u	0.38 u	-	0.38 u	0.38 u	**0.38 u**	0.38 u	0.38 u	0.38 u	0.38 u
	11-Apr-05	LO-IA06-SB06-1	0-3'	8270C	1	2 u	0.39 u	0.39 u	0.39 u	2 u	0.39 u	0.39 u	0.39 u	**0.39 u**	0.39 u	0.39 u	0.39 u	0.39 u	0.39 u	0.39 u	-	0.39 u	0.39 u	**0.39 u**	0.39 u	0.39 u	0.39 u	0.39 u
IA06-SD06	13-Apr-05	LO-IA06-SD06-1	0-1.5'	8270C	1	2.7 u	1.1 u	0.11 j	0.32 j	2.7 u	0.064 j	1.1 u	**0.62 j**	**0.5 j**	**0.88 j**	0.18 j	0.63 j	1.1 u	1.1 u	**1.1 u**	-	0.049 j	0.73 j	**0.066 j**	1.1 u	1.1 u	1.1 u	1.1 u
IA06-SD17	13-Apr-05	LO-IA06-SD17-1	0-1.5'	8270C	1	2.5 u	1 u	1 u	0.11 j	2.5 u	1 u	1 u	0.12 j	**0.16 j**	0.27 j	0.08 j	0.18 j	1 u	1 u	**1 u**	-	1 u	0.2 j	**1 u**	1 u	1 u	1 u	1 u
IA06-SS08	11-Apr-05	LO-IA06-SS08-1	0-1.5'	8270C	1	1.8 u	0.36 u	0.36 u	0.36 u	1.8 u	0.36 u	0.36 u	0.36 u	**0.36 u**	0.36 u	0.36 u	0.36 u	0.36 u	0.36 u	0.36 u	-	0.36 u	0.36 u	**0.36 u**	0.36 u	0.36 u	0.36 u	0.36 u
IA06-SS16	11-Apr-05	LO-IA06-SS16-1	0-1.5'	8270C	1	1.8 u	0.35 u	0.35 u	0.35 u	1.8 u	0.35 u	0.35 u	0.35 u	**0.35 u**	0.35 u	0.35 u	0.35 u	0.35 u	0.35 u	0.35 u	-	0.35 u	0.35 u	**0.35 u**	0.35 u	0.35 u	0.35 u	0.35 u
	11-Apr-05	LO-IA06-SS16-1-D	0-1.5'	8270C	1	1.7 u	0.33 u	0.33 u	0.33 u	1.7 u	0.33 u	0.33 u	0.33 u	**0.33 u**	0.33 u	0.33 u	0.33 u	0.33 u	0.33 u	0.33 u	-	0.33 u	0.33 u	**0.33 u**	0.33 u	0.33 u	0.33 u	0.33 u
IA06-SS35	12-Apr-05	LO-IA06-SS35-1	0-1.5'	8270C	1	1.9 u	0.38 u	0.38 u	0.38 u	1.9 u	0.38 u	0.38 u	0.38 u	**0.38 u**	0.38 u	0.38 u	0.38 u	0.38 u	0.38 u	0.38 u	-	0.38 u	0.38 u	**0.38 u**	0.38 u	0.38 u	0.38 u	0.38 u
IA06-SS40	12-Apr-05	LO-IA06-SS40-1	0-1.5'	8270C	1	1.9 u	0.38 u	0.38 u	0.38 u	1.9 u	0.38 u	0.38 u	0.38 u	**0.38 u**	0.38 u	0.38 u	0.38 u	0.38 u	0.38 u	0.38 u	-	0.38 u	0.38 u	**0.38 u**	0.38 u	0.38 u	0.38 u	0.38 u
IA06-SS45	13-Apr-05	LO-IA06-SS25-1	0-1.5'	8270C	1	2 u	0.79 u	0.79 u	0.068 j	2 u	0.79 u	0.79 u	**0.79 u**	**0.79 u**	**0.79 u**	0.79 u	0.79 u	0.79 u	0.79 u	**0.79 u**	-	0.79 u	0.79 u	**0.79 u**	0.79 u	0.79 u	0.79 u	0.79 u
IA08-SB01	30-Nov-04	GR-IA08-SB01-1	0-3'	8270C	1	0.72 u	0.36 u	0.36 u	1.4 u	0.72 u	0.4	0.36 u	**1.1**	**1.1**	**0.88**	0.68	0.84	0.36 u	0.36 u	0.36 u	0.36 u	0.72 u	1	**0.47**	0.36 u	0.36 u	0.36 u	0.36 u
	30-Nov-04	GR-IA08-SB01-1	0-3'	8270C-SIM	1	-	-	-	-	-	-	-	-	**0.98**	-	-	-	-	-	-	-	-	-	**0.2**	-	-	-	-
	30-Nov-04	GR-IA08-SB01-1	3-10'	8270C	1	0.7 u	0.35 u	0.35 u	1.4 u	0.7 u	0.35 u	0.35 u	0.35 u	**0.35 u**	0.35 u	0.35 u	0.35 u	0.35 u	0.35 u	0.35 u	0.35 u	0.7 u	0.35 u	**0.35 u**	0.35 u	0.35 u	0.35 u	0.35 u
	30-Nov-04	GR-IA08-SB01-1	3-10'	8270C-SIM	1	-	-	-	-	-	-	-	-	**0.13**	-	-	-	-	-	-	-	-	-	0.026	-	-	-	-
	30-Nov-04	GR-IA08-SB01-1-D	3-10'	8270C	1	0.7 u	0.35 u	0.35 u	1.4 u	0.7 u	0.35 u	0.35 u	0.35 u	**0.35 u**	0.35 u	0.35 u	0.35 u	0.35 u	0.35 u	0.35 u	0.35 u	0.7 u	0.35 u	**0.35 u**	0.35 u	0.35 u	0.35 u	0.35 u
	30-Nov-04	GR-IA08-SB01-1-D	3-10'	8270C-SIM	1	-	-	-	-	-	-	-	-	**0.094**	-	-	-	-	-	-	-	-	-	0.019	-	-	-	-
IA08-SB09	16-Dec-04	GR-IA08-SB09-1	0-3'	8270C	1	0.72 u	0.36 u	0.36 u	1.4 u	0.72 u	0.36 u	0.36 u	0.36 u	**0.36 u**	0.36 u	0.36 u	0.36 u	0.36 u	0.36 u	0.36 u	0.36 u	0.72 u	0.36 u	**0.36 u**	0.36 u	0.36 u	0.36 u	0.36 u
	16-Dec-04	GR-IA08-SB09-1	0-3'	8270C-SIM	1	-	-	-	-	-	-	-	-	**0.1**	-	-	-	-	-	-	-	-	-	0.014 u	-	-	-	-
	16-Dec-04	GR-IA08-SB09-1	3-10'	8270C	1	0.7 u	0.35 u	0.35 u	1.4 u	0.7 u	0.35 u	0.35 u	0.35 u	**0.35 u**	0.35 u	0.35 u	0.35 u	0.35 u	0.35 u	0.35 u	0.35 u	0.7 u	0.35 u	**0.35 u**	0.35 u	0.35 u	0.35 u	0.35 u
	16-Dec-04	GR-IA08-SB09-1	3-10'	8270C-SIM	1	-	-	-	-	-	-	-	-	**0.14**	-	-	-	-	-	-	-	-	-	0.017	-	-	-	-

Location

Notes:

NC No criteria listed under the regulation cited
ND Non-detect result (Original data unavailable - neither value nor detection limit provided)
- Parameter not analyzed

Analytic Flags:

u Not detected above laboratory reporting limits
j Estimated value - parameter detected between laboratory reporting limit and half of the laboratory reporting limit.
e Value exceeds analytical calibration limits
b Parameter detected in quality control blank and sample

Highlighting:

Value or Detection Limit exceeds Criteria 1 only
Value or Detection Limit exceeds Criteria 2 only
Value or Detection Limit exceeds both criteria

Supplemental Site Investigation

Analytic Method: 8270C and 8270C-SIM
Sample Matrix: Soil
Reporting Units: mg/kg
Sample Dates: 29-Nov-2004 to 13-Apr-2005

						4-Nitrophenol	Acenaphthene	Acenaphthylene	Acetophenone	Aniline (Phenylamine, aminobenzene)	Anthracene	Azobenzene	Benzo(a)anthracene	Benzo(a)pyrene	Benzo(b)fluoranthene	Benzo(g,h,i)perylene	Benzo(k)fluoranthene	Benzyl Butyl Phthalate	bis(2-chloroethoxy) methane	bis(2-chloroethyl) ether	Bis(2-chloroisopropyl)ether	bis(2-ethylhexyl) phthalate	Chrysene	Dibenz(a,h)Anthracene	Dibenzofuran	Diethyl Phthalate	Dimethyl Phthalate	di-n-Butyl Phthalate
	SSI Project Action Limit (PAL) - Wave 2 (SVOCs)					NC	370	100	7800	11	1000	4.4	0.62	0.062	0.62	1000	6.2	1200	NC	0.58	2	35	7	0.062	29	300	600	610
	Secondary Regulatory Criteria Not Selected																											
	Date	Sample ID	Depth	Method	Dilution																							
IA09-SB01	29-Nov-04	CA-IA09-SB01-1	0-3'	8270C	1	0.73 u	0.37 u	0.37 u	1.5 u	0.73 u	0.37 u	0.37 u	0.37 u	**0.37 u**	0.37 u	0.37 u	0.37 u	0.37 u	0.37 u	0.37 u	0.37 u	0.73 u	0.37 u	**0.37 u**	0.37 u	0.37 u	0.37 u	0.37 u
	29-Nov-04	CA-IA09-SB01-1	0-3'	8270C-SIM	1	-	-	-	-	-	-	-	-	0.052	-	-	-	-	-	-	-	-	-	0.015 u	-	-	-	-
	29-Nov-04	CA-IA09-SB01-1	3-10'	8270C	1	0.74 u	0.37 u	0.37 u	1.5 u	0.74 u	0.37 u	0.37 u	0.37 u	**0.37 u**	0.37 u	0.37 u	0.37 u	0.37 u	0.37 u	0.37 u	0.37 u	0.74 u	0.37 u	**0.37 u**	0.37 u	0.37 u	0.37 u	0.37 u
	29-Nov-04	CA-IA09-SB01-1	3-10'	8270C-SIM	1	-	-	-	-	-	-	-	-	0.05	-	-	-	-	-	-	-	-	-	0.015 u	-	-	-	-
IA10-SB01	13-Dec-04	GR-IA10-SB01-1	0-3'	8270C	1	0.76 u	0.38 u	0.38 u	1.5 u	0.76 u	0.38 u	0.38 u	0.38 u	**0.38 u**	0.38 u	0.38 u	0.38 u	0.38 u	0.38 u	0.38 u	0.38 u	0.76 u	0.38 u	**0.38 u**	0.38 u	0.38 u	0.38 u	0.38 u
	13-Dec-04	GR-IA10-SB01-1	0-3'	8270C-SIM	1	-	-	-	-	-	-	-	-	0.015 u	-	-	-	-	-	-	-	-	-	0.015 u	-	-	-	-
	13-Dec-04	GR-IA10-SB01-1	3-10'	8270C	1	0.7 u	0.35 u	0.35 u	1.4 u	0.7 u	0.35 u	0.35 u	0.35 u	**0.35 u**	0.35 u	0.35 u	0.35 u	0.35 u	0.35 u	0.35 u	0.35 u	0.7 u	0.35 u	**0.35 u**	0.35 u	0.35 u	0.35 u	0.35 u
	13-Dec-04	GR-IA10-SB01-1	3-10'	8270C-SIM	1	-	-	-	-	-	-	-	-	0.014 u	-	-	-	-	-	-	-	-	-	0.014 u	-	-	-	-
IA10-SB02	10-Dec-04	GR-IA10-SB02-1	0-3'	8270C	5	3.6 u	1.8 u	1.8 u	7.2 u	3.6 u	3.2	1.8 u	**6.1**	**5.5**	**3.8**	2.8	3.9	1.8 u	1.8 u	**1.8 u**	1.8 u	3.6 u	5.5	**2.3**	1.8 u	1.8 u	1.8 u	1.8 u
	10-Dec-04	GR-IA10-SB02-1	0-3'	8270C-SIM	5	-	-	-	-	-	-	-	-	**4.8**	-	-	-	-	-	-	-	-	-	**0.64**	-	-	-	-
	10-Dec-04	GR-IA10-SB02-1	3-10'	8270C	5	3.7 u	1.8 u	1.8 u	7.3 u	3.7 u	1.8 u	1.8 u	**1.8 u**	**2.1**	**1.8 u**	1.8 u	1.8 u	1.8 u	1.8 u	**1.8 u**	1.8 u	3.7 u	1.8 u	**1.8 u**	1.8 u	1.8 u	1.8 u	1.8 u
	10-Dec-04	GR-IA10-SB02-1	3-10'	8270C-SIM	5	-	-	-	-	-	-	-	-	**1.2**	-	-	-	-	-	-	-	-	-	**0.14**	-	-	-	-
	10-Dec-04	GR-IA10-SB02-1-D	3-10'	8270C	5	3.7 u	1.8 u	1.8 u	7.4 u	3.7 u	1.8 u	1.8 u	**1.8 u**	**1.8 u**	**1.8 u**	1.8 u	1.8 u	1.8 u	1.8 u	**1.8 u**	1.8 u	3.7 u	1.8 u	**1.8 u**	1.8 u	1.8 u	1.8 u	1.8 u
	10-Dec-04	GR-IA10-SB02-1-D	3-10'	8270C-SIM	5	-	-	-	-	-	-	-	-	**1.3**	-	-	-	-	-	-	-	-	-	**0.15**	-	-	-	-
IA10-SB03	15-Dec-04	GR-IA10-SB03-1	0-3'	8270C	1	0.74 u	0.37 u	0.37 u	1.5 u	0.74 u	0.37 u	0.37 u	0.37 u	**0.37 u**	0.37 u	0.37 u	0.37 u	0.37 u	0.37 u	0.37 u	0.37 u	0.74 u	0.37 u	**0.37 u**	0.37 u	0.37 u	0.37 u	0.37 u
	15-Dec-04	GR-IA10-SB03-1	0-3'	8270C-SIM	1	-	-	-	-	-	-	-	-	0.015 u	-	-	-	-	-	-	-	-	-	0.015 u	-	-	-	-
	15-Dec-04	GR-IA10-SB03-1	3-10'	8270C	1	0.73 u	0.37 u	0.37 u	1.5 u	0.73 u	0.37 u	0.37 u	0.37 u	**0.37 u**	0.37 u	0.37 u	0.37 u	0.37 u	0.37 u	0.37 u	0.37 u	0.73 u	0.37 u	**0.37 u**	0.37 u	0.37 u	0.37 u	0.37 u
	15-Dec-04	GR-IA10-SB03-1	3-10'	8270C-SIM	1	-	-	-	-	-	-	-	-	0.015 u	-	-	-	-	-	-	-	-	-	0.015 u	-	-	-	-
IA10-SB04	16-Dec-04	GR-IA10-SB04-1	0-3'	8270C	1	0.74 u	0.37 u	0.37 u	1.5 u	0.74 u	0.37 u	0.37 u	0.37 u	**0.37 u**	0.37 u	0.37 u	0.37 u	0.37 u	0.37 u	0.37 u	0.37 u	0.74 u	0.37 u	**0.37 u**	0.37 u	0.37 u	0.37 u	0.37 u
	16-Dec-04	GR-IA10-SB04-1	0-3'	8270C-SIM	1	-	-	-	-	-	-	-	-	0.024	-	-	-	-	-	-	-	-	-	0.015 u	-	-	-	-
	16-Dec-04	GR-IA10-SB04-1	3-10'	8270C	1	0.7 u	0.35 u	0.35 u	1.4 u	0.7 u	0.35 u	0.35 u	0.35 u	**0.35 u**	0.35 u	0.35 u	0.35 u	0.35 u	0.35 u	0.35 u	0.35 u	0.7 u	0.35 u	**0.35 u**	0.35 u	0.35 u	0.35 u	0.35 u
	16-Dec-04	GR-IA10-SB04-1	3-10'	8270C-SIM	1	-	-	-	-	-	-	-	-	0.014 u	-	-	-	-	-	-	-	-	-	0.014 u	-	-	-	-
IA11-SB01	29-Nov-04	LO-IA11-SB01-1	0-3'	8270C	1	0.81 u	1.2	0.5	1.6 u	0.81 u	1.9	0.41 u	**2**	**1.8**	**1.2**	1	1.4	0.41 u	0.41 u	0.41 u	0.41 u	0.81 u	1.7	**0.56**	1	0.41 u	0.41 u	0.41 u
	29-Nov-04	LO-IA11-SB01-1	0-3'	8270C-SIM	1	-	-	-	-	-	-	-	-	**1.5**	-	-	-	-	-	-	-	-	-	**0.3**	-	-	-	-
	29-Nov-04	LO-IA11-SB01-1	3-10'	8270C	1	0.71 u	0.35 u	0.35 u	1.4 u	0.71 u	0.35 u	0.35 u	0.35 u	**0.35 u**	0.35 u	0.35 u	0.35 u	0.35 u	0.35 u	0.35 u	0.35 u	0.71 u	0.35 u	**0.35 u**	0.35 u	0.35 u	0.35 u	0.35 u
	29-Nov-04	LO-IA11-SB01-1	3-10'	8270C-SIM	1	-	-	-	-	-	-	-	-	0.014 u	-	-	-	-	-	-	-	-	-	0.014 u	-	-	-	-
IA11-SB02	15-Dec-04	LO-IA11-SB02-1	0-3'	8270C	1	0.78 u	0.39 u	0.39 u	1.6 u	0.78 u	0.39 u	0.39 u	0.39 u	**0.39 u**	0.39 u	0.39 u	0.39 u	0.39 u	0.39 u	0.39 u	0.39 u	0.78 u	0.39 u	**0.39 u**	0.39 u	0.39 u	0.39 u	0.39 u
	15-Dec-04	LO-IA11-SB02-1	0-3'	8270C-SIM	1	-	-	-	-	-	-	-	-	0.019	-	-	-	-	-	-	-	-	-	0.016 u	-	-	-	-

Location

Notes:

NC No criteria listed under the regulation cited
ND Non-detect result (Original data unavailable - neither value nor detection limit provided)
- Parameter not analyzed

Analytic Flags:

u Not detected above laboratory reporting limits
j Estimated value - parameter detected between laboratory reporting limit and half of the laboratory reporting limit.
e Value exceeds analytical calibration limits
b Parameter detected in quality control blank and sample

Highlighting:

Value or Detection Limit exceeds Criteria 1 only
Value or Detection Limit exceeds Criteria 2 only
Value or Detection Limit exceeds both criteria

Supplemental Site Investigation

Analytic Method: 8270C and 8270C-SIM
Sample Matrix: Soil
Reporting Units: mg/kg
Sample Dates: 29-Nov-2004 to 13-Apr-2005

						di-n-Octyl Phthalate	Fluoranthene	Fluorene	Hexachlorobenzene	Hexachlorobutadiene	Hexachloroethane	Indeno(1,2,3-c,d)Pyrene	Isophorone	m-Cresol	Naphthalene	Nitrobenzene	Pentachlorophenol	Phenanthrene	Phenol	Pyrene
SSI Project Action Limit (PAL) - Wave 2 (SVOCs)						240	230	270	0.4	6	9	0.62	510	NC	5.6	2	3	100	20	230
Secondary Regulatory Criteria Not Selected																				
	Date	Sample ID	Depth	Method	Dilution															
IA01-SB02	10-Dec-04	GR-IA01-SB02-1	0-3'	8270C	1	0.37 u	1.2	0.37 u	0.37 u	0.73 u	0.37 u	0.58	0.37 u	0.44 u	0.37 u	0.37 u	1.5 u	0.5	0.51 u	0.91
	10-Dec-04	GR-IA01-SB02-1	0-3'	8270C-SIM	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	10-Dec-04	GR-IA01-SB02-1	3-10'	8270C	1	0.36 u	0.36 u	0.36 u	0.36 u	0.72 u	0.36 u	0.36 u	0.36 u	0.43 u	0.36 u	0.36 u	1.4 u	0.36 u	0.51 u	0.36 u
	10-Dec-04	GR-IA01-SB02-1	3-10'	8270C-SIM	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
IA02-SB01	30-Nov-04	GR-IA02-SB01-1	0-3'	8270C	1	0.39 u	0.39 u	0.39 u	0.39 u	0.78 u	0.39 u	0.39 u	0.39 u	-	0.39 u	0.39 u	1.6 u	0.39 u	0.54 u	0.39 u
	30-Nov-04	GR-IA02-SB01-1	0-3'	8270C-SIM	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	30-Nov-04	GR-IA02-SB01-1	3-10'	8270C	1	0.36 u	0.36 u	0.36 u	0.36 u	0.72 u	0.36 u	0.36 u	0.36 u	-	0.36 u	0.36 u	1.4 u	0.36 u	0.5 u	0.36 u
	30-Nov-04	GR-IA02-SB01-1	3-10'	8270C-SIM	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
IA02-SB02	02-Dec-04	GR-IA02-SB02-1	0-3'	8270C	1	0.38 u	0.38 u	0.38 u	0.38 u	0.76 u	0.38 u	0.38 u	0.38 u	-	0.38 u	0.38 u	1.5 u	0.38 u	0.53 u	0.38 u
	02-Dec-04	GR-IA02-SB02-1	0-3'	8270C-SIM	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	02-Dec-04	GR-IA02-SB02-1-M	3-10'	8270C	1	0.36 u	0.36 u	0.36 u	0.36 u	0.72 u	0.36 u	0.36 u	0.36 u	-	0.36 u	0.36 u	1.4 u	0.36 u	0.51 u	0.36 u
	02-Dec-04	GR-IA02-SB02-1-M	3-10'	8270C-SIM	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
IA02-SB13	13-Dec-04	GR-IA02-SB13-1	0-3'	8270C	1	0.37 u	0.37 u	0.37 u	0.37 u	0.73 u	0.37 u	0.37 u	0.37 u	-	0.37 u	0.37 u	1.5 u	0.37 u	0.51 u	0.37 u
	13-Dec-04	GR-IA02-SB13-1	0-3'	8270C-SIM	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	13-Dec-04	GR-IA02-SB13-1	3-10'	8270C	1	0.35 u	0.35 u	0.35 u	0.35 u	0.7 u	0.35 u	0.35 u	0.35 u	-	0.35 u	0.35 u	1.4 u	0.35 u	0.49 u	0.35 u
	13-Dec-04	GR-IA02-SB13-1	3-10'	8270C-SIM	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	13-Dec-04	GR-IA02-SB13-1-D	3-10'	8270C	1	0.35 u	0.35 u	0.35 u	0.35 u	0.7 u	0.35 u	0.35 u	0.35 u	-	0.35 u	0.35 u	1.4 u	0.35 u	0.49 u	0.35 u
	13-Dec-04	GR-IA02-SB13-1-D	3-10'	8270C-SIM	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
IA02-SB20	08-Dec-04	GR-IA02-SB20-1	0-3'	8270C	1	0.38 u	0.38 u	0.38 u	0.38 u	0.76 u	0.38 u	0.38 u	0.38 u	-	0.38 u	0.38 u	1.5 u	0.38 u	0.53 u	0.38 u
	08-Dec-04	GR-IA02-SB20-1	0-3'	8270C-SIM	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	08-Dec-04	GR-IA02-SB20-1-M	3-10'	8270C	1	0.36 u	0.36 u	0.36 u	0.36 u	0.72 u	0.36 u	0.36 u	0.36 u	-	0.36 u	0.36 u	1.4 u	0.36 u	0.51 u	0.36 u
	08-Dec-04	GR-IA02-SB20-1-M	3-10'	8270C-SIM	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
IA02-SB23	13-Dec-04	GR-IA02-SB23-1	0-3'	8270C	1	0.37 u	0.37 u	0.37 u	0.37 u	0.75 u	0.37 u	0.37 u	0.37 u	-	0.37 u	0.37 u	1.5 u	0.37 u	0.52 u	0.37 u
	13-Dec-04	GR-IA02-SB23-1	0-3'	8270C-SIM	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	13-Dec-04	GR-IA02-SB23-1	3-10'	8270C	1	0.4 u	0.4 u	0.4 u	**0.4 u**	0.8 u	0.4 u	0.4 u	0.4 u	-	0.4 u	0.4 u	1.6 u	0.4 u	0.56 u	0.4 u
	13-Dec-04	GR-IA02-SB23-1	3-10'	8270C-SIM	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	13-Dec-04	GR-IA02-SB23-1-D	3-10'	8270C	1	0.4 u	0.4 u	0.4 u	**0.4 u**	0.79 u	0.4 u	0.4 u	0.4 u	-	0.4 u	0.4 u	1.6 u	0.4 u	0.56 u	0.4 u
	13-Dec-04	GR-IA02-SB23-1-D	3-10'	8270C-SIM	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
IA02-SB30	15-Dec-04	GR-IA02-SB30-1	0-3'	8270C	1	0.37 u	0.37 u	0.37 u	0.37 u	0.75 u	0.37 u	0.37 u	0.37 u	-	0.37 u	0.37 u	1.5 u	0.37 u	0.52 u	0.37 u
	15-Dec-04	GR-IA02-SB30-1	0-3'	8270C-SIM	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	15-Dec-04	GR-IA02-SB30-1-M	3-10'	8270C	1	0.35 u	0.35 u	0.35 u	0.35 u	0.7 u	0.35 u	0.35 u	0.35 u	-	0.35 u	0.35 u	1.4 u	0.35 u	0.49 u	0.35 u
	15-Dec-04	GR-IA02-SB30-1-M	3-10'	8270C-SIM	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
IA03-SB02	13-Dec-04	GR-IA03-SB02-1	0-3'	8270C	1	0.37 u	0.37 u	0.37 u	0.37 u	0.74 u	0.37 u	0.37 u	0.37 u	-	0.37 u	0.37 u	1.5 u	0.37 u	0.52 u	0.37 u
	13-Dec-04	GR-IA03-SB02-1	0-3'	8270C-SIM	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	13-Dec-04	GR-IA03-SB02-1	3-10'	8270C	1	0.35 u	0.35 u	0.35 u	0.35 u	0.7 u	0.35 u	0.35 u	0.35 u	-	0.35 u	0.35 u	1.4 u	0.35 u	0.49 u	0.35 u
	13-Dec-04	GR-IA03-SB02-1	3-10'	8270C-SIM	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

Location

Notes:

NC No criteria listed under the regulation cited
ND Non-detect result (Original data unavailable - neither value nor detection limit provided)
- Parameter not analyzed

Analytic Flags:

u Not detected above laboratory reporting limits
j Estimated value - parameter detected between laboratory reporting limit and half of the laboratory reporting limit.
e Value exceeds analytical calibration limits
b Parameter detected in quality control blank and sample

Highlighting:

Value or Detection Limit exceeds Criteria 1 only
Value or Detection Limit exceeds Criteria 2 only
Value or Detection Limit exceeds both criteria

Supplemental Site Investigation

Analytic Method: 8270C and 8270C-SIM
Sample Matrix: Soil
Reporting Units: mg/kg
Sample Dates: 29-Nov-2004 to 13-Apr-2005

						di-n-Octyl Phthalate	Fluoranthene	Fluorene	Hexachlorobenzene	Hexachlorobutadiene	Hexachloroethane	Indeno(1,2,3-c,d)Pyrene	Isophorone	m-Cresol	Naphthalene	Nitrobenzene	Pentachlorophenol	Phenanthrene	Phenol	Pyrene
SSI Project Action Limit (PAL) - Wave 2 (SVOCs)						240	230	270	0.4	6	9	0.62	510	NC	5.6	2	3	100	20	230
Secondary Regulatory Criteria Not Selected																				
	Date	Sample ID	Depth	Method	Dilution															
IA03-SB04	15-Dec-04	GR-IA03-SB04-1	0-3'	8270C	1	0.37 u	1	0.37 u	0.37 u	0.73 u	0.37 u	0.55	0.37 u	-	0.37 u	0.37 u	1.5 u	0.54	0.51 u	0.85
	15-Dec-04	GR-IA03-SB04-1	0-3'	8270C-SIM	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	15-Dec-04	GR-IA03-SB04-1	3-10'	8270C	1	0.36 u	0.36 u	0.36 u	0.36 u	0.72 u	0.36 u	0.36 u	0.36 u	-	0.36 u	0.36 u	1.4 u	0.36 u	0.5 u	0.36 u
	15-Dec-04	GR-IA03-SB04-1	3-10'	8270C-SIM	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
IA05-SB07	10-Dec-04	GR-IA05-SB07-1	0-3'	8270C	1	0.39 u	0.39 u	0.39 u	0.39 u	0.78 u	0.39 u	0.39 u	0.39 u	0.47 u	0.39 u	0.39 u	1.6 u	0.39 u	0.55 u	0.39 u
	10-Dec-04	GR-IA05-SB07-1	0-3'	8270C-SIM	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	10-Dec-04	GR-IA05-SB07-1	3-10'	8270C	1	0.36 u	0.36 u	0.36 u	0.36 u	0.72 u	0.36 u	0.36 u	0.36 u	0.43 u	0.36 u	0.36 u	1.4 u	0.36 u	0.51 u	0.36 u
	10-Dec-04	GR-IA05-SB07-1	3-10'	8270C-SIM	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
IA06-SB03	11-Apr-05	LO-IA06-SB03-1	3-10'	8270C	1	0.38 u	0.38 u	0.38 u	0.38 u	0.38 u	0.38 u	0.38 u	0.38 u	-	0.38 u	0.38 u	1.9 u	0.38 u	0.38 u	0.38 u
	11-Apr-05	LO-IA06-SB03-1	0-3'	8270C	1	0.35 u	0.35 u	0.35 u	0.35 u	0.35 u	0.35 u	0.35 u	0.35 u	-	0.35 u	0.35 u	1.8 u	0.35 u	0.35 u	0.35 u
IA06-SB04	11-Apr-05	LO-IA06-SB04-1	3-10'	8270C	1	0.44 u	0.44 u	0.44 u	**0.44 u**	0.44 u	0.44 u	0.44 u	0.44 u	-	0.44 u	0.44 u	2.2 u	0.44 u	0.44 u	0.44 u
	11-Apr-05	LO-IA06-SB04-1	0-3'	8270C	1	0.37 u	0.37 u	0.37 u	0.37 u	0.37 u	0.37 u	0.37 u	0.37 u	-	0.37 u	0.37 u	1.8 u	0.37 u	0.37 u	0.37 u
IA06-SB05	11-Apr-05	LO-IA06-SB05-1	3-10'	8270C	1	0.38 u	0.38 u	0.38 u	0.38 u	0.38 u	0.38 u	0.38 u	0.38 u	-	0.38 u	0.38 u	1.9 u	0.38 u	0.38 u	0.38 u
	11-Apr-05	LO-IA06-SB05-1	0-3'	8270C	1	0.37 u	0.37 u	0.37 u	0.37 u	0.37 u	0.37 u	0.37 u	0.37 u	-	0.37 u	0.37 u	1.9 u	0.37 u	0.37 u	0.37 u
IA06-SB06	11-Apr-05	LO-IA06-SB06-1	3-10'	8270C	1	0.38 u	0.38 u	0.38 u	0.38 u	0.38 u	0.38 u	0.38 u	0.38 u	-	0.38 u	0.38 u	1.9 u	0.38 u	0.38 u	0.38 u
	11-Apr-05	LO-IA06-SB06-1	0-3'	8270C	1	0.39 u	0.39 u	0.39 u	0.39 u	0.39 u	0.39 u	0.39 u	0.39 u	-	0.39 u	0.39 u	2 u	0.39 u	0.39 u	0.39 u
IA06-SD06	13-Apr-05	LO-IA06-SD06-1	0-1.5'	8270C	1	1.1 u	1.6	1.1 u	**1.1 u**	1.1 u	1.1 u	0.17 j	1.1 u	-	1.1 u	1.1 u	2.7 u	0.18 j	0.13 j	1.2
IA06-SD17	13-Apr-05	LO-IA06-SD17-1	0-1.5'	8270C	1	1 u	0.36 j	1 u	**1 u**	1 u	1 u	0.077 j	1 u	-	1 u	1 u	2.5 u	0.18 j	1 u	0.25 j
IA06-SS08	11-Apr-05	LO-IA06-SS08-1	0-1.5'	8270C	1	0.36 u	0.36 u	0.36 u	0.36 u	0.36 u	0.36 u	0.36 u	0.36 u	-	0.36 u	0.36 u	1.8 u	0.36 u	0.36 u	0.36 u
IA06-SS16	11-Apr-05	LO-IA06-SS16-1	0-1.5'	8270C	1	0.35 u	0.35 u	0.35 u	0.35 u	0.35 u	0.35 u	0.35 u	0.35 u	-	0.35 u	0.35 u	1.8 u	0.35 u	0.35 u	0.35 u
	11-Apr-05	LO-IA06-SS16-1-D	0-1.5'	8270C	1	0.33 u	0.33 u	0.33 u	0.33 u	0.33 u	0.33 u	0.33 u	0.33 u	-	0.33 u	0.33 u	1.7 u	0.33 u	0.33 u	0.032 j
IA06-SS35	12-Apr-05	LO-IA06-SS35-1	0-1.5'	8270C	1	0.38 u	0.38 u	0.38 u	0.38 u	0.38 u	0.38 u	0.38 u	0.38 u	-	0.38 u	0.38 u	1.9 u	0.38 u	0.38 u	0.38 u
IA06-SS40	12-Apr-05	LO-IA06-SS40-1	0-1.5'	8270C	1	0.38 u	0.38 u	0.38 u	0.38 u	0.38 u	0.38 u	0.38 u	0.38 u	-	0.38 u	0.38 u	1.9 u	0.38 u	0.38 u	0.04 j
IA06-SS45	13-Apr-05	LO-IA06-SS25-1	0-1.5'	8270C	1	0.79 u	0.79 u	0.79 u	**0.79 u**	0.79 u	0.79 u	**0.79 u**	0.79 u	-	0.79 u	0.79 u	2 u	0.79 u	0.79 u	0.79 u
IA08-SB01	30-Nov-04	GR-IA08-SB01-1	0-3'	8270C	1	0.36 u	1.9	0.36 u	0.36 u	0.72 u	0.36 u	**0.81**	0.36 u	-	0.36 u	0.36 u	1.4 u	0.51	0.51 u	1.7
	30-Nov-04	GR-IA08-SB01-1	0-3'	8270C-SIM	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	30-Nov-04	GR-IA08-SB01-1	3-10'	8270C	1	0.35 u	0.35 u	0.35 u	0.35 u	0.7 u	0.35 u	0.35 u	0.35 u	-	0.35 u	0.35 u	1.4 u	0.35 u	0.49 u	0.35 u
	30-Nov-04	GR-IA08-SB01-1	3-10'	8270C-SIM	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	30-Nov-04	GR-IA08-SB01-1-D	3-10'	8270C	1	0.35 u	0.35 u	0.35 u	0.35 u	0.7 u	0.35 u	0.35 u	0.35 u	-	0.35 u	0.35 u	1.4 u	0.35 u	0.49 u	0.35 u
	30-Nov-04	GR-IA08-SB01-1-D	3-10'	8270C-SIM	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
IA08-SB09	16-Dec-04	GR-IA08-SB09-1	0-3'	8270C	1	0.36 u	0.36 u	0.36 u	0.36 u	0.72 u	0.36 u	0.36 u	0.36 u	-	0.36 u	0.36 u	1.4 u	0.36 u	0.5 u	0.36 u
	16-Dec-04	GR-IA08-SB09-1	0-3'	8270C-SIM	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	16-Dec-04	GR-IA08-SB09-1	3-10'	8270C	1	0.35 u	0.35 u	0.35 u	0.35 u	0.7 u	0.35 u	0.35 u	0.35 u	-	0.35 u	0.35 u	1.4 u	0.35 u	0.49 u	0.35 u
	16-Dec-04	GR-IA08-SB09-1	3-10'	8270C-SIM	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

Location

Notes:

NC No criteria listed under the regulation cited
ND Non-detect result (Original data unavailable - neither value nor detection limit provided)
- Parameter not analyzed

Analytic Flags:

u Not detected above laboratory reporting limits
j Estimated value - parameter detected between laboratory reporting limit and half of the laboratory reporting limit.
e Value exceeds analytical calibration limits
b Parameter detected in quality control blank and sample

Highlighting:

Value or Detection Limit exceeds Criteria 1 only
Value or Detection Limit exceeds Criteria 2 only
Value or Detection Limit exceeds both criteria

Supplemental Site Investigation

Analytic Method: 8270C and 8270C-SIM
Sample Matrix: Soil
Reporting Units: mg/kg
Sample Dates: 29-Nov-2004 to 13-Apr-2005

						di-n-Octyl Phthalate	Fluoranthene	Fluorene	Hexachlorobenzene	Hexachlorobutadiene	Hexachloroethane	Indeno(1,2,3-c,d)Pyrene	Isophorone	m-Cresol	Naphthalene	Nitrobenzene	Pentachlorophenol	Phenanthrene	Phenol	Pyrene
SSI Project Action Limit (PAL) - Wave 2 (SVOCs)						240	230	270	0.4	6	9	0.62	510	NC	5.6	2	3	100	20	230
Secondary Regulatory Criteria Not Selected																				
	Date	Sample ID	Depth	Method	Dilution															
IA09-SB01	29-Nov-04	CA-IA09-SB01-1	0-3'	8270C	1	0.37 u	0.37 u	0.37 u	0.37 u	0.73 u	0.37 u	0.37 u	0.37 u	-	0.37 u	0.37 u	1.5 u	0.37 u	0.51 u	0.37 u
	29-Nov-04	CA-IA09-SB01-1	0-3'	8270C-SIM	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	29-Nov-04	CA-IA09-SB01-1	3-10'	8270C	1	0.37 u	0.37 u	0.37 u	0.37 u	0.74 u	0.37 u	0.37 u	0.37 u	-	0.37 u	0.37 u	1.5 u	0.37 u	0.52 u	0.37 u
	29-Nov-04	CA-IA09-SB01-1	3-10'	8270C-SIM	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
IA10-SB01	13-Dec-04	GR-IA10-SB01-1	0-3'	8270C	1	0.38 u	0.38 u	0.38 u	0.38 u	0.76 u	0.38 u	0.38 u	0.38 u	-	0.38 u	0.38 u	1.5 u	0.38 u	0.53 u	0.38 u
	13-Dec-04	GR-IA10-SB01-1	0-3'	8270C-SIM	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	13-Dec-04	GR-IA10-SB01-1	3-10'	8270C	1	0.35 u	0.35 u	0.35 u	0.35 u	0.7 u	0.35 u	0.35 u	0.35 u	-	0.35 u	0.35 u	1.4 u	0.35 u	0.49 u	0.35 u
	13-Dec-04	GR-IA10-SB01-1	3-10'	8270C-SIM	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
IA10-SB02	10-Dec-04	GR-IA10-SB02-1	0-3'	8270C	5	1.8 u	13	1.8 u	**1.8 u**	3.6 u	1.8 u	**3.7**	1.8 u	2.2 u	1.8 u	1.8 u	**7.2 u**	8.1	2.5 u	11
	10-Dec-04	GR-IA10-SB02-1	0-3'	8270C-SIM	5	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	10-Dec-04	GR-IA10-SB02-1	3-10'	8270C	5	1.8 u	2.6	1.8 u	**1.8 u**	3.7 u	1.8 u	**1.8 u**	1.8 u	2.2 u	1.8 u	1.8 u	**7.3 u**	2	2.6 u	2.2
	10-Dec-04	GR-IA10-SB02-1	3-10'	8270C-SIM	5	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	10-Dec-04	GR-IA10-SB02-1-D	3-10'	8270C	5	1.8 u	2.6	1.8 u	**1.8 u**	3.7 u	1.8 u	**1.8 u**	1.8 u	2.2 u	1.8 u	1.8 u	**7.4 u**	2.2	2.6 u	2.2
	10-Dec-04	GR-IA10-SB02-1-D	3-10'	8270C-SIM	5	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
IA10-SB03	15-Dec-04	GR-IA10-SB03-1	0-3'	8270C	1	0.37 u	0.37 u	0.37 u	0.37 u	0.74 u	0.37 u	0.37 u	0.37 u	-	0.37 u	0.37 u	1.5 u	0.37 u	0.52 u	0.37 u
	15-Dec-04	GR-IA10-SB03-1	0-3'	8270C-SIM	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	15-Dec-04	GR-IA10-SB03-1	3-10'	8270C	1	0.37 u	0.37 u	0.37 u	0.37 u	0.73 u	0.37 u	0.37 u	0.37 u	-	0.37 u	0.37 u	1.5 u	0.37 u	0.51 u	0.37 u
	15-Dec-04	GR-IA10-SB03-1	3-10'	8270C-SIM	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
IA10-SB04	16-Dec-04	GR-IA10-SB04-1	0-3'	8270C	1	0.37 u	0.37 u	0.37 u	0.37 u	0.74 u	0.37 u	0.37 u	0.37 u	-	0.37 u	0.37 u	1.5 u	0.37 u	0.52 u	0.37 u
	16-Dec-04	GR-IA10-SB04-1	0-3'	8270C-SIM	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	16-Dec-04	GR-IA10-SB04-1	3-10'	8270C	1	0.35 u	0.35 u	0.35 u	0.35 u	0.7 u	0.35 u	0.35 u	0.35 u	-	0.35 u	0.35 u	1.4 u	0.35 u	0.49 u	0.35 u
	16-Dec-04	GR-IA10-SB04-1	3-10'	8270C-SIM	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
IA11-SB01	29-Nov-04	LO-IA11-SB01-1	0-3'	8270C	1	0.41 u	6.2	1.3	**0.41 u**	0.81 u	0.41 u	**1.1**	0.41 u	-	1.1	0.41 u	1.6 u	6.6	0.57 u	4.8
	29-Nov-04	LO-IA11-SB01-1	0-3'	8270C-SIM	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	29-Nov-04	LO-IA11-SB01-1	3-10'	8270C	1	0.35 u	0.35 u	0.35 u	0.35 u	0.71 u	0.35 u	0.35 u	0.35 u	-	0.35 u	0.35 u	1.4 u	0.35 u	0.5 u	0.35 u
	29-Nov-04	LO-IA11-SB01-1	3-10'	8270C-SIM	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
IA11-SB02	15-Dec-04	LO-IA11-SB02-1	0-3'	8270C	1	0.39 u	0.39 u	0.39 u	0.39 u	0.78 u	0.39 u	0.39 u	0.39 u	-	0.39 u	0.39 u	1.6 u	0.39 u	0.54 u	0.39 u
	15-Dec-04	LO-IA11-SB02-1	0-3'	8270C-SIM	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

Location

Notes:

NC No criteria listed under the regulation cited
ND Non-detect result (Original data unavailable - neither value nor detection limit provided)
- Parameter not analyzed

Analytic Flags:

u Not detected above laboratory reporting limits
j Estimated value - parameter detected between laboratory reporting limit and half of the laboratory reporting limit.
e Value exceeds analytical calibration limits
b Parameter detected in quality control blank and sample

Highlighting:

Value or Detection Limit exceeds Criteria 1 only
Value or Detection Limit exceeds Criteria 2 only
Value or Detection Limit exceeds both criteria

SSI - Summary of Extractable Petroleum Hydrocarbons Soil Analytical Results

Table 5-2c

Supplemental Site Investigation

Analytic Method: EPH-04-1 and EPH-MA
Sample Matrix: Soil
Reporting Units: mg/kg
Sample Dates: 29-Nov-2004 to 13-Apr-2005

						2-Methylnaphthalene	Acenaphthene	Acenaphthylene	Aliphatic Hydrocarbons (C19-C36)	Aliphatic Hydrocarbons (C9-C18)	Anthracene	Aromatic Hydrocarbons (C11-C22)	Aromatic Hydrocarbons (C11-C22), Unadjusted	Benzo(a)anthracene	Benzo(a)pyrene	Benzo(b)fluoranthene	Benzo(g,h,i)perylene	Benzo(k)fluoranthene	Chrysene	Dibenz(a,h)Anthracene	Fluoranthene	Fluorene	Indeno(1,2,3-c,d)Pyrene	Naphthalene	Phenanthrene	Pyrene
SSI Project Action Limit (PAL) - Wave 2 (EPH)						31	370	100	2500	1000	1000	800	NC	0.62	0.062	0.62	1000	6.2	7	0.062	230	270	0.62	5.6	100	230
Secondary Regulatory Criteria Not Selected																										
	Date	Sample ID	Depth	Method	Dilution																					
IA01-SB02	10-Dec-04	GR-IA01-SB02-1	0-3'	EPH-04-1	1	0.366 u	0.366 u	0.366 u	7.33 u	7.33 u	0.366 u	10.8	12.5	0.366 u	**0.366 u**	0.366 u	0.366 u	0.366 u	0.405	**0.366 u**	0.792	0.366 u	0.366 u	0.366 u	0.366 u	0.566
	10-Dec-04	GR-IA01-SB02-1	3-10'	EPH-04-1	1	0.362 u	0.362 u	0.362 u	7.25 u	7.25 u	0.362 u	7.25 u	7.25 u	0.362 u	**0.362 u**	0.362 u	0.362 u	0.362 u	0.362 u	**0.362 u**	0.362 u	0.362 u	0.362 u	0.362 u	0.362 u	0.362 u
IA02-SB01	30-Nov-04	GR-IA02-SB01-1	0-3'	EPH-04-1	1	0.388 u	0.388 u	0.388 u	7.75 u	7.75 u	0.388 u	7.75 u	7.75 u	0.388 u	**0.388 u**	0.388 u	0.388 u	0.388 u	0.388 u	**0.388 u**	0.388 u	0.388 u	0.388 u	0.388 u	0.388 u	0.388 u
	30-Nov-04	GR-IA02-SB01-1	3-10'	EPH-04-1	1	0.358 u	0.358 u	0.358 u	7.17 u	7.17 u	0.358 u	7.17 u	7.17 u	0.358 u	**0.358 u**	0.358 u	0.358 u	0.358 u	0.358 u	**0.358 u**	0.358 u	0.358 u	0.358 u	0.358 u	0.358 u	0.358 u
IA02-SB02	02-Dec-04	GR-IA02-SB02-1	0-3'	EPH-04-1	1	0.379 u	0.379 u	0.379 u	7.58 u	7.58 u	0.379 u	7.58 u	7.58 u	0.379 u	**0.379 u**	0.379 u	0.379 u	0.379 u	0.379 u	**0.379 u**	0.379 u	0.379 u	0.379 u	0.379 u	0.379 u	0.379 u
	02-Dec-04	GR-IA02-SB02-1-M	3-10'	EPH-04-1	1	0.362 u	0.362 u	0.362 u	7.25 u	7.25 u	0.362 u	7.25 u	7.25 u	0.362 u	**0.362 u**	0.362 u	0.362 u	0.362 u	0.362 u	**0.362 u**	0.362 u	0.362 u	0.362 u	0.362 u	0.362 u	0.362 u
IA02-SB13	13-Dec-04	GR-IA02-SB13-1	0-3'	EPH-04-1	1	0.366 u	0.366 u	0.366 u	7.33 u	7.33 u	0.366 u	7.33 u	7.33 u	0.366 u	**0.366 u**	0.366 u	0.366 u	0.366 u	0.366 u	**0.366 u**	0.366 u	0.366 u	0.366 u	0.366 u	0.366 u	0.366 u
	13-Dec-04	GR-IA02-SB13-1	3-10'	EPH-04-1	1	0.351 u	0.351 u	0.351 u	7.02 u	7.02 u	0.351 u	7.02 u	7.02 u	0.351 u	**0.351 u**	0.351 u	0.351 u	0.351 u	0.351 u	**0.351 u**	0.351 u	0.351 u	0.351 u	0.351 u	0.351 u	0.351 u
	13-Dec-04	GR-IA02-SB13-1-D	3-10'	EPH-04-1	1	0.351 u	0.351 u	0.351 u	7.02 u	7.02 u	0.351 u	7.02 u	7.02 u	0.351 u	**0.351 u**	0.351 u	0.351 u	0.351 u	0.351 u	**0.351 u**	0.351 u	0.351 u	0.351 u	0.351 u	0.351 u	0.351 u
IA02-SB20	08-Dec-04	GR-IA02-SB20-1	0-3'	EPH-04-1	1	0.379 u	0.379 u	0.379 u	11.5	7.58 u	0.379 u	10.5	10.5	0.379 u	**0.379 u**	0.379 u	0.379 u	0.379 u	0.379 u	**0.379 u**	0.379 u	0.379 u	0.379 u	0.379 u	0.379 u	0.379 u
	08-Dec-04	GR-IA02-SB20-1-M	3-10'	EPH-04-1	1	0.362 u	0.362 u	0.362 u	7.25 u	7.25 u	0.362 u	7.25 u	7.25 u	0.362 u	**0.362 u**	0.362 u	0.362 u	0.362 u	0.362 u	**0.362 u**	0.362 u	0.362 u	0.362 u	0.362 u	0.362 u	0.362 u
IA02-SB23	13-Dec-04	GR-IA02-SB23-1	0-3'	EPH-04-1	1	0.374 u	0.374 u	0.374 u	7.49 u	7.49 u	0.374 u	7.49 u	7.49 u	0.374 u	**0.374 u**	0.374 u	0.374 u	0.374 u	0.374 u	**0.374 u**	0.374 u	0.374 u	0.374 u	0.374 u	0.374 u	0.374 u
	13-Dec-04	GR-IA02-SB23-1	3-10'	EPH-04-1	1	0.402 u	0.402 u	0.402 u	8.03 u	8.03 u	0.402 u	8.03 u	8.03 u	0.402 u	**0.402 u**	0.402 u	0.402 u	0.402 u	0.402 u	**0.402 u**	0.402 u	0.402 u	0.402 u	0.402 u	0.402 u	0.402 u
	13-Dec-04	GR-IA02-SB23-1-D	3-10'	EPH-04-1	1	0.397 u	0.397 u	0.397 u	7.94 u	7.94 u	0.397 u	7.94 u	7.94 u	0.397 u	**0.397 u**	0.397 u	0.397 u	0.397 u	0.397 u	**0.397 u**	0.397 u	0.397 u	0.397 u	0.397 u	0.397 u	0.397 u
IA02-SB30	15-Dec-04	GR-IA02-SB30-1	0-3'	EPH-04-1	1	0.374 u	0.374 u	0.374 u	7.49 u	7.49 u	0.374 u	7.49 u	7.49 u	0.374 u	**0.374 u**	0.374 u	0.374 u	0.374 u	0.374 u	**0.374 u**	0.374 u	0.374 u	0.374 u	0.374 u	0.374 u	0.374 u
	15-Dec-04	GR-IA02-SB30-1-M	3-10'	EPH-04-1	1	0.351 u	0.351 u	0.351 u	7.02 u	7.02 u	0.351 u	7.02 u	7.02 u	0.351 u	**0.351 u**	0.351 u	0.351 u	0.351 u	0.351 u	**0.351 u**	0.351 u	0.351 u	0.351 u	0.351 u	0.351 u	0.351 u
IA03-SB02	13-Dec-04	GR-IA03-SB02-1	0-3'	EPH-04-1	1	0.37 u	0.37 u	0.37 u	7.41 u	7.41 u	0.37 u	7.41 u	7.41 u	0.37 u	**0.37 u**	0.37 u	0.37 u	0.37 u	0.37 u	**0.37 u**	0.37 u	0.37 u	0.37 u	0.37 u	0.37 u	0.37 u
	13-Dec-04	GR-IA03-SB02-1	3-10'	EPH-04-1	1	0.351 u	0.351 u	0.351 u	7.02 u	7.02 u	0.351 u	7.02 u	7.02 u	0.351 u	**0.351 u**	0.351 u	0.351 u	0.351 u	0.351 u	**0.351 u**	0.351 u	0.351 u	0.351 u	0.351 u	0.351 u	0.351 u
IA03-SB04	15-Dec-04	GR-IA03-SB04-1	0-3'	EPH-04-1	1	0.366 u	0.366 u	0.366 u	7.33 u	7.33 u	0.366 u	20.5	25.8	0.382	**0.439**	0.527	0.451	0.47	0.598	**0.366 u**	1.12	0.366 u	0.366 u	0.366 u	0.479	0.778
	15-Dec-04	GR-IA03-SB04-1	3-10'	EPH-04-1	1	0.358 u	0.358 u	0.358 u	7.17 u	7.17 u	0.358 u	7.17 u	7.17 u	0.358 u	**0.358 u**	0.358 u	0.358 u	0.358 u	0.358 u	**0.358 u**	0.358 u	0.358 u	0.358 u	0.358 u	0.358 u	0.358 u
IA05-SB07	10-Dec-04	GR-IA05-SB07-1	0-3'	EPH-04-1	1	0.392 u	0.392 u	0.392 u	7.84 u	7.84 u	0.392 u	7.84 u	7.84 u	0.392 u	**0.392 u**	0.392 u	0.392 u	0.392 u	0.392 u	**0.392 u**	0.392 u	0.392 u	0.392 u	0.392 u	0.392 u	0.392 u
	10-Dec-04	GR-IA05-SB07-1	3-10'	EPH-04-1	1	0.362 u	0.362 u	0.362 u	7.25 u	7.25 u	0.362 u	7.25 u	7.25 u	0.362 u	**0.362 u**	0.362 u	0.362 u	0.362 u	0.362 u	**0.362 u**	0.362 u	0.362 u	0.362 u	0.362 u	0.362 u	0.362 u
IA06-SB04	11-Apr-05	LO-IA06-SB04-1	3-10'	EPH_MA	1	1.3 u	1.3 u	1.3 u	11 u	8 u	1.3 u	23 u	-	**1.3 u**	**1.3 u**	**1.3 u**	1.3 u	1.3 u	1.3 u	**1.3 u**	1.3 u	1.3 u	**1.3 u**	1.3 u	1.3 u	1.3 u
	11-Apr-05	LO-IA06-SB04-1	0-3'	EPH_MA	1	1.1 u	1.1 u	1.1 u	8.9 u	6.7 u	1.1 u	19 u	-	**1.1 u**	**1.1 u**	**1.1 u**	1.1 u	1.1 u	1.1 u	**1.1 u**	1.1 u	1.1 u	**1.1 u**	1.1 u	1.1 u	1.1 u
IA06-SB06	11-Apr-05	LO-IA06-SB06-1	3-10'	EPH_MA	1	1.1 u	1.1 u	1.1 u	9 u	6.7 u	1.1 u	19 u	-	**1.1 u**	**1.1 u**	**1.1 u**	1.1 u	1.1 u	1.1 u	**1.1 u**	1.1 u	1.1 u	**1.1 u**	1.1 u	1.1 u	1.1 u
	11-Apr-05	LO-IA06-SB06-1	0-3'	EPH_MA	1	1.2 u	1.2 u	1.2 u	9.6 u	7.2 u	1.2 u	20 u	-	**1.2 u**	**1.2 u**	**1.2 u**	1.2 u	1.2 u	1.2 u	**1.2 u**	1.2 u	1.2 u	**1.2 u**	1.2 u	1.2 u	1.2 u
IA06-SD06	13-Apr-05	LO-IA06-SD06-1	0-1.5'	EPH_MA	1	1.6 u	1.6 u	1.6 u	13 u	9.7 u	1.6 u	19 j	-	**1.6 u**	**1.6 u**	**1.6 u**	1.6 u	1.6 u	1.6 u	**1.4 j**	1.7	1.6 u	**1.6 u**	1.6 u	1.6 u	1.3 j
IA06-SD17	13-Apr-05	LO-IA06-SD17-1	0-1.5'	EPH_MA	1	1.5 u	1.5 u	1.5 u	12 u	9.1 u	1.5 u	26 u	-	**1.5 u**	**1.5 u**	**1.5 u**	1.5 u	1.5 u	1.5 u	**0.84 j**	1.5 u	1.5 u	**1.5 u**	1.5 u	1.5 u	1.5 u
IA06-SS08	11-Apr-05	LO-IA06-SS08-1	0-1.5'	EPH_MA	1	1.1 u	1.1 u	1.1 u	8.7 u	6.5 u	1.1 u	18 u	-	**1.1 u**	**1.1 u**	**1.1 u**	1.1 u	1.1 u	1.1 u	**1.1 u**	1.1 u	1.1 u	**1.1 u**	1.1 u	1.1 u	1.1 u
IA06-SS16	11-Apr-05	LO-IA06-SS16-1	0-1.5'	EPH_MA	1	1.1 u	1.1 u	1.1 u	8.5 u	6.4 u	1.1 u	18 u	-	**1.1 u**	**1.1 u**	**1.1 u**	1.1 u	1.1 u	1.1 u	**1.1 u**	1.1 u	1.1 u	**1.1 u**	1.1 u	1.1 u	1.1 u
	11-Apr-05	LO-IA06-SS16-1-D	0-1.5'	EPH_MA	1	1 u	1 u	1 u	8 u	6 u	1 u	17 u	-	**1 u**	**1 u**	**1 u**	1 u	1 u	1 u	**1 u**	1 u	1 u	**1 u**	1 u	1 u	1 u
IA06-SS35	12-Apr-05	LO-IA06-SS35-1	0-1.5'	EPH_MA	1	1.2 u	1.2 u	1.2 u	4.8 j	5.2 j	1.2 u	20 u	-	**1.2 u**	**1.2 u**	**1.2 u**	1.2 u	1.2 u	1.2 u	**1.2 u**	1.2 u	1.2 u	**1.2 u**	1.2 u	1.2 u	1.2 u
IA06-SS40	12-Apr-05	LO-IA06-SS40-1	0-1.5'	EPH_MA	1	1.1 u	1.1 u	1.1 u	9.2 u	6.9 u	1.1 u	20 u	-	**1.1 u**	**1.1 u**	**1.1 u**	1.1 u	1.1 u	1.1 u	**1.1 u**	1.1 u	1.1 u	**1.1 u**	1.1 u	1.1 u	1.1 u
IA06-SS45	13-Apr-05	LO-IA06-SS25-1	0-1.5'	EPH_MA	1	1.2 u	1.2 u	1.2 u	9.6 u	7.2 u	1.2 u	20 u	-	**1.2 u**	**1.2 u**	**1.2 u**	1.2 u	1.2 u	1.2 u	**1.2 u**	1.2 u	1.2 u	**1.2 u**	1.2 u	1.2 u	1.2 u

Location

Notes:

NC No criteria listed under the regulation cited
ND Non-detect result (Original data unavailable - neither value nor detection limit provided)
- Parameter not analyzed

Analytic Flags:

u Not detected above laboratory reporting limits
j Estimated value - parameter detected between laboratory reporting limit and half of the laboratory reporting limit.
e Value exceeds analytical calibration limits
b Parameter detected in quality control blank and sample

Highlighting:

Value or Detection Limit exceeds Criteria 1 only
Value or Detection Limit exceeds Criteria 2 only
Value or Detection Limit exceeds both criteria

SSI - Summary of Extractable Petroleum Hydrocarbons Soil Analytical Results

Table 5-2c

Supplemental Site Investigation

Analytic Method: EPH-04-1 and EPH-MA
Sample Matrix: Soil
Reporting Units: mg/kg
Sample Dates: 29-Nov-2004 to 13-Apr-2005

						2-Methylnaphthalene	Acenaphthene	Acenaphthylene	Aliphatic Hydrocarbons (C19-C36)	Aliphatic Hydrocarbons (C9-C18)	Anthracene	Aromatic Hydrocarbons (C11-C22)	Aromatic Hydrocarbons (C11-C22), Unadjusted	Benzo(a)anthracene	Benzo(a)pyrene	Benzo(b)fluoranthene	Benzo(g,h,i)perylene	Benzo(k)fluoranthene	Chrysene	Dibenz(a,h)Anthracene	Fluoranthene	Fluorene	Indeno(1,2,3-c,d)Pyrene	Naphthalene	Phenanthrene	Pyrene
SSI Project Action Limit (PAL) - Wave 2 (EPH)						31	370	100	2500	1000	1000	800	NC	0.62	0.062	0.62	1000	6.2	7	0.062	230	270	0.62	5.6	100	230
Secondary Regulatory Criteria Not Selected																										
	Date	Sample ID	Depth	Method	Dilution																					
IA08-SB01	30-Nov-04	GR-IA08-SB01-1	0-3'	EPH-04-1	1	0.362 u	0.362 u	0.362 u	11.2	7.25 u	0.362 u	26.4	35.4	**0.8**	**0.963**	**0.801**	0.638	0.866	0.965	**0.362 u**	1.47	0.362 u	**0.684**	0.362 u	0.462	1.36
	30-Nov-04	GR-IA08-SB01-1	3-10'	EPH-04-1	1	0.351 u	0.351 u	0.351 u	18	7.02 u	0.351 u	13.1	13.1	0.351 u	**0.351 u**	0.351 u	0.351 u	0.351 u	0.351 u	**0.351 u**	0.351 u	0.351 u	0.351 u	0.351 u	0.351 u	0.351 u
	30-Nov-04	GR-IA08-SB01-1-D	3-10'	EPH-04-1	1	0.351 u	0.351 u	0.351 u	14.9	7.02 u	0.351 u	11.8	11.8	0.351 u	**0.351 u**	0.351 u	0.351 u	0.351 u	0.351 u	**0.351 u**	0.351 u	0.351 u	0.351 u	0.351 u	0.351 u	0.351 u
IA08-SB09	16-Dec-04	GR-IA08-SB09-1	0-3'	EPH-04-1	1	0.358 u	0.358 u	0.358 u	7.17 u	7.17 u	0.358 u	7.17 u	7.17 u	0.358 u	**0.358 u**	0.358 u	0.358 u	0.358 u	0.358 u	**0.358 u**	0.358 u	0.358 u	0.358 u	0.358 u	0.358 u	0.358 u
	16-Dec-04	GR-IA08-SB09-1	3-10'	EPH-04-1	1	0.351 u	0.351 u	0.351 u	7.02 u	7.02 u	0.351 u	7.02 u	7.02 u	0.351 u	**0.351 u**	0.351 u	0.351 u	0.351 u	0.351 u	**0.351 u**	0.351 u	0.351 u	0.351 u	0.351 u	0.351 u	0.351 u
IA09-SB01	29-Nov-04	CA-IA09-SB01-1	0-3'	EPH-04-1	1	0.366 u	0.366 u	0.366 u	7.33 u	7.33 u	0.366 u	7.33 u	7.33 u	0.366 u	**0.366 u**	0.366 u	0.366 u	0.366 u	0.366 u	**0.366 u**	0.366 u	0.366 u	0.366 u	0.366 u	0.366 u	0.366 u
	29-Nov-04	CA-IA09-SB01-1	3-10'	EPH-04-1	1	0.37 u	0.37 u	0.37 u	7.41 u	7.41 u	0.37 u	7.41 u	7.41 u	0.37 u	**0.37 u**	0.37 u	0.37 u	0.37 u	0.37 u	**0.37 u**	0.37 u	0.37 u	0.37 u	0.37 u	0.37 u	0.37 u
IA10-SB01	13-Dec-04	GR-IA10-SB01-1	0-3'	EPH-04-1	1	0.379 u	0.379 u	0.379 u	7.58 u	7.58 u	0.379 u	7.58 u	7.58 u	0.379 u	**0.379 u**	0.379 u	0.379 u	0.379 u	0.379 u	**0.379 u**	0.379 u	0.379 u	0.379 u	0.379 u	0.379 u	0.379 u
	13-Dec-04	GR-IA10-SB01-1	3-10'	EPH-04-1	1	0.351 u	0.351 u	0.351 u	7.02 u	7.02 u	0.351 u	7.02 u	7.02 u	0.351 u	**0.351 u**	0.351 u	0.351 u	0.351 u	0.351 u	**0.351 u**	0.351 u	0.351 u	0.351 u	0.351 u	0.351 u	0.351 u
IA10-SB02	10-Dec-04	GR-IA10-SB02-1	0-3'	EPH-04-1	5	1.81 u	1.81 u	1.81 u	36.2 u	36.2 u	1.96	138	202	**5.45**	**5.05**	**4.23**	2.72	4.32	6.04	**1.81 u**	13	1.81 u	**3**	1.81 u	6.97	11.3
	10-Dec-04	GR-IA10-SB02-1	3-10'	EPH-04-1	5	1.83 u	1.83 u	1.83 u	36.6 u	36.6 u	1.83 u	49.2	58.1	**1.83 u**	**1.83 u**	**1.83 u**	1.83 u	1.83 u	1.83 u	**1.83 u**	3.66	1.83 u	**1.83 u**	1.83 u	2.5	2.68
	10-Dec-04	GR-IA10-SB02-1-D	3-10'	EPH-04-1	5	1.85 u	1.85 u	1.85 u	37 u	37 u	1.85 u	38.9	45.7	**1.85 u**	**1.85 u**	**1.85 u**	1.85 u	1.85 u	1.85 u	**1.85 u**	2.56	1.85 u	**1.85 u**	1.85 u	1.86	2.4
IA10-SB03	15-Dec-04	GR-IA10-SB03-1	0-3'	EPH-04-1	1	0.37 u	0.37 u	0.37 u	7.41 u	7.41 u	0.37 u	7.41 u	7.41 u	0.37 u	**0.37 u**	0.37 u	0.37 u	0.37 u	0.37 u	**0.37 u**	0.37 u	0.37 u	0.37 u	0.37 u	0.37 u	0.37 u
	15-Dec-04	GR-IA10-SB03-1	3-10'	EPH-04-1	1	0.366 u	0.366 u	0.366 u	7.33 u	7.33 u	0.366 u	7.33 u	7.33 u	0.366 u	**0.366 u**	0.366 u	0.366 u	0.366 u	0.366 u	**0.366 u**	0.366 u	0.366 u	0.366 u	0.366 u	0.366 u	0.366 u
IA10-SB04	16-Dec-04	GR-IA10-SB04-1	0-3'	EPH-04-1	1	0.37 u	0.37 u	0.37 u	7.41 u	7.41 u	0.37 u	7.41 u	7.41 u	0.37 u	**0.37 u**	0.37 u	0.37 u	0.37 u	0.37 u	**0.37 u**	0.37 u	0.37 u	0.37 u	0.37 u	0.37 u	0.37 u
	16-Dec-04	GR-IA10-SB04-1	3-10'	EPH-04-1	1	0.351 u	0.351 u	0.351 u	7.02 u	7.02 u	0.351 u	7.02 u	7.02 u	0.351 u	**0.351 u**	0.351 u	0.351 u	0.351 u	0.351 u	**0.351 u**	0.351 u	0.351 u	0.351 u	0.351 u	0.351 u	0.351 u
IA11-SB01	29-Nov-04	LO-IA11-SB01-1	0-3'	EPH-04-1	1	0.406 u	0.792	0.406 u	8.13 u	8.13 u	1.26	40.8	64	**1.18**	**1.26**	**0.931**	0.683	1.02	1.47	**0.406 u**	4.52	1.01	**0.756**	0.624	4.6	3.1
	29-Nov-04	LO-IA11-SB01-1	3-10'	EPH-04-1	1	0.355 u	0.355 u	0.355 u	7.09 u	7.09 u	0.355 u	7.09 u	7.09 u	0.355 u	**0.355 u**	0.355 u	0.355 u	0.355 u	0.355 u	**0.355 u**	0.355 u	0.355 u	0.355 u	0.355 u	0.355 u	0.355 u

Location

Notes:

- **NC** No criteria listed under the regulation cited
- **ND** Non-detect result (Original data unavailable - neither value nor detection limit provided)
- **-** Parameter not analyzed

Analytic Flags:

- **u** Not detected above laboratory reporting limits
- **j** Estimated value - parameter detected between laboratory reporting limit and half of the laboratory reporting limit.
- **e** Value exceeds analytical calibration limits
- **b** Parameter detected in quality control blank and sample

Highlighting:

- Value or Detection Limit exceeds Criteria 1 only
- Value or Detection Limit exceeds Criteria 2 only
- Value or Detection Limit exceeds both criteria

Table 5-2d SSI - Summary of PCBs Soil Analytical Results

Supplemental Site Investigation

Analytic Method: 8082
Sample Matrix: Soil
Reporting Units: mg/kg
Sample Dates: 29-Nov-2004 to 13-Apr-2005

	Arochlor 1016	Arochlor 1221	Arochlor 1232	Arochlor 1242	Arochlor 1242/1016	Arochlor 1248	Arochlor 1254	Arochlor 1260	Arochlor 1262	Arochlor 1268
SSI Project Action Limit (PAL) - Wave 2 (PCBs)	2	0.22	0.22	0.22	NC	0.22	0.22	0.22	0.22	0.22
Secondary Regulatory Criteria Not Selected										

Location	Date	Sample ID	Depth	Method	DF									
IA01-SB02	10-Dec-04	GR-IA01-SB02-1	0-3'	8082	1	-	0.0366 u	0.0366 u	-	0.0366 u	0.0366 u	0.0366 u	0.0366 u	0.0366 u	0.0366 u
	10-Dec-04	GR-IA01-SB02-1	3-10'	8082	1	-	0.0362 u	0.0362 u	-	0.0362 u	0.0362 u	0.0362 u	0.0362 u	0.0362 u	0.0362 u
IA02-SB01	30-Nov-04	GR-IA02-SB01-1	0-3'	8082	1	-	0.0388 u	0.0388 u	-	0.0388 u	0.0388 u	0.0388 u	0.0388 u	0.0388 u	0.0388 u
	30-Nov-04	GR-IA02-SB01-1	3-10'	8082	1	-	0.0358 u	0.0358 u	-	0.0358 u	0.0358 u	0.0358 u	0.0358 u	0.0358 u	0.0358 u
IA02-SB02	02-Dec-04	GR-IA02-SB02-1	0-3'	8082	1	-	0.0379 u	0.0379 u	-	0.0379 u	0.0379 u	0.0379 u	0.0379 u	0.0379 u	0.0379 u
	02-Dec-04	GR-IA02-SB02-1-M	3-10'	8082	1	-	0.0362 u	0.0362 u	-	0.0362 u	0.0362 u	0.0362 u	0.0362 u	0.0362 u	0.0362 u
IA02-SB13	13-Dec-04	GR-IA02-SB13-1	0-3'	8082	1	-	0.0366 u	0.0366 u	-	0.0366 u	0.0366 u	0.0366 u	0.0366 u	0.0366 u	0.0366 u
	13-Dec-04	GR-IA02-SB13-1	3-10'	8082	1	-	0.0351 u	0.0351 u	-	0.0351 u	0.0351 u	0.0351 u	0.0351 u	0.0351 u	0.0351 u
	13-Dec-04	GR-IA02-SB13-1-D	3-10'	8082	1	-	0.0351 u	0.0351 u	-	0.0351 u	0.0351 u	0.0351 u	0.0351 u	0.0351 u	0.0351 u
IA02-SB20	08-Dec-04	GR-IA02-SB20-1	0-3'	8082	1	-	0.0379 u	0.0379 u	-	0.0379 u	0.0379 u	0.0379 u	0.0379 u	0.0379 u	0.0379 u
	08-Dec-04	GR-IA02-SB20-1-M	3-10'	8082	1	-	0.0362 u	0.0362 u	-	0.0362 u	0.0362 u	0.0362 u	0.0362 u	0.0362 u	0.0362 u
IA02-SB23	13-Dec-04	GR-IA02-SB23-1	0-3'	8082	1	-	0.0374 u	0.0374 u	-	0.0374 u	0.0374 u	0.0374 u	0.0374 u	0.0374 u	0.0374 u
	13-Dec-04	GR-IA02-SB23-1	3-10'	8082	1	-	0.0402 u	0.0402 u	-	0.0402 u	0.0402 u	0.0402 u	0.0402 u	0.0402 u	0.0402 u
	13-Dec-04	GR-IA02-SB23-1-D	3-10'	8082	1	-	0.0397 u	0.0397 u	-	0.0397 u	0.0397 u	0.0397 u	0.0397 u	0.0397 u	0.0397 u
IA02-SB30	15-Dec-04	GR-IA02-SB30-1	0-3'	8082	1	-	0.0374 u	0.0374 u	-	0.0374 u	0.0374 u	0.0374 u	0.0374 u	0.0374 u	0.0374 u
	15-Dec-04	GR-IA02-SB30-1-M	3-10'	8082	1	-	0.0351 u	0.0351 u	-	0.0351 u	0.0351 u	0.0351 u	0.0351 u	0.0351 u	0.0351 u
IA03-SB02	13-Dec-04	GR-IA03-SB02-1	0-3'	8082	1	-	0.037 u	0.037 u	-	0.037 u	0.037 u	0.037 u	0.037 u	0.037 u	0.037 u
	13-Dec-04	GR-IA03-SB02-1	3-10'	8082	1	-	0.0351 u	0.0351 u	-	0.0351 u	0.0351 u	0.0351 u	0.0351 u	0.0351 u	0.0351 u
IA03-SB04	15-Dec-04	GR-IA03-SB04-1	0-3'	8082	1	-	0.0366 u	0.0366 u	-	0.0366 u	0.0366 u	0.0366 u	0.0366 u	0.0366 u	0.0366 u
	15-Dec-04	GR-IA03-SB04-1	3-10'	8082	1	-	0.0358 u	0.0358 u	-	0.0358 u	0.0358 u	0.0358 u	0.0358 u	0.0358 u	0.0358 u
IA05-SB07	10-Dec-04	GR-IA05-SB07-1	0-3'	8082	1	-	0.0392 u	0.0392 u	-	0.0392 u	0.0392 u	0.0392 u	0.0392 u	0.0392 u	0.0392 u
	10-Dec-04	GR-IA05-SB07-1	3-10'	8082	1	-	0.0362 u	0.0362 u	-	0.0362 u	0.0362 u	0.0362 u	0.0362 u	0.0362 u	0.0362 u
IA06-SB04	11-Apr-05	LO-IA06-SB04-1	0-3'	8082	1	0.019 u	0.019 u	0.019 u	0.019 u	-	0.019 u	0.019 u	0.019 u	0.019 u	0.019 u
	11-Apr-05	LO-IA06-SB04-1	3-10'	8082	1	0.022 u	0.022 u	0.022 u	0.022 u	-	0.022 u	0.022 u	0.022 u	0.022 u	0.022 u
IA06-SB06	11-Apr-05	LO-IA06-SB06-1	0-3'	8082	1	0.02 u	0.02 u	0.02 u	0.02 u	-	0.02 u	0.02 u	0.02 u	0.02 u	0.02 u
	11-Apr-05	LO-IA06-SB06-1	3-10'	8082	1	0.019 u	0.019 u	0.019 u	0.019 u	-	0.019 u	0.019 u	0.019 u	0.019 u	0.019 u
IA06-SD06	13-Apr-05	LO-IA06-SD06-1	0-1.5'	8082	1	0.027 u	0.027 u	0.027 u	0.027 u	-	0.027 u	0.027 u	0.027 u	0.027 u	0.027 u

Notes:

- **NC** No criteria listed under the regulation cited
- **ND** Non-detect result (Original data unavailabl)
- **-** Parameter not analyzed

Analytic Flags:

- **u** Not detected above laboratory detection limits
- **j** Estimated value - parameter not detected above laboratory quantitation limits
- **e** Value exceeds analytical calibration limits
- **b** Parameter detected in quality control blank and sample

Highlighting:

- Value or Detection Limit exceeds Criteria 1 only
- Value or Detection Limit exceeds Criteria 2 only
- Value or Detection Limit exceeds both criteria

Table 5-2d SSI - Summary of PCBs Soil Analytical Results

Supplemental Site Investigation

Analytic Method: 8082
Sample Matrix: Soil
Reporting Units: mg/kg
Sample Dates: 29-Nov-2004 to 13-Apr-2005

	Arochlor 1016	Arochlor 1221	Arochlor 1232	Arochlor 1242	Arochlor 1242/1016	Arochlor 1248	Arochlor 1254	Arochlor 1260	Arochlor 1262	Arochlor 1268
SSI Project Action Limit (PAL) - Wave 2 (PCBs)	2	0.22	0.22	0.22	NC	0.22	0.22	0.22	0.22	0.22
Secondary Regulatory Criteria Not Selected										

Location	Date	Sample ID	Depth	Method	DF									
IA06-SD17	13-Apr-05	LO-IA06-SD17-1	0-1.5'	8082	1	0.025 u	0.025 u	0.025 u	0.025 u	-	0.025 u	0.025 u	0.025 u	0.025 u	0.025 u
IA06-SS08	11-Apr-05	LO-IA06-SS08-1	0-1.5'	8082	1	0.018 u	0.018 u	0.018 u	0.018 u	-	0.018 u	0.018 u	0.018 u	0.018 u	0.018 u
IA06-SS16	11-Apr-05	LO-IA06-SS16-1	0-1.5'	8082	1	0.018 u	0.018 u	0.018 u	0.018 u	-	0.018 u	0.018 u	0.018 u	0.018 u	0.018 u
	11-Apr-05	LO-IA06-SS16-1-D	0-1.5'	8082	1	0.017 u	0.017 u	0.017 u	0.017 u	-	0.017 u	0.017 u	0.017 u	0.017 u	0.017 u
IA06-SS35	12-Apr-05	LO-IA06-SS35-1	0-1.5'	8082	1	0.019 u	0.019 u	0.019 u	0.019 u	-	0.019 u	0.019 u	0.019 u	0.019 u	0.019 u
IA06-SS40	12-Apr-05	LO-IA06-SS40-1	0-1.5'	8082	1	0.019 u	0.019 u	0.019 u	0.019 u	-	0.019 u	0.019 u	0.019 u	0.019 u	0.019 u
IA06-SS45	13-Apr-05	LO-IA06-SS25-1	0-1.5'	8082	1	0.02 u	0.02 u	0.02 u	0.02 u	-	0.02 u	0.02 u	0.02 u	0.02 u	0.02 u
IA08-SB01	30-Nov-04	GR-IA08-SB01-1	0-3'	8082	1	-	0.0362 u	0.0362 u	-	0.0362 u	0.085	0.0362 u	0.0362 u	0.0362 u	0.0362 u
	30-Nov-04	GR-IA08-SB01-1	3-10'	8082	1	-	0.0351 u	0.0351 u	-	0.0351 u	0.0482	0.0351 u	0.0351 u	0.0351 u	0.0351 u
	30-Nov-04	GR-IA08-SB01-1-D	3-10'	8082	1	-	0.0351 u	0.0351 u	-	0.0351 u	0.0393	0.0351 u	0.0351 u	0.0351 u	0.0351 u
IA08-SB09	16-Dec-04	GR-IA08-SB09-1	0-3'	8082	1	-	0.0358 u	0.0358 u	-	0.0358 u	0.0358 u	0.0358 u	0.0358 u	0.0358 u	0.0358 u
	16-Dec-04	GR-IA08-SB09-1	3-10'	8082	1	-	0.0351 u	0.0351 u	-	0.0351 u	0.0351 u	0.0351 u	0.0351 u	0.0351 u	0.0351 u
IA09-SB01	29-Nov-04	CA-IA09-SB01-1	0-3'	8082	1	-	0.0366 u	0.0366 u	-	0.0366 u	0.0366 u	0.0366 u	0.0366 u	0.0366 u	0.0366 u
	29-Nov-04	CA-IA09-SB01-1	3-10'	8082	1	-	0.037 u	0.037 u	-	0.037 u	0.037 u	0.037 u	0.037 u	0.037 u	0.037 u
IA10-SB01	13-Dec-04	GR-IA10-SB01-1	0-3'	8082	1	-	0.0379 u	0.0379 u	-	0.0379 u	0.0379 u	0.0379 u	0.0379 u	0.0379 u	0.0379 u
	13-Dec-04	GR-IA10-SB01-1	3-10'	8082	1	-	0.0351 u	0.0351 u	-	0.0351 u	0.0351 u	0.0351 u	0.0351 u	0.0351 u	0.0351 u
IA10-SB02	10-Dec-04	GR-IA10-SB02-1	0-3'	8082	1	-	0.0362 u	0.0362 u	-	0.0362 u	0.0362 u	0.0362 u	0.0362 u	0.0362 u	0.0362 u
	10-Dec-04	GR-IA10-SB02-1	3-10'	8082	1	-	0.0366 u	0.0366 u	-	0.0366 u	0.0366 u	0.0366 u	0.0366 u	0.0366 u	0.0366 u
	10-Dec-04	GR-IA10-SB02-1-D	3-10'	8082	1	-	0.037 u	0.037 u	-	0.037 u	0.037 u	0.037 u	0.037 u	0.037 u	0.037 u
IA10-SB03	15-Dec-04	GR-IA10-SB03-1	0-3'	8082	1	-	0.037 u	0.037 u	-	0.037 u	0.037 u	0.037 u	0.037 u	0.037 u	0.037 u
	15-Dec-04	GR-IA10-SB03-1	3-10'	8082	1	-	0.0366 u	0.0366 u	-	0.0366 u	0.0366 u	0.0366 u	0.0366 u	0.0366 u	0.0366 u
IA10-SB04	16-Dec-04	GR-IA10-SB04-1	0-3'	8082	1	-	0.037 u	0.037 u	-	0.037 u	0.037 u	0.037 u	0.037 u	0.037 u	0.037 u
	16-Dec-04	GR-IA10-SB04-1	3-10'	8082	1	-	0.0351 u	0.0351 u	-	0.0351 u	0.0351 u	0.0351 u	0.0351 u	0.0351 u	0.0351 u
IA11-SB01	29-Nov-04	LO-IA11-SB01-1	0-3'	8082	1	-	0.0406 u	0.0406 u	-	0.0406 u	0.0406 u	0.0406 u	0.0406 u	0.0406 u	0.0406 u
	29-Nov-04	LO-IA11-SB01-1	3-10'	8082	1	-	0.0355 u	0.0355 u	-	0.0355 u	0.0355 u	0.0355 u	0.0355 u	0.0355 u	0.0355 u

Notes:

- **NC** No criteria listed under the regulation cited
- **ND** Non-detect result (Original data unavailabl)
- **-** Parameter not analyzed

Analytic Flags:

- **u** Not detected above laboratory detection limits
- **j** Estimated value - parameter not detected above laboratory quantitation limits
- **e** Value exceeds analytical calibration limits
- **b** Parameter detected in quality control blank and sample

Highlighting:

- Value or Detection Limit exceeds Criteria 1 only
- Value or Detection Limit exceeds Criteria 2 only
- Value or Detection Limit exceeds both criteria

Supplemental Site Investigation

Analytic Method: 8081A
Sample Matrix: Soil
Reporting Units: mg/kg
Sample Dates: 29-Nov-2004 to 13-Apr-2005

	4,4-DDD	4,4-DDE	4,4-DDT	Aldrin	Alpha-BHC	Alpha-Chlordane	Beta-BHC	Chlordane	Delta-BHC	Dieldrin	Endosulfan I	Endosulfan II	Endosulfan Sulfate	Endrin	Endrin Ketone	Gamma-BHC (Lindane)	Gamma-Chlordane	Heptachlor	Heptachlor Epoxide	Hexachlorobenzene	Methoxychlor	Toxaphene
SSI Project Action Limit (PAL) - Wave 2 (Pesticides)	0.24	0.17	0.17	0.029	0.09	NC	0.32	0.7	NC	0.03	NC	1	NC	1.8	NC	0.44	NC	0.11	0.053	0.3	31	NC
Secondary Regulatory Criteria Not Selected																						

	Date	Sample ID	Depth	Method	Dilution	4,4-DDD	4,4-DDE	4,4-DDT	Aldrin	Alpha-BHC	Alpha-Chlordane	Beta-BHC	Chlordane	Delta-BHC	Dieldrin	Endosulfan I	Endosulfan II	Endosulfan Sulfate	Endrin	Endrin Ketone	Gamma-BHC (Lindane)	Gamma-Chlordane	Heptachlor	Heptachlor Epoxide	Hexachlorobenzene	Methoxychlor	Toxaphene
IA01-SB02	10-Dec-04	GR-IA01-SB02-1	0-3'	8081A	1	0.00366 u	0.00366 u	0.00366 u	0.00366 u	0.00366 u	-	0.00366 u	0.0146 u	0.00366 u	0.00366 u	0.00366 u	0.00366 u	0.00366 u	0.00366 u	0.00366 u	0.00366 u	-	0.00366 u	0.00366 u	0.0146 u	0.00366 u	0.0146 u
	10-Dec-04	GR-IA01-SB02-1	3-10'	8081A	1	0.00362 u	0.00362 u	0.00362 u	0.00362 u	0.00362 u	-	0.00362 u	0.0145 u	0.00362 u	0.00362 u	0.00362 u	0.00362 u	0.00362 u	0.00362 u	0.00362 u	0.00362 u	-	0.00362 u	0.00362 u	0.0145 u	0.00362 u	0.0145 u
IA02-SB01	30-Nov-04	GR-IA02-SB01-1	0-3'	8081A	1	0.00388 u	0.00388 u	0.00687	0.00388 u	0.00388 u	-	0.00388 u	0.0155 u	0.00388 u	0.00388 u	0.00388 u	0.00388 u	0.00388 u	0.00388 u	0.00388 u	0.00388 u	-	0.00388 u	0.00388 u	0.0155 u	0.00388 u	0.0155 u
	30-Nov-04	GR-IA02-SB01-1	3-10'	8081A	1	0.00358 u	0.00358 u	0.00358 u	0.00358 u	0.00358 u	-	0.00358 u	0.0143 u	0.00358 u	0.00358 u	0.00358 u	0.00358 u	0.00358 u	0.00358 u	0.00358 u	0.00358 u	-	0.00358 u	0.00358 u	0.0143 u	0.00358 u	0.0143 u
IA02-SB02	02-Dec-04	GR-IA02-SB02-1	0-3'	8081A	1	0.00379 u	0.0148	0.0194	0.00379 u	0.00379 u	-	0.00379 u	0.0152 u	0.00379 u	0.00379 u	0.00379 u	0.00379 u	0.00379 u	0.00379 u	0.00379 u	0.00379 u	-	0.00379 u	0.00379 u	0.0152 u	0.00379 u	0.0152 u
	02-Dec-04	GR-IA02-SB02-1-M	3-10'	8081A	1	0.00362 u	0.00362 u	0.00362 u	0.00362 u	0.00362 u	-	0.00362 u	0.0145 u	0.00362 u	0.00362 u	0.00362 u	0.00362 u	0.00362 u	0.00362 u	0.00362 u	0.00362 u	-	0.00362 u	0.00362 u	0.0145 u	0.00362 u	0.0145 u
IA02-SB13	13-Dec-04	GR-IA02-SB13-1	0-3'	8081A	1	0.00366 u	0.00486	0.00478	0.00366 u	0.00366 u	-	0.00366 u	0.0146 u	0.00366 u	0.00366 u	0.00366 u	0.00366 u	0.00366 u	0.00366 u	0.00366 u	0.00366 u	-	0.00366 u	0.00366 u	0.0146 u	0.00366 u	0.0146 u
	13-Dec-04	GR-IA02-SB13-1	3-10'	8081A	1	0.00351 u	0.00351 u	0.00351 u	0.00351 u	0.00351 u	-	0.00351 u	0.014 u	0.00351 u	0.00351 u	0.00351 u	0.00351 u	0.00351 u	0.00351 u	0.00351 u	0.00351 u	-	0.00351 u	0.00351 u	0.014 u	0.00351 u	0.014 u
	13-Dec-04	GR-IA02-SB13-1-D	3-10'	8081A	1	0.00351 u	0.00351 u	0.00351 u	0.00351 u	0.00351 u	-	0.00351 u	0.014 u	0.00351 u	0.00351 u	0.00351 u	0.00351 u	0.00351 u	0.00351 u	0.00351 u	0.00351 u	-	0.00351 u	0.00351 u	0.014 u	0.00351 u	0.014 u
IA02-SB20	08-Dec-04	GR-IA02-SB20-1	0-3'	8081A	5	0.0189 u	0.0189 u	0.0189 u	0.0189 u	0.0189 u	-	0.0189 u	0.0758 u	0.0189 u	**0.0636**	0.0189 u	0.0189 u	0.0189 u	0.0189 u	0.0189 u	0.0189 u	-	0.0189 u	0.0189 u	0.0758 u	0.0189 u	0.0758 u
	08-Dec-04	GR-IA02-SB20-1-M	3-10'	8081A	1	0.00362 u	0.00362 u	0.00473	0.00362 u	0.00362 u	-	0.00362 u	0.0145 u	0.00362 u	0.00376	0.00362 u	0.00362 u	0.00362 u	0.00362 u	0.00362 u	0.00362 u	-	0.00362 u	0.00362 u	0.0145 u	0.00362 u	0.0145 u
IA02-SB23	13-Dec-04	GR-IA02-SB23-1	0-3'	8081A	5	0.0187 u	0.0187 u	0.0187 u	**0.103**	0.0187 u	-	0.0187 u	0.0749 u	0.0187 u	**0.183**	0.0187 u	0.0187 u	0.0187 u	0.0187 u	0.0187 u	0.0187 u	-	0.0187 u	0.0187 u	0.0749 u	0.0187 u	0.0749 u
	13-Dec-04	GR-IA02-SB23-1	3-10'	8081A	1	0.00402 u	0.00402 u	0.00402 u	0.0153	0.00402 u	-	0.00402 u	0.0161 u	0.00402 u	**0.0303**	0.00402 u	0.00402 u	0.00402 u	0.00402 u	0.00402 u	0.00402 u	-	0.00402 u	0.00402 u	0.0161 u	0.00402 u	0.0161 u
	13-Dec-04	GR-IA02-SB23-1-D	3-10'	8081A	1	0.00397 u	0.00397 u	0.00397 u	0.0144	0.00397 u	-	0.00397 u	0.0159 u	0.00397 u	0.0241	0.00397 u	0.00397 u	0.00397 u	0.00397 u	0.00397 u	0.00397 u	-	0.00397 u	0.00397 u	0.0159 u	0.00397 u	0.0159 u
IA02-SB30	15-Dec-04	GR-IA02-SB30-1	0-3'	8081A	50	0.187 u	**0.247**	**0.751**	**0.187 u**	**0.187 u**	-	0.187 u	**0.749 u**	0.187 u	**0.187 u**	0.187 u	0.187 u	0.187 u	0.187 u	0.187 u	0.187 u	-	**0.187 u**	**0.187 u**	**0.749 u**	0.187 u	0.749 u
	15-Dec-04	GR-IA02-SB30-1-M	3-10'	8081A	1	0.00351 u	0.0132	0.0228	0.00351 u	0.00351 u	-	0.00351 u	0.014 u	0.00351 u	0.00351 u	0.00351 u	0.00351 u	0.00351 u	0.00351 u	0.00351 u	0.00351 u	-	0.00351 u	0.00351 u	0.014 u	0.00351 u	0.014 u
IA03-SB02	13-Dec-04	GR-IA03-SB02-1	0-3'	8081A	5	0.0185 u	0.0718	0.141	0.0185 u	0.0185 u	-	0.0185 u	0.0741 u	0.0185 u	0.0185 u	0.0185 u	0.0185 u	0.0185 u	0.0185 u	0.0185 u	0.0185 u	-	0.0185 u	0.0185 u	0.0741 u	0.0185 u	0.0741 u
	13-Dec-04	GR-IA03-SB02-1	3-10'	8081A	1	0.00351 u	0.00351 u	0.00535	0.00351 u	0.00351 u	-	0.00351 u	0.014 u	0.00351 u	0.00351 u	0.00351 u	0.00351 u	0.00351 u	0.00351 u	0.00351 u	0.00351 u	-	0.00351 u	0.00351 u	0.014 u	0.00351 u	0.014 u
IA03-SB04	15-Dec-04	GR-IA03-SB04-1	0-3'	8081A	1	0.00366 u	0.0171	0.0216	0.00366 u	0.00366 u	-	0.00366 u	0.0146 u	0.00366 u	0.00366 u	0.00366 u	0.00366 u	0.00366 u	0.00366 u	0.00366 u	0.00366 u	-	0.00366 u	0.00366 u	0.0146 u	0.00366 u	0.0146 u
	15-Dec-04	GR-IA03-SB04-1	3-10'	8081A	1	0.00358 u	0.00358 u	0.00358 u	0.00358 u	0.00358 u	-	0.00358 u	0.0143 u	0.00358 u	0.00358 u	0.00358 u	0.00358 u	0.00358 u	0.00358 u	0.00358 u	0.00358 u	-	0.00358 u	0.00358 u	0.0143 u	0.00358 u	0.0143 u
IA05-SB07	10-Dec-04	GR-IA05-SB07-1	0-3'	8081A	1	0.00392 u	0.00392 u	0.00392 u	0.00392 u	0.00392 u	-	0.00392 u	0.0157 u	0.00392 u	0.00392 u	0.00392 u	0.00392 u	0.00392 u	0.00392 u	0.00392 u	0.00392 u	-	0.00392 u	0.00392 u	0.0157 u	0.00392 u	0.0157 u
	10-Dec-04	GR-IA05-SB07-1	3-10'	8081A	1	0.00362 u	0.00362 u	0.00362 u	0.00362 u	0.00362 u	-	0.00362 u	0.0145 u	0.00362 u	0.00362 u	0.00362 u	0.00362 u	0.00362 u	0.00362 u	0.00362 u	0.00362 u	-	0.00362 u	0.00362 u	0.0145 u	0.00362 u	0.0145 u
IA06-SB04	11-Apr-05	LO-IA06-SB04-1	3-10'	8081A	1	0.0044 u	0.0044 u	0.0044 u	0.0022 u	0.0022 u	0.0022 u	0.038 ep	0.022 u	0.0022 u	0.0044 u	0.0022 u	0.0044 u	0.0044 u	0.0044 u	0.0044 u	0.0022 u	0.0022 u	0.0013 jp	0.0022 u	-	0.022 u	-
	11-Apr-05	LO-IA06-SB04-1	3-10'	8081A	2	0.0089 u	0.0089 u	0.0089 u	0.0044 u	0.0044 u	0.0044 u	0.032 dp	0.044 u	0.0044 u	0.0089 u	0.0044 u	0.0089 u	0.0089 u	0.0089 u	0.0089 u	0.0044 u	0.0044 u	0.0044 u	0.0044 u	-	0.044 u	-
	11-Apr-05	LO-IA06-SB04-1	0-3'	8081A	1	0.0037 u	0.011	0.01	0.0019 u	0.0019 u	0.0019 u	0.0019 u	0.019 u	0.0019 u	0.0037 u	0.0019 u	0.0037 u	0.0037 u	0.0037 u	0.0037 u	0.0019 u	0.0019 u	0.0019 u	0.0019 u	-	0.019 u	-
IA06-SB06	11-Apr-05	LO-IA06-SB06-1	3-10'	8081A	1	0.024	0.0037 j	0.011	0.0019 u	0.0019 u	0.0019 u	0.02 p	0.019 u	0.0019 u	0.0038 u	0.0019 u	0.0038 u	0.0038 u	0.0038 u	0.0038 u	0.0019 u	0.0019 u	0.0019 u	0.0019 u	-	0.019 u	-
	11-Apr-05	LO-IA06-SB06-1	0-3'	8081A	3	0.076	0.012	0.072	0.0059 u	0.0059 u	0.0059 u	0.017 p	0.059 u	0.0059 u	0.012 u	0.0059 u	0.012 u	0.012 u	0.012 u	0.012 u	0.0059 u	0.0059 u	0.0059 u	0.0059 u	-	0.059 u	-
IA06-SD06	13-Apr-05	LO-IA06-SD06-1	0-1.5'	8081A	20	0.22	**0.95**	**0.72**	**0.054 u**	0.054 u	0.054 u	0.054 u	0.54 u	0.054 u	**0.11 u**	0.054 u	0.11 u	0.11 u	0.11 u	0.11 u	0.054 u	0.054 u	0.054 u	**0.054 u**	-	0.54 u	-
IA06-SD17	13-Apr-05	LO-IA06-SD17-1	0-1.5'	8081A	10	0.05 u	**0.3**	**0.2**	0.025 u	0.025 u	0.025 u	0.025 u	0.25 u	0.025 u	**0.05 u**	0.025 u	0.05 u	0.05 u	0.05 u	0.05 u	0.025 u	0.025 u	0.025 u	0.025 u	-	0.25 u	-
IA06-SS08	11-Apr-05	LO-IA06-SS08-1	0-1.5'	8081A	1	0.0036 u	0.0034 j	0.0041	0.0018 u	0.0018 u	0.0018 u	0.0018 u	0.018 u	0.0018 u	0.0036 u	0.0018 u	0.0036 u	0.0036 u	0.0036 u	0.0036 u	0.0018 u	0.0018 u	0.0018 u	0.0018 u	-	0.018 u	-
IA06-SS16	11-Apr-05	LO-IA06-SS16-1	0-1.5'	8081A	1	0.0035 u	0.0022 j	0.0027 j	0.0018 u	0.0018 u	0.0018 u	0.0017 jp	0.018 u	0.0018 u	0.0035 u	0.0018 u	0.0035 u	0.0035 u	0.0035 u	0.0035 u	0.0018 u	0.0018 u	0.0018 u	0.0018 u	-	0.018 u	-
	11-Apr-05	LO-IA06-SS16-1-D	0-1.5'	8081A	1	0.0033 u	0.0019 j	0.0024 j	0.0017 u	0.0017 u	0.0017 u	0.0061 p	0.017 u	0.0017 u	0.0033 u	0.0017 u	0.0033 u	0.0033 u	0.0033 u	0.0033 u	0.0017 u	0.0017 u	0.0017 u	0.0017 u	-	0.017 u	-
IA06-SS35	12-Apr-05	LO-IA06-SS35-1	0-1.5'	8081A	2	0.0077 u	0.019	0.073	0.0039 u	0.0039 u	0.0039 u	0.0039 u	0.039 u	0.0039 u	0.0077 u	0.0039 u	0.0077 u	0.0077 u	0.0077 u	0.0077 u	0.0039 u	0.0039 u	0.0039 u	0.0039 u	-	0.039 u	-
IA06-SS40	12-Apr-05	LO-IA06-SS40-1	0-1.5'	8081A	3	0.011 u	0.0078 j	0.018	0.0039 j	0.0057 u	0.0057 u	0.0057 u	0.057 u	0.0057 u	**0.054**	0.0057 u	0.011 u	0.011 u	0.011 u	0.011 u	0.0057 u	0.0057 u	0.0057 u	0.0057 u	-	0.057 u	-
IA06-SS45	13-Apr-05	LO-IA06-SS25-1	0-1.5'	8081A	1	0.004 u	0.004 u	0.0021 j	0.002 u	0.002 u	0.002 u	0.014 p	0.02 u	0.002 u	0.004 u	0.002 u	0.004 u	0.004 u	0.004 u	0.004 u	0.002 u	0.002 u	0.002 u	0.002 u	-	0.02 u	-

Location

Notes:

NC No criteria listed under the regulation cited
ND Non-detect result (Original data unavailable - neither value nor detection limit provided)
- Parameter not analyzed

Analytic Flags:

u Not detected above laboratory reporting limits
j Estimated value - parameter detected between laboratory reporting limit and half of the laboratory reporting limit.
e Value exceeds analytical calibration limits
b Parameter detected in quality control blank and sample

Highlighting:

Value or Detection Limit exceeds Criteria 1 only
Value or Detection Limit exceeds Criteria 2 only
Value or Detection Limit exceeds both criteria

SSI - Summary of Pesticides Soil Analytical Results

Table 5-2e

Supplemental Site Investigation

Analytic Method: 8081A
Sample Matrix: Soil
Reporting Units: mg/kg
Sample Dates: 29-Nov-2004 to 13-Apr-2005

						4,4-DDD	4,4-DDE	4,4-DDT	Aldrin	Alpha-BHC	Alpha-Chlordane	Beta-BHC	Chlordane	Delta-BHC	Dieldrin	Endosulfan I	Endosulfan II	Endosulfan Sulfate	Endrin	Endrin Ketone	Gamma-BHC (Lindane)	Gamma-Chlordane	Heptachlor	Heptachlor Epoxide	Hexachlorobenzene	Methoxychlor	Toxaphene
	SSI Project Action Limit (PAL) - Wave 2 (Pesticides)					0.24	0.17	0.17	0.029	0.09	NC	0.32	0.7	NC	0.03	NC	1	NC	1.8	NC	0.44	NC	0.11	0.053	0.3	31	NC
	Secondary Regulatory Criteria Not Selected																										
	Date	Sample ID	Depth	Method	Dilution																						
IA08-SB01	30-Nov-04	GR-IA08-SB01-1	0-3'	8081A	5	0.0181 u	0.0181 u	0.0181 u	0.0181 u	0.0181 u	-	0.0181 u	0.0725 u	0.0181 u	0.0181 u	0.0181 u	0.0181 u	0.0181 u	0.0181 u	0.0181 u	0.0181 u	-	0.0181 u	0.0181 u	0.0725 u	0.0181 u	0.0725 u
	30-Nov-04	GR-IA08-SB01-1	3-10'	8081A	5	0.0175 u	0.0175 u	0.0175 u	0.0175 u	0.0175 u	-	0.0175 u	0.0702 u	0.0175 u	0.0175 u	0.0175 u	0.0175 u	0.0175 u	0.0175 u	0.0175 u	0.0175 u	-	0.0175 u	0.0175 u	0.0702 u	0.0175 u	0.0702 u
	30-Nov-04	GR-IA08-SB01-1-D	3-10'	8081A	5	0.0175 u	0.0175 u	0.0175 u	0.0175 u	0.0175 u	-	0.0175 u	0.0702 u	0.0175 u	0.0175 u	0.0175 u	0.0175 u	0.0175 u	0.0175 u	0.0175 u	0.0175 u	-	0.0175 u	0.0175 u	0.0702 u	0.0175 u	0.0702 u
IA08-SB09	16-Dec-04	GR-IA08-SB09-1	0-3'	8081A	1	0.00358 u	0.00464	0.00358 u	0.00358 u	0.00358 u	-	0.00358 u	0.0143 u	0.00358 u	0.00358 u	0.00358 u	0.00358 u	0.00358 u	0.00358 u	0.00358 u	0.00358 u	-	0.00358 u	0.00358 u	0.0143 u	0.00358 u	0.0143 u
	16-Dec-04	GR-IA08-SB09-1	3-10'	8081A	1	0.00351 u	0.00351 u	0.00351 u	0.00351 u	0.00351 u	-	0.00351 u	0.014 u	0.00351 u	0.00351 u	0.00351 u	0.00351 u	0.00351 u	0.00351 u	0.00351 u	0.00351 u	-	0.00351 u	0.00351 u	0.014 u	0.00351 u	0.014 u
IA09-SB01	29-Nov-04	CA-IA09-SB01-1	0-3'	8081A	1	0.00366 u	0.00366 u	0.00366 u	0.00366 u	0.00366 u	-	0.00366 u	0.0146 u	0.00366 u	0.00366 u	0.00366 u	0.00366 u	0.00366 u	0.00366 u	0.00366 u	0.00366 u	-	0.00366 u	0.00366 u	0.0146 u	0.00366 u	0.0146 u
	29-Nov-04	CA-IA09-SB01-1	3-10'	8081A	1	0.0037 u	0.0037 u	0.0037 u	0.0037 u	0.0037 u	-	0.0037 u	0.0148 u	0.0037 u	0.0037 u	0.0037 u	0.0037 u	0.0037 u	0.0037 u	0.0037 u	0.0037 u	-	0.0037 u	0.0037 u	0.0148 u	0.0037 u	0.0148 u
IA10-SB01	13-Dec-04	GR-IA10-SB01-1	0-3'	8081A	1	0.00379 u	0.00509	0.00476	0.00379 u	0.00379 u	-	0.00379 u	0.0152 u	0.00379 u	0.00379 u	0.00379 u	0.00379 u	0.00379 u	0.00379 u	0.00379 u	0.00379 u	-	0.00379 u	0.00379 u	0.0152 u	0.00379 u	0.0152 u
	13-Dec-04	GR-IA10-SB01-1	3-10'	8081A	1	0.00351 u	0.00351 u	0.00351 u	0.00351 u	0.00351 u	-	0.00351 u	0.014 u	0.00351 u	0.00351 u	0.00351 u	0.00351 u	0.00351 u	0.00351 u	0.00351 u	0.00351 u	-	0.00351 u	0.00351 u	0.014 u	0.00351 u	0.014 u
IA10-SB02	10-Dec-04	GR-IA10-SB02-1	0-3'	8081A	2	0.00725 u	0.00725 u	0.00725 u	0.00725 u	0.00725 u	-	0.00725 u	0.029 u	0.00725 u	0.00725 u	0.00725 u	0.00725 u	0.00725 u	0.00725 u	0.00725 u	0.00725 u	-	0.00725 u	0.00725 u	0.029 u	0.00725 u	0.029 u
	10-Dec-04	GR-IA10-SB02-1	3-10'	8081A	2	0.0366 u	0.0366 u	0.0366 u	**0.0366 u**	0.0366 u	-	0.0366 u	0.146 u	0.0366 u	**0.0366 u**	0.0366 u	0.0366 u	0.0366 u	0.0366 u	0.0366 u	0.0366 u	-	0.0366 u	0.0366 u	0.146 u	0.0366 u	0.146 u
	10-Dec-04	GR-IA10-SB02-1-D	3-10'	8081A	2	0.00741 u	0.00741 u	0.00741 u	0.00741 u	0.00741 u	-	0.00741 u	0.0296 u	0.00741 u	0.00741 u	0.00741 u	0.00741 u	0.00741 u	0.00741 u	0.00741 u	0.00741 u	-	0.00741 u	0.00741 u	0.0296 u	0.00741 u	0.0296 u
IA10-SB03	15-Dec-04	GR-IA10-SB03-1	0-3'	8081A	1	0.0037 u	0.00393	0.00465	0.0037 u	0.0037 u	-	0.0037 u	0.0148 u	0.0037 u	**0.0383**	0.0037 u	0.0037 u	0.0037 u	0.0037 u	0.0037 u	0.0037 u	-	0.0037 u	0.0037 u	0.0148 u	0.0037 u	0.0148 u
	15-Dec-04	GR-IA10-SB03-1	3-10'	8081A	1	0.00366 u	0.00366 u	0.00366 u	0.00366 u	0.00366 u	-	0.00366 u	0.0146 u	0.00366 u	0.00564	0.00366 u	0.00366 u	0.00366 u	0.00366 u	0.00366 u	0.00366 u	-	0.00366 u	0.00366 u	0.0146 u	0.00366 u	0.0146 u
IA10-SB04	16-Dec-04	GR-IA10-SB04-1	0-3'	8081A	1	0.0037 u	0.013	0.0128	0.0037 u	0.0037 u	-	0.0037 u	0.0148 u	0.0037 u	0.0037 u	0.0037 u	0.0037 u	0.0037 u	0.0037 u	0.0037 u	0.0037 u	-	0.0037 u	0.0037 u	0.0148 u	0.0037 u	0.0148 u
	16-Dec-04	GR-IA10-SB04-1	3-10'	8081A	1	0.00351 u	0.00351 u	0.00351 u	0.00351 u	0.00351 u	-	0.00351 u	0.014 u	0.00351 u	0.00351 u	0.00351 u	0.00351 u	0.00351 u	0.00351 u	0.00351 u	0.00351 u	-	0.00351 u	0.00351 u	0.014 u	0.00351 u	0.014 u
IA11-SB01	29-Nov-04	LO-IA11-SB01-1	0-3'	8081A	50	0.203 u	**0.203 u**	**0.203 u**	**1.06**	**0.203 u**	-	0.203 u	**0.813 u**	0.203 u	**0.732**	0.203 u	0.203 u	0.203 u	0.203 u	0.203 u	0.203 u	-	**0.203 u**	**0.203 u**	**0.813 u**	0.203 u	0.813 u
	29-Nov-04	LO-IA11-SB01-1	3-10'	8081A	5	0.0177 u	0.0177 u	0.0177 u	**0.0826**	0.0177 u	-	0.0177 u	0.0709 u	0.0177 u	**0.0661**	0.0177 u	0.0177 u	0.0177 u	0.0177 u	0.0177 u	0.0177 u	-	0.0177 u	0.0177 u	0.0709 u	0.0177 u	0.0709 u
IA11-SB03	28-Jan-05	LO-IA11-SB03-1	0-3'	8081A	1	0.00362 u	0.00362 u	0.00362 u	0.00402	0.00362 u	-	0.00362 u	0.0145 u	0.00362 u	0.00384	0.00362 u	0.00362 u	0.00362 u	0.00362 u	0.00362 u	0.00362 u	-	0.00362 u	0.00362 u	0.0145 u	0.00362 u	0.0145 u
IA11-SB04	28-Jan-05	LO-IA11-SB04-1	0-3'	8081A	1	0.00362 u	0.00362 u	0.00362 u	0.00362 u	0.00362 u	-	0.00362 u	0.0145 u	0.00362 u	0.00912	0.00362 u	0.00362 u	0.00362 u	0.00362 u	0.00362 u	0.00362 u	-	0.00362 u	0.00362 u	0.0145 u	0.00362 u	0.0145 u
IA11-SB05	28-Jan-05	LO-IA11-SB05-1	0-3'	8081A	5	0.0187 u	0.0187 u	0.0187 u	0.0215	0.0187 u	-	0.0187 u	0.0749 u	0.0187 u	**0.0818**	0.0187 u	0.0187 u	0.0187 u	0.0187 u	0.0187 u	0.0187 u	-	0.0187 u	0.0187 u	0.0749 u	0.0187 u	0.0749 u
IA11-SB06	28-Jan-05	LO-IA11-SB06-1	0-3'	8081A	20	-	-	-	**0.214**	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	28-Jan-05	LO-IA11-SB06-1	0-3'	8081A	5	0.0181 u	0.0181 u	0.0181 u	0.0181 u	0.0181 u	-	0.0181 u	0.0725 u	0.0181 u	**0.162**	0.0181 u	0.0181 u	0.0181 u	0.0181 u	0.0181 u	0.0181 u	-	0.0181 u	0.0181 u	0.0725 u	0.0181 u	0.0725 u
SH-PD-01	13-Apr-05	SH-942-PD01-1	--	8081A	100	**0.4 u**	**0.4 u**	**0.4 u**	**0.13 j**	**0.2 u**	0.2 u	0.2 u	**2 u**	0.2 u	**4.2**	0.2 u	0.4 u	0.4 u	0.4 u	0.4 u	0.2 u	0.2 u	**0.2 u**	**0.2 u**	-	2 u	-
SH-PD-02	13-Apr-05	SH-931-PD02-1	--	8081A	400	**1.5 u**	**1.5 u**	**1.5 u**	**5**	**0.73 u**	0.73 u	**0.73 u**	**7.3 u**	0.73 u	**6.4**	0.73 u	**1.5 u**	1.5 u	1.5 u	1.5 u	**0.73 u**	0.73 u	**0.73 u**	**0.73 u**	-	7.3 u	-

Location

Notes:

NC No criteria listed under the regulation cited
ND Non-detect result (Original data unavailable - neither value nor detection limit provided)
- Parameter not analyzed

Analytic Flags:

u Not detected above laboratory reporting limits
j Estimated value - parameter detected between laboratory reporting limit and half of the laboratory reporting limit.
e Value exceeds analytical calibration limits
b Parameter detected in quality control blank and sample

Highlighting:

Value or Detection Limit exceeds Criteria 1 only
Value or Detection Limit exceeds Criteria 2 only
Value or Detection Limit exceeds both criteria

SSI - Summary of Target Analyte List Metals Soil Analytical Results

Table 5-2f

PASI - SSI

Analytic Method: 6010B and 7471A
Sample Matrix: Soil
Reporting Units: mg/kg
Sample Dates: 03-Nov-2004 to 02-May-2005

						Aluminum	Antimony	Arsenic	Barium	Beryllium	Cadmium	Calcium	Chromium	Cobalt	Copper	Iron	Lead	Magnesium	Manganese	Mercury	Nickel	Potassium	Selenium	Silver	Sodium	Thallium	Vanadium	Zinc
SSI Project Action Limit (PAL) - Wave 2 (Metals)						7600	3.1	0.39	540	0.7	2	NC	30	900	310	2300	300	NC	180	2.3	20	NC	39	39	NC	0.52	55	2300
Secondary Regulatory Criteria Not Selected																												
	Date	Sample ID	Depth	Method	Dilution																							
IA01-SB01	29-Nov-04	GR-IA01-SB01-1	0-3'	6010B	1	6300	2.2 u	**19**	19	0.22 u	0.45 u	590	12	5.1	11	**8600**	12	1900	**210**	-	15	710	2.2 u	0.45 u	90 u	**2.2 u**	9.9	25
	29-Nov-04	GR-IA01-SB01-1	0-3'	7471A	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.034 j	-	-	-	-	-	-	-	-
	29-Nov-04	GR-IA01-SB01-1	3-10'	6010B	1	6500	2.1 u	**34**	22	0.21 u	0.42 u	410	16	7.8	18	**12000**	11	2900	**330**	-	**27**	1100	2.1 u	0.42 u	84 u	**2.1 u**	11	27
	29-Nov-04	GR-IA01-SB01-1	3-10'	7471A	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.014 j	-	-	-	-	-	-	-	-
IA01-SB02	10-Dec-04	GR-IA01-SB02-1	0-3'	6010B	1	6200	2.2 u	**36**	20	0.22 u	0.44 u	1200	17	7.1	16	**12000**	9.7	3000	**280**	-	**26**	890	2.2 u	0.44 u	88 u	**2.2 u**	11	25
	10-Dec-04	GR-IA01-SB02-1	0-3'	7471A	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.0091 j	-	-	-	-	-	-	-	-
	10-Dec-04	GR-IA01-SB02-1	3-10'	6010B	1	6300	2.1 u	**28**	21	0.21 u	0.43 u	700	18	6.8	15	**11000**	7.4	3200	**260**	-	**24**	980	2.1 u	0.43 u	86 u	**2.1 u**	11	22
	10-Dec-04	GR-IA01-SB02-1	3-10'	7471A	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.0044 j	-	-	-	-	-	-	-	-
IA01-SB03	10-Dec-04	GR-IA01-SB03-1	3-10'	6010B	1	6600	2.1 u	**33**	20	0.21 u	0.43 u	610	17	7.3	18	**11000**	7.4	3100	**210**	-	**22**	1000	2.1 u	0.43 u	86 u	**2.1 u**	11	21
	10-Dec-04	GR-IA01-SB03-1	3-10'	7471A	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.087 u	-	-	-	-	-	-	-	-
	10-Dec-04	GR-IA01-SB03-1-D	3-10'	6010B	1	7300	2.1 u	**35**	22	0.21 u	0.43 u	560	18	7.1	20	**12000**	6.9	3400	**220**	-	**22**	1100	2.1 u	0.43 u	86 u	**2.1 u**	12	22
	10-Dec-04	GR-IA01-SB03-1-D	3-10'	7471A	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.087 u	-	-	-	-	-	-	-	-
	10-Dec-04	GR-IA01-SB03-1-M	0-3'	6010B	1	**9000**	2.3 u	**20**	13	0.23 u	0.45 u	550	14	5.1	8.3	**10000**	8.3	2200	140	-	16	560	2.3 u	0.45 u	91 u	**2.3 u**	12	21
	10-Dec-04	GR-IA01-SB03-1-M	0-3'	7471A	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.01 j	-	-	-	-	-	-	-	-
IA01-SB04	10-Dec-04	GR-IA01-SB04-1	0-3'	6010B	1	6500	2.2 u	**9.1**	10	0.22 u	0.45 u	580	7.2	2.8	3.8	**6300**	8.1	900	120	-	6.9	280	2.2 u	0.45 u	90 u	**2.2 u**	7.8	14
	10-Dec-04	GR-IA01-SB04-1	0-3'	7471A	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.017 j	-	-	-	-	-	-	-	-
	10-Dec-04	GR-IA01-SB04-1-M	3-10'	6010B	1	4700	2.1 u	**46**	13	0.21 u	0.43 u	450	14	5.4	8.7	**8300**	5.8	2200	**190**	-	16	720	2.1 u	0.43 u	85 u	**2.1 u**	8.1	15
	10-Dec-04	GR-IA01-SB04-1-M	3-10'	7471A	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.086 u	-	-	-	-	-	-	-	-
IA02-SB01	30-Nov-04	GR-IA02-SB01-1	0-3'	6010B	1	**7700**	2.3 u	**14**	18	0.23 u	0.46 u	110	10	3.9	5.8	**8600**	6.9	1300	**240**	-	9.3	440	2.3 u	0.46 u	93 u	**2.3 u**	10	18
	30-Nov-04	GR-IA02-SB01-1	0-3'	7471A	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.018 j	-	-	-	-	-	-	-	-
	30-Nov-04	GR-IA02-SB01-1	3-10'	6010B	1	7100	2.1 u	**17**	29	0.21 u	0.42 u	320	10	5.8	10	**9800**	6.2	2000	160	-	12	1300	2.1 u	0.42 u	85 u	**2.1 u**	12	22
	30-Nov-04	GR-IA02-SB01-1	3-10'	7471A	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.083 u	-	-	-	-	-	-	-	-
IA02-SB02	02-Dec-04	GR-IA02-SB02-1	0-3'	6010B	1	**11000**	2.2 u	**15**	49	0.22 u	0.45 u	270	12	7.2	13	**13000**	6.6	2300	**180**	-	12	1900	2.2 u	0.45 u	90 u	**2.2 u**	17	27
	02-Dec-04	GR-IA02-SB02-1	0-3'	7471A	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.0065 j	-	-	-	-	-	-	-	-
	02-Dec-04	GR-IA02-SB02-1-M	3-10'	6010B	1	3800	2.2 u	**18**	16	0.22 u	0.43 u	350	6.2	3.9	8.9	**6000**	4.6	1100	120	-	11	540	2.2 u	0.43 u	87 u	**2.2 u**	5.9	15
	02-Dec-04	GR-IA02-SB02-1-M	3-10'	7471A	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.079 u	-	-	-	-	-	-	-	-
IA02-SB03	02-Dec-04	GR-IA02-SB03-1	0-3'	6010B	1	6500	2.3 u	**17**	14	0.23 u	0.46 u	160	8.8	3.7	5	**7500**	7.4	1100	**220**	-	10	150	2.3 u	0.46 u	92 u	**2.3 u**	8.9	15
	02-Dec-04	GR-IA02-SB03-1	0-3'	7471A	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.017 j	-	-	-	-	-	-	-	-
	02-Dec-04	GR-IA02-SB03-1	3-10'	6010B	1	3900	2.1 u	**19**	12	0.21 u	0.41 u	1100	9.2	4.3	9.2	**7500**	5.4	1700	150	-	15	540	2.1 u	0.41 u	83 u	**2.1 u**	6.8	15
	02-Dec-04	GR-IA02-SB03-1	3-10'	7471A	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.084 u	-	-	-	-	-	-	-	-
	02-Dec-04	GR-IA02-SB03-1-D	3-10'	6010B	1	3600	2.1 u	**19**	10	0.21 u	0.42 u	1200	8.9	4.2	8.5	**7000**	5.7	1500	160	-	14	400	2.1 u	0.42 u	84 u	**2.1 u**	6	14
	02-Dec-04	GR-IA02-SB03-1-D	3-10'	7471A	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.082 u	-	-	-	-	-	-	-	-

Location

Notes:

NC No criteria listed under the regulation cited
ND Non-detect result (Original data unavailable - neither value nor detection limit provided)
- Parameter not analyzed

Analytic Flags:

u Not detected above laboratory reporting limits
j Estimated value - parameter detected between laboratory reporting limit and half of the laboratory reporting limit.
e Value exceeds analytical calibration limits
b Parameter detected in quality control blank and sample

Highlighting:

Value or Detection Limit exceeds Criteria 1 only
Value or Detection Limit exceeds Criteria 2 only
Value or Detection Limit exceeds both criteria

PASI - SSI

Analytic Method: 6010B and 7471A
Sample Matrix: Soil
Reporting Units: mg/kg
Sample Dates: 03-Nov-2004 to 02-May-2005

						Aluminum	Antimony	Arsenic	Barium	Beryllium	Cadmium	Calcium	Chromium	Cobalt	Copper	Iron	Lead	Magnesium	Manganese	Mercury	Nickel	Potassium	Selenium	Silver	Sodium	Thallium	Vanadium	Zinc
SSI Project Action Limit (PAL) - Wave 2 (Metals)						7600	3.1	0.39	540	0.7	2	NC	30	900	310	2300	300	NC	180	2.3	20	NC	39	39	NC	0.52	55	2300
Secondary Regulatory Criteria Not Selected																												
	Date	Sample ID	Depth	Method	Dilution																							
IA02-SB04	02-Dec-04	GR-IA02-SB04-1	0-3'	6010B	1	7100	2.4 u	**29**	18	0.24 u	0.48 u	250	14	7	17	**12000**	14	2400	**520**	-	**24**	530	2.4 u	0.48 u	97 u	**2.4 u**	12	24
	02-Dec-04	GR-IA02-SB04-1	0-3'	7471A	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.039 j	-	-	-	-	-	-	-	-
	02-Dec-04	GR-IA02-SB04-1	3-10'	6010B	1	5100	2.1 u	**27**	16	0.21 u	0.42 u	430	16	6	12	**9600**	7	2900	**200**	-	**20**	780	2.1 u	0.42 u	84 u	**2.1 u**	9.8	19
	02-Dec-04	GR-IA02-SB04-1	3-10'	7471A	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.079 u	-	-	-	-	-	-	-	-
	02-Dec-04	GR-IA02-SB04-1-D	0-3'	6010B	1	**7600**	2.4 u	**28**	20	0.24 u	0.49 u	360	15	6.1	14	**11000**	15	2400	**560**	-	**22**	510	2.4 u	0.49 u	98 u	**2.4 u**	12	23
	02-Dec-04	GR-IA02-SB04-1-D	0-3'	7471A	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.046 j	-	-	-	-	-	-	-	-
IA02-SB05	02-Dec-04	GR-IA02-SB05-1	0-3'	6010B	1	6100	2.2 u	**13**	11	0.22 u	0.45 u	970	7.8	3.1	5.7	**6800**	6	1400	120	-	8.3	220	2.2 u	0.45 u	89 u	**2.2 u**	7.3	13
	02-Dec-04	GR-IA02-SB05-1	0-3'	7471A	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.01 j	-	-	-	-	-	-	-	-
	02-Dec-04	GR-IA02-SB05-1	3-10'	6010B	1	2900	2.1 u	**11**	9.9	0.21 u	0.42 u	2400	5.9	2.6	5.7	**4800**	3.4	2100	88	-	7.8	430	2.1 u	0.42 u	84 u	**2.1 u**	4.6	12
	02-Dec-04	GR-IA02-SB05-1	3-10'	7471A	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.084 u	-	-	-	-	-	-	-	-
IA02-SB06	02-Dec-04	GR-IA02-SB06-1	0-3'	6010B	1	7300	2.2 u	**27**	21	0.22 u	0.44 u	420	22	8	12	**10000**	9.7	3400	**260**	-	**25**	1200	2.2 u	0.44 u	87 u	**2.2 u**	13	22
	02-Dec-04	GR-IA02-SB06-1	0-3'	7471A	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.014 j	-	-	-	-	-	-	-	-
	02-Dec-04	GR-IA02-SB06-1	3-10'	6010B	1	**7800**	2.1 u	**31**	29	0.21 u	0.42 u	610	24	9.5	20	**14000**	10	4300	**350**	-	**32**	1600	2.1 u	0.42 u	85 u	**2.1 u**	15	28
	02-Dec-04	GR-IA02-SB06-1	3-10'	7471A	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.083 u	-	-	-	-	-	-	-	-
IA02-SB07	06-Dec-04	GR-IA02-SB07-1	0-3'	6010B	1	**10000**	2.4 u	**34**	24	0.24 u	0.47 u	460	25	7.5	12	**14000**	18	3600	**390**	-	**26**	700	2.4 u	0.47 u	95 u	**2.4 u**	19	30
	06-Dec-04	GR-IA02-SB07-1	0-3'	7471A	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.049 j	-	-	-	-	-	-	-	-
	06-Dec-04	GR-IA02-SB07-1	3-10'	6010B	1	**8700**	2.2 u	**24**	22	0.22 u	0.45 u	240	16	6.7	12	**11000**	7.3	2700	**210**	-	19	670	2.2 u	0.45 u	90 u	**2.2 u**	13	20
	06-Dec-04	GR-IA02-SB07-1	3-10'	7471A	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.0082 j	-	-	-	-	-	-	-	-
IA02-SB08	06-Dec-04	GR-IA02-SB08-1	0-3'	6010B	1	**8600**	2.2 u	**21**	12	0.22 u	0.44 u	510	15	6.2	8.1	**10000**	7.3	2400	130	-	18	750	2.2 u	0.44 u	87 u	**2.2 u**	12	18
	06-Dec-04	GR-IA02-SB08-1	0-3'	7471A	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.014 j	-	-	-	-	-	-	-	-
	06-Dec-04	GR-IA02-SB08-1	3-10'	6010B	1	5200	2.1 u	**24**	17	0.21 u	0.42 u	590	16	6.3	10	**9300**	6.5	2300	**200**	-	**22**	980	2.1 u	0.42 u	84 u	**2.1 u**	8.9	18
	06-Dec-04	GR-IA02-SB08-1	3-10'	7471A	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.086 u	-	-	-	-	-	-	-	-
	06-Dec-04	GR-IA02-SB08-1-D	0-3'	6010B	1	**8400**	2.2 u	**20**	12	0.22 u	0.44 u	180	14	5.2	7.6	**9700**	7	2200	97	-	15	680	2.2 u	0.44 u	88 u	**2.2 u**	11	16
	06-Dec-04	GR-IA02-SB08-1-D	0-3'	7471A	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.023 j	-	-	-	-	-	-	-	-
IA02-SB09	07-Dec-04	GR-IA02-SB09-1	0-3'	6010B	1	**13000**	2.6 u	**38**	40	0.26 u	0.51 u	1100	**32**	9.5	24	**16000**	29	5500	**470**	-	**31**	2000	2.6 u	0.51 u	100 u	**2.6 u**	24	46
	07-Dec-04	GR-IA02-SB09-1	0-3'	7471A	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.06 j	-	-	-	-	-	-	-	-
	07-Dec-04	GR-IA02-SB09-1	3-10'	6010B	1	7400	2.1 u	**30**	26	0.21 u	0.42 u	1200	23	8.3	16	**13000**	9	4300	**280**	-	**27**	1700	2.1 u	0.42 u	84 u	**2.1 u**	15	30
	07-Dec-04	GR-IA02-SB09-1	3-10'	7471A	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.084 u	-	-	-	-	-	-	-	-
IA02-SB10	07-Dec-04	GR-IA02-SB10-1	0-3'	6010B	1	**9500**	2.2 u	**37**	21	0.22 u	0.45 u	480	26	7.9	27	**13000**	13	4200	**220**	-	**31**	1400	2.2 u	0.45 u	90 u	**2.2 u**	15	33
	07-Dec-04	GR-IA02-SB10-1	0-3'	7471A	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.1	-	-	-	-	-	-	-	-
	07-Dec-04	GR-IA02-SB10-1	3-10'	6010B	1	7300	2.1 u	**40**	23	0.21 u	0.42 u	500	22	7.7	16	**12000**	8.1	3900	**260**	-	**27**	1200	2.1 u	0.42 u	85 u	**2.1 u**	14	26
	07-Dec-04	GR-IA02-SB10-1	3-10'	7471A	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.015 j	-	-	-	-	-	-	-	-
	07-Dec-04	GR-IA02-SB10-1-D	3-10'	6010B	1	6800	2.1 u	**38**	20	0.21 u	0.42 u	490	21	7.6	16	**12000**	9.6	3700	**270**	-	**27**	1100	2.1 u	0.42 u	85 u	**2.1 u**	13	25
	07-Dec-04	GR-IA02-SB10-1-D	3-10'	7471A	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.073 u	-	-	-	-	-	-	-	-

Location

Notes:

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Analytic Flags:

u Not detected above laboratory reporting limits
j Estimated value - parameter detected between laboratory reporting limit and half of the laboratory reporting limit.
e Value exceeds analytical calibration limits
b Parameter detected in quality control blank and sample

Highlighting:

Value or Detection Limit exceeds Criteria 1 only
Value or Detection Limit exceeds Criteria 2 only
Value or Detection Limit exceeds both criteria

PASI - SSI

Analytic Method: 6010B and 7471A
Sample Matrix: Soil
Reporting Units: mg/kg
Sample Dates: 03-Nov-2004 to 02-May-2005

						Aluminum	Antimony	Arsenic	Barium	Beryllium	Cadmium	Calcium	Chromium	Cobalt	Copper	Iron	Lead	Magnesium	Manganese	Mercury	Nickel	Potassium	Selenium	Silver	Sodium	Thallium	Vanadium	Zinc
SSI Project Action Limit (PAL) - Wave 2 (Metals)						7600	3.1	0.39	540	0.7	2	NC	30	900	310	2300	300	NC	180	2.3	20	NC	39	39	NC	0.52	55	2300
Secondary Regulatory Criteria Not Selected																												
	Date	Sample ID	Depth	Method	Dilution																							
IA02-SB11	08-Dec-04	GR-IA02-SB11-1	0-3'	6010B	1	**14000**	2.5 u	**30**	21	0.25 u	0.5 u	410	**30**	7.8	36	**17000**	24	5100	**230**	-	**29**	870	2.5 u	0.5 u	100 u	**2.5 u**	20	46
	08-Dec-04	GR-IA02-SB11-1	0-3'	7471A	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.34	-	-	-	-	-	-	-	-
	08-Dec-04	GR-IA02-SB11-1-M	3-10'	6010B	1	**13000**	2.2 u	**38**	52	0.22 u	0.43 u	700	**40**	10	19	**19000**	11	8200	**340**	-	**37**	3400	2.2 u	0.43 u	86 u	**2.2 u**	24	37
	08-Dec-04	GR-IA02-SB11-1-M	3-10'	7471A	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.079 u	-	-	-	-	-	-	-	-
IA02-SB12	03-Dec-04	GR-IA02-SB12-1	0-3'	6010B	1	7000	2.9 u	**24**	19	0.29 u	0.59 u	690	19	5.2	14	**9700**	23	2500	170	-	**22**	690	2.9 u	0.59 u	120 u	**0.65 j**	13	38
	03-Dec-04	GR-IA02-SB12-1	0-3'	7471A	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.079 j	-	-	-	-	-	-	-	-
	03-Dec-04	GR-IA02-SB12-1	3-10'	6010B	1	**10000**	2.2 u	**42**	38	0.22 u	0.44 u	780	**32**	13	21	**17000**	13	6000	**500**	-	**37**	2500	2.2 u	0.44 u	88 u	**0.67 j**	23	38
	03-Dec-04	GR-IA02-SB12-1	3-10'	7471A	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.082 u	-	-	-	-	-	-	-	-
IA02-SB13	13-Dec-04	GR-IA02-SB13-1	0-3'	6010B	1	7500	2.2 u	**13**	17	0.22 u	0.44 u	380	13	3.6	5.6	**7800**	7	2100	140	-	9.7	780	2.2 u	0.44 u	87 u	**2.2 u**	11	16
	13-Dec-04	GR-IA02-SB13-1	0-3'	7471A	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.013 j	-	-	-	-	-	-	-	-
	13-Dec-04	GR-IA02-SB13-1	3-10'	6010B	1	2700	2.1 u	**5.3**	7.6	0.21 u	0.42 u	260	4.5	2.4	3.6	**4200**	2.5	900	83	-	4.9	400	2.1 u	0.42 u	84 u	**2.1 u**	4.1	9.2
	13-Dec-04	GR-IA02-SB13-1	3-10'	7471A	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.086 u	-	-	-	-	-	-	-	-
	13-Dec-04	GR-IA02-SB13-1-D	3-10'	6010B	1	2900	2.1 u	**6.3**	9.6	0.21 u	0.42 u	310	4.8	2.6	4	**4600**	2.6	970	98	-	5.3	460	2.1 u	0.42 u	84 u	**2.1 u**	4.8	10
	13-Dec-04	GR-IA02-SB13-1-D	3-10'	7471A	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.076 u	-	-	-	-	-	-	-	-
IA02-SB14	03-Dec-04	GR-IA02-SB14-1	0-3'	6010B	1	**9000**	2.3 u	**9.7**	16	0.23 u	0.46 u	150	11	2.9	5.6	**7200**	5.9	1200	70	-	6.7	530	2.3 u	0.46 u	92 u	**2.3 u**	10	13
	03-Dec-04	GR-IA02-SB14-1	0-3'	7471A	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.023 j	-	-	-	-	-	-	-	-
	03-Dec-04	GR-IA02-SB14-1	3-10'	6010B	1	2200	2.1 u	**8.8**	7.8	0.21 u	0.42 u	220	4.9	2.4	6	**3700**	3.3	700	82	-	4.9	330	2.1 u	0.42 u	84 u	**2.1 u**	3.6	9.3
	03-Dec-04	GR-IA02-SB14-1	3-10'	7471A	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.085 u	-	-	-	-	-	-	-	-
	03-Dec-04	GR-IA02-SB14-1-D	0-3'	6010B	1	**9200**	2.3 u	**8.9**	16	0.23 u	0.46 u	230	12	2.5	5	**7200**	7.8	1200	60	-	6.2	460	2.3 u	0.46 u	93 u	**2.3 u**	11	13
	03-Dec-04	GR-IA02-SB14-1-D	0-3'	7471A	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.028 j	-	-	-	-	-	-	-	-
IA02-SB15	03-Dec-04	GR-IA02-SB15-1	0-3'	6010B	1	6500	2.2 u	**9.2**	11	0.22 u	0.45 u	250	8.1	2.9	5	**5700**	9.4	1000	100	-	6.3	320	2.2 u	0.45 u	90 u	**2.2 u**	7.8	13
	03-Dec-04	GR-IA02-SB15-1	0-3'	7471A	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.012 j	-	-	-	-	-	-	-	-
	03-Dec-04	GR-IA02-SB15-1	3-10'	6010B	1	2500	2 u	**8.9**	8.4	0.2 u	0.41 u	220	5.1	2.7	5.7	**3800**	3.6	730	84	-	6	310	2 u	0.41 u	82 u	**2 u**	3.7	9.7
	03-Dec-04	GR-IA02-SB15-1	3-10'	7471A	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.082 u	-	-	-	-	-	-	-	-
IA02-SB16	06-Dec-04	GR-IA02-SB16-1	0-3'	6010B	1	**11000**	2.3 u	**27**	28	0.23 u	0.46 u	460	28	7.8	12	**14000**	11	4700	**220**	-	**26**	2300	2.3 u	0.46 u	92 u	**2.3 u**	19	26
	06-Dec-04	GR-IA02-SB16-1	0-3'	7471A	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.032 j	-	-	-	-	-	-	-	-
	06-Dec-04	GR-IA02-SB16-1	3-10'	6010B	1	6600	2.1 u	**45**	24	0.21 u	0.42 u	670	24	10	15	**14000**	8.8	3600	**350**	-	**32**	1700	2.1 u	0.42 u	84 u	**2.1 u**	12	26
	06-Dec-04	GR-IA02-SB16-1	3-10'	7471A	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.088 u	-	-	-	-	-	-	-	-
IA02-SB17	07-Dec-04	GR-IA02-SB17-1	0-3'	6010B	1	6800	2.2 u	**11**	12	0.22 u	0.45 u	250	9.1	3	41	**6700**	6.4	1200	100	-	9.1	300	2.2 u	0.45 u	90 u	**2.2 u**	8.2	13
	07-Dec-04	GR-IA02-SB17-1	0-3'	7471A	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.016 j	-	-	-	-	-	-	-	-
	07-Dec-04	GR-IA02-SB17-1	3-10'	6010B	1	**7800**	2.2 u	**28**	32	0.22 u	0.44 u	710	21	7.9	25	**12000**	6.5	3700	**240**	-	**26**	1500	2.2 u	0.44 u	87 u	**2.2 u**	14	23
	07-Dec-04	GR-IA02-SB17-1	3-10'	7471A	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.0032 j	-	-	-	-	-	-	-	-

Location

Notes:

NC No criteria listed under the regulation cited
ND Non-detect result (Original data unavailable - neither value nor detection limit provided)
- Parameter not analyzed

Analytic Flags:

u Not detected above laboratory reporting limits
j Estimated value - parameter detected between laboratory reporting limit and half of the laboratory reporting limit.
e Value exceeds analytical calibration limits
b Parameter detected in quality control blank and sample

Highlighting:

Value or Detection Limit exceeds Criteria 1 only
Value or Detection Limit exceeds Criteria 2 only
Value or Detection Limit exceeds both criteria

SSI - Summary of Target Analyte List Metals Soil Analytical Results

Table 5-2f

PASI - SSI

Analytic Method: 6010B and 7471A
Sample Matrix: Soil
Reporting Units: mg/kg
Sample Dates: 03-Nov-2004 to 02-May-2005

						Aluminum	Antimony	Arsenic	Barium	Beryllium	Cadmium	Calcium	Chromium	Cobalt	Copper	Iron	Lead	Magnesium	Manganese	Mercury	Nickel	Potassium	Selenium	Silver	Sodium	Thallium	Vanadium	Zinc
SSI Project Action Limit (PAL) - Wave 2 (Metals)						7600	3.1	0.39	540	0.7	2	NC	30	900	310	2300	300	NC	180	2.3	20	NC	39	39	NC	0.52	55	2300
Secondary Regulatory Criteria Not Selected																												
	Date	Sample ID	Depth	Method	Dilution																							
IA02-SB18	08-Dec-04	GR-IA02-SB18-1	0-3'	6010B	1	6400	2.2 u	**11**	10	0.22 u	0.44 u	300	8.8	3.2	4.5	**6800**	4.4	1400	100	-	8.7	430	2.2 u	0.44 u	89 u	**2.2 u**	8	13
	08-Dec-04	GR-IA02-SB18-1	0-3'	7471A	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.011 j	-	-	-	-	-	-	-	-
	08-Dec-04	GR-IA02-SB18-1	3-10'	6010B	1	7000	2.1 u	**17**	15	0.21 u	0.43 u	330	19	4.9	8.6	**11000**	4.8	3800	**180**	-	18	680	2.1 u	0.43 u	86 u	**2.1 u**	12	21
	08-Dec-04	GR-IA02-SB18-1	3-10'	7471A	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.09	-	-	-	-	-	-	-	-
	08-Dec-04	GR-IA02-SB18-1-D	3-10'	6010B	1	6800	2.1 u	**21**	13	0.21 u	0.42 u	300	17	4.9	9.7	**12000**	5.6	3700	**200**	-	18	560	2.1 u	0.42 u	84 u	**2.1 u**	11	22
	08-Dec-04	GR-IA02-SB18-1-D	3-10'	7471A	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.076 u	-	-	-	-	-	-	-	-
IA02-SB19	08-Dec-04	GR-IA02-SB19-1	0-3'	6010B	1	6200	2.2 u	**13**	10	0.22 u	0.45 u	330	9.3	3.6	4.8	**7700**	8.1	1800	100	-	9.8	510	2.2 u	0.45 u	90 u	**2.2 u**	8.4	14
	08-Dec-04	GR-IA02-SB19-1	0-3'	7471A	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.0086 j	-	-	-	-	-	-	-	-
	08-Dec-04	GR-IA02-SB19-1	3-10'	6010B	1	**7900**	2.1 u	**23**	20	0.21 u	0.42 u	740	21	7	11	**12000**	5	4300	**210**	-	**24**	1100	2.1 u	0.42 u	84 u	**2.1 u**	12	24
	08-Dec-04	GR-IA02-SB19-1	3-10'	7471A	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.082 u	-	-	-	-	-	-	-	-
IA02-SB20	08-Dec-04	GR-IA02-SB20-1	0-3'	6010B	1	5100	2.2 u	**9**	15	0.22 u	0.45 u	750	6.3	2.7	4.2	**5900**	12	1000	140	-	6.9	400	2.2 u	0.45 u	90 u	**2.2 u**	7.3	25
	08-Dec-04	GR-IA02-SB20-1	0-3'	7471A	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.014 j	-	-	-	-	-	-	-	-
	08-Dec-04	GR-IA02-SB20-1-M	3-10'	6010B	1	5700	2.2 u	**32**	21	0.22 u	0.43 u	490	16	5.9	13	**10000**	7	2500	**200**	-	18	800	2.2 u	0.43 u	87 u	**2.2 u**	10	20
	08-Dec-04	GR-IA02-SB20-1-M	3-10'	7471A	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.088 u	-	-	-	-	-	-	-	-
IA02-SB21	08-Dec-04	GR-IA02-SB21-1	0-3'	6010B	1	5900	2.2 u	**10**	10	0.22 u	0.43 u	290	9.5	3.3	4.2	**6800**	5.1	1500	100	-	9.3	350	2.2 u	0.43 u	87 u	**2.2 u**	8.2	13
	08-Dec-04	GR-IA02-SB21-1	0-3'	7471A	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.0069 j	-	-	-	-	-	-	-	-
IA02-SB23	13-Dec-04	GR-IA02-SB23-1	0-3'	6010B	1	**13000**	2.2 u	**19**	27	0.22 u	0.45 u	1800	18	7.2	15	**16000**	13	3800	**310**	-	**25**	1000	2.2 u	0.45 u	89 u	**2.2 u**	13	32
	13-Dec-04	GR-IA02-SB23-1	0-3'	7471A	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.018 j	-	-	-	-	-	-	-	-
	13-Dec-04	GR-IA02-SB23-1	3-10'	6010B	1	**12000**	2.4 u	**28**	20	0.24 u	0.48 u	510	24	8.2	16	**17000**	10	5000	**280**	-	**27**	1000	2.4 u	0.48 u	96 u	**2.4 u**	16	30
	13-Dec-04	GR-IA02-SB23-1	3-10'	7471A	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.011 j	-	-	-	-	-	-	-	-
	13-Dec-04	GR-IA02-SB23-1-D	3-10'	6010B	1	**12000**	2.4 u	**28**	19	0.24 u	0.47 u	580	23	7.6	14	**16000**	10	4900	**250**	-	**25**	960	2.4 u	0.47 u	94 u	**2.4 u**	15	30
	13-Dec-04	GR-IA02-SB23-1-D	3-10'	7471A	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.008 j	-	-	-	-	-	-	-	-
IA02-SB24	13-Dec-04	GR-IA02-SB24-1	0-3'	6010B	1	**12000**	2.2 u	**30**	31	0.22 u	0.44 u	890	26	8.5	16	**16000**	11	4800	**290**	-	**27**	1400	2.2 u	0.44 u	89 u	**2.2 u**	17	35
	13-Dec-04	GR-IA02-SB24-1	0-3'	7471A	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.013 j	-	-	-	-	-	-	-	-
	13-Dec-04	GR-IA02-SB24-1	3-10'	6010B	1	**14000**	2.3 u	**19**	45	0.23 u	0.46 u	910	21	8.8	16	**20000**	9.1	4600	**330**	-	**27**	2200	2.3 u	0.46 u	92 u	**2.3 u**	18	41
	13-Dec-04	GR-IA02-SB24-1	3-10'	7471A	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.092 u	-	-	-	-	-	-	-	-
IA02-SB25	13-Dec-04	GR-IA02-SB25-1	0-3'	6010B	1	**14000**	2.2 u	**23**	32	0.22 u	0.45 u	420	20	8.9	17	**20000**	12	4400	**360**	-	**27**	1400	2.2 u	0.45 u	90 u	**2.2 u**	15	39
	13-Dec-04	GR-IA02-SB25-1	0-3'	7471A	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.0084 j	-	-	-	-	-	-	-	-
	13-Dec-04	GR-IA02-SB25-1	3-10'	6010B	1	**16000**	2.2 u	**21**	45	0.22 u	0.44 u	560	23	10	17	**22000**	13	4600	**400**	-	**30**	2300	2.2 u	0.44 u	88 u	**2.2 u**	18	44
	13-Dec-04	GR-IA02-SB25-1	3-10'	7471A	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.089 u	-	-	-	-	-	-	-	-
IA02-SB26	13-Dec-04	GR-IA02-SB26-1	0-3'	6010B	1	**12000**	2.3 u	**13**	22	0.23 u	0.46 u	430	13	4.1	5.2	**11000**	10	2000	170	-	11	400	2.3 u	0.46 u	93 u	**2.3 u**	13	21
	13-Dec-04	GR-IA02-SB26-1	0-3'	7471A	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.027 j	-	-	-	-	-	-	-	-
	13-Dec-04	GR-IA02-SB26-1	3-10'	6010B	1	**9600**	2.2 u	**26**	21	0.22 u	0.44 u	420	18	6.3	10	**12000**	6.9	3600	**200**	-	18	960	2.2 u	0.44 u	89 u	**2.2 u**	12	23
	13-Dec-04	GR-IA02-SB26-1	3-10'	7471A	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.011 j	-	-	-	-	-	-	-	-

Location

Notes:

NC No criteria listed under the regulation cited
ND Non-detect result (Original data unavailable - neither value nor detection limit provided)
- Parameter not analyzed

Analytic Flags:

u Not detected above laboratory reporting limits
j Estimated value - parameter detected between laboratory reporting limit and half of the laboratory reporting limit.
e Value exceeds analytical calibration limits
b Parameter detected in quality control blank and sample

Highlighting:

Value or Detection Limit exceeds Criteria 1 only
Value or Detection Limit exceeds Criteria 2 only
Value or Detection Limit exceeds both criteria

SSI - Summary of Target Analyte List Metals Soil Analytical Results

Table 5-2f

PASI - SSI

Analytic Method: 6010B and 7471A
Sample Matrix: Soil
Reporting Units: mg/kg
Sample Dates: 03-Nov-2004 to 02-May-2005

						Aluminum	Antimony	Arsenic	Barium	Beryllium	Cadmium	Calcium	Chromium	Cobalt	Copper	Iron	Lead	Magnesium	Manganese	Mercury	Nickel	Potassium	Selenium	Silver	Sodium	Thallium	Vanadium	Zinc
SSI Project Action Limit (PAL) - Wave 2 (Metals)						7600	3.1	0.39	540	0.7	2	NC	30	900	310	2300	300	NC	180	2.3	20	NC	39	39	NC	0.52	55	2300
Secondary Regulatory Criteria Not Selected																												
	Date	Sample ID	Depth	Method	Dilution																							
IA02-SB27	13-Dec-04	GR-IA02-SB27-1	0-3'	6010B	1	6800	2.2 u	**8.7**	36	0.22 u	0.44 u	980	18	4.2	6.4	**8200**	3.1	2500	170	-	10	1700	2.2 u	0.44 u	88 u	**2.2 u**	14	15
	13-Dec-04	GR-IA02-SB27-1	0-3'	7471A	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.082 u	-	-	-	-	-	-	-	-
	13-Dec-04	GR-IA02-SB27-1	3-10'	6010B	1	6400	2.2 u	**14**	24	0.22 u	0.44 u	730	12	6.4	13	**11000**	8	1900	**250**	-	18	1000	2.2 u	0.44 u	88 u	**2.2 u**	9.1	22
	13-Dec-04	GR-IA02-SB27-1	3-10'	7471A	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.085 u	-	-	-	-	-	-	-	-
IA02-SB28	13-Dec-04	GR-IA02-SB28-1	0-3'	6010B	1	7100	2.2 u	**25**	15	0.22 u	0.45 u	410	11	6	13	**9700**	11	1700	**200**	-	18	530	2.2 u	0.45 u	89 u	**2.2 u**	8.7	20
	13-Dec-04	GR-IA02-SB28-1	0-3'	7471A	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.014 j	-	-	-	-	-	-	-	-
	13-Dec-04	GR-IA02-SB28-1	3-10'	6010B	1	2800	2.1 u	**25**	8.4	0.21 u	0.42 u	2100	6.4	5.3	12	**7200**	6.4	1200	**190**	-	17	350	2.1 u	0.42 u	84 u	**2.1 u**	4.6	14
	13-Dec-04	GR-IA02-SB28-1	3-10'	7471A	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.08 u	-	-	-	-	-	-	-	-
IA02-SB30	15-Dec-04	GR-IA02-SB30-1	0-3'	6010B	1	6900	2.2 u	**15**	14	0.22 u	0.45 u	370	13	4.5	7.3	**9000**	5.9	2600	140	-	14	460	2.2 u	0.45 u	90 u	**2.2 u**	9.9	18
	15-Dec-04	GR-IA02-SB30-1	0-3'	7471A	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.092 u	-	-	-	-	-	-	-	-
	15-Dec-04	GR-IA02-SB30-1-M	3-10'	6010B	1	4400	2.1 u	**12**	9.3	0.21 u	0.42 u	490	11	3.4	6	**8000**	3.4	2400	120	-	12	440	2.1 u	0.42 u	84 u	0.42 j	7.3	16
	15-Dec-04	GR-IA02-SB30-1-M	3-10'	7471A	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.079 u	-	-	-	-	-	-	-	-
IA02-SS01	13-Dec-04	GR-IA02-SS01-1	0-1.5'	6010B	1	**10000**	3 u	**18**	44	0.3 u	0.6 u	2500	26	7.5	46	**28000**	50	2400	**510**	-	**28**	680	3 u	0.6 u	120 u	**3 u**	14	96
	13-Dec-04	GR-IA02-SS01-1	0-1.5'	7471A	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.11 j	-	-	-	-	-	-	-	-
IA03-SB01	13-Dec-04	GR-IA03-SB01-1	0-3'	6010B	1	**11000**	2.3 u	**24**	23	0.23 u	0.46 u	320	21	5.2	7.8	**12000**	8.9	3500	**240**	-	17	790	2.3 u	0.46 u	92 u	**2.3 u**	14	19
	13-Dec-04	GR-IA03-SB01-1	0-3'	7471A	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.026 j	-	-	-	-	-	-	-	-
	13-Dec-04	GR-IA03-SB01-1	3-10'	6010B	1	6700	2.1 u	**27**	14	0.21 u	0.42 u	340	17	6	12	**13000**	5.9	3800	**210**	-	**22**	820	2.1 u	0.42 u	84 u	**2.1 u**	11	22
	13-Dec-04	GR-IA03-SB01-1	3-10'	7471A	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.078 u	-	-	-	-	-	-	-	-
	13-Dec-04	GR-IA03-SB01-1-D	0-3'	6010B	1	**10000**	2.3 u	**28**	18	0.23 u	0.46 u	190	17	4.9	9	**12000**	10	2900	**210**	-	16	540	2.3 u	0.46 u	93 u	**2.3 u**	13	19
	13-Dec-04	GR-IA03-SB01-1-D	0-3'	7471A	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.026 j	-	-	-	-	-	-	-	-
IA03-SB02	13-Dec-04	GR-IA03-SB02-1	0-3'	6010B	1	**10000**	2.2 u	**27**	16	0.22 u	0.44 u	360	24	6.3	14	**15000**	12	4800	**180**	-	**25**	920	2.2 u	0.44 u	89 u	**2.2 u**	16	28
	13-Dec-04	GR-IA03-SB02-1	0-3'	7471A	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.02 j	-	-	-	-	-	-	-	-
	13-Dec-04	GR-IA03-SB02-1	3-10'	6010B	1	**8500**	2.1 u	**17**	18	0.21 u	0.42 u	860	23	6.2	13	**14000**	6.5	4900	**210**	-	**23**	990	2.1 u	0.42 u	83 u	**2.1 u**	16	25
	13-Dec-04	GR-IA03-SB02-1	3-10'	7471A	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.0035 j	-	-	-	-	-	-	-	-
IA03-SB03	15-Dec-04	GR-IA03-SB03-1	0-3'	6010B	1	**9600**	2.6	**25**	24	0.22 u	0.44 u	590	24	6.1	16	**15000**	26	5000	**200**	-	**23**	1400	2.2 u	0.44 u	88 u	**2.2 u**	17	34
	15-Dec-04	GR-IA03-SB03-1	0-3'	7471A	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.12	-	-	-	-	-	-	-	-
	15-Dec-04	GR-IA03-SB03-1-M	3-10'	6010B	1	7200	2.1 u	**21**	16	0.21 u	0.42 u	380	21	5.1	9.8	**12000**	7.5	4300	**180**	-	19	940	2.1 u	0.42 u	84 u	**2.1 u**	12	27
	15-Dec-04	GR-IA03-SB03-1-M	3-10'	7471A	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.078 u	-	-	-	-	-	-	-	-
IA03-SB04	15-Dec-04	GR-IA03-SB04-1	0-3'	6010B	1	**9700**	2.2 u	**19**	17	0.22 u	0.44 u	300	20	5.6	9.8	**12000**	13	4000	**190**	-	18	810	2.2 u	0.44 u	88 u	**2.2 u**	14	24
	15-Dec-04	GR-IA03-SB04-1	0-3'	7471A	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.1	-	-	-	-	-	-	-	-
	15-Dec-04	GR-IA03-SB04-1	3-10'	6010B	1	**8100**	2.1 u	**31**	19	0.21 u	0.43 u	440	21	7	13	**14000**	7.8	4600	**240**	-	**24**	1100	2.1 u	0.43 u	85 u	**2.1 u**	14	31
	15-Dec-04	GR-IA03-SB04-1	3-10'	7471A	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.0071 j	-	-	-	-	-	-	-	-
IA03-SS01	03-Nov-04	GR-IA03-SS01-1	0-1.5'	6010B	1	6100	2.1 u	**24**	13	0.21 u	0.42 u	220	16	3.4	13	**9400**	13	2500	64	-	18	810	2.1 u	0.42 u	84 u	**2.1 u**	11	28
	03-Nov-04	GR-IA03-SS01-1	0-1.5'	7471A	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.62	-	-	-	-	-	-	-	-

Location

Notes:

NC No criteria listed under the regulation cited
ND Non-detect result (Original data unavailable - neither value nor detection limit provided)
- Parameter not analyzed

Analytic Flags:

u Not detected above laboratory reporting limits
j Estimated value - parameter detected between laboratory reporting limit and half of the laboratory reporting limit.
e Value exceeds analytical calibration limits
b Parameter detected in quality control blank and sample

Highlighting:

Value or Detection Limit exceeds Criteria 1 only
Value or Detection Limit exceeds Criteria 2 only
Value or Detection Limit exceeds both criteria

SSI - Summary of Target Analyte List Metals Soil Analytical Results

Table 5-2f

PASI - SSI

Analytic Method: 6010B and 7471A
Sample Matrix: Soil
Reporting Units: mg/kg
Sample Dates: 03-Nov-2004 to 02-May-2005

						Aluminum	Antimony	Arsenic	Barium	Beryllium	Cadmium	Calcium	Chromium	Cobalt	Copper	Iron	Lead	Magnesium	Manganese	Mercury	Nickel	Potassium	Selenium	Silver	Sodium	Thallium	Vanadium	Zinc
SSI Project Action Limit (PAL) - Wave 2 (Metals)						7600	3.1	0.39	540	0.7	2	NC	30	900	310	2300	300	NC	180	2.3	20	NC	39	39	NC	0.52	55	2300
Secondary Regulatory Criteria Not Selected																												
	Date	Sample ID	Depth	Method	Dilution																							
IA03-SS02	03-Nov-04	GR-IA03-SS02-1	0-1.5'	6010B	1	5800	2.1 u	**23**	12	0.21 u	0.42 u	200	14	3.7	14	**8900**	30	2100	79	-	16	660	2.1 u	0.42	84 u	**2.1 u**	9.6	31
	03-Nov-04	GR-IA03-SS02-1	0-1.5'	7471A	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.8	-	-	-	-	-	-	-	-
	03-Nov-04	GR-IA03-SS02-1-D	0-1.5'	6010B	1	5800	2.1 u	**26**	12	0.21 u	0.42 u	240	14	3.8	15	**9300**	31	2000	91	-	16	640	2.1 u	0.43	84 u	**2.1 u**	10	30
	03-Nov-04	GR-IA03-SS02-1-D	0-1.5'	7471A	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.76	-	-	-	-	-	-	-	-
IA03-SS03	03-Nov-04	GR-IA03-SS03-1	0-1.5'	6010B	1	6800	2.2 u	**16**	11	0.22 u	0.43 u	180	10	3.6	6.8	**7600**	10	1300	130	-	12	290	2.2 u	0.43 u	87 u	**2.2 u**	8.9	15
	03-Nov-04	GR-IA03-SS03-1	0-1.5'	7471A	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.03 j	-	-	-	-	-	-	-	-
IA03-SS04	03-Nov-04	GR-IA03-SS04-1	0-1.5'	6010B	1	7400	2.2 u	**19**	10	0.22 u	0.43 u	200	12	5.3	8.1	**8800**	7.9	1600	120	-	15	240	2.2 u	0.43 u	87 u	**2.2 u**	8.9	17
	03-Nov-04	GR-IA03-SS04-1	0-1.5'	7471A	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.028 j	-	-	-	-	-	-	-	-
IA03-SS05	03-Nov-04	GR-IA03-SS05-1	0-1.5'	6010B	1	**8000**	2.2 u	**13**	10	0.22 u	0.45 u	110	9.7	2.9	4.9	**8000**	10	1000	110	-	8.9	190	2.2 u	0.45 u	90 u	**2.2 u**	9.4	14
	03-Nov-04	GR-IA03-SS05-1	0-1.5'	7471A	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.063 j	-	-	-	-	-	-	-	-
IA03-SS06	03-Nov-04	GR-IA03-SS06-1-M	0-1.5'	6010B	1	4200	2.1 u	**24**	11	0.21 u	0.42 u	250	11	5.5	12	**8800**	8.6	1900	**180**	-	19	500	2.1 u	0.42 u	84 u	**2.1 u**	8	18
	03-Nov-04	GR-IA03-SS06-1-M	0-1.5'	7471A	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.0087 j	-	-	-	-	-	-	-	-
IA03-SS07	03-Nov-04	GR-IA03-SS07-1	0-1.5'	6010B	1	6200	2.1 u	**11**	10	0.21 u	0.42 u	82	7.2	2	3.1	**7000**	7	730	99	-	6.3	140	2.1 u	0.42 u	85 u	**2.1 u**	7.8	13
	03-Nov-04	GR-IA03-SS07-1	0-1.5'	7471A	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.03 j	-	-	-	-	-	-	-	-
IA03-SS08	03-Nov-04	GR-IA03-SS08-1	0-1.5'	6010B	1	7500	2.2 u	**20**	8.6	0.22 u	0.44 u	220	10	2.9	3.9	**7700**	6.9	1200	88	-	12	170	2.2 u	0.44 u	88 u	**2.2 u**	9.2	14
	03-Nov-04	GR-IA03-SS08-1	0-1.5'	7471A	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.018 j	-	-	-	-	-	-	-	-
IA03-SS09	03-Nov-04	GR-IA03-SS09-1	0-1.5'	6010B	1	5800	2.2 u	**11**	11	0.22 u	0.44 u	93	6.6	1.9	3	**6800**	8.4	620	84	-	6.5	110	2.2 u	0.44 u	88 u	**2.2 u**	7.4	13
	03-Nov-04	GR-IA03-SS09-1	0-1.5'	7471A	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.024 j	-	-	-	-	-	-	-	-
IA03-SS10	03-Nov-04	GR-IA03-SS10-1	0-1.5'	6010B	1	5300	2.1 u	**28**	12	0.21 u	0.42 u	260	12	5.2	11	**8400**	6.7	2200	150	-	17	690	2.1 u	0.42 u	84 u	**2.1 u**	8.8	17
	03-Nov-04	GR-IA03-SS10-1	0-1.5'	7471A	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.0055 j	-	-	-	-	-	-	-	-
IA03-SS11	03-Nov-04	GR-IA03-SS11-1	0-1.5'	6010B	1	7400	2.3 u	**19**	18	0.23 u	0.46 u	280	12	3.7	7.8	**9200**	16	1700	**190**	-	12	450	2.3 u	0.46 u	92 u	**2.3 u**	11	19
	03-Nov-04	GR-IA03-SS11-1	0-1.5'	7471A	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.038 j	-	-	-	-	-	-	-	-
IA03-SS12	03-Nov-04	GR-IA03-SS12-1	0-1.5'	6010B	1	6300	2.2 u	**20**	13	0.22 u	0.45 u	280	12	4.3	8.2	**8400**	11	1600	170	-	14	420	2.2 u	0.45 u	90 u	**2.2 u**	9.3	17
	03-Nov-04	GR-IA03-SS12-1	0-1.5'	7471A	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.021 j	-	-	-	-	-	-	-	-
IA03-SS13	03-Nov-04	GR-IA03-SS13-1	0-1.5'	6010B	1	5800	2.2 u	**19**	13	0.22 u	0.43 u	300	11	4	8.4	**7800**	9.4	1600	140	-	14	480	2.2 u	0.43 u	87 u	**2.2 u**	8.7	16
	03-Nov-04	GR-IA03-SS13-1	0-1.5'	7471A	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.022 j	-	-	-	-	-	-	-	-
IA03-SS14	03-Nov-04	GR-IA03-SS14-1	0-1.5'	6010B	1	5500	2.2 u	**14**	9.4	0.22 u	0.43 u	270	8.2	3.4	6.2	**6300**	6.2	1200	**180**	-	11	310	2.2 u	0.43 u	86 u	**2.2 u**	7.4	15
	03-Nov-04	GR-IA03-SS14-1	0-1.5'	7471A	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.022 j	-	-	-	-	-	-	-	-
IA03-SS15	04-Nov-04	GR-IA03-SS15-1	0-1.5'	6010B	1	7500	2.2 u	**20**	14	0.22 u	0.44 u	180	13	3.8	6.4	**9200**	9.6	1500	110	-	15	330	2.2 u	0.44 u	88 u	**2.2 u**	11	16
	04-Nov-04	GR-IA03-SS15-1	0-1.5'	7471A	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.023 j	-	-	-	-	-	-	-	-
IA03-SS16	04-Nov-04	GR-IA03-SS16-1	0-1.5'	6010B	1	**9900**	2.2 u	**24**	9	0.22 u	0.45 u	85	14	3.2	5.7	**11000**	9.2	1500	71	-	13	190	2.2 u	0.45 u	90 u	**2.2 u**	12	18
	04-Nov-04	GR-IA03-SS16-1	0-1.5'	7471A	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.02 j	-	-	-	-	-	-	-	-
IA03-SS17	04-Nov-04	GR-IA03-SS17-1	0-1.5'	6010B	1	**9100**	2.2 u	**27**	10	0.22 u	0.45 u	120	15	3.3	7.7	**10000**	15	1700	81	-	13	240	2.2 u	0.45 u	90 u	**2.2 u**	13	16
	04-Nov-04	GR-IA03-SS17-1	0-1.5'	7471A	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.039 j	-	-	-	-	-	-	-	-

Location

Notes:

NC No criteria listed under the regulation cited
ND Non-detect result (Original data unavailable - neither value nor detection limit provided)
- Parameter not analyzed

Analytic Flags:

u Not detected above laboratory reporting limits
j Estimated value - parameter detected between laboratory reporting limit and half of the laboratory reporting limit.
e Value exceeds analytical calibration limits
b Parameter detected in quality control blank and sample

Highlighting:

Value or Detection Limit exceeds Criteria 1 only
Value or Detection Limit exceeds Criteria 2 only
Value or Detection Limit exceeds both criteria

SSI - Summary of Target Analyte List Metals Soil Analytical Results

Table 5-2f

PASI - SSI

Analytic Method: 6010B and 7471A
Sample Matrix: Soil
Reporting Units: mg/kg
Sample Dates: 03-Nov-2004 to 02-May-2005

						Aluminum	Antimony	Arsenic	Barium	Beryllium	Cadmium	Calcium	Chromium	Cobalt	Copper	Iron	Lead	Magnesium	Manganese	Mercury	Nickel	Potassium	Selenium	Silver	Sodium	Thallium	Vanadium	Zinc
SSI Project Action Limit (PAL) - Wave 2 (Metals)						7600	3.1	0.39	540	0.7	2	NC	30	900	310	2300	300	NC	180	2.3	20	NC	39	39	NC	0.52	55	2300
Secondary Regulatory Criteria Not Selected																												
	Date	Sample ID	Depth	Method	Dilution																							
IA03-SS18	04-Nov-04	GR-IA03-SS18-1	0-1.5'	6010B	1	7000	2.2 u	**14**	12	0.22 u	0.44 u	97	9.2	2.6	5.9	**8300**	16	960	96	-	8.4	220	2.2 u	0.44 u	88 u	**2.2 u**	10	13
	04-Nov-04	GR-IA03-SS18-1	0-1.5'	7471A	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.022 j	-	-	-	-	-	-	-	-
IA03-SS19	04-Nov-04	GR-IA03-SS19-1	0-1.5'	6010B	1	**11000**	2.4 u	**12**	13	0.24 u	0.47 u	63	10	2.2	3.5	**9900**	8.4	740	95	-	7.4	130	2.4 u	0.47 u	94 u	**2.4 u**	12	12
	04-Nov-04	GR-IA03-SS19-1	0-1.5'	7471A	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.022 j	-	-	-	-	-	-	-	-
IA03-SS20	04-Nov-04	GR-IA03-SS20-1	0-1.5'	6010B	1	**9300**	2.3 u	**13**	13	0.23 u	0.46 u	89	11	2.5	4.4	**8800**	9.8	1000	75	-	9.4	280	2.3 u	0.46 u	93 u	**2.3 u**	11	13
	04-Nov-04	GR-IA03-SS20-1	0-1.5'	7471A	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.03 j	-	-	-	-	-	-	-	-
IA03-SS21	04-Nov-04	GR-IA03-SS21-1	0-1.5'	6010B	1	6300	2.3 u	**14**	8	0.23 u	0.45 u	93	8.4	2.4	4.9	**7000**	14	900	92	-	7.7	160	2.3 u	0.45 u	90 u	**2.3 u**	9.8	13
	04-Nov-04	GR-IA03-SS21-1	0-1.5'	7471A	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.034 j	-	-	-	-	-	-	-	-
IA03-SS22	04-Nov-04	GR-IA03-SS22-1	0-1.5'	6010B	1	**7600**	2.3 u	**10**	11	0.23 u	0.46 u	55	8.2	1.8	2.9	**7900**	11	550	85	-	5.8	120 u	2.3 u	0.46 u	93 u	**2.3 u**	10	10
	04-Nov-04	GR-IA03-SS22-1	0-1.5'	7471A	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.033 j	-	-	-	-	-	-	-	-
IA05-SB01	09-Dec-04	GR-IA05-SB01-1	0-3'	6010B	1	**9800**	2.4 u	**23**	13	0.24 u	0.47 u	310	16	4.1	6.2	**11000**	19	3000	160	-	15	370	2.4 u	0.47 u	94 u	**2.4 u**	14	20
	09-Dec-04	GR-IA05-SB01-1	0-3'	7471A	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.026 j	-	-	-	-	-	-	-	-
	09-Dec-04	GR-IA05-SB01-1-M	0-3'	6010B	1	6800	2.1 u	**28**	23	0.21 u	0.42 u	580	22	6.4	13	**11000**	7.3	3500	**200**	-	**21**	1200	2.1 u	0.42 u	83 u	**2.1 u**	13	20
	09-Dec-04	GR-IA05-SB01-1-M	0-3'	7471A	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.085 u	-	-	-	-	-	-	-	-
IA05-SB02	09-Dec-04	GR-IA05-SB02-1	0-3'	6010B	1	**7900**	2.2 u	**22**	8.2	0.22 u	0.44 u	160	15	4	7	**10000**	24	3000	110	-	16	290	2.2 u	0.44 u	88 u	**2.2 u**	10	18
	09-Dec-04	GR-IA05-SB02-1	0-3'	7471A	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.011 j	-	-	-	-	-	-	-	-
	09-Dec-04	GR-IA05-SB02-1	3-10'	6010B	1	**9000**	2.1 u	**24**	22	0.21 u	0.42 u	420	29	6	12	**13000**	6.6	5000	**180**	-	**23**	1400	2.1 u	0.42 u	85 u	**2.1 u**	15	22
	09-Dec-04	GR-IA05-SB02-1	3-10'	7471A	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.086 u	-	-	-	-	-	-	-	-
	09-Dec-04	GR-IA05-SB02-1-D	0-3'	6010B	1	**8000**	2.1 u	**22**	7.3	0.21 u	0.43 u	150	16	4.2	7.2	**11000**	12	3400	110	-	17	320	2.1 u	0.43 u	86 u	**2.1 u**	11	19
	09-Dec-04	GR-IA05-SB02-1-D	0-3'	7471A	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.0057 j	-	-	-	-	-	-	-	-
IA05-SB03	09-Dec-04	GR-IA05-SB03-1	0-3'	6010B	1	**10000**	2.4 u	**21**	23	0.24 u	0.48 u	450	18	5.2	6.4	**11000**	16	3200	**340**	-	19	600	2.4 u	0.48 u	96 u	**2.4 u**	15	26
	09-Dec-04	GR-IA05-SB03-1	0-3'	7471A	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.037 j	-	-	-	-	-	-	-	-
	09-Dec-04	GR-IA05-SB03-1	3-10'	6010B	1	6700	2.2 u	**35**	14	0.22 u	0.43 u	990	18	6.1	11	**13000**	9	3700	**220**	-	**23**	710	2.2 u	0.43 u	87 u	**2.2 u**	11	23
	09-Dec-04	GR-IA05-SB03-1	3-10'	7471A	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.082 u	-	-	-	-	-	-	-	-
IA05-SB04	09-Dec-04	GR-IA05-SB04-1	0-3'	6010B	1	**12000**	2.3 u	**22**	27	0.23 u	0.46 u	560	**33**	7	8.5	**14000**	8.7	4700	**270**	-	**24**	1800	2.3 u	0.46 u	92 u	**2.3 u**	21	26
	09-Dec-04	GR-IA05-SB04-1	0-3'	7471A	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.023 j	-	-	-	-	-	-	-	-
	09-Dec-04	GR-IA05-SB04-1	3-10'	6010B	1	7100	2.1 u	**33**	23	0.21 u	0.42 u	440	23	7.3	15	**11000**	7.6	3400	**230**	-	**25**	1300	2.1 u	0.42 u	85 u	**2.1 u**	14	22
	09-Dec-04	GR-IA05-SB04-1	3-10'	7471A	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.084 u	-	-	-	-	-	-	-	-
IA05-SB05	09-Dec-04	GR-IA05-SB05-1	0-3'	6010B	1	**9200**	2.3 u	**25**	22	0.23 u	0.46 u	410	18	5.7	8.7	**10000**	14	2300	**270**	-	18	760	2.3 u	0.46 u	92 u	**2.3 u**	13	22
	09-Dec-04	GR-IA05-SB05-1	0-3'	7471A	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.027 j	-	-	-	-	-	-	-	-
	09-Dec-04	GR-IA05-SB05-1	3-10'	6010B	1	6200	2.1 u	**22**	18	0.21 u	0.43 u	520	15	5.6	13	**9200**	7.4	2600	160	-	18	1000	2.1 u	0.43 u	86 u	**2.1 u**	11	18
	09-Dec-04	GR-IA05-SB05-1	3-10'	7471A	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.084 u	-	-	-	-	-	-	-	-

Location

Notes:

NC No criteria listed under the regulation cited
ND Non-detect result (Original data unavailable - neither value nor detection limit provided)
- Parameter not analyzed

Analytic Flags:

u Not detected above laboratory reporting limits
j Estimated value - parameter detected between laboratory reporting limit and half of the laboratory reporting limit.
e Value exceeds analytical calibration limits
b Parameter detected in quality control blank and sample

Highlighting:

Value or Detection Limit exceeds Criteria 1 only
Value or Detection Limit exceeds Criteria 2 only
Value or Detection Limit exceeds both criteria

SSI - Summary of Target Analyte List Metals Soil Analytical Results

Table 5-2f

PASI - SSI

Analytic Method: 6010B and 7471A
Sample Matrix: Soil
Reporting Units: mg/kg
Sample Dates: 03-Nov-2004 to 02-May-2005

						Aluminum	Antimony	Arsenic	Barium	Beryllium	Cadmium	Calcium	Chromium	Cobalt	Copper	Iron	Lead	Magnesium	Manganese	Mercury	Nickel	Potassium	Selenium	Silver	Sodium	Thallium	Vanadium	Zinc
SSI Project Action Limit (PAL) - Wave 2 (Metals)						7600	3.1	0.39	540	0.7	2	NC	30	900	310	2300	300	NC	180	2.3	20	NC	39	39	NC	0.52	55	2300
Secondary Regulatory Criteria Not Selected																												
	Date	Sample ID	Depth	Method	Dilution																							
IA05-SB06	09-Dec-04	GR-IA05-SB06-1	0-3'	6010B	1	**7700**	2.2 u	**21**	15	0.22 u	0.44 u	540	16	4.8	9.5	**8400**	16	2200	140	-	16	620	2.2 u	0.44 u	89 u	**2.2 u**	10	20
	09-Dec-04	GR-IA05-SB06-1	0-3'	7471A	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.019 j	-	-	-	-	-	-	-	-
	09-Dec-04	GR-IA05-SB06-1	3-10'	6010B	1	5100	2.1 u	**24**	18	0.21 u	0.43 u	600	14	6.6	14	**9300**	10	2800	**180**	-	**22**	1000	2.1 u	0.43 u	86 u	**2.1 u**	11	24
	09-Dec-04	GR-IA05-SB06-1	3-10'	7471A	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.085 u	-	-	-	-	-	-	-	-
	09-Dec-04	GR-IA05-SB06-1-D	0-3'	6010B	1	7200	2.2 u	**20**	16	0.22 u	0.44 u	530	16	4.4	8.9	**8300**	18	2100	170	-	15	590	2.2 u	0.44 u	88 u	**2.2 u**	10	19
	09-Dec-04	GR-IA05-SB06-1-D	0-3'	7471A	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.019 j	-	-	-	-	-	-	-	-
IA05-SB07	10-Dec-04	GR-IA05-SB07-1	0-3'	6010B	1	**8400**	2.3 u	**23**	13	0.23 u	0.47 u	290	13	4.2	6.4	**9100**	21	2000	130	-	15	330	2.3 u	0.47 u	94 u	**2.3 u**	11	19
	10-Dec-04	GR-IA05-SB07-1	0-3'	7471A	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.024 j	-	-	-	-	-	-	-	-
	10-Dec-04	GR-IA05-SB07-1	3-10'	6010B	1	**10000**	2.2 u	**30**	32	0.22 u	0.43 u	560	26	9	18	**15000**	8.1	5400	**250**	-	**30**	2000	2.2 u	0.43 u	86 u	**2.2 u**	19	29
	10-Dec-04	GR-IA05-SB07-1	3-10'	7471A	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.08 u	-	-	-	-	-	-	-	-
IA05-SB08	10-Dec-04	GR-IA05-SB08-1	0-3'	6010B	1	**8500**	2.3 u	**24**	22	0.23 u	0.45 u	860	20	6.5	13	**12000**	17	2900	**280**	-	**52**	860	2.3 u	0.45 u	91 u	**2.3 u**	12	29
	10-Dec-04	GR-IA05-SB08-1	0-3'	7471A	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.016 j	-	-	-	-	-	-	-	-
	10-Dec-04	GR-IA05-SB08-1	3-10'	6010B	1	**7900**	2.2 u	**38**	20	0.22 u	0.45 u	640	17	6.2	12	**11000**	12	3000	**190**	-	**24**	1000	2.2 u	0.45 u	90 u	**2.2 u**	12	23
	10-Dec-04	GR-IA05-SB08-1	3-10'	7471A	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.01 j	-	-	-	-	-	-	-	-
IA05-SB09	10-Dec-04	GR-IA05-SB09-1	0-3'	6010B	1	6200	2.2 u	**32**	18	0.22 u	0.43 u	1600	17	7.7	37	**13000**	8.1	2800	**300**	-	**27**	840	2.2 u	0.43 u	87 u	**2.2 u**	10	27
	10-Dec-04	GR-IA05-SB09-1	0-3'	7471A	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.0044 j	-	-	-	-	-	-	-	-
	10-Dec-04	GR-IA05-SB09-1	3-10'	6010B	1	7400	2.2 u	**23**	14	0.22 u	0.43 u	280	17	5.1	68	**9800**	7.2	2900	170	-	18	870	2.2 u	0.43 u	86 u	**2.2 u**	11	22
	10-Dec-04	GR-IA05-SB09-1	3-10'	7471A	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.0088 j	-	-	-	-	-	-	-	-
IA05-SS01	03-Nov-04	GR-IA05-SS01-1	0-1.5'	6010B	1	**8300**	2.3 u	**25**	16	0.23 u	0.46 u	350	17	4.9	8.7	**10000**	36	2000	**340**	-	17	370	2.3 u	0.46 u	92 u	**2.3 u**	16	40
	03-Nov-04	GR-IA05-SS01-1	0-1.5'	7471A	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.068 j	-	-	-	-	-	-	-	-
IA05-SS02	03-Nov-04	GR-IA05-SS02-1	0-1.5'	6010B	1	**7700**	2.1 u	**33**	11	0.21 u	0.42 u	400	16	5.7	13	**9200**	11	2300	100	-	**22**	580	2.1 u	0.42 u	85 u	**2.1 u**	11	19
	03-Nov-04	GR-IA05-SS02-1	0-1.5'	7471A	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.012 j	-	-	-	-	-	-	-	-
IA05-SS03	03-Nov-04	GR-IA05-SS03-1	0-1.5'	6010B	1	6500	2.3 u	**30**	20	0.23 u	0.46 u	660	16	6.7	15	**10000**	170	2600	**260**	-	**22**	930	2.3 u	0.46 u	92 u	**2.3 u**	13	30
	03-Nov-04	GR-IA05-SS03-1	0-1.5'	7471A	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.038 j	-	-	-	-	-	-	-	-
	03-Nov-04	GR-IA05-SS03-1-D	0-1.5'	6010B	1	6200	2.3 u	**32**	19	0.23 u	0.45 u	640	14	6.7	14	**11000**	180	2300	**300**	-	**21**	790	2.3 u	0.45 u	91 u	**2.3 u**	13	31
	03-Nov-04	GR-IA05-SS03-1-D	0-1.5'	7471A	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.04 j	-	-	-	-	-	-	-	-
IA05-SS04	03-Nov-04	GR-IA05-SS04-1	0-1.5'	6010B	1	6700	2.2 u	**20**	13	0.22 u	0.45 u	360	10	3.2	5.6	**7400**	55	1300	**230**	-	13	200	2.2 u	0.45 u	90 u	**2.2 u**	9	18
	03-Nov-04	GR-IA05-SS04-1	0-1.5'	7471A	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.031 j	-	-	-	-	-	-	-	-
IA05-SS05	03-Nov-04	GR-IA05-SS05-1	0-1.5'	6010B	1	**7600**	2.3 u	**21**	21	0.23 u	0.46 u	330	14	4.3	8.7	**9900**	35	1800	**290**	-	15	490	2.3 u	0.46 u	92 u	**2.3 u**	13	27
	03-Nov-04	GR-IA05-SS05-1	0-1.5'	7471A	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.054 j	-	-	-	-	-	-	-	-
IA05-SS06	03-Nov-04	GR-IA05-SS06-1	0-1.5'	6010B	1	6200	2.2 u	**19**	14	0.22 u	0.45 u	280	11	3.9	5.9	**7900**	18	1400	**310**	-	12	260	2.2 u	0.45 u	90 u	**2.2 u**	11	18
	03-Nov-04	GR-IA05-SS06-1	0-1.5'	7471A	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.048 j	-	-	-	-	-	-	-	-
	03-Nov-04	GR-IA05-SS06-1-D	0-1.5'	6010B	1	6200	2.3 u	**22**	13	0.23 u	0.45 u	260	11	4	6.2	**8400**	18	1400	**300**	-	12	240	2.3 u	0.45 u	91 u	**2.3 u**	12	18
	03-Nov-04	GR-IA05-SS06-1-D	0-1.5'	7471A	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.049 j	-	-	-	-	-	-	-	-

Location

Notes:

NC No criteria listed under the regulation cited
ND Non-detect result (Original data unavailable - neither value nor detection limit provided)
- Parameter not analyzed

Analytic Flags:

u Not detected above laboratory reporting limits
j Estimated value - parameter detected between laboratory reporting limit and half of the laboratory reporting limit.
e Value exceeds analytical calibration limits
b Parameter detected in quality control blank and sample

Highlighting:

Value or Detection Limit exceeds Criteria 1 only
Value or Detection Limit exceeds Criteria 2 only
Value or Detection Limit exceeds both criteria

SSI - Summary of Target Analyte List Metals Soil Analytical Results

Table 5-2f

PASI - SSI

Analytic Method: 6010B and 7471A
Sample Matrix: Soil
Reporting Units: mg/kg
Sample Dates: 03-Nov-2004 to 02-May-2005

						Aluminum	Antimony	Arsenic	Barium	Beryllium	Cadmium	Calcium	Chromium	Cobalt	Copper	Iron	Lead	Magnesium	Manganese	Mercury	Nickel	Potassium	Selenium	Silver	Sodium	Thallium	Vanadium	Zinc
SSI Project Action Limit (PAL) - Wave 2 (Metals)						7600	3.1	0.39	540	0.7	2	NC	30	900	310	2300	300	NC	180	2.3	20	NC	39	39	NC	0.52	55	2300
Secondary Regulatory Criteria Not Selected																												
	Date	Sample ID	Depth	Method	Dilution																							
IA06-SB03	11-Apr-05	LO-IA06-SB03-1	3-10'	6010B	1	**9380**	0.42 u	**14.1**	29.2	0.27 b	0.083 u	1150	25.4	5.2 b	8	**12400**	7.1	4600	166	-	18.3	1390	0.71	0.38 u	166 b	**0.88 u**	17.9	30.5
	11-Apr-05	LO-IA06-SB03-1	3-10'	7471A	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.018 u	-	-	-	-	-	-	-	-
	11-Apr-05	LO-IA06-SB03-1	0-3'	6010B	1	**12800**	0.65 b	**39.7**	40.3	0.43 b	0.095 b	1410	**40.8**	10.8	22.6	**21000**	13.9	7770	**377**	-	**39.5**	1990	0.69	0.37 u	210 b	**0.64 u**	25.2	40.1
	11-Apr-05	LO-IA06-SB03-1	0-3'	7471A	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.015 u	-	-	-	-	-	-	-	-
IA06-SB04	11-Apr-05	LO-IA06-SB04-1	3-10'	6010B	1	**14600**	0.52 b	**22**	24.4	0.42 b	0.088 b	1060	**30.4**	6.8	12.7	**16100**	9.6	5120	**216**	-	**22**	1080	0.5 b	0.41 u	202 b	**0.93 u**	20.4	35.2
	11-Apr-05	LO-IA06-SB04-1	3-10'	7471A	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.019 u	-	-	-	-	-	-	-	-
	11-Apr-05	LO-IA06-SB04-1	0-3'	6010B	1	**12500**	0.59 b	**41.4**	30	0.42 b	0.14 b	1190	**48.4**	10.9	18.8	**20800**	14.1	8050	**402**	-	**37.6**	1610	1.1	0.37 u	182 b	**0.64 u**	22.9	42
	11-Apr-05	LO-IA06-SB04-1	0-3'	7471A	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.017 u	-	-	-	-	-	-	-	-
IA06-SB05	11-Apr-05	LO-IA06-SB05-1	3-10'	6010B	1	4420	0.56 b	**18.1**	11.2 b	0.23 b	0.083 u	757	10.9	3.7 b	12.2	**8020**	23.2	2170	157	-	11.9	481 b	0.44 b	0.39 u	177 b	**0.67 u**	7.7	13.8
	11-Apr-05	LO-IA06-SB05-1	3-10'	7471A	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.018 u	-	-	-	-	-	-	-	-
	11-Apr-05	LO-IA06-SB05-1	0-3'	6010B	1	**11100**	2.2 b	**27.8**	22.7	0.65	0.12 b	970	**38.1**	7.6	138	**18600**	**424**	6930	**392**	-	**25.6**	1410	0.8	0.4 u	185 b	**0.68 u**	20.8	34.1
	11-Apr-05	LO-IA06-SB05-1	0-3'	7471A	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.015 u	-	-	-	-	-	-	-	-
IA06-SB06	11-Apr-05	LO-IA06-SB06-1	3-10'	6010B	1	6310	1 b	**16.8**	14.5 b	0.24 b	0.077 u	1090	23.2	4.9	63.8	**12300**	177	3590	**230**	-	17.4	719	0.58	0.36 u	158 b	**0.62 u**	13.5	29
	11-Apr-05	LO-IA06-SB06-1	3-10'	7471A	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.018 u	-	-	-	-	-	-	-	-
	11-Apr-05	LO-IA06-SB06-1	0-3'	6010B	1	**8580**	2.7 b	**12.2**	19.2 b	0.34 b	0.092 b	547	14.2	4.5 b	166	**11600**	**319**	2240	108	-	13.4	495	0.63	0.36 u	140 b	**0.62 u**	12.3	36.8
	11-Apr-05	LO-IA06-SB06-1	0-3'	7471A	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.019 u	-	-	-	-	-	-	-	-
IA06-SB08	11-Apr-05	LO-IA06-SS08-1	0-1.5'	6010B	1	**13000**	**10**	**46.1**	44.6	0.47 b	0.22 b	1540	**37.6**	13.5	23	**24800**	16.6	6830	**808**	-	**50.6**	1580	0.95	0.36 u	194 b	**0.63 u**	22.9	47.8
	11-Apr-05	LO-IA06-SS08-1	0-1.5'	7471A	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.016 u	-	-	-	-	-	-	-	-
IA06-SB16	11-Apr-05	LO-IA06-SS16-1	0-1.5'	6010B	1	**10800**	0.68 b	**41.1**	31.9	0.36 b	0.13 b	1300	**38.6**	10	20.4	**19900**	11	6600	**375**	-	**39**	1670	0.72	0.39 u	183 b	**0.67 u**	22.4	39.2
	11-Apr-05	LO-IA06-SS16-1	0-1.5'	7471A	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.015 u	-	-	-	-	-	-	-	-
	11-Apr-05	LO-IA06-SS16-1-D	0-1.5'	6010B	1	**11100**	0.7 b	**33**	36.8	0.35 b	0.13 b	1400	**38.1**	9.6	17.3	**17300**	12.3	6590	**315**	-	**34.5**	1870	0.76	0.36 u	207 b	**0.62 u**	21.8	38
	11-Apr-05	LO-IA06-SS16-1-D	0-1.5'	7471A	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.015 u	-	-	-	-	-	-	-	-
IA06-SD01	13-Apr-05	LO-IA06-SD01-1	0-0.5'	6010B	1	6190	0.62 u	**12.2**	11.6 b	0.51 b	0.13 b	7820	**34.1**	4.8 b	35.5	**9640**	28.8	3420	168	-	17.7	347 b	0.63 b	0.27 u	73.9 u	**0.97 u**	9.6	29.4
	13-Apr-05	LO-IA06-SD01-1	0-0.5'	7471A	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.026 u	-	-	-	-	-	-	-	-
IA06-SD02	13-Apr-05	LO-IA06-SD02-1	0-0.5'	6010B	1	**7890**	0.51 u	**14.3**	19.7 b	**0.98**	0.09 b	1660	14.4	7.2	19.6	**11100**	50.5	2580	**330**	-	18.3	327 b	0.81	0.22 u	61 u	**1.1 u**	11.6	201
	13-Apr-05	LO-IA06-SD02-1	0-0.5'	7471A	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.034 b	-	-	-	-	-	-	-	-
IA06-SD03	13-Apr-05	LO-IA06-SD03-1	0-0.5'	6010B	1	**11500**	0.55 u	**23.2**	28.6	**1.1**	0.12 b	2310	21.4	9.8	31.6	**17900**	80.7	4320	**576**	-	**27.6**	799	0.81	0.24 u	68.1 b	**0.85 u**	19.3	165
	13-Apr-05	LO-IA06-SD03-1	0-0.5'	7471A	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.043 b	-	-	-	-	-	-	-	-
IA06-SD04	13-Apr-05	LO-IA06-SD04-1	0-0.5'	6010B	1	**9020**	0.62 u	**13.2**	18.5 b	**0.87**	0.09 b	2240	13	4 b	59.3	**9210**	45.7	2060	111	-	14.7	278 b	0.77	0.27 u	73.5 u	**0.96 u**	13	123
	13-Apr-05	LO-IA06-SD04-1	0-0.5'	7471A	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.055	-	-	-	-	-	-	-	-
IA06-SD05	13-Apr-05	LO-IA06-SD05-1	0-0.5'	6010B	1	**10500**	0.56 u	**11.7**	16.7 b	0.5 b	0.082 u	2070	16.1	3.2 b	51.5	**10200**	23.2	2540	62.6	-	13.6	332 b	0.62 b	0.25 u	66.7 u	**0.87 u**	13.6	80.1
	13-Apr-05	LO-IA06-SD05-1	0-0.5'	7471A	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.036 b	-	-	-	-	-	-	-	-
IA06-SD06	13-Apr-05	LO-IA06-SD06-1	0-1.5'	6010B	1	**11100**	0.64 u	**13.5**	18.1 b	0.58 b	0.094 u	1640	14.6	3.1 b	40.2	**9330**	27	2260	54.4	-	14.1	338 b	0.59 u	0.28 u	76.2 u	**1 u**	13.6	99.4
	13-Apr-05	LO-IA06-SD06-1	0-1.5'	7471A	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.042 b	-	-	-	-	-	-	-	-
	13-Apr-05	LO-IA06-SD06-1	0-0.5'	6010B	1	**11300**	0.62 u	**11.9**	22.5 b	**0.77**	0.1 b	2940	16.9	3.5 b	45.6	**10400**	41.4	2850	70.6	-	17.6	362 b	0.64 u	0.27 u	74.2 u	**1.3 u**	15.5	146
	13-Apr-05	LO-IA06-SD06-1	0-0.5'	7471A	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.053 b	-	-	-	-	-	-	-	-

Location

Notes:

NC No criteria listed under the regulation cited
ND Non-detect result (Original data unavailable - neither value nor detection limit provided)
- Parameter not analyzed

Analytic Flags:

u Not detected above laboratory reporting limits
j Estimated value - parameter detected between laboratory reporting limit and half of the laboratory reporting limit.
e Value exceeds analytical calibration limits
b Parameter detected in quality control blank and sample

Highlighting:

Value or Detection Limit exceeds Criteria 1 only
Value or Detection Limit exceeds Criteria 2 only
Value or Detection Limit exceeds both criteria

SSI - Summary of Target Analyte List Metals Soil Analytical Results

Table 5-2f

PASI - SSI

Analytic Method: 6010B and 7471A
Sample Matrix: Soil
Reporting Units: mg/kg
Sample Dates: 03-Nov-2004 to 02-May-2005

	Date	Sample ID	Depth	Method	Dilution	Aluminum	Antimony	Arsenic	Barium	Beryllium	Cadmium	Calcium	Chromium	Cobalt	Copper	Iron	Lead	Magnesium	Manganese	Mercury	Nickel	Potassium	Selenium	Silver	Sodium	Thallium	Vanadium	Zinc
SSI Project Action Limit (PAL) - Wave 2 (Metals)						7600	3.1	0.39	540	0.7	2	NC	30	900	310	2300	300	NC	180	2.3	20	NC	39	39	NC	0.52	55	2300
Secondary Regulatory Criteria Not Selected																												
IA06-SD07	13-Apr-05	LO-IA06-SD07-1	0-0.5'	6010B	1	**11600**	1.1 b	**30.1**	23.3 b	0.58 b	0.079 u	2110	**31.3**	10	23.8	**19500**	113	6170	**408**	-	**33.1**	1120	0.73	0.24 u	64.4 u	**0.84 u**	23.4	133
	13-Apr-05	LO-IA06-SD07-1	0-0.5'	7471A	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.019 u	-	-	-	-	-	-	-	-
IA06-SD08	13-Apr-05	LO-IA06-SD08-1	0.5-1.5'	6010B	1	**8230**	0.73 b	**13.1**	23.5	0.38 b	0.066 u	1060	24.4	4.6 b	33.8	**13800**	55	4400	109	-	**20.8**	1200	0.42 u	0.2 u	77.2 b	**1.6**	16.7	34.2
	13-Apr-05	LO-IA06-SD08-1	0.5-1.5'	7471A	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.018 u	-	-	-	-	-	-	-	-
	13-Apr-05	LO-IA06-SD08-1	0-0.5'	6010B	1	**15100**	**3.1 b**	**20.8**	28.7 b	0.65 b	0.099 u	1920	**31**	9.4	**338**	**18100**	**855**	4470	**331**	-	**34.8**	679 b	0.63 u	0.3 u	80.4 u	**1.1 u**	27.2	99.2
	13-Apr-05	LO-IA06-SD08-1	0-0.5'	7471A	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.075	-	-	-	-	-	-	-	-
IA06-SD09	13-Apr-05	LO-IA06-SD09-1	0.5-1.5'	6010B	1	6340	0.52 b	**19.3**	10.7 b	0.31 b	0.073 u	529 b	13.3	3.2 b	9.6	**8140**	13.2	1890	91.5	-	13	383 b	0.47 u	0.22 u	94.5 b	**0.78 u**	8.8	20.9
	13-Apr-05	LO-IA06-SD09-1	0.5-1.5'	7471A	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.021 u	-	-	-	-	-	-	-	-
	13-Apr-05	LO-IA06-SD09-1	0-0.5'	6010B	1	**10400**	2.4 b	**14.8**	19.4 b	0.46 b	0.078 u	1520	16.9	4.4 b	120	**11100**	**498**	2480	97.7	-	**23.2**	447 b	0.5 u	0.24 u	63.8 u	**0.84 u**	16	51.9
	13-Apr-05	LO-IA06-SD09-1	0-0.5'	7471A	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.04 b	-	-	-	-	-	-	-	-
IA06-SD10	13-Apr-05	LO-IA06-SD10-1	0.5-1.5'	6010B	1	**7770**	0.53 b	**16.4**	12.5 b	0.37 b	0.072 u	1230	17.7	3.4 b	32.7	**9220**	110	2040	73.1	-	12.6	360 b	0.45 u	0.21 u	66.4 b	**0.76 u**	11.4	23.6
	13-Apr-05	LO-IA06-SD10-1	0.5-1.5'	7471A	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.022 u	-	-	-	-	-	-	-	-
	13-Apr-05	LO-IA06-SD10-1-D	0.5-1.5'	6010B	1	**8610**	0.51 b	**20.1**	13.2 b	0.39 b	0.071 u	1220	21.1	4.1 b	25.4	**12600**	97	2760	126	-	17.5	343 b	0.45 u	0.21 u	114 b	**0.75 u**	13.5	27.3
	13-Apr-05	LO-IA06-SD10-1-D	0.5-1.5'	7471A	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.018 u	-	-	-	-	-	-	-	-
	13-Apr-05	LO-IA06-SD10-1	0-0.5'	6010B	1	**12200**	2 b	**18.6**	27.8 b	0.47 b	0.088 u	2100	25.9	7.8	143	**16100**	**493**	4310	148	-	**33.7**	820	0.91	0.26 u	71.5 u	**0.94 u**	22.3	99.2
	13-Apr-05	LO-IA06-SD10-1	0-0.5'	7471A	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.05	-	-	-	-	-	-	-	-
	13-Apr-05	LO-IA06-SD10-1-D	0-0.5'	6010B	1	**10500**	1.8 b	**17.7**	19.7 b	0.39 b	0.076 u	1790	**32**	5.5 b	101	**14900**	**360**	4480	144	-	**28**	566 b	0.75	0.23 u	62.1 u	**1 b**	19.8	71.2
	13-Apr-05	LO-IA06-SD10-1-D	0-0.5'	7471A	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.039 b	-	-	-	-	-	-	-	-
IA06-SD11	13-Apr-05	LO-IA06-SD11-1	0.5-1.5'	6010B	1	**11100**	1.6 b	**15**	15.6 b	0.49 b	0.077 u	974	14.7	5 b	81.4	**11400**	**442**	1850	179	-	16.8	323 b	0.49 u	0.23 u	62.6 u	**0.82 u**	14.1	45.9
	13-Apr-05	LO-IA06-SD11-1	0.5-1.5'	7471A	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.027 b	-	-	-	-	-	-	-	-
	13-Apr-05	LO-IA06-SD11-1	0-0.5'	6010B	1	**12800**	2.4 b	**19.8**	25 b	0.56 b	0.087 u	2150	17.7	6.2 b	159	**12400**	**824**	1950	**330**	-	**22.6**	423 b	0.84	0.26 u	70.7 u	**0.93 u**	19	78.5
	13-Apr-05	LO-IA06-SD11-1	0-0.5'	7471A	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.07	-	-	-	-	-	-	-	-
IA06-SD12	13-Apr-05	LO-IA06-SD12-1	0-0.5'	6010B	1	**8700**	1.2 b	**14.2**	15.4 b	0.41 b	0.072 u	423 b	12.2	3.8 b	29.7	**9030**	173	1390	128	-	12.2	363 b	0.63	0.22 u	58.4 u	**0.76 u**	13.1	26.1
	13-Apr-05	LO-IA06-SD12-1	0-0.5'	7471A	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.048	-	-	-	-	-	-	-	-
IA06-SD13	13-Apr-05	LO-IA06-SD13-1	0.5-1.5'	6010B	1	**11300**	2.9 b	**7.8**	15.8 b	0.42 b	0.074 b	177 b	9.5	3.1 b	81.4	**10000**	**436**	751	128	-	13	255 b	0.46 b	0.19 u	59.9 b	**0.71 b**	12.7	32.5
	13-Apr-05	LO-IA06-SD13-1	0.5-1.5'	7471A	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.036 b	-	-	-	-	-	-	-	-
	13-Apr-05	LO-IA06-SD13-1	0-0.5'	6010B	1	**11100**	2 b	**27.8**	38.3	0.42 b	0.18 b	1230	**32.6**	8.5	71.2	**16900**	**903**	4660	**270**	-	**25.5**	1430	0.94	0.23 u	87.5 b	**0.82 u**	31.8	72.3
	13-Apr-05	LO-IA06-SD13-1	0-0.5'	7471A	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.064	-	-	-	-	-	-	-	-
IA06-SD14	13-Apr-05	LO-IA06-SD14-1	0-0.5'	6010B	1	6980	0.96 b	**9.1**	14.7 b	0.27 b	0.084 u	1010	11.9	2.8 b	9.3	**7640**	51.5	1380	76.3	-	8	267 b	1	0.25 u	68.5 u	**0.9 u**	12.1	23.9
	13-Apr-05	LO-IA06-SD14-1	0-0.5'	7471A	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.076	-	-	-	-	-	-	-	-
IA06-SD15	13-Apr-05	LO-IA06-SD15-1	0.5-1.5'	6010B	1	**11000**	0.63 b	**8.9**	11.6 b	0.48 b	0.065 u	171 b	13.1	5 b	8.4	**10900**	32	1780	94.1	-	11.4	338 b	0.41 u	0.19 u	52.8 u	**0.69 u**	13.5	20.6
	13-Apr-05	LO-IA06-SD15-1	0.5-1.5'	7471A	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.026 b	-	-	-	-	-	-	-	-
	13-Apr-05	LO-IA06-SD15-1	0-0.5'	6010B	1	**9720**	2.6 b	**9**	17.1 b	0.36 b	0.099 b	565 b	10.6	2.4 b	123	**9170**	**860**	836	53	-	18.3	342 b	1.5	0.28 u	75.7 u	**0.99 u**	19.4	28.8
	13-Apr-05	LO-IA06-SD15-1	0-0.5'	7471A	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.05	-	-	-	-	-	-	-	-
IA06-SD16	13-Apr-05	LO-IA06-SD16-1	0-0.5'	6010B	1	**10700**	0.96 b	**8.3**	15.8 b	0.42 b	0.1 b	914	11.4	2.8 b	23.4	**10000**	80.3	1090	62.7	-	8	358 b	0.61 u	0.26 u	70.4 u	**0.92 u**	14.7	39.7
	13-Apr-05	LO-IA06-SD16-1	0-0.5'	7471A	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.064	-	-	-	-	-	-	-	-

Location

Notes:

NC No criteria listed under the regulation cited
ND Non-detect result (Original data unavailable - neither value nor detection limit provided)
- Parameter not analyzed

Analytic Flags:

u Not detected above laboratory reporting limits
j Estimated value - parameter detected between laboratory reporting limit and half of the laboratory reporting limit.
e Value exceeds analytical calibration limits
b Parameter detected in quality control blank and sample

Highlighting:

Value or Detection Limit exceeds Criteria 1 only
Value or Detection Limit exceeds Criteria 2 only
Value or Detection Limit exceeds both criteria

PASI - SSI

Analytic Method: 6010B and 7471A
Sample Matrix: Soil
Reporting Units: mg/kg
Sample Dates: 03-Nov-2004 to 02-May-2005

						Aluminum	Antimony	Arsenic	Barium	Beryllium	Cadmium	Calcium	Chromium	Cobalt	Copper	Iron	Lead	Magnesium	Manganese	Mercury	Nickel	Potassium	Selenium	Silver	Sodium	Thallium	Vanadium	Zinc
SSI Project Action Limit (PAL) - Wave 2 (Metals)						7600	3.1	0.39	540	0.7	2	NC	30	900	310	2300	300	NC	180	2.3	20	NC	39	39	NC	0.52	55	2300
Secondary Regulatory Criteria Not Selected																												
	Date	Sample ID	Depth	Method	Dilution																							
IA06-SD17	13-Apr-05	LO-IA06-SD17-1	0-1.5'	6010B	1	**9140**	0.85 b	**9.7**	20.7 b	0.38 b	0.088 u	1820	12.7	3.2 b	6.8	**9170**	40.5	1460	120	-	7.9	455 b	0.61 u	0.26 u	71.3 u	**0.93 u**	14.6	29.4
	13-Apr-05	LO-IA06-SD17-1	0-1.5'	7471A	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.047	-	-	-	-	-	-	-	-
	13-Apr-05	LO-IA06-SD17-1	0-0.5'	6010B	1	**8820**	1 b	**11.9**	26.1 b	0.38 b	0.13 b	2360	14.4	3.2 b	9.4	**9800**	67.8	1580	167	-	8.4	458 b	1.3	0.28 u	76.1 u	**1 u**	15.9	38.6
	13-Apr-05	LO-IA06-SD17-1	0-0.5'	7471A	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.076	-	-	-	-	-	-	-	-
IA06-SS03	11-Apr-05	LO-IA06-SS03-1	0-0.5'	6010B	1	**8640**	1.2 u	**17.5**	21.1 b	0.4 b	0.11 u	1420	14	3.5 b	27.9	**10800**	37.7	2130	108	-	10.5	302 b	0.61 b	0.52 u	87.3 u	**1.2 u**	15.3	57.1
	11-Apr-05	LO-IA06-SS03-1	0-0.5'	7471A	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.052	-	-	-	-	-	-	-	-
IA06-SS04	12-Apr-05	LO-IA06-SS04-1	0-0.5'	6010B	1	**10700**	1.7 b	**24.3**	27	0.37 b	0.088 u	1460	28.3	8	28.7	**16600**	41.8	4710	**292**	-	**28.5**	957	0.42 u	0.41 u	101 b	**0.7 u**	20.9	67.9
	12-Apr-05	LO-IA06-SS04-1	0-0.5'	7471A	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.019 u	-	-	-	-	-	-	-	-
IA06-SS05	11-Apr-05	LO-IA06-SS05-1	0-0.5'	6010B	1	**11500**	1.3 b	**35.9**	32.5	0.38 b	0.1 b	1630	**39.5**	9.5	20.8	**20900**	56.7	6700	**350**	-	**40.2**	1760	0.61	0.41 u	110 b	**0.95 u**	23.7	75.2
	11-Apr-05	LO-IA06-SS05-1	0-0.5'	7471A	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.017 u	-	-	-	-	-	-	-	-
IA06-SS06	11-Apr-05	LO-IA06-SS06-1	0-0.5'	6010B	1	**10800**	1.7 b	**35.8**	35.5	0.37 b	0.082 u	1790	**35.3**	9.3	21.3	**20600**	34.5	6300	**451**	-	**34.5**	1590	0.39 u	0.38 u	66.6 b	**0.88 u**	21.8	59.8
	11-Apr-05	LO-IA06-SS06-1	0-0.5'	7471A	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.033 b	-	-	-	-	-	-	-	-
IA06-SS07	11-Apr-05	LO-IA06-SS07-1	0-0.5'	6010B	1	**10800**	1.2 b	**39.7**	27.9	0.35 b	0.083 u	1650	**34.6**	8.7	20.6	**18600**	44.4	6470	**326**	-	**35**	1390	0.39 u	0.38 u	64.9 u	**0.88 u**	22.4	59.3
	11-Apr-05	LO-IA06-SS07-1	0-0.5'	7471A	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.016 u	-	-	-	-	-	-	-	-
IA06-SS08	11-Apr-05	LO-IA06-SS08-1	0-0.5'	6010B	1	**8790**	0.86 b	**35.2**	27	0.35 b	0.073 u	1260	26.7	9.2	22.1	**17600**	35.8	5530	**350**	-	**33.8**	1370	0.35 u	0.34 u	57.6 u	**0.78 u**	17.4	47.3
	11-Apr-05	LO-IA06-SS08-1	0-0.5'	7471A	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.017 u	-	-	-	-	-	-	-	-
IA06-SS09	11-Apr-05	LO-IA06-SS09-1	0-0.5'	6010B	1	**10300**	1.4 b	**34**	26.5	0.37 b	0.085 u	1080	**34.9**	9.7	33.8	**20200**	44.1	6520	**385**	-	**35.9**	1230	0.4 u	0.39 u	74.1 b	**0.9 u**	20.2	60.2
	11-Apr-05	LO-IA06-SS09-1	0-0.5'	7471A	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.016 u	-	-	-	-	-	-	-	-
IA06-SS10	11-Apr-05	LO-IA06-SS10-1	0-0.5'	6010B	1	**14100**	1.3 b	**31.1**	35.6	0.55	0.085 u	4940	**31**	8.8	24.7	**17600**	34	5590	**409**	-	**31**	1560	0.4 u	0.39 u	401 b	**0.9 u**	19	55.6
	11-Apr-05	LO-IA06-SS10-1	0-0.5'	7471A	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.017 u	-	-	-	-	-	-	-	-
IA06-SS11	11-Apr-05	LO-IA06-SS11-1	0-0.5'	6010B	1	**7720**	1.3 b	**13**	23.4	0.28 b	0.086 u	1240	25.5	5.3 b	13.8	**13700**	125	4240	**227**	-	18.4	1190	0.72	0.4 u	124 b	**0.69 u**	19	47.9
	11-Apr-05	LO-IA06-SS11-1	0-0.5'	7471A	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.028 b	-	-	-	-	-	-	-	-
IA06-SS12	11-Apr-05	LO-IA06-SS12-1	0-0.5'	6010B	1	**10300**	1.2 b	**38.1**	26.9	0.37 b	0.089 u	1260	**30.3**	8.8	21.2	**18500**	48.7	6420	**362**	-	**32.8**	1420	0.42 u	0.41 u	70.1 b	**0.94 u**	21.3	39.2
	11-Apr-05	LO-IA06-SS12-1	0-0.5'	7471A	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.016 u	-	-	-	-	-	-	-	-
IA06-SS13	11-Apr-05	LO-IA06-SS13-1	0-0.5'	6010B	1	**12800**	1.1 b	**32.3**	50.9	0.34 b	0.073 u	1710	**52**	9.1	20	**17000**	16.5	7280	**360**	-	**35.5**	2910	0.35 u	0.34 u	175 b	**0.77 u**	25.8	40.5
	11-Apr-05	LO-IA06-SS13-1	0-0.5'	7471A	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.018 u	-	-	-	-	-	-	-	-
IA06-SS14	11-Apr-05	LO-IA06-SS14-1	0-0.5'	6010B	1	**10800**	1.2 b	**33.3**	30.1	0.37 b	0.09 u	1750	**34.2**	8.2	17.2	**17300**	27.1	5890	**300**	-	**32.7**	1310	0.43 u	0.42 u	76.9 b	**0.96 u**	23.1	46
	11-Apr-05	LO-IA06-SS14-1	0-0.5'	7471A	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.018 u	-	-	-	-	-	-	-	-
IA06-SS15	11-Apr-05	LO-IA06-SS15-1	0-0.5'	6010B	1	**9250**	1.1 b	**32.4**	28.9	0.34 b	0.081 u	1850	**30**	7.3	14.7	**15500**	15	5420	**252**	-	**28.9**	1410	0.63	0.37 u	68.2 b	**0.86 u**	18.2	33.6
	11-Apr-05	LO-IA06-SS15-1	0-0.5'	7471A	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.016 u	-	-	-	-	-	-	-	-
	11-Apr-05	LO-IA06-SS15-1-D	0-0.5'	6010B	1	**11100**	**3.3 b**	**35.7**	130	**1.1**	0.09 u	8280	**37.9**	14.2	11	**59400**	77.7	1340	**470**	-	**29.9**	1450	0.43 u	0.42 u	70.8 b	**2.2**	**114**	143
	11-Apr-05	LO-IA06-SS15-1-D	0-0.5'	7471A	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.015 u	-	-	-	-	-	-	-	-
IA06-SS16	11-Apr-05	LO-IA06-SS16-1	0-0.5'	6010B	1	**10100**	1.7 b	**32.8**	29.3	0.34 b	0.081 u	1270	**35.1**	8.5	18.7	**18800**	16.9	6780	**354**	-	**34**	1720	0.57	0.38 u	105 b	**0.65 u**	21.5	37.3
	11-Apr-05	LO-IA06-SS16-1	0-0.5'	7471A	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.017 u	-	-	-	-	-	-	-	-
IA06-SS17	12-Apr-05	LO-IA06-SS17-1	0-0.5'	6010B	1	**10300**	1.7 b	**30.2**	31.7	0.32 b	0.087 u	1670	**39**	9.1	19.4	**16900**	16.6	6290	**306**	-	**35.4**	1640	0.41 u	0.4 u	147 b	**0.69 u**	23.7	38.4
	12-Apr-05	LO-IA06-SS17-1	0-0.5'	7471A	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.016 u	-	-	-	-	-	-	-	-

Location

Notes:

NC No criteria listed under the regulation cited
ND Non-detect result (Original data unavailable - neither value nor detection limit provided)
- Parameter not analyzed

Analytic Flags:

u Not detected above laboratory reporting limits
j Estimated value - parameter detected between laboratory reporting limit and half of the laboratory reporting limit.
e Value exceeds analytical calibration limits
b Parameter detected in quality control blank and sample

Highlighting:

Value or Detection Limit exceeds Criteria 1 only
Value or Detection Limit exceeds Criteria 2 only
Value or Detection Limit exceeds both criteria

SSI - Summary of Target Analyte List Metals Soil Analytical Results

Table 5-2f

PASI - SSI

Analytic Method: 6010B and 7471A
Sample Matrix: Soil
Reporting Units: mg/kg
Sample Dates: 03-Nov-2004 to 02-May-2005

						Aluminum	Antimony	Arsenic	Barium	Beryllium	Cadmium	Calcium	Chromium	Cobalt	Copper	Iron	Lead	Magnesium	Manganese	Mercury	Nickel	Potassium	Selenium	Silver	Sodium	Thallium	Vanadium	Zinc
SSI Project Action Limit (PAL) - Wave 2 (Metals)						7600	3.1	0.39	540	0.7	2	NC	30	900	310	2300	300	NC	180	2.3	20	NC	39	39	NC	0.52	55	2300
Secondary Regulatory Criteria Not Selected																												
	Date	Sample ID	Depth	Method	Dilution																							
IA06-SS18	12-Apr-05	LO-IA06-SS18-1	0-0.5'	6010B	1	**9950**	2.1 b	**31.1**	26.9	0.3 b	0.092 u	1260	**31.6**	8.1	21.7	**15600**	31.1	5200	**306**	-	**30.7**	1060	0.44 u	0.43 u	113 b	**0.74 u**	20.7	43.3
	12-Apr-05	LO-IA06-SS18-1	0-0.5'	7471A	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.018 u	-	-	-	-	-	-	-	-
IA06-SS19	12-Apr-05	LO-IA06-SS19-1	0-0.5'	6010B	1	**13300**	0.96 b	**27.5**	32	0.34 b	0.062 u	1770	**60.7**	10.6	19.2	**21500**	11.4	8530	**333**	-	**41**	1680	0.83	0.19 u	50.8 u	**0.67 u**	28.9	39.7
	12-Apr-05	LO-IA06-SS19-1	0-0.5'	7471A	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.017 u	-	-	-	-	-	-	-	-
IA06-SS20	12-Apr-05	LO-IA06-SS20-1	0-0.5'	6010B	1	**11400**	2.1 b	**25.7**	25.5	0.35 b	0.064 u	1620	**36.6**	9.4	72.8	**18600**	240	6040	**283**	-	**34.4**	1190	0.43 b	0.19 u	52.3 u	**0.69 u**	23.3	42.9
	12-Apr-05	LO-IA06-SS20-1	0-0.5'	7471A	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.016 u	-	-	-	-	-	-	-	-
IA06-SS21	12-Apr-05	LO-IA06-SS21-1	0-0.5'	6010B	1	**8580**	2.2 b	**24.6**	16.8 b	0.34 b	0.095 u	1130	16.5	6.1	39.5	**13200**	163	2630	**221**	-	**23.5**	578 b	0.59 b	0.44 u	109 b	**0.76 u**	16	42.1
	12-Apr-05	LO-IA06-SS21-1	0-0.5'	7471A	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.037 b	-	-	-	-	-	-	-	-
IA06-SS22	13-Apr-05	LO-IA06-SS22-1	0-0.5'	6010B	1	**13600**	0.79 b	**29.7**	40.8	0.38 b	0.07 u	1670	**46.4**	10.7	46.3	**20800**	103	8320	**353**	-	**39.1**	2200	0.74	0.21 u	56.7 u	**0.8 b**	27.2	50.6
	13-Apr-05	LO-IA06-SS22-1	0-0.5'	7471A	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.015 u	-	-	-	-	-	-	-	-
IA06-SS23	13-Apr-05	LO-IA06-SS23-1	0-0.5'	6010B	1	**10400**	0.78 b	**29.9**	26.2	0.31 b	0.069 u	1120	**33.6**	8.5	30.9	**17100**	70	5940	**276**	-	**31.7**	1210	0.66	0.21 u	56 u	**0.97 u**	21.1	40.3
	13-Apr-05	LO-IA06-SS23-1	0-0.5'	7471A	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.018 u	-	-	-	-	-	-	-	-
IA06-SS24	13-Apr-05	LO-IA06-SS24-1	0-0.5'	6010B	1	**14500**	1.3 b	**38.5**	35.6	0.42 b	0.083 u	2350	**43.2**	11.7	68.8	**24000**	125	8550	**268**	-	**43.7**	1310	0.69	0.25 u	67.2 u	**1.6**	29.7	76.7
	13-Apr-05	LO-IA06-SS24-1	0-0.5'	7471A	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.024 b	-	-	-	-	-	-	-	-
IA06-SS25	13-Apr-05	LO-IA06-SS25-1	0-0.5'	6010B	1	**10800**	0.87 b	**47.1**	29.9	0.41 b	0.071 b	1780	**34**	9.1	114	**23600**	161	6360	**320**	-	**38.7**	1130	0.43 u	0.2 u	86.2 b	**0.72 u**	23.5	62.4
	13-Apr-05	LO-IA06-SS25-1	0-0.5'	7471A	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.018 u	-	-	-	-	-	-	-	-
IA06-SS26	13-Apr-05	LO-IA06-SS26-1	0-0.5'	6010B	1	**10000**	1.2 b	**26.4**	25.5	0.38 b	0.076 u	1510	**31.5**	8.2	46.1	**18400**	168	5750	**266**	-	**31.8**	986	0.53 u	0.23 u	61.6 u	**0.81 u**	19.7	46.6
	13-Apr-05	LO-IA06-SS26-1	0-0.5'	7471A	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.018 u	-	-	-	-	-	-	-	-
IA06-SS27	13-Apr-05	LO-IA06-SS27-1	0.5-1.5'	6010B	1	7350	0.89 b	**15.4**	17.8 b	0.32 b	0.066 u	808	20.9	4.1 b	82.5	**10100**	186	2680	131	-	16.1	630	0.42 u	0.2 u	88.7 b	**0.7 u**	11.9	28.7
	13-Apr-05	LO-IA06-SS27-1	0.5-1.5'	7471A	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.02 u	-	-	-	-	-	-	-	-
	13-Apr-05	LO-IA06-SS27-1	0-0.5'	6010B	1	**8400**	1.3 b	**16**	12.9 b	0.33 b	0.067 u	696	20.3	4.2 b	156	**11900**	**340**	3340	111	-	18.4	506 b	0.47 u	0.2 u	54.6 u	**0.72 u**	15.3	33.1
	13-Apr-05	LO-IA06-SS27-1	0-0.5'	7471A	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.021 b	-	-	-	-	-	-	-	-
IA06-SS28	12-Apr-05	LO-IA06-SS28-1	0-0.5'	6010B	1	**7620**	1.4 b	**17.5**	14.9 b	0.26 b	0.081 u	623	22.2	4 b	13.7	**11100**	41.5	3400	**195**	-	17.8	482 b	0.53	0.38 u	108 b	**0.65 u**	16.3	26.3
	12-Apr-05	LO-IA06-SS28-1	0-0.5'	7471A	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.03 b	-	-	-	-	-	-	-	-
IA06-SS29	12-Apr-05	LO-IA06-SS29-1	0-0.5'	6010B	1	**9020**	1.6 b	**20.5**	14.8 b	0.43 b	0.092 u	513 b	26.4	4 b	27	**13000**	172	4700	144	-	18	795	0.44 u	0.43 u	99.7 b	**0.74 u**	17.3	24.6
	12-Apr-05	LO-IA06-SS29-1	0-0.5'	7471A	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.028 b	-	-	-	-	-	-	-	-
IA06-SS30	12-Apr-05	LO-IA06-SS30-1	0.5-1.5'	6010B	1	**9230**	0.42 u	**10.9**	16.9 b	0.41 b	0.061 u	300 b	15.5	4.4 b	8.5	**11700**	21.9	2260	140	-	12.4	372 b	0.51 b	0.18 u	63.6 b	**0.66 u**	13.2	20.8
	12-Apr-05	LO-IA06-SS30-1	0.5-1.5'	7471A	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.019 b	-	-	-	-	-	-	-	-
	12-Apr-05	LO-IA06-SS30-1	0-0.5'	6010B	1	**9720**	2.6 b	**12**	13.5 b	0.38 b	0.092 u	478 b	15.2	3.1 b	48.7	**12600**	**438**	2650	146	-	13.5	367 b	0.44 u	0.43 u	78.2 b	**0.74 u**	15.6	28.4
	12-Apr-05	LO-IA06-SS30-1	0-0.5'	7471A	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.025 b	-	-	-	-	-	-	-	-
IA06-SS31	12-Apr-05	LO-IA06-SS31-1	0-0.5'	6010B	1	**9590**	1.9 b	**12.1**	21.1 b	0.37 b	0.094 u	277 b	14.9	2.7 b	21.7	**11500**	114	2240	178	-	13.1	311 b	0.59	0.44 u	78.9 b	**0.75 u**	14.6	24.3
	12-Apr-05	LO-IA06-SS31-1	0-0.5'	7471A	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.035	-	-	-	-	-	-	-	-
IA06-SS32	12-Apr-05	LO-IA06-SS32-1	0.5-1.5'	6010B	1	**11400**	0.7 b	**15.1**	16.1 b	0.43 b	0.062 u	148 b	15	4.2 b	16.5	**12400**	50.3	2200	82	-	14.3	296 b	0.39 u	0.19 u	61.4 b	**0.88 u**	13.6	21.8
	12-Apr-05	LO-IA06-SS32-1	0.5-1.5'	7471A	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.033 b	-	-	-	-	-	-	-	-
	12-Apr-05	LO-IA06-SS32-1	0-0.5'	6010B	1	**10100**	**4.6 b**	**14.8**	18.5 b	0.36 b	0.08 u	468 b	19	3.6 b	90.3	**12300**	**774**	2520	140	-	16.5	571	0.62	0.37 u	82 b	**0.85 u**	16.6	26.5
	12-Apr-05	LO-IA06-SS32-1	0-0.5'	7471A	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.039	-	-	-	-	-	-	-	-

Location

Notes:

NC No criteria listed under the regulation cited
ND Non-detect result (Original data unavailable - neither value nor detection limit provided)
- Parameter not analyzed

Analytic Flags:

u Not detected above laboratory reporting limits
j Estimated value - parameter detected between laboratory reporting limit and half of the laboratory reporting limit.
e Value exceeds analytical calibration limits
b Parameter detected in quality control blank and sample

Highlighting:

Value or Detection Limit exceeds Criteria 1 only
Value or Detection Limit exceeds Criteria 2 only
Value or Detection Limit exceeds both criteria

PASI - SSI

Analytic Method: 6010B and 7471A
Sample Matrix: Soil
Reporting Units: mg/kg
Sample Dates: 03-Nov-2004 to 02-May-2005

						Aluminum	Antimony	Arsenic	Barium	Beryllium	Cadmium	Calcium	Chromium	Cobalt	Copper	Iron	Lead	Magnesium	Manganese	Mercury	Nickel	Potassium	Selenium	Silver	Sodium	Thallium	Vanadium	Zinc
SSI Project Action Limit (PAL) - Wave 2 (Metals)						7600	3.1	0.39	540	0.7	2	NC	30	900	310	2300	300	NC	180	2.3	20	NC	39	39	NC	0.52	55	2300
Secondary Regulatory Criteria Not Selected																												
	Date	Sample ID	Depth	Method	Dilution																							
IA06-SS33	12-Apr-05	LO-IA06-SS33-1	0.5-1.5'	6010B	1	**10500**	0.39 u	**14.9**	18.6 b	0.45 b	0.058 u	160 b	15.1	4.3 b	11.2	**11800**	12.7	2050	109	-	14.8	277 b	0.37 u	0.23 b	47 u	**0.99**	13.5	23.3
	12-Apr-05	LO-IA06-SS33-1	0.5-1.5'	7471A	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.018 u	-	-	-	-	-	-	-	-
	12-Apr-05	LO-IA06-SS33-1	0-0.5'	6010B	1	**10100**	2.4 b	**14.7**	17.7 b	0.55	0.076 u	285 b	16.5	3 b	182	**12800**	**643**	2420	161	-	13.4	284 b	0.49	0.35 u	65.7 b	**0.61 u**	16.2	28
	12-Apr-05	LO-IA06-SS33-1	0-0.5'	7471A	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.029 b	-	-	-	-	-	-	-	-
IA06-SS34	12-Apr-05	LO-IA06-SS34-1	0.5-1.5'	6010B	1	**9530**	0.41 u	**13.2**	16.7 b	0.36 b	0.06 u	169 b	15.8	4.1 b	8	**11300**	47.1	2270	82.5	-	13.3	261 b	0.38 u	0.18 u	63 b	**0.64 u**	12.8	21.5
	12-Apr-05	LO-IA06-SS34-1	0.5-1.5'	7471A	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.017 u	-	-	-	-	-	-	-	-
	12-Apr-05	LO-IA06-SS34-1	0-0.5'	6010B	1	**8570**	1.9 b	**13.4**	13.4 b	0.3 b	0.081 u	412 b	20.1	3 b	76.1	**11300**	**452**	2780	143	-	13.1	460 b	0.44 b	0.37 u	87.1 b	**0.65 u**	14.8	23.6
	12-Apr-05	LO-IA06-SS34-1	0-0.5'	7471A	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.016 u	-	-	-	-	-	-	-	-
IA06-SS35	12-Apr-05	LO-IA06-SS35-1	0.5-1.5'	6010B	1	**16600**	0.61 b	**19.2**	74.1	0.69	0.065 u	942	**36.3**	7.9	12	**19400**	18.2	6360	**267**	-	**32.2**	1530	0.41 u	0.2 u	121 b	**0.92 u**	26	34
	12-Apr-05	LO-IA06-SS35-1	0.5-1.5'	7471A	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.018 u	-	-	-	-	-	-	-	-
	12-Apr-05	LO-IA06-SS35-1	0-0.5'	6010B	1	**9810**	**3.6 b**	**16.4**	14.2 b	0.3 b	0.086 u	317 b	17.6	3.1 b	134	**12000**	**973**	2460	111	-	13.5	337 b	0.93	0.4 u	110 b	**0.73 b**	16.3	31.7
	12-Apr-05	LO-IA06-SS35-1	0-0.5'	7471A	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.037	-	-	-	-	-	-	-	-
	12-Apr-05	LO-IA06-SS35-1	0-1.5'	6010B	1	**13200**	2.1 b	**22.6**	19.3 b	0.5 b	0.092 u	297 b	29.7	4.6 b	43.2	**16000**	**325**	4110	**213**	-	16.8	841	0.49 b	0.43 u	77.2 b	**0.74 u**	21.1	29.9
	12-Apr-05	LO-IA06-SS35-1	0-1.5'	7471A	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.018 u	-	-	-	-	-	-	-	-
IA06-SS36	12-Apr-05	LO-IA06-SS36-1	0.5-1.5'	6010B	1	**15000**	0.64 b	**25.5**	26.6	0.64	0.059 u	329 b	**32.7**	9.1	18.3	**21300**	44.6	4430	**438**	-	**29**	531	0.38 u	0.18 u	48.4 u	**0.84 u**	24.8	35.3
	12-Apr-05	LO-IA06-SS36-1	0.5-1.5'	7471A	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.018 u	-	-	-	-	-	-	-	-
	12-Apr-05	LO-IA06-SS36-1	0-0.5'	6010B	1	**10100**	**3.7 b**	**18.6**	17.9 b	0.41 b	0.086 u	429 b	24.3	3.9 b	113	**14700**	**1220**	3570	**199**	-	15.9	463 b	0.55	0.4 u	68.1 b	**1 b**	19.4	35.8
	12-Apr-05	LO-IA06-SS36-1	0-0.5'	7471A	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.042	-	-	-	-	-	-	-	-
IA06-SS37	12-Apr-05	LO-IA06-SS37-1	0.5-1.5'	6010B	1	**12900**	0.94 b	**15**	16.5 b	0.47 b	0.062 u	262 b	20.4	4.8 b	50.6	**15200**	196	3240	112	-	17	510 b	0.39 u	0.19 u	54.3 b	**0.66 u**	17.9	29.7
	12-Apr-05	LO-IA06-SS37-1	0.5-1.5'	7471A	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.025 b	-	-	-	-	-	-	-	-
	12-Apr-05	LO-IA06-SS37-1	0-0.5'	6010B	1	**8920**	2.3 b	**15.1**	13.9 b	0.28 b	0.083 u	454 b	17.9	2.6 b	116	**12600**	**777**	2190	129	-	12.5	400 b	0.59	0.39 u	79.4 b	**0.88 u**	19.6	24.3
	12-Apr-05	LO-IA06-SS37-1	0-0.5'	7471A	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.034	-	-	-	-	-	-	-	-
IA06-SS38	12-Apr-05	LO-IA06-SS38-1	0-0.5'	6010B	1	**10400**	1.8 b	**16.9**	19.3 b	0.38 b	0.079 u	720	**36**	4.4 b	25.4	**14300**	134	3930	**221**	-	**20.5**	1100	0.73	0.36 u	80.3 b	**0.84 u**	18.5	31.8
	12-Apr-05	LO-IA06-SS38-1	0-0.5'	7471A	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.039	-	-	-	-	-	-	-	-
	12-Apr-05	LO-IA06-SS38-1-D	0-0.5'	6010B	1	**8270**	2.1 b	**14.6**	11.9 b	0.27 b	0.084 u	353 b	15	3.2 b	25.5	**10300**	151	2370	137	-	13.5	366 b	0.5 b	0.39 u	76.7 b	**0.67 u**	13.4	24.9
	12-Apr-05	LO-IA06-SS38-1-D	0-0.5'	7471A	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.04	-	-	-	-	-	-	-	-
IA06-SS39	12-Apr-05	LO-IA06-SS39-1	0-0.5'	6010B	1	**8420**	1.9 b	**22.2**	15.7 b	0.29 b	0.12 b	931	15.4	2.5 b	25.3	**11200**	261	2610	110	-	13.1	291 b	0.57 b	0.44 u	82 b	**0.75 u**	16.4	26.1
	12-Apr-05	LO-IA06-SS39-1	0-0.5'	7471A	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.018 u	-	-	-	-	-	-	-	-
IA06-SS40	12-Apr-05	LO-IA06-SS40-1	0-0.5'	6010B	1	**10400**	1.6 b	**17.7**	17 b	0.32 b	0.1 u	241 b	21.6	3.2 b	44.6	**14200**	128	2700	169	-	13.9	280 b	0.49 u	0.48 u	87.5 b	**0.91 b**	20.3	27.9
	12-Apr-05	LO-IA06-SS40-1	0-0.5'	7471A	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.032 b	-	-	-	-	-	-	-	-
	12-Apr-05	LO-IA06-SS40-1	0-1.5'	6010B	1	**13000**	1.5 b	**19.2**	18.2	0.39 b	0.07 u	240 b	25.1	5.1	23.2	**13700**	47.7	3260	117	-	**20.4**	384 b	0.37 b	0.33 u	69.5 b	**0.99**	17.8	32.6
	12-Apr-05	LO-IA06-SS40-1	0-1.5'	7471A	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.032 b	-	-	-	-	-	-	-	-
IA06-SS41	13-Apr-05	LO-IA06-SS41-1	0-0.5'	6010B	1	**10600**	0.37 u	**10.9**	20.2	0.41 b	0.054 u	257 b	16.8	3.5 b	5.9	**13100**	22.6	2690	**201**	-	13.2	347 b	0.38 u	0.16 u	44.3 u	**0.58 u**	14.5	28.2
	13-Apr-05	LO-IA06-SS41-1	0-0.5'	7471A	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.034 b	-	-	-	-	-	-	-	-
IA06-SS42	13-Apr-05	LO-IA06-SS42-1	0-0.5'	6010B	1	6850	0.65 b	**13.3**	10.8 b	0.21 b	0.068 u	415 b	12.7	3.2 b	7	**9430**	14.9	2270	109	-	10.9	429 b	0.43 u	0.2 u	55 u	**0.72 u**	12.1	26.9
	13-Apr-05	LO-IA06-SS42-1	0-0.5'	7471A	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.027 b	-	-	-	-	-	-	-	-

Location

Notes:

NC No criteria listed under the regulation cited
ND Non-detect result (Original data unavailable - neither value nor detection limit provided)
- Parameter not analyzed

Analytic Flags:

u Not detected above laboratory reporting limits
j Estimated value - parameter detected between laboratory reporting limit and half of the laboratory reporting limit.
e Value exceeds analytical calibration limits
b Parameter detected in quality control blank and sample

Highlighting:

Value or Detection Limit exceeds Criteria 1 only
Value or Detection Limit exceeds Criteria 2 only
Value or Detection Limit exceeds both criteria

SSI - Summary of Target Analyte List Metals Soil Analytical Results

Table 5-2f

PASI - SSI

Analytic Method: 6010B and 7471A
Sample Matrix: Soil
Reporting Units: mg/kg
Sample Dates: 03-Nov-2004 to 02-May-2005

						Aluminum	Antimony	Arsenic	Barium	Beryllium	Cadmium	Calcium	Chromium	Cobalt	Copper	Iron	Lead	Magnesium	Manganese	Mercury	Nickel	Potassium	Selenium	Silver	Sodium	Thallium	Vanadium	Zinc
SSI Project Action Limit (PAL) - Wave 2 (Metals)						7600	3.1	0.39	540	0.7	2	NC	30	900	310	2300	300	NC	180	2.3	20	NC	39	39	NC	0.52	55	2300
Secondary Regulatory Criteria Not Selected																												
	Date	Sample ID	Depth	Method	Dilution																							
IA06-SS43	13-Apr-05	LO-IA06-SS43-1	0-0.5'	6010B	1	**11000**	0.76 b	**23.8**	17 b	0.38 b	0.066 u	645	27.1	5.5 b	11.8	**16900**	27.8	4250	**228**	-	**23**	535 b	0.87	0.2 u	53.9 u	**0.71 u**	18.8	41.3
	13-Apr-05	LO-IA06-SS43-1	0-0.5'	7471A	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.042	-	-	-	-	-	-	-	-
IA06-SS44	13-Apr-05	LO-IA06-SS44-1	0-0.5'	6010B	1	**10600**	0.48 u	**23.5**	16 b	0.33 b	0.075 b	450 b	23.6	4.9 b	20.8	**15100**	56.6	4040	125	-	**20**	545 b	0.54 b	0.21 u	56.6 u	**0.96 b**	19.3	38
	13-Apr-05	LO-IA06-SS44-1	0-0.5'	7471A	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.053	-	-	-	-	-	-	-	-
IA06-SS45	13-Apr-05	LO-IA06-SS45-1	0-0.5'	6010B	1	**11600**	0.54 u	**17.4**	31.1	0.35 b	0.18 b	1850	19.5	4.2 b	12.1	**14300**	47.3	2830	**331**	-	16.6	505 b	0.55 u	0.23 u	63.7 u	**0.84 u**	21.4	66.7
	13-Apr-05	LO-IA06-SS45-1	0-0.5'	7471A	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.081	-	-	-	-	-	-	-	-
	13-Apr-05	LO-IA06-SS25-1	0-1.5'	6010B	1	**8250**	0.55 b	**17.9**	19.8 b	0.23 b	0.061 u	1360	22.8	8	28.5	**17500**	44.7	4980	**459**	-	**23.7**	875	0.43 u	0.18 u	49.9 u	**0.65 u**	16.9	38.1
	13-Apr-05	LO-IA06-SS25-1	0-1.5'	7471A	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.019 u	-	-	-	-	-	-	-	-
IA06-SS46	02-May-05	LO-IA06-SS46-1	0-0.5'	6010B	1	**9890**	2.3 b	**13.3**	18 b	0.41 b	0.078 u	189 b	15.7	3.3 b	85.6	**11800**	**388**	1790	88.6	-	12.3	263 b	1	0.36 u	61.4 u	**0.83 u**	14.3	27.2
	02-May-05	LO-IA06-SS46-1	0-0.5'	7471A	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.019 b	-	-	-	-	-	-	-	-
IA06-SS47	02-May-05	LO-IA06-SS47-1	0-0.5'	6010B	1	**8110**	**3.7 b**	**13.9**	10.4 b	0.43 b	0.085 u	419 b	14.9	3.1 b	149	**10800**	**1170**	1850	117	-	11.9	331 b	1	0.39 u	66.7 u	**0.9 u**	12.5	30.6
	02-May-05	LO-IA06-SS47-1	0-0.5'	7471A	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.016 u	-	-	-	-	-	-	-	-
IA06-SS48	02-May-05	LO-IA06-SS48-1	0-0.5'	6010B	1	**9020**	**3.4 b**	**17.5**	11 b	0.44 b	0.087 u	280 b	20.7	4.9 b	263	**12200**	**4560**	2790	131	-	16.4	413 b	1	0.4 u	67.9 u	**1.2**	14.1	43.1
	02-May-05	LO-IA06-SS48-1	0-0.5'	7471A	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.016 b	-	-	-	-	-	-	-	-
IA06-TP01	11-Apr-05	LO-IA06-TP01-1	--	6010B	1	3930	0.94 u	**15.8**	7.8 b	0.18 b	0.09 u	433 b	10.3	3.6 b	6.5	**6930**	5.7	2150	168	-	14	398 b	0.43 u	0.42 u	70.8 u	**0.96 u**	6.7	14.7
	11-Apr-05	LO-IA06-TP01-1	--	7471A	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.018 u	-	-	-	-	-	-	-	-
IA06-TP02	11-Apr-05	LO-IA06-TP02-1	--	6010B	1	4820	0.93 u	**15.5**	6.9 b	0.23 b	0.089 u	418 b	9.8	5.2 b	6.7	**7230**	4.2	1960	**216**	-	12.5	357 b	0.43 u	0.41 u	70.1 u	**0.95 u**	7	13.6
	11-Apr-05	LO-IA06-TP02-1	--	7471A	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.02 u	-	-	-	-	-	-	-	-
IA06-TP03	11-Apr-05	LO-IA06-TP03-1	--	6010B	1	4790	0.91 u	**14.1**	9.6 b	0.31 b	0.088 u	837	11.1	4.8 b	6.1	**8190**	3	1940	**180**	-	14.7	464 b	0.42 u	0.41 u	68.9 u	**0.93 u**	9.8	17.9
	11-Apr-05	LO-IA06-TP03-1	--	7471A	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.02 u	-	-	-	-	-	-	-	-
IA06-TP04	11-Apr-05	LO-IA06-TP04-1	--	6010B	1	6460	0.91 u	**16.8**	9.4 b	0.34 b	0.088 u	552	13.3	5.4 b	10.1	**10800**	4.7	2890	171	-	18.5	550 b	0.42 u	0.41 u	69 u	**0.94 u**	10.7	23.2
	11-Apr-05	LO-IA06-TP04-1	--	7471A	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.017 u	-	-	-	-	-	-	-	-
IA07-SB01	29-Nov-04	GR-IA07-SB01-1	0-3'	6010B	1	5400	**11**	**27**	23	0.21 u	0.43 u	710	19	8.3	61	**12000**	**790**	3100	**300**	-	**43**	1300	2.1 u	0.43 u	86 u	**2.1 u**	12	26
	29-Nov-04	GR-IA07-SB01-1	0-3'	7471A	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.087 u	-	-	-	-	-	-	-	-
	29-Nov-04	GR-IA07-SB01-1	3-10'	6010B	1	2400	2.1 u	**22**	9.1	0.21 u	0.41 u	1100	7.5	5.1	12	**6900**	28	1400	**180**	-	18	390	2.1 u	0.41 u	83 u	**2.1 u**	5.2	16
	29-Nov-04	GR-IA07-SB01-1	3-10'	7471A	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.083 u	-	-	-	-	-	-	-	-
IA07-SB02	29-Nov-04	GR-IA07-SB02-1	0-3'	6010B	1	5900	**24**	**32**	18	0.22 u	0.44 u	520	14	6.9	55	**11000**	**1400**	2200	**280**	-	**34**	820	2.2 u	0.44 u	87 u	**2.2 u**	11	24
	29-Nov-04	GR-IA07-SB02-1	0-3'	7471A	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.0073 j	-	-	-	-	-	-	-	-
	29-Nov-04	GR-IA07-SB02-1	3-10'	6010B	1	2800	2.1 u	**27**	12	0.21 u	0.42 u	790	9.9	7.4	13	**10000**	21	1700	**260**	-	**25**	580	2.1 u	0.42 u	84 u	**2.1 u**	6.4	22
	29-Nov-04	GR-IA07-SB02-1	3-10'	7471A	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.08 u	-	-	-	-	-	-	-	-
IA07-SB03	29-Nov-04	GR-IA07-SB03-1	0-3'	6010B	1	5400	2.2 u	**28**	21	0.22 u	0.45 u	940	15	6.7	13	**9700**	29	2200	**250**	-	**22**	860	2.2 u	0.45 u	89 u	**2.2 u**	11	26
	29-Nov-04	GR-IA07-SB03-1	0-3'	7471A	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.018 j	-	-	-	-	-	-	-	-
	29-Nov-04	GR-IA07-SB03-1	3-10'	6010B	1	3700	2.1 u	**52**	17	0.21 u	0.43 u	980	13	6.5	12	**9500**	7.5	2100	**220**	-	**22**	820	2.1 u	0.43 u	86 u	**2.1 u**	8	23
	29-Nov-04	GR-IA07-SB03-1	3-10'	7471A	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.083 u	-	-	-	-	-	-	-	-

Location

Notes:

NC No criteria listed under the regulation cited
ND Non-detect result (Original data unavailable - neither value nor detection limit provided)
- Parameter not analyzed

Analytic Flags:

u Not detected above laboratory reporting limits
j Estimated value - parameter detected between laboratory reporting limit and half of the laboratory reporting limit.
e Value exceeds analytical calibration limits
b Parameter detected in quality control blank and sample

Highlighting:

Value or Detection Limit exceeds Criteria 1 only
Value or Detection Limit exceeds Criteria 2 only
Value or Detection Limit exceeds both criteria

SSI - Summary of Target Analyte List Metals Soil Analytical Results

Table 5-2f

PASI - SSI

Analytic Method: 6010B and 7471A
Sample Matrix: Soil
Reporting Units: mg/kg
Sample Dates: 03-Nov-2004 to 02-May-2005

						Aluminum	Antimony	Arsenic	Barium	Beryllium	Cadmium	Calcium	Chromium	Cobalt	Copper	Iron	Lead	Magnesium	Manganese	Mercury	Nickel	Potassium	Selenium	Silver	Sodium	Thallium	Vanadium	Zinc
SSI Project Action Limit (PAL) - Wave 2 (Metals)						7600	3.1	0.39	540	0.7	2	NC	30	900	310	2300	300	NC	180	2.3	20	NC	39	39	NC	0.52	55	2300
Secondary Regulatory Criteria Not Selected																												
	Date	Sample ID	Depth	Method	Dilution																							
IA07-SB04	29-Nov-04	GR-IA07-SB04-1	0-3'	6010B	1	4900	2.4	**25**	17	0.22 u	0.44 u	600	13	5.9	68	**9900**	120	2100	**250**	-	**22**	790	2.2 u	0.44 u	89 u	**2.2 u**	9.5	34
	29-Nov-04	GR-IA07-SB04-1	0-3'	7471A	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.014 j	-	-	-	-	-	-	-	-
	29-Nov-04	GR-IA07-SB04-1	3-10'	6010B	1	2600	2.1 u	**20**	11	0.21 u	0.42 u	1200	8.7	5.3	14	**7900**	14	1400	**230**	-	19	480	2.1 u	0.42 u	84 u	**2.1 u**	5.4	18
	29-Nov-04	GR-IA07-SB04-1	3-10'	7471A	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.088 u	-	-	-	-	-	-	-	-
IA07-SS01	04-Nov-04	GR-IA07-SS01-1	0-1.5'	6010B	1	6300	2.1 u	**23**	16	0.21 u	0.43 u	610	14	7.4	22	**11000**	140	2400	**240**	-	**24**	810	2.1 u	0.43 u	85 u	**2.1 u**	12	23
	04-Nov-04	GR-IA07-SS01-1	0-1.5'	7471A	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.034 j	-	-	-	-	-	-	-	-
IA07-SS02	04-Nov-04	GR-IA07-SS02-1-M	0-1.5'	6010B	1	6400	2.1 u	**20**	12	0.21 u	0.43 u	270	12	3.5	15	**7800**	120	1600	140	-	13	330	2.1 u	0.43 u	86 u	**2.1 u**	10	16
	04-Nov-04	GR-IA07-SS02-1-M	0-1.5'	7471A	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.05 j	-	-	-	-	-	-	-	-
IA07-SS03	04-Nov-04	GR-IA07-SS03-1	0-1.5'	6010B	1	5100	**12**	**24**	10	0.22 u	0.44 u	270	12	4.6	46	**8400**	**1200**	1800	**220**	-	**20**	650	2.2 u	0.44 u	89 u	**2.2 u**	10	21
	04-Nov-04	GR-IA07-SS03-1	0-1.5'	7471A	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.042 j	-	-	-	-	-	-	-	-
IA07-SS04	04-Nov-04	GR-IA07-SS04-1	0-1.5'	6010B	1	5200	2.1 u	**25**	10	0.21 u	0.43 u	220	12	4.6	11	**8400**	28	1700	160	-	15	540	2.1 u	0.43 u	86 u	**2.1 u**	9	17
	04-Nov-04	GR-IA07-SS04-1	0-1.5'	7471A	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.018 j	-	-	-	-	-	-	-	-
	04-Nov-04	GR-IA07-SS04-1-D	0-1.5'	6010B	1	4500	2.1 u	**24**	9.5	0.21 u	0.42 u	190	9.5	4.4	10	**7600**	20	1500	150	-	14	520	2.1 u	0.42 u	84 u	**2.1 u**	7.6	16
	04-Nov-04	GR-IA07-SS04-1-D	0-1.5'	7471A	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.0097 j	-	-	-	-	-	-	-	-
IA07-SS05	04-Nov-04	GR-IA07-SS05-1	0-1.5'	6010B	1	**9200**	2.5 u	**27**	24	0.25 u	0.49 u	510	19	5.3	15	**11000**	44	2400	**340**	-	16	680	2.5 u	0.49 u	99 u	**2.5 u**	18	32
	04-Nov-04	GR-IA07-SS05-1	0-1.5'	7471A	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.3	-	-	-	-	-	-	-	-
IA07-SS06	15-Nov-04	GR-IA07-SS06-1	0-1.5'	6010B	1	**10000**	2.3	**25**	23	0.23 u	0.46 u	730	23	6.6	26	**14000**	220	4400	**290**	-	**25**	940	2.3 u	0.46 u	91 u	**2.3 u**	17	46
	15-Nov-04	GR-IA07-SS06-1	0-1.5'	7471A	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.074 j	-	-	-	-	-	-	-	-
IA08-SB01	30-Nov-04	GR-IA08-SB01-1	0-3'	6010B	1	5800	2.1 u	**29**	26	0.21 u	0.43 u	1800	20	9.1	17	**13000**	12	3500	**290**	-	**31**	1600	2.1 u	0.43 u	86 u	**2.1 u**	12	28
	30-Nov-04	GR-IA08-SB01-1	0-3'	7471A	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.086 u	-	-	-	-	-	-	-	-
	30-Nov-04	GR-IA08-SB01-1	3-10'	6010B	1	4700	2.1 u	**32**	22	0.21 u	0.42 u	7900	19	8.3	15	**11000**	8	3600	**270**	-	**31**	1400	2.1 u	0.42 u	84 u	**2.1 u**	11	28
	30-Nov-04	GR-IA08-SB01-1	3-10'	7471A	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.081 u	-	-	-	-	-	-	-	-
	30-Nov-04	GR-IA08-SB01-1-D	3-10'	6010B	1	4500	2.1 u	**30**	21	0.21 u	0.42 u	7200	18	7.7	15	**11000**	8.2	3300	**250**	-	**29**	1400	2.1 u	0.42 u	83 u	**2.1 u**	10	26
	30-Nov-04	GR-IA08-SB01-1-D	3-10'	7471A	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.082 u	-	-	-	-	-	-	-	-
IA08-SB09	16-Dec-04	GR-IA08-SB09-1	0-3'	6010B	1	**7800**	2.1 u	**25**	31	0.21 u	0.43 u	2000	24	7.6	19	**13000**	11	4100	**230**	-	**26**	1900	2.1 u	0.43 u	85 u	**2.1 u**	15	30
	16-Dec-04	GR-IA08-SB09-1	0-3'	7471A	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.01 j	-	-	-	-	-	-	-	-
	16-Dec-04	GR-IA08-SB09-1	3-10'	6010B	1	4700	2.1 u	**36**	22	0.21 u	0.42 u	9100	20	8.8	16	**11000**	7.1	3200	**240**	-	**31**	1800	2.1 u	0.42 u	84 u	**2.1 u**	11	24
	16-Dec-04	GR-IA08-SB09-1	3-10'	7471A	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.0049 j	-	-	-	-	-	-	-	-
IA09-SB01	29-Nov-04	CA-IA09-SB01-1	0-3'	6010B	1	6600	2.2 u	**26**	38	0.22 u	0.44 u	5000	18	6.7	18	**12000**	24	3000	**240**	-	**22**	1300	2.2 u	0.44 u	88 u	**2.2 u**	13	31
	29-Nov-04	CA-IA09-SB01-1	0-3'	7471A	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.029 j	-	-	-	-	-	-	-	-
	29-Nov-04	CA-IA09-SB01-1	3-10'	6010B	1	4100	2.2 u	**20**	10	0.22 u	0.44 u	640	4.9	2.5	4.5	**4700**	4.9	810	100	-	5.2	320	2.2 u	0.44 u	88 u	**2.2 u**	4.4	11
	29-Nov-04	CA-IA09-SB01-1	3-10'	7471A	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.006 j	-	-	-	-	-	-	-	-
IA09-TP01-A1	04-Nov-04	CA-IA09-TP01-A1-M	0-2'	6010B	1	4000	2.1 u	**23**	14	0.21 u	0.43 u	520	11	5.1	11	**8500**	13	1800	**220**	-	17	580	2.1 u	0.43 u	85 u	**2.1 u**	7.6	22
	04-Nov-04	CA-IA09-TP01-A1-M	0-2'	7471A	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.04 j	-	-	-	-	-	-	-	-
IA09-TP01-A2	04-Nov-04	CA-IA09-TP01-A2-1	2-4'	6010B	1	3500	2.1 u	**15**	9.2	0.21 u	0.42 u	430	5	3.3	5.8	**5000**	14	910	120	-	7.6	350	2.1 u	0.42 u	84 u	**2.1 u**	4.8	18
	04-Nov-04	CA-IA09-TP01-A2-1	2-4'	7471A	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.0035 j	-	-	-	-	-	-	-	-

Location

Notes:

- **NC** No criteria listed under the regulation cited
- **ND** Non-detect result (Original data unavailable - neither value nor detection limit provided)
- **-** Parameter not analyzed

Analytic Flags:

- **u** Not detected above laboratory reporting limits
- **j** Estimated value - parameter detected between laboratory reporting limit and half of the laboratory reporting limit.
- **e** Value exceeds analytical calibration limits
- **b** Parameter detected in quality control blank and sample

Highlighting:

- Value or Detection Limit exceeds Criteria 1 only
- Value or Detection Limit exceeds Criteria 2 only
- Value or Detection Limit exceeds both criteria

SSI - Summary of Target Analyte List Metals Soil Analytical Results

Table 5-2f

PASI - SSI

Analytic Method: 6010B and 7471A
Sample Matrix: Soil
Reporting Units: mg/kg
Sample Dates: 03-Nov-2004 to 02-May-2005

						Aluminum	Antimony	Arsenic	Barium	Beryllium	Cadmium	Calcium	Chromium	Cobalt	Copper	Iron	Lead	Magnesium	Manganese	Mercury	Nickel	Potassium	Selenium	Silver	Sodium	Thallium	Vanadium	Zinc
SSI Project Action Limit (PAL) - Wave 2 (Metals)						7600	3.1	0.39	540	0.7	2	NC	30	900	310	2300	300	NC	180	2.3	20	NC	39	39	NC	0.52	55	2300
Secondary Regulatory Criteria Not Selected																												
	Date	Sample ID	Depth	Method	Dilution																							
IA09-TP01-A3	04-Nov-04	CA-IA09-TP01-A3-1	4-6'	6010B	1	**7600**	2.1 u	**34**	26	0.21 u	0.43 u	560	10	4.8	9.7	**9300**	14	2000	140	-	12	620	2.1 u	0.43 u	86 u	**2.1 u**	10	26
	04-Nov-04	CA-IA09-TP01-A3-1	4-6'	7471A	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.0047 j	-	-	-	-	-	-	-	-
IA09-TP01-B1	04-Nov-04	CA-IA09-TP01-B1-1	0-2'	6010B	1	4500	2.1 u	**24**	16	0.21 u	0.42 u	670	13	6.9	13	**9600**	18	2300	**290**	-	**20**	840	2.1 u	0.42 u	84 u	**2.1 u**	9	25
	04-Nov-04	CA-IA09-TP01-B1-1	0-2'	7471A	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.0046 j	-	-	-	-	-	-	-	-
IA09-TP01-B2	04-Nov-04	CA-IA09-TP01-B2-1	2-4'	6010B	1	5700	2.1 u	**35**	12	0.21 u	0.43 u	520	6.5	3.5	6.1	**7300**	11	1200	120	-	8.6	460	2.1 u	0.43 u	85 u	**2.1 u**	6.6	36
	04-Nov-04	CA-IA09-TP01-B2-1	2-4'	7471A	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.0054 j	-	-	-	-	-	-	-	-
IA09-TP01-B3	04-Nov-04	CA-IA09-TP01-B3-1	4-6'	6010B	1	7300	2.2 u	**18**	30	0.22 u	0.45 u	370	8.8	3.8	7.5	**8500**	22	1700	150	-	8.9	740	2.2 u	0.45 u	90 u	**2.2 u**	9.4	31
	04-Nov-04	CA-IA09-TP01-B3-1	4-6'	7471A	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.013 j	-	-	-	-	-	-	-	-
IA09-TP01-C1	04-Nov-04	CA-IA09-TP01-C1-1	0-2'	6010B	1	5600	2.3 u	**18**	19	0.23 u	0.45 u	410	9.7	4.1	11	**8300**	74	1400	160	-	13	420	2.3 u	0.45 u	91 u	**2.3 u**	8.6	44
	04-Nov-04	CA-IA09-TP01-C1-1	0-2'	7471A	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.039 j	-	-	-	-	-	-	-	-
IA09-TP01-C2	04-Nov-04	CA-IA09-TP01-C2-1	2-4'	6010B	1	6000	2.2 u	**22**	16	0.22 u	0.43 u	330	7.1	3.7	7.1	**6700**	17	1200	130	-	8.4	540	2.2 u	0.43 u	86 u	**2.2 u**	7.3	26
	04-Nov-04	CA-IA09-TP01-C2-1	2-4'	7471A	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.0089 j	-	-	-	-	-	-	-	-
IA09-TP01-C3	04-Nov-04	CA-IA09-TP01-C3-1	4-6'	6010B	1	5200	2.2 u	**70**	26	0.22 u	0.43 u	290	6.2	3.3	6.9	**6800**	27	1100	150	-	7.3	440	2.2 u	0.43 u	87 u	**2.2 u**	6.2	28
	04-Nov-04	CA-IA09-TP01-C3-1	4-6'	7471A	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.0094 j	-	-	-	-	-	-	-	-
IA09-TP01-D1	04-Nov-04	CA-IA09-TP01-D1-1	0-2'	6010B	1	5000	2.2 u	**18**	15	0.22 u	0.43 u	450	11	4	9	**7400**	33	1700	150	-	12	750	2.2 u	0.43 u	86 u	**2.2 u**	8.2	30
	04-Nov-04	CA-IA09-TP01-D1-1	0-2'	7471A	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.032 j	-	-	-	-	-	-	-	-
	04-Nov-04	CA-IA09-TP01-D1-1-D	0-2'	6010B	1	3000	2.2 u	**12**	7.9	0.22 u	0.43 u	280	6.5	2.6	5.9	**4600**	23	990	88	-	7.8	310	2.2 u	0.43 u	86 u	**2.2 u**	4.7	19
	04-Nov-04	CA-IA09-TP01-D1-1-D	0-2'	7471A	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.022 j	-	-	-	-	-	-	-	-
IA09-TP01-D2	04-Nov-04	CA-IA09-TP01-D2-1	2-4'	6010B	1	4500	2.1 u	**22**	13	0.21 u	0.43 u	510	9	4.4	16	**7800**	30	1500	150	-	13	460	2.1 u	0.43 u	86 u	**2.1 u**	7.1	34
	04-Nov-04	CA-IA09-TP01-D2-1	2-4'	7471A	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.0085 j	-	-	-	-	-	-	-	-
IA09-TP01-D3	04-Nov-04	CA-IA09-TP01-D3-1	4-6'	6010B	1	**8500**	2.3 u	**41**	23	0.23 u	0.46 u	320	11	4.8	9.8	**10000**	18	2000	130	-	11	730	2.3 u	0.46 u	91 u	**2.3 u**	12	29
	04-Nov-04	CA-IA09-TP01-D3-1	4-6'	7471A	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.014 j	-	-	-	-	-	-	-	-
IA10-SB01	13-Dec-04	GR-IA10-SB01-1	0-3'	6010B	1	**9100**	2.2 u	**10**	14	0.22 u	0.45 u	210	12	3.2	5.2	**8300**	6.1	1800	92	-	8.4	450	2.2 u	0.45 u	90 u	**2.2 u**	10	17
	13-Dec-04	GR-IA10-SB01-1	0-3'	7471A	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.018 j	-	-	-	-	-	-	-	-
	13-Dec-04	GR-IA10-SB01-1	3-10'	6010B	1	4900	2.1 u	**12**	18	0.21 u	0.42 u	420	12	4.1	8	**7800**	4.1	2100	130	-	10	960	2.1 u	0.42 u	84 u	**2.1 u**	8.7	18
	13-Dec-04	GR-IA10-SB01-1	3-10'	7471A	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.08 u	-	-	-	-	-	-	-	-
IA10-SB02	10-Dec-04	GR-IA10-SB02-1	0-3'	6010B	1	5600	2.2 u	**26**	28	0.22 u	0.43 u	5800	16	7.2	16	**12000**	12	2900	**280**	-	**23**	1500	2.2 u	0.43 u	87 u	**2.2 u**	11	30
	10-Dec-04	GR-IA10-SB02-1	0-3'	7471A	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.03 j	-	-	-	-	-	-	-	-
	10-Dec-04	GR-IA10-SB02-1	3-10'	6010B	1	5800	2.2 u	**19**	28	0.22 u	0.44 u	8600	16	6.1	13	**11000**	8.5	2700	**290**	-	19	1500	2.2 u	0.44 u	89	**2.2 u**	9.5	26
	10-Dec-04	GR-IA10-SB02-1	3-10'	7471A	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.0054 j	-	-	-	-	-	-	-	-
	10-Dec-04	GR-IA10-SB02-1-D	3-10'	6010B	1	5600	2.2 u	**22**	27	0.22 u	0.44 u	6800	16	6.2	13	**11000**	9.1	2600	**240**	-	19	1400	2.2 u	0.44 u	89	**2.2 u**	9.8	28
	10-Dec-04	GR-IA10-SB02-1-D	3-10'	7471A	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.0084 j	-	-	-	-	-	-	-	-
IA10-SB03	15-Dec-04	GR-IA10-SB03-1	0-3'	6010B	1	**12000**	2.2 u	**40**	20	0.22 u	0.44 u	690	28	7.3	18	**15000**	11	5600	**230**	-	**25**	1000	2.2 u	0.44 u	89 u	**2.2 u**	18	34
	15-Dec-04	GR-IA10-SB03-1	0-3'	7471A	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.03 j	-	-	-	-	-	-	-	-
	15-Dec-04	GR-IA10-SB03-1	3-10'	6010B	1	**11000**	2.2 u	**58**	20	0.22 u	0.44 u	450	28	8.4	16	**16000**	9.3	6300	**270**	-	**27**	1200	2.2 u	0.44 u	87 u	**2.2 u**	19	32
	15-Dec-04	GR-IA10-SB03-1	3-10'	7471A	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.082 u	-	-	-	-	-	-	-	-

Location

Notes:

- **NC** No criteria listed under the regulation cited
- **ND** Non-detect result (Original data unavailable - neither value nor detection limit provided)
- **-** Parameter not analyzed

Analytic Flags:

- **u** Not detected above laboratory reporting limits
- **j** Estimated value - parameter detected between laboratory reporting limit and half of the laboratory reporting limit.
- **e** Value exceeds analytical calibration limits
- **b** Parameter detected in quality control blank and sample

Highlighting:

- Value or Detection Limit exceeds Criteria 1 only
- Value or Detection Limit exceeds Criteria 2 only
- Value or Detection Limit exceeds both criteria

PASI - SSI

Analytic Method: 6010B and 7471A
Sample Matrix: Soil
Reporting Units: mg/kg
Sample Dates: 03-Nov-2004 to 02-May-2005

						Aluminum	Antimony	Arsenic	Barium	Beryllium	Cadmium	Calcium	Chromium	Cobalt	Copper	Iron	Lead	Magnesium	Manganese	Mercury	Nickel	Potassium	Selenium	Silver	Sodium	Thallium	Vanadium	Zinc
SSI Project Action Limit (PAL) - Wave 2 (Metals)						7600	3.1	0.39	540	0.7	2	NC	30	900	310	2300	300	NC	180	2.3	20	NC	39	39	NC	0.52	55	2300
Secondary Regulatory Criteria Not Selected																												
	Date	Sample ID	Depth	Method	Dilution																							
IA10-SB04	16-Dec-04	GR-IA10-SB04-1	0-3'	6010B	1	7400	2.2 u	**9.2**	13	0.22 u	0.44 u	170	7.4	2.9	3.8	**7200**	7.6	990	150	-	7	260	2.2 u	0.44 u	88 u	**2.2 u**	8.5	14
	16-Dec-04	GR-IA10-SB04-1	0-3'	7471A	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.027 j	-	-	-	-	-	-	-	-
	16-Dec-04	GR-IA10-SB04-1	3-10'	6010B	1	**8000**	2.1 u	**26**	28	0.21 u	0.42 u	440	18	7.2	15	**12000**	7.9	3200	**250**	-	**23**	1600	2.1 u	0.42 u	84 u	**2.1 u**	12	20
	16-Dec-04	GR-IA10-SB04-1	3-10'	7471A	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.0072 j	-	-	-	-	-	-	-	-
IA10-TP01-A1	04-Nov-04	GR-IA10-TP01-A1-1	0-2'	6010B	1	**9000**	2.3 u	**11**	19	0.23 u	0.45 u	180	8.5	3.2	3.4	**9000**	7.8	860	160	-	7.2	200	2.3 u	0.45 u	91 u	**2.3 u**	11	13
	04-Nov-04	GR-IA10-TP01-A1-1	0-2'	7471A	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.025 j	-	-	-	-	-	-	-	-
IA10-TP01-A2	04-Nov-04	GR-IA10-TP01-A2-1	2-4'	6010B	1	3700	2 u	**9.6**	8	0.2 u	0.41 u	440	5.9	4.9	3.5	**5000**	3.1	940	120	-	8	310	2 u	0.41 u	82 u	**2 u**	5.2	9.5
	04-Nov-04	GR-IA10-TP01-A2-1	2-4'	7471A	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.078 u	-	-	-	-	-	-	-	-
IA10-TP01-A3	04-Nov-04	GR-IA10-TP01-A3-1	4-6'	6010B	1	7000	2 u	**52**	13	0.2 u	0.41 u	500	14	6.3	10	**9200**	7.1	2400	**180**	-	**22**	740	2 u	0.41 u	82 u	**2 u**	9.3	21
	04-Nov-04	GR-IA10-TP01-A3-1	4-6'	7471A	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.078 u	-	-	-	-	-	-	-	-
IA10-TP01-B1	04-Nov-04	GR-IA10-TP01-B1-1	--	6010B	1	**10000**	2.2 u	**9.6**	23	0.22 u	0.45 u	91	9.4	3	2.8	**8900**	6.1	860	120	-	6.9	190	2.2 u	0.45 u	89 u	**2.2 u**	11	14
	04-Nov-04	GR-IA10-TP01-B1-1	--	7471A	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.018 j	-	-	-	-	-	-	-	-
	04-Nov-04	GR-IA10-TP01-B1-1-D	0-2'	6010B	1	**10000**	2.2 u	**9.9**	19	0.22 u	0.45 u	80	9.1	2.8	2.4	**8800**	5.5	830	90	-	7.4	180	2.2 u	0.45 u	90 u	**2.2 u**	11	12
	04-Nov-04	GR-IA10-TP01-B1-1-D	0-2'	7471A	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.016 j	-	-	-	-	-	-	-	-
IA10-TP01-B2	04-Nov-04	GR-IA10-TP01-B2-1	2-4'	6010B	1	5100	2.1 u	**9.5**	8.5	0.21 u	0.41 u	260	6.1	3	3.2	**5500**	3.2	940	69	-	6.7	300	2.1 u	0.41 u	83 u	**2.1 u**	6.2	9.8
	04-Nov-04	GR-IA10-TP01-B2-1	2-4'	7471A	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.084 u	-	-	-	-	-	-	-	-
IA10-TP01-B3	04-Nov-04	GR-IA10-TP01-B3-1	4-6'	6010B	1	5000	2 u	**34**	9.3	0.2 u	0.41 u	190	11	6.8	13	**8900**	6.2	2300	**180**	-	**24**	530	2 u	0.41 u	82 u	**2 u**	7.4	20
	04-Nov-04	GR-IA10-TP01-B3-1	4-6'	7471A	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.083 u	-	-	-	-	-	-	-	-
IA10-TP01-C1	04-Nov-04	GR-IA10-TP01-C1-1	0-2'	6010B	1	7400	2.1 u	**9**	10	0.21 u	0.43 u	83	7.6	3.1	2.9	**6800**	4.2	1000	71	-	6.3	290	2.1 u	0.43 u	86 u	**2.1 u**	8.2	12
	04-Nov-04	GR-IA10-TP01-C1-1	0-2'	7471A	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.011 j	-	-	-	-	-	-	-	-
IA10-TP01-C2	04-Nov-04	GR-IA10-TP01-C2-1	2-4'	6010B	1	5000	2 u	**26**	9.7	0.2 u	0.41 u	200	7.3	5.6	10	**9200**	5.5	1400	**190**	-	15	460	2 u	0.41 u	81 u	**2 u**	6.6	14
	04-Nov-04	GR-IA10-TP01-C2-1	2-4'	7471A	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.0051 j	-	-	-	-	-	-	-	-
IA10-TP01-C3	04-Nov-04	GR-IA10-TP01-C3-1	4-6'	6010B	1	**8100**	2 u	**40**	22	0.2 u	0.4 u	310	18	8.9	20	**13000**	9	4100	**210**	-	**35**	1200	2 u	0.4 u	81 u	**2 u**	14	32
	04-Nov-04	GR-IA10-TP01-C3-1	4-6'	7471A	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.076 u	-	-	-	-	-	-	-	-
IA10-TP01-D1	04-Nov-04	GR-IA10-TP01-D1-1	0-2'	6010B	1	**10000**	2.3 u	**11**	20	0.23 u	0.47 u	110	9.7	3.3	2.9	**9400**	8.1	960	150	-	8.3	200	2.3 u	0.47 u	94 u	**2.3 u**	12	16
	04-Nov-04	GR-IA10-TP01-D1-1	0-2'	7471A	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.034 j	-	-	-	-	-	-	-	-
IA10-TP01-D2	04-Nov-04	GR-IA10-TP01-D2-1	2-4'	6010B	1	3600	2 u	**9.6**	7.3	0.2 u	0.4 u	460	5.3	3.5	3.4	**4900**	3.2	990	110	-	7.4	350	2 u	0.4 u	81 u	**2 u**	5.4	9.9
	04-Nov-04	GR-IA10-TP01-D2-1	2-4'	7471A	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.0034 j	-	-	-	-	-	-	-	-
	04-Nov-04	GR-IA10-TP01-D2-1-D	2-4'	6010B	1	3700	2 u	**10**	7.4	0.2 u	0.41 u	480	5.4	3.5	3.3	**5000**	3.1	1000	100	-	7.5	350	2 u	0.41 u	82 u	**2 u**	5.5	9.9
	04-Nov-04	GR-IA10-TP01-D2-1-D	2-4'	7471A	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.081 u	-	-	-	-	-	-	-	-
IA10-TP01-D3	04-Nov-04	GR-IA10-TP01-D3-1	4-6'	6010B	1	6300	2 u	**38**	14	0.2 u	0.41 u	180	15	6.3	12	**11000**	9.8	2600	160	-	**26**	820	2 u	0.41 u	81 u	**2 u**	9.3	21
	04-Nov-04	GR-IA10-TP01-D3-1	4-6'	7471A	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.0058 j	-	-	-	-	-	-	-	-
IA10-TP02-A1	04-Nov-04	GR-IA10-TP02-A1-1	0-2'	6010B	1	7400	2.1 u	**6.1**	10	0.21 u	0.42 u	160	8	2	4.4	**6100**	9.6	800	40	-	5.5	250	2.1 u	0.42 u	85 u	**2.1 u**	8	12
	04-Nov-04	GR-IA10-TP02-A1-1	0-2'	7471A	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.022 j	-	-	-	-	-	-	-	-
IA10-TP02-A2	04-Nov-04	GR-IA10-TP02-A2-1	2-4'	6010B	1	3300	2 u	**7.4**	10	0.2 u	0.4 u	200	5.1	2.7	6.7	**3200**	3.4	750	56	-	6.2	330	2 u	0.4 u	80 u	**2 u**	4	10
	04-Nov-04	GR-IA10-TP02-A2-1	2-4'	7471A	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.077 u	-	-	-	-	-	-	-	-

Location

Notes:

- **NC** No criteria listed under the regulation cited
- **ND** Non-detect result (Original data unavailable - neither value nor detection limit provided)
- **-** Parameter not analyzed

Analytic Flags:

- **u** Not detected above laboratory reporting limits
- **j** Estimated value - parameter detected between laboratory reporting limit and half of the laboratory reporting limit.
- **e** Value exceeds analytical calibration limits
- **b** Parameter detected in quality control blank and sample

Highlighting:

- Value or Detection Limit exceeds Criteria 1 only
- Value or Detection Limit exceeds Criteria 2 only
- Value or Detection Limit exceeds both criteria

SSI - Summary of Target Analyte List Metals Soil Analytical Results

Table 5-2f

PASI - SSI

Analytic Method: 6010B and 7471A
Sample Matrix: Soil
Reporting Units: mg/kg
Sample Dates: 03-Nov-2004 to 02-May-2005

						Aluminum	Antimony	Arsenic	Barium	Beryllium	Cadmium	Calcium	Chromium	Cobalt	Copper	Iron	Lead	Magnesium	Manganese	Mercury	Nickel	Potassium	Selenium	Silver	Sodium	Thallium	Vanadium	Zinc
SSI Project Action Limit (PAL) - Wave 2 (Metals)						7600	3.1	0.39	540	0.7	2	NC	30	900	310	2300	300	NC	180	2.3	20	NC	39	39	NC	0.52	55	2300
Secondary Regulatory Criteria Not Selected																												
	Date	Sample ID	Depth	Method	Dilution																							
IA10-TP02-A3	04-Nov-04	GR-IA10-TP02-A3-1	4-6'	6010B	1	2200	2 u	**7.5**	6.2	0.2 u	0.4 u	120	3.6	2.3	5.4	**3600**	2.9	650	69	-	4.6	230	2 u	0.4 u	80 u	**2 u**	3.4	8.5
	04-Nov-04	GR-IA10-TP02-A3-1	4-6'	7471A	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.072 u	-	-	-	-	-	-	-	-
IA10-TP02-B1	04-Nov-04	GR-IA10-TP02-B1-1	0-2'	6010B	1	**7600**	2.1 u	**6.4**	11	0.21 u	0.42 u	62	7.7	2	3.5	**6600**	6.2	810	69	-	4.7	240	2.1 u	0.42 u	84 u	**2.1 u**	8.4	11
	04-Nov-04	GR-IA10-TP02-B1-1	0-2'	7471A	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.029 j	-	-	-	-	-	-	-	-
	04-Nov-04	GR-IA10-TP02-B1-1-D	0-2'	6010B	1	6300	2.1 u	**9.1**	7.9	0.21 u	0.42 u	50	6	1.6	3.6	**6200**	5.6	550	45	-	3.9	120	2.1 u	0.42 u	84 u	**2.1 u**	6.5	10
	04-Nov-04	GR-IA10-TP02-B1-1-D	0-2'	7471A	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.028 j	-	-	-	-	-	-	-	-
IA10-TP02-B2	04-Nov-04	GR-IA10-TP02-B2-1	2-4'	6010B	1	2900	2 u	**8.8**	6.2	0.2 u	0.41 u	65	4.8	2.9	6.5	**3900**	3.4	790	66	-	5.6	290	2 u	0.41 u	82 u	**2 u**	4.2	9.2
	04-Nov-04	GR-IA10-TP02-B2-1	2-4'	7471A	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.081 u	-	-	-	-	-	-	-	-
IA10-TP02-B3	04-Nov-04	GR-IA10-TP02-B3-1	4-6'	6010B	1	2300	2 u	**5.9**	6.5	0.2 u	0.41 u	120	3.4	2.3	4.8	**3300**	2.5	640	67	-	5.2	230	2 u	0.41 u	81 u	**2 u**	3.1	7.8
	04-Nov-04	GR-IA10-TP02-B3-1	4-6'	7471A	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.003 j	-	-	-	-	-	-	-	-
IA10-TP02-C1	04-Nov-04	GR-IA10-TP02-C1-1	0-2'	6010B	1	6800	2.1 u	**6.5**	12	0.21 u	0.43 u	78	5.8	1.6	3.4	**5200**	5.4	570	46	-	4	110 u	2.1 u	0.43 u	86 u	**2.1 u**	6.2	11
	04-Nov-04	GR-IA10-TP02-C1-1	0-2'	7471A	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.021 j	-	-	-	-	-	-	-	-
IA10-TP02-C2	04-Nov-04	GR-IA10-TP02-C2-1	2-4'	6010B	1	2300	2 u	**5.3**	6.5	0.2 u	0.41 u	83	3.2	2	4.4	**2700**	2.7	560	57	-	4.3	200	2 u	0.41 u	82 u	**2 u**	2.9	8
	04-Nov-04	GR-IA10-TP02-C2-1	2-4'	7471A	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.082 u	-	-	-	-	-	-	-	-
IA10-TP02-C3	04-Nov-04	GR-IA10-TP02-C3-1	4-6'	6010B	1	2200	2 u	**8.2**	7	0.2 u	0.4 u	140	3.7	2.8	6.4	**3400**	4.1	640	81	-	5.9	250	2 u	0.4 u	81 u	**2 u**	3.1	9.3
	04-Nov-04	GR-IA10-TP02-C3-1	4-6'	7471A	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.077 u	-	-	-	-	-	-	-	-
IA10-TP02-D1	04-Nov-04	GR-IA10-TP02-D1-1	0-2'	6010B	1	7500	2.1 u	**6.2**	12	0.21 u	0.42 u	130	6.8	1.8	4.4	**5700**	14	600	46	-	4.9	200	2.1 u	0.42 u	84 u	**2.1 u**	7.9	12
	04-Nov-04	GR-IA10-TP02-D1-1	0-2'	7471A	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.024 j	-	-	-	-	-	-	-	-
IA10-TP02-D2	04-Nov-04	GR-IA10-TP02-D2-1	2-4'	6010B	1	2600	2 u	**4.9**	6.4	0.2 u	0.4 u	87	4.1	2	3.8	**2600**	2.9	620	38	-	4.2	260	2 u	0.4 u	79 u	**2 u**	3.3	7.1
	04-Nov-04	GR-IA10-TP02-D2-1	2-4'	7471A	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.082 u	-	-	-	-	-	-	-	-
IA10-TP02-D3	04-Nov-04	GR-IA10-TP02-D3-1	4-6'	6010B	1	2000	2 u	**7**	4.5	0.2 u	0.41 u	230	2.9	2	4.4	**3400**	3.5	590	82	-	4.2	170	2 u	0.41 u	81 u	**2 u**	3.1	7.8
	04-Nov-04	GR-IA10-TP02-D3-1	4-6'	7471A	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.084 u	-	-	-	-	-	-	-	-
IA11-SB01	29-Nov-04	LO-IA11-SB01-1	0-3'	6010B	1	5600	2.4 u	**18**	18	0.24 u	0.48 u	2300	12	4.7	12	**8300**	19	1700	150	-	14	740	2.4 u	0.48 u	300	**2.4 u**	9.5	23
	29-Nov-04	LO-IA11-SB01-1	0-3'	7471A	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.058 j	-	-	-	-	-	-	-	-
	29-Nov-04	LO-IA11-SB01-1	3-10'	6010B	1	3700	2.1 u	**15**	8.1	0.21 u	0.42 u	430	7.7	3.4	7.2	**5400**	4.6	1100	91	-	11	280	2.1 u	0.42 u	84 u	**2.1 u**	4.8	13
	29-Nov-04	LO-IA11-SB01-1	3-10'	7471A	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.0054 j	-	-	-	-	-	-	-	-

Location

Notes:

- **NC** No criteria listed under the regulation cited
- **ND** Non-detect result (Original data unavailable - neither value nor detection limit provided)
- **-** Parameter not analyzed

Analytic Flags:

- **u** Not detected above laboratory reporting limits
- **j** Estimated value - parameter detected between laboratory reporting limit and half of the laboratory reporting limit.
- **e** Value exceeds analytical calibration limits
- **b** Parameter detected in quality control blank and sample

Highlighting:

- Value or Detection Limit exceeds Criteria 1 only
- Value or Detection Limit exceeds Criteria 2 only
- Value or Detection Limit exceeds both criteria

Supplemental Site Investigation

Analytic Method: 8290 and TEQ
Sample Matrix: Soil
Reporting Units: ng/Kg
Sample Dates: 29-Nov-2004 to 08-Feb-2005

						1,2,3,4,6,7,8-HpCDD	1,2,3,4,6,7,8-HpCDF	1,2,3,4,7,8,9-HpCDF	1,2,3,4,7,8-HxCDD	1,2,3,4,7,8-HxCDF	1,2,3,6,7,8-HxCDD	1,2,3,6,7,8-HxCDF	1,2,3,7,8,9-HxCDD	1,2,3,7,8,9-HxCDF	1,2,3,7,8-PeCDD	1,2,3,7,8-PeCDF	2,3,4,6,7,8-HxCDF	2,3,4,7,8-PeCDF	2,3,7,8-TCDD	2,3,7,8-TCDF	HpCDDs, Total	HpCDFs, Total	HxCDDs, Total	HxCDFs, Total	OCDD	OCDF	PeCDDs, Total	PeCDFs, Total
SSI Project Action Limit (PAL) - Wave 2 (Dioxins)						NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	3.9	NC	NC	NC	NC	NC	NC	NC	NC	NC
Secondary Regulatory Criteria Not Selected																												
	Date	Sample ID	Depth	Method	Dilution																							
IA09-SB01	29-Nov-04	CA-IA09-SB01-1	0-3'	8290	1	0.55 bj	0.253 bj	1.993 u	1.993 u	1.993 u	1.993 u	1.993 u	1.993 u	1.993 u	1.993 u	1.993 u	1.993 u	1.993 u	0.797 u	0.797 u	1.993 u	1.993 u	1.993 u	1.993 u	3.649 bj	0.434 bj	1.993 u	1.993 u
	29-Nov-04	CA-IA09-SB01-1	0-3'	TEQ	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	29-Nov-04	CA-IA09-SB01-1	3-10'	8290	1	2.064 u	0.287 bj	2.064 u	2.064 u	2.064 u	2.064 u	2.064 u	2.064 u	2.064 u	2.064 u	2.064 u	2.064 u	2.064 u	0.825 u	0.825 u	2.064 u	2.064 u	2.064 u	2.064 u	2.354 bj	4.129 u	2.064 u	2.064 u
	29-Nov-04	CA-IA09-SB01-1	3-10'	TEQ	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
IA10-SB01	13-Dec-04	GR-IA10-SB01-1	0-3'	8290	1	4.728 b	1.206 bj	2.075 u	2.075 u	0.366 j	0.208 j	0.146 j	0.206 j	2.075 u	2.075 u	2.075 u	0.157 j	0.101 j	0.83 u	0.83 u	2.075 u	2.075 u	2.075 u	2.075 u	38.535 b	1.993 bj	2.075 u	2.075 u
	13-Dec-04	GR-IA10-SB01-1	0-3'	TEQ	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	13-Dec-04	GR-IA10-SB01-1-M	3-10'	8290	1	2.018 u	2.018 u	2.018 u	2.018 u	0.077 j	2.018 u	2.018 u	2.018 u	2.018 u	2.018 u	2.018 u	2.018 u	2.018 u	0.807 u	0.807 u	2.018 u	2.018 u	2.018 u	2.018 u	2.081 bj	4.036 u	2.018 u	2.018 u
IA10-SB02	14-Dec-04	GR-IA10-SB02-1	0-3'	8290	1	4.486 b	1.499 bj	0.098 j	2.001 u	0.192 j	0.292 j	2.001 u	0.137 j	2.001 u	2.001 u	0.061 j	2.001 u	0.101 j	0.8 u	0.8 u	2.001 u	2.001 u	2.001 u	2.001 u	54.908 b	2.843 bj	2.001 u	2.001 u
	14-Dec-04	GR-IA10-SB02-1	0-3'	TEQ	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	14-Dec-04	GR-IA10-SB02-1	3-10'	8290	1	3.968 b	1.994 bj	2.112 u	2.112 u	0.225 j	0.338 j	2.112 u	0.162 j	2.112 u	2.112 u	2.112 u	2.112 u	0.12 j	0.844 u	0.844 u	2.112 u	2.112 u	2.112 u	2.112 u	32.414 b	2.672 bj	2.112 u	2.112 u
	14-Dec-04	GR-IA10-SB02-1	3-10'	TEQ	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	14-Dec-04	GR-IA10-SB02-1-D	3-10'	8290	1	3.194 b	1.861 bj	2.058 u	2.058 u	0.253 j	0.27 j	2.058 u	0.209 j	2.058 u	2.058 u	2.058 u	2.058 u	2.058 u	0.823 u	0.823 u	2.058 u	2.058 u	2.058 u	2.058 u	26.708 b	1.901 bj	2.058 u	2.058 u
	14-Dec-04	GR-IA10-SB02-1-D	3-10'	TEQ	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
IA10-SB03	15-Dec-04	GR-IA10-SB03-1	0-3'	8290	1	18.979 b	3.455 b	0.264 j	2.088 u	0.324 j	0.445 j	0.185 j	0.4 j	2.088 u	2.088 u	2.088 u	0.199 j	2.088 u	0.835 u	0.835 u	2.088 u	2.088 u	2.088 u	2.088 u	199.287 b	6.696 b	2.088 u	2.088 u
	15-Dec-04	GR-IA10-SB03-1	0-3'	TEQ	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	15-Dec-04	GR-IA10-SB03-1	3-10'	8290	1	1.027 bj	0.479 bj	2.058 u	2.058 u	0.123 j	2.058 u	2.058 u	2.058 u	2.058 u	2.058 u	2.058 u	2.058 u	2.058 u	0.823 u	0.823 u	2.058 u	2.058 u	2.058 u	2.058 u	9.463 b	0.953 bj	2.058 u	2.058 u
	15-Dec-04	GR-IA10-SB03-1	3-10'	TEQ	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
IA10-SB04	21-Dec-04	GR-IA10-SB04-1	0-3'	8290	1	4.245 b	3.399 b	0.558 j	2.144 u	0.847 j	0.252 j	0.323 j	0.481 j	2.144 u	0.107 j	0.248 j	0.594 j	0.444 j	-	0.857 u	2.144 u	2.144 u	2.144 u	2.144 u	21.267 b	4.269 bj	2.144 u	2.144 u
	21-Dec-04	GR-IA10-SB04-1	0-3'	TEQ	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	21-Dec-04	GR-IA10-SB04-1	3-10'	8290	1	0.509 bj	0.337 bj	1.994 u	1.994 u	0.149 j	1.994 u	1.994 u	1.994 u	1.994 u	1.994 u	1.994 u	1.994 u	1.994 u	0.797 u	0.797 u	1.994 u	1.994 u	1.994 u	1.994 u	4.178 b	0.573 bj	1.994 u	1.994 u
	16-Dec-04	GR-IA10-SB04-1	0-3'	8290	1	-	-	-	-	-	-	-	-	-	-	-	-	-	0.857 u	-	-	-	-	-	-	-	-	-	-
	15-Dec-04	GR-IA10-SB04-1-D	3-10'	8290	1	1.505 bj	0.528 bj	2.052 u	2.052 u	0.111 j	2.052 u	2.052 u	2.052 u	2.052 u	2.052 u	2.052 u	2.052 u	2.052 u	0.82 u	0.82 u	2.052 u	2.052 u	2.052 u	2.052 u	13.902 b	0.822 bj	2.052 u	2.052 u
	15-Dec-04	GR-IA10-SB04-1-D	3-10'	TEQ	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
IA11-SB01	08-Feb-05	LO-IA11-SB01-1	0-3'	8290	1	10.785 b	2.999 b	2.021 u	2.021 u	0.373 j	0.332 j	0.143 j	0.229 j	2.021 u	2.021 u	2.021 u	0.192 j	0.186 j	0.808 u	0.808 u	2.021 u	2.021 u	2.021 u	2.021 u	117.045 b	7.381 b	2.021 u	2.021 u
	08-Feb-05	LO-IA11-SB01-1	0-3'	TEQ	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	08-Feb-05	LO-IA11-SB01-1	3-10'	8290	1	1.992 u	1.992 u	1.992 u	1.992 u	0.053 j	1.992 u	1.992 u	1.992 u	1.992 u	1.992 u	1.992 u	1.992 u	1.992 u	0.797 u	0.797 u	1.992 u	1.992 u	1.992 u	0.053 j	0.703 j	3.985 u	1.992 u	1.992 u
	08-Feb-05	LO-IA11-SB01-1	3-10'	TEQ	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

Location

Notes:

NC No criteria listed under the regulation cited
ND Non-detect result (Original data unavailable - neither value nor detection limit provided)
- Parameter not analyzed

Analytic Flags:

u Not detected above laboratory reporting limits
j Estimated value - parameter detected between laboratory reporting limit and half of the laboratory reporting limit.
e Value exceeds analytical calibration limits
b Parameter detected in quality control blank and sample

Highlighting:

Value or Detection Limit exceeds Criteria 1 only
Value or Detection Limit exceeds Criteria 2 only
Value or Detection Limit exceeds both criteria

SSI - Summary of Dioxin/Furan Soil Analytical Results

Table 5-2g

Supplemental Site Investigation

Analytic Method: 8290 and TEQ
Sample Matrix: Soil
Reporting Units: ng/Kg
Sample Dates: 29-Nov-2004 to 08-Feb-2005

						TCDDs, Total	TCDFs, Total	Total TEQ
SSI Project Action Limit (PAL) - Wave 2 (Dioxins)						3.9	NC	3.9
Secondary Regulatory Criteria Not Selected								
	Date	Sample ID	Depth	Method	Dilution			
IA09-SB01	29-Nov-04	CA-IA09-SB01-1	0-3'	8290	1	0.797 u	0.797 u	-
	29-Nov-04	CA-IA09-SB01-1	0-3'	TEQ	1	-	-	0.08
	29-Nov-04	CA-IA09-SB01-1	3-10'	8290	1	0.825 u	0.825 u	-
	29-Nov-04	CA-IA09-SB01-1	3-10'	TEQ	1	-	-	0.12
IA10-SB01	13-Dec-04	GR-IA10-SB01-1	0-3'	8290	1	0.83 u	0.83 u	-
	13-Dec-04	GR-IA10-SB01-1	0-3'	TEQ	1	-	-	ND
	13-Dec-04	GR-IA10-SB01-1-M	3-10'	8290	1	0.807 u	0.807 u	0.117
IA10-SB02	14-Dec-04	GR-IA10-SB02-1	0-3'	8290	1	0.8 u	0.8 u	-
	14-Dec-04	GR-IA10-SB02-1	0-3'	TEQ	1	-	-	ND
	14-Dec-04	GR-IA10-SB02-1	3-10'	8290	1	0.844 u	0.844 u	-
	14-Dec-04	GR-IA10-SB02-1	3-10'	TEQ	1	-	-	ND
	14-Dec-04	GR-IA10-SB02-1-D	3-10'	8290	1	0.823 u	0.823 u	-
	14-Dec-04	GR-IA10-SB02-1-D	3-10'	TEQ	1	-	-	ND
IA10-SB03	15-Dec-04	GR-IA10-SB03-1	0-3'	8290	1	0.835 u	0.835 u	-
	15-Dec-04	GR-IA10-SB03-1	0-3'	TEQ	1	-	-	ND
	15-Dec-04	GR-IA10-SB03-1	3-10'	8290	1	0.823 u	0.823 u	-
	15-Dec-04	GR-IA10-SB03-1	3-10'	TEQ	1	-	-	ND
IA10-SB04	21-Dec-04	GR-IA10-SB04-1	0-3'	8290	1	0.857 u	0.857 u	-
	21-Dec-04	GR-IA10-SB04-1	0-3'	TEQ	1	-	-	ND
	21-Dec-04	GR-IA10-SB04-1	3-10'	8290	1	0.797 u	0.797 u	ND
	16-Dec-04	GR-IA10-SB04-1	0-3'	8290	1	-	-	-
	15-Dec-04	GR-IA10-SB04-1-D	3-10'	8290	1	0.82 u	0.82 u	-
	15-Dec-04	GR-IA10-SB04-1-D	3-10'	TEQ	1	-	-	ND
IA11-SB01	08-Feb-05	LO-IA11-SB01-1	0-3'	8290	1	0.808 u	0.808 u	-
	08-Feb-05	LO-IA11-SB01-1	0-3'	TEQ	1	-	-	0.46
	08-Feb-05	LO-IA11-SB01-1	3-10'	8290	1	0.797 u	0.797 u	-
	08-Feb-05	LO-IA11-SB01-1	3-10'	TEQ	1	-	-	0.12

Location

Notes:

NC No criteria listed under the regulation cited
ND Non-detect result (Original data unavailable - neither value nor detection limit provided)
- Parameter not analyzed

Analytic Flags:

u Not detected above laboratory reporting limits
j Estimated value - parameter detected between laboratory reporting limit and half of the laboratory reporting limit.
e Value exceeds analytical calibration limits
b Parameter detected in quality control blank and sample

Highlighting:

Value or Detection Limit exceeds Criteria 1 only
Value or Detection Limit exceeds Criteria 2 only
Value or Detection Limit exceeds both criteria

Table 5-2h

Summary of Soil Sample Perchlorate Analytical Results

Field Sample ID	Sample Date	Parameter EPA Method 8321A				Parameter EPA Method 160.3 MOD		
Investigation Area 2								
GR-IA02-SB01-1* (0-3)	12/2/2004	Perchlorate	1.2	U	µg/kg	Percent Moisture	12	%
GR-IA02-SB01-1-M* (3-10)	12/2/2004	Perchlorate	1.1	U	µg/kg	Percent Moisture	5.6	%
GR-IA02-SB02-1 (0-3)	12/2/2004	Perchlorate	1.1	U	µg/kg	Percent Moisture	12	%
GR-IA02-SB02-1-M (3-10)	12/2/2004	Perchlorate	1.1	U	µg/kg	Percent Moisture	5.6	%
GR-IA02-SB03-1 (0-3)	12/2/2004	Perchlorate	1.1	U	µg/kg	Percent Moisture	12	%
GR-IA02-SB03-1 (3-10)	12/2/2004	Perchlorate	1.0	U	µg/kg	Percent Moisture	4.6	%
GR-IA02-SB03-1-D (3-10)	12/2/2004	Perchlorate	1.1	U	µg/kg	Percent Moisture	5.1	%
GR-IA02-SB04-1 (0-3)	12/2/2004	Perchlorate	1.2	U	µg/kg	Percent Moisture	17	%
GR-IA02-SB04-1 (3-10)	12/2/2004	Perchlorate	1.1	U	µg/kg	Percent Moisture	5.7	%
GR-IA02-SB07-1 (0-3)	12/6/2004	Perchlorate	1.2	U	µg/kg	Percent Moisture	18	%
GR-IA02-SB07-1 (3-10)	12/6/2004	Perchlorate	1.1	U	µg/kg	Percent Moisture	11	%
GR-IA02-SB08-1 (0-3)	12/6/2004	Perchlorate	1.1	U	µg/kg	Percent Moisture	9.1	%
GR-IA02-SB08-1 (3-10)	12/6/2004	Perchlorate	1.1	U	µg/kg	Percent Moisture	6	%
GR-IA02-SB08-1-D (3-10)	12/6/2004	Perchlorate	1.1	U	µg/kg	Percent Moisture	10	%
GR-IA02-SB09-1 (0-3)	12/7/2004	Perchlorate	1.2	U	µg/kg	Percent Moisture	15	%
GR-IA02-SB09-1 (3-10)	12/7/2004	Perchlorate	1.1	U	µg/kg	Percent Moisture	5.4	%
GR-IA02-SB10-1 (0-3)	12/7/2004	Perchlorate	1.1	U	µg/kg	Percent Moisture	11	%
GR-IA02-SB10-1 (3-10)	12/7/2004	Perchlorate	1.1	U	µg/kg	Percent Moisture	6.1	%
GR-IA02-SB11-1 (0-3)	12/8/2004	Perchlorate	1.2	U	µg/kg	Percent Moisture	19	%
GR-IA02-SB11-1 (3-10)	12/8/2004	Perchlorate	1.1	U	µg/kg	Percent Moisture	7.3	%
GR-IA02-SB13-1 (0-3)	12/13/2004	Perchlorate	1.1	U	µg/kg	Percent Moisture	8.8	%
GR-IA02-SB13-1 (3-10)	12/13/2004	Perchlorate	1.1	U	µg/kg	Percent Moisture	5.6	%
GR-IA02-SB20-1 (0-3)	12/8/2004	Perchlorate	1.1	U	µg/kg	Percent Moisture	12	%
GR-IA02-SB20-1-D (0-3)	12/8/2004	Perchlorate	1.1	U	µg/kg	Percent Moisture	12	%
GR-IA02-SB20-1-M (3-10)	12/8/2004	Perchlorate	1.1	U	µg/kg	Percent Moisture	8.6	%
Investigation Area 8								
GR-IA08-SB01-1 (0-3)	11/30/2004	Perchlorate	1.1	U	µg/kg	Percent Moisture	6.6	%
GR-IA08-SB01-1 (3-10)	11/30/2004	Perchlorate	1.0	U	µg/kg	Percent Moisture	3.7	%
GR-IA08-SB01-1-D (3-10)	11/30/2004	Perchlorate	1.0	U	µg/kg	Percent Moisture	4.1	%
GR-IA08-SB05-1 (0-3)	12/2/2004	Perchlorate	1.1	U	µg/kg	Percent Moisture	13	%
GR-IA08-SB05-1 (3-10)	12/2/2004	Perchlorate	1.1	U	µg/kg	Percent Moisture	5.9	%
GR-IA08-SB06-1 (0-3)	12/2/2004	Perchlorate	1.1	U	µg/kg	Percent Moisture	9.6	%
GR-IA08-SB06-1 (3-10)	12/2/2004	Perchlorate	1.1	U	µg/kg	Percent Moisture	7.3	%

Notes:
EPA = U.S. Environmental Protection Agency
* = Sample location GR-IA02-SB01 was later changed to GR-IA02-MW03
U = Not detected, detection limit listed.
µg/kg = micrograms per kilogram (parts per billion).
µg/L = micrograms per liter (parts per billion).

SSI -Summary of Explosives Soil Analytical Results

Table 5-2i

Supplemental Site Investigation

Analytic Method: 8330
Sample Matrix: Soil
Reporting Units: mg/kg
Sample Dates: 30-Nov-2004 to 13-Apr-2005

						1,3,5-Trinitrobenzene	1,3-Dinitrobenzene	2,4,6-Trinitrotoluene	2,4-DAm6NT	2,4-Dinitrotoluene	2,6-DAm4NT	2,6-Dinitrotoluene	2-AminoDNT	2-Nitrotoluene	3-Nitrotoluene	4-AminoDNT	4-Nitrotoluene	HMX	Nitrobenzene	Nitroglycerin	PETN	Picric acid	RDX	Tetryl
SSI Project Action Limit (PAL) - Wave 2 (Explosives)						1800	0.61	16	NC	12	NC	6.1	NC	2.8	370	NC	38	3900	2	35	NC	NC	4.4	780
Secondary Regulatory Criteria Not Selected																								
	Date	Sample ID	Depth	Method	Dilution																			
IA02-SB01	30-Nov-04	GR-IA02-SB01-1	3-10'	8330	1	0.2 u	0.2 u	0.2 u	-	0.2 u	-	0.2 u	0.2 u	0.4 u	0.2 u	0.2 u	0.2 u	0.2 u	0.2 u	-	-	-	0.2 u	0.2 u
	30-Nov-04	GR-IA02-SB01-1	0-3'	8330	1	0.2 u	0.2 u	0.2 u	-	0.2 u	-	0.2 u	0.2 u	0.4 u	0.2 u	0.2 u	0.2 u	0.2 u	0.2 u	-	-	-	0.2 u	0.2 u
IA02-SB02	02-Dec-04	GR-IA02-SB02-1	3-10'	8330	1	0.2 u	0.2 u	0.2 u	-	0.2 u	-	0.2 u	0.2 u	0.4 u	0.2 u	0.2 u	0.2 u	0.2 u	0.2 u	-	-	-	0.2 u	0.2 u
	02-Dec-04	GR-IA02-SB02-1	0-3'	8330	1	0.2 u	0.2 u	0.2 u	-	0.2 u	-	0.2 u	0.2 u	0.4 u	0.2 u	0.2 u	0.2 u	0.2 u	0.2 u	-	-	-	0.2 u	0.2 u
IA02-SB03	02-Dec-04	GR-IA02-SB03-1	3-10'	8330	1	0.2 u	0.2 u	0.2 u	-	0.2 u	-	0.2 u	0.2 u	0.4 u	0.2 u	0.2 u	0.2 u	0.2 u	0.2 u	-	-	-	0.2 u	0.2 u
	02-Dec-04	GR-IA02-SB03-1-D	3-10'	8330	1	0.2 u	0.2 u	0.2 u	-	0.2 u	-	0.2 u	0.2 u	0.4 u	0.2 u	0.2 u	0.2 u	0.2 u	0.2 u	-	-	-	0.2 u	0.2 u
	02-Dec-04	GR-IA02-SB03-1	0-3'	8330	1	0.2 u	0.2 u	0.2 u	-	0.2 u	-	0.2 u	0.2 u	0.4 u	0.2 u	0.2 u	0.2 u	0.2 u	0.2 u	-	-	-	0.2 u	0.2 u
IA02-SB04	02-Dec-04	GR-IA02-SB04-1	3-10'	8330	1	0.2 u	0.2 u	0.2 u	-	0.2 u	-	0.2 u	0.2 u	0.4 u	0.2 u	0.2 u	0.2 u	0.2 u	0.2 u	-	-	-	0.2 u	0.2 u
	02-Dec-04	GR-IA02-SB04-1	0-3'	8330	1	0.2 u	0.2 u	0.2 u	-	0.2 u	-	0.2 u	0.2 u	0.4 u	0.2 u	0.2 u	0.2 u	0.2 u	0.2 u	-	-	-	0.2 u	0.2 u
IA02-SB05	02-Dec-04	GR-IA02-SB05-1	3-10'	8330	1	0.2 u	0.2 u	0.2 u	-	0.2 u	-	0.2 u	0.2 u	0.4 u	0.2 u	0.2 u	0.2 u	0.2 u	0.2 u	-	-	-	0.2 u	0.2 u
	02-Dec-04	GR-IA02-SB05-1	0-3'	8330	1	0.2 u	0.2 u	0.2 u	-	0.2 u	-	0.2 u	0.2 u	0.4 u	0.2 u	0.2 u	0.2 u	0.2 u	0.2 u	-	-	-	0.2 u	0.2 u
IA02-SB06	02-Dec-04	GR-IA02-SB06-1	3-10'	8330	1	0.2 u	0.2 u	0.2 u	-	0.2 u	-	0.2 u	0.2 u	0.4 u	0.2 u	0.2 u	0.2 u	0.2 u	0.2 u	-	-	-	0.2 u	0.2 u
	02-Dec-04	GR-IA02-SB06-1	0-3'	8330	1	0.2 u	0.2 u	0.2 u	-	0.2 u	-	0.2 u	0.2 u	0.4 u	0.2 u	0.2 u	0.2 u	0.2 u	0.2 u	-	-	-	0.2 u	0.2 u
IA02-SB07	06-Dec-04	GR-IA02-SB07-1	0-3'	8330	1	0.4 u	0.4 u	0.4 u	-	0.4 u	-	0.4 u	0.4 u	0.4 u	0.4 u	0.4 u	0.4 u	0.4 u	0.4 u	-	-	-	0.4 u	0.4 u
	06-Dec-04	GR-IA02-SB07-1	3-10'	8330	1	0.4 u	0.4 u	0.4 u	-	0.4 u	-	0.4 u	0.4 u	0.4 u	0.4 u	0.4 u	0.4 u	0.4 u	0.4 u	-	-	-	0.4 u	0.4 u
IA02-SB08	06-Dec-04	GR-IA02-SB08-1	3-10'	8330	1	0.4 u	0.4 u	0.4 u	-	0.4 u	-	0.4 u	0.4 u	0.4 u	0.4 u	0.4 u	0.4 u	0.4 u	0.4 u	-	-	-	0.4 u	0.4 u
	06-Dec-04	GR-IA02-SB08-1	0-3'	8330	1	0.4 u	0.4 u	0.4 u	-	0.4 u	-	0.4 u	0.4 u	0.4 u	0.4 u	0.4 u	0.4 u	0.4 u	0.4 u	-	-	-	0.4 u	0.4 u
IA02-SB09	07-Dec-04	GR-IA02-SB09-1	3-10'	8330	1	0.4 u	0.4 u	0.4 u	-	0.4 u	-	0.4 u	0.4 u	0.4 u	0.4 u	0.4 u	0.4 u	0.4 u	0.4 u	-	-	-	0.4 u	0.4 u
	07-Dec-04	GR-IA02-SB09-1	0-3'	8330	1	0.4 u	0.4 u	0.4 u	-	0.4 u	-	0.4 u	0.4 u	0.4 u	0.4 u	0.4 u	0.4 u	0.4 u	0.4 u	-	-	-	0.4 u	0.4 u
IA02-SB10	07-Dec-04	GR-IA02-SB10-1	3-10'	8330	1	0.4 u	0.4 u	0.4 u	-	0.4 u	-	0.4 u	0.4 u	0.4 u	0.4 u	0.4 u	0.4 u	0.4 u	0.4 u	-	-	-	0.4 u	0.4 u
	07-Dec-04	GR-IA02-SB10-1	0-3'	8330	1	0.4 u	0.4 u	0.4 u	-	0.4 u	-	0.4 u	0.4 u	0.4 u	0.4 u	0.4 u	0.4 u	0.4 u	0.4 u	-	-	-	0.4 u	0.4 u
IA02-SB12	03-Dec-04	GR-IA02-SB12-1	3-10'	8330	1	0.4 u	0.4 u	0.4 u	-	0.4 u	-	0.4 u	0.4 u	0.4 u	0.4 u	0.4 u	0.4 u	0.4 u	0.4 u	-	-	-	0.4 u	0.4 u
	03-Dec-04	GR-IA02-SB12-1	0-3'	8330	1	0.4 u	0.4 u	0.4 u	-	0.4 u	-	0.4 u	0.4 u	0.4 u	0.4 u	0.4 u	0.4 u	0.4 u	0.4 u	-	-	-	0.4 u	0.4 u
IA02-SB13	13-Dec-04	GR-IA02-SB13-1	0-3'	8330	1	0.4 u	0.4 u	0.4 u	-	0.4 u	-	0.4 u	0.4 u	0.4 u	0.4 u	0.4 u	0.4 u	0.4 u	0.4 u	-	-	-	0.4 u	0.4 u
	13-Dec-04	GR-IA02-SB13-1	3-10'	8330	1	0.4 u	0.4 u	0.4 u	-	0.4 u	-	0.4 u	0.4 u	0.4 u	0.4 u	0.4 u	0.4 u	0.4 u	0.4 u	-	-	-	0.4 u	0.4 u
	13-Dec-04	GR-IA02-SB13-1-D	3-10'	8330	1	0.4 u	0.4 u	0.4 u	-	0.4 u	-	0.4 u	0.4 u	0.4 u	0.4 u	0.4 u	0.4 u	0.4 u	0.4 u	-	-	-	0.4 u	0.4 u
IA02-SB14	03-Dec-04	GR-IA02-SB14-1	3-10'	8330	1	0.4 u	0.4 u	0.4 u	-	0.4 u	-	0.4 u	0.4 u	0.4 u	0.4 u	0.4 u	0.4 u	0.4 u	0.4 u	-	-	-	0.4 u	0.4 u
	03-Dec-04	GR-IA02-SB14-1	0-3'	8330	1	0.4 u	0.4 u	0.4 u	-	0.4 u	-	0.4 u	0.4 u	0.4 u	0.4 u	0.4 u	0.4 u	0.4 u	0.4 u	-	-	-	0.4 u	0.4 u
	03-Dec-04	GR-IA02-SB14-1-D	0-3'	8330	1	0.4 u	0.4 u	0.4 u	-	0.4 u	-	0.4 u	0.4 u	0.4 u	0.4 u	0.4 u	0.4 u	0.4 u	0.4 u	-	-	-	0.4 u	0.4 u
IA02-SB15	03-Dec-04	GR-IA02-SB15-1	3-10'	8330	1	0.4 u	0.4 u	0.4 u	-	0.4 u	-	0.4 u	0.4 u	0.4 u	0.4 u	0.4 u	0.4 u	0.4 u	0.4 u	-	-	-	0.4 u	0.4 u
	03-Dec-04	GR-IA02-SB15-1	0-3'	8330	1	0.4 u	0.4 u	0.4 u	-	0.4 u	-	0.4 u	0.4 u	0.4 u	0.4 u	0.4 u	0.4 u	0.4 u	0.4 u	-	-	-	0.4 u	0.4 u
IA02-SB16	06-Dec-04	GR-IA02-SB16-1	3-10'	8330	1	0.4 u	0.4 u	0.4 u	-	0.4 u	-	0.4 u	0.4 u	0.4 u	0.4 u	0.4 u	0.4 u	0.4 u	0.4 u	-	-	-	0.4 u	0.4 u
	06-Dec-04	GR-IA02-SB16-1	0-3'	8330	1	0.4 u	0.4 u	0.4 u	-	0.4 u	-	0.4 u	0.4 u	0.4 u	0.4 u	0.4 u	0.4 u	0.4 u	0.4 u	-	-	-	0.4 u	0.4 u
IA02-SB17	07-Dec-04	GR-IA02-SB17-1	3-10'	8330	1	0.4 u	0.4 u	0.4 u	-	0.4 u	-	0.4 u	0.4 u	0.4 u	0.4 u	0.4 u	0.4 u	0.4 u	0.4 u	-	-	-	0.4 u	0.4 u
	07-Dec-04	GR-IA02-SB17-1	0-3'	8330	1	0.4 u	0.4 u	0.4 u	-	0.4 u	-	0.4 u	0.4 u	0.4 u	0.4 u	0.4 u	0.4 u	0.4 u	0.4 u	-	-	-	0.4 u	0.4 u

Location

Notes:

NC No criteria listed under the regulation cited
ND Non-detect result (Original data unavailable - neither value nor detection limit provided)
- Parameter not analyzed

Analytic Flags:

u Not detected above laboratory reporting limits
j Estimated value - parameter detected between laboratory reporting limit and half of the laboratory reporting limit.
e Value exceeds analytical calibration limits
b Parameter detected in quality control blank and sample

Highlighting:

Value or Detection Limit exceeds Criteria 1 only
Value or Detection Limit exceeds Criteria 2 only
Value or Detection Limit exceeds both criteria

SSI -Summary of Explosives Soil Analytical Results

Table 5-2i

Supplemental Site Investigation

Analytic Method: 8330
Sample Matrix: Soil
Reporting Units: mg/kg
Sample Dates: 30-Nov-2004 to 13-Apr-2005

						1,3,5-Trinitrobenzene	1,3-Dinitrobenzene	2,4,6-Trinitrotoluene	2,4-Dam6NT	2,4-Dinitrotoluene	2,6-Dam4NT	2,6-Dinitrotoluene	2-AminoDNT	2-Nitrotoluene	3-Nitrotoluene	4-AminoDNT	4-Nitrotoluene	HMX	Nitrobenzene	Nitroglycerin	PETN	Picric acid	RDX	Tetryl
SSI Project Action Limit (PAL) - Wave 2 (Explosives)						1800	0.61	16	NC	12	NC	6.1	NC	2.8	370	NC	38	3900	2	35	NC	NC	4.4	780
Secondary Regulatory Criteria Not Selected																								
	Date	Sample ID	Depth	Method	Dilution																			
IA02-SB23	13-Dec-04	GR-IA02-SB23-1	0-3'	8330	1	0.4 u	0.4 u	0.4 u	-	0.4 u	-	0.4 u	0.4 u	0.4 u	0.4 u	0.4 u	0.4 u	0.4 u	0.4 u	-	-	-	0.4 u	0.4 u
	13-Dec-04	GR-IA02-SB23-1	3-10'	8330	1	0.4 u	0.4 u	0.4 u	-	0.4 u	-	0.4 u	0.4 u	0.4 u	0.4 u	0.4 u	0.4 u	0.4 u	0.4 u	-	-	-	0.4 u	0.4 u
	13-Dec-04	GR-IA02-SB23-1-D	3-10'	8330	1	0.4 u	0.4 u	0.4 u	-	0.4 u	-	0.4 u	0.4 u	0.4 u	0.4 u	0.4 u	0.4 u	0.4 u	0.4 u	-	-	-	0.4 u	0.4 u
IA02-SB24	13-Dec-04	GR-IA02-SB24-1	0-3'	8330	1	0.4 u	0.4 u	0.4 u	-	0.4 u	-	0.4 u	0.4 u	0.4 u	0.4 u	0.4 u	0.4 u	0.4 u	0.4 u	-	-	-	0.4 u	0.4 u
	13-Dec-04	GR-IA02-SB24-1	3-10'	8330	1	0.4 u	0.4 u	0.4 u	-	0.4 u	-	0.4 u	0.4 u	0.4 u	0.4 u	0.4 u	0.4 u	0.4 u	0.4 u	-	-	-	0.4 u	0.4 u
IA02-SB25	13-Dec-04	GR-IA02-SB25-1	0-3'	8330	1	0.4 u	0.4 u	0.4 u	-	0.4 u	-	0.4 u	0.4 u	0.4 u	0.4 u	0.4 u	0.4 u	0.4 u	0.4 u	-	-	-	0.4 u	0.4 u
	13-Dec-04	GR-IA02-SB25-1	3-10'	8330	1	0.4 u	0.4 u	0.4 u	-	0.4 u	-	0.4 u	0.4 u	0.4 u	0.4 u	0.4 u	0.4 u	0.4 u	0.4 u	-	-	-	0.4 u	0.4 u
IA02-SB26	13-Dec-04	GR-IA02-SB26-1	0-3'	8330	1	0.4 u	0.4 u	0.4 u	-	0.4 u	-	0.4 u	0.4 u	0.4 u	0.4 u	0.4 u	0.4 u	0.4 u	0.4 u	-	-	-	0.4 u	0.4 u
	13-Dec-04	GR-IA02-SB26-1	3-10'	8330	1	0.4 u	0.4 u	0.4 u	-	0.4 u	-	0.4 u	0.4 u	0.4 u	0.4 u	0.4 u	0.4 u	0.4 u	0.4 u	-	-	-	0.4 u	0.4 u
IA02-SB27	13-Dec-04	GR-IA02-SB27-1	0-3'	8330	1	0.4 u	0.4 u	0.4 u	-	0.4 u	-	0.4 u	0.4 u	0.4 u	0.4 u	0.4 u	0.4 u	0.4 u	0.4 u	-	-	-	0.4 u	0.4 u
	13-Dec-04	GR-IA02-SB27-1	3-10'	8330	1	0.4 u	0.4 u	0.4 u	-	0.4 u	-	0.4 u	0.4 u	0.4 u	0.4 u	0.4 u	0.4 u	0.4 u	0.4 u	-	-	-	0.4 u	0.4 u
IA02-SB28	14-Dec-04	GR-IA02-SB28-1	3-10'	8330	1	0.4 u	0.4 u	0.4 u	-	0.4 u	-	0.4 u	0.4 u	0.4 u	0.4 u	0.4 u	0.4 u	0.4 u	0.4 u	-	-	-	0.4 u	0.4 u
	14-Dec-04	GR-IA02-SB28-1	0-3'	8330	1	0.4 u	0.4 u	0.4 u	-	0.4 u	-	0.4 u	0.4 u	0.4 u	0.4 u	0.4 u	0.4 u	0.4 u	0.4 u	-	-	-	0.4 u	0.4 u
IA02-SB30	15-Dec-04	GR-IA02-SB30-1-M	3-10'	8330	1	0.4 u	0.4 u	0.4 u	-	0.4 u	-	0.4 u	0.4 u	0.4 u	0.4 u	0.4 u	0.4 u	0.4 u	0.4 u	-	-	-	0.4 u	0.4 u
	15-Dec-04	GR-IA02-SB30-1	0-3'	8330	1	0.4 u	0.4 u	0.4 u	-	0.4 u	-	0.4 u	0.4 u	0.4 u	0.4 u	0.4 u	0.4 u	0.4 u	0.4 u	-	-	-	0.4 u	0.4 u
IA02-SS01	13-Dec-04	GR-IA02-SS01-1	0-1.5'	8330	1	0.4 u	0.4 u	0.4 u	-	0.4 u	-	0.4 u	0.4 u	0.4 u	0.4 u	0.4 u	0.4 u	0.4 u	0.4 u	-	-	-	0.4 u	0.4 u
IA06-SB03	11-Apr-05	LO-IA06-SB03-1	3-10'	8330	1	0.12 u	0.12 u	0.12 u	0.12 u	0.12 u	0.25 u	0.12 u	0.12 u	0.12 u	0.12 u	0.12 u	0.12 u	0.12 u	0.12 u	2.5 u	5 u	0.12 u	0.12 u	0.12 u
	11-Apr-05	LO-IA06-SB03-1	0-3'	8330	1	0.12 u	0.12 u	0.12 u	0.12 u	0.081 j	0.25 u	0.12 u	0.12 u	0.12 u	0.12 u	0.12 u	0.12 u	0.12 u	0.12 u	2.5 u	5 u	0.12 u	0.12 u	0.12 u
IA06-SB04	11-Apr-05	LO-IA06-SB04-1	3-10'	8330	1	0.12 u	0.12 u	0.12 u	0.12 u	0.12 u	0.25 u	0.12 u	0.12 u	0.12 u	0.12 u	0.12 u	0.12 u	0.12 u	0.12 u	2.5 u	5 u	0.12 u	0.12 u	0.12 u
	11-Apr-05	LO-IA06-SB04-1	0-3'	8330	1	0.12 u	0.12 u	0.12 u	0.12 u	0.12	0.25 u	0.12 u	0.12 u	0.12 u	0.12 u	0.12 u	0.12 u	0.12 u	0.12 u	2.5 u	5 u	0.12 u	0.12 u	0.12 u
IA06-SB05	11-Apr-05	LO-IA06-SB05-1	3-10'	8330	1	0.12 u	0.12 u	0.12 u	0.12 u	0.12 u	0.25 u	0.12 u	0.12 u	0.12 u	0.12 u	0.12 u	0.12 u	0.12 u	0.12 u	2.5 u	5 u	0.12 u	0.12 u	0.12 u
	11-Apr-05	LO-IA06-SB05-1	0-3'	8330	1	0.12 u	0.12 u	0.12 u	0.12 u	0.12 u	0.25 u	0.12 u	0.12 u	0.12 u	0.12 u	0.12 u	0.12 u	0.12 u	0.12 u	2.5 u	5 u	0.12 u	0.12 u	0.12 u
IA06-SB06	11-Apr-05	LO-IA06-SB06-1	3-10'	8330	1	0.12 u	0.12 u	0.12 u	0.12 u	0.12 u	0.25 u	0.12 u	0.12 u	0.12 u	0.12 u	0.12 u	0.12 u	0.12 u	0.12 u	2.5 u	5 u	0.12 u	0.12 u	0.12 u
	11-Apr-05	LO-IA06-SB06-1	0-3'	8330	1	0.12 u	0.12 u	0.12 u	0.12 u	0.12 u	0.25 u	0.12 u	0.12 u	0.12 u	0.12 u	0.12 u	0.12 u	0.12 u	0.12 u	2.5 u	5 u	0.12 u	0.12 u	0.12 u
IA06-SD06	13-Apr-05	LO-IA06-SD06-1	0-1.5'	8330	1	0.12 u	0.12 u	0.12 u	0.12 u	0.12 u	0.25 u	0.12 u	0.12 u	0.12 u	0.12 u	0.12 u	0.12 u	0.12 u	0.12 u	2.5 u	5 u	0.12 u	0.12 u	0.12 u
IA06-SD17	13-Apr-05	LO-IA06-SD17-1	0-1.5'	8330	1	0.12 u	0.12 u	0.12 u	0.12 u	0.12 u	0.25 u	0.12 u	0.12 u	0.12 u	0.12 u	0.12 u	0.12 u	0.12 u	0.12 u	2.5 u	5 u	0.12 u	0.12 u	0.12 u
IA06-SS08	11-Apr-05	LO-IA06-SS08-1	0-1.5'	8330	1	0.12 u	0.12 u	0.12 u	0.12 u	0.12 u	0.25 u	0.12 u	0.12 u	0.12 u	0.12 u	0.12 u	0.12 u	0.12 u	0.12 u	2.5 u	5 u	0.12 u	0.12 u	0.12 u
IA06-SS16	11-Apr-05	LO-IA06-SS16-1	0-1.5'	8330	1	0.12 u	0.12 u	0.12 u	0.12 u	0.12 u	0.25 u	0.12 u	0.12 u	0.12 u	0.12 u	0.12 u	0.12 u	0.12 u	0.12 u	2.5 u	5 u	0.12 u	0.12 u	0.12 u
	11-Apr-05	LO-IA06-SS16-1-D	0-1.5'	8330	1	0.12 u	0.12 u	0.12 u	0.12 u	0.12 u	0.25 u	0.12 u	0.12 u	0.12 u	0.12 u	0.12 u	0.12 u	0.12 u	0.12 u	2.5 u	5 u	0.12 u	0.12 u	0.12 u
IA06-SS35	12-Apr-05	LO-IA06-SS35-1	0-1.5'	8330	1	0.12 u	0.12 u	0.12 u	0.12 u	0.12 u	0.25 u	0.12 u	0.12 u	0.12 u	0.12 u	0.12 u	0.12 u	0.12 u	0.12 u	2.5 u	5 u	0.12 u	0.12 u	0.12 u
IA06-SS40	12-Apr-05	LO-IA06-SS40-1	0-1.5'	8330	1	0.12 u	0.12 u	0.12 u	0.12 u	0.12 u	0.25 u	0.12 u	0.12 u	0.12 u	0.12 u	0.12 u	0.12 u	0.12 u	0.12 u	2.5 u	5 u	0.12 u	0.12 u	0.12 u
IA06-SS45	13-Apr-05	LO-IA06-SS25-1	0-1.5'	8330	1	0.12 u	0.12 u	0.12 u	0.12 u	0.12 u	0.25 u	0.12 u	0.12 u	0.12 u	0.12 u	0.12 u	0.12 u	0.12 u	0.12 u	2.5 u	5 u	0.12 u	0.12 u	0.12 u
IA08-SB01	30-Nov-04	GR-IA08-SB01-1	3-10'	8330	1	0.2 u	0.2 u	0.2 u	-	0.2 u	-	0.2 u	0.2 u	0.4 u	0.2 u	0.2 u	0.2 u	0.2 u	0.2 u	-	-	-	0.2 u	0.2 u
	30-Nov-04	GR-IA08-SB01-1-D	3-10'	8330	1	0.2 u	0.2 u	0.2 u	-	0.2 u	-	0.2 u	0.2 u	0.4 u	0.2 u	0.2 u	0.2 u	0.2 u	0.2 u	-	-	-	0.2 u	0.2 u
	30-Nov-04	GR-IA08-SB01-1	0-3'	8330	1	0.2 u	0.2 u	0.2 u	-	0.2 u	-	0.2 u	0.2 u	0.4 u	0.2 u	0.2 u	0.2 u	0.2 u	0.2 u	-	-	-	0.2 u	0.2 u

Location

Notes:

NC No criteria listed under the regulation cited
ND Non-detect result (Original data unavailable - neither value nor detection limit provided)
- Parameter not analyzed

Analytic Flags:

u Not detected above laboratory reporting limits
j Estimated value - parameter detected between laboratory reporting limit and half of the laboratory reporting limit.
e Value exceeds analytical calibration limits
b Parameter detected in quality control blank and sample

Highlighting:

Value or Detection Limit exceeds Criteria 1 only
Value or Detection Limit exceeds Criteria 2 only
Value or Detection Limit exceeds both criteria

Supplemental Site Investigation

Analytic Method: 8330
Sample Matrix: Soil
Reporting Units: mg/kg
Sample Dates: 30-Nov-2004 to 13-Apr-2005

						1,3,5-Trinitrobenzene	1,3-Dinitrobenzene	2,4,6-Trinitrotoluene	2,4-DamNT	2,4-Dinitrotoluene	2,6-DamNT	2,6-Dinitrotoluene	2-AminoDNT	2-Nitrotoluene	3-Nitrotoluene	4-AminoDNT	4-Nitrotoluene	HMX	Nitrobenzene	Nitroglycerin	PETN	Picric acid	RDX	Tetryl
SSI Project Action Limit (PAL) - Wave 2 (Explosives)						1800	0.61	16	NC	12	NC	6.1	NC	2.8	370	NC	38	3900	2	35	NC	NC	4.4	780
Secondary Regulatory Criteria Not Selected																								
	Date	Sample ID	Depth	Method	Dilution																			
IA08-SB09	16-Dec-04	GR-IA08-SB09-1	3-10'	8330	1	0.4 u	0.4 u	0.4 u	-	0.4 u	-	0.4 u	0.4 u	0.4 u	0.4 u	0.4 u	0.4 u	0.4 u	0.4 u	-	-	-	0.4 u	0.4 u
	16-Dec-04	GR-IA08-SB09-1	0-3'	8330	1	0.4 u	0.4 u	0.4 u	-	0.4 u	-	0.4 u	0.4 u	0.4 u	0.4 u	0.4 u	0.4 u	0.4 u	0.4 u	-	-	-	0.4 u	0.4 u

Location

Notes:

NC No criteria listed under the regulation cited
ND Non-detect result (Original data unavailable - neither value nor detection limit provided)
- Parameter not analyzed

Analytic Flags:

u Not detected above laboratory reporting limits
j Estimated value - parameter detected between laboratory reporting limit and half of the laboratory reporting limit.
e Value exceeds analytical calibration limits
b Parameter detected in quality control blank and sample

Highlighting:

Value or Detection Limit exceeds Criteria 1 only
Value or Detection Limit exceeds Criteria 2 only
Value or Detection Limit exceeds both criteria

Table 5-3a

Shallow Soil Sample Lithology
Investigation Area 2

Location ID	IA02-SS01	
Sample ID	GR-IA02-SS01-1	
Date Collected	13-Dec-04	
Depth Interval (ft bgs)		
0.0		Dark brown (10YR 3/6) fine SAND and Silt, with fine to coarse Gravel, moist loose. Contains much metal debris and household waste (pots, shoes, plastic toys, etc.)
0.1		
0.2		
0.3		
0.4		
0.5		
0.6		
0.7		
0.8		
0.9		
1.0		
1.1		
1.2		
1.3		
1.4		
1.5		

Table 5-3b

Shallow Soil Sample Lithology
Investigation Area 3

Location ID	IA03-SS01	IA03-SS02	IA03-SS03	IA03-SS07	IA03-SS08	IA03-SS09
Sample ID	GR-IA03-SS01-1	GR-IA03-SS02-1/D	GR-IA03-SS03-1	GR-IA03-SS07-1	GR-IA03-SS08-1	GR-IA03-SS09-1
Date Collected	3-Nov-04	3-Nov-04	3-Nov-04	3-Nov-04	3-Nov-04	3-Nov-04
Depth Interval (ft bgs)	**North Area**					
0.0 – 0.4	10YR 2/2 Dusky yellowish brown Organic matter, with fine SAND, trace silt, moist, loose.	5Y 2/1 Olive black SILT, some fine SAND with organic matter, moist, loose. E horizon (0.2-0.25') in soil pale gray fine sand.	5Y 6/1 Light olive gray fine SAND, trace fine subrounded Gravel, trace roots, moist, loose.	10YR 4/1 Brownish gray organic matter and silt, with fine Sand, moist, loose.	10YR 4/1 Brownish gray organic matter and silt, some fine Sand, moist, cohesive.	10YR 4/1 Brownish gray organic matter with Silt and fine and, moist, loose.
0.4 – 0.5	10YR 6/2 Pale yellow-brown fine SAND, trace Silt, trace medium-coarse Sand, trace fine-medium subrounded Gravel, moist, loose.	10YR 5/2 Yellow brown fine SAND, trace Silt, trace fine-medium subrounded Gravel, moist, loose.	10YR 5/2 Yellowish brown fine SAND, trace medium-coarse SAND, trace Silt, trace fine-medium subrounded Gravel, moist, loose.	E horizon bleached Dark Gray.		
0.5 – 1.5				10YR 6/6 Dark yellowish orange fine SAND, trace fine subrounded Gravel, moist, loose.	10YR 6/6 Dusky yellow-brown fine SAND, trace fine rounded Gravel, moist, loose.	10YR 6/6 Dusky Yellow brown fine SAND, moist, loose.

Table 5-3b

Shallow Soil Sample Lithology
Investigation Area 3

Location ID	IA03-SS10	IA03-SS11	IA03-SS12	IA03-SS13	IA03-SS14
Sample ID	GR-IA03-SS10-1	GR-IA03-SS11-1	GR-IA03-SS12-1	GR-IA03-SS13-1	GR-IA03-SS14-1
Date Collected	3-Nov-04	3-Nov-04	3-Nov-04	3-Nov-04	3-Nov-04
Depth Interval (ft bgs)	**North Area**				
0.0 – 0.2	10YR 4/1 Brownish gray fine SAND and SILT, with organic matter, moist, loose.	10YR 4/2 Dark Brown fine SAND with Silt, trace fine- medium subrounded Gravel, loose, moist.	10YR 4/2 Dark Brown fine SAND with Silt, trace fine- medium subrounded Gravel, loose, moist.	10YR 4/2 Dark Brown fine - medium SAND, trace Silt, trace fine-medium subrounded Gravel, loose, moist.	10YR 4/2 Dark Brown fine SAND, trace organics/roots, loose, moist.
0.3 – 1.5	10Y 5/2 Olive fine-medium SAND, little fine-medium subrounded Gravel, moist, loose.				10YR 6/6 Dark yellow brown fine-medium SAND, trace rounded Gravel (gravel fractures sharply), moist, loose.

Table 5-3b

Shallow Soil Sample Lithology
Investigation Area 3

Location ID	IA03-SS04	IA03-SS05	IA03-SS06	IA03-SS15	IA03-SS16	IA03-SS17
Sample ID	GR-IA03-SS04-1	GR-IA03-SS05-1	GR-IA03-SS06-1	GR-IA03-SS15-1	GR-IA03-SS16-1	GR-IA03-SS17-1
Date Collected	3-Nov-04	3-Nov-04	3-Nov-04	4-Nov-04	4-Nov-04	4-Nov-04
Depth Interval (ft bgs)	South Area					
0.0 – 0.8	10YR 3/1 Brownish black organic matter with Silt, with fine Sand, moist, cohesive.	10YR 3/1 Dusky yellow brown organic matter, with Silt, with Sand, moist, loose.	10YR 3/1 Dusky yellow brown fine SAND with organic matter, trace Silt, moist, loose.	10YR 2/1 Dark brown organic matter with Silt, trace fine Sand, moist, loose.	10YR 2/1 Dark brown organic matter with Silt, trace fine Sand, moist, loose.	10YR 2/1 Dark brown organic matter with silt, little fine Sand, moist, loose.
0.2 – 1.3		5Y 5/4 Olive brown fine SAND, trace Silt, trace medium- coarse Sand, moist, loose.	5Y 5/4 Olive brown fine SAND, trace Silt, trace medium- coarse Sand, moist, loose.	2.5Y 5/4 Yellow-brown fine-coarse SAND to fine-medium subangular Gravel, moist, loose.	10YR 5/6 Yellowish brown fine-medium Sand, trace fine subangular Gravel, moist, loose.	10YR 4/3 Dark yellow brown fine-coarse SAND, trace fine subrounded Gravel, moist, loose.
0.9 – 1.5	10YR 2/2 Dusky yellow brown fine-medium Sand, trace fine subangular Gravel, moist, loose.	10YR 7/6 Yellowish orange fine SAND, moist, loose, trace fine rounded Gravel.	10YR 7/6 Yellowish orange fine SAND, moist, loose, trace fine rounded Gravel.			

Table 5-3b

Shallow Soil Sample Lithology
Investigation Area 3

Location ID	IA03-SS18	IA03-SS19	IA03-SS20	IA03-SS21	IA03-SS22
Sample ID	GR-IA03-SS18-1	GR-IA03-SS19-1	GR-IA03-SS20-1	GR-IA03-SS21-1	GR-IA03-SS22-1
Date Collected	4-Nov-04	4-Nov-04	4-Nov-04	4-Nov-04	4-Nov-04
Depth Interval (ft bgs)	**South Area**				
0.0 – 0.2	10YR 2/1 Dark brown organic matter with Silt, little fine Sand, moist, loose.	10YR 2/1 Dark brown organic soil, trace silt, moist, loose.	10YR 2/1 Dark brown fine SAND, trace silt, trace organic matter, moist, loose.	10YR 2/1 Dark brown fine SAND and SILT, trace organic matter, moist, loose.	10YR 2/1 Dark brown fine SAND with Silt, moist, loose, trace organic matter.
0.3 – 1.5	2.5Y 4/3 dark olive brown fine-coarse SAND, moist, loose.	2.5Y 5/6 Light Olive brown fine SAND trace medium-coarse Sand, moist, loose.	10YR 4/4 dark yellow brown fine-medium SAND, moist, loose.	2.5Y 4/4 dark olive brown fine-medium SAND, trace fine subrounded Gravel, moist, loose.	10YR 5/4 Yellow brown fine SAND, trace fine rounded Gravel, moist, loose.

Table 5-3c

Shallow Soil Sample Lithology
Investigation Area 5

Location ID	IA5-SS01	IA05-SS02	IA05-SS03	IA05-SS04	IA05-SS05	IA05-SS06
Sample ID	GR-IA05-SS01-1	GR-IA05-SS02-1	GR-IA05-SS03-1/D	GR-IA05-SS04-1	GR-IA05-SS05-1	GR-IA05-SS06-1
Date Collected	3-Nov-04	3-Nov-04	3-Nov-04	3-Nov-04	3-Nov-04	3-Nov-04
Depth Interval (ft bgs)						
0.0 – 0.5	5Y 3/1 Dark Olive Brown fine -medium SAND, trace fine Gravel (subrounded), moist, loose, little organic/roots.	Dark Brownish gray (5YR 3/1) well graded Gravelly Sand, with organic matter/ roots.	5Y 2/1 Olive black fine-coarse SAND, little roots and organic matter, trace fine gravel, subrounded, moist, loose.	5Y 2/1 Olive black fine-coarse SAND, fine silt, little roots and organic matter, moist, loose.	5Y 3/1 Dark Olive brown fine SAND, little silt, trace fine- medium subrounded Gravel, moist, slightly cohesive.	5Y 2/1 Olive black Silt, some fine Sand, some organic matter, moist, loose.
0.5 – 1.5	5Y 4/2 Dark Olive brown fine-medium SAND, trace fine-medium subangular Gravel, trace organics, moist, loose.	5Y 5/4 Light olive brown well graded Gravelly Sand, trace organic matter/roots.	5Y 4/4 Moderate Olive brown fine-coarse SAND, trace roots and organic matter, little fine-medium subrounded Gravel, moist, loose.	10YR 6/6 Dark yellowish orange fine SAND, trace medium - coarse Sand, little fine - medium rounded Gravel, moist, loose.	5Y 4/1 Olive gray fine SAND, trace silt, trace fine-medium subangular Gravel, moist, slightly cohesive.	10YR 4/4 Dark yellow brown fine SAND, trace medium - coarse Sand, trace silt, trace roots, trace fine rounded Gravel, moist, loose.

Table 5-3d
IA-6 Shallow Soil Sample Descriptions
PASI/SSI Comprehensive Report
Study Area - Grant, Locust, and Cavite Housing Areas
Devens, Massachusetts

RANGE FLOOR

Location ID	IA06-SS03	IA06-SS12	IA06-SS13	IA06-SS14	IA06-SS15	IA06-SS16
Sample ID	LO-IA06-SS03-1	LO-IA06-SS12-1	LO-IA06-SS13-1	LO-IA06-SS14-1	LO-IA06-SS15-1	LO-IA06-SS16-1
Date Collected	11-Apr-05	11-Apr-05	11-Apr-05	11-Apr-05	11-Apr-05	11-Apr-05
Depth Interval (ft bgs)						
0.0 – 0.5	5YR 2.5/1 Black poorly graded Sandy SILT, wet, soft.	10YR 3/3 Dark brown well graded Silty fine SAND, with organic matter, moist, loose.	10YR 3/2 Very dark greyish brown well graded Silty fine SAND, with organic material, dry, loose.	10YR 3/1 Very dark grey well graded Silty fine SAND, moist, loose.	10YR 4/3 Brown well graded Silty fine SAND, subangular, dry, loose.	10YR 4/3 Brown well graded Silty fine SAND, subangular, dry, loose.
0.3 – 1.5	10YR 5/4 Yellowish brown poorly graded Sandy SILT, moist to wet, soft.	10YR 4/4 Dark yellowish brown well graded Gravelly Silty fine SAND, subangular, dry, loose.	10YR 4/6 Dark yellowish brown well graded Gravelly Silty fine SAND, subangular, dry, loose.	10YR 4/4 Dark yellowish brown well graded Gravelly Silty fine SAND, subangular, dry, cohesive.	10YR 4/4 Dark yellowish brown well graded Gravelly Silty fine SAND, subangular, dry, cohesive.	10YR 4/4 Dark yellowish brown well graded Gravelly Silty fine SAND, subangular, dry, cohesive.

Table 5-3d
IA-6 Shallow Soil Sample Descriptions
PASI/SSI Comprehensive Report
Study Area - Grant, Locust, and Cavite Housing Areas
Devens, Massachusetts

RANGE FLOOR

Location ID	IA06-SS17	IA06-SS18	IA06-SS19	IA06-SS20
Sample ID	LO-IA06-SS17-1	LO-IA06-SS18-1	LO-IA06-SS19-1	LO-IA06-SS20-1
Date Collected	12-Apr-05	12-Apr-05	12-Apr-05	12-Apr-05
Depth Interval (ft bgs)				
0.0 – 0.3	10YR 3/2 Very dark greyish brown well graded Silty fine SAND, with organic matter, dry, loose.	10YR 3/2 Very dark greyish brown well graded Silty fine SAND, with organic matter, dry, loose.	10YR 3/3 Dark brown well graded Silty fine SAND, with organic material, loose, dry.	10YR 3/2 Very dark greyish brown well graded Silty fine SAND, with organic matter, dry, loose.
0.3 – 0.4	10Y 5/4 Yellowish brown well graded Gravelly Silty fine SAND, subangular, dry, loose.	10YR 5/4 Yellowish brown well graded Silty fine SAND, cohesive, moist.	10YR 4/4 Dark yellowish brown well graded Gravelly Silty fine SAND, subangular, moist, loose.	10YR 4/4 Dark yellowish brown well graded Gravelly Silty fine SAND, subangular, moist, cohesive.
0.4 – 0.5		10YR 2/1 Black well graded Sandy SILT, nonplastic, moist, soft, soft.		
0.5 – 0.8		10YR 4/4 Dark yellowish brown Silty fine SAND, wet, loose.		
0.8 – 1.5			10YR 4/3 Brown poorly graded fine to medium SAND, subangular, wet, loose.	

Table 5-3d
IA-6 Shallow Soil Sample Descriptions
PASI/SSI Comprehensive Report
Study Area - Grant, Locust, and Cavite Housing Areas
Devens, Massachusetts

FIRING LINE

Location ID	IA06-SS04	IA06-SS05	IA06-SS06	IA06-SS07	IA06-SS08
Sample ID	LO-IA06-SS04-1	LO-IA06-SS05-1	LO-IA06-SS06-1	LO-IA06-SS07-1	LO-IA06-SS08-1
Date Collected	12-Apr-05	11-Apr-05	11-Apr-05	11-Apr-05	11-Apr-05
Depth Interval (ft bgs)					
0.0 – 0.4	10YR 2/1 Black well graded Silty fine SAND, some organic material, wet, loose.	10YR 3/2 Very dark greyish brown well graded Sandy SILT, dry, soft.	10YR 3/2 Very dark greyish brown well graded Gravelly Silty fine SAND, subrounded, some organic material, dry, loose.	10YR 3/2 Very dark greyish brown well graded Silty fine SAND, some organic material, dry, loose.	7.5YR 3/2 Dark brown well graded Sandy SILT, nonplastic, some organic material, dry, loose.
0.4 – 0.6		10YR 4/3 Brown well graded Gravelly Silty fine SAND, subangular, dry, loose.	10YR 5/4 Yellowish brown well graded Gravelly Silty fine SAND, subangular, dry, loose.		10YR 4/6 Dark yellowish brown well graded Gravelly Silty fine to coarse SAND, dry, cohesive.
0.6 – 1.5				10YR 5/4 Yellowish brown well graded Gravelly Silty fine to coarse SAND, subangular, dry, loose.	

Table 5-3d
IA-6 Shallow Soil Sample Descriptions
PASI/SSI Comprehensive Report
Study Area - Grant, Locust, and Cavite Housing Areas
Devens, Massachusetts

FIRING LINE

Location ID	IA06-SS09	IA06-SS10	IA06-SS11
Sample ID	LO-IA06-SS09-1	LO-IA06-SS10-1	LO-IA06-SS11-1
Date Collected	11-Apr-05	11-Apr-05	11-Apr-05
Depth Interval (ft bgs)			
0.0 - 0.2	10YR 3/2 Very dark greyish brown well graded Silty fine to medium SAND, subangular, some organic material, dry, loose.	10YR 3/3 Dark brown well graded Silty fine SAND, some organic material, dry, loose.	10YR 3/1 Very dark grey well graded Silty fine to medium SAND, subangular, dry, loose.
0.2 - 0.5	10YR 4/4 Dark yellowish brown well graded Gravelly Silty fine to coarse SAND, dry, cohesive.	10YR 4/4 Dark yellowish brown well graded Gravelly Silty fine to coarse SAND, dry, cohesive.	10YR 3/2 Very dark greyish brown well graded Gravelly Silty fine to coarse SAND, dry, cohesive.
1.0 - 1.5			10YR 4/4 Dark yellowish brown well graded Gravelly Silty fine to coarse SAND, subangular, dry, cohesive.

Table 5-3d
IA-6 Shallow Soil Sample Descriptions
PASI/SSI Comprehensive Report
Study Area - Grant, Locust, and Cavite Housing Areas
Devens, Massachusetts

SHORT SHOT

Location ID	IA06-SS21	IA06-SS22	IA06-SS23	IA06-SS24
Sample ID	LO-IA06-SS21-1	LO-IA06-SS22-1	LO-IA06-SS23-1	LO-IA06-SS24-1
Date Collected	12-Apr-05	13-Apr-05	13-Apr-05	13-Apr-05
Depth Interval (ft bgs)				
0.0 – 0.3	10YR 2/2 Very dark brown well graded Silty fine SAND, some organic material, dry, loose.	10YR 2/2 Very dark brown well graded Silty fine SAND, some organic material, dry, loose.	10YR 3/1 Very dark brown well graded Silty fine SAND, some organic material, dry, loose.	10YR 2/1 Black well graded Silty fine SAND, some organic material, dry, loose.
0.3 – 0.5	10YR 4/6 Dark yellowish brown well graded Silty fine SAND, dry, loose.	10YR 4/3 Brown well graded fine to medium Gravelly Silty SAND, subangular, wet, cohesive.	10YR 4/2 Dark greyish brown well graded fine to medium Gravelly Silty SAND, subangular, wet, cohesive.	
0.5 – 1.5				10YR 4/4 Dark Yellowish brown well graded fine to medium Silty Gravelly SAND, subangular, wet, cohesive.

Table 5-3d
IA-6 Shallow Soil Sample Descriptions
PASI/SSI Comprehensive Report
Study Area - Grant, Locust, and Cavite Housing Areas
Devens, Massachusetts

SHORT SHOT

Location ID	IA06-SS25	IA06-SS26	IA06-SS27	IA06-SS28
Sample ID	LO-IA06-SS25-1	LO-IA06-SS26-1	LO-IA06-SS27-1	LO-IA06-SS28-1
Date Collected	13-Apr-05	13-Apr-05	13-Apr-05	13-Apr-05
Depth Interval (ft bgs)				
0.0 – 0.3	10YR 2/2 Very dark brown well graded Silty fine SAND, some organic material, dry, loose.	10YR 3/2 Very dark greyish brown well graded Silty fine SAND, some organic material, dry, loose.	10YR 2/2 Very dark brown well graded Silty fine SAND, some organic material, dry, loose.	10YR 2/1 Black well graded Silty fine SAND, some organic material, dry, loose.
0.3 – 0.4		10YR 4/3 Brown well graded fine to medium Silty Gravelly SAND, subangular, moist, cohesive.	10YR 4/3 Brown well graded fine to medium Silty Gravelly SAND, subangular, wet, loose.	10YR 3/2 Very dark greyish brown well graded fine Silty SAND, moist, loose.
0.4 – 0.5	10YR 3/3 Dark brown well graded fine to medium Gravelly Silty SAND, subangular wet, cohesive.			
0.5 – 0.9				10YR 4/4 Dark yellowish brown well graded fine to medium Silty SAND, subangular, wet, cohesive.
1.4 – 1.5		10YR 5/3 Brown well graded Silty fine SAND, moist, loose.		

Table 5-3d
IA-6 Shallow Soil Sample Descriptions
PASI/SSI Comprehensive Report
Study Area - Grant, Locust, and Cavite Housing Areas
Devens, Massachusetts

HIGH SHOT

Location ID	IA06-SS31	IA06-SS32	IA06-SS33	IA06-SS34
Sample ID	LO-IA06-SS31-1	LO-IA06-SS32-1	LO-IA06-SS33-1	LO-IA06-SS34-1
Date Collected	12-Apr-05	12-Apr-05	12-Apr-05	12-Apr-05
Depth Interval (ft bgs)				
0.0 – 0.1 – 0.2	10YR 2/2 Very dark brown well graded Silty fine SAND, some organic material, dry, loose.	10YR 2/2 Very dark brown well graded Silty fine SAND, some organic material, dry, loose.	10YR 2/2 Very dark brown well graded Silty fine SAND, some organic material, dry, loose.	10YR 2/2 Very dark brown well graded Silty fine SAND, some organic material, dry, loose.
0.3 – 0.4 – 0.5 – 0.6 – 0.7 – 0.8 – 0.9 – 1.0 – 1.1 – 1.2 – 1.3 – 1.4 – 1.5	10YR 4/6 Dark yellowish brown well graded Silty fine SAND, dry, loose.	10YR 5/6 Yellowish brown well graded fine to medium Silty Gravelly SAND, subangular, wet, cohesive.	10YR 4/6 Dark yellowish brown well graded Silty fine SAND, dry, loose.	10YR 4/6 Dark yellowish brown well graded Silty fine SAND, dry, loose.

Table 5-3d
IA-6 Shallow Soil Sample Descriptions
PASI/SSI Comprehensive Report
Study Area - Grant, Locust, and Cavite Housing Areas
Devens, Massachusetts

HIGH SHOT

Location ID	IA06-SS35	IA06-SS36	IA06-SS37	IA06-SS38
Sample ID	LO-IA06-SS35-1	LO-IA06-SS36-1	LO-IA06-SS37-1	LO-IA06-SS38-1
Date Collected	12-Apr-05	12-Apr-05	12-Apr-05	12-Apr-05
Depth Interval (ft bgs)				
0.0 - 0.2	10YR 3/2 Very dark greyish brown well graded Silty fine SAND, some organic material, dry, loose.	10YR 2/2 Very dark brown well graded Silty fine SAND, some organic material, dry, loose.	10YR 2/2 Very dark brown well graded Silty fine SAND, some organic material, dry, loose.	10YR 2/2 Very dark brown well graded Silty fine SAND, some organic material, dry, loose.
0.2 - 1.5	10YR 5/6 Yellowish brown well graded fine Silty Gravelly SAND, subrounded, dry, loose.	10YR 5/6 Yellowish brown well graded fine Silty Gravelly SAND, subrounded, dry, loose.	10YR 5/6 Yellowish brown well graded fine Silty Gravelly SAND, subrounded, dry, loose.	10YR 4/4 Dark yellowish brown poorly graded Silty fine SAND, dry, loose.

Table 5-3d
IA-6 Shallow Soil Sample Descriptions
PASI/SSI Comprehensive Report
Study Area - Grant, Locust, and Cavite Housing Areas
Devens, Massachusetts

PRIMARY IMPACT **HILL SLOPE**

Location ID	IA06-SS29	IA06-SS30	IA06-SS39	IA06-SS40
Sample ID	LO-IA06-SS29-1	LO-IA06-SS30-1	LO-IA06-SS39-1	LO-IA06-SS40-1
Date Collected	12-Apr-05	12-Apr-05	12-Apr-05	12-Apr-05
Depth Interval (ft bgs)				
0.0 – 0.4	10YR 2/1 Very dark greyish brown well graded Silty fine SAND, with organic matter, dry, loose.	7.5 YR 3/1 Very dark grey well graded Silty fine SAND, some organic material, dry, loose.	10YR 2/1 Very dark greyish brown well graded Silty fine SAND, some organic material, dry, loose.	10YR 2/1 Very dark greyish brown well graded Silty fine SAND, some organic material, dry, loose.
0.4 – 0.9	10YR 3/4 Dark yellowish brown well graded Silty fine SAND, dry, loose.	10YR 4/6 Dark yellowish brown well graded Silty fine SAND, dry, loose.	10YR 4/6 Dark yellowish brown well graded fine to medium Silty Gravelly SAND, subangular, dry, loose.	10YR 5/6 Yellowish brown well graded fine to coarse Silty Gravelly SAND, subangular, dry, loose.
0.9 – 1.5	2.5 Y 5/6 Light olive brown poorly graded fine SAND, wet, loose.			

Table 5-3d
IA-6 Shallow Soil Sample Descriptions
PASI/SSI Comprehensive Report
Study Area - Grant, Locust, and Cavite Housing Areas
Devens, Massachusetts

SOUTHERN DEPRESSION

Location ID	IA06-SD01	IA06-SD02	IA06-SD03	IA06-SD04
Sample ID	LO-IA06-SD01-1	LO-IA06-SD02-1	LO-IA06-SD03-1	LO-IA06-SD04-1
Date Collected	13-Apr-05	13-Apr-05	13-Apr-05	13-Apr-05
Depth Interval (ft bgs)				
0.0 – 0.5	10YR 2/1 Black well graded Silty fine SAND, some organic material, wet, loose.	10YR 2/1 Black well graded Silty fine SAND, some organic material, wet, loose.	10YR 2/1 Black well graded Silty fine SAND, some organic material, wet, loose.	10YR 2/1 Black well graded Silty fine SAND, some organic material, wet, loose.
0.5 – 1.5	10YR 5/4 Yellowish brown poorly graded fine SAND, wet, loose.	10YR 4/3 Brown well graded Silty fine SAND, wet, loose.	10YR 4/4 Dark yellowish brown well graded Gravelly Silty fine SAND, subangular, wet, loose.	10YR 4/4 Dark yellowish brown well graded Gravelly Silty fine SAND, subangular, wet, loose.

Table 5-3d
IA-6 Shallow Soil Sample Descriptions
PASI/SSI Comprehensive Report
Study Area - Grant, Locust, and Cavite Housing Areas
Devens, Massachusetts

SOUTHERN DEPRESSION

Location ID	IA06-SD05	IA06-SD06	IA06-SD07
Sample ID	LO-IA06-SD05-1	LO-IA06-SD06-1	LO-IA06-SD07-1
Date Collected	13-Apr-05	13-Apr-05	13-Apr-05
Depth Interval (ft bgs)			
0.0 - 0.2	10YR 2/1 Black well graded Silty fine SAND, some organic material, wet, loose.	10YR 2/1 Black well graded Silty fine SAND, some organic material, wet, loose.	10YR 2/1 Black well graded Silty fine SAND, some organic material, wet, loose.
0.2 - 0.6	10YR 4/4 Dark yellowish brown well graded Gravelly Silty fine SAND, subangular, wet, loose.		10YR 3/3 Dark brown well graded Gravelly Silty fine SAND, subangular, wet, loose.
0.6 - 1.5		10YR 4/6 Dark yellowish brown well graded Silty fine SAND, wet, loose.	

Table 5-3d
IA-6 Shallow Soil Sample Descriptions
PASI/SSI Comprehensive Report
Study Area - Grant, Locust, and Cavite Housing Areas
Devens, Massachusetts

NORTHERN DEPRESSION

Location ID	IA06-SD08	IA06-SD09	IA06-SD10	IA06-SD11	IA06-SD12
Sample ID	LO-IA06-SD08-1	LO-IA06-SD09-1	LO-IA06-SD10-1	LO-IA06-SD11-1	LO-IA06-SD12-1
Date Collected	13-Apr-05	13-Apr-05	13-Apr-05	13-Apr-05	13-Apr-05
Depth Interval (ft bgs)					
0.0 – 0.3	10YR 2/1 Black well graded Silty fine SAND, some organic material, wet, loose.	10YR 2/1 Black well graded Silty fine SAND, some organic material, wet, loose.	10YR 3/1 Very dark grey well graded Silty fine SAND, some organic material, wet, loose.	10YR 2/1 Black well graded Silty fine SAND, some organic material, moist, loose.	10YR 3/2 Very dark greyish brown well graded Silty fine SAND, some organic material, moist, loose.
0.3 – 0.4	10YR 4/3 Brown well graded Gravelly Silty fine SAND,subangular, wet, loose.	10YR 4/4 Dark yellowish brown well graded Gravelly Silty fine SAND, subangular, wet, loose.			
0.8 – 1.0					10YR 5/6 Dark brown well graded Silty fine SAND, moist, loose.
1.0 – 1.5			10YR 5/3 Brown poorly graded fine SAND, wet, cohesive.		

Table 5-3d
IA-6 Shallow Soil Sample Descriptions
PASI/SSI Comprehensive Report
Study Area - Grant, Locust, and Cavite Housing Areas
Devens, Massachusetts

NORTHERN DEPRESSION

Location ID	IA06-SD13	IA06-SD14	IA06-SD15	IA06-SD16	IA06-SD17
Sample ID	LO-IA06-SD13-1	LO-IA06-SD14-1	LO-IA06-SD15-1	LO-IA06-SD16-1	LO-IA06-SD17-1
Date Collected	13-Apr-05	13-Apr-05	13-Apr-05	13-Apr-05	13-Apr-05
Depth Interval (ft bgs)					
0.0 – 0.1	10YR 3/2 Very dark greyish brown well graded Silty fine SAND, some organic material, wet, loose.	10YR 2/1 Black well graded Silty fine SAND, some organic material, wet, loose.	10YR 2/1 Black well graded Silty fine SAND, some organic material, wet, loose.	10YR 3/2 Very dark greyish brown well graded Silty fine SAND, some organic material, moist, loose.	10YR 2/1 Black well graded Silty fine SAND, some organic material, wet, loose.
0.5 – 0.6			10YR 4/4 Dark yellowish brown poorly graded fine SAND, wet, loose.	10YR 5/4 Yellowish brown poorly graded fine SAND, moist, loose.	
0.7 – 0.8		10YR 4/4 Dark yellowish brown well graded Silty fine SAND, some organic material, wet, loose.			10YR 3/3 Dark brown well graded Silty fine SAND, moist, cohesive.
1.0 – 1.1	10YR 5/6 Yellowish brown well graded Silty fine SAND, moist, loose.				

Table 5-3d
IA-6 Shallow Soil Sample Descriptions
PASI/SSI Comprehensive Report
Study Area - Grant, Locust, and Cavite Housing Areas
Devens, Massachusetts

AIRBORNE DISPERSION

Location ID	IA06-SS41	IA06-SS42	IA06-SS43	IA06-SS44	IA06-SS45
Sample ID	LO-IA06-SS41-1	LO-IA06-SS41-1	LO-IA06-SS43-1	LO-IA06-SS43-1	LO-IA06-SS45-1
Date Collected	13-Apr-05	13-Apr-05	13-Apr-05	13-Apr-05	13-Apr-05
Depth Interval (ft bgs)					
0.0 - 0.2	10YR 2/2 Very dark brown well graded Silty fine SAND, some organic material, wet, loose.	10YR 3/1 Very dark gray well graded Silty fine SAND, some organic material, dry, loose.	10YR 2/1 Black well graded Silty fine SAND, some organic material, dry, loose.	10YR 2/2 Very dark brown well graded Silty fine SAND, some organic material, dry, loose.	10YR 2/1 Black well graded Silty fine SAND, some organic material, dry, loose.
0.3 - 0.4	10YR 5/6 Yellowish brown poorly graded fine to medium SAND, dry, loose.	10YR 4/6 Dark yellowish brown well graded Silty fine SAND, dry, loose.		10YR 4/4 Dark yellowish brown well graded Gravelly Silty fine to mediumf SAND, subangular, dry, loose.	
0.5 - 1.5			10YR 4/6 Dark yellowish brown well graded Gravelly Silty fine to medium SAND, subrounded, dry, loose.		10YR 4/6 Dark yellowish brown well graded Gravelly Silty fine to medium SAND, subrounded, dry, loose.

Table 5-3e

Shallow Soil Sample Lithology
Investigation Area 7

Location ID	IA7-SS01	IA7-SS02	IA7-SS03	IA7-SS04	IA7-SS05	IA7-SS06
Sample ID	GR-IA07-SS01-1/D	GR-IA07-SS02-1	GR-IA07-SS03-1	GR-IA07-SS04-1/D	GR-IA07-SS05-1	GR-IA07-SS06-1
Date Collected	4-Nov-04	4-Nov-04	4-Nov-04	4-Nov-04	4-Nov-04	4-Nov-04
Depth Interval (ft bgs)						
0.0 – 0.5	10 YR 4/5 moderate brown fine SAND, little Silt, trace fine Gravel.	10 YR 4/5 Moderate Brown fine SAND, little silt, trace fine Gravel, moist, loose	10 YR 3/1 Dark fine SAND, little fine- medium Gravel, subrounded, trace Silt, moist, loose.	10 YR 2/1 Brownish black SILT, trace fine Sand, with organic matter, moist, loose.	10YR 3/2 Dark brown fine SAND, some Silt, trace fine - medium angular Gravel, moist, loose.	5 YR 3/2 Dark olive brown organic matter, trace fine Sand, trace Silt, moist, loose.
0.5 – 1.5	2.5 YR 4/3 Dark Yellow Brown fine-coarse SAND, little fine-medium angular gravel, moist, loose.	2.5 YR 4/3 Dark yellow brown fine- coarse SAND, little fine- medium angular Gravel, moist, loose.		10Y 6/2 Brown fine to coarse SAND, trace fine - medium rounded Gravel, moist, loose.		2.5 YR 3/2 Dark olive brownfine to coarse SAND, trace fine-medium subrounded Gravel, moist, loose.

Supplemental Site Investigation

Analytic Method: 8260B
Sample Matrix: Water
Reporting Units: mg/l
Sample Dates: 28-Dec-2004 to 29-Dec-2004

	Date	Sample ID	Depth	Method	Dilution	1,1,1,2-Tetrachloroethane	1,1,1-Trichloroethane	1,1,2,2-Tetrachloroethane	1,1,2-Trichloroethane	1,1-Dichloroethane	1,1-Dichloroethene	1,1-Dichloropropene	1,2,3-Trichlorobenzene	1,2,3-Trichloropropane	1,2,4-Trichlorobenzene	1,2,4-Trimethylbenzene	1,2-Dibromo-3-chloropropane	1,2-Dichlorobenzene	1,2-Dichloroethane	1,2-Dichloropropane	1,3,5-Trimethylbenzene	1,3-Dichlorobenzene	1,3-Dichloropropane	1,4-Dichlorobenzene	1,4-Dioxane	2,2-Dichloropropane	2-Butanone	2-Chlorotoluene
SSI Project Action Limit (PAL) - Wave 2 (VOCs)						50	20	0.004	0.016	20	7.1	NC	NC	NC	50	NC	NC	NC	0.037	0.015	NC	0.47	0.021	NC	NC	NC	NC	NC
Secondary Regulatory Criteria Not Selected																												
MW-01S	28-Dec-04	GR-MW-01S-1	--	8260B	1	0.0005 u	0.0005 u	0.0005 u	0.00075 u	0.00075 u	0.0005 u	0.0025 u	0.0025 u	0.005 u	0.0025 u	0.0025 u	0.0025 u	0.0025 u	0.0005 u	0.0018 u	0.0025 u	0.0025 u	0.0025 u	0.0025 u	0.25 u	0.0025 u	0.005 u	0.0025 u
	28-Dec-04	GR-MW-01S-1-D	--	8260B	1	0.0005 u	0.0005 u	0.0005 u	0.00075 u	0.00075 u	0.0005 u	0.0025 u	0.0025 u	0.005 u	0.0025 u	0.0025 u	0.0025 u	0.0025 u	0.0005 u	0.0018 u	0.0025 u	0.0025 u	0.0025 u	0.0025 u	0.0025 u	0.25 u	0.0025 u	0.005 u	0.0025 u
MW-02S	29-Dec-04	GR-MW-02S-1	--	8260B	1	0.0005 u	0.0005 u	0.0005 u	0.00075 u	0.00075 u	0.0005 u	0.0025 u	0.0025 u	0.005 u	0.0025 u	0.0025 u	0.0025 u	0.0025 u	0.0005 u	0.0018 u	0.0025 u	0.0025 u	0.0025 u	0.0025 u	0.25 u	0.0025 u	0.005 u	0.0025 u
MW-03S	28-Dec-04	GR-MW-03S-1	--	8260B	1	0.0005 u	0.0005 u	0.0005 u	0.00075 u	0.00075 u	0.0005 u	0.0025 u	0.0025 u	0.005 u	0.0025 u	0.0025 u	0.0025 u	0.0025 u	0.0005 u	0.0018 u	0.0025 u	0.0025 u	0.0025 u	0.0025 u	0.25 u	0.0025 u	0.005 u	0.0025 u
PZ-04S	29-Dec-04	GR-PZ-04S-1-M	--	8260B	1	0.0005 u	0.0005 u	0.0005 u	0.00075 u	0.00075 u	0.0005 u	0.0025 u	0.0025 u	0.005 u	0.0025 u	0.0025 u	0.0025 u	0.0025 u	0.0005 u	0.0018 u	0.0025 u	0.0025 u	0.0025 u	0.0025 u	0.25 u	0.0025 u	0.005 u	0.0025 u

Location

Notes:

NC No criteria listed under the regulation cited
ND Non-detect result (Original data unavailable - neither value nor detection limit provided)
- Parameter not analyzed

Analytic Flags:

u Not detected above laboratory reporting limits
j Estimated value - parameter detected between laboratory reporting limit and half of the laboratory reporting limit.
e Value exceeds analytical calibration limits
b Parameter detected in quality control blank and sample

Highlighting:

Value or Detection Limit exceeds Criteria 1 only
Value or Detection Limit exceeds Criteria 2 only
Value or Detection Limit exceeds both criteria

SSI Summary of Volatile Organic Compounds Groundwater Analytical Results

Table 5-4a

Supplemental Site Investigation

Analytic Method: 8260B
Sample Matrix: Water
Reporting Units: mg/l
Sample Dates: 28-Dec-2004 to 29-Dec-2004

						2-Hexanone	4-Chlorotoluene	4-Methyl-2-pentanone	Acetone	Benzene	Bromobenzene	Bromochloromethane	Bromodichloromethane	Bromoform	Bromomethane	Carbon Disulfide	Carbon Tetrachloride	Chlorobenzene	Chloroethane	Chloroform	Chloromethane	cis-1,2-Dichloroethene	cis-1,3-Dichloropropene	Dibromochloromethane	Dibromomethane	Dichlorodifluoromethane	Ethyl ether	Ethylbenzene
	SSI Project Action Limit (PAL) - Wave 2 (VOCs)					NC	NC	50	50	0.051	NC	NC	0.017	0.14	50	NC	0.0016	1	NC	0.47	NC	50	2	0.013	NC	NC	NC	2.1
	Secondary Regulatory Criteria Not Selected																											
	Date	Sample ID	Depth	Method	Dilution																							
MW-01S	28-Dec-04	GR-MW-01S-1	--	8260B	1	0.005 u	0.0025 u	0.005 u	0.005 u	0.0005 u	0.0025 u	0.0025 u	0.0005 u	0.002 u	0.001 u	0.005 u	0.0005 u	0.0005 u	0.001 u	0.00075 u	0.0025 u	0.0005 u	0.0005 u	0.0005 u	0.005 u	0.005 u	0.0025 u	0.0005 u
	28-Dec-04	GR-MW-01S-1-D	--	8260B	1	0.005 u	0.0025 u	0.005 u	0.005 u	0.0005 u	0.0025 u	0.0025 u	0.0005 u	0.002 u	0.001 u	0.005 u	0.0005 u	0.0005 u	0.001 u	0.00075 u	0.0025 u	0.0005 u	0.0005 u	0.0005 u	0.005 u	0.005 u	0.0025 u	0.0005 u
MW-02S	29-Dec-04	GR-MW-02S-1	--	8260B	1	0.005 u	0.0025 u	0.005 u	0.005 u	0.0005 u	0.0025 u	0.0025 u	0.0005 u	0.002 u	0.001 u	0.005 u	0.0005 u	0.0005 u	0.001 u	0.00075 u	0.0025 u	0.0005 u	0.0005 u	0.0005 u	0.005 u	0.005 u	0.0025 u	0.0005 u
MW-03S	28-Dec-04	GR-MW-03S-1	--	8260B	1	0.005 u	0.0025 u	0.005 u	0.005 u	0.0005 u	0.0025 u	0.0025 u	0.0005 u	0.002 u	0.001 u	0.005 u	0.0005 u	0.0005 u	0.001 u	0.00075 u	0.0025 u	0.0005 u	0.0005 u	0.0005 u	0.005 u	0.005 u	0.0025 u	0.0005 u
PZ-04S	29-Dec-04	GR-PZ-04S-1-M	--	8260B	1	0.005 u	0.0025 u	0.005 u	0.005 u	0.0005 u	0.0025 u	0.0025 u	0.0005 u	0.002 u	0.001 u	0.005 u	0.0005 u	0.0005 u	0.001 u	0.00075 u	0.0025 u	0.0005 u	0.0005 u	0.0005 u	0.005 u	0.005 u	0.0025 u	0.0005 u

Location

Notes:

- **NC** No criteria listed under the regulation cited
- **ND** Non-detect result (Original data unavailable - neither value nor detection limit provided)
- **-** Parameter not analyzed

Analytic Flags:

- **u** Not detected above laboratory reporting limits
- **j** Estimated value - parameter detected between laboratory reporting limit and half of the laboratory reporting limit.
- **e** Value exceeds analytical calibration limits
- **b** Parameter detected in quality control blank and sample

Highlighting:

- Value or Detection Limit exceeds Criteria 1 only
- Value or Detection Limit exceeds Criteria 2 only
- Value or Detection Limit exceeds both criteria

SSI Summary of Volatile Organic Compounds Groundwater Analytical Results

Table 5-4a

Supplemental Site Investigation

Analytic Method: 8260B
Sample Matrix: Water
Reporting Units: mg/l
Sample Dates: 28-Dec-2004 to 29-Dec-2004

						Ethylene Dibromide	Ethyl-Tert-Butyl-Ether	Hexachlorobutadiene	Isopropyl Ether	Isopropylbenzene	m,p-Xylenes	Methyl tert-butyl ether	Methylene Chloride	Naphthalene	n-Butylbenzene	n-Propylbenzene	o-Xylene	p-Isopropyltoluene	sec-Butylbenzene	Styrene	Tert-Amyl Methyl Ether	tert-Butylbenzene	Tetrachloroethene	Tetrahydrofuran	Toluene	trans-1,2-dichloroethene	trans-1,3-dichloropropene	Trichloroethene
SSI Project Action Limit (PAL) - Wave 2 (VOCs)						50	NC	3	NC	NC	NC	50	0.59	20	NC	NC	0.05	NC	NC	6	NC	NC	0.0033	NC	4	10	2	0.03
Secondary Regulatory Criteria Not Selected																												
	Date	Sample ID	Depth	Method	Dilution																							
MW-01S	28-Dec-04	GR-MW-01S-1	--	8260B	1	0.002 u	0.002 u	0.001 u	0.002 u	0.0005 u	0.0005 u	0.001 u	0.005 u	0.0025 u	0.0005 u	0.0005 u	0.0005 u	0.0005 u	0.0005 u	0.0005 u	0.002 u	0.0025 u	0.0005 u	0.01 u	0.00075 u	0.00075 u	0.0005 u	0.0005 u
	28-Dec-04	GR-MW-01S-1-D	--	8260B	1	0.002 u	0.002 u	0.001 u	0.002 u	0.0005 u	0.0005 u	0.001 u	0.005 u	0.0025 u	0.0005 u	0.0005 u	0.0005 u	0.0005 u	0.0005 u	0.0005 u	0.002 u	0.0025 u	0.0005 u	0.01 u	0.00075 u	0.00075 u	0.0005 u	0.0005 u
MW-02S	29-Dec-04	GR-MW-02S-1	--	8260B	1	0.002 u	0.002 u	0.001 u	0.002 u	0.0005 u	0.0005 u	0.001 u	0.005 u	0.0025 u	0.0005 u	0.0005 u	0.0005 u	0.0005 u	0.0005 u	0.0005 u	0.002 u	0.0025 u	0.0005 u	0.01 u	0.0014	0.00075 u	0.0005 u	0.0005 u
MW-03S	28-Dec-04	GR-MW-03S-1	--	8260B	1	0.002 u	0.002 u	0.001 u	0.002 u	0.0005 u	0.0005 u	0.001 u	0.005 u	0.0025 u	0.0005 u	0.0005 u	0.0005 u	0.0005 u	0.0005 u	0.0005 u	0.002 u	0.0025 u	0.0005 u	0.01 u	0.00075 u	0.00075 u	0.0005 u	0.0005 u
PZ-04S	29-Dec-04	GR-PZ-04S-1-M	--	8260B	1	0.002 u	0.002 u	0.001 u	0.002 u	0.0005 u	0.0005 u	0.001 u	0.005 u	0.0025 u	0.0005 u	0.0005 u	0.0005 u	0.0005 u	0.0005 u	0.0005 u	0.002 u	0.0025 u	0.0005 u	0.01 u	0.00075 u	0.00075 u	0.0005 u	0.0005 u

Location

Notes:

NC No criteria listed under the regulation cited
ND Non-detect result (Original data unavailable - neither value nor detection limit provided)
- Parameter not analyzed

Analytic Flags:

u Not detected above laboratory reporting limits
j Estimated value - parameter detected between laboratory reporting limit and half of the laboratory reporting limit.
e Value exceeds analytical calibration limits
b Parameter detected in quality control blank and sample

Highlighting:

Value or Detection Limit exceeds Criteria 1 only
Value or Detection Limit exceeds Criteria 2 only
Value or Detection Limit exceeds both criteria

Supplemental Site Investigation

Analytic Method: 8260B
Sample Matrix: Water
Reporting Units: mg/l
Sample Dates: 28-Dec-2004 to 29-Dec-2004

						Trichlorofluoromethane	Vinyl Chloride
SSI Project Action Limit (PAL) - Wave 2 (VOCs)						NC	0.0024
Secondary Regulatory Criteria Not Selected							
	Date	Sample ID	Depth	Method	Dilution		
MW-01S	28-Dec-04	GR-MW-01S-1	--	8260B	1	0.0025 u	0.001 u
	28-Dec-04	GR-MW-01S-1-D	--	8260B	1	0.0025 u	0.001 u
MW-02S	29-Dec-04	GR-MW-02S-1	--	8260B	1	0.0025 u	0.001 u
MW-03S	28-Dec-04	GR-MW-03S-1	--	8260B	1	0.0025 u	0.001 u
PZ-04S	29-Dec-04	GR-PZ-04S-1-M	--	8260B	1	0.0025 u	0.001 u

Location

Notes:

NC No criteria listed under the regulation cited
ND Non-detect result (Original data unavailable - neither value nor detection limit provided)
- Parameter not analyzed

Analytic Flags:

u Not detected above laboratory reporting limits
j Estimated value - parameter detected between laboratory reporting limit and half of the laboratory reporting limit.
e Value exceeds analytical calibration limits
b Parameter detected in quality control blank and sample

Highlighting:

Value or Detection Limit exceeds Criteria 1 only
Value or Detection Limit exceeds Criteria 2 only
Value or Detection Limit exceeds both criteria

Supplemental Site Investigation

Analytic Method: 8270C and 8270C-SIM
Sample Matrix: Water
Reporting Units: mg/l
Sample Dates: 28-Dec-2004 to 29-Dec-2004

						1,2,4-Trichlorobenzene	1,2-Dichlorobenzene	1,3-Dichlorobenzene	1,4-Dichlorobenzene	2,4,5-Trichlorophenol	2,4,6-Trichlorophenol	2,4-Dichlorophenol	2,4-Dimethylphenol	2,4-Dinitrophenol	2,4-Dinitrotoluene	2,6-Dinitrotoluene	2-Chloronaphthalene	2-Chlorophenol	2-Methylnaphthalene	2-methylphenol	2-Nitrophenol	3 & 4-Methylphenol	3,3-Dichlorobenzidine	4-Bromophenyl phenyl ether	4-Chloroaniline	4-Nitrophenol	Acenaphthene	Acenaphthylene
	SSI Project Action Limit (PAL) - Wave 2 (SVOCs)					0.07	1.3	0.96	0.19	3	0.0024	0.29	0.85	5.3	0.0034	NC	1.6	40	3	NC	NC	NC	0.000028	NC	0.3	NC	0.99	3
	Secondary Regulatory Criteria Not Selected																											
	Date	Sample ID	Depth	Method	Dilution																							
MW-01S	28-Dec-04	GR-MW-01S-1	--	8270C	1	0.005 u	0.005 u	0.005 u	0.005 u	0.005 u	**0.005 u**	0.01 u	0.01 u	0.02 u	**0.006 u**	0.005 u	0.006 u	0.006 u	0.008 u	0.006 u	0.02 u	0.006 u	**0.05 u**	0.005 u	0.005 u	0.01 u	0.005 u	0.005 u
	28-Dec-04	GR-MW-01S-1	--	8270C-SIM	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	28-Dec-04	GR-MW-01S-1-D	--	8270C	1	0.005 u	0.005 u	0.005 u	0.005 u	0.005 u	**0.005 u**	0.01 u	0.01 u	0.02 u	**0.006 u**	0.005 u	0.006 u	0.006 u	0.008 u	0.006 u	0.02 u	0.006 u	**0.05 u**	0.005 u	0.005 u	0.01 u	0.005 u	0.005 u
	28-Dec-04	GR-MW-01S-1-D	--	8270C-SIM	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
MW-02S	29-Dec-04	GR-MW-02S-1	--	8270C	1	0.0049 u	0.0049 u	0.0049 u	0.0049 u	0.0049 u	**0.0049 u**	0.0099 u	0.0099 u	0.02 u	**0.0059 u**	0.0049 u	0.0059 u	0.0059 u	0.0079 u	0.0059 u	0.02 u	0.0059 u	**0.049 u**	0.0049 u	0.0049 u	0.0099 u	0.0049 u	0.0049 u
	29-Dec-04	GR-MW-02S-1	--	8270C-SIM	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
MW-03S	28-Dec-04	GR-MW-03S-1	--	8270C	1	0.005 u	0.005 u	0.005 u	0.005 u	0.005 u	**0.005 u**	0.01 u	0.01 u	0.02 u	**0.006 u**	0.005 u	0.006 u	0.006 u	0.008 u	0.006 u	0.02 u	0.006 u	**0.05 u**	0.005 u	0.005 u	0.01 u	0.005 u	0.005 u
	28-Dec-04	GR-MW-03S-1	--	8270C-SIM	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
PZ-04S	29-Dec-04	GR-PZ-04S-1-M	--	8270C	1	0.005 u	0.005 u	0.005 u	0.005 u	0.005 u	**0.005 u**	0.01 u	0.01 u	0.02 u	**0.006 u**	0.005 u	0.006 u	0.006 u	0.008 u	0.006 u	0.02 u	0.006 u	**0.05 u**	0.005 u	0.005 u	0.01 u	0.005 u	0.005 u
	29-Dec-04	GR-PZ-04S-1-M	--	8270C-SIM	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

Location

Notes:

NC No criteria listed under the regulation cited
ND Non-detect result (Original data unavailable - neither value nor detection limit provided)
- Parameter not analyzed

Analytic Flags:

u Not detected above laboratory reporting limits
j Estimated value - parameter detected between laboratory reporting limit and half of the laboratory reporting limit.
e Value exceeds analytical calibration limits
b Parameter detected in quality control blank and sample

Highlighting:

Value or Detection Limit exceeds Criteria 1 only
Value or Detection Limit exceeds Criteria 2 only
Value or Detection Limit exceeds both criteria

SSI - Summary of Semi-Volatile Organic Compounds Groundwater Analytical Results

Table 5-4b

Supplemental Site Investigation

Analytic Method: 8270C and 8270C-SIM
Sample Matrix: Water
Reporting Units: mg/l
Sample Dates: 28-Dec-2004 to 29-Dec-2004

						Acetophenone	Aniline (Phenylamine, aminobenzene)	Anthracene	Azobenzene	Benzo(a)anthracene	Benzo(a)pyrene	Benzo(b)fluoranthene	Benzo(g,h,i)perylene	Benzo(k)fluoranthene	Benzyl Butyl Phthalate	bis(2-chloroethoxy) methane	bis(2-chloroethyl) ether	Bis(2-chloroisopropyl)ether	bis(2-ethylhexyl) phthalate	Chrysene	Dibenz(a,h)Anthracene	Dibenzofuran	Diethyl Phthalate	Dimethyl Phthalate	di-n-Butyl Phthalate	di-n-Octyl Phthalate	Fluoranthene	Fluorene
	SSI Project Action Limit (PAL) - Wave 2 (SVOCs)					NC	NC	3	NC	0.000018	0.000018	0.000018	3	0.000018	1.9	NC	0.00053	50	0.0022	0.000018	0.000018	NC	9	50	4.5	NC	0.14	3
	Secondary Regulatory Criteria Not Selected																											
	Date	Sample ID	Depth	Method	Dilution																							
MW-01S	28-Dec-04	GR-MW-01S-1	--	8270C	1	0.02 u	0.01 u	0.005 u	0.005 u	**0.005 u**	**0.005 u**	**0.005 u**	0.005 u	**0.005 u**	0.005 u	0.005 u	**0.005 u**	0.005 u	**0.01 u**	**0.005 u**	**0.005 u**	0.005 u	0.005 u	0.005 u	0.005 u	0.005 u	0.005 u	0.005 u
	28-Dec-04	GR-MW-01S-1	--	8270C-SIM	1	-	-	-	-	**0.0002 u**	**0.0002 u**	**0.0002 u**	-	**0.0002 u**	-	-	-	-	-	**0.0002 u**	**0.0002 u**	-	-	-	-	-	-	-
	28-Dec-04	GR-MW-01S-1-D	--	8270C	1	0.02 u	0.01 u	0.005 u	0.005 u	**0.005 u**	**0.005 u**	**0.005 u**	0.005 u	**0.005 u**	0.005 u	0.005 u	**0.005 u**	0.005 u	**0.01 u**	**0.005 u**	**0.005 u**	0.005 u	0.005 u	0.005 u	0.005 u	0.005 u	0.005 u	0.005 u
	28-Dec-04	GR-MW-01S-1-D	--	8270C-SIM	1	-	-	-	-	**0.0002 u**	**0.0002 u**	**0.0002 u**	-	**0.0002 u**	-	-	-	-	-	**0.0002 u**	**0.0002 u**	-	-	-	-	-	-	-
MW-02S	29-Dec-04	GR-MW-02S-1	--	8270C	1	0.02 u	0.0099 u	0.0049 u	0.0049 u	**0.0049 u**	**0.0049 u**	**0.0049 u**	0.0049 u	**0.0049 u**	0.0049 u	0.0049 u	**0.0049 u**	0.0049 u	**0.0099 u**	**0.0049 u**	**0.0049 u**	0.0049 u	0.0049 u	0.0049 u	0.0049 u	0.0049 u	0.0049 u	0.0049 u
	29-Dec-04	GR-MW-02S-1	--	8270C-SIM	1	-	-	-	-	**0.0002 u**	**0.0002 u**	**0.0002 u**	-	**0.0002 u**	-	-	-	-	-	**0.0002 u**	**0.0002 u**	-	-	-	-	-	-	-
MW-03S	28-Dec-04	GR-MW-03S-1	--	8270C	1	0.02 u	0.01 u	0.005 u	0.005 u	**0.005 u**	**0.005 u**	**0.005 u**	0.005 u	**0.005 u**	0.005 u	0.005 u	**0.005 u**	0.005 u	**0.01 u**	**0.005 u**	**0.005 u**	0.005 u	0.005 u	0.005 u	0.005 u	0.005 u	0.005 u	0.005 u
	28-Dec-04	GR-MW-03S-1	--	8270C-SIM	1	-	-	-	-	**0.0002 u**	**0.0002 u**	**0.0002 u**	-	**0.0002 u**	-	-	-	-	-	**0.0002 u**	**0.0002 u**	-	-	-	-	-	-	-
PZ-04S	29-Dec-04	GR-PZ-04S-1-M	--	8270C	1	0.02 u	0.01 u	0.005 u	0.005 u	**0.005 u**	**0.005 u**	**0.005 u**	0.005 u	**0.005 u**	0.005 u	0.005 u	**0.005 u**	0.005 u	**0.01 u**	**0.005 u**	**0.005 u**	0.005 u	0.005 u	0.005 u	0.005 u	0.005 u	0.005 u	0.005 u
	29-Dec-04	GR-PZ-04S-1-M	--	8270C-SIM	1	-	-	-	-	**0.0002 u**	**0.0002 u**	**0.0002 u**	-	**0.0002 u**	-	-	-	-	-	**0.0002 u**	**0.0002 u**	-	-	-	-	-	-	-

Location

Notes:

- **NC** No criteria listed under the regulation cited
- **ND** Non-detect result (Original data unavailable - neither value nor detection limit provided)
- **-** Parameter not analyzed

Analytic Flags:

- **u** Not detected above laboratory reporting limits
- **j** Estimated value - parameter detected between laboratory reporting limit and half of the laboratory reporting limit.
- **e** Value exceeds analytical calibration limits
- **b** Parameter detected in quality control blank and sample

Highlighting:

- Value or Detection Limit exceeds Criteria 1 only
- Value or Detection Limit exceeds Criteria 2 only
- Value or Detection Limit exceeds both criteria

Supplemental Site Investigation

Analytic Method: 8270C and 8270C-SIM
Sample Matrix: Water
Reporting Units: mg/l
Sample Dates: 28-Dec-2004 to 29-Dec-2004

						Hexachlorobenzene	Hexachlorobutadiene	Hexachloroethane	Indeno(1,2,3-c,d)Pyrene	Isophorone	Naphthalene	Nitrobenzene	Pentachlorophenol	Phenanthrene	Phenol	Pyrene
SSI Project Action Limit (PAL) - Wave 2 (SVOCs)						2.9E-07	0.018	0.0033	0.000018	0.96	20	0.69	0.003	0.05	2	0.02
Secondary Regulatory Criteria Not Selected																
	Date	Sample ID	Depth	Method	Dilution											
MW-01S	28-Dec-04	GR-MW-01S-1	--	8270C	1	**0.005 u**	0.01 u	**0.005 u**	**0.007 u**	0.005 u	0.005 u	0.005 u	**0.02 u**	0.005 u	0.007 u	0.005 u
	28-Dec-04	GR-MW-01S-1	--	8270C-SIM	1	**0.0008 u**	0.0005 u	-	**0.0002 u**	-	-	-	0.0008 u	-	-	-
	28-Dec-04	GR-MW-01S-1-D	--	8270C	1	**0.005 u**	0.01 u	**0.005 u**	**0.007 u**	0.005 u	0.005 u	0.005 u	**0.02 u**	0.005 u	0.007 u	0.005 u
	28-Dec-04	GR-MW-01S-1-D	--	8270C-SIM	1	**0.0008 u**	0.0005 u	-	**0.0002 u**	-	-	-	0.0008 u	-	-	-
MW-02S	29-Dec-04	GR-MW-02S-1	--	8270C	1	**0.0049 u**	0.0099 u	**0.0049 u**	**0.0069 u**	0.0049 u	0.0049 u	0.0049 u	**0.02 u**	0.0049 u	0.0069 u	0.0049 u
	29-Dec-04	GR-MW-02S-1	--	8270C-SIM	1	**0.00079 u**	0.00049 u	-	**0.0002 u**	-	-	-	0.00079 u	-	-	-
MW-03S	28-Dec-04	GR-MW-03S-1	--	8270C	1	**0.005 u**	0.01 u	**0.005 u**	**0.007 u**	0.005 u	0.005 u	0.005 u	**0.02 u**	0.005 u	0.007 u	0.005 u
	28-Dec-04	GR-MW-03S-1	--	8270C-SIM	1	**0.0008 u**	0.0005 u	-	**0.0002 u**	-	-	-	0.0008 u	-	-	-
PZ-04S	29-Dec-04	GR-PZ-04S-1-M	--	8270C	1	**0.005 u**	0.01 u	**0.005 u**	**0.007 u**	0.005 u	0.005 u	0.005 u	**0.02 u**	0.005 u	0.007 u	0.005 u
	29-Dec-04	GR-PZ-04S-1-M	--	8270C-SIM	1	**0.0008 u**	0.0005 u	-	**0.0002 u**	-	-	-	0.0008 u	-	-	-

Location

Notes:

NC No criteria listed under the regulation cited
ND Non-detect result (Original data unavailable - neither value nor detection limit provided)
- Parameter not analyzed

Analytic Flags:

u Not detected above laboratory reporting limits
j Estimated value - parameter detected between laboratory reporting limit and half of the laboratory reporting limit.
e Value exceeds analytical calibration limits
b Parameter detected in quality control blank and sample

Highlighting:

Value or Detection Limit exceeds Criteria 1 only
Value or Detection Limit exceeds Criteria 2 only
Value or Detection Limit exceeds both criteria

Supplemental Site Investigation

Analytic Method: EPH-04-1
Sample Matrix: Water
Reporting Units: mg/l
Sample Dates: 28-Dec-2004 to 29-Dec-2004

						2-Methylnaphthalene	Acenaphthene	Acenaphthylene	Aliphatic Hydrocarbons (C19-C36)	Aliphatic Hydrocarbons (C9-C18)	Anthracene	Aromatic Hydrocarbons (C11-C22)	Aromatic Hydrocarbons (C11-C22), Unadjusted	Benzo(a)anthracene	Benzo(a)pyrene	Benzo(b)fluoranthene	Benzo(g,h,i)perylene	Benzo(k)fluoranthene	Chrysene	Dibenz(a,h)Anthracene	Fluoranthene	Fluorene	Indeno(1,2,3-c,d)Pyrene	Naphthalene	Phenanthrene	Pyrene
SSI Project Action Limit (PAL) - Wave 2 (EPH)						3	5	3	20	20	NC	30	NC	0.037	NC	NC	3	NC	NC	NC	0.03	0.016	0.1	20	0.05	NC
Secondary Regulatory Criteria Not Selected																										
	Date	Sample ID	Depth	Method	Dilution																					
MW-01S	28-Dec-04	GR-MW-01S-1	--	EPH-04-1	1	0.0004 u	0.0004 u	0.0004 u	0.1 u	0.1 u	0.0004 u	0.1 u	0.1 u	0.0004 u	0.0002 u	0.0004 u	0.0004 u	0.0004 u	0.0004 u	0.0004 u	0.0004 u	0.0004 u	0.0004 u	0.0004 u	0.0004 u	0.0004 u	0.0004 u
	28-Dec-04	GR-MW-01S-1-D	--	EPH-04-1	1	0.0004 u	0.0004 u	0.0004 u	0.1 u	0.1 u	0.0004 u	0.1 u	0.1 u	0.0004 u	0.0002 u	0.0004 u	0.0004 u	0.0004 u	0.0004 u	0.0004 u	0.0004 u	0.0004 u	0.0004 u	0.0004 u	0.0004 u	0.0004 u	0.0004 u
MW-02S	29-Dec-04	GR-MW-02S-1	--	EPH-04-1	1	0.00044 u	0.00044 u	0.00044 u	0.111 u	0.111 u	0.00044 u	0.111 u	0.111 u	0.00044 u	0.00022 u	0.00044 u	0.00044 u	0.00044 u	0.00044 u	0.00044 u	0.00044 u	0.00044 u	0.00044 u	0.00044 u	0.00044 u	0.00044 u	0.00044 u
MW-03S	28-Dec-04	GR-MW-03S-1	--	EPH-04-1	1	0.0004 u	0.0004 u	0.0004 u	0.1 u	0.1 u	0.0004 u	0.1 u	0.1 u	0.0004 u	0.0002 u	0.0004 u	0.0004 u	0.0004 u	0.0004 u	0.0004 u	0.0004 u	0.0004 u	0.0004 u	0.0004 u	0.0004 u	0.0004 u	0.0004 u
PZ-04S	29-Dec-04	GR-PZ-04S-1-M	--	EPH-04-1	1	0.0004 u	0.0004 u	0.0004 u	0.1 u	0.1 u	0.0004 u	0.1 u	0.1 u	0.0004 u	0.0002 u	0.0004 u	0.0004 u	0.0004 u	0.0004 u	0.0004 u	0.0004 u	0.0004 u	0.0004 u	0.0004 u	0.0004 u	0.0004 u	0.0004 u

Location

Notes:

- **NC** No criteria listed under the regulation cited
- **ND** Non-detect result (Original data unavailable - neither value nor detection limit provided)
- **-** Parameter not analyzed

Analytic Flags:

- **u** Not detected above laboratory reporting limits
- **j** Estimated value - parameter detected between laboratory reporting limit and half of the laboratory reporting limit.
- **e** Value exceeds analytical calibration limits
- **b** Parameter detected in quality control blank and sample

Highlighting:

- Value or Detection Limit exceeds Criteria 1 only
- Value or Detection Limit exceeds Criteria 2 only
- Value or Detection Limit exceeds both criteria

Table 5-4d
Summary of Polychlorinated Biphenyls
Groundwater Analytical Results

Supplemental Site Investigation

Analytic Method: 8082
Sample Matrix: Water
Reporting Units: mg/l
Sample Dates: 28-Dec-2004 to 29-Dec-2004

	Arochlor 1221	Arochlor 1232	Arochlor 1242/1016	Arochlor 1248	Arochlor 1254	Arochlor 1260	Arochlor 1262	Arochlor 1268
SSI Project Action Limit (PAL) - Wave 2 (PCBs)	0.0003	0.0003	NC	0.0003	0.0003	0.0003	0.0003	0.0003
Secondary Regulatory Criteria Not Selected								

Location	Date	Sample ID	Depth	Method	DF							
MW-01S	28-Dec-04	GR-MW-01S-1	--	8082	1	0.00025 u	0.00025 u	0.00025 u	0.00025 u	0.00025 u	0.00025 u	0.00025 u	0.00025 u
	28-Dec-04	GR-MW-01S-1-D	--	8082	1	0.00025 u	0.00025 u	0.00025 u	0.00025 u	0.00025 u	0.00025 u	0.00025 u	0.00025 u
MW-02S	29-Dec-04	GR-MW-02S-1	--	8082	1	0.00025 u	0.00025 u	0.00025 u	0.00025 u	0.00025 u	0.00025 u	0.00025 u	0.00025 u
MW-03S	28-Dec-04	GR-MW-03S-1	--	8082	1	0.00025 u	0.00025 u	0.00025 u	0.00025 u	0.00025 u	0.00025 u	0.00025 u	0.00025 u
PZ-04S	29-Dec-04	GR-PZ-04S-1-M	--	8082	1	0.00025 u	0.00025 u	0.00025 u	0.00025 u	0.00025 u	0.00025 u	0.00025 u	0.00025 u

Notes:

- **NC** No criteria listed under the regulation cited
- **ND** Non-detect result (Original data unavailabl)
- **-** Parameter not analyzed

Analytic Flags:

- **u** Not detected above laboratory detection limits
- **j** Estimated value - parameter not detected above laboratory quantitation limits
- **e** Value exceeds analytical calibration limits
- **b** Parameter detected in quality control blank and sample

Highlighting:

- Value or Detection Limit exceeds Criteria 1 only
- Value or Detection Limit exceeds Criteria 2 only
- Value or Detection Limit exceeds both criteria

SSI - Summary of Pesticides Groundwater Analytical Results

Table 5-4e

Supplemental Site Investigation

Analytic Method: 8081A
Sample Matrix: Water
Reporting Units: mg/l
Sample Dates: 28-Dec-2004 to 29-Dec-2004

						4,4-DDD	4,4-DDE	4,4-DDT	Aldrin	Alpha-BHC	Beta-BHC	Chlordane	Delta-BHC	Dieldrin	Endosulfan I	Endosulfan II	Endosulfan Sulfate	Endrin	Endrin Ketone	Gamma-BHC (Lindane)	Heptachlor	Heptachlor Epoxide	Hexachlorobenzene	Methoxychlor
SSI Project Action Limit (PAL) - Wave 2 (Pesticides)						3.1E-07	2.2E-07	2.2E-07	5E-08	4.9E-06	0.000017	8.1E-07	NC	5.4E-08	0.002	0.002	0.089	0.00006	NC	0.0018	7.9E-08	3.9E-08	6	0.01
Secondary Regulatory Criteria Not Selected																								
	Date	Sample ID	Depth	Method	Dilution																			
MW-01S	28-Dec-04	GR-MW-01S-1	--	8081A	1	**0.00004 u**	**0.00004 u**	**0.00004 u**	**0.00002 u**	**0.00002 u**	**0.00002 u**	**0.0002 u**	0.00002 u	**0.00004 u**	0.00002 u	0.00004 u	0.00004 u	0.00004 u	0.00004 u	0.00002 u	**0.00002 u**	**0.00002 u**	0.0002 u	0.0002 u
	28-Dec-04	GR-MW-01S-1-D	--	8081A	1	**0.00004 u**	**0.00004 u**	**0.00004 u**	**0.00002 u**	**0.00002 u**	**0.00002 u**	**0.0002 u**	0.00002 u	**0.00004 u**	0.00002 u	0.00004 u	0.00004 u	0.00004 u	0.00004 u	0.00002 u	**0.00002 u**	**0.00002 u**	0.0002 u	0.0002 u
MW-02S	29-Dec-04	GR-MW-02S-1	--	8081A	1	**0.00004 u**	**0.00004 u**	**0.00004 u**	**0.00002 u**	**0.00002 u**	**0.00002 u**	**0.0002 u**	0.00002 u	**0.00004 u**	0.00002 u	0.00004 u	0.00004 u	0.00004 u	0.00004 u	0.00002 u	**0.00002 u**	**0.00002 u**	0.0002 u	0.0002 u
MW-03S	28-Dec-04	GR-MW-03S-1	--	8081A	1	**0.00004 u**	**0.00004 u**	**0.00004 u**	**0.00002 u**	**0.00002 u**	**0.00002 u**	**0.0002 u**	0.00002 u	**0.00004 u**	0.00002 u	0.00004 u	0.00004 u	0.00004 u	0.00004 u	0.00002 u	**0.00002 u**	**0.00002 u**	0.0002 u	0.0002 u
PZ-04S	29-Dec-04	GR-PZ-04S-1-M	--	8081A	1	**0.00004 u**	**0.00004 u**	**0.00004 u**	**0.00002 u**	**0.00002 u**	**0.00002 u**	**0.0002 u**	0.00002 u	**0.00004 u**	0.00002 u	0.00004 u	0.00004 u	0.00004 u	0.00004 u	0.00002 u	**0.00002 u**	**0.00002 u**	0.0002 u	0.0002 u

Location

Notes:

NC No criteria listed under the regulation cited
ND Non-detect result (Original data unavailable - neither value nor detection limit provided)
- Parameter not analyzed

Analytic Flags:

u Not detected above laboratory reporting limits
j Estimated value - parameter detected between laboratory reporting limit and half of the laboratory reporting limit.
e Value exceeds analytical calibration limits
b Parameter detected in quality control blank and sample

Highlighting:

Value or Detection Limit exceeds Criteria 1 only
Value or Detection Limit exceeds Criteria 2 only
Value or Detection Limit exceeds both criteria

SSI - Summary of Target Analyte List Metals Groundwater Analytical Results

Table 5-4f

Supplemental Site Investigation

Analytic Method: 6020A and 7470A
Sample Matrix: Water
Reporting Units: mg/l
Sample Dates: 28-Dec-2004 to 29-Dec-2004

						Aluminum	Antimony	Arsenic	Barium	Beryllium	Cadmium	Calcium	Chromium	Cobalt	Copper	Iron	Lead	Magnesium	Manganese	Mercury	Nickel	Potassium	Selenium	Silver	Sodium	Thallium	Vanadium	Zinc
SSI Project Action Limit (PAL) - Wave 2 (Metals)						NC	0.64	0.00014	50	0.05	0.004	NC	0.3	NC	NC	NC	0.01	NC	0.1	0.0003	0.2	NC	0.1	0.007	NC	0.00047	4	0.9
Secondary Regulatory Criteria Not Selected																												
	Date	Sample ID	Depth	Method	Dilution																							
MW-01S	28-Dec-04	GR-MW-01S-1	--	6020A	1	0.21	0.0002 j	**0.0011**	0.0137	0.0005 u	0.0004 u	44	0.0032	0.0028	0.001	0.476	0.0004	6.05	**0.274**	-	0.008	2.53	0.001 u	0.0001 u	26.7	0.0001 u	0.0004	0.0204
	28-Dec-04	GR-MW-01S-1	--	7470A	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.0002 u	-	-	-	-	-	-	-	-
	28-Dec-04	GR-MW-01S-1-D	--	6020A	1	0.431	0.0002 j	**0.0018**	0.0147	0.0005 u	0.0004 u	43.9	0.005	0.0031	0.0014	0.907	0.0007	6.1	**0.3068**	-	0.0121	2.59	0.001 u	0.0001	26.7	0.0001 u	0.0008	0.0198
	28-Dec-04	GR-MW-01S-1-D	--	7470A	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.0002 u	-	-	-	-	-	-	-	-
MW-02S	29-Dec-04	GR-MW-02S-1	--	6020A	1	1.24	0.0006	**0.0053**	0.0227	0.0005 u	0.0004 u	46	0.0046	0.0031	0.0032	2.61	0.0015	16.1	**1.541**	-	0.0136	16.5	0.001 u	0.0001 u	38.7	0.0001 u	0.0025	0.0299
	29-Dec-04	GR-MW-02S-1	--	7470A	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.0002 u	-	-	-	-	-	-	-	-
MW-03S	28-Dec-04	GR-MW-03S-1	--	6020A	1	0.738	0.0002 j	**0.0024**	0.0104	0.0005 u	0.0004 u	21.5	0.0185	0.0048	0.0024	1.42	0.001	3.35	0.0472	-	0.0185	1.31	0.001 u	0.0001 u	28	0.0001 u	0.001	0.0214
	28-Dec-04	GR-MW-03S-1	--	7470A	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.0002 u	-	-	-	-	-	-	-	-
PZ-04S	29-Dec-04	GR-PZ-04S-1-M	--	6020A	1	0.034	0.0002 u	**0.0007**	0.0092	0.0005 u	0.0004 u	22.5	0.001	0.0018	0.0005 j	0.114	0.0002 j	3.35	0.0098	-	0.0022	1.3	0.001 u	0.0001 u	28.2	0.0001 u	0.0002 j	0.0109
	29-Dec-04	GR-PZ-04S-1-M	--	7470A	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.0002 u	-	-	-	-	-	-	-	-

Location

Notes:

NC No criteria listed under the regulation cited
ND Non-detect result (Original data unavailable - neither value nor detection limit provided)
- Parameter not analyzed

Analytic Flags:

u Not detected above laboratory reporting limits
j Estimated value - parameter detected between laboratory reporting limit and half of the laboratory reporting limit.
e Value exceeds analytical calibration limits
b Parameter detected in quality control blank and sample

Highlighting:

Value or Detection Limit exceeds Criteria 1 only
Value or Detection Limit exceeds Criteria 2 only
Value or Detection Limit exceeds both criteria

SSI - Summary of Dioxin/Furan Groundwater Analytical Results

Table 5-4g

Supplemental Site Investigation

Analytic Method: 8290 and TEQ
Sample Matrix: Water
Reporting Units: pg/l
Sample Dates: 28-Dec-2004 to 12-Jan-2005

						1,2,3,4,6,7,8-HpCDD	1,2,3,4,6,7,8-HpCDF	1,2,3,4,7,8,9-HpCDF	1,2,3,4,7,8-HxCDD	1,2,3,4,7,8-HxCDF	1,2,3,6,7,8-HxCDD	1,2,3,6,7,8-HxCDF	1,2,3,7,8,9-HxCDD	1,2,3,7,8,9-HxCDF	1,2,3,7,8-PeCDD	1,2,3,7,8-PeCDF	2,3,4,6,7,8-HxCDF	2,3,4,7,8-PeCDF	2,3,7,8-TCDD	2,3,7,8-TCDF	HpCDDs, Total	HpCDFs, Total	HxCDDs, Total	HxCDFs, Total	OCDD	OCDF	PeCDDs, Total	PeCDFs, Total
	SSI Project Action Limit (PAL) - Wave 2 (Dioxins)					NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	0.0051	NC	NC	NC	NC	NC	NC	NC	NC	NC
	Secondary Regulatory Criteria Not Selected																											
	Date	Sample ID	Depth	Method	Dilution																							
MW-01S	30-Dec-04	GR-MW-01S-1-D	--	8290	1	0.562 bj	0.65 bj	25.51 u	25.51 u	0.791 bj	25.51 u	25.51 u	25.51 u	25.51 u	25.51 u	25.51 u	25.51 u	25.51 u	**10.204 u**	10.204 u	25.51 u	25.51 u	25.51 u	25.51 u	4.281 bj	51.02 u	25.51 u	25.51 u
	30-Dec-04	GR-MW-01S-1-D	--	TEQ	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	28-Dec-04	GR-MW-01S-1	--	8290	1	0.888 tr	0.848 bj	26.315 u	26.315 u	0.607 bj	26.315 u	26.315 u	26.315 u	26.315 u	26.315 u	26.315 u	26.315 u	26.315 u	**10.526 u**	10.526 u	0.888 bj	26.315 u	26.315 u	26.315 u	7.242 bj	52.631 u	26.315 u	26.315 u
	28-Dec-04	GR-MW-01S-1	--	TEQ	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
MW-02S	11-Jan-05	GR-MW-02S-1	--	8290	1	3.194 bj	29.411 u	29.411 u	29.411 u	29.411 u	29.411 u	29.411 u	29.411 u	29.411 u	29.411 u	29.411 u	29.411 u	29.411 u	**11.764 u**	11.764 u	29.411 u	29.411 u	29.411 u	29.411 u	31.447 bj	58.823 u	29.411 u	29.411 u
	11-Jan-05	GR-MW-02S-1	--	TEQ	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	04-Jan-05	GR-MW-02S-1	--	8290	1	-	-	-	-	-	-	-	-	-	-	-	-	-	**11.764 u**	-	-	-	-	-	-	-	-	-
	29-Dec-04	GR-MW-02S-1	--	8290	1	3.194 bj	29.411 u	29.411 u	29.411 u	29.411 u	29.411 u	29.411 u	29.411 u	29.411 u	29.411 u	29.411 u	29.411 u	29.411 u	-	11.764 u	29.411 u	29.411 u	29.411 u	29.411 u	31.447 bj	58.823 u	29.411 u	29.411 u
	29-Dec-04	GR-MW-02S-1	--	TEQ	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
MW-03S	30-Dec-04	GR-MW-03S-1	--	8290	1	0.612 bj	0.914 bj	25.51 u	25.51 u	0.929 bj	25.51 u	25.51 u	25.51 u	25.51 u	25.51 u	25.51 u	25.51 u	25.51 u	**10.204 u**	10.204 u	25.51 u	25.51 u	25.51 u	25.51 u	5.287 bj	51.02 u	25.51 u	25.51 u
	30-Dec-04	GR-MW-03S-1	--	TEQ	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
PZ-04S	12-Jan-05	GR-PZ-04S-1-M	--	8290	1	0.893 bj	0.887 bj	25.51 u	25.51 u	0.941 bj	25.51 u	25.51 u	25.51 u	25.51 u	25.51 u	25.51 u	25.51 u	25.51 u	**10.204 u**	10.204 u	25.51 u	25.51 u	25.51 u	25.51 u	5.507 bj	51.02 u	25.51 u	25.51 u
	12-Jan-05	GR-PZ-04S-1-M	--	TEQ	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	29-Dec-04	GR-PZ-04S-1-M	--	8290	1	0.893 bj	0.887 bj	25.51 u	25.51 u	0.941 bj	25.51 u	25.51 u	25.51 u	25.51 u	25.51 u	25.51 u	25.51 u	25.51 u	**10.204 u**	10.204 u	25.51 u	25.51 u	25.51 u	25.51 u	5.507 bj	51.02 u	25.51 u	25.51 u
	29-Dec-04	GR-PZ-04S-1-M	--	TEQ	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

Location

Notes:

NC No criteria listed under the regulation cited
ND Non-detect result (Original data unavailable - neither value nor detection limit provided)
- Parameter not analyzed

Analytic Flags:

u Not detected above laboratory reporting limits
j Estimated value - parameter detected between laboratory reporting limit and half of the laboratory reporting limit.
e Value exceeds analytical calibration limits
b Parameter detected in quality control blank and sample

Highlighting:

Value or Detection Limit exceeds Criteria 1 only
Value or Detection Limit exceeds Criteria 2 only
Value or Detection Limit exceeds both criteria

Supplemental Site Investigation

Analytic Method: 8290 and TEQ
Sample Matrix: Water
Reporting Units: pg/l
Sample Dates: 28-Dec-2004 to 12-Jan-2005

						TCDDs, Total	TCDFs, Total	Total TEQ
SSI Project Action Limit (PAL) - Wave 2 (Dioxins)						NC	NC	0.0051
Secondary Regulatory Criteria Not Selected								
	Date	Sample ID	Depth	Method	Dilution			
MW-01S	30-Dec-04	GR-MW-01S-1-D	--	8290	1	10.204 u	10.204 u	-
	30-Dec-04	GR-MW-01S-1-D	--	TEQ	1	-	-	**0.89**
	28-Dec-04	GR-MW-01S-1	--	8290	1	10.526 u	10.526 u	-
	28-Dec-04	GR-MW-01S-1	--	TEQ	1	-	-	**0.985**
MW-02S	11-Jan-05	GR-MW-02S-1	--	8290	1	11.764 u	11.764 u	-
	11-Jan-05	GR-MW-02S-1	--	TEQ	1	-	-	**1.82**
	04-Jan-05	GR-MW-02S-1	--	8290	1	-	-	-
	29-Dec-04	GR-MW-02S-1	--	8290	1	11.764 u	11.764 u	-
	29-Dec-04	GR-MW-02S-1	--	TEQ	1	-	-	ND
MW-03S	30-Dec-04	GR-MW-03S-1	--	8290	1	10.204 u	10.204 u	-
	30-Dec-04	GR-MW-03S-1	--	TEQ	1	-	-	**0.97**
PZ-04S	12-Jan-05	GR-PZ-04S-1-M	--	8290	1	10.204 u	10.204 u	-
	12-Jan-05	GR-PZ-04S-1-M	--	TEQ	1	-	-	**0.8171**
	29-Dec-04	GR-PZ-04S-1-M	--	8290	1	10.204 u	10.204 u	-
	29-Dec-04	GR-PZ-04S-1-M	--	TEQ	1	-	-	ND

Location

Notes:

NC No criteria listed under the regulation cited
ND Non-detect result (Original data unavailable - neither value nor detection limit provided)
- Parameter not analyzed

Analytic Flags:

u Not detected above laboratory reporting limits
j Estimated value - parameter detected between laboratory reporting limit and half of the laboratory reporting limit.
e Value exceeds analytical calibration limits
b Parameter detected in quality control blank and sample

Highlighting:

Value or Detection Limit exceeds Criteria 1 only
Value or Detection Limit exceeds Criteria 2 only
Value or Detection Limit exceeds both criteria

Table 5-4h

Summary of Groundwater Sample Perchlorate Analytical Results

Field Sample ID	Sample Date	Parameter EPA Method 8321A				MDEP Interim Drinking Water Standard	
Investigation Area 2							
GR-IA02-PZ04-1	1/28/2005	Perchlorate	0.2	U	µg/L	1	µg/L
GR-IA02-MW03-1	1/28/2005	Perchlorate	1	U	µg/L	1	µg/L
Investigation Area 8							
GR-IA08-MW01-1	1/28/2005	Perchlorate	0.21		µg/L	1	µg/L
GR-IA08-MW02-1	1/28/2005	Perchlorate	1	U	µg/L	1	µg/L

Notes:
EPA = U.S. Environmental Protection Agency
MDEP = Massachusetts Department of Environmental Protection
U = Not detected, detection limit listed.
µg/kg = micrograms per kilogram (parts per billion).
µg/L = micrograms per liter (parts per billion).

Supplemental Site Investigation

Analytic Method: 8330
Sample Matrix: Water
Reporting Units: mg/l
Sample Dates: 28-Dec-2004 to 29-Dec-2004

						1,3,5-Trinitrobenzene	1,3-Dinitrobenzene	2,4,6-Trinitrotoluene	2,4-Dinitrotoluene	2,6-Dinitrotoluene	2-AminoDNT	2-Nitrotoluene	3-Nitrotoluene	4-AminoDNT	4-Nitrotoluene	HMX	Nitrobenzene	RDX	Tetryl
SSI Project Action Limit (PAL) - Wave 2 (Explosives)						NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC
Secondary Regulatory Criteria Not Selected																			
	Date	Sample ID	Depth	Method	Dilution														
MW-01S	28-Dec-04	GR-MW-01S-1	--	8330	1	0.00076 u	0.00062 u	0.002 u	0.0012 u	0.00062 u	0.00062 u	0.00062 u	0.00062 u	0.00062 u	0.00062 u	0.00062 u	0.00062 u	0.002 u	0.00062 u
	28-Dec-04	GR-MW-01S-1-D	--	8330	1	0.00076 u	0.00062 u	0.002 u	0.0012 u	0.00062 u	0.00062 u	0.00062 u	0.00062 u	0.00062 u	0.00062 u	0.00062 u	0.00062 u	0.002 u	0.00062 u
MW-02S	29-Dec-04	GR-MW-02S-1	--	8330	1	0.00076 u	0.00062 u	0.002 u	0.0012 u	0.00062 u	0.00062 u	0.00062 u	0.00062 u	0.00062 u	0.00062 u	0.00062 u	0.00062 u	0.002 u	0.00062 u
MW-03S	28-Dec-04	GR-MW-03S-1	--	8330	1	-	0.00062 u	0.002 u	0.0012 u	0.00062 u	0.00062 u	0.00062 u	-	0.00062 u	0.00062 u	-	0.00062 u	-	0.00062 u
PZ-04S	29-Dec-04	GR-PZ-04S-1-M	--	8330	1	0.00076 u	0.00062 u	0.002 u	0.0012 u	0.00062 u	0.00062 u	0.00062 u	0.00062 u	0.00062 u	0.00062 u	0.00062 u	0.00062 u	0.002 u	0.00062 u

Location

Notes:

- **NC** No criteria listed under the regulation cited
- **ND** Non-detect result (Original data unavailable - neither value nor detection limit provided)
- **-** Parameter not analyzed

Analytic Flags:

- **u** Not detected above laboratory reporting limits
- **j** Estimated value - parameter detected between laboratory reporting limit and half of the laboratory reporting limit.
- **e** Value exceeds analytical calibration limits
- **b** Parameter detected in quality control blank and sample

Highlighting:

- Value or Detection Limit exceeds Criteria 1 only
- Value or Detection Limit exceeds Criteria 2 only
- Value or Detection Limit exceeds both criteria

Table 5-5a
Summary of Soil Project Action Levels
Former Grant, Locust Cavite Housing Areas

Analyte	Carcinogen (Ca) or Non-carcinogen (NC)	MCP Method 1 S-1/GW-3 Soil Standard (mg/kg)	EPA Region III RBCs (mg/kg)	EPA Region IX PRGs (mg/kg)	Project Action Limit (mg/kg)
TCL Volatiles (MCP) Soil 5035/8260B High level					
Acetone	NC	60	70,000	1,400	60
Amyl Methyl Ether (TAME), *tert-*					
Benzene	Ca	30	12	0.64	0.64
Bromobenzene	NC			28	2.8
Bromochloromethane					
Bromodichloromethane	Ca	20	10	0.82	0.82
Bromoform	Ca	200	81	62	62
Bromomethane	NC	50	110	3.9	0.39
Butylbenzene, *sec-*				220	220
Butylbenzene				240	240
Butylbenzene, *tert-*				390	390
Carbon Disulfide	NC		7,800	360	36
Carbon Tetrachloride	Ca	10	4.9	0.25	0.25
Chlorobenzene	NC	100	1,600	150	15
Chlorodibromomethane	Ca		7.6		7.6
Chloroethane	Ca		220	3	3
Chloroform	Ca	200	780	3.6	3.6
Chloromethane	NC			1.2	0.12
2-Chlorotoluene	NC		1,600	1,600	160
4-Chlorotoluene					
Dibromo-3-chloropropane	Ca		0.46	0.45	0.45
1,2-Dibromomethane (EDB)	Ca	0.1	0.0075	0.0069	0.0069
Dibromomethane	Ca		782	67	67
1,2-Dichlorobenzene (o-DCB)	NC	300	7,000	370	37
1,3-Dichlorobenzene (m-DCB)	NC	100	2,300	16	1.6
1,4-Dichlorobenzene (p-DCB)	Ca	50	27	3.4	3.4
Dichlorodifluoromethane	NC		16,000	94	9.4
1,1-Dichloroethane	NC	500	7,800	510	51
1,2-Dichloroethane	Ca	10	7	0.28	0.28
1,1-Dichloroethylene	Ca	500	3,900	120	120
Dichloroethylene, *cis-*	NC	100	780	43	4.3
Dichloroethylene, *trans-*	NC	500	1,600	69	6.9
1,2-Dichloropropane	Ca	10	9.4	0.34	0.34
1,3-Dichloropropane	NC		1,600	100	10
2,2-Dichloropropane					
Dichloropropene, *cis-1,3-*		3			3
Dichloropropene, *trans-1,3-*		3			3
Diethyl Ether			16,000		16,000
Diisopropyl Ether (DIPE)					
1,4-Dioxane	Ca		58	44	44
Ethyl Tertiary Butyl Ether (ETBE)					
Ethylbenzene	NC	500	7,800	8.9	0.89
Hexachlorobutadiene	Ca	6	8.2	6.2	6
Hexanone (MNBK)					
Isopropylbenzene (Cumene)	NC		7800	570	57
Isopropyltoluene, p-					
Methyl Ethyl Ketone (MEK)	NC	40	47000	7300	40
Methyl Isobutyl Ketone (MIBK)	NC	400		790	79
Methyl Tertiary Butyl Ether (MTBE)	Ca	100	160	62	62
Methylene Chloride	Ca		82	9.1	9.1
Naphthalene	NC	500	1600	56	5.6
Propylbenzene, n-				240	240
Styrene	NC	30	16000	1700	30
1,1,1,2-Tetrachloroethane	Ca	7	25	3.2	3.2
1,1,2,2-Tetrachloroethane	Ca	0.8	3.2	0.41	0.41
Tetrachloroethylene	Ca	30	1.2	1.5	1.2
Tetrahydrofuran (THF)	Ca		84	9.4	9.4
Toluene	NC	500	15,000	520	52
1,2,4-Trichlorobenzene	NC	500	780	650	65
1,2,3-Trichlorobenzene					
1,1,1-Trichloroethane	NC	500	22,000	1,200	120
1,1,2-Trichloroethane	Ca	4	11	0.73	0.73
Trichloroethylene (TCE)	Ca	90	1.6	0.053	0.053
Trichlorofluoromethane	NC		23,000	390	39
1,2,3-Trichloropropane	Ca		0.32	0.005	0.005
1,2,4-Trimethylbenzene	NC		3,900	52	5.2
1,3,5-Trimethylbenzene	NC		3,900	21	2.1
Vinyl Chloride	Ca	0.6	0.09	0.079	0.079
Xylene, o-	NC	300		270	27
Xylene, m-	NC	300		270	27
Xylene, p-	NC	300		270	27

Table 5-5a
Summary of Soil Project Action Levels
Former Grant, Locust Cavite Housing Areas

Analyte	Carcinogen (Ca) or Non-carcinogen (NC)	MCP Method 1 S-1/GW-3 Soil Standard (mg/kg)	EPA Region III RBCs (mg/kg)	EPA Region IX PRGs (mg/kg)	Project Action Limit (mg/kg)
TCL Semivolatiles (MCP) Soils 3545/2540C/8270C/8270C-SIM					
(1) Compounds to be analyzed by EPA 8270C-SIM.					
(2) Compounds to be analyzed by EPA 8270C-SIM.					
Acenaphthene	NC	1,000	4,700	3,700	370
Acenaphthylene		100			100
Acetophenone	NC		7,800		7800
Aniline	Ca		11	85	11
Anthracene	NC	1,000	23,000	22,000	1,000
Azobenzene	Ca		5.8	4.4	4.4
Benzo(a)anthracene	Ca	7	0.87	0.62	0.62
Benzo(a)pyrene (2)	Ca	2	0.087	0.062	0.062
Benzo(b)fluoranthene	Ca	7	0.87	0.62	0.62
Benzo(g,h,i)perylene		1,000			1,000
Benzo(k)fluoranthene	Ca	70	8.7	6.2	6.2
Bromophenyl phenyl ether, 4-					
Butyl benzyl phthalate	NC		16,000	12,000	1,200
Butyl phthalate, Di-n-	NC		7,800	6,100	610
Chloroaniline, 4-	NC	3	310	150	3
bis (Chloroethoxy)methane					
bis (2-Chloroethyl)ether	Ca	0.7	0.58		0.58
bis (2-Chloroisopropyl) ether	Ca	2	9.1		2
Chloronaphthalene, 2-	NC		6,300	4,900	490
Chlorophenol, 2-	NC	20	390	63	6.3
Chrysene	Ca	7	87	62	7
Dibenz(a,h)anthracene (2)	Ca	0.7	0.087	0.062	0.062
Dibenzofuran	NC		160	290	29
Dichlorobenzene, 1,2-	NC	300	7,000	370	37
Dichlorobenzene, 1,3-	NC	100	2,300	16	1.6
Dichlorobenzene, 1,4-	Ca	50	27	3.4	3.4
Dichlorobenzidine, 3,3'-	Ca	1	1.4	1.1	1
Dichlorophenol, 2,4-	NC	40	230	180	18
Diethyl phthalate	NC	300	63,000	49,000	300
Dimethyl phthalate		600	780,000	100,000	600
Dimethylphenol, 2,4-	NC	500	1,600	1,200	120
Dinitrophenol, 2,4-	NC	50	160	120	12
Dinitrotoluene, 2,4-	NC	2	160	120	2
Dinitrotoluene, 2,6-	NC		78	61	6.1
bis (2-Ethylhexyl)phthalate	Ca	200	46	35	35
Fluoranthene	NC	1,000	3,100	2,300	230
Fluorene	NC	1,000	3,100	2,700	270
Hexachlorobenzene	Ca	0.7	0.4	30	0.4
Hexachlorobutadiene	Ca	6	8.2	6.2	6
Hexachloroethane	Ca	9	46	35	9
Indeno (1,2,3-cd) pyrene	Ca	7	0.81	0.62	0.62
Isophorone	Ca		670	510	510
Methylnaphthalene, 2-		500	31		31
Methylphenol, 2-	NC		3,900	3,100	310
Methylphenol, 3- (1)	NC		3,900	3,100	310
Methylphenol, 4- (1)	NC		390	310	31
Naphthalene	NC	500	1,600	56	5.6
Nitrobenzene	NC		39	20	2
Nitrophenol, 2-					
Nitrophenol, 4-					
Octyl phthalate, di-n-	NC		2,100	2,400	240
Pentachlorophenol	Ca	10	5.3	3	3
Phenanthrene		100			100
Phenol	NC	20	23,000	37,000	20
Pyrene	NC	1,000	2,300	2,300	230
Trichlorobenzene, 1,2,4-	NC	500	780	650	65
Trichlorophenol, 2,4,5-	NC	600	7,800	6,100	600
Trichlorophenol, 2,4,6-	NC	20	58	6.1	0.61

Table 5-5a
Summary of Soil Project Action Levels
Former Grant, Locust Cavite Housing Areas

Analyte	Carcinogen (Ca) or Non-carcinogen (NC)	MCP Method 1 S-1/GW-3 Soil Standard (mg/kg)	EPA Region III RBCs (mg/kg)	EPA Region IX PRGs (mg/kg)	Project Action Limit (mg/kg)
Extractable Petroleum Hydrocarbons Soil MassDEP Method EPA-04-1					
Aliphatic Hydrocarbons (C_{19}-C_{36})		2,500			2,500
Aliphatic Hydrocarbons (C_9-C_{18})		1,000			1,000
Aromatic Hydrocarbons (C_{11}-C_{22})		800			800
Acenaphthene	NC	1,000	4700	3,700	370
Acenaphthylene		100			100
Anthracene		1,000	23,000	22,000	1,000
Benzo(a)anthracene	Ca	7	0.87	0.62	0.62
Benzo(a)pyrene	Ca	2	0.087	0.062	0.062
Benzo(b)fluoranthene	Ca	7	0.87	0.62	0.62
Benzo(g,h,i)perylene		1,000			1,000
Benzo(k)fluoranthene	Ca	70	8.7	6.2	6.2
Chrysene	Ca	7	87	62	7
Dibenz(a,h)Anthracene	Ca	0.7	0.087	0.062	0.062
Fluoranthene	NC	1,000	3,100	2,300	230
Fluorene	NC	1,000	3,100	2,700	270
Indeno(1,2,3-c,d)Pyrene	Ca	7	0.81	0.62	0.62
2-Methylnaphthalene		500	31		31
Naphthalene	NC	500	1,600	56	5.6
Phenanthrene	NC	100			100
Pyrene	NC	1,000		2,300	230
PCBs Soil 3545/8082					
Aroclor 1016 (1)	Ca	2	5.5	3.9	2
Aroclor 1221	Ca	2	0.32	0.22	0.22
Aroclor 1232	Ca	2	0.32	0.22	0.22
Aroclor 1242 (1)	Ca	2	0.32	0.22	0.22
Aroclor 1248	Ca	2	0.32	0.22	0.22
Aroclor 1254	Ca	2	0.32	0.22	0.22
Aroclor 1260	Ca	2	0.32	0.22	0.22
Aroclor 1262	Ca	2		0.22	0.22
Aroclor 1268	Ca	2		0.22	0.22
TCL Pesticides 3545/8081					
Aldrin	Ca	0.04	0.038	0.029	0.029
alpha-BHC	Ca		0.1	0.09	0.09
beta-BHC	Ca		0.35	0.32	0.32
gamma-BHC	Ca		0.49	0.44	0.44
delta-BHC					
Chlordane (nos), multicomponent mixture	Ca	0.7	1.8	1.6	0.7
alpha-chlordane					
gamma-chlordane					
4,4'-DDD	NC	4	2.7	2.4	0.24
4,4'-DDE	NC	3	1.9	1.7	0.17
4,4'-DDT	NC	3	1.9	1.7	0.17
Diedrin	Ca	0.05	0.04	0.03	0.03
Endosulfan I	NC	1			1
Endosufan II		1			1
Endosulfan Sulfate					
Endrin	NC	8	23	18	1.8
Endrin Ketone					
Heptachlor	Ca	0.2	0.14	0.11	0.11
Heptachlor epoxide	Ca	0.09	0.07	0.053	0.053
Hexachlorobenzene	Ca	0.7	0.4	0.3	0.3
Methoxychlor	NC	200	390	310	31
Dioxins Soils Method 8290					
2,3,7,8-Tetrachlorodibenzo-p-dioxin (TCDD)	Ca	2.00E-05	4.30E-06	3.90E-06	3.90E-06
1,2,3,7,8-Pentachlorodibenzo-p-dioxin (PeCDD)	Ca				
1,2,3,6,7,8-Hexachlorodibenzo-p-dioxin (HxCDD)	Ca				
1,2,3,4,7,8-Hexachlorodibenzo-p-dioxin (HxCDD)	Ca				
1,2,3,7,8,9-Hexachlorodibenzo-p-dioxin (HxCDD)	Ca				
1,2,3,4,6,7,8-Heptachlorodibenzo-p-dioxin (HpCDD)	Ca				
1,2,3,4,6,7,8,9-Octachlorodibenzo-p-dioxin (OCDD)	Ca				
2,3,7,8-Tetrachlorodibenzofuran (TCDF)	Ca				
1,2,3,7,8-Pentachlorodibenzofuran (PeCDF)	Ca				
2,3,4,7,8-Pentachlorodibenzofuran (PeCDF)	Ca				
1,2,3,6,7,8-Hexachlorodibenzofuran (HxCDF)	Ca				
1,2,3,7,8,9-Hexachlorodibenzofuran (HxCDF)	Ca				
1,2,3,4,7,8-Hexachlorodibenzofuran (HxCDF)	Ca				
2,3,4,6,7,8-Hexachlorodibenzofuran (HxCDF)	Ca				
1,2,3,4,6,7,8-Heptachlorodibenzofuran (HpCDF)	Ca				
1,2,3,4,7,8,9-Heptachlorodibenzofuran (HpCDF)	Ca				
1,2,3,4,6,7,8,9-Octachlorodibenzofuran (OCDF)	Ca				

Table 5-5a
Summary of Soil Project Action Levels
Former Grant, Locust Cavite Housing Areas

Analyte	Carcinogen (Ca) or Non-carcinogen (NC)	MCP Method 1 S-1/GW-3 Soil Standard (mg/kg)	EPA Region III RBCs (mg/kg)	EPA Region IX PRGs (mg/kg)	Project Action Limit (mg/kg)
TAL Metals Soils 6010B					
Aluminum	NC		78,000	76,000	7600
Antimony	NC	20	31	31	3.1
Arsenic	Ca	20	0.43	0.39	0.39
Barium	NC	1,000	5,500	5,400	540
Beryllium	NC	0.7	160	150	0.7
Cadmium	Ca	2	39	37	2
Calcium					
Chromium	Ca	30		210	30
Cobalt	Ca		1,600	900	900
Copper	NC		3,100	3,100	310
Iron	NC		23,000	23,000	2,300
Lead	NC	300		400	300
Magnesium	NC				
Manganese	NC		11,000	1,800	180
Nickel	NC	20	1,600	1,600	20
Potassium	NC				
Selenium	NC	400	390	390	39
Silver	NC	100	390	390	39
Sodium	NC				
Thallium	NC	8	5.5	5.2	0.52
Vanadium	NC	600	78	550	55
Zinc	NC	2,500	23,000	23,000	2300
TAL Metals Soils 7470					
Mercury	NC	20	23	23	2.3
Explosives Soils 8330/PDA					
1,3,5-Trinitrobenzene (1,3,5-TNB)	Ca		2,300	1,800	1,800
1,3-Dinitrobenzene (1,3-DNB)	NC		7.8	6.1	0.61
2,4,6-Trinitrotoluene (TNT)	Ca		21	16	16
2,4-Diamino-6-nitrotoluene (2,4-Dam-6NT)					
2,4-Dinitrotoluene (2,4-DNT)	NC		160	120	12
2,6-Diamino-4-nitrotoluene (2,6-DAm-4NT)					
2,6-Dinitrotoluene (2,6-DNT)	NC		78	61	6.1
2-Amino-4,6-dinitrotoluene (2-Am-DNT)					
2-Nitrotoluene (2-NT)	NC		2.8	730	2.8
3-Nitrotoluene (3-NT)	Ca		1,600	370	370
4-Amino-2,6-dinitrotoluene (4-Am-DNT)					
4-Nitrotoluene (4-NT)	Ca		38	370	38
HMX	NC		3,900		3,900
Nitrobenzene (NB)	NC		39	20	2
Nitroglycerin	Ca		46	35	35
PETN					
Picric Acid (trinitrophenol)					
RDX (Cyclonite)	Ca		5.8	4.4	4.4
Tetryl			780		780

Notes:
TCL - Target Compound List
MCP - Massachusetts Contingency Plan
EPA - U.S. Environmental Protection Agency
PRG - Preliminary Remediation Goals
RBC - Risk Based Concentrations
MDL - method detection limit
PQL - practical quantitation limit
mg/kg - milligrams per kilogram

Analyte	Carcinogen (Ca) or Non-carcinogen (NC)	MCP Method 1 GW-3 Groundwater Standard (µg/L)	EPA Water Quality Criteria (µg/L)	Project Action Limit (µg/L)
TCL Volatiles 8260B High level				
Acetone	NC	50,000		50,000
Amyl Methyl Ether (TAME), *tert-*				
Benzene	Ca	10000	51	51
Bromobenzene	NC			
Bromochloromethane				
Bromodichloromethane	Ca	50,000	17	17
Bromoform	Ca	50,000	140	140
Bromomethane	NC	50,000		50,000
Butylbenzene, *sec-*				
Butylbenzene				
Butylbenzene, *tert-*				
Carbon Disulfide	NC			
Carbon Tetrachloride	Ca	5,000	1.6	1.6
Chlorobenzene	NC	1,000	1,600	1,000
Chlorodibromomethane	Ca		13	13
Chloroethane	Ca			
Chloroform	Ca	10,000	470	470
Chloromethane	NC			
2-Chlorotoluene	NC			
4-Chlorotoluene				
Dibromo-3-chloropropane	Ca			
1,2-Dibromomethane (EDB)	Ca	50,000		50,000
Dibromomethane	Ca			
1,2-Dichlorobenzene (o-DCB)	NC	50,000	1,300	1,300
1,3-Dichlorobenzene (m-DCB)	NC	2000	960	960
1,4-Dichlorobenzene (p-DCB)	Ca	50,000	190	190
Dichlorodifluoromethane	NC			
1,1-Dichloroethane	NC	20,000		20,000
1,2-Dichloroethane	Ca	20,000	37	37
1,1-Dichloroethylene	Ca	30,000	7,100	7,100
Dichloroethylene, *cis-*	NC	50,000		50,000
Dichloroethylene, *trans-*	NC	50,000	10,000	10,000
1,2-Dichloropropane	Ca	50,000	15	15
1,3-Dichloropropane	NC		21	21
2,2-Dichloropropane				
Dichloropropene, *cis-1,3-*		2,000		2,000
Dichloropropene, *trans-1,3-*		2,000		2,000
Diethyl Ether				
Diisopropyl Ether (DIPE)				
1,4-Dioxane	Ca			
Ethyl Tertiary Butyl Ether (ETBE)				
Ethylbenzene	NC	4,000	2,100	2,100
Hexachlorobutadiene	Ca	3,000		3,000
Hexanone (MNBK)				
Isopropylbenzene (Cumene)	NC			
Isopropyltoluene, p-				
Methyl Ethyl Ketone (MEK)	NC	50,000		50,000
Methyl Isobutyl Ketone (MIBK)	NC	50,000		50,000
Methyl Tertiary Butyl Ether (MTBE)	Ca	50,000		50,000
Methylene Chloride	Ca		590	590
Naphthalene	NC	20,000		20,000
Propylbenzene, n-				
Styrene	NC	6,000		6,000
1,1,1,2-Tetrachloroethane	Ca	50,000		50,000
1,1,2,2-Tetrachloroethane	Ca	50,000	4	4
Tetrachloroethylene	Ca	30,000	3.3	3
Tetrahydrofuran (THF)	Ca			
Toluene	NC	4,000	15,000	4,000
1,2,4-Trichlorobenzene	NC	50,000		50,000
1,2,3-Trichlorobenzene				
1,1,1-Trichloroethane	NC	20,000		20,000
1,1,2-Trichloroethane	Ca	50,000	16	16
Trichloroethylene (TCE)	Ca	5,000	30	30
Trichlorofluoromethane	NC			
1,2,3-Trichloropropane	Ca			
1,2,4-Trimethylbenzene	NC			
1,3,5-Trimethylbenzene	NC			
Vinyl Chloride	Ca	50,000	2.4	2.4
Xylene, o-	NC	500		500
Xylene, m-	NC	500		500
Xylene, p-	NC	500		500
TCL Semivolatiles 8270C/8270C-SIM				
(1) Compounds to be analyzed by EPA 8270C-SIM.				

Analyte	Carcinogen (Ca) or Non-carcinogen (NC)	MCP Method 1 GW-3 Groundwater Standard (µg/L)	EPA Water Quality Criteria (µg/L)	Project Action Limit (µg/L)
(2) Compounds to be analyzed by EPA 8270C-SIM.				
Acenaphthene	NC	5,000	990	990
Acenaphthylene		3,000		3,000
Acetophenone	NC			
Aniline	Ca			
Anthracene	NC	3,000	40,000	3,000
Azobenzene	Ca			
Benzo(a)anthracene	Ca	1,000	0.018	
Benzo(a)pyrene (2)	Ca	500	0.018	0.018
Benzo(b)fluoranthene	Ca	400	0.018	0.018
Benzo(g,h,i)perylene		3,000		3,000
Benzo(k)fluoranthene	Ca	100	0.018	0.018
Bromophenyl phenyl ether, 4-				
Butyl benzyl phthalate	NC		1,900	1,900
Butyl phthalate, Di-n-	NC		4,500	4,500
Chloroaniline, 4-	NC	300		300
bis (Chloroethoxy)methane				
bis (2-Chloroethyl)ether	Ca	50,000	0.53	0.53
bis (2-Chloroisopropyl) ether	Ca	50,000	65,000	50,000
Chloronaphthalene, 2-	NC		1,600	1,600
Chlorophenol, 2-	NC	40,000		40,000
Chrysene	Ca	3,000	0.018	0.018
Dibenz(a,h)anthracene (2)	Ca	40	0.018	0.018
Dibenzofuran	NC			
Dichlorobenzene, 1,2-	NC	2,000	1300	1,300
Dichlorobenzene, 1,3-	NC	50,000	960	960
Dichlorobenzene, 1,4-	Ca	8,000	190	190
Dichlorobenzidine, 3,3'-	Ca	2,000	0.028	0.028
Dichlorophenol, 2,4-	NC	2,000	290	290
Diethyl phthalate	NC	9,000	44,000	9,000
Dimethyl phthalate		50,000	1,100,000	50,000
Dimethylphenol, 2,4-	NC	50,000	850	850
Dinitrophenol, 2,4-	NC	20,000	5,300	5,300
Dinitrotoluene, 2,4-	NC	50,000	3.4	3.4
Dinitrotoluene, 2,6-	NC			
bis (2-Ethylhexyl)phthalate	Ca	30	2	2
Fluoranthene	NC	200	140	140
Fluorene	NC	3,000	5,300	3,000
Hexachlorobenzene	Ca	6,000	0.00029	0.00029
Hexachlorobutadiene	Ca	3,000	18	18
Hexachloroethane	Ca	50,000	3.3	3
Indeno (1,2,3-cd) pyrene	Ca	100	0.018	0.018
Isophorone	Ca		960	960
Methylnaphthalene, 2-		3,000		3,000
Methylphenol, 2-	NC			
Methylphenol, 3- (1)	NC			
Methylphenol, 4- (1)	NC			
Naphthalene	NC	20,000		20,000
Nitrobenzene	NC		690	690
Nitrophenol, 2-				
Nitrophenol, 4-				
Octyl phthalate, di-n-	NC			
Pentachlorophenol	Ca	200	3	3
Phenanthrene		50		50
Phenol	NC	2,000	1,700,000	2,000
Pyrene	NC	20	4,000	20
Trichlorobenzene, 1,2,4-	NC	50,000	70	70
Trichlorophenol, 2,4,5-	NC	3,000	3,600	3,000
Trichlorophenol, 2,4,6-	NC	500	2.4	2.4

Summary of Groundwater Project Action Levels for Former Grant, Locust and Cavite Housing Areas

Analyte	Carcinogen (Ca) or Non-carcinogen (NC)	MCP Method 1 GW-3 Groundwater Standard (µg/L)	EPA Water Quality Criteria (µg/L)	Project Action Limit (µg/L)
Extractable Petroleum Hydrocarbons MassDEP Method EPA-04-1				
Aliphatic Hydrocarbons (C_{19}-C_{36})		20,000		20,000
Aliphatic Hydrocarbons (C_9-C_{18})		20,000		20,000
Aromatic Hydrocarbons (C_{11}-C_{22})		30,000		30,000
Acenaphthene	NC	5,000	990	990
Acenaphthylene		3,000		3,000
Anthracene		3,000	40,000	3,000
Benzo(a)anthracene	Ca	1,000	0.018	0.018
Benzo(a)pyrene	Ca	500	0.018	0.018
Benzo(b)fluoranthene	Ca	400	0.018	0.018
Benzo(g,h,i)perylene		3,000		3,000
Benzo(k)fluoranthene	Ca	100	0.018	0.018
Chrysene	Ca	3,000	0.018	0.018
Dibenz(a,h)Anthracene	Ca	40	0.018	0.018
Fluoranthene	NC	200	140	140
Fluorene	NC	3,000	5,300	3,000
Indeno(1,2,3-c,d)Pyrene	Ca	100	0.018	0.018
2-Methylnaphthalene		3,000		3,000
Naphthalene	NC	20,000		20,000
Phenanthrene	NC	50		50
Pyrene	NC	1,000	4,000	1,000
PCBs 8082				
Aroclor 1016 (1)	Ca	0.3		0.3
Aroclor 1221	Ca	0.3		0.3
Aroclor 1232	Ca	0.3		0.3
Aroclor 1242 (1)	Ca	0.3		0.3
Aroclor 1248	Ca	0.3		0.3
Aroclor 1254	Ca	0.3		0.3
Aroclor 1260	Ca	0.3		0.3
Aroclor 1262	Ca	0.3		0.3
Aroclor 1268	Ca	0.3		0.3
TCL Pesticides 8081				
Aldrin	Ca	20	0.00005	0.00005
alpha-BHC	Ca		0.0049	0.0049
beta-BHC	Ca		0.017	0.017
gamma-BHC	Ca		1.8	1.8
delta-BHC				
Chlordane (nos), multicomponent mixture	Ca	2	0.00081	0.00081
alpha-chlordane				
gamma-chlordane				
4,4'-DDD	NC	50	0.00031	0.00031
4,4'-DDE	NC	400	0.00022	0.00022
4,4'-DDT	NC	1	0.00022	0.00022
Diedrin	Ca	0.5	0.000054	0.000054
Endosulfan I	NC	2	89	2
Endosufan II		2		2
Endosulfan Sulfate			89	89
Endrin	NC	5	0.06	0.06
Endrin Ketone				
Heptachlor	Ca	1	0.000079	0.000079
Heptachlor epoxide	Ca	2	0.000039	0.000039
Hexachlorobenzene	Ca	6,000		6,000
Methoxychlor	NC	10		10
Dioxins Method 8290				
2,3,7,8-Tetrachlorodibenzo-p-dioxin (TCDD)	Ca	4.00E-02	5.10E-09	5.10E-09
1,2,3,7,8-Pentachlorodibenzo-p-dioxin (PeCDD)	Ca			
1,2,3,6,7,8-Hexachlorodibenzo-p-dioxin (HxCDD)	Ca			
1,2,3,4,7,8-Hexachlorodibenzo-p-dioxin (HxCDD)	Ca			
1,2,3,7,8,9-Hexachlorodibenzo-p-dioxin (HxCDD)	Ca			
1,2,3,4,6,7,8-Heptachlorodibenzo-p-dioxin (HpCDD)	Ca			
1,2,3,4,6,7,8,9-Octachlorodibenzo-p-dioxin (OCDD)	Ca			
2,3,7,8-Tetrachlorodibenzofuran (TCDF)	Ca			
1,2,3,7,8-Pentachlorodibenzofuran (PeCDF)	Ca			
2,3,4,7,8-Pentachlorodibenzofuran (PeCDF)	Ca			
1,2,3,6,7,8-Hexachlorodibenzofuran (HxCDF)	Ca			
1,2,3,7,8,9-Hexachlorodibenzofuran (HxCDF)	Ca			
1,2,3,4,7,8-Hexachlorodibenzofuran (HxCDF)	Ca			
2,3,4,6,7,8-Hexachlorodibenzofuran (HxCDF)	Ca			
1,2,3,4,6,7,8-Heptachlorodibenzofuran (HpCDF)	Ca			
1,2,3,4,7,8,9-Heptachlorodibenzofuran (HpCDF)	Ca			
1,2,3,4,6,7,8,9-Octachlorodibenzofuran (OCDF)	Ca			

Summary of Groundwater Project Action Levels for Former Grant, Locust and Cavite Housing Areas

Analyte	Carcinogen (Ca) or Non-carcinogen (NC)	MCP Method 1 GW-3 Groundwater Standard (µg/L)	EPA Water Quality Criteria (µg/L)	Project Action Limit (µg/L)
TAL Metals 6010B				
Aluminum	NC			
Antimony	NC	8,000	640	640
Arsenic	Ca	900	0.14	0.14
Barium	NC	50,000		50,000
Beryllium	NC	50		50
Cadmium	Ca	4		4
Calcium				
Chromium	Ca	300		300
Cobalt	Ca			
Copper	NC			
Iron	NC			
Lead	NC	10		10
Magnesium	NC			
Manganese	NC		100	100
Nickel	NC	200	4,600	200
Potassium	NC			
Selenium	NC	100	4200	100
Silver	NC	7		7
Sodium	NC			
Thallium	NC	3,000	0.47	0.47
Vanadium	NC	4,000		4,000
Zinc	NC	900	26,000	900
TAL Metals 7470				
Mercury	NC	20	0.3	0.3
Explosives 8330/PDA				
1,3,5-Trinitrobenzene (1,3,5-TNB)	Ca			
1,3-Dinitrobenzene (1,3-DNB)	NC			
2,4,6-Trinitrotoluene (TNT)	Ca			
2,4-Diamino-6-nitrotoluene (2,4-Dam-6NT)				
2,4-Dinitrotoluene (2,4-DNT)	NC			
2,6-Diamino-4-nitrotoluene (2,6-DAm-4NT)				
2,6-Dinitrotoluene (2,6-DNT)	NC			
2-Amino-4,6-dinitrotoluene (2-Am-DNT)				
2-Nitrotoluene (2-NT)	NC			
3-Nitrotoluene (3-NT)	Ca			
4-Amino-2,6-dinitrotoluene (4-Am-DNT)				
4-Nitrotoluene (4-NT)	Ca			
HMX	NC			
Nitrobenzene (NB)	NC			
Nitroglycerin	Ca			
PETN				
Picric Acid (trinitrophenol)				
RDX (Cyclonite)	Ca			
Tetryl				

Notes:
TCL - Target Compound List
MCP - Massachusetts Contingency Plan
EPA - U.S. Environmental Protection Agency
EPA Water Quality Criteria - National Recommended Water Quality Criteria for Human Consumption of Organisms
MDL - method detection limit
PQL - practical quantitation limit
mg/kg - milligrams per kilogram

Table 6-1
Summary of Analytical Sampling for PA/SI, SSI, and Supplemental IA-6 Investigation
PASI/SSI Comprehensive Report
Study Area - Grant, Locust, and Cavite Housing Areas
Devens, Massachusetts

Location	Sample Location Type					Sample Analyses									
						Full Suite TCL/TAL									
	Surface Soil (0-0.5 ft)	Shallow Soil (0-1.5 ft)	Soil Boring (0-3, 3-10 ft)	Test Pit (≥2 ft)	Monitoring Well	TCL VOCs 8260B*	TCL SVOCs 8270C*	TCL PCBs 8082*	TCL Pesticides 8081A*	TAL Metals 6010C*	MassDEP EPH*	Explosives 8330	Perchlorate 8321A	Dioxins/ Furans 8290	Total Samples
PA/SI Investigation															
Grant Housing Area								238 (75)		74		20			
Locust Housing Area								9		6					
Cavite Housing Area								8		2					
PA/SI Total Samples								255 (75)		82		20			357
SSI Investigation															
IA-1 Impact Berm Area			3			2	2	2	2	6	2	2			
IA-1 Firing Positions Area			1							2					
IA-1 Subtotal			4			2	2	2	2	8	2	2			
IA-2 Impact Area			11			2	2	2	2	20	2	20	20		
IA-2 Intermediate Area			10			4	4	4	4	20		20	4		
IA-2 Firing Point Area	1		6			2	2	2	2	11		13			
IA-2 Wells & Piezometers			7		2	6	6	6	6	6	6	6	6	2	
IA-2 Subtotal	1		34		2	14	14	14	14	57	8	59	30	2	
IA-3 Impact Berm North Area		3	2			2	2	2	2	7					
IA-3 Hill Slope North Area		8								8					
IA-3 Impact Berm South Area		3	2			2	2	2	2	7					
IA-3 Hill Slope South Area		8								8					
IA-3 Subtotal		22	4			4	4	4	4	30					
IA-5 Upper Impact Berm Area			3							6					
IA-5 Lower Impact Berm Area		6	4			2	2	2	2	14					
IA-5 Firing Position Area			2							4					
IA-5 Subtotal		6	9			2	2	2	2	24					
IA-7 Impact Berm Area			2							4					
IA-7 Firing Position Area		6	2							10					
IA-7 Subtotal		6	4							14					
IA-8 Area			6			6									
IA-8 Wells & Piezometers			6		2	6	6	6	6	6	6	6	6	2	
IA-8 Subtotal			12		2	12	6	6	6	6	6	6	6	2	
IA-9 Cavite Housing Area			1	1		2	2	2	2	14	2			2	
IA-9 Subtotal			1	1		2	2	2	2	14	2			2	
IA-10 Grant Housing Area			4	2		8	8	8	8	32	2			8	
IA-10 Subtotal			4	2		8	8	8	8	32	2			8	
IA-11 Locust Housing Area		4	2			2	1	2	6	2	2			2	
IA-11 Subtotal			2			2	1	2	6	2	2			10	
SSI Total Samples	1	34	74	3	4	46	39	40	44	187	22	67	36	24	505
Supplemental Investigation, Bryant Range/IA-6															
Firing Line Area	8	1	2			3	5	3	3	13	3	2		2	34
Impact Berm Area	2		2	4		2	4	2	2	10	2	2	2	2	26
Short Shot Area	8	1				1	1	1	1	9	1				14
High Shot Area	8	1				1	1	1	1	9	1				14
Hill Slope Area	2	1				1	1	1	1	3	1				8
Range Floor Area	10	1				1	1	1	1	11	1				16
Northern Depression/Swale Area	10	1				1	1	1	1	11	1				16
Southern Depression/Swale Area	7					1	1	1	1	8	1				13
Airborne Dispersion Area	5									5					5
IA-6 Total Samples	60	6	4	4		11	15	11	11	79	11	4	2	4	148
Total Samples						57	54	295	55	348	33	91	38	28	971

Notes:

EPH = extractable petroleum hydrocarbons
PAH = polycyclic aromatic hydrocarbons
QA/QC = quality assurance/quality control
TAL = target analyte list
VOC = volatile organic compounds
MS/MSD = matrix spike/matrix spike duplicate
PCB = polychlorinated biphenyls
SVOC = semi-volatile organic compounds
TCL = target compound list
Numbers in () are the number of composite samples collected. Thirteen of these samples were subsequently reanalyzed as 5 grab samples.

Table 6-2a
IA-01 Summary of Screened Analytical Results

Analyte	Project Action Level	Analyte Category (units)	GR-IA01-SB01-1 0-3 ft		GR-IA01-SB02-1 0-3 ft		GR-IA01-SB03-1-M 0-3 ft		GR-IA01-SB04-1 0-3 ft		GR-IA01-SB01-1 3-10 ft		GR-IA01-SB02-1 3-10 ft		GR-IA01-SB03-1 3-10 ft		GR-IA01-SB03-1-D 3-10 ft	
Acetone	60,000	VOCs (µg/kg)			14	V							19	V				
Benzo(a)anthracene	620	PAH (µg/kg)			490	V							360	U				
Benzo(a)pyrene	62	PAH (µg/kg)			660	V							76	V				
Benzo(b)fluoranthene	620	PAH (µg/kg)			440	V							360	U				
Benzo(g,h,i)perylene	1,000	PAH (µg/kg)			380	V							360	U				
Benzo(k)fluoranthene	6,200	PAH (µg/kg)			440	V							360	U				
Chrysene	7,000	PAH (µg/kg)			550	V							362	U				
Dibenz(a,h)Anthracene	62	PAH (µg/kg)			70	V							14	U				
Fluoranthene	23,000	PAH (µg/kg)			1200	V							360	U				
Indeno(1,2,3-c,d)Pyrene	620	PAH (µg/kg)			580	V							360	U				
Phenanthrene	100,000	PAH (µg/kg)			500	V							360	U				
Pyrene	230,000	PAH (µg/kg)			910	V							360	U				
Aluminum	7,600	Metals (mg/kg)	6300	V	6200	V	9000	V	6500	V	6500	V	6300	V	6600	V	7300	V
Arsenic	0.39	Metals (mg/kg)	19	V	36	V	20	V	9.1	V	34	V	28	V	33	V	35	V
Barium	540	Metals (mg/kg)	19	V	20	V	13	V	10	V	22	V	21	V	20	V	22	V
Calcium	NE	Metals (mg/kg)	590	V	1200	V	550	V	580	V	410	V	700	V	610	V	560	V
Chromium	30	Metals (mg/kg)	12	V	17	V	14	V	7.2	V	16	V	18	V	17	V	18	V
Cobalt	500	Metals (mg/kg)	5.1	V	7.1	V	5.1	V	2.8	V	7.8	V	6.8	V	7.3	V	7.1	V
Copper	310	Metals (mg/kg)	11	V	16	V	8.3	V	3.8	V	18	V	15	V	18	V	20	V
Iron	2,300	Metals (mg/kg)	8600	V	12000	V	10000	V	6300	V	12000	V	11000	V	11000	V	12000	V
Lead	300	Metals (mg/kg)	12	V	9.7	V	8.3	V	8.1	V	11	V	7.4	V	7.4	V	6.9	V
Magnesium	NE	Metals (mg/kg)	1900	V	3000	V	2200	V	900	V	2900	V	3200	V	3100	V	3400	V
Manganese	180	Metals (mg/kg)	210	V	280	V	140	V	120	V	330	V	260	V	210	V	220	V
Mercury	2.3	Metals (mg/kg)	0.034	J	NA	J	0.01	J	0.017	J	0.014	J	0.0044	J	0.087	U	0.087	U
Nickel	20	Metals (mg/kg)	15	V	26	V	16	V	6.9	V	27	V	24	V	22	V	22	V
Potassium	NE	Metals (mg/kg)	710	V	890	V	560	V	280	V	1100	V	980	V	1000	V	1100	V
Vanadium	55	Metals (mg/kg)	9.9	V	11	V	12	V	7.8	V	11	V	11	V	11	V	12	V
Zinc	2,300	Metals (mg/kg)	25	V	25	V	21	V	14	V	27	V	22	V	21	V	22	V

Notes:
mg/kg = Milligrams per kilogram (parts per million)
µg/kg = Micrograms per kilogram (parts per billion)
V = Valid result; substance detected.
J = Estimated result; substance detected, but below the detection limit.
U = Substance not detected; detection limit listed.
Highlighted results were detected above their Project Action Level.

Table 6-2a
IA-01 Summary of Screened Analytical Results

Analyte	Project Action Level	Analyte Category (units)	GR-IA01-SB04-1-M 3-10 ft		PASI-GR-GB-302-1 3-10 ft		PASI-GR-GB-302-2 3-10 ft		PASI-GR-GB-305-1 3-10 ft		PASI-GR-GB-305-2 3-10 ft	
Acetone	60,000	VOCs (µg/kg)										
Benzo(a)anthracene	620	PAH (µg/kg)										
Benzo(a)pyrene	62	PAH (µg/kg)										
Benzo(b)fluoranthene	620	PAH (µg/kg)										
Benzo(g,h,i)perylene	1,000	PAH (µg/kg)										
Benzo(k)fluoranthene	6,200	PAH (µg/kg)										
Chrysene	7,000	PAH (µg/kg)										
Dibenz(a,h)Anthracene	62	PAH (µg/kg)										
Fluoranthene	23,000	PAH (µg/kg)										
Indeno(1,2,3-c,d)Pyrene	620	PAH (µg/kg)										
Phenanthrene	100,000	PAH (µg/kg)										
Pyrene	230,000	PAH (µg/kg)										
Aluminum	7,600	Metals (mg/kg)	4700	V	8270	V	9700	V	7690	V	10500	V
Arsenic	0.39	Metals (mg/kg)	46	V	27.3	V	25.3	V	17.9	V	28.2	V
Barium	540	Metals (mg/kg)	13	V								
Calcium	NE	Metals (mg/kg)	450	V								
Chromium	30	Metals (mg/kg)	14	V								
Cobalt	500	Metals (mg/kg)	5.4	V								
Copper	310	Metals (mg/kg)	8.7	V								
Iron	2,300	Metals (mg/kg)	8300	V	11500	V	11800	V	10400	V	14500	V
Lead	300	Metals (mg/kg)	5.8	V								
Magnesium	NE	Metals (mg/kg)	2200	V								
Manganese	180	Metals (mg/kg)	190	V	196	V	185	V	215	V	288	V
Mercury	2.3	Metals (mg/kg)	0.086	U								
Nickel	20	Metals (mg/kg)	16	V	23.7	V	21.5	V	12.8	V	26.3	V
Potassium	NE	Metals (mg/kg)	720	V								
Vanadium	55	Metals (mg/kg)	8.1	V								
Zinc	2,300	Metals (mg/kg)	15	V								

Notes:
mg/kg = Milligrams per kilogram (parts per million)
µg/kg = Micrograms per kilogram (parts per billion)
V = Valid result; substance detected.
J = Estimated result; substance detected, but below the detection limit.
U = Substance not detected; detection limit listed.
Highlighted results were detected above their Project Action Level.

Table 6-2b
IA-1 Hazard Screening Calculation Summary
PASI/SSI Comprehensive Report
Study Area - Grant, Locust, and Cavite Housing Areas
Devens, Massachusetts

Analyte	Analyte Category (units)	Carcinogen (Ca) or Non-carcinogen (NC)	EPA Region IX Residential Soil PRG	Average Value	Maximum Value	95% UCL	Exposure Point Concentration (EPC)[1]	Screening Cancer Risk (SCR)	Screening Hazard Quotient (SHQ)
Benzo(a)pyrene	PAH (µg/kg)	Ca	62	368	660	611	611	1.E-05	
Dibenz(a,h)Anthracene	PAH (µg/kg)	Ca	62	42	70	64	64	1.E-06	
Aluminum	Metals (mg/kg)	NC	76,000	7,413	10,500	8,285	8,285		0.11
Arsenic	Metals (mg/kg)	Ca	0.39	27	46	32	32	8.E-05	
Iron	Metals (mg/kg)	NC	23,000	10,700	14,500	11,822	11,822		0.51
Manganese	Metals (mg/kg)	NC	1,800	220	330	251	251		0.14
Nickel	Metals (mg/kg)	NC	1,600	10	27	23	23		0.01
							Total	9.E-05	0.78

[1] = Lesser of Maximum or 95% UCL used.
PAH = polycyclic aromatic hydrocarbons
PRG = Preliminary Remediation Goals
UCL = Upper Confident Limit
PCB = polychlorinated biphenyls
NA = not applicable
mg/kg = milligrams per kilogram
µg/kg = micrograms per kilogram

Summary

Total Screening Cancer Risk: 9.E-05	TSCR>1E-04? No
Total Screening Hazard Quotient: 1	TSHI>1? No
Arsenic concentration is consistent with background.	
TSCR due to Arsenic: 8.E-05	TSCR w/o Arsenic: 1.E-05
TSCR due to Arsenic is <1E-04.	TSCR w/o Arsenic is <1E-04.
Total PCBs concentration is less than 1 mg/kg.	
TSCR w/o PCBs: NA	TSCR w/o PCBs: 8.E-05
	TSCR w/o PCBs is <1E-04.
PAHs concentration(s) are consistent with background.	
TSCR due to PAHs: 1.E-05	TSCR w/o to PAHs: 8.E-05
TSCR due to PAHs is <1E-04.	TSCR w/o PAHs is <1E-04.

Table 6-3a
IA-2 Summary of Screened Analytical Results
PASI/SSI Comprehensive Report
Study Area - Grant, Locust, and Cavite Housing Areas
Devens, Massachusetts

Analyte	Project Action Level	Analyte Category (units)	GR-IA01-SB03-1 3-10 ft	GR-IA01-SB03-1-D 3-10 ft	GR-IA01-SB03-1-M 0-3 ft	GR-IA02-SB01-1 0-3 ft	GR-IA02-SB01-1 3-10 ft	GR-IA02-SB02-1 0-3 ft	GR-IA02-SB02-1-M 3-10 ft	GR-IA02-SB03-1 0-3 ft	GR-IA02-SB03-1 3-10 ft
Aluminum	7,600	Metals (mg/kg)	6600 V	7300 V	9000 V	7700 V	7100 V	11000 V	3800 V	6500 V	3900 V
Arsenic	0.39	Metals (mg/kg)	33 V	35 V	20 V	14 V	17 V	15 V	18 V	17 V	19 V
Barium	540	Metals (mg/kg)	20 V	22 V	13 V	18 V	29 V	49 V	16 V	14 V	12 V
Calcium	NE	Metals (mg/kg)	610 V	560 V	550 V	110 V	320 V	270 V	350 V	160 V	1100 V
Chromium	30	Metals (mg/kg)	17 V	18 V	14 V	10 V	10 V	12 V	6.2 V	8.8 V	9.2 V
Cobalt	500	Metals (mg/kg)	7.3 V	7.1 V	5.1 V	3.9 V	5.8 V	7.2 V	3.9 V	3.7 V	4.3 V
Copper	310	Metals (mg/kg)	18 V	20 V	8.3 V	5.8 V	10 V	13 V	8.9 V	5 V	9.2 V
Iron	2,300	Metals (mg/kg)	11000 V	12000 V	10000 V	8600 V	9800 V	13000 V	6000 V	7500 V	7500 V
Lead	300	Metals (mg/kg)	7.4 V	6.9 V	8.3 V	6.9 V	6.2 V	6.6 V	4.6 V	7.4 V	5.4 V
Magnesium	NE	Metals (mg/kg)	3100 V	3400 V	2200 V	1300 V	2000 V	2300 V	1100 V	1100 V	1700 V
Manganese	180	Metals (mg/kg)	210 V	220 V	140 V	240 V	160 V	180 V	120 V	220 V	150 V
Mercury	2.3	Metals (mg/kg)	0.087 U	0.087 U	0.01 J	0.018 J	0.083 U	0.0065 J	0.079 U	0.017 J	0.084 U
Nickel	20	Metals (mg/kg)	22 V	22 V	16 V	9.3 V	12 V	12 V	11 V	10 V	15 V
Potassium	NE	Metals (mg/kg)	1000 V	1100 V	560 V	440 V	1300 V	1900 V	540 V	150 V	540 V
Silver	39	Metals (mg/kg)	0.43 U	0.43 U	0.45 U	0.46 U	0.42 U	0.45 U	0.43 U	0.46 U	0.41 U
Sodium	NE	Metals (mg/kg)	86 U	86 U	91 U	93 U	85 U	90 U	87 U	92 U	83 U
Thallium	0.52	Metals (mg/kg)	2.1 U	2.1 U	2.3 U	2.3 U	2.1 U	2.2 U	2.2 U	2.3 U	2.1 U
Vanadium	55	Metals (mg/kg)	11 V	12 V	12 V	10 V	12 V	17 V	5.9 V	8.9 V	6.8 V
Zinc	2,300	Metals (mg/kg)	21 V	22 V	21 V	18 V	22 V	27 V	15 V	15 V	15 V
Total TEQ	3.9	CDD/CDF (ng/kg)									
Benzo(a)pyrene	62	PAH (µg/kg)				16 U	14 U	15 U	14 U		
4,4-DDE	170	Pesticides (µg/kg)				3.88 U	3.58 U	14.8 V	3.62 U		
4,4-DDT	170	Pesticides (µg/kg)				6.87 V	3.58 U	19.4 V	3.62 U		
Aldrin	29	Pesticides (µg/kg)				3.88 U	3.58 U	3.79 U	3.62 U		
Dieldrin	30	Pesticides (µg/kg)				3.88 U	3.58 U	3.79 U	3.62 U		
Total PCBs	220	PCBs (µg/kg)				38.8 U	35.8 U	37.9 U	36.2 U		
Aliphatic Hydrocarbons (C_{19}-C_{36})	3,000	TPH (mg/kg)				7.75 U	7.17 U	7.58 U	7.25 U		
Aromatic Hydrocarbons (C_{11}-C_{22})	800	TPH (mg/kg)				7.75 U	7.17 U	7.58 U	7.25 U		
Acetone	60,000	VOCs (µg/kg)				28 V	7 U	7.8 V	17 V		
Carbon Disulfide	36,000	VOCs (µg/kg)				8.1 U	7 U	6.9 U	7.2 U		
Toluene	52	VOCs (µg/kg)				1.2 U	1 U	1 U	1.1 U		

Analyte	Project Action Level	Analyte Category (units)	GRB-03-04X 0-3 ft	GRB-03-04X 3-6 ft	GRB-03-04X 6-10 ft	GRB-03-06X 0-3 ft	GRB-03-06X 3-6 ft	GRB-03-06X 6-10 ft	GRB-03-07X 0-3 ft	GRB-03-07X 3-6 ft	GRB-03-07X 6-10 ft
Aluminum	7,600	Metals (mg/kg)	8100 V	7700 V	3700 V	6500 V	4200 V	3000 V	5200 V	2900 V	5000 V
Arsenic	0.39	Metals (mg/kg)	12 V	18 V	18 V	12 V	10 V	9 V	34 V	17 V	32 V
Iron	2,300	Metals (mg/kg)	10000 V	10000 V	21000 V	8100 V	7300 V	5300 V	12000 V	6700 V	12000 V
Manganese	180	Metals (mg/kg)	320 V	300 V	640 V	91 V	120 V	99 V	220 V	110 V	230 V
Nickel	20	Metals (mg/kg)	12 V	17 V	57 V	9.9 V	11 V	7.6 V	32 V	14 V	27 V
Arochlor 1260	220	PCBs (µg/kg)									

Notes:
mg/kg = Milligrams per kilogram (parts per million)
µg/kg = Micrograms per kilogram (parts per billion)
ng/kg = Nanograms per kilogram (parts per trillion)
V = Valid result; substance detected.
J = Estimated result; substance detected, but below the detection limit.
U = Substance not detected; detection limit listed.
Highlighted results were detected above their Project Action Level.

Table 6-3a
IA-2 Summary of Screened Analytical Results
PASI/SSI Comprehensive Report
Study Area - Grant, Locust, and Cavite Housing Areas
Devens, Massachusetts

Analyte	Project Action Level	Analyte Category (units)	GR-IA02-SB03-1-D 3-10 ft		GR-IA02-SB04-1 0-3 ft		GR-IA02-SB04-1 3-10 ft		GR-IA02-SB04-1-D 0-3 ft		GR-IA02-SB05-1 0-3 ft		GR-IA02-SB05-1 3-10 ft		GR-IA02-SB06-1 0-3 ft		GR-IA02-SB06-1 3-10 ft		GR-IA02-SB07-1 0-3 ft		GR-IA02-SB07-1 3-10 ft		GR-IA02-SB08-1 0-3 ft	
Aluminum	7,600	Metals (mg/kg)	3600	V	7100	V	5100	V	7600	V	6100	V	2900	V	7300	V	7800	V	10000	V	8700	V	8600	V
Arsenic	0.39	Metals (mg/kg)	19	V	29	V	27	V	28	V	13	V	11	V	27	V	31	V	34	V	24	V	21	V
Barium	540	Metals (mg/kg)	10	V	18	V	16	V	20	V	11	V	9.9	V	21	V	29	V	24	V	22	V	12	V
Calcium	NE	Metals (mg/kg)	1200	V	250	V	430	V	360	V	970	V	2400	V	420	V	610	V	460	V	240	V	510	V
Chromium	30	Metals (mg/kg)	8.9	V	14	V	16	V	15	V	7.8	V	5.9	V	22	V	24	V	25	V	16	V	15	V
Cobalt	500	Metals (mg/kg)	4.2	V	7	V	6	V	6.1	V	3.1	V	2.6	V	8	V	9.5	V	7.5	V	6.7	V	6.2	V
Copper	310	Metals (mg/kg)	8.5	V	17	V	12	V	14	V	5.7	V	5.7	V	12	V	20	V	12	V	12	V	8.1	V
Iron	2,300	Metals (mg/kg)	7000	V	12000	V	9600	V	11000	V	6800	V	4800	V	10000	V	14000	V	14000	V	11000	V	10000	V
Lead	300	Metals (mg/kg)	5.7	V	14	V	7	V	15	V	6	V	3.4	V	9.7	V	10	V	18	V	7.3	V	7.3	V
Magnesium	NE	Metals (mg/kg)	1500	V	2400	V	2900	V	2400	V	1400	V	2100	V	3400	V	4300	V	3600	V	2700	V	2400	V
Manganese	180	Metals (mg/kg)	160	V	520	V	200	V	560	V	120	V	88	V	260	V	350	V	390	V	210	V	130	V
Mercury	2.3	Metals (mg/kg)	0.082	U	0.039	J	0.079	U	0.046	J	0.01	J	0.084	U	0.014	J	0.083	U	0.049	J	0.0082	J	0.014	J
Nickel	20	Metals (mg/kg)	14	V	24	V	20	V	22	V	8.3	V	7.8	V	25	V	32	V	26	V	19	V	18	V
Potassium	NE	Metals (mg/kg)	400	V	530	V	780	V	510	V	220	V	430	V	1200	V	1600	V	700	V	670	V	750	V
Silver	39	Metals (mg/kg)	0.42	U	0.48	U	0.42	U	0.49	U	0.45	U	0.42	U	0.44	U	0.42	U	0.47	U	0.45	U	0.44	U
Sodium	NE	Metals (mg/kg)	84	U	97	U	84	U	98	U	89	U	84	U	87	U	85	U	95	U	90	U	87	U
Thallium	0.52	Metals (mg/kg)	2.1	U	2.4	U	2.1	U	2.4	U	2.2	U	2.1	U	2.2	U	2.1	U	2.4	U	2.2	U	2.2	U
Vanadium	55	Metals (mg/kg)	6	V	12	V	9.8	V	12	V	7.3	V	4.6	V	13	V	15	V	19	V	13	V	12	V
Zinc	2,300	Metals (mg/kg)	14	V	24	V	19	V	23	V	13	V	12	V	22	V	28	V	30	V	20	V	18	V
Total TEQ	3.9	CDD/CDF (ng/kg)																						
Benzo(a)pyrene	62	PAH (µg/kg)																						
4,4-DDE	170	Pesticides (µg/kg)																						
4,4-DDT	170	Pesticides (µg/kg)																						
Aldrin	29	Pesticides (µg/kg)																						
Dieldrin	30	Pesticides (µg/kg)																						
Total PCBs	220	PCBs (µg/kg)																						
Aliphatic Hydrocarbons (C_{19}-C_{36})	3,000	TPH (mg/kg)																						
Aromatic Hydrocarbons (C_{11}-C_{22})	800	TPH (mg/kg)																						
Acetone	60,000	VOCs (µg/kg)																						
Carbon Disulfide	36,000	VOCs (µg/kg)																						
Toluene	52	VOCs (µg/kg)																						

Analyte	Project Action Level	Analyte Category (units)	PASI-GR-CO-045-1 0-3 ft		PASI-GR-CO-046-1 0-3 ft		PASI-GR-CO-047-1 0-3 ft		PASI-GR-CO-048-1 0-3 ft		PASI-GR-CO-049-1 0-3 ft		PASI-GR-CO-050-1 0-3 ft		PASI-GR-CO-051-1 0-3 ft		PASI-GR-CO-052-1 0-3 ft		PASI-GR-CO-053-1 0-3 ft		PASI-GR-CO-054-1 0-3 ft		PASI-GR-CO-055-1 0-3 ft	
Aluminum	7,600	Metals (mg/kg)																						
Arsenic	0.39	Metals (mg/kg)																						
Iron	2,300	Metals (mg/kg)																						
Manganese	180	Metals (mg/kg)																						
Nickel	20	Metals (mg/kg)																						
Arochlor 1260	220	PCBs (µg/kg)	26	U	28	U	28	U	27	U	26	U	26	U	26	U	27	U	26	U	27	U	27	U

Notes:
mg/kg = Milligrams per kilogram (parts per million)
µg/kg = Micrograms per kilogram (parts per billion)
ng/kg = Nanograms per kilogram (parts per trillion)
V = Valid result; substance detected.
J = Estimated result; substance detected, but below the detection limit.
U = Substance not detected; detection limit listed.
Highlighted results were detected above their Project Action Level.

Table 6-3a
IA-2 Summary of Screened Analytical Results
PASI/SSI Comprehensive Report
Study Area - Grant, Locust, and Cavite Housing Areas
Devens, Massachusetts

Analyte	Project Action Level	Analyte Category (units)	GR-IA02-SB08-1 3-10 ft	GR-IA02-SB08-1-D 0-3 ft	GR-IA02-SB09-1 0-3 ft	GR-IA02-SB09-1 3-10 ft	GR-IA02-SB10-1 0-3 ft	GR-IA02-SB10-1 3-10 ft	GR-IA02-SB10-1-D 3-10 ft	GR-IA02-SB11-1 0-3 ft	GR-IA02-SB11-1-M 3-10 ft	GR-IA02-SB12-1 0-3 ft
Aluminum	7,600	Metals (mg/kg)	5200 V	8400 V	13000 V	7400 V	9500 V	7300 V	6800 V	14000 V	13000 V	7000 V
Arsenic	0.39	Metals (mg/kg)	24 V	20 V	38 V	30 V	37 V	40 V	38 V	30 V	38 V	24 V
Barium	540	Metals (mg/kg)	17 V	12 V	40 V	26 V	21 V	23 V	20 V	21 V	52 V	19 V
Calcium	NE	Metals (mg/kg)	590 V	180 V	1100 V	1200 V	480 V	500 V	490 V	410 V	700 V	690 V
Chromium	30	Metals (mg/kg)	16 V	14 V	32 V	23 V	26 V	22 V	21 V	30 V	40 V	19 V
Cobalt	500	Metals (mg/kg)	6.3 V	5.2 V	9.5 V	8.3 V	7.9 V	7.7 V	7.6 V	7.8 V	10 V	5.2 V
Copper	310	Metals (mg/kg)	10 V	7.6 V	24 V	16 V	27 V	16 V	16 V	36 V	19 V	14 V
Iron	2,300	Metals (mg/kg)	9300 V	9700 V	16000 V	13000 V	13000 V	12000 V	12000 V	17000 V	19000 V	9700 V
Lead	300	Metals (mg/kg)	6.5 V	7 V	29 V	9 V	13 V	8.1 V	9.6 V	24 V	11 V	23 V
Magnesium	NE	Metals (mg/kg)	2300 V	2200 V	5500 V	4300 V	4200 V	3900 V	3700 V	5100 V	8200 V	2500 V
Manganese	180	Metals (mg/kg)	200 V	97 V	470 V	280 V	220 V	260 V	270 V	230 V	340 V	170 V
Mercury	2.3	Metals (mg/kg)	0.086 U	0.023 J	0.06 J	0.084 U	0.1 V	0.015 J	0.073 U	0.34 V	0.079 U	0.079 J
Nickel	20	Metals (mg/kg)	22 V	15 V	31 V	27 V	31 V	27 V	27 V	29 V	37 V	22 V
Potassium	NE	Metals (mg/kg)	980 V	680 V	2000 V	1700 V	1400 V	1200 V	1100 V	870 V	3400 V	690 V
Silver	39	Metals (mg/kg)	0.42 U	0.44 U	0.51 U	0.42 U	0.45 U	0.42 U	0.42 U	0.5 U	0.43 U	0.59 U
Sodium	NE	Metals (mg/kg)	84 U	88 U	100 U	84 U	90 U	85 U	85 U	100 U	86 U	120 U
Thallium	0.52	Metals (mg/kg)	2.1 U	2.2 U	2.6 U	2.1 U	2.2 U	2.1 U	2.1 U	2.5 U	2.2 U	0.65 J
Vanadium	55	Metals (mg/kg)	8.9 V	11 V	24 V	15 V	15 V	14 V	13 V	20 V	24 V	13 V
Zinc	2,300	Metals (mg/kg)	18 V	16 V	46 V	30 V	33 V	26 V	25 V	46 V	37 V	38 V
Total TEQ	3.9	CDD/CDF (ng/kg)										
Benzo(a)pyrene	62	PAH (µg/kg)										
4,4-DDE	170	Pesticides (µg/kg)										
4,4-DDT	170	Pesticides (µg/kg)										
Aldrin	29	Pesticides (µg/kg)										
Dieldrin	30	Pesticides (µg/kg)										
Total PCBs	220	PCBs (µg/kg)										
Aliphatic Hydrocarbons (C_{19}-C_{36})	3,000	TPH (mg/kg)										
Aromatic Hydrocarbons (C_{11}-C_{22})	800	TPH (mg/kg)										
Acetone	60,000	VOCs (µg/kg)										
Carbon Disulfide	36,000	VOCs (µg/kg)										
Toluene	52	VOCs (µg/kg)										

Analyte	Project Action Level	Analyte Category (units)	PASI-GR-CO-056-1 0-3 ft	PASI-GR-CO-057-1 0-3 ft	PASI-GR-CO-058-1 0-3 ft	PASI-GR-CO-068-1 0-3 ft	PASI-GR-CO-069-1 0-3 ft	PASI-GR-CO-070-1 0-3 ft	PASI-GR-CO-071-1 0-3 ft	PASI-GR-CO-071-1D 0-3 ft	PASI-GR-CO-072-1 0-3 ft	PASI-GR-CO-073-1 0-3 ft
Aluminum	7,600	Metals (mg/kg)										
Arsenic	0.39	Metals (mg/kg)										
Iron	2,300	Metals (mg/kg)										
Manganese	180	Metals (mg/kg)										
Nickel	20	Metals (mg/kg)										
Arochlor 1260	220	PCBs (µg/kg)	26 U	28 U	26 U	28 U	26 U	24 U	26 U	26 U	25 U	26 U

Notes:
mg/kg = Milligrams per kilogram (parts per million)
µg/kg = Micrograms per kilogram (parts per billion)
ng/kg = Nanograms per kilogram (parts per trillion)
V = Valid result; substance detected.
J = Estimated result; substance detected, but below the detection limit.
U = Substance not detected; detection limit listed.
Highlighted results were detected above their Project Action Level.

Table 6-3a
IA-2 Summary of Screened Analytical Results
PASI/SSI Comprehensive Report
Study Area - Grant, Locust, and Cavite Housing Areas
Devens, Massachusetts

Analyte	Project Action Level	Analyte Category (units)	GR-IA02-SB12-1 3-10 ft	GR-IA02-SB13-1 0-3 ft	GR-IA02-SB13-1 3-10 ft	GR-IA02-SB13-1-D 3-10 ft	GR-IA02-SB14-1 0-3 ft	GR-IA02-SB14-1 3-10 ft	GR-IA02-SB14-1-D 0-3 ft	GR-IA02-SB15-1 0-3 ft	GR-IA02-SB15-1 3-10 ft
Aluminum	7,600	Metals (mg/kg)	10000 V	7500 V	2700 V	2900 V	9000 V	2200 V	9200 V	6500 V	2500 V
Arsenic	0.39	Metals (mg/kg)	42 V	13 V	5.3 V	6.3 V	9.7 V	8.8 V	8.9 V	9.2 V	8.9 V
Barium	540	Metals (mg/kg)	38 V	17 V	7.6 V	9.6 V	16 V	7.8 V	16 V	11 V	8.4 V
Calcium	NE	Metals (mg/kg)	780 V	380 V	260 V	310 V	150 V	220 V	230 V	250 V	220 V
Chromium	30	Metals (mg/kg)	32 V	13 V	4.5 V	4.8 V	11 V	4.9 V	12 V	8.1 V	5.1 V
Cobalt	500	Metals (mg/kg)	13 V	3.6 V	2.4 V	2.6 V	2.9 V	2.4 V	2.5 V	2.9 V	2.7 V
Copper	310	Metals (mg/kg)	21 V	5.6 V	3.6 V	4 V	5.6 V	6 V	5 V	5 V	5.7 V
Iron	2,300	Metals (mg/kg)	17000 V	7800 V	4200 V	4600 V	7200 V	3700 V	7200 V	5700 V	3800 V
Lead	300	Metals (mg/kg)	13 V	7 V	2.5 V	2.6 V	5.9 V	3.3 V	7.8 V	9.4 V	3.6 V
Magnesium	NE	Metals (mg/kg)	6000 V	2100 V	900 V	970 V	1200 V	700 V	1200 V	1000 V	730 V
Manganese	180	Metals (mg/kg)	500 V	140 V	83 V	98 V	70 V	82 V	60 V	100 V	84 V
Mercury	2.3	Metals (mg/kg)	0.082 U	0.013 J	0.086 U	0.076 U	0.023 J	0.085 U	0.028 J	0.012 J	0.082 U
Nickel	20	Metals (mg/kg)	37 V	9.7 V	4.9 V	5.3 V	6.7 V	4.9 V	6.2 V	6.3 V	6 V
Potassium	NE	Metals (mg/kg)	2500 V	780 V	400 V	460 V	530 V	330 V	460 V	320 V	310 V
Silver	39	Metals (mg/kg)	0.44 U	0.44 U	0.42 U	0.42 U	0.46 U	0.42 U	0.46 U	0.45 U	0.41 U
Sodium	NE	Metals (mg/kg)	88 U	87 U	84 U	84 U	92 U	84 U	93 U	90 U	82 U
Thallium	0.52	Metals (mg/kg)	0.67 J	2.2 U	2.1 U	2.1 U	2.3 U	2.1 U	2.3 U	2.2 U	2 U
Vanadium	55	Metals (mg/kg)	23 V	11 V	4.1 V	4.8 V	10 V	3.6 V	11 V	7.8 V	3.7 V
Zinc	2,300	Metals (mg/kg)	38 V	16 V	9.2 V	10 V	13 V	9.3 V	13 V	13 V	9.7 V
Total TEQ	3.9	CDD/CDF (ng/kg)									
Benzo(a)pyrene	62	PAH (µg/kg)		27 V	14 U	14 U					
4,4-DDE	170	Pesticides (µg/kg)		4.86 V	3.51 U	3.51 U					
4,4-DDT	170	Pesticides (µg/kg)		4.78 V	3.51 U	3.51 U					
Aldrin	29	Pesticides (µg/kg)		3.66 U	3.51 U	3.51 U					
Dieldrin	30	Pesticides (µg/kg)		3.66 U	3.51 U	3.51 U					
Total PCBs	220	PCBs (µg/kg)		36.6 U	35.1 U	35.1 U					
Aliphatic Hydrocarbons (C_{19}-C_{36})	3,000	TPH (mg/kg)		7.33 U	7.02 U	7.02 U					
Aromatic Hydrocarbons (C_{11}-C_{22})	800	TPH (mg/kg)		7.33 U	7.02 U	7.02 U					
Acetone	60,000	VOCs (µg/kg)		7.5 U	10 U	9.2 U					
Carbon Disulfide	36,000	VOCs (µg/kg)		7.5 U	10 U	9.2 U					
Toluene	52	VOCs (µg/kg)		1.1 U	1.6 U	1.4 U					

Analyte	Project Action Level	Analyte Category (units)	PASI-GR-CO-074-1 0-3 ft	PASI-GR-CO-075-1 0-3 ft	PASI-GR-GB-225-1 1-4 ft	PASI-GR-GB-226-1 0.5-3.5 ft	PASI-GR-GB-227-1 0.66-3.66 ft	PASI-GR-GB-228-1 0.75-3.75 ft	PASI-GR-GB-229-1 0.66-3.66 ft	PASI-GR-GB-230-1 0.66-3.66 ft	PASI-GR-GB-231-1 1-4 ft
Aluminum	7,600	Metals (mg/kg)									
Arsenic	0.39	Metals (mg/kg)									
Iron	2,300	Metals (mg/kg)									
Manganese	180	Metals (mg/kg)									
Nickel	20	Metals (mg/kg)									
Arochlor 1260	220	PCBs (µg/kg)	25 U	25 U	11 U	28 U	10 U	8.3 U	8.5 U	8.4 U	9.1 U

Notes:
mg/kg = Milligrams per kilogram (parts per million)
µg/kg = Micrograms per kilogram (parts per billion)
ng/kg = Nanograms per kilogram (parts per trillion)
V = Valid result; substance detected.
J = Estimated result; substance detected, but below the detection limit.
U = Substance not detected; detection limit listed.
Highlighted results were detected above their Project Action Level.

Table 6-3a
IA-2 Summary of Screened Analytical Results
PASI/SSI Comprehensive Report
Study Area - Grant, Locust, and Cavite Housing Areas
Devens, Massachusetts

Analyte	Project Action Level	Analyte Category (units)	GR-IA02-SB16-1 0-3 ft		GR-IA02-SB16-1 3-10 ft		GR-IA02-SB17-1 0-3 ft		GR-IA02-SB17-1 3-10 ft		GR-IA02-SB18-1 0-3 ft		GR-IA02-SB18-1 3-10 ft		GR-IA02-SB18-1-D 3-10 ft		GR-IA02-SB19-1 0-3 ft		GR-IA02-SB19-1 3-10 ft	
Aluminum	7,600	Metals (mg/kg)	11000	V	6600	V	6800	V	7800	V	6400	V	7000	V	6800	V	6200	V	7900	V
Arsenic	0.39	Metals (mg/kg)	27	V	45	V	11	V	28	V	11	V	17	V	21	V	13	V	23	V
Barium	540	Metals (mg/kg)	28	V	24	V	12	V	32	V	10	V	15	V	13	V	10	V	20	V
Calcium	NE	Metals (mg/kg)	460	V	670	V	250	V	710	V	300	V	330	V	300	V	330	V	740	V
Chromium	30	Metals (mg/kg)	28	V	24	V	9.1	V	21	V	8.8	V	19	V	17	V	9.3	V	21	V
Cobalt	500	Metals (mg/kg)	7.8	V	10	V	3	V	7.9	V	3.2	V	4.9	V	4.9	V	3.6	V	7	V
Copper	310	Metals (mg/kg)	12	V	15	V	41	V	25	V	4.5	V	8.6	V	9.7	V	4.8	V	11	V
Iron	2,300	Metals (mg/kg)	14000	V	14000	V	6700	V	12000	V	6800	V	11000	V	12000	V	7700	V	12000	V
Lead	300	Metals (mg/kg)	11	V	8.8	V	6.4	V	6.5	V	4.4	V	4.8	V	5.6	V	8.1	V	5	V
Magnesium	NE	Metals (mg/kg)	4700	V	3600	V	1200	V	3700	V	1400	V	3800	V	3700	V	1800	V	4300	V
Manganese	180	Metals (mg/kg)	220	V	350	V	100	V	240	V	100	V	180	V	200	V	100	V	210	V
Mercury	2.3	Metals (mg/kg)	0.032	J	0.088	U	0.016	J	0.0032	J	0.011	J	0.09	V	0.076	U	0.0086	J	0.082	U
Nickel	20	Metals (mg/kg)	26	V	32	V	9.1	V	26	V	8.7	V	18	V	18	V	9.8	V	24	V
Potassium	NE	Metals (mg/kg)	2300	V	1700	V	300	V	1500	V	430	V	680	V	560	V	510	V	1100	V
Silver	39	Metals (mg/kg)	0.46	U	0.42	U	0.45	U	0.44	U	0.44	U	0.43	U	0.42	U	0.45	U	0.42	U
Sodium	NE	Metals (mg/kg)	92	U	84	U	90	U	87	U	89	U	86	U	84	U	90	U	84	U
Thallium	0.52	Metals (mg/kg)	2.3	U	2.1	U	2.2	U	2.2	U	2.2	U	2.1	U	2.1	U	2.2	U	2.1	U
Vanadium	55	Metals (mg/kg)	19	V	12	V	8.2	V	14	V	8	V	12	V	11	V	8.4	V	12	V
Zinc	2,300	Metals (mg/kg)	26	V	26	V	13	V	23	V	13	V	21	V	22	V	14	V	24	V
Total TEQ	3.9	CDD/CDF (ng/kg)																		
Benzo(a)pyrene	62	PAH (µg/kg)																		
4,4-DDE	170	Pesticides (µg/kg)																		
4,4-DDT	170	Pesticides (µg/kg)																		
Aldrin	29	Pesticides (µg/kg)																		
Dieldrin	30	Pesticides (µg/kg)																		
Total PCBs	220	PCBs (µg/kg)																		
Aliphatic Hydrocarbons (C_{19}-C_{36})	3,000	TPH (mg/kg)																		
Aromatic Hydrocarbons (C_{11}-C_{22})	800	TPH (mg/kg)																		
Acetone	60,000	VOCs (µg/kg)																		
Carbon Disulfide	36,000	VOCs (µg/kg)																		
Toluene	52	VOCs (µg/kg)																		

Analyte	Project Action Level	Analyte Category (units)	PASI-GR-GB-232-1 0.83-3.83 ft		PASI-GR-GB-235-1 0.66-3.66 ft		PASI-GR-GB-236-1 0.83-3.83 ft		PASI-GR-GB-237-1 0.66-3.66 ft		PASI-GR-GB-238-1 0.75-3.75 ft		PASI-GR-GB-239-1 0.66-3.66 ft		PASI-GR-GB-240-1 0.33-3.33 ft		PASI-GR-GB-240-1D 0.33-3.33 ft		PASI-GR-GB-241-1 0.5-3.5 ft	
Aluminum	7,600	Metals (mg/kg)																		
Arsenic	0.39	Metals (mg/kg)																		
Iron	2,300	Metals (mg/kg)																		
Manganese	180	Metals (mg/kg)																		
Nickel	20	Metals (mg/kg)																		
Arochlor 1260	220	PCBs (µg/kg)	42	V	11	U	30	U	27	U	29	U	26	U	28	U	27	U	26	U

Notes:
mg/kg = Milligrams per kilogram (parts per million)
µg/kg = Micrograms per kilogram (parts per billion)
ng/kg = Nanograms per kilogram (parts per trillion)
V = Valid result; substance detected.
J = Estimated result; substance detected, but below the detection limit.
U = Substance not detected; detection limit listed.
Highlighted results were detected above their Project Action Level.

Table 6-3a
IA-2 Summary of Screened Analytical Results
PASI/SSI Comprehensive Report
Study Area - Grant, Locust, and Cavite Housing Areas
Devens, Massachusetts

Analyte	Project Action Level	Analyte Category (units)	GR-IA02-SB20-1 0-3 ft	GR-IA02-SB20-1-M 3-10 ft	GR-IA02-SB21-1 0-3 ft	GR-IA02-SB23-1 0-3 ft	GR-IA02-SB23-1 3-10 ft	GR-IA02-SB23-1-D 3-10 ft	GR-IA02-SB24-1 0-3 ft	GR-IA02-SB24-1 3-10 ft	GR-IA02-SB25-1 0-3 ft
Aluminum	7,600	Metals (mg/kg)	5100 V	5700 V	5900 V	13000 V	12000 V	12000 V	12000 V	14000 V	14000 V
Arsenic	0.39	Metals (mg/kg)	9 V	32 V	10 V	19 V	28 V	28 V	30 V	19 V	23 V
Barium	540	Metals (mg/kg)	15 V	21 V	10 V	27 V	20 V	19 V	31 V	45 V	32 V
Calcium	NE	Metals (mg/kg)	750 V	490 V	290 V	1800 V	510 V	580 V	890 V	910 V	420 V
Chromium	30	Metals (mg/kg)	6.3 V	16 V	9.5 V	18 V	24 V	23 V	26 V	21 V	20 V
Cobalt	500	Metals (mg/kg)	2.7 V	5.9 V	3.3 V	7.2 V	8.2 V	7.6 V	8.5 V	8.8 V	8.9 V
Copper	310	Metals (mg/kg)	4.2 V	13 V	4.2 V	15 V	16 V	14 V	16 V	16 V	17 V
Iron	2,300	Metals (mg/kg)	5900 V	10000 V	6800 V	16000 V	17000 V	16000 V	16000 V	20000 V	20000 V
Lead	300	Metals (mg/kg)	12 V	7 V	5.1 V	13 V	10 V	10 V	11 V	9.1 V	12 V
Magnesium	NE	Metals (mg/kg)	1000 V	2500 V	1500 V	3800 V	5000 V	4900 V	4800 V	4600 V	4400 V
Manganese	180	Metals (mg/kg)	140 V	200 V	100 V	310 V	280 V	250 V	290 V	330 V	360 V
Mercury	2.3	Metals (mg/kg)	0.014 J	0.088 U	0.0069 J	0.018 J	0.011 J	0.008 J	0.013 J	0.092 U	0.0084 J
Nickel	20	Metals (mg/kg)	6.9 V	18 V	9.3 V	25 V	27 V	25 V	27 V	27 V	27 V
Potassium	NE	Metals (mg/kg)	400 V	800 V	350 V	1000 V	1000 V	960 V	1400 V	2200 V	1400 V
Silver	39	Metals (mg/kg)	0.45 U	0.43 U	0.43 U	0.45 U	0.48 U	0.47 U	0.44 U	0.46 U	0.45 U
Sodium	NE	Metals (mg/kg)	90 U	87 U	87 U	89 U	96 U	94 U	89 U	92 U	90 U
Thallium	0.52	Metals (mg/kg)	2.2 U	2.2 U	2.2 U	2.2 U	2.4 U	2.4 U	2.2 U	2.3 U	2.2 U
Vanadium	55	Metals (mg/kg)	7.3 V	10 V	8.2 V	13 V	16 V	15 V	17 V	18 V	15 V
Zinc	2,300	Metals (mg/kg)	25 V	20 V	13 V	32 V	30 V	30 V	35 V	41 V	39 V
Total TEQ	3.9	CDD/CDF (ng/kg)									
Benzo(a)pyrene	62	PAH (µg/kg)	15 U	14 U		81 V	17 V	27 V			
4,4-DDE	170	Pesticides (µg/kg)	18.9 U	3.62 U		18.7 U	4.02 U	3.97 U			
4,4-DDT	170	Pesticides (µg/kg)	18.9 U	4.73 V		18.7 U	4.02 U	3.97 U			
Aldrin	29	Pesticides (µg/kg)	18.9 U	3.62 U		103 V	15.3 V	14.4 V			
Dieldrin	30	Pesticides (µg/kg)	63.6 V	3.76 V		183 V	30.3 V	24.1 V			
Total PCBs	220	PCBs (µg/kg)	37.9 U	36.2 U		37.4 U	40.2 U	39.7 U			
Aliphatic Hydrocarbons (C_{19}-C_{36})	3,000	TPH (mg/kg)	11.5 V	7.25 U		7.49 U	8.03 U	7.94 U			
Aromatic Hydrocarbons (C_{11}-C_{22})	800	TPH (mg/kg)	10.5 V	7.25 U		7.49 U	8.03 U	7.94 U			
Acetone	60,000	VOCs (µg/kg)	49 V	8.8 V		36 V	32 V	31 V			
Carbon Disulfide	36,000	VOCs (µg/kg)	11 U	8.4 U		9.7 U	8.8 U	11 U			
Toluene	52	VOCs (µg/kg)	1.6 U	1.2 U		1.5 V	1.3 U	1.7 U			

Analyte	Project Action Level	Analyte Category (units)	PASI-GR-GB-242-1 0.42-3.42 ft	PASI-GR-GB-243-1 0.83-3.83 ft	PASI-GR-GB-244-1 0.42-3.42 ft	PASI-GR-GB-245-1 0.5-3.5 ft	PASI-GR-GB-246-1 0.66-3.66 ft	PASI-GR-GB-247-1 0.5-3.5 ft	PASI-GR-GB-248-1 0.83-3.83 ft	PASI-GR-GB-249-1 0.66-3.66 ft	PASI-GR-GB-227-1 0.66-3.66 ft
Aluminum	7,600	Metals (mg/kg)									
Arsenic	0.39	Metals (mg/kg)									
Iron	2,300	Metals (mg/kg)									
Manganese	180	Metals (mg/kg)									
Nickel	20	Metals (mg/kg)									
Arochlor 1260	220	PCBs (µg/kg)	25 U	26 U	25 U	26 U	25 U	25 U	26 U	25 U	10 U

Notes:
mg/kg = Milligrams per kilogram (parts per million)
µg/kg = Micrograms per kilogram (parts per billion)
ng/kg = Nanograms per kilogram (parts per trillion)
V = Valid result; substance detected.
J = Estimated result; substance detected, but below the detection limit.
U = Substance not detected; detection limit listed.
Highlighted results were detected above their Project Action Level.

Table 6-3a
IA-2 Summary of Screened Analytical Results
PASI/SSI Comprehensive Report
Study Area - Grant, Locust, and Cavite Housing Areas
Devens, Massachusetts

Analyte	Project Action Level	Analyte Category (units)	GR-IA02-SB25-1 3-10 ft	GR-IA02-SB26-1 0-3 ft	GR-IA02-SB26-1 3-10 ft	GR-IA02-SB27-1 0-3 ft	GR-IA02-SB27-1 3-10 ft	GR-IA02-SB28-1 0-3 ft	GR-IA02-SB28-1 3-10 ft	GR-IA02-SB30-1 0-3 ft	GR-IA02-SB30-1-M 3-10 ft
Aluminum	7,600	Metals (mg/kg)	16000 V	12000 V	9600 V	6800 V	6400 V	7100 V	2800 V	6900 V	4400 V
Arsenic	0.39	Metals (mg/kg)	21 V	13 V	26 V	8.7 V	14 V	25 V	25 V	15 V	12 V
Barium	540	Metals (mg/kg)	45 V	22 V	21 V	36 V	24 V	15 V	8.4 V	14 V	9.3 V
Calcium	NE	Metals (mg/kg)	560 V	430 V	420 V	980 V	730 V	410 V	2100 V	370 V	490 V
Chromium	30	Metals (mg/kg)	23 V	13 V	18 V	18 V	12 V	11 V	6.4 V	13 V	11 V
Cobalt	500	Metals (mg/kg)	10 V	4.1 V	6.3 V	4.2 V	6.4 V	6 V	5.3 V	4.5 V	3.4 V
Copper	310	Metals (mg/kg)	17 V	5.2 V	10 V	6.4 V	13 V	13 V	12 V	7.3 V	6 V
Iron	2,300	Metals (mg/kg)	22000 V	11000 V	12000 V	8200 V	11000 V	9700 V	7200 V	9000 V	8000 V
Lead	300	Metals (mg/kg)	13 V	10 V	6.9 V	3.1 V	8 V	11 V	6.4 V	5.9 V	3.4 V
Magnesium	NE	Metals (mg/kg)	4600 V	2000 V	3600 V	2500 V	1900 V	1700 V	1200 V	2600 V	2400 V
Manganese	180	Metals (mg/kg)	400 V	170 V	200 V	170 V	250 V	200 V	190 V	140 V	120 V
Mercury	2.3	Metals (mg/kg)	0.089 U	0.027 J	0.011 J	0.082 U	0.085 U	0.014 J	0.08 U	0.092 U	0.079 U
Nickel	20	Metals (mg/kg)	30 V	11 V	18 V	10 V	18 V	18 V	17 V	14 V	12 V
Potassium	NE	Metals (mg/kg)	2300 V	400 V	960 V	1700 V	1000 V	530 V	350 V	460 V	440 V
Silver	39	Metals (mg/kg)	0.44 U	0.46 U	0.44 U	0.44 U	0.44 U	0.45 U	0.42 U	0.45 U	0.42 U
Sodium	NE	Metals (mg/kg)	88 U	93 U	89 U	88 U	88 U	89 U	84 U	90 U	84 U
Thallium	0.52	Metals (mg/kg)	2.2 U	2.3 U	2.2 U	2.2 U	2.2 U	2.2 U	2.1 U	2.2 U	0.42 J
Vanadium	55	Metals (mg/kg)	18 V	13 V	12 V	14 V	9.1 V	8.7 V	4.6 V	9.9 V	7.3 V
Zinc	2,300	Metals (mg/kg)	44 V	21 V	23 V	15 V	22 V	20 V	14 V	18 V	16 V
Total TEQ	3.9	CDD/CDF (ng/kg)									
Benzo(a)pyrene	62	PAH (µg/kg)								15 U	14 U
4,4-DDE	170	Pesticides (µg/kg)								247 V	13.2 V
4,4-DDT	170	Pesticides (µg/kg)								751 V	22.8 V
Aldrin	29	Pesticides (µg/kg)								187 U	3.51 U
Dieldrin	30	Pesticides (µg/kg)								187 U	3.51 U
Total PCBs	220	PCBs (µg/kg)								37.4 U	35.1 U
Aliphatic Hydrocarbons (C_{19}-C_{36})	3,000	TPH (mg/kg)								7.49 U	7.02 U
Aromatic Hydrocarbons (C_{11}-C_{22})	800	TPH (mg/kg)								7.49 U	7.02 U
Acetone	60,000	VOCs (µg/kg)								33 V	7.4 U
Carbon Disulfide	36,000	VOCs (µg/kg)								11 U	7.4 U
Toluene	52	VOCs (µg/kg)								1.7 U	1.1 U

Analyte	Project Action Level	Analyte Category (units)	PASI-GR-GB-228-1 0.75-3.75 ft	PASI-GR-GB-229-1 0.66-3.66 ft	PASI-GR-GB-230-1 0.66-3.66 ft	PASI-GR-GB-231-1 1-4 ft	PASI-GR-GB-232-1 0.83-3.83 ft	PASI-GR-GB-235-1 0.66-3.66 ft	PASI-GR-GB-236-1 0.83-3.83 ft	PASI-GR-GB-237-1 0.66-3.66 ft	PASI-GR-GB-238-1 0.75-3.75 ft
Aluminum	7,600	Metals (mg/kg)									
Arsenic	0.39	Metals (mg/kg)									
Iron	2,300	Metals (mg/kg)									
Manganese	180	Metals (mg/kg)									
Nickel	20	Metals (mg/kg)									
Arochlor 1260	220	PCBs (µg/kg)	8.3 U	8.5 U	8.4 U	9.1 U	42 V	11 U	30 U	27 U	29 U

Notes:
mg/kg = Milligrams per kilogram (parts per million)
µg/kg = Micrograms per kilogram (parts per billion)
ng/kg = Nanograms per kilogram (parts per trillion)
V = Valid result; substance detected.
J = Estimated result; substance detected, but below the detection limit.
U = Substance not detected; detection limit listed.
Highlighted results were detected above their Project Action Level.

Table 6-3a
IA-2 Summary of Screened Analytical Results
PASI/SSI Comprehensive Report
Study Area - Grant, Locust, and Cavite Housing Areas
Devens, Massachusetts

Analyte	Project Action Level	Analyte Category (units)	GR-IA02-SS01-1 0-1.5	GR-IA10-SB01-1 0-3 ft	GR-IA10-SB01-1 3-10 ft	GR-IA10-SB01-1-M 3-10 ft	GR-IA10-SB03-1 0-3 ft	GR-IA10-SB03-1 3-10 ft	GR-IA10-SB04-1 0-3 0-3 ft	GR-IA10-SB04-1 3-10 3-10ft	GR-IA10-SB04-1-D 3-10 3-10 ft
Aluminum	7,600	Metals (mg/kg)	10000 V	9100 V	4900 V		12000 V	11000 V	7400 V	8000 V	
Arsenic	0.39	Metals (mg/kg)	18 V	10 V	12 V		40 V	58 V	9.2 V	26 V	
Barium	540	Metals (mg/kg)	44 V	14 V	18 V		20 V	20 V	13 V	28 V	
Calcium	NE	Metals (mg/kg)	2500 V	210 V	420 V		690 V	450 V	170 V	440 V	
Chromium	30	Metals (mg/kg)	26 V	12 V	12 V		28 V	28 V	7.4 V	18 V	
Cobalt	500	Metals (mg/kg)	7.5 V	3.2 V	4.1 V		7.3 V	8.4 V	2.9 V	7.2 V	
Copper	310	Metals (mg/kg)	46 V	5.2 V	8 V		18 V	16 V	3.8 V	15 V	
Iron	2,300	Metals (mg/kg)	28000 V	8300 V	7800 V		15000 V	16000 V	7200 V	12000 V	
Lead	300	Metals (mg/kg)	50 V	6.1 V	4.1 V		11 V	9.3 V	7.6 V	7.9 V	
Magnesium	NE	Metals (mg/kg)	2400 V	1800 V	2100 V		5600 V	6300 V	990 V	3200 V	
Manganese	180	Metals (mg/kg)	510 V	92 V	130 V		230 V	270 V	150 V	250 V	
Mercury	2.3	Metals (mg/kg)	0.11 J	0.018 J	0.08 U		0.03 J	0.082 U	0.027 J	0.0072 J	
Nickel	20	Metals (mg/kg)	28 V	8.4 V	10 V		25 V	27 V	7 V	23 V	
Potassium	NE	Metals (mg/kg)	680 V	450 V	960 V		1000 V	1200 V	260 V	1600 V	
Silver	39	Metals (mg/kg)	0.6 U	0.45 U	0.42 U		0.44 U	0.44 U	0.44 U	0.42 U	
Sodium	NE	Metals (mg/kg)	120 U	90 U	84 U		89 U	87 U	88 U	84 U	
Thallium	0.52	Metals (mg/kg)	3 U	2.2 U	2.1 U		2.2 U	2.2 U	2.2 U	2.1 U	
Vanadium	55	Metals (mg/kg)	14 V	10 V	8.7 V		18 V	19 V	8.5 V	12 V	
Zinc	2,300	Metals (mg/kg)	96 V	17 V	18 V		34 V	32 V	14 V	20 V	
Total TEQ	3.9	CDD/CDF (ng/kg)		0.3189 U		0.117 V	0.478 U	0.115 U	0.772 U	0.15 U	0.119 U
Benzo(a)pyrene	62	PAH (µg/kg)		15 U	14 U		15 U	15 U	24 V	14 U	
4,4-DDE	170	Pesticides (µg/kg)		5.09 V	3.51 U		3.93 V	3.66 U	13 V	3.51 U	
4,4-DDT	170	Pesticides (µg/kg)		4.76 V	3.51 U		4.65 V	3.66 U	12.8 V	3.51 U	
Aldrin	29	Pesticides (µg/kg)		3.79 U	3.51 U		3.7 U	3.66 U	3.7 U	3.51 U	
Dieldrin	30	Pesticides (µg/kg)		3.79 U	3.51 U		38.3 V	5.64 V	3.7 U	3.51 U	
Total PCBs	220	PCBs (µg/kg)		37.9 U	35.1 U		37 U	36.6 U	37 U	35.1 U	
Aliphatic Hydrocarbons (C_{19}-C_{36})	3,000	TPH (mg/kg)		7.58 U	7.02 U		7.41 U	7.33 U	7.41 U	7.02 U	
Aromatic Hydrocarbons (C_{11}-C_{22})	800	TPH (mg/kg)		7.58 U	7.02 U		7.41 U	7.33 U	7.41 U	7.02 U	
Acetone	60,000	VOCs (µg/kg)		9.5 V	8 U		35 V	11 V	86 V	24 V	
Carbon Disulfide	36,000	VOCs (µg/kg)		9.5 U	8 U		7.7 U	9.2 U	7.6 U	11 V	
Toluene	52	VOCs (µg/kg)		1.4 U	1.3 V		1.2 U	1.4 V	1.1 U	1.5 U	

Analyte	Project Action Level	Analyte Category (units)	PASI-GR-GB-239-1 0.66-3.66 ft	PASI-GR-GB-240-1 0.33-3.33 ft	PASI-GR-GB-240-1D 0.33-3.33 ft	PASI-GR-GB-241-1 0.5-3.5 ft	PASI-GR-GB-242-1 0.42-3.42 ft	PASI-GR-GB-243-1 0.83-3.83 ft	PASI-GR-GB-244-1 0.42-3.42 ft	PASI-GR-GB-245-1 0.5-3.5 ft	PASI-GR-GB-246-1 0.66-3.66 ft
Aluminum	7,600	Metals (mg/kg)									
Arsenic	0.39	Metals (mg/kg)									
Iron	2,300	Metals (mg/kg)									
Manganese	180	Metals (mg/kg)									
Nickel	20	Metals (mg/kg)									
Arochlor 1260	220	PCBs (µg/kg)	26 U	28 U	27 U	26 U	25 U	26 U	25 U	26 U	25 U

Notes:
mg/kg = Milligrams per kilogram (parts per million)
µg/kg = Micrograms per kilogram (parts per billion)
ng/kg = Nanograms per kilogram (parts per trillion)
V = Valid result; substance detected.
J = Estimated result; substance detected, but below the detection limit.
U = Substance not detected; detection limit listed.
Highlighted results were detected above their Project Action Level.

Table 6-3a
IA-2 Summary of Screened Analytical Results
PASI/SSI Comprehensive Report
Study Area - Grant, Locust, and Cavite Housing Areas
Devens, Massachusetts

Analyte	Project Action Level	Analyte Category (units)	GR-IA10-TP02-A1-1 0-2 0-2 ft		GR-IA10-TP02-A2-1 2-4 2-4 ft		GR-IA10-TP02-A3-1 4-6 4-6 ft		GR-IA10-TP02-B1-1 0-2 0-2 ft		GR-IA10-TP02-B1-1-D 0-2 0-2 ft		GR-IA10-TP02-B2-1 2-4 2-4 ft		GR-IA10-TP02-B3-1 4-6 4-6 ft		GR-IA10-TP02-C1-1 0-2 0-2 ft		GR-IA10-TP02-C2-1 2-4 2-4 ft	
Aluminum	7,600	Metals (mg/kg)	7400	V	3300	V	2200	V	7600	V	6300	V	2900	V	2300	V	6800	V	2300	V
Arsenic	0.39	Metals (mg/kg)	6.1	V	7.4	V	7.5	V	6.4	V	9.1	V	8.8	V	5.9	V	6.5	V	5.3	V
Barium	540	Metals (mg/kg)	10	V	10	V	6.2	V	11	V	7.9	V	6.2	V	6.5	V	12	V	6.5	V
Calcium	NE	Metals (mg/kg)	160	V	200	V	120	V	62	V	50	V	65	V	120	V	78	V	83	V
Chromium	30	Metals (mg/kg)	8	V	5.1	V	3.6	V	7.7	V	6	V	4.8	V	3.4	V	5.8	V	3.2	V
Cobalt	500	Metals (mg/kg)	2	V	2.7	V	2.3	V	2	V	1.6	V	2.9	V	2.3	V	1.6	V	2	V
Copper	310	Metals (mg/kg)	4.4	V	6.7	V	5.4	V	3.5	V	3.6	V	6.5	V	4.8	V	3.4	V	4.4	V
Iron	2,300	Metals (mg/kg)	6100	V	3200	V	3600	V	6600	V	6200	V	3900	V	3300	V	5200	V	2700	V
Lead	300	Metals (mg/kg)	9.6	V	3.4	V	2.9	V	6.2	V	5.6	V	3.4	V	2.5	V	5.4	V	2.7	V
Magnesium	NE	Metals (mg/kg)	800	V	750	V	650	V	810	V	550	V	790	V	640	V	570	V	560	V
Manganese	180	Metals (mg/kg)	40	V	56	V	69	V	69	V	45	V	66	V	67	V	46	V	57	V
Mercury	2.3	Metals (mg/kg)	0.022	J	0.077	U	0.072	U	0.029	J	0.028	J	0.081	U	0.003	J	0.021	J	0.082	U
Nickel	20	Metals (mg/kg)	5.5	V	6.2	V	4.6	V	4.7	V	3.9	V	5.6	V	5.2	V	4	V	4.3	V
Potassium	NE	Metals (mg/kg)	250	V	330	V	230	V	240	V	120	V	290	V	230	V	110	U	200	V
Silver	39	Metals (mg/kg)	0.42	U	0.4	U	0.4	U	0.42	U	0.42	U	0.41	U	0.41	U	0.43	U	0.41	U
Sodium	NE	Metals (mg/kg)	85	U	80	U	80	U	84	U	84	U	82	U	81	U	86	U	82	U
Thallium	0.52	Metals (mg/kg)	2.1	U	2	U	2	U	2.1	U	2.1	U	2	U	2	U	2.1	U	2	U
Vanadium	55	Metals (mg/kg)	8	V	4	V	3.4	V	8.4	V	6.5	V	4.2	V	3.1	V	6.2	V	2.9	V
Zinc	2,300	Metals (mg/kg)	12	V	10	V	8.5	V	11	V	10	V	9.2	V	7.8	V	11	V	8	V
Total TEQ	3.9	CDD/CDF (ng/kg)																		
Benzo(a)pyrene	62	PAH (µg/kg)																		
4,4-DDE	170	Pesticides (µg/kg)																		
4,4-DDT	170	Pesticides (µg/kg)																		
Aldrin	29	Pesticides (µg/kg)																		
Dieldrin	30	Pesticides (µg/kg)																		
Total PCBs	220	PCBs (µg/kg)																		
Aliphatic Hydrocarbons (C_{19}-C_{36})	3,000	TPH (mg/kg)																		
Aromatic Hydrocarbons (C_{11}-C_{22})	800	TPH (mg/kg)																		
Acetone	60,000	VOCs (µg/kg)																		
Carbon Disulfide	36,000	VOCs (µg/kg)																		
Toluene	52	VOCs (µg/kg)																		

Analyte	Project Action Level	Analyte Category (units)	PASI-GR-GB-247-1 0.5-3.5 ft		PASI-GR-GB-248-1 0.83-3.83 ft		PASI-GR-GB-249-1 0.66-3.66 ft		PASI-GR-GB-250-1 0.5-3.5 ft		PASI-GR-GB-251-1 0.5-3.5 ft		PASI-GR-GB-306-1 0-0 ft		PASI-GR-GB-306-2 0-0 ft		PASI-GR-GB-307-1 0-0 ft		PASI-GR-GB-307-2 0-0 ft	
Aluminum	7,600	Metals (mg/kg)											10300	V	12000	V	9820	V	10900	V
Arsenic	0.39	Metals (mg/kg)											21.4	V	19.8	V	34	V	33	V
Iron	2,300	Metals (mg/kg)											16700	V	17800	V	13400	V	15400	V
Manganese	180	Metals (mg/kg)											355	V	315	V	173	V	202	V
Nickel	20	Metals (mg/kg)											27	V	28.3	V	30.9	V	35.4	V
Arochlor 1260	220	PCBs (µg/kg)	25	U	26	U	25	U	28	U	28	U								

Notes:
mg/kg = Milligrams per kilogram (parts per million)
µg/kg = Micrograms per kilogram (parts per billion)
ng/kg = Nanograms per kilogram (parts per trillion)
V = Valid result; substance detected.
J = Estimated result; substance detected, but below the detection limit.
U = Substance not detected; detection limit listed.
Highlighted results were detected above their Project Action Level.

Table 6-3a
IA-2 Summary of Screened Analytical Results
PASI/SSI Comprehensive Report
Study Area - Grant, Locust, and Cavite Housing Areas
Devens, Massachusetts

Analyte	Project Action Level	Analyte Category (units)	GR-IA10-TP02-C3-1 4-6 4-6 ft		GR-IA10-TP02-D1-1 0-2 0-2 ft		GR-IA10-TP02-D2-1 2-4 2-2 ft		GR-IA10-TP02-D3-1 4-6 4-6 ft	
Aluminum	7,600	Metals (mg/kg)	2200	V	7500	V	2600	V	2000	V
Arsenic	0.39	Metals (mg/kg)	8.2	V	6.2	V	4.9	V	7	V
Barium	540	Metals (mg/kg)	7	V	12	V	6.4	V	4.5	V
Calcium	NE	Metals (mg/kg)	140	V	130	V	87	V	230	V
Chromium	30	Metals (mg/kg)	3.7	V	6.8	V	4.1	V	2.9	V
Cobalt	500	Metals (mg/kg)	2.8	V	1.8	V	2	V	2	V
Copper	310	Metals (mg/kg)	6.4	V	4.4	V	3.8	V	4.4	V
Iron	2,300	Metals (mg/kg)	3400	V	5700	V	2600	V	3400	V
Lead	300	Metals (mg/kg)	4.1	V	14	V	2.9	V	3.5	V
Magnesium	NE	Metals (mg/kg)	640	V	600	V	620	V	590	V
Manganese	180	Metals (mg/kg)	81	V	46	V	38	V	82	V
Mercury	2.3	Metals (mg/kg)	0.077	U	0.024	J	0.082	U	0.084	U
Nickel	20	Metals (mg/kg)	5.9	V	4.9	V	4.2	V	4.2	V
Potassium	NE	Metals (mg/kg)	250	V	200	V	260	V	170	V
Silver	39	Metals (mg/kg)	0.4	U	0.42	U	0.4	U	0.41	U
Sodium	NE	Metals (mg/kg)	81	U	84	U	79	U	81	U
Thallium	0.52	Metals (mg/kg)	2	U	2.1	U	2	U	2	U
Vanadium	55	Metals (mg/kg)	3.1	V	7.9	V	3.3	V	3.1	V
Zinc	2,300	Metals (mg/kg)	9.3	V	12	V	7.1	V	7.8	V
Total TEQ	3.9	CDD/CDF (ng/kg)								
Benzo(a)pyrene	62	PAH (µg/kg)								
4,4-DDE	170	Pesticides (µg/kg)								
4,4-DDT	170	Pesticides (µg/kg)								
Aldrin	29	Pesticides (µg/kg)								
Dieldrin	30	Pesticides (µg/kg)								
Total PCBs	220	PCBs (µg/kg)								
Aliphatic Hydrocarbons (C_{19}-C_{36})	3,000	TPH (mg/kg)								
Aromatic Hydrocarbons (C_{11}-C_{22})	800	TPH (mg/kg)								
Acetone	60,000	VOCs (µg/kg)								
Carbon Disulfide	36,000	VOCs (µg/kg)								
Toluene	52	VOCs (µg/kg)								

Analyte	Project Action Level	Analyte Category (units)	PASI-GR-GB-308-1 0-0 ft		PASI-GR-GB-308-2 0-0 ft		PASI-GR-GB-309-1 0-0 ft		PASI-GR-GB-309-2 0-0 ft		PASI-GR-GB-310-1 0-0 ft		PASI-GR-GB-310-2 0-0 ft		PASI-GR-GB-311-1 0-0 ft		PASI-GR-GB-311-1D 0-0 ft		PASI-GR-GB-311-2 0-0 ft		PASI-GR-GB-311-2D 0-0 ft	
Aluminum	7,600	Metals (mg/kg)	8170	V	7150	V	10900	V	7160	V	6810	V	8600	V	11800	V	9240	V	9990	V	4.2	V
Arsenic	0.39	Metals (mg/kg)	26.1	V	36.1	V	11.1	V	13.9	V	20.3	V	24.1	V	25.7	V	15.8	V	40.9	V	10.2	V
Iron	2,300	Metals (mg/kg)	12900	V	12300	V	8440	V	6560	V	9410	V	12800	V	15200	V	9130	V	17.2	V	3	V
Manganese	180	Metals (mg/kg)	239	V	239	V	55.2	V	88	V	176	V	259	V	276	V	136	V	365	V	30.4	R
Nickel	20	Metals (mg/kg)	26.3	V	25.8	V	6.3	V	8.4	V	17.5	V	28.6	V	16.7	V	14.4	V	36.6	V	12.9	V
Arochlor 1260	220	PCBs (µg/kg)																				

Notes:
mg/kg = Milligrams per kilogram (parts per million)
µg/kg = Micrograms per kilogram (parts per billion)
ng/kg = Nanograms per kilogram (parts per trillion)
V = Valid result; substance detected.
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U = Substance not detected; detection limit listed.
Highlighted results were detected above their Project Action Level.

Table 6-3b
IA-2 Hazard Screening Calculation Summary
PASI/SSI Comprehensive Report
Study Area - Grant, Locust, and Cavite Housing Areas
Devens, Massachusetts

Analyte	Analyte Category (units)	Carcinogen (Ca) or Non-carcinogen (NC)	EPA Region IX Residential Soil PRG	Average Value	Maximum Value	95% UCL	Exposure Point Concentration (EPC)[1]	Screening Cancer Risk (SCR)	Screening Hazard Quotient (SHQ)
Aluminum	Metals (mg/kg)	NC	76,000	7,610	16,000	8,206	8,206		0.11
Arsenic	Metals (mg/kg)	Ca	0.39	19	58	22	22	6.E-05	
Chromium	Metals (mg/kg)	Ca	210	13	32	15	15	7.E-08	
Iron	Metals (mg/kg)	NC	23,000	10,274	28,000	13,934	13,934		0.61
Lead	Metals (mg/kg)	NC	400	8	50	9	9		0.02
Manganese	Metals (mg/kg)	NC	1,800	195	640	219	219		0.12
Nickel	Metals (mg/kg)	NC	1,600	18	57	23	23		0.01
Thallium	Metals (mg/kg)	Ca	5	1	2	1	1	2.E-07	
Benzo(a)pyrene	PAHs (µg/kg)	Ca	62	16	81	15	15	2.E-07	
4,4-DDE	Pesticides (µg/kg)	Ca	1,700	23	247	36	36	2.E-08	
4,4-DDT	Pesticides (µg/kg)	Ca	1,700	60	751	105	105	6.E-08	
Aldrin	Pesticides (µg/kg)	Ca	29	17	103	21	21	7.E-07	
Dieldrin	Pesticides (µg/kg)	Ca	30	31	183	35	35	1.E-06	
							Total	6.E-05	0.87

[1] = Lesser of Maximum or 95% UCL used.
PAH = polycyclic aromatic hydrocarbons
PRG = Preliminary Remediation Goals
UCL = Upper Confident Limit
PCB = polychlorinated biphenyls
NA = not applicable
mg/kg = milligrams per kilogram
µg/kg = micrograms per kilogram

Summary

Total Screening Cancer Risk: 6.E-05	TSCR>1E-04? No
Total Screening Hazard Quotient: 0.87	TSHI>1? No
Arsenic concentration is consistent with background.	
TSCR due to Arsenic: 6.E-05	TSCR w/o Arsenic: 3.E-06
TSCR due to Arsenic is <1E-04.	TSCR w/o Arsenic is <1E-04.
Total PCBs concentration is less than 1 mg/kg.	
TSCR due to PCBs: NA	TSCR w/o PCBs: 6.E-05
	TSCR w/o PCBs is <1E-04.
PAHs concentration(s) are consistent with background.	
TSCR due to PAHs: 2.E-07	TSCR w/o to PAHs: 6.E-05
TSCR due to PAHs is <1E-04.	TSCR w/o PAHs is <1E-04.

Table 6-4a
IA-03 Summary of Screened Analytical Results

Analyte	Project Action Level	Analyte Category (units)	GR-IA03-SB01-1 0-3 ft		GR-IA03-SB01-1 3-10 ft		GR-IA03-SB01-1-D 0-3 ft		GR-IA03-SB02-1 0-3 ft		GR-IA03-SB02-1 3-10 ft		GR-IA03-SB04-1 0-3 ft		GR-IA03-SB04-1 3-10 ft	
Aluminum	7,600	Metals (mg/kg)	11000	V	6700	V	10000	V	10000	V	8500	V	9700	V	8100	V
Antimony	3.1	Metals (mg/kg)	2.3	U	2.1	U	2.3	U	2.2	U	2.1	U	2.2	U	2.1	U
Arsenic	0.39	Metals (mg/kg)	24	V	27	V	28	V	27	V	17	V	19	V	31	V
Barium	540	Metals (mg/kg)	23	V	14	V	18	V	16	V	18	V	17	V	19	V
Calcium	NE	Metals (mg/kg)	320	V	340	V	190	V	360	V	860	V	300	V	440	V
Chromium	30	Metals (mg/kg)	21	V	17	V	17	V	24	V	23	V	20	V	21	V
Cobalt	500	Metals (mg/kg)	5.2	V	6	V	4.9	V	6.3	V	6.2	V	5.6	V	7	V
Copper	310	Metals (mg/kg)	7.8	V	12	V	9	V	14	V	13	V	9.8	V	13	V
Iron	2,300	Metals (mg/kg)	12000	V	13000	V	12000	V	15000	V	14000	V	12000	V	14000	V
Lead	300	Metals (mg/kg)	8.9	V	5.9	V	10	V	12	V	6.5	V	13	V	7.8	V
Magnesium	NE	Metals (mg/kg)	3500	V	3800	V	2900	V	4800	V	4900	V	4000	V	4600	V
Manganese	180	Metals (mg/kg)	240	V	210	V	210	V	180	V	210	V	190	V	240	V
Mercury	2.3	Metals (mg/kg)	0.026	J	0.078	U	0.026	J	0.02	J	0.0035	J	0.1	V	0.0071	J
Nickel	20	Metals (mg/kg)	17	V	22	V	16	V	25	V	23	V	18	V	24	V
Potassium	NE	Metals (mg/kg)	790	V	820	V	540	V	920	V	990	V	810	V	1100	V
Silver	39	Metals (mg/kg)	0.46	U	0.42	U	0.46	U	0.44	U	0.42	U	0.44	U	0.43	U
Vanadium	55	Metals (mg/kg)	14	V	11	V	13	V	16	V	16	V	14	V	14	V
Zinc	2,300	Metals (mg/kg)	19	V	22	V	19	V	28	V	25	V	24	V	31	V
Benzo(a)anthracene	620	PAHs (µg/kg)							370	U	350	U	380	V	358	U
Benzo(a)pyrene	62	PAHs (µg/kg)							39	V	14	U	620	V	24	V
Benzo(b)fluoranthene	620	PAHs (µg/kg)							370	U	350	U	527	V	358	U
Benzo(g,h,i)perylene	1,000	PAHs (µg/kg)							370	U	350	U	360	J	358	U
Benzo(k)fluoranthene	6,200	PAHs (µg/kg)							370	U	350	U	470	V	358	U
Chrysene	7,000	PAHs (µg/kg)							370	U	350	U	598	V	358	U
Dibenz(a,h)Anthracene	62	PAHs (µg/kg)							15	U	14	U	82	V	14	U
Fluoranthene	23,000	PAHs (µg/kg)							370	U	350	U	1120	V	358	U
Indeno(1,2,3-c,d)Pyrene	620	PAHs (µg/kg)							370	U	350	U	550	V	358	U
Phenanthrene	100,000	PAHs (µg/kg)							370	U	350	U	540	V	358	U
Pyrene	230,000	PAHs (µg/kg)							370	U	350	U	850	V	358	U
4,4-DDE	170	Pesticides (µg/kg)							71.8	V	3.51	U	17.1	V	3.58	U
4,4-DDT	170	Pesticides (µg/kg)							141	V	5.35	V	21.6	V	3.58	U
Aromatic Hydrocarbons (C_{11}-C_{22})	200	TPH (mg/kg)							7.41	U	7.02	U	25.8	V	7.17	U
Acetone	60,000	VOCs (µg/kg)							33	V	6.9	U	40	V	7.4	U
Toluene	500	VOCs (µg/kg)							1.2	U	1	U	1.7	U	1.1	V

Notes:
mg/kg = Milligrams per kilogram (parts per million)
µg/kg = Micrograms per kilogram (parts per billion)
V = Valid result; substance detected.
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Highlighted results were detected above their Project Action Level.
NE = Not established.

Table 6-4a
IA-03 Summary of Screened Analytical Results

Analyte	Project Action Level	Analyte Category (units)	GR-IA03-SB03-1 0-3 ft		GR-IA03-SB03-1-M 3-10 ft		GR-IA03-SS01-1 0-1.5 ft		GR-IA03-SS02-1 0-1.5 ft		GR-IA03-SS02-1-D 0-1.5 ft		GR-IA03-SS03-1 0-1.5 ft		GR-IA03-SS04-1 0-1.5 ft	
Aluminum	7,600	Metals (mg/kg)	9600	V	7200	V	6100	V	5800	V	5800	V	6800	V	7400	V
Antimony	3.1	Metals (mg/kg)	2.6	V	2.1	U	2.1	U	2.1	U	2.1	U	2.2	U	2.2	U
Arsenic	0.39	Metals (mg/kg)	25	V	21	V	24	V	23	V	26	V	16	V	19	V
Barium	540	Metals (mg/kg)	24	V	16	V	13	V	12	V	12	V	11	V	10	V
Calcium	NE	Metals (mg/kg)	590	V	380	V	220	V	200	V	240	V	180	V	200	V
Chromium	30	Metals (mg/kg)	24	V	21	V	16	V	14	V	14	V	10	V	12	V
Cobalt	500	Metals (mg/kg)	6.1	V	5.1	V	3.4	V	3.7	V	3.8	V	3.6	V	5.3	V
Copper	310	Metals (mg/kg)	16	V	9.8	V	13	V	14	V	15	V	6.8	V	8.1	V
Iron	2,300	Metals (mg/kg)	15000	V	12000	V	9400	V	8900	V	9300	V	7600	V	8800	V
Lead	300	Metals (mg/kg)	26	V	7.5	V	13	V	30	V	31	V	10	V	7.9	V
Magnesium	NE	Metals (mg/kg)	5000	V	4300	V	2500	V	2100	V	2000	V	1300	V	1600	V
Manganese	180	Metals (mg/kg)	200	V	180	V	64	V	79	V	91	V	130	V	120	V
Mercury	2.3	Metals (mg/kg)	0.12	V	0.078	U	0.62	V	0.8	V	0.76	V	0.03	J	0.028	J
Nickel	20	Metals (mg/kg)	23	V	19	V	18	V	16	V	16	V	12	V	15	V
Potassium	NE	Metals (mg/kg)	1400	V	940	V	810	V	660	V	640	V	290	V	240	V
Silver	39	Metals (mg/kg)	0.44	U	0.42	U	0.42	U	0.42	V	0.43	V	0.43	U	0.43	U
Vanadium	55	Metals (mg/kg)	17	V	12	V	11	V	9.6	V	10	V	8.9	V	8.9	V
Zinc	2,300	Metals (mg/kg)	34	V	27	V	28	V	31	V	30	V	15	V	17	V
Benzo(a)anthracene	620	PAHs (µg/kg)														
Benzo(a)pyrene	62	PAHs (µg/kg)														
Benzo(b)fluoranthene	620	PAHs (µg/kg)														
Benzo(g,h,i)perylene	1,000	PAHs (µg/kg)														
Benzo(k)fluoranthene	6,200	PAHs (µg/kg)														
Chrysene	7,000	PAHs (µg/kg)														
Dibenz(a,h)Anthracene	62	PAHs (µg/kg)														
Fluoranthene	23,000	PAHs (µg/kg)														
Indeno(1,2,3-c,d)Pyrene	620	PAHs (µg/kg)														
Phenanthrene	100,000	PAHs (µg/kg)														
Pyrene	230,000	PAHs (µg/kg)														
4,4-DDE	170	Pesticides (µg/kg)														
4,4-DDT	170	Pesticides (µg/kg)														
Aromatic Hydrocarbons (C_{11}-C_{22})	200	TPH (mg/kg)														
Acetone	60,000	VOCs (µg/kg)														
Toluene	500	VOCs (µg/kg)														

Notes:
mg/kg = Milligrams per kilogram (parts per million)
µg/kg = Micrograms per kilogram (parts per billion)
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Table 6-4a
IA-03 Summary of Screened Analytical Results

Analyte	Project Action Level	Analyte Category (units)	GR-IA03-SS05-1 0-1.5 ft		GR-IA03-SS06-1-M 0-1.5 ft		GR-IA03-SS07-1 0-1.5 ft		GR-IA03-SS08-1 0-1.5 ft		GR-IA03-SS09-1 0-1.5 ft		GR-IA03-SS10-1 0-1.5 ft		GR-IA03-SS11-1 0-1.5 ft	
Aluminum	7,600	Metals (mg/kg)	8000	V	4200	V	6200	V	7500	V	5800	V	5300	V	7400	V
Antimony	3.1	Metals (mg/kg)	2.2	U	2.1	U	2.1	U	2.2	U	2.2	U	2.1	U	2.3	U
Arsenic	0.39	Metals (mg/kg)	13	V	24	V	11	V	20	V	11	V	28	V	19	V
Barium	540	Metals (mg/kg)	10	V	11	V	10	V	8.6	V	11	V	12	V	18	V
Calcium	NE	Metals (mg/kg)	110	V	250	V	82	V	220	V	93	V	260	V	280	V
Chromium	30	Metals (mg/kg)	9.7	V	11	V	7.2	V	10	V	6.6	V	12	V	12	V
Cobalt	500	Metals (mg/kg)	2.9	V	5.5	V	2	V	2.9	V	1.9	V	5.2	V	3.7	V
Copper	310	Metals (mg/kg)	4.9	V	12	V	3.1	V	3.9	V	3	V	11	V	7.8	V
Iron	2,300	Metals (mg/kg)	8000	V	8800	V	7000	V	7700	V	6800	V	8400	V	9200	V
Lead	300	Metals (mg/kg)	10	V	8.6	V	7	V	6.9	V	8.4	V	6.7	V	16	V
Magnesium	NE	Metals (mg/kg)	1000	V	1900	V	730	V	1200	V	620	V	2200	V	1700	V
Manganese	180	Metals (mg/kg)	110	V	180	V	99	V	88	V	84	V	150	V	190	V
Mercury	2.3	Metals (mg/kg)	0.063	J	0.0087	J	0.03	J	0.018	J	0.024	J	0.0055	J	0.038	J
Nickel	20	Metals (mg/kg)	8.9	V	19	V	6.3	V	12	V	6.5	V	17	V	12	V
Potassium	NE	Metals (mg/kg)	190	V	500	V	140	V	170	V	110	V	690	V	450	V
Silver	39	Metals (mg/kg)	0.45	U	0.42	U	0.42	U	0.44	U	0.44	U	0.42	U	0.46	U
Vanadium	55	Metals (mg/kg)	9.4	V	8	V	7.8	V	9.2	V	7.4	V	8.8	V	11	V
Zinc	2,300	Metals (mg/kg)	14	V	18	V	13	V	14	V	13	V	17	V	19	V
Benzo(a)anthracene	620	PAHs (µg/kg)														
Benzo(a)pyrene	62	PAHs (µg/kg)														
Benzo(b)fluoranthene	620	PAHs (µg/kg)														
Benzo(g,h,i)perylene	1,000	PAHs (µg/kg)														
Benzo(k)fluoranthene	6,200	PAHs (µg/kg)														
Chrysene	7,000	PAHs (µg/kg)														
Dibenz(a,h)Anthracene	62	PAHs (µg/kg)														
Fluoranthene	23,000	PAHs (µg/kg)														
Indeno(1,2,3-c,d)Pyrene	620	PAHs (µg/kg)														
Phenanthrene	100,000	PAHs (µg/kg)														
Pyrene	230,000	PAHs (µg/kg)														
4,4-DDE	170	Pesticides (µg/kg)														
4,4-DDT	170	Pesticides (µg/kg)														
Aromatic Hydrocarbons (C_{11}-C_{22})	200	TPH (mg/kg)														
Acetone	60,000	VOCs (µg/kg)														
Toluene	500	VOCs (µg/kg)														

Notes:
mg/kg = Milligrams per kilogram (parts per million)
µg/kg = Micrograms per kilogram (parts per billion)
V = Valid result; substance detected.
J = Estimated result; substance detected, but below the detection limit.
U = Substance not detected; detection limit listed.
Highlighted results were detected above their Project Action Level.
NE = Not established.

Table 6-4a
IA-03 Summary of Screened Analytical Results

Analyte	Project Action Level	Analyte Category (units)	GR-IA03-SS12-1 0-1.5 ft		GR-IA03-SS13-1 0-1.5 ft		GR-IA03-SS14-1 0-1.5 ft		GR-IA03-SS15-1 0-1.5 ft		GR-IA03-SS16-1 0-1.5 ft		GR-IA03-SS17-1 0-1.5 ft		GR-IA03-SS18-1 0-1.5 ft	
Aluminum	7,600	Metals (mg/kg)	6300	V	5800	V	5500	V	7500	V	9900	V	9100	V	7000	V
Antimony	3.1	Metals (mg/kg)	2.2	U	2.2	U	2.2	U	2.2	U	2.2	U	2.2	U	2.2	U
Arsenic	0.39	Metals (mg/kg)	20	V	19	V	14	V	20	V	24	V	27	V	14	V
Barium	540	Metals (mg/kg)	13	V	13	V	9.4	V	14	V	9	V	10	V	12	V
Calcium	NE	Metals (mg/kg)	280	V	300	V	270	V	180	V	85	V	120	V	97	V
Chromium	30	Metals (mg/kg)	12	V	11	V	8.2	V	13	V	14	V	15	V	9.2	V
Cobalt	500	Metals (mg/kg)	4.3	V	4	V	3.4	V	3.8	V	3.2	V	3.3	V	2.6	V
Copper	310	Metals (mg/kg)	8.2	V	8.4	V	6.2	V	6.4	V	5.7	V	7.7	V	5.9	V
Iron	2,300	Metals (mg/kg)	8400	V	7800	V	6300	V	9200	V	11000	V	10000	V	8300	V
Lead	300	Metals (mg/kg)	11	V	9.4	V	6.2	V	9.6	V	9.2	V	15	V	16	V
Magnesium	NE	Metals (mg/kg)	1600	V	1600	V	1200	V	1500	V	1500	V	1700	V	960	V
Manganese	180	Metals (mg/kg)	170	V	140	V	180	V	110	V	71	V	81	V	96	V
Mercury	2.3	Metals (mg/kg)	0.021	J	0.022	J	0.022	J	0.023	J	0.02	J	0.039	J	0.022	J
Nickel	20	Metals (mg/kg)	14	V	14	V	11	V	15	V	13	V	13	V	8.4	V
Potassium	NE	Metals (mg/kg)	420	V	480	V	310	V	330	V	190	V	240	V	220	V
Silver	39	Metals (mg/kg)	0.45	U	0.43	U	0.43	U	0.44	U	0.45	U	0.45	U	0.44	U
Vanadium	55	Metals (mg/kg)	9.3	V	8.7	V	7.4	V	11	V	12	V	13	V	10	V
Zinc	2,300	Metals (mg/kg)	17	V	16	V	15	V	16	V	18	V	16	V	13	V
Benzo(a)anthracene	620	PAHs (µg/kg)														
Benzo(a)pyrene	62	PAHs (µg/kg)														
Benzo(b)fluoranthene	620	PAHs (µg/kg)														
Benzo(g,h,i)perylene	1,000	PAHs (µg/kg)														
Benzo(k)fluoranthene	6,200	PAHs (µg/kg)														
Chrysene	7,000	PAHs (µg/kg)														
Dibenz(a,h)Anthracene	62	PAHs (µg/kg)														
Fluoranthene	23,000	PAHs (µg/kg)														
Indeno(1,2,3-c,d)Pyrene	620	PAHs (µg/kg)														
Phenanthrene	100,000	PAHs (µg/kg)														
Pyrene	230,000	PAHs (µg/kg)														
4,4-DDE	170	Pesticides (µg/kg)														
4,4-DDT	170	Pesticides (µg/kg)														
Aromatic Hydrocarbons (C_{11}-C_{22})	200	TPH (mg/kg)														
Acetone	60,000	VOCs (µg/kg)														
Toluene	500	VOCs (µg/kg)														

Notes:
mg/kg = Milligrams per kilogram (parts per million)
µg/kg = Micrograms per kilogram (parts per billion)
V = Valid result; substance detected.
J = Estimated result; substance detected, but below the detection limit.
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Highlighted results were detected above their Project Action Level.
NE = Not established.

Table 6-4a
IA-03 Summary of Screened Analytical Results

Analyte	Project Action Level	Analyte Category (units)	GR-IA03-SS19-1 0-1.5 ft		GR-IA03-SS20-1 0-1.5 ft		GR-IA03-SS21-1 0-1.5 ft		GR-IA03-SS22-1 0-1.5 ft		IA3-001-A 0-0.5 ft		IA3-001-B 0-0.5 ft		IA3-001-C 0-0.5 ft	
Aluminum	7,600	Metals (mg/kg)	11000	V	9300	V	6300	V	7600	V						
Antimony	3.1	Metals (mg/kg)	2.4	U	2.3	U	2.3	U	2.3	U						
Arsenic	0.39	Metals (mg/kg)	12	V	13	V	14	V	10	V						
Barium	540	Metals (mg/kg)	13	V	13	V	8	V	11	V						
Calcium	NE	Metals (mg/kg)	63	V	89	V	93	V	55	V						
Chromium	30	Metals (mg/kg)	10	V	11	V	8.4	V	8.2	V						
Cobalt	500	Metals (mg/kg)	2.2	V	2.5	V	2.4	V	1.8	V						
Copper	310	Metals (mg/kg)	3.5	V	4.4	V	4.9	V	2.9	V						
Iron	2,300	Metals (mg/kg)	9900	V	8800	V	7000	V	7900	V						
Lead	300	Metals (mg/kg)	8.4	V	9.8	V	14	V	11	V	18.9	V	16.7	V	22.5	V
Magnesium	NE	Metals (mg/kg)	740	V	1000	V	900	V	550	V						
Manganese	180	Metals (mg/kg)	95	V	75	V	92	V	85	V						
Mercury	2.3	Metals (mg/kg)	0.022	J	0.03	J	0.034	J	0.033	J						
Nickel	20	Metals (mg/kg)	7.4	V	9.4	V	7.7	V	5.8	V						
Potassium	NE	Metals (mg/kg)	130	V	280	V	160	V	120	U						
Silver	39	Metals (mg/kg)	0.47	U	0.46	U	0.45	U	0.46	U						
Vanadium	55	Metals (mg/kg)	12	V	11	V	9.8	V	10	V						
Zinc	2,300	Metals (mg/kg)	12	V	13	V	13	V	10	V						
Benzo(a)anthracene	620	PAHs (µg/kg)														
Benzo(a)pyrene	62	PAHs (µg/kg)														
Benzo(b)fluoranthene	620	PAHs (µg/kg)														
Benzo(g,h,i)perylene	1,000	PAHs (µg/kg)														
Benzo(k)fluoranthene	6,200	PAHs (µg/kg)														
Chrysene	7,000	PAHs (µg/kg)														
Dibenz(a,h)Anthracene	62	PAHs (µg/kg)														
Fluoranthene	23,000	PAHs (µg/kg)														
Indeno(1,2,3-c,d)Pyrene	620	PAHs (µg/kg)														
Phenanthrene	100,000	PAHs (µg/kg)														
Pyrene	230,000	PAHs (µg/kg)														
4,4-DDE	170	Pesticides (µg/kg)														
4,4-DDT	170	Pesticides (µg/kg)														
Aromatic Hydrocarbons (C_{11}-C_{22})	200	TPH (mg/kg)														
Acetone	60,000	VOCs (µg/kg)														
Toluene	500	VOCs (µg/kg)														

Notes:
mg/kg = Milligrams per kilogram (parts per million)
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Table 6-4a
IA-03 Summary of Screened Analytical Results

Analyte	Project Action Level	Analyte Category (units)	IA3-001-D 0-0.5 ft		IA3-001-E 0-0.5 ft		IA3-001-E-D 0-0.5 ft		IA3-002-A 0-0.5 ft		IA3-002-B 0-0.5 ft		IA3-002-C 0-0.5 ft		IA3-002-D 0-0.5 ft	
Aluminum	7,600	Metals (mg/kg)														
Antimony	3.1	Metals (mg/kg)														
Arsenic	0.39	Metals (mg/kg)														
Barium	540	Metals (mg/kg)														
Calcium	NE	Metals (mg/kg)														
Chromium	30	Metals (mg/kg)														
Cobalt	500	Metals (mg/kg)														
Copper	310	Metals (mg/kg)														
Iron	2,300	Metals (mg/kg)														
Lead	300	Metals (mg/kg)	17.2	V	9.4	V	59.4	V	16.1	V	11	V	13.6	V	21.5	V
Magnesium	NE	Metals (mg/kg)														
Manganese	180	Metals (mg/kg)														
Mercury	2.3	Metals (mg/kg)														
Nickel	20	Metals (mg/kg)														
Potassium	NE	Metals (mg/kg)														
Silver	39	Metals (mg/kg)														
Vanadium	55	Metals (mg/kg)														
Zinc	2,300	Metals (mg/kg)														
Benzo(a)anthracene	620	PAHs (µg/kg)														
Benzo(a)pyrene	62	PAHs (µg/kg)														
Benzo(b)fluoranthene	620	PAHs (µg/kg)														
Benzo(g,h,i)perylene	1,000	PAHs (µg/kg)														
Benzo(k)fluoranthene	6,200	PAHs (µg/kg)														
Chrysene	7,000	PAHs (µg/kg)														
Dibenz(a,h)Anthracene	62	PAHs (µg/kg)														
Fluoranthene	23,000	PAHs (µg/kg)														
Indeno(1,2,3-c,d)Pyrene	620	PAHs (µg/kg)														
Phenanthrene	100,000	PAHs (µg/kg)														
Pyrene	230,000	PAHs (µg/kg)														
4,4-DDE	170	Pesticides (µg/kg)														
4,4-DDT	170	Pesticides (µg/kg)														
Aromatic Hydrocarbons (C_{11}-C_{22})	200	TPH (mg/kg)														
Acetone	60,000	VOCs (µg/kg)														
Toluene	500	VOCs (µg/kg)														

Notes:
mg/kg = Milligrams per kilogram (parts per million)
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Table 6-4a
IA-03 Summary of Screened Analytical Results

Analyte	Project Action Level	Analyte Category (units)	IA3-002-E 0-0.5 ft		IA3-002-E-D 0-0.5 ft		IA3-003-A 0-0.5 ft		IA3-003-B 0-0.5 ft		IA3-003-C 0-0.5 ft		IA3-003-D 0-0.5 ft		IA3-003-E 0-0.5 ft	
Aluminum	7,600	Metals (mg/kg)														
Antimony	3.1	Metals (mg/kg)														
Arsenic	0.39	Metals (mg/kg)														
Barium	540	Metals (mg/kg)														
Calcium	NE	Metals (mg/kg)														
Chromium	30	Metals (mg/kg)														
Cobalt	500	Metals (mg/kg)														
Copper	310	Metals (mg/kg)														
Iron	2,300	Metals (mg/kg)														
Lead	300	Metals (mg/kg)	16	V	8.4	V	20.8	V	10.9	V	16.7	V	10.5	V	18.7	V
Magnesium	NE	Metals (mg/kg)														
Manganese	180	Metals (mg/kg)														
Mercury	2.3	Metals (mg/kg)														
Nickel	20	Metals (mg/kg)														
Potassium	NE	Metals (mg/kg)														
Silver	39	Metals (mg/kg)														
Vanadium	55	Metals (mg/kg)														
Zinc	2,300	Metals (mg/kg)														
Benzo(a)anthracene	620	PAHs (µg/kg)														
Benzo(a)pyrene	62	PAHs (µg/kg)														
Benzo(b)fluoranthene	620	PAHs (µg/kg)														
Benzo(g,h,i)perylene	1,000	PAHs (µg/kg)														
Benzo(k)fluoranthene	6,200	PAHs (µg/kg)														
Chrysene	7,000	PAHs (µg/kg)														
Dibenz(a,h)Anthracene	62	PAHs (µg/kg)														
Fluoranthene	23,000	PAHs (µg/kg)														
Indeno(1,2,3-c,d)Pyrene	620	PAHs (µg/kg)														
Phenanthrene	100,000	PAHs (µg/kg)														
Pyrene	230,000	PAHs (µg/kg)														
4,4-DDE	170	Pesticides (µg/kg)														
4,4-DDT	170	Pesticides (µg/kg)														
Aromatic Hydrocarbons (C_{11}-C_{22})	200	TPH (mg/kg)														
Acetone	60,000	VOCs (µg/kg)														
Toluene	500	VOCs (µg/kg)														

Notes:
mg/kg = Milligrams per kilogram (parts per million)
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Table 6-4a
IA-03 Summary of Screened Analytical Results

Analyte	Project Action Level	Analyte Category (units)	IA3-004-A 0-0.5 ft		IA3-004-A-D 0-0.5 ft		IA3-004-B 0-0.5 ft		IA3-004-C 0-0.5 ft		IA3-004-D 0-0.5 ft		IA3-004-E 0-0.5 ft		IA3-005-A 0-0.5 ft	
Aluminum	7,600	Metals (mg/kg)														
Antimony	3.1	Metals (mg/kg)														
Arsenic	0.39	Metals (mg/kg)														
Barium	540	Metals (mg/kg)														
Calcium	NE	Metals (mg/kg)														
Chromium	30	Metals (mg/kg)														
Cobalt	500	Metals (mg/kg)														
Copper	310	Metals (mg/kg)														
Iron	2,300	Metals (mg/kg)														
Lead	300	Metals (mg/kg)	16.4	V	37.2027	R	28.8	V	51.5	V	29.9	V	9.8	V	11.5	V
Magnesium	NE	Metals (mg/kg)														
Manganese	180	Metals (mg/kg)														
Mercury	2.3	Metals (mg/kg)														
Nickel	20	Metals (mg/kg)														
Potassium	NE	Metals (mg/kg)														
Silver	39	Metals (mg/kg)														
Vanadium	55	Metals (mg/kg)														
Zinc	2,300	Metals (mg/kg)														
Benzo(a)anthracene	620	PAHs (µg/kg)														
Benzo(a)pyrene	62	PAHs (µg/kg)														
Benzo(b)fluoranthene	620	PAHs (µg/kg)														
Benzo(g,h,i)perylene	1,000	PAHs (µg/kg)														
Benzo(k)fluoranthene	6,200	PAHs (µg/kg)														
Chrysene	7,000	PAHs (µg/kg)														
Dibenz(a,h)Anthracene	62	PAHs (µg/kg)														
Fluoranthene	23,000	PAHs (µg/kg)														
Indeno(1,2,3-c,d)Pyrene	620	PAHs (µg/kg)														
Phenanthrene	100,000	PAHs (µg/kg)														
Pyrene	230,000	PAHs (µg/kg)														
4,4-DDE	170	Pesticides (µg/kg)														
4,4-DDT	170	Pesticides (µg/kg)														
Aromatic Hydrocarbons (C_{11}-C_{22})	200	TPH (mg/kg)														
Acetone	60,000	VOCs (µg/kg)														
Toluene	500	VOCs (µg/kg)														

Notes:
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Table 6-4a
IA-03 Summary of Screened Analytical Results

Analyte	Project Action Level	Analyte Category (units)	IA3-005-B 0-0.5 ft		IA3-005-C 0-0.5 ft		IA3-005-C-D 0-0.5 ft		IA3-005-C-D-D 0-0.5 ft		IA3-005-D 0-0.5 ft		IA3-005-E 0-0.5 ft		IA3-006-A 0-0.5 ft	
Aluminum	7,600	Metals (mg/kg)														
Antimony	3.1	Metals (mg/kg)														
Arsenic	0.39	Metals (mg/kg)														
Barium	540	Metals (mg/kg)														
Calcium	NE	Metals (mg/kg)														
Chromium	30	Metals (mg/kg)														
Cobalt	500	Metals (mg/kg)														
Copper	310	Metals (mg/kg)														
Iron	2,300	Metals (mg/kg)														
Lead	300	Metals (mg/kg)	52.7	V	17.7	V	13.9	V	16.6021	V	14.7	V	18.2	V	14.6	V
Magnesium	NE	Metals (mg/kg)														
Manganese	180	Metals (mg/kg)														
Mercury	2.3	Metals (mg/kg)														
Nickel	20	Metals (mg/kg)														
Potassium	NE	Metals (mg/kg)														
Silver	39	Metals (mg/kg)														
Vanadium	55	Metals (mg/kg)														
Zinc	2,300	Metals (mg/kg)														
Benzo(a)anthracene	620	PAHs (µg/kg)														
Benzo(a)pyrene	62	PAHs (µg/kg)														
Benzo(b)fluoranthene	620	PAHs (µg/kg)														
Benzo(g,h,i)perylene	1,000	PAHs (µg/kg)														
Benzo(k)fluoranthene	6,200	PAHs (µg/kg)														
Chrysene	7,000	PAHs (µg/kg)														
Dibenz(a,h)Anthracene	62	PAHs (µg/kg)														
Fluoranthene	23,000	PAHs (µg/kg)														
Indeno(1,2,3-c,d)Pyrene	620	PAHs (µg/kg)														
Phenanthrene	100,000	PAHs (µg/kg)														
Pyrene	230,000	PAHs (µg/kg)														
4,4-DDE	170	Pesticides (µg/kg)														
4,4-DDT	170	Pesticides (µg/kg)														
Aromatic Hydrocarbons (C_{11}-C_{22})	200	TPH (mg/kg)														
Acetone	60,000	VOCs (µg/kg)														
Toluene	500	VOCs (µg/kg)														

Notes:
mg/kg = Milligrams per kilogram (parts per million)
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J = Estimated result; substance detected, but below the detection limit.
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Table 6-4a
IA-03 Summary of Screened Analytical Results

Analyte	Project Action Level	Analyte Category (units)	IA3-006-B 0-0.5 ft		IA3-006-B-D 0-0.5 ft		IA3-006-C 0-0.5 ft		IA3-006-D 0-0.5 ft		IA3-006-D-D 0-0.5 ft		IA3-006-E 0-0.5 ft	
Aluminum	7,600	Metals (mg/kg)												
Antimony	3.1	Metals (mg/kg)												
Arsenic	0.39	Metals (mg/kg)												
Barium	540	Metals (mg/kg)												
Calcium	NE	Metals (mg/kg)												
Chromium	30	Metals (mg/kg)												
Cobalt	500	Metals (mg/kg)												
Copper	310	Metals (mg/kg)												
Iron	2,300	Metals (mg/kg)												
Lead	300	Metals (mg/kg)	45.3	V	24.8	V	52.2	V	11.4	V	11.3382	V	6.7	V
Magnesium	NE	Metals (mg/kg)												
Manganese	180	Metals (mg/kg)												
Mercury	2.3	Metals (mg/kg)												
Nickel	20	Metals (mg/kg)												
Potassium	NE	Metals (mg/kg)												
Silver	39	Metals (mg/kg)												
Vanadium	55	Metals (mg/kg)												
Zinc	2,300	Metals (mg/kg)												
Benzo(a)anthracene	620	PAHs (µg/kg)												
Benzo(a)pyrene	62	PAHs (µg/kg)												
Benzo(b)fluoranthene	620	PAHs (µg/kg)												
Benzo(g,h,i)perylene	1,000	PAHs (µg/kg)												
Benzo(k)fluoranthene	6,200	PAHs (µg/kg)												
Chrysene	7,000	PAHs (µg/kg)												
Dibenz(a,h)Anthracene	62	PAHs (µg/kg)												
Fluoranthene	23,000	PAHs (µg/kg)												
Indeno(1,2,3-c,d)Pyrene	620	PAHs (µg/kg)												
Phenanthrene	100,000	PAHs (µg/kg)												
Pyrene	230,000	PAHs (µg/kg)												
4,4-DDE	170	Pesticides (µg/kg)												
4,4-DDT	170	Pesticides (µg/kg)												
Aromatic Hydrocarbons (C_{11}-C_{22})	200	TPH (mg/kg)												
Acetone	60,000	VOCs (µg/kg)												
Toluene	500	VOCs (µg/kg)												

Notes:
mg/kg = Milligrams per kilogram (parts per million)
µg/kg = Micrograms per kilogram (parts per billion)
V = Valid result; substance detected.
J = Estimated result; substance detected, but below the detection limit.
U = Substance not detected; detection limit listed.
Highlighted results were detected above their Project Action Level.
NE = Not established.

Table 6-4b
IA-3 Hazard Screening Calculation Summary
PASI/SSI Comprehensive Report
Study Area - Grant, Locust, and Cavite Housing Areas
Devens, Massachusetts

Analyte	Analyte Category (units)	Carcinogen (Ca) or Non-carcinogen (NC)	EPA Region IX Residential Soil PRG	Average Value	Maximum Value	95% UCL	Exposure Point Concentration (EPC)[1]	Screening Cancer Risk (SCR)	Screening Hazard Quotient (SHQ)
Aluminum	Metals (mg/kg)	NC	76000	7553.33	11000	8098.35	8098.35		0.11
Arsenic	Metals (mg/kg)	Ca	0.39	19.77	31	21.65	21.65	6.E-05	
Iron	Metals (mg/kg)	NC	23000	9753.33	15000	10532.34	10532.34		0.46
Lead	Metals (mg/kg)	NC	400	17.10	59.4	19.34	19.34		0.05
Manganese	Metals (mg/kg)	NC	1800	138.37	240	155.21	155.21		0.09
Nickel	Metals (mg/kg)	NC	1600	14.41	25	16.16	16.16		0.01
Benzo(a)pyrene	PAHs (µg/kg)	Ca	62	172.50	620	556.09	556.09	9.E-06	
Dibenz(a,h)Anthracene	PAHs (µg/kg)	Ca	62	25.88	82	74.04	74.04	1.E-06	
Phenanthrene	PAHs (µg/kg)	NC	NE	269.75	540	342.06	342.06		
Pyrene	PAHs (µg/kg)	NC	2300	347.25	850	793.01	793.01		0.34
							Total:	7.E-05	1.05

NE = Not established.
[1] = Lesser of Maximum or 95% UCL used.
PAH = polycyclic aromatic hydrocarbons
PRG = Preliminary Remediation Goals
UCL = Upper Confident Limit
PCB = polychlorinated biphenyls
NA = not applicable
mg/kg = milligrams per kilogram
µg/kg = micrograms per kilogram

Summary

Total Screening Cancer Risk: 7.E-05	TSCR>1E-04? No
Total Screening Hazard Quotient: 1	TSHI>1? No
Arsenic concentration is consistent with background.	
TSCR due to Arsenic: 6.E-05	TSCR w/o Arsenic: 1.E-05
TSCR due to Arsenic is <1E-04.	TSCR w/o Arsenic is <1E-04.
Total PCBs concentration is less than 1 mg/kg.	
TSCR w/o PCBs: NA	TSCR w/o PCBs: 7.E-05
	TSCR w/o PCBs is <1E-04.
PAHs concentration(s) are consistent with background.	
TSCR due to PAHs: 1.E-05	TSCR w/o to PAHs: 6.E-05
TSCR due to PAHs is <1E-04.	TSCR w/o PAHs is <1E-04.

Table 6-5a
IA-5 Summary of Screened Analytical Results

Analyte	Project Action Level	Analyte Category (units)	GR-IA05-SB01-1 0-3 ft		GR-IA05-SB01-1-M 0-3 ft		GR-IA05-SB02-1 0-3 ft		GR-IA05-SB02-1 3-10 ft		GR-IA05-SB02-1-D 0-3 ft		GR-IA05-SB03-1 0-3 ft		GR-IA05-SB03-1 3-10 ft	
Aluminum	7,600	Metals (mg/kg)	9800	V	6800	V	7900	V	9000	V	8000	V	10000	V	6700	V
Arsenic	0.39	Metals (mg/kg)	23	V	28	V	22	V	24	V	22	V	21	V	35	V
Barium	540	Metals (mg/kg)	13	V	23	V	8.2	V	22	V	7.3	V	23	V	14	V
Calcium	NE	Metals (mg/kg)	310	V	580	V	160	V	420	V	150	V	450	V	990	V
Chromium	30	Metals (mg/kg)	16	V	22	V	15	V	29	V	16	V	18	V	18	V
Cobalt	500	Metals (mg/kg)	4.1	V	6.4	V	4	V	6	V	4.2	V	5.2	V	6.1	V
Copper	310	Metals (mg/kg)	6.2	V	13	V	7	V	12	V	7.2	V	6.4	V	11	V
Iron	2,300	Metals (mg/kg)	11000	V	11000	V	10000	V	13000	V	11000	V	11000	V	13000	V
Lead	300	Metals (mg/kg)	19	V	7.3	V	24	V	6.6	V	12	V	16	V	9	V
Magnesium	NE	Metals (mg/kg)	3000	V	3500	V	3000	V	5000	V	3400	V	3200	V	3700	V
Manganese	180	Metals (mg/kg)	160	V	200	V	110	V	180	V	110	V	340	V	220	V
Mercury	2	Metals (µg/kg)	0.026	J	0.0425	U	0.011	J	0.043	U	0.0057	J	0.037	J	0.041	U
Nickel	20	Metals (mg/kg)	15	V	21	V	16	V	23	V	17	V	19	V	23	V
Potassium	NE	Metals (mg/kg)	370	V	1200	V	290	V	1400	V	320	V	600	V	710	V
Vanadium	55	Metals (mg/kg)	14	V	13	V	10	V	15	V	11	V	15	V	11	V
Zinc	2,300	Metals (mg/kg)	20	V	20	V	18	V	22	V	19	V	26	V	23	V
Benzo(a)pyrene	62	PAH (µg/kg)														
Total PCBs	220	PCBs (µg/kg)														
Acetone	60,000	VOCs (µg/kg)														

Notes:
mg/kg = Milligrams per kilogram (parts per million)
µg/kg = Micrograms per kilogram (parts per billion)
V = Valid result; substance detected.
J = Estimated result; substance detected, but below the detection limit.
U = Substance not detected; detection limit listed.
Highlighted results were detected above their Project Action Level.

Table 6-5a
IA-5 Summary of Screened Analytical Results

Analyte	Project Action Level	Analyte Category (units)	GR-IA05-SB04-1 0-3 ft		GR-IA05-SB04-1 3-10 ft		GR-IA05-SB05-1 0-3 ft		GR-IA05-SB05-1 3-10 ft		GR-IA05-SB06-1 0-3 ft		GR-IA05-SB06-1 3-10 ft		GR-IA05-SB06-1-D 0-3 ft	
Aluminum	7,600	Metals (mg/kg)	12000	V	7100	V	9200	V	6200	V	7700	V	5100	V	7200	V
Arsenic	0.39	Metals (mg/kg)	22	V	33	V	25	V	22	V	21	V	24	V	20	V
Barium	540	Metals (mg/kg)	27	V	23	V	22	V	18	V	15	V	18	V	16	V
Calcium	NE	Metals (mg/kg)	560	V	440	V	410	V	520	V	540	V	600	V	530	V
Chromium	30	Metals (mg/kg)	33	V	23	V	18	V	15	V	16	V	14	V	16	V
Cobalt	500	Metals (mg/kg)	7	V	7.3	V	5.7	V	5.6	V	4.8	V	6.6	V	4.4	V
Copper	310	Metals (mg/kg)	8.5	V	15	V	8.7	V	13	V	9.5	V	14	V	8.9	V
Iron	2,300	Metals (mg/kg)	14000	V	11000	V	10000	V	9200	V	8400	V	9300	V	8300	V
Lead	300	Metals (mg/kg)	8.7	V	7.6	V	14	V	7.4	V	16	V	10	V	18	V
Magnesium	NE	Metals (mg/kg)	4700	V	3400	V	2300	V	2600	V	2200	V	2800	V	2100	V
Manganese	180	Metals (mg/kg)	270	V	230	V	270	V	160	V	140	V	180	V	170	V
Mercury	2	Metals (µg/kg)	0.023	J	0.042	U	0.027	J	0.042	U	0.019	J	0.0425	U	0.019	J
Nickel	20	Metals (mg/kg)	24	V	25	V	18	V	18	V	16	V	22	V	15	V
Potassium	NE	Metals (mg/kg)	1800	V	1300	V	760	V	1000	V	620	V	1000	V	590	V
Vanadium	55	Metals (mg/kg)	21	V	14	V	13	V	11	V	10	V	11	V	10	V
Zinc	2,300	Metals (mg/kg)	26	V	22	V	22	V	18	V	20	V	24	V	19	V
Benzo(a)pyrene	62	PAH (µg/kg)														
Total PCBs	220	PCBs (µg/kg)														
Acetone	60,000	VOCs (µg/kg)														

Notes:
mg/kg = Milligrams per kilogram (parts per million)
µg/kg = Micrograms per kilogram (parts per billion)
V = Valid result; substance detected.
J = Estimated result; substance detected, but below the detection limit.
U = Substance not detected; detection limit listed.
Highlighted results were detected above their Project Action Level.

Table 6-5a
IA-5 Summary of Screened Analytical Results

Analyte	Project Action Level	Analyte Category (units)	GR-IA05-SB07-1 0-3 ft		GR-IA05-SB07-1 3-10 ft		GR-IA05-SB08-1 0-3 ft		GR-IA05-SB08-1 3-10 ft		GR-IA05-SB09-1 0-3 ft		GR-IA05-SB09-1 3-10 ft		GR-IA05-SS01-1 0-1.5 ft	
Aluminum	7,600	Metals (mg/kg)	8400	V	10000	V	8500	V	7900	V	6200	V	7400	V	8300	V
Arsenic	0.39	Metals (mg/kg)	23	V	30	V	24	V	38	V	32	V	23	V	25	V
Barium	540	Metals (mg/kg)	13	V	32	V	22	V	20	V	18	V	14	V	16	V
Calcium	NE	Metals (mg/kg)	290	V	560	V	860	V	640	V	1600	V	280	V	350	V
Chromium	30	Metals (mg/kg)	13	V	26	V	20	V	17	V	17	V	17	V	17	V
Cobalt	500	Metals (mg/kg)	4.2	V	9	V	6.5	V	6.2	V	7.7	V	5.1	V	4.9	V
Copper	310	Metals (mg/kg)	6.4	V	18	V	13	V	12	V	37	V	68	V	8.7	V
Iron	2,300	Metals (mg/kg)	9100	V	15000	V	12000	V	11000	V	13000	V	9800	V	10000	V
Lead	300	Metals (mg/kg)	21	V	8.1	V	17	V	12	V	8.1	V	7.2	V	36	V
Magnesium	NE	Metals (mg/kg)	2000	V	5400	V	2900	V	3000	V	2800	V	2900	V	2000	V
Manganese	180	Metals (mg/kg)	130	V	250	V	280	V	190	V	300	V	170	V	340	V
Mercury	2	Metals (µg/kg)	0.024	J	0.04	U	0.016	J	0.01	J	0.0044	J	0.0088	J	0.068	J
Nickel	20	Metals (mg/kg)	15	V	30	V	52	V	24	V	27	V	18	V	17	V
Potassium	NE	Metals (mg/kg)	330	V	2000	V	860	V	1000	V	840	V	870	V	370	V
Vanadium	55	Metals (mg/kg)	11	V	19	V	12	V	12	V	10	V	11	V	16	V
Zinc	2,300	Metals (mg/kg)	19	V	29	V	29	V	23	V	27	V	22	V	40	V
Benzo(a)pyrene	62	PAH (µg/kg)	17	V	7	U										
Total PCBs	220	PCBs (µg/kg)	19.6	U	18.1	U										
Acetone	60,000	VOCs (µg/kg)	57	V	22	V										

Notes:
mg/kg = Milligrams per kilogram (parts per million)
µg/kg = Micrograms per kilogram (parts per billion)
V = Valid result; substance detected.
J = Estimated result; substance detected, but below the detection limit.
U = Substance not detected; detection limit listed.
Highlighted results were detected above their Project Action Level.

Table 6-5a
IA-5 Summary of Screened Analytical Results

Analyte	Project Action Level	Analyte Category (units)	GR-IA05-SS02-1 0-1.5 ft		GR-IA05-SS03-1 0-1.5 ft		GR-IA05-SS03-1-D 0-1.5 ft		GR-IA05-SS04-1 0-1.5 ft		GR-IA05-SS05-1 0-1.5 ft		GR-IA05-SS06-1 0-1.5 ft		GR-IA05-SS06-1-D 0-1.5 ft	
Aluminum	7,600	Metals (mg/kg)	7700	V	6500	V	6200	V	6700	V	7600	V	6200	V	6200	V
Arsenic	0.39	Metals (mg/kg)	33	V	30	V	32	V	20	V	21	V	19	V	22	V
Barium	540	Metals (mg/kg)	11	V	20	V	19	V	13	V	21	V	14	V	13	V
Calcium	NE	Metals (mg/kg)	400	V	660	V	640	V	360	V	330	V	280	V	260	V
Chromium	30	Metals (mg/kg)	16	V	16	V	14	V	10	V	14	V	11	V	11	V
Cobalt	500	Metals (mg/kg)	5.7	V	6.7	V	6.7	V	3.2	V	4.3	V	3.9	V	4	V
Copper	310	Metals (mg/kg)	13	V	15	V	14	V	5.6	V	8.7	V	5.9	V	6.2	V
Iron	2,300	Metals (mg/kg)	9200	V	10000	V	11000	V	7400	V	9900	V	7900	V	8400	V
Lead	300	Metals (mg/kg)	11	V	170	V	180	V	55	V	35	V	18	V	18	V
Magnesium	NE	Metals (mg/kg)	2300	V	2600	V	2300	V	1300	V	1800	V	1400	V	1400	V
Manganese	180	Metals (mg/kg)	100	V	260	V	300	V	230	V	290	V	310	V	300	V
Mercury	2	Metals (µg/kg)	0.012	J	0.038	J	0.04	J	0.031	J	0.054	J	0.048	J	0.049	J
Nickel	20	Metals (mg/kg)	22	V	22	V	21	V	13	V	15	V	12	V	12	V
Potassium	NE	Metals (mg/kg)	580	V	930	V	790	V	200	V	490	V	260	V	240	V
Vanadium	55	Metals (mg/kg)	11	V	13	V	13	V	9	V	13	V	11	V	12	V
Zinc	2,300	Metals (mg/kg)	19	V	30	V	31	V	18	V	27	V	18	V	18	V
Benzo(a)pyrene	62	PAH (µg/kg)														
Total PCBs	220	PCBs (µg/kg)														
Acetone	60,000	VOCs (µg/kg)														

Notes:
mg/kg = Milligrams per kilogram (parts per million)
µg/kg = Micrograms per kilogram (parts per billion)
V = Valid result; substance detected.
J = Estimated result; substance detected, but below the detection limit.
U = Substance not detected; detection limit listed.
Highlighted results were detected above their Project Action Level.

Table 6-5a
IA-5 Summary of Screened Analytical Results

Analyte	Project Action Level	Analyte Category (units)	IA5-001-A 0-0.5 ft		IA5-001-A-D 0-0.5 ft		IA5-001-B 0-0.5 ft		IA5-001-C 0-0.5 ft		IA5-001-D 0-0.5 ft		IA5-001-E 0-0.5 ft		IA5-002-A 0-0.5 ft	
Aluminum	7,600	Metals (mg/kg)														
Arsenic	0.39	Metals (mg/kg)														
Barium	540	Metals (mg/kg)														
Calcium	NE	Metals (mg/kg)														
Chromium	30	Metals (mg/kg)														
Cobalt	500	Metals (mg/kg)														
Copper	310	Metals (mg/kg)														
Iron	2,300	Metals (mg/kg)														
Lead	300	Metals (mg/kg)	51.3	V	43.5658	V	48.9	V	34.1	V	26.8	V	7	V	7	V
Magnesium	NE	Metals (mg/kg)														
Manganese	180	Metals (mg/kg)														
Mercury	2	Metals (µg/kg)														
Nickel	20	Metals (mg/kg)														
Potassium	NE	Metals (mg/kg)														
Vanadium	55	Metals (mg/kg)														
Zinc	2,300	Metals (mg/kg)														
Benzo(a)pyrene	62	PAH (µg/kg)														
Total PCBs	220	PCBs (µg/kg)														
Acetone	60,000	VOCs (µg/kg)														

Notes:
mg/kg = Milligrams per kilogram (parts per million)
µg/kg = Micrograms per kilogram (parts per billion)
V = Valid result; substance detected.
J = Estimated result; substance detected, but below the detection limit.
U = Substance not detected; detection limit listed.
Highlighted results were detected above their Project Action Level.

Table 6-5a
IA-5 Summary of Screened Analytical Results

Analyte	Project Action Level	Analyte Category (units)	IA5-002-B 0-0.5 ft		IA5-002-C 0-0.5 ft		IA5-002-D 0-0.5 ft		IA5-002-E 0-0.5 ft		IA5-003-A 0-0.5 ft		IA5-003-B 0-0.5 ft		IA5-003-C 0-0.5 ft	
Aluminum	7,600	Metals (mg/kg)														
Arsenic	0.39	Metals (mg/kg)														
Barium	540	Metals (mg/kg)														
Calcium	NE	Metals (mg/kg)														
Chromium	30	Metals (mg/kg)														
Cobalt	500	Metals (mg/kg)														
Copper	310	Metals (mg/kg)														
Iron	2,300	Metals (mg/kg)														
Lead	300	Metals (mg/kg)	7.2	V	89.7	V	31.7	V	203	V	203	V	45	V	15	V
Magnesium	NE	Metals (mg/kg)														
Manganese	180	Metals (mg/kg)														
Mercury	2	Metals (µg/kg)														
Nickel	20	Metals (mg/kg)														
Potassium	NE	Metals (mg/kg)														
Vanadium	55	Metals (mg/kg)														
Zinc	2,300	Metals (mg/kg)														
Benzo(a)pyrene	62	PAH (µg/kg)														
Total PCBs	220	PCBs (µg/kg)														
Acetone	60,000	VOCs (µg/kg)														

Notes:
mg/kg = Milligrams per kilogram (parts per million)
µg/kg = Micrograms per kilogram (parts per billion)
V = Valid result; substance detected.
J = Estimated result; substance detected, but below the detection limit.
U = Substance not detected; detection limit listed.
Highlighted results were detected above their Project Action Level.

Table 6-5a
IA-5 Summary of Screened Analytical Results

Analyte	Project Action Level	Analyte Category (units)	IA5-003-D 0-0.5 ft		IA5-003-D-D 0-0.5 ft		IA5-003-E 0-0.5 ft		IA5-004-A 0-0.5 ft		IA5-004-B 0-0.5 ft		IA5-004-C 0-0.5 ft		IA5-004-D 0-0.5 ft	
Aluminum	7,600	Metals (mg/kg)														
Arsenic	0.39	Metals (mg/kg)														
Barium	540	Metals (mg/kg)														
Calcium	NE	Metals (mg/kg)														
Chromium	30	Metals (mg/kg)														
Cobalt	500	Metals (mg/kg)														
Copper	310	Metals (mg/kg)														
Iron	2,300	Metals (mg/kg)														
Lead	300	Metals (mg/kg)	44	V	8.1	V	14.1	V	86.1	V	83.2	V	45.4	V	21.4	V
Magnesium	NE	Metals (mg/kg)														
Manganese	180	Metals (mg/kg)														
Mercury	2	Metals (µg/kg)														
Nickel	20	Metals (mg/kg)														
Potassium	NE	Metals (mg/kg)														
Vanadium	55	Metals (mg/kg)														
Zinc	2,300	Metals (mg/kg)														
Benzo(a)pyrene	62	PAH (µg/kg)														
Total PCBs	220	PCBs (µg/kg)														
Acetone	60,000	VOCs (µg/kg)														

Notes:
mg/kg = Milligrams per kilogram (parts per million)
µg/kg = Micrograms per kilogram (parts per billion)
V = Valid result; substance detected.
J = Estimated result; substance detected, but below the detection limit.
U = Substance not detected; detection limit listed.
Highlighted results were detected above their Project Action Level.

Table 6-5a
IA-5 Summary of Screened Analytical Results

Analyte	Project Action Level	Analyte Category (units)	IA5-004-E 0-0.5 ft		IA5-004-E-D 0-0.5 ft		IA5-005-A 0-0.5 ft		IA5-005-A-D 0-0.5 ft		IA5-005-B 0-0.5 ft		IA5-005-C 0-0.5 ft		IA5-005-D 0-0.5 ft	
Aluminum	7,600	Metals (mg/kg)														
Arsenic	0.39	Metals (mg/kg)														
Barium	540	Metals (mg/kg)														
Calcium	NE	Metals (mg/kg)														
Chromium	30	Metals (mg/kg)														
Cobalt	500	Metals (mg/kg)														
Copper	310	Metals (mg/kg)														
Iron	2,300	Metals (mg/kg)														
Lead	300	Metals (mg/kg)	12.5	V	11.6	V	19.8	V	16.1	V	26.1	V	15.2	V	27.2	V
Magnesium	NE	Metals (mg/kg)														
Manganese	180	Metals (mg/kg)														
Mercury	2	Metals (µg/kg)														
Nickel	20	Metals (mg/kg)														
Potassium	NE	Metals (mg/kg)														
Vanadium	55	Metals (mg/kg)														
Zinc	2,300	Metals (mg/kg)														
Benzo(a)pyrene	62	PAH (µg/kg)														
Total PCBs	220	PCBs (µg/kg)														
Acetone	60,000	VOCs (µg/kg)														

Notes:
mg/kg = Milligrams per kilogram (parts per million)
µg/kg = Micrograms per kilogram (parts per billion)
V = Valid result; substance detected.
J = Estimated result; substance detected, but below the detection limit.
U = Substance not detected; detection limit listed.
Highlighted results were detected above their Project Action Level.

Table 6-5a
IA-5 Summary of Screened Analytical Results

Analyte	Project Action Level	Analyte Category (units)	IA5-005-E 0-0.5 ft		PASI-GR-CO-027-1 0-3 ft		PASI-GR-CO-034-1 0-3 ft		PASI-GR-CO-043-1 0-3 ft		PASI-GR-GB-043A-1 0-3 ft		PASI-GR-GB-043B-1 0-3 ft	
Aluminum	7,600	Metals (mg/kg)												
Arsenic	0.39	Metals (mg/kg)												
Barium	540	Metals (mg/kg)												
Calcium	NE	Metals (mg/kg)												
Chromium	30	Metals (mg/kg)												
Cobalt	500	Metals (mg/kg)												
Copper	310	Metals (mg/kg)												
Iron	2,300	Metals (mg/kg)												
Lead	300	Metals (mg/kg)	26.5	V										
Magnesium	NE	Metals (mg/kg)												
Manganese	180	Metals (mg/kg)												
Mercury	2	Metals (µg/kg)												
Nickel	20	Metals (mg/kg)												
Potassium	NE	Metals (mg/kg)												
Vanadium	55	Metals (mg/kg)												
Zinc	2,300	Metals (mg/kg)												
Benzo(a)pyrene	62	PAH (µg/kg)												
Total PCBs	220	PCBs (µg/kg)			4.9	U	13	U	1100	V	4.7	U	4.5	U
Acetone	60,000	VOCs (µg/kg)												

Notes:
mg/kg = Milligrams per kilogram (parts per million)
µg/kg = Micrograms per kilogram (parts per billion)
V = Valid result; substance detected.
J = Estimated result; substance detected, but below the detection limit.
U = Substance not detected; detection limit listed.
Highlighted results were detected above their Project Action Level.

Table 6-5a
IA-5 Summary of Screened Analytical Results

Analyte	Project Action Level	Analyte Category (units)	PASI-GR-GB-043C-1 0-3 ft		PASI-GR-GB-043D-1 0-3 ft		PASI-GR-GB-043E-1 0-3 ft	
Aluminum	7,600	Metals (mg/kg)						
Arsenic	0.39	Metals (mg/kg)						
Barium	540	Metals (mg/kg)						
Calcium	NE	Metals (mg/kg)						
Chromium	30	Metals (mg/kg)						
Cobalt	500	Metals (mg/kg)						
Copper	310	Metals (mg/kg)						
Iron	2,300	Metals (mg/kg)						
Lead	300	Metals (mg/kg)						
Magnesium	NE	Metals (mg/kg)						
Manganese	180	Metals (mg/kg)						
Mercury	2	Metals (µg/kg)						
Nickel	20	Metals (mg/kg)						
Potassium	NE	Metals (mg/kg)						
Vanadium	55	Metals (mg/kg)						
Zinc	2,300	Metals (mg/kg)						
Benzo(a)pyrene	62	PAH (µg/kg)						
Total PCBs	220	PCBs (µg/kg)	1700	V	150	V	4.65	U
Acetone	60,000	VOCs (µg/kg)						

Notes:
mg/kg = Milligrams per kilogram (parts per million)
µg/kg = Micrograms per kilogram (parts per billion)
V = Valid result; substance detected.
J = Estimated result; substance detected, but below the detection limit.
U = Substance not detected; detection limit listed.
Highlighted results were detected above their Project Action Level.

Table 6-5b
IA-5 Hazard Screening Calculation Summary
PASI/SSI Comprehensive Report
Study Area - Grant, Locust, and Cavite Housing Areas
Devens, Massachusetts

Analyte	Analyte Category (units)	Carcinogen (Ca) or Non-carcinogen (NC)	EPA Region IX Residential Soil PRG	Average Value	Maximum Value	95% UCL	Exposure Point Concentration (EPC)[1]	Screening Cancer Risk (SCR)	Screening Hazard Quotient (SHQ)
Aluminum	Metals (mg/kg)	NC	76,000	7,875	12,000	8,423	8,423		0.11
Arsenic	Metals (mg/kg)	Ca	0.39	26	38	28	28	7.E-05	
Chromium	Metals (mg/kg)	Ca	210	18	33	20	20	9.E-08	
Iron	Metals (mg/kg)	NC	23,000	10,738	15,000	11,392	11,392		0.50
Lead	Metals (mg/kg)	NC	400	36	203	64	64		0.16
Manganese	Metals (mg/kg)	NC	1,800	224	340	8,423	340		0.19
Nickel	Metals (mg/kg)	NC	1,600	21	52	24	24		0.01
Total PCBs	PCBs (µg/kg)	Ca	220	302	1,700	83	83	4.E-07	
							Total:	7.E-05	0.97

[1] = Lesser of Maximum or 95% UCL used.
PAH = polycyclic aromatic hydrocarbons
PRG = Preliminary Remediation Goals
UCL = Upper Confident Limit
PCB = polychlorinated biphenyls
NA = not applicable
mg/kg = milligrams per kilogram
µg/kg = micrograms per kilogram

Summary

Total Screening Cancer Risk: 7.E-05	TSCR>1E-04? No
Total Screening Hazard Quotient: 1	TSHI>1? No
Arsenic concentration is consistent with background.	
TSCR due to Arsenic: 7.E-05	TSCR w/o Arsenic: 5.E-07
TSCR due to Arsenic is <1E-04.	TSCR w/o Arsenic is <1E-04.
Total PCBs concentration is greater than 1 mg/kg.	
TSCR due to PCBs: 4.E-07	TSCR w/o PCBs: 7.E-05
TSCR due to PCBs is <1E-04.	TSCR w/o PCBs is <1E-04.
PAHs concentration(s) are consistent with background.	
TSCR due to PAHs: NA	TSCR w/o to PAHs: 7.E-05
	TSCR w/o PAHs is <1E-04.

Table 6-6a
IA-6 Summary of Screened Analytical Results
PASI/SSI Comprehensive Report
Study Area - Grant, Locust, and Cavite Housing Areas
Devens, Massachusetts

Analyte	Project Action Level	Analyte Category (units)	IA6-001-A 0-0.5	IA6-001-B 0-0.5	IA6-001-C 0-0.5	IA6-001-D 0-0.5	IA6-001-E 0-0.5	IA6-001-E-D 0-0.5	IA6-002-A 0-0.5	IA6-002-B 0-0.5	IA6-002-C 0-0.5	IA6-002-D 0-0.5
Aluminum	7,600	Metals (mg/kg)										
Antimony	3.1	Metals (mg/kg)										
Arsenic	0.39	Metals (mg/kg)										
Barium	540	Metals (mg/kg)										
Beryllium	1	Metals (mg/kg)										
Cadmium	2	Metals (mg/kg)										
Calcium	NE	Metals (mg/kg)										
Chromium	30	Metals (mg/kg)										
Cobalt	900	Metals (mg/kg)										
Copper	310	Metals (mg/kg)										
Iron	2,300	Metals (mg/kg)										
Lead	30	Metals (mg/kg)	1000 V	610 V	760 V	280 V	340 V	290 V	2600 V	530 V	2.3 V	960 V
Magnesium	NE	Metals (mg/kg)										
Manganese	180	Metals (mg/kg)										
Mercury	2.3	Metals (mg/kg)										
Nickel	20	Metals (mg/kg)										
Potassium	NE	Metals (mg/kg)										
Selenium	39	Metals (mg/kg)										
Silver	39	Metals (mg/kg)										
Sodium	NE	Metals (mg/kg)										
Thallium	0.52	Metals (mg/kg)										
Vanadium	55	Metals (mg/kg)										
Zinc	2,300	Metals (mg/kg)										
Acenaphthylene	370,000	PAHs (µg/kg)										
Anthracene	100,000	PAHs (µg/kg)										
Benzo(a)anthracene	620	PAHs (µg/kg)										
Benzo(a)pyrene	62	PAHs (µg/kg)										
Benzo(b)fluoranthene	620	PAHs (µg/kg)										
Benzo(g,h,i)perylene	2,500	PAHs (µg/kg)										
Benzo(k)fluoranthene	6,200	PAHs (µg/kg)										
Chrysene	7,000	PAHs (µg/kg)										
Dibenz(a,h)Anthracene	62	PAHs (µg/kg)										
Fluoranthene	230,000	PAHs (µg/kg)										
Indeno(1,2,3-c,d)Pyrene	620	PAHs (µg/kg)										
Naphthalene	5,600	PAHs (µg/kg)										
Phenanthrene	100,000	PAHs (µg/kg)										
Pyrene	230,000	PAHs (µg/kg)										
Aldrin	29	Pesticides (µg/kg)										
4,4-DDD	240	Pesticides (µg/kg)										
4,4-DDE	170	Pesticides (µg/kg)										
4,4-DDT	170	Pesticides (µg/kg)										
Dieldrin	30	Pesticides (µg/kg)										
1,2,4-Trichlorobenzene	65,000	SVOCs (µg/kg)										
2,4-Dinitrotoluene	12,000	SVOCs (µg/kg)										
Acetophenone	7,800	SVOCs (µg/kg)										
bis(2-ethylhexyl) phthalate	35,000	SVOCs (µg/kg)										
Hexachlorobutadiene	6,000	SVOCs (µg/kg)										
Phenol	20,000	SVOCs (µg/kg)										
Aliphatic Hydrocarbons (C_{19}-C_{36})	3,000	TPH (mg/kg)										
Aliphatic Hydrocarbons (C_{9}-C_{18})	1,000	TPH (mg/kg)										
Aromatic Hydrocarbons (C_{11}-C_{22})	800	TPH (mg/kg)										
1,2,3-Trichlorobenzene	NE	VOCs (µg/kg)										
2-Butanone		VOCs (µg/kg)										
4-Isopropyltoluene	NE	VOCs (µg/kg)										
Acetone	60,000	VOCs (µg/kg)										
Carbon Disulfide	36,000	VOCs (µg/kg)										
Toluene	500,000	VOCs (µg/kg)										

Notes:
mg/kg = Milligrams per kilogram (parts per million)
µg/kg = Micrograms per kilogram (parts per billion)
V = Valid result; substance detected.
J = Estimated result; substance detected, but below the detection limit.
U = Substance not detected; detection limit listed.
Highlighted results were detected above their Project Action Level.

Table 6-6a
IA-6 Summary of Screened Analytical Results
PASI/SSI Comprehensive Report
Study Area - Grant, Locust, and Cavite Housing Areas
Devens, Massachusetts

Analyte	Project Action Level	Analyte Category (units)	IA6-002-E 0-0.5	LO-IA06-SB03-1 0-3	LO-IA06-SB03-1 3-10	LO-IA06-SB04-1 0-3	LO-IA06-SB04-1 3-10	LO-IA06-SB04-1-T 0-0	LO-IA06-SB05-1 0-3	LO-IA06-SB05-1 3-10	LO-IA06-SB06-1 0-3	LO-IA06-SB06-1 3-10
Aluminum	7,600	Metals (mg/kg)	12800 V	9380 V	12500 V	14600 V		11100 V	4420 V	8580 V	6310 V
Antimony	3.1	Metals (mg/kg)	0.65 B	0.42 U	0.59 B	0.52 B		2.2 B	0.56 B	2.7 B	1 B
Arsenic	0.39	Metals (mg/kg)	39.7 V	14.1 V	41.4 V	22 V		27.8 V	18.1 V	12.2 V	16.8 V
Barium	540	Metals (mg/kg)	40.3 V	29.2 V	30 V	24.4 V		22.7 V	11.2 B	19.2 B	14.5 B
Beryllium	1	Metals (mg/kg)	0.43 B	0.27 B	0.42 B	0.42 B		0.65 V	0.23 B	0.34 B	0.24 B
Cadmium	2	Metals (mg/kg)	0.095 B	0.083 U	0.14 B	0.088 B		0.12 B	0.083 U	0.092 B	0.077 U
Calcium	NE	Metals (mg/kg)	1410 V	1150 V	1190 V	1060 V		970 V	757 V	547 V	1090 V
Chromium	30	Metals (mg/kg)	40.8 V	25.4 V	48.4 V	30.4 V		38.1 V	10.9 V	14.2 V	23.2 V
Cobalt	900	Metals (mg/kg)	10.8 V	5.2 B	10.9 V	6.8 V		7.6 V	3.7 B	4.5 B	4.9 V
Copper	310	Metals (mg/kg)	22.6 V	8 V	18.8 V	12.7 V		138 V	12.2 V	166 V	63.8 V
Iron	2,300	Metals (mg/kg)	21000 V	12400 V	20800 V	16100 V		18600 V	8020 V	11600 V	12300 V
Lead	30	Metals (mg/kg)	1100 V	13.9 V	7.1 V	14.1 V	9.6 V		424 V	23.2 V	319 V	177 V
Magnesium	NE	Metals (mg/kg)	7770 V	4600 V	8050 V	5120 V		6930 V	2170 V	2240 V	3590 V
Manganese	180	Metals (mg/kg)	377 V	166 V	402 V	216 V		392 V	157 V	108 V	230 V
Mercury	2.3	Metals (mg/kg)	0.015 U	0.018 U	0.017 U	0.019 U		0.015 U	0.018 U	0.019 U	0.018 U
Nickel	20	Metals (mg/kg)	39.5 V	18.3 V	37.6 V	22 V		25.6 V	11.9 V	13.4 V	17.4 V
Potassium	NE	Metals (mg/kg)	1990 V	1390 V	1610 V	1080 V		1410 V	481 B	495 V	719 V
Selenium	39	Metals (mg/kg)	0.69 V	0.71 V	1.1 V	0.5 B		0.8 V	0.44 B	0.63 V	0.58 V
Silver	39	Metals (mg/kg)	0.37 U	0.38 U	0.37 U	0.41 U		0.4 U	0.39 U	0.36 U	0.36 U
Sodium	NE	Metals (mg/kg)	210 B	166 B	182 B	202 B		185 B	177 B	140 B	158 B
Thallium	0.52	Metals (mg/kg)	0.64 U	0.88 U	0.64 U	0.93 U		0.68 U	0.67 U	0.62 U	0.62 U
Vanadium	55	Metals (mg/kg)	25.2 V	17.9 V	22.9 V	20.4 V		20.8 V	7.7 V	12.3 V	13.5 V
Zinc	2,300	Metals (mg/kg)	40.1 V	30.5 V	42 V	35.2 V		34.1 V	13.8 V	36.8 V	29 V
Acenaphthylene	370,000	PAHs (µg/kg)	350 U	380 U	370 U	440 U		370 U	380 U	390 U	380 U
Anthracene	100,000	PAHs (µg/kg)	350 U	380 U	370 U	440 U		370 U	380 U	390 U	380 U
Benzo(a)anthracene	620	PAHs (µg/kg)	350 U	380 U	370 U	440 U		370 U	380 U	390 U	380 U
Benzo(a)pyrene	62	PAHs (µg/kg)	350 U	380 U	370 U	440 U		370 U	380 U	390 U	380 U
Benzo(b)fluoranthene	620	PAHs (µg/kg)	350 U	380 U	370 U	440 U		370 U	380 U	390 U	380 U
Benzo(g,h,i)perylene	2,500	PAHs (µg/kg)	350 U	380 U	370 U	440 U		370 U	380 U	390 U	380 U
Benzo(k)fluoranthene	6,200	PAHs (µg/kg)	350 U	380 U	370 U	440 U		370 U	380 U	390 U	380 U
Chrysene	7,000	PAHs (µg/kg)	350 U	380 U	370 U	440 U		370 U	380 U	390 U	380 U
Dibenz(a,h)Anthracene	62	PAHs (µg/kg)	350 U	380 U	370 U	440 U		370 U	380 U	390 U	380 U
Fluoranthene	230,000	PAHs (µg/kg)	350 U	380 U	370 U	440 U		370 U	380 U	390 U	380 U
Indeno(1,2,3-c,d)Pyrene	620	PAHs (µg/kg)	350 U	380 U	370 U	440 U		370 U	380 U	390 U	380 U
Naphthalene	5,600	PAHs (µg/kg)			4.6 U	5.6 U	5 U			5 U	5.6 U
Phenanthrene	100,000	PAHs (µg/kg)	350 U	380 U	370 U	440 U		370 U	380 U	390 U	380 U
Pyrene	230,000	PAHs (µg/kg)	350 U	380 U	370 U	440 U		370 U	380 U	390 U	380 U
Aldrin	29	Pesticides (µg/kg)			1.9 U	2.2 U				5.9 U	1.9 U
4,4-DDD	240	Pesticides (µg/kg)			3.7 U	8.9 U				76 V	24 V
4,4-DDE	170	Pesticides (µg/kg)			11 V	8.9 U				12 V	3.7 J
4,4-DDT	170	Pesticides (µg/kg)			10 V	8.9 U				72 V	11 V
Dieldrin	30	Pesticides (µg/kg)			3.7 U	8.9 U				12 U	3.8 U
1,2,4-Trichlorobenzene	65,000	SVOCs (µg/kg)			4.6 U	5.6 U	5 U			5 U	5.6 U
2,4-Dinitrotoluene	12,000	SVOCs (µg/kg)	81 J	120 U	120 V	120 U		120 U	120 U	120 U	120 U
Acetophenone	7,800	SVOCs (µg/kg)	350 U	380 U	370 U	440 U		370 U	380 U	390 U	380 U
bis(2-ethylhexyl) phthalate	35,000	SVOCs (µg/kg)	350 U	380 U	370 U	440 U		370 U	380 U	390 U	380 U
Hexachlorobutadiene	6,000	SVOCs (µg/kg)			4.6 U	5.6 U	5 U			5 U	5.6 U
Phenol	20,000	SVOCs (µg/kg)	350 U	380 U	370 U	440 U		370 U	380 U	390 U	380 U
Aliphatic Hydrocarbons (C_{19}-C_{36})	3,000	TPH (mg/kg)			8.9 U	11 U				9.6 U	9 U
Aliphatic Hydrocarbons (C_9-C_{18})	1,000	TPH (mg/kg)			6.7 U	8 U				7.2 U	6.7 U
Aromatic Hydrocarbons (C_{11}-C_{22})	800	TPH (mg/kg)			19 U	23 U				20 U	19 U
1,2,3-Trichlorobenzene	NE	VOCs (µg/kg)			4.6 U	5.6 U	5 U			5 U	5.6 U
2-Butanone		VOCs (µg/kg)			3.7 J	3 J	5 U			2.4 J	5.6 U
4-Isopropyltoluene	NE	VOCs (µg/kg)			4.6 U	5.6 U	5 U			5 U	5.6 U
Acetone	60,000	VOCs (µg/kg)			45 V	20 V	5 U			23 V	9.5 V
Carbon Disulfide	36,000	VOCs (µg/kg)			4.6 U	5.6 U	5 U			5 U	5.6 U
Toluene	500,000	VOCs (µg/kg)			4.6 U	5.6 U	5 U			5 U	5.6 U

Notes:
mg/kg = Milligrams per kilogram (parts per million)
µg/kg = Micrograms per kilogram (parts per billion)
V = Valid result; substance detected.
J = Estimated result; substance detected, but below the detection limit.
U = Substance not detected; detection limit listed.
Highlighted results were detected above their Project Action Level.

Table 6-6a
IA-6 Summary of Screened Analytical Results
PASI/SSI Comprehensive Report
Study Area - Grant, Locust, and Cavite Housing Areas
Devens, Massachusetts

Analyte	Project Action Level	Analyte Category (units)	LO-IA06-SD01-1 0-0.5	LO-IA06-SD02-1 0-0.5	LO-IA06-SD03-1 0-0.5	LO-IA06-SD04-1 0-0.5	LO-IA06-SD05-1 0-0.5	LO-IA06-SD06-1 0-0.5	LO-IA06-SD06-1 0-1.5	LO-IA06-SD07-1 0-0.5	LO-IA06-SD08-1 0.5-1.5	LO-IA06-SD08-1 0-0.5
Aluminum	7,600	Metals (mg/kg)	6190 V	7890 V	11500 V	9020 V	10500 V	11300 V	11100 V	11600 V	8230 V	15100 V
Antimony	3.1	Metals (mg/kg)	0.62 U	0.51 U	0.55 U	0.62 U	0.56 U	0.62 U	0.64 U	1.1 B	0.73 B	3.1 B
Arsenic	0.39	Metals (mg/kg)	12.2 V	14.3 V	23.2 V	13.2 V	11.7 V	11.9 V	13.5 V	30.1 V	13.1 V	20.8 V
Barium	540	Metals (mg/kg)	11.6 B	19.7 B	28.6 V	18.5 B	16.7 B	22.5 B	18.1 B	23.3 B	23.5 V	28.7 B
Beryllium	1	Metals (mg/kg)	0.51 B	0.98 V	1.1 V	0.87 V	0.5 B	0.77 V	0.58 B	0.58 B	0.38 B	0.65 B
Cadmium	2	Metals (mg/kg)	0.13 B	0.09 B	0.12 B	0.09 B	0.082 U	0.1 B	0.094 U	0.079 U	0.066 U	0.099 U
Calcium	NE	Metals (mg/kg)	7820 V	1660 V	2310 V	2240 V	2070 V	2940 V	1640 V	2110 V	1060 V	1920 V
Chromium	30	Metals (mg/kg)	34.1 V	14.4 V	21.4 V	13 V	16.1 V	16.9 V	14.6 V	31.3 V	24.4 V	31 V
Cobalt	900	Metals (mg/kg)	4.8 B	7.2 V	9.8 V	4 B	3.2 B	3.5 B	3.1 B	10 V	4.6 B	9.4 V
Copper	310	Metals (mg/kg)	35.5 V	19.6 V	31.6 V	59.3 V	51.5 V	45.6 V	40.2 V	23.8 V	33.8 V	338 V
Iron	2,300	Metals (mg/kg)	9640 V	11100 V	17900 V	9210 V	10200 V	10400 V	9330 V	19500 V	13800 V	18100 V
Lead	30	Metals (mg/kg)	28.8 V	50.5 V	80.7 V	45.7 V	23.2 V	41.4 V	27 V	113 V	55 V	855 V
Magnesium	NE	Metals (mg/kg)	3420 V	2580 V	4320 V	2060 V	2540 V	2850 V	2260 V	6170 V	4400 V	4470 V
Manganese	180	Metals (mg/kg)	168 V	330 V	576 V	111 V	62.6 V	70.6 V	54.4 V	408 V	109 V	331 V
Mercury	2.3	Metals (mg/kg)	0.026 U	0.034 B	0.043 B	0.055 V	0.036 B	0.053 B	0.042 B	0.019 U	0.018 U	0.075 V
Nickel	20	Metals (mg/kg)	17.7 V	18.3 V	27.6 V	14.7 V	13.6 V	17.6 V	14.1 V	33.1 V	20.8 V	34.8 V
Potassium	NE	Metals (mg/kg)	347 B	327 B	799 V	278 B	332 B	362 B	338 B	1120 V	1200 V	679 B
Selenium	39	Metals (mg/kg)	0.63 B	0.81 V	0.81 V	0.77 V	0.62 B	0.64 U	0.59 U	0.73 V	0.42 U	0.63 U
Silver	39	Metals (mg/kg)	0.27 U	0.22 U	0.24 U	0.27 U	0.25 U	0.27 U	0.28 U	0.24 U	0.2 U	0.3 U
Sodium	NE	Metals (mg/kg)	73.9 U	61 U	68.1 B	73.5 U	66.7 U	74.2 U	76.2 U	64.4 U	77.2 B	80.4 U
Thallium	0.52	Metals (mg/kg)	0.97 U	1.1 U	0.85 U	0.96 U	0.87 U	1.3 U	1 U	0.84 U	1.6 V	1.1 U
Vanadium	55	Metals (mg/kg)	9.6 V	11.6 V	19.3 V	13 V	13.6 V	15.5 V	13.6 V	23.4 V	16.7 V	27.2 V
Zinc	2,300	Metals (mg/kg)	29.4 V	201 V	165 V	123 V	80.1 V	146 V	99.4 V	133 V	34.2 V	99.2 V
Acenaphthylene	370,000	PAHs (µg/kg)							110 J			
Anthracene	100,000	PAHs (µg/kg)							64 J			
Benzo(a)anthracene	620	PAHs (µg/kg)							620 J			
Benzo(a)pyrene	62	PAHs (µg/kg)							500 J			
Benzo(b)fluoranthene	620	PAHs (µg/kg)							880 J			
Benzo(g,h,i)perylene	2,500	PAHs (µg/kg)							180 J			
Benzo(k)fluoranthene	6,200	PAHs (µg/kg)							630 J			
Chrysene	7,000	PAHs (µg/kg)							730 J			
Dibenz(a,h)Anthracene	62	PAHs (µg/kg)							1400 J			
Fluoranthene	230,000	PAHs (µg/kg)							1700 V			
Indeno(1,2,3-c,d)Pyrene	620	PAHs (µg/kg)							170 J			
Naphthalene	5,600	PAHs (µg/kg)							7.5 U			
Phenanthrene	100,000	PAHs (µg/kg)							180 J			
Pyrene	230,000	PAHs (µg/kg)							1300 J			
Aldrin	29	Pesticides (µg/kg)							54 U			
4,4-DDD	240	Pesticides (µg/kg)							220 V			
4,4-DDE	170	Pesticides (µg/kg)							950 V			
4,4-DDT	170	Pesticides (µg/kg)							720 V			
Dieldrin	30	Pesticides (µg/kg)							110 U			
1,2,4-Trichlorobenzene	65,000	SVOCs (µg/kg)							7.5 U			
2,4-Dinitrotoluene	12,000	SVOCs (µg/kg)							120 U			
Acetophenone	7,800	SVOCs (µg/kg)							320 J			
bis(2-ethylhexyl) phthalate	35,000	SVOCs (µg/kg)							49 J			
Hexachlorobutadiene	6,000	SVOCs (µg/kg)							7.5 U			
Phenol	20,000	SVOCs (µg/kg)							130 J			
Aliphatic Hydrocarbons (C_{19}-C_{36})	3,000	TPH (mg/kg)							13 U			
Aliphatic Hydrocarbons (C_9-C_{18})	1,000	TPH (mg/kg)							9.7 U			
Aromatic Hydrocarbons (C_{11}-C_{22})	800	TPH (mg/kg)							19 J			
1,2,3-Trichlorobenzene	NE	VOCs (µg/kg)							7.5 U			
2-Butanone		VOCs (µg/kg)							7.5 U			
4-Isopropyltoluene	NE	VOCs (µg/kg)							7.5 U			
Acetone	60,000	VOCs (µg/kg)							52 V			
Carbon Disulfide	36,000	VOCs (µg/kg)							7.3 U			
Toluene	500,000	VOCs (µg/kg)							7.5 U			

Notes:
mg/kg = Milligrams per kilogram (parts per million)
µg/kg = Micrograms per kilogram (parts per billion)
V = Valid result; substance detected.
J = Estimated result; substance detected, but below the detection limit.
U = Substance not detected; detection limit listed.
Highlighted results were detected above their Project Action Level.

Table 6-6a
IA-6 Summary of Screened Analytical Results
PASI/SSI Comprehensive Report
Study Area - Grant, Locust, and Cavite Housing Areas
Devens, Massachusetts

Analyte	Project Action Level	Analyte Category (units)	LO-IA06-SD09-1 0.5-1.5		LO-IA06-SD09-1 0-0.5		LO-IA06-SD10-1 0.5-1.5		LO-IA06-SD10-1 0-0.5		LO-IA06-SD10-1-D 0.5-1.5		LO-IA06-SD10-1-D 0-0.5		LO-IA06-SD11-1 0.5-1.5		LO-IA06-SD11-1 0-0.5		LO-IA06-SD12-1 0-0.5		LO-IA06-SD13-1 0.5-1.5	
Aluminum	7,600	Metals (mg/kg)	6340	V	10400	V	7770	V	12200	V	8610	V	10500	V	11100	V	12800	V	8700	V	11300	V
Antimony	3.1	Metals (mg/kg)	0.52	B	2.4	B	0.53	B	2	B	0.51	B	1.8	B	1.6	B	2.4	B	1.2	B	2.9	B
Arsenic	0.39	Metals (mg/kg)	19.3	V	14.8	V	16.4	V	18.6	V	20.1	V	17.7	V	15	V	19.8	V	14.2	V	7.8	V
Barium	540	Metals (mg/kg)	10.7	B	19.4	B	12.5	B	27.8	B	13.2	B	19.7	B	15.6	B	25	B	15.4	B	15.8	B
Beryllium	1	Metals (mg/kg)	0.31	B	0.46	B	0.37	B	0.47	B	0.39	B	0.39	B	0.49	B	0.56	B	0.41	B	0.42	B
Cadmium	2	Metals (mg/kg)	0.073	U	0.078	U	0.072	U	0.088	U	0.071	U	0.076	U	0.077	U	0.087	U	0.072	U	0.074	B
Calcium	NE	Metals (mg/kg)	529	B	1520	V	1230	V	2100	V	1220	V	1790	V	974	V	2150	V	423	B	177	B
Chromium	30	Metals (mg/kg)	13.3	V	16.9	V	17.7	V	25.9	V	21.1	V	32	V	14.7	V	17.7	V	12.2	V	9.5	V
Cobalt	900	Metals (mg/kg)	3.2	B	4.4	B	3.4	B	7.8	V	4.1	B	5.5	B	5	B	6.2	B	3.8	B	3.1	B
Copper	310	Metals (mg/kg)	9.6	V	120	V	32.7	V	143	V	25.4	V	101	V	81.4	V	159	V	29.7	V	81.4	V
Iron	2,300	Metals (mg/kg)	8140	V	11100	V	9220	V	16100	V	12600	V	14900	V	11400	V	12400	V	9030	V	10000	V
Lead	30	Metals (mg/kg)	13.2	V	498	V	110	V	493	V	97	V	360	V	442	V	824	V	173	V	436	V
Magnesium	NE	Metals (mg/kg)	1890	V	2480	V	2040	V	4310	V	2760	V	4480	V	1850	V	1950	V	1390	V	751	V
Manganese	180	Metals (mg/kg)	91.5	V	97.7	V	73.1	V	148	V	126	V	144	V	179	V	330	V	128	V	128	V
Mercury	2.3	Metals (mg/kg)	0.021	U	0.04	B	0.022	U	0.05	V	0.018	U	0.039	B	0.027	B	0.07	V	0.048	V	0.036	B
Nickel	20	Metals (mg/kg)	13	V	23.2	V	12.6	V	33.7	V	17.5	V	28	V	16.8	V	22.6	V	12.2	V	13	V
Potassium	NE	Metals (mg/kg)	383	B	447	B	360	B	820	V	343	B	566	B	323	B	423	B	363	B	255	B
Selenium	39	Metals (mg/kg)	0.47	U	0.5	U	0.45	U	0.91	V	0.45	U	0.75	V	0.49	U	0.84	V	0.63	V	0.46	B
Silver	39	Metals (mg/kg)	0.22	U	0.24	U	0.21	U	0.26	U	0.21	U	0.23	U	0.23	U	0.26	U	0.22	U	0.19	U
Sodium	NE	Metals (mg/kg)	94.5	B	63.8	U	66.4	B	71.5	U	114	B	62.1	U	62.6	U	70.7	U	58.4	U	59.9	B
Thallium	0.52	Metals (mg/kg)	0.78	U	0.84	U	0.76	U	0.94	U	0.75	U	1	B	0.82	U	0.93	U	0.76	U	0.71	B
Vanadium	55	Metals (mg/kg)	8.8	V	16	V	11.4	V	22.3	V	13.5	V	19.8	V	14.1	V	19	V	13.1	V	12.7	V
Zinc	2,300	Metals (mg/kg)	20.9	V	51.9	V	23.6	V	99.2	V	27.3	V	71.2	V	45.9	V	78.5	V	26.1	V	32.5	V
Acenaphthylene	370,000	PAHs (µg/kg)																				
Anthracene	100,000	PAHs (µg/kg)																				
Benzo(a)anthracene	620	PAHs (µg/kg)																				
Benzo(a)pyrene	62	PAHs (µg/kg)																				
Benzo(b)fluoranthene	620	PAHs (µg/kg)																				
Benzo(g,h,i)perylene	2,500	PAHs (µg/kg)																				
Benzo(k)fluoranthene	6,200	PAHs (µg/kg)																				
Chrysene	7,000	PAHs (µg/kg)																				
Dibenz(a,h)Anthracene	62	PAHs (µg/kg)																				
Fluoranthene	230,000	PAHs (µg/kg)																				
Indeno(1,2,3-c,d)Pyrene	620	PAHs (µg/kg)																				
Naphthalene	5,600	PAHs (µg/kg)																				
Phenanthrene	100,000	PAHs (µg/kg)																				
Pyrene	230,000	PAHs (µg/kg)																				
Aldrin	29	Pesticides (µg/kg)																				
4,4-DDD	240	Pesticides (µg/kg)																				
4,4-DDE	170	Pesticides (µg/kg)																				
4,4-DDT	170	Pesticides (µg/kg)																				
Dieldrin	30	Pesticides (µg/kg)																				
1,2,4-Trichlorobenzene	65,000	SVOCs (µg/kg)																				
2,4-Dinitrotoluene	12,000	SVOCs (µg/kg)																				
Acetophenone	7,800	SVOCs (µg/kg)																				
bis(2-ethylhexyl) phthalate	35,000	SVOCs (µg/kg)																				
Hexachlorobutadiene	6,000	SVOCs (µg/kg)																				
Phenol	20,000	SVOCs (µg/kg)																				
Aliphatic Hydrocarbons (C_{19}-C_{36})	3,000	TPH (mg/kg)																				
Aliphatic Hydrocarbons (C_9-C_{18})	1,000	TPH (mg/kg)																				
Aromatic Hydrocarbons (C_{11}-C_{22})	800	TPH (mg/kg)																				
1,2,3-Trichlorobenzene	NE	VOCs (µg/kg)																				
2-Butanone		VOCs (µg/kg)																				
4-Isopropyltoluene	NE	VOCs (µg/kg)																				
Acetone	60,000	VOCs (µg/kg)																				
Carbon Disulfide	36,000	VOCs (µg/kg)																				
Toluene	500,000	VOCs (µg/kg)																				

Notes:
mg/kg = Milligrams per kilogram (parts per million)
µg/kg = Micrograms per kilogram (parts per billion)
V = Valid result; substance detected.
J = Estimated result; substance detected, but below the detection limit.
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Highlighted results were detected above their Project Action Level.

Table 6-6a
IA-6 Summary of Screened Analytical Results
PASI/SSI Comprehensive Report
Study Area - Grant, Locust, and Cavite Housing Areas
Devens, Massachusetts

Analyte	Project Action Level	Analyte Category (units)	LO-IA06-SD13-1 0-0.5	LO-IA06-SD14-1 0-0.5	LO-IA06-SD15-1 0.5-1.5	LO-IA06-SD15-1 0-0.5	LO-IA06-SD16-1 0-0.5	LO-IA06-SD17-1 0-0.5	LO-IA06-SD17-1 0-1.5	LO-IA06-SS03-1 0-0.5	LO-IA06-SS04-1 0-0.5	LO-IA06-SS05-1 0-0.5
Aluminum	7,600	Metals (mg/kg)	11100 V	6980 V	11000 V	9720 V	10700 V	8820 V	9140 V	8640 V	10700 V	11500 V
Antimony	3.1	Metals (mg/kg)	2 B	0.96 B	0.63 B	2.6 B	0.96 B	1 B	0.85 B	1.2 U	1.7 B	1.3 B
Arsenic	0.39	Metals (mg/kg)	27.8 V	9.1 V	8.9 V	9 V	8.3 V	11.9 V	9.7 V	17.5 V	24.3 V	35.9 V
Barium	540	Metals (mg/kg)	38.3 V	14.7 B	11.6 B	17.1 B	15.8 B	26.1 B	20.7 B	21.1 B	27 V	32.5 V
Beryllium	1	Metals (mg/kg)	0.42 B	0.27 B	0.48 B	0.36 B	0.42 B	0.38 B	0.38 B	0.4 B	0.37 B	0.38 B
Cadmium	2	Metals (mg/kg)	0.18 B	0.084 U	0.065 U	0.099 B	0.1 B	0.13 B	0.088 U	0.11 U	0.088 U	0.1 B
Calcium	NE	Metals (mg/kg)	1230 V	1010 V	171 B	565 B	914 V	2360 V	1820 V	1420 V	1460 V	1630 V
Chromium	30	Metals (mg/kg)	32.6 V	11.9 V	13.1 V	10.6 V	11.4 V	14.4 V	12.7 V	14 V	28.3 V	39.5 V
Cobalt	900	Metals (mg/kg)	8.5 V	2.8 B	5 B	2.4 B	2.8 B	3.2 B	3.2 B	3.5 B	8 V	9.5 V
Copper	310	Metals (mg/kg)	71.2 V	9.3 V	8.4 V	123 V	23.4 V	9.4 V	6.8 V	27.9 V	28.7 V	20.8 V
Iron	2,300	Metals (mg/kg)	16900 V	7640 V	10900 V	9170 V	10000 V	9800 V	9170 V	10800 V	16600 V	20900 V
Lead	30	Metals (mg/kg)	903 V	51.5 V	32 V	860 V	80.3 V	67.8 V	40.5 V	37.7 V	41.8 V	56.7 V
Magnesium	NE	Metals (mg/kg)	4660 V	1380 V	1780 V	836 V	1090 V	1580 V	1460 V	2130 V	4710 V	6700 V
Manganese	180	Metals (mg/kg)	270 V	76.3 V	94.1 V	53 V	62.7 V	167 V	120 V	108 V	292 V	350 V
Mercury	2.3	Metals (mg/kg)	0.064 V	0.076 V	0.026 B	0.05 V	0.064 V	0.076 V	0.047 V	0.052 V	0.019 U	0.017 U
Nickel	20	Metals (mg/kg)	25.5 V	8 V	11.4 V	18.3 V	8 V	8.4 V	7.9 V	10.5 V	28.5 V	40.2 V
Potassium	NE	Metals (mg/kg)	1430 V	267 B	338 B	342 B	358 B	458 B	455 B	302 B	957 V	1760 V
Selenium	39	Metals (mg/kg)	0.94 V	1 V	0.41 U	1.5 V	0.61 U	1.3 V	0.61 U	0.61 B	0.42 U	0.61 V
Silver	39	Metals (mg/kg)	0.23 U	0.25 U	0.19 U	0.28 U	0.26 U	0.28 U	0.26 U	0.52 U	0.41 U	0.41 U
Sodium	NE	Metals (mg/kg)	87.5 B	68.5 U	52.8 U	75.7 U	70.4 U	76.1 U	71.3 U	87.3 U	101 B	110 B
Thallium	0.52	Metals (mg/kg)	0.82 U	0.9 U	0.69 U	0.99 U	0.92 U	1 U	0.93 U	1.2 U	0.7 U	0.95 U
Vanadium	55	Metals (mg/kg)	31.8 V	12.1 V	13.5 V	19.4 V	14.7 V	15.9 V	14.6 V	15.3 V	20.9 V	23.7 V
Zinc	2,300	Metals (mg/kg)	72.3 V	23.9 V	20.6 V	28.8 V	39.7 V	38.6 V	29.4 V	57.1 V	67.9 V	75.2 V
Acenaphthylene	370,000	PAHs (µg/kg)							1000 U			
Anthracene	100,000	PAHs (µg/kg)							1000 U			
Benzo(a)anthracene	620	PAHs (µg/kg)							120 J			
Benzo(a)pyrene	62	PAHs (µg/kg)							160 J			
Benzo(b)fluoranthene	620	PAHs (µg/kg)							270 J			
Benzo(g,h,i)perylene	2,500	PAHs (µg/kg)							80 J			
Benzo(k)fluoranthene	6,200	PAHs (µg/kg)							180 J			
Chrysene	7,000	PAHs (µg/kg)							200 J			
Dibenz(a,h)Anthracene	62	PAHs (µg/kg)							840 J			
Fluoranthene	230,000	PAHs (µg/kg)							360 J			
Indeno(1,2,3-c,d)Pyrene	620	PAHs (µg/kg)							77 J			
Naphthalene	5,600	PAHs (µg/kg)							7 U			
Phenanthrene	100,000	PAHs (µg/kg)							180 J			
Pyrene	230,000	PAHs (µg/kg)							250 J			
Aldrin	29	Pesticides (µg/kg)							25 U			
4,4-DDD	240	Pesticides (µg/kg)							50 U			
4,4-DDE	170	Pesticides (µg/kg)							300 V			
4,4-DDT	170	Pesticides (µg/kg)							200 V			
Dieldrin	30	Pesticides (µg/kg)							50 U			
1,2,4-Trichlorobenzene	65,000	SVOCs (µg/kg)							7 U			
2,4-Dinitrotoluene	12,000	SVOCs (µg/kg)							120 U			
Acetophenone	7,800	SVOCs (µg/kg)							110 J			
bis(2-ethylhexyl) phthalate	35,000	SVOCs (µg/kg)							1000 U			
Hexachlorobutadiene	6,000	SVOCs (µg/kg)							7 U			
Phenol	20,000	SVOCs (µg/kg)							1000 U			
Aliphatic Hydrocarbons (C_{19}-C_{36})	3,000	TPH (mg/kg)							12 U			
Aliphatic Hydrocarbons (C_9-C_{18})	1,000	TPH (mg/kg)							9.1 U			
Aromatic Hydrocarbons (C_{11}-C_{22})	800	TPH (mg/kg)							26 U			
1,2,3-Trichlorobenzene	NE	VOCs (µg/kg)							7 U			
2-Butanone		VOCs (µg/kg)							7 U			
4-Isopropyltoluene	NE	VOCs (µg/kg)							7 U			
Acetone	60,000	VOCs (µg/kg)							51 V			
Carbon Disulfide	36,000	VOCs (µg/kg)							7 U			
Toluene	500,000	VOCs (µg/kg)							7 U			

Notes:
mg/kg = Milligrams per kilogram (parts per million)
µg/kg = Micrograms per kilogram (parts per billion)
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Study Area - Grant, Locust, and Cavite Housing Areas
Devens, Massachusetts

Analyte	Project Action Level	Analyte Category (units)	LO-IA06-SS06-1 0-0.5	LO-IA06-SS07-1 0-0.5	LO-IA06-SS08-1 0-0.5	LO-IA06-SS08-1 0-1.5	LO-IA06-SS09-1 0-0.5	LO-IA06-SS10-1 0-0.5	LO-IA06-SS11-1 0-0.5	LO-IA06-SS12-1 0-0.5	LO-IA06-SS13-1 0-0.5	LO-IA06-SS14-1 0-0.5
Aluminum	7,600	Metals (mg/kg)	10800 V	10800 V	8790 V	13000 V	10300 V	14100 V	7720 V	10300 V	12800 V	10800 V
Antimony	3.1	Metals (mg/kg)	1.7 B	1.2 B	0.86 B	10 V	1.4 B	1.3 B	1.3 B	1.2 B	1.1 B	1.2 B
Arsenic	0.39	Metals (mg/kg)	35.8 V	39.7 V	35.2 V	46.1 V	34 V	31.1 V	13 V	38.1 V	32.3 V	33.3 V
Barium	540	Metals (mg/kg)	35.5 V	27.9 V	27 V	44.6 V	26.5 V	35.6 V	23.4 V	26.9 V	50.9 V	30.1 V
Beryllium	1	Metals (mg/kg)	0.37 B	0.35 B	0.35 B	0.47 B	0.37 B	0.55 V	0.28 B	0.37 B	0.34 B	0.37 B
Cadmium	2	Metals (mg/kg)	0.082 U	0.083 U	0.073 U	0.22 B	0.085 U	0.085 U	0.086 U	0.089 U	0.073 U	0.09 U
Calcium	NE	Metals (mg/kg)	1790 V	1650 V	1260 V	1540 V	1080 V	4940 V	1240 V	1260 V	1710 V	1750 V
Chromium	30	Metals (mg/kg)	35.3 V	34.6 V	26.7 V	37.6 V	34.9 V	31 V	25.5 V	30.3 V	52 V	34.2 V
Cobalt	900	Metals (mg/kg)	9.3 V	8.7 V	9.2 V	13.5 V	9.7 V	8.8 V	5.3 B	8.8 V	9.1 V	8.2 V
Copper	310	Metals (mg/kg)	21.3 V	20.6 V	22.1 V	23 V	33.8 V	24.7 V	13.8 V	21.2 V	20 V	17.2 V
Iron	2,300	Metals (mg/kg)	20600 V	18600 V	17600 V	24800 V	20200 V	17600 V	13700 V	18500 V	17000 V	17300 V
Lead	30	Metals (mg/kg)	34.5 V	44.4 V	35.8 V	16.6 V	44.1 V	34 V	125 V	48.7 V	16.5 V	27.1 V
Magnesium	NE	Metals (mg/kg)	6300 V	6470 V	5530 V	6830 V	6520 V	5590 V	4240 V	6420 V	7280 V	5890 V
Manganese	180	Metals (mg/kg)	451 V	326 V	350 V	808 V	385 V	409 V	227 V	362 V	360 V	300 V
Mercury	2.3	Metals (mg/kg)	0.033 B	0.016 U	0.017 U	0.016 U	0.016 U	0.017 U	0.028 B	0.016 U	0.018 U	0.018 U
Nickel	20	Metals (mg/kg)	34.5 V	35 V	33.8 V	50.6 V	35.9 V	31 V	18.4 V	32.8 V	35.5 V	32.7 V
Potassium	NE	Metals (mg/kg)	1590 V	1390 V	1370 V	1580 V	1230 V	1560 V	1190 V	1420 V	2910 V	1310 V
Selenium	39	Metals (mg/kg)	0.39 U	0.39 U	0.35 U	0.95 V	0.4 U	0.4 U	0.72 V	0.42 U	0.35 U	0.43 U
Silver	39	Metals (mg/kg)	0.38 U	0.38 U	0.34 U	0.36 U	0.39 U	0.39 U	0.4 U	0.41 U	0.34 U	0.42 U
Sodium	NE	Metals (mg/kg)	66.6 B	64.9 U	57.6 U	194 B	74.1 B	401 B	124 B	70.1 B	175 B	76.9 B
Thallium	0.52	Metals (mg/kg)	0.88 U	0.88 U	0.78 U	0.63 U	0.9 U	0.9 U	0.69 U	0.94 U	0.77 U	0.96 U
Vanadium	55	Metals (mg/kg)	21.8 V	22.4 V	17.4 V	22.9 V	20.2 V	19 V	19 V	21.3 V	25.8 V	23.1 V
Zinc	2,300	Metals (mg/kg)	59.8 V	59.3 V	47.3 V	47.8 V	60.2 V	55.6 V	47.9 V	39.2 V	40.5 V	46 V
Acenaphthylene	370,000	PAHs (µg/kg)				360 U						
Anthracene	100,000	PAHs (µg/kg)				360 U						
Benzo(a)anthracene	620	PAHs (µg/kg)				360 U						
Benzo(a)pyrene	62	PAHs (µg/kg)				360 U						
Benzo(b)fluoranthene	620	PAHs (µg/kg)				360 U						
Benzo(g,h,i)perylene	2,500	PAHs (µg/kg)				360 U						
Benzo(k)fluoranthene	6,200	PAHs (µg/kg)				360 U						
Chrysene	7,000	PAHs (µg/kg)				360 U						
Dibenz(a,h)Anthracene	62	PAHs (µg/kg)				360 U						
Fluoranthene	230,000	PAHs (µg/kg)				360 U						
Indeno(1,2,3-c,d)Pyrene	620	PAHs (µg/kg)				360 U						
Naphthalene	5,600	PAHs (µg/kg)				5 U						
Phenanthrene	100,000	PAHs (µg/kg)				360 U						
Pyrene	230,000	PAHs (µg/kg)				360 U						
Aldrin	29	Pesticides (µg/kg)				1.8 U						
4,4-DDD	240	Pesticides (µg/kg)				3.6 U						
4,4-DDE	170	Pesticides (µg/kg)				3.4 J						
4,4-DDT	170	Pesticides (µg/kg)				4.1 V						
Dieldrin	30	Pesticides (µg/kg)				3.6 U						
1,2,4-Trichlorobenzene	65,000	SVOCs (µg/kg)				5 U						
2,4-Dinitrotoluene	12,000	SVOCs (µg/kg)				120 U						
Acetophenone	7,800	SVOCs (µg/kg)				360 U						
bis(2-ethylhexyl) phthalate	35,000	SVOCs (µg/kg)				360 U						
Hexachlorobutadiene	6,000	SVOCs (µg/kg)				5 U						
Phenol	20,000	SVOCs (µg/kg)				360 U						
Aliphatic Hydrocarbons (C_{19}-C_{36})	3,000	TPH (mg/kg)				8.7 U						
Aliphatic Hydrocarbons (C_9-C_{18})	1,000	TPH (mg/kg)				6.5 U						
Aromatic Hydrocarbons (C_{11}-C_{22})	800	TPH (mg/kg)				18 U						
1,2,3-Trichlorobenzene	NE	VOCs (µg/kg)				5 U						
2-Butanone		VOCs (µg/kg)				6.6 V						
4-Isopropyltoluene	NE	VOCs (µg/kg)				5 J						
Acetone	60,000	VOCs (µg/kg)				110 V						
Carbon Disulfide	36,000	VOCs (µg/kg)				5 U						
Toluene	500,000	VOCs (µg/kg)				1.3 J						

Notes:
mg/kg = Milligrams per kilogram (parts per million)
µg/kg = Micrograms per kilogram (parts per billion)
V = Valid result; substance detected.
J = Estimated result; substance detected, but below the detection limit.
U = Substance not detected; detection limit listed.
Highlighted results were detected above their Project Action Level.

Table 6-6a
IA-6 Summary of Screened Analytical Results
PASI/SSI Comprehensive Report
Study Area - Grant, Locust, and Cavite Housing Areas
Devens, Massachusetts

Analyte	Project Action Level	Analyte Category (units)	LO-IA06-SS15-1 0-0.5	LO-IA06-SS15-1 0-0.5	LO-IA06-SS16-1 0-0.5	LO-IA06-SS16-1 0-1.5	LO-IA06-SS16-1-D 0-1.5	LO-IA06-SS17-1 0-0.5	LO-IA06-SS18-1 0-0.5	LO-IA06-SS19-1 0-0.5	LO-IA06-SS20-1 0-0.5	LO-IA06-SS21-1 0-0.5
Aluminum	7,600	Metals (mg/kg)	9250 V	11100 V	10100 V	10800 V	11100 V	10300 V	9950 V	13300 V	11400 V	8580 V
Antimony	3.1	Metals (mg/kg)	1.1 B	3.3 B	1.7 B	0.68 B	0.7 B	1.7 B	2.1 B	0.96 B	2.1 B	2.2 B
Arsenic	0.39	Metals (mg/kg)	32.4 V	35.7 V	32.8 V	41.1 V	33 V	30.2 V	31.1 V	27.5 V	25.7 V	24.6 V
Barium	540	Metals (mg/kg)	28.9 V	130 V	29.3 V	31.9 V	36.8 V	31.7 V	26.9 V	32 V	25.5 V	16.8 B
Beryllium	1	Metals (mg/kg)	0.34 B	1.1 V	0.34 B	0.36 B	0.35 B	0.32 B	0.3 B	0.34 B	0.35 B	0.34 B
Cadmium	2	Metals (mg/kg)	0.081 U	0.09 U	0.081 U	0.13 B	0.13 B	0.087 U	0.092 U	0.062 U	0.064 U	0.095 U
Calcium	NE	Metals (mg/kg)	1850 V	8280 V	1270 V	1300 V	1400 V	1670 V	1260 V	1770 V	1620 V	1130 V
Chromium	30	Metals (mg/kg)	30 V	37.9 V	35.1 V	38.6 V	38.1 V	39 V	31.6 V	60.7 V	36.6 V	16.5 V
Cobalt	900	Metals (mg/kg)	7.3 V	14.2 V	8.5 V	10 V	9.6 V	9.1 V	8.1 V	10.6 V	9.4 V	6.1 V
Copper	310	Metals (mg/kg)	14.7 V	11 V	18.7 V	20.4 V	17.3 V	19.4 V	21.7 V	19.2 V	72.8 V	39.5 V
Iron	2,300	Metals (mg/kg)	15500 V	59400 V	18800 V	19900 V	17300 V	16900 V	15600 V	21500 V	18600 V	13200 V
Lead	30	Metals (mg/kg)	15 V	77.7 V	16.9 V	11 V	12.3 V	16.6 V	31.1 V	11.4 V	240 V	163 V
Magnesium	NE	Metals (mg/kg)	5420 V	1340 V	6780 V	6600 V	6590 V	6290 V	5200 V	8530 V	6040 V	2630 V
Manganese	180	Metals (mg/kg)	252 V	470 V	354 V	375 V	315 V	306 V	306 V	333 V	283 V	221 V
Mercury	2.3	Metals (mg/kg)	0.016 U	0.015 U	0.017 U	0.015 U	0.015 U	0.016 U	0.018 U	0.017 U	0.016 U	0.037 B
Nickel	20	Metals (mg/kg)	28.9 V	29.9 V	34 V	39 V	34.5 V	35.4 V	30.7 V	41 V	34.4 V	23.5 V
Potassium	NE	Metals (mg/kg)	1410 V	1450 V	1720 V	1670 V	1870 V	1640 V	1060 V	1680 V	1190 V	578 B
Selenium	39	Metals (mg/kg)	0.63 V	0.43 U	0.57 V	0.72 V	0.76 V	0.41 U	0.44 U	0.83 V	0.43 B	0.59 B
Silver	39	Metals (mg/kg)	0.37 U	0.42 U	0.38 U	0.39 U	0.36 U	0.4 U	0.43 U	0.19 U	0.19 U	0.44 U
Sodium	NE	Metals (mg/kg)	68.2 B	70.8 B	105 B	183 B	207 B	147 B	113 B	50.8 U	52.3 U	109 B
Thallium	0.52	Metals (mg/kg)	0.86 U	2.2 V	0.65 U	0.67 U	0.62 U	0.69 U	0.74 U	0.67 U	0.69 U	0.76 U
Vanadium	55	Metals (mg/kg)	18.2 V	114 V	21.5 V	22.4 V	21.8 V	23.7 V	20.7 V	28.9 V	23.3 V	16 V
Zinc	2,300	Metals (mg/kg)	33.6 V	143 V	37.3 V	39.2 V	38 V	38.4 V	43.3 V	39.7 V	42.9 V	42.1 V
Acenaphthylene	370,000	PAHs (µg/kg)				350 U	330 U					
Anthracene	100,000	PAHs (µg/kg)				350 U	330 U					
Benzo(a)anthracene	620	PAHs (µg/kg)				350 U	330 U					
Benzo(a)pyrene	62	PAHs (µg/kg)				350 U	330 U					
Benzo(b)fluoranthene	620	PAHs (µg/kg)				350 U	330 U					
Benzo(g,h,i)perylene	2,500	PAHs (µg/kg)				350 U	330 U					
Benzo(k)fluoranthene	6,200	PAHs (µg/kg)				350 U	330 U					
Chrysene	7,000	PAHs (µg/kg)				350 U	330 U					
Dibenz(a,h)Anthracene	62	PAHs (µg/kg)				350 U	330 U					
Fluoranthene	230,000	PAHs (µg/kg)				350 U	330 U					
Indeno(1,2,3-c,d)Pyrene	620	PAHs (µg/kg)				350 U	330 U					
Naphthalene	5,600	PAHs (µg/kg)				5.5 U	5.8 U					
Phenanthrene	100,000	PAHs (µg/kg)				350 U	330 U					
Pyrene	230,000	PAHs (µg/kg)				350 U	32 J					
Aldrin	29	Pesticides (µg/kg)				1.8 U	1.7 U					
4,4-DDD	240	Pesticides (µg/kg)				3.5 U	3.3 U					
4,4-DDE	170	Pesticides (µg/kg)				2.2 J	1.9 J					
4,4-DDT	170	Pesticides (µg/kg)				2.7 J	2.4 J					
Dieldrin	30	Pesticides (µg/kg)				3.5 U	3.3 U					
1,2,4-Trichlorobenzene	65,000	SVOCs (µg/kg)				5.5 U	5.8 U					
2,4-Dinitrotoluene	12,000	SVOCs (µg/kg)				120 U	120 U					
Acetophenone	7,800	SVOCs (µg/kg)				350 U	330 U					
bis(2-ethylhexyl) phthalate	35,000	SVOCs (µg/kg)				350 U	330 U					
Hexachlorobutadiene	6,000	SVOCs (µg/kg)				5.5 U	5.8 U					
Phenol	20,000	SVOCs (µg/kg)				350 U	330 U					
Aliphatic Hydrocarbons (C_{19}-C_{36})	3,000	TPH (mg/kg)				8.5 U	8 U					
Aliphatic Hydrocarbons (C_9-C_{18})	1,000	TPH (mg/kg)				6.4 U	6 U					
Aromatic Hydrocarbons (C_{11}-C_{22})	800	TPH (mg/kg)				18 U	17 U					
1,2,3-Trichlorobenzene	NE	VOCs (µg/kg)				5.5 U	5.8 U					
2-Butanone		VOCs (µg/kg)				5.5 U	5.8 U					
4-Isopropyltoluene	NE	VOCs (µg/kg)				5.5 U	5.8 U					
Acetone	60,000	VOCs (µg/kg)				38 V	54 V					
Carbon Disulfide	36,000	VOCs (µg/kg)				5.5 U	1.7 J					
Toluene	500,000	VOCs (µg/kg)				5.5 U	5.8 U					

Notes:
mg/kg = Milligrams per kilogram (parts per million)
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V = Valid result; substance detected.
J = Estimated result; substance detected, but below the detection limit.
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Table 6-6a
IA-6 Summary of Screened Analytical Results
PASI/SSI Comprehensive Report
Study Area - Grant, Locust, and Cavite Housing Areas
Devens, Massachusetts

Analyte	Project Action Level	Analyte Category (units)	LO-IA06-SS22-1 0-0.5	LO-IA06-SS23-1 0-0.5	LO-IA06-SS24-1 0-0.5	LO-IA06-SS25-1 0-0.5	LO-IA06-SS25-1 0-1.5	LO-IA06-SS25-1-T 0-1.5	LO-IA06-SS26-1 0-0.5	LO-IA06-SS27-1 0.5-1.5	LO-IA06-SS27-1 0-0.5	LO-IA06-SS28-1 0-0.5
Aluminum	7,600	Metals (mg/kg)	13600 V	10400 V	14500 V	10800 V	8250 V		10000 V	7350 V	8400 V	7620 V
Antimony	3.1	Metals (mg/kg)	0.79 B	0.78 B	1.3 B	0.87 B	0.55 B		1.2 B	0.89 B	1.3 B	1.4 B
Arsenic	0.39	Metals (mg/kg)	29.7 V	29.9 V	38.5 V	47.1 V	17.9 V		26.4 V	15.4 V	16 V	17.5 V
Barium	540	Metals (mg/kg)	40.8 V	26.2 V	35.6 V	29.9 V	19.8 B		25.5 V	17.8 B	12.9 B	14.9 B
Beryllium	1	Metals (mg/kg)	0.38 B	0.31 B	0.42 B	0.41 B	0.23 B		0.38 B	0.32 B	0.33 B	0.26 B
Cadmium	2	Metals (mg/kg)	0.07 U	0.069 U	0.083 U	0.071 B	0.061 U		0.076 U	0.066 U	0.067 U	0.081 U
Calcium	NE	Metals (mg/kg)	1670 V	1120 V	2350 V	1780 V	1360 V		1510 V	808 V	696 V	623 V
Chromium	30	Metals (mg/kg)	46.4 V	33.6 V	43.2 V	34 V	22.8 V		31.5 V	20.9 V	20.3 V	22.2 V
Cobalt	900	Metals (mg/kg)	10.7 V	8.5 V	11.7 V	9.1 V	8 V		8.2 V	4.1 B	4.2 B	4 B
Copper	310	Metals (mg/kg)	46.3 V	30.9 V	68.8 V	114 V	28.5 V		46.1 V	82.5 V	156 V	13.7 V
Iron	2,300	Metals (mg/kg)	20800 V	17100 V	24000 V	23600 V	17500 V		18400 V	10100 V	11900 V	11100 V
Lead	30	Metals (mg/kg)	103 V	70 V	125 V	161 V	44.7 V		168 V	186 V	340 V	41.5 V
Magnesium	NE	Metals (mg/kg)	8320 V	5940 V	8550 V	6360 V	4980 V		5750 V	2680 V	3340 V	3400 V
Manganese	180	Metals (mg/kg)	353 V	276 V	268 V	320 V	459 V		266 V	131 V	111 V	195 V
Mercury	2.3	Metals (mg/kg)	0.015 U	0.018 U	0.024 B	0.018 U	0.019 U		0.018 U	0.02 U	0.021 B	0.03 B
Nickel	20	Metals (mg/kg)	39.1 V	31.7 V	43.7 V	38.7 V	23.7 V		31.8 V	16.1 V	18.4 V	17.8 V
Potassium	NE	Metals (mg/kg)	2200 V	1210 V	1310 V	1130 V	875 V		986 V	630 V	506 B	482 B
Selenium	39	Metals (mg/kg)	0.74 V	0.66 V	0.69 V	0.43 U	0.43 U		0.53 U	0.42 U	0.47 U	0.53 V
Silver	39	Metals (mg/kg)	0.21 U	0.21 U	0.25 U	0.2 U	0.18 U		0.23 U	0.2 U	0.2 U	0.38 U
Sodium	NE	Metals (mg/kg)	56.7 U	56 U	67.2 U	86.2 B	49.9 U		61.6 U	88.7 B	54.6 U	108 B
Thallium	0.52	Metals (mg/kg)	0.8 B	0.97 U	1.6 V	0.72 U	0.65 U		0.81 U	0.7 U	0.72 U	0.65 U
Vanadium	55	Metals (mg/kg)	27.2 V	21.1 V	29.7 V	23.5 V	16.9 V		19.7 V	11.9 V	15.3 V	16.3 V
Zinc	2,300	Metals (mg/kg)	50.6 V	40.3 V	76.7 V	62.4 V	38.1 V		46.6 V	28.7 V	33.1 V	26.3 V
Acenaphthylene	370,000	PAHs (µg/kg)					790 U					
Anthracene	100,000	PAHs (µg/kg)					790 U					
Benzo(a)anthracene	620	PAHs (µg/kg)					790 U					
Benzo(a)pyrene	62	PAHs (µg/kg)					790 U					
Benzo(b)fluoranthene	620	PAHs (µg/kg)					790 U					
Benzo(g,h,i)perylene	2,500	PAHs (µg/kg)					790 U					
Benzo(k)fluoranthene	6,200	PAHs (µg/kg)					790 U					
Chrysene	7,000	PAHs (µg/kg)					790 U					
Dibenz(a,h)Anthracene	62	PAHs (µg/kg)					790 U					
Fluoranthene	230,000	PAHs (µg/kg)					790 U					
Indeno(1,2,3-c,d)Pyrene	620	PAHs (µg/kg)					790 U					
Naphthalene	5,600	PAHs (µg/kg)					4.7 U	5 U				
Phenanthrene	100,000	PAHs (µg/kg)					790 U					
Pyrene	230,000	PAHs (µg/kg)					790 U					
Aldrin	29	Pesticides (µg/kg)					2 U					
4,4-DDD	240	Pesticides (µg/kg)					4 U					
4,4-DDE	170	Pesticides (µg/kg)					4 U					
4,4-DDT	170	Pesticides (µg/kg)					2.1 J					
Dieldrin	30	Pesticides (µg/kg)					4 U					
1,2,4-Trichlorobenzene	65,000	SVOCs (µg/kg)					4.7 U	5 U				
2,4-Dinitrotoluene	12,000	SVOCs (µg/kg)					120 U					
Acetophenone	7,800	SVOCs (µg/kg)					68 J					
bis(2-ethylhexyl) phthalate	35,000	SVOCs (µg/kg)					790 U					
Hexachlorobutadiene	6,000	SVOCs (µg/kg)					4.7 U	5 U				
Phenol	20,000	SVOCs (µg/kg)					790 U					
Aliphatic Hydrocarbons (C_{19}-C_{36})	3,000	TPH (mg/kg)					9.6 U					
Aliphatic Hydrocarbons (C_9-C_{18})	1,000	TPH (mg/kg)					7.2 U					
Aromatic Hydrocarbons (C_{11}-C_{22})	800	TPH (mg/kg)					20 U					
1,2,3-Trichlorobenzene	NE	VOCs (µg/kg)					4.7 U	5 U				
2-Butanone		VOCs (µg/kg)					2.9 J	5 U				
4-Isopropyltoluene	NE	VOCs (µg/kg)					4.7 U	5 U				
Acetone	60,000	VOCs (µg/kg)					26 V	5 U				
Carbon Disulfide	36,000	VOCs (µg/kg)					1.2 J	5 U				
Toluene	500,000	VOCs (µg/kg)					4.5 U	5 U				

Notes:
mg/kg = Milligrams per kilogram (parts per million)
µg/kg = Micrograms per kilogram (parts per billion)
V = Valid result; substance detected.
J = Estimated result; substance detected, but below the detection limit.
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Table 6-6a
IA-6 Summary of Screened Analytical Results
PASI/SSI Comprehensive Report
Study Area - Grant, Locust, and Cavite Housing Areas
Devens, Massachusetts

Analyte	Project Action Level	Analyte Category (units)	LO-IA06-SS29-1 0-0.5	LO-IA06-SS30-1 0.5-1.5	LO-IA06-SS30-1 0-0.5	LO-IA06-SS31-1 0-0.5	LO-IA06-SS32-1 0.5-1.5	LO-IA06-SS32-1 0-0.5	LO-IA06-SS33-1 0.5-1.5	LO-IA06-SS33-1 0-0.5	LO-IA06-SS34-1 0.5-1.5	LO-IA06-SS34-1 0-0.5
Aluminum	7,600	Metals (mg/kg)	9020 V	9230 V	9720 V	9590 V	11400 V	10100 V	10500 V	10100 V	9530 V	8570 V
Antimony	3.1	Metals (mg/kg)	1.6 B	0.42 U	2.6 B	1.9 B	0.7 B	4.6 B	0.39 U	2.4 B	0.41 U	1.9 B
Arsenic	0.39	Metals (mg/kg)	20.5 V	10.9 V	12 V	12.1 V	15.1 V	14.8 V	14.9 V	14.7 V	13.2 V	13.4 V
Barium	540	Metals (mg/kg)	14.8 B	16.9 B	13.5 B	21.1 B	16.1 B	18.5 B	18.6 B	17.7 B	16.7 B	13.4 B
Beryllium	1	Metals (mg/kg)	0.43 B	0.41 B	0.38 B	0.37 B	0.43 B	0.36 B	0.45 B	0.55 V	0.36 B	0.3 B
Cadmium	2	Metals (mg/kg)	0.092 U	0.061 U	0.092 U	0.094 U	0.062 U	0.08 U	0.058 U	0.076 U	0.06 U	0.081 U
Calcium	NE	Metals (mg/kg)	513 B	300 B	478 B	277 B	148 B	468 B	160 B	285 B	169 B	412 B
Chromium	30	Metals (mg/kg)	26.4 V	15.5 V	15.2 V	14.9 V	15 V	19 V	15.1 V	16.5 V	15.8 V	20.1 V
Cobalt	900	Metals (mg/kg)	4 B	4.4 B	3.1 B	2.7 B	4.2 B	3.6 B	4.3 B	3 B	4.1 B	3 B
Copper	310	Metals (mg/kg)	27 V	8.5 V	48.7 V	21.7 V	16.5 V	90.3 V	11.2 V	182 V	8 V	76.1 V
Iron	2,300	Metals (mg/kg)	13000 V	11700 V	12600 V	11500 V	12400 V	12300 V	11800 V	12800 V	11300 V	11300 V
Lead	30	Metals (mg/kg)	172 V	21.9 V	438 V	114 V	50.3 V	774 V	12.7 V	643 V	47.1 V	452 V
Magnesium	NE	Metals (mg/kg)	4700 V	2260 V	2650 V	2240 V	2200 V	2520 V	2050 V	2420 V	2270 V	2780 V
Manganese	180	Metals (mg/kg)	144 V	140 V	146 V	178 V	82 V	140 V	109 V	161 V	82.5 V	143 V
Mercury	2.3	Metals (mg/kg)	0.028 B	0.019 B	0.025 B	0.035 V	0.033 B	0.039 V	0.018 U	0.029 B	0.017 U	0.016 U
Nickel	20	Metals (mg/kg)	18 V	12.4 V	13.5 V	13.1 V	14.3 V	16.5 V	14.8 V	13.4 V	13.3 V	13.1 V
Potassium	NE	Metals (mg/kg)	795 V	372 B	367 B	311 B	296 B	571 V	277 B	284 B	261 B	460 B
Selenium	39	Metals (mg/kg)	0.44 U	0.51 B	0.44 U	0.59 V	0.39 U	0.62 V	0.37 U	0.49 V	0.38 U	0.44 B
Silver	39	Metals (mg/kg)	0.43 U	0.18 U	0.43 U	0.44 U	0.19 U	0.37 U	0.23 B	0.35 U	0.18 U	0.37 U
Sodium	NE	Metals (mg/kg)	99.7 B	63.6 B	78.2 B	78.9 B	61.4 B	82 B	47 U	65.7 B	63 B	87.1 B
Thallium	0.52	Metals (mg/kg)	0.74 U	0.66 U	0.74 U	0.75 U	0.88 U	0.85 U	0.99 V	0.61 U	0.64 U	0.65 U
Vanadium	55	Metals (mg/kg)	17.3 V	13.2 V	15.6 V	14.6 V	13.6 V	16.6 V	13.5 V	16.2 V	12.8 V	14.8 V
Zinc	2,300	Metals (mg/kg)	24.6 V	20.8 V	28.4 V	24.3 V	21.8 V	26.5 V	23.3 V	28 V	21.5 V	23.6 V
Acenaphthylene	370,000	PAHs (µg/kg)										
Anthracene	100,000	PAHs (µg/kg)										
Benzo(a)anthracene	620	PAHs (µg/kg)										
Benzo(a)pyrene	62	PAHs (µg/kg)										
Benzo(b)fluoranthene	620	PAHs (µg/kg)										
Benzo(g,h,i)perylene	2,500	PAHs (µg/kg)										
Benzo(k)fluoranthene	6,200	PAHs (µg/kg)										
Chrysene	7,000	PAHs (µg/kg)										
Dibenz(a,h)Anthracene	62	PAHs (µg/kg)										
Fluoranthene	230,000	PAHs (µg/kg)										
Indeno(1,2,3-c,d)Pyrene	620	PAHs (µg/kg)										
Naphthalene	5,600	PAHs (µg/kg)										
Phenanthrene	100,000	PAHs (µg/kg)										
Pyrene	230,000	PAHs (µg/kg)										
Aldrin	29	Pesticides (µg/kg)										
4,4-DDD	240	Pesticides (µg/kg)										
4,4-DDE	170	Pesticides (µg/kg)										
4,4-DDT	170	Pesticides (µg/kg)										
Dieldrin	30	Pesticides (µg/kg)										
1,2,4-Trichlorobenzene	65,000	SVOCs (µg/kg)										
2,4-Dinitrotoluene	12,000	SVOCs (µg/kg)										
Acetophenone	7,800	SVOCs (µg/kg)										
bis(2-ethylhexyl) phthalate	35,000	SVOCs (µg/kg)										
Hexachlorobutadiene	6,000	SVOCs (µg/kg)										
Phenol	20,000	SVOCs (µg/kg)										
Aliphatic Hydrocarbons (C_{19}-C_{36})	3,000	TPH (mg/kg)										
Aliphatic Hydrocarbons (C_9-C_{18})	1,000	TPH (mg/kg)										
Aromatic Hydrocarbons (C_{11}-C_{22})	800	TPH (mg/kg)										
1,2,3-Trichlorobenzene	NE	VOCs (µg/kg)										
2-Butanone		VOCs (µg/kg)										
4-Isopropyltoluene	NE	VOCs (µg/kg)										
Acetone	60,000	VOCs (µg/kg)										
Carbon Disulfide	36,000	VOCs (µg/kg)										
Toluene	500,000	VOCs (µg/kg)										

Notes:
mg/kg = Milligrams per kilogram (parts per million)
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Study Area - Grant, Locust, and Cavite Housing Areas
Devens, Massachusetts

Analyte	Project Action Level	Analyte Category (units)	LO-IA06-SS35-1 0.5-1.5	LO-IA06-SS35-1 0-0.5	LO-IA06-SS35-1 0-1.5	LO-IA06-SS35-1-T 0-1.5	LO-IA06-SS36-1 0.5-1.5	LO-IA06-SS36-1 0-0.5	LO-IA06-SS37-1 0.5-1.5	LO-IA06-SS37-1 0-0.5	LO-IA06-SS38-1 0-0.5	LO-IA06-SS38-1-D 0-0.5
Aluminum	7,600	Metals (mg/kg)	16600 V	9810 V	13200 V		15000 V	10100 V	12900 V	8920 V	10400 V	8270 V
Antimony	3.1	Metals (mg/kg)	0.61 B	3.6 B	2.1 B		0.64 B	3.7 B	0.94 B	2.3 B	1.8 B	2.1 B
Arsenic	0.39	Metals (mg/kg)	19.2 V	16.4 V	22.6 V		25.5 V	18.6 V	15 V	15.1 V	16.9 V	14.6 V
Barium	540	Metals (mg/kg)	74.1 V	14.2 B	19.3 B		26.6 V	17.9 B	16.5 B	13.9 B	19.3 B	11.9 B
Beryllium	1	Metals (mg/kg)	0.69 V	0.3 B	0.5 B		0.64 V	0.41 B	0.47 B	0.28 B	0.38 B	0.27 B
Cadmium	2	Metals (mg/kg)	0.065 U	0.086 U	0.092 U		0.059 U	0.086 U	0.062 U	0.083 U	0.079 U	0.084 U
Calcium	NE	Metals (mg/kg)	942 V	317 B	297 B		329 B	429 B	262 B	454 B	720 V	353 B
Chromium	30	Metals (mg/kg)	36.3 V	17.6 V	29.7 V		32.7 V	24.3 V	20.4 V	17.9 V	36 V	15 V
Cobalt	900	Metals (mg/kg)	7.9 V	3.1 B	4.6 B		9.1 V	3.9 B	4.8 B	2.6 B	4.4 B	3.2 B
Copper	310	Metals (mg/kg)	12 V	134 V	43.2 V		18.3 V	113 V	50.6 V	116 V	25.4 V	25.5 V
Iron	2,300	Metals (mg/kg)	19400 V	12000 V	16000 V		21300 V	14700 V	15200 V	12600 V	14300 V	10300 V
Lead	30	Metals (mg/kg)	18.2 V	973 V	325 V		44.6 V	1220 V	196 V	777 V	134 V	151 V
Magnesium	NE	Metals (mg/kg)	6360 V	2460 V	4110 V		4430 V	3570 V	3240 V	2190 V	3930 V	2370 V
Manganese	180	Metals (mg/kg)	267 V	111 V	213 V		438 V	199 V	112 V	129 V	221 V	137 V
Mercury	2.3	Metals (mg/kg)	0.018 U	0.037 V	0.018 U		0.018 U	0.042 V	0.025 B	0.034 V	0.039 V	0.04 V
Nickel	20	Metals (mg/kg)	32.2 V	13.5 V	16.8 V		29 V	15.9 V	17 V	12.5 V	20.5 V	13.5 V
Potassium	NE	Metals (mg/kg)	1530 V	337 B	841 V		531 V	463 B	510 B	400 B	1100 V	366 B
Selenium	39	Metals (mg/kg)	0.41 U	0.93 V	0.49 B		0.38 U	0.55 V	0.39 U	0.59 V	0.73 V	0.5 B
Silver	39	Metals (mg/kg)	0.2 U	0.4 U	0.43 U		0.18 U	0.4 U	0.19 U	0.39 U	0.36 U	0.39 U
Sodium	NE	Metals (mg/kg)	121 B	110 B	77.2 B		48.4 U	68.1 B	54.3 B	79.4 B	80.3 B	76.7 B
Thallium	0.52	Metals (mg/kg)	0.92 U	0.73 B	0.74 U		0.84 U	1 B	0.66 U	0.88 U	0.84 U	0.67 U
Vanadium	55	Metals (mg/kg)	26 V	16.3 V	21.1 V		24.8 V	19.4 V	17.9 V	19.6 V	18.5 V	13.4 V
Zinc	2,300	Metals (mg/kg)	34 V	31.7 V	29.9 V		35.3 V	35.8 V	29.7 V	24.3 V	31.8 V	24.9 V
Acenaphthylene	370,000	PAHs (µg/kg)			380 U							
Anthracene	100,000	PAHs (µg/kg)			380 U							
Benzo(a)anthracene	620	PAHs (µg/kg)			380 U							
Benzo(a)pyrene	62	PAHs (µg/kg)			380 U							
Benzo(b)fluoranthene	620	PAHs (µg/kg)			380 U							
Benzo(g,h,i)perylene	2,500	PAHs (µg/kg)			380 U							
Benzo(k)fluoranthene	6,200	PAHs (µg/kg)			380 U							
Chrysene	7,000	PAHs (µg/kg)			380 U							
Dibenz(a,h)Anthracene	62	PAHs (µg/kg)			380 U							
Fluoranthene	230,000	PAHs (µg/kg)			380 U							
Indeno(1,2,3-c,d)Pyrene	620	PAHs (µg/kg)			380 U							
Naphthalene	5,600	PAHs (µg/kg)			5.1 U	2 B						
Phenanthrene	100,000	PAHs (µg/kg)			380 U							
Pyrene	230,000	PAHs (µg/kg)			380 U							
Aldrin	29	Pesticides (µg/kg)			3.9 U							
4,4-DDD	240	Pesticides (µg/kg)			7.7 U							
4,4-DDE	170	Pesticides (µg/kg)			19 V							
4,4-DDT	170	Pesticides (µg/kg)			73 V							
Dieldrin	30	Pesticides (µg/kg)			7.7 U							
1,2,4-Trichlorobenzene	65,000	SVOCs (µg/kg)			5.1 U	1.7 B						
2,4-Dinitrotoluene	12,000	SVOCs (µg/kg)			120 U							
Acetophenone	7,800	SVOCs (µg/kg)			380 U							
bis(2-ethylhexyl) phthalate	35,000	SVOCs (µg/kg)			380 U							
Hexachlorobutadiene	6,000	SVOCs (µg/kg)			5.1 U	1.9 B						
Phenol	20,000	SVOCs (µg/kg)			380 U							
Aliphatic Hydrocarbons (C_{19}-C_{36})	3,000	TPH (mg/kg)			4.8 J							
Aliphatic Hydrocarbons (C_9-C_{18})	1,000	TPH (mg/kg)			5.2 J							
Aromatic Hydrocarbons (C_{11}-C_{22})	800	TPH (mg/kg)			20 U							
1,2,3-Trichlorobenzene	NE	VOCs (µg/kg)			5.1 U	2.4 B						
2-Butanone		VOCs (µg/kg)			9.6 V	5 U						
4-Isopropyltoluene	NE	VOCs (µg/kg)			2.9 J	5 U						
Acetone	60,000	VOCs (µg/kg)			130 V	5 U						
Carbon Disulfide	36,000	VOCs (µg/kg)			5.1 U	5 U						
Toluene	500,000	VOCs (µg/kg)			1.2 J	5 U						

Notes:
mg/kg = Milligrams per kilogram (parts per million)
µg/kg = Micrograms per kilogram (parts per billion)
V = Valid result; substance detected.
J = Estimated result; substance detected, but below the detection limit.
U = Substance not detected; detection limit listed.
Highlighted results were detected above their Project Action Level.

Table 6-6a
IA-6 Summary of Screened Analytical Results
PASI/SSI Comprehensive Report
Study Area - Grant, Locust, and Cavite Housing Areas
Devens, Massachusetts

Analyte	Project Action Level	Analyte Category (units)	LO-IA06-SS39-1 0-0.5	LO-IA06-SS40-1 0-0.5	LO-IA06-SS40-1 0-1.5	LO-IA06-SS41-1 0-0.5	LO-IA06-SS42-1 0-0.5	LO-IA06-SS43-1 0-0.5	LO-IA06-SS44-1 0-0.5	LO-IA06-SS45-1 0-0.5	LO-IA06-SS46-1 0-0.5	LO-IA06-SS47-1 0-0.5
Aluminum	7,600	Metals (mg/kg)	8420 V	10400 V	13000 V	10600 V	6850 V	11000 V	10600 V	11600 V	9890 V	8110 V
Antimony	3.1	Metals (mg/kg)	1.9 B	1.6 B	1.5 B	0.37 U	0.65 B	0.76 B	0.48 U	0.54 U	2.3 B	3.7 B
Arsenic	0.39	Metals (mg/kg)	22.2 V	17.7 V	19.2 V	10.9 V	13.3 V	23.8 V	23.5 V	17.4 V	13.3 V	13.9 V
Barium	540	Metals (mg/kg)	15.7 B	17 B	18.2 V	20.2 V	10.8 B	17 B	16 B	31.1 V	18 B	10.4 B
Beryllium	1	Metals (mg/kg)	0.29 B	0.32 B	0.39 B	0.41 B	0.21 B	0.38 B	0.33 B	0.35 B	0.41 B	0.43 B
Cadmium	2	Metals (mg/kg)	0.12 B	0.1 U	0.07 U	0.054 U	0.068 U	0.066 U	0.075 B	0.18 B	0.078 U	0.085 U
Calcium	NE	Metals (mg/kg)	931 V	241 B	240 B	257 B	415 B	645 V	450 B	1850 V	189 B	419 B
Chromium	30	Metals (mg/kg)	15.4 V	21.6 V	25.1 V	16.8 V	12.7 V	27.1 V	23.6 V	19.5 V	15.7 V	14.9 V
Cobalt	900	Metals (mg/kg)	2.5 B	3.2 B	5.1 V	3.5 B	3.2 B	5.5 B	4.9 B	4.2 B	3.3 B	3.1 B
Copper	310	Metals (mg/kg)	25.3 V	44.6 V	23.2 V	5.9 V	7 V	11.8 V	20.8 V	12.1 V	85.6 V	149 V
Iron	2,300	Metals (mg/kg)	11200 V	14200 V	13700 V	13100 V	9430 V	16900 V	15100 V	14300 V	11800 V	10800 V
Lead	30	Metals (mg/kg)	261 V	128 V	47.7 V	22.6 V	14.9 V	27.8 V	56.6 V	47.3 V	388 V	1170 V
Magnesium	NE	Metals (mg/kg)	2610 V	2700 V	3260 V	2690 V	2270 V	4250 V	4040 V	2830 V	1790 V	1850 V
Manganese	180	Metals (mg/kg)	110 V	169 V	117 V	201 V	109 V	228 V	125 V	331 V	88.6 V	117 V
Mercury	2.3	Metals (mg/kg)	0.018 U	0.032 B	0.032 B	0.034 B	0.027 B	0.042 V	0.053 V	0.081 V	0.019 B	0.016 U
Nickel	20	Metals (mg/kg)	13.1 V	13.9 V	20.4 V	13.2 V	10.9 V	23 V	20 V	16.6 V	12.3 V	11.9 V
Potassium	NE	Metals (mg/kg)	291 B	280 B	384 B	347 B	429 B	535 B	545 B	505 B	263 B	331 B
Selenium	39	Metals (mg/kg)	0.57 B	0.49 U	0.37 B	0.38 U	0.43 U	0.87 V	0.54 B	0.55 U	1 V	1 V
Silver	39	Metals (mg/kg)	0.44 U	0.48 U	0.33 U	0.16 U	0.2 U	0.2 U	0.21 U	0.23 U	0.36 U	0.39 U
Sodium	NE	Metals (mg/kg)	82 B	87.5 B	69.5 B	44.3 U	55 U	53.9 U	56.6 U	63.7 U	61.4 U	66.7 U
Thallium	0.52	Metals (mg/kg)	0.75 U	0.91 B	0.99 V	0.58 U	0.72 U	0.71 U	0.96 B	0.84 U	0.83 U	0.9 U
Vanadium	55	Metals (mg/kg)	16.4 V	20.3 V	17.8 V	14.5 V	12.1 V	18.8 V	19.3 V	21.4 V	14.3 V	12.5 V
Zinc	2,300	Metals (mg/kg)	26.1 V	27.9 V	32.6 V	28.2 V	26.9 V	41.3 V	38 V	66.7 V	27.2 V	30.6 V
Acenaphthylene	370,000	PAHs (µg/kg)			380 U							
Anthracene	100,000	PAHs (µg/kg)			380 U							
Benzo(a)anthracene	620	PAHs (µg/kg)			380 U							
Benzo(a)pyrene	62	PAHs (µg/kg)			380 U							
Benzo(b)fluoranthene	620	PAHs (µg/kg)			380 U							
Benzo(g,h,i)perylene	2,500	PAHs (µg/kg)			380 U							
Benzo(k)fluoranthene	6,200	PAHs (µg/kg)			380 U							
Chrysene	7,000	PAHs (µg/kg)			380 U							
Dibenz(a,h)Anthracene	62	PAHs (µg/kg)			380 U							
Fluoranthene	230,000	PAHs (µg/kg)			380 U							
Indeno(1,2,3-c,d)Pyrene	620	PAHs (µg/kg)			380 U							
Naphthalene	5,600	PAHs (µg/kg)			7 U							
Phenanthrene	100,000	PAHs (µg/kg)			380 U							
Pyrene	230,000	PAHs (µg/kg)			40 J							
Aldrin	29	Pesticides (µg/kg)			3.9 J							
4,4-DDD	240	Pesticides (µg/kg)			11 U							
4,4-DDE	170	Pesticides (µg/kg)			7.8 J							
4,4-DDT	170	Pesticides (µg/kg)			18 V							
Dieldrin	30	Pesticides (µg/kg)			54 V							
1,2,4-Trichlorobenzene	65,000	SVOCs (µg/kg)			7 U							
2,4-Dinitrotoluene	12,000	SVOCs (µg/kg)			120 U							
Acetophenone	7,800	SVOCs (µg/kg)			380 U							
bis(2-ethylhexyl) phthalate	35,000	SVOCs (µg/kg)			380 U							
Hexachlorobutadiene	6,000	SVOCs (µg/kg)			7 U							
Phenol	20,000	SVOCs (µg/kg)			380 U							
Aliphatic Hydrocarbons (C_{19}-C_{36})	3,000	TPH (mg/kg)			9.2 U							
Aliphatic Hydrocarbons (C_9-C_{18})	1,000	TPH (mg/kg)			6.9 U							
Aromatic Hydrocarbons (C_{11}-C_{22})	800	TPH (mg/kg)			20 U							
1,2,3-Trichlorobenzene	NE	VOCs (µg/kg)			7 U							
2-Butanone		VOCs (µg/kg)			4.6 J							
4-Isopropyltoluene	NE	VOCs (µg/kg)			7 U							
Acetone	60,000	VOCs (µg/kg)			83 V							
Carbon Disulfide	36,000	VOCs (µg/kg)			7 U							
Toluene	500,000	VOCs (µg/kg)			7 U							

Notes:
mg/kg = Milligrams per kilogram (parts per million)
µg/kg = Micrograms per kilogram (parts per billion)
V = Valid result; substance detected.
J = Estimated result; substance detected, but below the detection limit.
U = Substance not detected; detection limit listed.
Highlighted results were detected above their Project Action Level.

Table 6-6a
IA-6 Summary of Screened Analytical Results
PASI/SSI Comprehensive Report
Study Area - Grant, Locust, and Cavite Housing Areas
Devens, Massachusetts

Analyte	Project Action Level	Analyte Category (units)	LO-IA06-SS48-1 0-0.5		LO-IA06-TP01-1 0-0		LO-IA06-TP02-1 0-0		LO-IA06-TP03-1 0-0		LO-IA06-TP04-1 0-0	
Aluminum	7,600	Metals (mg/kg)	9020	V	3930	V	4820	V	4790	V	6460	V
Antimony	3.1	Metals (mg/kg)	3.4	B	0.94	U	0.93	U	0.91	U	0.91	U
Arsenic	0.39	Metals (mg/kg)	17.5	V	15.8	V	15.5	V	14.1	V	16.8	V
Barium	540	Metals (mg/kg)	11	B	7.8	B	6.9	B	9.6	B	9.4	B
Beryllium	1	Metals (mg/kg)	0.44	B	0.18	B	0.23	B	0.31	B	0.34	B
Cadmium	2	Metals (mg/kg)	0.087	U	0.09	U	0.089	U	0.088	U	0.088	U
Calcium	NE	Metals (mg/kg)	280	B	433	B	418	B	837	V	552	V
Chromium	30	Metals (mg/kg)	20.7	V	10.3	V	9.8	V	11.1	V	13.3	V
Cobalt	900	Metals (mg/kg)	4.9	B	3.6	B	5.2	B	4.8	B	5.4	B
Copper	310	Metals (mg/kg)	263	V	6.5	V	6.7	V	6.1	V	10.1	V
Iron	2,300	Metals (mg/kg)	12200	V	6930	V	7230	V	8190	V	10800	V
Lead	30	Metals (mg/kg)	4560	V	5.7	V	4.2	V	3	V	4.7	V
Magnesium	NE	Metals (mg/kg)	2790	V	2150	V	1960	V	1940	V	2890	V
Manganese	180	Metals (mg/kg)	131	V	168	V	216	V	180	V	171	V
Mercury	2.3	Metals (mg/kg)	0.016	B	0.018	U	0.02	U	0.02	U	0.017	U
Nickel	20	Metals (mg/kg)	16.4	V	14	V	12.5	V	14.7	V	18.5	V
Potassium	NE	Metals (mg/kg)	413	B	398	B	357	B	464	B	550	B
Selenium	39	Metals (mg/kg)	1	V	0.43	U	0.43	U	0.42	U	0.42	U
Silver	39	Metals (mg/kg)	0.4	U	0.42	U	0.41	U	0.41	U	0.41	U
Sodium	NE	Metals (mg/kg)	67.9	U	70.8	U	70.1	U	68.9	U	69	U
Thallium	0.52	Metals (mg/kg)	1.2	V	0.96	U	0.95	U	0.93	U	0.94	U
Vanadium	55	Metals (mg/kg)	14.1	V	6.7	V	7	V	9.8	V	10.7	V
Zinc	2,300	Metals (mg/kg)	43.1	V	14.7	V	13.6	V	17.9	V	23.2	V
Acenaphthylene	370,000	PAHs (µg/kg)										
Anthracene	100,000	PAHs (µg/kg)										
Benzo(a)anthracene	620	PAHs (µg/kg)										
Benzo(a)pyrene	62	PAHs (µg/kg)										
Benzo(b)fluoranthene	620	PAHs (µg/kg)										
Benzo(g,h,i)perylene	2,500	PAHs (µg/kg)										
Benzo(k)fluoranthene	6,200	PAHs (µg/kg)										
Chrysene	7,000	PAHs (µg/kg)										
Dibenz(a,h)Anthracene	62	PAHs (µg/kg)										
Fluoranthene	230,000	PAHs (µg/kg)										
Indeno(1,2,3-c,d)Pyrene	620	PAHs (µg/kg)										
Naphthalene	5,600	PAHs (µg/kg)										
Phenanthrene	100,000	PAHs (µg/kg)										
Pyrene	230,000	PAHs (µg/kg)										
Aldrin	29	Pesticides (µg/kg)										
4,4-DDD	240	Pesticides (µg/kg)										
4,4-DDE	170	Pesticides (µg/kg)										
4,4-DDT	170	Pesticides (µg/kg)										
Dieldrin	30	Pesticides (µg/kg)										
1,2,4-Trichlorobenzene	65,000	SVOCs (µg/kg)										
2,4-Dinitrotoluene	12,000	SVOCs (µg/kg)										
Acetophenone	7,800	SVOCs (µg/kg)										
bis(2-ethylhexyl) phthalate	35,000	SVOCs (µg/kg)										
Hexachlorobutadiene	6,000	SVOCs (µg/kg)										
Phenol	20,000	SVOCs (µg/kg)										
Aliphatic Hydrocarbons (C_{19}-C_{36})	3,000	TPH (mg/kg)										
Aliphatic Hydrocarbons (C_9-C_{18})	1,000	TPH (mg/kg)										
Aromatic Hydrocarbons (C_{11}-C_{22})	800	TPH (mg/kg)										
1,2,3-Trichlorobenzene	NE	VOCs (µg/kg)										
2-Butanone		VOCs (µg/kg)										
4-Isopropyltoluene	NE	VOCs (µg/kg)										
Acetone	60,000	VOCs (µg/kg)										
Carbon Disulfide	36,000	VOCs (µg/kg)										
Toluene	500,000	VOCs (µg/kg)										

Notes:
mg/kg = Milligrams per kilogram (parts per million)
µg/kg = Micrograms per kilogram (parts per billion)
V = Valid result; substance detected.
J = Estimated result; substance detected, but below the detection limit.
U = Substance not detected; detection limit listed.
Highlighted results were detected above their Project Action Level.

Table 6-6b
IA-6 Hazard Calculation Summary

Analyte	Analyte Category (units)	Carcinogen (Ca) or Non-carcinogen (NC)	EPA Region IX Residential Soil PRG	Average Value	Maximum Value	95% UCL	Exposure Point Concentration (EPC)[1]	Screening Cancer Risk (SCR)	Screening Hazard Quotient (SHQ)
Aluminum	Metals (mg/kg)	NC	76,000	9691.43	14600	10180.35	10180.35		0.13
Antimony	Metals (mg/kg)	NC	31	1.12	10	1.34	1.34		0.04
Arsenic	Metals (mg/kg)	Ca	0.39	21.35	46.1	23.73	23.73	6.1E-05	
Beryllium	Metals (mg/kg)	NC	150	0.41	1.1	0.44	0.44		0.003
Chromium	Metals (mg/kg)	Ca	210	24.02	60.7	26.44	26.44	1.3E-07	
Iron	Metals (mg/kg)	NC	23,000	13896.51	24800	14870.13	14870.13		0.65
Lead	Metals (mg/kg)	NC	400	75.31	643	107.83	107.83		0.27
Manganese	Metals (mg/kg)	NC	1,800	230.34	808	260.95	260.95		0.14
Nickel	Metals (mg/kg)	NC	1600	21.79	50.6	24.02	24.02		0.02
Thallium	Metals (mg/kg)	NC	5.2	0.45	1.6	0.50	0.50		0.10
Benzo(a)pyrene	PAHs (µg/kg)	Ca	62	50.90	190	309.54	190.00	3.1E-06	
Benzo(b)fluoranthene	PAHs (µg/kg)	Ca	62	258.64	880	382.37	382.37	6.2E-06	
Dibenz(a,h)Anthracene	PAHs (µg/kg)	Ca	62	50.97	190	309.48	190.00	3.1E-06	
							Total:	7.E-05	1.22

[1] = Lesser of Maximum or 95% UCL used.
PAH = polycyclic aromatic hydrocarbons
PRG = Preliminary Remediation Goals
UCL = Upper Confident Limit
PCB = polychlorinated biphenyls
NA = not applicable
mg/kg = milligrams per kilogram
µg/kg = micrograms per kilogram

Summary

Total Screening Cancer Risk: 7.E-05	TSCR>1E-04? No
Total Screening Hazard Quotient: 1	TSHI>1? No
Arsenic concentration is consistent with background.	
TSCR due to Arsenic: 6.E-05	TSCR w/o Arsenic: 1.E-05
TSCR due to Arsenic <1E-04.	TSCR w/o Arsenic is <1E-04.
Total PCBs concentration is less than 1 mg/kg.	
TSCR w/o PCBs: NA	TSCR w/o PCBs: 7.E-05
	TSCR w/o PCBs is <1E-04.
PAHs concentration(s) are consistent with background.	
TSCR due to PAHs: 1.E-05	TSCR w/o to PAHs: 6.E-05
TSCR due to PAHs is <1E-04.	TSCR w/o PAHs is <1E-04.

Table 6-7a
IA-07 Summary of Screened Analytical Results

Analyte	Project Action Level	Analyte Category (units)	GR-IA07-SB01-1 0-3 ft		GR-IA07-SB01-1 3-10 ft		GR-IA07-SB02-1 0-3 ft		GR-IA07-SB02-1 3-10 ft		GR-IA07-SB03-1 0-3 ft		GR-IA07-SB03-1 3-10 ft		GR-IA07-SB04-1 0-3 ft	
Aluminum	7,600	Metals (mg/kg)	5400	V	2400	V	5900	V	2800	V	5400	V	3700	V	4900	V
Antimony	3.1	Metals (mg/kg)	11	V	2.1	U	24	V	2.1	U	2.2	U	2.1	U	2.4	V
Arsenic	0.39	Metals (mg/kg)	27	V	22	V	32	V	27	V	28	V	52	V	25	V
Barium	540	Metals (mg/kg)	23	V	9.1	V	18	V	12	V	21	V	17	V	17	V
Calcium	NE	Metals (mg/kg)	710	V	1100	V	520	V	790	V	940	V	980	V	600	V
Chromium	30	Metals (mg/kg)	19	V	7.5	V	14	V	9.9	V	15	V	13	V	13	V
Cobalt	500	Metals (mg/kg)	8.3	V	5.1	V	6.9	V	7.4	V	6.7	V	6.5	V	5.9	V
Copper	310	Metals (mg/kg)	61	V	12	V	55	V	13	V	13	V	12	V	68	V
Iron	2,300	Metals (mg/kg)	12000	V	6900	V	11000	V	10000	V	9700	V	9500	V	9900	V
Lead	300	Metals (mg/kg)	790	V	28	V	1400	V	21	V	29	V	7.5	V	120	V
Magnesium	NE	Metals (mg/kg)	3100	V	1400	V	2200	V	1700	V	2200	V	2100	V	2100	V
Manganese	180	Metals (mg/kg)	300	V	180	V	280	V	260	V	250	V	220	V	250	V
Mercury	2.3	Metals (mg/kg)	0.087	U	0.083	U	0.0073	J	0.08	U	0.018	J	0.083	U	0.014	J
Nickel	20	Metals (mg/kg)	43	V	18	V	34	V	25	V	22	V	22	V	22	V
Potassium	NE	Metals (mg/kg)	1300	V	390	V	820	V	580	V	860	V	820	V	790	V
Vanadium	55	Metals (mg/kg)	12	V	5.2	V	11	V	6.4	V	11	V	8	V	9.5	V
Zinc	2,300	Metals (mg/kg)	26	V	16	V	24	V	22	V	26	V	23	V	34	V

Notes:
mg/kg = Milligrams per kilogram (parts per million)
µg/kg = Micrograms per kilogram (parts per billion)
V = Valid result; substance detected.
J = Estimated result; substance detected, but below the detection limit.
U = Substance not detected; detection limit listed.
Highlighted results were detected above their Project Action Level.

Table 6-7a
IA-07 Summary of Screened Analytical Results

Analyte	Project Action Level	Analyte Category (units)	GR-IA07-SB04-1 3-10 ft		GR-IA07-SS01-1 0-1.5 ft		GR-IA07-SS02-1-M 0-1.5 ft		GR-IA07-SS03-1 0-1.5 ft		GR-IA07-SS04-1 0-1.5 ft		GR-IA07-SS05-1 0-1.5 ft		GR-IA07-SS06-1 0-1.5 ft	
Aluminum	7,600	Metals (mg/kg)	2600	V	6300	V	6400	V	5100	V	5200	V	9200	V	10000	V
Antimony	3.1	Metals (mg/kg)	2.1	U	2.1	U	2.1	U	12	V	2.1	U	2.5	U	2.3	V
Arsenic	0.39	Metals (mg/kg)	20	V	23	V	20	V	24	V	25	V	27	V	25	V
Barium	540	Metals (mg/kg)	11	V	16	V	12	V	10	V	10	V	24	V	23	V
Calcium	NE	Metals (mg/kg)	1200	V	610	V	270	V	270	V	220	V	510	V	730	V
Chromium	30	Metals (mg/kg)	8.7	V	14	V	12	V	12	V	12	V	19	V	23	V
Cobalt	500	Metals (mg/kg)	5.3	V	7.4	V	3.5	V	4.6	V	4.6	V	5.3	V	6.6	V
Copper	310	Metals (mg/kg)	14	V	22	V	15	V	46	V	11	V	15	V	26	V
Iron	2,300	Metals (mg/kg)	7900	V	11000	V	7800	V	8400	V	8400	V	11000	V	14000	V
Lead	300	Metals (mg/kg)	14	V	140	V	120	V	1200	V	28	V	44	V	220	V
Magnesium	NE	Metals (mg/kg)	1400	V	2400	V	1600	V	1800	V	1700	V	2400	V	4400	V
Manganese	180	Metals (mg/kg)	230	V	240	V	140	V	220	V	160	V	340	V	290	V
Mercury	2.3	Metals (mg/kg)	0.088	U	0.034	J	0.05	J	0.042	J	0.018	J	0.3	V	0.074	J
Nickel	20	Metals (mg/kg)	19	V	24	V	13	V	20	V	15	V	16	V	25	V
Potassium	NE	Metals (mg/kg)	480	V	810	V	330	V	650	V	540	V	680	V	940	V
Vanadium	55	Metals (mg/kg)	5.4	V	12	V	10	V	10	V	9	V	18	V	17	V
Zinc	2,300	Metals (mg/kg)	18	V	23	V	16	V	21	V	17	V	32	V	46	V

Notes:
mg/kg = Milligrams per kilogram (parts per million)
µg/kg = Micrograms per kilogram (parts per billion)
V = Valid result; substance detected.
J = Estimated result; substance detected, but below the detection limit.
U = Substance not detected; detection limit listed.
Highlighted results were detected above their Project Action Level.

Table 6-7b
IA-7 Hazard Screening Calculation Summary
PASI/SSI Comprehensive Report
Study Area - Grant, Locust, and Cavite Housing Areas
Devens, Massachusetts

Analyte	Analyte Category (units)	Carcinogen (Ca) or Non-carcinogen (NC)	EPA Region IX Residential Soil PRG	Average Value	Maximum Value	95% UCL	Exposure Point Concentration (EPC)[1]	Screening Cancer Risk (SCR)	Screening Hazard Quotient (SHQ)
Aluminum	Metals (mg/kg)	NC	76,000	5,379	10,000	6,433	6,433		0.08
Antimony	Metals (mg/kg)	NC	31	4	24	12	12		0.40
Arsenic	Metals (mg/kg)	Ca	0.39	27	52	31	31	8.E-05	
Iron	Metals (mg/kg)	NC	23,000	9,821	14,000	10,720	10,720		0.47
Lead	Metals (mg/kg)	NC	400	297	1,400	666	666		1.66
Manganese	Metals (mg/kg)	NC	1,800	240	340	266	266		0.15
Nickel	Metals (mg/kg)	NC	1,600	23	43	27	27		0.02
							Total:	8.E-05	2.78

[1] = Lesser of Maximum or 95% UCL used.
PAH = polycyclic aromatic hydrocarbons
PRG = Preliminary Remediation Goals
UCL = Upper Confident Limit
PCB = polychlorinated biphenyls
NA = not applicable
mg/kg = milligrams per kilogram
µg/kg = micrograms per kilogram

Summary

Total Screening Cancer Risk: 8.E-05	TSCR>1E-04? No
Total Screening Hazard Quotient: 3	TSHI>1? No
Arsenic concentration is consistent with background.	
TSCR due to Arsenic: 8.E-05	TSCR w/o Arsenic: NA
TSCR due to Arsenic is <1E-04.	
Total PCBs concentration is less than 1 mg/kg.	
TSCR w/o PCBs: NA	TSCR w/o PCBs: 8.E-05
	TSCR w/o PCBs is <1E-04.
PAHs concentration(s) are consistent with background.	
TSCR due to PAHs: NA	TSCR w/o to PAHs: 8.E-05
	TSCR w/o PAHs is <1E-04.

Table 6-8a
IA-8 Summary of Screened Analytical Results
PASI/SSI Comprehensive Report
Study Area - Grant, Locust, and Cavite Housing Areas
Devens, Massachusetts

Analyte	Project Action Level	Analyte Category (units)	GR-IA08-SB01-1 0-3 ft	GR-IA08-SB01-1 3-10 ft	GR-IA08-SB01-1-D 3-10 ft	GR-IA08-SB02-1 8-10 ft	GR-IA08-SB02-1-D 8-10 ft	GR-IA08-SB03-1 0-2 ft	GR-IA08-SB04-1 2-4 ft	GR-IA08-SB05-1 40-42 ft	GR-IA08-SB05-1 6-8 ft	GR-IA08-SB06-1 0-2 ft	GR-IA08-SB07-1 4-6 ft	GR-IA08-SB09-1 0-3 ft	GR-IA08-SB09-1 3-10 ft
Aluminum	7,600	Metals (mg/kg)	5800 V	4700 V	4500 V									7800 V	4700 V
Arsenic	0.39	Metals (mg/kg)	29 V	32 V	30 V									25 V	36 V
Barium	540	Metals (mg/kg)	26 V	22 V	21 V									31 V	22 V
Calcium	NE	Metals (mg/kg)	1800 V	7900 V	7200 V									2000 V	9100 V
Chromium	30	Metals (mg/kg)	20 V	19 V	18 V									24 V	20 V
Cobalt	500	Metals (mg/kg)	9.1 V	8.3 V	7.7 V									7.6 V	8.8 V
Copper	310	Metals (mg/kg)	17 V	15 V	15 V									19 V	16 V
Iron	2,300	Metals (mg/kg)	13000 V	11000 V	11000 V									13000 V	11000 V
Lead	300	Metals (mg/kg)	12 V	8 V	8.2 V									11 V	7.1 V
Magnesium	NE	Metals (mg/kg)	3500 V	3600 V	3300 V									4100 V	3200 V
Manganese	180	Metals (mg/kg)	290 V	270 V	250 V									230 V	240 V
Mercury	2.3	Metals (mg/kg)	0.086 U	0.081 U	0.082 U									0.01 J	0.0049 J
Nickel	20	Metals (mg/kg)	31 V	31 V	29 V									26 V	31 V
Potassium	NE	Metals (mg/kg)	1600 V	1400 V	1400 V									1900 V	1800 V
Sodium	39	Metals (mg/kg)	86 U	84 U	83 U									85 U	84 U
Vanadium	55	Metals (mg/kg)	12 V	11 V	10 V									15 V	11 V
Zinc	2,300	Metals (mg/kg)	28 V	28 V	26 V									30 V	24 V
Anthracene	1,000,000	PAH (µg/kg)	400 V	350 U	351 U									360 U	350 U
Benzo(a)anthracene	620	PAH (µg/kg)	1100 V	351 U	351 U									360 U	350 U
Benzo(a)pyrene	62	PAH (µg/kg)	1100 V	351 U	351 U									100 V	140 V
Benzo(b)fluoranthene	620	PAH (µg/kg)	880 V	351 U	351 U									360 U	350 U
Benzo(g,h,i)perylene	1,000	PAH (µg/kg)	680 V	351 U	351 U									360 U	350 U
Benzo(k)fluoranthene	6,200	PAH (µg/kg)	866 V	351 U	351 U									360 U	350 U
Chrysene	7,000	PAH (µg/kg)	1000 V	351 U	351 U									360 U	350 U
Dibenz(a,h)Anthracene	62	PAH (µg/kg)	470 V	351 U	351 U									14 U	17 V
Fluoranthene	23,000	PAH (µg/kg)	1900 V	351 U	351 U									360 U	350 U
Indeno(1,2,3-c,d)Pyrene	620	PAH (µg/kg)	810 V	351 U	351 U									360 U	350 U
Naphthalene	5,600	PAH (µg/kg)	4.5 U	7.7 U	9.4 U	3.2 U	3.9 V	5 U	5.4 U	6.8 U	3.8 U	4.8 U	6.6 U	360 U	350 U
Phenanthrene	100,000	PAH (µg/kg)	510 V	351 U	351 U									360 U	350 U
Pyrene	230,000	PAH (µg/kg)	1700 V	351 U	351 U									360 U	350 U
Total PCBs	220	PCBs (µg/kg)	85 V	48.2 V	39.3 V									35.8 U	35.1 U
Aliphatic Hydrocarbons (C_{19}-C_{36})	3000	TPH (mg/kg)	11.2 V	18 V	14.9 V									7.33 U	7.41 U
Aromatic Hydrocarbons (C_{11}-C_{22})	200	TPH (mg/kg)	35.4 V	13.1 V	11.8 V									7.33 U	7.41 U
Acetone	60,000	VOCs (µg/kg)	9 U	15 U	19 U	6.4 U	6.1 V	10 U	11 U	14 U	7.7 U	16 V	13 U	11 V	15 V
Benzene	640	VOCs (µg/kg)	0.9 U	1.5 U	1.9 U	0.64 U	0.56 U	1 U	1.1 U	1.4 U	0.77 U	0.96 U	1.3 U	0.66 U	0.78 U
m,p-Xylenes	27,000	VOCs (µg/kg)	0.9 U	1.5 U	1.9 U	0.64 U	0.76 V	1 U	1.1 U	1.4 U	0.77 U	0.96 U	1.3 U	0.66 U	0.78 U
o-Xylene	27,000	VOCs (µg/kg)	0.9 U	1.5 U	1.9 U	0.64 U	0.56 U	1 U	1.1 U	1.4 U	0.77 U	0.96 U	1.3 U	0.66 U	0.78 U
p-Isopropyltoluene	100,000	VOCs (µg/kg)	0.9 U	1.5 U	1.9 U	0.64 U	0.56 U	1 U	1.1 U	1.4 U	0.77 U	5.3 V	1.3 U	0.66 U	0.78 U
Toluene	500	VOCs (µg/kg)	2.3 V	2.3 U	2.8 U	0.97 U	0.84 U	1.5 U	1.6 U	2 U	1.2 U	2.2 V	2 U	0.98 U	1.2 U

Notes:
mg/kg = Milligrams per kilogram (parts per million)
µg/kg = Micrograms per kilogram (parts per billion)
V = Valid result; substance detected.
J = Estimated result; substance detected, but below the detection limit.
U = Substance not detected; detection limit listed.
Highlighted results were detected above their Project Action Level.
NE = Not established.

Table 6-8a
IA-8 Summary of Screened Analytical Results
PASI/SSI Comprehensive Report
Study Area - Grant, Locust, and Cavite Housing Areas
Devens, Massachusetts

Analyte	Project Action Level	Analyte Category (units)	GR-IA10-SB02-1 0-3 ft	GR-IA10-SB02-1 3-10 ft	GR-IA10-SB02-1-D 3-10 ft	PASI-GR-CO-009-1 0-3 ft	PASI-GR-CO-010-1 0-3 ft	PASI-GR-CO-010-1D 0-3 ft	PASI-GR-CO-011-1 0-3 ft	PASI-GR-CO-011-1M 0-3 ft	PASI-GR-CO-012-1 0-3 ft	PASI-GR-CO-013-1 0-3 ft	PASI-GR-CO-014-1 0-3 ft	PASI-GR-CO-016-1 0-3 ft
Aluminum	7,600	Metals (mg/kg)	5600 V	5800 V	5600 V									
Arsenic	0.39	Metals (mg/kg)	26 V	19 V	22 V									
Barium	540	Metals (mg/kg)	28 V	28 V	27 V									
Calcium	NE	Metals (mg/kg)	5800 V	8600 V	6800 V									
Chromium	30	Metals (mg/kg)	16 V	16 V	16 V									
Cobalt	500	Metals (mg/kg)	7.2 V	6.1 V	6.2 V									
Copper	310	Metals (mg/kg)	16 V	13 V	13 V									
Iron	2,300	Metals (mg/kg)	12000 V	11000 V	11000 V									
Lead	300	Metals (mg/kg)	12 V	8.5 V	9.1 V									
Magnesium	NE	Metals (mg/kg)	2900 V	2700 V	2600 V									
Manganese	180	Metals (mg/kg)	280 V	290 V	240 V									
Mercury	2.3	Metals (mg/kg)	0.03 J	0.0054 J	0.0084 J									
Nickel	20	Metals (mg/kg)	23 V	19 V	19 V									
Potassium	NE	Metals (mg/kg)	1500 V	1500 V	1400 V									
Sodium	39	Metals (mg/kg)	87 U	89 V	89 V									
Vanadium	55	Metals (mg/kg)	11 V	9.5 V	9.8 V									
Zinc	2,300	Metals (mg/kg)	30 V	26 V	28 V									
Anthracene	1,000,000	PAH (µg/kg)	3200 V	1830 U	1850 U									
Benzo(a)anthracene	620	PAH (µg/kg)	6100 V	1830 U	1850 U									
Benzo(a)pyrene	62	PAH (µg/kg)	5500 V	2100 V	1300 V									
Benzo(b)fluoranthene	620	PAH (µg/kg)	4230 V	1830 U	1850 U									
Benzo(g,h,i)perylene	1,000	PAH (µg/kg)	2800 V	1830 U	1850 U									
Benzo(k)fluoranthene	6,200	PAH (µg/kg)	4320 V	1830 U	1850 U									
Chrysene	7,000	PAH (µg/kg)	6040 V	1830 U	1850 U									
Dibenz(a,h)Anthracene	62	PAH (µg/kg)	2300 V	1830 U	1850 U									
Fluoranthene	23,000	PAH (µg/kg)	13000 V	3660 V	2600 V									
Indeno(1,2,3-c,d)Pyrene	620	PAH (µg/kg)	3700 V	1830 U	1850 U									
Naphthalene	5,600	PAH (µg/kg)	5.1 V	20 V	6 V									
Phenanthrene	100,000	PAH (µg/kg)	8100 V	2500 V	2200 V									
Pyrene	230,000	PAH (µg/kg)	11300 V	2680 V	2400 V									
Total PCBs	220	PCBs (µg/kg)	36.2 U	36.6 U	37 U	9.9 U	11 U	10 U	11 U	9.1 U	9.5 U	11 U	10 U	9.7 U
Aliphatic Hydrocarbons (C_{19}-C_{36})	3000	TPH (mg/kg)	36.2 U	36.6 U	37 U									
Aromatic Hydrocarbons (C_{11}-C_{22})	200	TPH (mg/kg)	202 V	58.1 V	45.7 V									
Acetone	60,000	VOCs (µg/kg)	6.5 U	9.2 U	6.7 U									
Benzene	640	VOCs (µg/kg)	0.65 U	2.6 V	1.2 V									
m,p-Xylenes	27,000	VOCs (µg/kg)	0.65 U	2.6 V	0.67 U									
o-Xylene	27,000	VOCs (µg/kg)	0.65 U	2.2 V	0.67 U									
p-Isopropyltoluene	100,000	VOCs (µg/kg)	0.65 U	0.92 U	0.67 U									
Toluene	500	VOCs (µg/kg)	0.97 U	4.8 V	1.7 V									

Notes:
mg/kg = Milligrams per kilogram (parts per million)
µg/kg = Micrograms per kilogram (parts per billion)
V = Valid result; substance detected.
J = Estimated result; substance detected, but below the detection limit.
U = Substance not detected; detection limit listed.
Highlighted results were detected above their Project Action Level.
NE = Not established.

Table 6-8a
IA-8 Summary of Screened Analytical Results
PASI/SSI Comprehensive Report
Study Area - Grant, Locust, and Cavite Housing Areas
Devens, Massachusetts

Analyte	Project Action Level	Analyte Category (units)	PASI-GR-CO-023-1 0-3 ft	PASI-GR-GB-015A-1 0-3 ft	PASI-GR-GB-015B-1 0-3 ft	PASI-GR-GB-015C-1 0-3 ft	PASI-GR-GB-015D-1 0-3 ft	PASI-GR-GB-015E-1 0-3 ft	PASI-GR-GB-017A-1 0-3 ft	PASI-GR-GB-017B-1 0-3 ft	PASI-GR-GB-017C-1 0-3 ft	PASI-GR-GB-017D-1 0-3 ft	PASI-GR-GB-017E-1 0-3 ft
Aluminum	7,600	Metals (mg/kg)											
Arsenic	0.39	Metals (mg/kg)											
Barium	540	Metals (mg/kg)											
Calcium	NE	Metals (mg/kg)											
Chromium	30	Metals (mg/kg)											
Cobalt	500	Metals (mg/kg)											
Copper	310	Metals (mg/kg)											
Iron	2,300	Metals (mg/kg)											
Lead	300	Metals (mg/kg)											
Magnesium	NE	Metals (mg/kg)											
Manganese	180	Metals (mg/kg)											
Mercury	2.3	Metals (mg/kg)											
Nickel	20	Metals (mg/kg)											
Potassium	NE	Metals (mg/kg)											
Sodium	39	Metals (mg/kg)											
Vanadium	55	Metals (mg/kg)											
Zinc	2,300	Metals (mg/kg)											
Anthracene	1,000,000	PAH (µg/kg)											
Benzo(a)anthracene	620	PAH (µg/kg)											
Benzo(a)pyrene	62	PAH (µg/kg)											
Benzo(b)fluoranthene	620	PAH (µg/kg)											
Benzo(g,h,i)perylene	1,000	PAH (µg/kg)											
Benzo(k)fluoranthene	6,200	PAH (µg/kg)											
Chrysene	7,000	PAH (µg/kg)											
Dibenz(a,h)Anthracene	62	PAH (µg/kg)											
Fluoranthene	23,000	PAH (µg/kg)											
Indeno(1,2,3-c,d)Pyrene	620	PAH (µg/kg)											
Naphthalene	5,600	PAH (µg/kg)											
Phenanthrene	100,000	PAH (µg/kg)											
Pyrene	230,000	PAH (µg/kg)											
Total PCBs	220	PCBs (µg/kg)	11 U	2600 V	9.3 U	9 U	9.5 U	9.2 U	460 V	9 U	41 V	9.4 U	9.6 U
Aliphatic Hydrocarbons (C_{19}-C_{36})	3000	TPH (mg/kg)											
Aromatic Hydrocarbons (C_{11}-C_{22})	200	TPH (mg/kg)											
Acetone	60,000	VOCs (µg/kg)											
Benzene	640	VOCs (µg/kg)											
m,p-Xylenes	27,000	VOCs (µg/kg)											
o-Xylene	27,000	VOCs (µg/kg)											
p-Isopropyltoluene	100,000	VOCs (µg/kg)											
Toluene	500	VOCs (µg/kg)											

Notes:
mg/kg = Milligrams per kilogram (parts per million)
µg/kg = Micrograms per kilogram (parts per billion)
V = Valid result; substance detected.
J = Estimated result; substance detected, but below the detection limit.
U = Substance not detected; detection limit listed.
Highlighted results were detected above their Project Action Level.
NE = Not established.

Table 6-8a
IA-8 Summary of Screened Analytical Results
PASI/SSI Comprehensive Report
Study Area - Grant, Locust, and Cavite Housing Areas
Devens, Massachusetts

Analyte	Project Action Level	Analyte Category (units)	PASI-GR-GB-018A-1 0-3 ft	PASI-GR-GB-018B-1 0-3 ft	PASI-GR-GB-018C-1 0-3 ft	PASI-GR-GB-018D-1 0-3 ft	PASI-GR-GB-018E-1 0-3 ft	PASI-GR-GB-019A-1 0-3 ft	PASI-GR-GB-019B-1 0-3 ft	PASI-GR-GB-019C-1 0-3 ft	PASI-GR-GB-019D-1 0-3 ft	PASI-GR-GB-019E-1 0-3 ft	PASI-GR-GB-020A-1 0-3 ft
Aluminum	7,600	Metals (mg/kg)											
Arsenic	0.39	Metals (mg/kg)											
Barium	540	Metals (mg/kg)											
Calcium	NE	Metals (mg/kg)											
Chromium	30	Metals (mg/kg)											
Cobalt	500	Metals (mg/kg)											
Copper	310	Metals (mg/kg)											
Iron	2,300	Metals (mg/kg)											
Lead	300	Metals (mg/kg)											
Magnesium	NE	Metals (mg/kg)											
Manganese	180	Metals (mg/kg)											
Mercury	2.3	Metals (mg/kg)											
Nickel	20	Metals (mg/kg)											
Potassium	NE	Metals (mg/kg)											
Sodium	39	Metals (mg/kg)											
Vanadium	55	Metals (mg/kg)											
Zinc	2,300	Metals (mg/kg)											
Anthracene	1,000,000	PAH (µg/kg)											
Benzo(a)anthracene	620	PAH (µg/kg)											
Benzo(a)pyrene	62	PAH (µg/kg)											
Benzo(b)fluoranthene	620	PAH (µg/kg)											
Benzo(g,h,i)perylene	1,000	PAH (µg/kg)											
Benzo(k)fluoranthene	6,200	PAH (µg/kg)											
Chrysene	7,000	PAH (µg/kg)											
Dibenz(a,h)Anthracene	62	PAH (µg/kg)											
Fluoranthene	23,000	PAH (µg/kg)											
Indeno(1,2,3-c,d)Pyrene	620	PAH (µg/kg)											
Naphthalene	5,600	PAH (µg/kg)											
Phenanthrene	100,000	PAH (µg/kg)											
Pyrene	230,000	PAH (µg/kg)											
Total PCBs	220	PCBs (µg/kg)	27 U	120 V	4100 V	530 V	26 U	1100 V	870 V	26 U	27 U	27 U	8.8 U
Aliphatic Hydrocarbons (C_{19}-C_{36})	3000	TPH (mg/kg)											
Aromatic Hydrocarbons (C_{11}-C_{22})	200	TPH (mg/kg)											
Acetone	60,000	VOCs (µg/kg)											
Benzene	640	VOCs (µg/kg)											
m,p-Xylenes	27,000	VOCs (µg/kg)											
o-Xylene	27,000	VOCs (µg/kg)											
p-Isopropyltoluene	100,000	VOCs (µg/kg)											
Toluene	500	VOCs (µg/kg)											

Notes:
mg/kg = Milligrams per kilogram (parts per million)
µg/kg = Micrograms per kilogram (parts per billion)
V = Valid result; substance detected.
J = Estimated result; substance detected, but below the detection limit.
U = Substance not detected; detection limit listed.
Highlighted results were detected above their Project Action Level.
NE = Not established.

Table 6-8a
IA-8 Summary of Screened Analytical Results
PASI/SSI Comprehensive Report
Study Area - Grant, Locust, and Cavite Housing Areas
Devens, Massachusetts

Analyte	Project Action Level	Analyte Category (units)	PASI-GR-GB-020B-1 0-3 ft	PASI-GR-GB-020C-1 0-3 ft	PASI-GR-GB-020D-1 0-3 ft	PASI-GR-GB-020E-1 0-3 ft	PASI-GR-GB-021A-1 0-3 ft	PASI-GR-GB-021B-1 0-3 ft	PASI-GR-GB-021C-1 0-3 ft	PASI-GR-GB-021D-1 0-3 ft	PASI-GR-GB-021E-1 0-3 ft	PASI-GR-GB-022A-1 0-3 ft	PASI-GR-GB-022B-1 0-3 ft
Aluminum	7,600	Metals (mg/kg)											
Arsenic	0.39	Metals (mg/kg)											
Barium	540	Metals (mg/kg)											
Calcium	NE	Metals (mg/kg)											
Chromium	30	Metals (mg/kg)											
Cobalt	500	Metals (mg/kg)											
Copper	310	Metals (mg/kg)											
Iron	2,300	Metals (mg/kg)											
Lead	300	Metals (mg/kg)											
Magnesium	NE	Metals (mg/kg)											
Manganese	180	Metals (mg/kg)											
Mercury	2.3	Metals (mg/kg)											
Nickel	20	Metals (mg/kg)											
Potassium	NE	Metals (mg/kg)											
Sodium	39	Metals (mg/kg)											
Vanadium	55	Metals (mg/kg)											
Zinc	2,300	Metals (mg/kg)											
Anthracene	1,000,000	PAH (µg/kg)											
Benzo(a)anthracene	620	PAH (µg/kg)											
Benzo(a)pyrene	62	PAH (µg/kg)											
Benzo(b)fluoranthene	620	PAH (µg/kg)											
Benzo(g,h,i)perylene	1,000	PAH (µg/kg)											
Benzo(k)fluoranthene	6,200	PAH (µg/kg)											
Chrysene	7,000	PAH (µg/kg)											
Dibenz(a,h)Anthracene	62	PAH (µg/kg)											
Fluoranthene	23,000	PAH (µg/kg)											
Indeno(1,2,3-c,d)Pyrene	620	PAH (µg/kg)											
Naphthalene	5,600	PAH (µg/kg)											
Phenanthrene	100,000	PAH (µg/kg)											
Pyrene	230,000	PAH (µg/kg)											
Total PCBs	220	PCBs (µg/kg)	9.2 U	9.2 U	9.1 U	750 V	300 V	190 V	610 V	9.4 U	9.4 U	27 U	26 U
Aliphatic Hydrocarbons (C_{19}-C_{36})	3000	TPH (mg/kg)											
Aromatic Hydrocarbons (C_{11}-C_{22})	200	TPH (mg/kg)											
Acetone	60,000	VOCs (µg/kg)											
Benzene	640	VOCs (µg/kg)											
m,p-Xylenes	27,000	VOCs (µg/kg)											
o-Xylene	27,000	VOCs (µg/kg)											
p-Isopropyltoluene	100,000	VOCs (µg/kg)											
Toluene	500	VOCs (µg/kg)											

Notes:
mg/kg = Milligrams per kilogram (parts per million)
µg/kg = Micrograms per kilogram (parts per billion)
V = Valid result; substance detected.
J = Estimated result; substance detected, but below the detection limit.
U = Substance not detected; detection limit listed.
Highlighted results were detected above their Project Action Level.
NE = Not established.

Table 6-8a
IA-8 Summary of Screened Analytical Results
PASI/SSI Comprehensive Report
Study Area - Grant, Locust, and Cavite Housing Areas
Devens, Massachusetts

Analyte	Project Action Level	Analyte Category (units)	PASI-GR-GB-022C-1 0-3 ft		PASI-GR-GB-022D-1 0-3 ft		PASI-GR-GB-022E-1 0-3 ft		PASI-GR-GB-200-1 1.75-4.75		PASI-GR-GB-201-1 1.33-4.33		PASI-GR-GB-217-1 1-4 ft		PASI-GR-GB-218-1 1-4 ft		PASI-GR-GB-219-1 1-4 ft		PASI-GR-GB-220-1 1.33-4.33 ft		PASI-GR-GB-220-1-D 1.33-4.33 ft	
Aluminum	7,600	Metals (mg/kg)																				
Arsenic	0.39	Metals (mg/kg)																				
Barium	540	Metals (mg/kg)																				
Calcium	NE	Metals (mg/kg)																				
Chromium	30	Metals (mg/kg)																				
Cobalt	500	Metals (mg/kg)																				
Copper	310	Metals (mg/kg)																				
Iron	2,300	Metals (mg/kg)																				
Lead	300	Metals (mg/kg)																				
Magnesium	NE	Metals (mg/kg)																				
Manganese	180	Metals (mg/kg)																				
Mercury	2.3	Metals (mg/kg)																				
Nickel	20	Metals (mg/kg)																				
Potassium	NE	Metals (mg/kg)																				
Sodium	39	Metals (mg/kg)																				
Vanadium	55	Metals (mg/kg)																				
Zinc	2,300	Metals (mg/kg)																				
Anthracene	1,000,000	PAH (µg/kg)																				
Benzo(a)anthracene	620	PAH (µg/kg)																				
Benzo(a)pyrene	62	PAH (µg/kg)																				
Benzo(b)fluoranthene	620	PAH (µg/kg)																				
Benzo(g,h,i)perylene	1,000	PAH (µg/kg)																				
Benzo(k)fluoranthene	6,200	PAH (µg/kg)																				
Chrysene	7,000	PAH (µg/kg)																				
Dibenz(a,h)Anthracene	62	PAH (µg/kg)																				
Fluoranthene	23,000	PAH (µg/kg)																				
Indeno(1,2,3-c,d)Pyrene	620	PAH (µg/kg)																				
Naphthalene	5,600	PAH (µg/kg)																				
Phenanthrene	100,000	PAH (µg/kg)																				
Pyrene	230,000	PAH (µg/kg)																				
Total PCBs	220	PCBs (µg/kg)	27	U	1500	V	26	U	9.4	U	10	U	13000	V	37	V	6100	V	12	U	11	U
Aliphatic Hydrocarbons (C_{19}-C_{36})	3000	TPH (mg/kg)																				
Aromatic Hydrocarbons (C_{11}-C_{22})	200	TPH (mg/kg)																				
Acetone	60,000	VOCs (µg/kg)																				
Benzene	640	VOCs (µg/kg)																				
m,p-Xylenes	27,000	VOCs (µg/kg)																				
o-Xylene	27,000	VOCs (µg/kg)																				
p-Isopropyltoluene	100,000	VOCs (µg/kg)																				
Toluene	500	VOCs (µg/kg)																				

Notes:
mg/kg = Milligrams per kilogram (parts per million)
µg/kg = Micrograms per kilogram (parts per billion)
V = Valid result; substance detected.
J = Estimated result; substance detected, but below the detection limit.
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Highlighted results were detected above their Project Action Level.
NE = Not established.

Table 6-8b
IA-8 Hazard Screening Calculation Summary
PASI/SSI Comprehensive Report
Study Area - Grant, Locust, and Cavite Housing Areas
Devens, Massachusetts

Analyte	Analyte Category (units)	Carcinogen (Ca) or Non-carcinogen (NC)	EPA Region IX Residential Soil PRG	Average Value	Maximum Value	95% UCL	Exposure Point Concentration (EPC)[1]	Screening Cancer Risk (SCR)	Screening Hazard Quotient (SHQ)
Aluminum	Metals (mg/kg)	NC	76,000	5,475	5,800	6,666	5,800		0.08
Arsenic	Metals (mg/kg)	Ca	0.39	27	32	33	32	8.E-05	
Iron	Metals (mg/kg)	NC	23,000	11,750	13,000	12,729	12,729		0.55
Manganese	Metals (mg/kg)	NC	1,800	283	290	288	288		0.16
Nickel	Metals (mg/kg)	NC	1,600	26	31	31	31		0.02
Benzo(a)anthracene	PAH (µg/kg)	Ca	620	2,073	6,100	5,938	5,938	1.E-05	
Benzo(a)pyrene	PAH (µg/kg)	Ca	62	2,219	5,500	6,543	5,500	9.E-05	
Benzo(b)fluoranthene	PAH (µg/kg)	Ca	620	1,550	4,230	3,951	3,951	6.E-06	
Dibenz(a,h)Anthracene	PAH (µg/kg)	Ca	62	965	2,300	2,059	2,059	3.E-05	
Indeno(1,2,3-c,d)Pyrene	PAH (µg/kg)	Ca	620	1,400	3,700	3,419	3,419	6.E-06	
Total PCBs	PCBs (µg/kg)	Ca	220	287	6,100	747	747	3.E-06	
							Total:	2.E-04	0.81

[1] = Lesser of Maximum or 95% UCL used.
NE = not established
PAH = polycyclic aromatic hydrocarbons
PRG = Preliminary Remediation Goals
UCL = Upper Confident Limit
PCB = polychlorinated biphenyls
NA = not applicable
mg/kg = milligrams per kilogram
µg/kg = micrograms per kilogram
µg/kg = micrograms per kilogram

Summary

Total Screening Cancer Risk: 2.E-04	TSCR>1E-04? Yes
Total Screening Hazard Quotient: 1	TSHI>1? No
Arsenic concentration is consistent with background.	
TSCR due to Arsenic: 8.E-05	TSCR w/o Arsenic: 1.E-04
TSCR due to Arsenic is <1E-04.	TSCR w/o Arsenic is >1E-04.
Total PCBs concentration is greater than 1 mg/kg.	
TSCR due to PCBs: 3.E-06	TSCR w/o PCBs: 2.E-04
TSCR due to PCBs is <1E-04.	TSCR w/o PCBs is >1E-04.
PAHs concentration(s) are consistent with background.	
TSCR due to PAHs: 1.E-04	TSCR w/o to PAHs: 9.E-05
TSCR due to PAHs equals 1E-04.	TSCR w/o PAHs is <1E-04.

There is no EPA Region IX PRG for TPH; the MCP S-1 standard for C_{11}-C_{22} aromatic hydrocarbons is 800 mg/kg.

Table 6-9a
IA-09 Summary of Positive Analytical Results

Analyte	Project Action Level	Analyte Category (units)	CA-IA09-SB01-1 0-3 ft		CA-IA09-SB01-1 3-10 ft		CA-IA09-TP01-A1-M 0-2 ft		CA-IA09-TP01-A2-1 2-4 ft		CA-IA09-TP01-A3-1 4-6 ft		CA-IA09-TP01-B1-1 0-2 ft		CA-IA09-TP01-B2-1 2-4 ft	
Aluminum	7,600	Metals (mg/kg)	6600	V	4100	V	4000	V	3500	V	7600	V	4500	V	5700	V
Arsenic	0.39	Metals (mg/kg)	26	V	20	V	23	V	15	V	34	V	24	V	35	V
Barium	540	Metals (mg/kg)	38	V	10	V	14	V	9.2	V	26	V	16	V	12	V
Calcium	NE	Metals (mg/kg)	5000	V	640	V	520	V	430	V	560	V	670	V	520	V
Chromium	30	Metals (mg/kg)	18	V	4.9	V	11	V	5	V	10	V	13	V	6.5	V
Cobalt	500	Metals (mg/kg)	6.7	V	2.5	V	5.1	V	3.3	V	4.8	V	6.9	V	3.5	V
Copper	310	Metals (mg/kg)	18	V	4.5	V	11	V	5.8	V	9.7	V	13	V	6.1	V
Iron	2,300	Metals (mg/kg)	12000	V	4700	V	8500	V	5000	V	9300	V	9600	V	7300	V
Lead	300	Metals (mg/kg)	24	V	4.9	V	13	V	14	V	14	V	18	V	11	V
Magnesium	NE	Metals (mg/kg)	3000	V	810	V	1800	V	910	V	2000	V	2300	V	1200	V
Manganese	180	Metals (mg/kg)	240	V	100	V	220	V	120	V	140	V	290	V	120	V
Mercury	2.3	Metals (mg/kg)	0.029	J	0.006	J	0.04	J	0.0035	J	0.0047	J	0.0046	J	0.0054	J
Nickel	20	Metals (mg/kg)	22	V	5.2	V	17	V	7.6	V	12	V	20	V	8.6	V
Potassium	NE	Metals (mg/kg)	1300	V	320	V	580	V	350	V	620	V	840	V	460	V
Vanadium	55	Metals (mg/kg)	13	V	4.4	V	7.6	V	4.8	V	10	V	9	V	6.6	V
Zinc	2,300	Metals (mg/kg)	31	V	11	V	22	V	18	V	26	V	25	V	36	V
Total TEQ	2.3	Dioxins (ng/kg)	0.08	V	0.12	V										
Benzo(a)pyrene	62	PAH (µg/kg)	52	V	50	V										
Arochlor 1248	220	PCBs (µg/kg)	36.6	U	37	U										
Arochlor 1260	220	PCBs (µg/kg)	36.6	U	37	U										

Notes:
mg/kg = Milligrams per kilogram (parts per million)
µg/kg = Micrograms per kilogram (parts per billion)
ng/kg = Nanograms per kilogram (parts per trillion)
V = Valid result; substance detected.
J = Estimated result; substance detected, but below the detection limit.
U = Substance not detected; detection limit listed.
R = Result rejected due to problems identified during data validation.
Highlighted results were detected above their Project Action Level.

Table 6-9a
IA-09 Summary of Positive Analytical Results

Analyte	Project Action Level	Analyte Category (units)	CA-IA09-TP01-B3-1 4-6 ft		CA-IA09-TP01-C1-1 0-2 ft		CA-IA09-TP01-C2-1 2-4 ft		CA-IA09-TP01-C3-1 4-6 ft		CA-IA09-TP01-D1-1 0-2 ft		CA-IA09-TP01-D1-1-D 0-2 ft		CA-IA09-TP01-D2-1 2-4 ft		CA-IA09-TP01-D3-1 4-6 ft	
Aluminum	7,600	Metals (mg/kg)	7300	V	5600	V	6000	V	5200	V	5000	V	3000	V	4500	V	8500	V
Arsenic	0.39	Metals (mg/kg)	18	V	18	V	22	V	70	V	18	V	12	V	22	V	41	V
Barium	540	Metals (mg/kg)	30	V	19	V	16	V	26	V	15	V	7.9	V	13	V	23	V
Calcium	NE	Metals (mg/kg)	370	V	410	V	330	V	290	V	450	V	280	V	510	V	320	V
Chromium	30	Metals (mg/kg)	8.8	V	9.7	V	7.1	V	6.2	V	11	V	6.5	V	9	V	11	V
Cobalt	500	Metals (mg/kg)	3.8	V	4.1	V	3.7	V	3.3	V	4	V	2.6	V	4.4	V	4.8	V
Copper	310	Metals (mg/kg)	7.5	V	11	V	7.1	V	6.9	V	9	V	5.9	V	16	V	9.8	V
Iron	2,300	Metals (mg/kg)	8500	V	8300	V	6700	V	6800	V	7400	V	4600	V	7800	V	10000	V
Lead	300	Metals (mg/kg)	22	V	74	V	17	V	27	V	33	V	23	V	30	V	18	V
Magnesium	NE	Metals (mg/kg)	1700	V	1400	V	1200	V	1100	V	1700	V	990	V	1500	V	2000	V
Manganese	180	Metals (mg/kg)	150	V	160	V	130	V	150	V	150	V	88	V	150	V	130	V
Mercury	2.3	Metals (mg/kg)	0.013	J	0.039	J	0.0089	J	0.0094	J	0.032	J	0.022	J	0.0085	J	0.014	J
Nickel	20	Metals (mg/kg)	8.9	V	13	V	8.4	V	7.3	V	12	V	7.8	V	13	V	11	V
Potassium	NE	Metals (mg/kg)	740	V	420	V	540	V	440	V	750	V	310	V	460	V	730	V
Vanadium	55	Metals (mg/kg)	9.4	V	8.6	V	7.3	V	6.2	V	8.2	V	4.7	V	7.1	V	12	V
Zinc	2,300	Metals (mg/kg)	31	V	44	V	26	V	28	V	30	V	19	V	34	V	29	V
Total TEQ	2.3	Dioxins (ng/kg)																
Benzo(a)pyrene	62	PAH (µg/kg)																
Arochlor 1248	220	PCBs (µg/kg)																
Arochlor 1260	220	PCBs (µg/kg)																

Notes:
mg/kg = Milligrams per kilogram (parts per million)
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R = Result rejected due to problems identified during data validation.
Highlighted results were detected above their Project Action Level.

Table 6-9a
IA-09 Summary of Positive Analytical Results

Analyte	Project Action Level	Analyte Category (units)	PASI-CT-CO-001-1 0-3 ft		PASI-CT-CO-002-1 0-3 ft		PASI-CT-CO-003-1 0-3 ft		PASI-CT-CO-004-1 0-3 ft		PASI-CT-CO-005-1 0-3 ft		PASI-CT-CO-006-1 0-3 ft		PASI-CT-CO-007-1 0-3 ft		PASI-CT-CO-008-1 0-3 ft	
Aluminum	7,600	Metals (mg/kg)																
Arsenic	0.39	Metals (mg/kg)																
Barium	540	Metals (mg/kg)																
Calcium	NE	Metals (mg/kg)																
Chromium	30	Metals (mg/kg)																
Cobalt	500	Metals (mg/kg)																
Copper	310	Metals (mg/kg)																
Iron	2,300	Metals (mg/kg)																
Lead	300	Metals (mg/kg)																
Magnesium	NE	Metals (mg/kg)																
Manganese	180	Metals (mg/kg)																
Mercury	2.3	Metals (mg/kg)																
Nickel	20	Metals (mg/kg)																
Potassium	NE	Metals (mg/kg)																
Vanadium	55	Metals (mg/kg)																
Zinc	2,300	Metals (mg/kg)																
Total TEQ	2.3	Dioxins (ng/kg)																
Benzo(a)pyrene	62	PAH (µg/kg)																
Arochlor 1248	220	PCBs (µg/kg)	9.4	U	9.4	U	9.2	U	9.3	U	9.3	U	9.6	U	8.9	U	9.3	U
Arochlor 1260	220	PCBs (µg/kg)	8.5	U	8.6	U	8.3	U	8.5	U	8.5	U	8.7	U	8.1	U	8.4	U

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Table 6-9a
IA-09 Summary of Positive Analytical Results

Analyte	Project Action Level	Analyte Category (units)	PASI-CT-GB-001A-1 0-3 ft		PASI-CT-GB-001B-1 0-3 ft		PASI-CT-GB-001C-1 0-3 ft		PASI-CT-GB-001D-1 0-3 ft		PASI-CT-GB-001E-1 0-3 ft		PASI-CT-GB-002A-1 0-3 ft		PASI-CT-GB-002B-1 0-3 ft		PASI-CT-GB-002C-1 0-3 ft	
Aluminum	7,600	Metals (mg/kg)																
Arsenic	0.39	Metals (mg/kg)																
Barium	540	Metals (mg/kg)																
Calcium	NE	Metals (mg/kg)																
Chromium	30	Metals (mg/kg)																
Cobalt	500	Metals (mg/kg)																
Copper	310	Metals (mg/kg)																
Iron	2,300	Metals (mg/kg)																
Lead	300	Metals (mg/kg)																
Magnesium	NE	Metals (mg/kg)																
Manganese	180	Metals (mg/kg)																
Mercury	2.3	Metals (mg/kg)																
Nickel	20	Metals (mg/kg)																
Potassium	NE	Metals (mg/kg)																
Vanadium	55	Metals (mg/kg)																
Zinc	2,300	Metals (mg/kg)																
Total TEQ	2.3	Dioxins (ng/kg)																
Benzo(a)pyrene	62	PAH (µg/kg)																
Arochlor 1248	220	PCBs (µg/kg)	110	V	9.5	U	9.4	U	9.5	U	9.5	U	9.6	U	9.6	U	9.4	U
Arochlor 1260	220	PCBs (µg/kg)	8.4	U	8.6	U	8.5	U	8.6	U	8.6	U	8.7	U	8.7	U	8.5	U

Notes:
mg/kg = Milligrams per kilogram (parts per million)
µg/kg = Micrograms per kilogram (parts per billion)
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Table 6-9a
IA-09 Summary of Positive Analytical Results

Analyte	Project Action Level	Analyte Category (units)	PASI-CT-GB-002D-1 0-3 ft		PASI-CT-GB-002E-1 0-3 ft		PASI-CT-GB-003A-1 0-3 ft		PASI-CT-GB-003B-1 0-3 ft		PASI-CT-GB-003C-1 0-3 ft		PASI-CT-GB-003D-1 0-3 ft		PASI-CT-GB-003E-1 0-3 ft	
Aluminum	7,600	Metals (mg/kg)														
Arsenic	0.39	Metals (mg/kg)														
Barium	540	Metals (mg/kg)														
Calcium	NE	Metals (mg/kg)														
Chromium	30	Metals (mg/kg)														
Cobalt	500	Metals (mg/kg)														
Copper	310	Metals (mg/kg)														
Iron	2,300	Metals (mg/kg)														
Lead	300	Metals (mg/kg)														
Magnesium	NE	Metals (mg/kg)														
Manganese	180	Metals (mg/kg)														
Mercury	2.3	Metals (mg/kg)														
Nickel	20	Metals (mg/kg)														
Potassium	NE	Metals (mg/kg)														
Vanadium	55	Metals (mg/kg)														
Zinc	2,300	Metals (mg/kg)														
Total TEQ	2.3	Dioxins (ng/kg)														
Benzo(a)pyrene	62	PAH (µg/kg)														
Arochlor 1248	220	PCBs (µg/kg)	9.6	U	9.7	U	9.4	U	9.7	U	9.2	U	9.3	U	9.4	U
Arochlor 1260	220	PCBs (µg/kg)	8.7	U	8.8	U	8.5	U	8.8	U	8.3	U	8.4	U	8.5	U

Notes:
mg/kg = Milligrams per kilogram (parts per million)
µg/kg = Micrograms per kilogram (parts per billion)
ng/kg = Nanograms per kilogram (parts per trillion)
V = Valid result; substance detected.
J = Estimated result; substance detected, but below the detection limit.
U = Substance not detected; detection limit listed.
R = Result rejected due to problems identified during data validation.
Highlighted results were detected above their Project Action Level.

Notes:
mg/kg = Milligrams per kilogram (parts per million)
µg/kg = Micrograms per kilogram (parts per billion)
ng/kg = Nanograms per kilogram (parts per trillion)
V = Valid result; substance detected.
J = Estimated result; substance detected, but below the detection limit.
U = Substance not detected; detection limit listed.
R = Result rejected due to problems identified during data validation.
Highlighted results were detected above their Project Action Level.

Table 6-9a
IA-09 Summary of Positive Analytical Results

Analyte	Project Action Level	Analyte Category (units)	PASI-CT-GB-004A-1 0-3 ft		PASI-CT-GB-004B-1 0-3 ft		PASI-CT-GB-004C-1 0-3 ft		PASI-CT-GB-004D-1 0-3 ft		PASI-CT-GB-004E-1 0-3 ft		PASI-CT-GB-005A-1 0-2.5 ft		PASI-CT-GB-005B-1 0-3 ft		PASI-CT-GB-005C-1 0-2.5 ft	
Aluminum	7,600	Metals (mg/kg)																
Arsenic	0.39	Metals (mg/kg)																
Barium	540	Metals (mg/kg)																
Calcium	NE	Metals (mg/kg)																
Chromium	30	Metals (mg/kg)																
Cobalt	500	Metals (mg/kg)																
Copper	310	Metals (mg/kg)																
Iron	2,300	Metals (mg/kg)																
Lead	300	Metals (mg/kg)																
Magnesium	NE	Metals (mg/kg)																
Manganese	180	Metals (mg/kg)																
Mercury	2.3	Metals (mg/kg)																
Nickel	20	Metals (mg/kg)																
Potassium	NE	Metals (mg/kg)																
Vanadium	55	Metals (mg/kg)																
Zinc	2,300	Metals (mg/kg)																
Total TEQ	2.3	Dioxins (ng/kg)																
Benzo(a)pyrene	62	PAH (µg/kg)																
Arochlor 1248	220	PCBs (µg/kg)	9.5	U	9.3	U	9.7	U	9.7	U	9.5	U	9.3	U	9.4	U	9.8	U
Arochlor 1260	220	PCBs (µg/kg)	8.6	U	8.4	U	8.8	U	76	V	8.6	U	8.4	U	8.5	U	8.9	U

Notes:
mg/kg = Milligrams per kilogram (parts per million)
µg/kg = Micrograms per kilogram (parts per billion)
ng/kg = Nanograms per kilogram (parts per trillion)
V = Valid result; substance detected.
J = Estimated result; substance detected, but below the detection limit.
U = Substance not detected; detection limit listed.
R = Result rejected due to problems identified during data validation.
Highlighted results were detected above their Project Action Level.

Table 6-9a
IA-09 Summary of Positive Analytical Results

Analyte	Project Action Level	Analyte Category (units)	PASI-CT-GB-005D-1 0-3 ft		PASI-CT-GB-005E-1 0-3 ft		PASI-CT-GB-006A-1 0-3 ft		PASI-CT-GB-006B-1 0-3 ft		PASI-CT-GB-006C-1 0-3 ft		PASI-CT-GB-006D-1 0-3 ft		PASI-CT-GB-006E-1 0-3 ft	
Aluminum	7,600	Metals (mg/kg)														
Arsenic	0.39	Metals (mg/kg)														
Barium	540	Metals (mg/kg)														
Calcium	NE	Metals (mg/kg)														
Chromium	30	Metals (mg/kg)														
Cobalt	500	Metals (mg/kg)														
Copper	310	Metals (mg/kg)														
Iron	2,300	Metals (mg/kg)														
Lead	300	Metals (mg/kg)														
Magnesium	NE	Metals (mg/kg)														
Manganese	180	Metals (mg/kg)														
Mercury	2.3	Metals (mg/kg)														
Nickel	20	Metals (mg/kg)														
Potassium	NE	Metals (mg/kg)														
Vanadium	55	Metals (mg/kg)														
Zinc	2,300	Metals (mg/kg)														
Total TEQ	2.3	Dioxins (ng/kg)														
Benzo(a)pyrene	62	PAH (µg/kg)														
Arochlor 1248	220	PCBs (µg/kg)	9.2	U	9.5	U	9.4	U	9.4	U	9.5	U	9.5	U	9.5	U
Arochlor 1260	220	PCBs (µg/kg)	8.3	U	8.6	U	8.6	U	8.6	U	8.6	U	8.6	U	8.6	U

Notes:
mg/kg = Milligrams per kilogram (parts per million)
µg/kg = Micrograms per kilogram (parts per billion)
ng/kg = Nanograms per kilogram (parts per trillion)
V = Valid result; substance detected.
J = Estimated result; substance detected, but below the detection limit.
U = Substance not detected; detection limit listed.
R = Result rejected due to problems identified during data validation.
Highlighted results were detected above their Project Action Level.

Table 6-9a
IA-09 Summary of Positive Analytical Results

Analyte	Project Action Level	Analyte Category (units)	PASI-CT-GB-007A-1 0-3 ft		PASI-CT-GB-007B-1 0-3 ft		PASI-CT-GB-007C-1 0-3 ft		PASI-CT-GB-007D-1 0-3 ft		PASI-CT-GB-007E-1 0-3 ft		PASI-CT-GB-008A-1 0-3 ft		PASI-CT-GB-008B-1 0-3 ft	
Aluminum	7,600	Metals (mg/kg)														
Arsenic	0.39	Metals (mg/kg)														
Barium	540	Metals (mg/kg)														
Calcium	NE	Metals (mg/kg)														
Chromium	30	Metals (mg/kg)														
Cobalt	500	Metals (mg/kg)														
Copper	310	Metals (mg/kg)														
Iron	2,300	Metals (mg/kg)														
Lead	300	Metals (mg/kg)														
Magnesium	NE	Metals (mg/kg)														
Manganese	180	Metals (mg/kg)														
Mercury	2.3	Metals (mg/kg)														
Nickel	20	Metals (mg/kg)														
Potassium	NE	Metals (mg/kg)														
Vanadium	55	Metals (mg/kg)														
Zinc	2,300	Metals (mg/kg)														
Total TEQ	2.3	Dioxins (ng/kg)														
Benzo(a)pyrene	62	PAH (µg/kg)														
Arochlor 1248	220	PCBs (µg/kg)	9.6	U	10	U	8.9	U	9.8	U	9.6	U	9.1	U	9.1	U
Arochlor 1260	220	PCBs (µg/kg)	8.7	U	9.2	U	8.1	U	8.9	U	8.7	U	8.3	U	8.3	U

Notes:
mg/kg = Milligrams per kilogram (parts per million)
µg/kg = Micrograms per kilogram (parts per billion)
ng/kg = Nanograms per kilogram (parts per trillion)
V = Valid result; substance detected.
J = Estimated result; substance detected, but below the detection limit.
U = Substance not detected; detection limit listed.
R = Result rejected due to problems identified during data validation.
Highlighted results were detected above their Project Action Level.

Table 6-9a
IA-09 Summary of Positive Analytical Results

Analyte	Project Action Level	Analyte Category (units)	PASI-CT-GB-008C-1 0-3 ft		PASI-CT-GB-008D-1 0-3 ft		PASI-CT-GB-008E-1 0-3 ft		PASI-CT-GB-500-1 0-1.5 ft		PASI-CT-GB-500-2 1.5-3 ft		PASI-CT-GB-500-3 3-6 ft		PASI-CT-GB-501-1 0-1.25 ft		PASI-CT-GB-501-2 1.25-2.25 ft	
Aluminum	7,600	Metals (mg/kg)							6200	V	4700	V	4800	V	6200	V	7000	V
Arsenic	0.39	Metals (mg/kg)							8.3	V	5.6	V	8.7	V	22	V	20	V
Barium	540	Metals (mg/kg)																
Calcium	NE	Metals (mg/kg)																
Chromium	30	Metals (mg/kg)																
Cobalt	500	Metals (mg/kg)																
Copper	310	Metals (mg/kg)																
Iron	2,300	Metals (mg/kg)							6400	V	4500	V	6800	V	16000	V	12000	V
Lead	300	Metals (mg/kg)																
Magnesium	NE	Metals (mg/kg)																
Manganese	180	Metals (mg/kg)							130	V	42	V	110	V	140	V	220	V
Mercury	2.3	Metals (mg/kg)																
Nickel	20	Metals (mg/kg)							6.9	V	4.3	V	8.4	V	11	V	18	V
Potassium	NE	Metals (mg/kg)																
Vanadium	55	Metals (mg/kg)																
Zinc	2,300	Metals (mg/kg)																
Total TEQ	2.3	Dioxins (ng/kg)																
Benzo(a)pyrene	62	PAH (µg/kg)																
Arochlor 1248	220	PCBs (µg/kg)	8.9	U	9.2	U	9.1	U										
Arochlor 1260	220	PCBs (µg/kg)	8.1	U	8.4	U	8.3	U										

Notes:
mg/kg = Milligrams per kilogram (parts per million)
µg/kg = Micrograms per kilogram (parts per billion)
ng/kg = Nanograms per kilogram (parts per trillion)
V = Valid result; substance detected.
J = Estimated result; substance detected, but below the detection limit.
U = Substance not detected; detection limit listed.
R = Result rejected due to problems identified during data validation.
Highlighted results were detected above their Project Action Level.

Table 6-9a
IA-09 Summary of Positive Analytical Results

Analyte	Project Action Level	Analyte Category (units)	PASI-CT-GB-501-3 2.25-3 ft		PASI-CT-GB-501-4 3-6 ft		PASI-CT-GB-502-1 0-1 ft		PASI-CT-GB-502-2 1-3 ft		PASI-CT-GB-502-3 3-6 ft		PASI-CT-GB-502-3DUP 3-6 ft	
Aluminum	7,600	Metals (mg/kg)	6200	V	3900	V	7300	V	4000	V	7700	V	7700	V
Arsenic	0.39	Metals (mg/kg)	4.3	V	8.2	V	15	V	130	V	15	V	13	V
Barium	540	Metals (mg/kg)												
Calcium	NE	Metals (mg/kg)												
Chromium	30	Metals (mg/kg)												
Cobalt	500	Metals (mg/kg)												
Copper	310	Metals (mg/kg)												
Iron	2,300	Metals (mg/kg)	4900	V	6000	V	8500	V	14000	V	8000	V	9500	V
Lead	300	Metals (mg/kg)												
Magnesium	NE	Metals (mg/kg)												
Manganese	180	Metals (mg/kg)	51	V	100	V	280	V	350	V	260	V	240	V
Mercury	2.3	Metals (mg/kg)												
Nickel	20	Metals (mg/kg)	4.8	V	6.2	V	12	V	24	V	11	V	17	R
Potassium	NE	Metals (mg/kg)												
Vanadium	55	Metals (mg/kg)												
Zinc	2,300	Metals (mg/kg)												
Total TEQ	2.3	Dioxins (ng/kg)												
Benzo(a)pyrene	62	PAH (µg/kg)												
Arochlor 1248	220	PCBs (µg/kg)												
Arochlor 1260	220	PCBs (µg/kg)												

Notes:
mg/kg = Milligrams per kilogram (parts per million)
µg/kg = Micrograms per kilogram (parts per billion)
ng/kg = Nanograms per kilogram (parts per trillion)
V = Valid result; substance detected.
J = Estimated result; substance detected, but below the detection limit.
U = Substance not detected; detection limit listed.
R = Result rejected due to problems identified during data validation.
Highlighted results were detected above their Project Action Level.

Table 6-9b
IA-9 Hazard Screening Calculation Summary
PASI/SSI Comprehensive Report
Study Area - Grant, Locust, and Cavite Housing Areas
Devens, Massachusetts

Analyte	Analyte Category (units)	Carcinogen (Ca) or Non-carcinogen (NC)	EPA Region IX Residential Soil PRG	Average Value	Maximum Value	95% UCL	Exposure Point Concentration (EPC)[1]	Screening Cancer Risk (SCR)	Screening Hazard Quotient (SHQ)
Aluminum	Metals (mg/kg)	NC	76,000	5,671	8,500	6,957	6,957		0.09
Arsenic	Metals (mg/kg)	Ca	0	26	130	43	43	1.E-04	
Iron	Metals (mg/kg)	NC	23,000	8,354	16,000	9,370	9,370		0.41
Lead	Metals (mg/kg)	NC	400	23	74	31	31		0.08
Manganese	Metals (mg/kg)	NC	1,800	164	350	191	191		0.11
Nickel	Metals (mg/kg)	NC	1,600	11	24	13	13		0.01
Vanadium	Metals (mg/kg)	Ca	78	14	114	9	9	1.E-07	
							Total:	1.E-04	0.69

[1] = Lesser of Maximum or 95% UCL used.
PAH = polycyclic aromatic hydrocarbons
PRG = Preliminary Remediation Goals
UCL = Upper Confident Limit
PCB = polychlorinated biphenyls
NA = not applicable
mg/kg = milligrams per kilogram
µg/kg = micrograms per kilogram

Summary

Total Screening Cancer Risk: 1.E-04	TSCR>1E-04? No
Total Screening Hazard Quotient: 1	TSHI>1? No
Arsenic concentration is consistent with background.	
TSCR due to Arsenic: 1.E-04	TSCR w/o Arsenic: 1.E-07
TSCR due to Arsenic equals 1E-04.	TSCR w/o Arsenic is <1E-04.
Total PCBs concentration is less than 1 mg/kg.	
TSCR w/o PCBs: NA	TSCR w/o PCBs: 1.E-04
	TSCR w/o PCBs is <1E-04.
PAHs concentration(s) are consistent with background.	
TSCR due to PAHs: NA	TSCR w/o to PAHs: 1.E-04
	TSCR w/o PAHs is <1E-04.

Table 6-9c
IA-9 Arsenic Sample Analytical Results Distribution
PASI/SSI Comprehensive Report
Study Area - Grant, Locust, and Cavite Housing Areas
Devens, Massachusetts

Sample Location	CA-IA09-SB01	CA-IA09-TP01-A	CA-IA09-TP01-B	CA-IA09-TP01-C	CA-IA09-TP01-D	CT-GB-500	CT-GB-501	CT-GB-502
Depth Interval (ft bgs) 0	26	23	24	18	18/15	8.3	22	15
1							20	130
2		15	35	22	22	5.6	4.3	
3	20					8.7	8.2	15
4		34	18	70	41			
5								
6								
7								
8								
9								
10								

Arsenic concentrations in milligrams per kilogram.

Table 6-10a
IA-10 Summary of Screened Results

Analyte	Project Action Level	Analyte Category (units)	GR-IA01-SB01-1 0-3 ft		GR-IA01-SB01-1 3-10 ft		GR-IA01-SB02-1 0-3 ft		GR-IA01-SB02-1 3-10 ft		GR-IA01-SB03-1 3-10 ft		GR-IA01-SB03-1-D 3-10 ft		GR-IA01-SB03-1-M 0-3 ft	
Aluminum	7,600	Metals (mg/kg)	6300	V	6500	V	6200	V	6300	V	6600	V	7300	V	9000	V
Antimony	3.1	Metals (mg/kg)	1.1	U	1.05	U	1.1	U	1.05	U	1.05	U	1.05	U	1.15	U
Arsenic	0.39	Metals (mg/kg)	19	V	34	V	36	V	28	V	33	V	35	V	20	V
Barium	540	Metals (mg/kg)	19	V	22	V	20	V	21	V	20	V	22	V	13	V
Calcium	NE	Metals (mg/kg)	590	V	410	V	1200	V	700	V	610	V	560	V	550	V
Chromium	30	Metals (mg/kg)	12	V	16	V	17	V	18	V	17	V	18	V	14	V
Cobalt	500	Metals (mg/kg)	5.1	V	7.8	V	7.1	V	6.8	V	7.3	V	7.1	V	5.1	V
Copper	310	Metals (mg/kg)	11	V	18	V	16	V	15	V	18	V	20	V	8.3	V
Iron	2,300	Metals (mg/kg)	8600	V	12000	V	12000	V	11000	V	11000	V	12000	V	10000	V
Lead	300	Metals (mg/kg)	12	V	11	V	9.7	V	7.4	V	7.4	V	6.9	V	8.3	V
Magnesium	NE	Metals (mg/kg)	1900	V	2900	V	3000	V	3200	V	3100	V	3400	V	2200	V
Manganese	180	Metals (mg/kg)	210	V	330	V	280	V	260	V	210	V	220	V	140	V
Mercury	2.3	Metals (mg/kg)	0.034	J	0.014	J	0.0091	J	0.0044	J	0.0435	U	0.0435	U	0.01	J
Nickel	20	Metals (mg/kg)	15	V	27	V	26	V	24	V	22	V	22	V	16	V
Potassium	NE	Metals (mg/kg)	710	V	1100	V	890	V	980	V	1000	V	1100	V	560	V
Thallium	1	Metals (mg/kg)	1.1	U	1.05	U	1.1	U	1.05	U	1.05	U	1.05	U	1.15	U
Vanadium	55	Metals (mg/kg)	9.9	V	11	V	11	V	11	V	11	V	12	V	12	V
Zinc	2,300	Metals (mg/kg)	25	V	27	V	25	V	22	V	21	V	22	V	21	V
Anthracene	1,000	PAH (µg/kg)					183	U	180	U						
Benzo(a)anthracene	620	PAH (µg/kg)					490	V	180	U						
Benzo(a)pyrene	62	PAH (µg/kg)					660	V	76	V						
Benzo(b)fluoranthene	620	PAH (µg/kg)					440	V	180	U						
Benzo(g,h,i)perylene	2,500	PAH (µg/kg)					380	V	180	U						
Benzo(k)fluoranthene	6,200	PAH (µg/kg)					440	V	180	U						
Chrysene	7,000	PAH (µg/kg)					550	V	180	U						
Dibenz(a,h)Anthracene	62	PAH (µg/kg)					70	V	7	U						
Fluoranthene	230,000	PAH (µg/kg)					1200	V	180	U						
Indeno(1,2,3-c,d)Pyrene	620	PAH (µg/kg)					580	V	180	U						
Naphthalene	4,000	PAH (µg/kg)					1.75	U	2.3	U						
Phenanthrene	100,000	PAH (µg/kg)					500	V	180	U						
Pyrene	230,000	PAH (µg/kg)					910	V	180	U						
Total PCBs	220	PCBs (µg/kg)					18.3	U	18.1	U						
4,4-DDE	170	Pesticides (µg/kg)					1.83	U	1.81	U						
4,4-DDT	170	Pesticides (µg/kg)					1.83	U	1.81	U						
Aldrin	29	Pesticides (µg/kg)					1.83	U	1.81	U						
Dieldrin	30	Pesticides (µg/kg)					1.83	U	1.81	U						
Aliphatic Hydrocarbons (C_{19}-C_{36})	3,000	TPH (mg/kg)					3.665	U	3.625	U						
Aromatic Hydrocarbons (C_{11}-C_{22})	800	TPH (mg/kg)					12.5	V	3.625	U						
Acetone	60,000	VOCs (µg/kg)					14	V	19	V						
m,p-Xylenes	500	VOCs (µg/kg)					0.35	U	0.46	U						
p-Isopropyltoluene	NE	VOCs (µg/kg)					0.35	U	0.46	U						
Toluene	500	VOCs (µg/kg)					0.5	U	0.7	U						

Notes:
mg/kg = Milligrams per kilogram (parts per million)
µg/kg = Micrograms per kilogram (parts per billion)
ng/kg = Nanograms per kilogram (parts per trillion)
V = Valid result; substance detected.
J = Estimated result; substance detected, but below the detection limit.
U = Substance not detected; detection limit listed.
Highlighted results were detected above their Project Action Level.

Table 6-10a
IA-10 Summary of Screened Results

Analyte	Project Action Level	Analyte Category (units)	IA5-001-B 0-0 ft.5 ft		IA5-001-C 0-0 ft.5 ft		IA5-001-D 0-0 ft.5 ft		IA5-001-E 0-0 ft.5 ft		IA5-002-A 0-0 ft.5 ft		IA5-002-B 0-0 ft.5 ft		IA5-002-C 0-0 ft.5 ft	
Aluminum	7,600	Metals (mg/kg)														
Antimony	3.1	Metals (mg/kg)														
Arsenic	0.39	Metals (mg/kg)														
Barium	540	Metals (mg/kg)														
Calcium	NE	Metals (mg/kg)														
Chromium	30	Metals (mg/kg)														
Cobalt	500	Metals (mg/kg)														
Copper	310	Metals (mg/kg)														
Iron	2,300	Metals (mg/kg)														
Lead	300	Metals (mg/kg)	48.9	V	34.1	V	26.8	V	7	V	7	V	7.2	V	89.7	V
Magnesium	NE	Metals (mg/kg)														
Manganese	180	Metals (mg/kg)														
Mercury	2.3	Metals (mg/kg)														
Nickel	20	Metals (mg/kg)														
Potassium	NE	Metals (mg/kg)														
Thallium	1	Metals (mg/kg)														
Vanadium	55	Metals (mg/kg)														
Zinc	2,300	Metals (mg/kg)														
Anthracene	1,000	PAH (µg/kg)														
Benzo(a)anthracene	620	PAH (µg/kg)														
Benzo(a)pyrene	62	PAH (µg/kg)														
Benzo(b)fluoranthene	620	PAH (µg/kg)														
Benzo(g,h,i)perylene	2,500	PAH (µg/kg)														
Benzo(k)fluoranthene	6,200	PAH (µg/kg)														
Chrysene	7,000	PAH (µg/kg)														
Dibenz(a,h)Anthracene	62	PAH (µg/kg)														
Fluoranthene	230,000	PAH (µg/kg)														
Indeno(1,2,3-c,d)Pyrene	620	PAH (µg/kg)														
Naphthalene	4,000	PAH (µg/kg)														
Phenanthrene	100,000	PAH (µg/kg)														
Pyrene	230,000	PAH (µg/kg)														
Total PCBs	220	PCBs (µg/kg)														
4,4-DDE	170	Pesticides (µg/kg)														
4,4-DDT	170	Pesticides (µg/kg)														
Aldrin	29	Pesticides (µg/kg)														
Dieldrin	30	Pesticides (µg/kg)														
Aliphatic Hydrocarbons (C_{19}-C_{36})	3,000	TPH (mg/kg)														
Aromatic Hydrocarbons (C_{11}-C_{22})	800	TPH (mg/kg)														
Acetone	60,000	VOCs (µg/kg)														
m,p-Xylenes	500	VOCs (µg/kg)														
p-Isopropyltoluene	NE	VOCs (µg/kg)														
Toluene	50	VOCs (µg/kg)														

Notes:
mg/kg = Milligrams per kilogram (parts per million)
µg/kg = Micrograms per kilogram (parts per billion)
ng/kg = Nanograms per kilogram (parts per trillion)
V = Valid result; substance detected.
J = Estimated result; substance detected, but below the detection limit.
U = Substance not detected; detection limit listed.
Highlighted results were detected above their Project Action Level.

Table 6-10a
IA-10 Summary of Screened Results

Analyte	Project Action Level	Analyte Category (units)	PASI-GR-CO-001-1 0-3 ft	PASI-GR-CO-002-1 0-3 ft	PASI-GR-CO-003-1 0-3 ft	PASI-GR-CO-004-1 0-3 ft	PASI-GR-CO-005-1 0-3 ft	PASI-GR-CO-006-1 0-3 ft	PASI-GR-CO-007-1 0-3 ft
Total PCBs	220	PCBs (µg/kg)	4.75 U	5 U	4.7 U	4.7 U	4.85 U	270 V	5 U

Analyte	Project Action Level	Analyte Category (units)	PASI-GR-GB-018B-1 0-3 ft	PASI-GR-GB-018C-1 0-3 ft	PASI-GR-GB-018D-1 0-3 ft	PASI-GR-GB-018E-1 0-3 ft	PASI-GR-GB-019A-1 0-3 ft	PASI-GR-GB-019B-1 0-3 ft	PASI-GR-GB-019C-1 0-3 ft
Total PCBs	220	PCBs (µg/kg)	120 V	4100 V	530 V	13 U	1100 V	870 V	13 U

Notes:
mg/kg = Milligrams per kilogram (parts per million)
µg/kg = Micrograms per kilogram (parts per billion)
ng/kg = Nanograms per kilogram (parts per trillion)
V = Valid result; substance detected.
J = Estimated result; substance detected, but below the detection limit.
U = Substance not detected; detection limit listed.
Highlighted results were detected above their Project Action Level.

Table 6-10a
IA-10 Summary of Screened Results

Analyte	Project Action Level	Analyte Category (units)	GR-IA01-SB04-1 0-3 ft		GR-IA01-SB04-1-M 3-10 ft		GR-IA02-SB01-1 0-3 ft		GR-IA02-SB01-1 3-10 ft		GR-IA02-SB02-1 0-3 ft		GR-IA02-SB02-1 3-10 ft		GR-IA02-SB02-1-M 3-10 ft	
Aluminum	7,600	Metals (mg/kg)	6500	V	4700	V	7700	V	7100	V	11000	V			3800	V
Antimony	3.1	Metals (mg/kg)	1.1	U	1.05	U	1.15	U	1.05	U	1.1	U			1.1	U
Arsenic	0.39	Metals (mg/kg)	9.1	V	46	V	14	V	17	V	15	V			18	V
Barium	540	Metals (mg/kg)	10	V	13	V	18	V	29	V	49	V			16	V
Calcium	NE	Metals (mg/kg)	580	V	450	V	110	V	320	V	270	V			350	V
Chromium	30	Metals (mg/kg)	7.2	V	14	V	10	V	10	V	12	V			6.2	V
Cobalt	500	Metals (mg/kg)	2.8	V	5.4	V	3.9	V	5.8	V	7.2	V			3.9	V
Copper	310	Metals (mg/kg)	3.8	V	8.7	V	5.8	V	10	V	13	V			8.9	V
Iron	2,300	Metals (mg/kg)	6300	V	8300	V	8600	V	9800	V	13000	V			6000	V
Lead	300	Metals (mg/kg)	8.1	V	5.8	V	6.9	V	6.2	V	6.6	V			4.6	V
Magnesium	NE	Metals (mg/kg)	900	V	2200	V	1300	V	2000	V	2300	V			1100	V
Manganese	180	Metals (mg/kg)	120	V	190	V	240	V	160	V	180	V			120	V
Mercury	2.3	Metals (mg/kg)	0.017	J	0.043	U	0.018	J	0.0415	U	0.0065	J			0.0395	U
Nickel	20	Metals (mg/kg)	6.9	V	16	V	9.3	V	12	V	12	V			11	V
Potassium	NE	Metals (mg/kg)	280	V	720	V	440	V	1300	V	1900	V			540	V
Thallium	1	Metals (mg/kg)	1.1	U	1.05	U	1.15	U	1.05	U	1.1	U			1.1	U
Vanadium	55	Metals (mg/kg)	7.8	V	8.1	V	10	V	12	V	17	V			5.9	V
Zinc	2,300	Metals (mg/kg)	14	V	15	V	18	V	22	V	27	V			15	V
Anthracene	1,000	PAH (µg/kg)					195	U	180	U	190	U			180	U
Benzo(a)anthracene	620	PAH (µg/kg)					195	U	180	U	190	U			180	U
Benzo(a)pyrene	62	PAH (µg/kg)					8	U	7	U	7.5	U			7	U
Benzo(b)fluoranthene	620	PAH (µg/kg)					195	U	180	U	190	U			180	U
Benzo(g,h,i)perylene	2,500	PAH (µg/kg)					195	U	180	U	190	U			180	U
Benzo(k)fluoranthene	6,200	PAH (µg/kg)					195	U	180	U	190	U			180	U
Chrysene	7,000	PAH (µg/kg)					194	U	179	U	189.5	U			180	U
Dibenz(a,h)Anthracene	62	PAH (µg/kg)					8	U	7	U	7.5	U			7	U
Fluoranthene	230,000	PAH (µg/kg)					194	U	179	U	189.5	U			180	U
Indeno(1,2,3-c,d)Pyrene	620	PAH (µg/kg)					195	U	180	U	190	U			180	U
Naphthalene	4,000	PAH (µg/kg)					2	U	1.75	U	1.75	U			1.8	U
Phenanthrene	100,000	PAH (µg/kg)					195	U	180	U	190	U			180	U
Pyrene	230,000	PAH (µg/kg)					194	U	179	U	189.5	U			180	U
Total PCBs	220	PCBs (µg/kg)					19.4	U	17.9	U	18.95	U			18.1	U
4,4-DDE	170	Pesticides (µg/kg)					1.94	U	1.79	U	14.8	V			1.81	U
4,4-DDT	170	Pesticides (µg/kg)					6.87	V	1.79	U	19.4	V			1.81	U
Aldrin	29	Pesticides (µg/kg)					1.94	U	1.79	U	1.895	U			1.81	U
Dieldrin	30	Pesticides (µg/kg)					1.94	U	1.79	U	1.895	U			1.81	U
Aliphatic Hydrocarbons (C_{19}-C_{36})	3,000	TPH (mg/kg)					3.875	U	3.585	U	3.79	U			3.625	U
Aromatic Hydrocarbons (C_{11}-C_{22})	800	TPH (mg/kg)					3.875	U	3.585	U	3.79	U			3.625	U
Acetone	60,000	VOCs (µg/kg)					28	V	3.5	U	7.8	V			17	V
m,p-Xylenes	500	VOCs (µg/kg)					0.405	U	0.35	U	0.345	U			0.36	U
p-Isopropyltoluene	NE	VOCs (µg/kg)					0.405	U	0.35	U	0.345	U			0.36	U
Toluene	500	VOCs (µg/kg)					0.6	U	0.5	U	0.5	U			0.55	U

Notes:
mg/kg = Milligrams per kilogram (parts per million)
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ng/kg = Nanograms per kilogram (parts per trillion)
V = Valid result; substance detected.
J = Estimated result; substance detected, but below the detection limit.
U = Substance not detected; detection limit listed.
Highlighted results were detected above their Project Action Level.

Table 6-10a
IA-10 Summary of Screened Results

Analyte	Project Action Level	Analyte Category (units)	IA5-002-D 0-0 ft.5 ft		IA5-002-E 0-0 ft.5 ft		IA5-003-A 0-0 ft.5 ft		IA5-003-B 0-0 ft.5 ft		IA5-003-C 0-0 ft.5 ft		IA5-003-D 0-0 ft.5 ft		IA5-003-E 0-0 ft.5 ft	
Aluminum	7,600	Metals (mg/kg)														
Antimony	3.1	Metals (mg/kg)														
Arsenic	0.39	Metals (mg/kg)														
Barium	540	Metals (mg/kg)														
Calcium	NE	Metals (mg/kg)														
Chromium	30	Metals (mg/kg)														
Cobalt	500	Metals (mg/kg)														
Copper	310	Metals (mg/kg)														
Iron	2,300	Metals (mg/kg)														
Lead	300	Metals (mg/kg)	31.7	V	203	V	203	V	45	V	15	V	14.1	V	14.1	V
Magnesium	NE	Metals (mg/kg)														
Manganese	180	Metals (mg/kg)														
Mercury	2.3	Metals (mg/kg)														
Nickel	20	Metals (mg/kg)														
Potassium	NE	Metals (mg/kg)														
Thallium	1	Metals (mg/kg)														
Vanadium	55	Metals (mg/kg)														
Zinc	2,300	Metals (mg/kg)														
Anthracene	1,000	PAH (µg/kg)														
Benzo(a)anthracene	620	PAH (µg/kg)														
Benzo(a)pyrene	62	PAH (µg/kg)														
Benzo(b)fluoranthene	620	PAH (µg/kg)														
Benzo(g,h,i)perylene	2,500	PAH (µg/kg)														
Benzo(k)fluoranthene	6,200	PAH (µg/kg)														
Chrysene	7,000	PAH (µg/kg)														
Dibenz(a,h)Anthracene	62	PAH (µg/kg)														
Fluoranthene	230,000	PAH (µg/kg)														
Indeno(1,2,3-c,d)Pyrene	620	PAH (µg/kg)														
Naphthalene	4,000	PAH (µg/kg)														
Phenanthrene	100,000	PAH (µg/kg)														
Pyrene	230,000	PAH (µg/kg)														
Total PCBs	220	PCBs (µg/kg)														
4,4-DDE	170	Pesticides (µg/kg)														
4,4-DDT	170	Pesticides (µg/kg)														
Aldrin	29	Pesticides (µg/kg)														
Dieldrin	30	Pesticides (µg/kg)														
Aliphatic Hydrocarbons (C_{19}-C_{36})	3,000	TPH (mg/kg)														
Aromatic Hydrocarbons (C_{11}-C_{22})	800	TPH (mg/kg)														
Acetone	60,000	VOCs (µg/kg)														
m,p-Xylenes	500	VOCs (µg/kg)														
p-Isopropyltoluene	NE	VOCs (µg/kg)														
Toluene	50	VOCs (µg/kg)														

Notes:
mg/kg = Milligrams per kilogram (parts per million)
µg/kg = Micrograms per kilogram (parts per billion)
ng/kg = Nanograms per kilogram (parts per trillion)
V = Valid result; substance detected.
J = Estimated result; substance detected, but below the detection limit.
U = Substance not detected; detection limit listed.
Highlighted results were detected above their Project Action Level.

Table 6-10a
IA-10 Summary of Screened Results

Analyte	Project Action Level	Analyte Category (units)	PASI-GR-CO-008-1 0-3 ft	PASI-GR-CO-009-1 0-3 ft	PASI-GR-CO-010-1 0-3 ft	PASI-GR-CO-011-1 0-3 ft	PASI-GR-CO-012-1 0-3 ft	PASI-GR-CO-013-1 0-3 ft	PASI-GR-CO-014-1 0-3 ft
Total PCBs	220	PCBs (µg/kg)	13000 V	4.95 U	5 U	4.55 U	4.75 U	5.5 U	5 U

Analyte	Project Action Level	Analyte Category (units)	PASI-GR-GB-019D-1 0-3 ft	PASI-GR-GB-019E-1 0-3 ft	PASI-GR-GB-020A-1 0-3 ft	PASI-GR-GB-020B-1 0-3 ft	PASI-GR-GB-020C-1 0-3 ft	PASI-GR-GB-020D-1 0-3 ft	PASI-GR-GB-020E-1 0-3 ft
Total PCBs	220	PCBs (µg/kg)	13.5 U	13.5 U	4.4 U	4.6 U	4.6 U	39 V	750 V

Notes:
mg/kg = Milligrams per kilogram (parts per million)
µg/kg = Micrograms per kilogram (parts per billion)
ng/kg = Nanograms per kilogram (parts per trillion)
V = Valid result; substance detected.
J = Estimated result; substance detected, but below the detection limit.
U = Substance not detected; detection limit listed.
Highlighted results were detected above their Project Action Level.

Table 6-10a
IA-10 Summary of Screened Results

Analyte	Project Action Level	Analyte Category (units)	GR-IA02-SB03-1 0-3 ft		GR-IA02-SB03-1 3-10 ft		GR-IA02-SB04-1 0-3 ft		GR-IA02-SB04-1 3-10 ft		GR-IA02-SB05-1 0-3 ft		GR-IA02-SB05-1 3-10 ft		GR-IA02-SB06-1 0-3 ft	
Aluminum	7,600	Metals (mg/kg)	6500	V	3900	V	7600	V	5100	V	6100	V	2900	V	7300	V
Antimony	3.1	Metals (mg/kg)	1.15	U	1.05	U	1.2	U	1.05	U	1.1	U	1.05	U	1.1	U
Arsenic	0.39	Metals (mg/kg)	17	V	19	V	29	V	27	V	13	V	11	V	27	V
Barium	540	Metals (mg/kg)	14	V	12	V	20	V	16	V	11	V	9.9	V	21	V
Calcium	NE	Metals (mg/kg)	160	V	1200	V	360	V	430	V	970	V	2400	V	420	V
Chromium	30	Metals (mg/kg)	8.8	V	9.2	V	15	V	16	V	7.8	V	5.9	V	22	V
Cobalt	500	Metals (mg/kg)	3.7	V	4.3	V	7	V	6	V	3.1	V	2.6	V	8	V
Copper	310	Metals (mg/kg)	5	V	9.2	V	17	V	12	V	5.7	V	5.7	V	12	V
Iron	2,300	Metals (mg/kg)	7500	V	7500	V	12000	V	9600	V	6800	V	4800	V	10000	V
Lead	300	Metals (mg/kg)	7.4	V	5.7	V	15	V	7	V	6	V	3.4	V	9.7	V
Magnesium	NE	Metals (mg/kg)	1100	V	1700	V	2400	V	2900	V	1400	V	2100	V	3400	V
Manganese	180	Metals (mg/kg)	220	V	160	V	560	V	200	V	120	V	88	V	260	V
Mercury	2.3	Metals (mg/kg)	0.017	J	0.041	U	0.046	J	0.0395	U	0.01	J	0.042	U	0.014	J
Nickel	20	Metals (mg/kg)	10	V	15	V	24	V	20	V	8.3	V	7.8	V	25	V
Potassium	NE	Metals (mg/kg)	150	V	540	V	530	V	780	V	220	V	430	V	1200	V
Thallium	1	Metals (mg/kg)	1.15	U	1.05	U	1.2	U	1.05	U	1.1	U	1.05	U	1.1	U
Vanadium	55	Metals (mg/kg)	8.9	V	6.8	V	12	V	9.8	V	7.3	V	4.6	V	13	V
Zinc	2,300	Metals (mg/kg)	15	V	15	V	24	V	19	V	13	V	12	V	22	V
Anthracene	1,000	PAH (µg/kg)														
Benzo(a)anthracene	620	PAH (µg/kg)														
Benzo(a)pyrene	62	PAH (µg/kg)														
Benzo(b)fluoranthene	620	PAH (µg/kg)														
Benzo(g,h,i)perylene	2,500	PAH (µg/kg)														
Benzo(k)fluoranthene	6,200	PAH (µg/kg)														
Chrysene	7,000	PAH (µg/kg)														
Dibenz(a,h)Anthracene	62	PAH (µg/kg)														
Fluoranthene	230,000	PAH (µg/kg)														
Indeno(1,2,3-c,d)Pyrene	620	PAH (µg/kg)														
Naphthalene	4,000	PAH (µg/kg)														
Phenanthrene	100,000	PAH (µg/kg)														
Pyrene	230,000	PAH (µg/kg)														
Total PCBs	220	PCBs (µg/kg)														
4,4-DDE	170	Pesticides (µg/kg)														
4,4-DDT	170	Pesticides (µg/kg)														
Aldrin	29	Pesticides (µg/kg)														
Dieldrin	30	Pesticides (µg/kg)														
Aliphatic Hydrocarbons (C_{19}-C_{36})	3,000	TPH (mg/kg)														
Aromatic Hydrocarbons (C_{11}-C_{22})	800	TPH (mg/kg)														
Acetone	60,000	VOCs (µg/kg)														
m,p-Xylenes	500	VOCs (µg/kg)														
p-Isopropyltoluene	NE	VOCs (µg/kg)														
Toluene	500	VOCs (µg/kg)														

Notes:
mg/kg = Milligrams per kilogram (parts per million)
µg/kg = Micrograms per kilogram (parts per billion)
ng/kg = Nanograms per kilogram (parts per trillion)
V = Valid result; substance detected.
J = Estimated result; substance detected, but below the detection limit.
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Highlighted results were detected above their Project Action Level.

Table 6-10a
IA-10 Summary of Screened Results

Analyte	Project Action Level	Analyte Category (units)	IA5-004-A 0-0 ft.5 ft		IA5-004-B 0-0 ft.5 ft		IA5-004-C 0-0 ft.5 ft		IA5-004-D 0-0 ft.5 ft		IA5-004-E 0-0 ft.5 ft		IA5-005-A 0-0 ft.5 ft		IA5-005-B 0-0 ft.5 ft	
Aluminum	7,600	Metals (mg/kg)														
Antimony	3.1	Metals (mg/kg)														
Arsenic	0.39	Metals (mg/kg)														
Barium	540	Metals (mg/kg)														
Calcium	NE	Metals (mg/kg)														
Chromium	30	Metals (mg/kg)														
Cobalt	500	Metals (mg/kg)														
Copper	310	Metals (mg/kg)														
Iron	2,300	Metals (mg/kg)														
Lead	300	Metals (mg/kg)	86.1	V	83.2	V	45.4	V	21.4	V	12.5	V	19.8	V	26.1	V
Magnesium	NE	Metals (mg/kg)														
Manganese	180	Metals (mg/kg)														
Mercury	2.3	Metals (mg/kg)														
Nickel	20	Metals (mg/kg)														
Potassium	NE	Metals (mg/kg)														
Thallium	1	Metals (mg/kg)														
Vanadium	55	Metals (mg/kg)														
Zinc	2,300	Metals (mg/kg)														
Anthracene	1,000	PAH (µg/kg)														
Benzo(a)anthracene	620	PAH (µg/kg)														
Benzo(a)pyrene	62	PAH (µg/kg)														
Benzo(b)fluoranthene	620	PAH (µg/kg)														
Benzo(g,h,i)perylene	2,500	PAH (µg/kg)														
Benzo(k)fluoranthene	6,200	PAH (µg/kg)														
Chrysene	7,000	PAH (µg/kg)														
Dibenz(a,h)Anthracene	62	PAH (µg/kg)														
Fluoranthene	230,000	PAH (µg/kg)														
Indeno(1,2,3-c,d)Pyrene	620	PAH (µg/kg)														
Naphthalene	4,000	PAH (µg/kg)														
Phenanthrene	100,000	PAH (µg/kg)														
Pyrene	230,000	PAH (µg/kg)														
Total PCBs	220	PCBs (µg/kg)														
4,4-DDE	170	Pesticides (µg/kg)														
4,4-DDT	170	Pesticides (µg/kg)														
Aldrin	29	Pesticides (µg/kg)														
Dieldrin	30	Pesticides (µg/kg)														
Aliphatic Hydrocarbons (C_{19}-C_{36})	3,000	TPH (mg/kg)														
Aromatic Hydrocarbons (C_{11}-C_{22})	800	TPH (mg/kg)														
Acetone	60,000	VOCs (µg/kg)														
m,p-Xylenes	500	VOCs (µg/kg)														
p-Isopropyltoluene	NE	VOCs (µg/kg)														
Toluene	50	VOCs (µg/kg)														

Notes:
mg/kg = Milligrams per kilogram (parts per million)
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V = Valid result; substance detected.
J = Estimated result; substance detected, but below the detection limit.
U = Substance not detected; detection limit listed.
Highlighted results were detected above their Project Action Level.

Table 6-10a
IA-10 Summary of Screened Results

Analyte	Project Action Level	Analyte Category (units)	PASI-GR-CO-015-1 0-3 ft	PASI-GR-CO-016-1 0-3 ft	PASI-GR-CO-017-1 0-3 ft	PASI-GR-CO-018-1 0-3 ft	PASI-GR-CO-019-1 0-3 ft	PASI-GR-CO-020-1 0-3 ft	PASI-GR-CO-021-1 0-3 ft
Total PCBs	220	PCBs (µg/kg)	560 V	4.85 U	390 V	1800 V	160 V	63 V	240 V

Analyte	Project Action Level	Analyte Category (units)	PASI-GR-GB-021A-1 0-3 ft	PASI-GR-GB-021B-1 0-3 ft	PASI-GR-GB-021C-1 0-3 ft	PASI-GR-GB-021D-1 0-3 ft	PASI-GR-GB-021E-1 0-3 ft	PASI-GR-GB-022A-1 0-3 ft	PASI-GR-GB-022B-1 0-3 ft
Total PCBs	220	PCBs (µg/kg)	300 V	190 V	610 V	4.7 U	4.7 U	13.5 U	13 U

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mg/kg = Milligrams per kilogram (parts per million)
µg/kg = Micrograms per kilogram (parts per billion)
ng/kg = Nanograms per kilogram (parts per trillion)
V = Valid result; substance detected.
J = Estimated result; substance detected, but below the detection limit.
U = Substance not detected; detection limit listed.
Highlighted results were detected above their Project Action Level.

Table 6-10a
IA-10 Summary of Screened Results

Analyte	Project Action Level	Analyte Category (units)	GR-IA02-SB06-1 3-10 ft		GR-IA02-SB07-1 0-3 ft		GR-IA02-SB07-1 3-10 ft		GR-IA02-SB08-1 0-3 ft		GR-IA02-SB08-1 3-10 ft		GR-IA02-SB09-1 0-3 ft		GR-IA02-SB09-1 3-10 ft	
Aluminum	7,600	Metals (mg/kg)	7800	V	10000	V	8700	V	8600	V	5200	V	13000	V	7400	V
Antimony	3.1	Metals (mg/kg)	1.05	U	1.2	U	1.1	U	1.1	U	1.05	U	1.3	U	1.05	U
Arsenic	0.39	Metals (mg/kg)	31	V	34	V	24	V	21	V	24	V	38	V	30	V
Barium	540	Metals (mg/kg)	29	V	24	V	22	V	12	V	17	V	40	V	26	V
Calcium	NE	Metals (mg/kg)	610	V	460	V	240	V	510	V	590	V	1100	V	1200	V
Chromium	30	Metals (mg/kg)	24	V	25	V	16	V	15	V	16	V	32	V	23	V
Cobalt	500	Metals (mg/kg)	9.5	V	7.5	V	6.7	V	6.2	V	6.3	V	9.5	V	8.3	V
Copper	310	Metals (mg/kg)	20	V	12	V	12	V	8.1	V	10	V	24	V	16	V
Iron	2,300	Metals (mg/kg)	14000	V	14000	V	11000	V	10000	V	9300	V	16000	V	13000	V
Lead	300	Metals (mg/kg)	10	V	18	V	7.3	V	7.3	V	6.5	V	29	V	9	V
Magnesium	NE	Metals (mg/kg)	4300	V	3600	V	2700	V	2400	V	2300	V	5500	V	4300	V
Manganese	180	Metals (mg/kg)	350	V	390	V	210	V	130	V	200	V	470	V	280	V
Mercury	2.3	Metals (mg/kg)	0.0415	U	0.049	J	0.0082	J	0.023	J	0.043	U	0.06	J	0.042	U
Nickel	20	Metals (mg/kg)	32	V	26	V	19	V	18	V	22	V	31	V	27	V
Potassium	NE	Metals (mg/kg)	1600	V	700	V	670	V	750	V	980	V	2000	V	1700	V
Thallium	1	Metals (mg/kg)	1.05	U	1.2	U	1.1	U	1.1	U	1.05	U	1.3	U	1.05	U
Vanadium	55	Metals (mg/kg)	15	V	19	V	13	V	12	V	8.9	V	24	V	15	V
Zinc	2,300	Metals (mg/kg)	28	V	30	V	20	V	18	V	18	V	46	V	30	V
Anthracene	1,000	PAH (µg/kg)														
Benzo(a)anthracene	620	PAH (µg/kg)														
Benzo(a)pyrene	62	PAH (µg/kg)														
Benzo(b)fluoranthene	620	PAH (µg/kg)														
Benzo(g,h,i)perylene	2,500	PAH (µg/kg)														
Benzo(k)fluoranthene	6,200	PAH (µg/kg)														
Chrysene	7,000	PAH (µg/kg)														
Dibenz(a,h)Anthracene	62	PAH (µg/kg)														
Fluoranthene	230,000	PAH (µg/kg)														
Indeno(1,2,3-c,d)Pyrene	620	PAH (µg/kg)														
Naphthalene	4,000	PAH (µg/kg)														
Phenanthrene	100,000	PAH (µg/kg)														
Pyrene	230,000	PAH (µg/kg)														
Total PCBs	220	PCBs (µg/kg)														
4,4-DDE	170	Pesticides (µg/kg)														
4,4-DDT	170	Pesticides (µg/kg)														
Aldrin	29	Pesticides (µg/kg)														
Dieldrin	30	Pesticides (µg/kg)														
Aliphatic Hydrocarbons (C_{19}-C_{36})	3,000	TPH (mg/kg)														
Aromatic Hydrocarbons (C_{11}-C_{22})	800	TPH (mg/kg)														
Acetone	60,000	VOCs (µg/kg)														
m,p-Xylenes	500	VOCs (µg/kg)														
p-Isopropyltoluene	NE	VOCs (µg/kg)														
Toluene	500	VOCs (µg/kg)														

Notes:
mg/kg = Milligrams per kilogram (parts per million)
µg/kg = Micrograms per kilogram (parts per billion)
ng/kg = Nanograms per kilogram (parts per trillion)
V = Valid result; substance detected.
J = Estimated result; substance detected, but below the detection limit.
U = Substance not detected; detection limit listed.
Highlighted results were detected above their Project Action Level.

Table 6-10a
IA-10 Summary of Screened Results

Analyte	Project Action Level	Analyte Category (units)	IA5-005-C 0-0 ft.5 ft		IA5-005-D 0-0 ft.5 ft		IA5-005-E 0-0 ft.5 ft		GR-IA08-SB01-1 0-3 ft		GR-IA08-SB01-1 3-10 ft		GR-IA08-SB02-1 8-10 ft		GR-IA08-SB03-1 0-2 ft	
Aluminum	7,600	Metals (mg/kg)							5800	V	4700	V				
Antimony	3.1	Metals (mg/kg)							1.05	U	1.05	U				
Arsenic	0.39	Metals (mg/kg)							29	V	32	V				
Barium	540	Metals (mg/kg)							26	V	22	V				
Calcium	NE	Metals (mg/kg)							1800	V	7900	V				
Chromium	30	Metals (mg/kg)							20	V	19	V				
Cobalt	500	Metals (mg/kg)							9.1	V	8.3	V				
Copper	310	Metals (mg/kg)							17	V	15	V				
Iron	2,300	Metals (mg/kg)							13000	V	11000	V				
Lead	300	Metals (mg/kg)	15.2	V	27.2	V	26.5	V	12	V	8.2	V				
Magnesium	NE	Metals (mg/kg)							3500	V	3600	V				
Manganese	180	Metals (mg/kg)							290	V	270	V				
Mercury	2.3	Metals (mg/kg)							0.043	U	0.0405	U				
Nickel	20	Metals (mg/kg)							31	V	31	V				
Potassium	NE	Metals (mg/kg)							1600	V	1400	V				
Thallium	1	Metals (mg/kg)							1.05	U	1.05	U				
Vanadium	55	Metals (mg/kg)							12	V	11	V				
Zinc	2,300	Metals (mg/kg)							28	V	28	V				
Anthracene	1,000	PAH (µg/kg)							400	V	175	U				
Benzo(a)anthracene	620	PAH (µg/kg)							1100	V	175	U				
Benzo(a)pyrene	62	PAH (µg/kg)							1100	V	130	V				
Benzo(b)fluoranthene	620	PAH (µg/kg)							880	V	175	U				
Benzo(g,h,i)perylene	2,500	PAH (µg/kg)							680	V	175	U				
Benzo(k)fluoranthene	6,200	PAH (µg/kg)							866	V	175	U				
Chrysene	7,000	PAH (µg/kg)							1000	V	175	U				
Dibenz(a,h)Anthracene	62	PAH (µg/kg)							470	V	26	V				
Fluoranthene	230,000	PAH (µg/kg)							1470	V	175	U				
Indeno(1,2,3-c,d)Pyrene	620	PAH (µg/kg)							810	V	175	U				
Naphthalene	4,000	PAH (µg/kg)							2.25	U	3.85	U	3.9	V	2.5	U
Phenanthrene	100,000	PAH (µg/kg)							510	V	175	U				
Pyrene	230,000	PAH (µg/kg)							1700	V	175	U				
Total PCBs	220	PCBs (µg/kg)							85	V	48.2	V				
4,4-DDE	170	Pesticides (µg/kg)							9.05	U	8.75	U				
4,4-DDT	170	Pesticides (µg/kg)							9.05	U	8.75	U				
Aldrin	29	Pesticides (µg/kg)							9.05	U	8.75	U				
Dieldrin	30	Pesticides (µg/kg)							9.05	U	8.75	U				
Aliphatic Hydrocarbons (C_{19}-C_{36})	3,000	TPH (mg/kg)							11.2	V	18	V				
Aromatic Hydrocarbons (C_{11}-C_{22})	800	TPH (mg/kg)							35.4	V	13.1	V				
Acetone	60,000	VOCs (µg/kg)							4.5	U	7.5	U	6.1	V	5	U
m,p-Xylenes	500	VOCs (µg/kg)							0.45	U	0.75	U	0.76	V	0.5	U
p-Isopropyltoluene	NE	VOCs (µg/kg)							0.45	U	0.75	U	0.28	U	0.5	U
Toluene	50	VOCs (µg/kg)							2.3	V	1.15	U	0.42	U	0.75	U

Notes:
mg/kg = Milligrams per kilogram (parts per million)
µg/kg = Micrograms per kilogram (parts per billion)
ng/kg = Nanograms per kilogram (parts per trillion)
V = Valid result; substance detected.
J = Estimated result; substance detected, but below the detection limit.
U = Substance not detected; detection limit listed.
Highlighted results were detected above their Project Action Level.

Table 6-10a
IA-10 Summary of Screened Results

Analyte	Project Action Level	Analyte Category (units)	PASI-GR-CO-022-1 0-3 ft	PASI-GR-CO-023-1 0-3 ft	PASI-GR-CO-024-1 0-3 ft	PASI-GR-CO-025-1 0-3 ft	PASI-GR-CO-026-1 0-3 ft	PASI-GR-CO-027-1 0-3 ft	PASI-GR-CO-028-1 0-3 ft
Total PCBs	220	PCBs (µg/kg)	310 V	5.5 U	5.5 U	4.6 U	5.5 U	4.9 U	5.5 U

Analyte	Project Action Level	Analyte Category (units)	PASI-GR-GB-022C-1 0-3 ft	PASI-GR-GB-022D-1 0-3 ft	PASI-GR-GB-022E-1 0-3 ft	PASI-GR-GB-024A-1 0-3 ft	PASI-GR-GB-024B-1 0-3 ft	PASI-GR-GB-024C-1 0-3 ft	PASI-GR-GB-024D-1 0-3 ft
Total PCBs	220	PCBs (µg/kg)	13.5 U	1500 V	13 U	5 U	5 U	5.5 U	6 U

Notes:
mg/kg = Milligrams per kilogram (parts per million)
µg/kg = Micrograms per kilogram (parts per billion)
ng/kg = Nanograms per kilogram (parts per trillion)
V = Valid result; substance detected.
J = Estimated result; substance detected, but below the detection limit.
U = Substance not detected; detection limit listed.
Highlighted results were detected above their Project Action Level.

Table 6-10a
IA-10 Summary of Screened Results

Analyte	Project Action Level	Analyte Category (units)	GR-IA02-SB10-1 0-3 ft		GR-IA02-SB10-1 3-10 ft		GR-IA02-SB11-1 0-3 ft		GR-IA02-SB11-1-M 3-10 ft		GR-IA02-SB12-1 0-3 ft		GR-IA02-SB12-1 3-10 ft		GR-IA02-SB13-1 0-3 ft	
Aluminum	7,600	Metals (mg/kg)	9500	V	7300	V	14000	V	13000	V	7000	V	10000	V	7500	V
Antimony	3.1	Metals (mg/kg)	1.1	U	1.05	U	1.25	U	1.1	U	1.45	U	1.1	U	1.1	U
Arsenic	0.39	Metals (mg/kg)	37	V	40	V	30	V	38	V	24	V	42	V	13	V
Barium	540	Metals (mg/kg)	21	V	23	V	21	V	52	V	19	V	38	V	17	V
Calcium	NE	Metals (mg/kg)	480	V	500	V	410	V	700	V	690	V	780	V	380	V
Chromium	30	Metals (mg/kg)	26	V	22	V	30	V	40	V	19	V	32	V	13	V
Cobalt	500	Metals (mg/kg)	7.9	V	7.7	V	7.8	V	10	V	5.2	V	13	V	3.6	V
Copper	310	Metals (mg/kg)	27	V	16	V	36	V	19	V	14	V	21	V	5.6	V
Iron	2,300	Metals (mg/kg)	13000	V	12000	V	17000	V	19000	V	9700	V	17000	V	7800	V
Lead	300	Metals (mg/kg)	13	V	9.6	V	24	V	11	V	23	V	13	V	7	V
Magnesium	NE	Metals (mg/kg)	4200	V	3900	V	5100	V	8200	V	2500	V	6000	V	2100	V
Manganese	180	Metals (mg/kg)	220	V	270	V	230	V	340	V	170	V	500	V	140	V
Mercury	2.3	Metals (mg/kg)	0.1	V	0.015	J	0.34	V	0.0395	U	0.079	J	0.041	U	0.013	J
Nickel	20	Metals (mg/kg)	31	V	27	V	29	V	37	V	22	V	37	V	9.7	V
Potassium	NE	Metals (mg/kg)	1400	V	1200	V	870	V	3400	V	690	V	2500	V	780	V
Thallium	1	Metals (mg/kg)	1.1	U	1.05	U	1.25	U	1.1	U	0.65	J	0.67	J	1.1	U
Vanadium	55	Metals (mg/kg)	15	V	14	V	20	V	24	V	13	V	23	V	11	V
Zinc	2,300	Metals (mg/kg)	33	V	26	V	46	V	37	V	38	V	38	V	16	V
Anthracene	1,000	PAH (µg/kg)													185	U
Benzo(a)anthracene	620	PAH (µg/kg)													185	U
Benzo(a)pyrene	62	PAH (µg/kg)													27	V
Benzo(b)fluoranthene	620	PAH (µg/kg)													185	U
Benzo(g,h,i)perylene	2,500	PAH (µg/kg)													185	U
Benzo(k)fluoranthene	6,200	PAH (µg/kg)													185	U
Chrysene	7,000	PAH (µg/kg)													183	U
Dibenz(a,h)Anthracene	62	PAH (µg/kg)													7.5	U
Fluoranthene	230,000	PAH (µg/kg)													183	U
Indeno(1,2,3-c,d)Pyrene	620	PAH (µg/kg)													185	U
Naphthalene	4,000	PAH (µg/kg)													1.9	U
Phenanthrene	100,000	PAH (µg/kg)													185	U
Pyrene	230,000	PAH (µg/kg)													183	U
Total PCBs	220	PCBs (µg/kg)													18.3	U
4,4-DDE	170	Pesticides (µg/kg)													4.86	V
4,4-DDT	170	Pesticides (µg/kg)													4.78	V
Aldrin	29	Pesticides (µg/kg)													1.83	U
Dieldrin	30	Pesticides (µg/kg)													1.83	U
Aliphatic Hydrocarbons (C_{19}-C_{36})	3,000	TPH (mg/kg)													3.665	U
Aromatic Hydrocarbons (C_{11}-C_{22})	800	TPH (mg/kg)													3.665	U
Acetone	60,000	VOCs (µg/kg)													3.75	U
m,p-Xylenes	500	VOCs (µg/kg)													0.375	U
p-Isopropyltoluene	NE	VOCs (µg/kg)													0.375	U
Toluene	500	VOCs (µg/kg)													0.55	U

Notes:
mg/kg = Milligrams per kilogram (parts per million)
µg/kg = Micrograms per kilogram (parts per billion)
ng/kg = Nanograms per kilogram (parts per trillion)
V = Valid result; substance detected.
J = Estimated result; substance detected, but below the detection limit.
U = Substance not detected; detection limit listed.
Highlighted results were detected above their Project Action Level.

Table 6-10a
IA-10 Summary of Screened Results

Analyte	Project Action Level	Analyte Category (units)	GR-IA08-SB04-1 2-4 ft		GR-IA08-SB05-1 40-42 ft		GR-IA08-SB05-1 6-8		GR-IA08-SB06-1 0-2 ft		GR-IA08-SB07-1 4-6 ft		GR-IA08-SB09-1 0-3 ft		GR-IA08-SB09-1 3-10 ft	
Aluminum	7,600	Metals (mg/kg)											7800	V	4700	V
Antimony	3.1	Metals (mg/kg)											2.1	U	2.1	U
Arsenic	0.39	Metals (mg/kg)											25	V	36	V
Barium	540	Metals (mg/kg)											31		22	
Calcium	NE	Metals (mg/kg)											2000		9100	
Chromium	30	Metals (mg/kg)											24	V	20	V
Cobalt	500	Metals (mg/kg)											7.6		8.8	
Copper	310	Metals (mg/kg)											19		16	
Iron	2,300	Metals (mg/kg)											13000	V	11000	V
Lead	300	Metals (mg/kg)											11	V	7.1	V
Magnesium	NE	Metals (mg/kg)											4100		3200	
Manganese	180	Metals (mg/kg)											230	V	240	V
Mercury	2.3	Metals (mg/kg)											0.01	J	0.0049	J
Nickel	20	Metals (mg/kg)											26	V	31	V
Potassium	NE	Metals (mg/kg)											1900		1800	
Thallium	1	Metals (mg/kg)											2.1	U	2.1	U
Vanadium	55	Metals (mg/kg)											15		11	
Zinc	2,300	Metals (mg/kg)											30		24	
Anthracene	1,000	PAH (µg/kg)											360	U	350	U
Benzo(a)anthracene	620	PAH (µg/kg)											360	U	350	U
Benzo(a)pyrene	62	PAH (µg/kg)											100	V	140	V
Benzo(b)fluoranthene	620	PAH (µg/kg)											360	U	350	U
Benzo(g,h,i)perylene	2,500	PAH (µg/kg)											360	U	350	U
Benzo(k)fluoranthene	6,200	PAH (µg/kg)											360	U	350	U
Chrysene	7,000	PAH (µg/kg)											360	U	350	U
Dibenz(a,h)Anthracene	62	PAH (µg/kg)											14	U	17	V
Fluoranthene	230,000	PAH (µg/kg)											360	U	350	U
Indeno(1,2,3-c,d)Pyrene	620	PAH (µg/kg)											360	U	350	U
Naphthalene	4,000	PAH (µg/kg)	2.7	U	3.4	U	1.9	U	2.4	U	3.3	U	360	U	350	U
Phenanthrene	100,000	PAH (µg/kg)											360	U	350	U
Pyrene	230,000	PAH (µg/kg)											360	U	350	U
Total PCBs	220	PCBs (µg/kg)											35.8	U	35.1	U
4,4-DDE	170	Pesticides (µg/kg)											4.64	V	3.51	U
4,4-DDT	170	Pesticides (µg/kg)											3.58	U	3.51	U
Aldrin	29	Pesticides (µg/kg)											3.58	U	3.51	U
Dieldrin	30	Pesticides (µg/kg)											3.58	U	3.51	U
Aliphatic Hydrocarbons (C_{19}-C_{36})	3,000	TPH (mg/kg)											7.17	U	7.02	U
Aromatic Hydrocarbons (C_{11}-C_{22})	800	TPH (mg/kg)											7.17	U	7.02	U
Acetone	60,000	VOCs (µg/kg)	5.5	U	7	U	3.85	U	16	V	6.5	U	11	V	15	V
m,p-Xylenes	500	VOCs (µg/kg)	0.55	U	0.7	U	0.385	U	0.48	U	0.65	U	0.66	U	0.78	U
p-Isopropyltoluene	NE	VOCs (µg/kg)	0.55	U	0.7	U	0.385	U	5.3	V	0.65	U	0.66	U	0.78	U
Toluene	50	VOCs (µg/kg)	0.8	U	1	U	0.6	U	2.2	V	1	U	0.98	U	1.2	U

Notes:
mg/kg = Milligrams per kilogram (parts per million)
µg/kg = Micrograms per kilogram (parts per billion)
ng/kg = Nanograms per kilogram (parts per trillion)
V = Valid result; substance detected.
J = Estimated result; substance detected, but below the detection limit.
U = Substance not detected; detection limit listed.
Highlighted results were detected above their Project Action Level.

Table 6-10a
IA-10 Summary of Screened Results

Analyte	Project Action Level	Analyte Category (units)	PASI-GR-CO-029-1 0-3 ft	PASI-GR-CO-030-1 0-3 ft	PASI-GR-CO-031-1 0-3 ft	PASI-GR-CO-032-1 0-3 ft	PASI-GR-CO-033-1 0-3 ft	PASI-GR-CO-034-1 0-3 ft	PASI-GR-CO-035-1 0-3 ft
Total PCBs	220	PCBs (µg/kg)	5.5 U	15 U	16.5 U	16.5 U	16 U	13 U	13.5 U

Analyte	Project Action Level	Analyte Category (units)	PASI-GR-GB-024E-1 0-3 ft	PASI-GR-GB-025A-1 0-3 ft	PASI-GR-GB-025B-1 0-3 ft	PASI-GR-GB-025C-1 0-3 ft	PASI-GR-GB-025D-1 0-3 ft	PASI-GR-GB-025E-1 0-3 ft	PASI-GR-GB-036A-1 0-3 ft
Total PCBs	220	PCBs (µg/kg)	5 U	4.65 U	4.9 U	5 U	5 U	4.9 U	180 V

Notes:
mg/kg = Milligrams per kilogram (parts per million)
µg/kg = Micrograms per kilogram (parts per billion)
ng/kg = Nanograms per kilogram (parts per trillion)
V = Valid result; substance detected.
J = Estimated result; substance detected, but below the detection limit.
U = Substance not detected; detection limit listed.
Highlighted results were detected above their Project Action Level.

Table 6-10a
IA-10 Summary of Screened Results

Analyte	Project Action Level	Analyte Category (units)	GR-IA02-SB13-1 3-10 ft		GR-IA02-SB14-1 3-10 ft		GR-IA02-SB14-1 0-3 ft		GR-IA02-SB15-1 0-3 ft		GR-IA02-SB15-1 3-10 ft		GR-IA02-SB16-1 0-3 ft		GR-IA02-SB16-1 3-10 ft	
Aluminum	7,600	Metals (mg/kg)	2900	V	2200	V	9200	V	6500	V	2500	V	11000	V	6600	V
Antimony	3.1	Metals (mg/kg)	1.05	U	1.05	U	1.15	U	1.1	U	1	U	1.15	U	1.05	U
Arsenic	0.39	Metals (mg/kg)	6.3	V	8.8	V	9.7	V	9.2	V	8.9	V	27	V	45	V
Barium	540	Metals (mg/kg)	9.6	V	7.8	V	16	V	11	V	8.4	V	28	V	24	V
Calcium	NE	Metals (mg/kg)	310	V	220	V	230	V	250	V	220	V	460	V	670	V
Chromium	30	Metals (mg/kg)	4.8	V	4.9	V	12	V	8.1	V	5.1	V	28	V	24	V
Cobalt	500	Metals (mg/kg)	2.6	V	2.4	V	2.9	V	2.9	V	2.7	V	7.8	V	10	V
Copper	310	Metals (mg/kg)	4	V	6	V	5.6	V	5	V	5.7	V	12	V	15	V
Iron	2,300	Metals (mg/kg)	4600	V	3700	V	7200	V	5700	V	3800	V	14000	V	14000	V
Lead	300	Metals (mg/kg)	2.6	V	3.3	V	7.8	V	9.4	V	3.6	V	11	V	8.8	V
Magnesium	NE	Metals (mg/kg)	970	V	700	V	1200	V	1000	V	730	V	4700	V	3600	V
Manganese	180	Metals (mg/kg)	98	V	82	V	70	V	100	V	84	V	220	V	350	V
Mercury	2.3	Metals (mg/kg)	0.038	U	0.0425	U	0.028	J	0.012	J	0.041	U	0.032	J	0.044	U
Nickel	20	Metals (mg/kg)	5.3	V	4.9	V	6.7	V	6.3	V	6	V	26	V	32	V
Potassium	NE	Metals (mg/kg)	460	V	330	V	530	V	320	V	310	V	2300	V	1700	V
Thallium	1	Metals (mg/kg)	1.05	U	1.05	U	1.15	U	1.1	U	1	U	1.15	U	1.05	U
Vanadium	55	Metals (mg/kg)	4.8	V	3.6	V	11	V	7.8	V	3.7	V	19	V	12	V
Zinc	2,300	Metals (mg/kg)	10	V	9.3	V	13	V	13	V	9.7	V	26	V	26	V
Anthracene	1,000	PAH (µg/kg)	175	U												
Benzo(a)anthracene	620	PAH (µg/kg)	175	U												
Benzo(a)pyrene	62	PAH (µg/kg)	7	U												
Benzo(b)fluoranthene	620	PAH (µg/kg)	175	U												
Benzo(g,h,i)perylene	2,500	PAH (µg/kg)	175	U												
Benzo(k)fluoranthene	6,200	PAH (µg/kg)	175	U												
Chrysene	7,000	PAH (µg/kg)	175	U												
Dibenz(a,h)Anthracene	62	PAH (µg/kg)	7	U												
Fluoranthene	230,000	PAH (µg/kg)	175	U												
Indeno(1,2,3-c,d)Pyrene	620	PAH (µg/kg)	175	U												
Naphthalene	4,000	PAH (µg/kg)	2.3	U												
Phenanthrene	100,000	PAH (µg/kg)	175	U												
Pyrene	230,000	PAH (µg/kg)	175	U												
Total PCBs	220	PCBs (µg/kg)	17.55	U												
4,4-DDE	170	Pesticides (µg/kg)	1.755	U												
4,4-DDT	170	Pesticides (µg/kg)	1.755	U												
Aldrin	29	Pesticides (µg/kg)	1.755	U												
Dieldrin	30	Pesticides (µg/kg)	1.755	U												
Aliphatic Hydrocarbons (C_{19}-C_{36})	3,000	TPH (mg/kg)	3.51	U												
Aromatic Hydrocarbons (C_{11}-C_{22})	800	TPH (mg/kg)	3.51	U												
Acetone	60,000	VOCs (µg/kg)	4.6	U												
m,p-Xylenes	500	VOCs (µg/kg)	0.46	U												
p-Isopropyltoluene	NE	VOCs (µg/kg)	0.46	U												
Toluene	500	VOCs (µg/kg)	0.7	U												

Notes:
mg/kg = Milligrams per kilogram (parts per million)
µg/kg = Micrograms per kilogram (parts per billion)
ng/kg = Nanograms per kilogram (parts per trillion)
V = Valid result; substance detected.
J = Estimated result; substance detected, but below the detection limit.
U = Substance not detected; detection limit listed.
Highlighted results were detected above their Project Action Level.

Table 6-10a
IA-10 Summary of Screened Results

Analyte	Project Action Level	Analyte Category (units)	GR-IA10-SB01-1 0-3 ft		GR-IA10-SB01-1 3-10 ft		GR-IA10-SB02-1 0-3 ft		GR-IA10-SB02-1 3-10 ft		GR-IA10-SB02-1-D 3-10 ft		GR-IA10-SB03-1 0-3 ft		GR-IA10-SB03-1 3-10 ft	
Aluminum	7,600	Metals (mg/kg)	9100	V	4900	V	5600	V	5800	V	5600	V	12000	V	11000	V
Antimony	3.1	Metals (mg/kg)	2.2	U	2.1	U	2.2	U	2.2	U	2.2	U	2.2	U	2.2	U
Arsenic	0.39	Metals (mg/kg)	10	V	12	V	26	V	19	V	22	V	40	V	58	V
Barium	540	Metals (mg/kg)	14	V	18	V	28	V	28	V	27	V	20	V	20	V
Calcium	NE	Metals (mg/kg)	210	V	420	V	5800	V	8600	V	6800	V	690	V	450	V
Chromium	30	Metals (mg/kg)	12	V	12	V	16	V	16	V	16	V	28	V	28	V
Cobalt	500	Metals (mg/kg)	3.2	V	4.1	V	7.2	V	6.1	V	6.2	V	7.3	V	8.4	V
Copper	310	Metals (mg/kg)	5.2	V	8	V	16	V	13	V	13	V	18	V	16	V
Iron	2,300	Metals (mg/kg)	8300	V	7800	V	12000	V	11000	V	11000	V	15000	V	16000	V
Lead	300	Metals (mg/kg)	6.1	V	4.1	V	12	V	8.5	V	9.1	V	11	V	9.3	V
Magnesium	NE	Metals (mg/kg)	1800	V	2100	V	2900	V	2700	V	2600	V	5600	V	6300	V
Manganese	180	Metals (mg/kg)	92	V	130	V	280	V	290	V	240	V	230	V	270	V
Mercury	2.3	Metals (mg/kg)	0.018	J	0.08	U	0.03	J	0.0054	J	0.0084	J	0.03	J	0.082	U
Nickel	20	Metals (mg/kg)	8.4	V	10	V	23	V	19	V	19	V	25	V	27	V
Potassium	NE	Metals (mg/kg)	450		960	V	1500	V	1500	V	1400	V	1000	V	1200	V
Thallium	1	Metals (mg/kg)	2.2		2.1	U	2.2	U	2.2	U	2.2	U	2.2	U	2.2	U
Vanadium	55	Metals (mg/kg)	10		8.7	V	11	V	9.5	V	9.8	V	18	V	19	V
Zinc	2,300	Metals (mg/kg)	17		18	V	30	V	26	V	28	V	34	V	32	V
Anthracene	1,000	PAH (µg/kg)	380	U	350	U	3200	V	1800	U	1800	U	370	U	370	U
Benzo(a)anthracene	620	PAH (µg/kg)	380	U	350	U	6100	V	1800	U	1800	U	370	U	370	U
Benzo(a)pyrene	62	PAH (µg/kg)	380	U	350	U	5500	V	1800	U	1800	U	370	U	370	U
Benzo(b)fluoranthene	620	PAH (µg/kg)	380	U	350	U	3800	V	1800	U	1800	U	370	U	370	U
Benzo(g,h,i)perylene	2,500	PAH (µg/kg)	380	U	350	U	2800	V	1800	U	1800	U	370	U	370	U
Benzo(k)fluoranthene	6,200	PAH (µg/kg)	380	U	350	U	3900	V	1800	U	1800	U	370	U	370	U
Chrysene	7,000	PAH (µg/kg)	380	U	350	U	5500	V	1800	U	1800	U	370	U	370	U
Dibenz(a,h)Anthracene	62	PAH (µg/kg)	380	U	350	U	2300	V	1800	U	1800	U	370	U	370	U
Fluoranthene	230,000	PAH (µg/kg)	380	U	350	U	13000	V	1800	U	1800	U	370	U	370	U
Indeno(1,2,3-c,d)Pyrene	620	PAH (µg/kg)	380	U	350	U	3700	V	1800	U	1800	U	370	U	370	U
Naphthalene	4,000	PAH (µg/kg)	380	U	350	U	1800	U	1800	U	1800	U	370	U	370	U
Phenanthrene	100,000	PAH (µg/kg)	380	U	350	U	2	U	1800	U	1800	U	370	U	370	U
Pyrene	230,000	PAH (µg/kg)	380	U	350	U	2200	U	1800	U	1800	U	370	U	370	U
Total PCBs	220	PCBs (µg/kg)	37.9	U	35.1	U	36.2	U	36.6	U	37	U	37	U	36.6	U
4,4-DDE	170	Pesticides (µg/kg)	5.09	V	3.51	U	7.28	U	36.6	U	7.41	U	3.93	V	3.66	U
4,4-DDT	170	Pesticides (µg/kg)	4.76	V	3.51	U	7.28	U	36.6	U	7.41	U	4.65	V	3.66	U
Aldrin	29	Pesticides (µg/kg)	3.79	U	3.51	U	7.28	U	36.6	U	7.41	U	37	U	3.66	U
Dieldrin	30	Pesticides (µg/kg)	3.79	U	3.51	U	7.28	U	36.6	U	7.41	U	38.3	V	5.64	
Aliphatic Hydrocarbons (C_{19}-C_{36})	3,000	TPH (mg/kg)	7.58	U	7.02	U	36.2	U	36.6	U	37	U	7.41	U	7.33	U
Aromatic Hydrocarbons (C_{11}-C_{22})	800	TPH (mg/kg)	7.58	U	7.02	U	36.2	U	36.6	U	37	U	7.41	U	7.33	U
Acetone	60,000	VOCs (µg/kg)	9.5	V	8	U	6.5	U	9.2	U	6.7	U	35	V	11	V
m,p-Xylenes	500	VOCs (µg/kg)	0.95	U	0.8	U	0.65	U	2.6	V	0.67	U	0.77	U	0.92	U
p-Isopropyltoluene	NE	VOCs (µg/kg)	0.95	U	0.8	U	0.65	U	0.92	U	0.67	U	0.77	U	0.92	U
Toluene	50	VOCs (µg/kg)	1.4	U	1.3	U	0.97	U	4.8	V	1.7	V	1.2	U	1.4	V

Notes:
mg/kg = Milligrams per kilogram (parts per million)
µg/kg = Micrograms per kilogram (parts per billion)
ng/kg = Nanograms per kilogram (parts per trillion)
V = Valid result; substance detected.
J = Estimated result; substance detected, but below the detection limit.
U = Substance not detected; detection limit listed.
Highlighted results were detected above their Project Action Level.

Table 6-10a
IA-10 Summary of Screened Results

Analyte	Project Action Level	Analyte Category (units)	PASI-GR-CO-036-1 0-3 ft	PASI-GR-CO-037-1 0-3 ft	PASI-GR-CO-038-1 0-3 ft	PASI-GR-CO-039-1 0-3 ft	PASI-GR-CO-040-1 0-3 ft	PASI-GR-CO-041-1 0-3 ft	PASI-GR-CO-042-1 0-3 ft
Total PCBs	220	PCBs (µg/kg)	4700 V	13.5 U	15 U	15.5 U	16.5 U	16 U	14.5 U

Analyte	Project Action Level	Analyte Category (units)	PASI-GR-GB-036B-1 0-3 ft	PASI-GR-GB-036C-1 0-3 ft	PASI-GR-GB-036D-1 0-3 ft	PASI-GR-GB-036E-1 0-3 ft	PASI-GR-GB-043A-1 0-3 ft	PASI-GR-GB-043B-1 0-3 ft	PASI-GR-GB-043C-1 0-3 ft
Total PCBs	220	PCBs (µg/kg)	830 V	330 V	1300 V	14 U	4.7 U	4.5 U	1700 V

Notes:
mg/kg = Milligrams per kilogram (parts per million)
µg/kg = Micrograms per kilogram (parts per billion)
ng/kg = Nanograms per kilogram (parts per trillion)
V = Valid result; substance detected.
J = Estimated result; substance detected, but below the detection limit.
U = Substance not detected; detection limit listed.
Highlighted results were detected above their Project Action Level.

Table 6-10a
IA-10 Summary of Screened Results

Analyte	Project Action Level	Analyte Category (units)	GR-IA02-SB17-1 0-3 ft		GR-IA02-SB17-1 3-10 ft		GR-IA02-SB18-1 0-3 ft		GR-IA02-SB18-1 3-10 ft		GR-IA02-SB19-1 0-3 ft		GR-IA02-SB19-1 3-10 ft		GR-IA02-SB20-1 0-3 ft	
Aluminum	7,600	Metals (mg/kg)	6800	V	7800	V	6400	V	7000	V	6200	V	7900	V	5100	V
Antimony	3.1	Metals (mg/kg)	1.1	U	1.1	U	1.1	U	1.05	U	1.1	U	1.05	U	1.1	U
Arsenic	0.39	Metals (mg/kg)	11	V	28	V	11	V	21	V	13	V	23	V	9	V
Barium	540	Metals (mg/kg)	12	V	32	V	10	V	15	V	10	V	20	V	15	V
Calcium	NE	Metals (mg/kg)	250	V	710	V	300	V	330	V	330	V	740	V	750	V
Chromium	30	Metals (mg/kg)	9.1	V	21	V	8.8	V	19	V	9.3	V	21	V	6.3	V
Cobalt	500	Metals (mg/kg)	3	V	7.9	V	3.2	V	4.9	V	3.6	V	7	V	2.7	V
Copper	310	Metals (mg/kg)	41	V	25	V	4.5	V	9.7	V	4.8	V	11	V	4.2	V
Iron	2,300	Metals (mg/kg)	6700	V	12000	V	6800	V	12000	V	7700	V	12000	V	5900	V
Lead	300	Metals (mg/kg)	6.4	V	6.5	V	4.4	V	5.6	V	8.1	V	5	V	12	V
Magnesium	NE	Metals (mg/kg)	1200	V	3700	V	1400	V	3800	V	1800	V	4300	V	1000	V
Manganese	180	Metals (mg/kg)	100	V	240	V	100	V	200	V	100	V	210	V	140	V
Mercury	2.3	Metals (mg/kg)	0.016	J	0.0032	J	0.011	J	0.09	V	0.0086	J	0.041	U	0.014	J
Nickel	20	Metals (mg/kg)	9.1	V	26	V	8.7	V	18	V	9.8	V	24	V	6.9	V
Potassium	NE	Metals (mg/kg)	300	V	1500	V	430	V	680	V	510	V	1100	V	400	V
Thallium	1	Metals (mg/kg)	1.1	U	1.1	U	1.1	U	1.05	U	1.1	U	1.05	U	1.1	U
Vanadium	55	Metals (mg/kg)	8.2	V	14	V	8	V	12	V	8.4	V	12	V	7.3	V
Zinc	2,300	Metals (mg/kg)	13	V	23	V	13	V	22	V	14	V	24	V	25	V
Anthracene	1,000	PAH (µg/kg)													190	U
Benzo(a)anthracene	620	PAH (µg/kg)													190	U
Benzo(a)pyrene	62	PAH (µg/kg)													7.5	U
Benzo(b)fluoranthene	620	PAH (µg/kg)													190	U
Benzo(g,h,i)perylene	2,500	PAH (µg/kg)													190	U
Benzo(k)fluoranthene	6,200	PAH (µg/kg)													190	U
Chrysene	7,000	PAH (µg/kg)													189.5	U
Dibenz(a,h)Anthracene	62	PAH (µg/kg)													7.5	U
Fluoranthene	230,000	PAH (µg/kg)													189.5	U
Indeno(1,2,3-c,d)Pyrene	620	PAH (µg/kg)													190	U
Naphthalene	4,000	PAH (µg/kg)													2.7	U
Phenanthrene	100,000	PAH (µg/kg)													190	U
Pyrene	230,000	PAH (µg/kg)													189.5	U
Total PCBs	220	PCBs (µg/kg)													18.95	U
4,4-DDE	170	Pesticides (µg/kg)													9.45	U
4,4-DDT	170	Pesticides (µg/kg)													9.45	U
Aldrin	29	Pesticides (µg/kg)													9.45	U
Dieldrin	30	Pesticides (µg/kg)													63.6	V
Aliphatic Hydrocarbons (C_{19}-C_{36})	3,000	TPH (mg/kg)													11.5	V
Aromatic Hydrocarbons (C_{11}-C_{22})	800	TPH (mg/kg)													10.5	V
Acetone	60,000	VOCs (µg/kg)													49	V
m,p-Xylenes	500	VOCs (µg/kg)													0.55	U
p-Isopropyltoluene	NE	VOCs (µg/kg)													0.55	U
Toluene	500	VOCs (µg/kg)													0.8	U

Notes:
mg/kg = Milligrams per kilogram (parts per million)
µg/kg = Micrograms per kilogram (parts per billion)
ng/kg = Nanograms per kilogram (parts per trillion)
V = Valid result; substance detected.
J = Estimated result; substance detected, but below the detection limit.
U = Substance not detected; detection limit listed.
Highlighted results were detected above their Project Action Level.

Table 6-10a
IA-10 Summary of Screened Results

Analyte	Project Action Level	Analyte Category (units)	GR-IA10-SB04-1 0-3 ft		GR-IA10-SB04-1 3-10 ft		GRB-03-01X 0-3 ft		GRB-03-01X 3-6 ft		GRB-03-01X 6-10 ft		GRB-03-02X 0-3 ft		GRB-03-02X 3-6 ft	
Aluminum	7,600	Metals (mg/kg)	7400	V	8000	V	7400	V	9200	V	10000	V	10000	V	13000	V
Antimony	3.1	Metals (mg/kg)	2.2	U	2.1	U										
Arsenic	0.39	Metals (mg/kg)	9.2	V	26	V	11	V	52	V	32	V	47	V	38	V
Barium	540	Metals (mg/kg)	13	V	28	V										
Calcium	NE	Metals (mg/kg)	170	V	440	V										
Chromium	30	Metals (mg/kg)	7.4	V	18	V										
Cobalt	500	Metals (mg/kg)	2.9	V	7.2	V										
Copper	310	Metals (mg/kg)	3.8	V	15	V										
Iron	2,300	Metals (mg/kg)	7200	V	12000	V	7700	V	15000	V	19000	V	22000	V	23000	V
Lead	300	Metals (mg/kg)	7.6	V	7.9	V										
Magnesium	NE	Metals (mg/kg)	990	V	3200	V										
Manganese	180	Metals (mg/kg)	150	V	250	V	82	V	270	V	380	V	420	V	470	V
Mercury	2.3	Metals (mg/kg)	0.027	J	0.0072	J										
Nickel	20	Metals (mg/kg)	7	V	23	V	8.6	V	34	V	46	V	50	V	48	V
Potassium	NE	Metals (mg/kg)	260	V	1600	V										
Thallium	1	Metals (mg/kg)	2.2	U	2.1	U										
Vanadium	55	Metals (mg/kg)	8.5	V	12	V										
Zinc	2,300	Metals (mg/kg)	14	V	20	V										
Anthracene	1,000	PAH (µg/kg)	370	U	350	U										
Benzo(a)anthracene	620	PAH (µg/kg)	370	U	350	U										
Benzo(a)pyrene	62	PAH (µg/kg)	370	U	350	U										
Benzo(b)fluoranthene	620	PAH (µg/kg)	370	U	350	U										
Benzo(g,h,i)perylene	2,500	PAH (µg/kg)	370	U	350	U										
Benzo(k)fluoranthene	6,200	PAH (µg/kg)	370	U	350	U										
Chrysene	7,000	PAH (µg/kg)	370	U	350	U										
Dibenz(a,h)Anthracene	62	PAH (µg/kg)	370	U	350	U										
Fluoranthene	230,000	PAH (µg/kg)	370	U	350	U										
Indeno(1,2,3-c,d)Pyrene	620	PAH (µg/kg)	370	U	350	U										
Naphthalene	4,000	PAH (µg/kg)	370	U	350	U										
Phenanthrene	100,000	PAH (µg/kg)	370	U	350	U										
Pyrene	230,000	PAH (µg/kg)	370	U	350	U										
Total PCBs	220	PCBs (µg/kg)	37	U	35.1	U										
4,4-DDE	170	Pesticides (µg/kg)	13	V	3.51	U										
4,4-DDT	170	Pesticides (µg/kg)	12.8	V	3.51	U										
Aldrin	29	Pesticides (µg/kg)	37	U	3.51	U										
Dieldrin	30	Pesticides (µg/kg)	37	U	3.51	U										
Aliphatic Hydrocarbons (C_{19}-C_{36})	3,000	TPH (mg/kg)	7.41	U	7.02	U										
Aromatic Hydrocarbons (C_{11}-C_{22})	800	TPH (mg/kg)	7.41	U	7.02	U										
Acetone	60,000	VOCs (µg/kg)	86	V	24	V										
m,p-Xylenes	500	VOCs (µg/kg)	0.76	U	0.99	U										
p-Isopropyltoluene	NE	VOCs (µg/kg)	0.76	U	0.99	U										
Toluene	50	VOCs (µg/kg)	1.1	U	1.5	U										

Notes:
mg/kg = Milligrams per kilogram (parts per million)
µg/kg = Micrograms per kilogram (parts per billion)
ng/kg = Nanograms per kilogram (parts per trillion)
V = Valid result; substance detected.
J = Estimated result; substance detected, but below the detection limit.
U = Substance not detected; detection limit listed.
Highlighted results were detected above their Project Action Level.

Table 6-10a
IA-10 Summary of Screened Results

Analyte	Project Action Level	Analyte Category (units)	PASI-GR-CO-043-1 0-3 ft	PASI-GR-CO-044-1 0-3 ft	PASI-GR-CO-045-1 0-3 ft	PASI-GR-CO-046-1 0-3 ft	PASI-GR-CO-047-1 0-3 ft	PASI-GR-CO-048-1 0-3 ft	PASI-GR-CO-049-1 0-3 ft
Total PCBs	220	PCBs (µg/kg)	1100 V	14.5 U	14 U	15 U	15.5 U	15 U	14.5 U

Analyte	Project Action Level	Analyte Category (units)	PASI-GR-GB-043D-1 0-3 ft	PASI-GR-GB-043E-1 0-3 ft	PASI-GR-GB-200-1 1.75-4.75 ft	PASI-GR-GB-201-1 1.33-4.33 ft	PASI-GR-GB-202-1 1-4 ft	PASI-GR-GB-203-1 1.33-4.33 ft	PASI-GR-GB-204-1
Total PCBs	220	PCBs (µg/kg)	150 V	4.65 U	4.7	5 U	5 U	5 U	4.95

Notes:
mg/kg = Milligrams per kilogram (parts per million)
µg/kg = Micrograms per kilogram (parts per billion)
ng/kg = Nanograms per kilogram (parts per trillion)
V = Valid result; substance detected.
J = Estimated result; substance detected, but below the detection limit.
U = Substance not detected; detection limit listed.
Highlighted results were detected above their Project Action Level.

Table 6-10a
IA-10 Summary of Screened Results

Analyte	Project Action Level	Analyte Category (units)	GR-IA02-SB20-1-M 3-10 ft		GR-IA02-SB21-1 0-3 ft		GR-IA02-SB23-1 0-3 ft		GR-IA02-SB23-1 3-10 ft		GR-IA02-SB24-1 0-3 ft		GR-IA02-SB24-1 3-10 ft		GR-IA02-SB25-1 0-3 ft	
Aluminum	7,600	Metals (mg/kg)	5700	V	5900	V	13000	V	12000	V	12000	V	14000	V	14000	V
Antimony	3.1	Metals (mg/kg)	1.1	U	1.1	U	1.1	U	1.2	U	1.1	U	1.15	U	1.1	U
Arsenic	0.39	Metals (mg/kg)	32	V	10	V	19	V	28	V	30	V	19	V	23	V
Barium	540	Metals (mg/kg)	21	V	10	V	27	V	20	V	31	V	45	V	32	V
Calcium	NE	Metals (mg/kg)	490	V	290	V	1800	V	580	V	890	V	910	V	420	V
Chromium	30	Metals (mg/kg)	16	V	9.5	V	18	V	24	V	26	V	21	V	20	V
Cobalt	500	Metals (mg/kg)	5.9	V	3.3	V	7.2	V	8.2	V	8.5	V	8.8	V	8.9	V
Copper	310	Metals (mg/kg)	13	V	4.2	V	15	V	16	V	16	V	16	V	17	V
Iron	2,300	Metals (mg/kg)	10000	V	6800	V	16000	V	17000	V	16000	V	20000	V	20000	V
Lead	300	Metals (mg/kg)	7	V	5.1	V	13	V	10	V	11	V	9.1	V	12	V
Magnesium	NE	Metals (mg/kg)	2500	V	1500	V	3800	V	5000	V	4800	V	4600	V	4400	V
Manganese	180	Metals (mg/kg)	200	V	100	V	310	V	280	V	290	V	330	V	360	V
Mercury	2.3	Metals (mg/kg)	0.044	U	0.0069	J	0.018	J	0.011	J	0.013	J	0.046	U	0.0084	J
Nickel	20	Metals (mg/kg)	18	V	9.3	V	25	V	27	V	27	V	27	V	27	V
Potassium	NE	Metals (mg/kg)	800	V	350	V	1000	V	1000	V	1400	V	2200	V	1400	V
Thallium	1	Metals (mg/kg)	1.1	U	1.1	U	1.1	U	1.2	U	1.1	U	1.15	U	1.1	U
Vanadium	55	Metals (mg/kg)	10	V	8.2	V	13	V	16	V	17	V	18	V	15	V
Zinc	2,300	Metals (mg/kg)	20	V	13	V	32	V	30	V	35	V	41	V	39	V
Anthracene	1,000	PAH (µg/kg)	180	U			185	U	200	U						
Benzo(a)anthracene	620	PAH (µg/kg)	180	U			185	U	200	U						
Benzo(a)pyrene	62	PAH (µg/kg)	7	U			81	V	27	V						
Benzo(b)fluoranthene	620	PAH (µg/kg)	180	U			185	U	200	U						
Benzo(g,h,i)perylene	2,500	PAH (µg/kg)	180	U			185	U	200	U						
Benzo(k)fluoranthene	6,200	PAH (µg/kg)	180	U			185	U	200	U						
Chrysene	7,000	PAH (µg/kg)	180	U			185	U	200	U						
Dibenz(a,h)Anthracene	62	PAH (µg/kg)	7	U			7.5	U	8	U						
Fluoranthene	230,000	PAH (µg/kg)	180	U			185	U	200	U						
Indeno(1,2,3-c,d)Pyrene	620	PAH (µg/kg)	180	U			185	U	200	U						
Naphthalene	4,000	PAH (µg/kg)	2.1	U			2.4	U	2.2	U						
Phenanthrene	100,000	PAH (µg/kg)	180	U			185	U	200	U						
Pyrene	230,000	PAH (µg/kg)	180	U			185	U	200	U						
Total PCBs	220	PCBs (µg/kg)	18.1	U			18.7	U	20.1	U						
4,4-DDE	170	Pesticides (µg/kg)	1.81	U			9.35	U	2.01	U						
4,4-DDT	170	Pesticides (µg/kg)	4.73	V			9.35	U	2.01	U						
Aldrin	29	Pesticides (µg/kg)	1.81	U			103	V	15.3	V						
Dieldrin	30	Pesticides (µg/kg)	3.76	V			183	V	30.3	V						
Aliphatic Hydrocarbons (C_{19}-C_{36})	3,000	TPH (mg/kg)	3.625	U			3.745	U	4.015	U						
Aromatic Hydrocarbons (C_{11}-C_{22})	800	TPH (mg/kg)	3.625	U			3.745	U	4.015	U						
Acetone	60,000	VOCs (µg/kg)	8.8	V			36	V	32	V						
m,p-Xylenes	500	VOCs (µg/kg)	0.42	U			0.485	U	0.44	U						
p-Isopropyltoluene	NE	VOCs (µg/kg)	0.42	U			0.485	U	0.44	U						
Toluene	500	VOCs (µg/kg)	0.6	U			1.5	V	0.65	U						

Notes:
mg/kg = Milligrams per kilogram (parts per million)
µg/kg = Micrograms per kilogram (parts per billion)
ng/kg = Nanograms per kilogram (parts per trillion)
V = Valid result; substance detected.
J = Estimated result; substance detected, but below the detection limit.
U = Substance not detected; detection limit listed.
Highlighted results were detected above their Project Action Level.

Table 6-10a
IA-10 Summary of Screened Results

Analyte	Project Action Level	Analyte Category (units)	GRB-03-03X 0-3 ft		GRB-03-03X 3-6 ft		GRB-03-03X 6-10 ft		GRB-03-04X 0-3 ft		GRB-03-04X 3-6 ft		GRB-03-04X 6-10 ft		GRB-03-05X 0-3 ft	
Aluminum	7,600	Metals (mg/kg)	7500	V	7200	V	7500	V	8100	V	7700	V	3700	V	5800	V
Antimony	3.1	Metals (mg/kg)														
Arsenic	0.39	Metals (mg/kg)	24	V	14	V	12	V	12	V	18	V	18	V	20	V
Barium	540	Metals (mg/kg)														
Calcium	NE	Metals (mg/kg)														
Chromium	30	Metals (mg/kg)														
Cobalt	500	Metals (mg/kg)														
Copper	310	Metals (mg/kg)														
Iron	2,300	Metals (mg/kg)	12000	V	8700	V	9000	V	10000	V	10000	V	21000	V	10000	V
Lead	300	Metals (mg/kg)														
Magnesium	NE	Metals (mg/kg)														
Manganese	180	Metals (mg/kg)	250	V	95	V	170	V	320	V	300	V	640	V	240	V
Mercury	2.3	Metals (mg/kg)														
Nickel	20	Metals (mg/kg)	25	V	16	V	11	V	12	V	17	V	57	V	23	V
Potassium	NE	Metals (mg/kg)														
Thallium	1	Metals (mg/kg)														
Vanadium	55	Metals (mg/kg)														
Zinc	2,300	Metals (mg/kg)														
Anthracene	1,000	PAH (µg/kg)														
Benzo(a)anthracene	620	PAH (µg/kg)														
Benzo(a)pyrene	62	PAH (µg/kg)														
Benzo(b)fluoranthene	620	PAH (µg/kg)														
Benzo(g,h,i)perylene	2,500	PAH (µg/kg)														
Benzo(k)fluoranthene	6,200	PAH (µg/kg)														
Chrysene	7,000	PAH (µg/kg)														
Dibenz(a,h)Anthracene	62	PAH (µg/kg)														
Fluoranthene	230,000	PAH (µg/kg)														
Indeno(1,2,3-c,d)Pyrene	620	PAH (µg/kg)														
Naphthalene	4,000	PAH (µg/kg)														
Phenanthrene	100,000	PAH (µg/kg)														
Pyrene	230,000	PAH (µg/kg)														
Total PCBs	220	PCBs (µg/kg)														
4,4-DDE	170	Pesticides (µg/kg)														
4,4-DDT	170	Pesticides (µg/kg)														
Aldrin	29	Pesticides (µg/kg)														
Dieldrin	30	Pesticides (µg/kg)														
Aliphatic Hydrocarbons (C_{19}-C_{36})	3,000	TPH (mg/kg)														
Aromatic Hydrocarbons (C_{11}-C_{22})	800	TPH (mg/kg)														
Acetone	60,000	VOCs (µg/kg)														
m,p-Xylenes	500	VOCs (µg/kg)														
p-Isopropyltoluene	NE	VOCs (µg/kg)														
Toluene	50	VOCs (µg/kg)														

Notes:
mg/kg = Milligrams per kilogram (parts per million)
µg/kg = Micrograms per kilogram (parts per billion)
ng/kg = Nanograms per kilogram (parts per trillion)
V = Valid result; substance detected.
J = Estimated result; substance detected, but below the detection limit.
U = Substance not detected; detection limit listed.
Highlighted results were detected above their Project Action Level.

Table 6-10a
IA-10 Summary of Screened Results

Analyte	Project Action Level	Analyte Category (units)	PASI-GR-CO-050-1 0-3 ft	PASI-GR-CO-051-1 0-3 ft	PASI-GR-CO-052-1 0-3 ft	PASI-GR-CO-053-1 0-3 ft	PASI-GR-CO-054-1 0-3 ft	PASI-GR-CO-055-1 0-3 ft	PASI-GR-CO-056-1 0-3 ft
Total PCBs	220	PCBs (µg/kg)	14.5 U	14.5 U	14.5 U	14 U	14.5 U	15 U	14.5 U

Analyte	Project Action Level	Analyte Category (units)	PASI-GR-GB-205-1	PASI-GR-GB-206-1	PASI-GR-GB-207-1	PASI-GR-GB-208-1	PASI-GR-GB-209-1	PASI-GR-GB-210-1	PASI-GR-GB-211-1
Total PCBs	220	PCBs (µg/kg)	5	5	5.5	5	5	5	5.5

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µg/kg = Micrograms per kilogram (parts per billion)
ng/kg = Nanograms per kilogram (parts per trillion)
V = Valid result; substance detected.
J = Estimated result; substance detected, but below the detection limit.
U = Substance not detected; detection limit listed.
Highlighted results were detected above their Project Action Level.

Table 6-10a
IA-10 Summary of Screened Results

Analyte	Project Action Level	Analyte Category (units)	GR-IA02-SB25-1 3-10 ft		GR-IA02-SB26-1 0-3 ft		GR-IA02-SB26-1 3-10 ft		GR-IA02-SB27-1 0-3 ft		GR-IA02-SB27-1 3-10 ft		GR-IA02-SB28-1 0-3 ft		GR-IA02-SB28-1 3-10 ft	
Aluminum	7,600	Metals (mg/kg)	16000	V	12000	V	9600	V	6800	V	6400	V	7100	V	2800	V
Antimony	3.1	Metals (mg/kg)	1.1	U	1.15	U	1.1	U	1.1	U	1.1	U	1.1	U	1.05	U
Arsenic	0.39	Metals (mg/kg)	21	V	13	V	26	V	8.7	V	14	V	25	V	25	V
Barium	540	Metals (mg/kg)	45	V	22	V	21	V	36	V	24	V	15	V	8.4	V
Calcium	NE	Metals (mg/kg)	560	V	430	V	420	V	980	V	730	V	410	V	2100	V
Chromium	30	Metals (mg/kg)	23	V	13	V	18	V	18	V	12	V	11	V	6.4	V
Cobalt	500	Metals (mg/kg)	10	V	4.1	V	6.3	V	4.2	V	6.4	V	6	V	5.3	V
Copper	310	Metals (mg/kg)	17	V	5.2	V	10	V	6.4	V	13	V	13	V	12	V
Iron	2,300	Metals (mg/kg)	22000	V	11000	V	12000	V	8200	V	11000	V	9700	V	7200	V
Lead	300	Metals (mg/kg)	13	V	10	V	6.9	V	3.1	V	8	V	11	V	6.4	V
Magnesium	NE	Metals (mg/kg)	4600	V	2000	V	3600	V	2500	V	1900	V	1700	V	1200	V
Manganese	180	Metals (mg/kg)	400	V	170	V	200	V	170	V	250	V	200	V	190	V
Mercury	2.3	Metals (mg/kg)	0.0445	U	0.027	J	0.011	J	0.041	U	0.0425	U	0.014	J	0.04	U
Nickel	20	Metals (mg/kg)	30	V	11	V	18	V	10	V	18	V	18	V	17	V
Potassium	NE	Metals (mg/kg)	2300	V	400	V	960	V	1700	V	1000	V	530	V	350	V
Thallium	1	Metals (mg/kg)	1.1	U	1.15	U	1.1	U	1.1	U	1.1	U	1.1	U	1.05	U
Vanadium	55	Metals (mg/kg)	18	V	13	V	12	V	14	V	9.1	V	8.7	V	4.6	V
Zinc	2,300	Metals (mg/kg)	44	V	21	V	23	V	15	V	22	V	20	V	14	V
Anthracene	1,000	PAH (µg/kg)														
Benzo(a)anthracene	620	PAH (µg/kg)														
Benzo(a)pyrene	62	PAH (µg/kg)														
Benzo(b)fluoranthene	620	PAH (µg/kg)														
Benzo(g,h,i)perylene	2,500	PAH (µg/kg)														
Benzo(k)fluoranthene	6,200	PAH (µg/kg)														
Chrysene	7,000	PAH (µg/kg)														
Dibenz(a,h)Anthracene	62	PAH (µg/kg)														
Fluoranthene	230,000	PAH (µg/kg)														
Indeno(1,2,3-c,d)Pyrene	620	PAH (µg/kg)														
Naphthalene	4,000	PAH (µg/kg)														
Phenanthrene	100,000	PAH (µg/kg)														
Pyrene	230,000	PAH (µg/kg)														
Total PCBs	220	PCBs (µg/kg)														
4,4-DDE	170	Pesticides (µg/kg)														
4,4-DDT	170	Pesticides (µg/kg)														
Aldrin	29	Pesticides (µg/kg)														
Dieldrin	30	Pesticides (µg/kg)														
Aliphatic Hydrocarbons (C_{19}-C_{36})	3,000	TPH (mg/kg)														
Aromatic Hydrocarbons (C_{11}-C_{22})	800	TPH (mg/kg)														
Acetone	60,000	VOCs (µg/kg)														
m,p-Xylenes	500	VOCs (µg/kg)														
p-Isopropyltoluene	NE	VOCs (µg/kg)														
Toluene	500	VOCs (µg/kg)														

Notes:
mg/kg = Milligrams per kilogram (parts per million)
µg/kg = Micrograms per kilogram (parts per billion)
ng/kg = Nanograms per kilogram (parts per trillion)
V = Valid result; substance detected.
J = Estimated result; substance detected, but below the detection limit.
U = Substance not detected; detection limit listed.
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Table 6-10a
IA-10 Summary of Screened Results

Analyte	Project Action Level	Analyte Category (units)	GRB-03-05X 3-6 ft		GRB-03-06X 0-3 ft		GRB-03-06X 3-6 ft		GRB-03-06X 6-10 ft		GRB-03-07X 0-3 ft		GRB-03-07X 3-6 ft		GRB-03-07X 6-10 ft	
Aluminum	7,600	Metals (mg/kg)	13000	V	6500	V	4200	V	3000	V	5200	V	2900	V	5000	V
Antimony	3.1	Metals (mg/kg)														
Arsenic	0.39	Metals (mg/kg)	26	V	12	V	10	V	9	V	34	V	17	V	32	V
Barium	540	Metals (mg/kg)														
Calcium	NE	Metals (mg/kg)														
Chromium	30	Metals (mg/kg)														
Cobalt	500	Metals (mg/kg)														
Copper	310	Metals (mg/kg)														
Iron	2,300	Metals (mg/kg)	16000	V	8100	V	7300	V	5300	V	12000	V	6700	V	12000	V
Lead	300	Metals (mg/kg)														
Magnesium	NE	Metals (mg/kg)														
Manganese	180	Metals (mg/kg)	280	V	91	V	120	V	99	V	220	V	110	V	230	V
Mercury	2.3	Metals (mg/kg)														
Nickel	20	Metals (mg/kg)	29	V	9.9	V	11	V	7.6	V	32	V	14	V	27	V
Potassium	NE	Metals (mg/kg)														
Thallium	1	Metals (mg/kg)														
Vanadium	55	Metals (mg/kg)														
Zinc	2,300	Metals (mg/kg)														
Anthracene	1,000	PAH (µg/kg)														
Benzo(a)anthracene	620	PAH (µg/kg)														
Benzo(a)pyrene	62	PAH (µg/kg)														
Benzo(b)fluoranthene	620	PAH (µg/kg)														
Benzo(g,h,i)perylene	2,500	PAH (µg/kg)														
Benzo(k)fluoranthene	6,200	PAH (µg/kg)														
Chrysene	7,000	PAH (µg/kg)														
Dibenz(a,h)Anthracene	62	PAH (µg/kg)														
Fluoranthene	230,000	PAH (µg/kg)														
Indeno(1,2,3-c,d)Pyrene	620	PAH (µg/kg)														
Naphthalene	4,000	PAH (µg/kg)														
Phenanthrene	100,000	PAH (µg/kg)														
Pyrene	230,000	PAH (µg/kg)														
Total PCBs	220	PCBs (µg/kg)														
4,4-DDE	170	Pesticides (µg/kg)														
4,4-DDT	170	Pesticides (µg/kg)														
Aldrin	29	Pesticides (µg/kg)														
Dieldrin	30	Pesticides (µg/kg)														
Aliphatic Hydrocarbons (C_{19}-C_{36})	3,000	TPH (mg/kg)														
Aromatic Hydrocarbons (C_{11}-C_{22})	800	TPH (mg/kg)														
Acetone	60,000	VOCs (µg/kg)														
m,p-Xylenes	500	VOCs (µg/kg)														
p-Isopropyltoluene	NE	VOCs (µg/kg)														
Toluene	50	VOCs (µg/kg)														

Notes:
mg/kg = Milligrams per kilogram (parts per million)
µg/kg = Micrograms per kilogram (parts per billion)
ng/kg = Nanograms per kilogram (parts per trillion)
V = Valid result; substance detected.
J = Estimated result; substance detected, but below the detection limit.
U = Substance not detected; detection limit listed.
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Table 6-10a
IA-10 Summary of Screened Results

Analyte	Project Action Level	Analyte Category (units)	PASI-GR-CO-057-1 0-3 ft	PASI-GR-CO-058-1 0-3 ft	PASI-GR-CO-059-1 0-3 ft	PASI-GR-CO-060-1 0-3 ft	PASI-GR-CO-061-1 0-3 ft	PASI-GR-CO-062-1 0-3 ft	PASI-GR-CO-063-1 0-3 ft
Total PCBs	220	PCBs (µg/kg)	15 U	14.5 U	14.5 U	14 U	15 U	14.5 U	13.5 U

Analyte	Project Action Level	Analyte Category (units)	PASI-GR-GB-212-1	PASI-GR-GB-213-1	PASI-GR-GB-214-1	PASI-GR-GB-215-1	PASI-GR-GB-216-1	PASI-GR-GB-218-1	PASI-GR-GB-220-1
Total PCBs	220	PCBs (µg/kg)	6.5	4.6	4.5	4.55	4.45	4.85	6

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J = Estimated result; substance detected, but below the detection limit.
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Table 6-10a
IA-10 Summary of Screened Results

Analyte	Project Action Level	Analyte Category (units)	GR-IA02-SB30-1 0-3 ft		GR-IA02-SB30-1-M 3-10 ft		GR-IA02-SS01-1 0-1.5 ft		GR-IA05-SB01-1 0-3 ft		GR-IA05-SB02-1 0-3 ft		GR-IA05-SB02-1 3-10 ft		GR-IA05-SB03-1 0-3 ft	
Aluminum	7,600	Metals (mg/kg)	6900	V	4400	V	10000	V	9800	V	8000	V	9000	V	10000	V
Antimony	3.1	Metals (mg/kg)	1.1	U	1.05	U	1.5	U	1.2	U	1.1	U	1.05	U	1.2	U
Arsenic	0.39	Metals (mg/kg)	15	V	12	V	18	V	28	V	22	V	24	V	21	V
Barium	540	Metals (mg/kg)	14	V	9.3	V	44	V	23	V	8.2	V	22	V	23	V
Calcium	NE	Metals (mg/kg)	370	V	490	V	2500	V	580	V	160	V	420	V	450	V
Chromium	30	Metals (mg/kg)	13	V	11	V	26	V	22	V	16	V	29	V	18	V
Cobalt	500	Metals (mg/kg)	4.5	V	3.4	V	7.5	V	6.4	V	4.2	V	6	V	5.2	V
Copper	310	Metals (mg/kg)	7.3	V	6	V	46	V	13	V	7.2	V	12	V	6.4	V
Iron	2,300	Metals (mg/kg)	9000	V	8000	V	28000	V	11000	V	11000	V	13000	V	11000	V
Lead	300	Metals (mg/kg)	5.9	V	3.4	V	50	V	19	V	24	V	6.6	V	16	V
Magnesium	NE	Metals (mg/kg)	2600	V	2400	V	2400	V	3500	V	3400	V	5000	V	3200	V
Manganese	180	Metals (mg/kg)	140	V	120	V	510	V	200	V	110	V	180	V	340	V
Mercury	2.3	Metals (mg/kg)	0.046	U	0.0395	U	0.11	J	0.026	J	0.011	J	0.043	U	0.037	J
Nickel	20	Metals (mg/kg)	14	V	12	V	28	V	21	V	17	V	23	V	19	V
Potassium	NE	Metals (mg/kg)	460	V	440	V	680	V	1200	V	320	V	1400	V	600	V
Thallium	1	Metals (mg/kg)	1.1	U	0.42	J	1.5	U	1.05	U	1.1	U	1.05	U	1.2	U
Vanadium	55	Metals (mg/kg)	9.9	V	7.3	V	14	V	14	V	11	V	15	V	15	V
Zinc	2,300	Metals (mg/kg)	18	V	16	V	96	V	20	V	19	V	22	V	26	V
Anthracene	1,000	PAH (µg/kg)	185	U	175	U										
Benzo(a)anthracene	620	PAH (µg/kg)	185	U	175	U										
Benzo(a)pyrene	62	PAH (µg/kg)	7.5	U	7	U										
Benzo(b)fluoranthene	620	PAH (µg/kg)	185	U	175	U										
Benzo(g,h,i)perylene	2,500	PAH (µg/kg)	185	U	175	U										
Benzo(k)fluoranthene	6,200	PAH (µg/kg)	185	U	175	U										
Chrysene	7,000	PAH (µg/kg)	185	U	175	U										
Dibenz(a,h)Anthracene	62	PAH (µg/kg)	7.5	U	7	U										
Fluoranthene	230,000	PAH (µg/kg)	185	U	175	U										
Indeno(1,2,3-c,d)Pyrene	620	PAH (µg/kg)	185	U	175	U										
Naphthalene	4,000	PAH (µg/kg)	2.8	U	1.85	U										
Phenanthrene	100,000	PAH (µg/kg)	185	U	175	U										
Pyrene	230,000	PAH (µg/kg)	185	U	175	U										
Total PCBs	220	PCBs (µg/kg)	18.7	U	17.55	U										
4,4-DDE	170	Pesticides (µg/kg)	247	V	13.2	V										
4,4-DDT	170	Pesticides (µg/kg)	751	V	22.8	V										
Aldrin	29	Pesticides (µg/kg)	93.5	U	1.755	U										
Dieldrin	30	Pesticides (µg/kg)	93.5	U	1.755	U										
Aliphatic Hydrocarbons (C_{19}-C_{36})	3,000	TPH (mg/kg)	3.745	U	3.51	U										
Aromatic Hydrocarbons (C_{11}-C_{22})	800	TPH (mg/kg)	3.745	U	3.51	U										
Acetone	60,000	VOCs (µg/kg)	33	V	3.7	U										
m,p-Xylenes	500	VOCs (µg/kg)	0.55	U	0.37	U										
p-Isopropyltoluene	NE	VOCs (µg/kg)	0.55	U	0.37	U										
Toluene	500	VOCs (µg/kg)	0.85	U	0.55	U										

Notes:
mg/kg = Milligrams per kilogram (parts per million)
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V = Valid result; substance detected.
J = Estimated result; substance detected, but below the detection limit.
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Table 6-10a
IA-10 Summary of Screened Results

Analyte	Project Action Level	Analyte Category (units)	GRB-03-08X 0-3 ft		GRB-03-08X 3-6 ft		GRB-03-08X 6-10 ft		GRB-03-09X 0-3 ft		GRB-03-09X 3-6 ft		GRB-03-09X 6-10 ft		PASI-GR-GB-301-1 0-0 ft	
Aluminum	7,600	Metals (mg/kg)	9600	V	9200	V	8500	V	8200	V	5100	V	2000	V	4760	V
Antimony	3.1	Metals (mg/kg)														
Arsenic	0.39	Metals (mg/kg)	27	V	22	V	19	V	68	V	28	V	15	V	13.1	V
Barium	540	Metals (mg/kg)														
Calcium	NE	Metals (mg/kg)														
Chromium	30	Metals (mg/kg)														
Cobalt	500	Metals (mg/kg)														
Copper	310	Metals (mg/kg)														
Iron	2,300	Metals (mg/kg)	16000	V	14000	V	14000	V	23000	V	13000	V	5000	V	7200	V
Lead	300	Metals (mg/kg)														
Magnesium	NE	Metals (mg/kg)														
Manganese	180	Metals (mg/kg)	270	V	270	V	260	V	280	V	320	V	83	V	127	V
Mercury	2.3	Metals (mg/kg)														
Nickel	20	Metals (mg/kg)	32	V	30	V	28	V	73	V	29	V	8.4	V	13.3	V
Potassium	NE	Metals (mg/kg)														
Thallium	1	Metals (mg/kg)														
Vanadium	55	Metals (mg/kg)														
Zinc	2,300	Metals (mg/kg)														
Anthracene	1,000	PAH (µg/kg)														
Benzo(a)anthracene	620	PAH (µg/kg)														
Benzo(a)pyrene	62	PAH (µg/kg)														
Benzo(b)fluoranthene	620	PAH (µg/kg)														
Benzo(g,h,i)perylene	2,500	PAH (µg/kg)														
Benzo(k)fluoranthene	6,200	PAH (µg/kg)														
Chrysene	7,000	PAH (µg/kg)														
Dibenz(a,h)Anthracene	62	PAH (µg/kg)														
Fluoranthene	230,000	PAH (µg/kg)														
Indeno(1,2,3-c,d)Pyrene	620	PAH (µg/kg)														
Naphthalene	4,000	PAH (µg/kg)														
Phenanthrene	100,000	PAH (µg/kg)														
Pyrene	230,000	PAH (µg/kg)														
Total PCBs	220	PCBs (µg/kg)														
4,4-DDE	170	Pesticides (µg/kg)														
4,4-DDT	170	Pesticides (µg/kg)														
Aldrin	29	Pesticides (µg/kg)														
Dieldrin	30	Pesticides (µg/kg)														
Aliphatic Hydrocarbons (C_{19}-C_{36})	3,000	TPH (mg/kg)														
Aromatic Hydrocarbons (C_{11}-C_{22})	800	TPH (mg/kg)														
Acetone	60,000	VOCs (µg/kg)														
m,p-Xylenes	500	VOCs (µg/kg)														
p-Isopropyltoluene	NE	VOCs (µg/kg)														
Toluene	50	VOCs (µg/kg)														

Notes:
mg/kg = Milligrams per kilogram (parts per million)
µg/kg = Micrograms per kilogram (parts per billion)
ng/kg = Nanograms per kilogram (parts per trillion)
V = Valid result; substance detected.
J = Estimated result; substance detected, but below the detection limit.
U = Substance not detected; detection limit listed.
Highlighted results were detected above their Project Action Level.

Table 6-10a
IA-10 Summary of Screened Results

Analyte	Project Action Level	Analyte Category (units)	PASI-GR-CO-064-1 0-3 ft	PASI-GR-CO-065-1 0-3 ft	PASI-GR-CO-066-1 0-3 ft	PASI-GR-CO-067-1 0-3 ft	PASI-GR-CO-068-1 0-3 ft	PASI-GR-CO-069-1 0-3 ft	PASI-GR-CO-070-1 0-3 ft
Total PCBs	220	PCBs (µg/kg)	14 U	14 U	13.5 U	14 U	15 U	14 U	13.5 U

Analyte	Project Action Level	Analyte Category (units)	PASI-GR-GB-221-1	PASI-GR-GB-222-1	PASI-GR-GB-223-1	PASI-GR-GB-224-1	PASI-GR-GB-225-1	PASI-GR-GB-226-1	PASI-GR-GB-227-1
Total PCBs	220	PCBs (µg/kg)	5.5	5.5	5	4.6	6	15.5	5.5

Notes:
mg/kg = Milligrams per kilogram (parts per million)
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ng/kg = Nanograms per kilogram (parts per trillion)
V = Valid result; substance detected.
J = Estimated result; substance detected, but below the detection limit.
U = Substance not detected; detection limit listed.
Highlighted results were detected above their Project Action Level.

Table 6-10a
IA-10 Summary of Screened Results

Analyte	Project Action Level	Analyte Category (units)	GR-IA05-SB03-1 3-10 ft		GR-IA05-SB04-1 0-3 ft		GR-IA05-SB04-1 3-10 ft		GR-IA05-SB05-1 0-3 ft		GR-IA05-SB05-1 3-10 ft		GR-IA05-SB06-1 0-3 ft		GR-IA05-SB06-1 3-10 ft	
Aluminum	7,600	Metals (mg/kg)	6700	V	12000	V	7100	V	9200	V	6200	V	7700	V	5100	V
Antimony	3.1	Metals (mg/kg)	1.1	U	1.15	U	1.05	U	1.15	U	1.05	U	1.1	U	1.05	U
Arsenic	0.39	Metals (mg/kg)	35	V	22	V	33	V	25	V	22	V	21	V	24	V
Barium	540	Metals (mg/kg)	14	V	27	V	23	V	22	V	18	V	16	V	18	V
Calcium	NE	Metals (mg/kg)	990	V	560	V	440	V	410	V	520	V	540	V	600	V
Chromium	30	Metals (mg/kg)	18	V	33	V	23	V	18	V	15	V	16	V	14	V
Cobalt	500	Metals (mg/kg)	6.1	V	7	V	7.3	V	5.7	V	5.6	V	4.8	V	6.6	V
Copper	310	Metals (mg/kg)	11	V	8.5	V	15	V	8.7	V	13	V	9.5	V	14	V
Iron	2,300	Metals (mg/kg)	13000	V	14000	V	11000	V	10000	V	9200	V	8400	V	9300	V
Lead	300	Metals (mg/kg)	9	V	8.7	V	7.6	V	14	V	7.4	V	18	V	10	V
Magnesium	NE	Metals (mg/kg)	3700	V	4700	V	3400	V	2300	V	2600	V	2200	V	2800	V
Manganese	180	Metals (mg/kg)	220	V	270	V	230	V	270	V	160	V	170	V	180	V
Mercury	2.3	Metals (mg/kg)	0.041	U	0.023	J	0.042	U	0.027	J	0.042	U	0.019	J	0.0425	U
Nickel	20	Metals (mg/kg)	23	V	24	V	25	V	18	V	18	V	16	V	22	V
Potassium	NE	Metals (mg/kg)	710	V	1800	V	1300	V	760	V	1000	V	620	V	1000	V
Thallium	1	Metals (mg/kg)	1.1	U	1.15	U	1.05	U	1.15	U	1.05	U	1.1	U	1.05	U
Vanadium	55	Metals (mg/kg)	11	V	21	V	14	V	13	V	11	V	10	V	11	V
Zinc	2,300	Metals (mg/kg)	23	V	26	V	22	V	22	V	18	V	20	V	24	V
Anthracene	1,000	PAH (µg/kg)														
Benzo(a)anthracene	620	PAH (µg/kg)														
Benzo(a)pyrene	62	PAH (µg/kg)														
Benzo(b)fluoranthene	620	PAH (µg/kg)														
Benzo(g,h,i)perylene	2,500	PAH (µg/kg)														
Benzo(k)fluoranthene	6,200	PAH (µg/kg)														
Chrysene	7,000	PAH (µg/kg)														
Dibenz(a,h)Anthracene	62	PAH (µg/kg)														
Fluoranthene	230,000	PAH (µg/kg)														
Indeno(1,2,3-c,d)Pyrene	620	PAH (µg/kg)														
Naphthalene	4,000	PAH (µg/kg)														
Phenanthrene	100,000	PAH (µg/kg)														
Pyrene	230,000	PAH (µg/kg)														
Total PCBs	220	PCBs (µg/kg)														
4,4-DDE	170	Pesticides (µg/kg)														
4,4-DDT	170	Pesticides (µg/kg)														
Aldrin	29	Pesticides (µg/kg)														
Dieldrin	30	Pesticides (µg/kg)														
Aliphatic Hydrocarbons (C_{19}-C_{36})	3,000	TPH (mg/kg)														
Aromatic Hydrocarbons (C_{11}-C_{22})	800	TPH (mg/kg)														
Acetone	60,000	VOCs (µg/kg)														
m,p-Xylenes	500	VOCs (µg/kg)														
p-Isopropyltoluene	NE	VOCs (µg/kg)														
Toluene	500	VOCs (µg/kg)														

Notes:
mg/kg = Milligrams per kilogram (parts per million)
µg/kg = Micrograms per kilogram (parts per billion)
ng/kg = Nanograms per kilogram (parts per trillion)
V = Valid result; substance detected.
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Table 6-10a
IA-10 Summary of Screened Results

Analyte	Project Action Level	Analyte Category (units)	PASI-GR-GB-301-2 0-0 ft		PASI-GR-GB-302-1 0-0 ft		PASI-GR-GB-302-2 0-0 ft		PASI-GR-GB-303-1 0-0 ft		PASI-GR-GB-303-2 0-0 ft		PASI-GR-GB-304-1 0-0 ft		PASI-GR-GB-304-2 0-0 ft	
Aluminum	7,600	Metals (mg/kg)	8840	V	8270	V	9700	V	9830	V	8980	V	9270	V	8350	V
Antimony	3.1	Metals (mg/kg)														
Arsenic	0.39	Metals (mg/kg)	66.4	V	27.3	V	25.3	V	29.8	V	35.9	V	44.7	V	25.7	V
Barium	540	Metals (mg/kg)														
Calcium	NE	Metals (mg/kg)														
Chromium	30	Metals (mg/kg)														
Cobalt	500	Metals (mg/kg)														
Copper	310	Metals (mg/kg)														
Iron	2,300	Metals (mg/kg)	18800	V	11500	V	11800	V	14600	V	14400	V	17400	V	16300	V
Lead	300	Metals (mg/kg)														
Magnesium	NE	Metals (mg/kg)														
Manganese	180	Metals (mg/kg)	384	V	196	V	185	V	252	V	365	V	247	V	256	V
Mercury	2.3	Metals (mg/kg)														
Nickel	20	Metals (mg/kg)	33.3	V	23.7	V	21.5	V	27.4	V	28.1	V	34.6	V	30.8	V
Potassium	NE	Metals (mg/kg)														
Thallium	1	Metals (mg/kg)														
Vanadium	55	Metals (mg/kg)														
Zinc	2,300	Metals (mg/kg)														
Anthracene	1,000	PAH (µg/kg)														
Benzo(a)anthracene	620	PAH (µg/kg)														
Benzo(a)pyrene	62	PAH (µg/kg)														
Benzo(b)fluoranthene	620	PAH (µg/kg)														
Benzo(g,h,i)perylene	2,500	PAH (µg/kg)														
Benzo(k)fluoranthene	6,200	PAH (µg/kg)														
Chrysene	7,000	PAH (µg/kg)														
Dibenz(a,h)Anthracene	62	PAH (µg/kg)														
Fluoranthene	230,000	PAH (µg/kg)														
Indeno(1,2,3-c,d)Pyrene	620	PAH (µg/kg)														
Naphthalene	4,000	PAH (µg/kg)														
Phenanthrene	100,000	PAH (µg/kg)														
Pyrene	230,000	PAH (µg/kg)														
Total PCBs	220	PCBs (µg/kg)														
4,4-DDE	170	Pesticides (µg/kg)														
4,4-DDT	170	Pesticides (µg/kg)														
Aldrin	29	Pesticides (µg/kg)														
Dieldrin	30	Pesticides (µg/kg)														
Aliphatic Hydrocarbons (C_{19}-C_{36})	3,000	TPH (mg/kg)														
Aromatic Hydrocarbons (C_{11}-C_{22})	800	TPH (mg/kg)														
Acetone	60,000	VOCs (µg/kg)														
m,p-Xylenes	500	VOCs (µg/kg)														
p-Isopropyltoluene	NE	VOCs (µg/kg)														
Toluene	50	VOCs (µg/kg)														

Notes:
mg/kg = Milligrams per kilogram (parts per million)
µg/kg = Micrograms per kilogram (parts per billion)
ng/kg = Nanograms per kilogram (parts per trillion)
V = Valid result; substance detected.
J = Estimated result; substance detected, but below the detection limit.
U = Substance not detected; detection limit listed.
Highlighted results were detected above their Project Action Level.

Table 6-10a
IA-10 Summary of Screened Results

Analyte	Project Action Level	Analyte Category (units)	PASI-GR-CO-071-1 0-3 ft	PASI-GR-CO-072-1 0-3 ft	PASI-GR-CO-073-1 0-3 ft	PASI-GR-CO-074-1 0-3 ft	PASI-GR-CO-075-1 0-3 ft	PASI-GR-GB-006A-1 0-3 ft	PASI-GR-GB-006B-1 0-3 ft
Total PCBs	220	PCBs (µg/kg)	14 U	13.5 U	14 U	14 U	14 U	15.5 U	14.5 U

Analyte	Project Action Level	Analyte Category (units)	PASI-GR-GB-228-1	PASI-GR-GB-229-1	PASI-GR-GB-230-1	PASI-GR-GB-231-1	PASI-GR-GB-232-1	PASI-GR-GB-233-1	PASI-GR-GB-234-1 0.75-3.75 ft
Total PCBs	220	PCBs (µg/kg)	4.55	4.65	4.6	5	5	14.5	16

Notes:
mg/kg = Milligrams per kilogram (parts per million)
µg/kg = Micrograms per kilogram (parts per billion)
ng/kg = Nanograms per kilogram (parts per trillion)
V = Valid result; substance detected.
J = Estimated result; substance detected, but below the detection limit.
U = Substance not detected; detection limit listed.
Highlighted results were detected above their Project Action Level.

Table 6-10a
IA-10 Summary of Screened Results

Analyte	Project Action Level	Analyte Category (units)	GR-IA05-SB07-1 0-3 ft		GR-IA05-SB07-1 3-10 ft		GR-IA05-SB08-1 0-3 ft		GR-IA05-SB08-1 3-10 ft		GR-IA05-SB09-1 0-3 ft		GR-IA05-SB09-1 3-10 ft		GR-IA05-SS01-1 0-1.5 ft	
Aluminum	7,600	Metals (mg/kg)	8400	V	10000	V	8500	V	7900	V	6200	V	7400	V	8300	V
Antimony	3.1	Metals (mg/kg)	1.15	U	1.1	U	1.15	U	1.1	U	1.1	U	1.1	U	1.15	U
Arsenic	0.39	Metals (mg/kg)	23	V	30	V	24	V	38	V	32	V	23	V	25	V
Barium	540	Metals (mg/kg)	13	V	32	V	22	V	20	V	18	V	14	V	16	V
Calcium	NE	Metals (mg/kg)	290	V	560	V	860	V	640	V	1600	V	280	V	350	V
Chromium	30	Metals (mg/kg)	13	V	26	V	20	V	17	V	17	V	17	V	17	V
Cobalt	500	Metals (mg/kg)	4.2	V	9	V	6.5	V	6.2	V	7.7	V	5.1	V	4.9	V
Copper	310	Metals (mg/kg)	6.4	V	18	V	13	V	12	V	37	V	68	V	8.7	V
Iron	2,300	Metals (mg/kg)	9100	V	15000	V	12000	V	11000	V	13000	V	9800	V	10000	V
Lead	300	Metals (mg/kg)	21	V	8.1	V	17	V	12	V	8.1	V	7.2	V	36	V
Magnesium	NE	Metals (mg/kg)	2000	V	5400	V	2900	V	3000	V	2800	V	2900	V	2000	V
Manganese	180	Metals (mg/kg)	130	V	250	V	280	V	190	V	300	V	170	V	340	V
Mercury	2.3	Metals (mg/kg)	0.024	J	0.04	U	0.016	J	0.01	J	0.0044	J	0.0088	J	0.068	J
Nickel	20	Metals (mg/kg)	15	V	30	V	52	V	24	V	27	V	18	V	17	V
Potassium	NE	Metals (mg/kg)	330	V	2000	V	860	V	1000	V	840	V	870	V	370	V
Thallium	1	Metals (mg/kg)	1.15	U	1.1	U	1.15	U	1.1	U	1.1	U	1.1	U	1.15	U
Vanadium	55	Metals (mg/kg)	11	V	19	V	12	V	12	V	10	V	11	V	16	V
Zinc	2,300	Metals (mg/kg)	19	V	29	V	29	V	23	V	27	V	22	V	40	V
Anthracene	1,000	PAH (µg/kg)	195	U	180	U										
Benzo(a)anthracene	620	PAH (µg/kg)	195	U	180	U										
Benzo(a)pyrene	62	PAH (µg/kg)	17	V	7	U										
Benzo(b)fluoranthene	620	PAH (µg/kg)	195	U	180	U										
Benzo(g,h,i)perylene	2,500	PAH (µg/kg)	195	U	180	U										
Benzo(k)fluoranthene	6,200	PAH (µg/kg)	195	U	180	U										
Chrysene	7,000	PAH (µg/kg)	195	U	180	U										
Dibenz(a,h)Anthracene	62	PAH (µg/kg)	8	U	7	U										
Fluoranthene	230,000	PAH (µg/kg)	195	U	180	U										
Indeno(1,2,3-c,d)Pyrene	620	PAH (µg/kg)	195	U	180	U										
Naphthalene	4,000	PAH (µg/kg)	2.95	U	3.9	U										
Phenanthrene	100,000	PAH (µg/kg)	195	U	180	U										
Pyrene	230,000	PAH (µg/kg)	195	U	180	U										
Total PCBs	220	PCBs (µg/kg)	19.6	U	18.1	U										
4,4-DDE	170	Pesticides (µg/kg)	1.96	U	1.81	U										
4,4-DDT	170	Pesticides (µg/kg)	1.96	U	1.81	U										
Aldrin	29	Pesticides (µg/kg)	1.96	U	1.81	U										
Dieldrin	30	Pesticides (µg/kg)	1.96	U	1.81	U										
Aliphatic Hydrocarbons (C_{19}-C_{36})	3,000	TPH (mg/kg)	3.92	U	3.625	U										
Aromatic Hydrocarbons (C_{11}-C_{22})	800	TPH (mg/kg)	3.92	U	3.625	U										
Acetone	60,000	VOCs (µg/kg)	57	V	22	V										
m,p-Xylenes	500	VOCs (µg/kg)	0.6	U	0.8	U										
p-Isopropyltoluene	NE	VOCs (µg/kg)	0.6	U	0.8	U										
Toluene	500	VOCs (µg/kg)	0.9	U	1.15	U										

Notes:
mg/kg = Milligrams per kilogram (parts per million)
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U = Substance not detected; detection limit listed.
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Table 6-10a
IA-10 Summary of Screened Results

Analyte	Project Action Level	Analyte Category (units)	PASI-GR-GB-305-1 0-0 ft		PASI-GR-GB-305-2 0-0 ft		PASI-GR-GB-306-1 0-0 ft		PASI-GR-GB-306-2 0-0 ft		PASI-GR-GB-307-1 0-0 ft		PASI-GR-GB-307-2 0-0 ft		PASI-GR-GB-308-1 0-0 ft	
Aluminum	7,600	Metals (mg/kg)	7690	V	10500	V	10300	V	12000	V	9820	V	10900	V	8170	V
Antimony	3.1	Metals (mg/kg)														
Arsenic	0.39	Metals (mg/kg)	17.9	V	28.2	V	21.4	V	19.8	V	34	V	33	V	26.1	V
Barium	540	Metals (mg/kg)														
Calcium	NE	Metals (mg/kg)														
Chromium	30	Metals (mg/kg)														
Cobalt	500	Metals (mg/kg)														
Copper	310	Metals (mg/kg)														
Iron	2,300	Metals (mg/kg)	10400	V	14500	V	16700	V	17800	V	13400	V	15400	V	12900	V
Lead	300	Metals (mg/kg)														
Magnesium	NE	Metals (mg/kg)														
Manganese	180	Metals (mg/kg)	215	V	288	V	355	V	315	V	173	V	202	V	239	V
Mercury	2.3	Metals (mg/kg)														
Nickel	20	Metals (mg/kg)	12.8	V	26.3	V	27	V	28.3	V	30.9	V	35.4	V	26.3	V
Potassium	NE	Metals (mg/kg)														
Thallium	1	Metals (mg/kg)														
Vanadium	55	Metals (mg/kg)														
Zinc	2,300	Metals (mg/kg)														
Anthracene	1,000	PAH (µg/kg)														
Benzo(a)anthracene	620	PAH (µg/kg)														
Benzo(a)pyrene	62	PAH (µg/kg)														
Benzo(b)fluoranthene	620	PAH (µg/kg)														
Benzo(g,h,i)perylene	2,500	PAH (µg/kg)														
Benzo(k)fluoranthene	6,200	PAH (µg/kg)														
Chrysene	7,000	PAH (µg/kg)														
Dibenz(a,h)Anthracene	62	PAH (µg/kg)														
Fluoranthene	230,000	PAH (µg/kg)														
Indeno(1,2,3-c,d)Pyrene	620	PAH (µg/kg)														
Naphthalene	4,000	PAH (µg/kg)														
Phenanthrene	100,000	PAH (µg/kg)														
Pyrene	230,000	PAH (µg/kg)														
Total PCBs	220	PCBs (µg/kg)														
4,4-DDE	170	Pesticides (µg/kg)														
4,4-DDT	170	Pesticides (µg/kg)														
Aldrin	29	Pesticides (µg/kg)														
Dieldrin	30	Pesticides (µg/kg)														
Aliphatic Hydrocarbons (C_{19}-C_{36})	3,000	TPH (mg/kg)														
Aromatic Hydrocarbons (C_{11}-C_{22})	800	TPH (mg/kg)														
Acetone	60,000	VOCs (µg/kg)														
m,p-Xylenes	500	VOCs (µg/kg)														
p-Isopropyltoluene	NE	VOCs (µg/kg)														
Toluene	50	VOCs (µg/kg)														

Notes:
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Table 6-10a
IA-10 Summary of Screened Results

Analyte	Project Action Level	Analyte Category (units)	PASI-GR-GB-006C-1 0-3 ft	PASI-GR-GB-006E-1 0-3 ft	PASI-GR-GB-008A-1 0-3 ft	PASI-GR-GB-008B-1 0-3 ft	PASI-GR-GB-008C-1 0-3 ft	PASI-GR-GB-008D-1 0-3 ft	PASI-GR-GB-008E-1 0-3 ft
Total PCBs	220	PCBs (µg/kg)	510 V	14.5 U	14 U	14.5 U	15 U	14.5 U	14 U

Analyte	Project Action Level	Analyte Category (units)	PASI-GR-GB-235-1 0.66-3.66 ft	PASI-GR-GB-236-1 0.83-3.83 ft	PASI-GR-GB-237-1 0.66-3.66 ft	PASI-GR-GB-238-1 0.75-3.75 ft	PASI-GR-GB-239-1 0.66-3.66 ft	PASI-GR-GB-240-1 0.33-3.33 ft	PASI-GR-GB-241-1 1.5-3.5 ft
Total PCBs	220	PCBs (µg/kg)	6	16.5	15	15.5	14.5	15	14.5

Notes:
mg/kg = Milligrams per kilogram (parts per million)
µg/kg = Micrograms per kilogram (parts per billion)
ng/kg = Nanograms per kilogram (parts per trillion)
V = Valid result; substance detected.
J = Estimated result; substance detected, but below the detection limit.
U = Substance not detected; detection limit listed.
Highlighted results were detected above their Project Action Level.

Table 6-10a
IA-10 Summary of Screened Results

Analyte	Project Action Level	Analyte Category (units)	GR-IA05-SS02-1 0-1.5 ft		GR-IA05-SS03-1 0-1.5 ft		GR-IA05-SS04-1 0-1.5 ft		GR-IA05-SS05-1 0-1.5 ft		GR-IA05-SS06-1 0-1.5 ft		IA5-001-A 0-0.5 ft	
Aluminum	7,600	Metals (mg/kg)	7700	V	6500	V	6700	V	7600	V	6200	V		
Antimony	3.1	Metals (mg/kg)	1.05	U	1.15	U	1.1	U	1.15	U	1.15	U		
Arsenic	0.39	Metals (mg/kg)	33	V	32	V	20	V	21	V	22	V		
Barium	540	Metals (mg/kg)	11	V	20	V	13	V	21	V	14	V		
Calcium	NE	Metals (mg/kg)	400	V	660	V	360	V	330	V	280	V		
Chromium	30	Metals (mg/kg)	16	V	16	V	10	V	14	V	11	V		
Cobalt	500	Metals (mg/kg)	5.7	V	6.7	V	3.2	V	4.3	V	4	V		
Copper	310	Metals (mg/kg)	13	V	15	V	5.6	V	8.7	V	6.2	V		
Iron	2,300	Metals (mg/kg)	9200	V	11000	V	7400	V	9900	V	8400	V		
Lead	300	Metals (mg/kg)	11	V	180	V	55	V	35	V	18	V	51.3	V
Magnesium	NE	Metals (mg/kg)	2300	V	2600	V	1300	V	1800	V	1400	V		
Manganese	180	Metals (mg/kg)	100	V	300	V	230	V	290	V	310	V		
Mercury	2.3	Metals (mg/kg)	0.012	J	0.04	J	0.031	J	0.054	J	0.049	J		
Nickel	20	Metals (mg/kg)	22	V	22	V	13	V	15	V	12	V		
Potassium	NE	Metals (mg/kg)	580	V	930	V	200	V	490	V	260	V		
Thallium	1	Metals (mg/kg)	1.05	U	1.15	U	1.1	U	1.15	U	1.15	U		
Vanadium	55	Metals (mg/kg)	11	V	13	V	9	V	13	V	12	V		
Zinc	2,300	Metals (mg/kg)	19	V	31	V	18	V	27	V	18	V		
Anthracene	1,000	PAH (µg/kg)												
Benzo(a)anthracene	620	PAH (µg/kg)												
Benzo(a)pyrene	62	PAH (µg/kg)												
Benzo(b)fluoranthene	620	PAH (µg/kg)												
Benzo(g,h,i)perylene	2,500	PAH (µg/kg)												
Benzo(k)fluoranthene	6,200	PAH (µg/kg)												
Chrysene	7,000	PAH (µg/kg)												
Dibenz(a,h)Anthracene	62	PAH (µg/kg)												
Fluoranthene	230,000	PAH (µg/kg)												
Indeno(1,2,3-c,d)Pyrene	620	PAH (µg/kg)												
Naphthalene	4,000	PAH (µg/kg)												
Phenanthrene	100,000	PAH (µg/kg)												
Pyrene	230,000	PAH (µg/kg)												
Total PCBs	220	PCBs (µg/kg)												
4,4-DDE	170	Pesticides (µg/kg)												
4,4-DDT	170	Pesticides (µg/kg)												
Aldrin	29	Pesticides (µg/kg)												
Dieldrin	30	Pesticides (µg/kg)												
Aliphatic Hydrocarbons (C_{19}-C_{36})	3,000	TPH (mg/kg)												
Aromatic Hydrocarbons (C_{11}-C_{22})	800	TPH (mg/kg)												
Acetone	60,000	VOCs (µg/kg)												
m,p-Xylenes	500	VOCs (µg/kg)												
p-Isopropyltoluene	NE	VOCs (µg/kg)												
Toluene	500	VOCs (µg/kg)												

Notes:
mg/kg = Milligrams per kilogram (parts per million)
µg/kg = Micrograms per kilogram (parts per billion)
ng/kg = Nanograms per kilogram (parts per trillion)
V = Valid result; substance detected.
J = Estimated result; substance detected, but below the detection limit.
U = Substance not detected; detection limit listed.
Highlighted results were detected above their Project Action Level.

Table 6-10a
IA-10 Summary of Screened Results

Analyte	Project Action Level	Analyte Category (units)	PASI-GR-GB-308-2 0-0 ft		PASI-GR-GB-309-1 0-0 ft		PASI-GR-GB-309-2 0-0 ft		PASI-GR-GB-310-1 0-0 ft		PASI-GR-GB-310-2 0-0 ft		PASI-GR-GB-311-1 0-0 ft		PASI-GR-GB-311-2 0-0 ft	
Aluminum	7,600	Metals (mg/kg)	7150	V	10900	V	7160	V	6810	V	8600	V	11800	V	9990	V
Antimony	3.1	Metals (mg/kg)														
Arsenic	0.39	Metals (mg/kg)	36.1	V	11.1	V	13.9	V	20.3	V	24.1	V	25.7	V	40.9	V
Barium	540	Metals (mg/kg)														
Calcium	NE	Metals (mg/kg)														
Chromium	30	Metals (mg/kg)														
Cobalt	500	Metals (mg/kg)														
Copper	310	Metals (mg/kg)														
Iron	2,300	Metals (mg/kg)	12300	V	8440	V	6560	V	9410	V	12800	V	15200	V	17.2	V
Lead	300	Metals (mg/kg)														
Magnesium	NE	Metals (mg/kg)														
Manganese	180	Metals (mg/kg)	239	V	55.2	V	88	V	176	V	259	V	276	V	365	V
Mercury	2.3	Metals (mg/kg)														
Nickel	20	Metals (mg/kg)	25.8	V	6.3	V	8.4	V	17.5	V	28.6	V	16.7	V	36.6	V
Potassium	NE	Metals (mg/kg)														
Thallium	1	Metals (mg/kg)														
Vanadium	55	Metals (mg/kg)														
Zinc	2,300	Metals (mg/kg)														
Anthracene	1,000	PAH (µg/kg)														
Benzo(a)anthracene	620	PAH (µg/kg)														
Benzo(a)pyrene	62	PAH (µg/kg)														
Benzo(b)fluoranthene	620	PAH (µg/kg)														
Benzo(g,h,i)perylene	2,500	PAH (µg/kg)														
Benzo(k)fluoranthene	6,200	PAH (µg/kg)														
Chrysene	7,000	PAH (µg/kg)														
Dibenz(a,h)Anthracene	62	PAH (µg/kg)														
Fluoranthene	230,000	PAH (µg/kg)														
Indeno(1,2,3-c,d)Pyrene	620	PAH (µg/kg)														
Naphthalene	4,000	PAH (µg/kg)														
Phenanthrene	100,000	PAH (µg/kg)														
Pyrene	230,000	PAH (µg/kg)														
Total PCBs	220	PCBs (µg/kg)														
4,4-DDE	170	Pesticides (µg/kg)														
4,4-DDT	170	Pesticides (µg/kg)														
Aldrin	29	Pesticides (µg/kg)														
Dieldrin	30	Pesticides (µg/kg)														
Aliphatic Hydrocarbons (C_{19}-C_{36})	3,000	TPH (mg/kg)														
Aromatic Hydrocarbons (C_{11}-C_{22})	800	TPH (mg/kg)														
Acetone	60,000	VOCs (µg/kg)														
m,p-Xylenes	500	VOCs (µg/kg)														
p-Isopropyltoluene	NE	VOCs (µg/kg)														
Toluene	50	VOCs (µg/kg)														

Notes:
mg/kg = Milligrams per kilogram (parts per million)
µg/kg = Micrograms per kilogram (parts per billion)
ng/kg = Nanograms per kilogram (parts per trillion)
V = Valid result; substance detected.
J = Estimated result; substance detected, but below the detection limit.
U = Substance not detected; detection limit listed.
Highlighted results were detected above their Project Action Level.

Table 6-10a
IA-10 Summary of Screened Results

Analyte	Project Action Level	Analyte Category (units)	PASI-GR-GB-015A-1 0-3 ft	PASI-GR-GB-015B-1 0-3 ft	PASI-GR-GB-015C-1 0-3 ft	PASI-GR-GB-015D-1 0-3 ft	PASI-GR-GB-015E-1 0-3 ft	PASI-GR-GB-017A-1 0-3 ft	PASI-GR-GB-017B-1 0-3 ft
Total PCBs	220	PCBs (µg/kg)	2600 V	4.65 U	4.5 U	4.75 U	4.6 U	460 V	4.5 U

Analyte	Project Action Level	Analyte Category (units)	PASI-GR-GB-242-1 0.42-3.42 ft	PASI-GR-GB-243-1 0.83-3.83 ft	PASI-GR-GB-244-1 0.42-3.42 ft	PASI-GR-GB-245-1 1.5-3.5 ft	PASI-GR-GB-246-1 0.66-3.66 ft	PASI-GR-GB-247-1 1.5-3.5 ft	PASI-GR-GB-248-1 0.83-3.83 ft
Total PCBs	220	PCBs (µg/kg)	13.5	14.5	14	14.5	14	14	14.5

Notes:
mg/kg = Milligrams per kilogram (parts per million)
µg/kg = Micrograms per kilogram (parts per billion)
ng/kg = Nanograms per kilogram (parts per trillion)
V = Valid result; substance detected.
J = Estimated result; substance detected, but below the detection limit.
U = Substance not detected; detection limit listed.
Highlighted results were detected above their Project Action Level.

Table 6-10a
IA-10 Summary of Screened Results

Analyte	Project Action Level	Analyte Category (units)
Aluminum	7,600	Metals (mg/kg)
Antimony	3.1	Metals (mg/kg)
Arsenic	0.39	Metals (mg/kg)
Barium	540	Metals (mg/kg)
Calcium	NE	Metals (mg/kg)
Chromium	30	Metals (mg/kg)
Cobalt	500	Metals (mg/kg)
Copper	310	Metals (mg/kg)
Iron	2,300	Metals (mg/kg)
Lead	300	Metals (mg/kg)
Magnesium	NE	Metals (mg/kg)
Manganese	180	Metals (mg/kg)
Mercury	2.3	Metals (mg/kg)
Nickel	20	Metals (mg/kg)
Potassium	NE	Metals (mg/kg)
Thallium	1	Metals (mg/kg)
Vanadium	55	Metals (mg/kg)
Zinc	2,300	Metals (mg/kg)
Anthracene	1,000	PAH (µg/kg)
Benzo(a)anthracene	620	PAH (µg/kg)
Benzo(a)pyrene	62	PAH (µg/kg)
Benzo(b)fluoranthene	620	PAH (µg/kg)
Benzo(g,h,i)perylene	2,500	PAH (µg/kg)
Benzo(k)fluoranthene	6,200	PAH (µg/kg)
Chrysene	7,000	PAH (µg/kg)
Dibenz(a,h)Anthracene	62	PAH (µg/kg)
Fluoranthene	230,000	PAH (µg/kg)
Indeno(1,2,3-c,d)Pyrene	620	PAH (µg/kg)
Naphthalene	4,000	PAH (µg/kg)
Phenanthrene	100,000	PAH (µg/kg)
Pyrene	230,000	PAH (µg/kg)
Total PCBs	220	PCBs (µg/kg)
4,4-DDE	170	Pesticides (µg/kg)
4,4-DDT	170	Pesticides (µg/kg)
Aldrin	29	Pesticides (µg/kg)
Dieldrin	30	Pesticides (µg/kg)
Aliphatic Hydrocarbons (C_{19}-C_{36})	3,000	TPH (mg/kg)
Aromatic Hydrocarbons (C_{11}-C_{22})	800	TPH (mg/kg)
Acetone	60,000	VOCs (µg/kg)
m,p-Xylenes	500	VOCs (µg/kg)
p-Isopropyltoluene	NE	VOCs (µg/kg)
Toluene	500	VOCs (µg/kg)

Notes:
mg/kg = Milligrams per kilogram (parts per million)
µg/kg = Micrograms per kilogram (parts per billion)
ng/kg = Nanograms per kilogram (parts per trillion)
V = Valid result; substance detected.
J = Estimated result; substance detected, but below the detection limit.
U = Substance not detected; detection limit listed.
Highlighted results were detected above their Project Action Level.

Table 6-10a
IA-10 Summary of Screened Results

Analyte	Project Action Level	Analyte Category (units)
Aluminum	7,600	Metals (mg/kg)
Antimony	3.1	Metals (mg/kg)
Arsenic	0.39	Metals (mg/kg)
Barium	540	Metals (mg/kg)
Calcium	NE	Metals (mg/kg)
Chromium	30	Metals (mg/kg)
Cobalt	500	Metals (mg/kg)
Copper	310	Metals (mg/kg)
Iron	2,300	Metals (mg/kg)
Lead	300	Metals (mg/kg)
Magnesium	NE	Metals (mg/kg)
Manganese	180	Metals (mg/kg)
Mercury	2.3	Metals (mg/kg)
Nickel	20	Metals (mg/kg)
Potassium	NE	Metals (mg/kg)
Thallium	1	Metals (mg/kg)
Vanadium	55	Metals (mg/kg)
Zinc	2,300	Metals (mg/kg)
Anthracene	1,000	PAH (µg/kg)
Benzo(a)anthracene	620	PAH (µg/kg)
Benzo(a)pyrene	62	PAH (µg/kg)
Benzo(b)fluoranthene	620	PAH (µg/kg)
Benzo(g,h,i)perylene	2,500	PAH (µg/kg)
Benzo(k)fluoranthene	6,200	PAH (µg/kg)
Chrysene	7,000	PAH (µg/kg)
Dibenz(a,h)Anthracene	62	PAH (µg/kg)
Fluoranthene	230,000	PAH (µg/kg)
Indeno(1,2,3-c,d)Pyrene	620	PAH (µg/kg)
Naphthalene	4,000	PAH (µg/kg)
Phenanthrene	100,000	PAH (µg/kg)
Pyrene	230,000	PAH (µg/kg)
Total PCBs	220	PCBs (µg/kg)
4,4-DDE	170	Pesticides (µg/kg)
4,4-DDT	170	Pesticides (µg/kg)
Aldrin	29	Pesticides (µg/kg)
Dieldrin	30	Pesticides (µg/kg)
Aliphatic Hydrocarbons (C_{19}-C_{36})	3,000	TPH (mg/kg)
Aromatic Hydrocarbons (C_{11}-C_{22})	800	TPH (mg/kg)
Acetone	60,000	VOCs (µg/kg)
m,p-Xylenes	500	VOCs (µg/kg)
p-Isopropyltoluene	NE	VOCs (µg/kg)
Toluene	50	VOCs (µg/kg)

Notes:
mg/kg = Milligrams per kilogram (parts per million)
µg/kg = Micrograms per kilogram (parts per billion)
ng/kg = Nanograms per kilogram (parts per trillion)
V = Valid result; substance detected.
J = Estimated result; substance detected, but below the detection limit.
U = Substance not detected; detection limit listed.
Highlighted results were detected above their Project Action Level.

Table 6-10a
IA-10 Summary of Screened Results

Analyte	Project Action Level	Analyte Category (units)	PASI-GR-GB-017C-1 0-3 ft		PASI-GR-GB-017D-1 0-3 ft		PASI-GR-GB-017E-1 0-3 ft		PASI-GR-GB-018A-1 0-3 ft	
Total PCBs	220	PCBs (µg/kg)	41	V	4.7	U	4.8	U	13.5	U

Analyte	Project Action Level	Analyte Category (units)	PASI-GR-GB-249-1 0.66-3.66 ft		PASI-GR-GB-250-1 1.5-3.5 ft		PASI-GR-GB-251-1 1.5-3.5 ft	
Total PCBs	220	PCBs (µg/kg)	14		15.5		15.5	

Notes:
mg/kg = Milligrams per kilogram (parts per million)
µg/kg = Micrograms per kilogram (parts per billion)
ng/kg = Nanograms per kilogram (parts per trillion)
V = Valid result; substance detected.
J = Estimated result; substance detected, but below the detection limit.
U = Substance not detected; detection limit listed.
Highlighted results were detected above their Project Action Level.

Table 6-10b
IA-10 Hazard Screening Calculation Summary
PASI/SSI Comprehensive Report
Study Area - Grant, Locust, and Cavite Housing Areas
Devens, Massachusetts

Analyte	Analyte Category (units)	Carcinogen (Ca) or Non-carcinogen (NC)	EPA Region IX Residential Soil PRG	Average Value	Maximum Value	95% UCL	Exposure Point Concentration (EPC)1	Screening Cancer Risk (SCR)	Screening Hazard Quotient (SHQ)
Aluminum	Metals (mg/kg)	NC	76,000	7839	16,000	8,205	8,205		0.11
Arsenic	Metals (mg/kg)	Ca	0.39	25	68	26	26	7.E-05	
Chromium	Metals (mg/kg)	Ca	210	17	40	18	18	9.E-08	
Iron	Metals (mg/kg)	NC	23,000	11559	28,000	13,116	13,116		0.57
Lead	Metals (mg/kg)	NC	400	20	203	32	32		0.08
Manganese	Metals (mg/kg)	NC	1,800	231	640	246	246		0.14
Nickel	Metals (mg/kg)	NC	1,600	22	73	26	26		0.02
Thallium	Metals (mg/kg)	NC	5.2	1	1.1	0.63	0.63		0.12
Anthracene	PAH (µg/kg)	NC	1,000	305	3,200	205	205		0.21
Benzo(a)anthracene	PAH (µg/kg)	Ca	620	464	6,100	402	402	6.E-07	
Benzo(a)pyrene	PAH (µg/kg)	Ca	62	354	5,500	347	347	6.E-06	
Benzo(b)fluoranthene	PAH (µg/kg)	Ca	620	372	3,800	279	279	5.E-07	
Benzo(g,h,i)perylene	PAH (µg/kg)	Ca	NE	274	2,800	209	209		
Dibenz(a,h)Anthracene	PAH (µg/kg)	Ca	62	178	2,300	160	160	3.E-06	
Fluoranthene	PAH (µg/kg)	NC	2,300	749	13,000	781	781		0.34
Indeno(1,2,3-c,d)Pyrene	PAH (µg/kg)	Ca	620	371	3,700	275	275	4.E-07	
Total PCBs	PCBs (µg/kg)	Ca	220	170	13,000	274	274	1.E-06	
4,4-DDE	Pesticides (µg/kg)	Ca	1,700	13	247	15	15	9.E-09	
4,4-DDT	Pesticides (µg/kg)	Ca	1,700	32	751	42	42	2.E-08	
Aldrin	Pesticides (µg/kg)	Ca	29	11	103	9	9	3.E-07	
Dieldrin	Pesticides (µg/kg)	Ca	30	18	183	14	14	5.E-07	
							Total:	8.E-05	1.58

[1] = Lesser of Maximum or 95% UCL used.
PAH = polycyclic aromatic hydrocarbons
PRG = Preliminary Remediation Goals
UCL = Upper Confident Limit
PCB = polychlorinated biphenyls
NA = not applicable
mg/kg = milligrams per kilogram
µg/kg = micrograms per kilogram

Summary

Total Screening Cancer Risk: 8.E-05	TSCR>1E-04? No
Total Screening Hazard Quotient: 2	TSHI>1? Yes, excess risk.
Arsenic concentration is consistent with background.	
TSCR due to Arsenic: 7.E-05	TSCR w/o Arsenic: 1.E-05
TSCR due to Arsenic is <1E-04.	TSCR w/o Arsenic is <1E-04.
Total PCBs concentration is less than 1 mg/kg.	
TSCR due to PCBs: 1.E-06	TSCR w/o PCBs: 8.E-05
TSCR due to PCBs is <1E-04.	TSCR w/o PCBs is <1E-04.
PAHs concentration(s) are consistent with background.	
TSCR due to PAHs: 1.E-05	TSCR w/o to PAHs: 7.E-05
TSCR due to PAHs is <1E-04.	TSCR w/o PAHs is <1E-04.

Table 6-11a
IA-11 Summary of Screened Analytical Results

Analyte	Project Action	Analyte Category (units)	GR-IA03-SB01-1 0-3 ft		GR-IA03-SB01-1 3-10 ft		GR-IA03-SB01-1-D 0-3 ft		GR-IA03-SB02-1 0-3 ft		GR-IA03-SB02-1 3-10 ft		GR-IA03-SS04-1 0-1.5 ft		GR-IA03-SS05-1 0-1.5 ft	
Aluminum	7,600	Metals (mg/kg)	11000	V	10000	V	10000	V	10000	V	8500	V	7400	V	8000	V
Arsenic	0.39	Metals (mg/kg)	24	V	28	V	28	V	27	V	17	V	19	V	13	V
Barium	540	Metals (mg/kg)	23	V	18	V	18	V	16	V	18	V	10	V	10	V
Calcium	NE	Metals (mg/kg)	320	V	340	V	190	V	360	V	860	V	200	V	110	V
Chromium	30	Metals (mg/kg)	21	V	17	V	17	V	24	V	23	V	12	V	9.7	V
Cobalt	500	Metals (mg/kg)	5.2	V	6	V	4.9	V	6.3	V	6.2	V	5.3	V	2.9	V
Copper	310	Metals (mg/kg)	7.8	V	12	V	9	V	14	V	13	V	8.1	V	4.9	V
Iron	2,300	Metals (mg/kg)	12000	V	13000	V	12000	V	15000	V	14000	V	8800	V	8000	V
Lead	300	Metals (mg/kg)	8.9	V	10	V	10	V	12	V	6.5	V	7.9	V	10	V
Magnesium	NE	Metals (mg/kg)	3500	V	3800	V	2900	V	4800	V	4900	V	1600	V	1000	V
Manganese	180	Metals (mg/kg)	240	V	210	V	210	V	180	V	210	V	120	V	110	V
Mercury	2.3	Metals (mg/kg)	0.026	J	0.078	U	0.026	J	0.02	J	0.0035	J	0.028	J	0.063	J
Nickel	20	Metals (mg/kg)	17	V	22	V	16	V	25	V	23	V	15	V	8.9	V
Potassium	NE	Metals (mg/kg)	790	V	820	V	540	V	920	V	990	V	240	V	190	V
Sodium	NE	Metals (mg/kg)	92	U	93	U	93	U	89	U	83	U	87	U	90	U
Vanadium	55	Metals (mg/kg)	14	V	13	V	13	V	16	V	16	V	8.9	V	9.4	V
Zinc	2,300	Metals (mg/kg)	19	V	22	V	19	V	28	V	25	V	17	V	14	V
Acenaphthene	200	PAHs (µg/kg)							370	U	350	U				
Acenaphthylene	100	PAHs (µg/kg)							370	U	350	U				
Anthracene	1,000	PAHs (µg/kg)							370	U	350	U				
Benzo(a)anthracene	620	PAHs (µg/kg)							370	U	350	U				
Benzo(a)pyrene	62	PAHs (µg/kg)							39	V	14	U				
Benzo(b)fluoranthene	620	PAHs (µg/kg)							370	U	350	U				
Benzo(g,h,i)perylene	1,000	PAHs (µg/kg)							370	U	350	U				
Benzo(k)fluoranthene	6,200	PAHs (µg/kg)							370	U	350	U				
Chrysene	7,000	PAHs (µg/kg)							370	U	350	U				
Dibenz(a,h)Anthracene	62	PAHs (µg/kg)							15	U	14	U				
Fluoranthene	23,000	PAHs (µg/kg)							370	U	350	U				
Fluorene	270,000	PAHs (µg/kg)							370	U	350	U				
Indeno(1,2,3-c,d)Pyrene	620	PAHs (µg/kg)							370	U	350	U				
2-Methylnaphthalene	620	PAHs (µg/kg)							370	U	350	U				
Naphthalene	4,000	PAHs (µg/kg)							4.1	U	3.5	U				
Phenanthrene	100,000	PAHs (µg/kg)							370	U	350	U				
Pyrene	230,000	PAHs (µg/kg)							370	U	350	U				
Total TEQ	230,000	CDDs/CDFs (ng/kg)														
Total PCBs	220	PCBs (µg/kg)														
4,4-DDE	170	Pesticides (µg/kg)							71.8	V	3.51	U				
4,4-DDT	170	Pesticides (µg/kg)							141	V	5.35	V				
Aldrin	29	Pesticides (µg/kg)							18.5	U	3.51	U				
Dieldrin	30	Pesticides (µg/kg)							18.5	U	3.51	U				
Dibenzofuran	290,000	SVOCs (µg/kg)							370	U	350	U				
Aromatic Hydrocarbons (C_{11}-C_{22})	800	TPH (mg/kg)							7.41	U	7.02	U				
Acetone	60,000	VOCs (µg/kg)							33	V	6.9	U				

Notes:
mg/kg = Milligrams per kilogram (parts per million)
µg/kg = Micrograms per kilogram (parts per billion)
ng/kg = Nanograms per kilogram (parts per trillion)
V = Valid result; substance detected.
J = Estimated result; substance detected, but below the detection limit.
U = Substance not detected; detection limit listed.
Highlighted results were detected above their Project Action Level.

Table 6-11a
IA-11 Summary of Screened Analytical Results

Analyte	Project Action	Analyte Category (units)	GR-IA03-SS06-1-M 0-1.5 ft		GR-IA03-SS15-1 0-1.5 ft		GR-IA03-SS16-1 0-1.5 ft		GR-IA03-SS17-1 0-1.5 ft		GR-IA03-SS18-1 0-1.5 ft		GR-IA03-SS19-1 0-1.5 ft		GR-IA03-SS20-1 0-1.5 ft	
Aluminum	7,600	Metals (mg/kg)	4200	V	7500	V	9900	V	9100	V	7000	V	11000	V	9300	V
Arsenic	0.39	Metals (mg/kg)	24	V	20	V	24	V	27	V	14	V	12	V	13	V
Barium	540	Metals (mg/kg)	11	V	14	V	9	V	10	V	12	V	13	V	13	V
Calcium	NE	Metals (mg/kg)	250	V	180	V	85	V	120	V	97	V	63	V	89	V
Chromium	30	Metals (mg/kg)	11	V	13	V	14	V	15	V	9.2	V	10	V	11	V
Cobalt	500	Metals (mg/kg)	5.5	V	3.8	V	3.2	V	3.3	V	2.6	V	2.2	V	2.5	V
Copper	310	Metals (mg/kg)	12	V	6.4	V	5.7	V	7.7	V	5.9	V	3.5	V	4.4	V
Iron	2,300	Metals (mg/kg)	8800	V	9200	V	11000	V	10000	V	8300	V	9900	V	8800	V
Lead	300	Metals (mg/kg)	8.6	V	9.6	V	9.2	V	15	V	16	V	8.4	V	9.8	V
Magnesium	NE	Metals (mg/kg)	1900	V	1500	V	1500	V	1700	V	960	V	740	V	1000	V
Manganese	180	Metals (mg/kg)	180	V	110	V	71	V	81	V	96	V	95	V	75	V
Mercury	2.3	Metals (mg/kg)	0.0087	J	0.023	J	0.02	J	0.039	J	0.022	J	0.022	J	0.03	J
Nickel	20	Metals (mg/kg)	19	V	15	V	13	V	13	V	8.4	V	7.4	V	9.4	V
Potassium	NE	Metals (mg/kg)	500	V	330	V	190	V	240	V	220	V	130	V	280	V
Sodium	NE	Metals (mg/kg)	84	U	88	U	90	U	90	U	88	U	94	U	93	U
Vanadium	55	Metals (mg/kg)	8	V	11	V	12	V	13	V	10	V	12	V	11	V
Zinc	2,300	Metals (mg/kg)	18	V	16	V	18	V	16	V	13	V	12	V	13	V
Acenaphthene	200	PAHs (µg/kg)														
Acenaphthylene	100	PAHs (µg/kg)														
Anthracene	1,000	PAHs (µg/kg)														
Benzo(a)anthracene	620	PAHs (µg/kg)														
Benzo(a)pyrene	62	PAHs (µg/kg)														
Benzo(b)fluoranthene	620	PAHs (µg/kg)														
Benzo(g,h,i)perylene	1,000	PAHs (µg/kg)														
Benzo(k)fluoranthene	6,200	PAHs (µg/kg)														
Chrysene	7,000	PAHs (µg/kg)														
Dibenz(a,h)Anthracene	62	PAHs (µg/kg)														
Fluoranthene	23,000	PAHs (µg/kg)														
Fluorene	270,000	PAHs (µg/kg)														
Indeno(1,2,3-c,d)Pyrene	620	PAHs (µg/kg)														
2-Methylnaphthalene	620	PAHs (µg/kg)														
Naphthalene	4,000	PAHs (µg/kg)														
Phenanthrene	100,000	PAHs (µg/kg)														
Pyrene	230,000	PAHs (µg/kg)														
Total TEQ	230,000	CDDs/CDFs (ng/kg)														
Total PCBs	220	PCBs (µg/kg)														
4,4-DDE	170	Pesticides (µg/kg)														
4,4-DDT	170	Pesticides (µg/kg)														
Aldrin	29	Pesticides (µg/kg)														
Dieldrin	30	Pesticides (µg/kg)														
Dibenzofuran	290,000	SVOCs (µg/kg)														
Aromatic Hydrocarbons (C_{11}-C_{22})	800	TPH (mg/kg)														
Acetone	60,000	VOCs (µg/kg)														

Notes:
mg/kg = Milligrams per kilogram (parts per million)
µg/kg = Micrograms per kilogram (parts per billion)
ng/kg = Nanograms per kilogram (parts per trillion)
V = Valid result; substance detected.
J = Estimated result; substance detected, but below the detection limit.
U = Substance not detected; detection limit listed.
Highlighted results were detected above their Project Action Level.

Table 6-11a
IA-11 Summary of Screened Analytical Results

Analyte	Project Action	Analyte Category (units)	GR-IA03-SS21-1 0-1.5 ft		LOB-03-01X 0-3 ft		LOB-03-01X 3-6 ft		LOB-03-01X 6-10 ft		LOB-03-02X 0-3 ft		LOB-03-02X 3-6 ft		LOB-03-02X_DUP 3-6 ft	
Aluminum	7,600	Metals (mg/kg)	6300	V	5400	V	2500	V	2100	V	11000	V	7300	V	4500	V
Arsenic	0.39	Metals (mg/kg)	14	V	22	V	23	V	14	V	52	V	22	V	21	V
Barium	540	Metals (mg/kg)	8	V												
Calcium	NE	Metals (mg/kg)	93	V												
Chromium	30	Metals (mg/kg)	8.4	V												
Cobalt	500	Metals (mg/kg)	2.4	V												
Copper	310	Metals (mg/kg)	4.9	V												
Iron	2,300	Metals (mg/kg)	7000	V	12000	V	6100	V	5500	V	19000	V	10000	V	6900	V
Lead	300	Metals (mg/kg)	14	V												
Magnesium	NE	Metals (mg/kg)	900	V												
Manganese	180	Metals (mg/kg)	92	V	230	V	100	V	120	V	330	V	260	V	140	V
Mercury	2.3	Metals (mg/kg)	0.034	J												
Nickel	20	Metals (mg/kg)	7.7	V	25	V	11	V	9.3	V	36	V	20	V	16	V
Potassium	NE	Metals (mg/kg)	160	V												
Sodium	NE	Metals (mg/kg)	90	U												
Vanadium	55	Metals (mg/kg)	9.8	V												
Zinc	2,300	Metals (mg/kg)	13	V												
Acenaphthene	200	PAHs (µg/kg)														
Acenaphthylene	100	PAHs (µg/kg)														
Anthracene	1,000	PAHs (µg/kg)														
Benzo(a)anthracene	620	PAHs (µg/kg)														
Benzo(a)pyrene	62	PAHs (µg/kg)														
Benzo(b)fluoranthene	620	PAHs (µg/kg)														
Benzo(g,h,i)perylene	1,000	PAHs (µg/kg)														
Benzo(k)fluoranthene	6,200	PAHs (µg/kg)														
Chrysene	7,000	PAHs (µg/kg)														
Dibenz(a,h)Anthracene	62	PAHs (µg/kg)														
Fluoranthene	23,000	PAHs (µg/kg)														
Fluorene	270,000	PAHs (µg/kg)														
Indeno(1,2,3-c,d)Pyrene	620	PAHs (µg/kg)														
2-Methylnaphthalene	620	PAHs (µg/kg)														
Naphthalene	4,000	PAHs (µg/kg)														
Phenanthrene	100,000	PAHs (µg/kg)														
Pyrene	230,000	PAHs (µg/kg)														
Total TEQ	230,000	CDDs/CDFs (ng/kg)														
Total PCBs	220	PCBs (µg/kg)														
4,4-DDE	170	Pesticides (µg/kg)														
4,4-DDT	170	Pesticides (µg/kg)														
Aldrin	29	Pesticides (µg/kg)														
Dieldrin	30	Pesticides (µg/kg)														
Dibenzofuran	290,000	SVOCs (µg/kg)														
Aromatic Hydrocarbons (C_{11}-C_{22})	800	TPH (mg/kg)														
Acetone	60,000	VOCs (µg/kg)														

Notes:
mg/kg = Milligrams per kilogram (parts per million)
µg/kg = Micrograms per kilogram (parts per billion)
ng/kg = Nanograms per kilogram (parts per trillion)
V = Valid result; substance detected.
J = Estimated result; substance detected, but below the detection limit.
U = Substance not detected; detection limit listed.
Highlighted results were detected above their Project Action Level.

Table 6-11a
IA-11 Summary of Screened Analytical Results

Analyte	Project Action	Analyte Category (units)	LOB-03-02X 6-10 ft		LOB-03-03X 0-3 ft		LOB-03-03X 3-6 ft		LOB-03-04X 0-3 ft		LOB-03-04X 3-6 ft		LOB-03-04X 6-10 ft		LO-IA11-SB01-1 0-3 ft	
Aluminum	7,600	Metals (mg/kg)	3600	V	8400	V	8200	V	7100	V	8100	V	13000	V	5600	V
Arsenic	0.39	Metals (mg/kg)	19	V	21	V	21	V	20	V	17	V	22	V	18	V
Barium	540	Metals (mg/kg)													18	V
Calcium	NE	Metals (mg/kg)													2300	V
Chromium	30	Metals (mg/kg)													12	V
Cobalt	500	Metals (mg/kg)													4.7	V
Copper	310	Metals (mg/kg)													12	V
Iron	2,300	Metals (mg/kg)	8000	V	11000	V	14000	V	15000	V	22000	V	29000	V	8300	V
Lead	300	Metals (mg/kg)													19	V
Magnesium	NE	Metals (mg/kg)													1700	V
Manganese	180	Metals (mg/kg)	170	V	120	V	350	V	350	V	430	V	690	V	150	V
Mercury	2.3	Metals (mg/kg)													0.058	J
Nickel	20	Metals (mg/kg)	16	V	16	V	25	V	24	V	31	V	48	V	14	V
Potassium	NE	Metals (mg/kg)													740	V
Sodium	NE	Metals (mg/kg)													300	V
Vanadium	55	Metals (mg/kg)													9.5	V
Zinc	2,300	Metals (mg/kg)													23	V
Acenaphthene	200	PAHs (µg/kg)													1200	V
Acenaphthylene	100	PAHs (µg/kg)													500	V
Anthracene	1,000	PAHs (µg/kg)													1900	V
Benzo(a)anthracene	620	PAHs (µg/kg)													2000	V
Benzo(a)pyrene	62	PAHs (µg/kg)													1800	V
Benzo(b)fluoranthene	620	PAHs (µg/kg)													1200	V
Benzo(g,h,i)perylene	1,000	PAHs (µg/kg)													1000	V
Benzo(k)fluoranthene	6,200	PAHs (µg/kg)													1400	V
Chrysene	7,000	PAHs (µg/kg)													1700	V
Dibenz(a,h)Anthracene	62	PAHs (µg/kg)													560	V
Fluoranthene	23,000	PAHs (µg/kg)													6200	V
Fluorene	270,000	PAHs (µg/kg)													1300	V
Indeno(1,2,3-c,d)Pyrene	620	PAHs (µg/kg)													1100	V
2-Methylnaphthalene	620	PAHs (µg/kg)													410	V
Naphthalene	4,000	PAHs (µg/kg)													3100	V
Phenanthrene	100,000	PAHs (µg/kg)													6600	V
Pyrene	230,000	PAHs (µg/kg)													4800	V
Total TEQ	230,000	CDDs/CDFs (ng/kg)													0.46	V
Total PCBs	220	PCBs (µg/kg)														
4,4-DDE	170	Pesticides (µg/kg)													203	U
4,4-DDT	170	Pesticides (µg/kg)													203	U
Aldrin	29	Pesticides (µg/kg)													1060	V
Dieldrin	30	Pesticides (µg/kg)													732	V
Dibenzofuran	290,000	SVOCs (µg/kg)													1000	V
Aromatic Hydrocarbons (C_{11}-C_{22})	800	TPH (mg/kg)													64	V
Acetone	60,000	VOCs (µg/kg)													450	U

Notes:
mg/kg = Milligrams per kilogram (parts per million)
µg/kg = Micrograms per kilogram (parts per billion)
ng/kg = Nanograms per kilogram (parts per trillion)
V = Valid result; substance detected.
J = Estimated result; substance detected, but below the detection limit.
U = Substance not detected; detection limit listed.
Highlighted results were detected above their Project Action Level.

Table 6-11a
IA-11 Summary of Screened Analytical Results

Analyte	Project Action	Analyte Category (units)	LO-IA11-SB01-1 3-10 ft		LO-IA11-SB02-1 0-3 ft		PASI-LO-CO-001-1 0-3 ft		PASI-LO-CO-002-1 0-3 ft		PASI-LO-CO-003-1 0-3 ft		PASI-LO-CO-004-1 0-3 ft		PASI-LO-CO-005-1 0-3 ft	
Aluminum	7,600	Metals (mg/kg)	3700	V												
Arsenic	0.39	Metals (mg/kg)	15	V												
Barium	540	Metals (mg/kg)	8.1	V												
Calcium	NE	Metals (mg/kg)	430	V												
Chromium	30	Metals (mg/kg)	7.7	V												
Cobalt	500	Metals (mg/kg)	3.4	V												
Copper	310	Metals (mg/kg)	7.2	V												
Iron	2,300	Metals (mg/kg)	5400	V												
Lead	300	Metals (mg/kg)	4.6	V												
Magnesium	NE	Metals (mg/kg)	1100	V												
Manganese	180	Metals (mg/kg)	91	V												
Mercury	2.3	Metals (mg/kg)	0.0054	J												
Nickel	20	Metals (mg/kg)	11	V												
Potassium	NE	Metals (mg/kg)	280	V												
Sodium	NE	Metals (mg/kg)	84	U												
Vanadium	55	Metals (mg/kg)	4.8	V												
Zinc	2,300	Metals (mg/kg)	13	V												
Acenaphthene	200	PAHs (µg/kg)	350	U	390	U										
Acenaphthylene	100	PAHs (µg/kg)	350	U	390	U										
Anthracene	1,000	PAHs (µg/kg)	350	U	390	U										
Benzo(a)anthracene	620	PAHs (µg/kg)	350	U	390	U										
Benzo(a)pyrene	62	PAHs (µg/kg)	14	U	19	V										
Benzo(b)fluoranthene	620	PAHs (µg/kg)	350	U	390	U										
Benzo(g,h,i)perylene	1,000	PAHs (µg/kg)	350	U	390	U										
Benzo(k)fluoranthene	6,200	PAHs (µg/kg)	350	U	390	U										
Chrysene	7,000	PAHs (µg/kg)	350	U	390	U										
Dibenz(a,h)Anthracene	62	PAHs (µg/kg)	14	U	16	U										
Fluoranthene	23,000	PAHs (µg/kg)	350	U	390	U										
Fluorene	270,000	PAHs (µg/kg)	350	U	390	U										
Indeno(1,2,3-c,d)Pyrene	620	PAHs (µg/kg)	350	U	390	U										
2-Methylnaphthalene	620	PAHs (µg/kg)	350	U	390	U										
Naphthalene	4,000	PAHs (µg/kg)	3.8	U	390	U										
Phenanthrene	100,000	PAHs (µg/kg)	350	U	390	U										
Pyrene	230,000	PAHs (µg/kg)	350	U	390	U										
Total TEQ	230,000	CDDs/CDFs (ng/kg)	0.12	V												
Total PCBs	220	PCBs (µg/kg)					27	U	27	U	27	U	26	U	25	U
4,4-DDE	170	Pesticides (µg/kg)	17.7	U												
4,4-DDT	170	Pesticides (µg/kg)	17.7	U												
Aldrin	29	Pesticides (µg/kg)	82.6	V												
Dieldrin	30	Pesticides (µg/kg)	66.1	V												
Dibenzofuran	290,000	SVOCs (µg/kg)	350	U	390	U										
Aromatic Hydrocarbons (C_{11}-C_{22})	800	TPH (mg/kg)	7.09	U												
Acetone	60,000	VOCs (µg/kg)	18	V												

Notes:
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µg/kg = Micrograms per kilogram (parts per billion)
ng/kg = Nanograms per kilogram (parts per trillion)
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J = Estimated result; substance detected, but below the detection limit.
U = Substance not detected; detection limit listed.
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Table 6-11a
IA-11 Summary of Screened Analytical Results

Analyte	Project Action	Analyte Category (units)	PASI-LO-CO-006-1 0-3 ft		PASI-LO-GB-200-1 0.33-3.33 ft		PASI-LO-GB-201-1 0.5-3.5 ft		PASI-LO-GB-202-1 0.66-3.66 ft	
Aluminum	7,600	Metals (mg/kg)								
Arsenic	0.39	Metals (mg/kg)								
Barium	540	Metals (mg/kg)								
Calcium	NE	Metals (mg/kg)								
Chromium	30	Metals (mg/kg)								
Cobalt	500	Metals (mg/kg)								
Copper	310	Metals (mg/kg)								
Iron	2,300	Metals (mg/kg)								
Lead	300	Metals (mg/kg)								
Magnesium	NE	Metals (mg/kg)								
Manganese	180	Metals (mg/kg)								
Mercury	2.3	Metals (mg/kg)								
Nickel	20	Metals (mg/kg)								
Potassium	NE	Metals (mg/kg)								
Sodium	NE	Metals (mg/kg)								
Vanadium	55	Metals (mg/kg)								
Zinc	2,300	Metals (mg/kg)								
Acenaphthene	200	PAHs (µg/kg)								
Acenaphthylene	100	PAHs (µg/kg)								
Anthracene	1,000	PAHs (µg/kg)								
Benzo(a)anthracene	620	PAHs (µg/kg)								
Benzo(a)pyrene	62	PAHs (µg/kg)								
Benzo(b)fluoranthene	620	PAHs (µg/kg)								
Benzo(g,h,i)perylene	1,000	PAHs (µg/kg)								
Benzo(k)fluoranthene	6,200	PAHs (µg/kg)								
Chrysene	7,000	PAHs (µg/kg)								
Dibenz(a,h)Anthracene	62	PAHs (µg/kg)								
Fluoranthene	23,000	PAHs (µg/kg)								
Fluorene	270,000	PAHs (µg/kg)								
Indeno(1,2,3-c,d)Pyrene	620	PAHs (µg/kg)								
2-Methylnaphthalene	620	PAHs (µg/kg)								
Naphthalene	4,000	PAHs (µg/kg)								
Phenanthrene	100,000	PAHs (µg/kg)								
Pyrene	230,000	PAHs (µg/kg)								
Total TEQ	230,000	CDDs/CDFs (ng/kg)								
Total PCBs	220	PCBs (µg/kg)	26	U	9.6	U	42	V	8.4	U
4,4-DDE	170	Pesticides (µg/kg)								
4,4-DDT	170	Pesticides (µg/kg)								
Aldrin	29	Pesticides (µg/kg)								
Dieldrin	30	Pesticides (µg/kg)								
Dibenzofuran	290,000	SVOCs (µg/kg)								
Aromatic Hydrocarbons (C_{11}-C_{22})	800	TPH (mg/kg)								
Acetone	60,000	VOCs (µg/kg)								

Notes:
mg/kg = Milligrams per kilogram (parts per million)
µg/kg = Micrograms per kilogram (parts per billion)
ng/kg = Nanograms per kilogram (parts per trillion)
V = Valid result; substance detected.
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U = Substance not detected; detection limit listed.
Highlighted results were detected above their Project Action Level.

Table 6-11b
IA-11 Hazard Screening Calculation Summary
PASI/SSI Comprehensive Report
Study Area - Grant, Locust, and Cavite Housing Areas
Devens, Massachusetts

Analyte	Analyte Category (units)	Carcinogen (Ca) or Non-carcinogen (NC)	EPA Region IX Residential Soil PRG	Average Value	Maximum Value	95% UCL	Exposure Point Concentration (EPC)[1]	Screening Cancer Risk (SCR)	Screening Hazard Quotient (SHQ)
Aluminum	Metals (mg/kg)	NC	76,000	8,031	11,000	8,316	8,316		0.11
Arsenic	Metals (mg/kg)	Ca	0.39	21	52	27	27	7.E-05	
Iron	Metals (mg/kg)	NC	23,000	11,448	29,000	15,637	15,637		0.68
Manganese	Metals (mg/kg)	NC	1,800	195	690	304	304		0.17
Nickel	Metals (mg/kg)	NC	1,600	18	48	21	21		0.01
Benzo(a)anthracene	PAHs (µg/kg)	Ca	620	546	2,000	1,568	1,568	3.E-06	
Benzo(a)pyrene	PAHs (µg/kg)	Ca	62	374	1,800	1,381	1,381	2.E-05	
Benzo(b)fluoranthene	PAHs (µg/kg)	Ca	620	386	1,200	962	962	2.E-06	
Dibenz(a,h)Anthracene	PAHs (µg/kg)	Ca	62	118	560	430	430	7.E-06	
Indeno(1,2,3-c,d)Pyrene	PAHs (µg/kg)	Ca	620	366	1,100	887	887	1.E-06	
Aldrin	Pesticides (µg/kg)	Ca	29	174	1,060	595	595	2.E-05	
Dieldrin	Pesticides (µg/kg)	Ca	30	133	732	418	418	1.E-05	
							Total:	1.E-04	0.97

[1] = Lesser of Maximum or 95% UCL used.
PAH = polycyclic aromatic hydrocarbons
PRG = Preliminary Remediation Goals
UCL = Upper Confident Limit
PCB = polychlorinated biphenyls
NA = not applicable
mg/kg = milligrams per kilogram
µg/kg = micrograms per kilogram

Summary

Total Screening Cancer Risk: 1.E-04	TSCR>1E-04? Yes
Total Screening Hazard Quotient: 1	TSHI>1? No
Arsenic concentration is consistent with background.	
TSCR due to Arsenic: 7.E-05	TSCR w/o Arsenic: 7.E-05
TSCR due to Arsenic is <1E-04.	TSCR w/o Arsenic is <1E-04.
Total PCBs concentration is less than 1 mg/kg.	
TSCR due to PCBs: NA	TSCR w/o PCBs: 1.E-04
	TSCR w/o PCBs is >1E-04.
PAHs concentration(s) are consistent with background.	
TSCR due to PAHs: 3.E-05	TSCR w/o to PAHs: 1.E-04
TSCR due to PAHs is <1E-04.	TSCR w/o PAHs equals 1E-04.

APPENDIX A

TEST PIT LOGS

Test Pit: CT-500



Location:	Cavite Housing Area
Project Name:	Devens PA/SI
Project Number:	03886.518.045
Project Manager:	Erin Kinney
Logged By:	Jared Markham
Date Logged:	11/7/2003
Excavation Method:	Backhoe
Total Depth:	6 feet
Ground Surf. Elev.:	

Remarks:
Gas line encountered at 1.3 feet bg.

Stratigraphic Unit	Sample Number	Depth (ft)	Material Description
FILL	1	0	Brown, well graded, silty medium sand with trace of fine to coarse gravel. (SM)
		0.3	Brown, well graded, fine to medium sand with clasts of dark brown medium sand and black medium sand with little charcoal. (SW)
OUTWASH	2	1.5	Orange-brown, poorly graded, fine to medium sand with trace of fine gravel. (SP)
	3	2.8	Light brown, poorly graded, medium sand. (SP)
		6	

Location:	Cavite Housing Area
Project Name:	Devens PA/SI
Project Number:	03886.518.045
Project Manager:	Erin Kinney
Logged By:	Jared Markham
Date Logged:	11/7/2003
Excavation Method:	Backhoe
Total Depth:	6 feet
Ground Surf. Elev.:	
Remarks:	



Test Pit: CT-501

Stratigraphic Unit	Sample Number	Depth (ft)	Material Description
FILL	1	0	Brown to grey, well graded, fine to medium sand with some coarse gravel and clasts of dark-brown to black sand. (SW)
OUTWASH	2	1.25	Orange-brown, fine to medium sand with little coarse gravel. (SW)
	3	2.25	Light brown, poorly graded, medium sand. (SP)
	4		
		6	

Test Pit: CT-502



Location:	Cavite Housing Area
Project Name:	Devens PA/SI
Project Number:	03886.518.045
Project Manager:	Erin Kinney
Logged By:	Jared Markham
Date Logged:	11/7/2003
Excavation Method:	Backhoe
Total Depth:	6 feet
Ground Surf. Elev.:	
Remarks:	

Stratigraphic Unit	Sample Number	Depth (ft)	Material Description
FILL	1	0	Dark brown, well graded silty sand with little coarse gravel. (SM)
	2	1.0	Brown, well graded medium sand with some coarse gravel and little cobbles. Some clasts of dark brown to black medium sand at base of unit. (SW)
OUTWASH	3	3.0	Dark orangish-brown, poorly graded medium sand. (SP)
		3.75	Orangish-brown, poorly graded medium sand. (SP)
		6	

Location:	Grant Housing Area
Project Name:	Devens PA/SI
Project Number:	03886.518.045
Project Manager:	Erin Kinney
Logged By:	Andrew Harris
Date Logged:	12/2/2003
Excavation Method:	Backhoe
Total Depth:	6 feet
Ground Surf. Elev.:	
Remarks:	

Test Pit: GR-300



Stratigraphic Unit	Sample Number	Depth (ft)	Material Description
FILL	1	0.0	Dark brown, well graded silty fine sand with little fine gravel. (SM)
		0.4	Light brown, well graded coarse sand with fine and coarse gravel. (SW)
GROUND MORAINE		1.5	Dark Brown, well graded fine sand with a trace of fine gravel and pockets of dark brown to black well graded fine sand near top of unit. Irregular boundary with units above/below. (SW)
		2.0	Orange-brown, well graded fine sand with a trace of sub-angular fine gravel. Diffuse boundary with unit below. (SW)
	2	3.0	Brown, well graded fine sand with a traces of silt, sub-rounded fine and coarse gravels, and subrounded cobbles. Diffuse boundary with unit below. (SW)
OUTWASH		4.5	Light brown, poorly graded fine sand with prominent bedding planes dipping to the west. (SP)
		6.0	

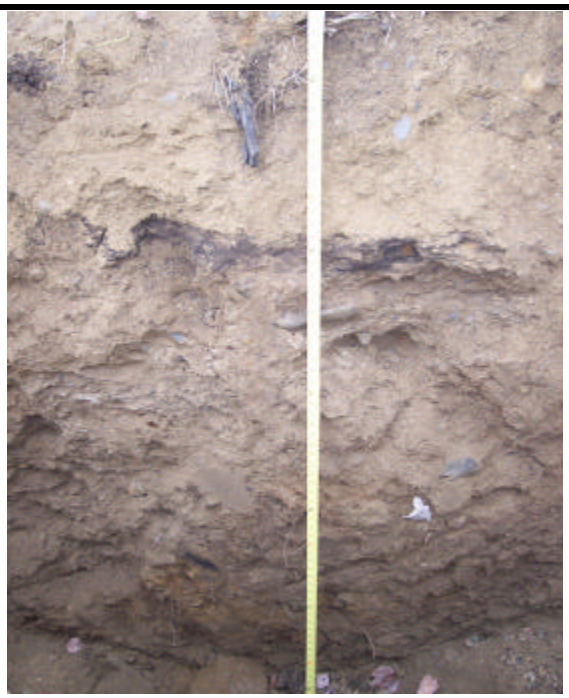
Test Pit: GR-301

Location:	Grant Housing Area
Project Name:	Devens PA/SI
Project Number:	03886.518.045
Project Manager:	Erin Kinney
Logged By:	Andrew Harris
Date Logged:	12/2/2003
Excavation Method:	Backhoe
Total Depth:	6 feet
Ground Surf. Elev.:	
Remarks:	



Stratigraphic Unit	Sample Number	Depth (ft)	Material Description
FILL		0.0	Dark brown, well graded silty fine sand with a trace of fine gravel. (SM)
OUTWASH		0.8	Light brown, poorly graded medium sand with cobbles (subrounded) and some coarse gravel. (SP)
	1	1.25	Brown, poorly graded, clast supported, coarse gravel with subrounded cobbles. Matrix is a well graded coarse sand with 30 percent fine gravel. Diffuse boundary with unit below. (GP)
	2	4.5	Orange-brown, well graded coarse sand with little subrounded fine to coarse gravel and a trace of subrounded cobbles. Massive; no apparent bedding. (SW)
		6.0	

Test Pit: GR-302



Location:	Grant Housing Area
Project Name:	Devens PA/SI
Project Number:	03886.518.045
Project Manager:	Erin Kinney
Logged By:	Andrew Harris
Date Logged:	12/2/2003
Excavation Method:	Backhoe
Total Depth:	6 feet
Ground Surf. Elev.:	
Remarks:	

Stratigraphic Unit	Sample Number	Depth (ft)	Material Description
FILL	1	0.0	Brown, well graded medium sand with little subangular fine gravel. (SW)
		1.2	Brown, well graded medium sand with some subangular fine gravel and trace of subrounded coarse gravel to cobbles. A discontinuous, 2-inch seam of dark brown poorly graded fine sand located at top of unit. (SW)
	2	4.2 to 5.2	Orange brown, well graded silty medium sand with little fine to coarse gravel and intermixed pockets of brown, well graded silty medium sand. (SM)
OUTWASH		5.4	Brown, well graded medium sand with little subrunded fine to coarse gravel. No apparent bedding. (SW)
		6.0	

Location:	Grant Housing Area
Project Name:	Devens PA/SI
Project Number:	03886.518.045
Project Manager:	Erin Kinney
Logged By:	Andrew Harris
Date Logged:	12/2/2003
Excavation Method:	Backhoe
Total Depth:	6 feet
Ground Surf. Elev.:	
Remarks:	

Test Pit: GR-303



Stratigraphic Unit	Sample Number	Depth (ft)	Material Description
FILL	1	0.0	Brown, well graded silty coarse sand with little fine gravel and a trace of coarse gravel. (SM)
		0.9 to 1.4	Dark brown, well graded silty fine sand with a trace of fine gravel. (SM)
	2	1.5 to 1.9	Brown, well graded medium sand with some fine to coarse subrounded gravel and with little silt. (SW-SM)
OUTWASH		5.0	Dark brown, poorly graded silty fine sand. (SM)
		5.75	Orange brown, well graded silty fine to medium sand with a trace of fine gravel. (SM)
		6.0	

Location:	Grant Housing Area
Project Name:	Devens PA/SI
Project Number:	03886.518.045
Project Manager:	Erin Kinney
Logged By:	Andrew Harris
Date Logged:	12/2/2003
Excavation Method:	Backhoe
Total Depth:	6 feet
Ground Surf. Elev.:	
Remarks:	

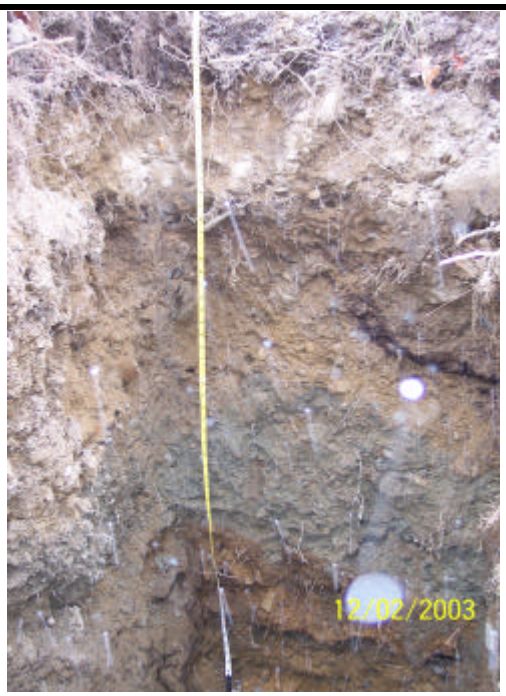


Test Pit: GR-304

Stratigraphic Unit	Sample Number	Depth (ft)	Material Description
FILL	1	0.0	Dark brown, well graded silty medium sand with a trace of fine gravel. (SM)
		0.3	Light brown, well graded coarse sand with some fine to coarse subrounded gravel. (SW)
GROUND MORAINE		1.5	Brown, well graded silty fine to coarse sand with some sub-rounded fine gravel and little subrounded coarse gravel and cobbles. (SM)
OUTWASH	2	4.0	Brown, well graded silty fine to coarse sand with some sub-rounded fine gravel and little subrounded coarse gravel and cobbles. Gravel oriented in subhorizontal bedding planes. (SM)
		6.0	

Location:	Grant Housing Area
Project Name:	Devens PA/SI
Project Number:	03886.518.045
Project Manager:	Erin Kinney
Logged By:	Andrew Harris
Date Logged:	12/2/2003
Excavation Method:	Backhoe
Total Depth:	6 feet
Ground Surf. Elev.:	
Remarks:	

Test Pit: GR-305



Stratigraphic Unit	Sample Number	Depth (ft)	Material Description
FILL	1	0.0	Dark brown, well graded silty fine sand with a trace of fine gravel. (SM)
		0.8	Brown, well graded medium to coarse sand with some sub-angular fine to coarse gravel and a trace of cobbles. Near base of unit, discontinuous pocket of dark brown fine sand (SW)
	2	3.0 to 3.6	Grey, clayey fine sand with little subangular to angular fine gravel. Firm with low plasticity. (SC)
		4.0 to 4.5	Orange brown to brown (intermixed pockets), well graded silty medium sand with traces of subrounded cobbles and fine gravel. Thin (<1.5-inch), discontinuous layer of charcoal near base of unit. (SM)
OUTWASH		5.4	Orange brown, well graded coarse sand with some subrounded to subangular fine gravel in subhorizontal bedding planes. (SW)
		6.0	

Location:	Grant Housing Area
Project Name:	Devens PA/SI
Project Number:	03886.518.045
Project Manager:	Erin Kinney
Logged By:	Andrew Harris
Date Logged:	12/2/2003
Excavation Method:	Backhoe
Total Depth:	6 feet
Ground Surf. Elev.:	
Remarks:	

Test Pit: GR-306



Stratigraphic Unit	Sample Number	Depth (ft)	Material Description
FILL		0.0	Dark brown, well graded medium sand with some subangular fine to coarse gravel. (SW)
TILL	1	0.7	Olive brown, sandy clay with some angular coarse gravel to cobbles. Firm; medium plasticity. Few pockets of well graded coarse sand to fine gravel. (CL)
	2		
		6.0	

Location:	Grant Housing Area
Project Name:	Devens PA/SI
Project Number:	03886.518.045
Project Manager:	Erin Kinney
Logged By:	Andrew Harris
Date Logged:	12/2/2003
Excavation Method:	Backhoe
Total Depth:	6 feet
Ground Surf. Elev.:	
Remarks:	



Test Pit: GR-307

Stratigraphic Unit	Sample Number	Depth (ft)	Material Description
FILL		0.0	Dark brown, well graded medium sand with little fine gravel. (SW)
GROUND MORAINE	1	0.8	Yellow brown, well graded silty fine to medium sand with little subrounded coarse gravel. Few lenses of soft silt. Diffuse boundary with unit below. (SM)
OUTWASH	2	3.5 to 4.2	Brown, well graded silty sand with little coarse gravel and cobbles. Faint subhorizontal bedding of sand unit. Some areas of cut and fill containing poorly graded fine gravel with a trace of sand. Tops of cut and fill units sloping to the south. Some lenses of soft silt. (SM)
		6.0	

Location:	Grant Housing Area
Project Name:	Devens PA/SI
Project Number:	03886.518.045
Project Manager:	Erin Kinney
Logged By:	Andrew Harris
Date Logged:	12/2/2003
Excavation Method:	Backhoe
Total Depth:	6 feet
Ground Surf. Elev.:	
Remarks:	



Test Pit: GR-308

Stratigraphic Unit	Sample Number	Depth (ft)	Material Description
FILL	1	0.0	Dark brown, well graded medium sand with little fine gravel. (SW)
		0.8	Brown, well graded silty medium sand with little fine gravel and a trace of coarse gravel to cobbles. (SM)
GROUND MORAINE	2	4.0	Brown, well graded silty fine sand with a trace of fine gravel. (SM)
		6.0	

Location:	Grant Housing Area
Project Name:	Devens PA/SI
Project Number:	03886.518.045
Project Manager:	Erin Kinney
Logged By:	Andrew Harris
Date Logged:	12/2/2003
Excavation Method:	Backhoe
Total Depth:	6 feet
Ground Surf. Elev.:	
Remarks:	

Test Pit: GR-309



Stratigraphic Unit	Sample Number	Depth (ft)	Material Description
FILL		0.0	Dark brown, poorly graded silty medium sand with a trace of fine gravel. (SM)
OUTWASH	1	0.4	Brown, poorly graded medium sand with little subrounded fine to coarse gravel. Diffuse boundary with unit below. (SP)
	2	2.2	Brown, poorly graded medium to coarse sand, coarsening upwards from trace of cobbles and little fine and coarse gravel to some fine to coarse gravel and little cobbles. Some distinct subhorizontal bedding laminations and some pockets of poorly graded medium to coarse sand. (SP)
		6.0	

Location:	Grant Housing Area
Project Name:	Devens PA/SI
Project Number:	03886.518.045
Project Manager:	Erin Kinney
Logged By:	Andrew Harris
Date Logged:	12/2/2003
Excavation Method:	Backhoe
Total Depth:	6 feet
Ground Surf. Elev.:	
Remarks:	



Test Pit: GR-310

Stratigraphic Unit	Sample Number	Depth (ft)	Material Description
FILL		0.0	Dark brown, poorly graded silty medium sand with a trace of fine gravel. (SM)
OUTWASH	1	0.3	Brown, well graded fine to coarse subrounded to rounded gravel with sone subhorizontal orientation. Matirx of well graded fine to coarse sand. Some lenses of clast supported fine gravel. Some lenses of poorly graded fine sand. (GW)
	2		
		6.0	

Location:	Grant Housing Area
Project Name:	Devens PA/SI
Project Number:	03886.518.045
Project Manager:	Erin Kinney
Logged By:	Andrew Harris
Date Logged:	12/2/2003
Excavation Method:	Backhoe
Total Depth:	6 feet
Ground Surf. Elev.:	
Remarks:	

Test Pit: GR-311



Stratigraphic Unit	Sample Number	Depth (ft)	Material Description
FILL		0.0	Brown, well graded medium sand with a trace of coarse gravel. (SW)
GROUND MORAINE	1	1.0	Brown, well graded, rounded to subrounded fine to coarse gravel with some cobbles. Matix of well graded fine to coarse sand. Diffuse, irregular boundary with unit below. (GW)
OUTWASH	2	3.7	Light brown, poorly graded medium sand coarsening upwards from clean sand to some fine to coarse gravel. Some lenses of fine gravel in cut and fill structures. (SP)
		5.0 to 5.3	Brown, poorly graded fine gravel with some coarse sand. Some subhorizontal bedding. Top of unit sloping to the south. (GP)
		6.0	

Location:	Locust Housing Area
Project Name:	Devens PA/SI
Project Number:	03886.518.045
Project Manager:	Erin Kinney
Logged By:	Andrew Harris
Date Logged:	12/2/2003
Excavation Method:	Backhoe
Total Depth:	6 feet
Ground Surf. Elev.:	
Remarks:	

Test Pit: LO-300



Stratigraphic Unit	Sample Number	Depth (ft)	Material Description
FILL		0	Dark brown, well graded silty fine sand. (SM)
OUTWASH	1	1.1	Orange brown, well graded silty fine sand with a trace of fine gravel. (SM)
	2	2.2	Brown, well graded fine to coarse sand. Some lenses of sandy fine gravel with a trace of coarse gravel to cobbles. Some subhorizontal bedding of sand within unit. (SW)
		6.0	

Location:	Locust Housing Area
Project Name:	Devens PA/SI
Project Number:	03886.518.045
Project Manager:	Erin Kinney
Logged By:	Andrew Harris
Date Logged:	12/2/2003
Excavation Method:	Backhoe
Total Depth:	6 feet
Ground Surf. Elev.:	
Remarks:	



Test Pit: LO-301

Stratigraphic Unit	Sample Number	Depth (ft)	Material Description
FILL		0.0	Dark brown, well graded silty sand with a trace of fine gravel. (SM)
OUTWASH	1	0.5	Light brown, poorly graded fine sand with two series of fining upwards sequences from a well graded coarse sand with little fine gravel. Top third of unit grades up into a yellow brown poorly graded fine sand with out gravel. Some sand laminations throughout. (SP)
		1.8	Light brown, poorly graded fine sand with lenses (< 0.5 inches) of silt. Silt lense deformation indicates shearing and loading. Some subhorizontal bedding planes within sand unit. (SP)
	2	4.8 to 5.2	Brown, poorly graded medium sand coarsening upwards to a well graded coarse sand with little fine gravel. (SP)
		6.0	

Location:	Locust Housing Area
Project Name:	Devens PA/SI
Project Number:	03886.518.045
Project Manager:	Erin Kinney
Logged By:	Andrew Harris
Date Logged:	12/2/2003
Excavation Method:	Backhoe
Total Depth:	6 feet
Ground Surf. Elev.:	
Remarks:	



Test Pit: LO-302

Stratigraphic Unit	Sample Number	Depth (ft)	Material Description
FILL	1	0.0	Dark brown, well graded silty sand with a trace of fine gravel. (SM)
		0.5	Brown, well graded fine sand with a trace of fine to coarse subrounded gravel. Some lenses of dark brown, silty fine sand throughout, but increasing in occurance with depth. (SW)
OUTWASH	2	3.7 to 5.0	Orange brown, well graded fine sand with a trace of fine gravel. Diffuse boundary with unit below. (SW)
		5.5	Brown, well graded coarse sand, coarsening upwards to a sandy fine gravel. (SW)
		6.0	

Location:	Grant Housing Area
Project Name:	Devens SSI
Project Number:	03886.518.045
Project Manager:	Erin Kinney
Logged By:	Joseph Schmidl, PG
Date Logged:	11/4/2004
Excavation Method:	Backhoe
Total Depth:	6 feet
Ground Surf. Elev.:	

Remarks:
Test pit was excavated 6 ft x 6 ft x 6 ft
Soil samples GR-IA10-TP01A1 to -TP01D3 collected from sidewalls of test pit.

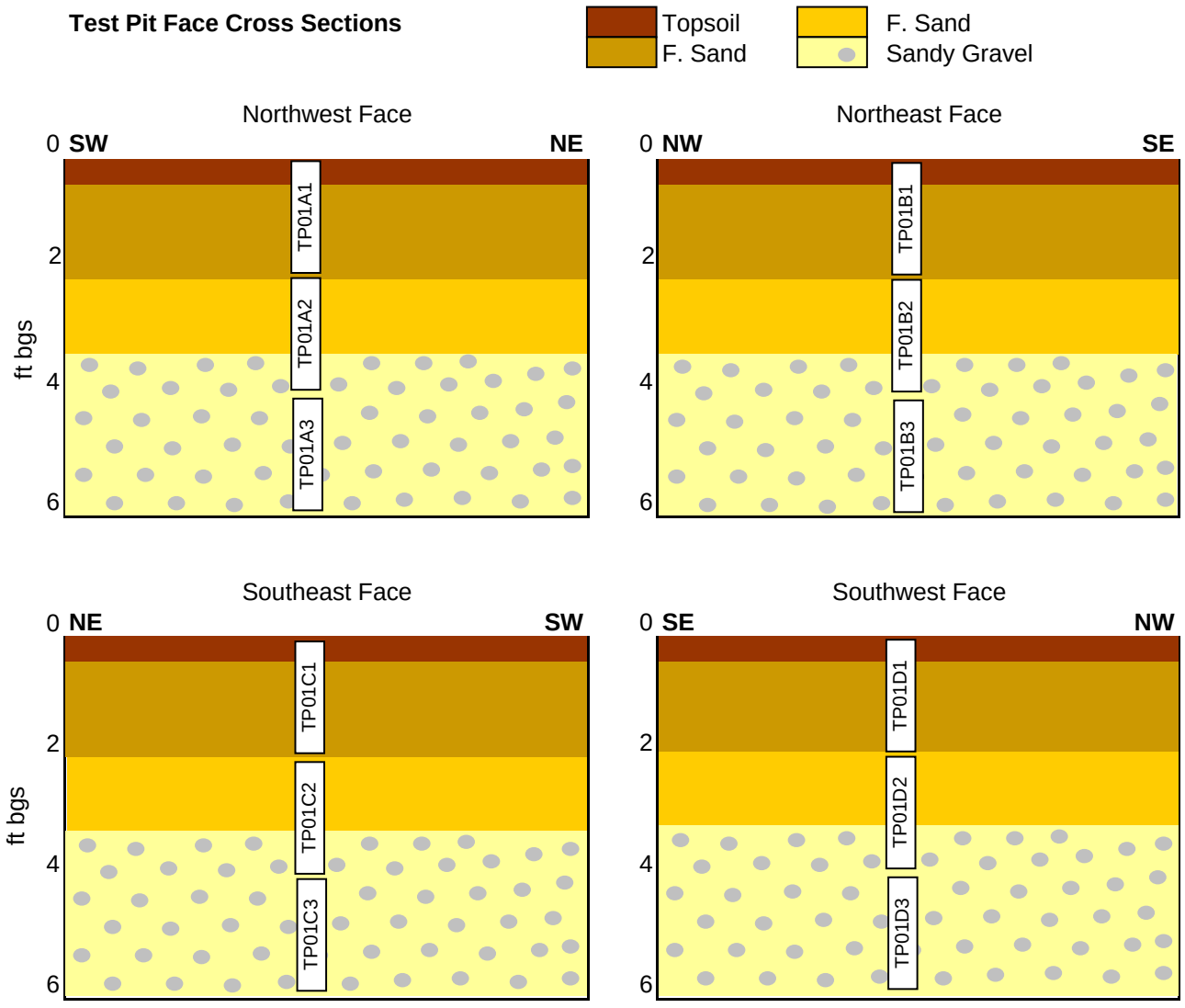


North and east faces of Test Pit, depth 4 ft bgs

Stratigraphic Unit	Sample Number	Depth (ft)	Material Description
LOAM		0.5	Dark brown 10YR 2/4, well graded Silty Sand (SM).
FILL	TP01A1 TP01B1 TP01C1 TP01D1	2.0	Dark yellow brown (10YR 6/6), poorly graded fine Sand (SP).
OUTWASH	TP01A2 TP01B2 TP01C2 TP01D2	3.5	Pale yellow (10YR 8/4) poorly graded fine Sand. No apparent bedding. Few iron accumulation mottles and layers at 2.5 to 3 ft bgs.
TILL/ BEDROCK	TP01A3 TP01B3 TP01C3 TP01D3	6.0	Pale yellow brown (10 YR 6/2) poorly graded Sandy Gravel (GP).
		Bottom of test pit	

Location:	Grant Housing Area
Project Name:	Devens SSI
Project Number:	03886.518.045
Project Manager:	Erin Kinney
Logged By:	Joseph Schmidl, PG
Date Logged:	11/4/2004
Excavation Method:	Backhoe
Total Depth:	6 feet
Ground Surf. Elev.:	
Remarks:	

Test Pit Face Cross Sections



Location:	Grant Housing Area
Project Name:	Devens SSI
Project Number:	03886.518.045
Project Manager:	Erin Kinney
Logged By:	Joseph Schmidl, PG
Date Logged:	11/4/2004
Excavation Method:	Backhoe
Total Depth:	6 feet
Ground Surf. Elev.:	

Remarks:
Test pit was excavated 6 ft x 6 ft x 6 ft
Soil samples GR-IA10-TP02A1 to -TP02D3 collected from sidewalls of test pit.

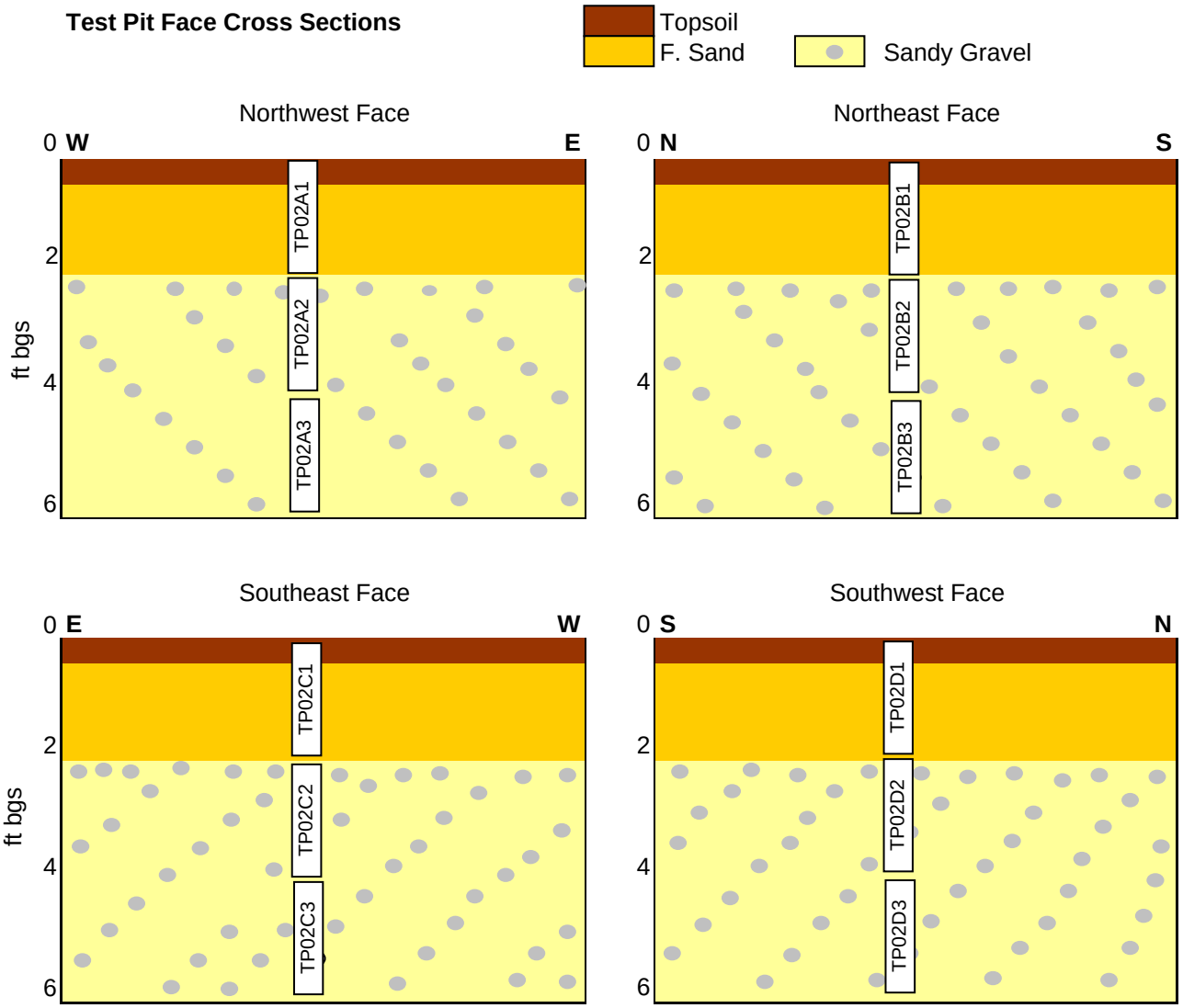


South and west faces of Test Pit, depth 6 ft bgs

Stratigraphic Unit	Sample Number	Depth (ft)	Material Description
LOAM		0.4	Dark brown 10YR 2/2, well graded Silty Sand (SM), tr. Gravel.
FILL	TP02A1 TP02B1 TP02C1 TP02D1	2.0	Dark yellow brown (10YR 6/6), poorly graded fine to coarse Gravelly Sand (SP).
OUTWASH	TP02A2 TP02B2 TP02C2 TP02D2 TP02A3 TP02B3 TP02C3 TP02D3	6.0	Pale yellow (10YR 7/2) poorly graded fine to coarse Gravelly Sand (SP). Apparent forset bedding, dip variable, but mostly dipping SE at about 40º.
		Bottom of test pit	

Location:	Grant Housing Area
Project Name:	Devens SSI
Project Number:	03886.518.045
Project Manager:	Erin Kinney
Logged By:	Joseph Schmidl, PG
Date Logged:	11/4/2004
Excavation Method:	Backhoe
Total Depth:	6 feet
Ground Surf. Elev.:	
Remarks:	

Test Pit Face Cross Sections



Test Pit: IA-9 Test Pit 01

Location:	Cavite Housing Area
Project Name:	Devens SSI
Project Number:	03886.518.045
Project Manager:	Erin Kinney
Logged By:	Joseph Schmidl, PG
Date Logged:	11/4/2004
Excavation Method:	Backhoe
Total Depth:	6 feet
Ground Surf. Elev.:	

Remarks:
Test pit was excavated 6 ft x 6 ft x 6 ft
Soil Samples CA-IA09-TP01A1 to -TP01D3 collected from side walls of test pit.

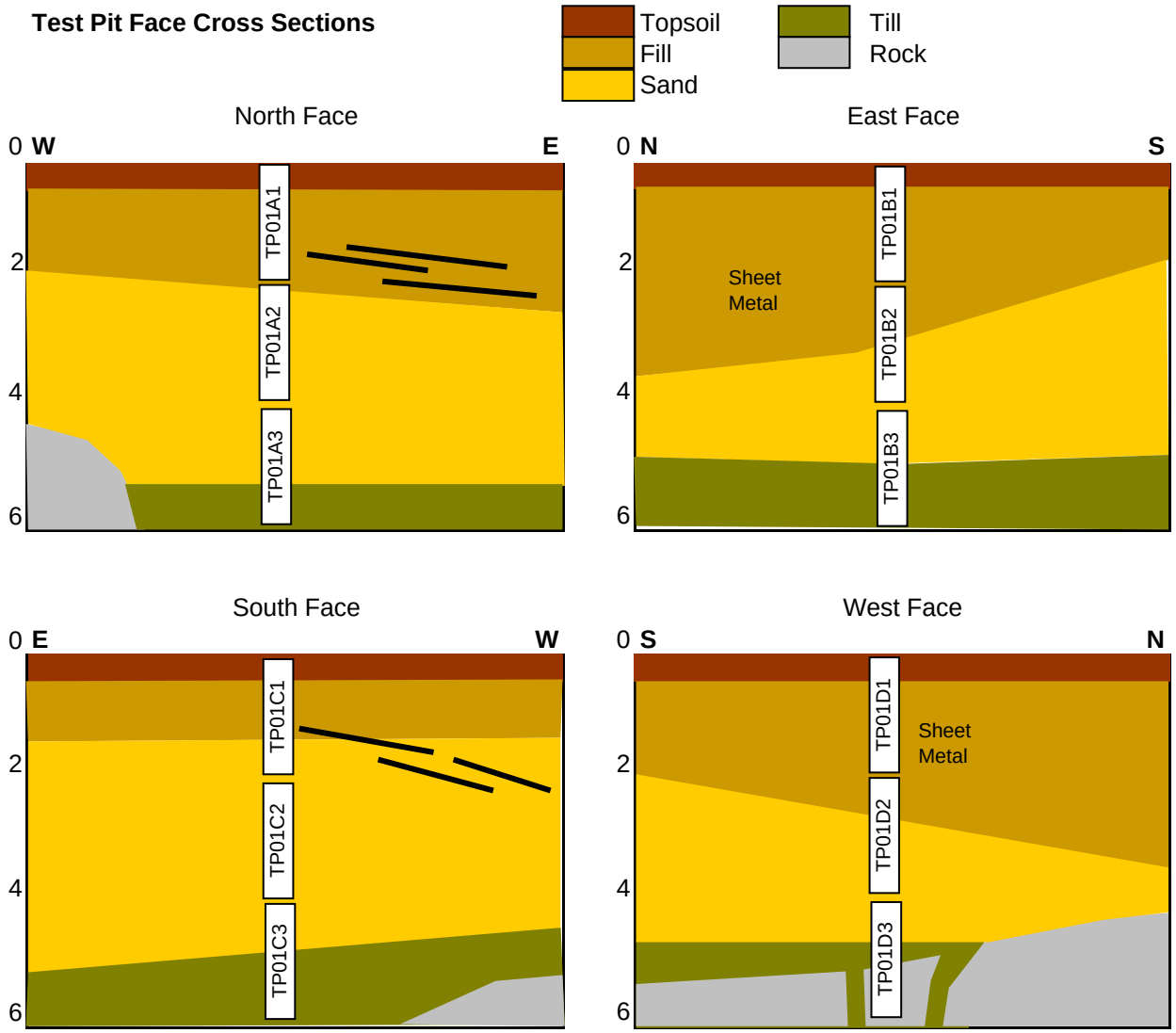


South Face of Test Pit, depth 2 ft bgs

Stratigraphic Unit	Sample Number	Depth (ft)	Material Description
LOAM		0.5	Dark brown 10YR 3/4, well graded Silty Sand with little coarse gravel. (SM)
FILL	TP01A1 TP01B1 TP01C1 TP01D1	1.8 to 3.8	Brown (10YR 4/4), well graded medium Sand with some coarse gravel and little cobbles (SP). Some thin layers of dark brown (10 YR 2/4) medium sand an scrap metal within the fill.
OUTWASH	TP01A2 TP01B2 TP01C2 TP01D2	4.5 to 6.0	Pale yellow brown (10YR 8/4) poorly graded fine Sand. No apparent bedding. Few iron accumulation mottles and layers at 2.5 to 3 ft bgs.
	TP01A3 TP01B3		
TILL/ BEDROCK	TP01C3 TP01D3	6.0	Pale olive brown (10Y 6/2) well-graded Gravelly Clay, dense and cohesive. Bedrock is pale gray, foliated Ayer Granite, slightly weathered. Bedrock is approximately 4.5 ft bgs at west end of test pit, > 6 ft bgs at east end.
		Bottom of test pit	

Location:	Cavite Housing Area
Project Name:	Devens SSI
Project Number:	03886.518.045
Project Manager:	Erin Kinney
Logged By:	Joseph Schmidl, PG
Date Logged:	11/4/2004
Excavation Method:	Backhoe
Total Depth:	6 feet
Ground Surf. Elev.:	
Remarks:	

Test Pit Face Cross Sections



APPENDIX B

SOIL BORING LOGS

Soil Boring Log

Area: Grant	**Boring Date: November 29, 2004**	**Drilling Contractor: Geosearch**
Investigation Area: IA-1	**Boring Method: 3-in SS**	**Driller: Joe Keenan**
Boring ID: SB-01	**Drilling Method: 4¼-in. HSA**	**WESTON Geologist: A. Klappholz**
	Note: 140lb hammer used to	**Client: USACE**
Total Depth (ft bgs): 10.0	**advance the split spoons.**	

Depth Interval	Penetration/Recovery	WESTON Sample	Blow Count	Soil Classification	Lithologic Description	Soil Headspace
0.50	2.0/1.0	GR-IA01-SB01-1 (0'-3')	3-3-3-2	SM	0-0.4 ft. Brown (5YR 3/3) Silty m-f subangular SAND and organics, moist, loose. LOAM	0.0
1.0				SP	0.4-1.0 ft. Brown (5YR 3/3) Gravelly Silty m-f subangular SAND, dry, loose. OUTWASH (Kame)	
1.5						
2.0						
2.5	2.0/1.3		2-2-2-1	SP	Brown (5YR 3/3) Gravelly Silty m-f subangular SAND, dry, loose. OUTWASH (Kame)	
3.0						
3.5		GR-IA01-SB01-1 (3'-10')				0.0
4.0						
4.5	2.0/1.2		2-2-3-8	SW	Brown (5YR 4/4) well graded Gravelly Silty c-f angular SAND, dry, loose. OUTWASH (Kame)	
5.0						
5.5						
6.0						
6.5	2.0/1.4		8-10-13-13	SW	Brown (5YR 4/4) well graded Gravelly Silty c-f angular SAND, dry, loose. OUTWASH (Kame)	
7.0						
7.5						
8.0						
8.5	2.0/1.5		20-19-18-19	GP	Brown (5YR 4/4) Sandy Silty m-f angular GRAVEL, dry, loose. OUTWASH (Kame)	
9.0						
9.5						
10.0						
10.5						
11.0						
11.5						
12.0						
12.5						
13.0						
13.5						
14.0						
14.5						
15.0						
15.0						
15.0						

Soil Boring Log

Area: Grant	**Boring Date: December 10, 2004**	**Drilling Contractor: GEOSEARCH**
Investigation Area: IA-1	**Boring Method: 3-in SS**	**Driller: Ken Byland**
Boring ID: SB-02	**Drilling Method: 4¼-in. HSA**	**WESTON Geologist: J. Schmidl**
	Note: 140-lb hammer used to	**Client: USACE**
Total Depth (ft bgs): 10.0	**advance the split spoons.**	

Depth Interval	Penetration/ Recovery	WESTON Sample	Blow Count	Soil Classification	Lithologic Description	Soil Headspace
0.50 1.0 1.5 2.0	2.0/1.8	GR-IA01-SB02-1 (0'-3')	11-7-12-15	ML SP	0.0-0.4 ft. Dark grayish brown (10YR 4/2) Sandy SILT, trace organic material, moist, cohesive. OUTWASH 0.4-1.8 ft. Grayish Brown (10YR 5/2) graded Gravelly m-f SAND, moist, loose. OUTWASH (Esker)	3.5
2.5 3.0 3.5 4.0	2.0/1.2		13-18-19-15	SP	Grayish brown (10YR 5/2) Gravelly f-m SAND, moist, loose. OUTWASH (Esker)	5.0
4.5 5.0 5.5 6.0	2.0/1.1	GR-IA01-SB02-1 (3'-10')	13-15-18-19	SP	Dark Yellowish Brown (10YR 4/4) Gravelly Silty m-c SAND, moist, loose. OUTWASH (Kame)	3.3
6.5 7.0 7.5 8.0	2.0/1.0		13-18-19-15	SP	Dark Yellowish Brown (10YR 4/4) Gravelly Silty m SAND, moist, loose. OUTWASH (Kame)	1.3
8.5 9.0 9.5 10.0	2.0/1.5		10-7-8-8	SP	Dark Yellowish Brown (10YR 4/4) Gravelly m-c SAND, moist, loose. OUTWASH (Kame)	4.3
10.5 11.0 11.5 12.0						
12.5 13.0 13.5 14.0						
14.5 15.0 15.0 15.0						

Soil Boring Log

Area: Grant	**Boring Date: December 10, 2004**	**Drilling Contractor: GEOSEARCH**
Investigation Area: IA-1	**Boring Method: 3-in SS**	**Driller: Ken Byland**
Boring ID: SB-03	**Drilling Method: 4¼-in. HSA**	**WESTON Geologist: J. Schmidl**
	Note: 140-lb hammer used to	**Client: USACE**
Total Depth (ft bgs): 10.0	**advance the split spoons.**	

Depth Interval	Penetration/ Recovery	WESTON Sample	Blow Count	Soil Classification	Lithologic Description	Soil Headspace
0.50 1.0 1.5 2.0	2.0/1.4	GR-IA01-SB03-1 (0'-3')	5-8-8-12	SM SP	0-0.8 ft. Dark grayish brown (10YR 4/2) Gravelly Silty fine SAND, trace organic material, moist, cohesive. OUTWASH (Kame) 0.8-1.4 ft. Dark yellowish brown (10YR 4/6) Gravelly fine SAND, moist, cohesive. OUTWASH (Esker)	4.6
2.5 3.0 3.5 4.0	2.0/1.2		5-12-13-7	SP SP	4.0-4.2 ft. Dark yellowish brown (10YR 4/6) Gravelly fine SAND, moist, cohesive. OUTWASH (Esker) 4.2-5.2 ft. Dark yellowish brown (10YR 4/4) graded Gravelly f-c SAND, moist, slightly cohesive. OUTWASH (Esker)	5.6
4.5 5.0 5.5 6.0	2.0/1.2	GR-IA01-SB03-1 (3'-10')	13-14-13-14	SP	Dark yellowish brown (10YR 4/4) graded Gravelly f-c SAND, moist, slightly cohesive. OUTWASH (Kame)	0.0
6.5 7.0 7.5 8.0	2.0/0.9		13-12-11-11	SP	Dark yellowish brown (10YR 4/4) graded Gravelly f-c SAND, moist, slightly cohesive. OUTWASH (Esker)	1.5
8.5 9.0 9.5 10.0	2.0/1.5		10-7-8-8	SP ML	8.0-9.2 ft. Greyish brown (10YR 5/2) poorly graded beds of m-c SAND, Light brownish grey (10YR 6/2) fine SAND, Light yellowish brown (10YR 6/4) SILT, moist, loose to cohesive. OUTWASH (Kame) 1.2-1.5 ft. Olive (5Y 5/4) Gravelly SILT, SILT, little m rounded gravel, moist, cohesive. OUTWASH (Kame)	3.8
10.5 11.0 11.5 12.0						
12.5 13.0 13.5 14.0						
14.5 15.0 15.0 15.0						

Soil Boring Log

Area: Grant	**Boring Date: December 10, 2004**	**Drilling Contractor: Geosearch**
Investigation Area: IA-1	**Boring Method: 3-in SS**	**Driller: Joe Keenan**
Boring ID: SB-04	**Drilling Method: 4¼-in. HSA**	**WESTON Geologist: A. Klappholz**
	Note: 140lb hammer used to	**Client: USACE**
Total Depth (ft bgs): 10.0	**advance the split spoons.**	

Depth Interval	Penetration/v Recovery	WESTON Sample	Blow Count	Soil Classification	Lithologic Description	Soil Headspace
0.50 1.0 1.5 2.0	2.0/2.0	GR-IA01-SB04-1 (0'-3')	2-2-4-6	SM SP	0-0.8 ft. Very Dark Brown (10YR 2/1) Silty Gravelly fine SAND and organics, moist, loose. LOAM 0.8-2.0 ft. Dark Yellowish Brown (10YR 4/4) Silty Gravelly m-f subangular SAND, moist, compact. OUTWASH (Kame)	0.0
2.5 3.0 3.5 4.0	2.0/2.0		4-8-8-8	SP	2.0-2.8 ft. Dark Yellowish Brown (10YR 4/4) Silty m-f subangular SAND, dry, loose. OUTWASH (Kame) 2.8-3.1 ft. Crushed angular weathered shale fragments. 3.1 -3.5 ft. Dark Yellowish Brown (10YR 4/4) Gravelly Silty m-f subangular SAND, dry, very dense. OUTWASH (Kame) 3.5-4.0 ft. Yellowish Brown (10YR 5/4) Silty m-f subangular SAND, dry, loose-compact. OUTWASH (Kame)	4.0
4.5 5.0 5.5 6.0	2.0/2.0	GR-IA01-SB04-1 (3'-10')	3-7-7-9	SP	Yellowish Brown (10YR 5/4) Silty m-f subangular SAND, dry, loose-compact. OUTWASH (Kame)	0.0
6.5 7.0 7.5 8.0	2.0/1.5		7-1-12-16	SP	Brown (10YR 4/3) Gravelly Silty c-f subangular SAND, dry, loose. OUTWASH (Kame)	9.4
8.5 9.0 9.5 10.0	2.0/1.7		18-20-20-22	SP	Brown (10YR 4/3) Gravelly Silty c-f subangular SAND, dry, loose. OUTWASH (Kame)	0.0
10.5 11.0 11.5 12.0 12.5 13.0 13.5 14.0 14.5 15.0 15.0 15.0						

SOIL BORING/WELL CONSTRUCTION LOG

Site: Devens SSI	**Boring/Well ID: MW-3**	**Sampling Method: 3-inch SS**
Investigation Area: IA-02	**Drilling Company: GEOSEARCH**	**Surface Elevation:**
Weston Geologist: A. Klappholz	**Driller: Joe Keenan**	**Total Depth: 45 ft**
Date: November 30, 2004	**Boring Method: 4¼-inch HSA**	**Water Level: 39 ft**

Depth (ft bgs)	Sample Interval	Well Construction	Sample Type	Pen/ Rec	Blow Count	Soil Classification	Lithologic Description	NAPL Show/ Oil/Sheen	Soil Headspace (units>BKG)
1	0-2		SS	2.0/1.2	4-4-7-11	SM	0.0-0.2 ft. Very Dark Brown (5Y 2.5/2) Sandy nonplastic SILT, with organic material, moist, loose. LOAM. 0.2-1.2 ft: Dark Yellowish Brown (10YR 4/4) Silty m-f subangular SAND, moist, loose. OUTWASH (Kame)	None	0.0
2									
3	2-4		SS	2.0/1.9	4-4-7-11	SP-SM SP ML	2.0-0.4 ft. Dark Yellowish Brown (10YR 4/4) Silty m-f subangular SAND, moist, loose. 2.4-3.0 ft. Grayish Brown (10YR 5/2) Silty fine SAND, moist, dense. 3.0-3.2 ft. Brown (10YR 5/3) Silty m-f subangular SAND, dry, loose. 3.2-3.9 Grayish Brown (10YR 5/2) Sandy slightly plastic SILT, dry, firm. OUTWASH (Kame)	None	0.0
4									
5	4-6		SS	2.0/2.0	18-24-15-14	ML SP	4.0-5.2 ft. Grayish Brown 1910YR5/2) Sandy slightly plastic SILT, dry, firm, with an occassional Light Yellowish Brown (10YR 6/4) Silty fine SAND seam, dry, loose. 5.2-5.8 ft. Light Gray (10YR 7/2) poorly graded Silty fine SAND, dry, loose. 5.8-6.0 ft. Light Brownish Gray (2.5Y 6/2) Silty m-f subangular SAND, moist, loose. OUTWASH (Kame)	None	0.0
6									
7	6-8		SS	2.0/1.5	10-10-8-7	SP-SW SW-SM	6.0-6.2 ft. Light Brownish Gray (2.5Y 6/2) SAND, moist, loose. 6.2-7.4 ft. Pale brown (10YR 6/3), interbedded, poorly graded subangular medium SAND; Pale brown (10YR 6/3) Silty m-f subangular SAND; Reddish brown (2.5YR 5/4) well graded Gravelly c-f subangular SAND; Light brown (7.5YR 6/3) Silty m-f subangular SAND, dry, loose. OUTWASH	None	0.0
8									
9	8-10		SS	2.0/1.2	6-16-13-16	SP-SW	8.0-8.2 ft.Light reddish brown (2.5YR 6/4) poorly graded Gravelly Silty medium subrounded SAND, dry, loose. 8.2-8.4 ft. Brown (10YR 5/3) Sandy Silty m-f angular GRAVEL, dry, loose. 8.4-9.2 ft. Pale Brown (10YR 6/3) Silty subangular c-f SAND, dry, loose. OUTWASH (Kame)	None	0.0
10									
11	10-12		SS	2.0/1.7	11-13-17-15	SP	Strong Brown (7.5YR 5/6) Gravelly c-m angular SAND, dry, dense. OUTWASH (Esker)	None	0.0
12									
13	12-14		SS	2.0/1.1	17-27-25-31	SP-SM	12.0-12.7 ft. Strong Brown (7.5YR 5/6) Gravelly c-m angular SAND, dry, dense. 12.7-13.1 ft. Brown (10YR 5/3) Silty m-f subangular SAND, dry, loose. OUTWASH (Esker)	None	0.0
14									
15	14-16		SS	2.0/1.4	17-17-19-21	SW-SP ML-SP	14.0-14.3 ft. Brown (10YR5/3) well graded c-f subrounded SAND, dry, loose. 14.3-14.35 ft. Black (10YR 2/1) poorly graded m subangular SAND, Fe accumulation at 14.35 ft. 14.35-14.7 ft. Pinkish Grey (7.5YR 6/2) well graded Silty m subangular SAND, dry, loose. OUTWASH (Kame) 14.7-15.3 ft. Light Olive Brown (2.5Y 5/3) slightly plastic SILT, moist, firm. 15.3-15.4 ft. Grayish Brown (2.5Y 5/2) Silty f SAND, dry, loose-compact. OUTWASH (Kame)	None	0.0
16									
17	16-18		SS	2.0/1.5	22-19-24-23	SP ML	16.0-17.1 ft. Light Yellowish Brown (2.5Y 6/3) Silty f SAND, visible beds, some weathering, dry, loose. 17.1-17.5 ft. Light Olive Brown (2.5Y 5/3) slightly plastic SILT, moist, firm. OUTWASH (Kame)	None	0.0
18									
19	18-20		SS	2.0/1.7	21-21-25-27	SM-ML SM	18.0-18.5 ft. Light Yellowish Brown (2.5Y 6/3) Silty f SAND, visible rust stains, dry, loose. 18.5-18.8 ft. Light 18.8-19.7 ft. Light Yellowish Brown (2.5Y 6/3) Silty f SAND, visible rust stains, dry, loose. OUTWASH (Kame)	None	0.0
20									
21	20-22		SS	2.0/1.6	13-13-15-18	SP	20.0-21.0 ft. Pale Yellow (2.5Y 8/3) Gravelly subangular m SAND, dry, loose. OUTWASH Esker) 21.0-21.6 ft. Grayish Brown (2.5Y 5/2) Gravelly c-f angular SAND, dry, loose. OUTWASH	None	0.0
22									
23	22-24		SS	2.0/1.3	21-35-34-33	SP	Grayish Brown (2.5Y 5/2) Gravelly c-f angular SAND, dry, loose. OUTWASH (Esker)	None	0.0
24									
25	24-26		SS	1.75/1.5	39-33-41-50/3"	SP	Grayish Brown (2.5Y 5/2) Gravelly c-f angular SAND, dry, loose. OUTWASH (Esker)	None	0.0
26									
27	26-28		SS	2.0/1.5	12-50-24-37	SP	26-26.7 ft. Brown (10YR 5/3) Gravelly m-f subangular SAND, dry, loose. 26.7-27.0 ft. Angular cobble fragments. 27.0-27.5 ft. Grayish Brown (2.5Y 5/2) Gravelly c-f angular sand, with m angular gravel, loose, dry. OUTWASH (Esker)	None	0.0
28									
29	28-30		SS	2.0/1.6	38-44-46-46	SP	Pale Brown (10YR 6/3) Gravelly c-f subrounded SAND, dry, loose. OUTWASH (Esker)	None	0.0
30									

Sample Type:

SOIL BORING/WELL CONSTRUCTION LOG

Site: Devens SSI	**Boring/Well ID: MW-3**	**Sampling Method: 3-inch SS**
Investigation Area: IA-02	**Drilling Company: GEOSEARCH**	**Surface Elevation:**
Weston Geologist: A. Klappholz	**Driller: Joe Keenan**	**Total Depth: 45 ft**
Date: November 30, 2004	**Boring Method: 4¼-inch HSA**	**Water Level: 39 ft**

Depth (ft bgs)	Sample Interval	Well Construction	Sample Type	Pen/ Rec	Blow Count	Soil Classification	Lithologic Description	NAPL Show/ Oil/Sheen	Soil Headspace (units>BKG)
31	30-32		SS	2.0/1.5	16-24-36-18	SP	30.0-31.3 ft. Pale brown (10YR 6/3) Gravelly c-f subrounded SAND, dry, loose. 31.3-31.5 ft. Light Brownish Gray (2.5Y 6/2) m-f subrounded SAND, dry, loose. OUTWASH (Esker)	None	0.0
32									
33	32-34		SS	2.0/1.7	18-24-26-20	SP	32.0-32.9 ft. Light Brownish Gray (2.5Y 6/2) m-f subrounded SAND, dry, loose. OUTWASH (Esker) 32.9-33.7 ft. Light Yellowish Brown (2.5Y 6/3) Silty f SAND, some visible bedding with rust stains, dry, loose.	None	0.0
34									
35	34-36		SS	2.0/1.9	10-14-16-22	SP	Light Yellowish Brown (2.5Y 6/3) poorly graded m subrounded-subangular SAND, visible bedding, dry, loose. OUTWASH (Esker)	None	0.0
36									
37	36-38		SS	2.0/2.0	18-18-20-22	SP	Light Yellowish Brown (2.5Y 6/3) poorly graded m subrounded-subangular SAND, visible bedding, dry, loose. OUTWASH (Esker)	None	0.0
38									
39	38-40		SS	2.0/1.6	9-9-10-7	SP	38-38.7 ft. Light Yellowish Brown (2.5Y 6/3) SAND as above. 38.7-39.2 ft. Light Yellowish Brown (2.5Y 6/3) c-m subrounded SAND, moist, loose. OUTWASH (Esker) 39.2-39.6 ft. Grayish Brown (2.5Y 5/2) poorly graded m subrounded SAND, saturated, loose. OUTWASH (Esker)	None	0.0
40									
41	40-42		SS	2.0/1.9	6-10-14-17	SP SM	40.0-40.7 ft. Grayish Brown (2.5Y 5/2) poorly graded m subrounded SAND, saturated, loose. OUTWASH (Esker) 40.7-42.0 ft. Olive Brown (2.5Y 4/3) Silty Gravelly c-f subangular SAND, saturated, dense. ABLATION TILL	None	0.0
42									
43	42-44		SS	2.0/2.0	14-15-15-18	SP SM	42.0-43.2 ft. Grayish Brown (2.5Y 5/2) poorly graded m subrounded SAND, saturated, loose. OUTWASH (possibly 43.2-44.0 ft. Olive Brown (2.5Y 4/3) Silty Gravelly c-f subangular SAND, saturated, dense. ABLATION TILL	None	0.0
44									
45	44-46		SS	0.9/1.3	18-50/5"	SM	44.0-45.3 ft. Olive Brown (2.5Y 4/3) Silty Gravelly c-f subangular SAND, saturated, dense. ABLATION TILL	None	0.0
46							End of Boring.		
47	46-48						Well constructed using 10-slot, 2-in OD PVC screen, #2 silica sand, bentonite chips, and cement/ bentonite grout.		
48									
49	48-50								
50									
51	50-52								
52									
53	52-54								
54									
55	54-56								
56									
57	56-58								
58									
59	58-60								
60									

SOIL BORING/WELL CONSTRUCTION LOG

Site: Devens SSI	**Boring/Well ID: MW-4**	**Sampling Method: 3-inch SS**
Investigation Area: IA-02	**Drilling Company: GEOSEARCH**	**Surface Elevation:**
Weston Geologist: A. Klappholz	**Driller: Joe Keenan**	**Total Depth: 18.0 ft**
Date: December 15-16, 2004	**Boring Method: 4¼-inch HSA**	**Water Level: 12 ft**

Depth (ft bgs)	Sample Interval	Well Construction	Sample Type	Pen/ Rec	Blow Count	Soil Classification	Lithologic Description	NAPL Show/ Oil/Sheen	Soil Headspace (units>BKG)
1	0-2		SS	2.0/1.5	13-8-8-7	SP	0.0-0.2 ft. Very Dark Brown (5Y 2.5/2) Sandy nonplastic SILT, with organic material, moist, loose. LOAM. 0.2-1.2 ft: Dark Yellowish Brown (10YR 4/4) Silty m-f subangular SAND, moist, loose. 1.3-1.5 ft. Light Yellowish Brown (2.5Y 6/4) Silty m-f subangular SAND, dry, loose. FILL	None	2.5
3	2-4		SS	2.0/1.7	7-8-13-14	SP	Light Yellowish Brown (2.5Y 6/4) Silty m-f subangular SAND, dry, loose. FILL	None	2.7
5	4-6		SS	2.0/1.5	11-13-11-12	SP-SM	Brown (10YR 5/3) well graded Gravelly Silty c-f subangular SAND, dry, loose. OUTWASH (Kame)	None	2.9
7	6-8		SS	2.0/1.4	10-11-8-7	SW	Brown (10YR 5/3) well graded Silty c-f subangular SAND, moist, loose. OUTWASH (Kame)	None	2.2
9	8-10		SS	2.0/1.4	10-18-18-20	SM	8.0-8.7 ft. Brown (10YR 5/3) well graded Silty c-f subangular SAND, moist, loose. 8.7-9.4 ft. Light Yellowish Brown (10YR 6/4) Silty fine SAND, moist, compact. OUTWASH (Kame)	None	2.0
11	10-12		SS	2.0/1.4	7-8-11-13	SM	Yellowish Brown (10YR 5/4) Silty fine SAND, wet, compact. OUTWASH (Kame)	None	1.3
13	12-14		SS	2.0/1.4	7-8-13-14	SP SM	12.0-12.7 ft. Strong Brown (7.5YR 5/6) Gravelly c-m angular SAND, dry, dense. OUTWASH (Esker) 12.7-13.1 ft. Brown (10YR 5/3) Silty m-f subangular SAND, saturated, loose. OUTWASH (Kame)	None	1.9
15	14-16		SS	2.0/1.4	9-13-13-14	SM ML SP	14.0-15.4 ft. Yellowish Brown (10YR 5/4) Silty m-f subangular SAND, saturated, loose. OUTWASH (Kame) 14.7-15.3 ft. Light Olive Brown (2.5Y 5/3) slightly plastic SILT, moist, firm. 15.3-15.4 ft. Grayish Brown (2.5Y 5/2) Silty f SAND, saturated, loose. OUTWASH (Kame)	None	2.6
17	16-18		SS	2.0/2.0	8-23-37-48	SM ML	16.0-17.5 ft. Brown (10YR 5/3) Silty m-f subangular SAND, saturated, loose. OUTWASH (Kame) 17.5-18.0 ft. Light Yellowish Brown (2.5Y 6/4) Gravelly Sandy nonplastic SILT, dry, dense-very dense.	None	5.6
19	18-20						End of Boring. Well constructed using 10-slot, 2-in OD PVC screen, #00 sand from 18-17.5 ft. bgs, #2 silica sand from 17.5-6 ft. bgs, bentonite chips, and cement/ bentonite grout.		
21	20-22								
23	22-24								
25	24-26								
27	26-28								
29	28-30								

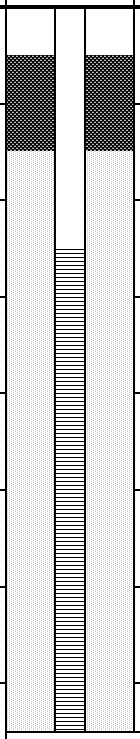
SOIL BORING/WELL CONSTRUCTION LOG

Site: Devens SSI	**Boring/Well ID: PZ-04**	**Sampling Method: 3-inch SS**
Investigation Area: IA-02	**Drilling Company: GEOSEARCH**	**Surface Elevation:**
Weston Geologist: A. Klappholz	**Driller: Joe Keenan**	**Total Depth: 22 ft**
Date: December 1, 2004	**Boring Method: 4¼-inch HSA**	**Water Level: 20 ft**

Depth (ft bgs)	Sample Interval	Well Construction	Sample Type	Pen/ Rec	Blow Count	Soil Classification	Lithologic Description	NAPL Show/ Oil/Sheen	Soil Headspace (units>BKG)
1	0-2		SS	2.0/1.2	2-5-5-5	SM-SP	0.0-0.2 ft. Very Dark Brown (5Y 2.5/2) Sandy nonplastic SILT, with organic material, moist, loose. LOAM. 0.2-1.2 ft: Dark Yellowish Brown (10YR 4/4) Silty m-f subangular SAND, moist, loose. OUTWASH (Kame)	None	0.0
3	2-4		SS	2.0/1.6	4-7-7-7	SP SW	2.0-2.5 ft. Light Yellowish Brown (2.5Y 6/4) Silty m-f subangular SAND, moist, loose. 2.5-3.6 ft. Pale Brown (10YR 6/3) well graded Silty c-f angular SAND, dry, loose. OUTWASH (Kame)	None	0.0
5	4-6		SS	2.0/2.0	8-7-7-8	SW	Pale Brown (10YR 6/3) well graded Gravelly c-f angular SAND, dry, loose. OUTWASH (Kame)	None	0.0
7	6-8		SS	2.0/1.2	6-9-9-10	SP SW	6.0-6.2 ft. Pale Brown (10YR 6/3) well graded Gravelly c-f angular SAND, dry, loose. 6.2-6.6 ft. Brownish Yellow (10YR 6/6) poorly graded Silty m subangular SAND, dry, loose. 6.6-7.0 ft. Dark Yellowish Brown (10YR 3/4) Silty c-f angular SAND, mostly m-f sand, dry, loose. 7.0-7.2 ft. Olive Brown (2.5Y 4/4) well graded c-f angular SAND, dry, loose. OUTWASH (Esker)	None	0.0
9	8-10		SS	2.0/1.6	8-9-13-13	SW	Dark Brown (10YR 3/3) well graded c-f subangular Gravelly SAND, dry, loose. OUTWASH (Esker)	None	0.0
11	10-12		SS	2.0/1.0	12-14-14-14	SW	Dark Brown (10YR 3/3) well graded c-f subangular Gravelly SAND, dry, loose. OUTWASH (Esker)	None	0.0
13	12-14		SS	2.0/2.0	18-17-18-18	SW	Dark Brown (10YR 3/3) well graded c-f subangular Gravelly SAND, dry, loose. OUTWASH (Esker)	None	0.0
15	14-16		SS	2.0/1.2	9-13-13-14	SP	Brown (10YR 4/3) Gravelly c-m subangular SAND, dry, loose. OUTWASH (Esker)	None	0.0
17	16-18		SS	2.0/1.0	25-18-16-15	SP	Brown (10YR 4/3) Gravelly c-m subangular SAND, dry, loose. OUTWASH (Esker) Gravel plugged the bottom of the split spoon, which is	None	0.0
19	18-20		SS	2.0/1.0	2-5-7-9	SP	Very Dark Grayish Brown (10YR 3/2) Gravelly c-m SAND, saturated, loose. OUTWASH (Esker)	None	0.0
21	20-22		SS	2.0/0.7	2-3-3-4	SP	Very Dark Grayish Brown (10YR 3/2) Gravelly c-m angular SAND, saturated, loose. OUTWASH (Esker)	None	0.0
23	22-24						End of Boring. Well constructed using 10-slot, 2-in OD PVC screen, #2 silica sand, bentonite chips, and cement/ bentonite grout.		
25	24-26								
27	26-28								
29	28-30								

SOIL BORING/WELL CONSTRUCTION LOG

Site: Devens SSI	**Boring/Well ID: PZ-05**	**Sampling Method: 3-inch SS**
Investigation Area: IA-02	**Drilling Company: GEOSEARCH**	**Surface Elevation:**
Weston Geologist: A. Klappholz	**Driller: Joe Keenan**	**Total Depth: 15 ft**
Date: December 1, 2004	**Boring Method: 4¼-inch HSA**	**Water Level: 8 ft**

Depth (ft bgs)	Sample Interval	Well Construction	Sample Type	Pen/ Rec	Blow Count	Soil Classification	Lithologic Description	NAPL Show/ Oil/Sheen	Soil Headspace (units>BKG)
1	0-2		SS	2.0/0.4	4-5-5-2	ML	Very Dark Brown (5Y 2.5/2) Sandy nonplastic SILT, with organic material, moist, loose. LOAM.	None	0.0
3	2-4		SS	2.0/1.2	5-5-7-9	SM	Dark Brown (10YR 3/3) Silty Gravelly f SAND, moist, loose. OUTWASH (Kame)	None	0.0
5	4-6		SS	2.0/1.8	4-5-7-6	SM	Dark Brown (10YR 3/3) Silty Gravelly m-f angular SAND, moist, loose. OUTWASH (Kame)	None	0.0
7	6-8		SS	2.0/1.1	8-9-6-9	SM-ML SP	6.0-6.8 ft. Dark Brown (10YR 3/3) Silty Gravelly m-f angular SAND, moist, loose. 6.8-7.0 ft. Dark Brown (10YR 3/3) Sandy nonplastic SILT, moist, soft-firm. 7.0-7.1 ft.Strong Brown (7.5YR 5/6) poorly graded m SAND, moist, loose. Iron staining at interface with the above silty sand. OUTWASH (Kame)	None	0.0
9	8-10		SS	2.0/1.3	3-6-4-2	SP	8.0-8.3 ft. Brown (10YR 4/3) Gravelly Silty m subangular SAND, moist-saturated, loose. 8.3-9.3 ft. Brown (10YR 4/3) Silty f SAND, saturated, compact. OUTWASH (Kame)	None	0.0
11	10-12		SS	2.0/1.7	3-5-5-6	SP	Brown (10YR 4/3) Silty f SAND, saturated, compact. OUTWASH (Kame)	None	0.0
13	12-14		SS	0.9/1.5	6-50/5"	SP ML-SM	12.0-13 ft. Brown (10YR 4/3) Silty f SAND, saturated, compact. OUTWASH (Kame) 13.0-13.2 ft. Brownish Yellow (10YR 6/6) Sandy nonplastic SILT, saturated, firm. ABLATION TILL 13.2-14.5 ft. Brownish Yellow (10YR 6/6) Silty Gravelly f SAND, saturated, compact-dense. LODGEMENT TILL.	None	0.0
15	14-16		SS	0.2/0.0	50/2"	SP	No recovery.	None	0.0
17	16-18						End of Boring. Well constructed using 10-slot, 2-in OD PVC screen, #00 silica sand, and bentonite chips.		
19	18-20								
21	20-22								
23	22-24								
25	24-26								
27	26-28								
29	28-30								

SOIL BORING/WELL CONSTRUCTION LOG

Site: Devens SSI	**Boring/Well ID: PZ-06**	**Sampling Method: 3-inch SS**
Investigation Area: IA-02	**Drilling Company: GEOSEARCH**	**Surface Elevation:**
Weston Geologist: A. Klappholz	**Driller: Ken Byland**	**Total Depth: 49.4 ft**
Date: December 13-14, 2004	**Boring Method: 4¼-inch HSA**	**Water Level: 42 ft**

Depth (ft bgs)	Sample Interval	Well Construction	Sample Type	Pen/ Rec	Blow Count	Soil Classification	Lithologic Description	NAPL Show/ Oil/Sheen	Soil Headspace (units>BKG)
1	0-2		SS	2.0/0.8	6-8-10-13	SM	0.0-0.2 ft. Very Dark Brown (5Y 2.5/2) Sandy nonplastic SILT, with organic material, moist, loose. LOAM 0.2-1.2 ft: Dark Yellowish Brown (10YR 4/4) Silty m-f subangular SAND, moist, loose. FILL	None	0.0
3	2-4		SS	2.0/1.4	10-8-8-8	SM	Yellowish Brown (10YR 5/4) Silty Gravelly m-f subangular SAND, dry, loose. FILL	None	0.0
5	4-6		SS	2.0/1.6	9-9-9-9	SM-SP	Dark Yellowish Brown (10YR 4/4) Silty Gravelly m-f subangular SAND, dry, loose. FILL	None	1.3
7	6-8		SS	2.0/1.5	12-10-11-12	SM-SP	Brown (10YR 4/3) Gravelly Silty c-f subangular SAND, dry, loose. OUTWASH	None	0.0
9	8-10		SS	2.0/1.6	15-20-20-20	SM-SP	Yellowish Brown (10YR 5/4) Gravelly Silty c-f subangular SAND, dry, loose. OUTWASH	None	0.0
11	10-12		SS	2.0/1.5	20-10-9-7	SM-SP	Yellowish Brown (10YR 5/4) Gravelly Silty f-c SAND, dry, loose. OUTWASH	None	15.4
13	12-14		SS	2.0/1.6	8-11-14-7	GW SM	Strong Brown (7.5YR 5/6) Gravelly c-m angular SAND, dry, dense. 12.7-13.1 ft. Brown (10YR 5/3) Silty m-f subangular SAND, dry, loose. OUTWASH	None	3.1
15	14-16		SS	2.0/1.5	12-14-13-15	GW	Yellowish Brown (10YR 5/4) Sandy Silty m-f subangular-angular GRAVEL, dry, loose. OUTWASH	None	4.5
17	16-18		SS	0.4/0.4	50/4"	GW	Yellowish Brown (10YR 5/4) Sandy Silty m-f subangular-angular GRAVEL, dry, loose. OUTWASH	None	4.8
19	18-20		SS	2.0/1.5	21-21-25-27	SM/ML SP	18.0-18.5 ft. Light Yellowish Brown (2.5Y 6/3) Silty f SAND, Fe accumulation, dry, loose. 18.5-19.0 ft. Light Olive Brown (2.5Y 5/3) slightly plastic SILT, moist, firm. 19.0-19.5 ft. Pale Brown (10YR 6/3) Silty m-f subangular SAND, dry, loose. OUTWASH	None	5.0
21	20-22		SS	2.0/1.8	6-9-11-11	SP	Pale Brown (10YR 6/3) Silty m-f subangular SAND, dry, loose. With an occassional poorly graded fine sand seam. OUTWASH	None	7.8
23	22-24		SS	2.0/1.7	8-11-15-17	SP SP-SW	22.0-23.0 ft. Light brownish gray (10YR 6/2), interbedded Silty f-m subangular SAND and f SAND, dry, loose. OUTWASH 23.0-23.4 ft. Light Brownish Gray (2.5Y 6/2), interbedded Silty f SAND and SILT, dry, loose. 23.4-23.7 ft. Grayish Brown (10YR 5/3) well graded Silty	None	4.4
25	24-26		SS	2.0/1.5	11-13-13-11	SM	Light Grayish Brown (10YR 6/2) Silty f SAND, dry, loose. With an occassional silt nonplastic seam. OUTWASH	None	3.1
27	26-28		SS	2.0/1.6	12-14-14-15	ML SM	26.0-26.6 ft. Light Yellowish Brown (2.5Y 6/4) nonplastic SILT, moist, firm-stiff. 26.6-27.6 Pale Brown (10YR 6/3) Silty m-f subangular SAND, dry, loose. OUTWASH	None	0.0
29	28-30		SS	2.0-1.6	14-14-14-15	ML SM	28.0-28.4 ft. Pale Brown (10YR 6/3) Silty m-f subangular SAND, dry, loose. 28.4-29.0 ft. Light Yellowish Brown (2.5Y 6/4) nonplastic SILT, moist, hard. 29.0-29.6 ft. Light Yellowish Brown (2.5Y 6/3) Silty f SAND, dry, loose. OUTWASH	None	0.0

Sample Type:

SOIL BORING/WELL CONSTRUCTION LOG

Site: Devens SSI	**Boring/Well ID: PZ-06**	**Sampling Method: 3-inch SS**
Investigation Area: IA-02	**Drilling Company: GEOSEARCH**	**Surface Elevation:**
Weston Geologist: A. Klappholz	**Driller: Ken Byland**	**Total Depth: 49.4 ft**
Date: December 13-14, 2004	**Boring Method: 4¼-inch HSA**	**Water Level: 42 ft**

Depth (ft bgs)	Sample Interval	Well Construction	Sample Type	Pen/ Rec	Blow Count	Soil Classification	Lithologic Description	NAPL Show/ Oil/Sheen	Soil Headspace (units>BKG)
31	30-32		SS	2.0-1.8	11-15-25-15	SP	30.0-31.3 ft. Light Yellowish Brown (2.5Y 6/3) m-f subangular SAND, dry, loose. With some iron staining. 31.3-31.8 ft. Pale Brown (10YR 6/3) Gravelly c-f subangular SAND, dry, loose. OUTWASH (Kame)	None	2.6
32									
33	32-34		SS	2.0-1.6	18-35-32-33	SP	32.0-33.3 ft. Pale Brown (10YR 6/3) Gravelly c-f subangular SAND, dry, loose. 33.3-34.6 ft. Pale Brown (10YR 6/3) Silty f SAND, dry, loose. OUTWASH (Kame)	None	3.1
34									
35	34-36		SS	2.0-1.7	33-41-50-42	SP	34.0-34.5 ft. Pale Brown (10YR 6/3) Silty f SAND, dry, loose. 34.5-35.7 Pale Brown (10YR 6/3) Gravelly c-f subangular SAND, dry, compact. OUTWASH (Kame)	None	1.0
36									
37	36-38		SS	2.0-1.7	41-41-36-34	SP	Pale Brown (10YR 6/3) Gravelly c-f subangular SAND, dry, compact. OUTWASH (Esker)	None	1.0
38									
39	38-40		SS	2.0-1.8	12-20-22-28	SP	Pale Brown (10YR 6/3) Gravelly c-f subangular SAND, dry, compact. OUTWASH (Esker)	None	0.0
40									
41	40-42		SS	2.0-1.8	9-16-15-15	SW-SP	Pale Brown (10YR 6/3) c-f subangular SAND, dry, loose. With a poorly graded fine sand seam at 41.1-41.3 ft. OUTWASH (Esker)	None	8.1
42									
43	42-44		SS	2.0-1.7	14-17-21-22	SW	Pale Brown (10YR 6/3) c-f subangular SAND, saturated, loose. OUTWASH (Esker)	None	9.1
44									
45	44-46		SS	2.0-1.8	9-13-22-19	ML	Brown (10YR 4/3) Gravelly Sandy nonplastic SILT, saturated, dense-very dense. LODGEMENT TILL	None	5.0
46									
47	46-48		SS	1.1-1.0	28-49-60/1"	ML	Brown (10YR 4/3) Gravelly Sandy nonplastic SILT, saturated, dense-very dense. LODGEMENT TILL	None	8.9
48									
49	48-50		NS				Auger advanced to 49 ft, to pentrate what is presumed to be a boulder.		
50			SS	1.4-1.1	33-49-50/5"	ML	Brown (10YR 4/3) Gravelly Sandy nonplastic SILT, saturated, dense-very dense. LODGEMENT TILL	None	9.7
51	50-52						End of Boring.		
52									
53	52-54						Well constructed using 10-slot, 2-in OD PVC screen, #00 sand from 50-44 ft., #2 silica sand from 44-38 ft, bentonite chips, and cement/		
54									
55	54-56						NS = Not sampled.		
56									
57	56-58								
58									
59	58-60								
60									

Soil Boring Log

Area: Grant	**Boring Date: December 8, 2004**	**Drilling Contractor: Geosearch**
Investigation Area: IA-02	**Boring Method: 4-ft Macrosampler**	**Driller: Jason Jatulkewicz**
Boring ID: SB-01	**Drilling Method: Direct-push**	**WESTON Geologist: J. Schmidl**
		Client: USACE
Total Depth (ft bgs): 16.0		

Depth Interval	Penetration/ Recovery	WESTON Sample	Blow Count	Soil Classification	Lithologic Description	Soil Headspace
0.50 1.0 1.5 2.0 2.5 3.0 3.5 4.0	4.0/2.1			SP	Brown grading to yellow brown (10YR 5/8) poorly graded Gravelly fine SAND, moist, loose. Thin bed of medium SAND noted at 1.7 ft. FLUVIAL	0.0
4.5 5.0 5.5 6.0 6.5 7.0 7.5 8.0	4.0/1.9			SP	Light Yellow brown (10YR 5/2) poorly graded medium SAND, moist to very moist, loose. FLUVIAL	0.0
8.5 9.0 9.5 10.0 10.5 11.0 11.5 12.0	NR			SP	Light yellow brown (10Y 5/2) poorly graded medium SAND, grading to pale yellow brown (10YR 6/4) fine SAND, moist loose. FLUVIAL	0.0
12.5 13.0 13.5 14.0 14.5 15.0 15.5 16.0	NR			SP	Light yellow brown (10Y 3/4) poorly graded fine SAND, moist, slightly cohesive. FLUVIAL	0.0

Soil Boring Log

Area: Grant	**Boring Date: December 7, 2004**	**Drilling Contractor: Geosearch**
Investigation Area: IA-2	**Boring Method: 3-in SS**	**Driller: Joe Keenan**
Boring ID: SB-10	**Drilling Method: 4¼-in. HSA**	**WESTON Geologist: A. Klappholz**
	Note: 140lb hammer used to	**Client: USACE**
Total Depth (ft bgs): 10.0	**advance the split spoons.**	

Depth Interval	Penetration/ Recovery	WESTON Sample	Blow Count	Soil Classification	Lithologic Description	Soil Headspace
0.50 1.0 1.5 2.0	2.0/1.8	GR-IA02-SB10-1 (0'-3')	2-6-6-7	SM SM	0-0.6 ft. Very dark gray (5YR 3/1) Silty fine SAND and organics, moist, compact. LOAM 0.6-1.8 ft Dark yellowish brown (10YR 4/4) Gravelly Silty c-f subangular SAND, dry loose. OUTWASH (Kame)	0.0
2.5 3.0 3.5 4.0	2.0/1.3		10-10-16-20	SP	Yellowish brown (10YR 5/4) Gravelly Silty c-f subangular SAND, dry, compact. OUTWASH (Kame)	0.0
4.5 5.0 5.5 6.0	2.0/1.7	GR-IA02-SB10-1 (3'-10')	21-12-14-11	SP	Yellowish brown (10YR 5/4) Gravelly Silty c-f subangular SAND, dry, compact. OUTWASH (Kame)	0.0
6.5 7.0 7.5 8.0	2.0/1.5		21-10-12-10	SP	Dark yellowish brown (10YR 4/4) Gravelly Silty c-f SAND, dry, compact. OUTWASH (Kame)	0.0
8.5 9.0 9.5 10.0	2.0/1.2		18-28-23-15	SP	Yellowish brown (10YR 4/4) Gravelly Silty c-f SAND, dry, compact. OUTWASH (Kame)	0.0
10.5 11.0 11.5 12.0 12.5 13.0 13.5 14.0 14.5 15.0 15.0 15.0						

Soil Boring Log

Area: Grant	**Boring Date: December 8, 2004**	**Drilling Contractor: Geosearch**
Investigation Area: IA-2	**Boring Method: Direct Push**	**Driller: Jason Jatulkewicz**
Boring ID: SB-11	**Drilling Method: 4-ft. Liner**	**WESTON Geologist: A. Klappholz**
	Note: 140lb hammer used to	**Client: USACE**
Total Depth (ft bgs): 10.0	**advance the split spoons.**	

Depth Interval	Penetration/ Recovery	WESTON Sample	Blow Count	Soil Classification	Lithologic Description	Soil Headspace
0.50 1.0 1.5 2.0	2.0/1	GR-IA02-SB11-1 (0'-3')	NR	SM SM	0-0.2 ft. Black (7.5YR 2.5/1) Silty fine SAND and organics, moist, loose. LOAM 0.2-1.0 ft Brown (10YR 4/3) Silty Gravelly m-f subangular SAND, dry loose. OUTWASH (Kame)	0.0
2.5 3.0 3.5 4.0	2.0/0.7		NR	SW	Brown (10YR 4/3) Gravelly Silty c-f subangular SAND, dry, loose. OUTWASH (Kame)	0.0
4.5 5.0 5.5 6.0	2.0/1.3	GR-IA02-SB11-1 (3'-10')	NR	SP	Brown (7.5YR 4/4) Gravelly Silty c-f subangular SAND, dry, loose. OUTWASH (Kame)	0.0
6.5 7.0 7.5 8.0	2.0/2.0		NR	SP	Brown (7.5YR 4/4) Gravelly Silty c-f subangular SAND, dry, loose. OUTWASH (Kame)	0.0
8.5 9.0 9.5 10.0			NR	SP	Brown (7.5YR 4/4) Gravelly Silty c-f subangular SAND, dry, loose. OUTWASH (Kame)	0.0
10.5 11.0 11.5 12.0 12.5 13.0 13.5 14.0 14.5 15.0 15.0 15.0					NR = Not recorded.	

Soil Boring Log

Area: Grant	**Boring Date: December 3, 2004**	**Drilling Contractor: Geosearch**
Investigation Area: IA-2	**Boring Method: 3-in SS**	**Driller: Shawn Preston**
Boring ID: SB-12	**Drilling Method: 4¼-in. HSA**	**WESTON Geologist: A. Klappholz**
	Note: 140lb hammer used to	**Client: USACE**
Total Depth (ft bgs): 10.0	**advance the split spoons.**	

Depth Interval	Penetration/ Recovery	WESTON Sample	Blow Count	Soil Classification	Lithologic Description	Soil Headspace
0.50 1.0 1.5 2.0	2.0/0.5	GR-IA02-SB12-1 (0'-3')	2-2-5-7	SM	0-0.5 ft. Dark Reddish Brown (5YR 2.5/2) Silty c-f subangular SAND and organics, moist, loose. LOAM A cobble was observed lodged in the barrel of the split spoon, preventing additional recovery.	0.0
2.5 3.0 3.5 4.0	2.0/2.0		60-120/2"	SM	Dark Yellowish Brown (10YR 4/4) Silty Gravelly c-f subangular SAND, dry, loose. OUTWASH (Kame)	0.0
4.5 5.0 5.5 6.0	2.0/1.5	GR-IA02-SB12-1 (3'-10')	94-36-50-34	GP	Dark Brown (10YR 3/3) Sandy Silty c-m subangular GRAVEL, dry, dense to compact in some spots. ABLATION TILL	0.0
6.5 7.0 7.5 8.0	2.0/1.5		38-41-62-36	GP	Dark Brown (10YR 3/3) Sandy Silty c-m subangular GRAVEL, dry, dense to compact in some spots. ABLATION TILL	0.0
8.5 9.0 9.5 10.0	2.0/1.5		28-79-150/6"	GP	Dark Brown (10YR 3/3) Sandy Silty c-m subangular GRAVEL, dry, dense to compact in some spots. ABLATION TILL	0.0
10.5 11.0 11.5 12.0 12.5 13.0 13.5 14.0 14.5 15.0 15.0 15.0						

Soil Boring Log

Area: Grant	**Boring Date: December 13, 2004**	**Drilling Contractor: Geosearch**
Investigation Area: IA-2	**Boring Method: 3-in SS**	**Driller: Shawn Preston**
Boring ID: SB-13	**Drilling Method: 4¼-in. HSA**	**WESTON Geologist: A. Klappholz**
	Note: 140lb hammer used to	**Client: USACE**
Total Depth (ft bgs): 10.0	**advance the split spoons.**	

Depth Interval	Penetration/ Recovery	WESTON Sample	Blow Count	Soil Classification	Lithologic Description	Soil Headspace
0.50 1.0 1.5 2.0	2.0/2.0	GR-IA02-SB13-1 (0'-3')	7-9-9-9	SM SM	0-0.8 ft. Dark Reddish Brown (5YR 2.5/2) Silty f-f subangular SAND and organics, moist, compact. LOAM. 0.8-2.0 ft Yellowish Brown (10YR 5/4) Silty fine SAND, dry, loose. OUTWASH (Kame)	5.6
2.5 3.0 3.5 4.0	2.0/1.9	GR-IA02-SB13-1 (3'-10')	8-11-10-8	SW	Yellowish Brown (10YR 5/4) well graded c-f subangular SAND, dry, loose. OUTWASH (Esker)	0.0
4.5 5.0 5.5 6.0	2.0/1.8		9-10-10-15	SW	Yellowish Brown (10YR 5/4) well graded Gravelly c-f subangular SAND, dry, loose. OUTWASH (Esker)	0.0
6.5 7.0 7.5 8.0	2.0/2.0		10-10-11-15	SW	Light Yellowish Brown (10YR 6/4) well graded Gravelly c-f subangular SAND, dry, loose. OUTWASH (Esker)	3.8
8.5 9.0 9.5 10.0	2.0/2.0		12-12-12-12	SW SP	Light Yellowish Brown (10YR 6/4) well graded Gravelly c-f subangular SAND, dry, loose. OUTWASH (Esker)	0.0
10.5 11.0 11.5 12.0 12.5 13.0 13.5 14.0 14.5 15.0 15.0 15.0						

Soil Boring Log

Area: Grant	**Boring Date: December 3, 2004**	**Drilling Contractor: Geosearch**
Investigation Area: IA-2	**Boring Method: 3-in SS**	**Driller: Shawn Preston**
Boring ID: SB-14	**Drilling Method: 4¼-in. HSA**	**WESTON Geologist: A. Klappholz**
	Note: 140lb hammer used to	**Client: USACE**
Total Depth (ft bgs): 10.0	**advance the split spoons.**	

Depth Interval	Penetration/ Recovery	WESTON Sample	Blow Count	Soil Classification	Lithologic Description	Soil Headspace
0.50 1.0 1.5 2.0	2.0/1.7	GR-IA02-SB14-1 (0'-3')	5-7-9-11	SM SM	0-0.6 ft. Dark Reddish Brown (5YR 2.5/2) Silty m-f SAND and organics, moist, compact. LOAM. 0.6-1.7 ft Dark Yellowish Brown (10YR 4/6) Silty m-f SAND, moist, compact. OUTWASH (Kame)	0.0
2.5 3.0 3.5 4.0	2.0/1.8		19-20-18-22	SW	Yellowish Brown (10YR 5/4) well graded Gravelly c-f SAND, dry, loose. OUTWASH (Esker)	0.0
4.5 5.0 5.5 6.0	2.0/2.0	GR-IA02-SB14-1 (3'-10')	26-30-28-43	SW	Yellowish Brown (10YR 5/4) Gravelly c-f SAND, dry, loose. OUTWASH (Esker)	0.0
6.5 7.0 7.5 8.0	2.0/1.8		23-26-28-26	SW	Yellowish Brown (10YR 5/4) Gravelly c-f SAND, dry, loose. OUTWASH (Esker)	0.0
8.5 9.0 9.5 10.0	2.0/1.8		28-30-28-54	SW	Yellowish Brown (10YR 5/4) Gravelly c-f SAND, dry, loose. OUTWASH (Esker)	0.0
10.5 11.0 11.5 12.0 12.5 13.0 13.5 14.0 14.5 15.0 15.0 15.0						

Soil Boring Log

Area: Grant	**Boring Date: December 3, 2004**	**Drilling Contractor: Geosearch**
Investigation Area: IA-2	**Boring Method: 3-in SS**	**Driller: Shawn Preston**
Boring ID: SB-15	**Drilling Method: 4¼-in. HSA**	**WESTON Geologist: A. Klappholz**
	Note: 140lb hammer used to	**Client: USACE**
Total Depth (ft bgs): 10.0	**advance the split spoons.**	

Depth Interval	Penetration/ Recovery	WESTON Sample	Blow Count	Soil Classification	Lithologic Description	Soil Headspace
0.50 1.0 1.5 2.0	2.0/1.6	GR-IA02-SB15-1 (0'-3')	5-5-5-10	SM SM	0-0.5 ft. Dark Reddish Brown (5YR 2.5/2) Silty m-f subangular SAND and organics, moist, loose. LOAM 0.5-1.6 ft Dark Yellowish Brown (10YR 4/6) Silty m-f subangular SAND, moist, loose. OUTWASH (Kame)	0.0
2.5 3.0 3.5 4.0	2.0/1.6		19-20-18-22	SW SP	2-2.6 ft. Yellowish Brown (10YR 5/4) well graded Gravelly c-f subangular SAND, dry, loose. OUTWASH 2.6-3.6 ft. Light Yellowish Brown (10YR 6/4) Gravelly m -f subangular SAND, dry, loose. OUTWASH (Esker)	0.0
4.5 5.0 5.5 6.0	2.0/1.5	GR-IA02-SB15-1 (3'-10')	16-23-24-20	SW	Light Gray (2.5Y 7/2) well graded Gravelly Silty c-f subangular SAND, dry, very loose. OUTWASH (Esker)	0.0
6.5 7.0 7.5 8.0	2.0/1.6		28-34-28-28	SW	Light Yellowish Brown (10YR 6/4) well graded Gravelly Silty c-f subangular SAND, dry, loose. OUTWASH (Esker)	0.0
8.5 9.0 9.5 10.0	2.0/1.5		30-29-32-39	SP	Very Pale Brown (10YR 7/3) Gravelly Silty medium subangular SAND, visible bands of iron oxide accumulation, dry, loose. OUTWASH (Kame)	0.0
10.5 11.0 11.5 12.0 12.5 13.0 13.5 14.0 14.5 15.0 15.0 15.0						

Soil Boring Log

Area: Grant	**Boring Date: December 6, 2004**	**Drilling Contractor: Geosearch**
Investigation Area: IA-2	**Boring Method: 3-in SS**	**Driller: Joe Keenan**
Boring ID: SB-16	**Drilling Method: 4¼-in. HSA**	**WESTON Geologist: A. Klappholz**
	Note: 140lb hammer used to	**Client: USACE**
Total Depth (ft bgs): 10.0	**advance the split spoons.**	

Depth Interval	Penetration/ Recovery	WESTON Sample	Blow Count	Soil Classification	Lithologic Description	Soil Headspace
0.50 1.0 1.5 2.0	2.0/2.0	GR-IA02-SB16-1 (0'-3')	3-2-4-6	ML SP	0-0.6 ft. Black (7.5YR 2.5/1) Sandy SILT and organics, moist, loose. LOAM 0.6-2.0 ft. Dark Yellowish Brown (10YR 4/6) Gravelly Silty m-f subangular SAND, dry, compact. ABLATION TILL	0.0
2.5 3.0 3.5 4.0	2.0/1.9		36-36-41-48	SW	Dark Yellowish Brown (10YR 4/6) well graded Gravelly Silty c-f subangular SAND, dry, compact-dense. ABLATION TILL	0.0
4.5 5.0 5.5 6.0	2.0/1.9	GR-IA02-SB16-1 (3'-10')	33-30-28-28	SW	Dark Yellowish Brown (10YR 4/4) well graded Gravelly Silty c-f subangular SAND, dry, compact-dense. ABLATION TILL	0.0
6.5 7.0 7.5 8.0	2.0/1.7		26-18-22-21	SW	Yellowish Brown (10YR 4/6) well graded Gravelly Silty c-f subangular SAND, dry, compact-dense. ABLATION TILL	0.0
8.5 9.0 9.5 10.0	2.0/1.9		33-29-23-25	SW	Yellowish Brown (10YR 4/6) well graded Gravelly Silty c-f subangular SAND, dry, compact-dense. ABLATION TILL	18.4
10.5 11.0 11.5 12.0 12.5 13.0 13.5 14.0 14.5 15.0 15.0 15.0						

Soil Boring Log

Area: Grant	**Boring Date: December 7, 2004**	**Drilling Contractor: Geosearch**
Investigation Area: IA-2	**Boring Method: 3-in SS**	**Driller: Joe Keenan**
Boring ID: SB-17	**Drilling Method: 4¼-in. HSA**	**WESTON Geologist: A. Klappholz**
	Note: 140lb hammer used to	**Client: USACE**
Total Depth (ft bgs): 10.0	**advance the split spoons.**	

Depth Interval	Penetration/ Recovery	WESTON Sample	Blow Count	Soil Classification	Lithologic Description	Soil Headspace
0.50 1.0 1.5 2.0	2.0/1.7	GR-IA02-SB17-1 (0'-3')	2-2-6-8	SM SM	0-0.3 ft. Black (5YR 2.5/1) Silty fine SAND and organics, moist, loose. LOAM 0.3-1.7 ft Dark Yellowish Brown (10YR 4/4) Silty Gravelly fine SAND, dry loose. OUTWASH (Kame)	0.0
2.5 3.0 3.5 4.0	2.0/1.3		3-3-7-11	SM	Dark Yellowish Brown (10YR 4/4) Silty Gravelly fine SAND, dry, loose. OUTWASH (Kame)	0.0
4.5 5.0 5.5 6.0	2.0/1.4	GR-IA02-SB17-1 (3'-10')	19-19-18-18	SP	Dark Yellowish Brown (10YR 4/6) Gravelly Silty fine SAND, dry, compact-dense. OUTWASH (Kame)	0.0
6.5 7.0 7.5 8.0	2.0/1.5		12-14-16-15	SP	Dark yellowish brown (10YR 4/6) Gravelly Silty fine SAND, dry, compact-dense. OUTWASH (Kame)	0.0
8.5 9.0 9.5 10.0	2.0/1.4		14-14-18-20	SP SP	8-8.4 ft. Yellowish Brown (10YR 5/3) Sandy nonplastic SILT, dry, firm. OUTWASH (Kame) 8.4-9.0 ft. Light Yellowish Brown (10YR 6/4) Silty fine SAND, dry, compact. OUTWASH (Kame) 9.0-9.4 ft. Light Yellowish Brown (10YR 6/4) Silty c-f subangular SAND, dry, loose. OUTWASH (Kame)	0.0
10.5 11.0 11.5 12.0 12.5 13.0 13.5 14.0 14.5 15.0 15.0 15.0						

Soil Boring Log

Area: Grant	**Boring Date: December 8, 2004**	**Drilling Contractor: Geosearch**
Investigation Area: IA-2	**Boring Method: 3-in SS**	**Driller: Joe Keenan**
Boring ID: SB-18	**Drilling Method: 4¼-in. HSA**	**WESTON Geologist: A. Klappholz**
	Note: 140lb hammer used to	**Client: USACE**
Total Depth (ft bgs): 10.0	**advance the split spoons.**	

Depth Interval	Penetration/ Recovery	WESTON Sample	Blow Count	Soil Classification	Lithologic Description	Soil Headspace
0.50 1.0 1.5 2.0	2.0/1.5	GR-IA02-SB18-1 (0'-3')	2-2-6-8	SM SM	0-0.4 ft. Black (7.5YR 2.5/1) Silty c-f subangular SAND and organics, moist, loose. LOAM 0.4-1.5 ft. Brownish Yellow (10YR 6/6) Silty m-f subangular SAND, dry loose. OUTWASH (Kame)	0.0
2.5 3.0 3.5 4.0	2.0/1.7		3-3-7-11	SM GP	2-3.3 ft. Brownish Yellow (10YR 6/6) Silty m-f subangular SAND, dry loose. OUTWASH (Kame) 3.3-3.7 ft. Yellowish Brown (10YR 5/4) Sandy m-f subangular GRAVEL, dry, loose. OUTWASH (Esker)	0.0
4.5 5.0 5.5 6.0	2.0/1.4	GR-IA02-SB18-1 (3'-10')	10-15-15-13	GP SW	4-4.8 ft. Yellowish Brown (10YR 5/4) Sandy m-f subangular GRAVEL, dry, loose. OUTWASH (Esker) 4.8-5.4 ft. Brownish Yellow (10YR 6/6) Silty c-f subangular SAND, dry, loose. OUTWASH (Esker)	0.0
6.5 7.0 7.5 8.0	2.0/1.5		10-10-10-13	SW	Brownish Yellow (10YR 6/6) well graded Gravelly Silty c-f subangular SAND, dry, loose. OUTWASH (Kame)	0.0
8.5 9.0 9.5 10.0	2.0/1.9		12-12-16-15	SW	Light Yellowish Brown (10YR 6/6) well graded Gravelly Silty c-f subangular SAND, dry, loose. Two 1/2-inch Yellowish Brown (10YR 5/8) Silty fine Sand lenses at 0.5 and 1.3 ft., moist, soft. OUTWASH (Kame)	0.0
10.5 11.0 11.5 12.0 12.5 13.0 13.5 14.0 14.5 15.0 15.0 15.0						

Soil Boring Log

Area: Grant	**Boring Date: December 8, 2004**	**Drilling Contractor: Geosearch**
Investigation Area: IA-2	**Boring Method: 3-in SS**	**Driller: Joe Keenan**
Boring ID: SB-19	**Drilling Method: 4¼-in. HSA**	**WESTON Geologist: A. Klappholz**
	Note: 140lb hammer used to	**Client: USACE**
Total Depth (ft bgs): 10.0	**advance the split spoons.**	

Depth Interval	Penetration/ Recovery	WESTON Sample	Blow Count	Soil Classification	Lithologic Description	Soil Headspace
0.50 1.0 1.5 2.0	2.0/1.1	GR-IA02-SB19-1 (0'-3')	1-1-1-2	SM SM	0-0.5 ft. Black (10YR 2/1) Silty fine SAND and organics, moist, loose. LOAM 0.4-1.1 ft. Dark Yellowish Brown (10YR 4/6) Silty m-f subangular SAND, dry loose. OUTWASH (Kame)	0.0
2.5 3.0 3.5 4.0	2.0/1.6		2-5-11-11	SP SP	2-3.0 ft. Brownish Yellow (10YR 6/6) Silty m-f subangular SAND, dry, loose. OUTWASH (Kame) 3.0-3.6 ft. Brownish Yellow (10YR 6/6) Gravelly Silty m-f subangular SAND, dry, compact. OUTWASH (Kame)	0.0
4.5 5.0 5.5 6.0	2.0/1.6	GR-IA02-SB19-1 (3'-10')	7-10-15-20	SP	Interbedded brownish yellow (10YR 6/6) to light yellowish brown (10YR 6/4) Gravelly Silty m-f subangular SAND, dark yellowish brown (10YR 4/4) Sandy SILT, and pale brown (10YR 6/3) poorly graded Silty fine SAND, dry, loose. OUTWASH (Kame)	0.0
6.5 7.0 7.5 8.0	2.0/1.5		33-35-20-15	SP / ML SP	6.0-7.5 ft. Light Yellowish Brown (10YR 6/4) Gravelly m-f subangular SAND, dry, loose. Contains a 0.05-ft bed of dark yellowish brown (10YR 4/4) Sandy nonplastic SILT at 6.3 ft. OUTWASH (Kame)	0.0
8.5 9.0 9.5 10.0	2.0/1.8		9-17-13-19	SP ML	8.0-9.5 ft. Light Yellowish Brown (10YR 6/6) Gravelly m-f subangular SAND, dry, loose. OUTWASH (Kame) 9.5 -9.8 ft. Yellow (10YR 8/6) Sandy SILT, dry, very loose. OUTWASH (Kame)	0.0
10.5 11.0 11.5 12.0 12.5 13.0 13.5 14.0 14.5 15.0 15.0 15.0						

Soil Boring Log

Area: Grant	**Boring Date: December 2, 2004**	**Drilling Contractor: Geosearch**
Investigation Area: IA-2	**Boring Method: 3-in SS**	**Driller: Joe Keenan**
Boring ID: SB-02	**Drilling Method: 4¼-in. HSA**	**WESTON Geologist: A. Klappholz**
	Note: 140lb hammer used to	**Client: USACE**
Total Depth (ft bgs): 10.0	**advance the split spoons.**	

Depth Interval	Penetration/ Recovery	WESTON Sample	Blow Count	Soil Classification	Lithologic Description	Soil Headspace
0.50 1.0 1.5 2.0	2.0/1.4	GR-IA02-SB02-1 (0'-3')	3-4-4-7	SM	0.0-0.2 ft. Yellowish Brown (10YR 5/8) Silty m-f subangular SAND, moist, loose. FILL. 0.2-0.4 ft.Very Dark Gray (10YR 3/1) Silty m -f SAND and organics, moist, 0.4-1.0 ft. Brown (5YR 3/3) Silty c-f angular to subangular SAND, moist, loose. OUTWASH (Kame) 1.0-1.4 ft. Yellowish Brown (10YR 5/8) Poorly graded Silty fine SAND, dry, compact. OUTWASH (Kame)	0.0
2.5 3.0 3.5 4.0	2.0/1.5		12-16-12-14	SM	2.0-2.75 ft. Reddish Brown (2.5YR 5/3) Silty fine subangular SAND, dry, compact. OUTWASH (Kame) 2.75-2.8 ft. Yellowish Brown (10YR 5/6) Silty m-f subangular SAND, dry, loose. FLUVIAL 2.8-3.5 ft. Reddish Brown (2.5YR 5/3) poorly graded Silty fine SAND, dry, compact. OUTWASH (Kame)	0.0
4.5 5.0 5.5 6.0	2.0/1.8	GR-IA02-SB02-1-M (3'-10')	18-34-23-25	SP SW	4.0-4.8 ft. Light Yellowish Brown (2.5YR 6/3) Silty medium subangular SAND, dry, loose. OUTWASH (Kame) 4.8-5.8 ft. Light Olive Brown (2.5Y 5/4) Gravelly c-f subangular SAND, dry, firm. OUTWASH (Esker)	0.0
6.5 7.0 7.5 8.0	2.0/1.9		30-60-30-20	SW	Light Olive Brown (2.5Y 5/4) Gravelly c -f subangular SAND, dry, firm. OUTWASH (Esker)	0.0
8.5 9.0 9.5 10.0	2.0/1.6		26-26-26-20	SP	Light Yellowish Brown (2.5Y 6/4) m-f subrounded SAND, dry, loose. OUTWASH (Esker)	0.0
10.5 11.0 11.5 12.0 12.5 13.0 13.5 14.0 14.5 15.0 15.5 16.0						

Soil Boring Log

Area: Grant	**Boring Date: December 8, 2004**	**Drilling Contractor: Geosearch**
Investigation Area: IA-2	**Boring Method: 3-in SS**	**Driller: Joe Keenan**
Boring ID: SB-20	**Drilling Method: 4¼-in. HSA**	**WESTON Geologist: A. Klappholz**
	Note: 140lb hammer used to	**Client: USACE**
Total Depth (ft bgs): 10.0	**advance the split spoons.**	

Depth Interval	Penetration/ Recovery	WESTON Sample	Blow Count	Soil Classification	Lithologic Description	Soil Headspace
0.50 1.0 1.5 2.0	2.0/1.2	GR-IA02-SB20-1 (0'-3')	1-1-1-1	SM SP	0-0.4 ft. Black (7.5YR 2.5/1) Silty SAND and organics, fiine sand, some nonplastic silt, some organic material, moist, loose. LOAM 0.4-1.2 ft. Dark Yellowish Brown (10YR 4/6) Silty m-f subangular fine SAND, trace organic material, dry loose. OUTWASH (Kame)	0.0
2.5 3.0 3.5 4.0	2.0/1.8		2-3-3-4	SP	Dark Yellowish Brown (10YR 4/4) Silty m-f subangular SAND, little organic material, dry, loose. OUTWASH (Kame)	0.0
4.5 5.0 5.5 6.0	2.0/1.8	GR-IA02-SB20-1 (3'-10')	15-19-19-17	SP	Dark Yellowish Brown (10YR 4/4) Gravelly Silty c-f subangular-subrounded SAND, dry, compact. OUTWASH (Kame)	0.0
6.5 7.0 7.5 8.0	2.0/1.2		13-13-17-15	SP	Dark Yellowish Brown (10YR 4/4) Gravelly Silty c-f subangular-subrounded SAND, dry, compact. OUTWASH (Kame)	0.0
8.5 9.0 9.5 10.0	2.0/1.5		15-15-17-15	SP SP	8-8.9 ft. Dark Yellowish Brown (10YR 4/4) Gravelly Silty c-f subangular-subrounded SAND, dry, compact. OUTWASH (Kame) 8.9 -9.5 ft. Yellowish Brown (10YR 5/4) Silty m-f subangular SAND, dry, loose. OUTWASH (Kame)	0.0
10.5 11.0 11.5 12.0 12.5 13.0 13.5 14.0 14.5 15.0 15.0 15.0						

Soil Boring Log

Area: Grant	**Boring Date: December 8, 2004**	**Drilling Contractor: Geosearch**
Investigation Area: IA-2	**Boring Method: 3-in SS**	**Driller: Joe Keenan**
Boring ID: SB-21	**Drilling Method: 4¼-in. HSA**	**WESTON Geologist: A. Klappholz**
	Note: 140lb hammer used to	**Client: USACE**
Total Depth (ft bgs): 10.0	**advance the split spoons.**	

Depth Interval	Penetration/ Recovery	WESTON Sample	Blow Count	Soil Classification	Lithologic Description	Soil Headspace
0.50	2.0/1.9	GR-IA02-SB21-1 (0'-3')	2-3-3-3	SM	0-0.4 ft. Reddish Black (2.5YR 2.5/1) Sandy nonplastic SILT and organics, moist, loose. LOAM	0.0
1.0				SM	0.4-1.2 ft. Dark Yellowish Brown (10YR 4/6) Gravelly Silty m-f subangular SAND, trace organic material, dry loose. OUTWASH (Kame)	
1.5						
2.0				SP	1.2-1.9 ft. Brownish Yellow (10YR 6/6) poorly graded m-f subangular SAND, dry, loose. OUTWASH (Esker)	
2.5	2.0/1.3		2-3-3-6	SP	Brownish Yellow (10YR 6/6) m-f subangular SAND, dry, loose. OUTWASH (Esker)	0.0
3.0						
3.5						
4.0						
4.5	2.0/1.1	GR-IA02-SB21-1 (3'-10')	4-6-11-13	SP	Dark Brown (7.5YR 3/3) Gravelly Silty c-f subangular SAND, dry, loose. OUTWASH (Kame)	0.0
5.0						
5.5						
6.0						
6.5	2.0/1.7		10-12-12-12	SP	Dark Brown (7.5YR 3/3) Gravelly Silty c-f subangular SAND, dry, loose. OUTWASH (Kame)	0.0
7.0						
7.5						
8.0						
8.5	2.0/1.7		15-15-17-15	SW	Dark Brown (7.5YR 3/3) Gravelly Silty c-f subangular SAND, dry, loose. OUTWASH (Kame)	0.0
9.0						
9.5						
10.0						
10.5						
11.0						
11.5						
12.0						
12.5						
13.0						
13.5						
14.0						
14.5						
15.0						
15.0						
15.0						

Soil Boring Log

Area: Grant	**Boring Date: December 13, 2004**	**Drilling Contractor: GEOSEARCH**
Investigation Area: IA-02	**Boring Method: 3-in SS**	**Driller: Ken Byland**
Boring ID: SB-23	**Drilling Method: 4¼-in. HSA**	**WESTON Geologist: J. Schmidl**
	Note: 140-lb hammer used to	**Client: USACE**
Total Depth (ft bgs): 10.0	**advance the split spoons.**	

Depth Interval	Penetration/ Recovery	WESTON Sample	Blow Count	Soil Classification	Lithologic Description	Soil Headspace
0.5 1.0 1.5 2.0	2.0/0.4	GR-IA02-SB23-1 (0'-3')	15-30-38-32	SP	Yellow Brown (10YR 5/4) poorly graded Gravelly Silty fine SAND, gravel including shale and concrete, moist, cohesive. FILL	0.0
2.5 3.0 3.5 4.0	2.0/1.5		23-30-28-30	ML	Dark Yellow (5Y 6/6) Gravelly Sandy SILT, with iron weathering, moist, cohesive. OUTWASH (Kame)	0.0
4.5 5.0 5.5 6.0	2.0/1.5	GR-IA02-SB23-1 (3'-10')	9-12-12-16	ML SP SP	4.0-4.4 ft. Dark Yellow Brown (10YR 4/2) Gravelly Sandy SILT, moist, cohesive. OUTWASH (Kame) 4.4-5.1 ft. Dark Yellow Orange (10YR 6/6) Gravelly fine SAND, moist, slightly cohesive. OUTWASH (Kame) 5.1-5.5 ft. Pale Yellow Brown (10YR 6/4) poorly graded fine SAND, moist, loose. OUTWASH (Kame)	0.0
6.5 7.0 7.5 8.0	2.0/1		8-15-15-19	SP SP	6.0-6.2 ft. Pale Yellow Brown (10YR 6/4) poorly graded fine SAND, moist, loose. OUTWASH (Kame) 6.2-7.0 ft. Pale yellow brown (10YR 6/4) Gravelly f-c SAND, moist, loose. OUTWASH (Kame)	0.0
8.5 9.0 9.5 10.0	2.0/1.5		17-22-26-23	SP	Pale yellow brown (10YR 6/4) Gravelly c-f SAND, moist, loose. OUTWASH (Kame)	0.0
10.5 11.0 11.5 12.0						
12.5 13.0 13.5 14.0						
14.5 15.0 15.0 15.0						

Soil Boring Log

Area: Grant	**Boring Date: December 13, 2004**	**Drilling Contractor: GEOSEARCH**
Investigation Area: IA-02	**Boring Method: 3-in SS**	**Driller: Ken Byland**
Boring ID: SB-24	**Drilling Method: 4¼-in. HSA**	**WESTON Geologist: J. Schmidl**
	Note: 140-lb hammer used to	**Client: USACE**
Total Depth (ft bgs): 10.0	**advance the split spoons.**	

Depth Interval	Penetration/ Recovery	WESTON Sample	Blow Count	Soil Classification	Lithologic Description	Soil Headspace
0.5 1.0 1.5 2.0	2.0/1.6	GR-IA02-SB24-1 (0'-3')	10-12-15-11	ML ML	0-0.3 ft Dark Yellow Brown (10YR 3/2) poorly graded Sandy SILT, trace organic material, moist, cohesive. 0.3-1.6 ft. Light Yellow Gray (5Y 6/3) Sandy Gravelly SILT, moist, cohesive. OUTWASH (Kame)	0.0
2.5 3.0 3.5 4.0	2.0/1.0		9-12-11-11	ML	Light Yellow gray (5Y 6/3) Sandy Gravelly Clayey SILT, moist, cohesive. ABLATION TILL	0.0
4.5 5.0 5.5 6.0	2.0/0.0	GR-IA02-SB24-1 (3'-10')	21-29-26-21		No recovery.	
6.5 7.0 7.5 8.0	2.0/0.5		21-33-36-35	ML	Pale olive (5Y 6/4) Clayey Sandy Gravelley SILT, moist, very cohesive. ABLATION TILL	0.0
8.5 9.0 9.5 10.0	2.0/1.6		32-33-88-120/5"	CL	Pale olive (10YR 6/2) Silty Gravelley CLAY, moist, very cohesive. ABLATION TILL	0.0
10.5 11.0 11.5 12.0						
12.5 13.0 13.5 14.0						
14.5 15.0 15.0 15.0						

Soil Boring Log

Area: Grant	**Boring Date: December 13, 2004**	**Drilling Contractor: GEOSEARCH**
Investigation Area: IA-02	**Boring Method: 3-in SS**	**Driller: Ken Byland**
Boring ID: SB-25	**Drilling Method: 4¼-in. HSA**	**WESTON Geologist: J. Schmidl**
	Note: 140-lb hammer used to	**Client: USACE**
Total Depth (ft bgs): 10.0	**advance the split spoons.**	

Depth Interval	Penetration/ Recovery	WESTON Sample	Blow Count	Soil Classification	Lithologic Description	Soil Headspace
0.5	2.0/1.6	GR-IA02-SB25-1 (0'-3')	11-17-20-19	SM	0.0-0.4 ft Dark Reddish Brown (5YR 3/2) Silty Gravelley fine SAND, moist, cohesive.	0.0
1.0				SM-ML	0.4-1.6 ft. Olive (5Y 5/4) Silty Clayey Gravelley fine SAND, moist, very cohesive. Clay content increases with depth. ABLATION TILL	
1.5						
2.0						
2.5	2.0/1.3		19-20-18-11	SM/ML	2.0-2.9 ft. Olive (5Y 5/4) Clayey Gravelley fine SANDY SILT, moist, very cohesive. Clay content increases with depth. ABLATION TILL	0.0
3.0						
3.5		GR-IA02-SB25-1 (3'-10')		ML	2.9-3.3 Olive (5Y 4/4) Clayey Gravelley SILT, moist, very cohesive. ABLATION TILL	
4.0						
4.5	2.0/1.5		21-33-34-36	CL	Olive Gray (5Y 4/2) Silty Gravelley CLAY, moist, very cohesive. Heavily weathered gravel. ABLATION TILL	0.0
5.0						
5.5						
6.0						
6.5	2.0/1.5		30-43-46-64	CL	Olive Gray (5Y 4/2) Silty Gravelley CLAY, moist, very cohesive. ABLATION TILL	0.0
7.0						
7.5						
8.0						
8.5	2.0/1.6		29-36-46-52	CL	Olive Gray (5Y 4/2) Silty Gravelley CLAY, moist, very cohesive. ABLATION TILL	0.0
9.0						
9.5						
10.0						
10.5						
11.0						
11.5						
12.0						
12.5						
13.0						
13.5						
14.0						
14.5						
15.0						
15.0						
15.0						

SOIL BORING LOG

Area: Grant	**Boring Date: December 13, 2004**	**Drilling Contractor: GEOSEARCH**
Investigation Area: IA-02	**Boring Method: 3-in SS**	**Driller: Ken Byland**
Boring ID: SB-26	**Drilling Method: 4¼-in. HSA**	**WESTON Geologist: J. Schmidl**
	Note: 140-lb hammer used to	**Client: USACE**
Total Depth (ft bgs): 10.0	**advance the split spoons.**	

Depth Interval	Penetration/ Recovery	WESTON Sample	Blow Count	Soil Classification	Lithologic Description	Soil Headspace
0.5 1.0 1.5 2.0	2.0/1.5	GR-IA02-SB26-1 (0'-3')	10-10-11-11	SP SP	0.0-1.2 ft. Dark Yellowish Brown (10YR 4/4) Silty Gravelley f SAND, trace organic material, moist, slightly cohesive. LOAM / OUTWASH (Kame) 1.2-1.5 ft. Light Yellowish Brown (10YR 6/4) f SAND, moist, slightly cohesive. OUTWASH (Kame)	0.0
2.5 3.0 3.5 4.0	2.0/1.5		7-6-5-5	SP	Light Yellowish Brown (10 YR 6/4) f SAND, moist, slightly cohesive. OUTWASH (Kame)	8.5
4.5 5.0 5.5 6.0	2.0/1.0	GR-IA02-SB26-1 (3'-10')	5-6-8-12	SP	Light Yellowish Brown (10YR 6/4) Gravelley f SAND, trace organic material, moist, loose. OUTWASH (Esker)	25.3
6.5 7.0 7.5 8.0	2.0/0.9		19-21-23-34	SP	Very Pale Brown (10YR 7/3) Gravelly m-f SAND, moist, loose. OUTWASH (Esker)	27.2
8.5 9.0 9.5 10.0	2.0/0.9		26-55-102 for 3"	SP SM	8.0-8.5 ft. Very Pale Brown (10YR 7/3) Gravelly m-f SAND, moist, loose. 8.5-8.9 ft. Olive (5Y 5/4) Silty Gravelley f SAND, wet, cohesive. OUTWASH (Esker)	30.0
10.5 11.0 11.5 12.0						
12.5 13.0 13.5 14.0						
14.5 15.0 15.0 15.0						

SOIL BORING LOG

Area: Grant	**Boring Date: December 13, 2004**	**Drilling Contractor: GEOSEARCH**
Investigation Area: IA-02	**Boring Method: 3-in SS**	**Driller: Ken Byland**
Boring ID: SB-27	**Drilling Method: 4¼-in. HSA**	**WESTON Geologist: J. Schmidl**
	Note: 140-lb hammer used to	**Client: USACE**
Total Depth (ft bgs): 10.0	**advance the split spoons.**	

Depth Interval	Penetration/ Recovery	WESTON Sample	Blow Count	Soil Classification	Lithologic Description	Soil Headspace
0.50 1.0 1.5 2.0	2.0/1.5	GR-IA02-SB27-1 (0'-3')	7-8-8-13	SM	Pale Olive (5Y 6/4) Silty Gravelley f SAND, moist to wet, loose. ABLATION TILL	12.9
2.5 3.0 3.5 4.0	2.0/1.1		7-8-11-7	SM	Pale Olive (5Y 6/4) Silty Gravelley f SAND, moist to wet, loose. ABLATION TILL	8.3
4.5 5.0 5.5 6.0	2.0/0.8	GR-IA02-SB27-1 (3'-10')	25-36-57-55	ML	Pale Olive (5Y 6/4) Sandy Gravelley SILT, moist, cohesive. ABLATION TILL	16.1
6.5 7.0 7.5 8.0	2.0/1.5		13-13-25-30	ML	Pale Olive (5Y 6/4) Sandy Gravelley SILT, very moist, cohesive. ABLATION TILL	27.2
8.5 9.0 9.5 10.0	2.0/1.6		48-46-52-63	ML	Olive (5Y 5/3) Gravelley Clayey SILT, moist, very cohesive. Heavily weathered gravel. ABLATION TILL	16.2
10.5 11.0 11.5 12.0						
12.5 13.0 13.5 14.0						
14.5 15.0 15.0 15.0						

SOIL BORING LOG

Area: Grant	**Boring Date: December 13, 2004**	**Drilling Contractor: GEOSEARCH**
Investigation Area: IA-02	**Boring Method: 3-in SS**	**Driller: Ken Byland**
Boring ID: SB-28	**Drilling Method: 4¼-in. HSA**	**WESTON Geologist: J. Schmidl**
	Note: 140-lb hammer used to	**Client: USACE**
Total Depth (ft bgs): 10.0	**advance the split spoons.**	

Depth Interval	Penetration/ Recovery	WESTON Sample	Blow Count	Soil Classification	Lithologic Description	Soil Headspace
0.50 1.0 1.5 2.0	2.0/1.6	GR-IA02-SB28-1 (0'-3')	6-8-11-11	SM SM SP	0-0.4 ft. Pale yellow (5Y 7/4) Sandy SILT, trace organic material, wet, cohesive. LOAM 0.4-1.4 ft. Pale yellow (5Y 7/4) poorly graded Sandy Gravelley SILT, wet cohesive. 1.4-1.6 ft. Brownish yellow (10YR 6/6) graded Gravelley medium SAND, moist, loose. OUTWASH (Esker)	1.0
2.5 3.0 3.5 4.0	2.0/1.3		6-10-9-11	SP	Brownish yellow (10YR 6/6) graded Gravelly medium SAND, moist, loose. OUTWASH (Esker)	11.1
4.5 5.0 5.5 6.0	2.0/1.2	GR-IA02-SB28-1 (3'-10')	6-9-8-7	SP	Brownish yellow (10YR 6/6) poorly graded Gravelly medium SAND, moist, loose. OUTWASH (Esker)	11.2
6.5 7.0 7.5 8.0	2.0/1.6		11-8-9-11	SW	Light yellowish brown (10YR 6/4) well graded Gravelly c-f SAND. OUTWASH (Esker)	2.3
8.5 9.0 9.5 10.0	2.0/1.5		13-18-23-24	SW	Light yellowish brown (10YR 6/4) well graded Gravelly c-f SAND. as above, one large bed. OUTWASH (Esker)	2.6
10.5 11.0 11.5 12.0						
12.5 13.0 13.5 14.0						
14.5 15.0 15.0 15.0						

Soil Boring Log

Area: Grant	**Boring Date: December 14, 2004**	**Drilling Contractor: Geosearch**
Investigation Area: IA-2	**Boring Method: 3-in SS**	**Driller: Joe Keenan**
Boring ID: SB-29	**Drilling Method: 4¼-in. HSA**	**WESTON Geologist: A. Klappholz**
	Note: 140lb hammer used to	**Client: USACE**
Total Depth (ft bgs): 10.0	**advance the split spoons.**	

Depth Interval	Penetration/ Recovery	WESTON Sample	Blow Count	Soil Classification	Lithologic Description	Soil Headspace
0.50 1.0 1.5 2.0	2.0/2.0	GR-IA02-SB29-1 (0'-3')	W.O.H-2-3	SM SM	0-0.3 ft. Black (10YR 2/1) Silty fine SAND and organics, dry, loose. LOAM 0.3-2.0 ft. Dark Yellowish Brown (10YR 4/6) Silty Gravelly m-f subangular SAND, dry, loose. OUTWASH (Kame)	4.7
2.5 3.0 3.5 4.0	2.0/2.0		5-8-8-7	SM ML	2.0-3.0 ft. Light Olive Brown (2.5Y 5/4) Silty fine SAND, dry, dense. OUTWASH (Kame) 3.0-4.0 ft. Light Olive Brown (2.5Y 5/4) Sandy slightly plastic SILT, dry, dense. OUTWASH (Kame)	23
4.5 5.0 5.5 6.0	2.0/1.9	GR-IA02-SB29-1 (3'-10')	4-8-10-10	ML SP ML	4.0-5.3 ft. Brown (2.5Y 5/4) Sandy slightly plastic SILT, dry, dense. OUTWASH (Kame) 5.3-5.5 ft. Yellowish Brown (10YR 5/6) Silty m-f subangular SAND, moist, loose. OUTWASH (Kame) 5.5-5.9 ft. Brown (2.5Y 5/4) Sandy slightly plastic SILT, dry, dense. OUTWASH (Kame)	8.9
6.5 7.0 7.5 8.0	2.0/2.0		7-12-15-16	SP / ML SP	6.0-7.5 ft. Interbedded Yellowish Brown (10YR 5/6) Silty m-f subangular SAND and Brown (2.5Y 5/4) Sandy slightly plastic SILT, dry, loose to dense. OUTWASH (Kame) 7.5-8.0 ft. Light Gray (10YR 7/2) Silty m-f SAND, dry, loose, with iron stained lenses. OUTWASH (Kame)	24.5
8.5 9.0 9.5 10.0	2.0/1.7		17-17-15-13	SW SP SW	8.0-9.0 ft. Dark Yellowish Brown (10YR 4/4) well graded Gravelly c-f subangular SAND, dry, compact. OUTWASH (Kame) 9.0-9.1 ft. Pale Yellow (2.5Y 7/4) poorly graded Silty fine SAND, dry, loose. OUTWASH (Kame) 9.1-9.7 ft. Dark Yellowish Brown (10YRR 4/4) well graded c-f subangular SAND, dry, loose. OUTWASH (Kame)	22
10.5 11.0 11.5 12.0 12.5 13.0 13.5 14.0 14.5 15.0 15.0 15.0						

Soil Boring Log

Area: Grant	**Boring Date: December 2, 2004**	**Drilling Contractor: Geosearch**
Investigation Area: IA-2	**Boring Method: 3-in SS**	**Driller: Joe Keenan**
Boring ID: SB-03	**Drilling Method: 4¼-in. HSA**	**WESTON Geologist: A. Klappholz**
	Note: 140lb hammer used to	**Client: USACE**
Total Depth (ft bgs): 10.0	**advance the split spoons.**	

Depth Interval	Penetration / Recovery	WESTON Sample	Blow Count	Soil Classification	Lithologic Description	Soil Headspace
0.50 1.0 1.5 2.0	2.0/1.3	GR-IA02-SB03-1 (0'-3')	6-3-3-6	SM	0-0.3 ft. Dark Reddish Brown (5YR 2.5/2) Silty fine SAND and organics, moist, loose. LOAM 0.3-1.3 ft.Very Dark Gray (10YR 3/1) Silty m-f subangular SAND, moist, loose. OUTWASH (Kame)	0.0
2.5 3.0 3.5 4.0	2.0/1.6	GR-IA02-SB03-1 (3'-10')	10-10-18-25	SM	Dark Yellowish Brown (10YR 4/6) m-f subangular SAND, trace angular schist fragments, moist, loose. OUTWASH (Esker)	0.0
4.5 5.0 5.5 6.0	2.0/2.0		27-26-25-22	SP SP SP SW	4.0-4.5 ft. Dark Yellowish Brown (10YR 4/6) m-f subangular SAND, trace angular schist fragments, moist, loose. OUTWASH (Esker) 4.5-4.9 ft. Dark Yellowish Brown (10YR 4/6) Silty m-f subrounded SAND, trace weathered schist with Fe oxide accumulation, moist, compact. OUTWASH (Kame) 4.9-5.6 ft. Brownish Yellow (10Y 6/6) Silty m-f subrounded SAND, moist, loose. OUTWASH (Kame) 5.6-6.0 ft. Yellowish Brown (10YR 5/4) well graded Gravelly c-f angular SAND, dry, loose. OUTWASH	0.0
6.5 7.0 7.5 8.0	2.0/1.8		28-20-28-22	SP	Brown (10YR 5/3) m-f subrounded SAND, dry, loose. OUTWASH (Esker)	0.0
8.5 9.0 9.5 10.0	2.0/1.5		21-18-21-23	SP	Brown (10YR 5/3) m-f subrounded SAND, dry, loose. OUTWASH (Esker)	0.0
10.5 11.0 11.5 12.0 12.5 13.0 13.5 14.0 14.5 15.0 15.0 15.0						

Soil Boring Log

Area: Grant	**Boring Date: December 10, 2004**	**Drilling Contractor: Geosearch**
Investigation Area: IA-2	**Boring Method: 3-in SS**	**Driller: Joe Keenan**
Boring ID: SB-30	**Drilling Method: 4¼-in. HSA**	**WESTON Geologist: A. Klappholz**
	Note: 140lb hammer used to	**Client: USACE**
Total Depth (ft bgs): 10.0	**advance the split spoons.**	

Depth Interval	Penetration/ Recovery	WESTON Sample	Blow Count	Soil Classification	Lithologic Description	Soil Headspace
0.50 1.0 1.5 2.0	2.0/1.1	None	3-16-14-12	SM GP	0-0.6 ft. Dark Brown (10YR 3/3) Silty m-f subangular SAND, some organic material, wet, loose. FILL 0.4-1.1 ft. Crushed Granite fragments.	0.0
2.5 3.0 3.5 4.0	2.0/1.5	None	9-8-7-7	SM ML	2.0-3.1 ft. Light Yellowish Brown (2.5Y 6/4) Silty Gravelly m-f subangular SAND, moist, loose. FILL 3.1-3.5 ft. Light Yellowish Brown (2.5 Y 6/4) Sandy nonplastic SILT, moist, firm. OUTWASH (Kame)	0.0
4.5 5.0 5.5 6.0	2.0/1.5	None	3-4-4-3	SM SM ML	4-4.6 ft. Yellowish Brown (10YR 5/4) Silty fine SAND, moist, loose. OUTWASH (Kame) 4.6-5.0 ft. Yellowish Brown (10YR 5/4) Silty m-f subangular SAND, moist, loose. OUTWASH (Kame) 5.0-5.5 ft. Yellowish Brown (10YR 5/4) Sandy nonplastic SILT, dry, soft. OUTWASH (Kame)	0.0
6.5 7.0 7.5 8.0	2.0/1.6	None	4-6-6-12	ML SM	6-7.1 ft. Yellowish Brown (10YR 5/4) Sandy nonplastic SILT with occassional fine Sand lenses, dry, soft. OUTWASH (Kame) 7.1-7.6 ft. Brown (10YR 5/3) Silty fine SAND, moist, loose. OUTWASH (Kame)	0.0
8.5 9.0 9.5 10.0	2.0/1.8	None	10-13-13-21	ML SW ML	8.0-8.2 ft. Yellowish Brown (10YR 5/4) Gravelly nonplastic SILT, dry, dense. ABLATION TILL 8.2-8.7 Brown (10YR 5/3) Gravelly c-f subangular SAND, dry, firm. OUTWASH (Kame) 8.7-8.8 ft. Yellowish Brown (10YR 5/4) Gravelly nonplastic SILT, dry, firm. LODGEMENT TILL	0.0
10.5 11.0 11.5 12.0	2.0/1.2	None	21-29-50/4"	ML	Yellowish Brown (10YR 5/4) Gravelly Sandy nonplastic SILT, dry, dense. LODGEMENT TILL.	0.0
12.5 13.0 13.5 14.0	2.0/0.1	None	50/3"	ML	0-0.1 ft. Yellowish Brown (10YR 5/4) Gravelly SILT, as above.	0.0
14.5 15.0 15.0 15.0						

Soil Boring Log

Area: Grant	**Boring Date: December 2, 2004**	**Drilling Contractor: Geosearch**
Investigation Area: IA-2	**Boring Method: 3-in SS**	**Driller: Joe Keenan**
Boring ID: SB-04	**Drilling Method: 4¼-in. HSA**	**WESTON Geologist: A. Klappholz**
	Note: 140lb hammer used to	**Client: USACE**
Total Depth (ft bgs): 10.0	**advance the split spoons.**	

Depth Interval	Penetration / Recovery	WESTON Sample	Blow Count	Soil Classification	Lithologic Description	Soil Headspace
0.50 1.0 1.5 2.0	2.0/0.5	GR-IA02-SB04-1 (0'-3')	1-6-18-30	SP	Dark Reddish Brown (5YR 2.5/2) Silty fine SAND and organics, moist, loose. LOAM	0.0
2.5 3.0 3.5 4.0	2.0/1.6		14-12-10-12	SP	2 -2.5 ft. Dark Yellowish Brown (10YR 4/4) Silty medium subangular SAND, dry, loose. Weathered schist at 0.5 ft. bgs. OUTWASH (Kame) 2.5-3.6 ft. Dark Yellowish Brown (10YR 4/6) c-f subangular SAND, dry, loose. OUTWASH (Esker)	0.0
4.5 5.0 5.5 6.0	2.0/1.3	GR-IA02-SB04-1 (3'-10')	22-40-26-18	SP	Dark Yellowish Brown (10Y 4/6) c-f subrounded SAND, some angular weathered schist, moist, loose. OUTWASH (Esker)	0.0
6.5 7.0 7.5 8.0	2.0/1.2		22-19-17-16	SW	Dark Yellowish Brown (10YR 4/6) Gravelly c -f subrounded SAND, dry, loose. OUTWASH (Esker)	0.0
8.5 9.0 9.5 10.0	2.0/1.2		19-27-25-25	SW	Yellowish Brown (10YR 5/4) Gravelly c-f subangular SAND, with weathered schist, dry, loose. OUTWASH (Esker)	0.0
10.5 11.0 11.5 12.0 12.5 13.0 13.5 14.0 14.5 15.0 15.0 15.0						

Soil Boring Log

Area: Grant	**Boring Date: December 2, 2004**	**Drilling Contractor: Geosearch**
Investigation Area: IA-2	**Boring Method: 3-in SS**	**Driller: Joe Keenan**
Boring ID: SB-05	**Drilling Method: 4¼-in. HSA**	**WESTON Geologist: A. Klappholz**
	Note: 140lb hammer used to	**Client: USACE**
Total Depth (ft bgs): 10.0	**advance the split spoons.**	

Depth Interval	Penetration / Recovery	WESTON Sample	Blow Count	Soil Classification	Lithologic Description	Soil Headspace
0.50 1.0 1.5 2.0	2.0/2.0	GR-IA02-SB05-1 (0'-3')	4-4-6-8	SM SM SP	0-0.4 ft. Dark Reddish Brown (5YR 2.5/2) Silty fine SAND and organics, moist, loose. LOAM 0.4-1.6 ft. Dark Yellowish Brown (10YR 3/6) Silty fine SAND, moist, loose to compact. OUTWASH (Kame) 1.6-2.0 ft. Yellowish Brown (10YR 5/6) Silty m-f subangular SAND, moist, soft. OUTWASH (Kame)	0.0
2.5 3.0 3.5 4.0	2.0/1.8		9-10-13-17	SP SP	2 -2.6 ft. Yellowish Brown (10YR 5/6) Silty m-f subangular SAND, moist, soft. OUTWASH (Kame) 2.6-3.8 ft. Light Yellowish Brown (2.5Y 6/4) fine SAND, some visible bedding with iron stains, dry, compact. OUTWASH (Kame)	0.0
4.5 5.0 5.5 6.0	2.0/2.0	GR-IA02-SB05-1 (3'-10')	29-29-35-32	SP	Light Yellowish Brown (2.5Y 4/6) fine SAND, some visible bedding with iron stains, dry, compact. OUTWASH (Kame)	0.0
6.5 7.0 7.5 8.0	2.0/2.0		27-27-27-34	SP	Light Yellowish Brown (2.5Y 4/6) fine SAND, some visible bedding with iron stains, dry, compact. OUTWASH (Kame)	0.0
8.5 9.0 9.5 10.0	2.0/1.5		22-30-75-120/4"	SP SW	8-8.3 ft.Pale Yellow (2.5YR 7/4) m-f subrounded SAND, visisble bedding with iron stains, dry, loose. OUTWASH (Kame) 8.3-9.5 ft.Yellowish Brown (10YR 5/4) Gravelly c-f angular SAND, dry, compact. OUTWASH (Esker)	0.0
10.5 11.0 11.5 12.0 12.5 13.0 13.5 14.0 14.5 15.0 15.0 15.0						

Soil Boring Log

Area: Grant	**Boring Date: December 2, 2004**	**Drilling Contractor: Geosearch**
Investigation Area: IA-2	**Boring Method: 3-in SS**	**Driller: Joe Keenan**
Boring ID: SB-06	**Drilling Method: 4¼-in. HSA**	**WESTON Geologist: A. Klappholz**
	Note: 140lb hammer used to	**Client: USACE**
Total Depth (ft bgs): 10.0	**advance the split spoons.**	

Depth Interval	Penetration/ Recovery	WESTON Sample	Blow Count	Soil Classification	Lithologic Description	Soil Headspace
0.50 1.0 1.5 2.0	2.0/1.5	GR-IA02-SB06-1 (0'-3')	8-14-16-22	SM SP	0-0.4 ft. Dark Reddish Brown (5YR 2.5/2) Silty c -f subangular SAND and organics, moist, loose. LOAM 0.4-1.5 ft. Strong Brown (7.5YR 4/6) Gravelly Silty m-f subangular SAND, dry, compact. OUTWASH (Kame)	0.0
2.5 3.0 3.5 4.0	2.0/1.2		34-30-24-32	GP	Dark Yellowish Brown (10YR 4/6) Sandy medium subrounded to subangular GRAVEL, dry, compact. OUTWASH (Esker)	0.0
4.5 5.0 5.5 6.0	2.0/1.5	GR-IA02-SB06-1 (3'-10')	36-45-22-37	GP	4.0-5.5 ft. Dark Yellowish Brown (10YR 4/6) Sandy c-m subrounded to subangular GRAVEL, dry, dense. OUTWASH (Esker) 5.2-5.3 ft. Dark Yellowish Brown (10YR 4/6) nonplastic SILT, dry, firm-stiff. OUTWASH (Kame)	0.0
6.5 7.0 7.5 8.0	2.0/0.8		45-35-30-45	GP	Dark Yellowish Brown (10YR 4/6) Sandy c-m subrounded to subangular GRAVEL, dry, dense. OUTWASH (Esker)	0.0
8.5 9.0 9.5 10.0	2.0/2.0		90-40-34-24	GP	Dark Yellowish Brown (10YR 4/6) Sandy c-m subrounded to subangular GRAVEL, dry, dense. OUTWASH (Esker)	0.0
10.5 11.0 11.5 12.0 12.5 13.0 13.5 14.0 14.5 15.0 15.0 15.0						

Soil Boring Log

Area: Grant	**Boring Date: December 6, 2004**	**Drilling Contractor: Geosearch**
Investigation Area: IA-2	**Boring Method: 3-in SS**	**Driller: Joe Keenan**
Boring ID: SB-07	**Drilling Method: 4¼-in. HSA**	**WESTON Geologist: A. Klappholz**
	Note: 140lb hammer used to	**Client: USACE**
Total Depth (ft bgs): 10.0	**advance the split spoons.**	

Depth Interval	Penetration/ Recovery	WESTON Sample	Blow Count	Soil Classification	Lithologic Description	Soil Headspace
0.50 1.0 1.5 2.0	2.0/0.4	GR-IA02-SB07-1 (0'-3')	1-2-2-6	SM	Black (5YR 2.5/1) Silty fine SAND and organics, moist, loose. LOAM	0.0
2.5 3.0 3.5 4.0	2.0/1.1		5-6-6-6	GW	Dark Yellowish Brown (10YR 4/4) well graded Sandy c-f subangular to subrounded GRAVEL, dry, loose. OUTWASH (Esker)	0.0
4.5 5.0 5.5 6.0	2.0/1.3	GR-IA02-SB07-1 (3'-10')	10-10-10-12	SP	Light Gray (10YR 4/6) Gravelly m-f subangular SAND, dry, compact. OUTWASH (Esker)	0.0
6.5 7.0 7.5 8.0	2.0/0.5		13-13-15-17	SP	Light Gray (10YR 4/6) Gravelly m -f subangular SAND, dry, compact. 3-inch coarse gravel observed blocking the split spoon barrel. OUTWASH (Esker)	0.0
8.5 9.0 9.5 10.0	2.0/2.0		17-15-19-21	SP	Brown (10YR 4/3) Gravelly Silty m-f subangular SAND, dry, dense to very dense. ABLATION TILL	0.0
10.5 11.0 11.5 12.0 12.5 13.0 13.5 14.0 14.5 15.0 15.0 15.0						

Soil Boring Log

Area: Grant	**Boring Date: December 6, 2004**	**Drilling Contractor: Geosearch**
Investigation Area: IA-2	**Boring Method: 3-in SS**	**Driller: Joe Keenan**
Boring ID: SB-08	**Drilling Method: 4¼-in. HSA**	**WESTON Geologist: A. Klappholz**
	Note: 140lb hammer used to	**Client: USACE**
Total Depth (ft bgs): 10.0	**advance the split spoons.**	

Depth Interval	Penetration/ Recovery	WESTON Sample	Blow Count	Soil Classification	Lithologic Description	Soil Headspace
0.50 1.0 1.5 2.0	2.0/0.4	GR-IA02-SB08-1 (0'-3')	2-2-3-4	SM	0.0-2.0 ft. Yellowish Brown (10YR 5/6) Silty m-f subrounded SAND, dry, loose. From 1.4-1.5 ft, Silty coarse angular SAND dry, loose. OUTWASH (Kame)	0.0
2.5 3.0 3.5 4.0	2.0/1.3		16-18-16-10	GP	Dark Yellowish Brown (10YR 4/4) Sandy Silty m-f subangular to subrounded GRAVEL, dry, loose. OUTWASH (Kame)	0.0
4.5 5.0 5.5 6.0	2.0/1.6	GR-IA02-SB08-1 (3'-10')	44-42-36-28	GP SP	4-4.8 ft. Dark Yellowish Brown (10YR 4/4) Sandy Silty m-f subangular to subrounded GRAVEL, dry, loose. OUTWASH (Kame) 4.8-5.6 ft. Yellowish Brown (10YR 5/4) Gravelly Silty m-f subangular SAND, dry, compact. OUTWASH (Kame)	0.0
6.5 7.0 7.5 8.0	2.0/1.3		33-33-35-31	SP	Yellowish Brown (10YR 5/4) Gravelly Silty m -f subangular SAND, dry, compact. OUTWASH (Kame)	0.0
8.5 9.0 9.5 10.0	2.0/1.3		28-32-30-30	SP	Yellowish Brown (10YR 5/4) Gravelly Silty m-f subangular SAND, dry, compact. OUTWASH (Kame)	0.0
10.5 11.0 11.5 12.0 12.5 13.0 13.5 14.0 14.5 15.0 15.0 15.0						

Soil Boring Log

Area: Grant	**Boring Date: December 7, 2004**	**Drilling Contractor: Geosearch**
Investigation Area: IA-2	**Boring Method: 3-in SS**	**Driller: Joe Keenan**
Boring ID: SB-09	**Drilling Method: 4¼-in. HSA**	**WESTON Geologist: A. Klappholz**
	Note: 140lb hammer used to	**Client: USACE**
Total Depth (ft bgs): 10.0	**advance the split spoons.**	

Depth Interval	Penetration/ Recovery	WESTON Sample	Blow Count	Soil Classification	Lithologic Description	Soil Headspace
0.50 1.0 1.5 2.0	2.0/1.2	GR-IA02-SB09-1 (0'-3')	2-2-3-2	SM SM	0-0.8 ft. Very Dark Gray (5YR 3/1) Silty fine SAND and organics, moist, compact. LOAM 0.6-1.2 ft Dark Brown (7.5YR 3/4) Silty gravelly m-f subangular SAND, dry loose. OUTWASH (Kame)	0.0
2.5 3.0 3.5 4.0	2.0/1.5		15-22-22-44	GW	Dark Yellowish Brown (10YR 4/4) well graded Sandy Silty c-f angular GRAVEL, dry, compact. OUTWASH (Kame)	0.0
4.5 5.0 5.5 6.0	2.0/1.5	GR-IA02-SB09-1 (3'-10')	43-40-39-40	SP	Yellowish Brown (10YR 5/4) Gravelly Silty c-f subangular SAND, dry, compact. OUTWASH (Kame)	0.0
6.5 7.0 7.5 8.0	2.0/0.7		23-26-28-26	SW	Dark Yellowish Brown (10YR 4/6) Gravelly Silty c-f subangular SAND, dry, compact. OUTWASH (Kame)	0.0
8.5 9.0 9.5 10.0	2.0/0.8		18-28-23-15	SW	Yellowish Brown (10YR 5/4) Gravelly Silty c-f subangular SAND, dry, compact. OUTWASH (Kame)	0.0
10.5 11.0 11.5 12.0 12.5 13.0 13.5 14.0 14.5 15.0 15.0 15.0						

Soil Boring Log

Area: Grant	**Boring Date: December 13, 2004**	**Drilling Contractor: Geosearch**
Investigation Area: IA-3	**Boring Method: 3-in SS**	**Driller: Joe Keenan**
Boring ID: SB-01	**Drilling Method: 4¼-in. HSA**	**WESTON Geologist: A. Klappholz**
	Note: 140lb hammer used to	**Client: USACE**
Total Depth (ft bgs): 10.0	**advance the split spoons.**	

Depth Interval	Penetration/ Recovery	WESTON Sample	Blow Count	Soil Classification	Lithologic Description	Soil Headspace
0.50 1.0 1.5 2.0	2.0/1.9	GR-IA03-SB01-1 (0'-3')	6-5-3-5	SM SM SM	0-0.1 ft. Very Dark Gray (10YR 3/1) Silty m-f SAND and organics, moist, loose. LOAM 0.1-0.7 ft. Dark Brown (7.5YR 3/3) Silty m-f subangular SAND and organics, dry, compact. LOAM 0.7-1.9 ft. Dark Yellowish Brown (10YR 4/4) Silty Gravelly c-f subangular SAND, moist, compact-dense. OUTWASH (Kame)	0.0
2.5 3.0 3.5 4.0	2.0/1.4		7-7-6-6	SM SW	2-2.9 ft. Dark Yellowish Brown (10YR 4/4) Silty Gravelly c-f subangular SAND, moist, compact-dense. OUTWASH (Kame) 2.9-3.4 ft. Brown (10YR 4/3) well graded Gravelly c-f subangular SAND, dry, loose. OUTWASH (Esker)	3.8
4.5 5.0 5.5 6.0	2.0/1.5	GR-IA03-SB01-1 (3'-10')	5-7-10-12	SW	Brown (10YR 4/3) well graded Gravelly c-f subrounded SAND, dry, loose. OUTWASH (Esker)	0.0
6.5 7.0 7.5 8.0	2.0/1.8		12-16-16-16	SW	Brown (10YR 4/3) well graded Gravelly Silty c-f subangular SAND, dry, loose. OUTWASH (Kame)	0.0
8.5 9.0 9.5 10.0	2.0/2.0		15-13-13-16	SW / ML SP	8.0-8.6 ft. Brown (10YR 4/3) well graded Gravelly Silty c-f subangular SAND, dry, loose. Layer of light olive brown (2.5Y 5/4) nonplastic SILT, at 8.6-8.65 ft. OUTWASH (Kame) 8.6-10.0 Interbeds of pale brown (10YR 6/3) poorly graded Silty c-f subangular SAND, m-f sands are compact, coarse sands are loose, all are dry. OUTWASH (Kame)	0.0
10.5 11.0 11.5 12.0 12.5 13.0 13.5 14.0 14.5 15.0 15.0 15.0						

Soil Boring Log

Area: Grant	**Boring Date: December 13, 2004**	**Drilling Contractor: Geosearch**
Investigation Area: IA-3	**Boring Method: 3-in SS**	**Driller: Joe Keenan**
Boring ID: SB-02	**Drilling Method: 4¼-in. HSA**	**WESTON Geologist: A. Klappholz**
	Note: 140lb hammer used to	**Client: USACE**
Total Depth (ft bgs): 10.0	**advance the split spoons.**	

Depth Interval	Penetration/ Recovery	WESTON Sample	Blow Count	Soil Classification	Lithologic Description	Soil Headspace
0.50 1.0 1.5 2.0	2.0/1.3	GR-IA03-SB02-1 (0'-3')	1-2-2-7	SM SP	0.0-0.3 ft. Black (7.5YR 2.5/1) Silty m-f subangular SAND and organics, dry, loose. LOAM 0.3-1.3 ft. Dark Yellowish Brown (10YR 4/4) poorly graded Silty Gravelly c f subangular SAND, dry, compact. OUTWASH (Kame)	0.0
2.5 3.0 3.5 4.0	2.0/1.5		10-10-7-8	SP	2.0-2.6 ft. Dark Yellowish Brown (10YR 4/4) poorly graded Silty Gravelly c-f subangular SAND, dry, compact. OUTWASH (Kame) 2.6-3.4 ft. Brown (10YR 5/3) poorly graded Silty c-f subangular SAND, dry, loose. OUTWASH (Kame) 3.4-3.5 ft. Light Yellowish Brown (10YR 6/4) poorly graded Silty fine SAND, dry, loose. OUTWASH (Kame)	4.0
4.5 5.0 5.5 6.0	2.0/1.4	GR-IA03-SB02-1 (3'-10')	12-12-14-14	SP SW	4.0-4.2 ft. Brown (10YR 4/3) poorly graded Silty fine SAND, dry, loose. OUTWASH (Kame) 4.2-5.4 ft. Dark Yellowish Brown (10YR 3/6) well graded Gravelly Silty c-f subangular SAND, dry, dense-very dense. OUTWASH (Kame)	0.0
6.5 7.0 7.5 8.0	2.0/1.7		11-9-8-9	SW SP	6.0-6.8 ft. Dark Yellowish Brown (10YR 3/6) well graded Gravelly Silty c-f subangular SAND, dry, dense. OUTWASH (Kame) 6.8-7.7 ft. 0.025- to 0.05-ft bedded Pale Brown (10YR 6/3) poorly graded Silty c-f SAND, dry, loose. OUTWASH (Kame)	9.4
8.5 9.0 9.5 10.0	2.0/1.6		10-11-12-18	SP	0.3-ft beds of Pale Brown (10YR 6/3) SAND, poorly graded Silty c-f SAND, dry, loose. OUTWASH (Kame)	0.0
10.5 11.0 11.5 12.0 12.5 13.0 13.5 14.0 14.5 15.0 15.0 15.0						

Soil Boring Log

Area: Grant	**Boring Date: December 15, 2004**	**Drilling Contractor: Geosearch**
Investigation Area: IA-3	**Boring Method: 3-in SS**	**Driller: Jason Jalutkewicz**
Boring ID: SB-03	**Drilling Method: 4¼-in. HSA**	**WESTON Geologist: A. Klappholz**
	Note: 140lb hammer used to	**Client: USACE**
Total Depth (ft bgs): 10.0	**advance the split spoons.**	

Depth Interval	Penetration/ Recovery	WESTON Sample	Blow Count	Soil Classification	Lithologic Description	Soil Headspace
0.50 1.0 1.5 2.0	2.0/1.7	GR-IA03-SB03-1 (0'-3')	5-6-13-21	SM SP	0-0.8 ft. Very Dark Grayish Brown (10YR 3/2) Silty m-f subangular SAND, race organic material, dry, loose. FILL/LOAM 0.8-1.7 ft. Dark Brown (10YR 3/3) Gravelly Silty c-f subangular SAND, dry, compact. OUTWASH (Kame)	0.5
2.5 3.0 3.5 4.0	2.0/1.3		22-22-22-23	SW	Dark Yellowish Brown (10YR 4/4) well graded Gravelly c-f subangular SAND, dry, compact. OUTWASH (Kame)	0.8
4.5 5.0 5.5 6.0	2.0/1.4	GR-IA03-SB03-1 (3'-10')	25-44-34-23	SP SP	4-4.9 ft. Yellowish Brown (10YR 5/4) Gravelly Silty m-f subangular SAND, dry, dense. OUTOUTWASH (Kame)WASH 4.9-5.4 ft. Brownish Yellow (10YR 6/4) Silty m-f subangular SAND, dry, loose. OUTOUTWASH (Kame)WASH	1.0
6.5 7.0 7.5 8.0	2.0/1.3		10-12-11-12	SP	Brownish Yellow (10YR 6/4) Silty m-f subangular SAND, dry, loose. OUTWASH (Kame)	0.2
8.5 9.0 9.5 10.0	2.0/1.4		11-14-12-13	SP	Yellowish Brown (10YR 5/4) Silty m-f subangular SAND, dry, soft. OUTWASH (Kame)	0.6
10.5 11.0 11.5 12.0 12.5 13.0 13.5 14.0 14.5 15.0 15.0 15.0						

Soil Boring Log

Area: Grant	**Boring Date: December 15, 2004**	**Drilling Contractor: Geosearch**
Investigation Area: IA-3	**Boring Method: 3-in SS**	**Driller: Jason Jalutkewicz**
Boring ID: SB-04	**Drilling Method: 4¼-in. HSA**	**WESTON Geologist: A. Klappholz**
	Note: 140lb hammer used to	**Client: USACE**
Total Depth (ft bgs): 10.0	**advance the split spoons.**	

Depth Interval	Penetration/ Recovery	WESTON Sample	Blow Count	Soil Classification	Lithologic Description	Soil Headspace
0.50 1.0 1.5 2.0	2.0/1.3	GR-IA03-SB04-1 (0'-3')	4-5-5-10	SM SM	0.0-0.2 ft. Very Dark Brown (7.5YR 2.5/2) Silty fine SAND and organics, dry, loose. LOAM 0.2-1.3 ft. Yellowish Brown (10YR 5/4) Silty Gravelly m-f subangular SAND, dry, loose. OUTWASH (Kame)	1.2
2.5 3.0 3.5 4.0	2.0/1.5		4-4-4-4	SM SP	2 -2.7 ft. Yellowish Brown (10YR 5/4) Silty m-f subangular SAND, dry, loose. OUTWASH (Kame) 2.7-3.5 ft. Light Yellowish Brown (10YR 6/4) Silty m -f subangular SAND, dry, loose. OUTWASH (Kame)	1.4
4.5 5.0 5.5 6.0	2.0/1.1	GR-IA03-SB04-1 (3'-10')	14-24-28-32	SP GP	4.0-4.2 ft. Light Yellowish Brown (10YR 6/4) Silty m-f subangular SAND, dry, loose. OUTWASH (Kame) Dark Yellowish Brown (10YR 3/4) Sandy GRAVEL, m-f angular-subangular gravel, c-f subangular sand, trace silt, dry, compact. OUTWASH (Kame)	2.1
6.5 7.0 7.5 8.0	2.0/1.4		29-30-38-40	SW	Dark Brown (10YR 4/3) well graded Gravelly c-f subangular SAND, dry, compact. OUTWASH (Kame)	1.8
8.5 9.0 9.5 10.0	2.0/1.8		27-20-15-18	SW SM SP	8-8.8 ft. Dark Brown (10YR 4/3) well graded Gravelly c-f subangular SAND, dry, compact. OUTWASH (Kame) 8.8-9.0 ft. Yellowish Brown (10YR 5/4) Silty fine SAND, dry, dense. OUTWASH (Kame) 9.0-9.8 ft. Pale Brown (10YR 6/3) Silty m-f subangular SAND, dry, loose. OUTWASH (Kame)	0.8
10.5 11.0 11.5 12.0 12.5 13.0 13.5 14.0 14.5 15.0 15.0 15.0						

Soil Boring Log

Area: Grant	**Boring Date: December 9, 2004**	**Drilling Contractor: Geosearch**
Investigation Area: IA-5	**Boring Method: 3-in SS**	**Driller: Joe Keenan**
Boring ID: SB-01	**Drilling Method: 4¼-in. HSA**	**WESTON Geologist: A. Klappholz**
	Note: 140lb hammer used to	**Client: USACE**
Total Depth (ft bgs): 10.0	**advance the split spoons.**	

Depth Interval	Penetration/ Recovery	WESTON Sample	Blow Count	Soil Classification	Lithologic Description	Soil Headspace
0.50 1.0 1.5 2.0	2.0/0.7	GR-IA05-SB01-1 (0'-3')	W.O.H-2-3	SM SM	0-0.2 ft. Reddish black (2.5YR 2.5/1) Silty m-f subangular SAND and organics, moist, loose. LOAM 0.2-0.7 ft. Dark yellowish brown (10YR 4/4) Silty m-f subangular SAND, little organic material, dry loose. FILL	0.0
2.5 3.0 3.5 4.0	2.0/0.7		2-2-2-3	SM	Yellowish brown (10YR 5/4) Silty Gravelly m-f subangular SAND, dry, loose. FILL	0.0
4.5 5.0 5.5 6.0	2.0/1.6	GR-IA05-SB01-1 (3'-10')	8-8-10-13	SM SW / SM SM	4.0-4.4 ft. Yellowish brown (10YR 5/4) Silty Gravelly m-f subangular SAND, dry, loose. FILL 4.4-5.6 ft. Pale brown (10YR 6/3) well graded Gravelly Silty c-f subangular SAND, dry, loose. From 5.0-5.1 ft, Pale brown (10YR 6/3) Silty fine SAND,dry, loose. OUTWASH (Kame)	0.0
6.5 7.0 7.5 8.0	2.0/1.5		11-11-15-20	SP	Pale brown (10YR 6/3) well graded Gravelly Silty c-f subangular SAND, dry, loose. OUTWASH (Kame)	0.0
8.5 9.0 9.5 10.0	2.0/1.6		30-30-30-30	SP	Pale brown (10YR 6/3) well graded Gravelly Silty c-f subangular SAND, dry, loose. OUTWASH (Kame)	0.0
10.5 11.0 11.5 12.0 12.5 13.0 13.5 14.0 14.5 15.0 15.0 15.0						

Soil Boring Log

Area: Grant	**Boring Date: December 9, 2004**	**Drilling Contractor: Geosearch**
Investigation Area: IA-5	**Boring Method: 3-in SS**	**Driller: Joe Keenan**
Boring ID: SB-02	**Drilling Method: 4¼-in. HSA**	**WESTON Geologist: A. Klappholz**
	Note: 140lb hammer used to	**Client: USACE**
Total Depth (ft USACE): 10.0	**advance the split spoons.**	

Depth Interval	Penetration/ Recovery	WESTON Sample	Blow Count	Soil Classification	Lithologic Description	Soil Headspace
0.50 1.0 1.5 2.0	2.0/1.9	GR-IA05-SB02-1 (0'-3')	W.O.H-1-1-1	SM SM	0-0.4 ft. Black (10YR 2/1) Silty m-f subangular SAND and organics, moist, loose. LOAM 0.4-1.9 ft. Dark Yellowish Brown (10YR 4/4) Silty c-f subangular SAND, dry, loose. FILL	0.0
2.5 3.0 3.5 4.0	2.0/1.3		1-2-2-3	SM	Dark Yellowish Brown (10YR 4/4) Silty c-f subangular SAND, dry, loose. OUTWASH (Kame)	0.0
4.5 5.0 5.5 6.0	2.0/1.5	GR-IA05-SB02-1 (3'-10')	3-3-3-11	SP	Yellowish Brown (10YR 5/4) Gravelly Silty m-f subangular SAND, dry, loose. OUTWASH (Kame)	0.0
6.5 7.0 7.5 8.0	2.0/1.5		7-10-10-12	GP	Light Yellowish Brown (10YR 6/4) Silty SANDY GRAVEL, dry, loose-compact. OUTWASH (Kame)	3.8
8.5 9.0 9.5 10.0	2.0/1.3		8-8-15-15	GP	Light Yellowish Brown (10YR 6/4) Silty SANDY GRAVEL, dry, loose-compact. OUTWASH (Kame)	0.0
10.5 11.0 11.5 12.0 12.5 13.0 13.5 14.0 14.5 15.0 15.0 15.0						

Soil Boring Log

Area: Grant	**Boring Date: December 9, 2004**	**Drilling Contractor: Geosearch**
Investigation Area: IA-5	**Boring Method: 3-in SS**	**Driller: Joe Keenan**
Boring ID: SB-03	**Drilling Method: 4¼-in. HSA**	**WESTON Geologist: A. Klappholz**
	Note: 140lb hammer used to	**Client: USACE**
Total Depth (ft bgs): 10.0	**advance the split spoons.**	

Depth Interval	Penetration/ Recovery	WESTON Sample	Blow Count	Soil Classification	Lithologic Description	Soil Headspace
0.50 1.0 1.5 2.0	2.0/1.0	GR-IA05-SB03-1 (0'-3')	1-1-1-3	SM SM	0-0.6 ft. Black (10YR 2/1) Silty m-f subangular SAND and organics, moist, loose. LOAM 0.4-1.0 ft. Dark Yellowish Brown (10YR 4/4) Silty fine SAND, dry loose. OUTWASH (Kame)	0.0
2.5 3.0 3.5 4.0	2.0/1.1		6-6-10-17	SM SW ML	2-2.5 ft. Dark Yellowish Brown (10YR 4/4) Silty fine SAND, dry loose. OUTWASH (Kame) 2.5-3.0 Yellowish Brown (10YR 5/4) well graded Silty Gravelly c -f subangular SAND, dry, loose-compact. OUTWASH (Kame) 3.0-3.1 ft. Light Yellowish Brown (10YR6/4) nonplastic SILT, dry, firm. OUTWASH (Kame)	0.0
4.5 5.0 5.5 6.0	2.0/1.0	GR-IA05-SB03-1 (3'-10')	21-30-28-20	ML SP	4-4.1 ft. Light Yellowish Brown (10YR 6/4) nonplastic SILT, dry, firm. OUTWASH (Kame) 4.1-5.0 ft. Dark Yellowish Brown (10YR 4/4) Gravelly Silty m-f subangular SAND, dry, compact. OUTWASH (Kame)	0.0
6.5 7.0 7.5 8.0	2.0/1.5		17-15-9-9	SP SP	6-6.9 ft. Dark Yellowish Brown (10YR 4/4) Gravelly Silty m-f subangular SAND, dry, compact. OUTWASH (Kame) 6.9-7.4 ft. Brownish Yellow (10YR 6/3) Silty fine SAND, visible bedding with iron staining, moist, compact. OUTWASH (Kame) 7.4-7.5 ft. Yellowish Brown (10YR /4) c-f subangular SAND, dry, loose. OUTWASH (Kame)	0.0
8.5 9.0 9.5 10.0	2.0/2.0		7-7-8-9	SW	Light Gray (10YR 7/2) well graded Gravelly c-f subangular SAND, dry, very loose. OUTWASH (Kame)	0.0
10.5 11.0 11.5 12.0 12.5 13.0 13.5 14.0 14.5 15.0 15.0 15.0						

Soil Boring Log

Area: Grant	**Boring Date: December 9, 2004**	**Drilling Contractor: Geosearch**
Investigation Area: IA-5	**Boring Method: 3-in SS**	**Driller: Joe Keenan**
Boring ID: SB-04	**Drilling Method: 4¼-in. HSA**	**WESTON Geologist: A. Klappholz**
	Note: 140lb hammer used to	**Client: USACE**
Total Depth (ft bgs): 10.0	**advance the split spoons.**	

Depth Interval	Penetration/ Recovery	WESTON Sample	Blow Count	Soil Classification	Lithologic Description	Soil Headspace
0.50 1.0 1.5 2.0	2.0/1.5	GR-IA05-SB04-1 (0'-3')	1-1-4-7	SM SP	0-0.3 ft. Very Dark Brown (10YR 2/1) Silty fine SAND and organics, dry, loose. LOAM 0.3-1.5 ft. Dark Yellowish Brown (10YR 4/6) m-f subangular SAND, little organic material, moist, compact. OUTWASH (Kame)	0.0
2.5 3.0 3.5 4.0	2.0/1.3		9-12-14-14	GW	0-1.3 ft. Dark Yellowish Brown (10YR 4/4) Sandy m-c subrounded-subangular GRAVEL, dry, loose. OUTWASH (Esker)	0.0
4.5 5.0 5.5 6.0	2.0/1.6	GR-IA05-SB04-1 (3'-10')	15-13-13-13	SW	Dark Yellowish Brown (10YR 4/6) well graded Gravelly Silty c-f subangular SAND, dry, compact. OUTWASH (Kame)	0.0
6.5 7.0 7.5 8.0	2.0/1.5		21-15-23-23	SW	Yellowish Brown (10YR 5/4) well graded Gravelly Silty c-f subangular SAND, dry, compact. OUTWASH (Kame)	0.0
8.5 9.0 9.5 10.0	2.0/1.6		10-21-37-33	SW	Dark Yellowish Brown (10YR 4/4) well graded Gravelly Silty c-f subangular SAND, dry, compact. OUTWASH (Kame)	0.0
10.5 11.0 11.5 12.0 12.5 13.0 13.5 14.0 14.5 15.0 15.0 15.0						

Soil Boring Log

Area: Grant	**Boring Date: December 9, 2004**	**Drilling Contractor: Geosearch**
Investigation Area: IA-5	**Boring Method: 3-in SS**	**Driller: Joe Keenan**
Boring ID: SB-05	**Drilling Method: 4¼-in. HSA**	**WESTON Geologist: A. Klappholz**
	Note: 140lb hammer used to	**Client: USACE**
Total Depth (ft bgs): 10.0	**advance the split spoons.**	

Depth Interval	Penetration/ Recovery	WESTON Sample	Blow Count	Soil Classification	Lithologic Description	Soil Headspace
0.50 1.0 1.5 2.0	2.0/1.3	GR-IA05-SB05-1 (0'-3')	WOH-3-4	SM SM	0-1.0 ft. Very Dark Gray (10YR 3/1) Silty m-f SAND, trace organic material, moist, loose. LOAM 1.0 -1.3 ft. Dark Yellowish Brown (10YR 4/4) Silty m-f subangular SAND, dry, loose. FILL	0.0
2.5 3.0 3.5 4.0	2.0/1.4		3-3-7-10	SP-SM	Dark Yellowish Brown (10YR 4/4) Gravelly Silty m-f subangular SAND, moist, loose. OUTWASH (Kame)	0.0
4.5 5.0 5.5 6.0	2.0/1.2	GR-IA05-SB05-1 (3'-10')	11-9-7-7	SP-SM SP	4-4.8 ft. Dark Yellowish Brown (10YR 4/4) Gravelly Silty m-f subangular SAND, moist, loose. OUTWASH (Kame) 4.8-52 ft. Yellowish Brown (10YR 5/4) Silty m-f subangular SAND, dry, loose. OUTWASH (Kame)	5.4
6.5 7.0 7.5 8.0	2.0/1.5		6-5-7-5	SW	Yellowish Brown (10YR 5/4) Gravelly Silty well graded c-f subangular SAND, dry compact. OUTWASH (Kame)	6.2
8.5 9.0 9.5 10.0	2.0/1.8		10-21-37-33	SW	Yellowish Brown (10YR 5/4) Gravelly Silty well graded c-f subangular SAND, dry compact. OUTWASH (Kame)	0.8
10.5 11.0 11.5 12.0 12.5 13.0 13.5 14.0 14.5 15.0 15.0 15.0						

Soil Boring Log

Area: Grant	**Boring Date: December 9, 2004**	**Drilling Contractor: Geosearch**
Investigation Area: IA-5	**Boring Method: 3-in SS**	**Driller: Joe Keenan**
Boring ID: SB-06	**Drilling Method: 4¼-in. HSA**	**WESTON Geologist: A. Klappholz**
	Note: 140lb hammer used to	**Client: USACE**
Total Depth (ft bgs): 10.0	**advance the split spoons.**	

Depth Interval	Penetration/ Recovery	WESTON Sample	Blow Count	Soil Classification	Lithologic Description	Soil Headspace
0.50 1.0 1.5 2.0	2.0/1.4	GR-IA05-SB06-1 (0'-3')	1-5-6-8	SM SP	0.0-0.7 ft. Black (10YR 2/1) Silty Gravelly m-f subangular SAND, moist, loose. LOAM 0.7 -1.4 ft. Yellowish Brown (10YR 5/6) Gravelly Silty m-f subangular SAND, dry, loose. OUTWASH (Kame)	0.0
2.5 3.0 3.5 4.0	2.0/1.6		10-8-9-9	SP SP	2.0 -2.8 ft. Yellowish Brown (10YR 5/6) Gravelly Silty m-f subangular SAND, dry, loose. OUTWASH (Kame) 2.8-3.6 ft. Yellowish Brown (10YR 5/4) Gravelly Silty m-f subangular-subrounded SAND, dry, loose. OUTWASH (Kame)	0.0
4.5 5.0 5.5 6.0	2.0/1.7	GR-IA05-SB06-1 (3'-10')	13-13-13-13	SP	Yellowish Brown (10YR 5/4) Gravelly Silty m-f subangular-subrounded SAND, dry, loose. OUTWASH (Kame)	0.0
6.5 7.0 7.5 8.0	2.0/1.7		13-14-17-18	SP	Yellowish Brown (10YR 5/4) Gravelly Silty c-f subangular-subrounded SAND, dry compact. OUTWASH (Kame)	0.0
8.5 9.0 9.5 10.0	2.0/1.8		16-12-8-10	SP	Yellowish Brown (10YR 5/4) Gravelly Silty c-f subangular-subrounded SAND, dry compact. OUTWASH (Kame)	2.5
10.5 11.0 11.5 12.0 12.5 13.0 13.5 14.0 14.5 15.0 15.0 15.0						

Soil Boring Log

Area: Grant	**Boring Date: December 10, 2004**	**Drilling Contractor: Geosearch**
Investigation Area: IA-5	**Boring Method: 3-in SS**	**Driller: Joe Keenan**
Boring ID: SB-07	**Drilling Method: 4¼-in. HSA**	**WESTON Geologist: A. Klappholz**
	Note: 140lb hammer used to	**Client: USACE**
Total Depth (ft bgs): 10.0	**advance the split spoons.**	

Depth Interval	Penetration/ Recovery	WESTON Sample	Blow Count	Soil Classification	Lithologic Description	Soil Headspace
0.50 1.0 1.5 2.0	2.0/1.3	GR-IA05-SB07-1 (0'-3')	1-1-2-3	SM SP	0-0.6 ft. Dark Yellowish Brown (10YR 4/4) Silty fine SAND, little organic material, moist, loose. LOAM 0.6 -1.3 ft. Dark Yellowish Brown (10YR 4/4) Silty Gravelly m-f subangular SAND, dry, loose. OUTWASH (Kame)	0.0
2.5 3.0 3.5 4.0	2.0/1.4		4-5-12-14	SP	Dark Yellowish Brown (10YR 4/4) Gravelly Silty m-f subangular SAND, dry, loose. OUTWASH (Kame)	0.0
4.5 5.0 5.5 6.0	2.0/1.5	GR-IA05-SB07-1 (3'-10')	10-18-26-22	SP	Brown (10YR 4/3) Gravelly Silty m-f subangular SAND, dry, dense. OUTWASH (Kame)	0.0
6.5 7.0 7.5 8.0	2.0/1.6		18-18-21-19	SW	Brown (10YR 4/3) well graded Gravelly Silty c-f subangular SAND, dry, dense. OUTWASH (Kame)	0.0
8.5 9.0 9.5 10.0	2.0/1.5		20-20-20-18	SW	Dark Yellowish Brown (10YR 4/4) well graded Gravelly Silty c-f subangular SAND, dry, dense. OUTWASH (Kame)	0.8
10.5 11.0 11.5 12.0 12.5 13.0 13.5 14.0 14.5 15.0 15.0 15.0						

SOIL BORING LOG

Area: Grant	**Boring Date: December 10, 2004**	**Drilling Contractor: GEOSEARCH**
Investigation Area: IA-5	**Boring Method: 3-in SS**	**Driller: Ken Byland**
Boring ID: SB-08	**Drilling Method: 4¼-in. HSA**	**WESTON Geologist: J. Schmidl**
	Note: 140-lb hammer used to	**Client: USACE**
Total Depth (ft bgs): 10.0	**advance the split spoons.**	

Depth Interval	Penetration/ Recovery	WESTON Sample	Blow Count	Soil Classification	Lithologic Description	Soil Headspace
0.50 1.0 1.5 2.0	2.0/1.4	GR-IA05-SB08-1 (0'-3')	28-39-120/5"	SP	0-0.8 ft. Dark Yellowish Brown (10YR 4/4) Gravelly f SAND, moist, slightly cohesive. OUTWASH (Esker)	0.0
2.5 3.0 3.5 4.0	2.0/1.0		15-12-10-10	SP	Dark Yellowish Brown (10YR 4/4) Gravelly f SAND, moist, cohesive. OUTWASH (Esker)	0.0
4.5 5.0 5.5 6.0	2.0/0.1	GR-IA05-SB08-1 (3'-10')	6-8-8-9	SP	Dark Yellowish Brown (10YR 4/4) Gravelly f SAND, moist, cohesive. OUTWASH (Esker)	0.0
6.5 7.0 7.5 8.0	2.0/0.2		7-8-9-7	SP	Dark Yellowish Brown (10YR 4/4) Gravelly f SAND, moist, cohesive. OUTWASH (Esker)	0.0
8.5 9.0 9.5 10.0	2.0/1.1		8-10-28-29	SP	Grayish Brown (10YR 5/2) Gravelly c-f SAND, moist, loose. OUTWASH (Esker)	0.0
10.5 11.0 11.5 12.0						
12.5 13.0 13.5 14.0						
14.5 15.0 15.0 15.0						

SOIL BORING LOG

Area: Grant	**Boring Date: December 10, 2004**	**Drilling Contractor: GEOSEARCH**
Investigation Area: IA-5	**Boring Method: 3-in SS**	**Driller: Ken Byland**
Boring ID: SB-09	**Drilling Method: 4¼-in. HSA**	**WESTON Geologist: J. Schmidl**
	Note: 140-lb hammer used to	**Client: USACE**
Total Depth (ft bgs): 10.0	**advance the split spoons.**	

Depth Interval	Penetration/ Recovery	WESTON Sample	Blow Count	Soil Classification	Lithologic Description	Soil Headspace
0.50 1.0 1.5 2.0	2.0/1.4	GR-IA05-SB09-1 (0'-3')	12-13-16-17	SP	Dark Grayish Brown (10YR 4/2) Gravelly m-f SAND, moist, loose. OUTWASH (Esker)	0.0
2.5 3.0 3.5 4.0	2.0/1.3		11-13-8-8	SP SP	2-2.6 ft. Dark Grayish Brown (10YR 4/2) Gravelly m-f SAND, moist, loose. OUTWASH (Esker) 2.6-3.3 ft. Yellowish Brown (10YR 5/4) Gravelly m-f SAND. OUTWASH (Esker)	0.0
4.5 5.0 5.5 6.0	2.0/0.0	GR-IA05-SB09-1 (3'-10')	43-38-37-43		No recovery due to granite lodged in the split spoon.	Not available
6.5 7.0 7.5 8.0	2.0/0.0		30-23-25-25		No recovery. Likely Sandy GRAVEL. OUTWASH (Esker)	Not available
8.5 9.0 9.5 10.0	2.0/0.0		23-25-24-21		No recovery. Likely Sandy GRAVEL. OUTWASH (Esker)	Not available
10.5 11.0 11.5 12.0						
12.5 13.0 13.5 14.0						
14.5 15.0 15.0 15.0						

SOIL BORING LOG

Area: Locust	**Boring Date: April 11, 2005**	**Drilling Contractor: GEOSEARCH**
Investigation Area: IA-06	**Boring Method: 5-ft MacroSampler**	**Driller: John**
Boring ID: SB-03	**Drilling Method: Direct Push**	**WESTON Geologist: D. Klapholz**
		Client: USACE
Total Depth (ft bgs): 10.0		

Depth Interval	Penetration/ Recovery	WESTON Sample	Blow Count	Soil Classification	Lithologic Description	Soil Headspace (units >BKG)
0.5	5.0/3.5	LO-IA06-SB06-1 (0'-3')		OL	0.0-0.3 ft. Very dark greyish brown (10YR 3/2) well graded Sandy SILT, nonplastic, some organic material, wet, soft. (LOAM)	n/a
1.0				SW	0.3-1.2 ft. Dark Yellowish Brown (10YR 4/4) well graded fine to medium Gravelly SAND, subangular to subrounded, compact, wet. (OUTWASH)	
1.5						
2.0				ML	1.2-1.8 ft. Very dark grey (10YR 3/1) well graded Sandy SILT, nonplastic, wet, firm. (FLUVIAL)	
2.5				SP	1.8-3.5 ft. Yellowish brown (10YR 5/4) poorly graded fine to coarse Gravelly SAND, subrounded, compact, wet. (OUTWASH)	n/a
3.0						
3.5		LO-IA06-SB06-1 (3'-10')				
4.0						
4.5						n/a
5.0						
5.5	5.0/4.7			SP	5.0-9.7 ft. Yellowish brown (10YR 5/4) poorly graded fine to medium Gravelly SAND, compact, wet. (OUTWASH)	
6.0						
6.5						n/a
7.0						
7.5						
8.0						
8.5						n/a
9.0						
9.5						
10.0						
10.5					End of Boring.	
11.0						
11.5						
12.0						
12.5						
13.0						
13.5						
14.0						
14.5						
15.0						
15.0						
15.0						

SOIL BORING LOG

Area: Locust	**Boring Date: April 11, 2005**	**Drilling Contractor: GEOSEARCH**
Investigation Area: IA-06	**Boring Method: 5-ft MacroSampler**	**Driller: John**
Boring ID: SB-04	**Drilling Method: Direct Push**	**WESTON Geologist: D. Klapholz**
		Client: USACE
Total Depth (ft bgs): 10.0		

Depth Interval	Penetration/ Recovery	WESTON Sample	Blow Count	Soil Classification	Lithologic Description	Soil Headspace (units >BKG)
0.5	5.0/3.0	LO-IA06-SB04-1 (0'-3')		OL	0.0-0.2 ft. Very dark greyish brown (10YR 3/2) poorly graded Sandy SILT, nonplastic, some organic material, dry, soft. (LOAM)	
1.0				SW	0.2-3.0 ft. Dark yellowish brown (10YR 4/4) well graded fine to coarse Gravelly SAND, subangular, compact, dry. (FILL)	n/a
1.5						
2.0						
2.5						n/a
3.0						
3.5		LO-IA06-SB04-1 (3'-10')				
4.0						
4.5						n/a
5.0						
5.5	5.0/4.2			ML	5.0-5.4 ft. Black (5YR 2.5/1) well graded Clayey SILT, slightly plastic, firm, moist. (LOAM)	
6.0					5.4-8.7 ft. Olive brown (2.5Y 4/3) poorly graded Sandy SILT, slightly plastic, soft, moist. (OUTWASH)	
6.5						n/a
7.0						
7.5						
8.0						
8.5						n/a
9.0				SP	8.7-9.2 ft. Brown (10YR 4/3) well graded Gravelly fine to coarse SAND, subangular gravel, wet, dense. (OUTWASH)	
9.5						
10.0						
10.5					End of Boring.	
11.0						
11.5						
12.0						
12.5						
13.0						
13.5						
14.0						
14.5						
15.0						
15.0						
15.0						

SOIL BORING LOG

Area: Locust	**Boring Date: April 11, 2005**	**Drilling Contractor: GEOSEARCH**
Investigation Area: IA-06	**Boring Method: 5-ft MacroSampler**	**Driller: John**
Boring ID: SB-05	**Drilling Method: Direct Push**	**WESTON Geologist: D. Klapholz**
		Client: USACE
Total Depth (ft bgs): 10.0		

Depth Interval	Penetration/ Recovery	WESTON Sample	Blow Count	Soil Classification	Lithologic Description	Soil Headspace (units >BKG)
0.5	5.0/3.0	LO-IA06-SB05-1 (0'-3')		OL	0.0-0.4 ft. Very dark greyish brown (10YR 3/2) poorly graded Sandy SILT, nonplastic, some organic material, moist, soft. (LOAM)	
1.0				SW	0.4-3.0 ft. Dark yellowish brown (10YR 4/4) well graded Gravelly fine to medium SAND, subangular, cohesive, wet. (OUTWASH)	n/a
1.5						
2.0						
2.5						n/a
3.0						
3.5		LO-IA06-SB05-1 (3'-10')				
4.0						
4.5						n/a
5.0						
5.5	5.0/4.1				5.0-7.0 ft. Yellowish brown (10YR 5/4) well graded Gravelly fine SAND, subrounded, cohesive, wet. (OUTWASH)	
6.0						
6.5						n/a
7.0						
7.5				ML	7.0-7.7 ft. Light olive brown (2.5Y 5/4) well graded Sandy SILT, nonpastic, firm, wet. (FLUVIAL)	
8.0				SW	7.7-8.4 ft. Yellowish brown (10YR 5/4) well graded Gravelly fine SAND, subrounded, cohesive, wet. (OUTWASH)	
8.5						n/a
9.0				ML	8.4-9.1 ft. Light olive brown (2.5Y 5/4) poorly graded Sandy SILT, nonplastic, some iron stained bands, firm, wet. (FLUVIAL)	
9.5						
10.0						
10.5					End of Boring.	
11.0						
11.5						
12.0						
12.5						
13.0						
13.5						
14.0						
14.5						
15.0						
15.0						
15.0						

SOIL BORING LOG

Area: Locust	**Boring Date: April 11, 2005**	**Drilling Contractor: GEOSEARCH**
Investigation Area: IA-06	**Boring Method: 5-ft MacroSampler**	**Driller: John**
Boring ID: SB-06	**Drilling Method: Direct Push**	**WESTON Geologist: D. Klapholz**
		Client: USACE
Total Depth (ft bgs): 10.0		

Depth Interval	Penetration/ Recovery	WESTON Sample	Blow Count	Soil Classification	Lithologic Description	Soil Headspace (units >BKG)
0.5	5.0/3.5	LO-IA06-SB06-1 (0'-3')		OL	0.0-0.3 ft. Very dark greyish brown (10YR 3/2) well graded Sandy SILT, nonplastic, some organic material, wet, soft. (LOAM)	n/a
1.0				SW	0.3-1.2 ft. Dark yellowish brown (10YR 4/4) well graded Gravelly fine to medium SAND, subangular to subrounded, cohesive, wet. (OUTWASH)	
1.5						
2.0				ML	1.2-1.8 ft. Very dark grey (10YR 3/1) well graded Sandy SILT, nonplastic, wet, firm. (FLUVIAL)	
2.5				SW	1.8-3.5 ft. Yellowish brown (10YR 5/4) well sorted Gravelly fine to medium SAND, subrounded, cohesive, wet. (OUTWASH)	n/a
3.0						
3.5		LO-IA06-SB06-1 (3'-10')				
4.0						
4.5						n/a
5.0						
5.5	5.0/4.7			SW	5.0-9.7 ft. Yellowish brown (10YR 5/4) well graded Gravelly fine to medium SAND, subrounded, cohesive, wet. (OUTWASH)	
6.0						
6.5						n/a
7.0						
7.5						
8.0						
8.5						n/a
9.0						
9.5						
10.0						
10.5					End of Boring.	
11.0						
11.5						
12.0						
12.5						
13.0						
13.5						
14.0						
14.5						
15.0						
15.0						
15.0						

SOIL BORING LOG

Area: Grant	**Boring Date: December 15, 2004**	**Drilling Contractor: GEOSEARCH**
Investigation Area: IA-07	**Boring Method: 3-in SS**	**Driller: Ken Byland**
Boring ID: SB-01	**Drilling Method: 4¼-in. HSA**	**WESTON Geologist: J. Schmidl**
	Note: 140-lb hammer used to	**Client: USACE**
Total Depth (ft bgs): 10.0	**advance the split spoons.**	

Depth Interval	Penetration/ Recovery	WESTON Sample	Blow Count	Soil Classification	Lithologic Description	Soil Headspace (units >BKG)
0.50 1.0 1.5 2.0	2.0/1.3	GR-IA10-SB03-1 (0'-3')	3-4-4-9	SP	Dark yellow brown (10YR 4/3), poorly graded Gravelly f-c SAND, moist, loose. FILL	
2.5 3.0 3.5 4.0	2.0/1.5		11-11-9-12	SP	Dark yellow brown (10YR 4/3), poorly graded Gravelly f-c SAND, moist, loose. FILL	
4.5 5.0 5.5 6.0	2.0/1.7	GR-IA10-SB03-1 (3'-10')	12-13-11-13	SP	4.0-5.5 ft: Dark yellow brown (10YR 4/3), poorly graded Gravelly f-c SAND, moist, loose. FILL 5.5-5.7 ft: Pale olive brown (2.5YR 5/3), poorly graded Gravelly f-c SAND, some bedding visible, moist, loose. OUTWASH (Kame)	
6.5 7.0 7.5 8.0	2.0/1.6		14-14-12-18	SP	Pale yellow brown (10YR 6/2), poorly graded Gravelly f-m SAND, sorted in beds, moist, loose. OUTWASH (Kame)	
8.5 9.0 9.5 10.0	2.0/1.0		14-9-9-11	SP	Yellow brown (10YR 4/4), poorly graded Gravelly m-c SAND, moist, loose. OUTWASH (Kame)	
10.5 11.0 11.5 12.0 12.5 13.0 13.5 14.0 14.5 15.0 15.0 15.0					End of Boring.	

Soil Boring Log

Area: Grant	**Boring Date: November 29, 2004**	**Drilling Contractor: Geosearch**
Investigation Area: IA-7	**Boring Method: 3-in SS**	**Driller: Joe Keenan**
Boring ID: SB-02	**Drilling Method: 4¼-in. HSA**	**WESTON Geologist: A. Klappholz**
	Note: 140lb hammer used to	**Client: USACE**
Total Depth (ft bgs): 10.0	**advance the split spoons.**	

Depth Interval	Penetration/ Recovery	WESTON Sample	Blow Count	Soil Classification	Lithologic Description	Soil Headspace
0.50 1.0 1.5 2.0	2.0/1.5	GR-IA07-SB02-1 (0'-3')	2-4-5-5	SM GP	0.0-0.4 ft. Dark Brown (7.5YR 3/4) Silty m-f subangular SAND and organics, moist, loose. LOAM 0.4-1.5 ft. Dark Brown (7.5YR 3/4) Sandy Silty f-m angular GRAVEL, dry, loose. FILL	0.0
2.5 3.0 3.5 4.0	2.0/1.5	GR-IA07-SB02-1 (3'-10')	8-9-9-9	GP SW	2.0-3.0 ft. Dark Brown (7.5YR 3/4) Sandy Silty f-m angular GRAVEL, dry, loose. FILL 3.0-3.5 ft. Dark Brown (7.5YR 3/3) well graded Gravelly Silty c -f angular SAND, dry, loose. OUTWASH (Kame)	
4.5 5.0 5.5 6.0	2.0/2.0		8-12-14-14	SM SM SW	4.0-4.6 ft. Dark Brown (7.5YR 3/3) poorly graded Silty medium subangular SAND, dry, loose. OUTWASH (Kame) 4.6-5.0 ft. Dark Brown (7.5YR 3/3) well graded Silty c-f subangular SAND, dry, loose. OUTWASH (Kame) 5.0-6.0 ft. Dark Brown (7.5YR 3/3) well graded Gravelly Silty c-f subangular SAND, dry, loose. OUTWASH (Kame)	
6.5 7.0 7.5 8.0	2.0/1.8		15-15-18-19	SW SP GP	6-6.7 ft. Dark Brown (7.5YR 3/3) well graded Gravelly Silty c-f subangular SAND, dry, loose. OUTWASH (Kame) 6.7-6.85 ft. Dark Brown (7.5YR 3/3) poorly graded Silty medium subangular SAND, dry, loose. OUTWASH (Kame) 6.85-7.8 ft. Dark Brown (7.5YR 3/3) Sandy Silty angular m-f GRAVEL, dry, loose. OUTWASH (Kame)	0.0
8.5 9.0 9.5 10.0	2.0/1.7		34-34-32-30	GP	Dark Brown (7.5YR 3/3) Sandy Silty angular m-f GRAVEL, dry, loose. OUTWASH (Kame)	
10.5 11.0 11.5 12.0 12.5 13.0 13.5 14.0 14.5 15.0 15.0 15.0						

Soil Boring Log

Area: Grant	**Boring Date: November 29, 2004**	**Drilling Contractor: Geosearch**
Investigation Area: IA-7	**Boring Method: 3-in SS**	**Driller: Joe Keenan**
Boring ID: SB-03	**Drilling Method: 4¼-in. HSA**	**WESTON Geologist: A. Klappholz**
	Note: 140lb hammer used to	**Client: USACE**
Total Depth (ft bgs): 10.0	**advance the split spoons.**	

Depth Interval	Penetration/ Recovery	WESTON Sample	Blow Count	Soil Classification	Lithologic Description	Soil Headspace
0.5 1.0 1.5 2.0	2.0/1.75	GR-IA07-SB03-1 (0'-3')	5-9-18-32	SM SM	0-0.3 ft. Vey Dark Brown (7.5YR 2.5/2) Silty m -f subangular SAND and organics, moist, loose. LOAM 0.3-1.75 ft. Very Dark Brown (7.5YR 2.5/2) Silty Gravelly m-f subangular SAND, dry-moist, compact. FILL	0.0
2.5 3.0 3.5 4.0	2.0/0.0	GR-IA07-SB03-1 (3'-10')	24-18-30-32		Split spoon jammed with a gneiss cobble.	
4.5 5.0 5.5 6.0	2.0/1.8		14-24-20-18	GP SP	4.0-5.3 ft. Brown (7.5YR 2.5/2) Sandy Silty angular m-f GRAVEL, dry, dense. OUTWASH (Kame) 5.3-5.8 ft. Brown (7.5YR 5/3) poorly graded Silty medium subangular SAND, dry, loose. OUTWASH (Kame)	
6.5 7.0 7.5 8.0	2.0/1.5		13-10-8-12	SP SM	6.0-7.3 ft. Brown (7.5YR 5/3) poorly graded Silty medium subangular SAND, dry, loose. OUTWASH (Kame) 7.3-7.5 ft. Brown (7.5YR 5/3) poorly graded Silty fine SAND, moist, loose. OUTWASH (Kame)	0.0
8.5 9.0 9.5 10.0	2.0/2.0		8-10-20-27	GP ML	8.0-9.0 ft. Brown (7.5YR 5/3) Sandy Silty m -f angular GRAVEL, dry, dense. ABLATION TILL 9.0-9.1 ft. Brown (7.5YR 5/3) poorly graded Silty medium subangular SAND, dry, compact. ABLATION TILL 9.1-10.0 ft. Brown (7.5YR 5/3) Sandy Gravelly slightly plastic SILT, moist, firm. ABLATION TILL	
10.5 11.0 11.5 12.0 12.5 13.0 13.5 14.0 14.5 15.0 15.0 15.0						

Soil Boring Log

Area: Grant	**Boring Date: November 29, 2004**	**Drilling Contractor: Geosearch**
Investigation Area: IA-7	**Boring Method: 3-in SS**	**Driller: Joe Keenan**
Boring ID: SB-04	**Drilling Method: 4¼-in. HSA**	**WESTON Geologist: A. Klappholz**
	Note: 140lb hammer used to	**Client: USACE**
Total Depth (ft bgs): 10.0	**advance the split spoons.**	

Depth Interval	Penetration/ Recovery	WESTON Sample	Blow Count	Soil Classification	Lithologic Description	Soil Headspace
0.50 1.0 1.5 2.0	2.0/1.5	GR-IA07-SB04-1 (0'-3')	6-9-12-16	SM SM	0-0.4 ft. Brown (7.5YR 4/2) Silty m-f subangular SAND and organics, moist, loose. LOAM 0.4-1.5 ft. Brown (7.5YR 4/2) Silty Gravelly m-f subangular SAND, dry, loose. FILL	0.0
2.5 3.0	2.0/1.8		14-18-20-27	GP	2-2.9 ft. Brown (7.5YR 4/2) Sandy Silty angular GRAVEL, dry, loose. FILL	
3.5 4.0		GR-IA07-SB04-1 (3'-10')		SW	2.9-3.8 ft. Brown (7.5YR 5/4) well graded Gravelly Silty c-f subangular SAND, dry, loose. Weathered shale observed lodged in the bottom of the split spoon. OUTWASH (Kame)	0.0
4.5 5.0 5.5 6.0	2.0/1.7		34-33-18-12	SW	Brown (7.5YR 5/4) well graded Silty Gravelly c-f subangular SAND, dry, loose. OUTWASH (Kame)	
6.5 7.0 7.5 8.0	2.0/1.5		8-10-13-13	SW	Brown (7.5YR 5/4) well graded Silty Gravelly c-f subangular SAND, dry, loose. OUTWASH (Kame)	
8.5 9.0 9.5 10.0	2.0/1.2		20-19-18-19	SW SP	8.0 -8.7 ft. Brown (7.5YR 5/4) well graded Silty Gravelly c-f subangular SAND, dry, loose. OUTWASH (Kame) 8.7-9.2 ft. Brown (7.5YR 5/4) poorly graded Silty medium subangular SAND, moist, loose. OUTWASH (Kame)	
10.5 11.0 11.5 12.0 12.5 13.0 13.5 14.0 14.5 15.0 15.0 15.0						

SOIL BORING/WELL CONSTRUCTION LOG

Site: Devens SSI	**Boring/Well ID: SB-08/MW-1**	**Sampling Method: 3-inch SS**
Investigation Area: IA-08	**Drilling Company: EDI**	**Surface Elevation:**
Weston Geologist: J. Schmidl	**Driller: Ken Byland**	**Total Depth: 46.8 ft bgs**
Date: 12/14-15/2004	**Boring Method: 4¼-inch HSA**	**Water Level:**

Depth (ft bgs)	Sample Interval	Well Construction	Sample Type	Pen/ Rec	Blow Count	Soil Classification	Lithologic Description	NAPL Show/ Oil/Sheen	Soil Headspace (units>BKG)
1	0-2						0 to 10-ft depth intervals not sampled; see log for IA-08 SB-06, located 5 ft to the south.		
2									
3	2-4								
4									
5	4-6								
6									
7	6-8								
8									
9	8-10								
10									
11	10-12		SS	0.9/0.6	35-120/5"	SP	Olive brown (5Y 5/4), poorly graded, Gravelly SAND, moist, cohesive. OUTWASH (Esker)	None	0.3
12									
13	12-14		SS	0.8/0.4	15-120/4"	SP	Olive gray (5Y 6/2), poorly graded, Gravelly SAND, dry, loose. OUTWASH (Esker)	None	9.6
14									
15	14-16		SS	2.0/1.4	33-34-38-39	SP	Light olive brown (2.5YR 6/2) poorly graded, Gravelly f-c SAND, moist, loose. OUTWASH (Esker)	None	5.6
16									
17	16-18		SS	0.7/0.4	57-120/3"	SW	Light olive brown (2.5YR 6/2) poorly graded, Gravelly f-c SAND, moist, loose. OUTWASH (Esker)	None	5.9
18									
19	18-20		SS	0.2/0.1	120/3"	SW-SM	Light olive gray (5YR 6/2) well graded, Gravelly Silty f-c SAND, dry, loose. OUTWASH (Kame)	None	13.4
20									
21	20-22		SS	1.4/0.5	59-108-120/5"	SW-SM	Light olive gray (5YR 6/2) well graded, Gravelly Silty f-c SAND, dry, loose. OUTWASH (Kame)	None	14.7
22									
23	22-24		SS	1.2/1.1	47-55-120/3"	SW-SM	Light olive gray (5YR 6/2) well graded, Gravelly Silty f-c SAND, dry, loose. OUTWASH (Kame)	None	11.9
24									
25	24-26		SS	0.5/0.2	120/5"	SW-SM	Light olive brown (5YR 5/4) well graded, Gravelly f-c SAND, dry, loose. OUTWASH (Esker)	None	11.9
26									
27	26-28		SS	0.1/0.0	120/2"		No recovery.	None	
28									
29	28-30		SS	0.3/0/0	120/3"		No recovery.	None	
30									

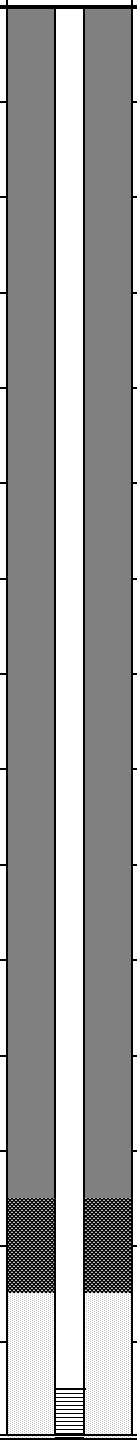
SOIL BORING/WELL CONSTRUCTION LOG

Site: Devens SSI	**Boring/Well ID: SB-08/MW-1**	**Sampling Method: 3-inch SS**
Investigation Area: IA-08	**Drilling Company: EDI**	**Surface Elevation:**
Weston Geologist: J. Schmidl	**Driller: Ken Byland**	**Total Depth: 46.8 ft bgs**
Date: 12/14-15/2004	**Boring Method: 4¼-inch HSA**	**Water Level:**

Depth (ft bgs)	Sample Interval	Well Construction	Sample Type	Pen/ Rec	Blow Count	Soil Classification	Lithologic Description	NAPL Show/ Oil/Sheen	Soil Headspace (units>BKG)
31	30-32		SS	2.0/1.6	50-52-40-43	SW-SM	Olive brown (5Y 5/4), well graded, Gravelly Silty SAND, moist, cohesive. Silt increases with depth. ABLATION TILL	None	0.0
33	32-34		SS	2.0/1.2	20-29-33-32	SW-SM	Olive brown (5Y 5/4), well graded, Gravelly Silty SAND, moist, cohesive. ABLATION TILL	None	0.0
35	34-36		SS	2.0/0.9	33-35-40-110	GW	Olive brown (5Y 5/4), well graded, Sandy GRAVEL, moist, cohesive. ABLATION TILL	None	0.0
37	36-38		SS	1.7/1.5	85-90-100-120/3"	GM	Dark olive brown (10Y 4/4) well graded, Gravelly Sandy SILT, saturated, slightly cohesive. ABLATION TILL	None	0.0
39	38-40		SS	2.0/0.6	3-17-17-24	GM	Dark gray (N3) well graded, Sandy Silty GRAVEL, saturated, loose. ABLATION TILL	None	4.7
41	40-42		SS	2.0/0.8	17-26-23-28	SW-SM	Olive brown (2.5Y 5/3) well graded, Gravelly Silty SAND, saturated, slightly cohesive. ABLATION TILL	None	23.0
43	42-44		SS	2.0/0.4	11-16-23-25	SW-SM	Olive brown (2.5Y 5/3) well graded, Gravelly Silty SAND, saturated, slightly cohesive. ABLATION TILL	None	8.9
45	44-46		SS	2.0/1.3	26-47-68-110	SW-SM	Olive brown (2.5Y 5/3) well graded, Gravelly Silty SAND, saturated, slightly cohesive. ABLATION TILL	None	24.5
47	46-48		SS	0.8/0.6	68-120/3"	GM	Olive brown (2.5Y 5/3) well graded, Gravelly Sandy SILT, saturated, slightly cohesive. Auger refusal at 46.8 ft bgs. ABLATION TILL	None	22.0
49	48-50						End of Boring.		
51	50-52						Well constructed using 10-slot, 2-in OD PVC screen, #2 silica sand, bentonite chips, and cement/bentonite grout.		
53	52-54						Boring backfilled with bentonite chips from 41.0 to 46.8 ft, prior to well installation.		
55	54-56								
57	56-58								
59	58-60								

SOIL BORING/WELL CONSTRUCTION LOG

Site: Devens SSI	**Boring/Well ID: SB-9/MW-02**	**Sampling Method: 3-inch SS**
Investigation Area: IA-08	**Drilling Company: EDI**	**Surface Elevation:**
Weston Geologist: J. Schmidl/D. Klapholz	**Driller: Ken Byland**	**Total Depth: 45 ft bgs**
Date: 12/16-17/04	**Boring Method: 4¼-inch HSA**	**Water Level:**

Depth (ft bgs)	Sample Interval	Well Construction	Sample Type	Pen/ Rec	Blow Count	Soil Classification	Lithologic Description	NAPL Show/ Oil/Sheen	Soil Headspace (units>BKG)
1	0-2		SS	2.0/1.3	33-30-33-35	SW	Olive brown (2.5Y 4/4) well graded Gravelly f-c SAND, moist, slightly cohesive. FILL	None	3.3
3	2-4		SS	2.0/1.2	21-40-32-37	SW	Olive brown (2.5Y 4/4) well graded Gravelly f-c SAND, moist, slightly cohesive. FILL	None	6.8
5	4-6		SS	2.0/1.2	8-11-24-23	SW-SM SP	4.0-4.5 ft: Olive brown (2.5Y 4/3) well graded Gravelly Silty SAND, moist, cohesive. FILL 5.0-5.2 ft: Pale gray, poorly graded Gravelly m. SAND, moist, loose. OUTWASH (Esker)	None	6.3
7	6-8		SS	2.0/1.4	35-43-59-63	SP	Pale gray, poorly graded, Gravelly m. SAND, moist, loose. OUTWASH (Esker)	None	5.8
9	8-10		SS	2.0/1.4	28-35-46-60	SP	Pale gray, poorly graded, Gravelly m. SAND, moist, loose. OUTWASH (Esker)	None	9.2
11	10-12		SS	2.0/1.5	28-30-36-43	SW	Light yellow brown (2.5Y 6/3), graded, Gravelly f-c SAND, moist, loose. OUTWASH (Esker)	None	7.2
13	12-14		SS	2.0/1.3	41-40-53-50	SW	Light yellow brown (2.5Y 6/3), graded, Gravelly f-c SAND, moist, loose. OUTWASH (Esker)	None	7.6
15	14-16		SS	2.0/1.5	32-40-46-50	SW	Light yellow brown (2.5Y 6/3), graded, Gravelly f-c SAND, moist, loose. OUTWASH (Esker)	None	6.2
17	16-18		SS	2.0/1.5	41-43-50-49	SW	Light yellow brown (2.5Y 6/3), graded, Gravelly f-c SAND, moist, loose. OUTWASH (Esker)	None	4.0
19	18-20		SS	2.0/1.3	41-50-55-80	SW	Light yellow brown (2.5Y 6/3), graded, Gravelly f-c SAND, moist, loose. OUTWASH (Esker)	None	3.5
21	20-22		SS	1.4/0.8	53-60-120/5"	SW	Light yellow brown (2.5Y 6/3), graded, Gravelly f-c SAND, moist, loose. OUTWASH (Esker)	None	7.5
23	22-24		SS	1.3/0.9	90-100-120/4"	SW	Light yellow brown (2.5Y 6/3), graded, Gravelly f-c SAND, moist, loose. OUTWASH (Esker)	None	6.8
25	24-26		SS	0.4/0.4	120/5"	SW	Light yellow brown (2.5Y 6/3), graded, Gravelly f-c SAND, wet, loose. OUTWASH (Esker)	None	8.1
27	26-28		SS	0.4/0.0	120/5"		No recovery.	None	
29	28-30		SS	0.3/0.0	120/4"		No recovery.	None	

SOIL BORING/WELL CONSTRUCTION LOG

Site: Devens SSI	**Boring/Well ID: SB-9/MW-02**	**Sampling Method: 3-inch SS**
Investigation Area: IA-08	**Drilling Company: EDI**	**Surface Elevation:**
Weston Geologist: J. Schmidl/D. Kla	**Driller: Ken Byland**	**Total Depth: 45 ft bgs**
Date: 12/16-17/04	**Boring Method: 4¼-inch HSA**	**Water Level:**

Depth (ft bgs)	Sample Interval	Well Construction	Sample Type	Pen/ Rec	Blow Count	Soil Classification	Lithologic Description	NAPL Show/ Oil/Sheen	Soil Headspace (units>BKG)
31	30-32		SS	0.9/0.7	69-120/5"	SW	Light yellow brown (2.5Y 6/3), graded, Gravelly f-c SAND, moist, loose. OUTWASH (Esker)	None	4.5
33	32-34		SS	2.0/1.3	43-46-44-45	SW	Dark gray brown (2.5Y 4/2), graded, Gravelly f-c SAND, saturated, slightly cohesive. OUTWASH (Esker)	None	6.9
35	34-36		SS	0.9/0.7	180-120/5"	SW	Dark gray brown (2.5Y 4/2), graded, Gravelly f-c SAND, saturated, slightly cohesive. OUTWASH (Esker)	None	7.7
37	36-38		SS	2.0/1.4	31-64-88-36	GM	Dark gray brown (2.5Y 4/2), well graded, Sandy Silty GRAVEL, saturated, cohesive. ABLATION TILL	None	17.7
39	38-40		SS	0.3/0.3	120/3"	GM	Dark gray brown (2.5Y 4/2), graded, Gravelly f-c SAND, saturated, slightly cohesive. ABLATION TILL	None	0.0
41	40-42		SS	0.4/0.4	120/5"	GW	Light olive brown (2.5Y 5/3), well graded, Silty GRAVEL, saturated, firm. LODGEMENT TILL	None	0.0
43	42-44		SS	0.3/0.3	120/3"	GM	Light olive brown (2.5Y 5/3), well graded, Silty GRAVEL, saturated, dense. LODGEMENT TILL	None	0.0
45	44-46		SS	0.3/0.3	120/3"	GP	Olive brown (2.5Y 4/4), well graded, Sandy Silty GRAVEL, saturated, firm. LODGEMENT TILL Auger refusal at 45 ft bgs.	None	0.0
47	46-48						End of Boring.		
49	48-50						Well constructed using 10-slot, 2-in OD PVC screen, #00 silica sand, bentonite chips, and cement/bentonite grout.		
51	50-52								
53	52-54								
55	54-56								
57	56-58								
59	58-60								

SOIL BORING/WELL CONSTRUCTION LOG

Site: Devens SSI	**Boring/Well ID: PZ-01**	**Sampling Method: 3-inch SS**
Investigation Area: IA-08	**Drilling Company: EDI**	**Surface Elevation:**
Weston Geologist: J. Schmidl	**Driller: Ken Byland**	**Total Depth: 38 ft bgs**
Date: 11/29-30/04	**Boring Method: 4¼-inch HSA**	**Water Level:**

Depth (ft bgs)	Sample Interval	Well Construction	Sample Type	Pen/ Rec	Blow Count	Soil Classification	Lithologic Description	NAPL Show/ Oil/Sheen	Soil Headspace (units>BKG)
1	0-2		SS	2.0/1.8	7-17-16-12	ML ML	0-1.2 ft: Dark brown (5Y 3/4) poorly graded Sandy SILT, moist, cohesive. 1.2-1.8 ft: Gray brown (10YR 4/1), well graded, Sandy SILT, moist, loose. FILL	None	0.0
2									
3	2-4		SS	2.0/1.0	21-30-20-12	ML	Gray brown (10YR 4/1) well graded, Sandy SILT, moist, loose. FILL	None	0.0
4									
5	4-6		SS	2.0/1.3	30-33-16-16	SP SW	Dark yellow brown (10YR 4/2) poorly graded, SAND, moist, loose; grades to well graded, m-c Gravelly SAND, moist, loose. OUTWASH (Esker)	None	0.0
6									
7	6-8		SS	2.0/1.5	10-10-8-7	SP	Gray brown (10YR 6/2) poorly graded, Gravelly c. SAND, moist, loose; grades to pale yellow brown (10 YR 7/2), poorly graded, f. SAND, moist loose. OUTWASH (Esker)	None	0.0
8									
9	8-10		SS	2.0/1.4	8-7-9-13	SP	Very pale yellow brown (10 YR 7/2), poorly graded, f. SAND, moist loose. Lenses of m. sand or Silt, dipping at 10º. OUTWASH (Esker)	None	0.0
10									
11	10-12		SS	2.0/1.7	15-15-11-9	SP SP-SM	10.0-10.8 ft: Light yellow brown (10YR 6/4), poorly graded f. SAND, moist, loose. OUTWASH (Esker) 10.8-11.7 ft: Dark yellow brown (10YR 4/2), gravelly Silty f. SAND, moist, loose. OUTWASH (Kame)	None	0.0
12									
13	12-14		SS	2.0/1.3	15-15-14-12	SP-SM	Dark yellow brown (10YR 4/2), Gravelly Silty f. SAND, moist, loose. OUTWASH (Kame)	None	0.0
14									
15	14-16		SS	2.0/1.3	12-12-12-8	SP	Pale yellow brown (10YR 5/2) poorly graded, Gravelly f-m SAND, moist, loose. OUTWASH (Esker)	None	0.0
16									
17	16-18		SS	2.0/1.5	10-10-7-8	SW	Olive gray (5Y 3/2) well graded, Gravelly f-c SAND, moist, loose. OUTWASH (Esker)	None	0.0
18									
19	18-20		SS	2.0/1.5	1-1-80-80	SW-SM SW-SM	18.0-19.0 ft: Olive gray (5Y 3/2) well graded, gravelly f-c SAND, moist, loose. OUTWASH 19.0-19.5 ft: Olive brown (5Y 3/4), well graded, Gravelly Silty f. SAND, moist, dense. TILL	None	0.0
20									
21	20-22		SS	0.7/0.7	70-120/2"	SW-SM	Olive brown (5Y 4/2), well graded, Gravelly Silty SAND, moist, dense. ABLATION TILL	None	0.0
22									
23	22-24		SS	2.0/1.3	30-43-45-55	SW-SM	Olive brown (5Y 4/2), well graded, Gravelly Silty SAND, moist, dense. ABLATION TILL	None	0.0
24									
25	24-26		SS	0.8/0.8	65-120/3"	SW-SM	Olive brown (5Y 4/2), well graded, Gravelly Silty SAND, moist, dense. ABLATION TILL	None	0.0
26									
27	26-28		SS	0.5/0.5	140-120/0"	SW-SM	Olive brown (5Y 4/2), well graded, Gravelly Silty SAND, moist, dense. ABLATION TILL	None	0.0
28									
29	28-30		SS	1.3-1.3	40-115-120/4"	SW-SM	Olive brown (5Y 4/2), well graded, Gravelly Silty SAND, wet, dense. ABLATION TILL	None	0.0
30									

SOIL BORING/WELL CONSTRUCTION LOG

Site: Devens SSI	**Boring/Well ID: PZ-01**	**Sampling Method: 3-inch SS**
Investigation Area: IA-08	**Drilling Company: EDI**	**Surface Elevation:**
Weston Geologist: J. Schmidl	**Driller: Ken Byland**	**Total Depth: 38 ft bgs**
Date: 11/29-30/04	**Boring Method: 4¼-inch HSA**	**Water Level:**

Depth (ft bgs)	Sample Interval	Well Construction	Sample Type	Pen/ Rec	Blow Count	Soil Classification	Lithologic Description	NAPL Show/ Oil/Sheen	Soil Headspace (units>BKG)
31	30-32		SS	1.3/1.3	70-70-120/4"	SW-SM	30.0-30.7 ft: Olive brown (5Y 4/2), well graded, Gravelly Silty SAND, wet, dense. ABLATION TILL 30.7-31.3 ft: Olive brown (5Y 4/2), well graded, Gravelly Sandy SILT, saturated, dense. LODGEMENT TILL	None	
32									
33	32-34		SS	0.4/0.4	125/5"	GM	Olive brown (5Y 4/2), well graded, Gravelly Sandy SILT, saturated, dense. LODGEMENT TILL	None	
34									
35	34-36		SS	0.2/0.2	120/2"	GM	Olive brown (5Y 4/2), well graded, Gravelly Sandy SILT, saturated, dense. LODGEMENT TILL	None	
36									
37	36-38		SS	2.0/0.7	17-25-27-35	GM	Dark olive brown (10Y 4/4) well graded, Gravelly Sandy SILT, wet, dense. LODGEMENT TILL	None	
38									
39	38-40						End of Boring.		
40									
41	40-42						Well constructed using 10-slot, 2-in OD PVC screen, #00 silica sand, bentonite chips, and cement/bentonite grout.		
42									
43	42-44								
44									
45	44-46								
46									
47	46-48								
48									
49	48-50								
50									
51	50-52								
52									
53	52-54								
54									
55	54-56								
56									
57	56-58								
58									
59	58-60								
60									

SOIL BORING/WELL CONSTRUCTION LOG

Site: Devens SSI	**Boring/Well ID: PZ-02**	**Sampling Method: 3-inch SS**
Investigation Area: IA-08	**Drilling Company: EDI**	**Surface Elevation:**
Weston Geologist: J. Schmidl	**Driller: Ken Byland**	**Total Depth: 46 ft bgs**
Date: 12/8-9/04	**Boring Method: 4¼-inch HSA**	**Water Level:**

Depth (ft bgs)	Sample Interval	Well Construction	Sample Type	Pen/ Rec	Blow Count	Soil Classification	Lithologic Description	NAPL Show/ Oil/Sheen	Soil Headspace (units>BKG)
1 2	0-2		SS	2.0/1.1	4-4-4-4	SM GP-GM	0-0.8 ft: Dark yellow brown (10YR 4/2) well graded, Gravelly Silty SAND, wet, cohesive. 0.8-1.1 ft: Gray brown (5YR 4/2), well graded, Gravelly Sandy SILT, moist, slightly cohesive. FILL	None	1.1
3 4	2-4		SS	2.0/0.7	2-4-6-8	SM	Light yellow brown (10YR 5/2) well graded, Silty SAND, moist, loose. FILL	None	0.4
5 6	4-6		SS	2.0/1.4	15-56-39-62	SP	4.0-4.3 ft: Yellow brown (10YR 5/4) poorly graded, Gravelly f. SAND, moist, cohesive. 4.3-5.4 ft: Light yellow brown (10YR 6/4) poorly graded, m-c Gravelly SAND, moist, loose. OUTWASH (Esker)	None	3.6
7 8	6-8		SS	2.0/1.3	70-90-110-115	SP	Light yellow brown (10YR 6/4) poorly graded, m-c Gravelly SAND, moist, loose. OUTWASH (Esker)	None	2.7
9 10	8-10		SS	2.0/1.1	15-24-22-30	SP SP	8.0-8.9 ft: Light yellow brown (10 YR 5/3), poorly graded, Gravelly f-m/m-c SAND, moist, loose. 8.9-9.1 ft: Pale yellow brown (10YR 7/2), poorly graded, f. SAND, moist, loose, in 0.05-ft thick beds. OUTWASH	None	2.9
11 12	10-12		SS	2.0/1.4	13-13-14-14	GM SP	10.0-10.7 ft: Yellow brown (10YR 6/4), well graded, Gravelly Sandy SILT, saturated, cohesive. ABLATION TILL 10.7-11.4 ft: Pale yellow brown (10YR 7/2), poorly graded, m-c SAND, moist, loose. Perched water on silt. OUTWASH	None	2.4
13 14	12-14		SS	2.0/1.5	12-13-17-21	SW-SM GM	12.0-13.1 ft: Pale yellow brown (10YR 7/2), well graded, Gravelly Silty SAND, moist, loose. ABLATION TILL 13.1-13.5 ft: Light olive brown (5Y 5/3), well graded, Gravelly SILT, wet, cohesive. ABLATION TILL	None	3.5
15 16	14-16		SS	2.0/1.4	11-14-17-16	GM	Light olive brown (5Y 5/3), well graded, Gravelly SILT, wet, cohesive. ABLATION TILL	None	3.4
17 18	16-18		SS	2.0/1.3	60-30-30-57	GM	Light olive brown (5Y 5/3) well graded, Gravelly SILT, wet, cohesive. ABLATION TILL	None	7.9
19 20	18-20		SS	1.3/1.2	31-43-120/4"	GM	Light olive brown (5Y 5/3) well graded, Gravelly SILT, wet, dense. LODGEMENT TILL	None	2.2
21 22	20-22		SS	2.0/1.6	35-48-69-82	GM	Light olive brown (5Y 5/3) well graded, Gravelly SILT, wet, dense. LODGEMENT TILL	None	2.0
23 24	22-24		SS	1.3/1.4	60-110-120/4"	GM	Light olive brown (5Y 5/3) well graded, Gravelly SILT, wet, dense. LODGEMENT TILL	None	4.7
25 26	24-26		SS	2.0/1.5	13-35-72-85	GM	Light olive brown (5Y 5/3) well graded, Gravelly SILT, wet, dense. LODGEMENT TILL	None	2.5
27 28	26-28		SS	1.8/1.8	95-95-110-120/3"	GM	Light olive brown (5Y 5/3) well graded, Gravelly SILT, wet, dense. LODGEMENT TILL	None	3.6
29 30	28-30		SS	1.8/1.8	63-78-116-120/4"	GM	Light olive brown (5Y 5/3) well graded, Gravelly Clayey SILT, wet, dense. LODGEMENT TILL	None	1.0

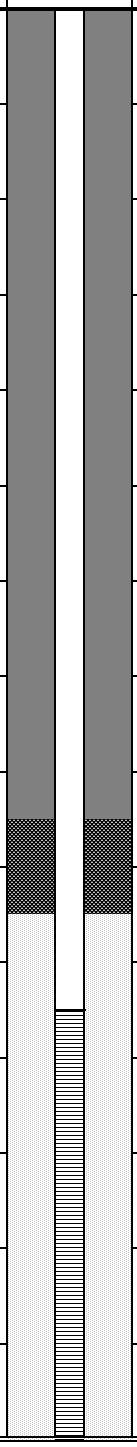
SOIL BORING/WELL CONSTRUCTION LOG

Site: Devens SSI	**Boring/Well ID: PZ-02**	**Sampling Method: 3-inch SS**
Investigation Area: IA-08	**Drilling Company: EDI**	**Surface Elevation:**
Weston Geologist: J. Schmidl	**Driller: Ken Byland**	**Total Depth: 46 ft bgs**
Date: 12/8-9/04	**Boring Method: 4¼-inch HSA**	**Water Level:**

Depth (ft bgs)	Sample Interval	Well Construction	Sample Type	Pen/ Rec	Blow Count	Soil Classification	Lithologic Description	NAPL Show/ Oil/Sheen	Soil Headspace (units>BKG)
31	30-32		SS	0.9/1.0	58-120/5"	GM	Light olive brown (5Y 5/3) well graded, Gravelly Clayey SILT, wet, dense. LODGEMENT TILL	None	0.5
32									
33	32-34		SS	1.4/1.4	56-100-120/5"	GM	Light olive brown (5Y 5/3) well graded, Gravelly Clayey SILT, wet, dense. LODGEMENT TILL	None	0.9
34									
35	34-36		SS	0.9/1.0	65-120/5"	GM	Light olive brown (5Y 5/3) well graded, Gravelly Clayey SILT, wet, dense. LODGEMENT TILL	None	2.8
36									
37	36-38		SS	0.9/1.0	56-120/5"	GM	Light olive brown (5Y 5/3) well graded, Gravelly Clayey SILT, wet, dense. LODGEMENT TILL	None	NR
38									
39	38-40		SS	2.0/1.7	64-120-100-116	GM	Light olive brown (5Y 5/3) well graded, Gravelly Clayey SILT, wet, dense. LODGEMENT TILL	None	3.6
40									
41	40-42		SS	0.8/1.0	69-94-120/3"	GM	Light olive brown (5Y 5/3) well graded, Gravelly Clayey SILT, very wet, dense. LODGEMENT TILL	None	7.5
42									
43	42-44		SS	2.0/1.4	57-56-48-62	GM	Olive brown (5Y 4/3), well graded, Gravelly Sandy SILT, wet, cohesive. LODGEMENT TILL	None	4.0
44									
45	44-46		SS	2.0/1.9	48-57-69-68	GM	Olive brown (5Y 4/3) well graded, Gravelly Sandy SILT, saturated, very cohesive. LODGEMENT TILL	None	3.1
46									
47	46-48						End of Boring.		
48									
49	48-50						Well constructed using 10-slot, 2-in OD PVC screen, #00 silica sand, bentonite chips, and cement/bentonite grout.		
50									
51	50-52						NR= Not Recorded		
52									
53	52-54								
54									
55	54-56								
56									
57	56-58								
58									
59	58-60								
60									

SOIL BORING/WELL CONSTRUCTION LOG

Site: Devens SSI	**Boring/Well ID: PZ-03**	**Sampling Method: 3-inch SS**
Investigation Area: IA-08	**Drilling Company: EDI**	**Surface Elevation:**
Weston Geologist: J. Schmidl	**Driller: Ken Byland**	**Total Depth: 31 ft bgs**
Date: 12/7/2004	**Boring Method: 4¼-inch HSA**	**Water Level:**

Depth (ft bgs)	Sample Interval	Well Construction	Sample Type	Pen/ Rec	Blow Count	Soil Classification	Lithologic Description	NAPL Show/ Oil/Sheen	Soil Headspace (units>BKG)
1	0-2		SS	20./1.4	8-9-10-10-	SW-SM	Dark yellow brown (10YR 4/4) well graded, Gravelly Silty SAND, moist, slightly cohesive. FILL	None	
2									
3	2-4		SS	2.0/1.1	10-10-10-7	SW-SM SP	2.0-2.8 ft: Dark yellow brown (10YR 4/4) well graded, Gravelly Silty SAND, moist, slightly cohesive. FILL Sharp 2.8-3.1ft: Light yellow brown (10YR 6/4) poorly graded, f. SAND, moist, slightly cohesive. FLUVIAL	None	
4									
5	4-6		SS	2.0/1.0	11-8-7-8	SP	Light yellow brown (10YR 6/4) poorly graded, f. SAND, moist, slightly cohesive. OUTWASH (Esker)	None	
6									
7	6-8		SS	2.0/1.1	5-8-9-13	SP	Pale yellow brown (10YR 7/5) poorly graded, f. SAND, moist, slightly cohesive. OUTWASH (Esker)	None	
8									
9	8-10		SS	2.0/1.5	5-5-7-10	SP	Pale yellow brown (10YR 7/5) poorly graded, f. SAND, moist, slightly cohesive. OUTWASH (Esker)	None	
10									
11	10-12		SS	2.0/1.5	3-3-7-5	SP	Pale yellow brown (10YR 7/5) poorly graded, f. SAND, moist, slightly cohesive. OUTWASH (Esker)	None	
12									
13	12-14		SS	2.0/1.3	5-5-6-6	SP	Pale yellow brown (10YR 7/5) poorly graded, f. SAND, moist, slightly cohesive. OUTWASH (Esker)	None	
14									
15	14-16		SS	2.0/1.6	6-8-10-6	SP	Pale yellow brown (10YR 7/5) poorly graded, f. SAND, moist, slightly cohesive. M. Sand at 15.4 ft. OUTWASH (Esker)	None	
16									
17	16-18		SS	2.0/0.8	2-11-21-16	SP GP	16.0-16.5 ft: Pale yellow brown (10YR 7/5) poorly graded, f. SAND, moist, slightly cohesive. M. Sand at 15.4 ft. 16.5-16.8 ft: Dark gray (N3) schist Gravel. OUTWASH (Esker)	None	
18									
19	18-20		SS	2.0/1.5	11-18-18-20	SW	Dark yellow brown (10YR 4/2) well graded, Gravelly f-c SAND, moist, dense. OUTWASH (ESKER)	None	
20									
21	20-22		SS	2.0/1.3	18-20-19-20	SW	Dark yellow brown (10YR 4/2) well graded, Gravelly f-c SAND, moist, dense. OUTWASH (Esker)	None	
22									
23	22-24		SS	2.0/1.4	25-28-33-38	SP SW	22.0-23.0 ft: Dark yellow brown (10YR 4/2) well graded, Gravelly f-c SAND, moist, dense. 23.0-23.4 ft: Light yellow brown (10YR 7/5), well graded, Gravelly f. SAND, moist, loose. OUTWASH (Esker)	None	
24									
25	24-26		SS	2.0/1.3	13-15-16-18	SW	Dark yellow brown (10YR 4/2) well graded, Gravelly f-c SAND, wet, loose. Saturated at 25.0 ft bgs. OUTWASH (Esker)	None	
26									
27	26-28		SS	2.0/1.3	5-7-9-12	SW	Dark yellow brown (10YR 4/2) well graded, Gravelly f-c SAND, saturated, loose. OUTWASH (Esker)	None	
28									
29	28-30		SS	2.0/0.8	5-15-29-32	GP	Dark yellow brown (10YR 4/4) well graded, Sandy GRAVEL, saturated, loose. OUTWASH (Esker)	None	
30									

SOIL BORING/WELL CONSTRUCTION LOG

Site: Devens SSI	**Boring/Well ID: PZ-03**	**Sampling Method: 3-inch SS**
Investigation Area: IA-08	**Drilling Company: EDI**	**Surface Elevation:**
Weston Geologist: J. Schmidl	**Driller: Ken Byland**	**Total Depth: 31 ft bgs**
Date: 12/7/2004	**Boring Method: 4¼-inch HSA**	**Water Level:**

Depth (ft bgs)	Sample Interval	Well Construction	Sample Type	Pen/ Rec	Blow Count	Soil Classification	Lithologic Description	NAPL Show/ Oil/Sheen	Soil Headspace (units>BKG)
31	30-32		SS	2.0/0.9	15-33-55-72	GP	Dark gray (N3) to red brown (10R 3/6) weathered shale GRAVEL, saturated, loose. OUTWASH (Esker)	None	0.5
32									
33	32-34						End of Boring.		
34									
35	34-36						Well constructed using 10-slot, 2-in OD PVC screen, #2 silica sand, bentonite chips, and cement/bentonite grout.		
36									
37	36-38								
38									
39	38-40								
40									
41	40-42								
42									
43	42-44								
44									
45	44-46								
46									
47	46-48								
48									
49	48-50								
50									
51	50-52								
52									
53	52-54								
54									
55	54-56								
56									
57	56-58								
58									
59	58-60								
60									

SOIL BORING/WELL CONSTRUCTION LOG

Site: Devens SSI	**Boring/Well ID: SB-01**	**Sampling Method: 3-inch SS**
Investigation Area: IA-08	**Drilling Company: EDI**	**Surface Elevation:**
Weston Geologist: J. Schmidl	**Driller: Ken Byland**	**Total Depth: 48.5 ft bgs**
Date: 11/30-12/2/2004	**Boring Method: 4¼-inch HSA**	**Water Level:**

Depth (ft bgs)	Sample Interval	Analytical Samples	Sample Type	Pen/ Rec	Blow Count	Soil Classification	Lithologic Description	NAPL Show/ Oil/Sheen	Soil Headspace (units>BKG)
1	0-2	GR-IA08-SS01-1	SS	2.0/1.3	25-40-40-43	SP-SM	Olive brown (5Y 5/4), well graded, Gravelly Silty f. SAND, moist, cohesive. FILL	None	0.0
2									
3	2-4		SS	2.0/1.7	45-38-45-55	SP-SM	Olive brown (5Y 5/4), well graded, Gravelly Silty f. SAND, moist, cohesive. Brown at 3.2 ft bgs. FILL	None	0.0
4									
5	4-5	GR-IA08-SB01-1 and GR-IA08-SB01-1-D	n/a				Boulder.	None	n/a
6	5-7		SS	2.0/0.7	30-35-70-110	SP-SM	Olive brown (5Y 3/4), well graded, Gravelly Silty f. SAND, moist, cohesive. FILL	None	0.0
7									
8	7-8		SS	0.3/0.0	120/3"		No recovery.	None	n/a
9	8-10		SS	2.0/1.5	16-27-33-50	SP	Very pale brown (10YR 8/4), poorly graded, f. SAND, moist. Loose. Grades to Gravelly m. Sand at 8.5 ft bgs. OUTWASH (Kame)	None	0.0
10									
11	10-12		SS	2.0/1.4	35-70-120-120	SP	Interbedded (0.2 to 0.5 ft thick), grayish brown (10YR 5/2), poorly graded, Gravelly f. Sand and light brownish gray (5YR 7/1), poorly graded, Gravelly Silty vf. SAND, moist, loose. OUTWASH (Kame)	None	0.0
12									
13	12-14		SS	0.3/0.3	120/3"	SM	Pale Yellow brown (10YR 6/2), well graded, Gravelly Sandy SILT, moist, loose. Boulder from 13 to 14 ft bgs. OUTWASH (Kame)	None	0.0
14									
15	14-16		SS	0.7/0.4	35-120/2"	SM	Pale olive gray (5Y 6/2), well graded, Gravelly Sandy SILT, moist, loose. ABLATION TILL	None	0.0
16									
17	16-18		SS	2.0/1.4	37-55-120/5"	SM	Pale olive gray (5Y 6/2), well graded, Gravelly Sandy SILT, moist, loose. OUTWASH (Kame)	None	0.0
18									
19	18-20		SS	0.8/0.7	65-120/4"	SM	Pale olive gray (5Y 6/2), well graded, Gravelly Sandy SILT, moist, loose. OUTWASH (Kame)	None	0.0
20									
21	20-22		SS	0.3/0.1	120/3"	SM	Pale olive gray (5Y 6/2), well graded, Gravelly Sandy SILT, moist, loose. OUTWASH (Kame)	None	0.0
22									
23	22-24		SS	0.7/0.5	120-120/2"	SM	Pale olive gray (5Y 6/2), well graded, Gravelly Sandy SILT, moist, loose. OUTWASH (Kame)	None	0.0
24									
25	24-26		SS	2.0/1.0	50-115-120-115	SM	Pale olive gray (5Y 4/2), well graded, Gravelly Sandy SILT, moist, loose. OUTWASH (Kame)	None	0.0
26									
27	26-28		SS	0.3/0.3	120/3"	SM	Pale olive gray (5Y 4/2), well graded, Gravelly Sandy SILT, moist, loose. Boulder from 26 to 28 ft bgs. OUTWASH (Kame)	None	0.0
28									
29	28-30		SS	0.4/0.4	120/5"	SW	Pale Yellow brown (5Y 6/2), graded, f-c Gravelly SAND, moist, loose. Boulder from 26 to 28 ft bgs. OUTWASH (Kame)	None	0.0
30									

Sample Type:

SOIL BORING/WELL CONSTRUCTION LOG

Site: Devens SSI	**Boring/Well ID: SB-01**	**Sampling Method: 3-inch SS**
Investigation Area: IA-08	**Drilling Company: EDI**	**Surface Elevation:**
Weston Geologist: J. Schmidl	**Driller: Ken Byland**	**Total Depth: 48.5 ft bgs**
Date: 11/30-12/2/2004	**Boring Method: 4¼-inch HSA**	**Water Level:**

Depth (ft bgs)	Sample Interval	Analytical Samples	Sample Type	Pen/ Rec	Blow Count	Soil Classification	Lithologic Description	NAPL Show/ Oil/Sheen	Soil Headspace (units>BKG)
31	30-32		SS	0.4/0.4	120/5"	SM	Pale olive gray (5Y 4/2), well graded, Gravelly Sandy SILT, moist, loose. OUTWASH (Kame)	None	0.0
32									
33	32-35		n/a				Boulders encountered continuously during drilling. No split spoons advanced.	None	
34									
35									
36	35-37		SS	2.0/1.8	50-35-35-30	SP-SM	Dark yellow brown (10YR 5/2), well graded, Gravelly Silty f. SAND, saturated, loose. OUTWASH (Kame)	None	0.0
37									
38	37-39		SS	2.0/1.7	25-25-40-35	SP-SM	Dark yellow brown (10YR 5/2), well graded, Gravelly Silty f. SAND, saturated, loose. OUTWASH (Kame)	None	0.0
39									
40	39-40		n/a				Not sampled.		
41	40-42		SS	2.0/1.4	10-10-25-23	SP	Yellow brown (10YR 5/4), well graded, Gravelly c. SAND, saturated, loose. OUTWASH (Kame)	None	0.0
42									
43	42-44		SS	2.0/1.9	23-25-33-35	SP	Yellow brown (10YR 5/4), well graded, Gravelly c. SAND, saturated, loose. OUTWASH (Kame)	None	0.0
44									
45	44-46		SS	2.0/1.7	25-25-25-25	SW-SM	Yellow brown (10YR 5/5), well graded, Gravelly f-c Silty SAND, saturated, loose. OUTWASH (Kame)	None	0.0
46									
47	46-48		SS	2.0/1.6	23-20-25-50	SW-SM GP-GM	46.0-47.0 ft: Yellow brown (10YR 5/5), well graded, Gravelly f-c Silty SAND, saturated, loose. OUTWASH (Kame) 47.0-47.6 ft: Brown (10YR 5/4), well graded, Gravelly Sandy SILT, saturated, cohesive. ABLATION TILL	None	0.0
48									
49	48-50		n/a				Auger refusal on bedrock at 48.5 ft bgs.	None	
50									
51	50-52						End of Boring.		
52									
53	52-54								
54									
55	54-56								
56									
57	56-58								
58									
59	58-60								
60									

SOIL BORING LOG

Area: Grant	**Boring Date: December 3, 2004**	**Drilling Contractor: GEOSEARCH**
Investigation Area: IA-08	**Boring Method: 3-in SS**	**Driller: Ken Byland**
Boring ID: SB-02	**Drilling Method: 4¼-in. HSA**	**WESTON Geologist: J. Schmidl**
	Note: 140-lb hammer used to	**Client: USACE**
Total Depth (ft bgs): 10.0	advance the split spoons.	

Depth Interval	Penetration/ Recovery	WESTON Sample	Blow Count	Soil Classification	Lithologic Description	Soil Headspace (units >BKG)
0.50 1.0 1.5 2.0	2.0/1.8	GR-IA08-SB02-1 (0'-3')	10-13-6-9	SP-SM	Yellow brown (10YR 5/4), well graded, Gravelly Silty f. SAND, moist, slightly cohesive. FILL	0.0
2.5 3.0 3.5 4.0	2.0/0.7		13-14-13-8	SP-SM	Yellow brown (10YR 5/4), well graded, Gravelly Silty f. SAND, contains asphalt, moist, slightly cohesive. FILL	0.0
4.5 5.0 5.5 6.0	2.0/1.3	GR-IA08-SB02-1 (3'-10')	6-9-10-13	SP-SM	Yellow brown (10YR 5/4), well graded, Gravelly Silty f. SAND, wet, slightly cohesive. FILL	0.0
6.5 7.0 7.5 8.0	2.0/1.0		15-15-10-7	SP-SM	Yellow brown (10YR 5/4), well graded, Gravelly Silty f. SAND, wet, slightly cohesive. FILL	0.0
8.5 9.0 9.5 10.0	2.0/1.5		9-10-11-14	SW	Yellow brown (10YR 5/4), graded, Gravelly f-c SAND, moist, loose. OUTWASH (Kame)	1.5
10.5 11.0 11.5 12.0 12.5 13.0 13.5 14.0 14.5 15.0 15.0 15.0					End of Boring.	

SOIL BORING LOG

Area: Grant	**Boring Date: December 9, 2004**	**Drilling Contractor: GEOSEARCH**
Investigation Area: IA-08	**Boring Method: 3-in SS**	**Driller: Ken Byland**
Boring ID: SB-03	**Drilling Method: 4¼-in. HSA**	**WESTON Geologist: J. Schmidl**
	Note: 140-lb hammer used to	**Client: USACE**
Total Depth (ft bgs): 10.0	advance the split spoons.	

Depth Interval	Penetration/ Recovery	WESTON Sample	Blow Count	Soil Classification	Lithologic Description	Soil Headspace (units >BKG)
0.50 1.0 1.5 2.0	2.0/1.4	GR-IA08-SB03-1 (0'-3')	17-25-25-25	SP-SM	Olive brown (5Y 5/4), well graded, Gravelly Silty f. SAND, moist, slightly cohesive. FILL	1.7
2.5 3.0 3.5 4.0	2.0/0.9		17-15-18-25	SP-SM	Olive brown (5Y 5/4), well graded, Gravelly Silty f. SAND, moist, slightly cohesive. FILL	0.0
4.5 5.0 5.5 6.0	2.0/0.6	GR-IA08-SB03-1 (3'-10')	16-7-5-5	SP-SM	Olive brown (5Y 5/4), well graded, Gravelly Silty f. SAND, moist, slightly cohesive. FILL	0.0
6.5 7.0 7.5 8.0	2.0/1.1		15-15-10-7	SP-SM SW-SM	6.0-6.3 ft: Olive brown (5Y 5/4), well graded, Gravelly Silty f. SAND, moist, slightly cohesive. FILL 6.3-7.1 ft: Yellow brown (10YR 5/4), graded, Gravelly Silty f-c SAND, moist, loose. OUTWASH (Kame)	0.4
8.5 9.0 9.5 10.0	2.0/0.0		21-26-36-30		No recovery.	
10.5 11.0 11.5 12.0 12.5 13.0 13.5 14.0 14.5 15.0 15.0 15.0					End of Boring.	

SOIL BORING LOG

Area: Grant	**Boring Date: December 3, 2004**	**Drilling Contractor: GEOSEARCH**
Investigation Area: IA-08	**Boring Method: 3-in SS**	**Driller: Ken Byland**
Boring ID: SB-04	**Drilling Method: 4¼-in. HSA**	**WESTON Geologist: J. Schmidl**
	Note: 140-lb hammer used to	**Client: USACE**
Total Depth (ft bgs): 10.0	advance the split spoons.	

Depth Interval	Penetration/ Recovery	WESTON Sample	Blow Count	Soil Classification	Lithologic Description	Soil Headspace (units >BKG)
0.50	2.0/1.6	GR-IA08-SB04-1 (0'-3')	11-10-25-24	SW-SM	0.0-0.2 ft. Dusky yellow brown (10YR 2/2), well graded Gravelly Silty f-c SAND, moist, cohesive. TOPSOIL	0.0
1.0					0.2-1.0 ft: Yellow brown (10YR 6/4), well graded, Gravelly m-c SAND, wet, loose. FILL	
1.5				SP-SM	1.0-1.6 ft: Yellow brown (10YR 5/4), well graded, Gravelly Silty f. SAND, moist, cohesive. FILL	
2.0						
2.5	2.0/1.2		15-13-9-11	SP-SM	Yellow brown (10YR 5/4), well graded, Gravelly Silty f. SAND, moist, cohesive. FILL	0.0
3.0						
3.5						
4.0						
4.5	2.0/1.7	GR-IA08-SB04-1 (3'-10')	10-9-9-10	SW	Pale yellow brown (10YR 6/2), Gravelly f-m SAND, moist, loose. OUTWASH (Kame)	0.0
5.0						
5.5						
6.0						
6.5	2.0/1.4		8-10-9-12	SW	Pale yellow brown (10YR 6/2), Gravelly f-m SAND, moist, loose. OUTWASH (Kame)	0.0
7.0						
7.5						
8.0						
8.5	2.0/1.3		9-15-24-35	SW	8.0-8.5 ft: Pale yellow brown (10YR 6/2), Gravelly f-m SAND, moist, loose. OUTWASH (Kame)	0.0
9.0						
9.5				SW	8.5-9.3 ft: Pale olive gray (5Y 5/2), Gravelly f-c SAND, moist, loose. OUTWASH (Kame)	
10.0						
10.5					End of Boring.	
11.0						
11.5						
12.0						
12.5						
13.0						
13.5						
14.0						
14.5						
15.0						
15.0						
15.0						

SOIL BORING/WELL CONSTRUCTION LOG

Site: Devens SSI	**Boring/Well ID: SB-05**	**Sampling Method: 3-inch SS**
Investigation Area: IA-08	**Drilling Company: EDI**	**Surface Elevation:**
Weston Geologist: J. Schmidl	**Driller: Ken Byland**	**Total Depth: 43.0 ft bgs**
Date: 12/5-6/2004	**Boring Method: 4¼-inch HSA**	**Water Level:**

Depth (ft bgs)	Sample Interval	Analytical Samples	Sample Type	Pen/ Rec	Blow Count	Soil Classification	Lithologic Description	NAPL Show/ Oil/Sheen	Soil Headspace (units>BKG)
1	0-2	GR-IA08-SS05-1	SS	2.0/1.2	10-11-9-13	SP-SM	0.0-0.2 ft: Dusky yellow brown (10YR 2/2) Sandy SILT, with roots, wet, cohesive. 0.2-1.2 ft: Olive brown (5Y 5/1), well graded, Gravelly Silty f. SAND, moist, slightly cohesive. FILL	None	0.0
2									
3	2-4		SS	2.0/0.1	9-7-7-8	SP-SM	Olive brown (5Y 5/1), well graded, Gravelly Silty f. SAND, moist, slightly cohesive. FILL	None	0.0
4									
5	4-6	GR-IA08-SB05-1	SS	2.0/1.3	11-18-30-34	SP-SM SW-SM	4.0-4.3 ft: Olive brown (5Y 5/1), well graded, Gravelly Silty f. SAND, moist, slightly cohesive. FILL 4.3-5.3 ft: Dark yellow brown (10YR 4/4) Gravelly Silty SAND, moist, loose. OUTWASH (Kame)	None	0.0
6									
7	6-8		SS	2.0/1.6	33-23-26-29	SW-SM	Dark yellow brown (10YR 4/4) Gravelly Silty SAND, moist, loose. OUTWASH (Kame)	None	0.0
8									
9	8-10		SS	0.9/0.8	35-120/4"	SW-SM	Yellow brown (10YR 5/2), well graded, Gravelly Silty f. SAND, moist, slightly cohesive. OUTWASH (Kame)	None	0.0
10									
11	10-12		SS	0.8/0.8	33-120/5"	GM	Light Olive gray (5Y 5/2), Silty GRAVEL, dry, loose. OUTWASH (Kame)	None	0.0
12									
13	12-14		SS	0.8/0.9	20-120/3"	GM	Light Olive gray (5Y 5/2), well graded, Silty GRAVEL, dry, loose. OUTWASH (Kame)	None	0.0
14									
15	14-16		SS	2.0/1.4	30-74-54-56	SP	Light yellow brown (10YR 5/2), poorly graded, interbedded, Gravelly m-c SAND and Gravelly f. SAND moist, loose. OUTWASH (Esker)	None	0.0
16									
17	16-18		SS	2.0/1.5	39-50-55-69	SP	Light Olive gray (5Y 5/2), poorly graded, Gravelly SAND, moist to 17 ft bgs, wet below, loose. OUTWASH (Esker)	None	0.0
18									
19	18-20		SS	0.8/0.5	45-120/3"	SP	Light Olive gray (5Y 5/2), poorly graded, Gravelly SAND, moist, loose. OUTWASH (Esker)	None	0.0
20									
21	20-22		SS	1.3/0.9	50-120-120/3"	SP	Light Olive gray (5Y 5/2), poorly graded, Gravelly SAND, wet, loose. OUTWASH (Esker)	None	0.0
22									
23	22-24		SS	0.4/0.1	120/5"	GW	Gray (N4) shale GRAVEL.	None	0.0
24									
25	24-26		SS	0.9/0.5	30-120/5"	SW	Light Olive gray (5Y 5/3), well graded, Gravelly SAND, moist, slightly cohesive. OUTWASH (Kame)	None	0.0
26									
27	26-28		SS	1.3/1.0	60-60-120/4"	GM	Olive brown (5Y 5/4), well graded, Gravelly SILT, wet, cohesive. ABLATION TILL	None	
28									
29	28-30		SS	2.0/1.3	62-88-45-31	GM	Olive gray (5Y 5/3), well graded, Gravelly SILT, moist, cohesive. ABLATION TILL	None	0.0
30									

Sample Type:

SOIL BORING/WELL CONSTRUCTION LOG

Site: Devens SSI	**Boring/Well ID: SB-05**	**Sampling Method: 3-inch SS**
Investigation Area: IA-08	**Drilling Company: EDI**	**Surface Elevation:**
Weston Geologist: J. Schmidl	**Driller: Ken Byland**	**Total Depth: 43.0 ft bgs**
Date: 12/5-6/2004	**Boring Method: 4¼-inch HSA**	**Water Level:**

Depth (ft bgs)	Sample Interval	Analytical Samples	Sample Type	Pen/ Rec		Soil Classification	Lithologic Description	NAPL Show/ Oil/Sheen	Soil Headspace (units>BKG)
31	30-32		SS	0.9/0.7	35-120/5"	GM	Olive gray (5Y 5/3), well graded, Gravelly SILT, moist, cohesive. ABLATION TILL	None	0.0
32									
33	32-34		SS	2.0/1.7	69-110-70-55	GM	Olive gray (5Y 5/3), well graded, Gravelly SILT, moist, cohesive. ABLATION TILL	None	0.0
34									
35	34-36		SS	2.0/1.3	24-30-40-35	GM	Olive brown (5Y 5/4), well graded, Silty GRAVEL, saturated, cohesive. ABLATION TILL	None	0.0
36									
37	36-38		SS	0.7/0.4	69-120/2"	GM	Olive brown (5Y 5/4), well graded, Silty GRAVEL, saturated, cohesive. ABLATION TILL	None	0.0
38									
39	38-40		SS	0.2/0.0	120/2"	GM	No recovery.	None	
40									
41	40-42		SS	0.8/0.4	60-120/4"	GM	Olive brown (5Y 5/4), well graded, Sandy Silty Gravel, saturated, cohesive. ABLATION TILL	None	0.0
42									
43	42-44		SS	0.1/0.1	120/1"		Dark gray (N4) schist GRAVEL. Augered 1 ft into bedrock to confirm.	None	0.0
44									
45	44-46						End of Boring.		
46									
47	46-48								
48									
49	48-50								
50									
51	50-52								
52									
53	52-54								
54									
55	54-56								
56									
57	56-58								
58									
59	58-60								
60									

SOIL BORING LOG

Area: Grant	**Boring Date: 12/9/2004**	**Drilling Contractor: EDI**
Investigation Area: IA-8	**Boring Method: 3-in SS**	**Driller: Ken Byland**
Boring ID: SB-6	**Drilling Method: 4¼-in. HSA**	**WESTON Geologist: J. Schmidl**
	Note: 140-lb hammer used to advance the split-spoons.	**Client: USACOE**
Total Depth (ft bgs): 10.0		

Depth Interval	Penetration/ Recovery	WESTON Sample	Blow Count	Soil Classification	Lithologic Description	Soil Headspace (units >BKG)
0.50 1.0 1.5 2.0	2.0/1.2	GR-IA08-SB06-1 (0'-3')	14-19-25-29	ML	0.0-0.3 ft: Dusky yellow brown (10YR 2/2), poorly graded Silt with roots, moist, cohesive. 0.3-1.2 ft: Dark yellow brown (10YR 5/3), well graded, Gravelly SAND, moist, loose. FILL	17.8
2.5 3.0 3.5 4.0	2.0/1.0		31-20-15-15	SW	Dark yellow brown (10YR 5/3), well graded, Gravelly SAND, moist, loose. FILL	2.4
4.5 5.0 5.5 6.0	2.0/0.7	GR-IA08-SB06-1 (3'-10')	45-80-93-80	SW-SM	Light olive gray (5Y 6/2) well graded Gravelly Silty SAND, moist, cohesive. OUTWASH	1.7
6.5 7.0 7.5 8.0	2.0/1.3		45-24-31-26	SW-SM SW	6.0-6.6 ft: Light olive gray (5Y 6/2) well graded Gravelly Silty SAND, moist, cohesive. 6.6-7.3 ft: Light olive gray (5Y 6/2) well graded Gravelly SAND, moist, loose. OUTWASH (Esker)	0.6
8.5 9.0 9.5 10.0	0.7/0.8		65-120/2"	SW-SM	Light olive gray (5Y 6/2) well graded Gravelly Silty SAND, dry, loose. OUTWASH (Kame)	0.8
10.5 11.0 11.5 12.0 12.5 13.0 13.5 14.0 14.5 15.0 15.0 15.0					End of Boring.	

SOIL BORING LOG

Area: Grant	**Boring Date: 12/6/2004**	**Drilling Contractor: EDI**
Investigation Area: IA-8	**Boring Method: 3-in SS**	**Driller: Ken Byland**
Boring ID: SB-7	**Drilling Method: 4¼-in. HSA**	**WESTON Geologist: J. Schmidl**
	Note: 140-lb hammer used to advance the split-spoons.	**Client: USACOE**
Total Depth (ft bgs): 10.0		

Depth Interval	Penetration/ Recovery	WESTON Sample	Blow Count	Soil Classification	Lithologic Description	Soil Headspace (units >BKG)
0.50 1.0 1.5 2.0	2.0/1.9	GR-IA08-SB07-1 (0'-3')	15-16-20-33	SP	Olive brown (5Y 5/4), poorly graded Gravelly f. SAND, moist, slightly cohesive. FILL	0.0
2.5 3.0 3.5 4.0	2.0/1.5		35-40-25-30	SW	Dark yellow brown (10YR 6/6), Gravelly f-m SAND, moist, loose. FILL	0.0
4.5 5.0 5.5 6.0	2.0/1.4	GR-IA08-SB07-1 (3'-10')	25-30-17-15	SW	Dark yellow brown (10YR 7/6), Gravelly f-m SAND, moist, loose. FILL	0.0
6.5 7.0 7.5 8.0	2.0/0.0		45-52-55-45		No recovery due to cobble.	0.0
8.5 9.0 9.5 10.0	2.0/0.1		33-52-45-33	SP-SM	Yellow brown (10YR 4/4), well graded, Gravelly Silty f. SAND, moist, loose. FILL	0.0
10.5 11.0 11.5 12.0 12.5 13.0 13.5 14.0 14.5 15.0 15.0 15.0					End of Boring.	

Soil Boring Log

Area: Grant	**Boring Date: December 13, 2004**	**Drilling Contractor: Geosearch**
Investigation Area: IA-10	**Boring Method: 3-in SS**	**Driller: Joe Keenan**
Boring ID: SB-01	**Drilling Method: 4¼-in. HSA**	**WESTON Geologist: A. Klappholz**
	Note: 140lb hammer used to	**Client: USACE**
Total Depth (ft bgs): 10.0	**advance the split spoons.**	

Depth Interval	Penetration/ Recovery	WESTON Sample	Blow Count	Soil Classification	Lithologic Description	Soil Headspace
0.50 1.0 1.5 2.0	2.0/2	GR-IA10-SB01-1 (0'-3')	5-9-14-15	SM SM	0.0-1.1 ft. Brown (7.5YR 5/4) Silty Gravelly m-f subangular SAND, dry, very dense. FILL 1.1-2.0 ft. Yellowish Brown (10YR 5/4) Silty Gravelly m-f subangular SAND, dry, very dense. FILL	0.0
2.5 3.0 3.5 4.0	2.0/1.2		10-10-13-14	SW	Light Olive Brown (2.5Y 5/4) well graded Gravelly c-f subangular-subrounded SAND, dry, loose. OUTWASH (Kame)	4.6
4.5 5.0 5.5 6.0	2.0/1.9	GR-IA10-SB01-1 (3'-10')	15-17-21-19	SW	Light Olive Brown (2.5Y 5/4) well graded Gravelly c-f subangular-subrounded SAND, dry, loose. OUTWASH (Kame)	7.7
6.5 7.0 7.5 8.0	2.0/1.8		14-14-15-14	SW	Light Yellowish Brown (2.5Y 6/3) well graded Gravelly c-f subangular-subrounded SAND, dry, loose. OUTWASH (Kame)	7.6
8.5 9.0 9.5 10.0	2.0/1.8		15-15-16-15	SW SW	8.0-9.1 ft. Light Yellowish Brown (2.5YR 6/3) well graded Gravelly c-f subangular-subrounded SAND, dry, loose. OUTWASH (Kame) 9.1-9.8 ft. Light Yellowish Brown (2.5YR 6/3) well graded c-f subangular SAND, dry, loose. OUTWASH (Kame)	4.0
10.5 11.0 11.5 12.0 12.5 13.0 13.5 14.0 14.5 15.0 15.0 15.0						

SOIL BORING LOG

Area: Grant	**Boring Date: December 10, 2004**	**Drilling Contractor: GEOSEARCH**
Investigation Area: IA-10	**Boring Method: 3-in SS**	**Driller: Ken Byland**
Boring ID: SB-02	**Drilling Method: 4¼-in. HSA**	**WESTON Geologist: J. Schmidl**
	Note: 140-lb hammer used to	**Client: USACE**
Total Depth (ft bgs): 10.0	**advance the split spoons.**	

Depth Interval	Penetration/ Recovery	WESTON Sample	Blow Count	Soil Classification	Lithologic Description	Soil Headspace
0.50 1.0 1.5 2.0	2.0/1.5	GR-IA10-SB02-1 (0'-3')	6-8-11-11	SM	Olive Gray (5Y 4/2) Silty Gravelly f SAND, moist, cohesive. OUTWASH (Kame)	0.0
2.5 3.0 3.5 4.0	2.0/0.9		25-25-35-38	SM	Olive Gray (5Y 4/2) Silty Gravelley fine SAND, moist, cohesive. OUTWASH (Kame)	0.0
4.5 5.0 5.5 6.0	20./1.3	GR-IA10-SB02-1 (3'-10') GR-IA10-SB02-1-D (3'-10')	45-88-75-89	SP	Olive Gray (5Y 4/2) Gravelly Silty fine SAND, moist, cohesive. OUTWASH (Kame)	0.0
6.5 7.0 7.5 8.0	0.9/0.0		75-120/5"		No recovery.	0.0
8.5 9.0 9.5 10.0	0.9/0.5		95-120/5"	SP	Olive (5Y 4/3) Gravelly Silty fine SAND, moist, cohesive. ABLATION TILL	0.0
10.5 11.0 11.5 12.0						
12.5 13.0 13.5 14.0						
14.5 15.0 15.0 15.0						

SOIL BORING LOG

Area: Grant	**Boring Date: December 15, 2004**	**Drilling Contractor: GEOSEARCH**
Investigation Area: IA-10	**Boring Method: 3-in SS**	**Driller: Ken Byland**
Boring ID: SB-03	**Drilling Method: 4¼-in. HSA**	**WESTON Geologist: J. Schmidl**
	Note: 140-lb hammer used to	**Client: USACE**
Total Depth (ft bgs): 10.0	**advance the split spoons.**	

Depth Interval	Penetration/ Recovery	WESTON Sample	Blow Count	Soil Classification	Lithologic Description	Soil Headspace (units >BKG)
0.50 1.0 1.5 2.0	2.0/1.5	GR-IA10-SB03-1 (0'-3')	5-8-11-15	SW	0-0.5 ft. Dusky yellow brown (10YR 2/2), well graded Gravelly Silty SAND, moist, cohesive. TOPSOIL 0.5-1.5 ft: Yellow brown (10YR 5/4), well graded, Gravelly Silty f. SAND, moist, cohesive. OUTWASH (Kame)	0.5
2.5 3.0 3.5 4.0	2.0/1.1		22-18-17-18	SW	Yellow brown (10YR 5/4), well graded, Gravelly Silty f. SAND, moist, cohesive. OUTWASH (Kame)	0.8
4.5 5.0 5.5 6.0	2.0/1.5	GR-IA10-SB03-1 (3'-10')	13-16-18-20	SW	Yellow brown (10YR 5/4), well graded, Gravelly Silty f. SAND, moist, cohesive. OUTWASH (Kame)	1.0
6.5 7.0 7.5 8.0	2.0/1.4		18-20-19-23	SW	Yellow brown (10YR 5/4), well graded, Gravelly Silty f. SAND, moist, cohesive. OUTWASH (Kame)	0.2
8.5 9.0 9.5 10.0	2.0/1.3		6-8-12-15	SW	Pale yellow brown (10YR 6/3), poorly graded, Gravelly f-m SAND, moist, loose. OUTWASH (Kame)	0.6
10.5 11.0 11.5 12.0					End of Boring.	
12.5 13.0 13.5 14.0						
14.5 15.0 15.0 15.0						

SOIL BORING LOG

Area: Grant	**Boring Date: December 16, 2004**	**Drilling Contractor: GEOSEARCH**
Investigation Area: IA-10	**Boring Method: 3-in SS**	**Driller: Ken Byland**
Boring ID: SB-04	**Drilling Method: 4¼-in. HSA**	**WESTON Geologist: J. Schmidl**
	Note: 140-lb hammer used to	**Client: USACE**
Total Depth (ft bgs): 10.0	**advance the split spoons.**	

Depth Interval	Penetration/ Recovery	WESTON Sample	Blow Count	Soil Classification	Lithologic Description	Soil Headspace (units >BKG)
0.50 1.0 1.5 2.0	2.0/1.6	GR-IA10-SB04-1 (0'-3')	5-3-3-4	SP	0.0-0.6 ft. Dusky yellow brown (5YR 2/2), poorly graded Sandy SILT, with roots, moist, cohesive. TOPSOIL 0.6-1.3 ft: Yellow brown (10YR 5/4), poorly graded, Gravelly f. SAND, with roots, moist, slightly cohesive. OUTWASH (Esker)	2.5
2.5 3.0 3.5 4.0	2.0/1.1		22-18-17-18	SP	2.0-3.1 ft: Yellow brown (10YR 5/4), poorly graded, Gravelly f. SAND, with roots, moist, slightly cohesive. OUTWASH (Esker) 3.1-3.6 ft: Light yellow brown (10YR 6/4), poorly graded, Gravelly f-m SAND, moist, slightly cohesive. OUTWASH (Esker)	0.0
4.5 5.0 5.5 6.0	2.0/1.1	GR-IA10-SB04-1 (3'-10')	7-17-17-17	SP	Light yellow brown (10YR 6/4), poorly graded, Gravelly f-m SAND, moist, slightly cohesive. OUTWASH (Esker)	1.5
6.5 7.0 7.5 8.0	2.0/1.3		22-23-33-34	SP	Light yellow brown (10YR 6/4), poorly graded, Gravelly f SAND, dry, loose. OUTWASH (Esker)	1.6
8.5 9.0 9.5 10.0	2.0/1.5		15-20-25-35	SW	Light yellow brown (10YR 6/4), poorly graded, Gravelly f SAND, dry, loose. OUTWASH (Esker)	0.8
10.5 11.0 11.5 12.0					End of Boring.	
12.5 13.0 13.5 14.0						
14.5 15.0 15.0 15.0						

Soil Boring Log

Area: Locust	**Boring Date: November 29, 2004**	**Drilling Contractor: Geosearch**
Investigation Area: IA-11	**Boring Method: 3-in SS**	**Driller: Joe Keenan**
Boring ID: SB-01	**Drilling Method: 4¼-in. HSA**	**WESTON Geologist: A. Klappholz**
	Note: 140lb hammer used to	**Client: USACE**
Total Depth (ft bgs): 10.0	**advance the split spoons.**	

Depth Interval	Penetration/ Recovery	WESTON Sample	Blow Count	Soil Classification	Lithologic Description	Soil Headspace
0.50	2.0/1.6	LO-IA11-SB01-1 (0'-3')	8-6-12-13	SM	0.0-0.4 ft. Dark Brown (7.5YR 3/4) Silty m-f subangular SAND and organics, moist, loose. LOAM	40
1.0				SM	0.4-1.6 ft. Brown (7.5YR 4/3) Silty Gravelly well graded c-f SAND, dry, loose. FILL	
1.5						
2.0						
2.5	2.0/2.0		8-19-14-14	ML	2.0-3.0 ft. Strong Brown (7.5YR 5/8) Sandy Gravelly nonplastic SILT, moist, soft-firm, swampish odor identified. FILL	
3.0						
3.5		LO-IA11-SB01-1 (3'-10')		SM	3.0-4.0 ft. Strong Brown (7.5YR 5/8) Silty c-f subangular SAND, dry, compact. FILL	0.0
4.0						
4.5	2.0/1.6		10-10-10-10	SM	Yellowish Brown (10YR 5/4) Silty m-f subangular SAND, loose-compact, dry. OUTWASH (Kame)	
5.0						
5.5						
6.0						
6.5	2.0/1.75		10-8-10-10	SM	Yellowish Brown (10YR 5/4) Silty m-f subangular SAND, loose, dry. OUTWASH (Kame)	
7.0						
7.5						
8.0						
8.5	2.0/1.6		10-12-11-10	SM	8.0-9.1 ft. Yellowish Brown (10YR 5/4) Silty c-f subangular SAND, loose, dry. OUTWASH (Kame)	
9.0						
9.5				SP	9.1-9.6 Yellowish Brown (10YR 5/4) poorly graded Silty fine subangular SAND, dry, loose. OUTWASH (Kame)	
10.0						
10.5						
11.0						
11.5						
12.0						
12.5						
13.0						
13.5						
14.0						
14.5						
15.0						
15.0						
15.0						

Soil Boring Log

Area: Locust	**Boring Date: December 15, 2004**	**Drilling Contractor: Geosearch**
Investigation Area: IA-11	**Boring Method: 3-in SS**	**Driller: Jason Jalutkewicz**
Boring ID: SB-02	**Drilling Method: 4¼-in. HSA**	**WESTON Geologist: A. Klappholz**
	Note: 140lb hammer used to	**Client: USACE**
Total Depth (ft bgs): 10.0	**advance the split spoons.**	

Depth Interval	Penetration/ Recovery	WESTON Sample	Blow Count	Soil Classification	Lithologic Description	Soil Headspace
0.50 1.0 1.5 2.0	2.0/1.1	LO-IA11-SB02-1 (0'-3')	9-12-15-120/1"	SM SM	0-0.4 ft. Black (10YR 2/1) Silty m-f subangular SAND, trace organics, dry loose. LOAM 0.4-1.1 ft. Light Olive Brown (2.5Y 5/3) Silty Gravelly fine SAND, dry, dense. FILL	1.2
2.5 3.0 3.5 4.0	2.0/1.0		18-25-32-38	SM	Light Olive Brown (2.5YR 5/3) Silty Gravelly fine SAND, dry, dense. FILL	2.4
4.5 5.0 5.5 6.0	2.0/1.8	LO-IA11-SB02-1 (3'-10')	10-11-10-10	SM SP	4 -4.8 ft. Light Olive Brown (2.5Y 5/3) Silty Gravelly fine SAND, dry, dense. FILL 4.8- 5.8 ft. Light Reddish Brown (2.5Y 7/4) Silty m-f subangular SAND, dry, loose. OUTWASH (Kame)	2.4
6.5 7.0 7.5 8.0	2.0/1.8		11-11-9-10	SP SP SP	6-6.3 ft. Light Reddish Brown (2.5Y 7/4) Silty m-f subangular SAND, dry, loose. OUTWASH (Kame) 6.3-6.6 ft. Yellowish Brown (10YR 5/8) Silty m-f subangular SAND, dry, loose. OUTWASH (Kame) 6.6-7.8 ft. Pale Yellow (2.5Y 7/4) Silty Gravelly m-f subangular SAND, dry, loose. OUTWASH (Kame)	1.8
8.5 9.0 9.5 10.0	2.0/1.9		8-9-9-11	SP SP	8.0-9.6 ft. Light Yellowish Brown (2..5YR 6/4) Silty c-f subangular SAND, dry, loose. OUTWASH (Kame) 9.6-9.9 ft. Pale Yellow (2.5Y 7/3) Silty fine SAND, dry, loose. OUTWASH (Kame)	1.2
10.5 11.0 11.5 12.0 12.5 13.0 13.5 14.0 14.5 15.0 15.0 15.0						

APPENDIX C

ARSENIC CONCENTRATION STATISTICAL ANALYSIS

U.S. Army Corps of Engineers

New England District
Concord, Massachusetts

STUDY AREAS - GRANT, LOCUST, AND CAVITE HOUSING AREAS FORMER FORT DEVENS ARMY INSTALLATION DEVENS, MASSACHUSETTS

Contract No. DACA31-00-D-0023
Task Order No. 0046

INTERNAL DRAFT ARSENIC BACKGROUND STATISTICAL ANALYSIS

JUNE 2005

01M-0007

WESTON SOLUTIONS

INTERNAL DRAFT

ARSENIC BACKGROUND STATISTICAL ANALYSIS
STUDY AREA – GRANT, LOCUST, AND CAVITE HOUSING AREAS
FORMER FORT DEVENS ARMY INSTALLATION
DEVENS, MASSACHUSETTS

Contract No. DACA31-00-D-0023
Delivery Order No. 0046

Prepared for:

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June 2005

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LIST OF ACRONYMS

A-D	Anderson-Darling
BW	Base-wide
CENAE	U.S. Army Corps of Engineers, New England District
K-S	Kolmogorov-Smirnov
mg/kg	milligrams per kilogram
SA	Study Area
PASI	Preliminary Assessment Site Inspection
SEK	Standard erros for kurtosis
SES	Standard errors for skewness
SSI data set	Supplemental Site Investigations Data Set
S-W	Shapiro-Wilks
WESTON®	Weston Solutions, Inc.
WRS	Wilcoxon Rank Sum

1. STATISTICAL ANALYSIS

A detailed statistical analysis was performed on arsenic concentrations derived from four recent data sets associated with the this Study Area (SA) within the former Fort Devens in order to ascertain if apparent elevated arsenic concentrations were naturally occurring or anthropogenic in origin. The data sets included the Base-wide (BW) background data set derived by the U.S. Army Corps of Engineers, New England District (CENAE, 2003b) and three data subsets from the SA.

The analysis utilized the comparison of the central tendencies of the arsenic data (rather than the use of extreme value statistics) that allowed for robust statistical comparison of various data set distributions. The use of central tendencies also facilitated the quantitative analysis of potential correlations between arsenic and other collocated metals. Despite initial statistical test results that indicated the arsenic data from the BW and SA data sets were from two different populations, a closer inspection of the relationship between arsenic and other naturally occurring collocated metals determined that no difference could be resolved between the arsenic concentrations in the BW and SA data sets. Consequently, the SA data set is presumed to represent naturally occurring arsenic within this SA at the former Fort Devens.

1.1 OVERVIEW

The SA data sets used in this analysis included data collected by Nobis Engineering (Nobis T4 data set), data collected by Weston Solutions, Inc. (WESTON®) during initial Preliminary Assessment Site Inspection (PASI) investigations (Random data set) and data collected by WESTON during recent Supplemental Site Investigations (SSI data set). Each data set also included paired concentration data for iron, and nickel.

The sequential analysis of the arsenic data was developed to conclusively identify any samples with elevated arsenic concentrations that might be attributed to a potential anthropogenic source within the SA. Initial first order comparisons of the SA and BW data sets indicated that the SA data set is elevated compared with the BW data set. Normally this would indicate that an anthropogenic source of arsenic is likely present. However, anecdotal evidence suggested that

the elevated arsenic concentrations in the SA may be naturally occurring and related to elevated concentrations of arsenic in local bedrock.

In an attempt to ascertain if the distribution of the ratio of arsenic to other collocated naturally occurring metals (e.g., iron and nickel) in the SA data set is distinguishable from the arsenic ratios in the BW data set, the arsenic concentrations from each sample for both the SA and the BW were normalized (e.g., standardized) against that sample's iron and nickel concentrations. The resulting population testing (with no outliers excluded) for the normalized SA and BW data sets indicated that these data sets can not be distinguished from each other and that a potential anthropogenic source for arsenic was not identified.

The sequential analyses for the arsenic data sets included:

- Descriptive statistics for each data subset.
- Determination of appropriate distribution functions for each data set.
- Testing of the BW and individual SA data subsets to determine if data sets can be combined.
- Derivation of prediction limits for the BW data set.
- Normalization of arsenic concentration with iron and nickel.
- Population testing of the normalized BW and SA data sets.

1.2 SEQUENTIAL ANALYSIS APPROACH

1.2.1 Descriptive Statistics

Data sets were imported into Minitab v14.3 for data reduction and statistical analysis. Descriptive statistics were calculated for all data in each data set. The summaries are presented in Table A-1 located in Attachment A.

1.2.1.1 Identification of outliers – Histograms and Box and Whisker plots

Outliers were only excluded in some of the exploratory statistical analyses in an attempt to explore their effect on the data and to assess whether their origin was from natural variability or

systematic error. Conclusions for the investigation were based on data sets with no outliers excluded.

Outliers were identified using histograms and box and whisker plots (boxplots) rather than Rosner's Test, since the latter requires that the data be normally distributed (Attachment B-1). Potential outliers were excluded and boxplots regenerated to ensure that additional outliers did not result from modification of the data sets (Attachment B-2).

Descriptive statistics were recalculated for each data set with the outliers excluded. The summaries are presented in Table A-2 located in Attachment A.

1.2.1.2 Normality testing for each data subset

The Anderson-Darling (A-D) test for normality is independent of distribution type and has greater statistical power than other common normality tests. Following the exclusion of outliers, the A-D test was used to determine whether the untransformed and log-transformed data were distributed normally.

The null and alternate hypotheses utilized for this normality test were:

- **Null Hypothesis H_o** – Data Set is Normally Distributed (p-value ≥ 0.05)
- **Alternate Hypothesis H_a** – Data Set is not Normally Distributed (p-value < 0.05)

At the 95% confidence level (alpha = 0.05), associated *p*-values from the A-D test must be equal to or greater than 0.05 to meet the normality condition. The magnitude of any *p*-value greater than 0.05 is not used to evaluate the apparent 'goodness' of the determination; instead, a *p*-value greater than 0.05 only indicates retention of the null hypothesis (i.e., that the underlying data distribution is normal at this confidence interval).

The results of these calculations (Table 1) indicate that only after the data is log-transformed do three out of four of the data sets have normalized distributions. However, the SSI subset does not meet the normality condition, even when log-transformed data are used.

Table 1

Anderson-Darling Normality Evaluation Using Alpha=0.05

All Data Points Included

Analyte / *p*-Value	Background	Study Area		
	NobisT3	NobisT4	Random	SSI
Arsenic	<0.005	<0.005	<0.005	<0.005
Arsenic (*ln*)	0.278	0.278	0.492	<0.005

Note: Blue typeface indicates acceptable p-values

In an effort to normalize the data that failed the initial A-D tests (and to facilitate subsequent calculations), data sets were trimmed of pairs of high and low data points, boxplots regenerated to ensure that outliers were not created, and the trimmed data sets were tested for normality again using the same null and alternate hypotheses outlined above. Although these trimmed data points may not be detected as outliers, they could influence the normality determination by introducing skewness into the distributions.

To minimize attenuation of the original collections of data points, no data more than six data points (three high/three low) were trimmed. From the results of this analysis (Table 2) the "best fit" distribution function for each data set was identified (Table 3).

Table 2

Anderson-Darling Normality Evaluation Using Alpha=0.05

Outliers Excluded/Data Sets Trimmed

Analyte / *p*-Value	Background	Study Area		
	NobisT3	NobisT4	Random	SSI
Arsenic	--	--	--	--
Points excluded	0	1	2	4
Arsenic (*ln*)	0.278	0.455	0.873	--
Points excluded	0	1	2	6
Total data points collected	110	42	40	178

Notes: Blue typeface indicates acceptable p-values
Empty cells indicate that the associated data could not be normalized by excluding outliers or by trimming

Table 3

Data Set Distribution using Alpha=0.05

Outliers Excluded

Analyte	Background	Study Area		
	NobisT3	NobisT4	Random	SSI
Arsenic	lognormal	lognormal	lognormal	nonparametric

1.2.1.3 Comparison of Study Area data subsets

In order to determine whether the three subsets of SA data could be combined into a single data set, the Kruskal-Wallis statistical test was selected. This nonparametric test is used to make inferences about the equality of medians from multiple populations when the distributions have similar distribution functions and variances. Standard errors for skewness (SES) and kurtosis (SEK), along with the ratio of skewness and kurtosis to their respective standard errors, were calculated for each data subset. These results are tabulated in Table 4.

Table 4

Comparison of Distribution Functions (Untransformed Data)

Analyte	Parameter	Background	Study Area		
		NobisT3	NobisT4	Random	SSI
Arsenic	SES	0.234	0.383	0.397	0.186
	SEK	0.467	0.765	0.795	0.371
	Skewness/SES	2.8	3.8	3.3	1.3
	Kurtosis/SEK	-0.4	2.7	2.9	-1.5
	Variance	69.1	162.2	457.7	117.2

Notes: Red typeface indicates the value lies outside the range -2..2
SES – Standard Error of Skewness
SEK – Standard Error of Kurtosis
Variance – Variance of the median value

The data distribution for each subset was compared with one for the entire SA dataset. The null and alternate hypotheses for this test were:

- **Null Hypothesis H_o** – Data Set (x_o) ≤ Data Set (x_1) (p-value ≥ 0.05)
- **Alternate Hypothesis H_a** – Data Set (x_o) > Data Set (x_1) (p-value < 0.05)

This comparison was made both for the data set with outliers excluded and for the complete data set where no results were excluded. The data subset comparisons are presented in Table 5 and Table 6 indicate that the complete SA data set (pooled subsets; no outliers excluded) may be treated as a single population. Consequently, unless otherwise noted, all subsequent statistical tests included the entire SA data set (i.e., no outliers excluded).

Table 5

Kruskal-Wallis *p*-Values for Study Area Subsets using Alpha=0.05

Outliers Excluded

Area	Arsenic *p*-Value
Nobis T4 versus Random	0.367
Nobis T4 versus SSI	0.533
Random versus SSI	0.459
Pooled SA Sub-sets	0.603

Notes: Blue typeface indicates acceptable p-values

Table 6

Kruskal-Wallis *p*-Values for Study Area Subsets using Alpha=0.05

All Data Points Included

Area	Arsenic *p*-Value
Nobis T4 versus Random	0.498
Nobis T4 versus SSI	0.582
Random versus SSI	0.611
Pooled SA Sub-sets	0.735

Note: Blue typeface indicates acceptable p-values

1.2.2 Normality Testing for Background and Combined Study Area Data Subsets

Normality testing was performed on the log-transformed BW and SA (combined NobisT4, Random, and SSI) data sets, both with and without outliers determined previously.

- **Null Hypothesis H_o** – Data Set is Normally Distributed (p-value $\geq$ 0.05)
- **Alternate Hypothesis H_a** – Data Set is not Normally Distributed (p-value < 0.05)

Results from both the A-D and Kolmogorov-Smirnov (K-S) tests were evaluated. The A-D test is based on the K-S test, but is computation-intensive and provides more robust characterization of data points in the tails of the distribution.

Initially, tests for outliers were used to facilitate normality testing by evaluating the distributions for the individual data subsets. Following the approach described in Subsection 1.2.1.3, the complete SA-arsenic data set was evaluated for outliers; even after excluding outliers and iteratively trimming high/low data points the processed dataset could not be normalized. As shown in Table 5 and Table 6, excluding outliers does not change the acceptance conditions for the null hypotheses; i.e., the comparability of data subset medians is not changed (at the Alpha = 0.05 level) by the inclusion or exclusion of outliers.

The distribution functions and p-values, determined using the K-S test, for the BW and SA data groups (Table 7) indicate that while the null hypothesis is accepted for the BW data set, it is rejected for the SW data set. Consequently, for all subsequent calculations, the SA-arsenic data set was assumed to be represented by a nonparametric distribution, when applicable.

Table 7

Arsenic Data Set Distributions using Alpha=0.05

Test	Outliers Excluded		All Data Points Included	
	Background	Study Area	Background	Study Area
K-S Normality Test	--	nonparametric	lognormal	nonparametric
p-Value	--	<0.005	0.278	<0.005

Note: Blue typeface indicates acceptable p-values
No outliers were assigned for the BW data set

1.2.2.1 Skewness, Kurtosis, and Associated Parameters

Skewness, Kurtosis, associated standard errors of each, and ratios were calculated for the BW and SA datasets using untransformed and transformed data points, and are presented in Table 8. All data points collected were used to create this table.

Table 8

Comparison of Distribution Functions

Parameter	Background		Study Area	
	Arsenic	Arsenic (*ln*)	Arsenic	Arsenic (*ln*)
Skewness	0.65	-0.44	2.72	-0.23
Kurtosis	-0.21	-0.05	16.42	0.29
SES	0.23	0.23	0.15	0.15
SEK	0.47	0.47	0.30	0.30
Skewness/SES	2.8	-1.9	18	1.5
Kurtosis/SEK	0.45	0.11	55	0.97
Variance	69.0	0.258	176	0.292
Total Data Points	110		260	

Note: Red typeface indicates the value lies outside the range (-2..2)

1.2.2.2 Histograms and Boxplots

Histograms and boxplots were generated for each data set on untransformed and transformed data points, and are presented in Attachment C. All data points collected were used to create these figures.

1.2.2.3 Probability plots

Normal probability plots were generated for each data set on untransformed and transformed data points, and are presented in Attachment C. All data points collected were used to create these figures.

1.2.3 Testing the Combined BW and SA Data Sets

Several parameters must be considered when selecting the appropriate method for testing to see if the BW and SA data sets can be combined. These include:

- Distribution functions for the two data sets – The BW data distribution is lognormal while the SA data distribution is nonparametric.
- Variances of the two data sets – These are significantly different for the two data sets.

- Number of data points in each data set – The SA data set contains approximately 2.4-times more data points that the BW data set.
- Censored (non-detected) data points – Neither data set contained censored data.

Although the BW data distribution function is lognormal, the SA data set could not be transformed to a normal distribution – even when outliers were excluded and high/low data points trimmed. As a result, and considering that the SA data set contains approximately 2.4 times more data points as the BW data set, non-parametric hypothesis testing is the appropriate test strategy. The null and alternate hypotheses used to test if these two data sets could be combined are:

- **Null Hypothesis H_o** – SA Data Set ≤ BW Data Set (p-value ≥ 0.05)
- **Alternate Hypothesis H_a** – SA Data Set > BW Data Set (p-value < 0.05)

1.2.3.1 Satterthwaite Test

The Satterthwaite test does not have a requirement that variances be similar but does require that data sets have normal (or normalized) distribution functions. This criterion was not met for the SA data set.

1.2.3.2 Kruskal-Wallis Test

The K-W test is appropriate for comparing data sets whose distribution functions are of similar shape and with similar variances. Neither of these criteria is met for either the BW or SA data sets.

1.2.3.3 Wilcoxon Rank Sum Test

The Wilcoxon Rank Sum (WRS) test is a nonparametric technique used to detect differences in the medians of the data sets. A one-sample WRS test was applied to the SA data set, using the BW median value. Results from this test are listed in.

The resulting *p*-values (Table 9) indicate that H_o must be rejected and that the medians of the BW and SA data sets are statistically different.

Table 9

Wilcoxon Rank Sum Test using Alpha=0.05

Data Set	Median	Confidence Interval		Wilcoxon Statistic	P-Value
		Lower	Upper		
Background	16.0	15.5	18.9	--	--
Study Area (adjusted)	21.8	20.5	23.0	26469	0.00

1.2.4 Regression Analysis and Prediction Intervals

Since initial statistical comparisons of the BW and SA data set medians indicated that the two data sets were statistically different, regression analysis and the application of prediction limits were completed to better understand how these two data sets differed and to identify which specific data points might fall outside the anticipated predicted range for the arsenic population.

1.2.4.1 Background Data Set

Prediction limits were calculated for the lognormal BW data set using regression techniques. The confidence interval was set at 95% for each of the following regression analyses.

- Ln-Arsenic versus ln-Nickel
- Ln-Arsenic versus ln-Iron

Regression statistics are listed in Table 10, with graphical summaries shown in Attachment D.

Table 10

Regression Summary – Background Data Set

Statistic	Arsenic versus Iron	Arsenic versus Nickel
Slope	0.7614	0.9589
Intercept	4.194	0.6717
Coefficient of Variation (R^2)	56.8%	71.7%
Variance (S^2)	0.1125	0.0738

*Note: ln_Arsenic = intercept + slope * ln_Metal*

1.2.4.2 Study Area Data Set

Prediction limits for the next future observation were calculated for the lognormal SA data set using regression techniques. Although this data set did not meet the K-S requirement for normality, the absolute values of the ratios of skewness and kurtosis to their respective standard errors were each less than two. Results from this empirical 'rule of thumb' test are often used to assess whether the data distribution function of the measured values is not normal (i.e., the data can't be normally distributed if both the S/SES and K/SEK ratios exceed two). This, and inspection of the probability plots, suggests that the K-S test may be influenced by unimportant deviation from normality due to contributions from the data points in the tails of the SA distribution. Testing indicated that when several small data points (sample concentrations less that 9 milligrams per kilogram) were omitted, the data set yielded an acceptable K-S *p*-value. In order to facilitate the following specific statistical analyses, the log-transformed SA arsenic data are assumed to follow a normal distribution.

The confidence interval was set at 95% for each of the following regression analyses.

- Ln-Arsenic versus ln-Nickel
- Ln-Arsenic versus ln-Iron

Regression statistics are listed in Table 11, with graphical summaries shown in Attachment D.

Table 11

Regression Summary – Study Area Data Set

Statistic	Arsenic versus Iron	Arsenic versus Nickel
Slope	0.9117	0.7383
Intercept	-5.376	0.9546
Coefficient of Variation (R^2)	49.3%	66.8%
Variance (S^2)	0.1486	0.0975

*Note: ln_Arsenic = intercept + slope * ln_METAL*

1.2.4.3 Background versus Study Area Data Sets

Prediction intervals (limits; PL) and confidence intervals determined from regression analysis for the BW data set were applied to the SA data set in order to identify the data points from the SA set that fell outside the BW prediction intervals. The affected data points for the comparison of log-transformed arsenic versus iron SA data set are listed in Table 12. The affected data points for the comparison of log-transformed arsenic versus nickel SA data set are listed in Table 13. Graphs of the SA data sets overlaid on the corresponding BW-PL lines are included as Attachment D.

While the bulk of these affected data points fell above the upper BW prediction limit (i.e., more arsenic than the corresponding iron or nickel concentration would have predicted), several data points fell below the lower BW prediction limit (i.e., less arsenic than the corresponding iron or nickel concentration would have predicted). For nickel, which possessed a better correlation coefficient to arsenic than the corresponding iron concentrations, the number of affected points for the arsenic versus nickel was only just above the 95% confidence level for this prediction limit (i.e., 5.8%).

Table 12

Study Area Iron Data Points Exceeding the Background Prediction Intervals

Sub Set	Station Name	Field Sample I D	Arsenic (mg/kg)	Ln Arsenic	Iron (mg/kg)	Ln Iron
SSI	IA09-TP01-C3	CA-IA09-TP01-C3-1	70.0	4.248495	6800	8.824678
NobisT4	GRB-03-09X	GRB-03-09X (0-3)	68.0	4.219508	23000	10.04325
Random	GR-301	PASI-GR-GB-301-2	66.4	4.195697	18800	9.841612
Random	LO-301	PASI-LO-GB-301-1	58.9	4.075841	11800	9.375855
SSI	IA10-SB03	GR-IA10-SB03-1	58.0	4.060443	16000	9.680344
NobisT4	GRB-03-01X	GRB-03-01X (3-6)	52.0	3.951244	15000	9.615805
SSI	IA07-SB03	GR-IA07-SB03-1	52.0	3.951244	9500	9.159047
SSI	IA10-TP01-A3	GR-IA10-TP01-A3-1	52.0	3.951244	9200	9.126959
SSI	IA01-SB04	GR-IA01-SB04-1-M	46.0	3.828641	8300	9.024011
SSI	IA02-SB16	GR-IA02-SB16-1	45.0	3.806662	14000	9.546813
SSI	IA09-TP01-D3	CA-IA09-TP01-D3-1	41.0	3.713572	10000	9.21034

Table 12

Study Area Iron Data Points Exceeding the Background Prediction Intervals
(continued)

SSI	IA02-SB10	GR-IA02-SB10-1	40.0	3.688879	12000	9.392662
SSI	IA05-SB08	GR-IA05-SB08-1	38.0	3.637586	12000	9.392662
SSI	IA10-TP01-D3	GR-IA10-TP01-D3-1	38.0	3.637586	11000	9.305651
SSI	IA08-SB09	GR-IA08-SB09-1	36.0	3.583519	11000	9.305651
SSI	IA01-SB03	GR-IA01-SB03-1	35.0	3.555348	11000	9.305651
SSI	IA09-TP01-B2	CA-IA09-TP01-B2-1	35.0	3.555348	7300	8.89563
NobisT4	GRB-03-07X	GRB-03-07X (0-3)	34.0	3.526361	12000	9.392662
SSI	IA01-SB01	GR-IA01-SB01-1	34.0	3.526361	12000	9.392662
SSI	IA10-TP01-B3	GR-IA10-TP01-B3-1	34.0	3.526361	8900	9.093807
SSI	IA09-TP01-A3	CA-IA09-TP01-A3-1	34.0	3.526361	9300	9.13777
SSI	IA05-SS02	GR-IA05-SS02-1	33.0	3.496508	9200	9.126959
NobisT4	LOB-03-01X	LOB-03-01X (3-6)	23.0	3.135494	6100	8.716044
SSI	IA09-SB01	CA-IA09-SB01-1	20.0	2.995732	4700	8.455318
SSI	IA02-SS01	GR-IA02-SS01-1	18.0	2.890372	28000	10.23996
Random	CT-501	PASI-CT-GB-501-3	4.3	1.458615	4900	8.49699
SSI	IA09-TP01-C3	CA-IA09-TP01-C3-1	70.0	4.248495	6800	8.824678
NobisT4	GRB-03-09X	GRB-03-09X (0-3)	68.0	4.219508	23000	10.04325
Random	GR-301	PASI-GR-GB-301-2	66.4	4.195697	18800	9.841612
Random	LO-301	PASI-LO-GB-301-1	58.9	4.075841	11800	9.375855
SSI	IA10-SB03	GR-IA10-SB03-1	58.0	4.060443	16000	9.680344
NobisT4	GRB-03-01X	GRB-03-01X (3-6)	52.0	3.951244	15000	9.615805
SSI	IA07-SB03	GR-IA07-SB03-1	52.0	3.951244	9500	9.159047
SSI	IA10-TP01-A3	GR-IA10-TP01-A3-1	52.0	3.951244	9200	9.126959
SSI	IA01-SB04	GR-IA01-SB04-1-M	46.0	3.828641	8300	9.024011
SSI	IA02-SB16	GR-IA02-SB16-1	45.0	3.806662	14000	9.546813
SSI	IA09-TP01-D3	CA-IA09-TP01-D3-1	41.0	3.713572	10000	9.21034
SSI	IA02-SB10	GR-IA02-SB10-1	40.0	3.688879	12000	9.392662
SSI	IA05-SB08	GR-IA05-SB08-1	38.0	3.637586	12000	9.392662
Random	CT-502	PASI-CT-GB-502-2	130	4.867535	14000	9.546813

mg/kg = milligrams per kilogram

Table 13

Study Area Nickel Data Points Exceeding the Background Prediction Intervals

Sub Set	Station Name	Field Sample I D	Arsenic (mg/kg)	Ln Arsenic	Nickel (mg/kg)	Ln Nickel
SSI	IA09-TP01-C3	CA-IA09-TP01-C3-1	70.0	4.248495	7.3	1.987874
Random	GR-301	PASI-GR-GB-301-2	66.4	4.195697	33.3	3.505557
Random	LO-301	PASI-LO-GB-301-1	58.9	4.075841	22.1	3.095578
Random	CT-502	PASI-CT-GB-502-2	130	4.867535	24.0	3.178054
SSI	IA10-SB03	GR-IA10-SB03-1	58.0	4.060443	27.0	3.295837
SSI	IA07-SB03	GR-IA07-SB03-1	52.0	3.951244	22.0	3.091042
SSI	IA10-TP01-A3	GR-IA10-TP01-A3-1	52.0	3.951244	22.0	3.091042
SSI	IA01-SB04	GR-IA01-SB04-1-M	46.0	3.828641	16.0	2.772589
SSI	IA09-TP01-B2	CA-IA09-TP01-B2-1	35.0	3.555348	8.6	2.151762
SSI	IA09-TP01-A3	CA-IA09-TP01-A3-1	34.0	3.526361	12.0	2.484907
NobisT4	LOB-03-04X	LOB-03-04X (6-10)	22.0	3.091042	48.0	3.871201
SSI	IA09-SB01	CA-IA09-SB01-1	20.0	2.995732	5.2	1.648659
NobisT4	GRB-03-04X	GRB-03-04X (6-10)	18.0	2.890372	57.0	4.043051
NobisT4	LOB-03-04X	LOB-03-04X (3-6)	17.0	2.833213	31.0	3.433987
Random	CT-501	PASI-CT-GB-501-3	4.3	1.458615	4.8	1.568616

mg/kg = milligrams per kilogram

1.2.5 Normalization (Standardization) of Background and Study Area Data Points – All Data Points Included

While the high degree of correlation between the arsenic and other metals, nickel in particular, suggests that the elevated arsenic concentrations identified in the SA are naturally occurring, an additional level of statistical analysis was completed. This final level of investigation analyzed the ratio of arsenic concentrations to its collocated iron and nickel concentrations.

For each complete data set (i.e., no outliers excluded), the arsenic data point for each sample was divided by the collocated iron and nickel data point value to normalize (standardize) the arsenic concentration relative to each of the other two analytes. The natural logarithm was calculated for each standardized data point (ratio) and the resulting data sets tested for outliers and normality.

1.2.5.1 Identification of outliers – Box and Whisker plots

Outliers were identified using box and whisker plots (boxplots) rather than Rosner's Test, since the latter requires that the data be normally distributed. Potential outliers were not excluded for the test. Boxplots for each complete data set are included in Attachment E.

1.2.5.2 Normality testing

Normality testing was performed on the complete normalized BW and SA data. The null and alternate hypotheses utilized for this normality test were:

- **Null Hypothesis H_o** – Data Set is Normally Distributed (p-value $\geq$ 0.05)
- **Alternate Hypothesis H_a** – Data Set is not Normally Distributed (p-value < 0.05)

Results from the K-S and Shapiro-Wilks (S-W) tests were evaluated for the standardized log-transformed data (As/Fe and As/Ni) for both BW and SA data sets. The S-W test, which is similar to the D'Agostino-Pearson test, is specifically designed to detect departures from normality without requiring that the mean or variance of the hypothesized normal distribution be specified in advance. This test tends to be more powerful than the K-S test when the underlying distribution functions are normal. The results from these two tests for normality are shown in Table 14.

Table 14

Normality Testing for Standardized Background and Study Area Data Sets using Kolmogorov-Smirnov and Shapiro-Wilks Statistics

Data Set / p-Value	Ln (As/Fe)		Ln (As/Ni)	
	K-S	S-W	K-S	S-W
Background	0.114	0.031 (R = 0.986)	0.123	>0.100 (R = 0.993)
Study Area	0.131	<0.010 (R = 0.988)	<0.010	<0.010 (R = 0.950)

Note: Blue typeface indicates acceptable p-values for Alpha = 0.05

These results indicate acceptance of the null hypothesis for both test statistics (K-S and S-W) only for the arsenic-nickel data from the BW data set. However, both test statistics reject the null hypothesis for the log-transformed arsenic-nickel data from the SA data set. In addition, the test statistic results for the log-transformed arsenic-iron data do no indicate a clear finding for normality (i.e., the K-S statistic indicates acceptance of the null hypothesis while the K-S statistic rejects the null hypothesis) for either the BW or SA data sets. As a result, non-parametric statistical tests are the most appropriate means to test the BW and SA data sets.

1.2.5.3 Skewness, Kurtosis, and associated parameters

Skewness, Kurtosis, associated standard errors of each, and ratios were calculated for the BW and SA datasets using the ratios of the log-transformed data points, and are presented in Table15. All data points collected were used to create this table.

Table 15

Comparison of Distribution Functions – All Data Points Included

Parameter	Background		Study Area	
	Ln (As/Fe)	Ln (As/Ni)	Ln (As/Fe)	Ln (As/Ni)
Skewness	0.52	0.32	0.32	1.07
Kurtosis	1.00	-0.42	1.72	6.58
SES	0.2335	0.2335	0.1519	0.1519
SEK	0.4671	0.4671	0.3038	0.3038
Skewness/SES	2.23	1.37	2.11	7.04
Kurtosis/SEK	2.14	-0.90	5.66	21.6
Variance (S^2)	0.126	0.117	0.149	0.122
Total Data Points	110		260	

Note: Red typeface indicates the value lies outside the range (-2..2)

1.2.5.4 Probability Plots

Probability plots were generated for the standardized log-transformed data (As/Fe and As/Ni) for both BW and SA data sets. These plots are included in Attachment E.

1.2.5.5 Box and Whisker Plots

Boxplots were generated for each data set on the transformed data points. These plots are included in Attachment E. All points collected were used to create these figures.

1.2.6 Population Testing on Standardized Data Sets – All Data Points Included

Since the normality testing of the standardized data sets indicated parametric testing of the data sets was not appropriate, a two-sample T-test and associated tests for equal variances (F-test, Levene's test) were not performed. Given the data set distributions, a non-parametric, two-sample rank-sum testing (also called the Mann-Whitney test, or the two-sample Wilcoxon rank sum test) was used to detect differences in the medians of the log-transformed data sets and to evaluate the following hypotheses:

- **Null Hypothesis H_o** – SA Data Set median ≤ BW Data Set median (point estimate within or equal to the 95% confidence interval of the median)
- **Alternate Hypothesis H_a** – SA Data Set median> BW Data Set median (point estimate greater or less than the 95% confidence interval)

The equality of two population medians was performed, and the corresponding point estimate and confidence interval for each standardized data set was calculated. An assumption for the Mann-Whitney test is that the data are independent random samples from two populations that have the same shape and whose variances are equal.

Results from the Mann-Whitney test for both standardized, log-transformed data subsets indicate that the null hypothesis must be retained. The medians of the standardized data sets are not statistically different between the Background and Study Areas. Results from these tests are listed in Table 16.

Table 16

Mann-Whitney Test Results - Transformed

Ln (As / Fe)			Ln (As / Ni)		
W-statistic	**Point Estimate**	**95% CI**	**W-statistic**	**Point Estimate**	**95% CI**
14942	-0.2085	-0.2877 to -0.1323	15859	-0.1248	-0.1948 to -0.0544

Note: Blue typeface indicates the point estimate is within the 95% confidence interval of the test

1.3 SUMMARY

Despite initial statistical test results that indicated the arsenic data from the BW and SA data sets were from two different populations, a closer inspection of the relationship between arsenic and other naturally occurring collocated metals determined that no difference could be resolved between the arsenic concentrations in the BW and SA data sets. Consequently, the SA data set is presumed to represent naturally occurring arsenic within this SA at the former Fort Devens.

Although the BW data distribution was lognormal, the distributions of the data subsets for the SA subsets were varied (i.e., lognormal and nonparametric). The statistical testing on the arsenic subsets indicated that the SA data subsets could be pooled and compared to the BW data set. Based on first order statistical analyses, these two data sets appeared to be from two different populations, with the SA set populated by greater arsenic concentrations.

Regression analysis and the application of prediction limits were completed to better understand how the BW and SA data sets differed and to identify which specific data points might fall outside the anticipated predicted range for the arsenic population. The high degree of correlation between arsenic and nickel and the limited number of sample points that fell outside of the BW prediction limits suggested a naturally occurring source for all arsenic samples within the SA.

In order to confirm this conclusion, the arsenic concentrations in each data set were standardized against iron and nickel concentrations on a per-sample basis. The tests for normality performed on the complete log-transformed data sets indicated the need for non-parametric testing of the standardized data sets. The medians of the log-transformed, complete standardized data sets were tested for equality using the Mann-Whitney test. The results indicated that the null hypothesis must be retained; the standardized median arsenic-iron and arsenic-nickel concentrations in the BW and SA populations are not different at the 95% confidence level for the log-transformed data sets.

ATTACHMENT A

DESCRIPTIVE STATISTICS SUMMARIES FOR COMPLETE DATA SETS

Table A-1
Descriptive Statistics: Aluminum, Arsenic, Iron, Nickel – All Data Included

Variable	SubSet	Total Count	N	N*	Mean	SE Mean	SD	Variance	CV	Sum of Squares	Min.	Q1	Median	Q3	Max.	Range	IQR	Skewness	SES	S/SES	Kurtosis	SEK	K/SEK
Aluminum	NobisT3	110	110	0	6313	252	2638	6959653	41.79	5142160000	1700	4000	6100	8325	13000	11300	4325	0.27	0.234	1.2	-0.73	0.467	-1.6
	NobisT4	42	42	0	6802	449	2909	8464141	42.77	2290470000	2000	4200	7250	8675	13000	11000	4475	0.17	0.378	0.4	-0.66	0.756	-0.9
	Random	40	40	0	8274	394	2493	6216485	30.14	2980475000	3900	6353	8045	9950	14800	10900	3598	0.33	0.387	0.9	-0.03	0.775	0.0
	SSI	178	178	0	7037	201	2686	7213533	38.17	10091440000	2000	5200	6800	8525	16000	14000	3325	0.50	0.184	2.7	0.44	0.367	1.2
Aluminum (*ln*)	NobisT3	110	110	0	8.6517	0.0445	0.4668	0.2179	5.40	8257.4732	7.4384	8.2940	8.7160	9.0270	9.4727	2.0343	0.7330	-0.53	0.234	-2.3	-0.41	0.467	-0.9
	NobisT4	42	42	0	8.7185	0.0763	0.4944	0.2444	5.67	3202.5607	7.6009	8.3428	8.8887	9.0676	9.4727	1.8718	0.7248	-0.65	0.378	-1.7	-0.44	0.756	-0.6
	Random	40	40	0	8.9739	0.0502	0.3175	0.1008	3.54	3225.1666	8.2687	8.7558	8.9927	9.2053	9.6024	1.3337	0.4495	-0.43	0.387	-1.1	-0.19	0.775	-0.2
	SSI	178	178	0	8.7782	0.0317	0.4229	0.1789	4.82	13747.9195	7.6009	8.5564	8.8247	9.0507	9.6803	2.0794	0.4943	-0.72	0.184	-3.9	0.49	0.367	1.3
Arsenic	NobisT3	110	110	0	17.609	0.792	8.311	69.078	47.20	41638.260	3.800	11.000	16.000	23.000	38.000	34.200	12.000	0.65	0.234	2.8	-0.21	0.467	-0.4
	NobisT4	42	42	0	22.80	1.97	12.74	162.18	55.85	28487.29	7.70	14.75	19.50	26.25	68.00	60.30	11.50	1.79	0.378	4.7	3.51	0.756	4.6
	Random	40	40	0	26.45	3.38	21.39	457.74	80.90	45830.73	4.30	15.00	20.90	32.20	130.00	125.70	17.20	3.21	0.387	8.3	13.86	0.775	17.9
	SSI	178	178	0	22.362	0.812	10.827	117.224	48.42	109762.090	4.900	13.750	22.000	28.000	70.000	65.100	14.250	0.91	0.184	5.0	1.84	0.367	5.0
Arsenic (*ln*)	NobisT3	110	110	0	2.7500	0.0484	0.5081	0.2582	18.48	860.0120	1.3350	2.3979	2.7726	3.1355	3.6376	2.3026	0.7376	-0.44	0.234	-1.9	-0.05	0.467	-0.1
	NobisT4	42	42	0	3.0041	0.0751	0.4865	0.2366	16.19	388.7476	2.0412	2.6908	2.9701	3.2675	4.2195	2.1783	0.5767	0.42	0.378	1.1	0.21	0.756	0.3
	Random	40	40	0	3.058	0.104	0.656	0.430	21.44	390.904	1.459	2.708	3.039	3.471	4.868	3.409	0.763	0.02	0.387	0.1	1.07	0.775	1.4
	SSI	178	178	0	2.9817	0.0394	0.5262	0.2769	17.65	1631.5353	1.5892	2.6205	3.0910	3.3322	4.2485	2.6593	0.7117	-0.50	0.184	-2.7	-0.23	0.367	-0.6
Iron	NobisT3	110	110	0	10367	522	5474	29963873	52.80	15088900000	3000	6350	8650	13250	30000	27000	6900	1.23	0.234	5.3	1.54	0.467	3.3
	NobisT4	42	42	0	12469	876	5680	32258287	45.55	7852630000	4500	8075	11500	15250	29000	24500	7175	0.91	0.378	2.4	0.46	0.756	0.6
	Random	40	40	0	11820	593	3750	14064515	31.73	6136775700	4500	8620	11900	14575	18800	14300	5955	-0.20	0.387	-0.5	-0.80	0.775	-1.0
	SSI	178	178	0	9842	285	3806	14487527	38.68	19804760000	2600	7500	9300	12000	28000	25400	4500	1.04	0.184	5.7	2.80	0.367	7.6
Iron (*ln*)	NobisT3	110	110	0	9.1199	0.0480	0.5031	0.2531	5.52	9176.5419	8.0064	8.7561	9.0653	9.4912	10.3090	2.3026	0.7351	0.14	0.234	0.6	-0.58	0.467	-1.2
	NobisT4	42	42	0	9.3325	0.0698	0.4526	0.2048	4.85	3666.3781	8.4118	8.9965	9.3492	9.6319	10.2751	1.8632	0.6354	-0.03	0.378	-0.1	-0.53	0.756	-0.7
	Random	40	40	0	9.3194	0.0574	0.3629	0.1317	3.89	3479.1885	8.4118	9.0616	9.3843	9.5871	9.8416	1.4298	0.5255	-0.83	0.387	-2.1	-0.04	0.775	-0.1
	SSI	178	178	0	9.1183	0.0303	0.4043	0.1634	4.43	14828.5473	7.8633	8.9227	9.1378	9.3927	10.2400	2.3767	0.4700	-0.57	0.184	-3.1	0.92	0.367	2.5
Nickel	NobisT3	110	110	0	17.48	1.03	10.80	116.67	61.79	46330.59	3.40	8.50	14.00	26.00	46.00	42.60	17.50	0.84	0.234	3.6	-0.16	0.467	-0.3
	NobisT4	42	42	0	24.49	2.30	14.92	222.73	60.95	34313.08	7.60	11.75	21.50	31.25	73.00	65.40	19.50	1.26	0.378	3.3	1.63	0.756	2.2
	Random	40	40	0	19.84	1.49	9.44	89.05	47.58	19209.98	4.30	11.63	18.95	27.93	36.60	32.30	16.30	0.01	0.387	0.1	-1.17	0.775	-1.5
	SSI	178	178	0	17.142	0.672	8.962	80.317	52.28	66518.420	4.000	9.050	16.000	24.000	52.000	48.000	14.950	0.61	0.184	3.3	0.28	0.367	0.8
Nickel (*ln*)	NobisT3	110	110	0	2.6665	0.0611	0.6404	0.4101	24.01	826.8459	1.2238	2.1401	2.6391	3.2581	3.8286	2.6049	1.1180	-0.05	0.234	-0.2	-0.97	0.467	-2.1
	NobisT4	42	42	0	3.0272	0.0918	0.5953	0.3543	19.66	399.4107	2.0281	2.4632	3.0656	3.4419	4.2905	2.2623	0.9788	0.06	0.378	0.2	-0.82	0.756	-1.1
	Random	40	40	0	2.8442	0.0928	0.5868	0.3444	20.63	337.0047	1.4586	2.4530	2.9416	3.3295	3.6000	2.1414	0.8765	-0.77	0.387	-2.0	-0.34	0.775	-0.4
	SSI	178	178	0	2.6875	0.0438	0.5846	0.3418	21.75	1346.1065	1.3863	2.2027	2.7726	3.1781	3.9512	2.5649	0.9753	-0.40	0.184	-2.2	-0.80	0.367	-2.2

Notes:
N — *Number of data points used;*
*N** — *Number of data points excluded ;*
SE — *Standard Error;*
SD — *Standard Deviation;*
CV — *Coefficient of Variation;*
Q1 — *First Quartile;*
Q3 — *Third Quartile;*
IQR — *Inter-Quartile Range;*
SES — *Standard Error of Skewness;*
S/SES — *Skewness/Standard Error of Skewness;*
SEK — *Standard Error of Kurtosis;*
K/SEK — *Kurtosis/Standard Error of Kurtosis;*
ln — *Natural Logarithm;*

TABLE A-2
Descriptive Statistics: Aluminum, Arsenic, Iron, Nickel – Outliers Excluded

Variable	SubSet	Total Count	N	N*	Mean	SE Mean	SD	Variance	CV	Sum of Squares	Min.	Q1	Median	Q3	Max.	Range	IQR	Skewness	SES	S/SES	Kurtosis	SEK	K/SEK
Aluminum	NobisT3	110	110	0	6313	252	2638	6959653	41.79	5142160000	1700	4000	6100	8325	13000	11300	4325	0.27	0.234	1.2	-0.73	0.467	-1.6
	NobisT4	42	42	0	6802	449	2909	8464141	42.77	2290470000	2000	4200	7250	8675	13000	11000	4475	0.17	0.378	0.4	-0.66	0.756	-0.9
	Random	40	40	0	8274	394	2493	6216485	30.14	2980475000	3900	6353	8045	9950	14800	10900	3598	0.33	0.387	0.9	-0.03	0.775	0.0
	SSI	178	174	4	6866	186	2459	6045625	35.81	9247440000	2000	5200	6800	8350	13000	11000	3150	0.20	0.186	1.1	-0.15	0.371	-0.4
Aluminum (*ln*)	NobisT3	110	110	0	8.6517	0.0445	0.4668	0.2179	5.40	8257.4732	7.4384	8.2940	8.7160	9.0270	9.4727	2.0343	0.7330	-0.53	0.234	-2.3	-0.41	0.467	-0.9
	NobisT4	42	42	0	8.7185	0.0763	0.4944	0.2444	5.67	3202.5607	7.6009	8.3428	8.8887	9.0676	9.4727	1.8718	0.7248	-0.65	0.378	-1.7	-0.44	0.756	-0.6
	Random	40	40	0	8.9739	0.0502	0.3175	0.1008	3.54	3225.1666	8.2687	8.7558	8.9927	9.2053	9.6024	1.3337	0.4495	-0.43	0.387	-1.1	-0.19	0.775	-0.2
	SSI	178	178	0	8.7782	0.0317	0.4229	0.1789	4.82	13747.9195	7.6009	8.5564	8.8247	9.0507	9.6803	2.0794	0.4943	-0.72	0.184	-3.9	0.49	0.367	1.3
Arsenic	NobisT3	110	110	0	17.609	0.792	8.311	69.078	47.20	41638.260	3.800	11.000	16.000	23.000	38.000	34.200	12.000	0.65	0.234	2.8	-0.21	0.467	-0.4
	NobisT4	42	41	1	21.70	1.67	10.67	113.92	49.19	23863.29	7.70	14.50	19.00	25.00	52.00	44.30	10.50	1.44	0.383	3.8	2.06	0.765	2.7
	Random	40	38	2	24.31	2.14	13.22	174.70	54.38	28912.24	5.60	15.00	20.90	30.60	66.40	60.80	15.60	1.33	0.397	3.3	2.28	0.795	2.9
	SSI	178	174	4	21.543	0.714	9.415	88.646	43.70	96090.090	4.900	13.000	22.000	27.000	46.000	41.100	14.000	0.25	0.186	1.3	-0.57	0.371	-1.5
Arsenic (*ln*)	NobisT3	110	110	0	2.7500	0.0484	0.5081	0.2582	18.48	860.0120	1.3350	2.3979	2.7726	3.1355	3.6376	2.3026	0.7376	-0.44	0.234	-1.9	-0.05	0.467	-0.1
	NobisT4	42	41	1	2.9745	0.0707	0.4525	0.2047	15.21	370.9434	2.0412	2.6736	2.9444	3.2181	3.9512	1.9100	0.5445	0.23	0.383	0.6	0.01	0.765	0.0
	Random	40	38	2	3.0528	0.0882	0.5436	0.2955	17.81	365.0833	1.7228	2.7081	3.0395	3.4200	4.1957	2.4729	0.7120	-0.25	0.397	-0.6	0.15	0.795	0.2
	SSI	178	172	6	2.9852	0.0370	0.4847	0.2349	16.24	1572.9287	1.8083	2.6391	3.0910	3.3231	3.9512	2.1430	0.6841	-0.55	0.187	-2.9	-0.48	0.374	-1.3
Iron	NobisT3	110	107	3	9873	450	4651	21633692	47.11	12722900000	3000	6200	8500	13000	21000	18000	6800	0.74	0.237	3.1	-0.41	0.474	-0.9
	NobisT4	42	37	5	11897	733	4460	19894159	37.49	5953380000	5300	8400	11000	14500	22000	16700	6100	0.70	0.403	1.7	-0.18	0.805	-0.2
	Random	40	40	0	11820	593	3750	14064515	31.73	6136775700	4500	8620	11900	14575	18800	14300	5955	-0.20	0.387	-0.5	-0.80	0.775	-1.0
	SSI	178	171	7	9576	240	3145	9888069	32.84	17361710000	3200	7500	9300	12000	18000	14800	4500	0.28	0.187	1.5	-0.15	0.375	-0.4
Iron (*ln*)	NobisT3	110	110	0	9.1199	0.0480	0.5031	0.2531	5.52	9176.5419	8.0064	8.7561	9.0653	9.4912	10.3090	2.3026	0.7351	0.14	0.234	0.6	-0.58	0.467	-1.2
	NobisT4	42	42	0	9.3325	0.0698	0.4526	0.2048	4.85	3666.3781	8.4118	8.9965	9.3492	9.6319	10.2751	1.8632	0.6354	-0.03	0.378	-0.1	-0.53	0.756	-0.7
	Random	40	34	6	9.3463	0.0476	0.2774	0.0769	2.97	2972.5673	8.7641	9.1378	9.3843	9.5767	9.7232	0.9591	0.4389	-0.70	0.420	-1.7	-0.50	0.840	-0.6
	SSI	178	167	11	9.1719	0.0247	0.3190	0.1018	3.48	14065.5397	8.3428	8.9619	9.1695	9.3927	9.9988	1.6560	0.4308	-0.01	0.190	-0.1	-0.08	0.379	-0.2
Nickel	NobisT3	110	108	2	17.35	1.01	10.46	109.37	60.29	44203.03	3.70	8.53	14.00	25.75	45.00	41.30	17.23	0.81	0.236	3.4	-0.23	0.471	-0.5
	NobisT4	42	40	2	23.70	2.04	12.88	165.85	54.35	28926.32	7.70	12.50	21.50	30.75	57.00	49.30	18.25	0.88	0.403	2.3	0.15	0.804	0.2
	Random	40	40	0	19.84	1.49	9.44	89.05	47.58	19209.98	4.30	11.63	18.95	27.93	36.60	32.30	16.30	0.01	0.387	0.0	-1.17	0.775	-1.5
	SSI	178	172	6	17.090	0.630	8.257	68.183	48.32	61895.650	4.600	9.475	16.500	24.000	37.000	32.400	14.525	0.29	0.187	1.6	-0.91	0.374	-2.4
Nickel (*ln*)	NobisT3	110	108	2	2.6691	0.0598	0.6210	0.3856	23.27	810.6898	1.3083	2.1430	2.6391	3.2483	3.8067	2.4983	1.1053	-0.02	0.236	-0.1	-1.06	0.471	-2.2
	NobisT4	42	42	0	3.0272	0.0918	0.5953	0.3543	19.66	399.4107	2.0281	2.4632	3.0656	3.4419	4.2905	2.2623	0.9788	0.06	0.378	0.2	-0.82	0.756	-1.1
	Random	40	37	3	2.8957	0.0832	0.5059	0.2560	17.47	319.4563	1.8245	2.5053	2.9601	3.3232	3.5667	1.7422	0.8178	-0.66	0.403	-1.6	-0.60	0.805	-0.7
	SSI	178	172	6	2.7032	0.0418	0.5480	0.3003	20.27	1308.1793	1.5261	2.2486	2.8029	3.1781	3.6109	2.0849	0.9295	-0.43	0.187	-2.3	-0.93	0.374	-2.5

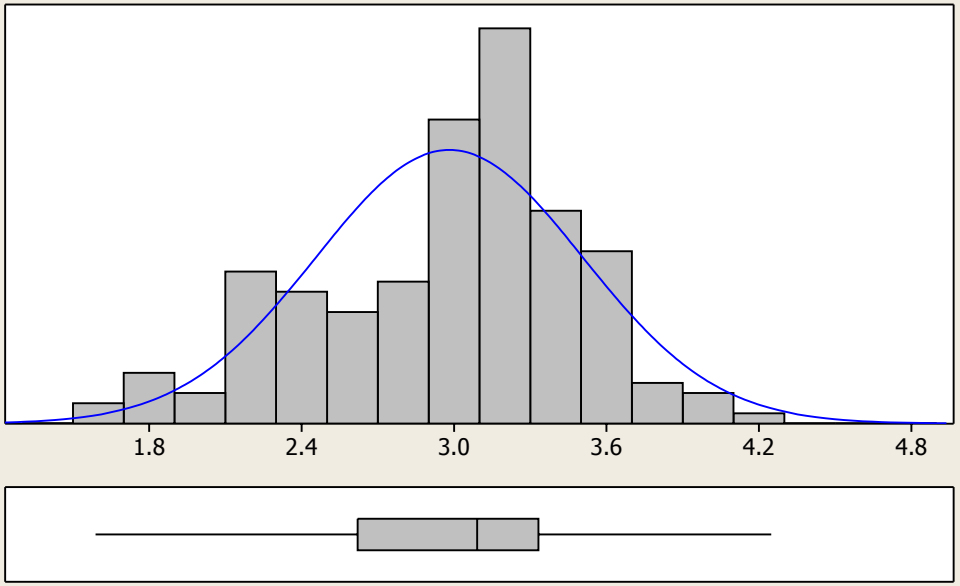
Notes:
N — *Number of data points used;*
*N** — *Number of data points excluded ;*
SE — *Standard Error;*
SD — *Standard Deviation;*
CV — *Coefficient of Variation;*
Q1 — *First Quartile;*
Q3 — *Third Quartile;*
IQR — *Inter-Quartile Range;*
SES — *Standard Error of Skewness;*
S/SES — *Skewness/Standard Error of Skewness;*
SEK — *Standard Error of Kurtosis;*
K/SEK — *Kurtosis/Standard Error of Kurtosis;*
ln — *Natural Logarithm;*

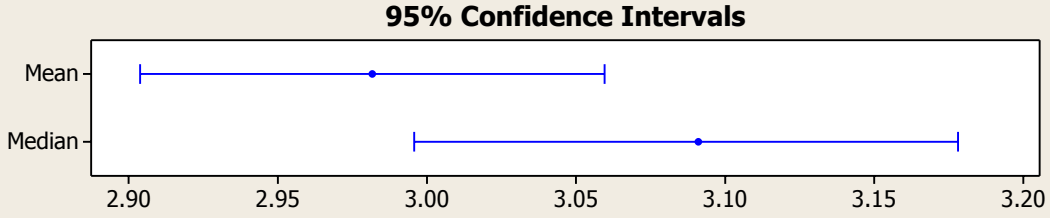
ATTACHMENT B-1

HISTOGRAMS, BOXPLOTS, AND PROBABILITY PLOTS FOR DATASETS AND SUBSETS – WITH OUTLIERS INCLUDED

Summary for ln_Arsenic

SubSet = SSI

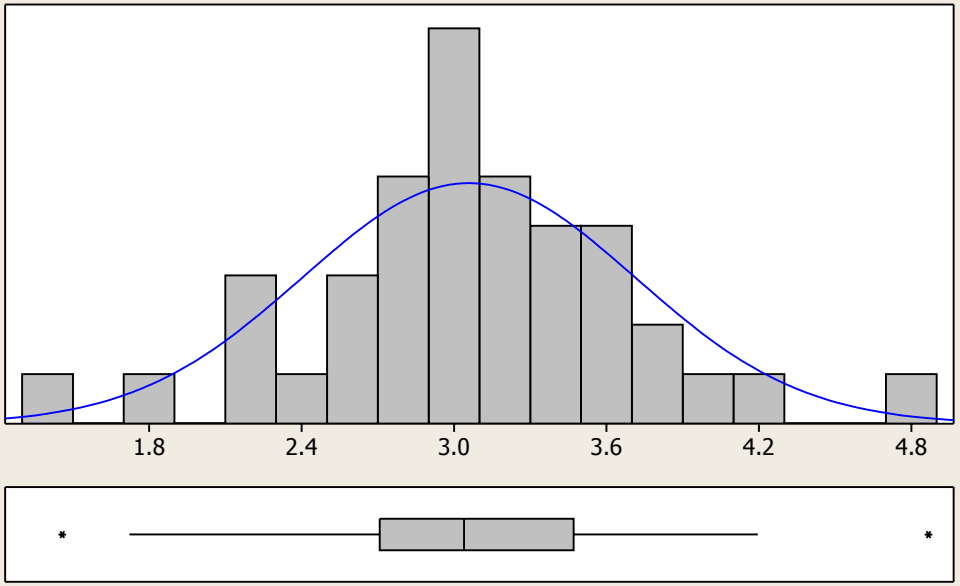




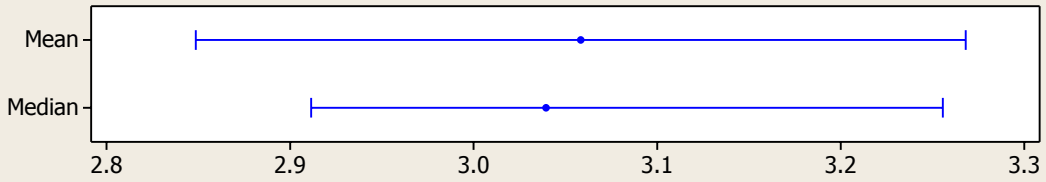
Anderson-Darling Normality Test	
A-Squared	2.50
P-Value <	0.005
Mean	2.9817
StDev	0.5262
Variance	0.2769
Skewness	-0.496365
Kurtosis	-0.234107
N	178
Minimum	1.5892
1st Quartile	2.6205
Median	3.0910
3rd Quartile	3.3322
Maximum	4.2485
95% Confidence Interval for Mean	
2.9039	3.0595
95% Confidence Interval for Median	
2.9957	3.1781
95% Confidence Interval for StDev	
0.4766	0.5874

Summary for ln_Arsenic

SubSet = Random



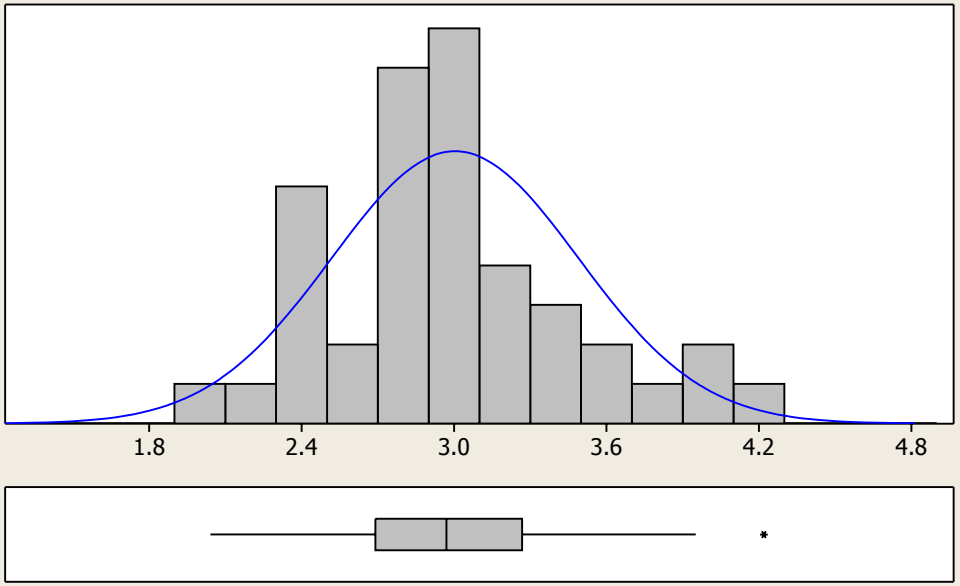
95% Confidence Intervals

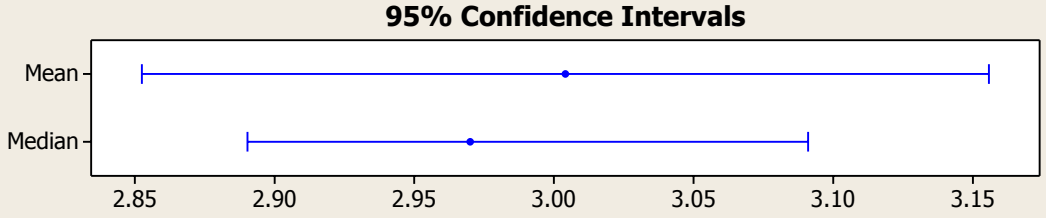


Anderson-Darling Normality Test	
A-Squared	0.34
P-Value	0.492
Mean	3.0583
StDev	0.6557
Variance	0.4299
Skewness	0.02473
Kurtosis	1.07014
N	40
Minimum	1.4586
1st Quartile	2.7081
Median	3.0395
3rd Quartile	3.4710
Maximum	4.8675
95% Confidence Interval for Mean	
2.8486	3.2680
95% Confidence Interval for Median	
2.9115	3.2556
95% Confidence Interval for StDev	
0.5371	0.8419

Summary for ln_Arsenic

SubSet = NobisT4

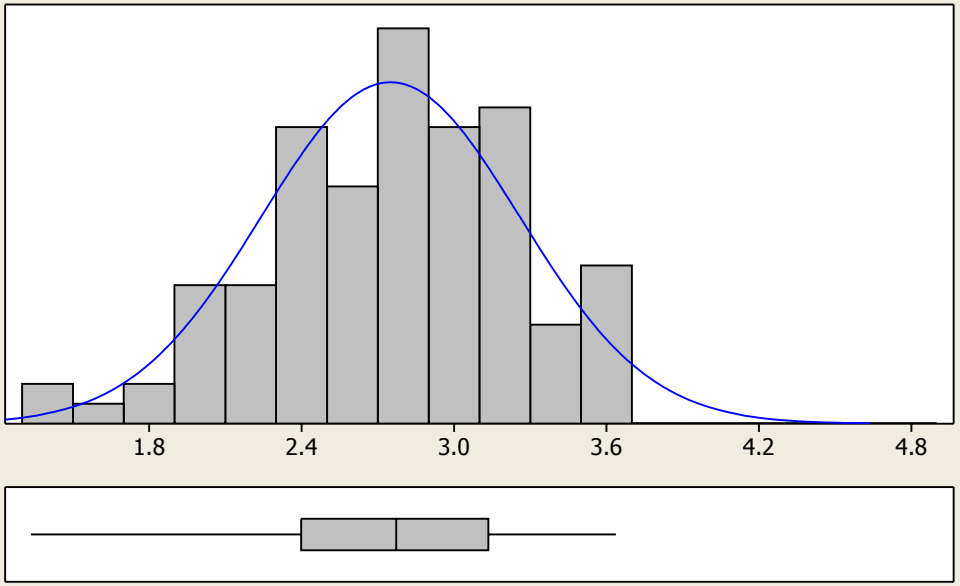


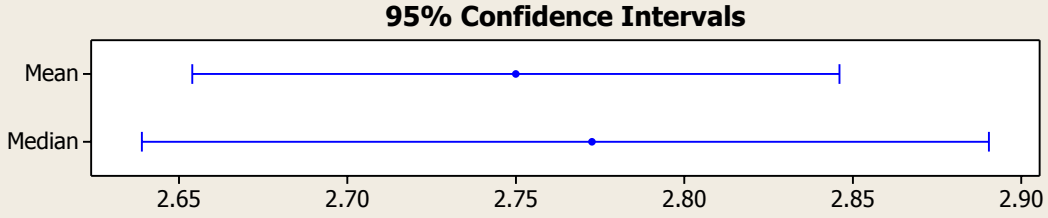


Anderson-Darling Normality Test	
A-Squared	0.44
P-Value	0.278
Mean	3.0041
StDev	0.4865
Variance	0.2366
Skewness	0.417068
Kurtosis	0.208015
N	42
Minimum	2.0412
1st Quartile	2.6908
Median	2.9701
3rd Quartile	3.2675
Maximum	4.2195
95% Confidence Interval for Mean	
2.8526	3.1557
95% Confidence Interval for Median	
2.8904	3.0910
95% Confidence Interval for StDev	
0.4003	0.6203

Summary for ln_Arsenic

SubSet = NobisT3

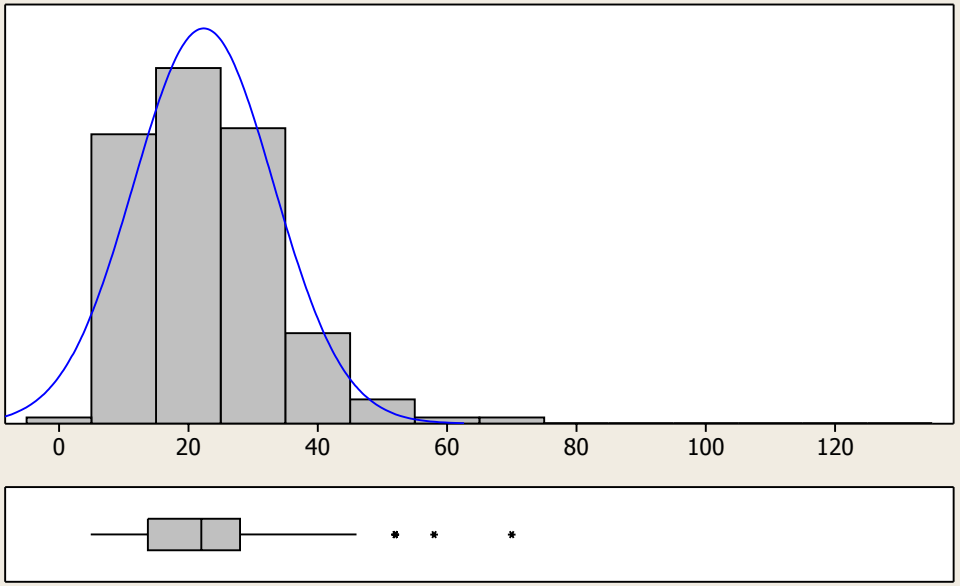


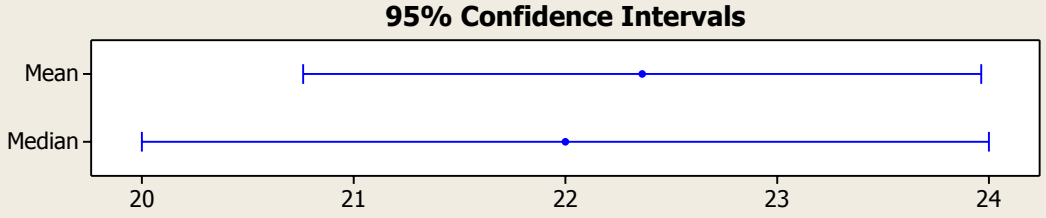


Anderson-Darling Normality Test	
A-Squared	0.45
P-Value	0.278
Mean	2.7500
StDev	0.5081
Variance	0.2582
Skewness	-0.439823
Kurtosis	-0.053939
N	110
Minimum	1.3350
1st Quartile	2.3979
Median	2.7726
3rd Quartile	3.1355
Maximum	3.6376
95% Confidence Interval for Mean	
2.6540	2.8460
95% Confidence Interval for Median	
2.6391	2.8904
95% Confidence Interval for StDev	
0.4487	0.5858

Summary for Arsenic

SubSet = SSI



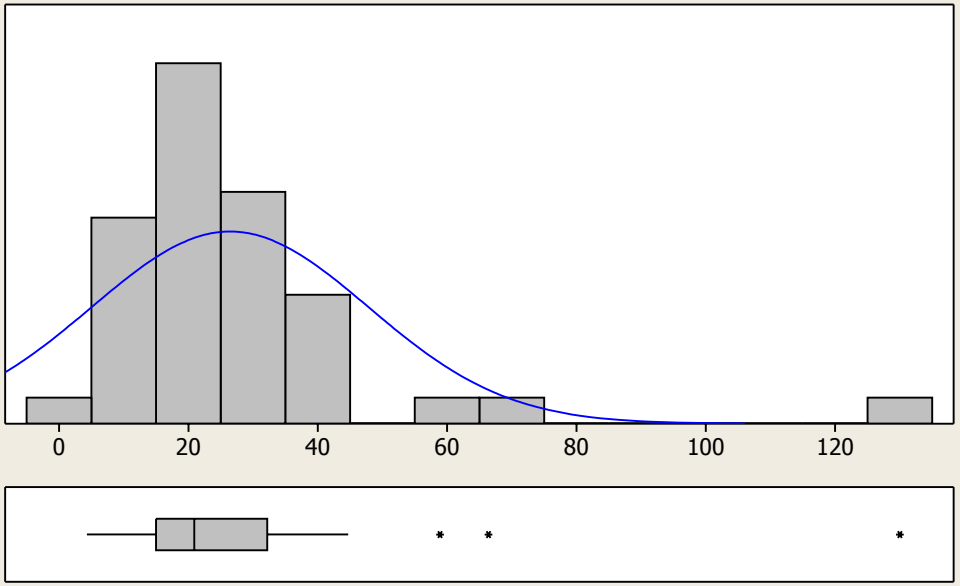


Anderson-Darling Normality Test	
A-Squared	1.36
P-Value <	0.005
Mean	22.362
StDev	10.827
Variance	117.224
Skewness	0.91286
Kurtosis	1.84410
N	178
Minimum	4.900
1st Quartile	13.750
Median	22.000
3rd Quartile	28.000
Maximum	70.000

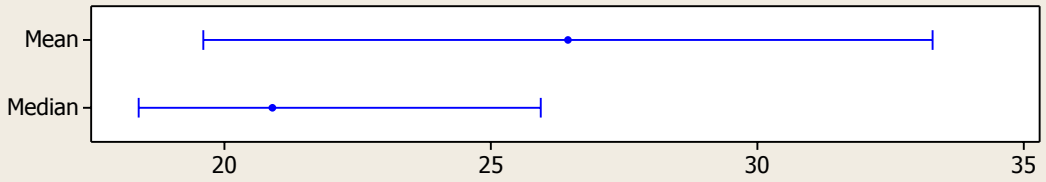
95% Confidence Interval for Mean	
20.761	23.964
95% Confidence Interval for Median	
20.000	24.000
95% Confidence Interval for StDev	
9.807	12.086

Summary for Arsenic

SubSet = Random



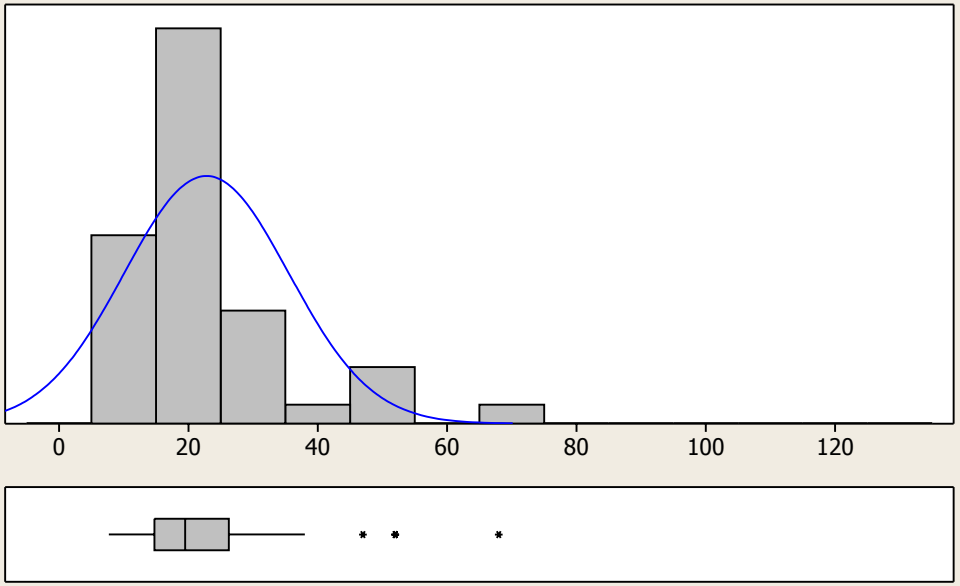
95% Confidence Intervals

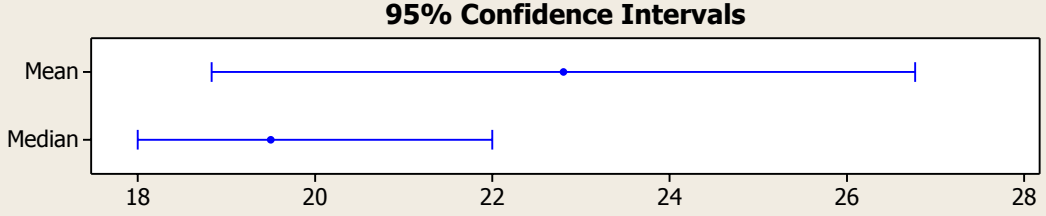


Anderson-Darling Normality Test	
A-Squared	2.89
P-Value <	0.005
Mean	26.448
StDev	21.395
Variance	457.742
Skewness	3.2117
Kurtosis	13.8554
N	40
Minimum	4.300
1st Quartile	15.000
Median	20.900
3rd Quartile	32.200
Maximum	130.000
95% Confidence Interval for Mean	
19.605	33.290
95% Confidence Interval for Median	
18.393	25.936
95% Confidence Interval for StDev	
17.526	27.472

Summary for Arsenic

SubSet = NobisT4

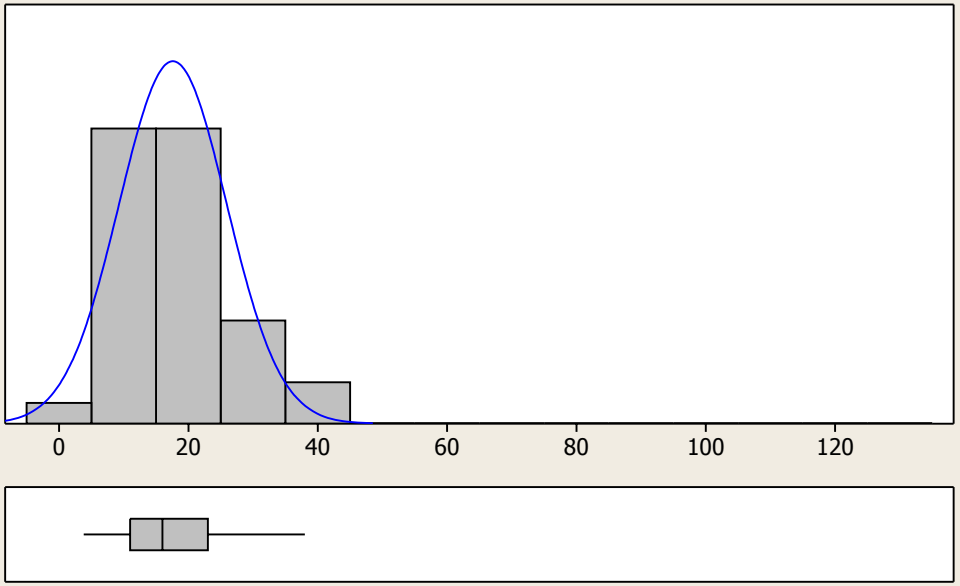


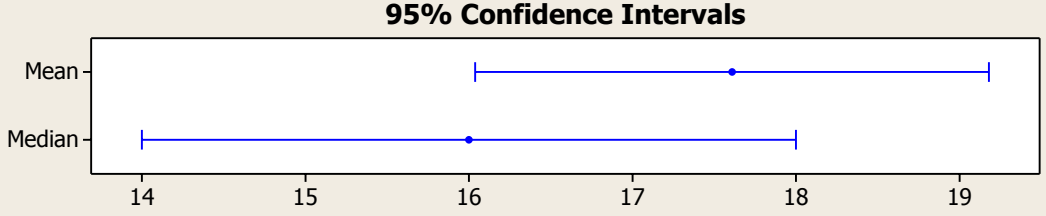


Anderson-Darling Normality Test	
A-Squared	2.36
P-Value <	0.005
Mean	22.802
StDev	12.735
Variance	162.182
Skewness	1.78599
Kurtosis	3.50857
N	42
Minimum	7.700
1st Quartile	14.750
Median	19.500
3rd Quartile	26.250
Maximum	68.000
95% Confidence Interval for Mean	
18.834	26.771
95% Confidence Interval for Median	
18.000	22.000
95% Confidence Interval for StDev	
10.478	16.239

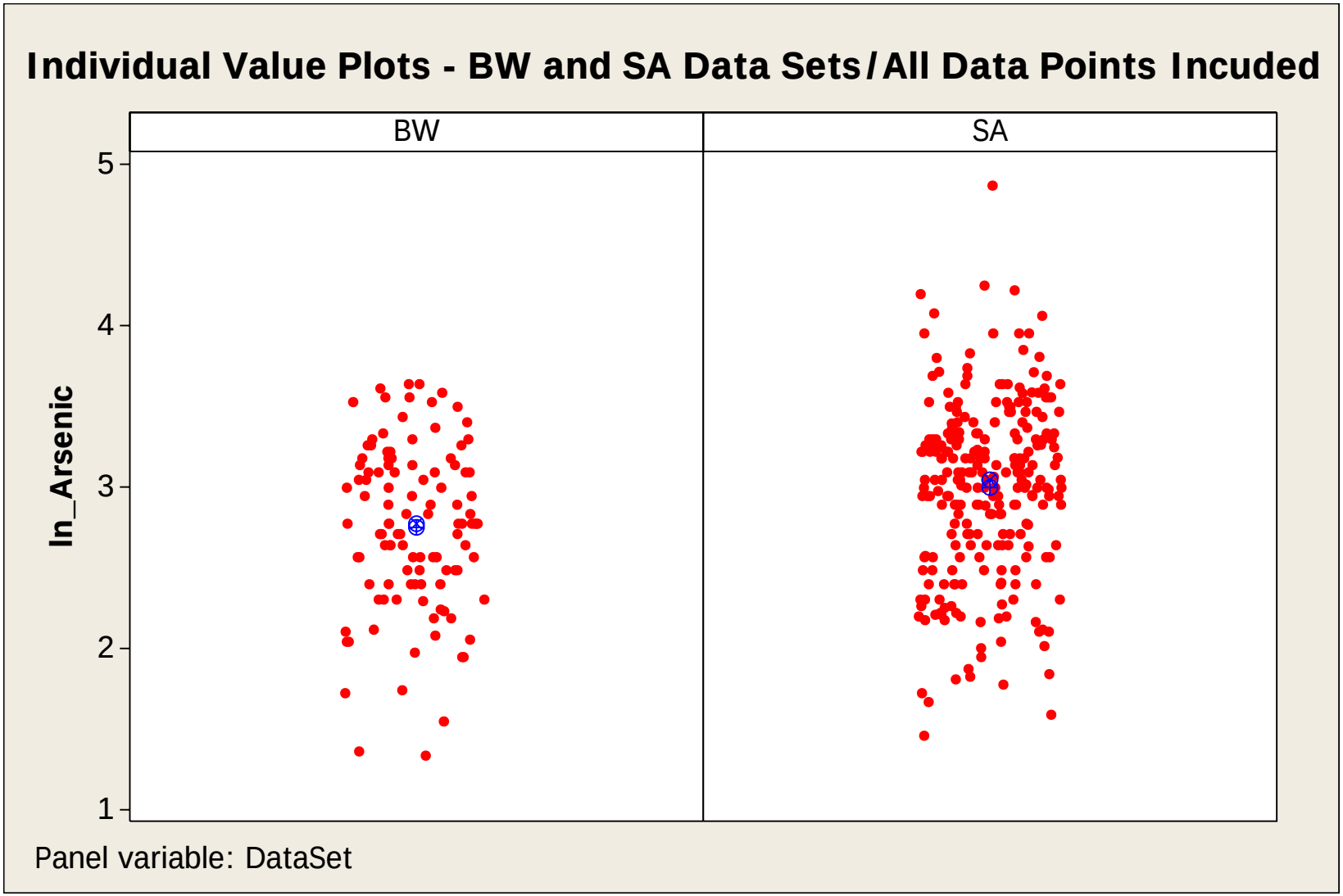
Summary for Arsenic

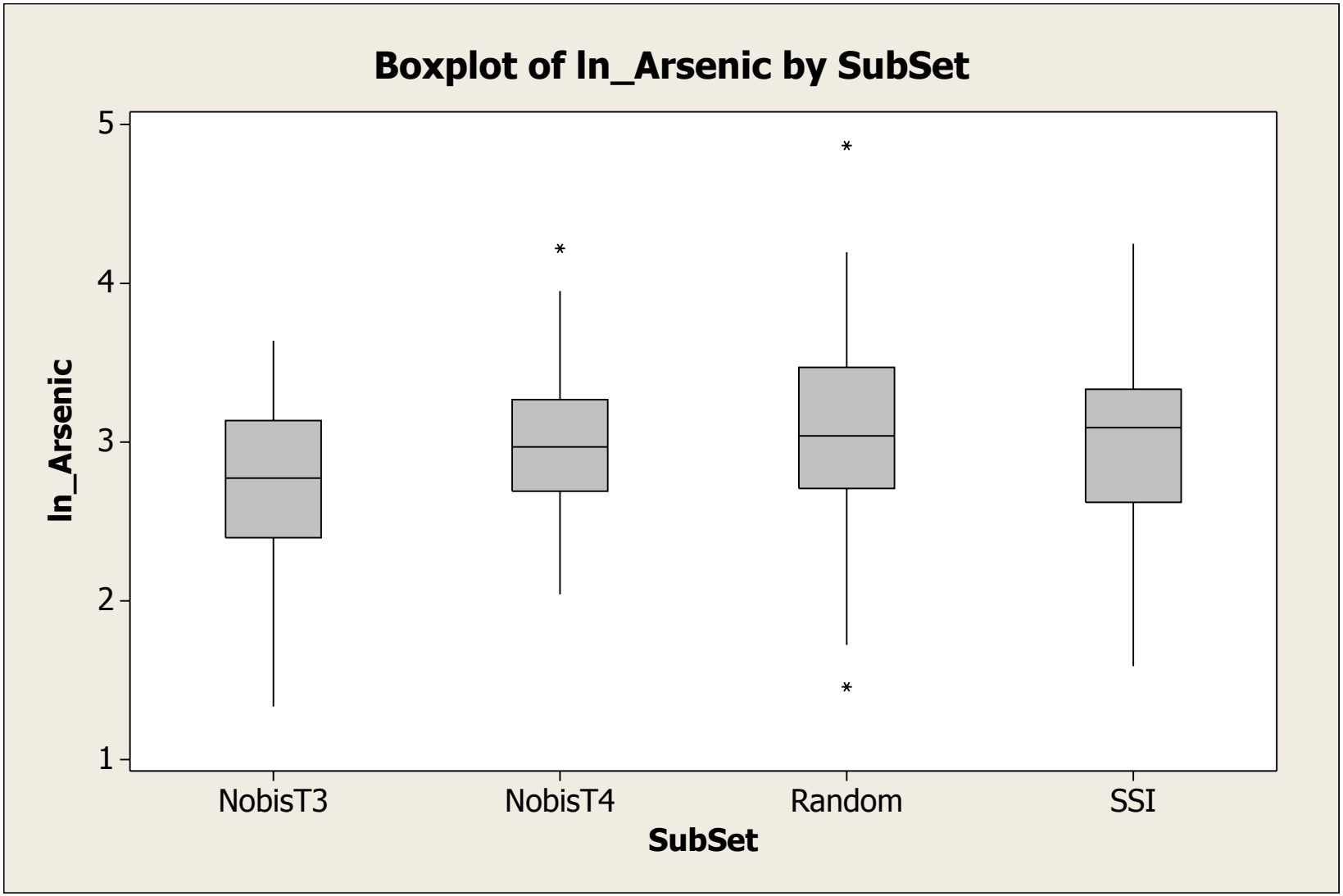
SubSet = NobisT3

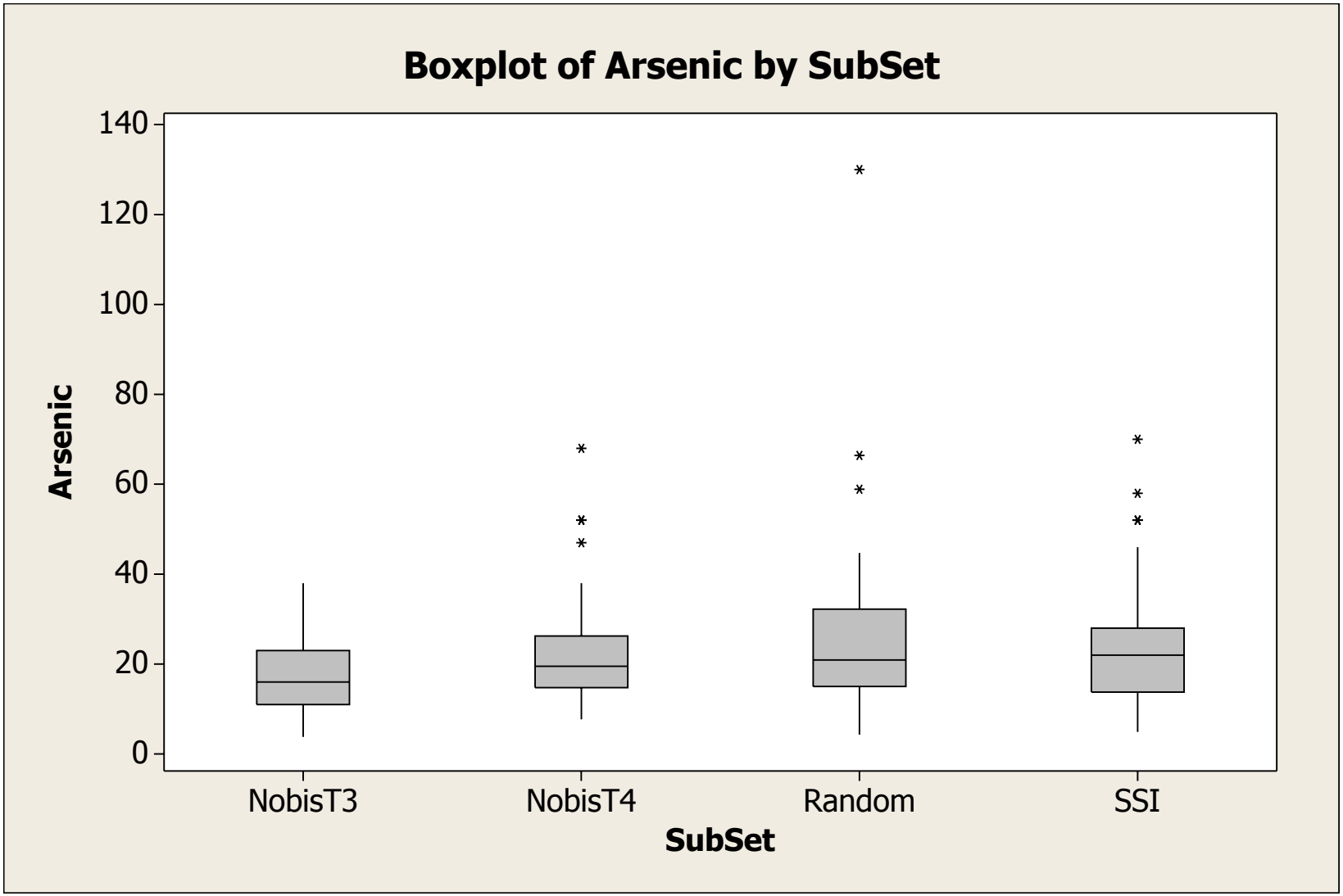




Anderson-Darling Normality Test	
A-Squared	1.41
P-Value <	0.005
Mean	17.609
StDev	8.311
Variance	69.078
Skewness	0.646281
Kurtosis	-0.210988
N	110
Minimum	3.800
1st Quartile	11.000
Median	16.000
3rd Quartile	23.000
Maximum	38.000
95% Confidence Interval for Mean	
16.038	19.180
95% Confidence Interval for Median	
14.000	18.000
95% Confidence Interval for StDev	
7.339	9.582


Individual Value Plots - BW and SA Data Sets/All Data Points Incuded
BW
SA
ln_Arsenic
5
4
3
2
1
Panel variable: DataSet


Boxplot of ln_Arsenic by SubSet
ln_Arsenic
5
4
3
2
1
NobisT3
NobisT4
Random
SSI
SubSet

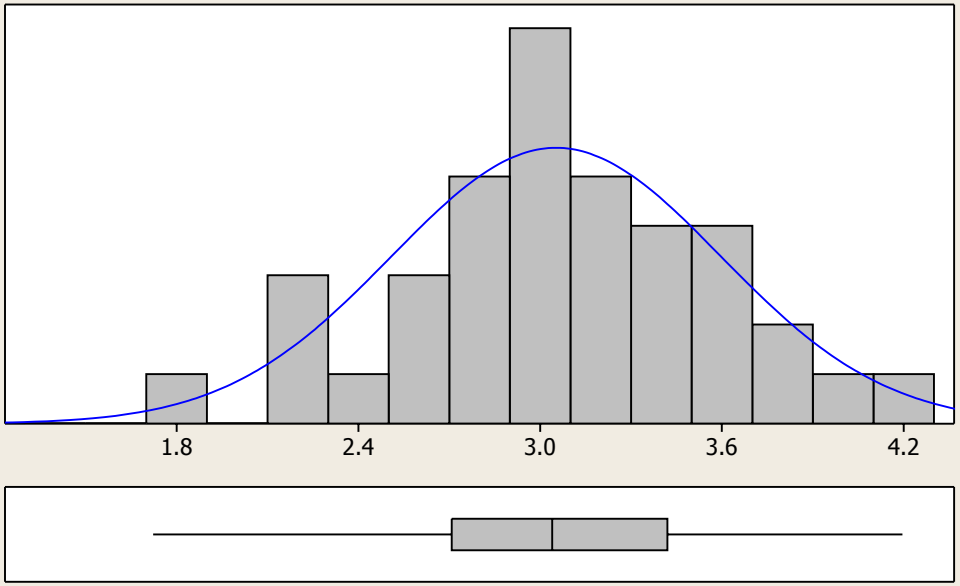

Boxplot of Arsenic by SubSet
Arsenic
140
120
100
80
60
40
20
0
NobisT3
NobisT4
Random
SSI
SubSet

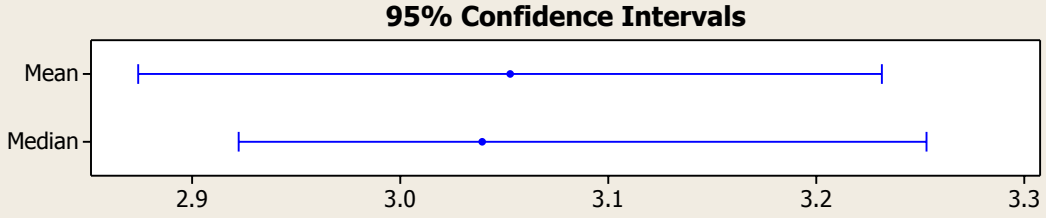
ATTACHMENT B-2

HISTOGRAMS, BOXPLOTS, AND PROBABILITY PLOTS FOR DATASETS AND SUBSETS – WITH OUTLIERS EXCLUDED

Summary for ln_Arsenic - Outliers Excluded

SubSet = Random

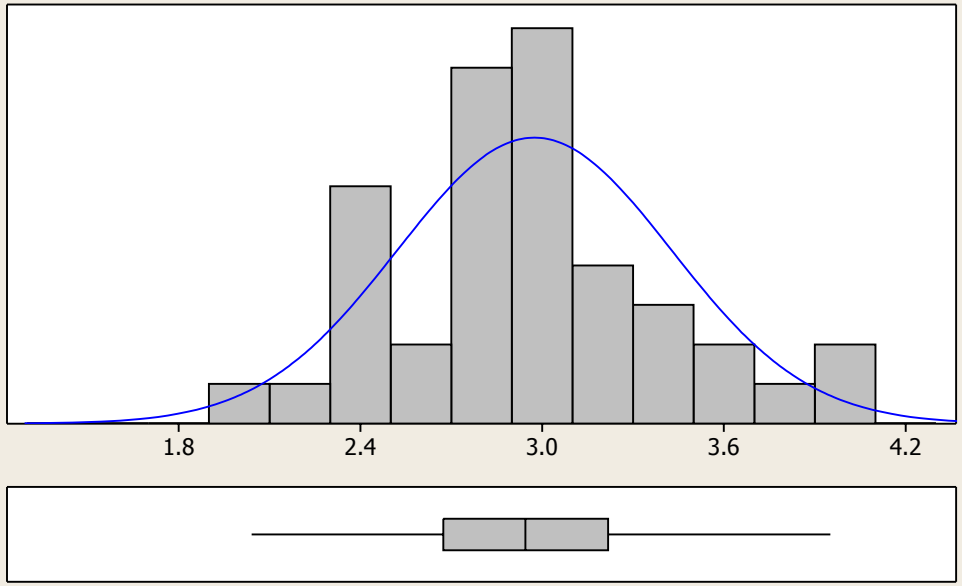


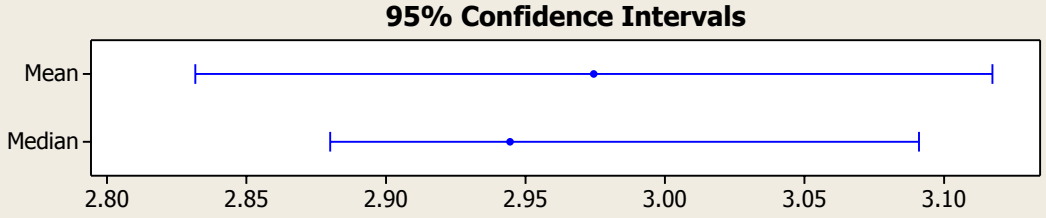


Anderson-Darling Normality Test	
A-Squared	0.20
P-Value	0.873
Mean	3.0528
StDev	0.5436
Variance	0.2955
Skewness	-0.246695
Kurtosis	0.152836
N	38
Minimum	1.7228
1st Quartile	2.7081
Median	3.0395
3rd Quartile	3.4200
Maximum	4.1957
95% Confidence Interval for Mean	
2.8742	3.2315
95% Confidence Interval for Median	
2.9224	3.2530
95% Confidence Interval for StDev	
0.4432	0.7033

Summary for ln_Arsenic - Outliers Excluded

SubSet = NobisT4

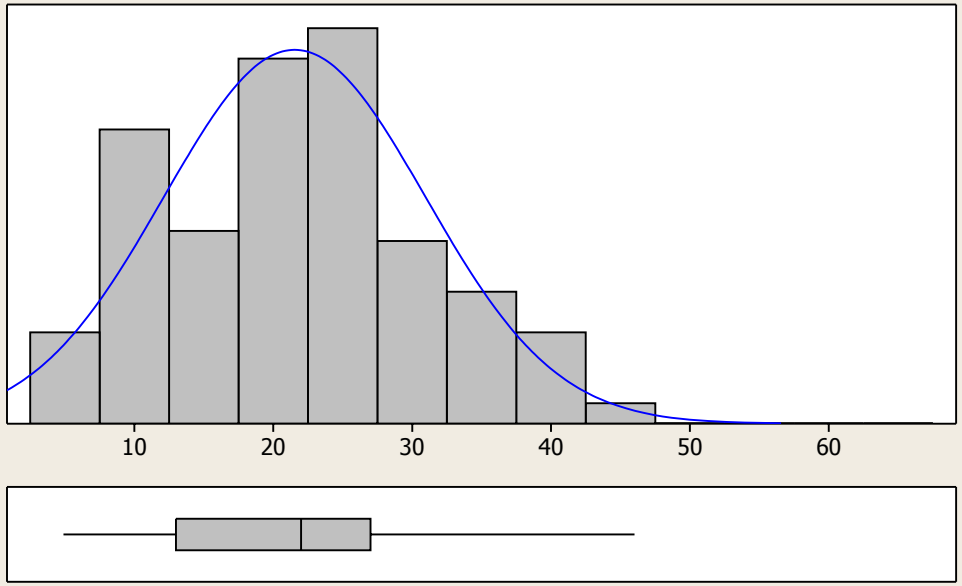




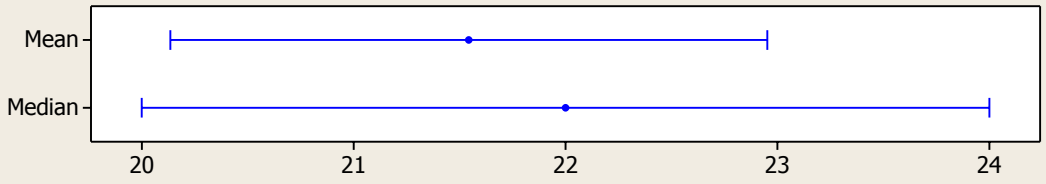
Anderson-Darling Normality Test	
A-Squared	0.35
P-Value	0.455
Mean	2.9745
StDev	0.4525
Variance	0.2047
Skewness	0.229489
Kurtosis	0.014732
N	41
Minimum	2.0412
1st Quartile	2.6736
Median	2.9444
3rd Quartile	3.2181
Maximum	3.9512
95% Confidence Interval for Mean	
2.8317	3.1173
95% Confidence Interval for Median	
2.8800	3.0910
95% Confidence Interval for StDev	
0.3715	0.5789

Summary for Arsenic - Outliers Excluded

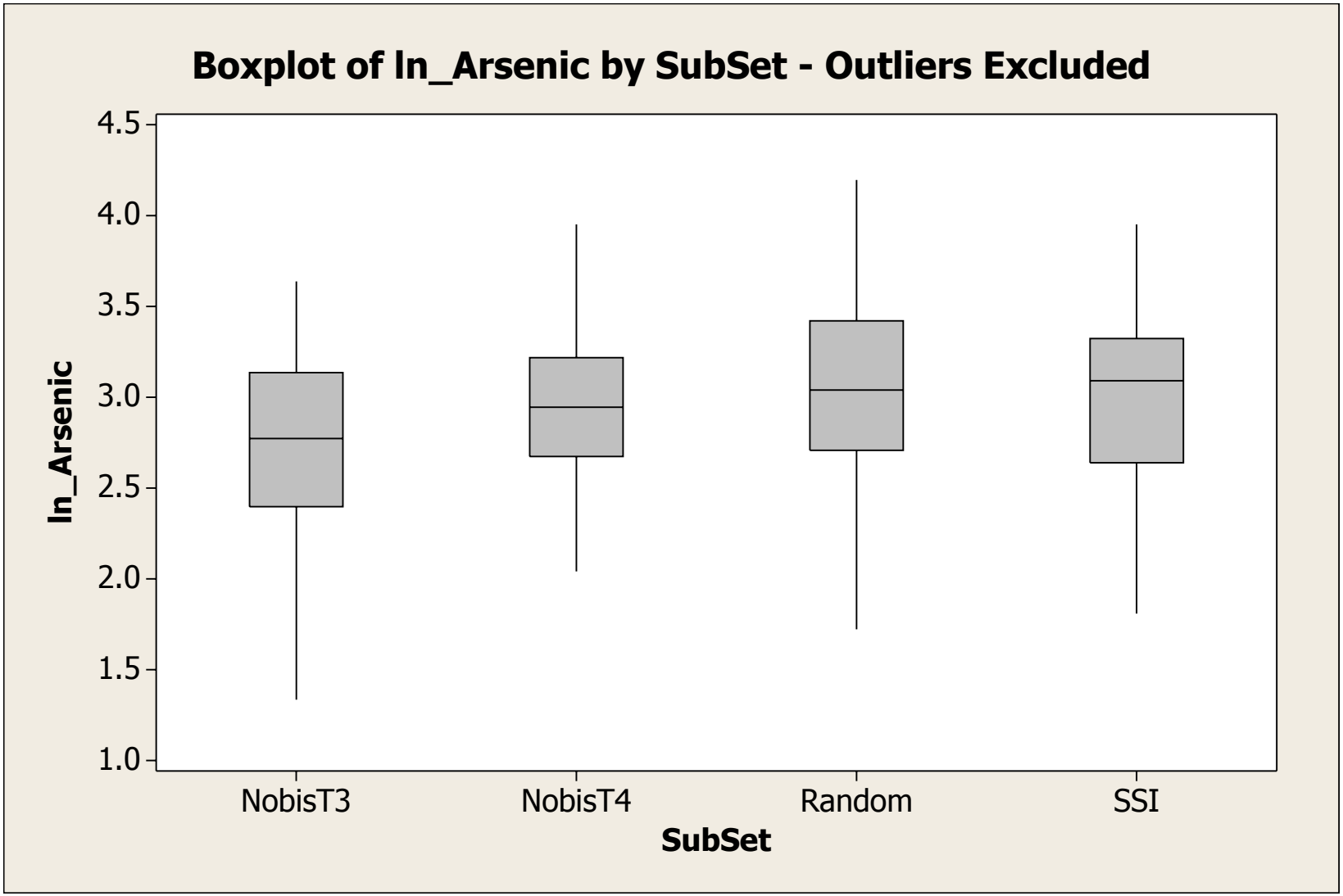
SubSet = SSI

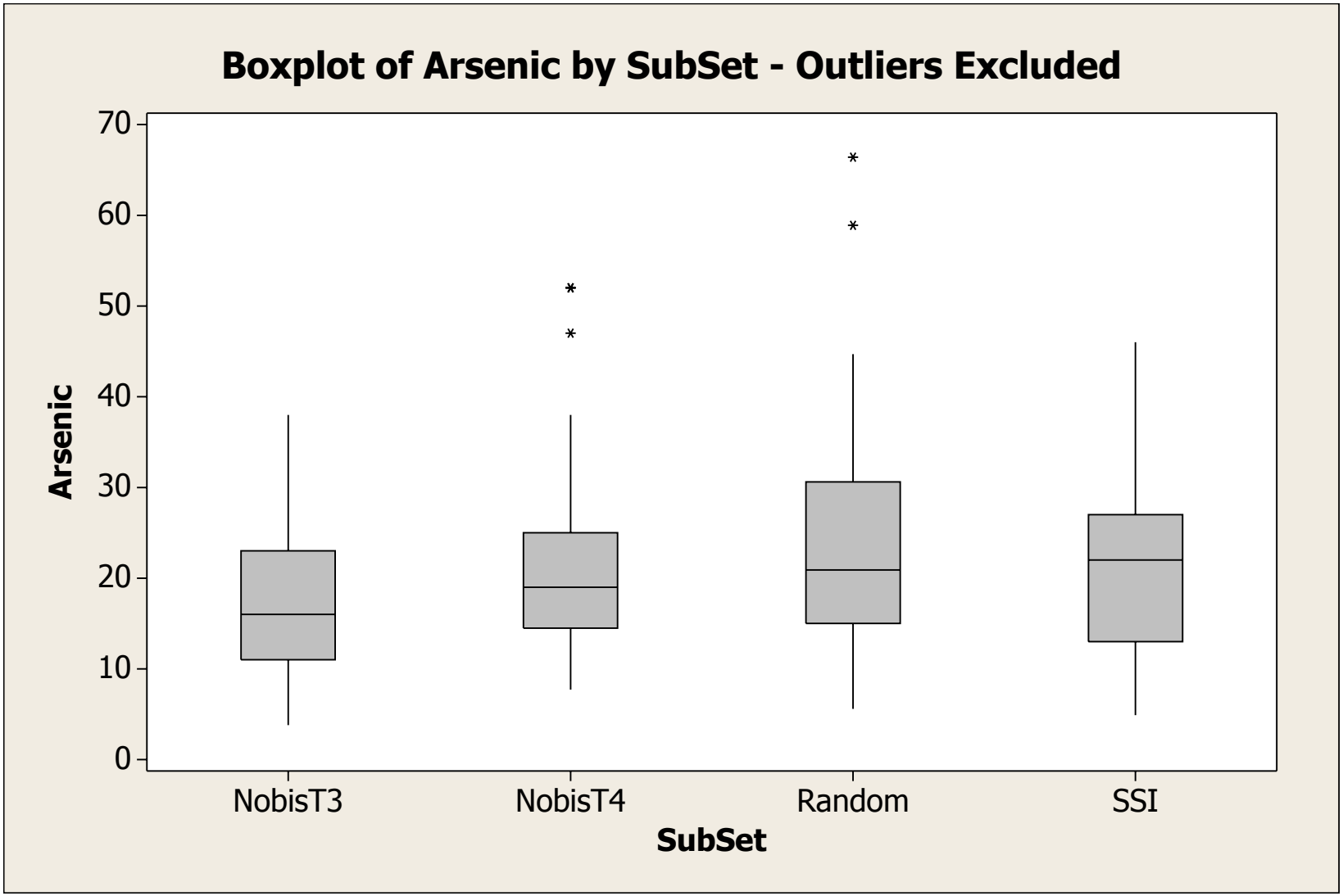


95% Confidence Intervals



Anderson-Darling Normality Test	
A-Squared	0.97
P-Value	0.014
Mean	21.543
StDev	9.415
Variance	88.646
Skewness	0.246060
Kurtosis	-0.571822
N	174
Minimum	4.900
1st Quartile	13.000
Median	22.000
3rd Quartile	27.000
Maximum	46.000
95% Confidence Interval for Mean	
20.134	22.952
95% Confidence Interval for Median	
20.000	24.000
95% Confidence Interval for StDev	
8.519	10.524


Boxplot of ln_Arsenic by SubSet - Outliers Excluded
ln_Arsenic
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
NobisT3
NobisT4
Random
SSI
SubSet

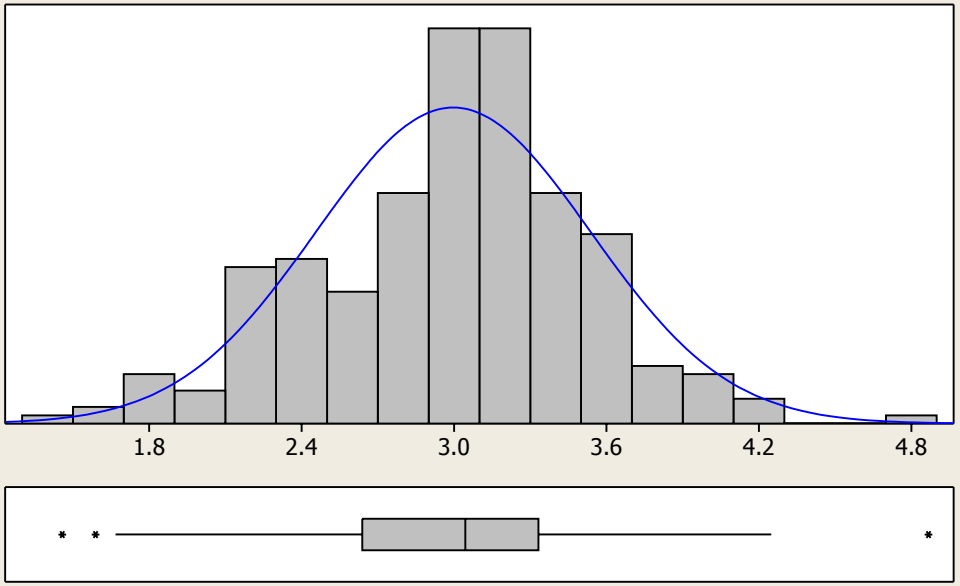

Boxplot of Arsenic by SubSet - Outliers Excluded
Arsenic
70
60
50
40
30
20
10
0
NobisT3
NobisT4
Random
SSI
SubSet

ATTACHMENT C

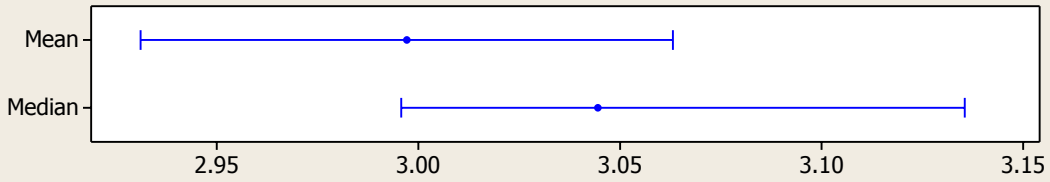
HYPOTHESIS TESTING – BACKGROUND VERSUS STUDY AREA DATA SETS

Summary for ln_Arsenic

DataSet = SA



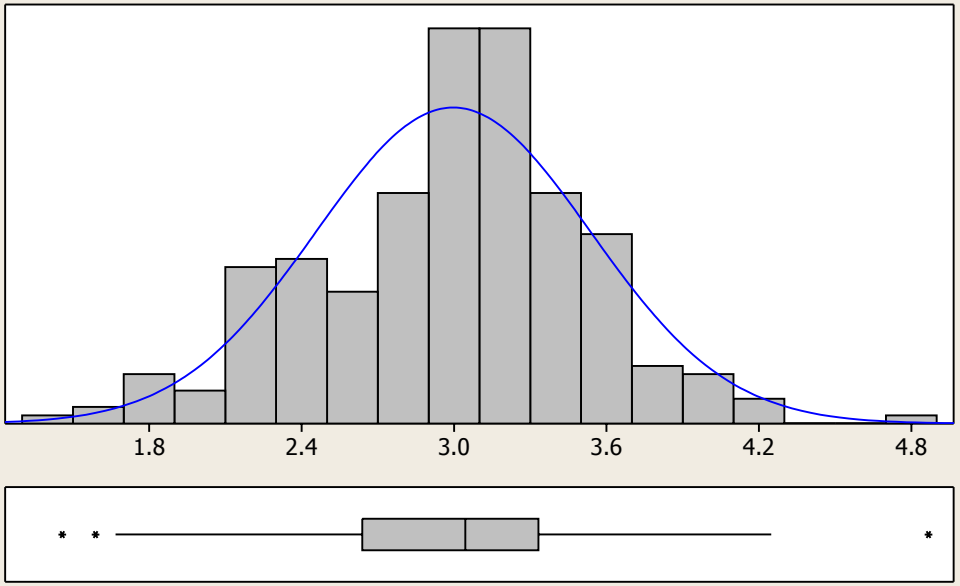
95% Confidence Intervals



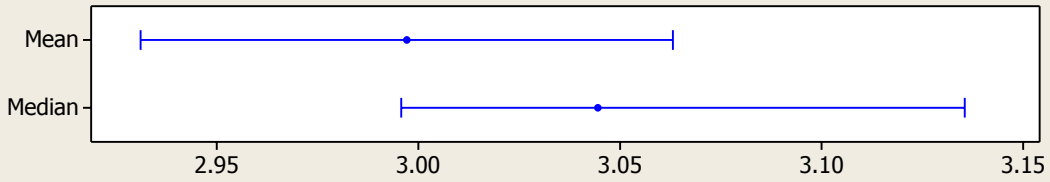
Anderson-Darling Normality Test	
A-Squared	1.78
P-Value <	0.005
Mean	2.9971
StDev	0.5405
Variance	0.2922
Skewness	-0.233991
Kurtosis	0.288436
N	260
Minimum	1.4586
1st Quartile	2.6391
Median	3.0445
3rd Quartile	3.3322
Maximum	4.8675
95% Confidence Interval for Mean	
2.9311	3.0631
95% Confidence Interval for Median	
2.9957	3.1355
95% Confidence Interval for StDev	
0.4977	0.5914

Summary for ln_Arsenic

DataSet = SA



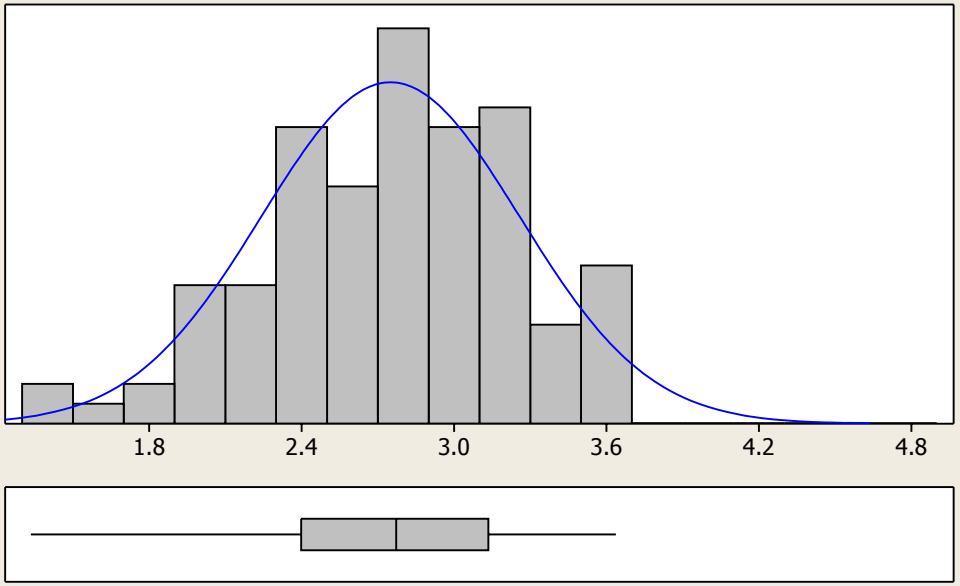
95% Confidence Intervals

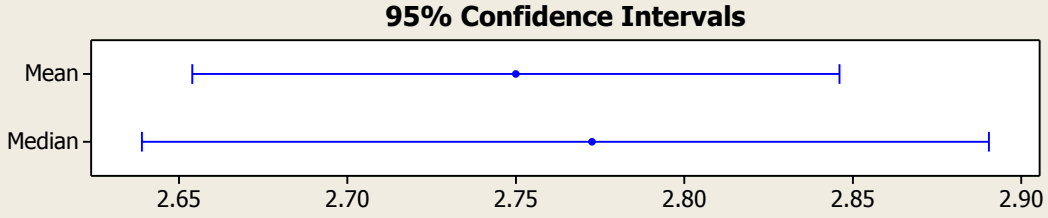


Anderson-Darling Normality Test	
A-Squared	1.78
P-Value <	0.005
Mean	2.9971
StDev	0.5405
Variance	0.2922
Skewness	-0.233991
Kurtosis	0.288436
N	260
Minimum	1.4586
1st Quartile	2.6391
Median	3.0445
3rd Quartile	3.3322
Maximum	4.8675
95% Confidence Interval for Mean	
2.9311	3.0631
95% Confidence Interval for Median	
2.9957	3.1355
95% Confidence Interval for StDev	
0.4977	0.5914

Summary for ln_Arsenic

DataSet = BW

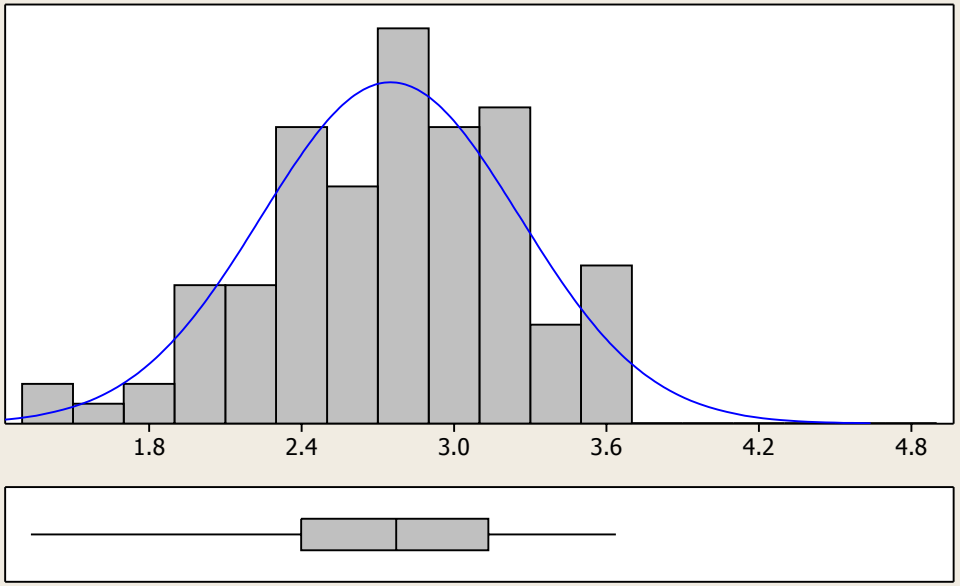


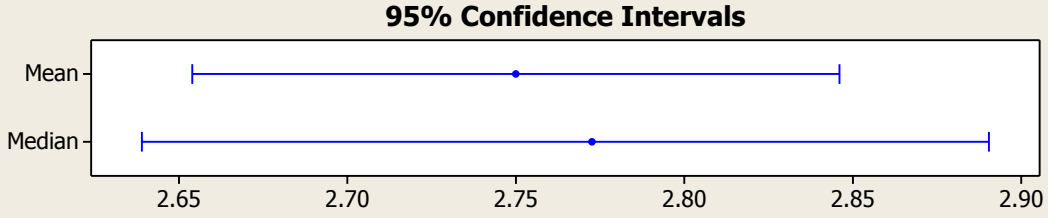


Anderson-Darling Normality Test	
A-Squared	0.45
P-Value	0.278
Mean	2.7500
StDev	0.5081
Variance	0.2582
Skewness	-0.439823
Kurtosis	-0.053939
N	110
Minimum	1.3350
1st Quartile	2.3979
Median	2.7726
3rd Quartile	3.1355
Maximum	3.6376
95% Confidence Interval for Mean	
2.6540	2.8460
95% Confidence Interval for Median	
2.6391	2.8904
95% Confidence Interval for StDev	
0.4487	0.5858

Summary for ln_Arsenic

DataSet = BW

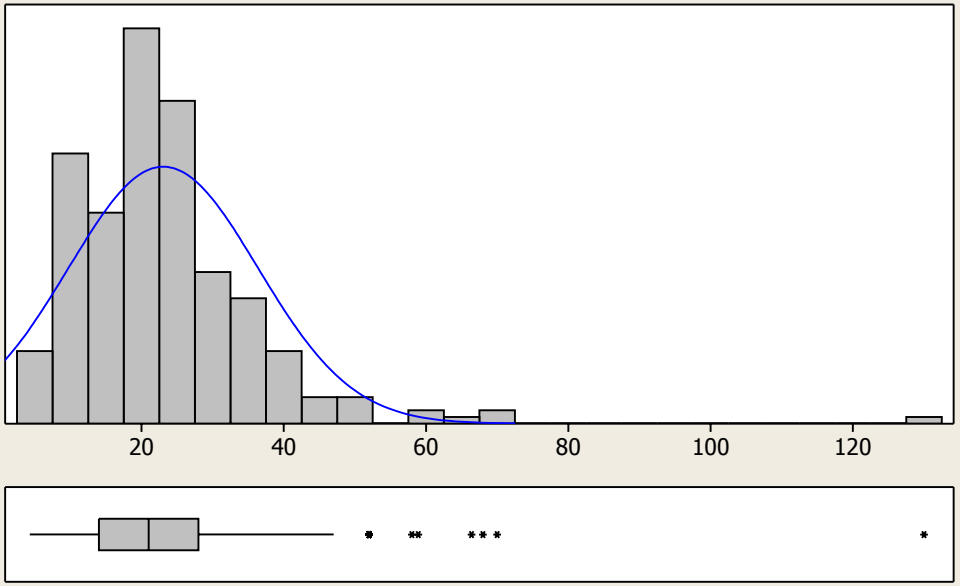


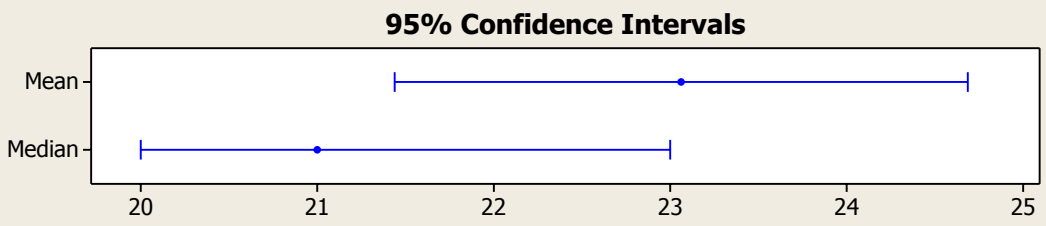


Anderson-Darling Normality Test	
A-Squared	0.45
P-Value	0.278
Mean	2.7500
StDev	0.5081
Variance	0.2582
Skewness	-0.439823
Kurtosis	-0.053939
N	110
Minimum	1.3350
1st Quartile	2.3979
Median	2.7726
3rd Quartile	3.1355
Maximum	3.6376
95% Confidence Interval for Mean	
2.6540	2.8460
95% Confidence Interval for Median	
2.6391	2.8904
95% Confidence Interval for StDev	
0.4487	0.5858

Summary for Arsenic

DataSet = SA

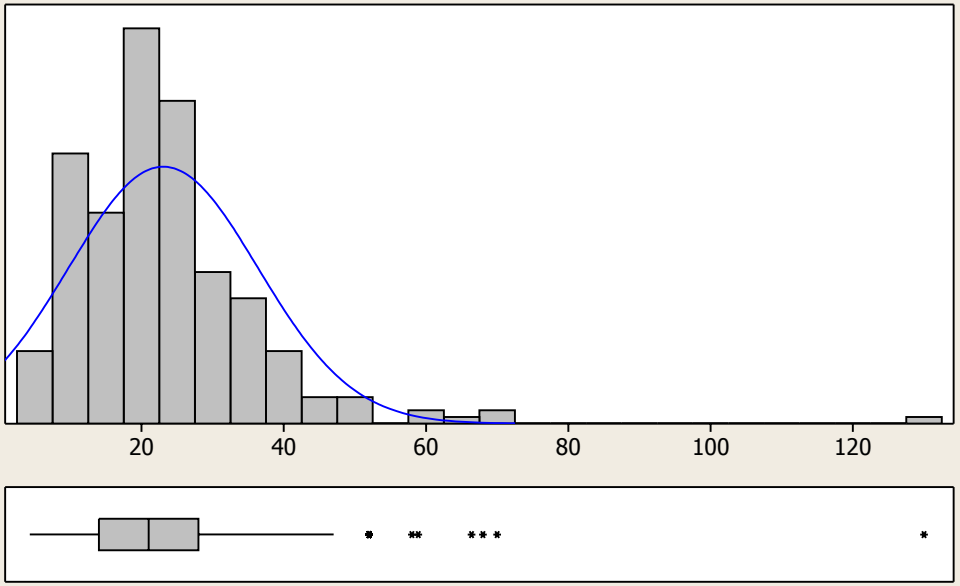


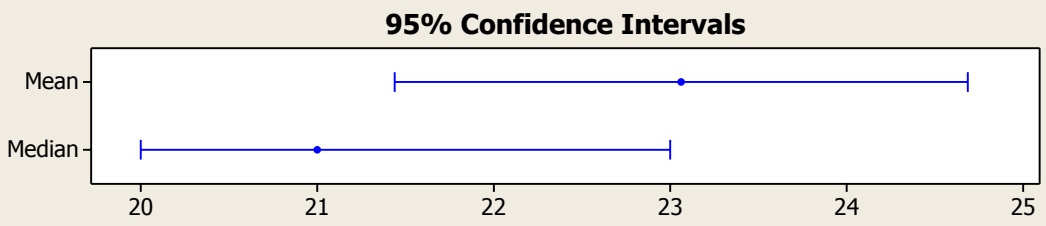


Anderson-Darling Normality Test	
A-Squared	6.04
P-Value <	0.005
Mean	23.062
StDev	13.298
Variance	176.828
Skewness	2.7240
Kurtosis	16.4206
N	260
Minimum	4.300
1st Quartile	14.000
Median	21.000
3rd Quartile	28.000
Maximum	130.000
95% Confidence Interval for Mean	
21.438	24.686
95% Confidence Interval for Median	
20.000	23.000
95% Confidence Interval for StDev	
12.244	14.551

Summary for Arsenic

DataSet = SA

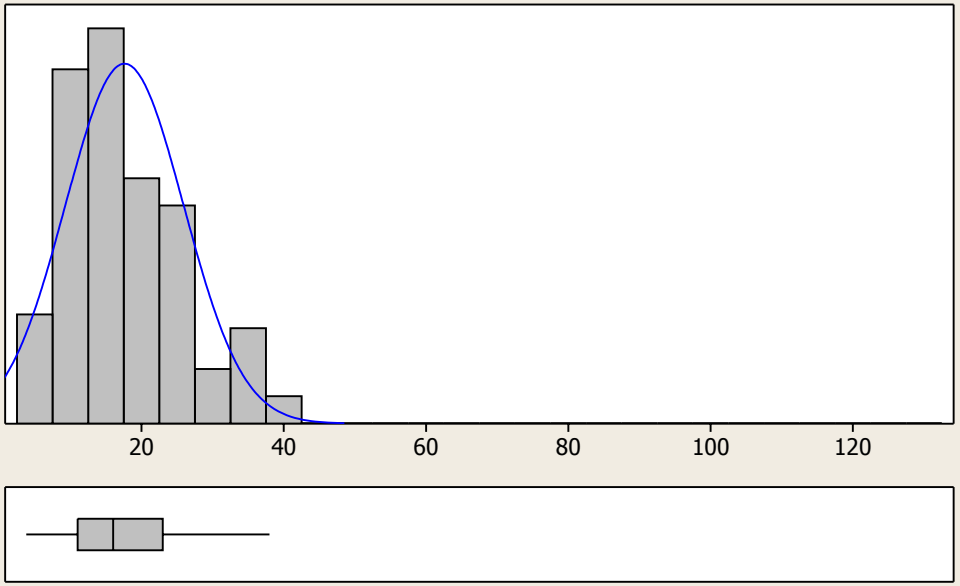


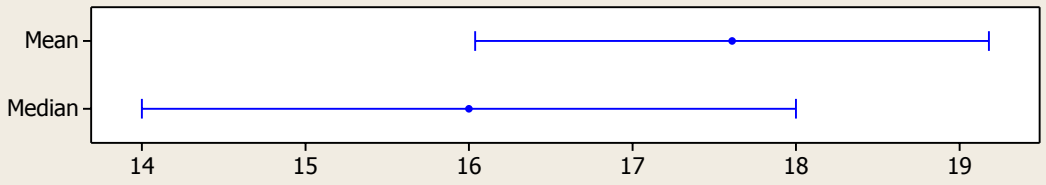


Anderson-Darling Normality Test	
A-Squared	6.04
P-Value <	0.005
Mean	23.062
StDev	13.298
Variance	176.828
Skewness	2.7240
Kurtosis	16.4206
N	260
Minimum	4.300
1st Quartile	14.000
Median	21.000
3rd Quartile	28.000
Maximum	130.000
95% Confidence Interval for Mean	
21.438	24.686
95% Confidence Interval for Median	
20.000	23.000
95% Confidence Interval for StDev	
12.244	14.551

Summary for Arsenic

DataSet = BW

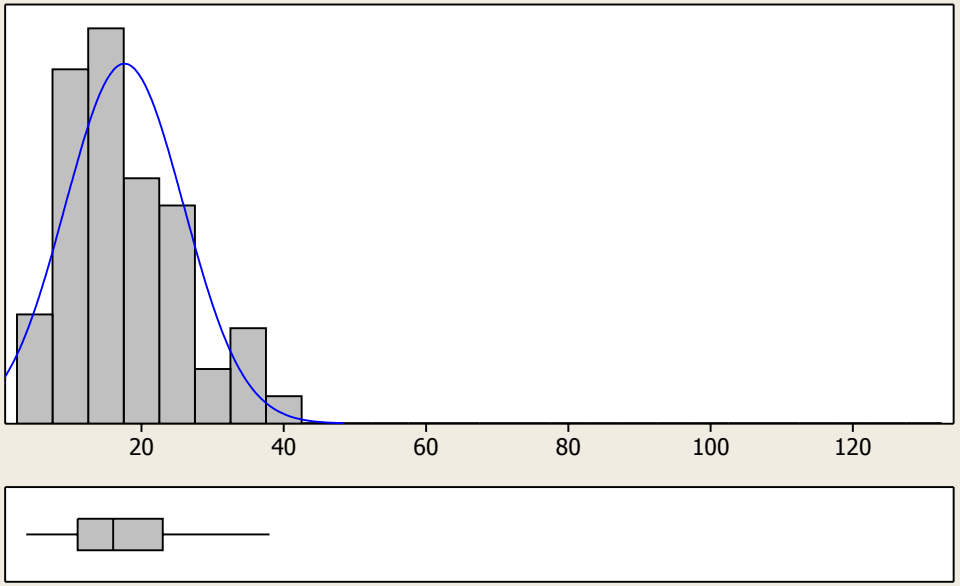


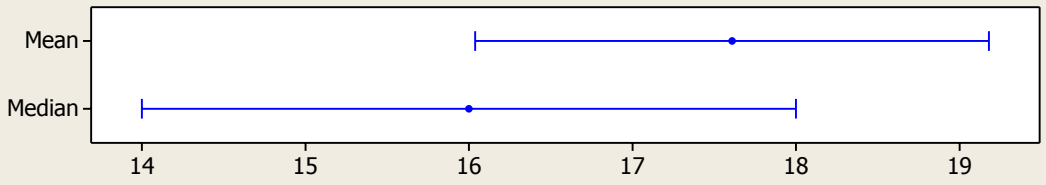


Anderson-Darling Normality Test	
A-Squared	1.41
P-Value <	0.005
Mean	17.609
StDev	8.311
Variance	69.078
Skewness	0.646281
Kurtosis	-0.210988
N	110
Minimum	3.800
1st Quartile	11.000
Median	16.000
3rd Quartile	23.000
Maximum	38.000
95% Confidence Interval for Mean	
16.038	19.180
95% Confidence Interval for Median	
14.000	18.000
95% Confidence Interval for StDev	
7.339	9.582

Summary for Arsenic

DataSet = BW





Anderson-Darling Normality Test	
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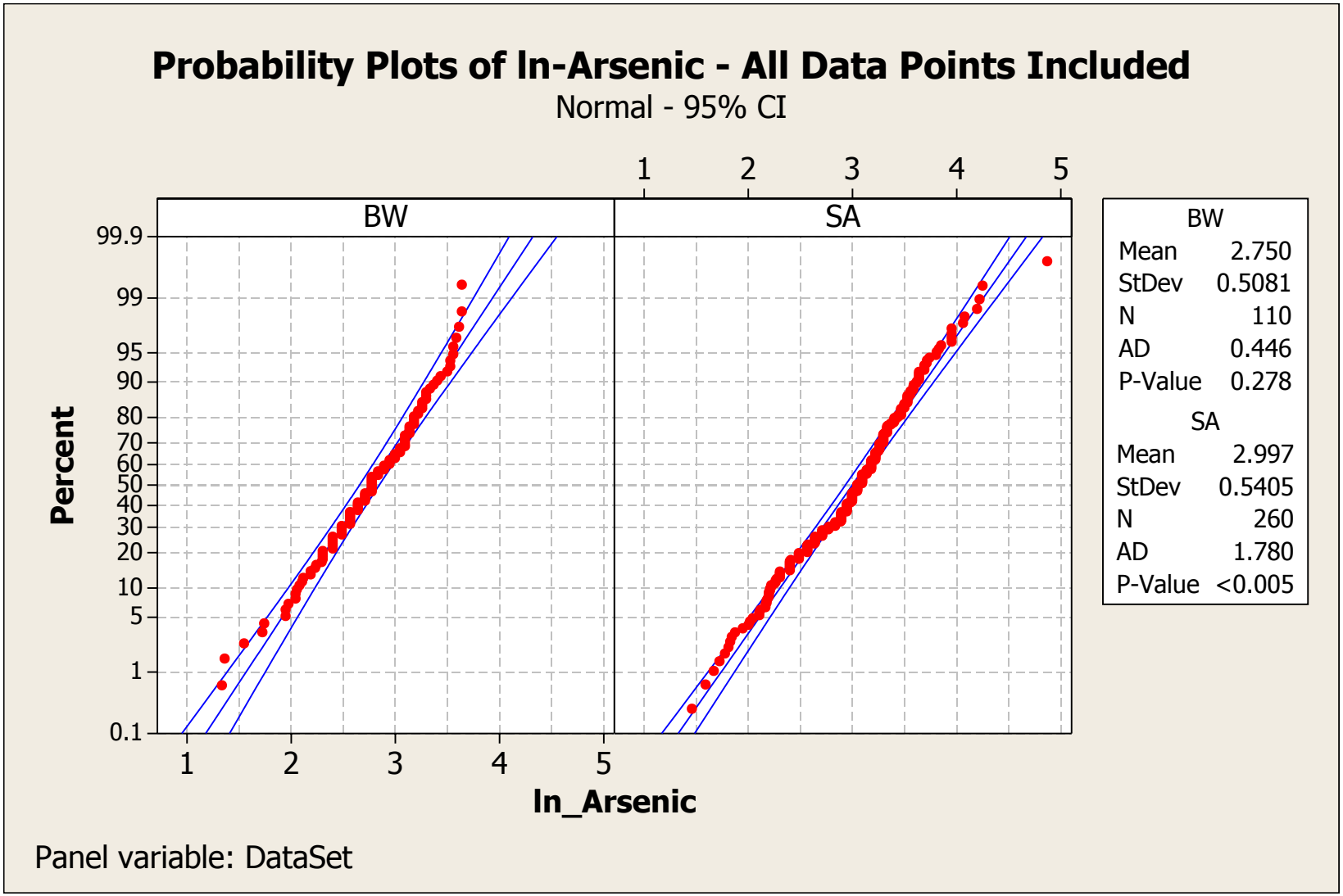
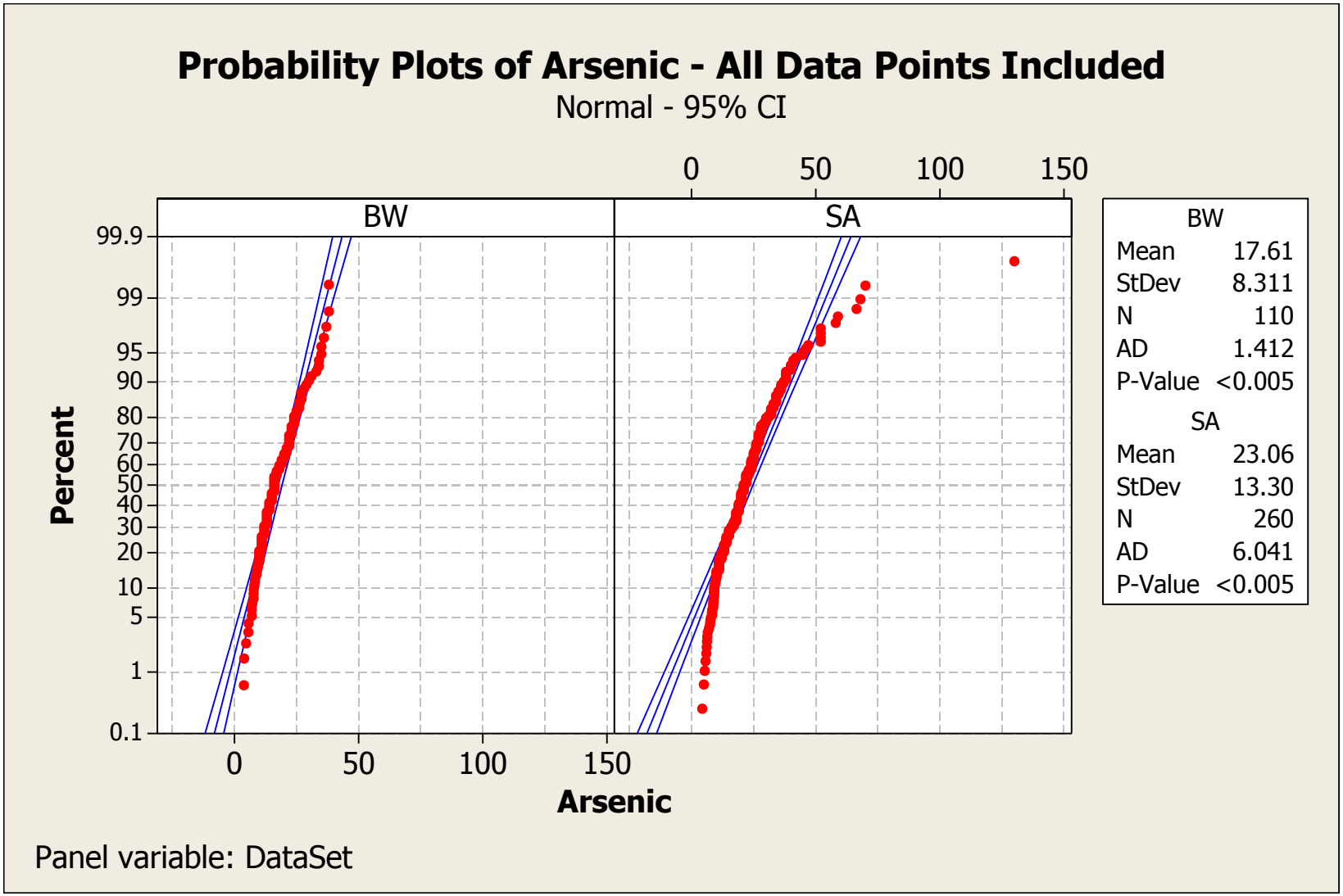
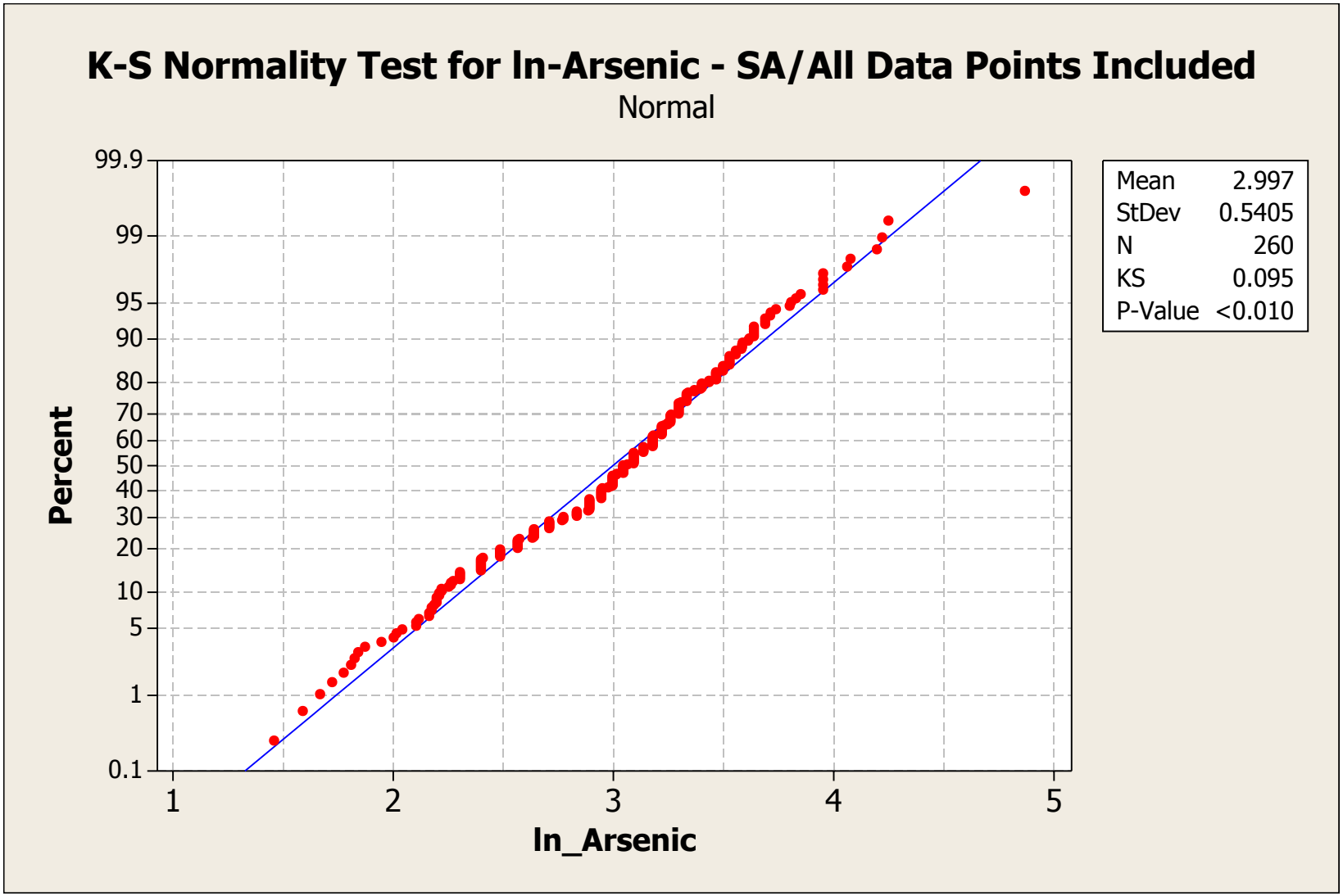
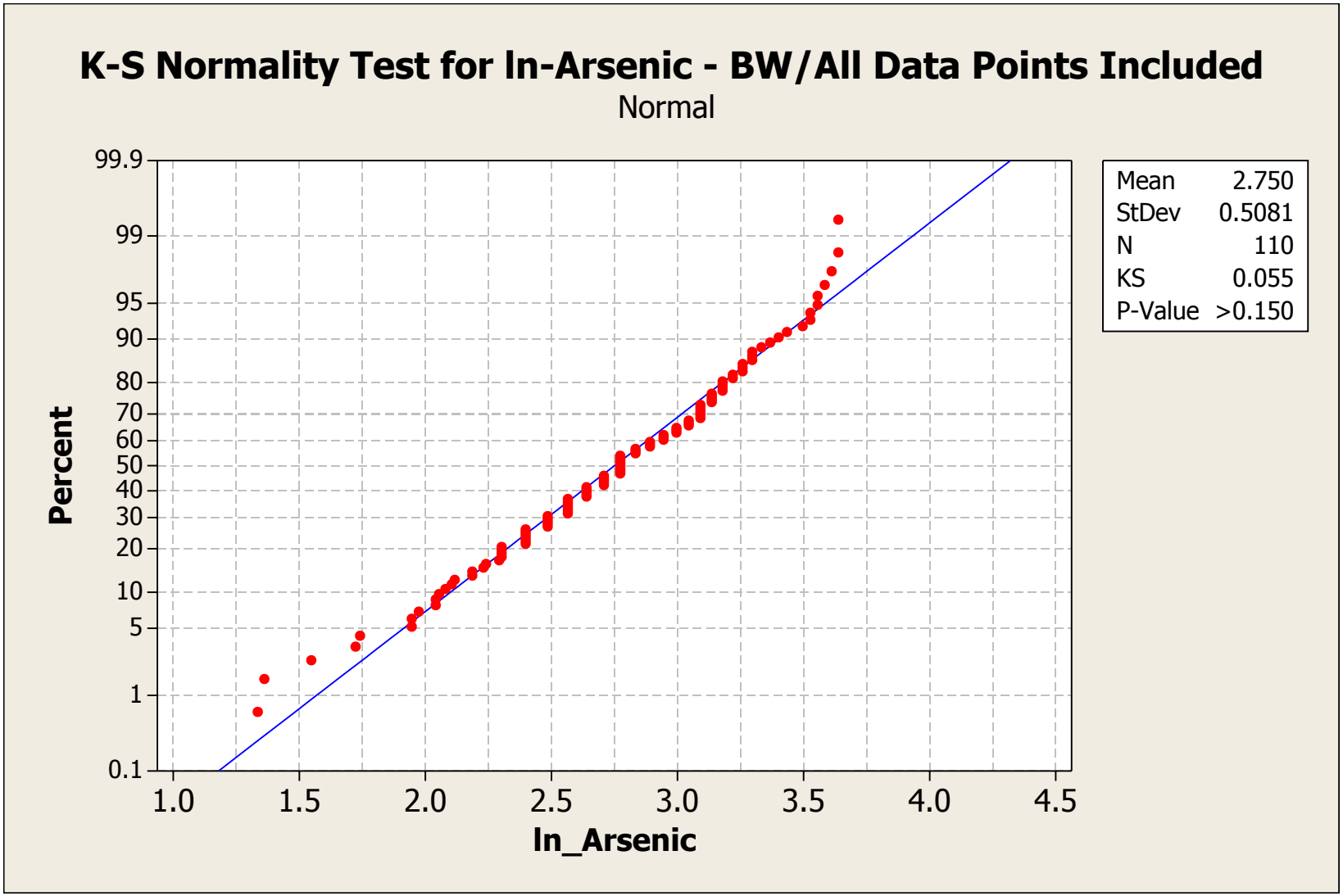
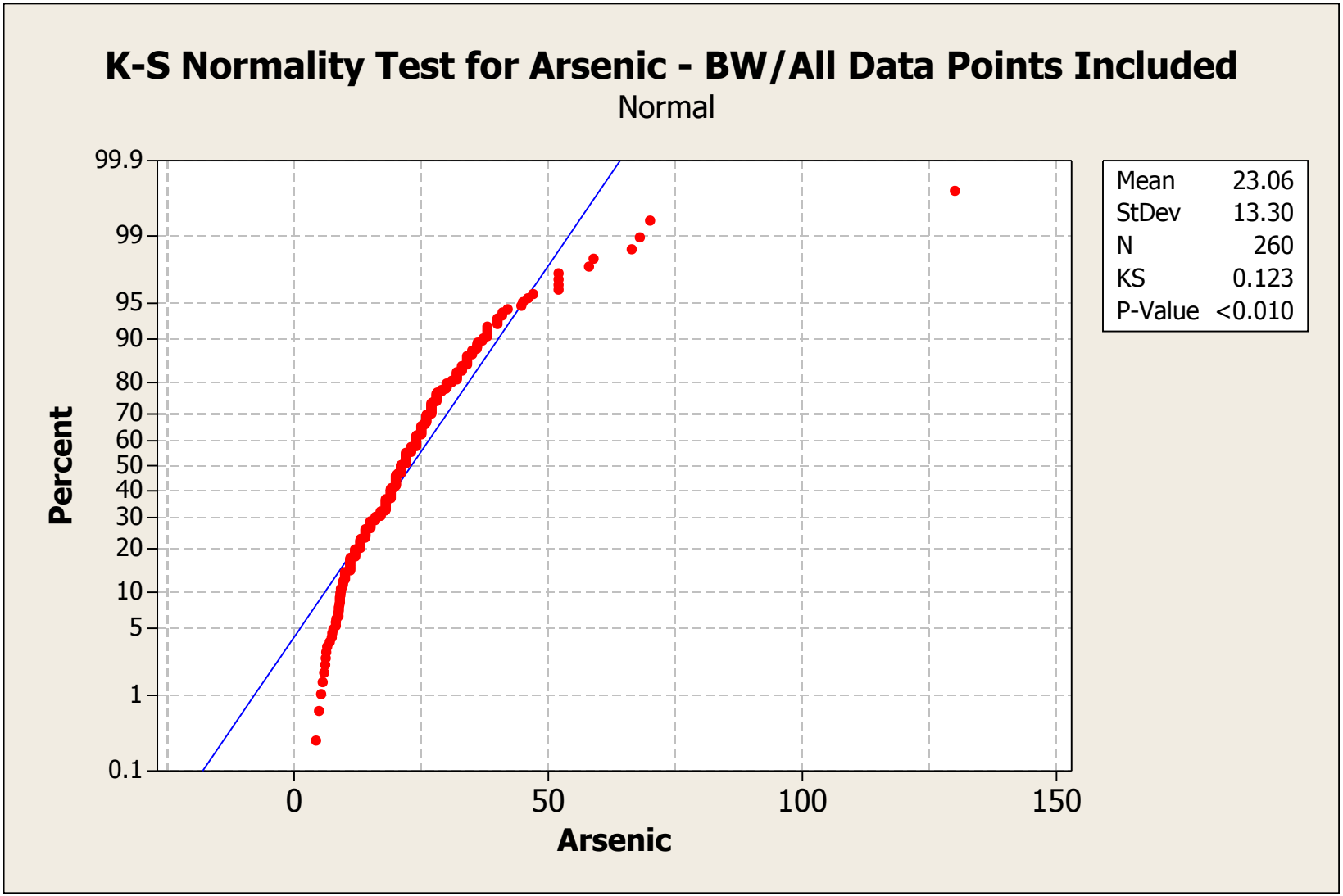
95% Confidence Interval for Mean	
16.038	19.180
95% Confidence Interval for Median	
14.000	18.000
95% Confidence Interval for StDev	
7.339	9.582

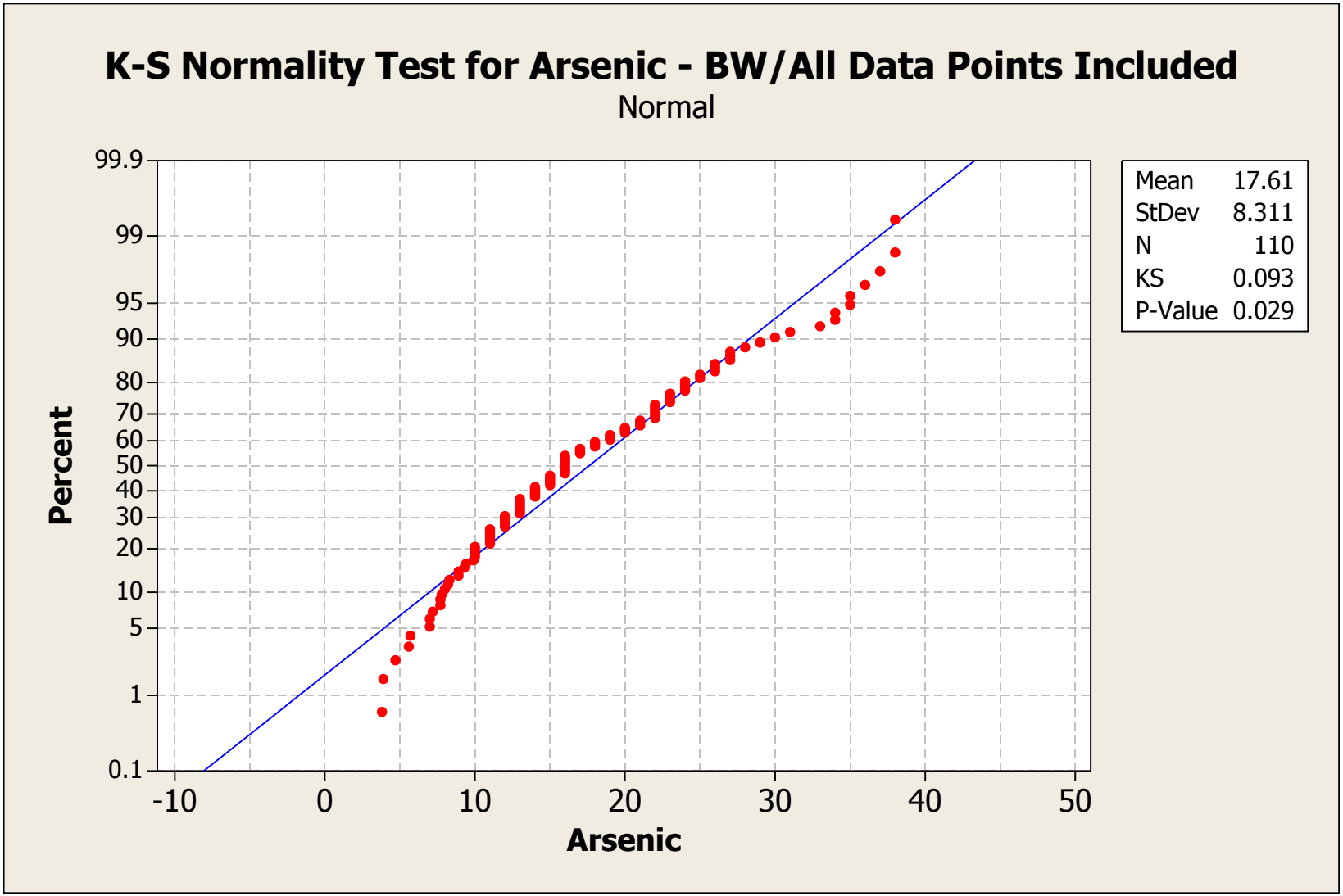

Probability Plots of ln-Arsenic - All Data Points Included
Normal - 95% CI
BW
SA
Percent
99.9
99
95
90
80
70
60
50
40
30
20
10
5
1
0.1
1
2
3
4
5
ln_Arsenic
BW
Mean 2.750
StDev 0.5081
N 110
AD 0.446
P-Value 0.278
SA
Mean 2.997
StDev 0.5405
N 260
AD 1.780
P-Value <0.005
Panel variable: DataSet

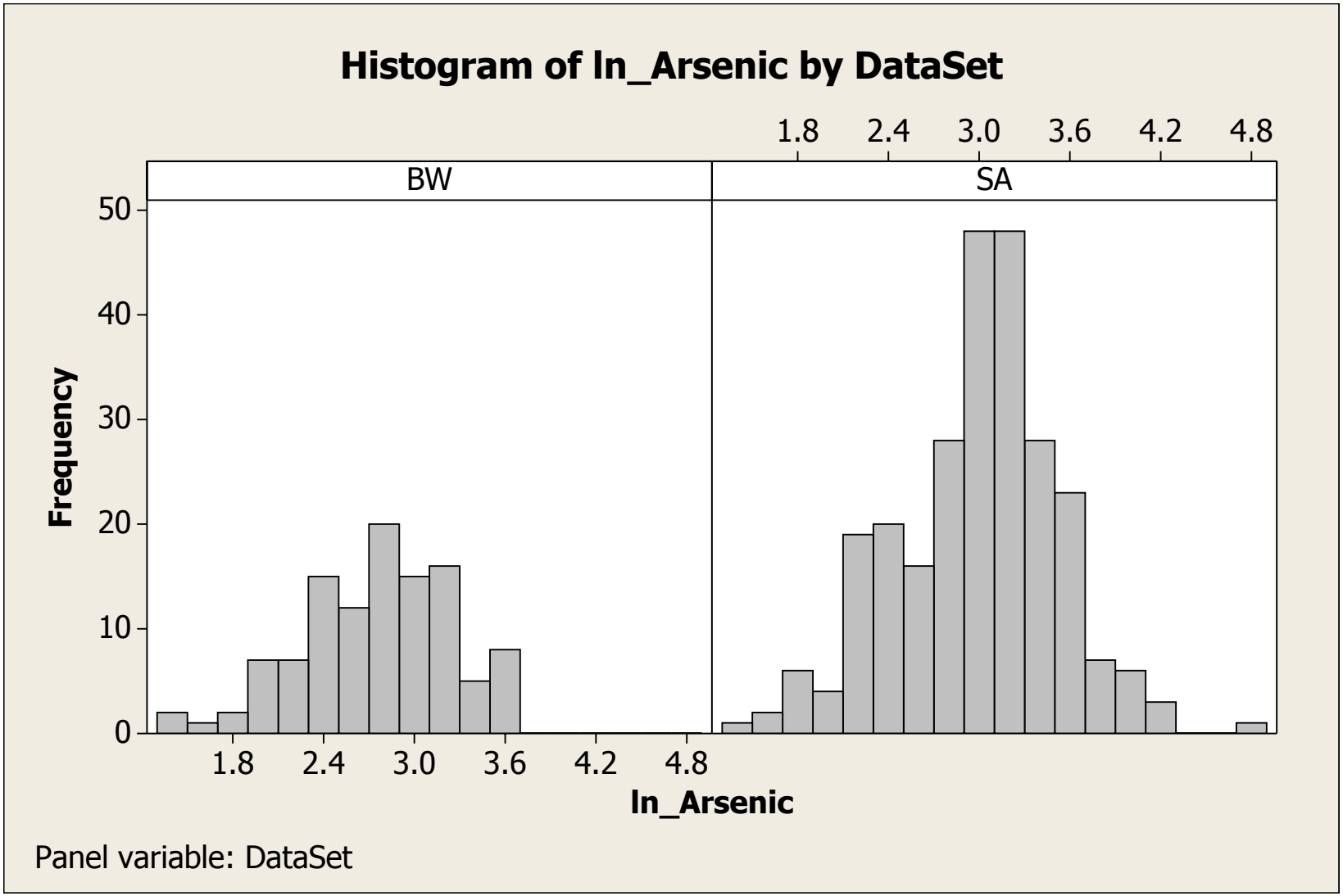

Probability Plots of Arsenic - All Data Points Included
Normal - 95% CI
BW
SA
Percent
99.9
99
95
90
80
70
60
50
40
30
20
10
5
1
0.1
0
50
100
150
Arsenic
BW
Mean 17.61
StDev 8.311
N 110
AD 1.412
P-Value <0.005
SA
Mean 23.06
StDev 13.30
N 260
AD 6.041
P-Value <0.005
Panel variable: DataSet

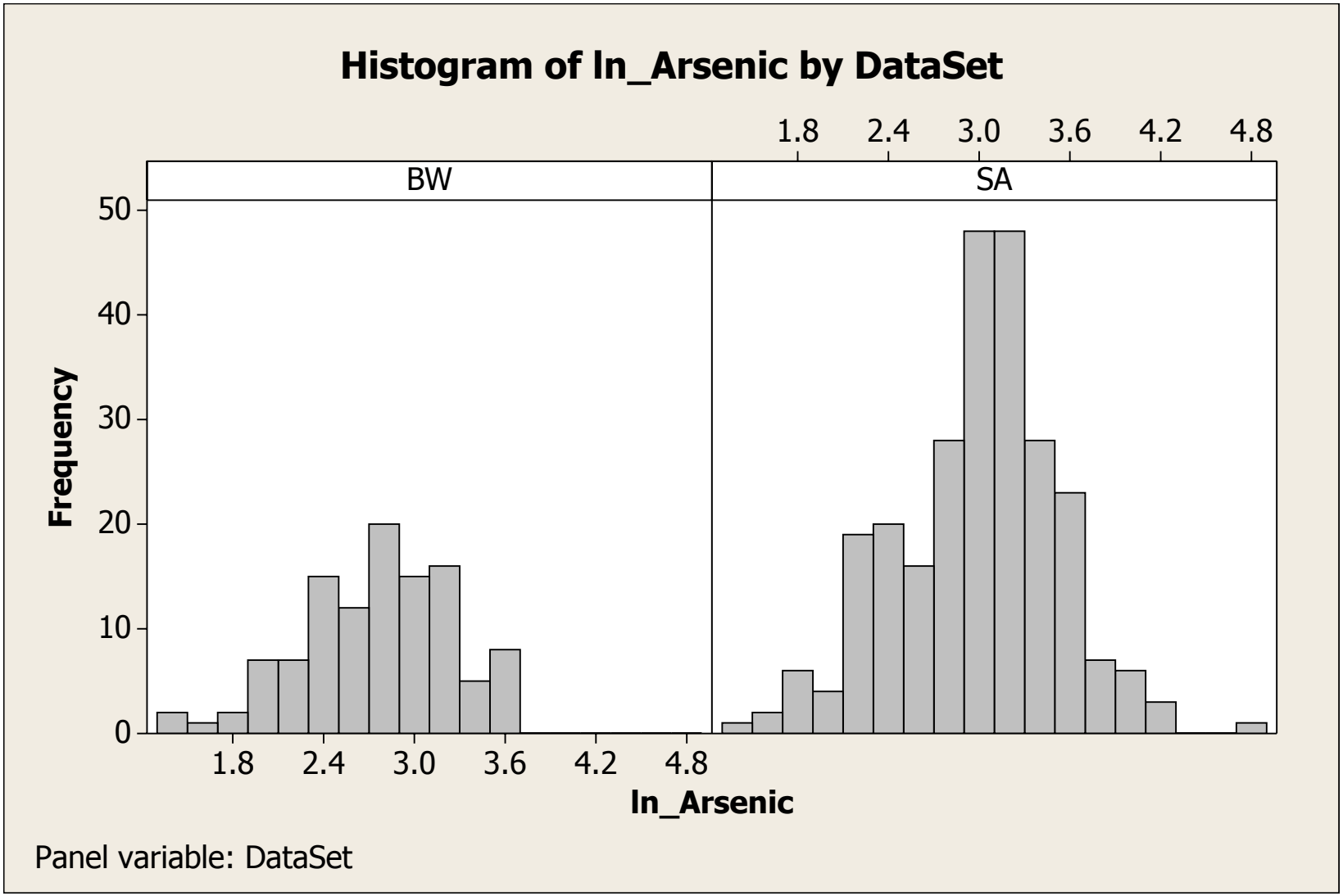

K-S Normality Test for ln-Arsenic - SA/All Data Points Included
Normal
Percent
99.9
99
95
90
80
70
60
50
40
30
20
10
5
1
0.1
1
2
3
4
5
ln_Arsenic
Mean 2.997
StDev 0.5405
N 260
KS 0.095
P-Value <0.010

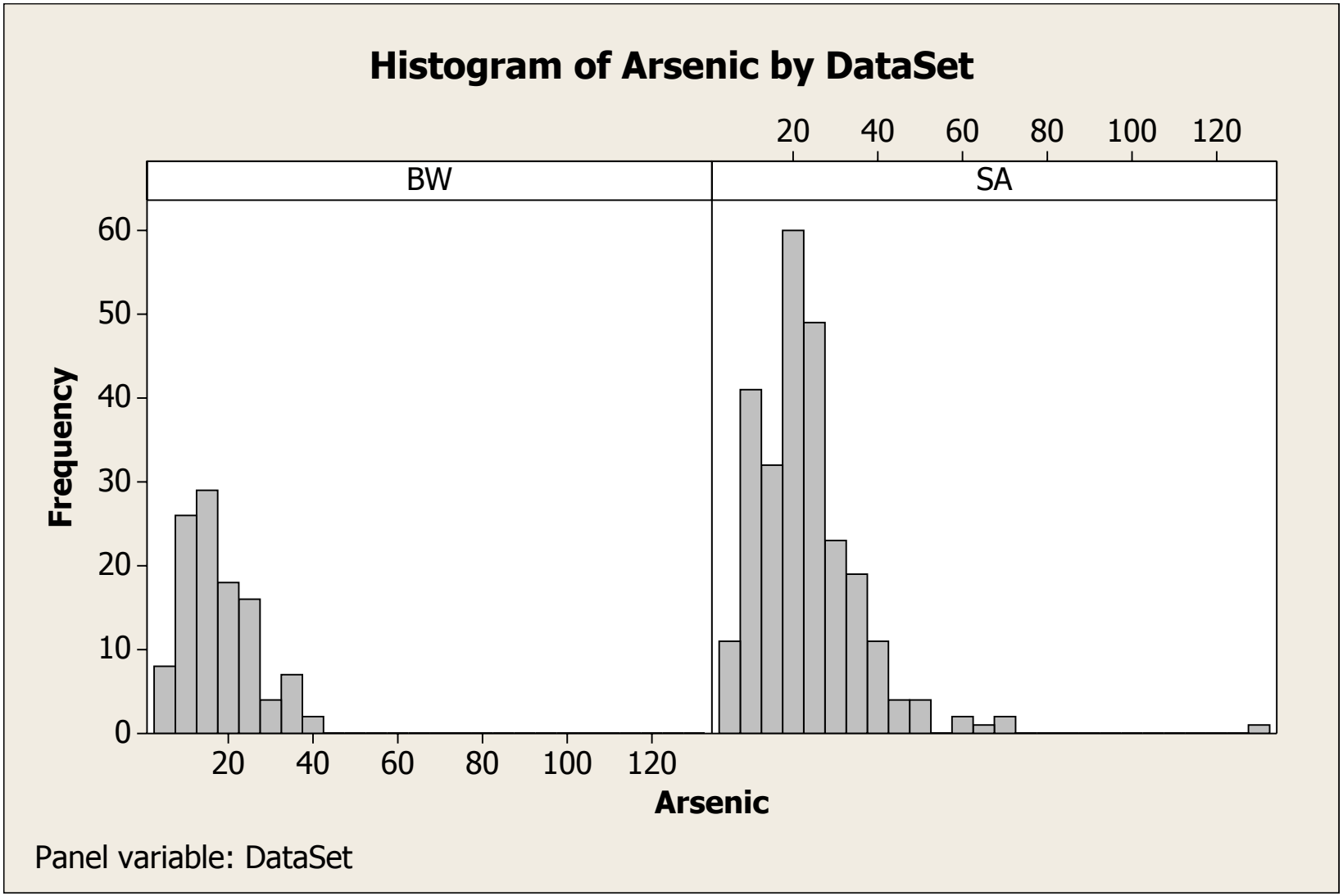

K-S Normality Test for ln-Arsenic - BW/All Data Points Included
Normal
Percent
99.9
99
95
90
80
70
60
50
40
30
20
10
5
1
0.1
1.0
1.5
2.0
2.5
3.0
3.5
4.0
4.5
ln_Arsenic
Mean 2.750
StDev 0.5081
N 110
KS 0.055
P-Value >0.150

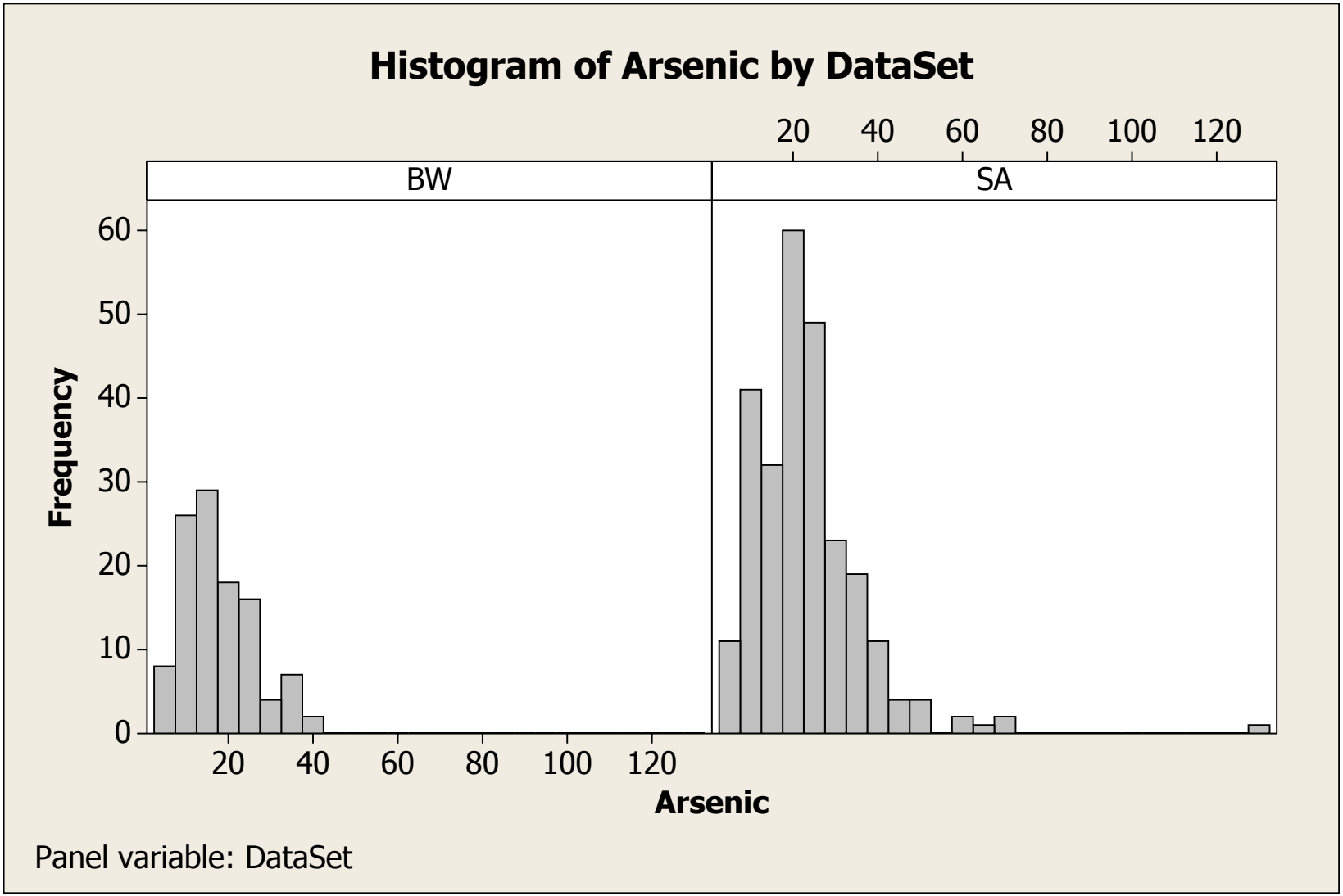

K-S Normality Test for Arsenic - BW/All Data Points Included
Normal
Percent
99.9
99
95
90
80
70
60
50
40
30
20
10
5
1
0.1
0
50
100
150
Arsenic
Mean 23.06
StDev 13.30
N 260
KS 0.123
P-Value <0.010

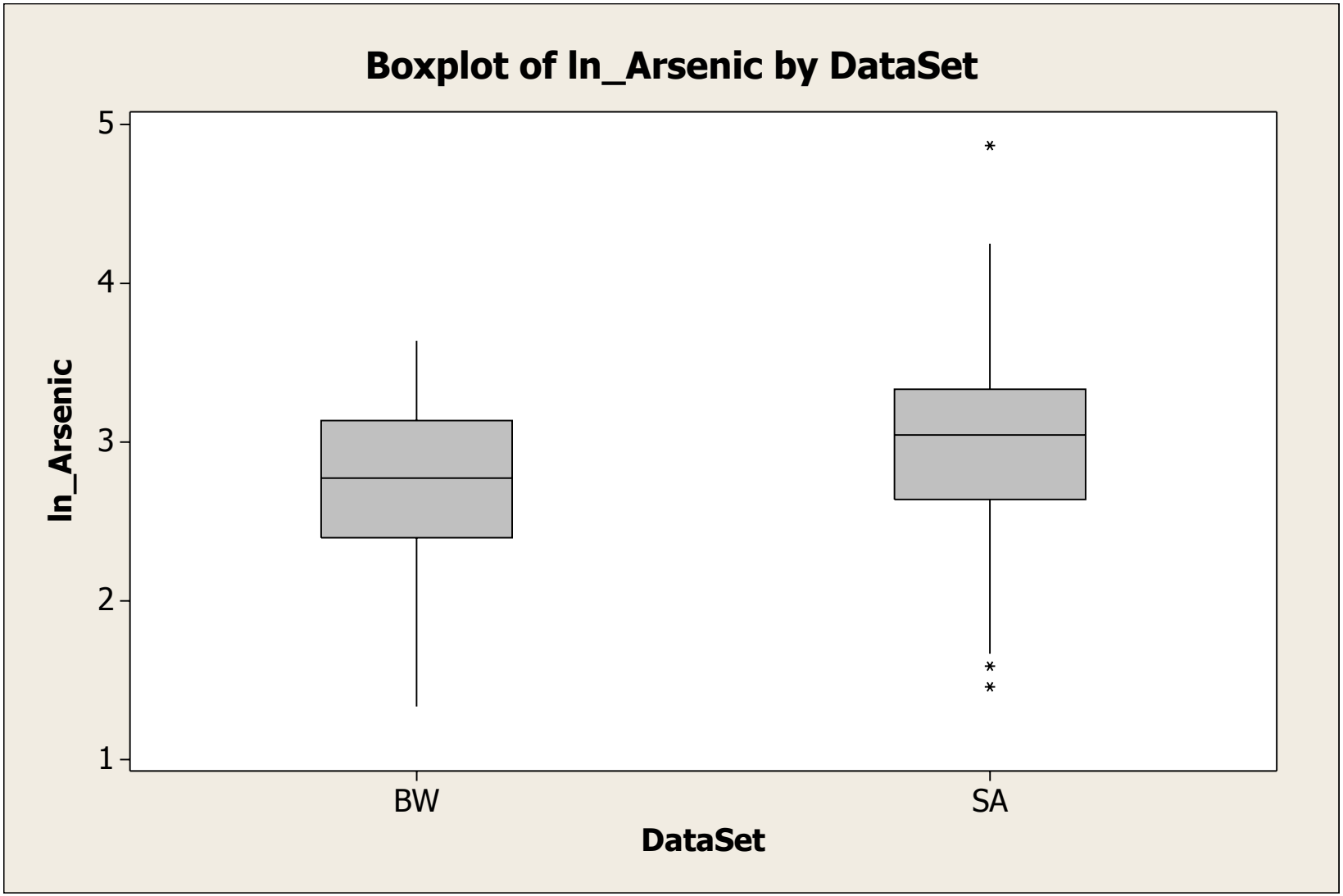

K-S Normality Test for Arsenic - BW/All Data Points Included
Normal
Percent
99.9
99
95
90
80
70
60
50
40
30
20
10
5
1
0.1
-10
0
10
20
30
40
50
Arsenic
Mean 17.61
StDev 8.311
N 110
KS 0.093
P-Value 0.029

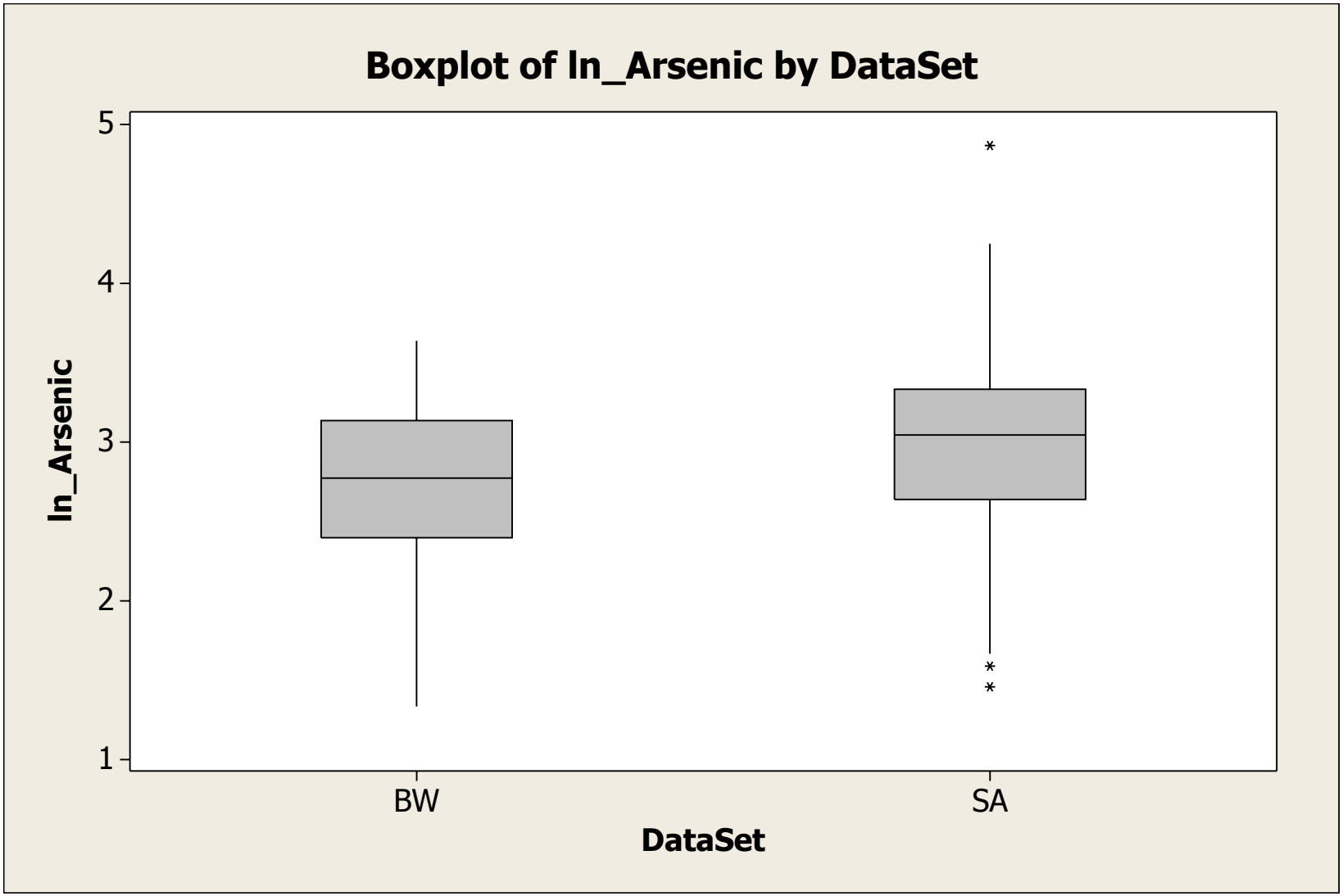

Histogram of ln_Arsenic by DataSet
BW
SA
1.8
2.4
3.0
3.6
4.2
4.8
Frequency
0
10
20
30
40
50
ln_Arsenic
Panel variable: DataSet

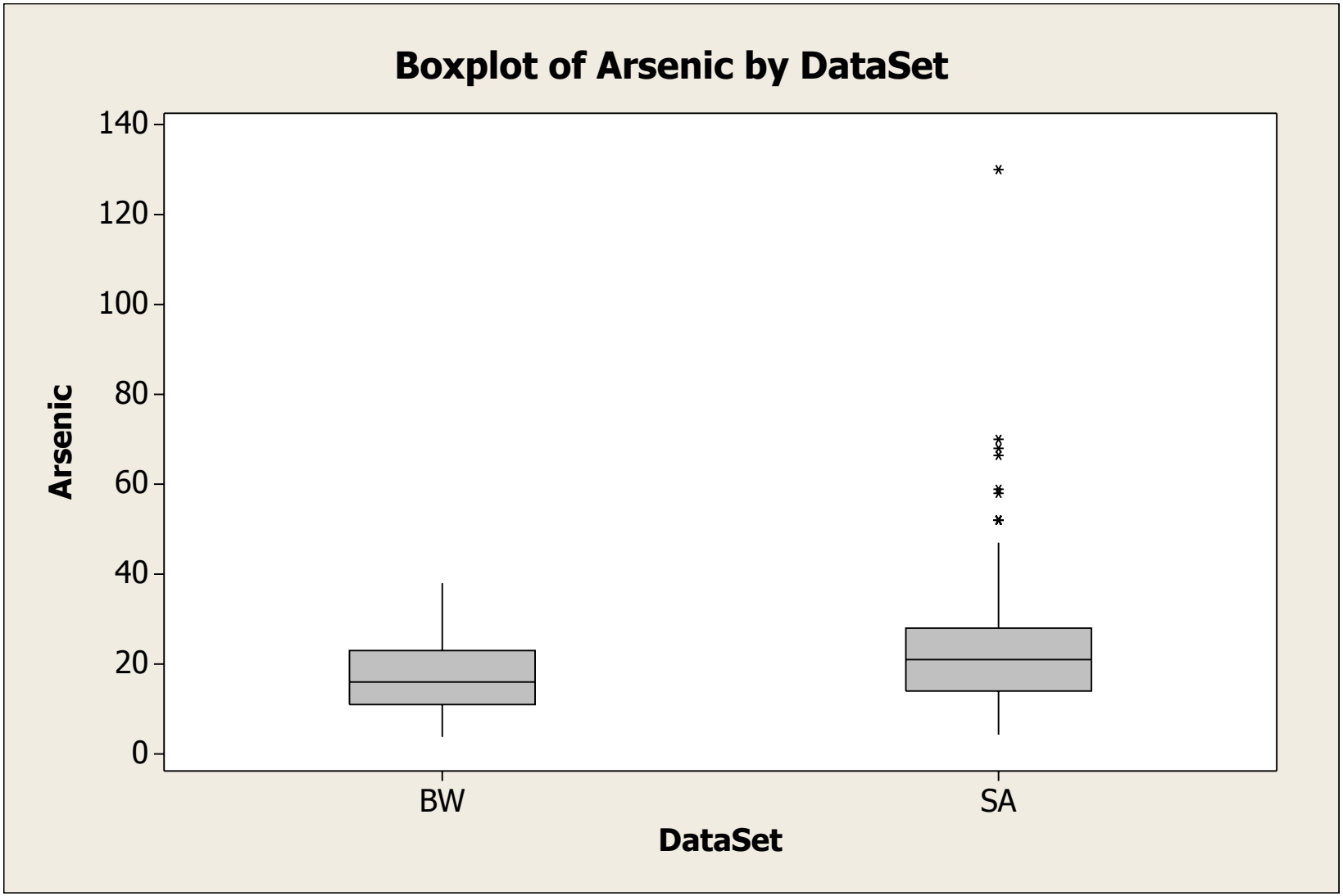

Histogram of ln_Arsenic by DataSet
BW
SA
1.8
2.4
3.0
3.6
4.2
4.8
Frequency
0
10
20
30
40
50
ln_Arsenic
Panel variable: DataSet

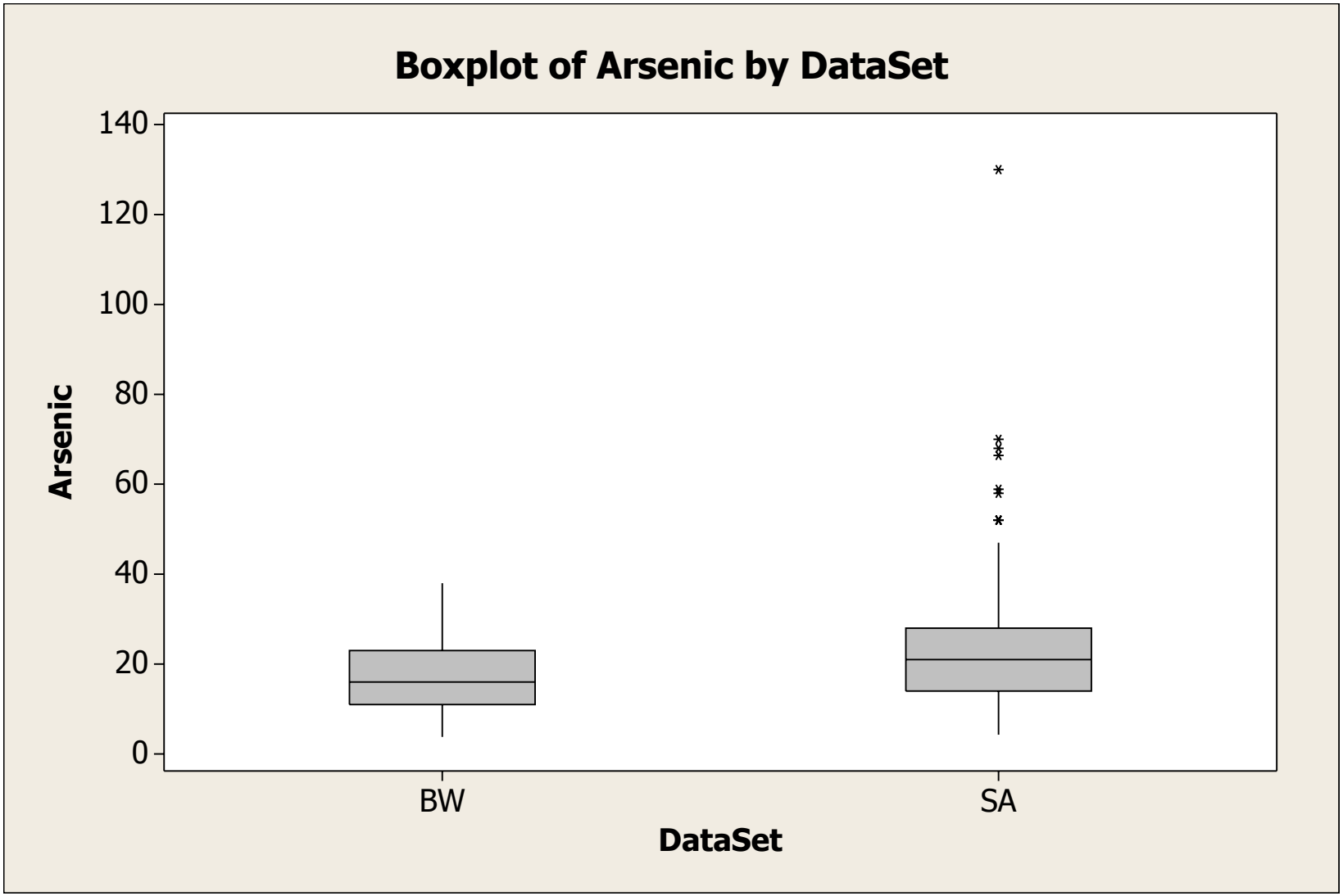

Histogram of Arsenic by DataSet
BW
SA
Frequency
Arsenic
0
10
20
30
40
50
60
20
40
60
80
100
120
Panel variable: DataSet


Histogram of Arsenic by DataSet
BW
SA
Frequency
Arsenic
0
10
20
30
40
50
60
20
40
60
80
100
120
Panel variable: DataSet


Boxplot of ln_Arsenic by DataSet
ln_Arsenic
5
4
3
2
1
BW
SA
DataSet

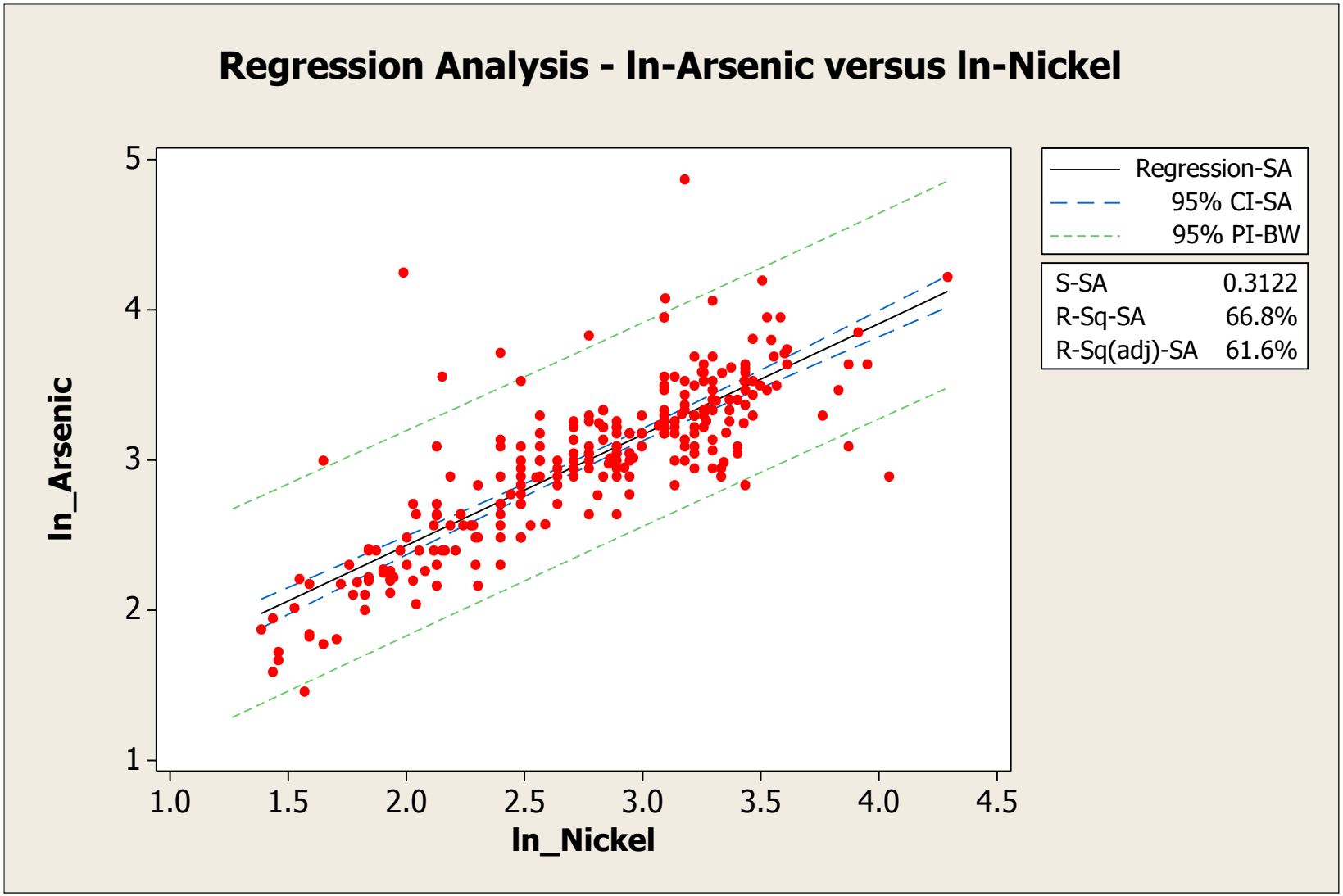

Boxplot of ln_Arsenic by DataSet
ln_Arsenic
5
4
3
2
1
BW
SA
DataSet

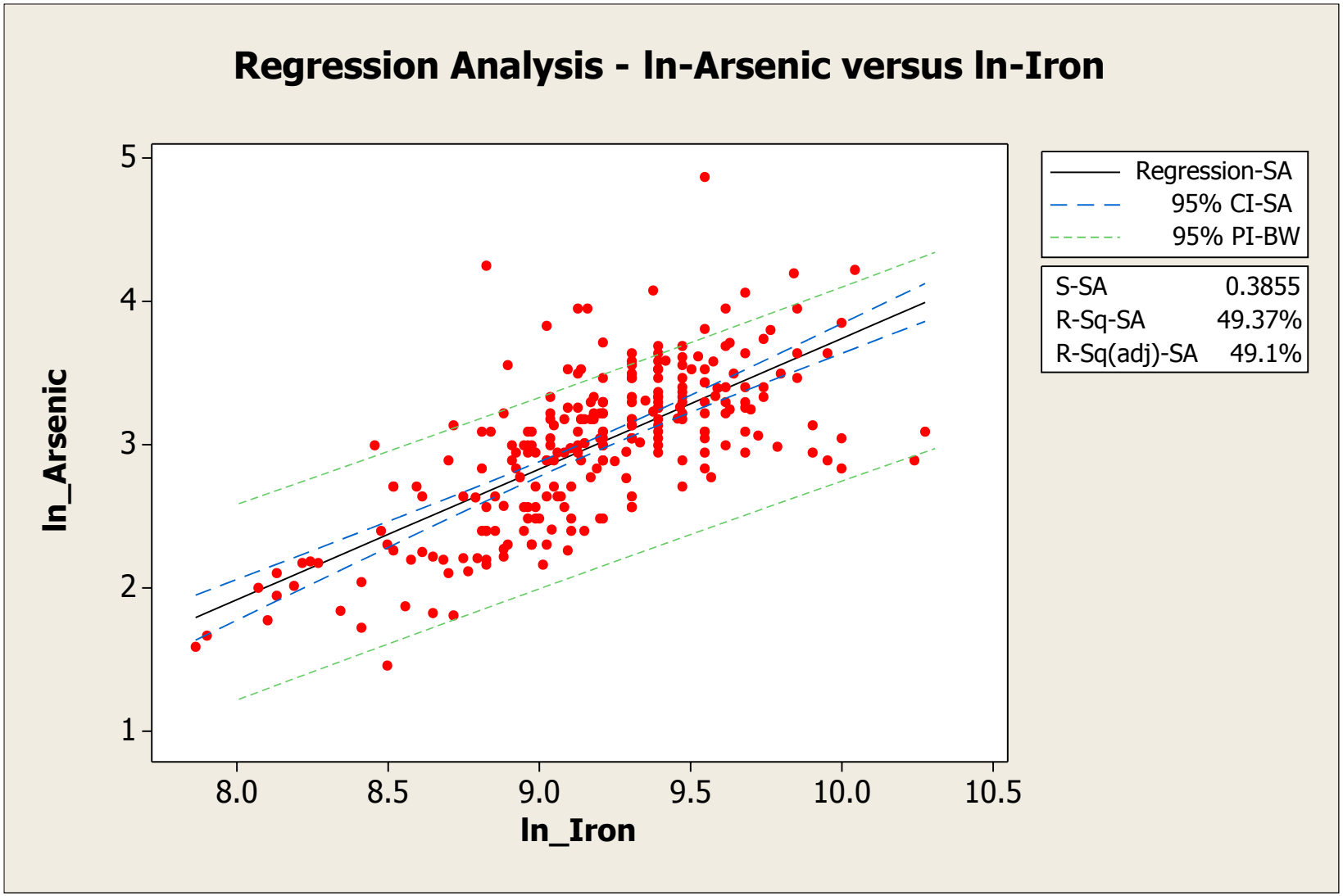

Boxplot of Arsenic by DataSet
Arsenic
140
120
100
80
60
40
20
0
BW
SA
DataSet

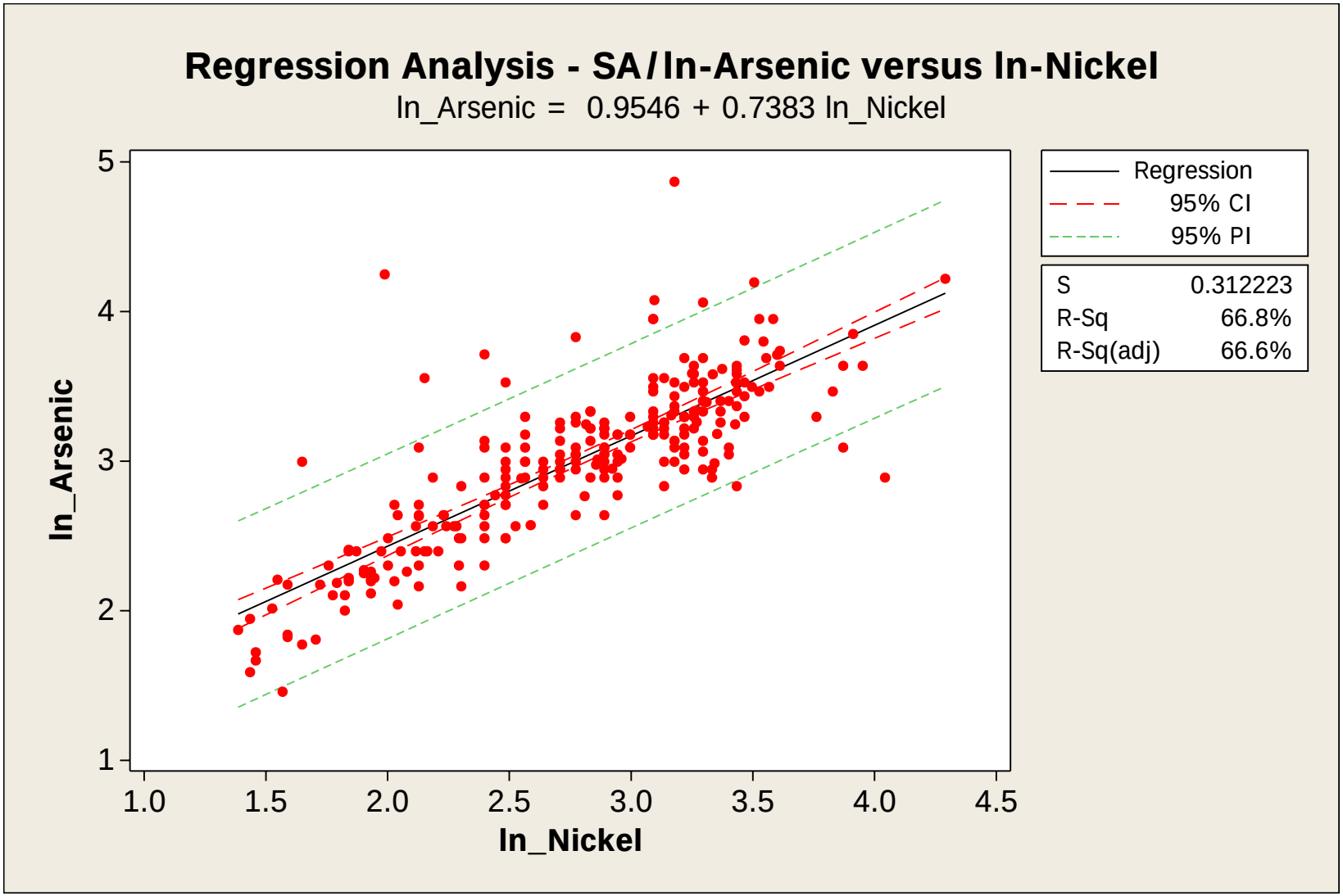

Boxplot of Arsenic by DataSet
Arsenic
140
120
100
80
60
40
20
0
BW
SA
DataSet

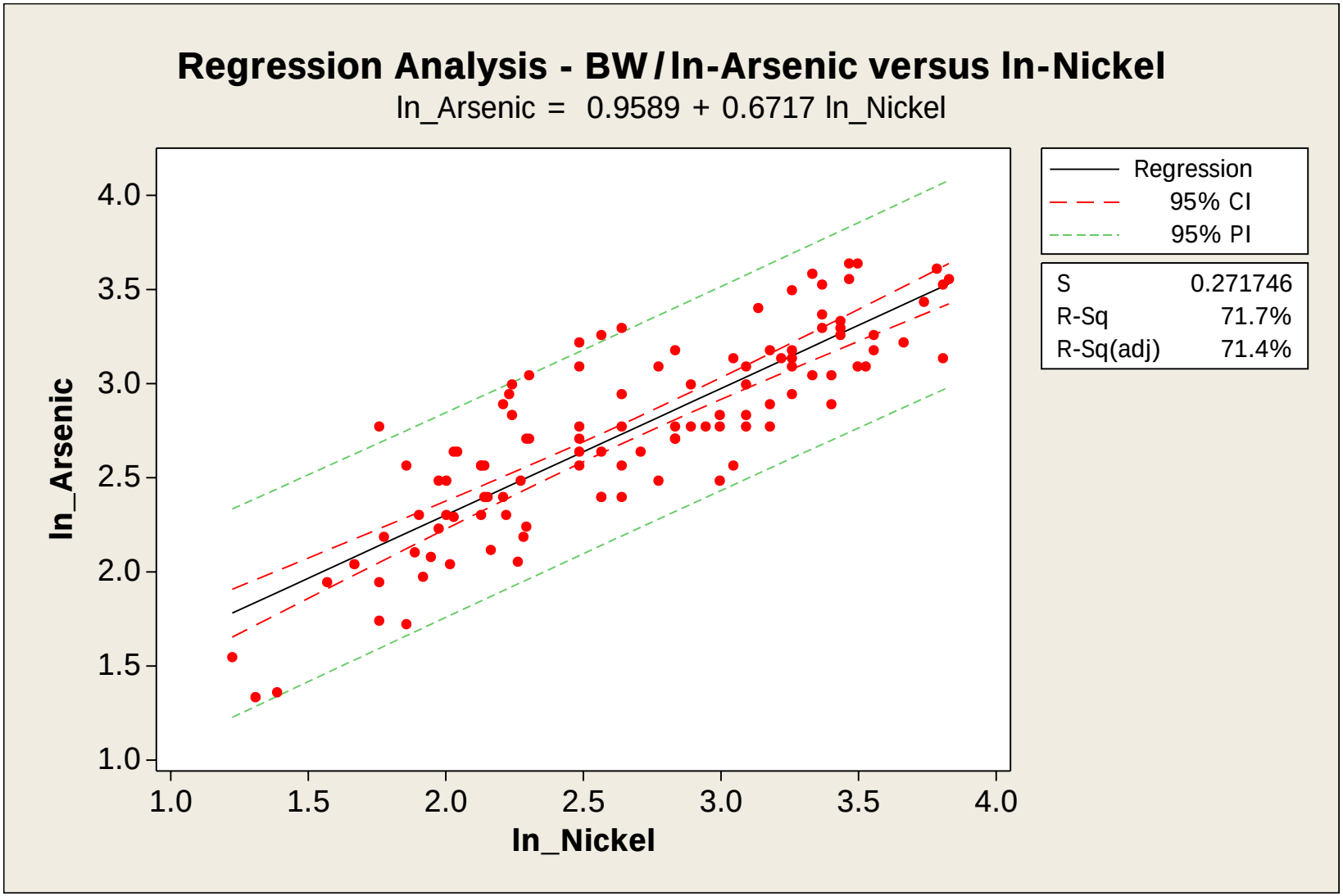
ATTACHMENT D

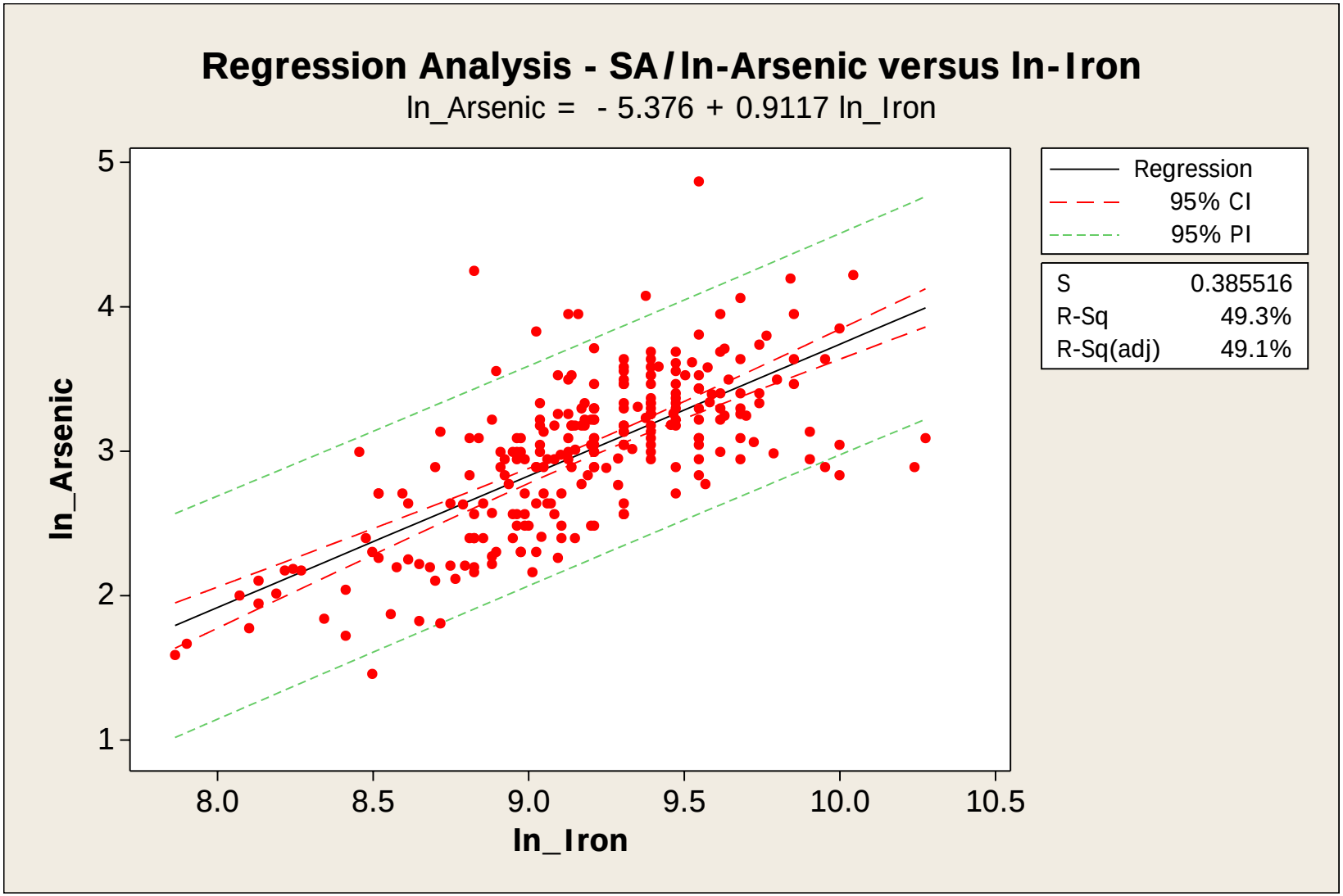
REGRESSION ANALYSIS AND PREDICTION INTERVALS

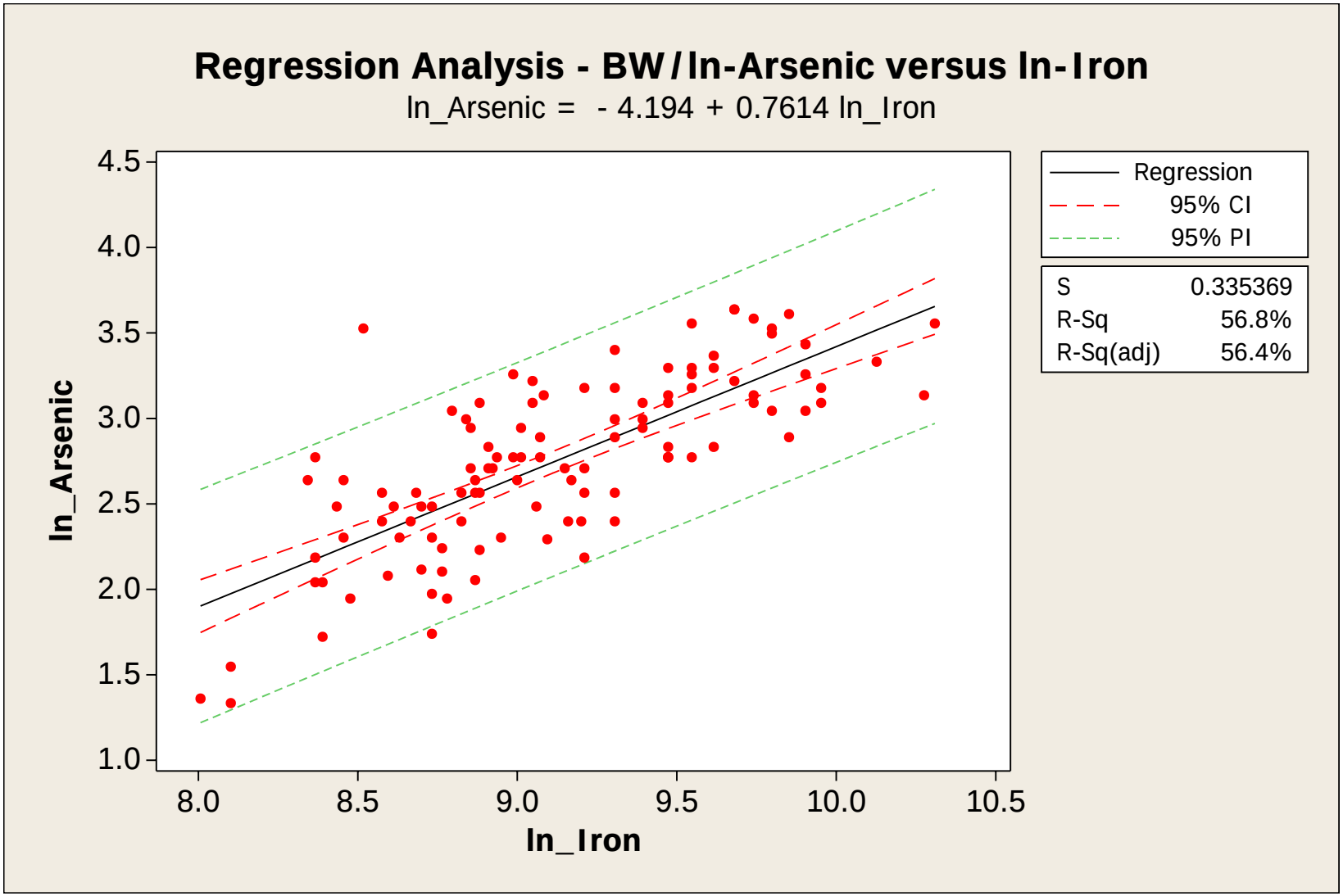

Regression Analysis - ln-Arsenic versus ln-Nickel
ln_Arsenic
ln_Nickel
5
4
3
2
1
1.0
1.5
2.0
2.5
3.0
3.5
4.0
4.5
Regression-SA
95% CI-SA
95% PI-BW
S-SA 0.3122
R-Sq-SA 66.8%
R-Sq(adj)-SA 61.6%


Regression Analysis - ln-Arsenic versus ln-Iron
ln_Arsenic
ln_Iron
5
4
3
2
1
8.0
8.5
9.0
9.5
10.0
10.5
Regression-SA
95% CI-SA
95% PI-BW
S-SA 0.3855
R-Sq-SA 49.37%
R-Sq(adj)-SA 49.1%


Regression Analysis - SA / ln-Arsenic versus ln-Nickel
ln_Arsenic = 0.9546 + 0.7383 ln_Nickel
ln_Arsenic
ln_Nickel
1
2
3
4
5
1.0
1.5
2.0
2.5
3.0
3.5
4.0
4.5
Regression
95% CI
95% PI
S 0.312223
R-Sq 66.8%
R-Sq(adj) 66.6%

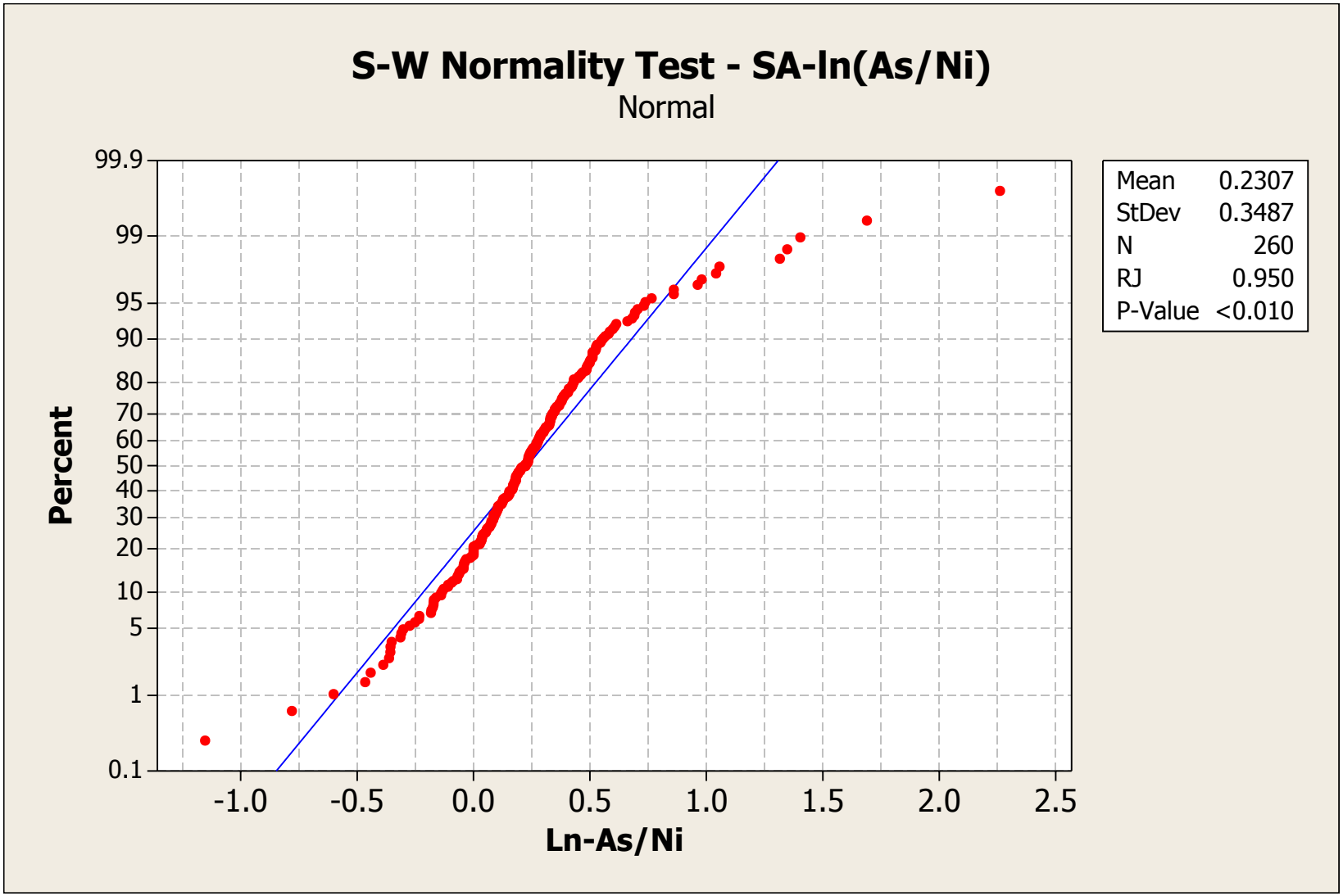

Regression Analysis - BW / ln-Arsenic versus ln-Nickel
ln_Arsenic = 0.9589 + 0.6717 ln_Nickel
Regression
95% CI
95% PI
S 0.271746
R-Sq 71.7%
R-Sq(adj) 71.4%
ln_Arsenic
ln_Nickel
4.0
3.5
3.0
2.5
2.0
1.5
1.0
1.0
1.5
2.0
2.5
3.0
3.5
4.0

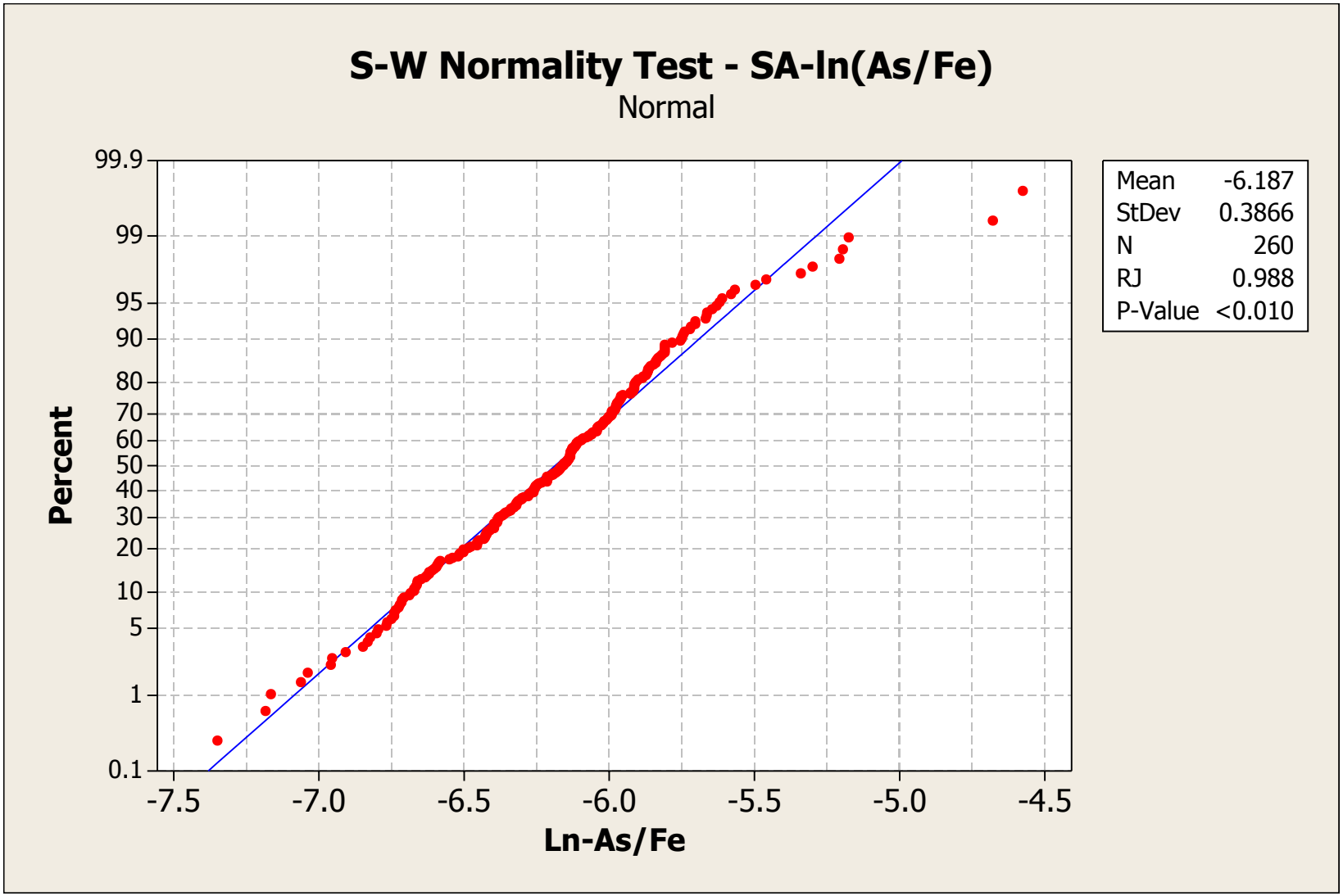

Regression Analysis - SA/In-Arsenic versus In-Iron
ln_Arsenic = - 5.376 + 0.9117 ln_Iron
ln_Arsenic
ln_Iron
5
4
3
2
1
8.0
8.5
9.0
9.5
10.0
10.5
Regression
95% CI
95% PI
S 0.385516
R-Sq 49.3%
R-Sq(adj) 49.1%

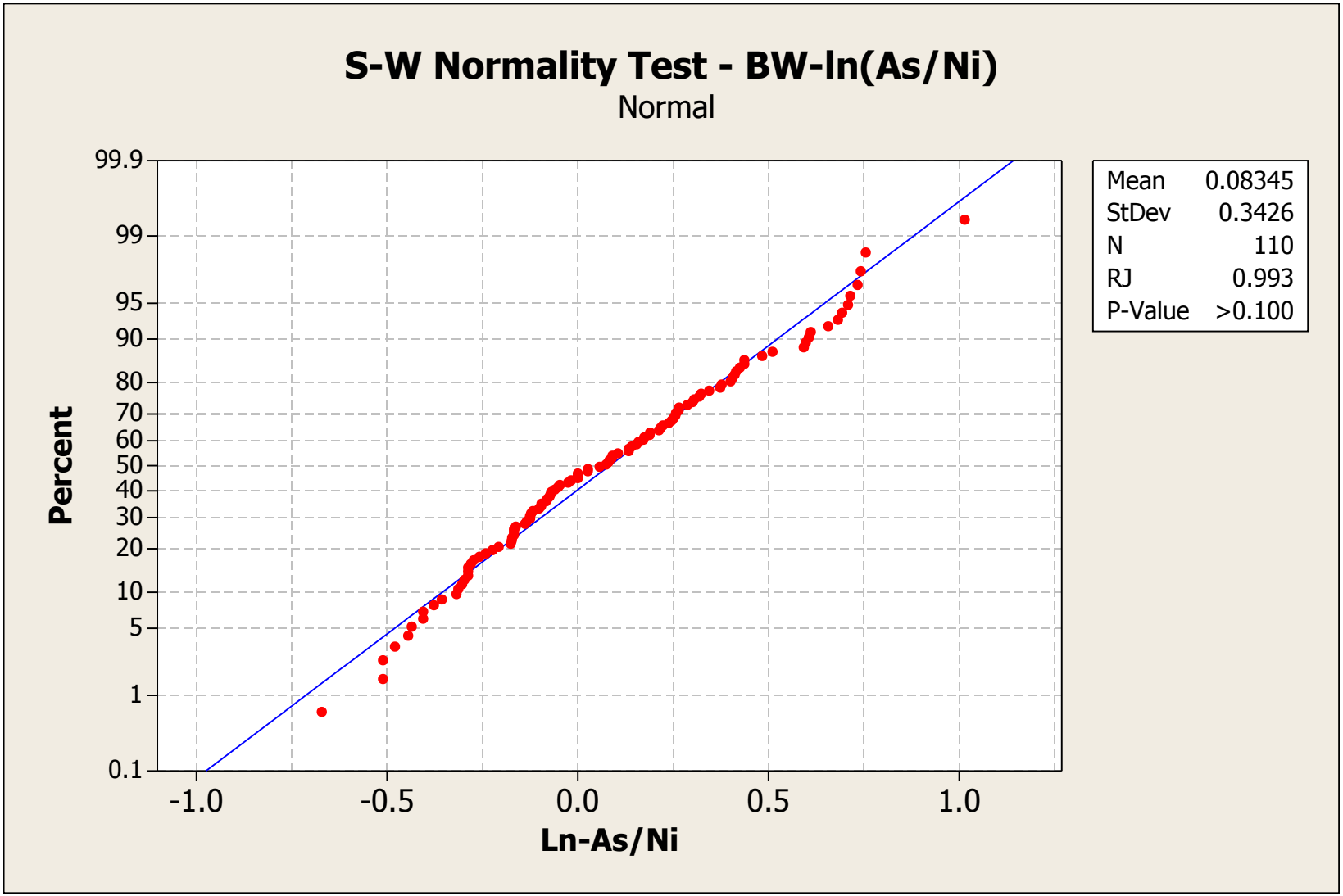

Regression Analysis - BW / ln-Arsenic versus ln-Iron
ln_Arsenic = - 4.194 + 0.7614 ln_Iron
ln_Arsenic
ln_Iron
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
8.0
8.5
9.0
9.5
10.0
10.5
Regression
95% CI
95% PI
S 0.335369
R-Sq 56.8%
R-Sq(adj) 56.4%

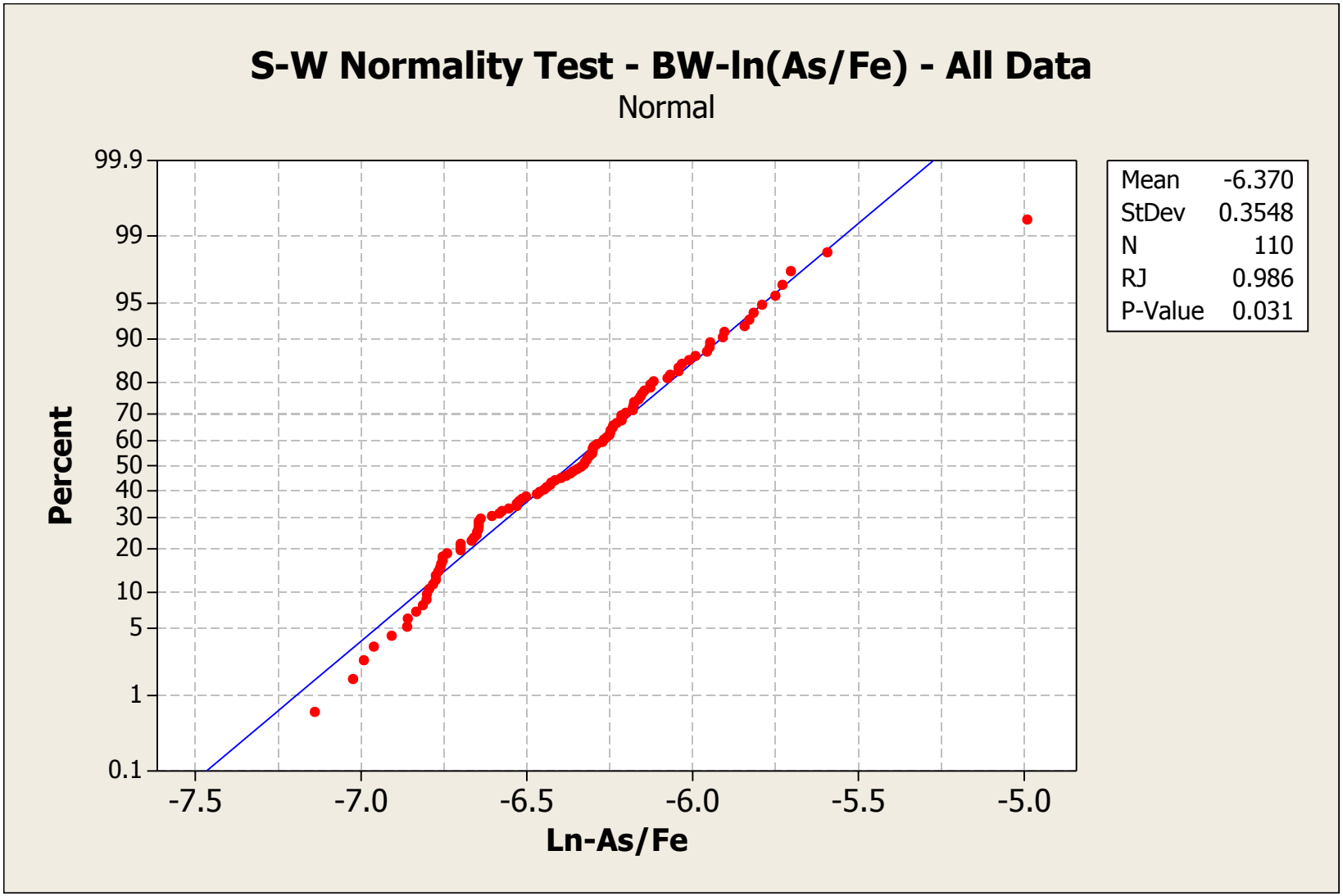
ATTACHMENT E

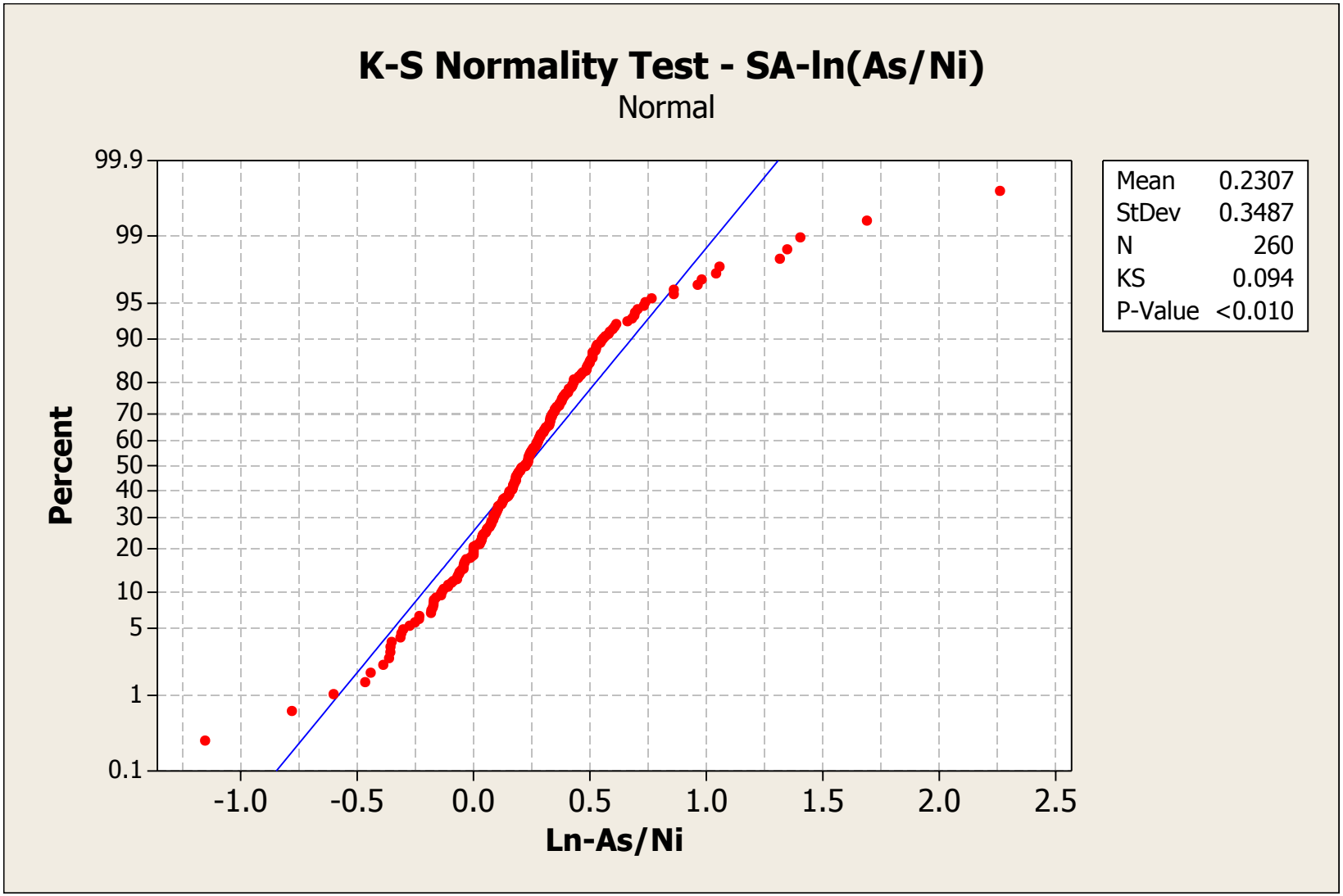
STANDARDIZED DATA SET TESTING

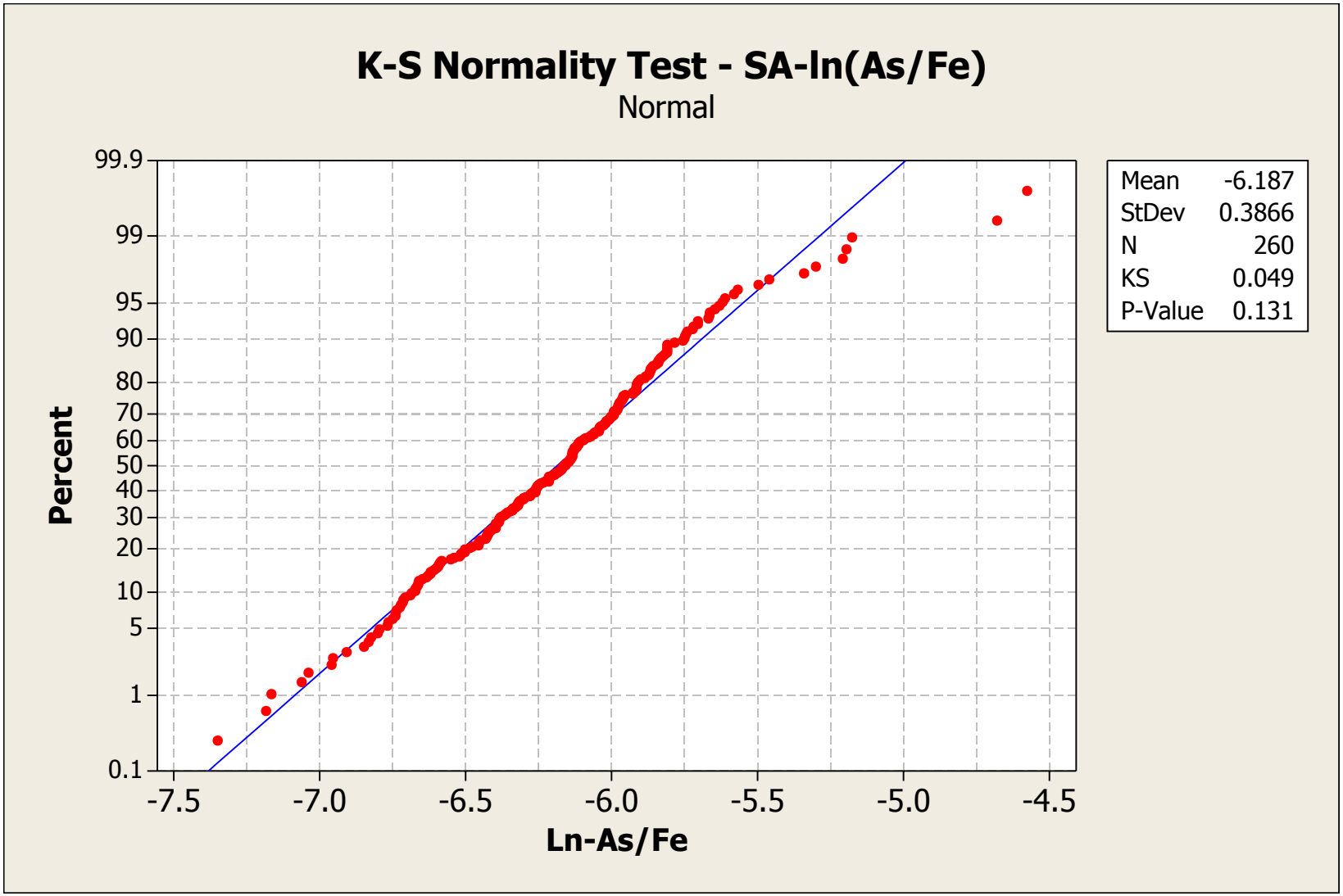

S-W Normality Test - SA-ln(As/Ni)
Normal
Percent
99.9
99
95
90
80
70
60
50
40
30
20
10
5
1
0.1
-1.0
-0.5
0.0
0.5
1.0
1.5
2.0
2.5
Ln-As/Ni
Mean 0.2307
StDev 0.3487
N 260
RJ 0.950
P-Value <0.010

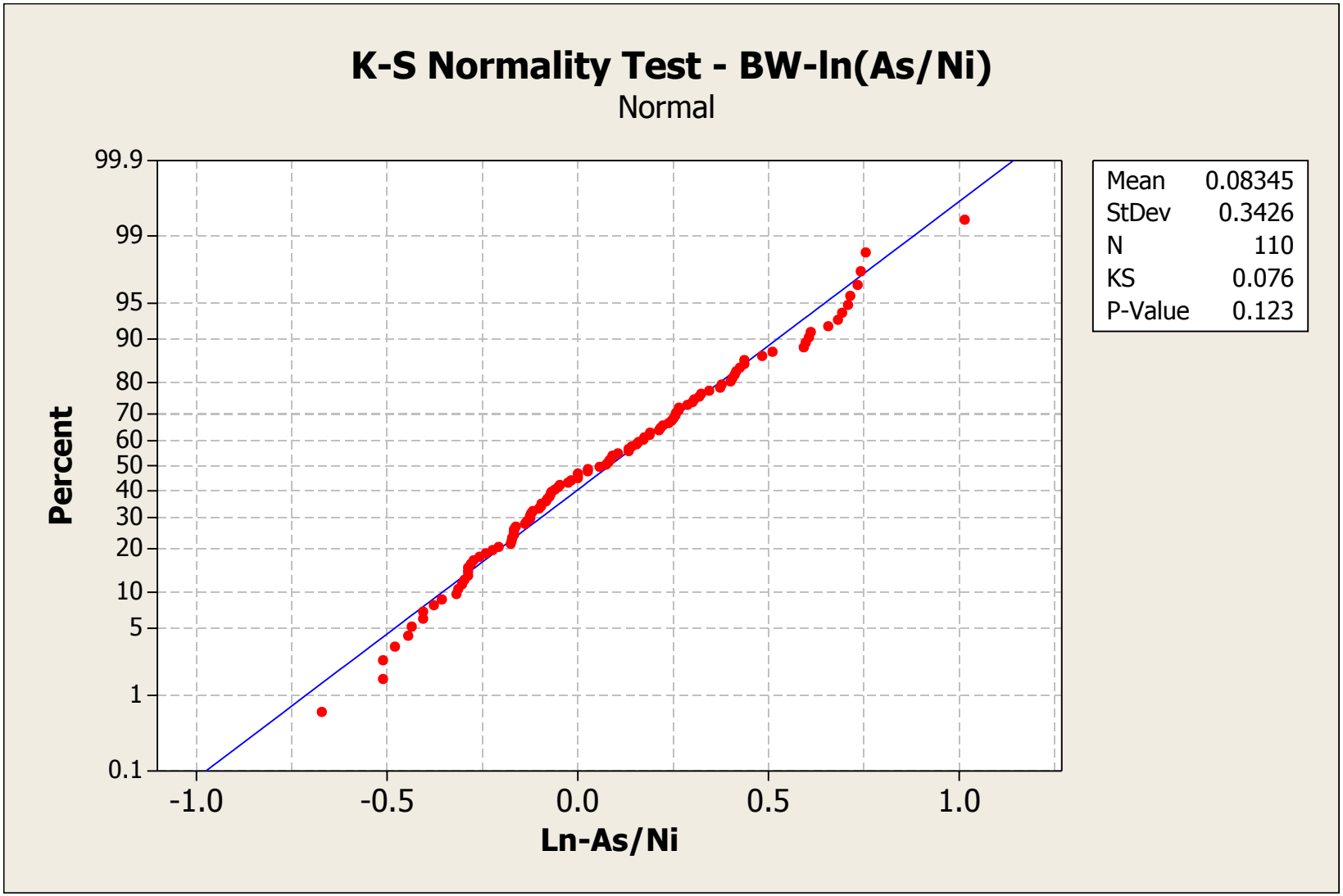

S-W Normality Test - SA-ln(As/Fe)
Normal
Percent
99.9
99
95
90
80
70
60
50
40
30
20
10
5
1
0.1
-7.5
-7.0
-6.5
-6.0
-5.5
-5.0
-4.5
Ln-As/Fe
Mean -6.187
StDev 0.3866
N 260
RJ 0.988
P-Value <0.010

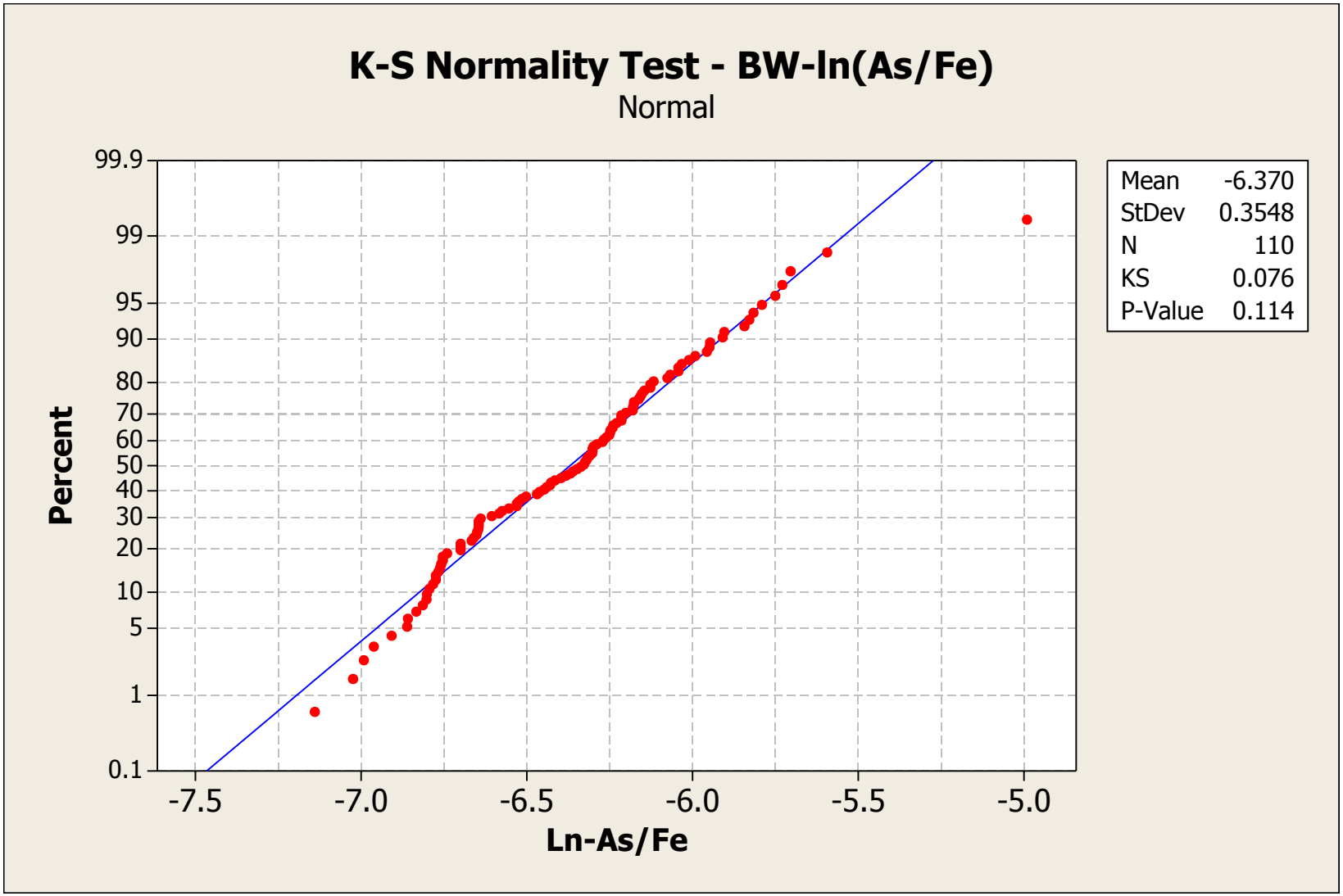

S-W Normality Test - BW-ln(As/Ni)
Normal
Percent
99.9
99
95
90
80
70
60
50
40
30
20
10
5
1
0.1
-1.0
-0.5
0.0
0.5
1.0
Ln-As/Ni
Mean 0.08345
StDev 0.3426
N 110
RJ 0.993
P-Value >0.100


S-W Normality Test - BW-ln(As/Fe) - All Data
Normal
Percent
99.9
99
95
90
80
70
60
50
40
30
20
10
5
1
0.1
-7.5
-7.0
-6.5
-6.0
-5.5
-5.0
Ln-As/Fe
Mean -6.370
StDev 0.3548
N 110
RJ 0.986
P-Value 0.031


K-S Normality Test - SA-ln(As/Ni)
Normal
Percent
99.9
99
95
90
80
70
60
50
40
30
20
10
5
1
0.1
-1.0
-0.5
0.0
0.5
1.0
1.5
2.0
2.5
Ln-As/Ni
Mean 0.2307
StDev 0.3487
N 260
KS 0.094
P-Value <0.010


K-S Normality Test - SA-ln(As/Fe)
Normal
Percent
99.9
99
95
90
80
70
60
50
40
30
20
10
5
1
0.1
-7.5
-7.0
-6.5
-6.0
-5.5
-5.0
-4.5
Ln-As/Fe
Mean -6.187
StDev 0.3866
N 260
KS 0.049
P-Value 0.131


K-S Normality Test - BW-ln(As/Ni)
Normal
Percent
99.9
99
95
90
80
70
60
50
40
30
20
10
5
1
0.1
-1.0
-0.5
0.0
0.5
1.0
Ln-As/Ni
Mean 0.08345
StDev 0.3426
N 110
KS 0.076
P-Value 0.123


K-S Normality Test - BW-ln(As/Fe)
Normal
Percent
99.9
99
95
90
80
70
60
50
40
30
20
10
5
1
0.1
-7.5
-7.0
-6.5
-6.0
-5.5
-5.0
Ln-As/Fe
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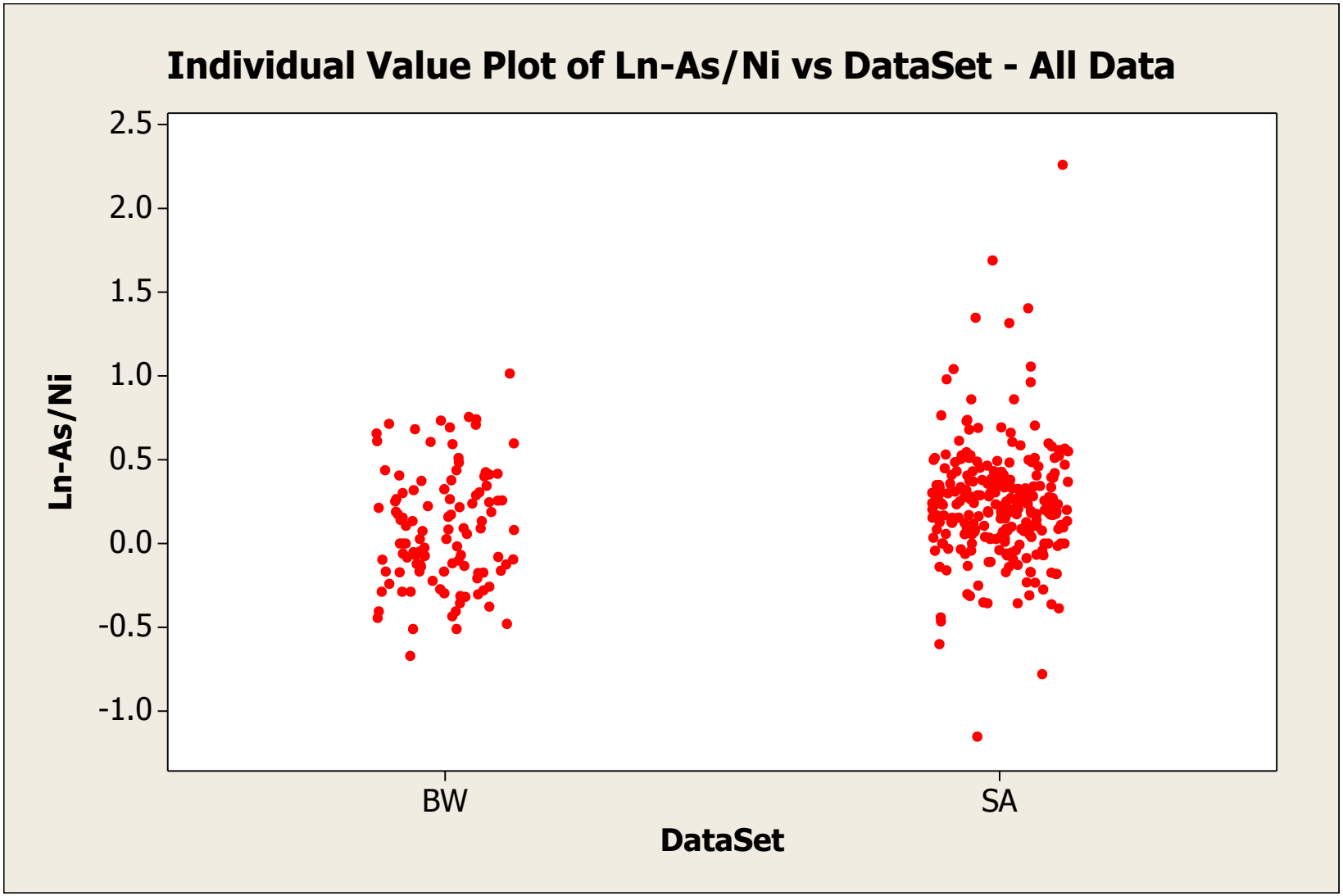
StDev 0.3548
N 110
KS 0.076
P-Value 0.114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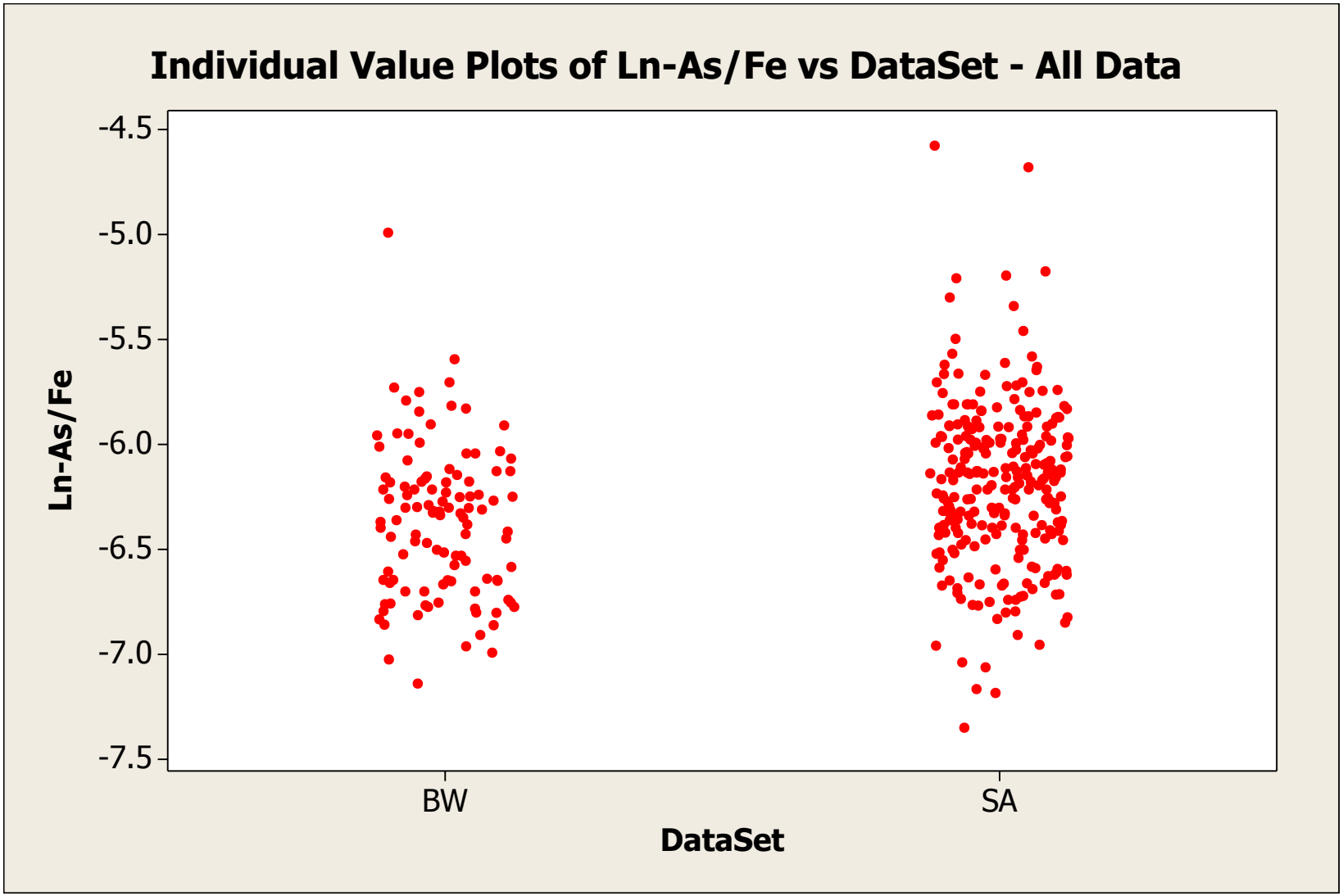
2.0
1.5
1.0
0.5
0.0
-0.5
-1.0
BW
SA
DataSet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-5.5
-6.0
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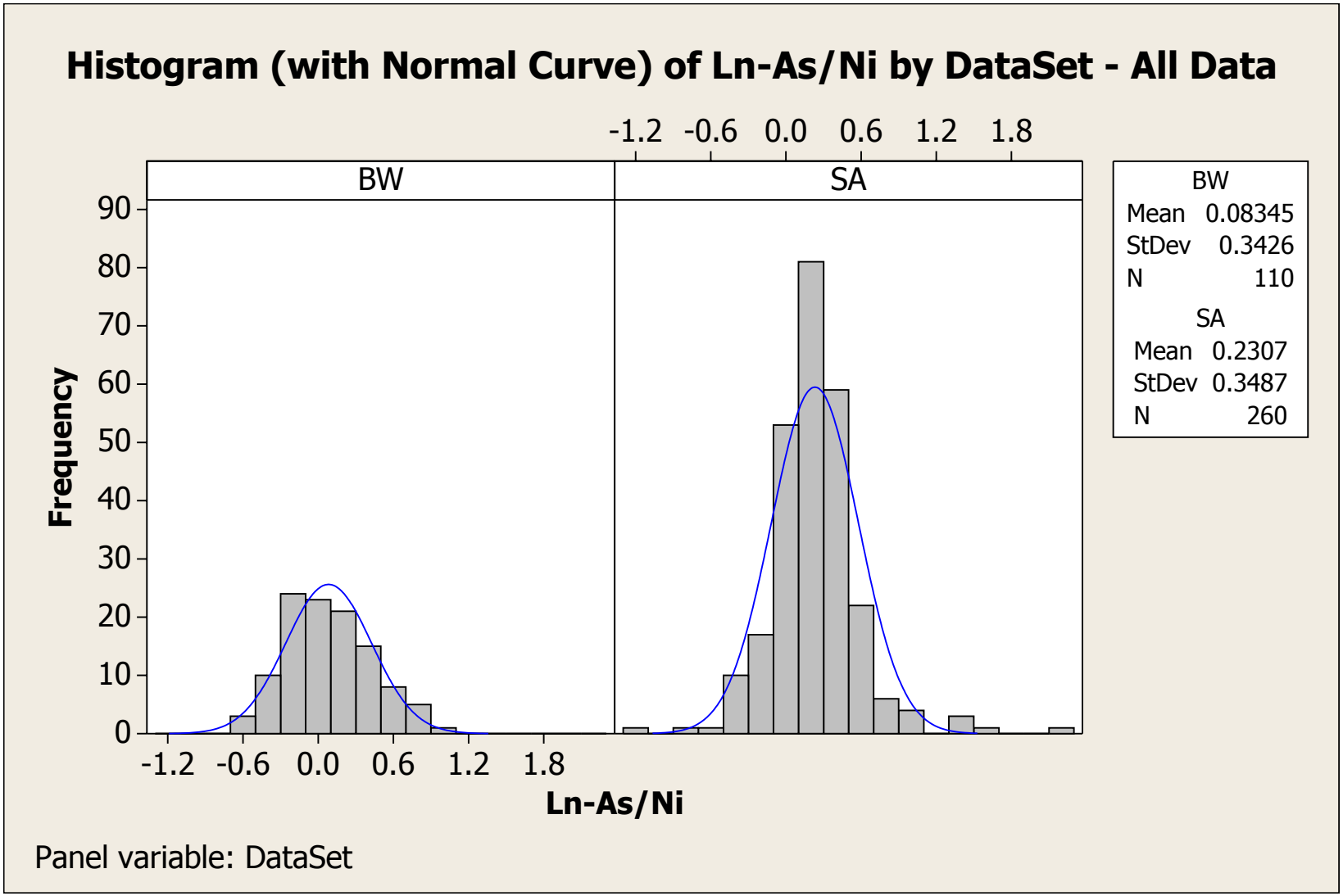
-7.5
BW
SA
DataSet


Histogram (with Normal Curve) of Ln-As/Ni by DataSet - All Data
BW
SA
Frequency
Ln-As/Ni
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0.0
0.6
1.2
1.8
0
10
20
30
40
50
60
70
80
90
BW
Mean 0.08345
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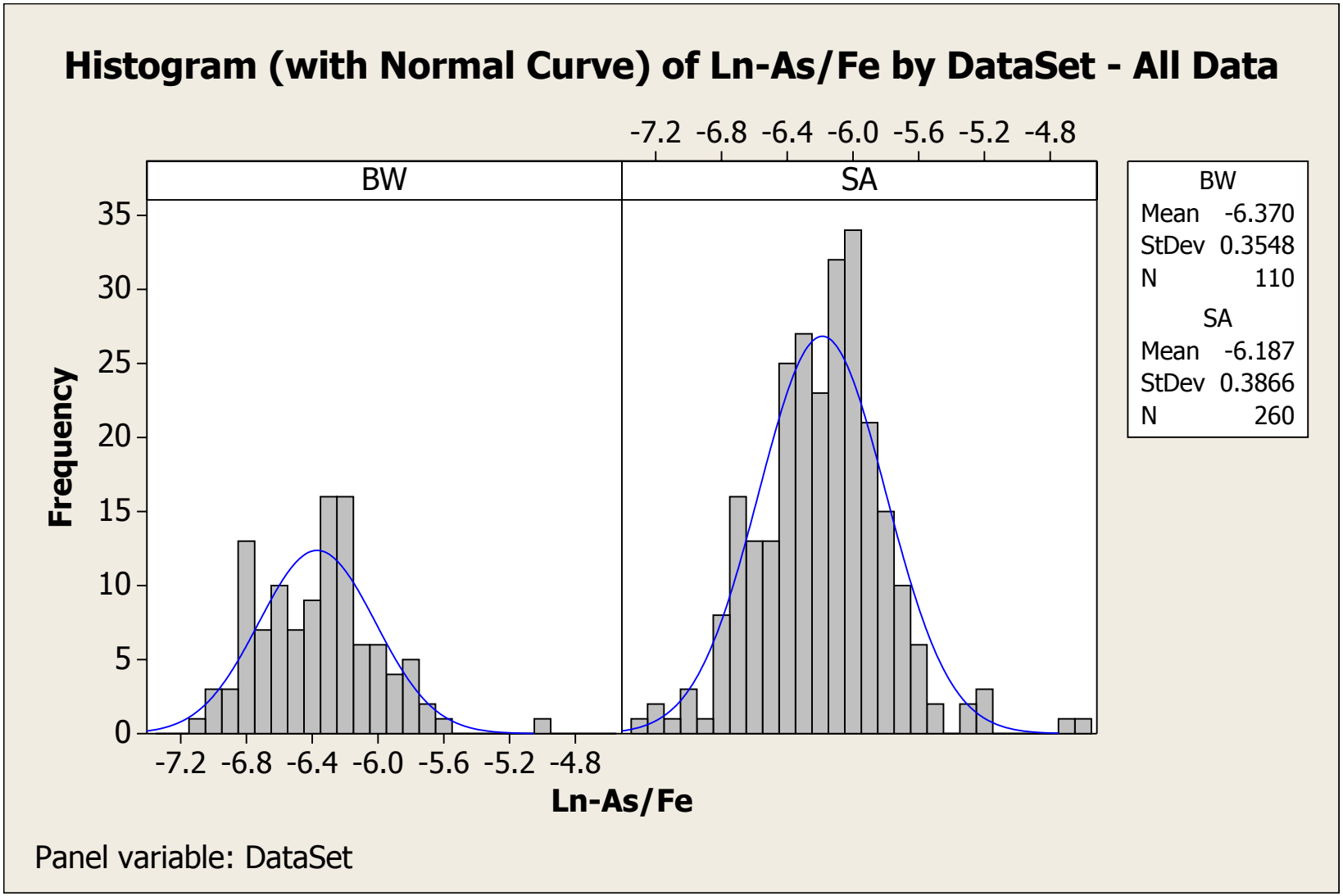
N 110
SA
Mean 0.2307
StDev 0.3487
N 260
Panel variable: DataSet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BW
SA
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Frequency
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5
10
15
20
25
30
35
Ln-As/Fe
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StDev 0.3548
N 110
SA
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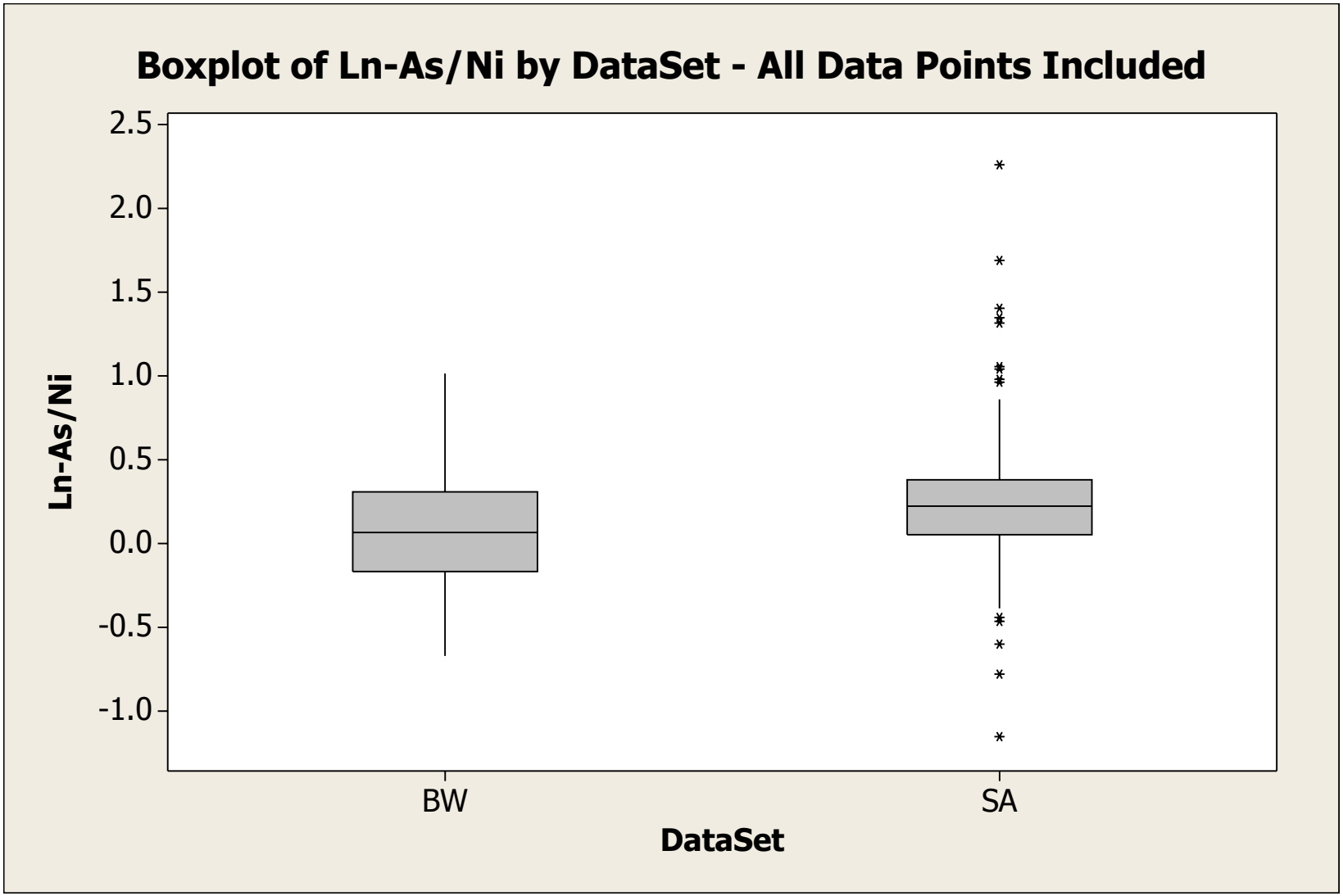
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1.0
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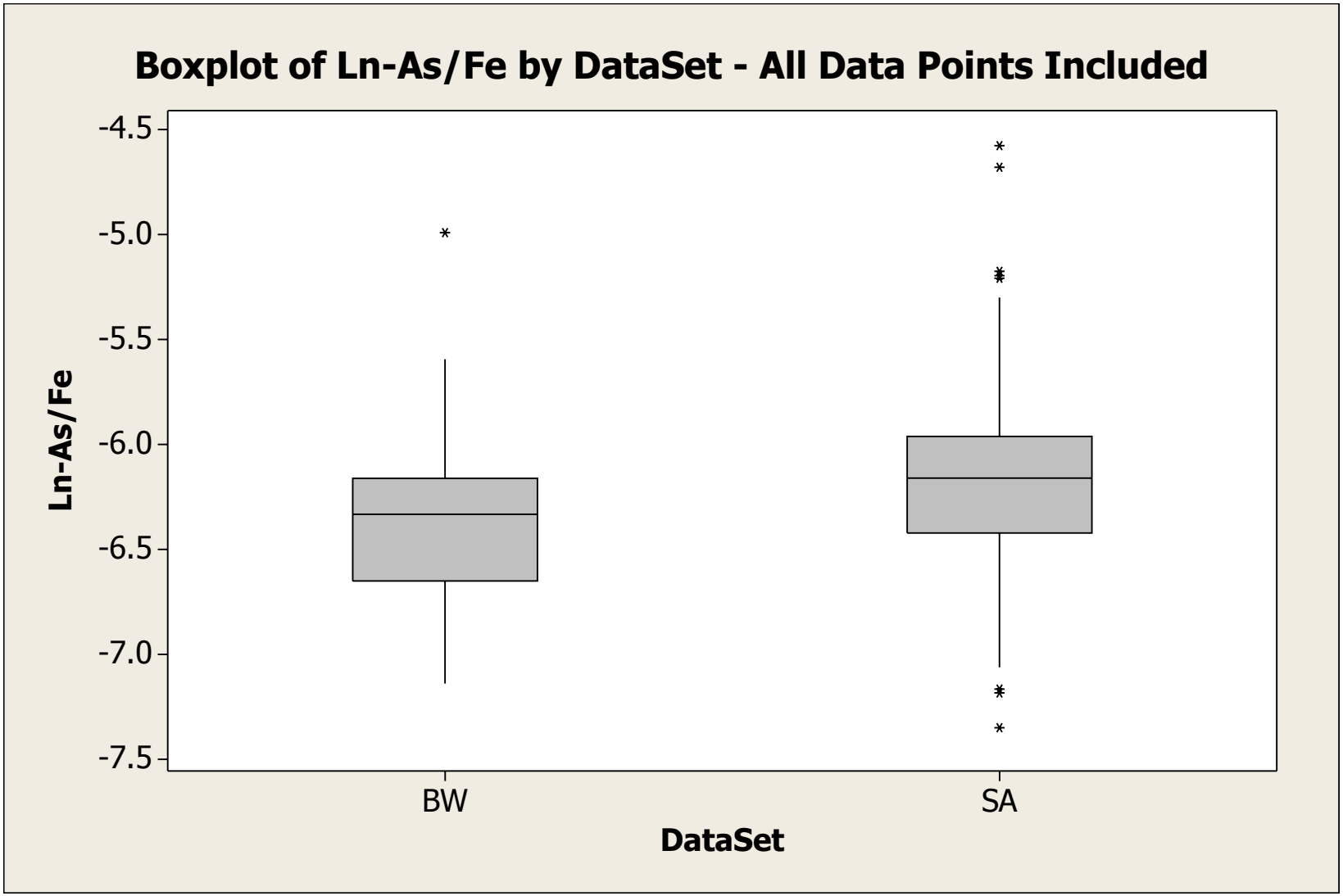
-0.5
-1.0
BW
SA
DataSet


Boxplot of Ln-As/Fe by DataSet - All Data Points Included
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-5.0
-5.5
-6.0
-6.5
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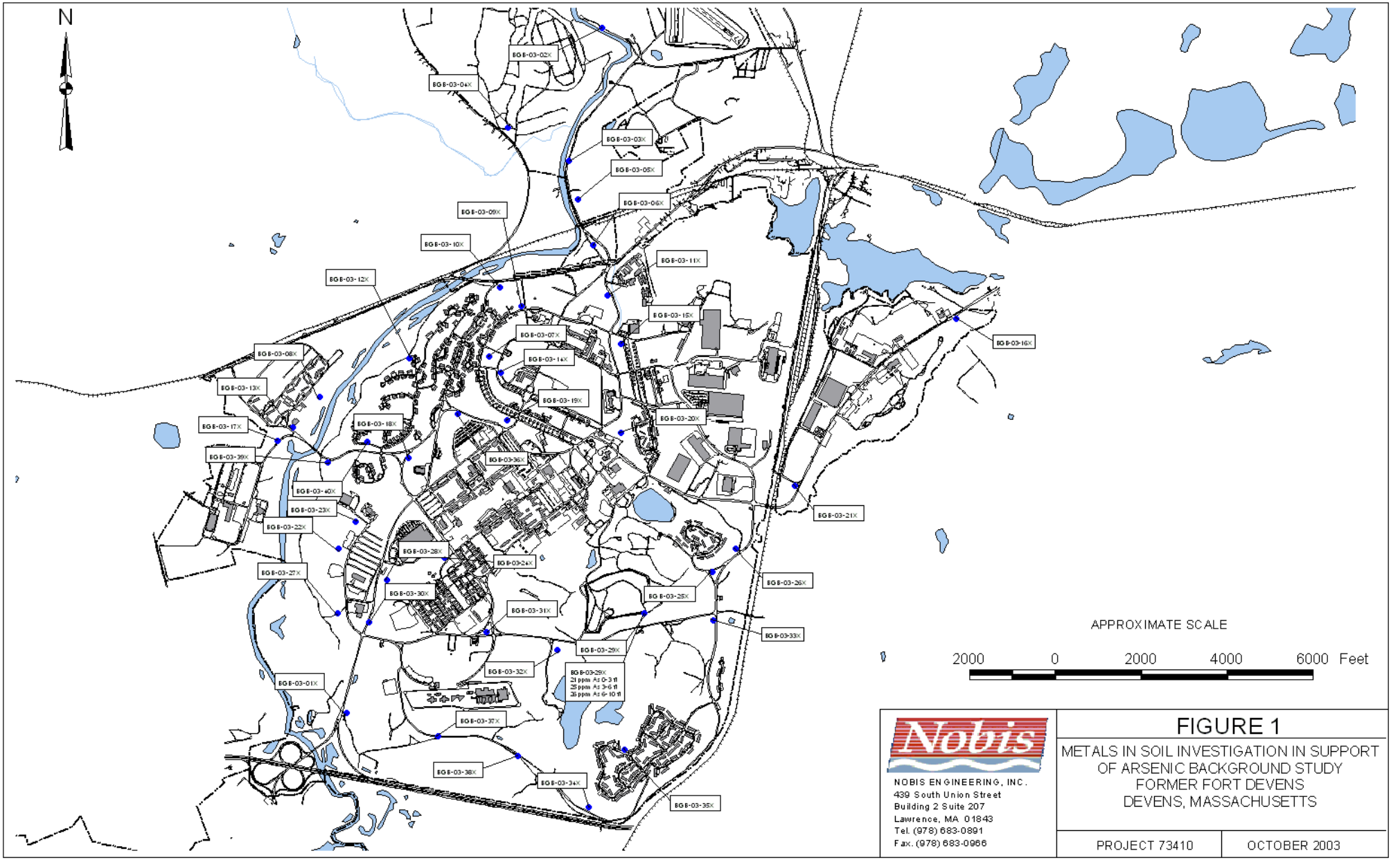
-7.5
BW
SA
DataSet



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Fax. (978) 683-0966

FIGURE 1

METALS IN SOIL INVESTIGATION IN SUPPORT OF ARSENIC BACKGROUND STUDY
FORMER FORT DEVENS
DEVENS, MASSACHUSETTS

PROJECT 73410 | OCTOBER 2003

APPENDIX D

FINAL EXPANDED CONCEPTUAL SITE MODEL

FINAL
EXPANDED CONCEPTUAL SITE MODEL
INVESTIGATION AREA - GRANT, LOCUST, AND CAVITE HOUSING AREAS
FORMER FORT DEVENS
DEVENS, MASSACHUSETTS

Prepared by:

U.S. ARMY CORP OF ENGINEERS
MILITARY MUNITIONS CENTER OF EXPERTISE
US ARMY ENGINEERING AND SUPPORT CENTER
HUNTSVILLE, ALABAMA

October 2006

DCN: DVNPASI-103106-AAWA

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LIST OF ACRONYMS

ASR	*Archives Search Report*
bgs	below ground surface
BRAC	Base Realignment and Closure
CSM	Conceptual Site Model
DGM	Digital Geophysical Mapping
ECSM	Expanded Conceptual Site Model
EM	electromagnetic
ft	foot/feet
FUDS	Formerly Used Defense Site
HA	Housing Area
HFA	Human Factors Application
IA	Investigation Area
MEC	munitions and explosives of concern
mm	millimeter
NDCEE	National Defense Center for Environmental Excellence
OER	Ordnance & Explosives Remediation, Inc.
PA/SI	Preliminary Assessment/Site Inspection
SA	Study Area
U.S.	United States
USACE	U.S. Army Corps of Engineers
UXO	unexploded ordnance
WESTON®	Weston Solutions, Inc.

SECTION 1

PURPOSE

1. PURPOSE

The purpose of this paper is to present a brief Conceptual Site Model (CSM) of the potential training and range areas in the vicinity of the Study Areas (SA) Grant, Locust, and Cavite Housing Areas (HA) of the former Fort Devens, Massachusetts. The CSM will aid in the development and execution of the subsequent actions on the area.

SECTION 2

BACKGROUND

2. BACKGROUND

Fort Devens has been used by the military for training since 1917, and was used extensively until its selection for closure by the 1988 Base Realignment and Closure (BRAC) Commission. From the referenced *Archives Search Report* (*ASR*) (USACE, 1995), several ranges and training areas existed in and around these HAs. The ranges were in use until closed by the construction of the roads, housing, and/or other buildings that impacted the viability of the range.

In the development of this CSM, several documents were used to focus the CSM. The documents are the *ASR* (Reference 1), *Draft Ordnance, Ammunition and Explosives Sampling Report* (Reference 2), *Final Ordnance, Ammunition, and Explosive Removal Action Report* (Reference 3), *The American Arsena*" (Reference 4), *DA Pam 385-63, Range Safety* (Reference 5), *Development of a Database for Ordnance Related Civilian Accidents* (Reference 6), and *Site Specific Final Report Digital Geophysical Mapping (DGM) & Unexploded Ordnance (UXO) Removal Former Grant Housing Area, Former Fort Devens, Harvard, Worcester County, Massachusetts* (Reference 7).

SECTION 3

AREAS OF CONCERN

3. AREAS OF CONCERN

Figure 2-1 from the Weston Solutions, Inc. *Preliminary Assessment/Site Inspection* (PA/SI) *Work Plan* (Attachment A) shows the areas of concern [Investigation Areas (IA)] that are contained within or are adjacent to the SA. The areas are summarized in the following subsections. All references to IA numbers refer to the numbering system used in the PA/SI.

3.1 CAVITE HOUSING AREA

The southern portion of the Cavite HA crosses into an area identified in the *ASR*'s 1922 data as a possible trench warfare area (IA-4). No trenches are visible on any aerial photographs of this area. Further investigation suggests that the feature location identifications on the 1922 map in the *ASR* (USACE, 1995) were incorrectly oriented.

3.2 LOCUST HOUSING AREA

The Locust HA is surrounded on the east, north, and west by three possible range areas, which were identified in the *ASR* (USACE, 1995). The ranges are as follows:

- **IA-6:** identified as a rifle/machine gun range (visible on the 1943 and 1951 aerial photos and historical base maps as Bryant Range).
- **IA-3:** a possible rifle range (visible on the 1922 aerial photo).
- **IA-7:** a possible sub-caliber anti-tank range (visible on the 1943 and 1951 aerial photos and historical base maps).

3.3 GRANT HOUSING AREA

The Grant HA contains four possible ranges. The ranges are as follows:

- **IA-5:** a sub-caliber anti-tank range (identified in the 1943 and 1951 aerial photos and historical base maps).
- **IA-1:** identified in the *ASR's* 1922 data as a possible training area, but based on additional information as a possible rifle range.

- **IA-2:** identified in the 1922 aerial photos as a possible training area or range.

- A currently un-numbered area [the vicinity of the Oak (Oak Circle) HA (southwest end of the Grant HA)], which by the data derived from the *Final Ordnance, Ammunition, and Explosive Removal Action Report* [Human Factors Application (HFA), 1996], appears to have been an impact area for a 37-millimeter (mm) anti-tank range. This impact area may have used IA-2 as the firing point.

SECTION 4

DISCUSSION

4. DISCUSSION

4.1 SUB-CALIBER AND KNOWN DISTANCE RANGES (IA-1, 3, 5, 6 & 7)

The *ASR* (USACE, 1995) annotated several of the IAs as 1,000-inch sub-caliber anti-tank training ranges, or show on the maps/aerial photos as short distance rifle ranges. The military often uses sub-caliber devices or shorter known distance ranges (currently 25 meters) to train soldiers in the employment of their weapons. These ranges were constructed with:

- A staging/training area where soldiers conducted activities in preparation for firing the weapons.
- The firing line - a linear line of soldiers engaged in actual firing of weapons. The physical area available on the range dictates the length of the firing line. Typically, about 10 feet (ft) exists between soldiers on the firing line.
- The target line - there is one target holder and paper silhouette target for each soldier firing. The paper/cardboard target is used to see where the bullet penetrated; thus, allowing the soldier's weapons proficiency to be judged.
- An earthen berm area – the berm is behind the target and used to catch spent bullets.
- Safety zone – an area beyond the berm where "stray" bullets would fly and impact.

Attachment B depicts a typical construction and layout of a 37-mm anti-tank sub-caliber training range. This range construction is highly likely for IAs 1, 3, 5, and 6. By assessing the terrain and locations of base activities (e.g., positioning the range so that the safety area does not include housing or other normally occupied structures), the ranges can be sited on a map to show likely layout and orientation.

This type of range used small arms as the ordnance item. Reference for a .22 caliber bullet is enclosed (Attachment C). The potential contamination from this type of munition is the lead bullet (40 grains), which is projected into the earthen berm. No explosives are used on this type of range and the propellant (smokeless or black powder) is consumed upon firing. The brass cartridge casing is typically collected and recycled.

IA-3, 5, 6 and 7 ranges are physically well defined and the impact berms are clearly identifiable. The location of the IA-1 range is not well defined.

The *ASR* (USACE, 1995) identifies IA-1 as a possible training area (1922), but does not include it as a range area. However, after reviewing the *ASR* (USACE, 1995) and a 1930s-era topographical map of the Ayer Quadrangle (Attachment D), IA-1 has the appearance of being a rifle range with distance targets. The topographical map depicts man-made linear features, which could be either target lines or different distance firing points. The southwest edge of this IA is a box canyon formed by esker deposits, which would form a natural earthen berm providing a bullet backstop. Subsequent aerial photographs and the current Ayer Quadrangle topographical maps indicate that all of the esker deposits that formed the box canyon (e.g., the presumed backstop) have been removed. Without further information, IA-1 should be considered a rifle range and sampled for lead.

4.2 IA-2, 1922 TRAINING AREA AND/OR RANGE

IA-2 sits on top of a hill with no surrounding natural earthen berms or other means of stopping fired munitions. In the 1922 aerial photos, the area is cleared of trees or other vegetation. In order for it to be a rifle range, there would need to be some means of stopping fired bullets, or target placement location. Since such features are not present, this area is discounted as a rifle or sub-caliber range. However, when the entire area is looked at, IA-2 is a likely firing point for 37-mm anti-tank weapons, with the northern portion of the Oak HA serving as the impact area.

The 37-mm anti-tank weapon is a direct fire weapon; that is, you need to see the target to engage it. The target area needs to be in direct line-of-sight from the weapon's firing point. IA-2 presents an ideal firing point for a target area on the Oak HA hillside. There is a clear line of sight from the firing point to the impact/target area. Additionally, the distance between the two areas is appropriate to the weapon being employed (slightly less than the maximum effective range of 1,200 yards). Given the construction of Grant Road and Hospital Street in the 1930s, the laundry facility in the 1940s, and the HA's in the 1950s and 1960s, it is likely that this range was only used for a short period of time in the 1920s and subsequently, closed and moved to the south post range area.

The use of the Oak HA hillside as a target area was confirmed during ordnance sampling and removal actions in 1995 and 1996. During these actions, in excess of 50 unexploded 37-mm projectiles were located and destroyed. Most of the unexploded ordnance (UXO) located were in

two dense clusters indicating the former location of a target. Figure 4-1 *Area 11 Remediation Effort* shows the extent of the removal action and the locations of UXO found. Also shown on this attachment are the locations of sampling grids from the 1995 ordnance investigation and sampling. The majority of the UXO located were on the northern slope of the hill upon which the Oak HA was built. All of the UXO have been plotted by using the coordinates provided on the UXO Locations Sheets within the *Draft Ordnance, Ammunition, and Explosive Sampling Report* (HFA, 1995) and the *Final Ordnance, Ammunition, and Explosive Removal Action Report* (HFA, 1996). This represents correct presentation of the UXO located during these activities. Note that a majority of the UXO originally reported for Survey Grid Y21 was incorrectly mapped on the Y21 Location Sheet based upon how the grid's placement was interpreted. The correct locations of these UXO, as indicated by their individual coordinates, are in the adjacent Y22 grid, as placed in the CSM.

In 2005 and 2006, Massachusetts Development and Finance Agency retained Ordnance & Explosives Remediation, Inc. (OER) to perform a Digital Geophysical Mapping (DGM) investigation and munitions and explosives of concern (MEC) removal from the former Grant HA. The DGM was performed using a Geonics EM-61 unit to identify subsurface electromagnetic anomalies that could be MEC related items. Following the DGM, OER, and its subcontractors reaquired and marked the anomalies, and excavated, identified, and removed those items. Trees and severe slopes prevented OER from achieving 100% coverage with the DGM, but OER believes that these issues did not affect the overall goal of demonstrating that the site is suitable for residential end land use (OER, 2006).

Approximately 15 pieces of 37-mm anti-tank ordnance and 1,870 pounds of MEC scrap were recovered from the site, mostly located on the north side of Oak Hill, the presumed impact area. In addition, six 3-inch-diameter Stokes mortars and 30 other miscellaneous ordnance items were recovered from the area. These items were distributed evenly across the site in a way that suggests that the ordnance were not associated with specific training areas. The ordnance recovered was detonated in place, and all MEC-related scrap was removed from the site (OER, 2006). The conclusions of the earlier versions of the Expanded Conceptual Site Model (ECSM) did not change substantially in light of subsequent DGM data collection in the Grant HA.

4.2.1 37-mm Range Design and Layout (IA-2)

The firing point, 37-mm effective range distance, and impact area for range IA-2 are shown in Figure 4-2, *IA-2 Range Features*. Figure 4-3, *Cross Section Location Map* shows two likely firing lanes from IA-2 to the target area on Oak HA hillside. Figure 4-4 *Cross Sections A-A' and B-B'* are cross sections of elevation from the firing point to the target area clearly showing the lines of site that existed during range use and the locations of UXO recovered along these lines of site, further verifying the assumption of IA-2 as the firing point and Oak HA hillside as the target. There are no terrain features between the firing point and the impact area that present a potential for an intermediate or alternative target area. The terrain is shallower between the firing point and the target area and any missed targeting would be reasonably anticipated to impact near the target area. The artillery would have had to have been aimed at an unusually severe angle up or down to have any missed targeting in the area between the firing point and the target and removal area.

No additional 37-mm items were found in the areas investigated (Figures 4-5, 4-6, 4-7) surrounding the impact area outside of the removal area and no ordnance related items except an inert practice mine. The inert practice mine is not associated with the IA-2 range activities and is likely the result of soldier training at some point in time after the 37-mm range was abandoned. The inert practice mine is classified as munitions debris.

Figure 4-7 *Area 11 and 17 UXO Investigation Grids* shows the areas sampled between the IA-2 firing point and the Oak HA hillside. No UXO was found outside of the removal area boundaries. During the removal effort in the target area, most UXO was located immediately in/around the target area. However, several lone UXO were located some distances away from the target. The UXO not at the target location could be due to either incorrect aiming or a munition that ricocheted off some object at its initial point of impact. For example, a ricochet would explain the presence of the UXO removed from Grid C-11, which is in the "shadow" of a small knoll and not in line-of-sight with the firing point.

4.2.2 37-mm UXO Penetration Depth and Detection Systems Overview

The depths to which a munition penetrates beneath the ground surface are a function of the impact velocity and impact angle, the momentum of the item, and the soil conditions into which the items are impacting. The 37-mm UXO were found at depths up to 18 inches during the UXO survey and removal. The actual maximum depth that the 37-mm UXO on this site is unknown due to the inability of the detection systems to ensure detection of all 37-mm UXO throughout the presence below surface. We can use some empirical predictions to conservatively (very conservatively in some cases) estimate the penetration. These estimates of penetration depths were based solely on physics models, and, for a lack of information, assumed worst-case scenario parameters; the estimated depths were calculated using impact velocities that were equal to the muzzle velocity, and with impact angles of 90 degrees (vertically downward). Though these parameters are unrealistic, they were nonetheless used in early modeling because of the inability to accurately predict impact velocity and the variation on impact angle. The results of those models indicated that a 37-mm round, fired vertically into the ground from zero altitude, could penetrate 3.9 ft through homogeneous sand, and to 7.9 ft through homogeneous clay. More recently, the National Defense Center for Environmental Excellence (NDCEE) compiled a database that captures, among other things, the depth of recovered UXO. That database has 385 records of 35-mm and 37-mm projectiles that were recovered from depths ranging from the surface to 40 inches. It should be noted that all of the 35-mm and 37-mm projectiles reported at depths greater than 24 inches in that database were detected using the Schonstedt GA52CX. Based on the information contained in the NDCEE UXO database, and experience at removal actions throughout the United States (U.S.), it is reasonable to expect that the vast majority of 37-mm projectiles would occur in the upper 20 inches of soil at any site throughout the U.S. The range of the maximum depth for this case will be dependent on the soil type at the point of impact and the actual angle of impact (angles of impact other than 90 degrees will result in lower penetration). Therefore, we can only bound the actual depth from 18 (maximum depth of found UXO) to 94.8 inches (maximum empirical depth in clay, 90 degree impact, at muzzle velocity) with the vast majority (if not all) of all items found within the first 20 inches below surface.

The Schonstedt GA52CX, which was used in the UXO survey and removal, is a vertical gradient magnetometer commonly referred to as a vertical gradiometer. Because this instrument, like all other vertical gradiometers commonly used today, is a passive metal detector, its capabilities and limitations are a function of the instrument's sensitivities, and more importantly, the magnetic field being generated by the target objective. As with all magnetic sources, the strength of the generated field decreases as a function of $1/r^3$, where r equals the distance between the source and the detector. What this means when searching for 37-mm projectiles is that when they are located 12 inches below the ground surface, the magnetic field they produce is relatively strong and the vertical gradient (i.e., the difference in the magnetic field as it is measured at two different heights above the ground) is relatively strong as well. However, as the items are located further and further away from the magnetic gradiometer sensors, two things happen: the magnetic field generated by the item (as measured at the location of the sensors) drops off rapidly (as a function of $1/r^3$) and the vertical gradient approaches zero. There is still considerable debate within the scientific community as to how best to model the magnetic fields of UXO in order to predict detection capabilities of commonly used magnetometers and gradiometers. Based on empirical data gathered at numerous prove-outs and demonstrations across the country, it has been noted that the magnetic gradient from 37-mm and similarly sized UXO typically becomes undetectable when buried at depths between 18 and 24 inches below ground surface (bgs). Exceptions to these generalized limits, both shallow and deep, do occur and are often related to the type of soil in which the items are located. In order to quantify the actual detection capabilities, an equipment demonstration must be performed. Depending on the site characteristics and operator skill, the typical effective detection depth for 37-mm UXO is in the range of 18 to 24 inches.

Another type of detector commonly used to detect UXO is the electromagnetic (EM) detector. Unlike magnetic systems, EM metal detectors are "active" devices and they generate an electromagnetic signal that propagates through the ground. The EM metal detectors are essentially ground conductivity measuring devices. When a solid piece of metal is present below the sensor, the effective conductivity of the volume of earth being analyzed beneath the sensor increases (i.e., more metal beneath the instrument equals increased conductivity of the volume of earth being analyzed.). Other factors contribute to the detection capabilities of EM devices, but

most significant is depth because, unlike magnetics where the generated field drops off as a function of $1/r^3$, EM signals drop off as a function of $1/r^6$. What these limitations mean when EM tools are used for detecting small UXO is that EM sensor sizes must be kept small so that the volume being interrogated beneath the sensor is not so large that the presence of a single small item will not significantly increase the conductivity of the interrogated volume. In order to quantify the actual detection capabilities, an equipment demonstration must be performed. Depending on the site characteristics and system design, the typical effective detection depth for 37-mm UXO is in the range of 16 to 24 inches.

The maximum depth of 37-mm found in and around the impact are during the UXO survey and removal action may exceed the consistently reliable detection depth of the Schonstedt 52CX, EM 61, or any other detection system. No removal action using geophysical techniques and anomaly removal can guarantee 100% elimination of 37-mm items from the site. Due to the technical limitations of the geophysical detection systems, the potential residual 37-mm presence is un-quantifiable. The residual UXO can only be expressed in relative terms. Any investigation may result in additional discovery of UXO, regardless of detection system used. The assessment of residual 37-mm potential is not likely to be altered by additional investigation.

4.2.3 37-mm UXO Source Presence Overview

There is a potential for finding additional 37-mm within the target area located inside the removal area. The potential results from this being the intended point of impact, with the majority of shots impacting in or very near this area. The potential residual is due to the inability to consistently and reliably detect all 37-mm throughout its potential presence below ground surface. No surface residual 37-mm presence is expected. There is a potential to detect additional items below the consistently reliable detection depth.

The areas adjacent to the impact area and within the removal area have a lower potential than the impact area for finding any residual 37-mm. The lower potential is due to this area not being the intended point of impact for 37-mm and all items are the result of missed targeting and/or ricochet. The potential residual results from the inability to consistently reliably detect all 37-mm throughout its potential presence below ground surface. Based upon the sampling that was conducted in Areas 2, 11, 17 and the Additional Ammunition Area, it appears that ricochets

were confined to a fairly small region around the target area. No surface residual 37-mm presence is expected. There is a potential to detect additional items below the consistently reliable detection depth.

The area outside the removal area has lower potential for finding residual 37-mm items than the impact area and the potential continues to decrease as the distance from the impact area increases. The lower potential is due to this area not being the intended point of impact for 37-mm and all potential items are the result of missed targeting and/or ricochet. There is a potential for subsurface residual 37-mm presence below the reliable detection depth for those areas intrusively investigated. There is a potential for both surface and subsurface residual 37-mm presence for those areas not intrusively investigated.

Data sheets for 37-mm projectiles and a towed anti-tank weapon are attached (Attachment E) to illustrate the types of ordnance and weapon system that might have been used on this range. The munition is a fixed case item with propellant contained (e.g., no loose propellant bags). Based on the *Final Ordnance, Ammunition, and Explosive Removal Action Report* (HFA, 1996), it seems likely that both armor piercing and high explosive rounds were fired (due to what was found and the amount of ordnance scrap, over 2,700 pounds).

4.2.4 37-mm Range Contaminants

This range would have distinct areas of explosives contamination (the firing point, the intermediate terrain, and the impact/target area). Perchlorate is not considered a potential contaminant for several reasons:

- The IA-2 37-mm range was likely active in the 1920s and 1930s. Grant and Hospital Roads were constructed in the 1930s; thus, this area was likely abandoned as a firing range. During this time period (pre-WWII), perchlorate was not a common propellant for munitions.
- Given the high solubility of perchlorate, it is highly unlikely any residual perchlorate would remain in the soil after 70 to 85 years, had it been used.

- The most likely type of weapon being tested in the IA-2 37-mm range typically employed a fixed case, TNT-based propellant.
- The presence of rockets and missiles using solid propellant or open burning/detonation are two of the most likely causes of perchlorate contamination at Department of Defense locations. Neither of these is known to have been present at the former Fort Devens.

The firing point might have propellant particles on the ground that was ejected from the gun tube during firing. The propellant was most likely some form of black powder, or as shown in the data sheets nitro-glycerin based. Also possible in this area would be discarded military munitions. Given the terrain, unused munitions would most likely have been thrown over the hillside into the woods. Burial is unlikely given terrain and geology.

The intermediate terrain consists of the area the projectiles would travel over while on the way to the target. It is possible that a projectile could impact here if fired low at the target. If this occurred, possible explosives residue from functioned ordnance may be possible. The 37-mm projectile is constructed of steel, so lead would not be a concern in this area.

The impact area would contain UXO, possible explosives residue, and scrap metals from functioned ordnance. The projectiles were made of steel, so lead should not be a concern in the area.

4.3 PHYSICAL TRAINING AREA (IA-4, 9)

As previously stated, the Cavite HA's southern edge touches IA-4, the possible trench warfare training area. This area was included in initial UXO survey work completed by HFA (Area 15; Figure 4-8). No UXO was located in this area during that effort. Reviewing data, it seems unlikely that IA-4 was anything other than a physical training area. The base had considerable structures and facilities built around the area and the use of ordnance in this area would endanger those facilities. IA-4 has been developed into warehousing and no ordnance has been reported as being found during construction, supporting the conclusion that this was a physical training area only and no munitions were employed.

Based on premise that IA-4 was a physical training area, there would be no ordnance-related contamination in the Cavite HA from past activities.

SECTION 5

RISK AND EXPOSURE

5. RISK AND EXPOSURE PATHWAYS

5.1 EXPECTED CONTAMINATION SUMMARY

Table 5-1 lists the expected types of contamination by IA.

Table 5-1 Potential Range Contamination

Area	Housing Area	Potential Contamination	Remarks
IA-1 Firing Points	Grant	None	2003 and 2004 soil sampling indicated no lead contamination.
IA-1 Targets/Berm	Grant	Lead	Multiple Target Lines Possible
IA-2 Firing Points	Grant	Propellant Residue Discarded Military Munitions	2003 and 2004 soil sampling indicated no lead contamination.
IA-2 Intermediate Terrain	Grant	Unexploded Ordnance Explosives	Possible short rounds impacting high, facing elevations
IA-2 Impact Area	Oak	Unexploded Ordnance Explosives	2004 soil sampling indicated no lead contamination.
IA-3 Firing Points	Locust	None	2003 and 2004 soil sampling indicated no lead contamination.
IA-3 Target/Berm	Locust/Oak	Lead	Terrain allows range to be oriented in either a north-south or south-north fashion. 2003 and 2004 soil sampling indicated no lead contamination.
IA-4	Cavite	None	
IA-5 Firing Points	Grant	None	Not sampled.
IA-5 Target/Berm	Grant	Lead	2003 and 2004 soil sampling indicated no lead contamination.
IA-6 Firing Points	Locust	None	2005 soil sampling indicated no lead contamination.
IA-6 Target/Berm	Locust	Lead	2003 and 2005 soil sampling indicated lead contamination.
IA-7 Firing Points	Locust	None	
IA-7 Target/Berm	Locust	None	2004 soil sampling indicated minimal lead contamination.

5.2 RISK AND EXPOSURE

5.2.1 IA 1, 3, 4, 5, 6 and 7

The risk and exposure to UXO at these IA's is not present as no UXO has been found or is suspected in these areas. This CSM will not further address human health risks due to exposures in these areas, but will defer to the results of the chemical sampling conducted in the fall of 2003.

5.2.2 IA-2

The release mechanisms describe how UXO was introduced into the environment. The release mechanisms identified include releases that resulted from intentional activities, such as firing into a target area, and releases that may be incidental to the ordnance-related activities, such as long or short round fired into a range safety fan. The release mechanisms also include mishandling, loss, or abandonment of items; burial of excess rounds at a firing point; and burning of extra/unused propellant. **Error! Reference source not found.** presents the various release mechanisms associated with each primary source type.

5.3 UXO MIGRATION AND TRANSPORT

The migration and transport mechanisms identified for UXO contamination include the following and are described below:

- **Frost Heave:** Frost heave may slowly work subsurface objects to the surface over time. The extreme frost depths from S*oil Mechanics*, NAVFAC DM 7.1, May 1982, Page 7.1-4.2 indicate extreme frost depths can reach 40 inches at this location. Items found at greater depths will not migrate to the surface. Items found at depths up to 40 inches bgs have the potential to migrate to the surface because of the frost heave (U.S. Navy, 1982), if it is the right soil type and has sufficient moisture in the soil.

- **Erosion:** Erosion on banks and hillsides may allow items to be exposed in the future. Erosion may also carry the items from higher grounds (hill side) to lower areas (stream bed or wetland area). Areas with no vegetative or no surface covering have a higher erosion potential. Areas with steep slopes or angles have the greatest erosion potential.

Table 5-2 UXO Release Mechanisms

UXO Activity	Primary Source	Primary Release Mechanisms	Potential UXO Contamination	Initial Contamination by UXO
Weapons Training	Firing Point	Loss or Discard	Non-Functioned Munitions	Ground Surface
				Below Grade
		Disposal of Dud Munitions Particulates from Firing	Propellant Residuals	Ground Surface
				Sediment/Soils
			Explosive Residuals	Ground Surface
				Sediments/Soils
	Target Areas	Munitions Firing, Range Maintenance/Clearance Activities	Fully Functioned Munitions (Scrap)	Ground Surface
				Below Grade
			Partially Functioned Munitions (UXO)	Ground Surface
				Below Grade
			Failed to Function Munitions (UXO)	Ground Surface
				Below Grade
	Range Safety Fans	Munitions Firing, Range Maintenance/Clearance Activities	Fully Functioned Munitions (Scrap)	Ground Surface
				Below Grade
			Partially Functioned Munitions (UXO)	Ground Surface
				Below Grade
			Failed to Function Munitions (UXO)	Ground Surface
				Below Grade

- **Soil Disturbance:** Any disturbance of the surface soil or subsurface soil through digging, excavations, or disturbance of the soil may allow for the migration of items and movement of items. Construction activities associated with homes and utilities may lead or could in the future lead to the migration of items. Removal of trees and root systems may also lead to migration of items found at depth. The spreading of soils found at depth after excavations on the surface, backfilling of excavations with site soils, and off-site transportation and disposal of extra soil may lead to the migration of items.

- **Hydrology Effects:** As mentioned previously, there are numerous water bodies, stream, and intermittent streams in the SA. Surface waters and rainwater can assist in the migration of materials and items through erosion and transport mechanisms. Overland surface water flow can carry small items to sinks where they are deposited. Surface water may also infiltrate through the soil and move subsurface items. The infiltrating water has the potential to carry subsurface contaminants associated with explosives, explosive residuals, propellants, and materials used to burn propellants.

5.4 UXO EXPOSURE PATHWAYS

The daily routines, activities, and outdoor habits of the residential community, base workers, construction workers, and recreational users have an impact on the potential for interaction with UXO. Surface UXO is not expected in the removal area and other investigative areas. There is a potential for surface UXO in areas not investigated. However, intrusive activities have the greatest potential for exposure due to the fact that fired UXO tends to come to rest below grade. Figure 5-1 shows the various depths the UXO was located at during the HFA Investigation and Removal.

The maximum depth of 37-mm found in the impact area during the UXO survey and removal action exceeds the consistently reliable detection depth of any detection system. Some UXO may remain in the removal area below the effective detection depth of the detection systems. Any investigation of the impact area and surrounding areas may result in additional discovery of UXO, regardless of detection system used. The location and relative potential for residual presences are discussed in Subsection 4.2.1.

Based upon historical and other information reviewed, the most probable areas for UXO residual presence are:

- The target area (previously cleared by HFA).
- The area around the target area within the removal area (previously cleared by HFA) that could have 37-mm resulting from ricochets or missed targeting.
- The area near the removal area that could have 37-mm resulting from ricochets or missed targeting.

Figure 5-2 provides a graphical representation of the source-pathway-receptors process for UXO. This flowchart was prepared in accordance with the guidance contained in the U.S. Environmental Protection Agency's *Handbook on the Management of Ordnance and Explosives at Closed, Transferring and Transferred Ranges and Other Sites*, August 2003, Chapter 9.

> *"Please note that since exposure to UXO often times requires direct action and/or contact, it is possible that a person may recognize a UXO hazard and choose not to have a direct action and/or contact that will prevent the exposure pathway, for safety concerns, from coming to completion."*

SECTION 6

37-MM RANGE UXO PATHWAY ANALYSIS

6. 37-MM RANGE UXO PATHWAY ANALYSIS

The UXO related pathways are described in terms of the source UXO presence, potential receptors that may interact with the UXO and their access to the UXO, and characteristics of the activities that the potential receptors conduct that could lead to interaction with the UXO.

6.1 UXO SOURCE

6.1.1 Historical UXO Use

There is a clearly defined 37-mm range (Figure 4-2), including the target area, contained within the 38-acre removal area (Figure 4-1) within the Oak (Oak Circle) HA and the firing point (IA-2) northeast of that target area. The effective range of the 37-mm firing from IA-2 falls within the target area. Although the target area is contained within the Oak HA, 37-mm resulting from missed targeting and ricochet have been found in the adjoining areas.

6.1.2 UXO Source Presence Characteristics

As stated in previous sections, the target area and the area surrounding the target area are the two potential areas of residual presence associated with the 37-mm range.

6.1.2.1 Target Area

6.1.2.1.1 Extent of UXO Presence

There is a potential for finding additional 37-mm UXO within the target area located within the Oak HA. As stated elsewhere, a quantitative prediction of the residual presence is impossible due to the technical limitations of current geophysical detection systems. Since this was the intended point of impact, it can be said in general that the potential is higher here than in other areas surrounding it.

6.1.2.1.2 Depth of UXO Presence

The 37-mm UXO were found at depths up to 18 inches during the UXO survey (1995) and the removal action (1996). Due to the limitations of detection equipment used, it is not possible to tell how deep they can go or their distribution below ground surface. As stated earlier, it is

expected that the vast majority of any potential residual 37-mm UXO will be in the first 20 inches bgs. The maximum depth could be up to 95 inches below the surface but should be much lower and depends upon the impact velocity, angle of impact, and soil type. At the time the removal was completed on the target area, 37-mm would not be expected to be found down to the detectable limits of the detection system. The actual detection limits depend on the site conditions and system configuration and operation. The detection system used in the removal action has been able to detect 37-mm at other sites up to 40 inches bgs. It is reasonable to expect that at least the first 18 inches was clear of UXO. However, the position of potential residual subsurface 37-mm could be altered by factors such as erosion and frost heave. Erosion has a significant potential for altering the soil cover on a hillside such as is found in and surrounding the target area. It is impossible to predict the extent of the alteration over time. It is conceivable that any residual 37-mm potentially present could be brought to the surface over time.

6.1.2.2 Ricochet and Missed Targeting Area

6.1.2.2.1 Extent of UXO Presence

The 37-mm UXO were found in the removal area during the UXO survey and the removal action outside of the target area. The presence of these items is due to either missed targeting or ricocheting off the target area. The pre-removal presence would have been lower than the presence inside the target area, since the target area was the intended point of impact. The removal action removed the detectable items within the area directly adjacent to the target area. This area was the most likely, outside of the target area, to have a 37-mm presence. The areas outside of the removal area surrounding the target area have the potential for having residual 37-mm presence. Due to their distance from the intended point of impact in the target area, the potential for 37-mm presence before the removal action was less than the impact area or the remainder of the removal area. No 37-mm UXO have been found in the investigations outside of the removal area.

Due to technical limitations of the geophysical detection equipment, it is impossible to quantify the potential for residual 37-mm, but the relative potential for finding residual UXO is lower than the potential within the target area.

6.1.2.2.2 Depth of UXO Presence

The 37-mm UXO were found at depths up to 18 inches during the UXO survey (1995) and the removal action (1996). As stated earlier, a range for the maximum 37-mm UXO penetration depth is from 18 to 95 inches, with the majority of any potential 37-mm UXO in the first 20 inches.

In the removal area, at the time the removal was completed, no 37-mm UXO would be expected on the surface or subsurface to around a depth of 18 inches. However, the position of potential residual subsurface 37-mm could be altered by factors such as erosion and frost heave. Erosion has a significant potential for altering the soil cover on a hillside such as is found in and surrounding the target area. It is impossible to predict the extent of the alteration over time. It is conceivable that any residual 37-mm potentially present could be brought to the surface over time.

There is a potential for residual 37-mm (if any) in the area surrounding the removal area for 37-mm to be found both surface and subsurface. While no items have been found on the surface during the investigations or at any other time, the 37-mm is small and can be easily overlooked by those not looking for it. As stated elsewhere in this document, any subsurface UXO could be brought to the surface by actions such as erosion or frost heave.

6.2 POTENTIAL RECEPTORS

The critical receptor groups that should be assessed are construction workers and residents. The construction workers should be assessed because their activities are the most intrusively intense while temporary and sporadic. The residents should be assessed because of the frequency that they conduct their activities on the site.

6.2.1 Construction Workers

The construction worker may access the site and come into contact with any residual 37-mm via intrusive activities associated with the performance of their work. It is expected that these activities are likely to extend throughout the depth range for the 37-mm. Construction can be intensely intrusive with depths of intrusion often to 4 ft and more within the construction footprint. It is not anticipated that there will be any intrusive activities conducted outside of the

construction footprint. However, the construction workers may access the areas outside of the construction footprint.

6.2.2 Residents

The residents have ready access to the site and common residential activities intrude to around 2 ft bgs. Most intrusive activities will be confined to depths associated with gardening with a maximum intrusion of about 1 ft bgs within their residential property. Less frequently, intrusions to around 2 ft bgs are possible, associated with minor construction (fences, etc) or major planting (bushes, trees, etc). The residents have access to the areas outside of their property and may conduct non-intrusive activities. Intrusive activities outside of the resident's property are not anticipated, and if conducted will be very infrequent and shallow (under 1 foot).

6.3 INTERACTION

6.3.1 Accident Study

The U.S. Army Corps of Engineers has developed a database of accidents that occurred on Formerly Used Defense Site (FUDS) and BRAC properties. The database is constantly updated and its development is documented in the *Development of a Database for Ordnance Related Civilian Accidents Final Report*, dated 31 January 2003 (Reference 6).

6.3.1.1 Primary Accident Factors

The major factors involved in accidents involving UXO on FUDS or transferred BRAC sites can be deduced from the database entries to be if the item was located on or above the ground surface and whether or not the item was picked up.

Of the 38 accidents captured in the database at this date, all but 9 were related (or presumed to be related based on other factors concerning the accident) to UXO items found on or above the surface. There is not enough information to determine where the UXO involved in the other nine accidents was found. None of the accidents captured in the database could be confirmed to involve subsurface UXO.

All but three accidents involved the receptor picking the item up, two accidents not having picked up the item, and one unknown.

While, at this time, there is not a method for quantifying UXO related risk, it can be said that the risks are much higher if the UXO is on the surface and if the UXO is picked up.

6.3.2 Construction Workers

Construction workers conduct activities involving the construction and modification of residences and the associated infrastructure (sewer, electrical, etc). These activities involve intrusion below ground surface within the construction footprint throughout the potential depth of the 37-mm presence. A 37-mm could be caused to function by handling it or by impacting it with construction equipment. Because the 37-mm UXO looks like a big bullet, untrained receptors may be curious and pick them up.

6.3.3 Residents

Residents conduct activities involving the maintenance and other common everyday activities. These activities primarily involve no intrusion below ground surface. Some activities such as gardening involve shallow intrusion below ground surface of up to 1 foot. Less frequent activities such as installing fencing or planting a tree may involve intrusion up to 2 ft bgs. A 37-mm could be caused to function by handling it or by impacting it with hand tools. Because the 37-mm UXO looks like big bullet, untrained receptors maybe curious and pick them up.

6.4 BASELINE PATHWAY ASSESSMENT

The baseline pathway assessment for the target area is shown in Table 6-1. The baseline pathway assessment for the removal area excluding the target area is shown in Table 6-2. The baseline pathway assessment for the area surrounding the target area outside the removal area is shown in Table 6-3.

Table 6-1 Baseline Pathway Potential Within the Former 37mm Target Area

Activities	Source	Interaction							Receptor		Potential Completed Pathway
	UXO Presence	UXO Contact Potential Level (1)				Energy Application Potential (3)	UXO Sensitivity	UXO Type	Exposed Population		
		UXO Site Stability	*Potential UXO Depth (2)*	*Activity Intrusion*					*UXO Site Access*		
Residents conducting their everyday activities on their property	Potential residual UXO in low quantity	*Potential instability noted from erosion*	*over 18"*	*less than 1 foot*	Low. No interaction expected. If UXO depth reduced by instability the potential for contact will increase	Significant - item is curious looking and untrained receptors may handle it	High - fuzed item	High - HE Item - 37mm black powder	*No restriction to site*	1-12? Daily	No interaction is expected - instability of site may change this potential
Residents conducting their less common more intrusive activities on their property	Potential residual UXO in low quantity	*Potential instability noted from erosion*	*over 18"*	*less than 2'*	Moderate-High, potential interaction below 1'. If UXO depth reduced by instability the potential for contact will increase	Significant - item is curious looking and untrained receptors may handle it	High - fuzed item	High - HE Item - 37mm black powder	*No restriction to site*	1-12? Daily	Low-moderate - Contact possible
Residents conducting activities off their property	Potential residual UXO in low quantity	*Potential instability noted from erosion*	*over 18"*	*anticipated surface only*	Low. No interaction expected. If UXO depth reduced by instability the potential for contact will increase	Significant - item is curious looking and untrained receptors may handle it	High - fuzed item	High - HE Item - 37mm black powder	*No restriction to site*	<20? Daily	No interaction is expected - instability of site may change this potential
Construction workers conducting their activities within the construction footprint	Potential residual UXO in low quantity	*Potential instability noted from erosion*	*over 18"*	*up to and potentially exceeding 4'*	High, potential interaction below 1'. If UXO depth reduced by instability the potential for contact will increase	Significant - item is curious looking and untrained receptors may handle it	High - fuzed item	High - HE Item - 37mm black powder	*No restriction to site*	1-12? Daily	Moderate - High. Intensive intrusive activities have high probability of resulting in contact with any potential UXO
Construction workers conducting their activities outside the construction footprint	Potential residual UXO in low quantity	*Potential instability noted from erosion*	*over 18"*	*anticipated surface only*	Low. No interaction anticipated. If UXO depth reduced by instability the potential for contact will increase	Significant - item is curious looking and untrained receptors may handle it	High - fuzed item	High - HE Item - 37mm black powder	*No restriction to site*	1-12? Daily	No interaction is expected - instability of site may change this potential

(1) The potential for contact is assessed based upon the assumption that UXO is present at the intrusion point
(2) Expected minimum depth assumes residual UXO presence. Depth may vary due to site characteristics and geophysical detection system operation
(3) The energy application potential is assessed assuming that an item is contacted.

Table 6-2 Baseline Pathway Potential Outside the Former 37mm Target Area Within the Removal Area

Activities	Source	Interaction							Receptor		Potential Completed Pathway
	UXO Presence	UXO Contact Potential Level (1)				Energy Application Potential (3)	UXO Sensitivity	UXO Type	Exposed Population		
		UXO Site Stability	*Potential UXO Depth (2)*	*Activity Intrusion*					*UXO Site Access*		
Residents conducting their everyday activities on their property	Potential residual UXO in low quantity - less potential than target area	*Potential instability noted from erosion*	*over 18"*	*less than 1 foot*	Low. No interaction expected. If UXO depth reduced by instability the potential for contact will increase	Significant - item is curious looking and untrained receptors may handle it	High - fuzed item	High - HE Item - 37mm black powder	*No restriction to site*	1-12? Daily	Low. Receptor should not interact with any potential UXO - risk could change over time
Residents conducting their less common more intrusive activities on their property	Potential residual UXO in low quantity - less potential than target area	*Potential instability noted from erosion*	*over 18"*	*less than 2'*	Moderate-High, potential interaction below 1'. If UXO depth reduced by instability the potential for contact will increase	Significant - item is curious looking and untrained receptors may handle it	High - fuzed item	High - HE Item - 37mm black powder	*No restriction to site*	1-12? Daily	Low - Moderate. receptor may interact with any potential UXO which may be present in very low quantities
Residents conducting activities off their property	Potential residual UXO in low quantity - less potential than target area	*Potential instability noted from erosion*	*over 18"*	*anticipated surface only*	Low. No interaction expected. If UXO depth reduced by instability the potential for contact will increase	Significant - item is curious looking and untrained receptors may handle it	High - fuzed item	High - HE Item - 37mm black powder	*No restriction to site*	<20? Daily	Low. Receptor should not interact with any potential UXO - risk could change over time
Construction workers conducting their activities within the construction footprint	Potential residual UXO in low quantity - less potential than target area	*Potential instability noted from erosion*	*over 18"*	*up to and potentially exceeding 4'*	High, potential interaction below 1'. If UXO depth reduced by instability the potential for contact will increase	Significant - item is curious looking and untrained receptors may handle it	High - fuzed item	High - HE Item - 37mm black powder	*No restriction to site*	1-12? Daily	Moderate - High. If UXO is present in the construction footprint, there is likely to be interaction. Expectation of UXO present minimal - very low quantities
Construction workers conducting their activities outside the construction footprint	Potential residual UXO in low quantity - less potential than target area	*Potential instability noted from erosion*	*over 18"*	*anticipated surface only*	Low. No interaction anticipated. If UXO depth reduced by instability the potential for contact will increase	Significant - item is curious looking and untrained receptors may handle it	High - fuzed item	High - HE Item - 37mm black powder	*No restriction to site*	1-12? Daily	Low. Receptor should not interact with any potential UXO - risk could change over time

(1) The potential for contact is assessed based upon the assumption that UXO is present at the intrusion point
(2) Expected minimum depth assumes residual UXO presence. Depth may vary due to site characteristics and geophysical detection system operation
(3) The energy application potential is assessed assuming that an item is contacted.

Table 6-3 Baseline Pathway Potential Outside the Removal Area

Activities	Source	Interaction							Receptor		Potential Completed Pathway
	UXO Presence	UXO Contact Potential Level (1)				Energy Application Potential (3)	UXO Sensitivity	UXO Type	Exposed Population		
		UXO Site Stability	*Potential UXO Depth (2)*	*Activity Intrusion*					*UXO Site Access*		
Residents conducting their everyday activities on their property	Potential residual UXO in low quantity - less potential than target area- decreasing with distance from target	*Potential instability noted from erosion*	*Potential surface*	*less than 1 foot*	High, potential UXO on surface	Significant - item is curious looking and untrained receptors may handle it	High - fuzed item	High - HE Item - 37mm black powder	*No restriction to site*	1-12? Daily	Low - Moderate. Quantities of residual UXO expected to be very low if any
Residents conducting their less common more intrusive activities on their property	Potential residual UXO in low quantity - less potential than target area- decreasing with distance from target	*Potential instability noted from erosion*	*Potential surface*	*less than 2'*	High, potential UXO on surface	Significant - item is curious looking and untrained receptors may handle it	High - fuzed item	High - HE Item - 37mm black powder	*No restriction to site*	1-12? Daily	Low. Quantities of residual UXO expected to be very low if any. Potential
Residents conducting activities off their property	Potential residual UXO in low quantity - less potential than target area- decreasing with distance from target	*Potential instability noted from erosion*	*Potential surface*	*anticipated surface only*	High, potential UXO on surface	Significant - item is curious looking and untrained receptors may handle it	High - fuzed item	High - HE Item - 37mm black powder	*No restriction to site*	<20? Daily	Low - Moderate. Quantities of residual UXO expected to be very low if any, if present contact probable
Construction workers conducting their activities within the construction footprint	Potential residual UXO in low quantity - less potential than target area- decreasing with distance from target	*Potential instability noted from erosion*	*Potential surface*	*up to and potentially exceeding 4'*	High, potential UXO on surface	Significant - item is curious looking and untrained receptors may handle it	High - fuzed item	High - HE Item - 37mm black powder	*No restriction to site*	1-12? Daily	Moderate - High. If UXO is present in the construction footprint, there is likely to be interaction. Expectation of UXO present minimal - very low quantities
Construction workers conducting their activities outside the construction footprint	Potential residual UXO in low quantity - less potential than target area- decreasing with distance from target	*Potential instability noted from erosion*	*Potential surface*	*anticipated surface only*	High, potential UXO on surface	Significant - item is curious looking and untrained receptors may handle it	High - fuzed item	High - HE Item - 37mm black powder	*No restriction to site*	1-12? Daily	Low. Receptor should not interact with any potential UXO - risk could change over time

(1) The potential for contact is assessed based upon the assumption that UXO is present at the intrusion point
(2) Expected minimum depth assumes residual UXO presence. Depth may vary due to site characteristics and geophysical detection system operation
(3) The energy application potential is assessed assuming that an item is contacted.

6.5 PATHWAY MITIGATION ANALYSIS

The potential for a completed UXO-related pathway will be lowered by:

- Reducing the UXO presence.
- Reducing the receptor's access to the UXO.
- Reducing the potential for contact and interaction with the UXO.

The potential for a completed pathway is low for all activities except those activities with significant intrusiveness within the resident's property. The objective of any mitigation activity is to manage risks on the site so that the potential for a completed is low. In this case, it is not viable to reduce access to the area potentially containing the UXO. Therefore, only reduction of UXO presence and/or reduction of the potential for interaction with the UXO are available to reduce the potential for a completed pathway.

6.5.1 Reduction of UXO Presence

Due to limitations on current systems, there is no assurance that all UXO is removed using the industry standard anomaly detection and removal. The greatest potential for a completed pathway is within the resident's property. While the perceived potential for residual UXO will not be impacted by a removal action, since the remaining presence cannot be quantified, any items removed will reduce the risk. As stated above, there has not been identified any accidents on FUDS or BRAC property involving sub-surface items and a removal of any potential surface items will significantly reduce the risk.

6.5.2 Reduction of Interaction Potential

Land Use Controls including notification of hazards and safety education have been used to reduce the likelihood of a hazardous interaction. While just because an item is picked up does not mean that there will be a hazardous event (note that we have identified only 38 incidents from over 1,300 properties), the potential for hazardous event does increase. All serious injuries and deaths documented in the accident database resulted from the item being picked up. Notification and training can be used to reduce the likelihood of an item being picked up.

6.5.3 Recommended Action

Since the greatest potential to either construction workers or residents for a completed pathway is within the former target area, located in the Oak Housing section of Area 11, construction support is recommended for the target area along with safety training and notification of construction workers, residents, and surrounding community.

Since there is a potential for a completed pathway in the Grant Housing section Area 11, excluding the target area, safety training and notification of the construction workers, residents, and surrounding community are recommended.

SECTION 7

CONCLUSIONS

7. CONCLUSIONS

The characterization of the UXO survey is fully developed and sufficient to identify the areas of concern that have a potential for UXO. The only identified area of concern with potential residual UXO presence is the 37-mm range associated with IA-2.

Firing-range activities were presumed to have occurred within each of the identified IAs. IA-1 is no longer physically in existence. The approximate berm area in IA-1 should be sampled for lead.

Analytical results from samples collected from the IA-3 and IA-5 impact berms do not indicate the presence of lead at concentrations that would present unacceptable risks to human health or the environment. Consequently, no further investigation of potential lead-contamination is recommended within IA-3 and IA-5.

IA-6 is not physically located within any of the housing areas. At IA-6, the analytical results indicate the presence of lead that is above the Massachusetts Contingency Plan Reportable Concentration Standards (RCS-1) Standard of 300 milligrams per kilogram that is likely associated with the former range activities.

IA-7 is not physically located within any of the HAs. Research indicates that this location was an outdoor sub-caliber anti-tank range. This area has been substantially reworked. The approximate berm area in IA-7 should be sampled for lead.

The characteristics of the 37-mm range are clearly defined with the target area located in the Oak (Oak Circle) HA and the firing point located to the northeast at IA-2. The effective range of the 37-mm falls within the target area, given IA-2 as the firing point. There is a low potential for finding 37-mm UXO remaining on the site and the potential is higher in the former impact area with the potential decreasing outside of it as the distance increases from the target area. Any additional investigation is not going to alter the characterization of the range features and the perception of residual UXO presence.

There is a potential for a completed UXO related pathway within the former range. There is a higher potential within proposed residential footprints within the former target area. The former

target area is located in the Oak HA of Area 11, and not located in the study areas. Although outside of the study area, construction support is recommended to include a clearance to detection limits of the residential footprints within the former target area. In addition to he construction support, safety training and notification of the construction workers, residents, and surrounding community is also recommended.

There is a lower potential for a completed UXO related pathway on the former range within Grant Housing section Area 11, excluding the target area. Safety training and notification of the construction workers, residents, and surrounding community are recommended.

In 2005 and 2006, a DGM investigation and mMEC removal was performed in the former Grant HA. Following the DGM, the investigation reaquired and marked the anomalies, and excavated, identified and removed the items discovered. Approximately 15 pieces of 37-mm anti-tank ordnance and 1,870 pounds of MEC scrap were recovered from the site, mostly located on the north side of Oak Hill, the presumed impact area. In addition, six 3-inch-diameter Stokes mortars and 30 other miscellaneous ordnance items were recovered from the area. These items were distributed evenly across the site in a way that suggests that the ordnance were not associated with specific training areas. The ordnance recovered was detonated in place, and all MEC-related scrap was removed from the site. The conclusions of the earlier versions of the ECSM did not change substantially in light of subsequent DGM data collection in the Grant HA.

Recommend this report be made available for both public and regulator comment. Further development and assessment is required to fully develop and implement the recommended action.

SECTION 8

REFERENCES

8. REFERENCES

1. *Archives Search Report* (*ASR*), prepared by the U.S. Army Corps of Engineers (USACE) in 1995.

2. *Draft Ordnance, Ammunition and Explosives Sampling Report*, prepared by Human Factors Application (HFA) in 1995, who was under contract to the USACE.

3. *Final Ordnance, Ammunition, and Explosive Removal Action Report* prepared by HFA in 1996.

4. *The American Arsenal*, by Ian Hogg, published by Greenpole Books in 2001.

5. DA Pam 385-63, Range Safety.

6. *Development of a Database for Ordnance Related Civilian Accidents*", Final Report, dated 31 January 2003, U.S. Army Corps of Engineers, Huntsville, AL

7. *Site Specific Final Report Digital Geophysical Mapping (DGM) & Unexploded Ordnance(UXO) Removal Former Grant Housing Area, Former Fort Devens, Harvard, Worcester County, Massachusetts*. Ordnance & Explosives Remediation, Inc. 22 March 2006.

FIGURES

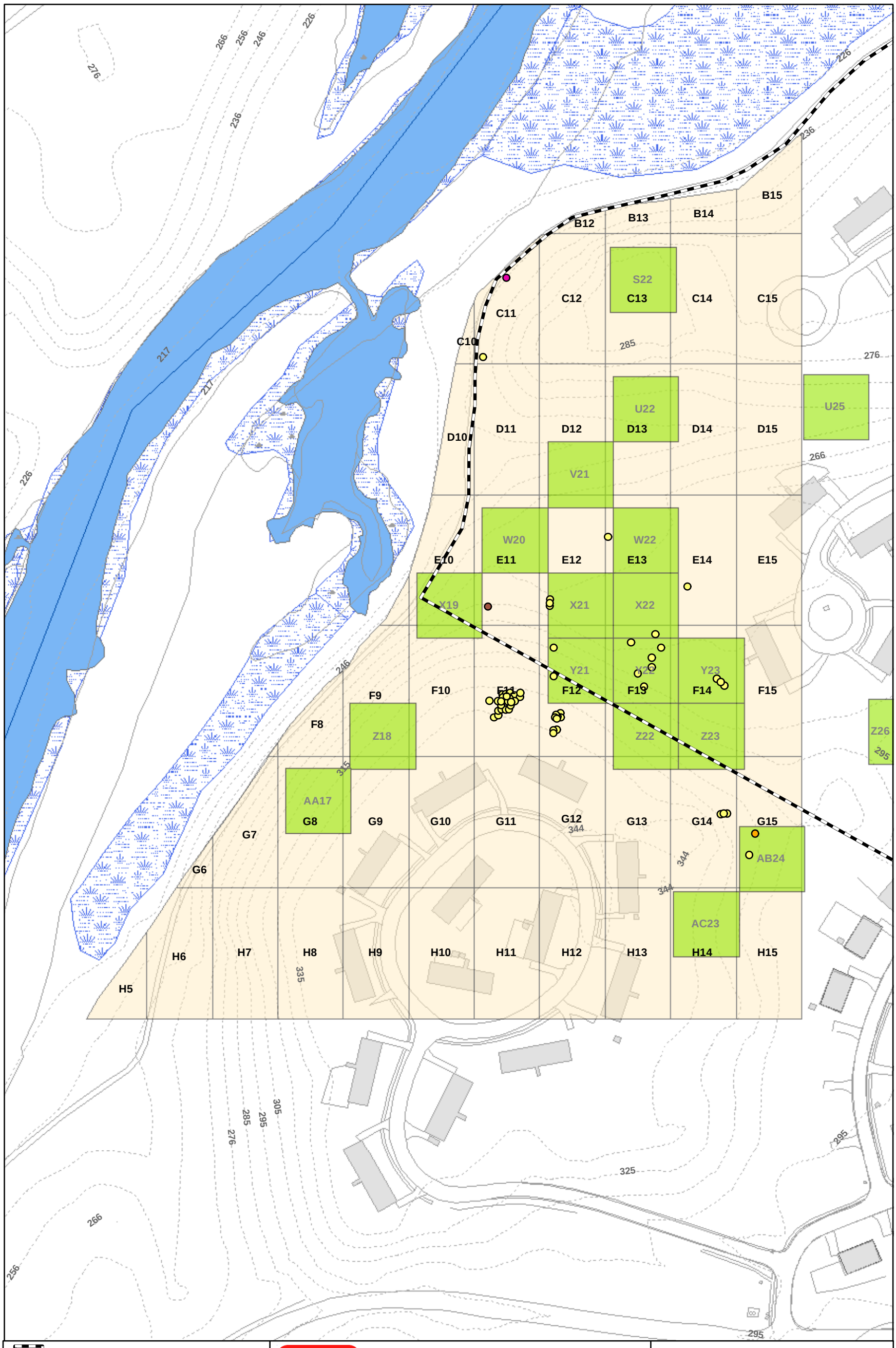
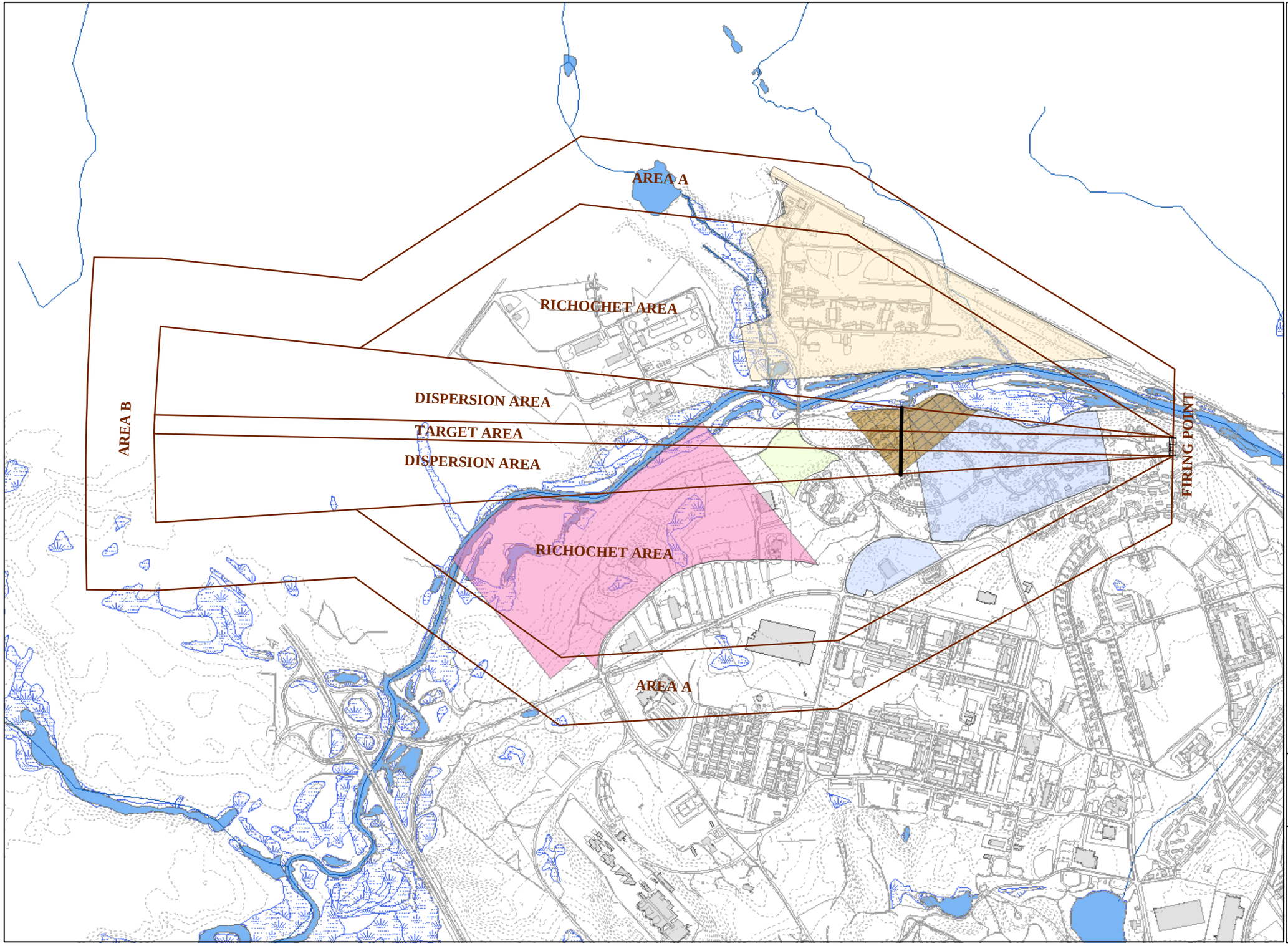


Figure 4-1
Area 11
Remediation Effort

Ft. Devens, Massachusetts

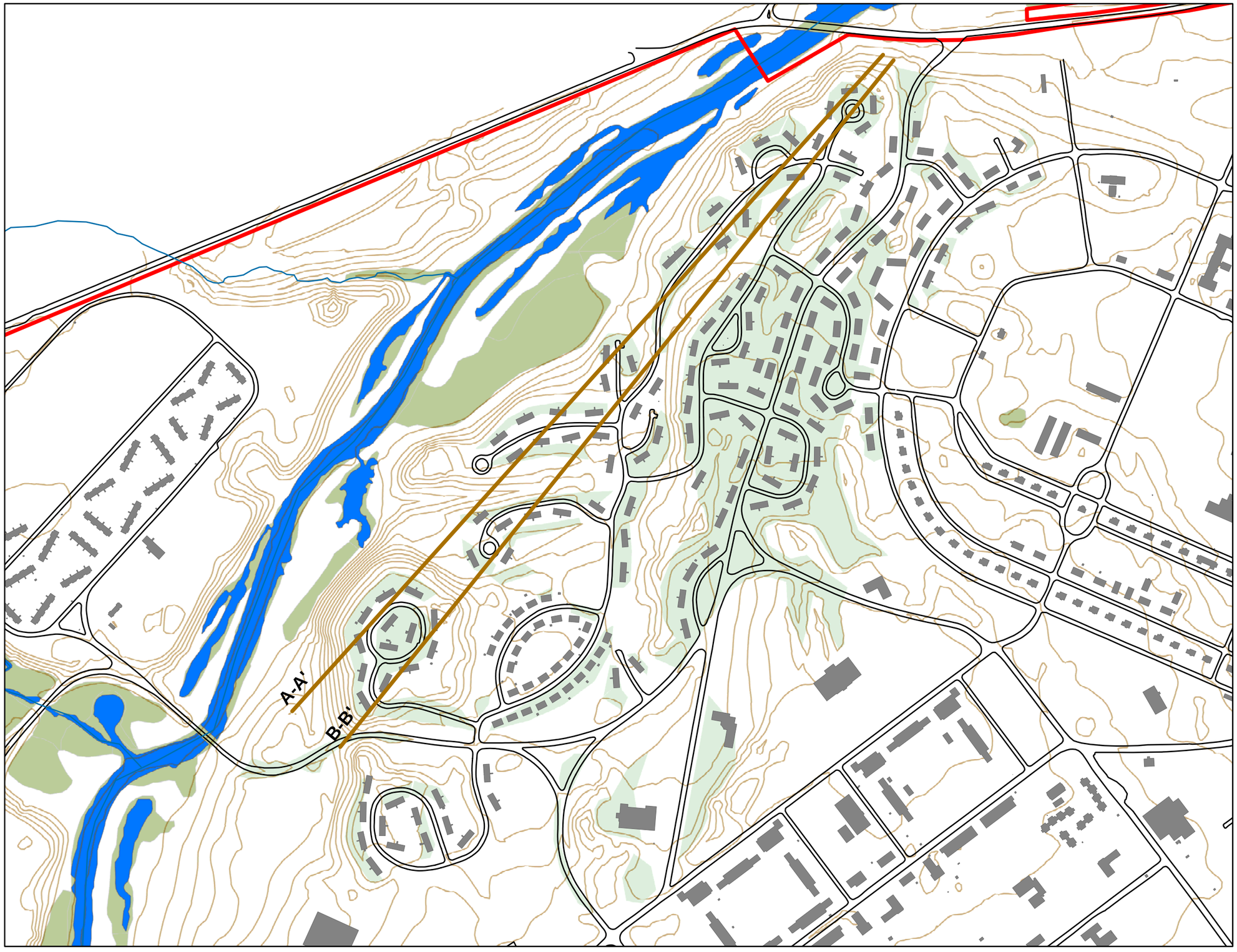


Legend

- Firing Range
- Area 2
- Area 11
- Area 17
- Ammo Area
- Remediation Grid
- Topographic Contours
- Effective Range

0 600 1,200 2,400
Feet

Figure 4-2
IA-2 Surface Danger Zone
Ft. Devens, Massachusetts



Legend

- section_locations
- Devens_boundary
- wetland

cutfill

- cutfill

N

0 400 800 Feet

CROSS-SECTION LOCATION MAP

CONCEPTUAL SITE MODEL
GRANT, LOCUST, & CAVITE HOUSING AREAS
DEVENS, MASSACHUSETTS

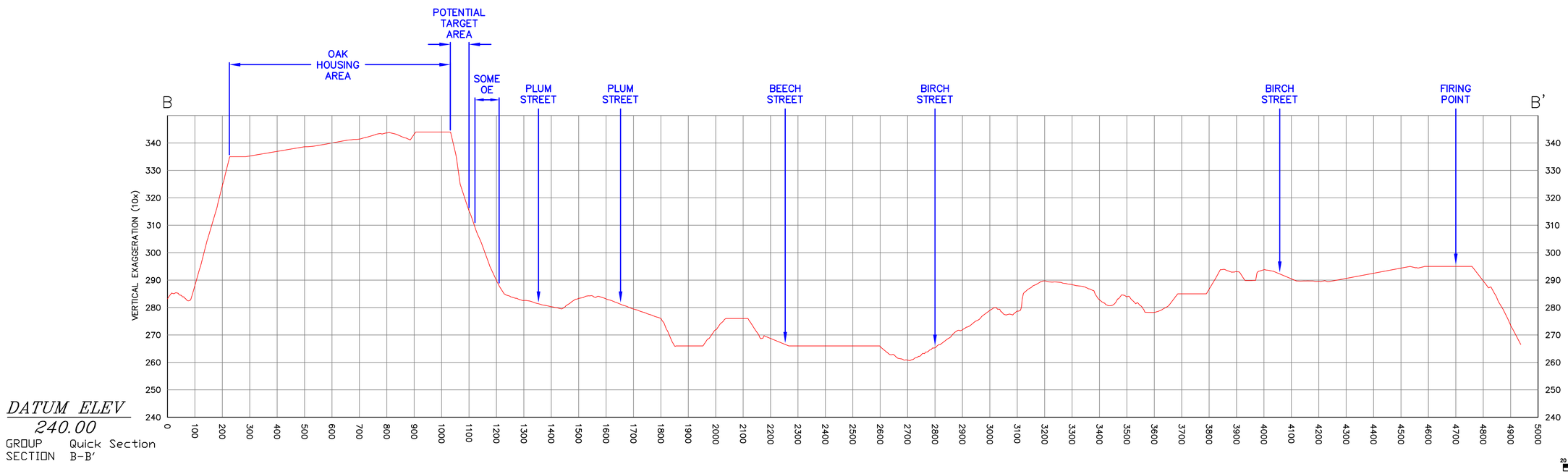
FIGURE 4-3

WESTON SOLUTIONS

US Army Corps of Engineers®

WESTON SOLUTIONS, INC. MAY 2004





VERTICAL SCALE
20 10 0 10 20
APPROXIMATE SCALE IN FEET

HORIZONTAL SCALE
200 100 0 100 200
APPROXIMATE SCALE IN FEET

NO.	DATE	APPR.	REVISION	NO.	DATE	APPR.	REVISION

CONCEPTUAL SITE MODEL
STUDY AREA – GRANT, LOCUST, AND CAVITE HOUSING AREAS
DEVENS, MASSACHUSETTS

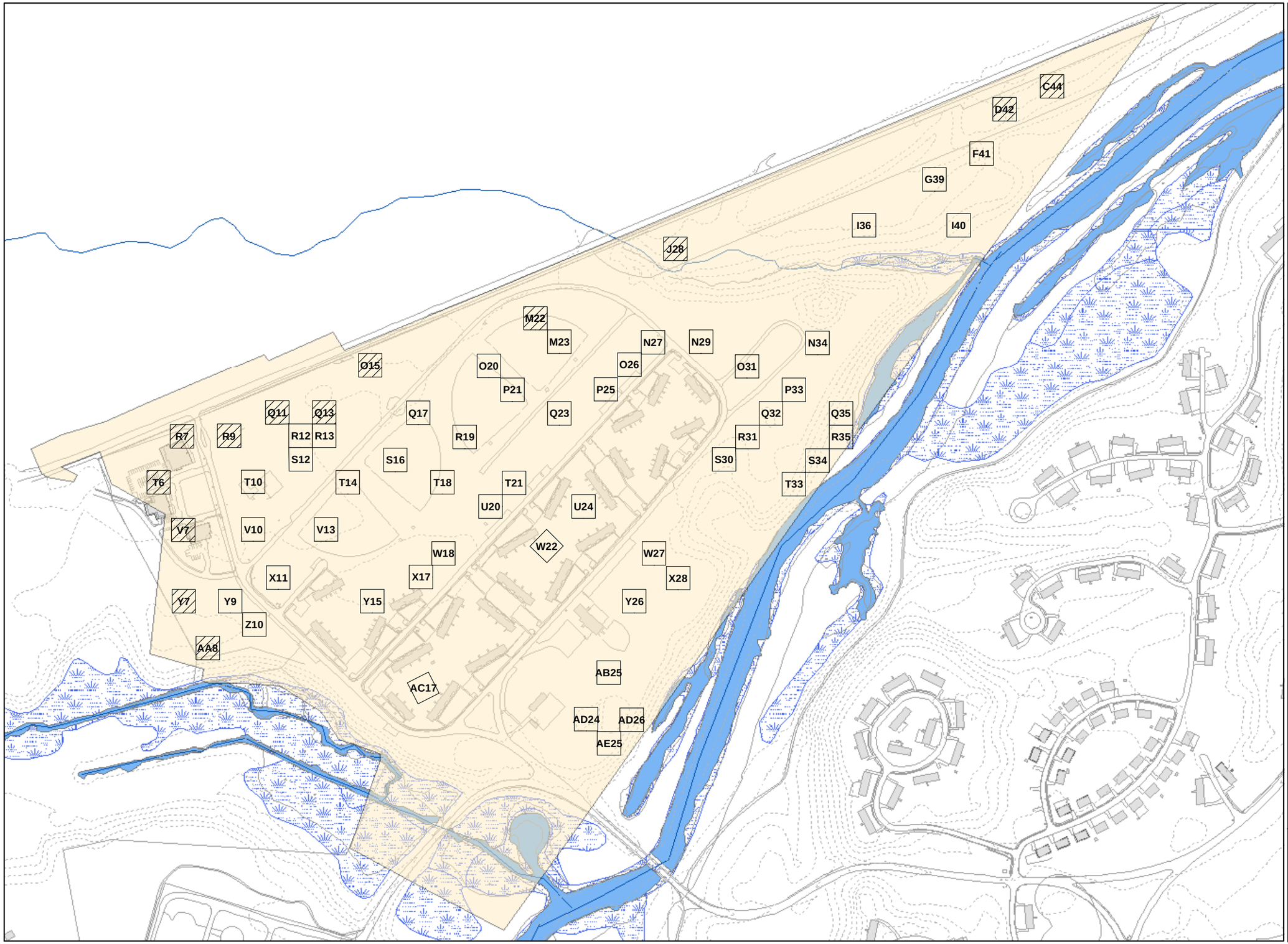
WESTON SOLUTIONS
MANCHESTER NEW HAMPSHIRE

CHECKED	DATE	CLIENT APPROVALS	DATE
DES. ENG.			
PROJ. ENG.			
PROJ. MGR.			
APPROVED			
APPROVED		ISSUED FOR	DATE

DEPARTMENT OF THE ARMY
NEW ENGLAND DISTRICT
CORPS OF ENGINEERS
CONCORD, MASSACHUSETTS

CROSS–SECTIONS A–A' AND B–B'

DRAWN	DATE	FIGURE NO.	REV. NO.
BEG	MAY 2004	4–4	
SCALE	W.O. NO.	SHT. ___ OF ___	
AS SHOWN	03886.518.045		



Legend

- Area 2
- 100' x 100' Survey Grid
- Not Surveyed - Within 200' of Base Boundary
- Topographic Contours

N
W E
S

0 200 400 800
Feet

Figure 4-5
Area 2
UXO Investigation Grids
Ft. Devens, Massachusetts

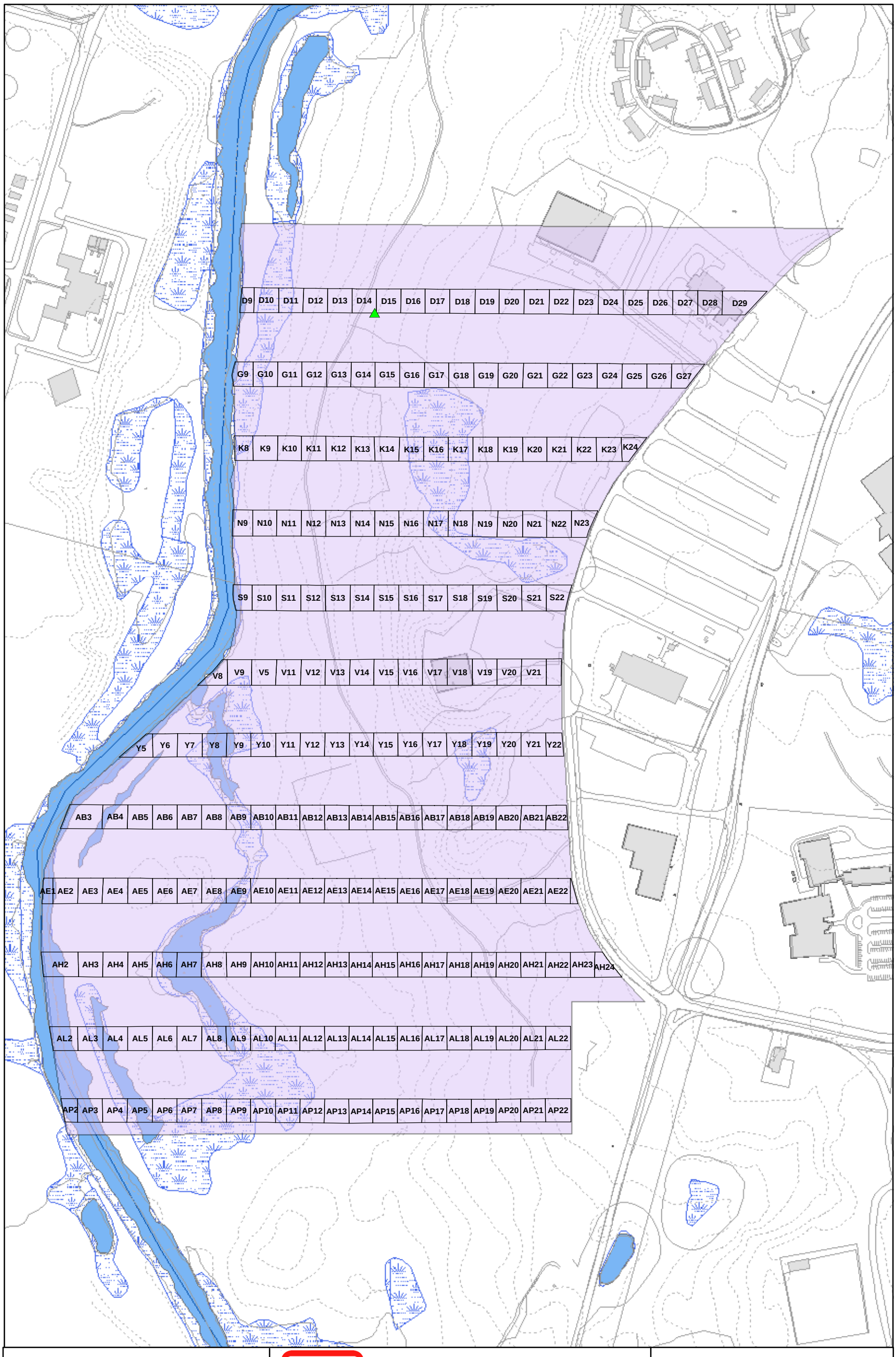


Figure 4-6
Additional Ammunition, Ordnance, and Explosives Area
UXO Investigation Grids
Ft. Devens, Massachusetts

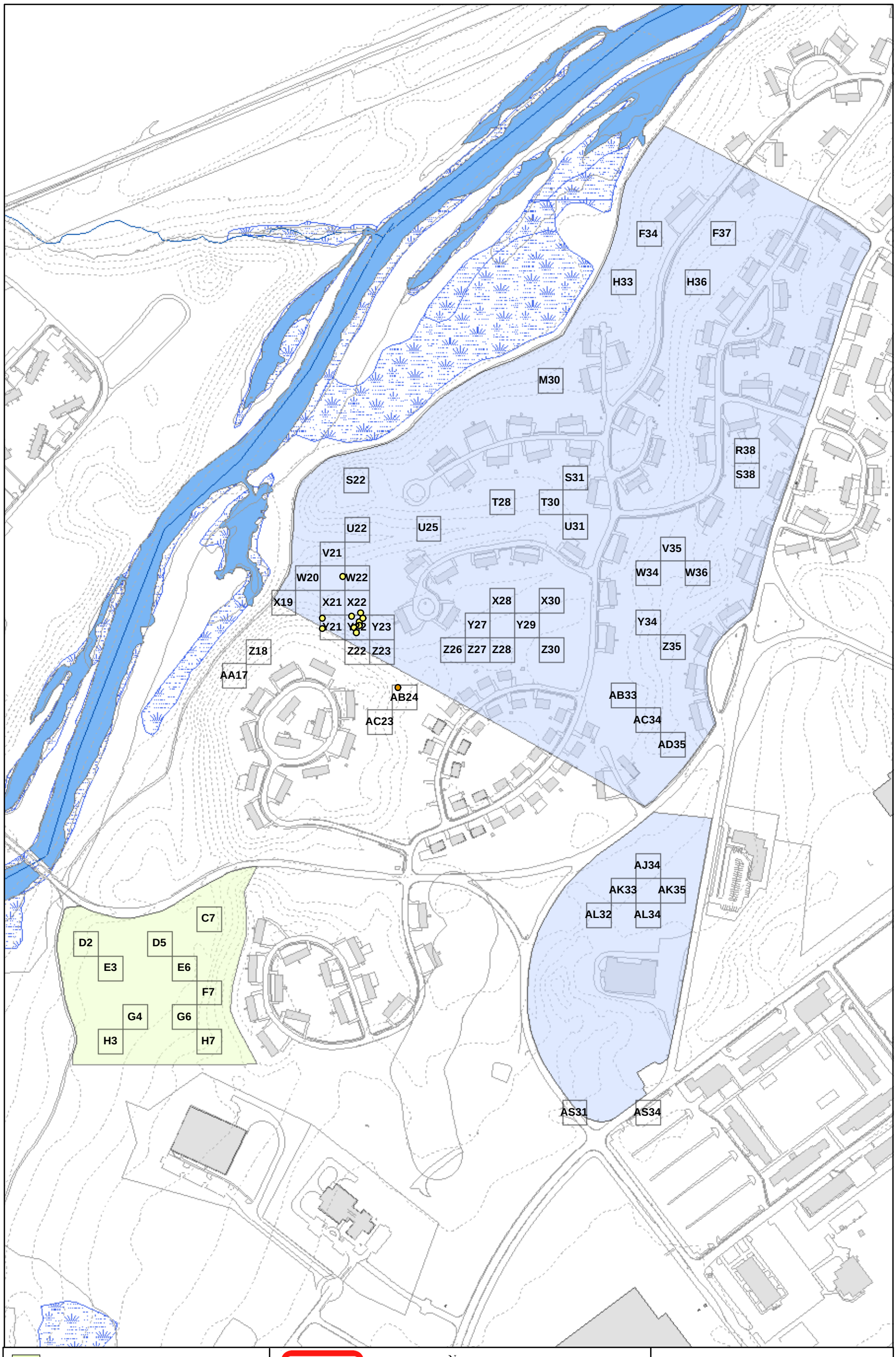


Figure 4-7
Area 11 and 17
UXO Investigation Grids

Ft. Devens, Massachusetts

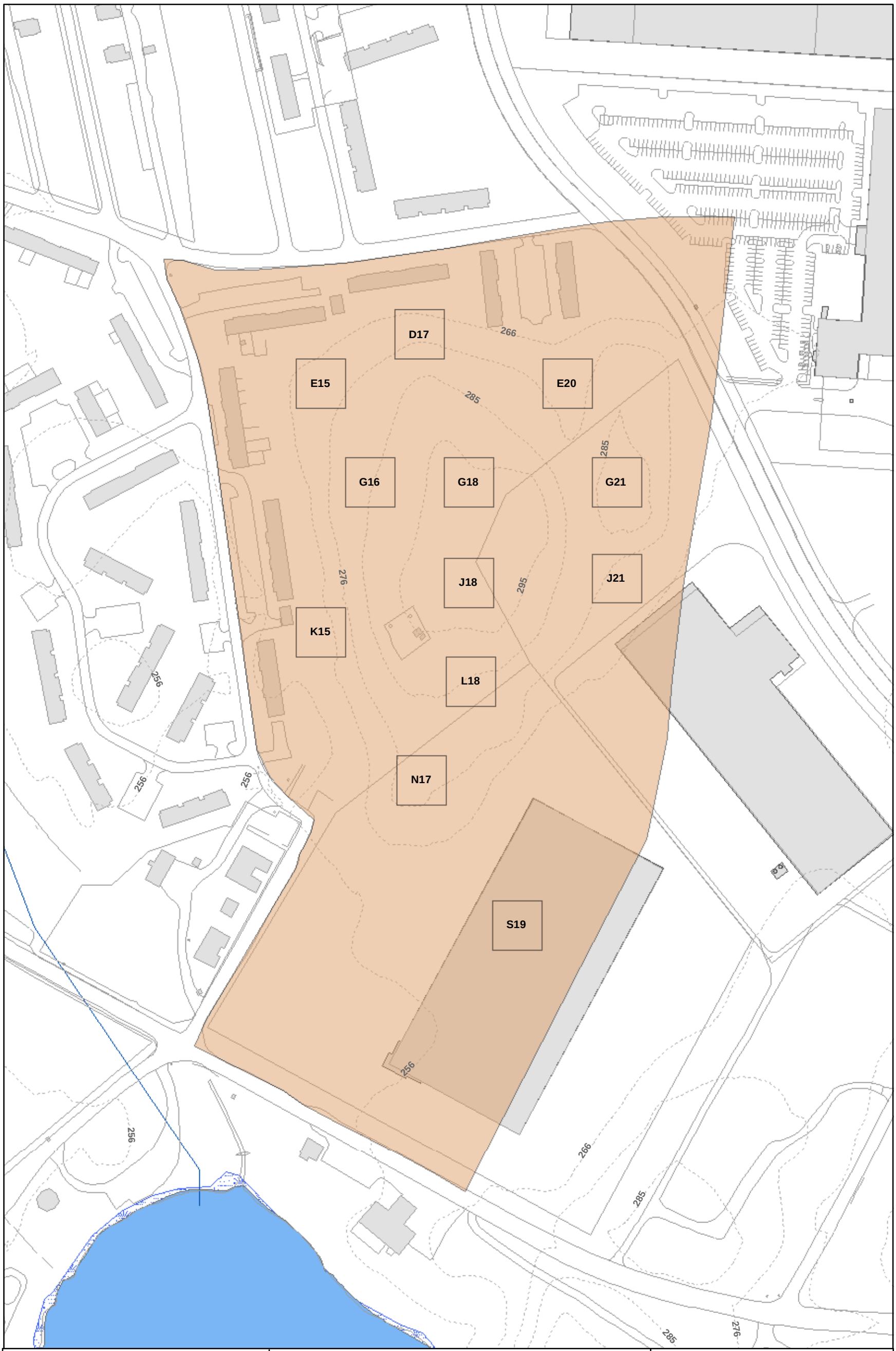


Figure 4-8
Area 15
UXO Investigation Grids
Ft. Devens, Massachusetts

Figure 5-1 UXO Recovery Depths Oak HA Hillside

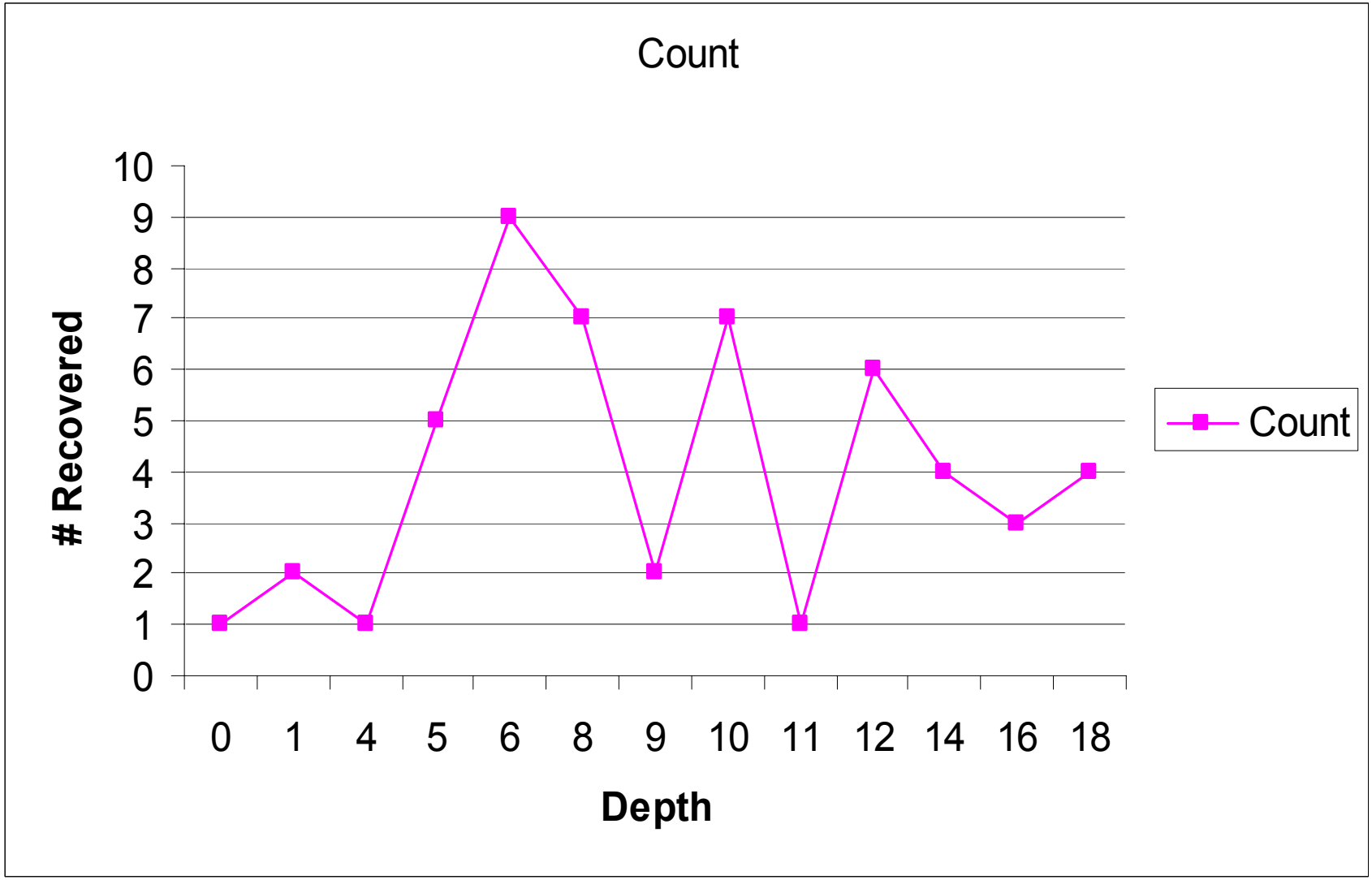
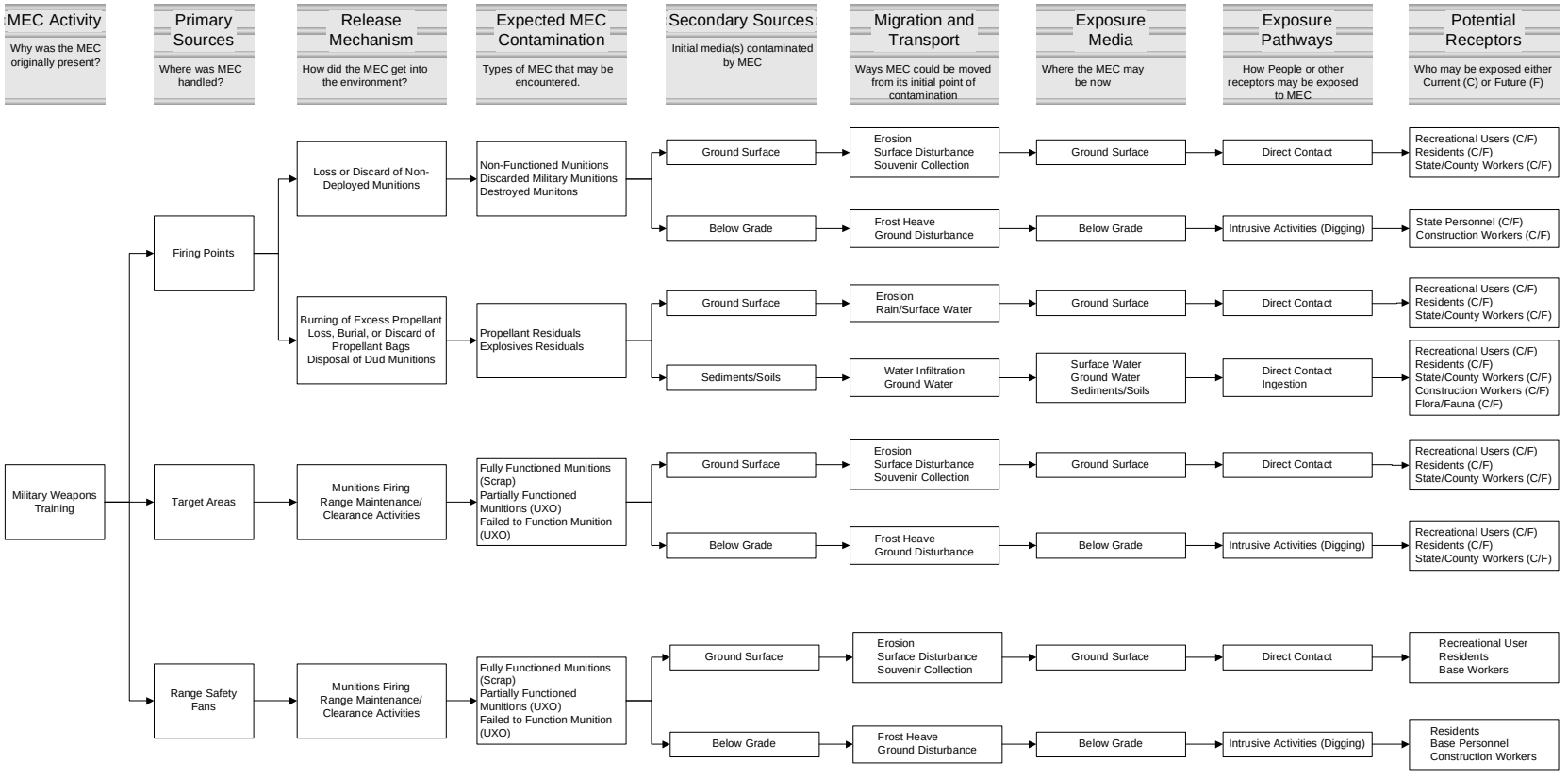


Figure 5-2: MEC Pathways Analysis Flowchart

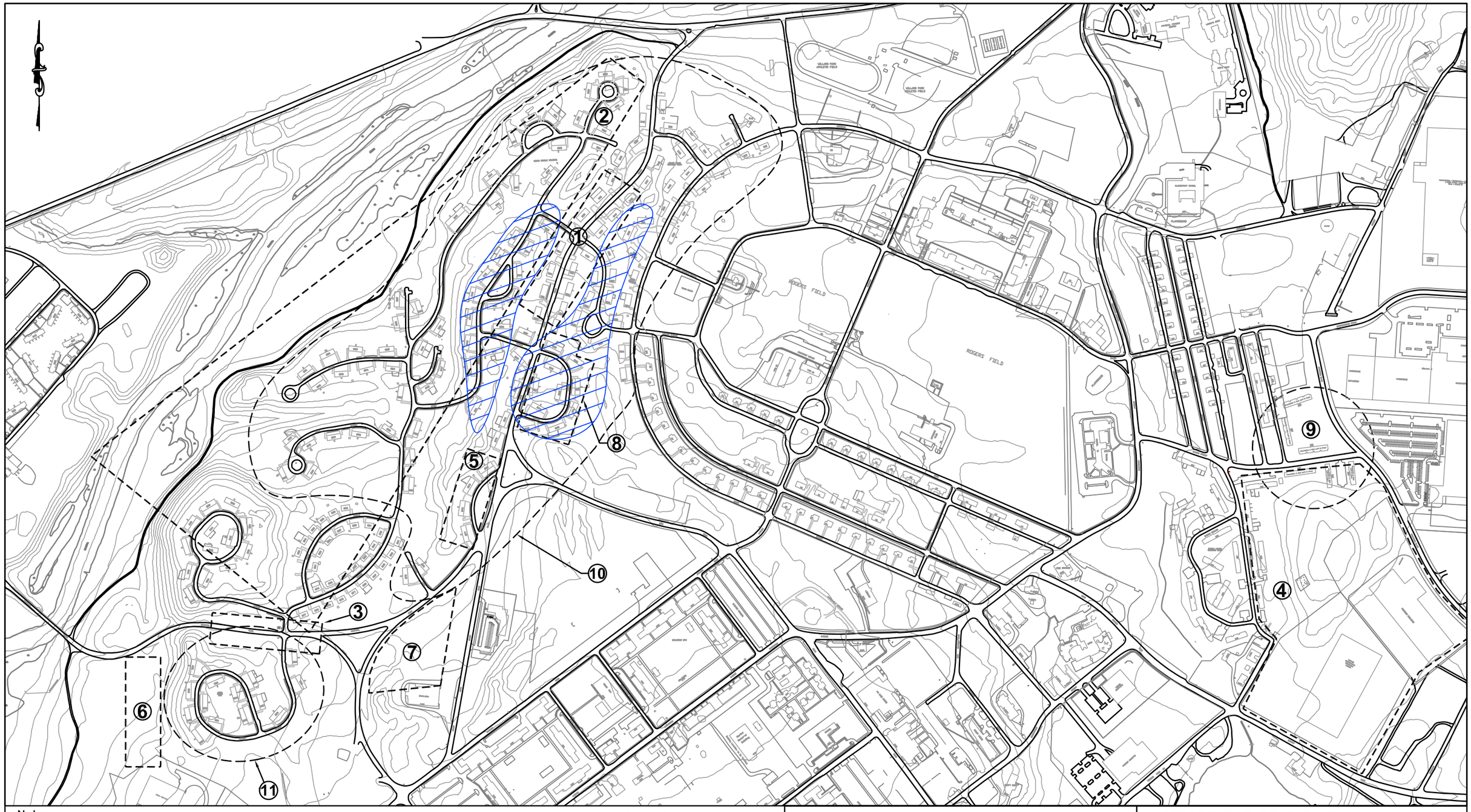


Former Fort Devens, IA-2

Weston Solutions	5/5/2004	Drawn By: chh

ATTACHMENT A

FIGURE 2-1 (PA/SI) INVESTIGATION AREAS WITHIN THE GRANT, LOCUST AND CAVITE HOUSING AREAS



Notes

** Based on information gathered from the Archives Search Report – (Findings, Maps, Conclusions and Recommendations), Fort Devens, U.S. Army Corps of Engineers, St. Louis District, US Dept. of Defense BRAC, Ordnance, Ammunition and Explosives, May 1995.

1. 1922 – Possible Training Area
2. 1922 – Possible Training Area and/or Range
3. 1922 – Possible Rifle Range
4. 1922 – Possible Tranch Warfare Training Area
5. 1943 & 1951 – Anti-tank Range
6. 1943 & 1951 – Rifle and Machine Gun Range
7. 1943 & 1951 – Anti-tank Range
8. Former Laundry Facility
9. Entire Cavite Housing Area referred to as a Training Area – 1954, 1957, 1961.
10. Entire Grant Housing Area west of Grant Road is referred to as a Training Area – 1954, 1957.
11. Entire Locust Housing Area is referred to as a Training Area – 1954, 1957, 1961.

Legend

Investigation Area (IA) Boundary

Area of Significant Mining of Sand and Gravel

GRAPHIC SCALE

600 300 0 300 600

APPROXIMATE SCALE IN FEET

INVESTIGATION AREAS (IAs) WITHIN THE GRANT, LOCUST, & CAVITE HOUSING AREAS

DEPARTMENT OF THE ARMY
NEW ENGLAND DISTRICT
CORPS OF ENGINEERS
CONCORD, MASSACHUSETTS

PA/SI WORK PLAN
FORMER FORT DEVENS MILITARY INSTALLATION
DEVENS, MASSACHUSETTS

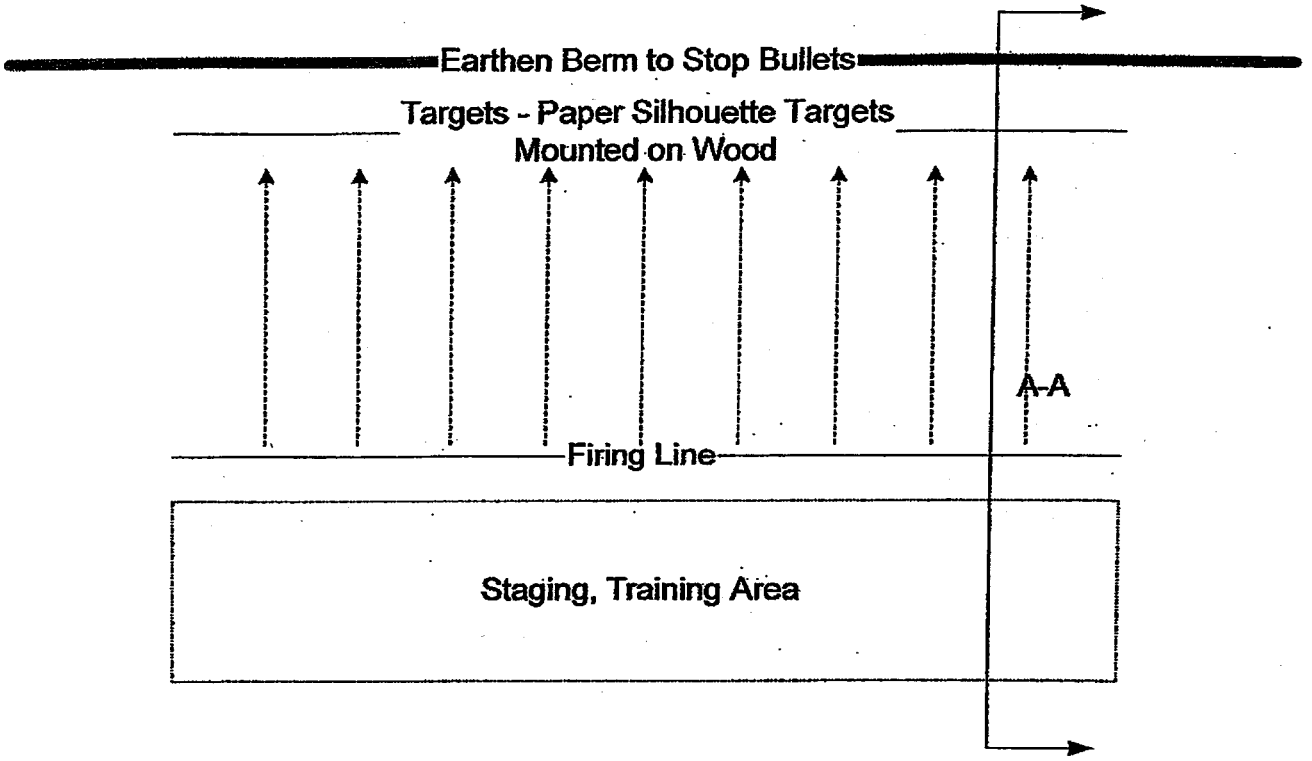
WESTON SOLUTIONS
MANCHESTER NEW HAMPSHIRE

DRAWN BEG
DATE DEC 2003
FIGURE NO. 2-1

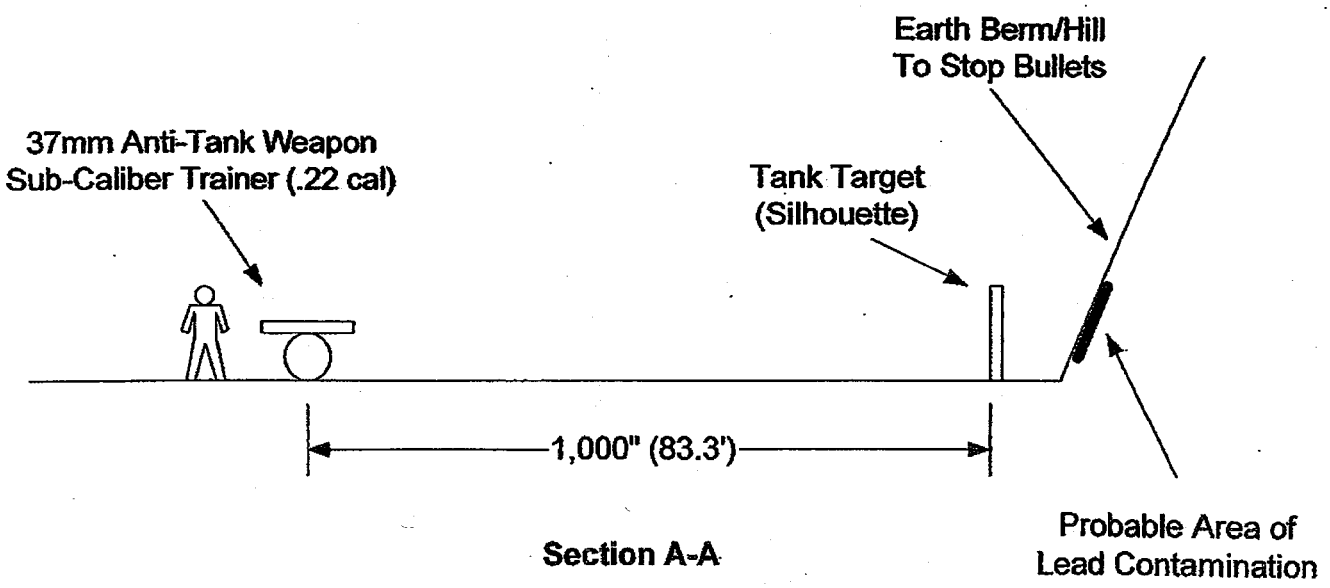
M:\Design\DWG\ACOE\FTDEVENS\PEST_SOIL\bldg samp maps\PRESENTATION\PASI Report\PASI UXO Report\FIG 2-1.dwg, LAYOUT1, 12/15/2003 10:38:36 AM, murrot, 1:1

ATTACHMENT B

37 MM ANTI TANK SUB-CALIBER TRAINING RANGE LAYOUT



37 mm Anti-Tank Sub-Caliber
Training Range Layout



Section A-A

WESTON Solutions		
1,000" Sub-Cal Range	12/9/2003	chh

ATTACHMENT C

SUBCALIBER AMMUNITION FOR FIELD ARTILLERY, SEACOST GUNS, AND MORTARS DATA SHEET

CHAPTER 3
SMALL-ARMS AMMUNITION

3–1. General

Small-arms ammunition, as used herein, describes a cartridge or families of cartridges intended for use in various types of hand-held or mounted weapons through 30 millimeter. Within a caliber designation, these weapons may include one or more of the following: rifles (except recoilless), carbines, pistols, revolvers, machineguns and shotguns. For purposes of this publication, small-arms ammunition may be grouped as cartridges intended primarily for combat or training purposes (API, HEI, tracer or ball); for training purposes only (blank or dummy); or for special purposes (rifle grenade or spotter-tracer). Refer to TM 9–1305–200 for more detailed information on small-arms ammunition.

3–2. Cartridges

In general, a small-arms cartridge is identified as an assembly of a cartridge case, primer, a quantity of propellant within the cartridge case, and a bullet or projectile. Blank and rifle grenade cartridges are sealed with paper closure disks in lieu of bullets. Dummy cartridges are composed of a cartridge case and a bullet. Some dummy cartridges contain inert granular materials to simulate the weight and balance of live cartridges. A typical cartridge and the terminology of its components are shown in figure 3–1.

a. Case. Although steel, aluminum, zinc and plastic materials have been used experimentally, brass, a composition of 70 percent copper and 30

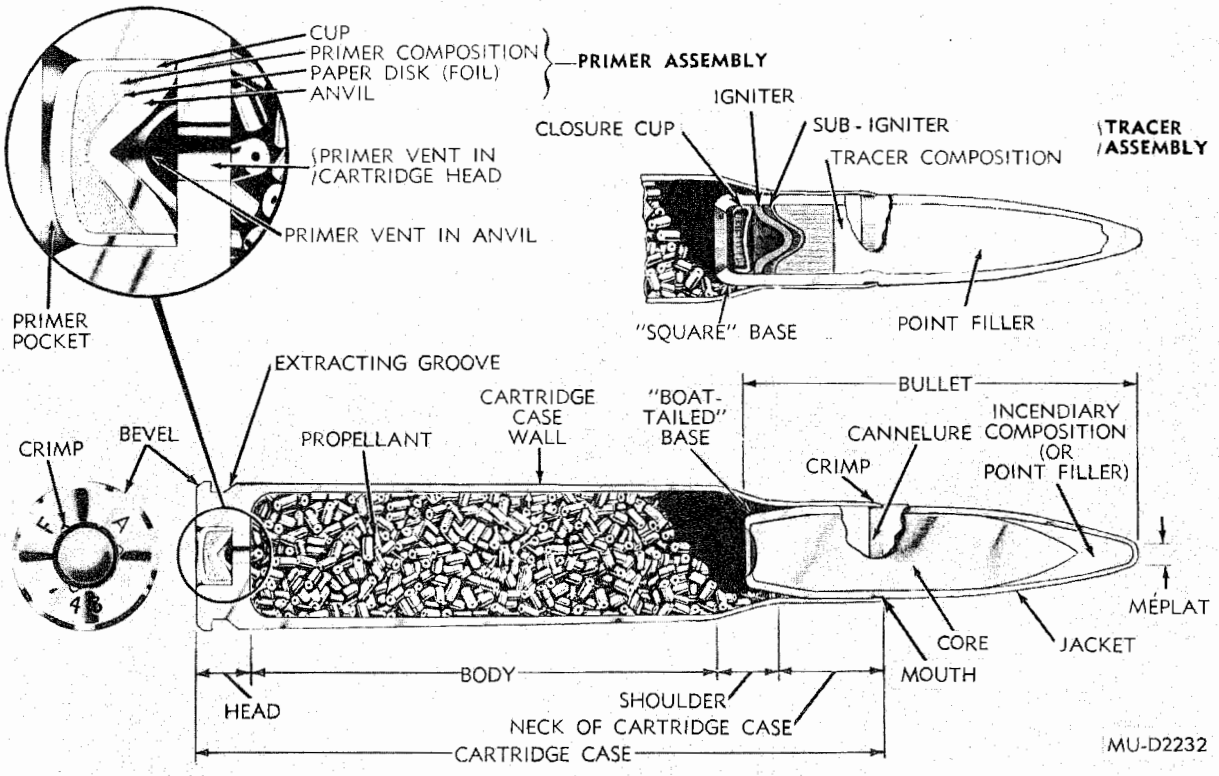


Figure 3–1. Typical cartridge (sectioned).

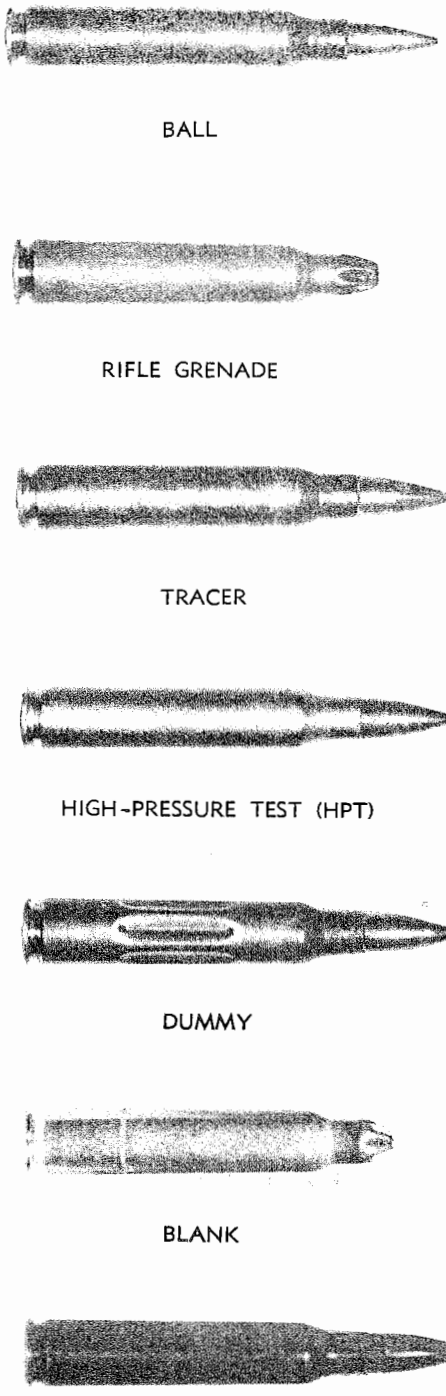


Figure 3–6. 5.56MM cartridges.

percent zinc, is the most commonly used material for cartridge cases. Steel, as well as brass, is an approved material for caliber .45 cartridge cases. Brass, paper and plastic are used for 12 gage shotshell bodies and aluminum is used for military-type .410 gage shotshell bodies. Configurations of cartridges and bullets are illustrated in figures 3–2 through 3–11.

b. Propellant. Cartridges are loaded with varying weights of propellant. This is to impart sufficient velocity (within safe pressures) to the projectile to obtain the required ballistic performance. These propellants are either of the single-base (nitrocellulose) or double-base (nitrocellulose and nitroglycerine) type. The propellant grain configuration may be cylindrical with a single, lengthwise perforation, spheroid (ball) or flake. Most propellants are coated with a deterrent (to assist in controlling the rate of combustion) and with a final coating of graphite (to facilitate flow of propellant and eliminate static electricity in loading cartridges).

c. Primer. Small-arms cartridges contain either a percussion or electric primer. The percussion primer consists of a brass or gilding metal cup that contains a pellet of sensitive explosive material secured by a paper disk and a brass anvil. The electric primer consists of an electrode button in contact with the priming composition, a primer cup assembly and insulators. A blow from the firing pin of the weapon on the center of the percussion primer cup base compresses the primer composition between the cup and the anvil. This causes the composition to explode. The function of the electric primer is accomplished by a firing pin with electrical potential, which contacts the electrode button. This allows current to flow through the energy-sensitive priming composition to the grounded primer cup and cartridge case, exploding the priming composition. Holes or vents in the anvil or closure cup allow the flame to pass through the primer vent in the cartridge case and ignite the propellant. Rimfire ammunition, such as the caliber .22 cartridge, does not contain a primer assembly. Instead, the primer composition is spun into the rim of the cartridge case and the propellant is in intimate contact with the composition. On firing, the firing pin strikes the rim of the cartridge case, compressing the primer composition and initiating its explosion.

d. Bullet. With few exceptions, bullets through caliber .50 are assemblies of a jacket and a lead or steel core. They may contain other components or

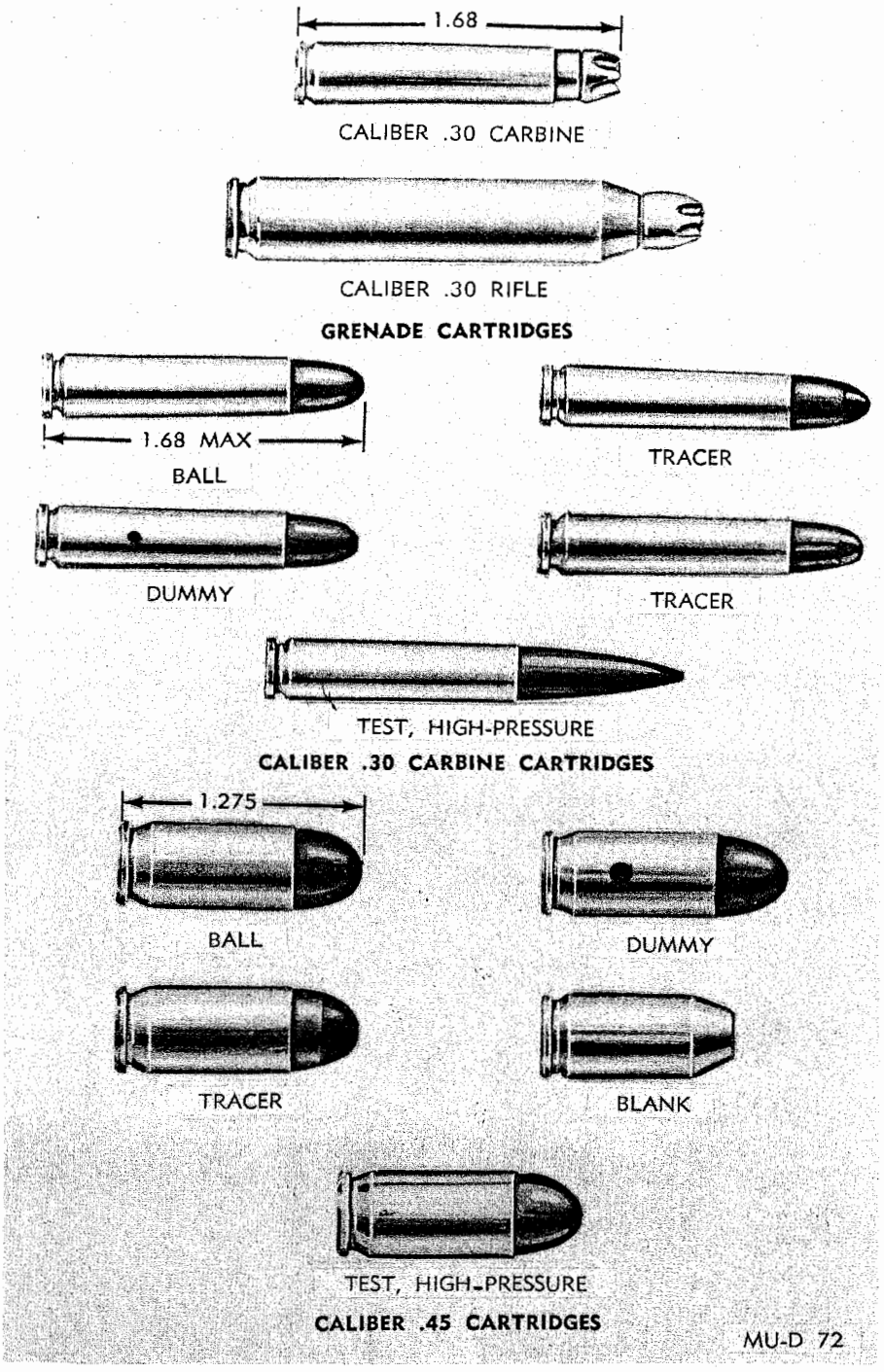
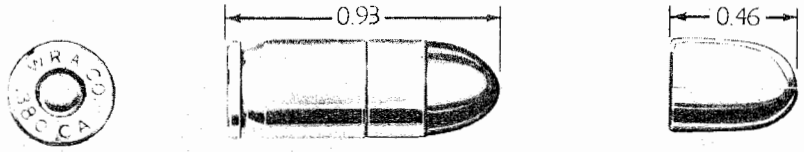


Figure 3–8. Caliber .30 carbine and caliber .45 cartridges.

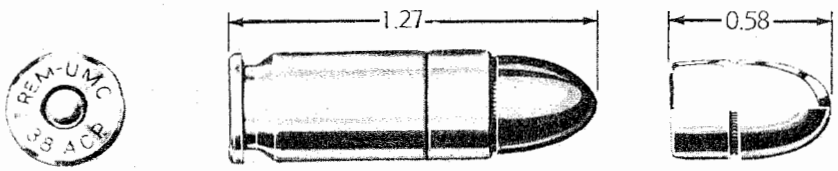
chemicals which provide the terminal ballistic characteristics of the bullet type. The bullet jacket may be either gilding metal, gilding-metal clad steel, or copper plated steel. Caliber .30 and 7.62-mm frangible bullets are molded of powdered lead and a friable plastic which pulverizes into dust upon impact with the target. The pellets used in shotgun shells are spheres of lead alloys varying from 0.08 inch to 0.33 inch in diameter.

3–3. Ball Cartridge

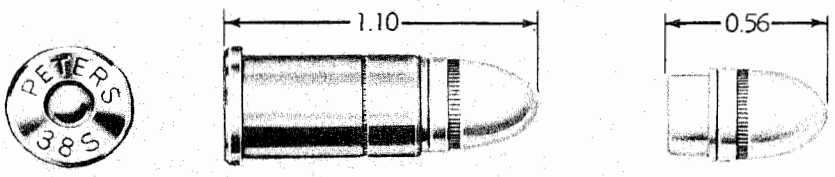
The ball cartridge is intended for use in rifles, carbines, pistols, revolvers and/or machineguns against personnel and unarmored targets. The bullet, as designed for general purpose combat and training requirements, normally consists of a metal jacket and a lead slug. Caliber .50 ball bullet and 7.62-mm, Ball M59 bullet contain soft steel cores.



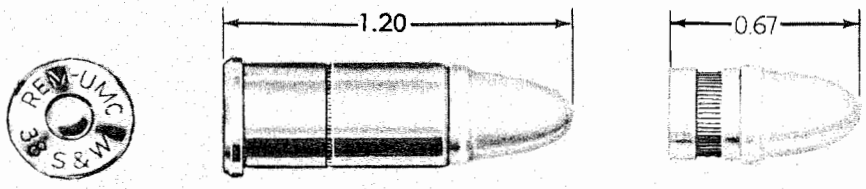
CALIBER .380, BALL, AUTOMATIC PISTOL, 95-GRAIN BULLET (9-MM SHORT)



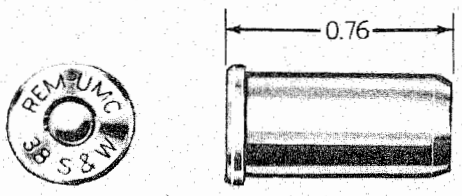
BALL, SUPER AUTOMATIC COLT, 130-GRAIN BULLET, METAL JACKET



BALL, SHORT COLT, 125- OR 130-GRAIN BULLET



BALL, S&W, 146-GRAIN BULLET



BLANK, REVOLVER, S&W

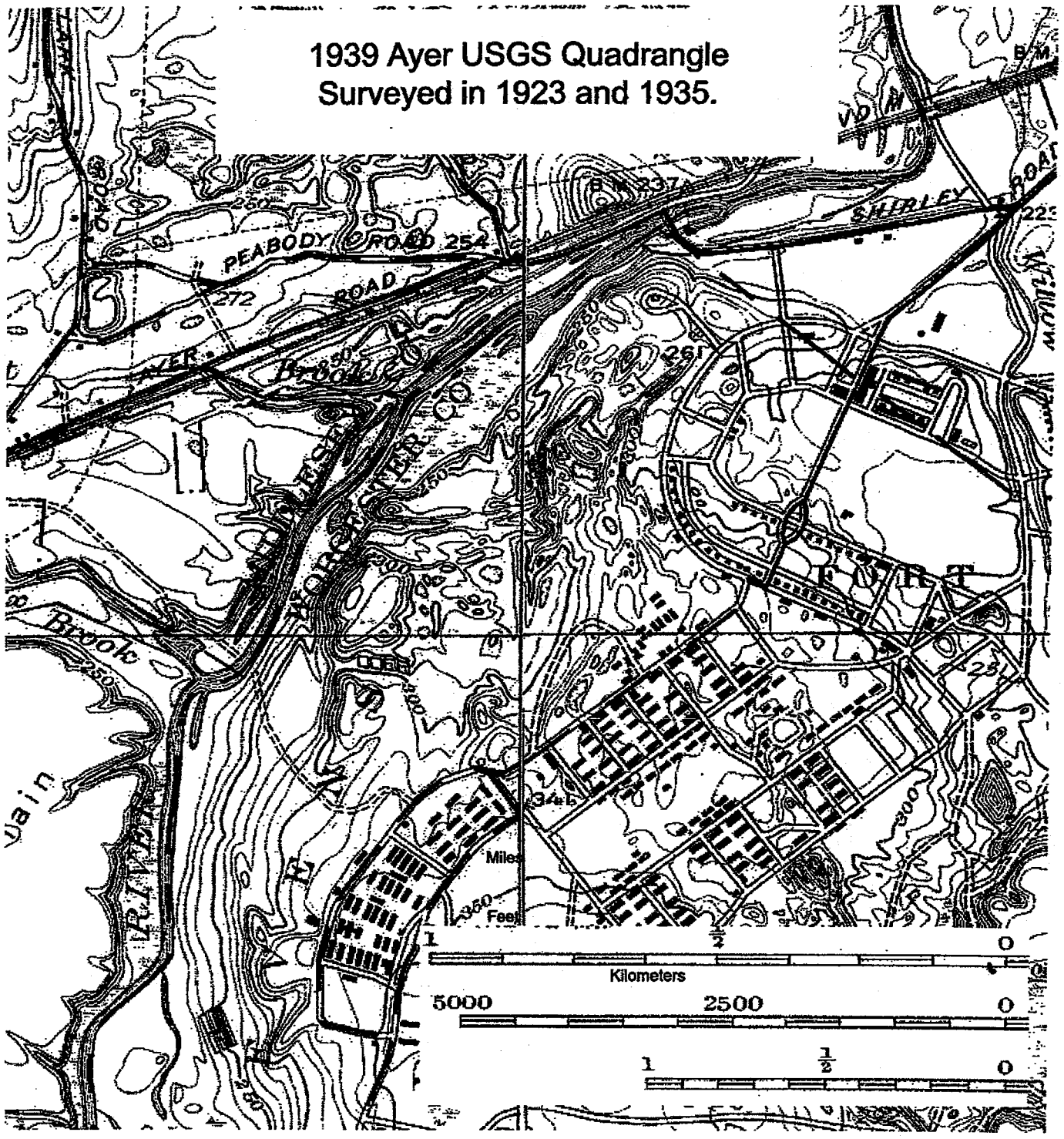
ORD D109-A

Figure 3–13. Caliber .38 cartridges.

ATTACHMENT D

1939 AYER USGS QUADRANGLE SURVEYED IN 1923 AND 1935

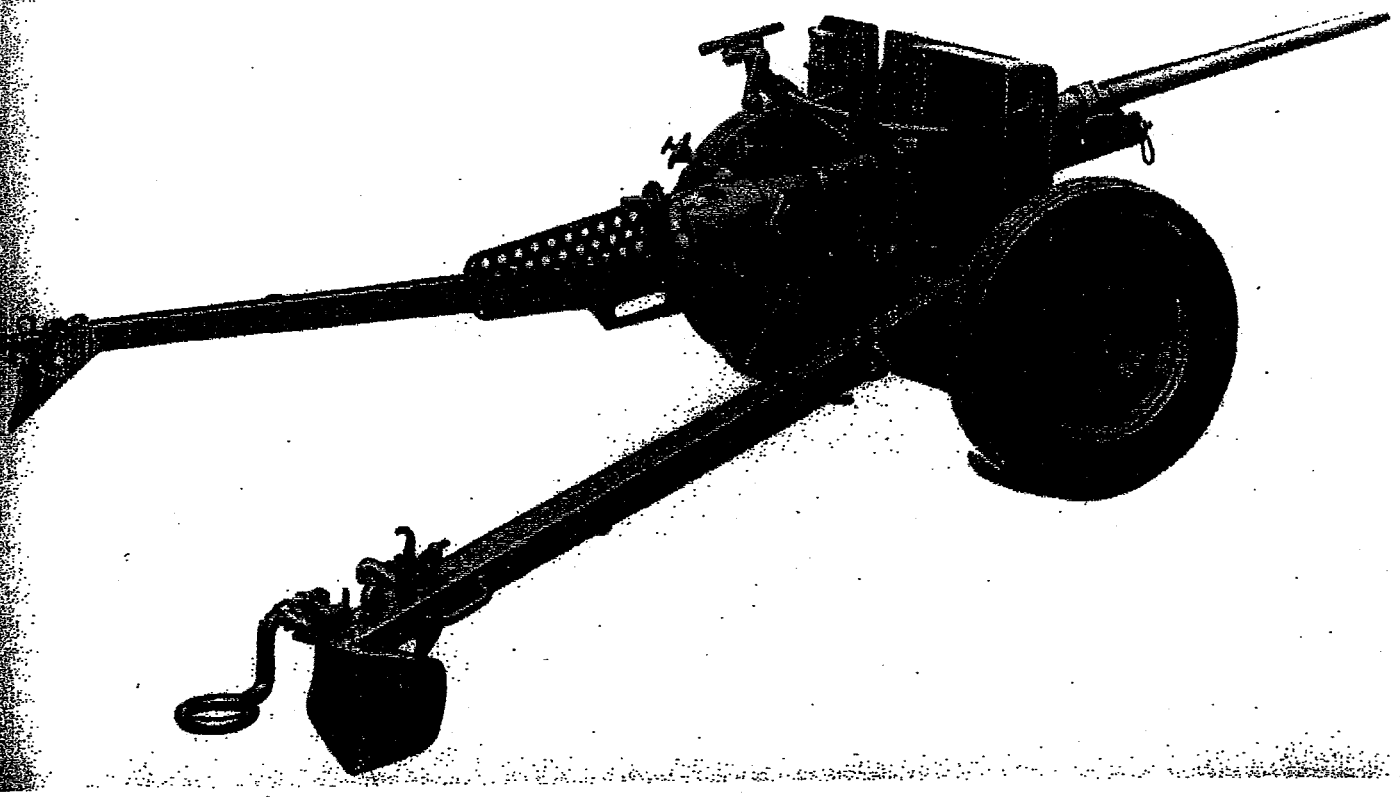
1939 Ayer USGS Quadrangle
Surveyed in 1923 and 1935.



ATTACHMENT E

37MM PROJECTILE DATA SHEETS

37 MM GUN M3A1 ON CARRIAGE M4A1 – STANDARD



PRINCIPAL CHARACTERISTICS

Weight of gun	191lbs.
Weight of gun and carriage	950 pounds (travel order)
	912 pounds (firing order)
Length of gun	82.5 ins.
Rifling:	
Grooves	12
Twist	Uniform right-hand, one turn in 25 calibers
Type of breech mechanism	Vertical sliding wedge, manual
Type of recoil mechanism	Hydro-spring, constant length
Recoil length	20 inches
Maximum elevation	+15 degrees
Maximum depression	–10 degrees
Traverse	60 degrees (30R to 30L)
Weight of APC shot	1.92 pounds
Weight of propelling charge	0.53 pound FNH
Weight of complete round	3.36 pounds
Muzzle velocity	2900 feet per second
Maximum range	12,800 yards (HE); 7500 yards (APC)
Armor penetration	2.4 inches at 500 yards range
Rate of fire	15/20 rounds per minute

RECONSTRUCTED PAGE 1 June 1944

The 37mm Gun M3 is a highly mobile light anti-tank weapon. Development began in 1937, authorized by OCM 13348 of 14 January 1937, and resulted in the 37mm Gun T10 which was standardized as the 37mm Gun M3 in October 1938. Production at Watervliet Arsenal began in November 1938 and the first guns were delivered early in 1940. In June 1940 large production orders were given, and by the spring of 1941 production had reached 150 guns per month. Production was terminated in the summer of 1943, all necessary stocks having been provided and the 57mm Gun M1 having been standardized as a replacement. The Gun M3 is now Limited Standard.

THE 37MM GUN M3A1 is the Gun M3 with the muzzle threaded to accept a five-port Solothurn-type muzzle brake. Combat experience indicated that this brake was not necessary and they have been removed from service, but all M3A1 guns retain the threaded muzzle.

The gun is a monobloc, auto-frettaged tube carrying a vertical sliding wedge breech block, manually operated. A pull-type percussion firing mechanism is fitted into the breech block.

37 MM GUN M3A1 ON CARRIAGE M4A1– STANDARD

THE CARRIAGE M4 is a split trail carriage with shield, and with a shoulder guard which protects the gunner from the recoiling parts. It uses a hydro-spring recoil mechanism giving a constant-length recoil stroke at all angles of elevation. The M4 carriage was declared Limited Standard in January 1944.

THE CARRIAGE M4A1 is the M4 carriage with modifications to the traversing mechanism to permit the traversing handwheel gear to be thrown out of engagement so as to allow the gunner to make a quick traverse switch between targets by pushing or pulling on the shoulder guard to move the upper carriage. The traversing gear can then be reconnected to permit fine adjustment on to the target. The Carriage M4A1 was authorized as Standard in January 1944.

Ammunition

The 37mm Gun M3A1 fires fixed rounds of ammunition using AP, APC, HE and Canister projectiles. The AP Shot M74 is a solid steel shot carrying a tracer in the base. It weighs 1.92 pounds and can penetrate 1.42 inches of armor plate at 500 yards range. The HE Shell M63 is a pointed steel shell fitted with Fuze B D M58 and filled with 1.36 ounces of flaked TNT. The APC Shot M51B1 or M51B2 weighs 1.92 pounds and is a pointed steel shot with piercing and ballistic caps. It carries a base tracer and can penetrate 2.40 inches of armor at 500 yards range. The Canister Shot M2 is a terne-plate cylinder containing 122 3/8 inch steel balls packed in resin. When fired, the casing breaks and the balls are ejected from the gun in the manner of a shotgun charge, to a maximum effective range of about 250 yards.

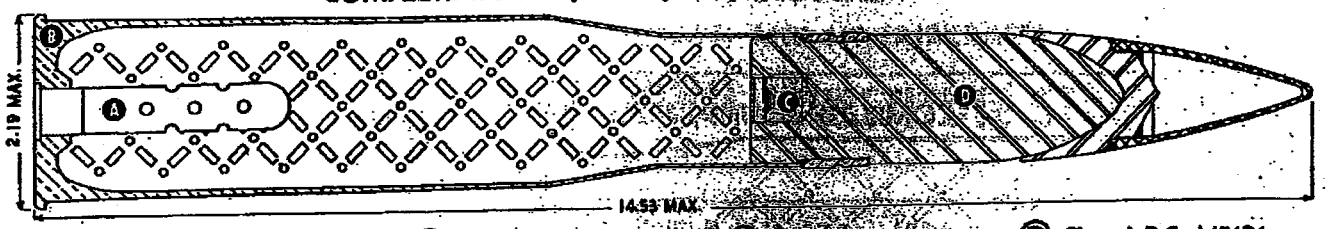
REFERENCES—OCM 13348; FM 23-70; SNL A-44



SHOT, ARMOR-PIERCING CAPPED, 37 MM, M51B1, M51B2—STANDARD

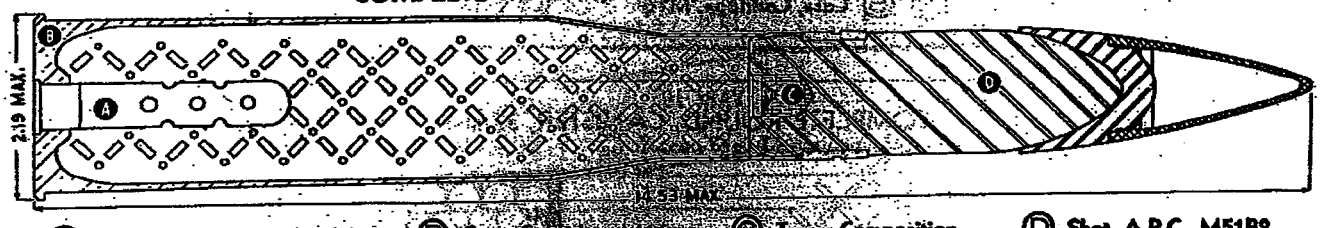
ROUND FOR ANTITANK GUN, M3A1; TANK GUNS, M5A1 AND M6

COMPLETE ROUND, SHOT, A.P.C., 37 mm, M51B1



Ⓐ Primer, Percussion, M38A1 Ⓑ Case, Cartridge, M16 Ⓒ Tracer Composition Ⓓ Shot, A.P.C., M51B1

COMPLETE ROUND, SHOT, A.P.C., 37 mm, M51B2



Ⓐ Primer, Percussion, M38A1 Ⓑ Case, Cartridge, M16 Ⓒ Tracer Composition Ⓓ Shot, A.P.C., M51B2

During World War I, slow-moving, lightly armored vehicles were extremely vulnerable to guns of 37 mm and 75 mm calibers. With increased mobility, speed, and armor protection of tanks and combat vehicles, these weapons became limited in use.

The mobile antitank guns were developed to meet the new conditions. The standardization of the mobile 37 mm antitank gun, M3A1, together with the tank guns, M5A1 and M6, with their higher muzzle velocities, compensated for the added protection which the increased mobility and thicker armor plate gave tanks and combat vehicles.

SHOT, ARMOR-PIERCING CAP, 37mm, M51B1 and M51B2—STANDARD—The shots, A.P.C., M51B1 and M51B2, consist of three components: body, cap, and windshield. The windshield improves the ballistics of the shell and the cap gives better penetration against face-hardened armor plate. The sole difference between the two shots lies in the armor-piercing cap. The cap on the M51B1 shot comes to a point; the cap on the M51B2 shot has a rounded point. The shot includes neither fuze nor bursting charge, but contains a tracer element with a burning time of three seconds. The regular windshield is a thin steel ogive, 360° crimped onto the cap; an alternate is the aluminous windshield.

The complete round, weighing 3.48 pounds, consists of the M16 brass cartridge case, or the M16B1 substitute standard steel case; the M38A1 primer; either the M51B1 or the M51B2 A.P.C. projectile; and a propelling charge of 0.53 pound of M2 powder or 0.57 pound of M5 powder.

The M2 and M5 FNH powders are an Hercules NG formula with 7-perforation grains having a web of 0.04 inch. The standard muzzle velocity with this charge is 2900 feet per second in the M3A1 and M6 guns. In the shorter M5A1 gun the velocity is 2855 feet per second.

(Note: Target practice shot, M51A2, is listed in the Table of Characteristics below.)

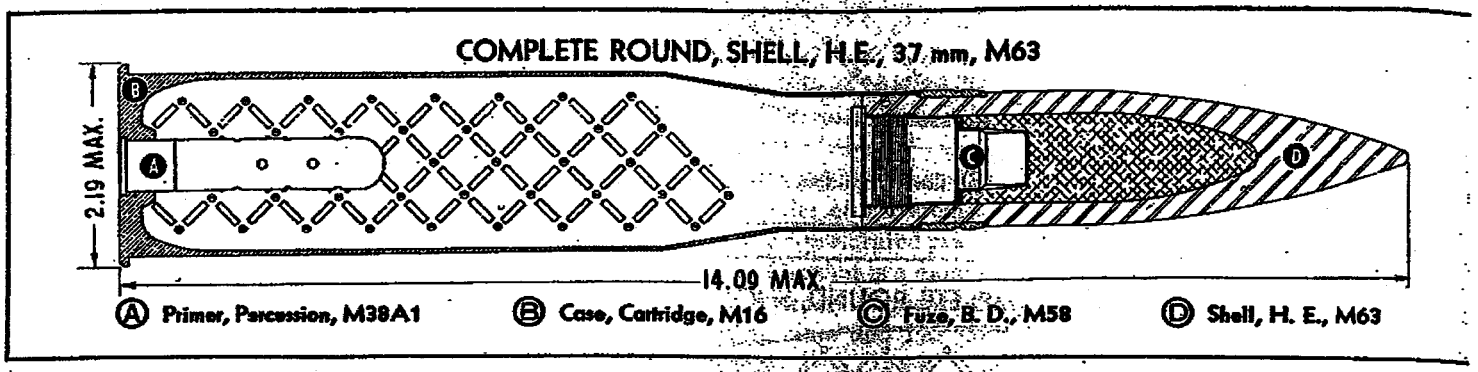
CHARACTERISTICS

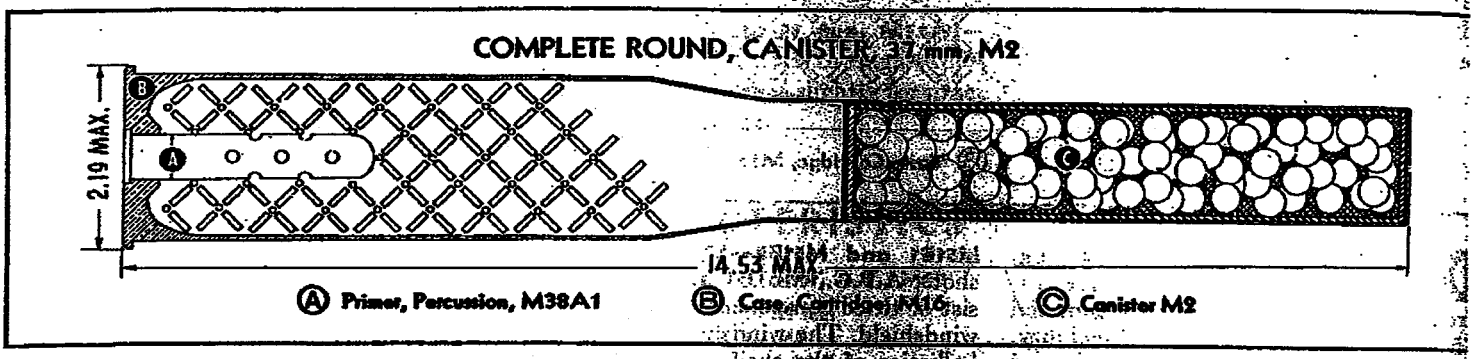
	Shot, A.P.C., M51B1 Shot, A.P.C., M51B2	Shot, T.P., M51A2
Caliber	37 mm	37 mm
Model of Gun	M3A1, M5A1, and M6	M3A1, M5A1, and M6
Proj. Weight	1.92 lb.	1.92 lb.
Primer	M38A1*	M38A1†††
Cartridge Case	M16**	M16**
Propelling Charge and Weight	FNH powder, 0.53 lb.***	FNH powder, 0.47 lb.
Complete Round Weight	3.48 lb.†	3.42 lb.
Muzzle Velocity	2,900 f/s††	2,600 f/s
Maximum Range	12,850 yards‡	—
Chamber Capacity	19.35 cu. ins.	19.35 cu. ins.
Rated Max. Pressure, p.s.i.	50,000	45,000
Armor Penetration at 20°		
Homogeneous Plate		
500 yards	2.4 ins.	—
1,000 yards	2.1 ins.	—
Face-Hard. Plate		
500 yards	2.1 ins.	—
1,000 yards	1.8 ins.	—

*Or M38B2 Substitute Standard.
**The steel cartridge case, M16B1, is substitute standard for use in the M3A1, M5A1, and M6 guns.
***0.53 lb. of M2 powder, 0.57 lb. of M5 powder.
†3.52 lb. with M5 powder.
††2,855 f/s in M5A1 gun.
‡12,725 yds. in M5A1 gun.
†††The M23A3 percussion primer is authorized for assembly in this round until present stocks are exhausted.

SHELL, HIGH-EXPLOSIVE, 37 MM, M63— STANDARD
CANISTER, 37 MM, M2—STANDARD

ROUNDS FOR ANTITANK GUN, M3A1; TANK GUNS, M5A1 AND M6





HIGH-EXPLOSIVE, 37 mm, M63—STANDARD—This shell has superseded the Mk. II high-explosive shell, now used only as subcaliber ammunition. The bursting charge is 0.085 pound of TNT, functioned by the base detonating fuze, M58. Weights of the cartridge case, M16, and propelling charge of FHN powder are 0.93 pound and 0.49 pound, respectively. The steel cartridge case, M16B1, is substitute standard for use in the M3A1, M5A1 and M6 guns.

The complete round uses the M38A1 percussion primer and a propelling charge of M1 powder with single-perforation grains and 0.027 inch web [illegible]

CANISTER, 37 mm, M2—STANDARD—Canister, M2, as the designation implies, is little more than a can filled with approximately 122 lead balls which are imbedded in a resin matrix [illegible]

The canister is used primarily as tank armament against personnel. The shock of discharge ruptures the case and the canister leaves the gun with a muzzle velocity of 2,500 feet per second. The can bursts within 100 feet after discharge.

The weight of the complete round is 3.49 pounds of which 1.94 pounds is the canister load. Weight of the propelling charge of FNH powder is 0.52 pound.

The propelling charge is an M1 class powder having an 85–10–5 formula, seven perforations per grain with a web of 0.019 inch.

CHARACTERISTICS

	Shell, H.E., M63	Canister, M2
Caliber	37 mm	37 mm
Model of Gun	M3A1, M5A1, and M6	M3A1, M5A1, and M6
Proj. Weight	1.61 lb.	1.94 lb.
Proj. Charge and Weight	TNT, 0.085 lb.	122 balls
Fuze	B.D., M58	—
Primer	M38A1†	M38A1†
Cartridge Case	M16*	M16*
Propelling Charge and Weight	FNH powder, 0.49 lb.	FNH powder, 0.52 lb.
Complete Round Weight	3.13 lb.	3.49 lb.
Muzzle Velocity	2,600 f/s**	2,500 f/s
Maximum Range	9,500 yards***	—
Chamber Capacity	19.19 cu. ins.	19.35 cu. ins.
Rated Max. Pressure, p.s.i.	40,000	—

†Or M38B2 substitute standard.
*The steel cartridge case, M16B1, is substitute standard for use in the M3A1, M5A1 and M6 guns for training only.

**2,565 f/s in M5A1 gun.
***9,425 yds. in M5A1 gun.

APPENDIX E

SITE SPECIFIC FINAL REPORT, DIGITAL GEOPHYSICAL MAPPING & UNEXPLODED ORDINANCE REMOVAL

Prepared for:

MassDevelopment
33 Andrews Parkway
Devens, MA 01434

Site Specific Final Report
Digital Geophysical Mapping (DGM)
&
Unexploded Ordnance (UXO) Removal
Former Grant Road Housing Area
Former Ft Devens
Harvard, Worcester, Massachusetts

Prepared by:

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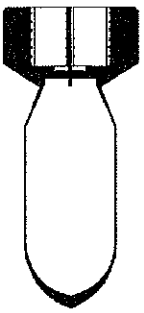

22 March 2006

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1. Introduction

Ordnance & Explosives Remediation, Inc. (OER) was retained by Massachusetts Development Finance Agency (MassDevelopment) to perform a Digital Geophysical Mapping (DGM) investigation and Munitions and Explosives of Concern (MEC) removal of an approximately 130-acre parcel on the former Fort Devens known as the former Grant Road Housing Area. OER used Risk Reduction Resources, Inc. (RRR) to perform the DGM portion of the scope of work and OER performed the MEC portion of the scope of work.

1.1. Background

Fort Devens was an active U. S. Army installation from its founding in 1917 through its inclusion in the Base Realignment and Closure (BRAC) process in the early 1990's. The Army produced an Archive Search Report (ASR) in 1995 which identified several areas on the installation that were suspected of being former firing ranges or training areas that could contain MEC. See the ASR for a detailed history of Fort Devens, its climate, topography, and uses throughout its history.

An Ordnance, Ammunition & Explosives Sampling Action was conducted by the Army through its contractor in 1995 to identify areas that contained MEC and the extent of the problem. During that investigation several sites were identified as former firing ranges contaminated with MEC, one of which was the former Grant Road Housing Area that had been a 37mm firing range before its use as a housing area. See the Army contractor's report for the results of its sampling action and its recommendations for further work.

The Army contractor's 1995 investigation report recommended that subsurface removal be performed at the former 37mm firing range impact area located within the former Grant Road Housing Area and a portion of the former Oak Housing Area. An Ordnance, Ammunition & Explosives Time Critical Removal Action was conducted at the 37mm firing range impact area by the Army's contractor in 1996 leading to the removal of a number of 37mm fired, armed and unexploded ordnance (UXO) items. All the live ordnance items discovered during that investigation were detonated in place by the Army's contractor upon discovery. The contractor's work was inspected and accepted by the onsite Army representative. See the contractor's report on the removal action.

After the removal action, the Army considered the site acceptably safe and conveyed the site to MassDevelopment for unrestricted use, assuming any development would be accompanied by UXO Construction Support in case UXO was encountered. MassDevelopment began planning to develop the former Grant Road Housing Area for residential end land use without further ordnance related cleanup in 2004. In advance of that development, the Massachusetts Department of Environmental Protection (DEP) and the Environmental Protection Agency (EPA) raised concerns about the scope of the prior efforts to identify and remove UXO. OER was retained to develop an appropriate scope of work that would satisfy DEP and EPA's concerns about the adequacy of the Army's previous investigation and removal action at this site.

A scope of work was developed and submitted to DEP and EPA for their review and comment. Resulting comments and concerns were added to the scope of work which was submitted for another review and comment. There were no additional comments and MassDevelopment directed OER to produce a work plan to implement the scope of work, which was also submitted to DEP and EPA for review and comment. DEP and EPA comments were accepted by MassDevelopment, incorporated into the work plan, and a final work plan was published. Once that process was completed MassDevelopment directed OER to begin fieldwork.

The work plan approved by MassDevelopment, DEP, and EPA is on file at MassDevelopment. The approved scope of work is contained in the work plan and summarized below.

1.2. Statement of Work (SOW)

The approved scope or statement of work required OER and its subcontractors to perform a geophysical investigation (digital geophysical mapping (DGM)) to identify subsurface anomalies that could be MEC related items; reacquire and mark those anomalies; excavate, identify, and remove those items on 100% of the approximately 130-acre project site. It was anticipated that the site would be fairly clean, given the sampling and removal action work already conducted within the project footprint. It was also assumed that the removal of the housing area buildings and foundations would have removed some potentially large anomalies associated with the area's use as a housing area.

The Army had also conducted pesticide remediation in the Grant Road Housing Area, during which large amounts of soil were excavated and removed from the site which was then backfilled with clean fill. As a result, we assumed there would be few anomalies associated with these pesticide remediated areas.

The SOW included the following tasks:

- Establish survey control in support of the differential global positioning system (DGPS) required during the geophysical investigation and reacquisition of subsurface anomalies.
- Perform a geophysical investigation to map the approximately 130-acre project area using digital recording geophysical equipment and DGPS, validate and process the collected data, and generate maps from the processed data.
- Reacquire and mark all the selected subsurface anomalies detected during the geophysical investigation.
- Excavate, identify, record, and remove the selected subsurface anomalies marked during reacquisition.
- Dispose of all UXO (MEC) items by on-site detonation.
- Visually inspect each item of ordnance related scrap collected during removal, demilitarize ordnance related items as necessary, and remove them for off-site disposal as scrap metal if in suitable condition or to a Subtitle D landfill otherwise.
- Produce a final report documenting the work performed.

In addition to these tasks MassDevelopment contracted for brush removal to be performed at the site to allow for improved line of sight for the survey equipment (DGPS) and maneuver room for the DGM equipment. The brush clearing task included removing all trees less than a specified diameter at chest height (usually 6-inches depending on density of trees), removing dead or damaged trees and fallen timber, and mowing or flush cutting all underbrush.

1.3. Aim and Objective

The aim and objective of the work was to demonstrate to the satisfaction of DEP and EPA that the site was sufficiently protective of human health, safety and the environment from an MEC perspective so that it is suitable for residential end land use without restriction as planned by MassDevelopment.

1.4. Probability of Solution Accomplishment

OER planned to perform 100% coverage of the project area, but achieving that goal was not possible because of trees which we could not map beneath and some severe terrain that DGM could not safely map. To the greatest extent possible those data gaps were outlined by the geo team and searched using handheld magnetometers by the MEC team. Any detected anomalies were excavated, identified and removed. OER believes that these issues did not affect the overall goal of demonstrating that the site is suitable for residential end land use.

Other areas of the project site were paved, or contained subsurface utilities which were not removed prior to the mapping and removal work. The paved areas were not mapped. OER believes it likely that the process of road bed construction and paving, trench excavation and utility burial when the housing area was established would have identified any buried MEC items.

This approach was felt to give the highest probability of solution accomplishment.

2. Discussion

This section provides a detailed discussion of the technical effort or work performed, covering procedures, equipment, facilities, data, and results both expected and unexpected.

2.1. Tree and Brush Clearance

MassDevelopment contracted for tree and brush removal to be performed prior to OER mobilizing to the site to begin the site control, grid survey, and data collection. As described in the SOW section above, trees less than a specified diameter (usually 6-inches) and brush were cleared from the project site.

OER initially did not provide UXO construction support during the tree and brush removal task because discussions between MassDevelopment and OER indicated that there was little likelihood that a MEC item would be located on the surface given the area's long history as a housing area and all the previous MEC detection and removal work that the Army reported as having been completed.

2.2. First MEC Item Found

During a visit to the site by MassDevelopment and EPA on 3 November 2004, toward the end of the tree and brush clearance phase of the project, and prior to OER's mobilization to the site, one of the EPA representatives found a partial 37mmprojectile on the surface at the boundary of the Oak and Grant Road Housing Areas. See figure 2-1 below.



Figure 2-1: Partial 37mm projectile found in situ at the boundary of the Oak and Grant Road Housing Areas during the 3 November 2004 visit to the site by MassDevelopment and EPA at the beginning of fieldwork.

The Army BRAC office was contacted and it directed one of its UXO contractors to the site where the round was identified as a partial round containing no explosive hazard.

This item was located on the surface in an area previously cleared by the Army's contractor during the 1996 removal action. It should have been found during that contractor's clearance of the area while its employees were using handheld magnetometers to locate and clear subsurface anomalies. This incident invalidated OER's earlier assumption that there would be no need for UXO support during brush clearance given the Army's previous work.

2.3. First Mobilization

OER's first mobilization to the site occurred during the week ending on Sunday 14 November 2004 and included Jeff Baird, the project geophysist, and two geophysical technicians.

OER mobilized one UXO supervisor in during the week ending 21 November 2004 to help clear and install the test grid, and assist as needed during grid layout across the open and accessible portion of the site where RRR planned to conduct towed array data collection using a tow vehicle and a trailer equipped with multiple EM-61 Mk 2 sensors.

The geophysical team demobilized during the week ending 19 December 2004 after collecting all the data possible using the towed array.

2.4. Second Mobilization

OER's second mobilization occurred during late April 2005. The geophysical team and two UXO technicians mobilized to the site to continue grid layout and data collection. The UXO team also conducted a surface clearance for the reasons identified in section 2.5.

2.5. Surface MEC Sweep

OER had assumed during the planning stage that the target hill would be fairly clean from an ordnance perspective given that the Army's contractor reported that it had performed a subsurface removal action of that same area in 1996; the subsurface program would have identified any surface MEC, therefore OER assumed that any 37mm projectile, partial 37mm projectile or large 37mm projectile case fragment (frag) on or near the surface would have been removed during the previous clearance.

The previous clearance had been conducted "mag & flag" style by a team of UXO technicians walking in a line abreast formation searching using handheld magnetometers to locate and mark surface or subsurface ferro-metallic items. Once a section of the site was flagged the team would excavate, identify, and remove each flagged anomaly.

The OER geophysical team gridding the impact area hill noticed during its set up and preparation to map the impact area a larger than anticipated amount of metal on the surface. In discussions with MassDevelopment OER recommended that a surface clearance be conducted by the UXO team prior to collecting geophysical data. The purpose of the sweep was to locate and remove any surface metal to give the geophysical team a better chance of detecting deeply buried 37mm related items. OER also indicated that since a partial 37mm projectile had been found on the surface at the project boundary during a previous site visit that other ordnance related items might also be found on or near the surface.

2.5.1. Surface Sweep Process

The surface sweep was conducted by the UXO team walking in a line abreast formation back and forth across the impact area hill within the project footprint searching visually and electronically for any surface metal. The UXO team used Schonstedt GA-52Cx handheld magnetometers to detect any ferro-magnetic metal item within the detection limits of the instrument. All magnetometers were tested each morning on the test grid prior to being employed in the search area.

2.5.2. Surface Sweep Results in the Impact Area

During its sweep of the target hill the UXO team located two (2) fired, armed and unexploded 37mm projectiles (UXO), two (2) partial 37mm projectiles with fuzes intact, an empty rifle grenade, and approximately 220 pounds of 37mm projectile case fragments (frag) on the surface.

In discussions with MassDevelopment it was deemed prudent to assign one UXO technician to the survey team while they were performing land survey and planting grid stakes in case there was other surface UXO on the site. It was also deemed appropriate to continue the surface sweep across the site since OER was finding UXO on the surface in an area that had already been cleared.

2.5.3. Extended Surface Sweep

The extended surface sweep produced one more 37mm projectile and several other empty ordnance items. The table below shows all the ordnance related items recovered during the initial and extended surface sweeps. All the live items and the three (3) 37mm projectiles were disposed of by the Army's current BRAC contractor, the Massachusetts State Police Bomb Squad, or a U. S. military active duty Explosive Ordnance Disposal (EOD) team.

Date	Grid	# of	UXO's	OE Items	Northing	Easting
04/26/05	C2	1	UXO 37mm/fuzed		3022989	621510
05/02/05	B2			37mm half w/fuze	3023045	621361
05/02/05	A2			37mm half w/fuze	3023087	621296
05/03/05	C3	1	UXO 37mm/fuzed		3023272	621547
05/04/05	C1			Empty rifle grenade	3022816	621663
05/10/05	D3	1	UXO 37mm/fuzed		3023198	621847
05/10/05	D2			Empty rifle grenade	3023080	621876
05/10/05	F3			Empty rifle grenade		
05/11/05	E4			Empty Flash Tube	3023363	622040
05/12/05	E5			Rifle grenade tail boom	3023675	622073
05/16/05	E6			Belt of blank ammo	3023766	622039
05/23/05	H3			Empty rifle grenade	3023120	622696
05/23/05	I4			Empty rifle grenade	3023309	622744
05/24/05	H5			MK II training grenade	3023504	622579
05/25/05	L12			French VB2 grenade	3024952	623465
06/03/05	L14	3		Frag from Stokes 13		

Table 2-1: UXO and ordnance related items recovered during the surface sweep.

The surface sweep was halted in mid-June in favor of excavation. As OER learned more about the site during the surface sweep OER concluded that the impact area of the site was most likely to produce ordnance items while the farther we moved to the northeast the less likely we were to find ordnance items.

2.6. *Geophysical Investigation*

The geophysical investigation was made up of several parts which included: establishing survey control of the project area; subdividing the project area into grids; assembling and testing equipment; collecting data; and reacquiring and marking anomalies.

2.6.1. Survey Control

Two survey control points were provided by MassDevelopment and were used to complete the grid layouts and geophysical surveys. They are listed as follows:

S119-S

2" Brass Disk set in concrete – stamped "Devens Engineering Massachusetts"

N 3021412.49

E 622739.96

S120-S

Stone Bound Drilled Hole

N 3022687.75

E 622977.81

2.6.2. Grid Survey

The first land survey task involved mapping the perimeter of the survey areas and dividing the areas into 200-foot by 200-foot grids arranged in a North/South – East/West configuration. Each grid corner was assigned a unique designation and marked with a survey stake containing the designation. The grid designations were assigned letter values (A, B, C, etc.) for latitudinal lines and numbered values (1, 2, 3, etc.) for the longitudinal lines (see the figure below). Initially, the survey work was completed using the DGPS/RTK system described below. However, to complete the grid layout in the wooded areas, the RTS method was used.

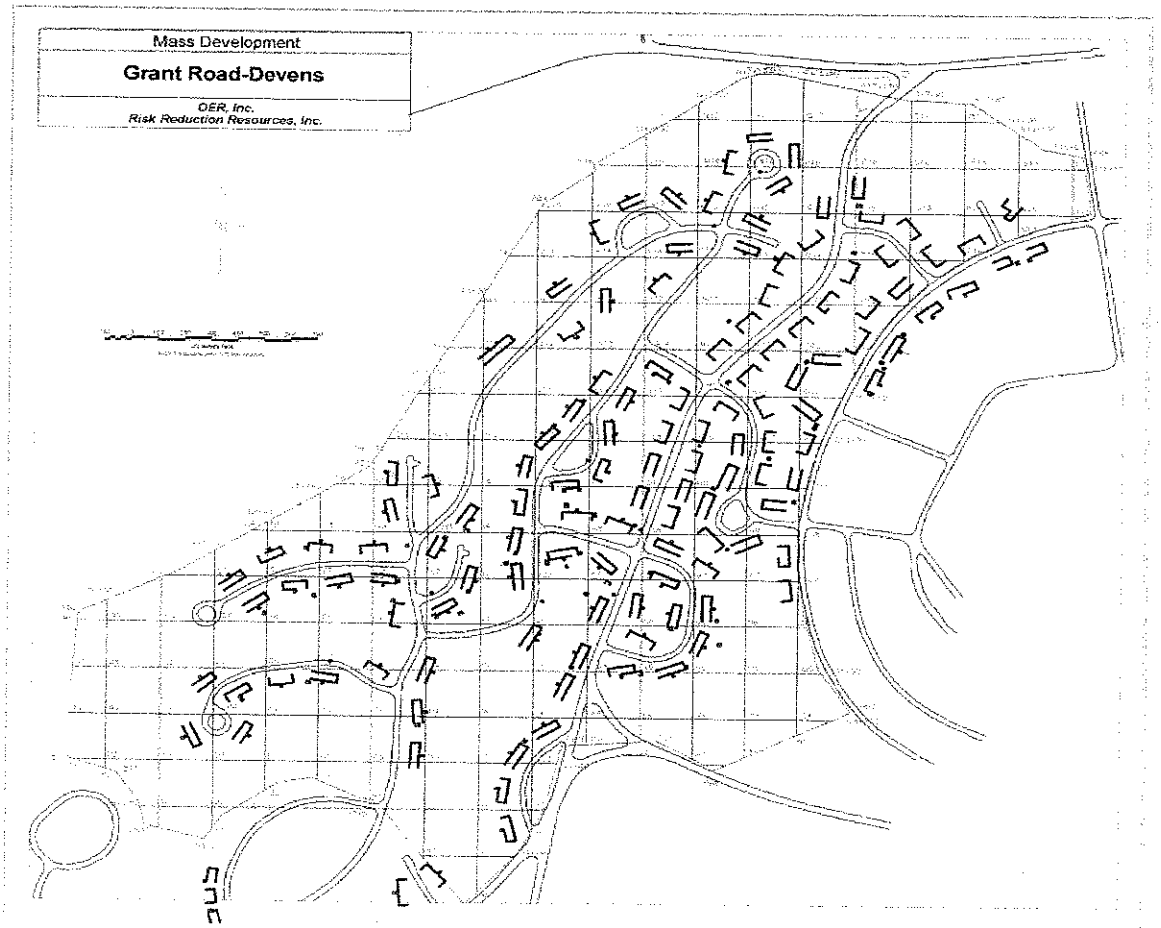


Figure 2-2: Site grid layout with established road locations and former and existing house pads (dark rectangles). Blue line denotes limit of brush cutting or property extent.

2.6.3. Equipment

The first portion of the geophysical survey was completed using a towed array of Geonics EM61 MKII total metals detectors (EM61) coupled to a Leica real-time kinetics, differential global positioning system (RTK/DGPS) receiver. This multiple sensor array was towed behind a Polaris six-wheel drive Ranger all terrain vehicle. The second portion of the geophysical survey was completed using single instrument Geonics EM61 MKII metal detectors in a man-portable configuration. Two navigation methods were used: the Leica 1200 Series Robotic Total Station (RTS), and the fiducial method for the positioning system.

2.6.3.1. Multiple Sensor Array

The multiple sensor array (MSA) was arranged on a trailer and towed behind an all terrain vehicle (Polaris 6x6 Ranger). A balance between the pulling power of the tow vehicle and the structural strength of the trailer containing the instruments was established that prevented the surveying of more extreme terrain. The terrain not surveyed by the MSA typically consisted of areas under trees where the RTK/DGPS receiver could not locate sufficient satellites, very steep ridge lines and treed areas where the MSA could not fit between the trees.

The EM61 operates by firing short electromagnetic pulses into the ground. The pulses generate secondary electrical fields in the soils and conductive targets. The electrical fields in the surrounding soils rapidly dissipate whereas induced electric fields in conductive bodies (metal) dissipate more slowly. Once a magnetic pulse has been emitted, the EM61 shuts down for a short time and then starts up in receiver mode. The induced electric and magnetic fields in the soils will have dissipated by the time the instrument shifts to receiver mode but will not have fully dissipated in conductive metals. The decaying magnetic fields in the conductive targets are detected by the instrument at three times as measured from the time the initial pulse ends. The instrument response is transmitted to a microprocessor that converts the instrument response to a millivolt (mV) value. The mV value is then saved in a database with a time stamp used to match the instrument response with a specific geographic location determined by the DGPS. The data from the array of instruments (four detectors with three responses each compiled with geographic positions) are integrated in a separate computer that transfers a single data stream into a field computer. The field computer displays the data collection path on a site overlay. The path display also shows detection instrument responses that provide preliminary indications of anomaly density within a given survey area.



Figure 2-3: Six-wheel drive Ranger tow vehicle. Geophysics team members are checking continuity of all electrical connections prior to starting a mapping session.

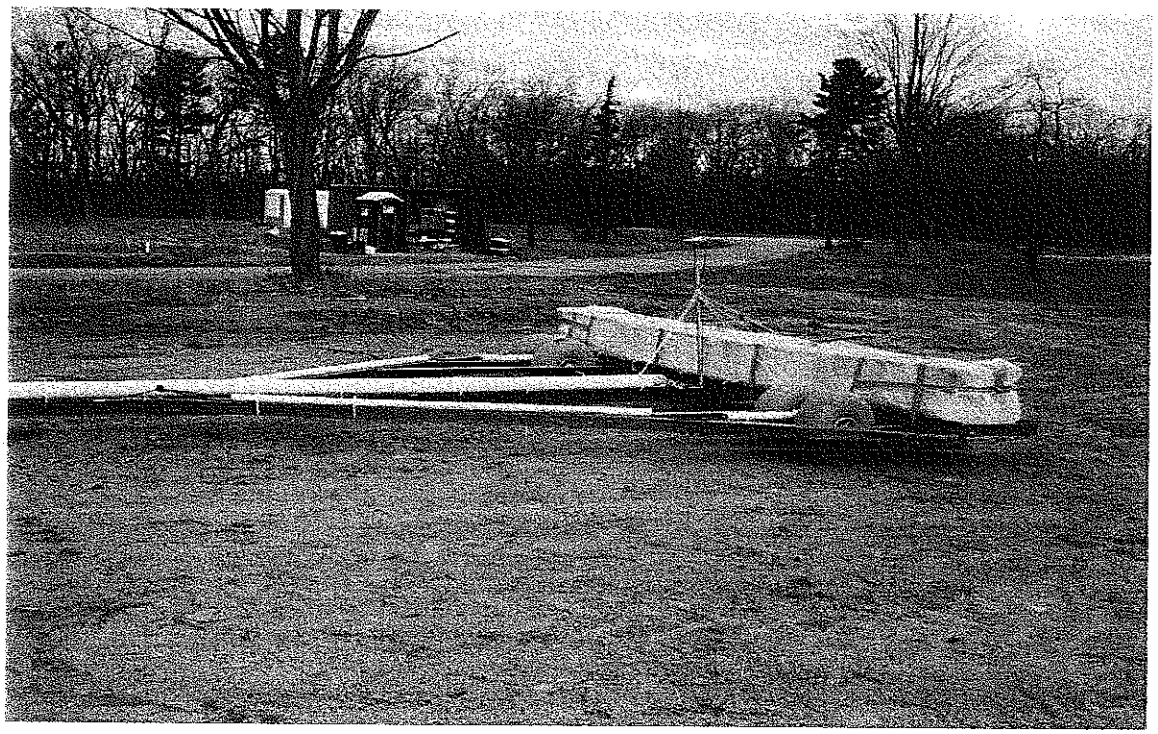


Figure 2-4: Towed Multiple Sensor Array (MSA) showing four EM-61 Mk II sensors wrapped in plastic and the DGPS antenna.

2.6.3.2. Leica Model 1200 RTK/DGPS

Location surveying was accomplished using a Leica Model 1200 survey-grade, differential global positioning system. The RTK/DGPS unit operated using a geographically referenced known location (Massachusetts Mainland State Plane Coordinate System; NAD-83) base station. A rover RTK/DGPS mobile receiving unit was used to collect remote point data (complete the grid stakeout survey).

The differential GPS system operated by both the base and rover RTK/DGPS units receiving positioning information from the same satellites. However, due to atmospheric interference and other conditions, the positioning of a single GPS unit was accurate only to within 30 feet. Since the base station was programmed to "know" that it was at a previously surveyed position, it was capable of calculating a solution to the position variances transmitted by the satellite configuration. The base station then transmitted this solution to the rover unit which, in turn, applied the correction to the position data it received. This method using the Leica system permitted centimeter level positioning accuracy during static surveys and decimeter accuracy during the geophysical survey.

The same principle applied to positioning the DGPS rover on the multiple sensor array. By assigning the rover antenna position relative to the center of each sensor, accurate geophysical data positioning was achieved. Occasional dropouts of the DGPS were experienced during the geophysical survey. Where the dropouts exceeded 20 feet in length, the instrument operator repeated the survey across the area. When shorter gaps were identified, a data gap was noted on the map and the intrusive investigation teams cleared the gap area.

2.6.3.3. Leica Model 1200 Robotic Total Station

A Leica Series 1200 robotic total station (RTS) was used to lay out the grid corners of the project area and conduct a portion of the geophysical surveys. The RTS operated under the same principles of a total station survey instrument with the exception that the unit automatically tracked the prism on the survey rod using servo motors built within the unit. An RTS was used by establishing the position of the unit on the ground within the context of NAD83, Massachusetts Mainland State Plane Coordinates. This was accomplished by a method known as re-section. To re-section, the operator set up the instrument in a location where at least three known surveyed positions (references) could be seen by line of sight. By measuring the distances and angles of the reference points with respect to the RTS, the resulting triangulation calculations determined the position of the instrument. The RTS was then able to survey subsequent positions and store them in the system or, for use during the geophysical survey, export the positions to the EM61 MK II data collector to provide geographical positions to the instrument responses.

2.6.3.4. Geonics EM61 MKII

The single instrument Geonics EM61 MK II was mounted on wheels with a PVC cradle developed to facilitate the transport of the unit along survey lanes. The instrument operator was positioned at the rear of the cradle and carried/operated the electronics. The operator also lifted the instrument over obstacles taller than the base of the unit. A second person pulled the instrument using a strap at the front end of the cradle. The theory of the operation of the EM61 MK II is described above.

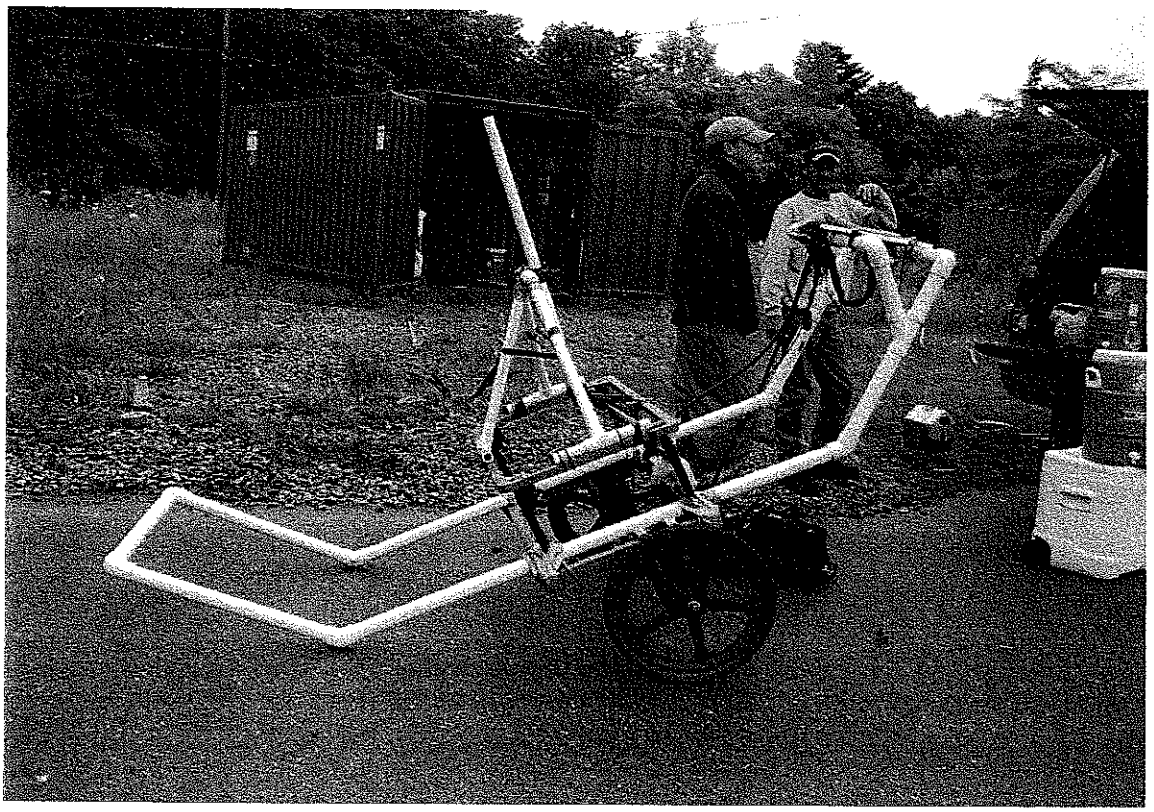


Figure 2-5: EM-61 Mk II in single unit man portable mode. The operator's equipment pack holding the electronics and the data logger are on the ground on the far side. The RTS antenna has not yet been put on the mast.

2.6.3.5. Fiducial Method

This method relied on the use of fiducial markers which were ground references within the geophysical survey lanes to calibrate local coordinate ground reference positions to the EM61 data. Grids geophysically surveyed using fiducial markers were initiated at surveyed grid corners (usually the southwest corner stake) and progressed within parallel lanes spaced at three-foot increments. Fiducial markers were placed at 25-foot intervals along each lane. The instrument operator depressed a marker button on the EM61 controls to insert a reference point each time they passed over a fiducial marker. This action provided ground location reference points within the data stream for the survey lane being traveled. By depressing the bottom at the start, on every fiducial point in the lane, and at the end of the lane, the data analyst is able to use the references in the data to correctly position the data as a function of the distance from the lane origin. It should be noted that geophysical surveys using fiducial markers were only performed on those grids where there was no significantly uneven terrain, because, in essence, the operator was establishing the instrument position in local coordinates relative to the grid stakes. Uneven terrain would cause the linear distance between fiducial markers to be variable since a level line is always shorter than a line in which the terrain rises and falls within the line ends. Once the data collection session was completed, the geophysical analyst (Site Geophysicist) would translate and rotate the local coordinates to establish State Plane Coordinates.

2.6.3.6. Robotic Total Station (RTS)

The RTS method of data collection used parallel lanes laid out in a rectangular grid similar to those used for the fiducial method. While a single unit EM61 MK II was used to traverse the grids along the pre-established lanes similar to that performed using the fiducial method, the instrument position was established using a robotic total station (RTS) whose position was tied into the State Plane Coordinates. The RTS used laser technology to transmit a beam of light to a reflector prism

situated atop the center of the EM61. The laser beam was reflected back to the RTS which then calculated the prism location relative to the RTS. The coordinates were then transmitted via radio back to a receiver carried by the instrument operator. The receiver was directly connected to the field data logger of the EM61 which stored the data of both the EM61 responses and the positions of the instrument. Internal clocks within the RTS and the EM61 data logger were synchronized prior to initiating data collection and each line of data collected by the two instruments contained a time stamp. Positioning data was merged with the EM61 instrument response data during post-processing using the time stamps to match the correct position of the EM61 instrument responses. The RTS method was used in areas of uneven terrain where the fiducial method would have resulted in positional inaccuracies beyond tolerable limits. One drawback of the RTS method was that it relied on line-of-sight requirements between the RTS and the prism located atop the EM61. In densely wooded areas the geophysical team had to prune low branches off trees to improve instrument line of sight and were required to perform multiple setups of the RTS to assure adequate line of sight and thus achieve adequate positioning accuracy without large data gaps.

2.6.4. Geophysical Survey

The second phase of the survey entailed the collection of geophysical data. The survey was completed by traversing a 200' x 200' grid along parallel lines spaced the width of the MSA footprint. The MSA has a detector footprint of twelve (12) feet. Each data collection session was named after the survey stake located in the southwest corner of the grid being surveyed or the nearest stake to the southwest corner of the survey. Because the site was regularly interrupted by wooded areas and other areas that were inaccessible to the towed survey equipment the shapes of the survey datasets were typically irregular and followed the pre-existing barriers. The survey lanes were established by placing nylon pin flags within the outside wheel marks of the trailer containing the sensors. The tow vehicle operator was then able to follow pre-existing paths set parallel to the original survey path, where practical. Once the large open areas were completed by the MSA, the less accessible wooded and steep areas were covered by the single instrument man-portable units. See the figure below showing the areas covered by each method.

EM61 instrument response data was collected in "automatic mode" at a rate of ten (10) readings per second. RTK/DGPS data was collected at a rate of one (1) reading per second. The positioning of EM61 data collected between RTK/DGPS readings was accomplished by linear interpolation. During the use of the RTS system, positions were transmitted at an average rate of seven (7) times per second. EM61 data positions using the RTS method were also developed using linear interpolation.

EM61 response data and RTK/DGPS (or RTS) data was then stored in a field computer carried within the towing vehicle (or a data collector mounted on the transport cradle during single EM61 surveys). At the end of a data collection session, data was downloaded into a computer for processing and interpretation.

Field books were maintained that contained grid sketches, geophysical collection parameters, equipment operators/team members, battery storage capacities, and other details deemed pertinent to interpret the data being collected.

The multiple sensor array data collection was completed during November and December of 2004. Work was stopped in December 2004 for the winter. The man-transported EM61 MK II work (RTS and fiducial methods) was performed in the wooded areas between April and November 2005.

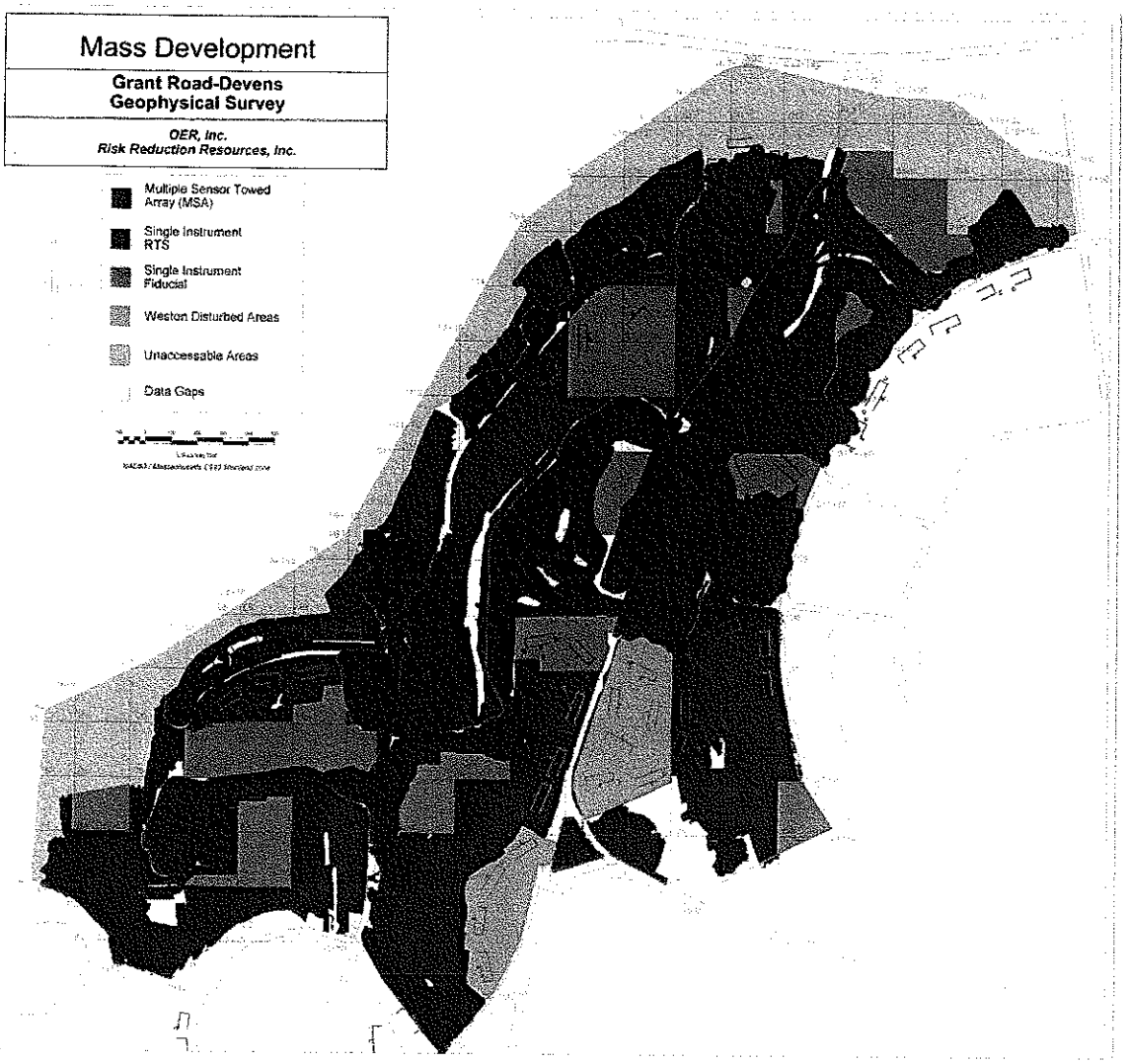


Figure 2-6: Geophysical survey components. The Multiple Sensor Towed Array (MSA) was the first phase of the survey and is represented in blue. The MSA covered open areas relatively devoid of tree coverage. The second phase of the investigation involved the single instrument man-portable units and included a team with the RTS system (red) and a team using fiducials (dark green) to record the instrument location. The area in grey was inaccessible; the light green shows area disturbed by Weston during its pesticide remediation after data was collected and before excavation began. White areas are data gaps later cleared by the UXO team.

2.7. Site Description

2.7.1. Geophysical Investigation Program Objectives

The geophysical investigation planned for the subject site was designed to identify unexploded ordnance in the near surface soils by detecting the electrically conductive materials from which they were constructed. The detection capabilities of the geophysical survey equipment depended on the mass and shape of the targets, as well how deeply the targets are buried. In other words, the smaller the item the more difficult it is for the detection equipment to see, and the more deeply buried the item the more difficult it is to detect. Small items that are deeply buried would be

undetectable. A 37mm projectile is a small item that can be detected to a given depth depending on its orientation and the state of deterioration of its case. The more deteriorated the case, the harder it will be to detect. Some 37mm projectiles will be more detectable at a given depth because of differences in their orientation relative to the sensor. There is no one depth of detection that we can categorically state for the EM-61 Mk II used in this application.

2.7.2. Investigation Area

The specific areas investigated during the geophysical survey were the cleared portions of the study area that were not under power lines nor too steep to drive or walk over. Other areas not surveyed included groves of trees and brush that were not cleared or areas of extensive vegetation with insufficient clearance to allow the geophysical team to safely map. Areas inaccessible to the MSA were covered by the man-portable units in the second phase of the survey. Areas not accessible by these single units were later cleared of metallic debris using handheld magnetometers. A general outline map showing the method used in each area is presented above. Detailed high resolution color maps by grid are included in Appendix A.

2.7.3. Anticipated UXO

Previously completed studies of portions of this site identified the primary ordnance of interest to be 37mm projectiles and some amount of inert training ordnance like hand grenades, rifle grenades, and flares. All of the anticipated UXO was comprised primarily of iron with small amounts of aluminum. While projected quantities of UXO were not known, OER assumed they would be low given previous sampling and clearance actions. Previous studies had identified the 37mm impact area and it was assumed we would find some concentration of ordnance related material there, and a scattering of inert training ordnance across the site.

2.7.4. UXO Anticipated Depth

The geophysical investigation was anticipated to consistently detect metallic substances of a size representing a 37mm projectile to a maximum depth of 0.75 feet below grade. The property was used as a 37mm firing range and later as a small unit training area. While previous studies identified live UXO, most were found at depths of less than one foot.

During excavation and removal operations 37mm projectiles were excavated down to 24" below ground surface (bgs) although most were recovered within 8" of the surface.

2.7.5. Topography

The topography of the subject site was a stepped terrain with steep (20-30 feet tall) gradations generally striking north/south. Relatively level building lots and paved roadways were located on level terrain between the steps. Overall, there was a vertical drop of 60 feet in elevation toward the west across the area. The terrain of much of the site appeared significantly altered by cut and fill operations presumably during the site's conversion to a housing area.

2.7.6. Vegetation

The area surveyed was initially cleared of small trees and brush. However, as the growing season set in during the man-portable, single EM61 phase of the project, the geophysical data collection teams were required to complete supplemental brush clearing and removal of tree limbs to facilitate the use of the RTS line of sight navigation equipment.

2.7.7. Geologic Conditions

The subject site was situated on sandy loam. The geology of the Northeastern section of Massachusetts was typically represented by igneous intrusive formations in metamorphic bedrock. The surface geomorphology was typically formed by glacial and alluvial deposits from the Pleistocene Epoch.

2.7.8. Soil Conditions

Soils across the site consisted of poorly sorted shallow alluvial deposits in the higher elevations and steeper terrain. Since the overall terrain of the site was steeply sloped with relatively small level areas, surface water runoff as well as shallow groundwater flow was probably toward the west.

2.7.9. Shallow Groundwater Conditions

Shallow groundwater was anticipated to exist across the site; however, it was never encountered during the geophysical survey or subsequent intrusive investigations.

2.7.10. Geophysical Conditions

Conditions were well suited to conducting a geophysical survey that entailed the detection of metallic items in the shallow subsurface. Mineralization within the soils, a potential source of influence, was considered to be moderately high, but not so high that the effectiveness of the survey was compromised. Areas surrounding former residential structures were found to contain metallic debris from construction and demolition, creating a significant background noise condition that probably increased considerably the number of non-UXO/MEC anomalies compared to a site that had never been developed. However, since the targets of interest (37mm projectiles) were of similar size, mass, and shape of typical construction and demolition debris, the selection of the higher quantity of anomalies was justified to reduce residual risk.

2.7.11. Site Utilities

Many utilities such as sanitary sewer lines, water lines, and gas lines existed within the study area as well as overhead high powered electrical lines. Any areas that resembled utilities were demarcated on the final maps so as not to disturb these utilities nor endanger the dig teams. While the high powered electrical lines were temporarily turned off during the geophysical investigation, an area located in Grid C5 was not geophysically surveyed because the high voltage lines were too close to the ground causing sufficient interference so as to render the data unusable. That area instead was cleared by the UXO intrusive teams at the end of the project.

2.7.12. Man-made Features

Former structure foundations, paved roads, concrete and steel drainage pipes, jersey barriers, telephone poles and other features existed within the study area. While the former housing pads (plus a four foot buffer around the pads) were not excavated, most had large quantities of cement with rebar surrounding these areas. A large buried antenna-like grid of solid copper wire was also discovered in the north portion of the site. The orientation and projected coordinates of the antenna are presented in the figure below.

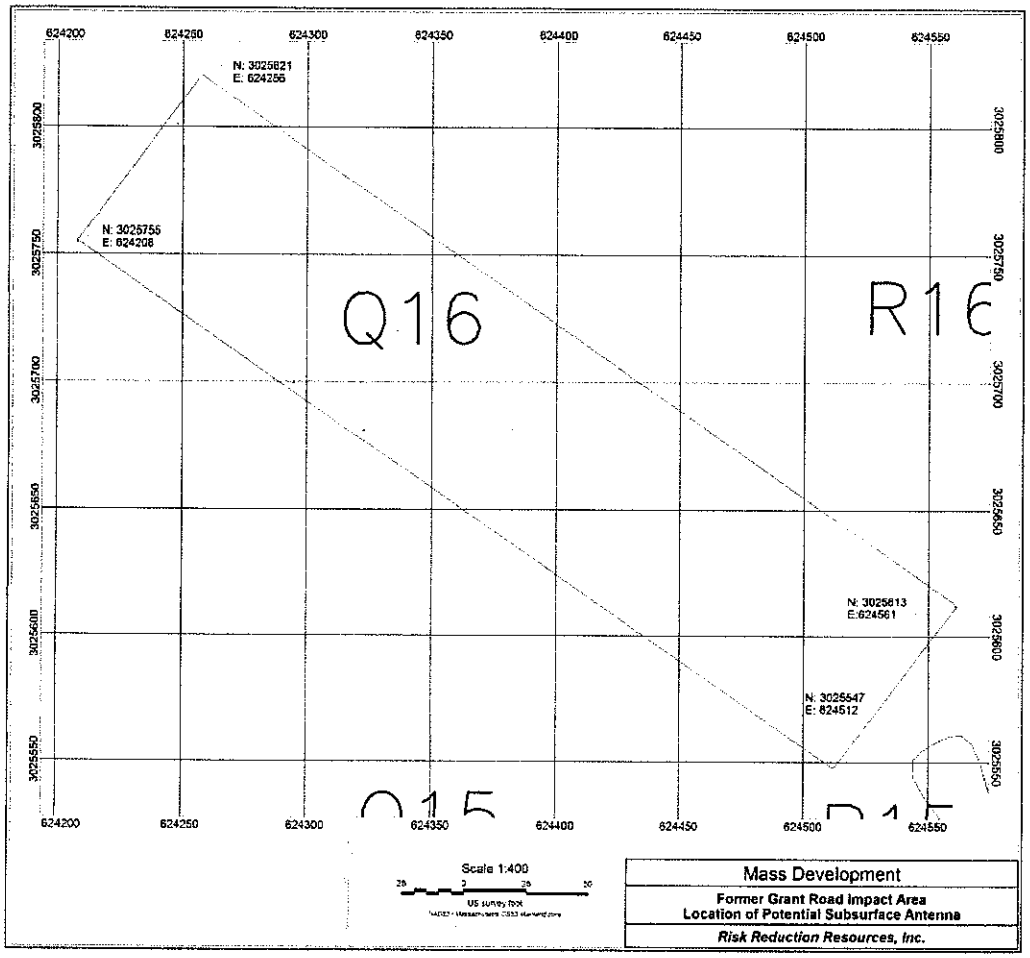


Figure 2-7: Location of suspected buried antenna array with location given in Massachusetts State Plane Coordinates.

2.7.13. Geophysical Personnel

The geophysical survey was completed under the direction of a Project Geophysicist (Jeff Baird). The Project Geophysicist was responsible for the final data interpretations and anomaly selection. Victoria Rystrom was the Site Geophysicist and was responsible for all initial data processing and anomaly selection. A separate, Quality Control (QC) Geophysicist (Jeffrey Leberfinger, ARM Group) was responsible for instrument quality control results relating to the geophysical survey.

The Site Geophysicist, in consultation with the Project Geophysicist, was responsible for the initial layout of the project perimeter and grid assignments, as well as for all data collection methods, downloads, data processing, and interpretation. The Site Geophysicist was responsible for the daily QC instrumentation prove-outs and review of initial data quality.

The QC geophysicist reviewed 10% of all of the data collected and selected anomalies that generally fell below the selection threshold with the intention of demonstrating that no electrically conductive targets of a similar size, shape, or mass were detected during the geophysical survey analyses. Results of the QC selections did not identify any conductive materials that exceeded the above-stated parameters.

The instrument operators were responsible for data collection and maintaining the instruments in good working condition.

2.7.14. Production Rates

Depending upon the quality of the brush clearing efforts, daily production rates for the geophysical survey averaged seven (7) acres per day using the MSA. Production rates varied greatly depending upon terrain. The man-portable units averaged two - three acres a day.

2.7.15. Data Resolution

EM61 data was recorded at a rate of ten (10) readings per second. Given that the instrument averaged approximately two (2) miles an hour while traversing a given grid, data density equaled approximately one data point every 0.3 feet. Using the survey path markers noted in the previous section, lateral data density was 100 percent in areas where the terrain permitted since the width of the travel lane was less than the width of the MSA footprint. As anticipated, gaps in data were present due to maneuvering around trees, ridge lines and under power lines. The excluded areas (data gaps) were investigated as part of the UXO clearance operations.

2.7.16. Data Processing

Geophysical data collected during the investigation was downloaded from the field computer/data logger once per day, at a minimum. Data was then processed in the following programs:

- Data collected using the multiple sensor array was collected and compiled in the field using Survey Mapper software. This proprietary software merged instrument response data with geographic positioning in a real-time mode. The final exported file contained all of the information used to initiate data processing and analysis. The initial processing included leveling the data to establish a baseline background value, correcting for the lag time inherent in data collection and assigning a geographic coordinate to each instrument response.
- Geomar Software Trackmaker 61: The field version of Trackmaker 61 was used to collect data during the man-portable phase of the geophysical survey when using the RTS. The proprietary software collected both the positioning data from the RTS and the EM61 data and stored them in a single database. The office version of Trackmaker 61 was used by the Site Geophysicist to merge the data into two data streams and create an .xyz file.
- Geonics Dat61 MK II: Used to convert RTS .R61 and Allegro files generated by using the Fiducial Method to .M61 files. The .M61 files were used to process fiducial position files and output the fiducial method files as .xyz files for Oasis Montaj.
- Geosoft Oasis Montaj: Used to filter and reduce data drift, and then used to create color contour maps of relative instrument responses over the surveyed terrain. Anomaly selections were then made and plotted on the maps for re-acquisition purposes. The anomaly selection data, i.e., coordinates and anomaly values, were then exported into a comma delimited file for use in dig sheet development.
- Microsoft Excel: Used to create dig sheets referencing all of the selected anomaly geographic coordinates, instrument response, and intrusive operation data entry, i.e., anomaly identification, depth, etc.

2.7.17. Instrument Standardization

The geophysical instrumentation was standardized using a single 100-foot line trending north/south containing buried, 1.5-inch pipe approximately six inches in length. This configuration is approximately that of a 37mm projectile. The pieces were buried at various depths and orientations (Figure 2-8). Instrument lag was assessed by traversing the test line at differing velocities. Instrument lags are defined as the difference between the time that the EM61 actually responds to the magnetic field generated by the anomaly and the time that the data is processed by the field computer and placed into the database in the same computer with a time stamp attached. The time stamps are then used to merge the positioning data stream (provided by the DGPS or RTS) with the data stream of the EM61. By evaluating the position drift resulting from the varying velocities, a time based lag factor of 0.25 seconds was applied to the data. By

applying the lag correction to the data, a large anomaly that was detected by an instrument passing over it twice in opposite directions, still appears in the final data presentation as a single anomaly. Without the lag correction, the large anomaly would appear as either two separate anomalies or as an elongated and irregularly shaped anomaly.

2.7.17.1. Standardization Procedures

Prior to beginning the geophysical survey, the EM61 coupled to the RTK/DGPS (or RTS) unit traversed a test line. A standard six line test was utilized to determine instrument response to the anticipated targets of interest, consistency of positioning, instrument lag generated by traversing the test line at different velocities and optimal MSA speed. A map of the test line as detected by the MSA is displayed in Figure 2-8.

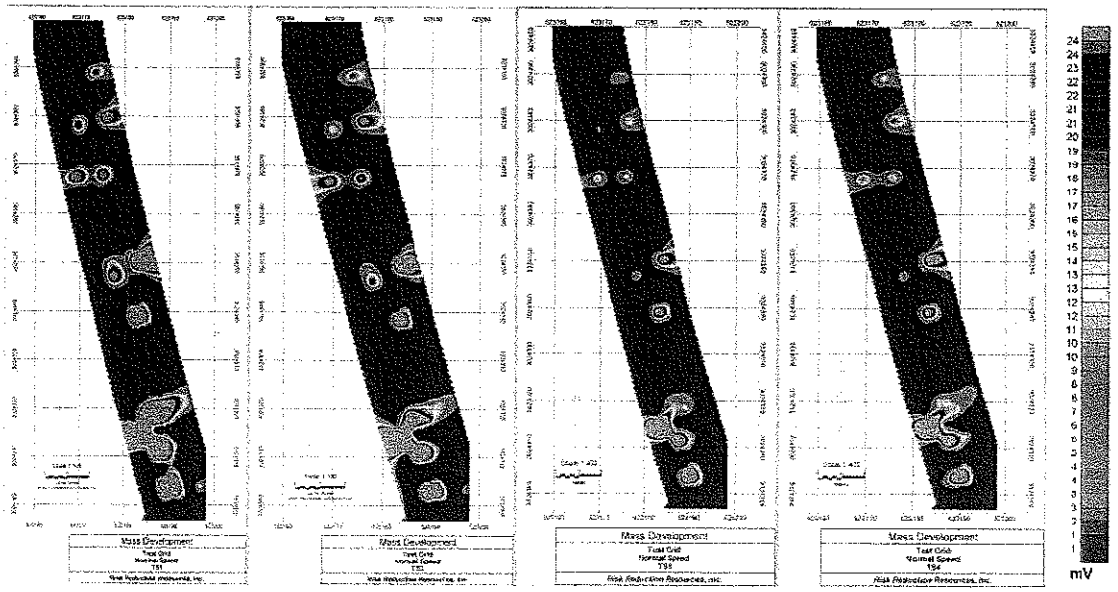


Figure 2-8: A comparison of all time gates in the test grid. The second map represents the optimal time gate of TS2. X's mark known locations of buried targets.

The first parameter needed was to determine the optimal time gate for use in processing. The EM61 MK II outputs position, X and Y, electromagnetic values for multiple time gates, TS1, TS2, TS3 and TS4, and Time. Several runs through the test grid determined that the second time gate, TS2, was best in locating the items placed in the grid (Figure 2-8). This data channel was used for all subsequent processing.

Data from the tests were then analyzed to determine if instrument responses were consistent and if any significant positioning latency was detected (Figure 2-9). Latency is produced by a lag between the instruments' response to a target and the recording of the response as data into the field computer. For the calculation the test lines were run as follows:

1. Traverse the line north and then south at normal speed with no targets to establish a background standard.
2. Plant targets of interest at varying depths along the test line and traverse the line north and then south at normal speed.
3. Traverse the line with the targets still in place north at a fast speed and then south at a slow speed.

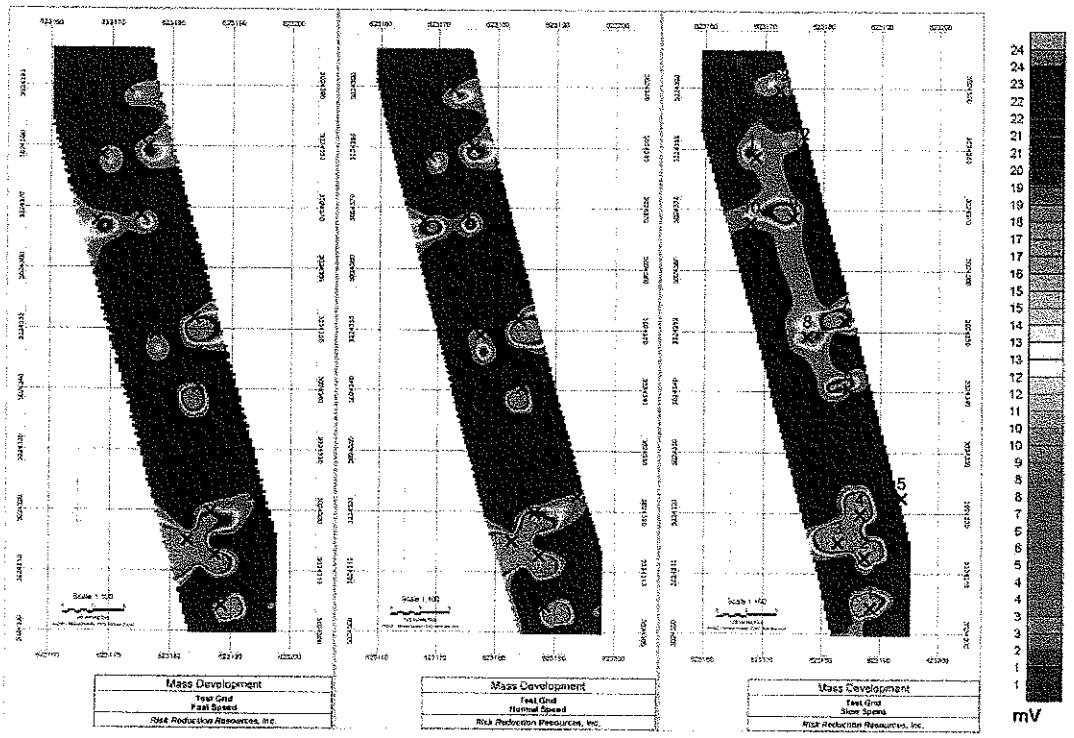


Figure 2-9: Test Grids showing the effects of different vehicle speed. X's are known locations of targets. Depths, orientation and mV reading are listed in Table 2-2. Maps show from left to right, Fast, Normal and Slow speeds. While the location of the anomalies across these different maps is very similar, the mV readings vary considerably depending on the depth and orientation of the target. At a constant medium speed for the MSA, a 15 mV is considered an acceptable threshold for this project.

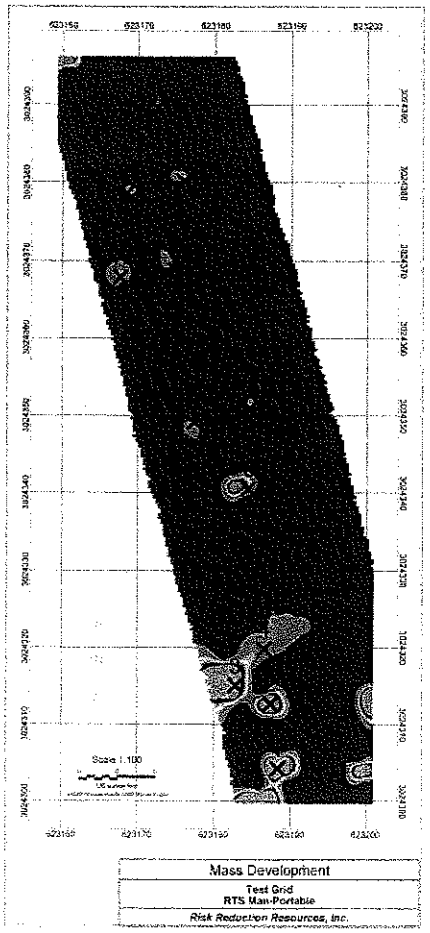
Item	Depth	Orientation	Fast mV	Normal mV	Slow mV
1	8"	Vertical	88	105	71
2	7"	45 deg.	57	84	69
3	5"	Horizontal	125	131	54
4	9"	Horizontal	29	32	61
5	9"	30 deg.	8.5	9.4	0
6	12"	45 deg	50	59	24
7	12"	Vertical	38	47	40
8	15"	30 deg.	14	21	19
9	18"	Vertical	19	26	35
10	18"	45 deg.	24	33	16
11	15"	Horizontal	13.5	16	21
12	18"	45 deg.	22.5	28	14
13	21"	Vertical	14.5	20	15

Table 2-2: List of simulated 37mm depths and orientations shown in Figure 2-9 above.

A lag time of 0.25 seconds was found. The lag time corresponded to a data shift of approximately 2.0 feet as can be seen in Figure 2-9 in the Fast Speed run; the southern anomalies are stretched. This exercise also helped us to determine the optimal speed to drive the Ranger in order to minimize the noise from the vehicle.

Based upon the instrument responses (Table 2-2), an initial anomaly selection threshold of 15 mV was used. Approximately 10 percent of the anomalies picked fell below that threshold to ensure all anomalies of interest were investigated.

In the second phase of the geophysical investigation the single unit man-portable EM61 MK II was used. The test grid run for this set up is shown in Figure 2-10. Compared to the MSA the mV readings of the man-portable are significantly lower (Table 2-3). The minimum threshold for the man-portable, single instrument units was set at 7 mV with an additional 10 percent for targets of lower readings with shapes of interest.



Item	Depth	Orientation	Man-Portable mV
1	8"	Vertical	71
2	7"	45 deg.	46
3	5"	Horizontal	46
4	9"	Horizontal	13
5	9"	30 deg.	11
6	12"	45 deg	33
7	12"	Vertical	7
8	15"	30 deg.	9
9	18"	Vertical	11
10	18"	45 deg.	13
11	15"	Horizontal	9
12	18"	45 deg.	10
13	21"	Vertical	7

Figure 2-10: Test Grid using man-portable with RTS navigation.

Table 2-3: mV readings for Man-Portable unit.

2.7.18. Instrument Drift

Two types of drift occur with the EM61 system: one from instrument background noise and the other from the extended period of data collection.

Typically, variations in instrument background noise were the primary problem in the response drift. The background noise was usually the result of dust and dirt on electrical connections and on the electrical components of the data collection system. If noise levels were excessive, the system was thoroughly cleaned and the problem resolved.

Historical usage of the EM61 MK II total metals detector has revealed a slight tendency to experience signal drift only over relatively long periods of time (40 minutes of data collection). The drift was readily corrected in the processing stage of data analysis using Geosoft Oasis Montaj (See Section 8.2.2.)

No significant response drift over the static test targets were identified over the course of the project that were not immediately identified and rectified.

2.7.19. Abbreviated Standardization Checks

Instrument data repeatability was demonstrated by a static test at a single point containing no detectable targets for a period of three (3) minutes. The same test was then conducted with a trailer hitch ball under each of the sensors for the same time interval. The data collected during

these two tests was then downloaded and analyzed to determine if significant changes in both instrument response and geographic positioning have occurred.

These static tests were conducted daily before beginning geophysical survey operations to ensure that the instruments were performing on consistently throughout the geophysical survey process. The graph below (Figure 2-11) shows an example of a static test. There is peak response when the ball is placed under the instrument, then a constant reading, then another peak as it is removed and placed under the next instrument. A similar test was done daily for the single instrument man-portable units.

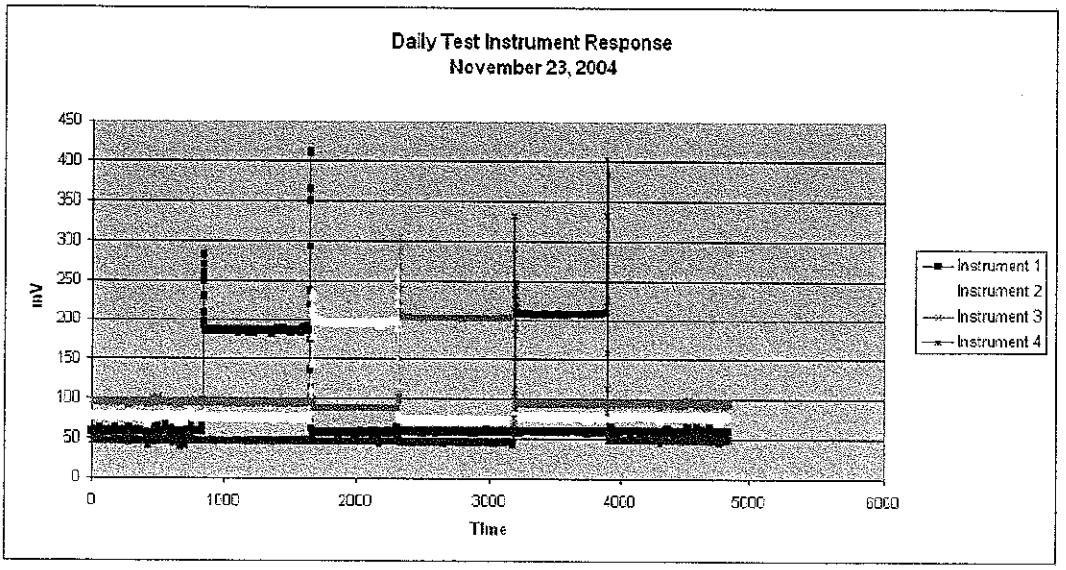


Figure 2-11: An example of a daily instrument response test.

2.8. *Data Processing, Correction and Analysis*

Data was processed using the computer programs listed in Section 2.7.16.

2.8.1. Gridding

2.8.1.1. Multiple Sensor Array

The data was uploaded into Geosoft Oasis Montaj via a database created by the Survey Mapper software. An analysis of the instrument response in profile format provided an overall view of data quality and consistency. Data profiles also allowed the analyst to remove spurious data. Instrument drift and positioning assessments were conducted and, if necessary, corrected.

Color contour maps depicting the EM61 response were created by gridding the point data using the minimum curvature technique and assigned specific colors for given instrument response values (see color scale bar in Figures 2-8 and 2-9). The maps were geographically referenced so that anomalies selected for investigation were able to be reacquired. The collections of maps generated during the geophysical investigation are displayed in Appendix A.

2.8.1.2. Single Sensor Array

The RTS data file format was converted using Geonics' Dat61MK2 then uploaded into Geomar Software's Trackmaker 61. Trackmaker 61 positions the data. Once an xyz file is produced the data is processed as noted in Section 2.7.16.

The fiducial data was uploaded into Geonics' Dat61MK2 where the fiducial marks in the data are denoted on each survey lane. The analyst set the beginnings and ends of each survey lane to provide a proper representation of the grid surveyed. Then, since fiducial markers represented a

specific interval along a survey lane, the markers were translated to their proper position on the map to stretch/compress data between two adjacent markers (which on the ground were placed at 25 foot intervals). The stretching/compressing of the data caused the data to be positioned via linear interpolation between the fiducial points. Again, the purpose of using fiducial markers was that they represented calibration points for data positioning along a lane. Since an operator could not possibly traverse lanes at exactly the same velocity along the length of a lane, and data was being collected at a rate of 10 readings per second, the analyst was able to properly distribute the instrument readings to positions between the fiducial markers. Obviously, the more fiducial markers that are placed in a lane, the more accurately the analyst can position the data. Experience had demonstrated that placing the fiducial markers at 25-foot intervals resulted in sufficient accuracy for the analyst to use during anomaly selection.

Any note of obstacles was made at this point (e.g., a rock pile) and also made in the final grid. Once an .xyz file is produced the data is uploaded into Geosoft Oasis Montaj and then warped to fit the projection of maps used. In this case it is NAD83/Massachusetts CS83 Mainland. The data was then gridded as in Section 2.8.1.

2.8.2. Instrument Drift Correction

Geosoft Oasis Montaj had a drift correction sub-routine to compensate for geophysical instrument drift. The sub-routine corrected drift based upon an analysis of data collected over a given time period and provided a mathematical solution to increase/reduce background data values to an averaged value without altering the magnitude or positions of spikes and signals of interest (see Figure 2-12).

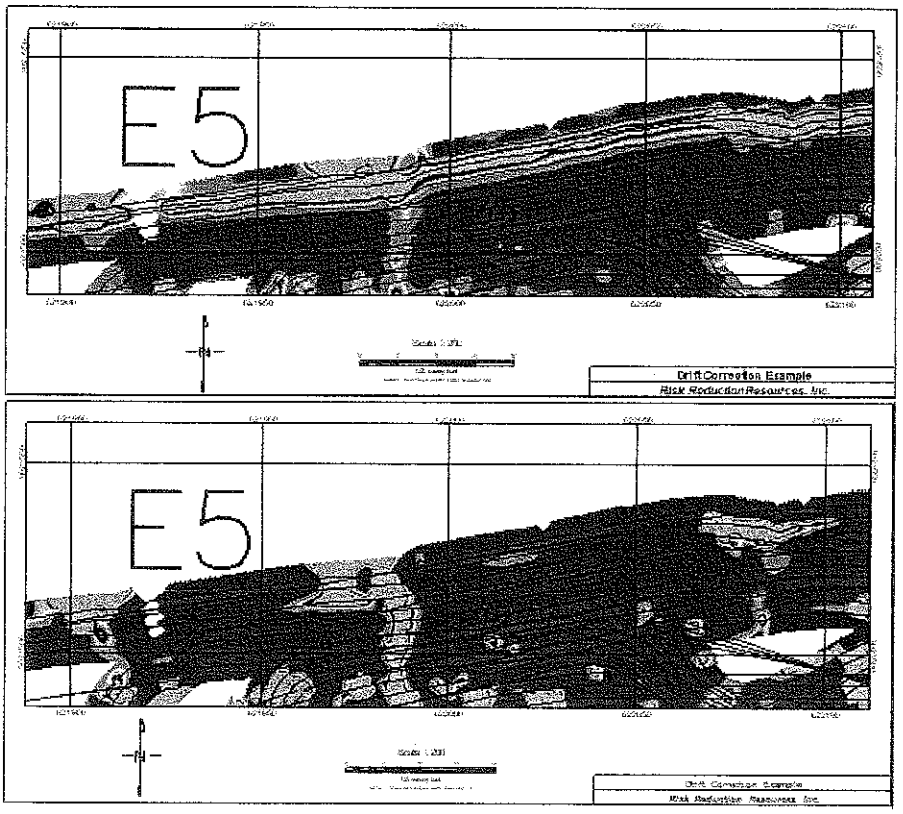


Figure 2-12: Example of drift correction. The top grid is a sample of Grid E5 and shows instruments 2 and 3 drifted towards the end of the data collection process (pink streaks along the top line of the data). The grid on the bottom corrects for the drift. Black lines are individual instrument tracks of the MSA.

2.8.3. Digital Filtering and Enhancement

Data collected using the EM61 MK II generally required no significant filtering or enhancement.

2.8.4. Correlation with Ground Truth

Correlation with ground truth was tested daily by the static tests.

2.9. Quantitative Interpretation and Dig Sheet Development

Quantitative interpretation of the collected geophysical survey data was performed by the site geophysicist in coordination with the Project Geophysicist and the data collection teams.

2.9.1. Target Selection

Based upon available information and data collected within the test grid using both the MSA and man-portable data, it was anticipated that 37 mm projectiles buried at two (2) feet below grade would present the lowest instrument response value for anomaly selection criteria. OER believed this depth was sufficient to identify 37mm projectiles, as they were unlikely to penetrate below this depth. Therefore, anomalies were selected during the geophysical survey that had an instrument response curve similar to those response curves representing the 37mm projectiles in the test grid and having a minimum response value of seven (7) mV (as described in Section 2.7.17.1). Also, as a quality control measure, approximately ten percent of the selected anomalies had response values or similarly shaped response curves (with respect to those identified in the test grid) at or below the anomaly selection threshold (7 mV). Target selection was initially made at a minimum of three (3) foot intervals. Targets were digitized by hand from the color shaded grids and compiled with their x, y locations and mV readings into an Excel file, which was then formatted into a dig sheet to be distributed to the UXO supervisor.

Data collection overlap occurred between the data files. All data files that fit within a specific 200' x 200' grid were overlapped such that the clearest information was on top. For example, in a dense anomaly area the MSA response tended to saturate due to the additive effect of the multiple instruments. In this case the single instrument man-portable provided more delineated targets. In a less dense anomaly area, the sensitivity of the MSA was preferred over the single instrument. The data was then cropped to the specific 200' x 200' grid and a color map was made with the selected targets.

Areas of saturation (mostly near house pads) were digitized and reacquired along with the data gaps.

Areas identified as utilities were demarcated as such on the color maps and were not investigated intrusively.

2.10. Anomaly Reacquisition

The identification and position of each anomaly to be investigated was uploaded into the DGPS unit which provided navigation directions back to the anomaly. Upon identifying the anomaly location via the coordinates provided in the RTK/DGPS unit, intrusive investigations were completed in accordance to industry standards outlined in Chapter 2 of the Work Plan.

2.11. Feedback Process

At the end of each day's intrusive investigations, the UXO Supervisor submitted the completed dig sheets to the Site Geophysicist. During the intrusive investigation the Site Geophysicist examined the results of the intrusive investigation teams and adjusted the picking process. Initially, the anomaly count included many anomalies whose values were substantially below the established thresholds to determine if the anomaly threshold was at an appropriate level to detect the objects of interest, particularly in the impact areas. A large amount of "no-contacts" (a reacquired selected target that produces no anomaly) were reported by the intrusive teams after

completing work on the first few grids. Analysis of the no-contacts by the Site and Project Geophysicists, in consultation with the QC Geophysicist, resulted in the adjustment of the anomaly selection process that allowed the intrusive teams to still find all of the targets of interest as well as targets of similar size, shape, and mass, but reduce the number of no-contacts to approximately 10%. As well the distance between picks was increased to 4 feet.

2.12. Geophysics Records Management

All data were backed up daily onto a compact disk which was retained by the Project Geophysicist and QC Geophysicist. Daily backup of the analyzed data was also performed by the Site Geophysicist. Weekly backups of all data were burned onto CDs and DVDs which were retained by the Project Geophysicist. All hardcopy reports (dig sheets) were also retained by the Project Geophysicist.

2.13. Excavation and Removal

Once anomalies were reacquired and marked by the geophysics team they would be excavated by the UXO team with the seven-man team dividing into three digging pairs and the seventh man serving as the recorder. Each reacquired and marked grid came with a dig sheet which listed all the marked anomalies by grid name and number. Each dig pair worked an area of the grid separated from the other two digging pairs. One member of the digging pair would use a Schonstedt GA-52Cx handheld magnetometer to pinpoint the source of signal at a particular marked anomaly, and the other member of that pair would excavate the anomaly. Working together they would excavate each anomaly, identify it, remove it from the excavation, report the result to the recorder, and recheck the excavation to insure there was no other source of signal. Each digging pair typically searched an area that was ten to fifteen feet in diameter around the flag placed by the reacquisition team. Sometimes these search areas overlapped with the next nearest flagged anomaly and sometimes both flags marked different magnetic poles of the same anomaly.

Some marked anomalies would produce multiple items. For example, the digging pair might remove a length of field telephone communications wire from the excavation which would have been the strongest source of signal detected by the magnetometer, and when the magnetometer operator checks the excavation after the first anomaly had been removed he detects another anomaly. The second anomaly is removed and the hole is checked again. This process is repeated as often as needed until there is no source of signal left in the area of the flag marking that anomaly. If the digging pair was excavating an anomaly that turned out to be an old crumbling bucket, for example, they would have to remove it in pieces until they got it all and to insure there was not another anomaly under that one.

Each grid proceeded in this manner until all the marked anomalies had been excavated, identified, removed (if possible), and reported to the recorder. Not all anomalies could be removed by the digging pair because of size or difficulty. Those anomalies would be reported to the recorder as backhoe digs and left for later. Once the grid was otherwise finished one digging pair would be assigned to use the backhoe to mechanically excavate all the backhoe digs and record the results.

There were several high density areas that were too densely packed with anomalies for the Geophysist to pick individual anomalies. These areas would be outlined in the field by the reacquisition team and excavated en masse by the backhoe team. Excavated and identified anomalies were then listed on the dig sheet as having come from a single dig, although the area excavated may have covered several hundred square feet.

2.14. MEC Recovered

During the excavation and removal phase several MEC items were recovered as well as several other ordnance related items of significance. Seventeen (17) fired, fuzed (armed), unexploded black powder filled 37mm projectiles were recovered from grids A-3, B-3, and C-2 which make up

the bulk of the impact area hillside. Also recovered from this area were one (1) fired 37mm armor piercing (AP) round (solid steel), an empty rifle grenade, and a mine flare container with an unfired detonator. This is the same area covered by the Army's contractor in its 1996 UXO Removal Action.

Date	Grid	Flag#	# of	UXO's	OE Items	Northing	Easting
07/11/05	A3	6	1	UXO 37mm/fuzed		3023102	621198
07/12/05	A3	39	1	UXO 37mm/fuzed		3023136	621220
07/13/05	A3	151	1	Mine Flare w/det		3023167	621263
07/14/05	A3	151			37mm AP	3023167	621263
07/14/05	B3	567	1	UXO 37mm/fuzed		3023165	621331
07/25/05	B3	656	1	UXO 37mm/fuzed		3023209	621312
07/25/05	A3	151	1	UXO 37mm/fuzed		3023167	621263
07/27/05	A3	102 QC	1	UXO 37mm/fuzed		3023143	621293
08/02/05	C2	184	1	UXO 37mm/fuzed		3023031	621562
08/02/05	C2	172	1	UXO 37mm/fuzed		3023037	621531
08/02/05	C2	172	1	UXO 37mm/fuzed		3023037	621531
08/03/05	C2	197	1	UXO 37mm/fuzed		3023028	621540
08/03/05	C2	202	1	UXO 37mm/fuzed		3023023	621523
08/04/05	C2	198	1	UXO 37mm/fuzed		3023025	621537
08/04/05	C2	198	1	UXO 37mm/fuzed		3023025	621537
08/08/05	C2	202	1	UXO 37mm/fuzed		3023023	621523
08/08/05	C2	214	1	UXO 37mm/fuzed		3023017	621517
08/11/05	C2	201	1	UXO 37mm/fuzed		3023029	621513
08/11/05	C2	217	1	UXO 37mm/fuzed		3023006	621509
08/15/05	C1	168			Empty rifle grenade	3022805	621667
08/22/05	F3	65			Empty rifle grenade	3023273	622164
08/22/05	F3	103			Empty rifle grenade	3023291	622293
08/22/05	F3	143			Empty rifle grenade	3023107	622282
08/25/05	C5	84	1	3" Stokes unfuzed		3023589	621622
09/01/05	F4	50	1	UXO Rifle grenade		3023306	622188
09/01/05	F4	58			Empty rifle grenade	3023304	622113
09/07/05	G8	197			mine flare body empty	3024202	622499
09/12/05	E5	228	1	AT Mine fuze		3023548	621911
09/12/05	E5	135	1	AT Mine fuze		3023569	622001
09/12/05	E5	258			Empty rifle grenade	3023566	621911
09/12/05	G5		1	37mm w/casing		3023680	622423
09/15/05	D5	130	1	3" stokes unfuzed		3023514	621748
09/19/05	H5	183			Training Hand Grenade	3023604	622612
09/19/05	H5	30			Empty rifle grenade	3023507	622613
09/22/05	I3	278			Empty rifle grenade	3023267	622708
10/04/05	I10	9			Training Hand Grenade	3024646	622727
10/06/05	H9	56	1	UXO 37mm unfired		3024431	622523
10/10/05	I12	6	1	UXO 37mm w/casing		3025097	622872
10/10/05	I12	87			Training Hand Grenade	3025015	622843
10/10/05	I13	3			Empty Mine Flare Body	3025114	622855
10/19/05	L12	213			French VB2 Trainer	3024947	623368

10/19/05	L12	237			French VB2 Trainer	3024932	623410
10/19/05	M16	22	1	AT Mine Trainer		3025722	623547
10/24/05	O16	99			Empty AP Mine	3025708	624015
10/27/05	K8	259	1	3" Stokes unfuzed		3024106	623205
11/28/05	N13	72	1	3" Stokes unfuzed		3025294	623870
11/28/05	N10	151	1	3" Stokes unfuzed		3024691	623702
11/30/05	L8	55	1	3" Stokes unfuzed		3024127	623437
			31		17		

Table 2-4: Unexploded ordnance (UXO) and other significant ordnance related items recovered during the excavation phase by date, grid number and flag, quantity, item description, and geographic location.

Other ordnance items recovered during this phase included items indicating that this area had been used for small unit tactics and maneuver type training: empty or training rifle grenades, both U. S. and French; mine flare bodies; anti-tank (AT) mine fuzes; training hand grenades; and blank small arms ammunition.

Also recovered during this phase were six (6) 3" Stokes mortars and a small quantity of case fragments (frag). The area where the Stokes were recovered was all low land that appeared to have been filled, probably when the housing area was being constructed. It is probable that the Stokes came to the project site in fill brought from the south side of the base. Given the very small amount of Stokes related frag recovered from the site OER does not believe this area was a Stokes impact area.

2.14.1. 37mm Projectile

This target practice cartridge is used in subcaliber 37mm guns fitted to larger weapons for practice firing and training. This ammunition was originally developed during World War I in response to the need for armor piercing weapons, but quickly became obsolete as armor quickly became thicker. It was relegated to training for larger caliber weapons.

The 37mm projectile consists of a black powder filled steel projectile crimped to a steel cartridge case and fitted with a base-detonating practice fuze. A rotating band encircles the projectile near the base. The cartridge case is loosely filled with propellant and is fitted with a percussion primer.

When the weapon is fired, the firing pin strikes the primer to ignite the propelling charge. The rotating band engages the barrel rifling to impart spin to the projectile and prevent escape of pressure past the projectile. Rapidly expanding gases from the burning propellant drive the projectile through the barrel with the velocity required to reach the target. Upon impact, the base detonating fuze ignites the black powder filler in the projectile, simulating the detonation of a service projectile.

The projectile typically has a range of 4,980 yards fired at a muzzle velocity of 1,100 feet per second (fps).



Figure 2-13: 37mm projectile found in the impact area. The item is only excavated to the point where a positive identification can be made. All fuzed items were left in situ for the disposal team.

2.14.2. 3" Stokes or Trench Mortar

The 3" trench mortar shell consists of a cylindrical steel casing, with a steel base and steel head that are screwed on. The steel head serves to close the nose of the shell, and also seats the booster jacket and fuze. The steel base serves to close the tail end and seats the cartridge container. Depending on the type of shell, the filler will either be trinitrotoluene (TNT), white phosphorus (WP), or inert filler with black powder to act as a spotting charge.

The booster jacket seated in the steel head consists of a one piece drawn steel cup with a supporting flange formed on one end. It serves to seat the booster charge consisting of mercury fulminate, tetryl, and TNT or black powder if a practice shell. The fuze that screws into the head is known as the Mk VI "always acting" percussion fuze. Because the shell is unstable in flight, the fuze is designed to function regardless of how lands. In face, it usually travels end over end.

The safety pin is removed and the shell is dropped down the mortar tube. When the shell strikes the firing pin located at the bottom of the tube the percussion primer fires igniting the propellant charge. The gases produced expel the shell from the tube. Acceleration compresses the set back spring releasing the safety fork arming the fuze.

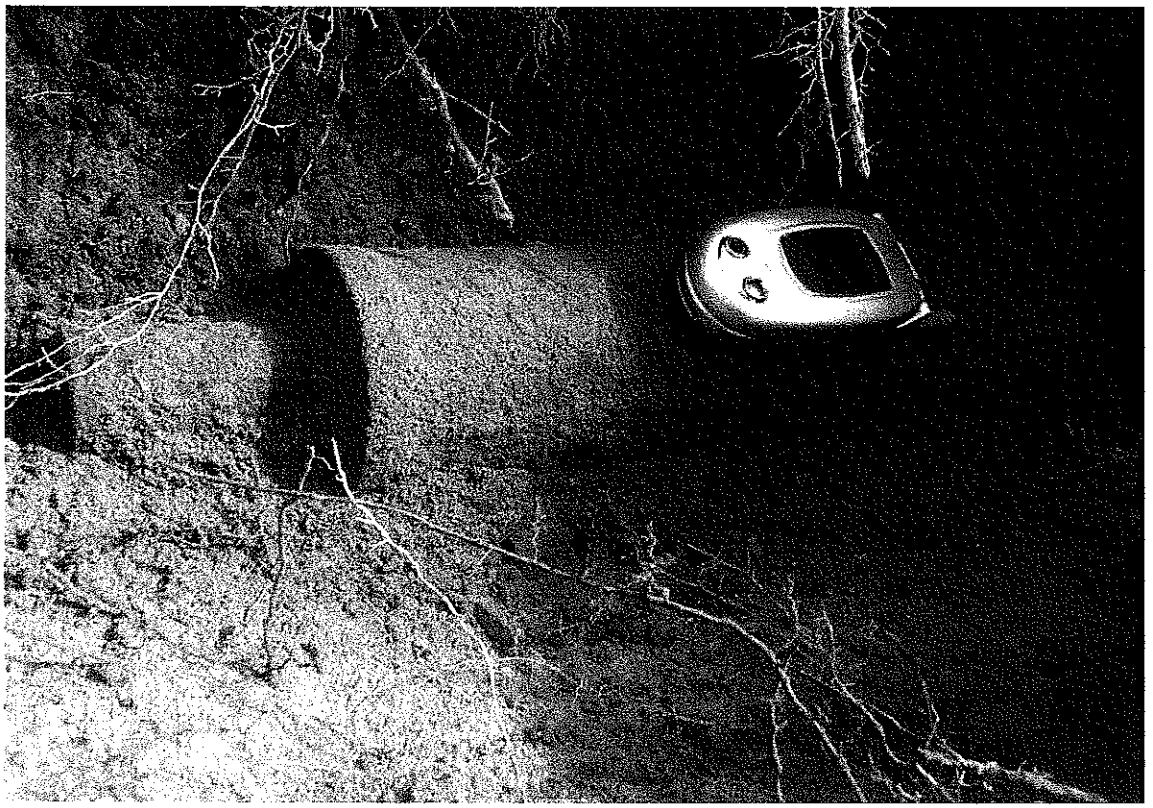


Figure 2-14: 3" Stokes mortar showing the typical cylindrical steel body, steel base, and smaller diameter cartridge case on the left end of the picture.

2.14.3. Training Grenades

Several types of training grenades were found including Mk 2 hand grenades, French VB2 and US M9 and smoke grenades. All of these items were inert.

Two different varieties of Mk 2 training hand grenades were found. The first is a one piece hollow cast iron hand grenade with a hole at the base and a hole at the top of the body next to the fuze allowing visual inspection of the inside. The second type is an Mk 2 training hand grenade with a threaded fuze well and a hollow body with a hole at the base. This type may be used with a live fuze and is usually loaded with a small black powder charge; a cork seals the base opening. The grenade is used the same way as a high explosive loaded grenade: grasping the grenade body with the throwing hand, removing the safety pin, and throwing the grenade. Upon release the safety lever is thrown off by the force of the released spring loaded firing pin. The firing pin strikes a percussion primer which lights a powder train delay which burns approximately 4 seconds and then fires the detonator. The detonator fires the black powder charge, which emits a sound and smoke signal. The grenade may be recovered and reloaded for reuse.

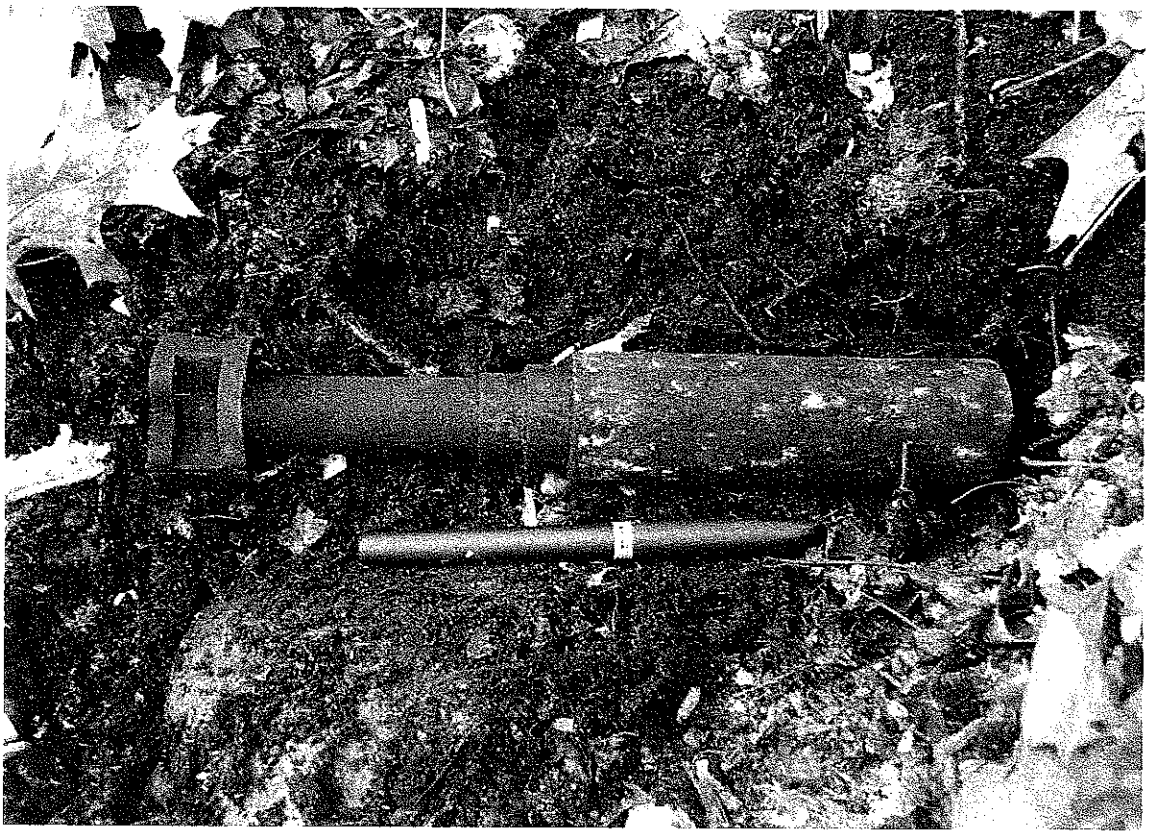


Figure 2-15: Empty M9A1 rifle grenade.

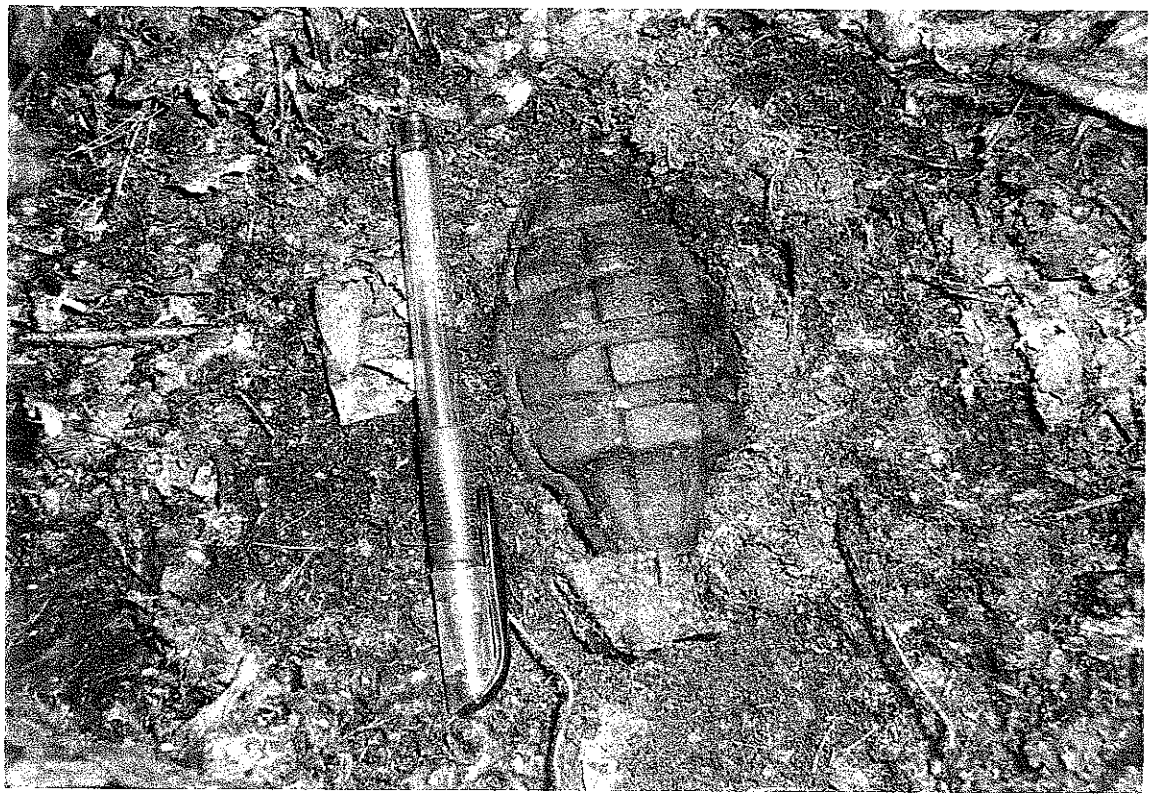


Figure 2-16: Mk 2 training hand grenade with functioning fuze.

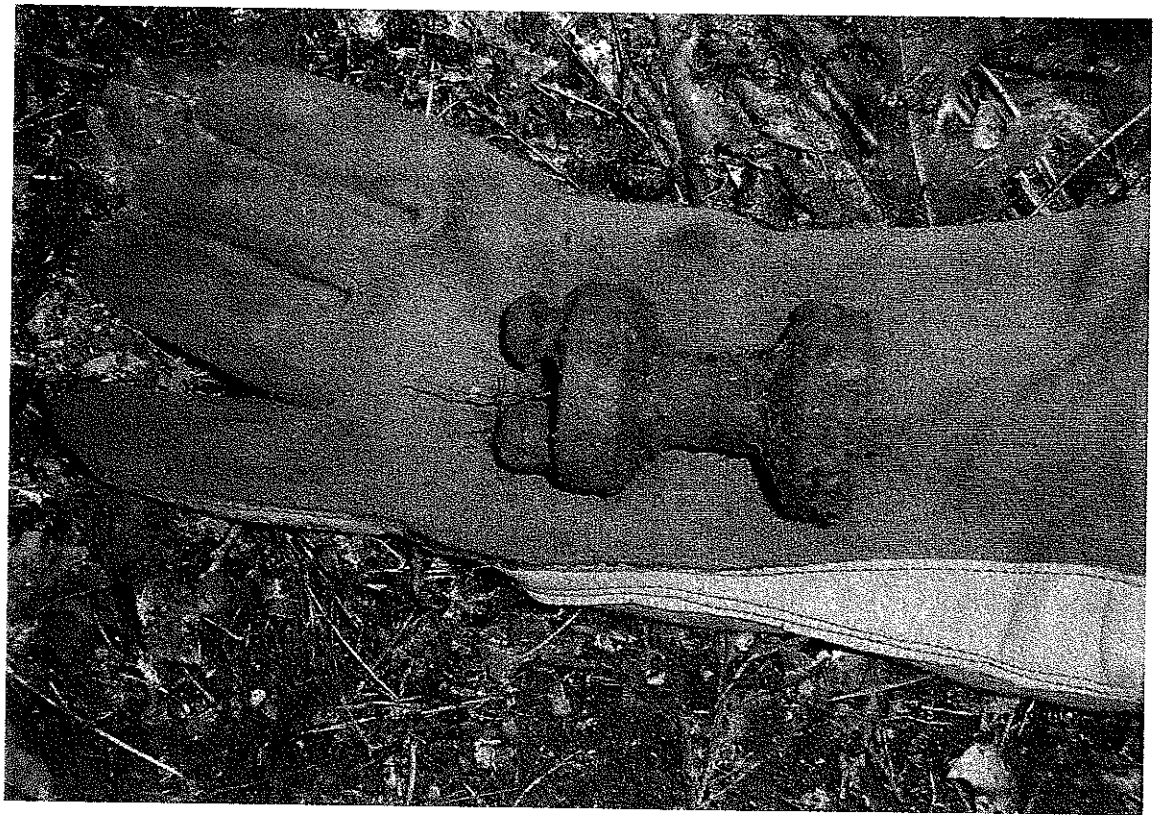


Figure 2-17: French VB2 training rifle grenade.

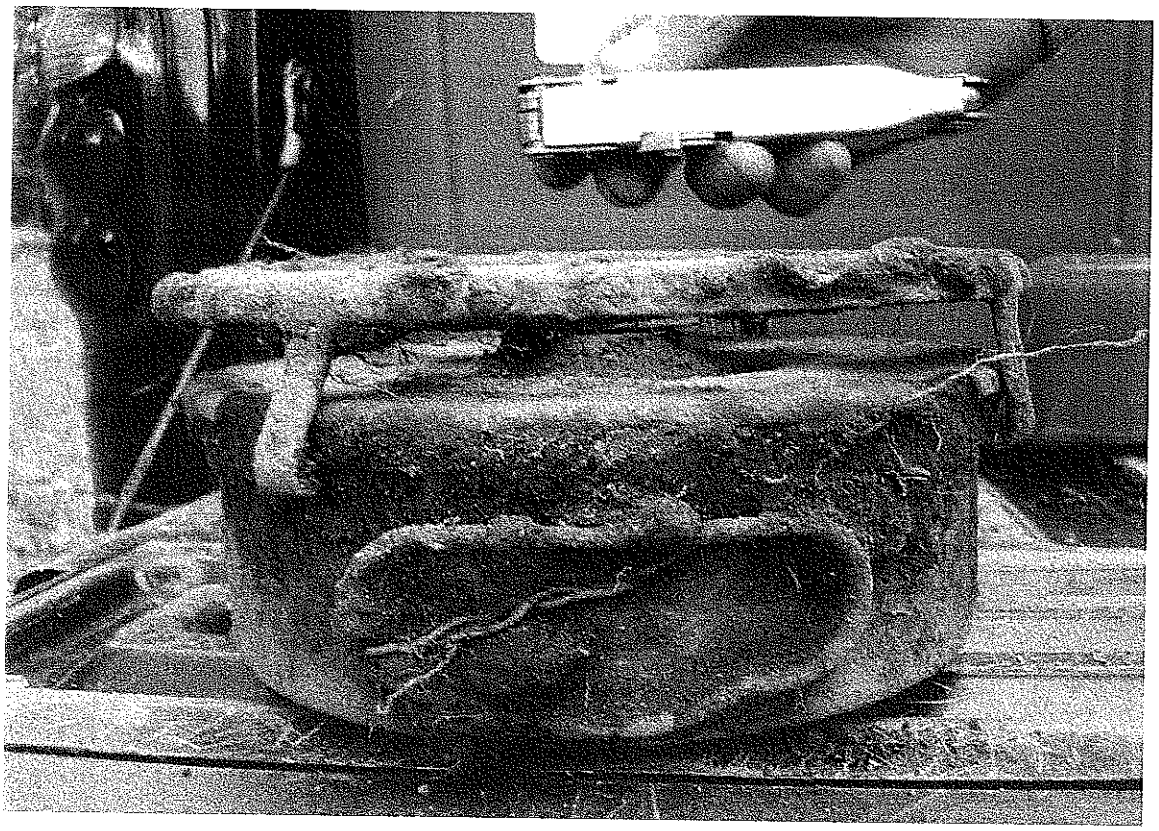


Figure 2-18: M16 training anti-tank mine.

2.15. Scrap Management

Public Works (PW) provided a two cubic yard dumpster on site for non-ordnance related metal scrap. During the surface clearance metal scrap was collected and separated into ordnance related and non-ordnance related metal scrap. All ordnance related metal scrap was collected in 5-gallon buckets and stored in a locked Conex box on site. Non-ordnance related metal scrap was piled at grid corners or on the nearest road if there was one close to the edge of the grid being searched. At the end of each workday the non-ordnance related metal scrap was collected in the site truck, transported to the PW dumpster on site and deposited. The site supervisor would call PW as needed to have the dumpster emptied and relocated.

The same process was used during the excavation phase with ordnance related metal scrap deposited into 5-gallon buckets and consolidated in the Conex box and non-ordnance related metal scrap collected in the truck and emptied in the dumpster at the end of each workday.

By the end of the project approximately twenty (20) two cubic yard dumpsters had been filled and hauled off site by PW.

2.16. Disposal of MEC

Explosive disposal of located unexploded ordnance (UXO) items was performed by the Army's BRAC contractor, a nearby active duty military Explosive Ordnance Disposal (EOD) detachment, or the Massachusetts State Police Bomb Squad depending availability.

When an item was located that could not be confirmed as not containing an explosive filler the site supervisor notified the OER Project Manager who notified the MassDevelopment Project Manager. The MassDevelopment Project Manager alerted the Army BRAC office on Devens, which arranged for someone to perform the disposal. Once the UXO Supervisor had made his notification, the item would be photographed in situ, have its location recorded, sandbagged in place, flagged, and the UXO team would continue on.

If the item could not be disposed of on the same day it was found, the local Massachusetts State Police Barracks would be notified to provide security until the UXO team returned the next morning or until the item or items were disposed of. This procedure was used for all items except the unfuzed 3" Stokes mortars recovered late in the project. Those items were stored overnight in the on site Conex box until they were disposed of.

2.16.1. Collection of Soil after a Disposal Shot

DEP and EPA requested in their comments to the scope of work that after each disposal shot the UXO team remove a six inch layer of soil from the location of the disposal shot. Depending on the size of the shot from one to four 5-gallon buckets of soil could be removed. The collected soil was sealed in plastic 5-gallon buckets and stored in the fenced PW equipment yard.

The donor explosive used for each disposal shot depended on who was performing the shot: the Massachusetts State Police Bomb Squad and military EOD detachments both used electric blasting caps, to det cord, to C-4 as an explosive train while Weston, the Army's BRAC contractor, used commercial explosives provided by a local vendor. In this case electric blasting caps, to det cord, to 1/3rd pound cast boosters, or electric blasting caps to 1/3rd pound cast boosters.

Each disposal shot was set up and then sandbagged in place before being initiated to limit fragmentation, blast effect (shock and noise), and heat (fireball). Each shot was set up with the donor explosives placed on top of the ordnance items being disposed of to blow the items down into the ground as opposed to placing the donor explosive under the items being disposed of and blowing them up.

All ordnance items located during the project were detonated of on site during the project.

Date	Quantity of Buckets	UXO	Donor Explosive	Provider
04/26/05	4	37mm (1 each)	C-4	MA Bomb Squad
05/03/05	4	37mm (1 complete & 2 partials with fuze)	Cast Booster	Weston
05/11/05	4	37mm (1 each)	C-4	EOD
07/18/05	12	37mm (3 each & 1 mine flare det)	Cast Booster	Weston
07/26/05	8	37mm (2 each)	C-4	EOD
07/28/05	4	37mm (1 each)	C-4	EOD
08/05/05	14	37mm (7 each)	Cast Booster	Weston
08/08/05	4	37mm (2 each)	Cast Booster	Weston
08/11/05	4	37mm (2 each)	Cast Booster	Weston
08/30/05	1	3" Stokes (1 each)	Cast Booster	Weston
09/01/05	2	Rifle Grenade, Star Cluster (1 each)	Cast Booster	Weston
09/13/05	2	Mine Fuzes (2 each & 1 each 37mm)	Cast Booster	Weston
09/15/05	2	3" Stokes (1 each)	Cast Booster	Weston
10/06/05	2	37mm (1 each)	C-4	MA Bomb Squad
10/19/05	2	37mm (1 each with case & 1 each AT mine fuze)	Cast Booster	Weston
11/30/05	2	3" Stokes (4 each unfuzed)	Cast Booster	Weston
	71			

Table 2-5: This table shows the date of each shot, the number of 5-gallon buckets of soil collected, the ordnance disposed of, the donor explosive used to initiate the shot, and the entity performing the disposal.

2.17. *Disposal of Ordnance Related Scrap*

At the end of the project all of the ordnance related scrap collected during the project was re-inspected to insure it contained no visible trace of energetic material. Those items that did not contain any visible trace of energetic material were evaluated to determine if they were of a shape that would be recognizable as ordnance or ordnance related. If they were not in a form easily recognizable as ordnance they were placed in the PW scrap metal dumpster for recycling. An example of this would be the many buckets full of 37mm case fragments (frag).

If they were recognizable as ordnance or ordnance related they were demilitarized on site by being sufficiently deformed as to be unrecognizable as ordnance or ordnance related. For example, of this would be the empty rifle grenades, mine flares, and mine cases are of light construction and were easily demilitarized with a hammer or backhoe. Once these items were demilitarized they were placed in the PW scrap metal dumpster for recycling.

PW was then called to remove the dumpster and was issued a form 1348-1 signed by the UXO Supervisor and UXO Project Manager attesting that all the items turned in had been visually inspected several times and contained no visual trace of energetic material. PW transferred the material to a local scrap metal dealer for smelting and reuse.

Those items that were not UXO but that did contain an energetic filler or that could not be sufficiently demilitarized on site with the tools available to the UXO team were shipped off site for disposal. The items that did contain or were suspected to contain some energetic filler were half a 5-gallon bucket of unfired blank 7.62 and smaller caliber ammunition. The one item that was not demilitarized on site was a one piece hollow steel cast Mk 2 training grenade.

3. Documentation

3.1. Previous Work

The following reports or previous work were available and were used for reference at the time the work reported herein was being planned and performed:

- Ordnance & Explosives Waste Chemical Warfare Materials Archive Search Report Findings for Fort Devens, Ayer, MA, May 1995
- Ordnance, Ammunition & Explosives Sampling Action, Fort Devens, MA. Draft Sampling Action Report, UXO 95121 HFA, 29 December 1995
- Draft Removal Action Report, Volume I, Ordnance, Ammunition & Explosives Time Critical Removal Action Devens RFTA, Ft. Devens, MA, UXO 96102 HFA, 10 October 1996
- Draft Preliminary Assessment / Site Inspection Report: Study Areas – Grant, Locust, and Cavite Housing Areas, Former Fort Devens Army Installation, Devens, MA, November 2004
- Draft Final Supplemental Site Investigation Work Plan: Study Areas – Grant, Locust, and Cavite Housing Areas, Former Fort Devens Army Installation, Devens, MA November 2004
- Human Factors Applications, Inc. Ordnance & Explosive Waste Remediation UXO Identification Guide, November 1995

3.2. Concurrent Work

The following reports of concurrent work were produced or came available during our fieldwork:

- U. S. Army Corps of Engineers, New England District, Investigation Areas – Grant, Locust, and Cavite Housing Areas, Former Fort Devens Army Installation, Draft Final Expanded Conceptual Site Model, June 2004

3.3. Current Work

OER produced weekly reports for the weeks where fieldwork occurred. Those reports cover the fieldwork periods from November through December 2004, and April through December 2005. They contain private financial information and as such have been filed separately. They are not part of this report.

OER also produced a report on the previous time critical removal action performed on the impact area hillside by HFA in 1996. That report is filed as separate correspondence with MassDevelopment.

4. Tests

4.1. Geophysics Quality Control (QC)

Once the Site and Project Geophysicists completed the analysis of a given data set, 10 % of the data sets were submitted to the QC Geophysicist who completed a second, independent analysis of the data. The QC geophysicist overlaid the anomaly selections made by the Project Geophysicist and evaluated the preliminary analyses. The QC Geophysicist then added to the anomaly list at his discretion.

Once the QC Geophysicist completed the second evaluation, a dig sheet was generated containing a list of all of the anomalies to be investigated. The dig sheet was used by the investigative team to record all pertinent information regarding the results of the anomaly investigation. Figure 4-1 shows an example of selected QC picks along with the original Site and Project Geophysicist picks.

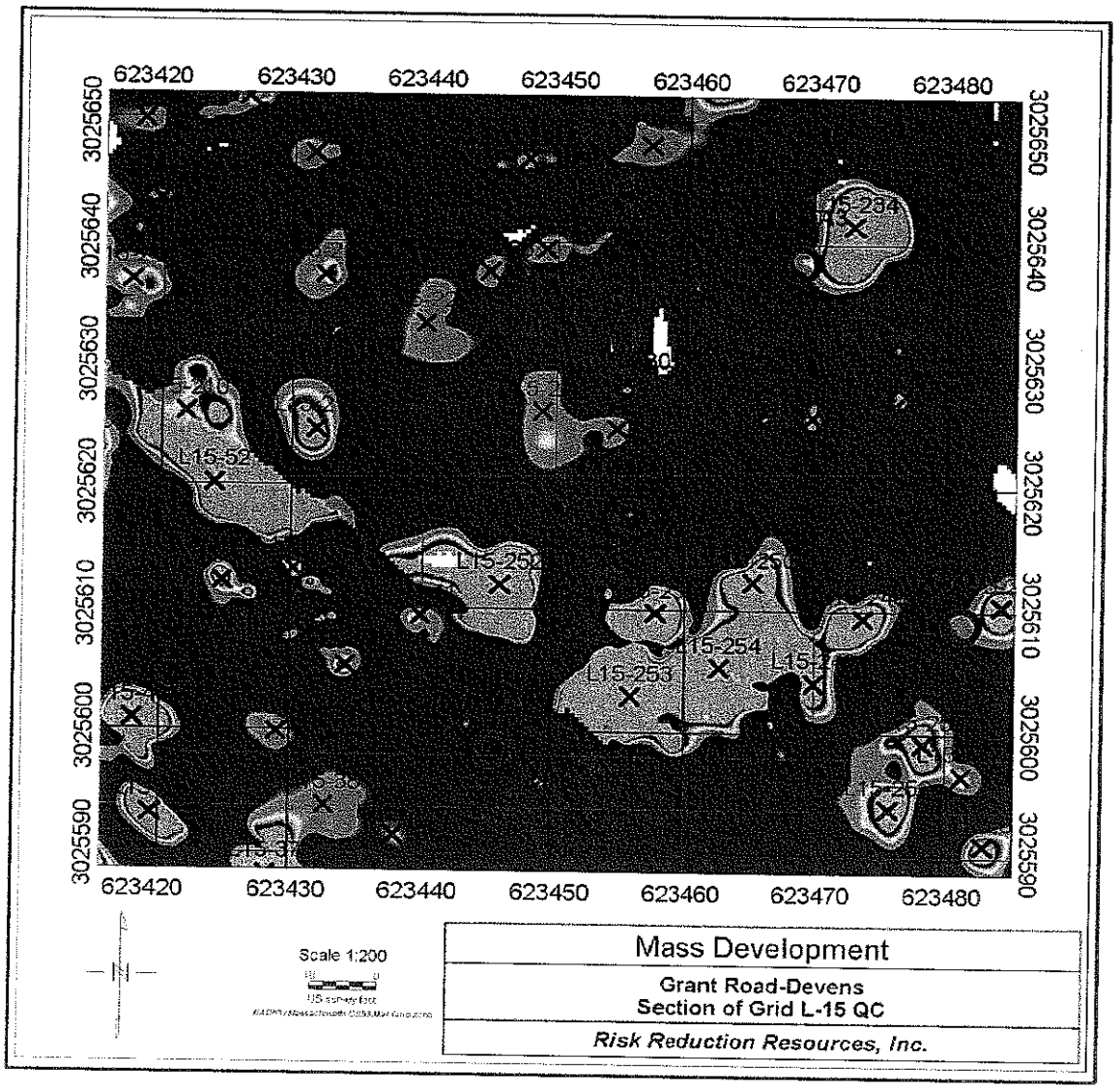


Figure 4-1: An example of QC picks added to the anomaly selection. Red O's denote location of QC picks, black denote Site and Project Geophysicists.

4.2. Excavation Quality Control (QC)

Quality control inspections were performed on all grids toward the end of the excavation phase. The UXO Supervisor or a UXO technician designated by him would search approximately 10 to 20% of each grid by walking back and forth across the grid searching with a Schonstedt GA-52Cx handheld magnetometer. When the magnetometer detected an anomaly he would stop and excavate that anomaly and make note of it on his inspection form.

We performed 100% QC on the grids on the impact area hillside and did find one 37mm projectile in grid A-3. All of the other items excavated during the QC inspections were small items below the target selection threshold established by the geophysicists.

5. Summary

Ordnance & Explosives Remediation, Inc. (OER) was retained by Massachusetts Development Finance Agency (MassDevelopment) to perform a Digital Geophysical Mapping (DGM) investigation and Munitions and Explosives of Concern (MEC) removal of an approximately 130-acre parcel on the former Fort Devens known as the Grant Road Housing Area. Previous to being a housing area that parcel had been used as a 37mm firing range and an area used for maneuver and small unit tactics training for light troops.

Fort Devens was an active installation from World War I through the mid-1990's when it was closed as part of the Base Realignment and Closure (BRAC) process. An Archive Search Report (ASR) was produced in May 1995 by the US Army Corps of Engineers St. Louis District. Human Factors Applications, Inc. (HFA) performed a sampling action of 22 sites at Fort Devens for the US Army Corps of Engineers, Huntsville Division in 1995.

HFA sampled Area 11 which included the former Grant Road Housing Area (Site 12). During sampling HFA found ten live 37mm projectiles in HFA grids W-22, Y-21, and Y-22. HFA recommended in their report that a subsurface removal action be performed in Area 11, Site 12.

HFA performed an Ordnance, Ammunition, and Explosives Removal Action of three Fort Devens sites in 1996. One of the three sites was Site 12 where HFA reports to have located 44 individual MEC items: forty-two (42) 37mm projectiles, 1 signal flare, and 1 mine flare. All MEC located was disposed of in place by detonation according to the report, and all MEC-related scrap was removed from the site. All the grids were inspected by the government representative and accepted as detailed in the report.

In both investigations above HFA used handheld magnetometers to locate surface and subsurface ferro-magnetic anomalies.

OER performed DGM and excavated and removed 37,494 picked anomalies, performed mass excavations of several high density areas, cleared several data gaps, and performed hundreds of quality control excavations. OER's investigation and removal action recovered 20 MEC items (nineteen (19) 37mm projectiles and one (1) 3" Stokes mortar) in the area previously reported as cleared by HFA during its 1996 removal action. Two (2) 37mm projectiles and approximately two hundred twenty (220) pounds of 37mm projectile case fragments (frag) were found during the surface sweep that was performed prior to the DGM of that HFA cleared area. During the subsurface removal seventeen (17) 37mm projectiles, one (1) 3" Stokes mortar, and approximately 1,870 pounds of frag were removed. All of the subsurface discoveries were located within 18" of the surface.

In total, OER located and removed 34 unexploded ordnance (UXO) items, 30 inert training ordnance items, several hundred rounds of blank small arms ammunition, and thousands of pounds of ordnance related metal scrap (mostly 37mm frag from the impact area).

6. Conclusion

The former Grant Road Housing Area was formerly a 37mm firing range as described in the Army's Archive Search Report (ASR). Prior to being used as a housing area it was also an area used for small unit training as evidenced by the amount of training ordnance items recovered during the surface sweep and the excavation phases: empty rifle grenades, flash tubes, tail booms, belted blank 7.62 ammunition, individual expended 5.56 blanks, mine flares, training hand grenades, French VB2 rifle grenades, an M1 mine, and non-ordnance related items like field communications wire.

Figure 6-1 below shows the distribution of 37mm ordnance recovered across the site. The firing point was in the area of the circle at the top of the map at approximately grid N-16. According to one of the maps in the ASR there were two firing lines which seem to correspond to the two distinct clusters on the impact area hillside to be expected as there are no other clear sight lines across the site. The firing line is bounded on the left side by a line of hills and on the right side by a heavy band of trees and underbrush and then a river.

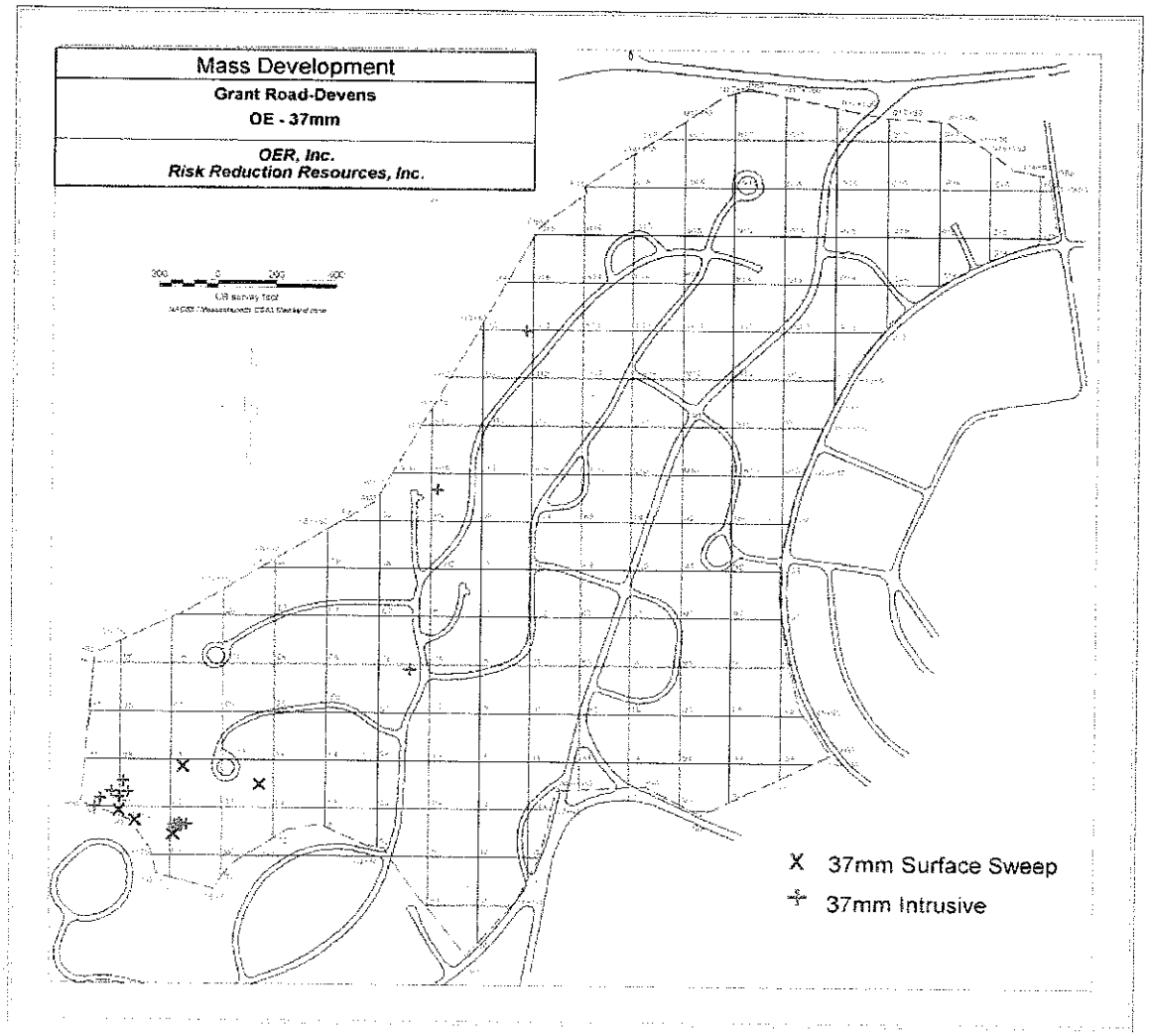


Figure 6-1: Distribution of 37mm ordnance across the project site. Notice the two concentrations in the lower left of the map which is the former hillside impact area.

The project area also produced six (6) 3" diameter Stokes mortars; see Figure 6-2 below. OER does not believe this area was used as a firing range for Stokes mortars because there is no

pattern to the distribution of the six Stokes we found, and we did not find an abundance of frag from Stokes which would be expected if the area had been used as a Stokes impact area. The six Stokes were all found in low areas that likely received fill from somewhere else when the housing area was originally constructed.

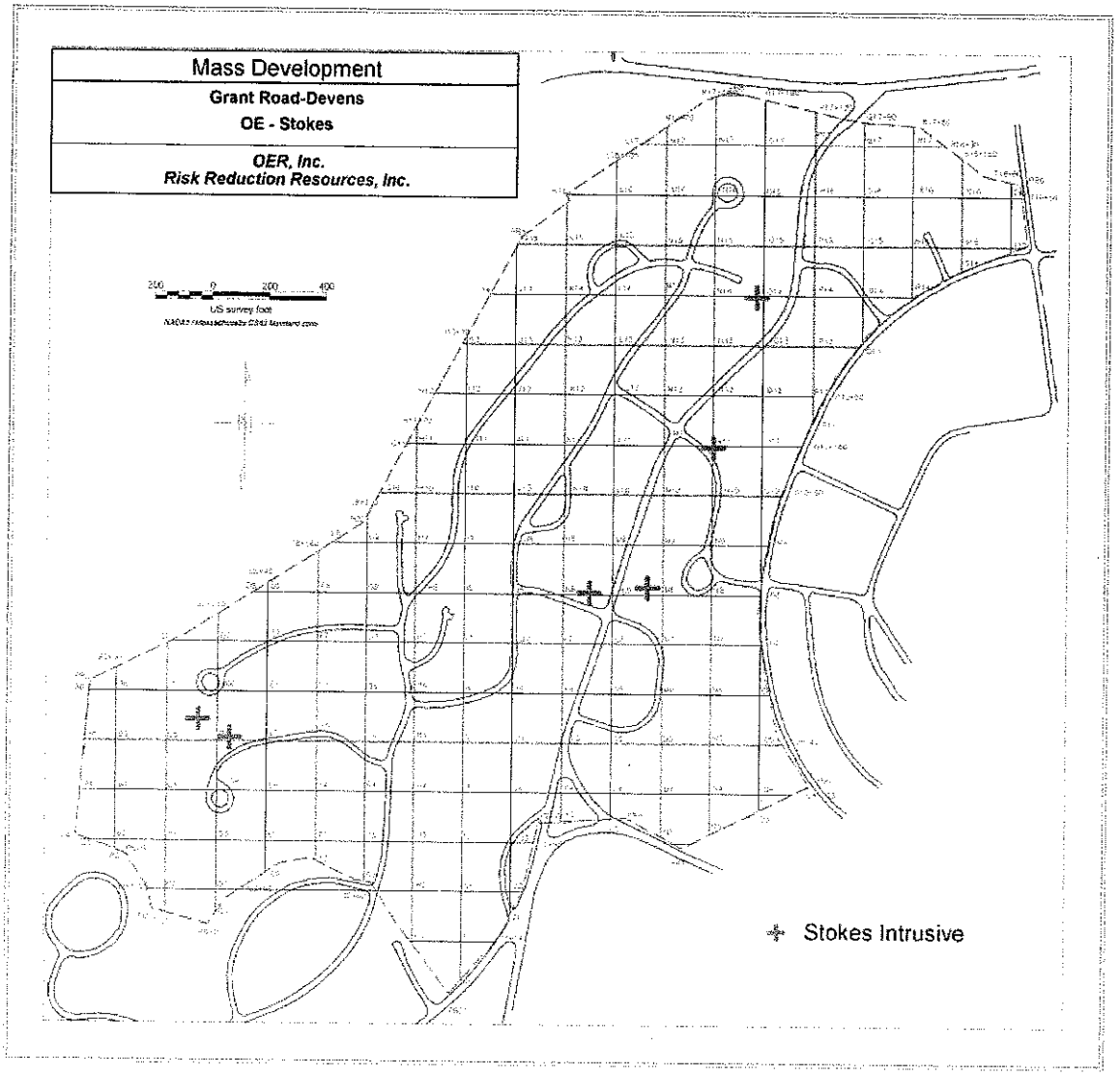


Figure 6-2: Distribution of Stokes mortar ordnance items across the project site.

The distribution of ordnance other than 37mm projectiles and Stokes mortars across the site does not show any real pattern other than it appears that training was conducted predominately in the southwestern portion of the site away from Grant Road, which was a well traveled route; see Figure 6-3 below. To the west of Grant Road the land falls away, which would have provided natural cover to troops practicing maneuver and small unit tactics in the field. To the east of Grant Road the land is flat and level, and provides no natural cover. To the west of the project area is a thickly wooded hillside descending to a public road and then to a river.

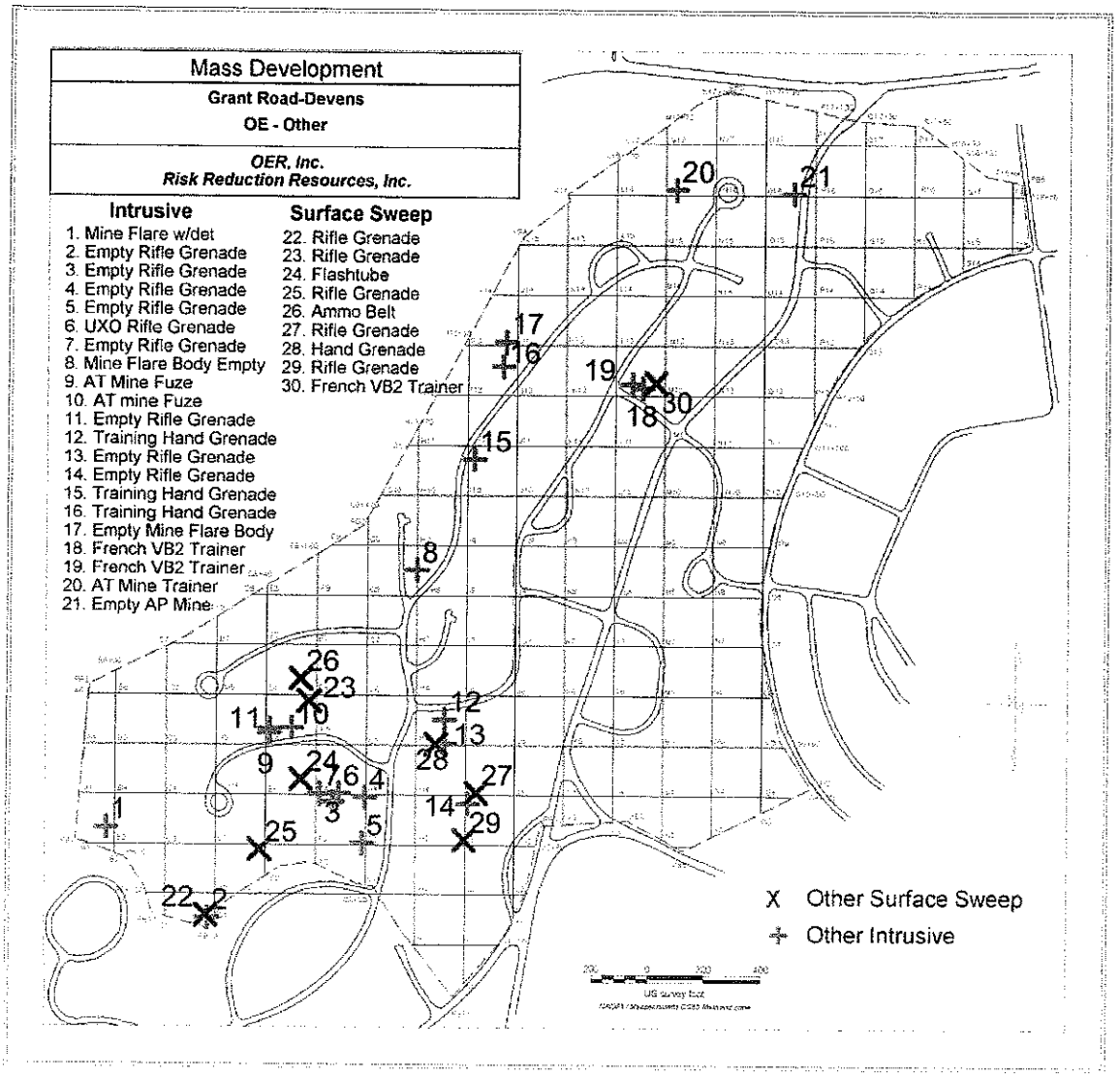


Figure 6-3: Distribution of ordnance other than 37mm projectiles and Stokes mortars across the project site. The number by each item is for identification purposes only and does not indicate the order in which the items were located.

While OER did not initially plan to perform a surface clearance, UXO and frag were found in the impact area that we assumed the previous contractor would have removed.

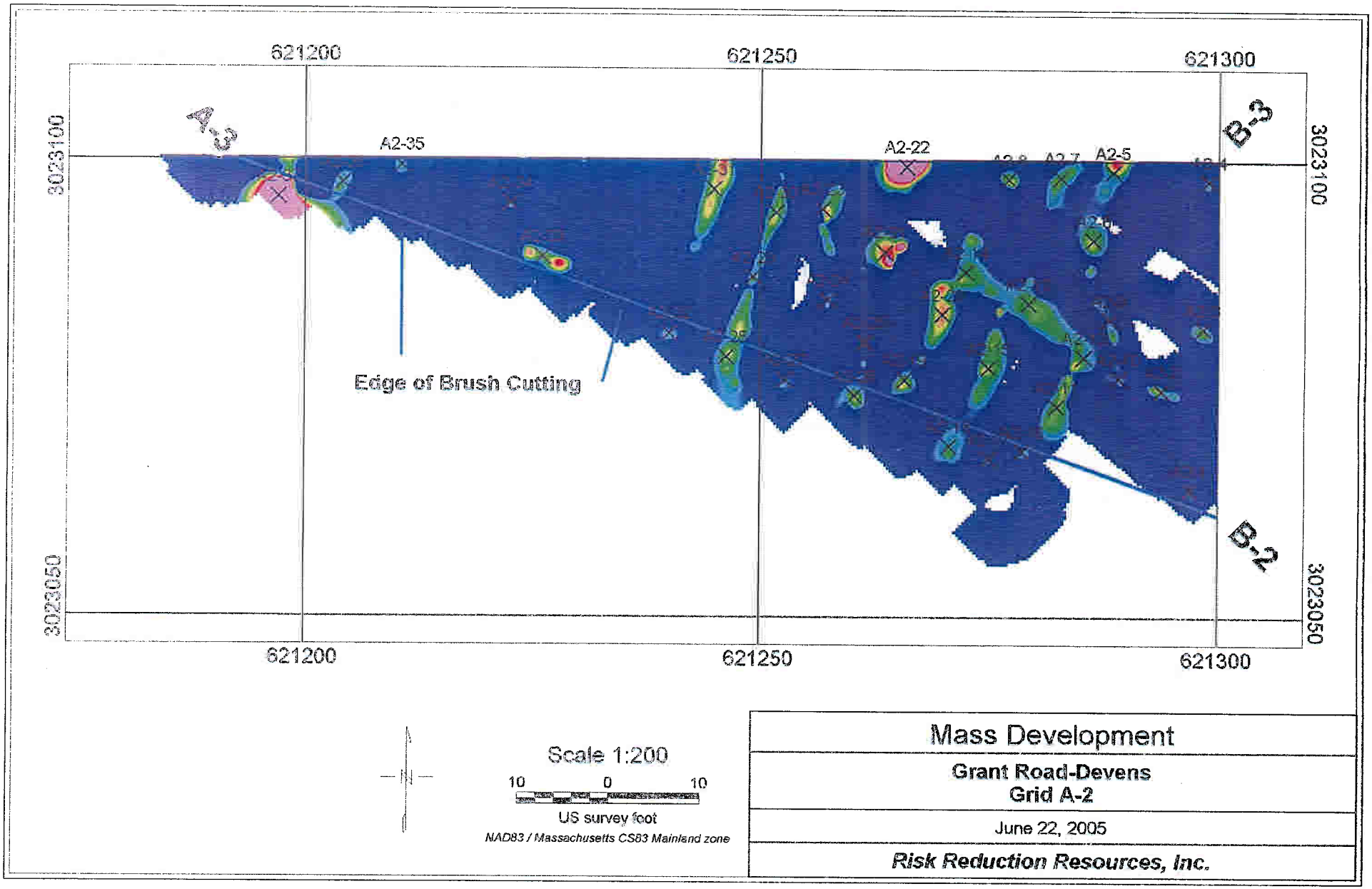
The geophysical methods used worked well, with a vast majority of marked anomalies producing some piece of metal. Most of the metal recovered across the site was related to the site's use as a former housing area: construction debris, household trash, car and machinery parts, fencing, toys, tools, cans, bottle tops, shotgun shells, etc. Some of the marked anomalies were related to the existing underground utilities and infrastructure: gas lines, water lines, sewer lines, storm drains, fire mains, utility pole anchors, etc.

The only area where OER consistently found MEC was the former impact area, which was the area previously cleared by the Army in 1996. All of the 37mm projectiles we found were between the surface and 24" below ground surface (BGS). There were two distinct concentrations of 37mm related finds in the impact area hillside with the density thinning rapidly with distance. We did find 37mm related items away from these two concentrations but not in any predictable pattern and not deeply buried indicating to us that they were probably ricochets.

With the exception of the two areas of concentration on the impact area hillside the remainder of the project site is suitable for development for residential end use. It is possible there will be more 37mm projectiles found in the Oak Housing Area where it borders the Grant Road Housing Area, as 37mm related items have been found right up to the project boundary.

APPENDIX A

GEOPHYSICAL MAPS BY INDIVIDUAL GRID



Scale 1:200

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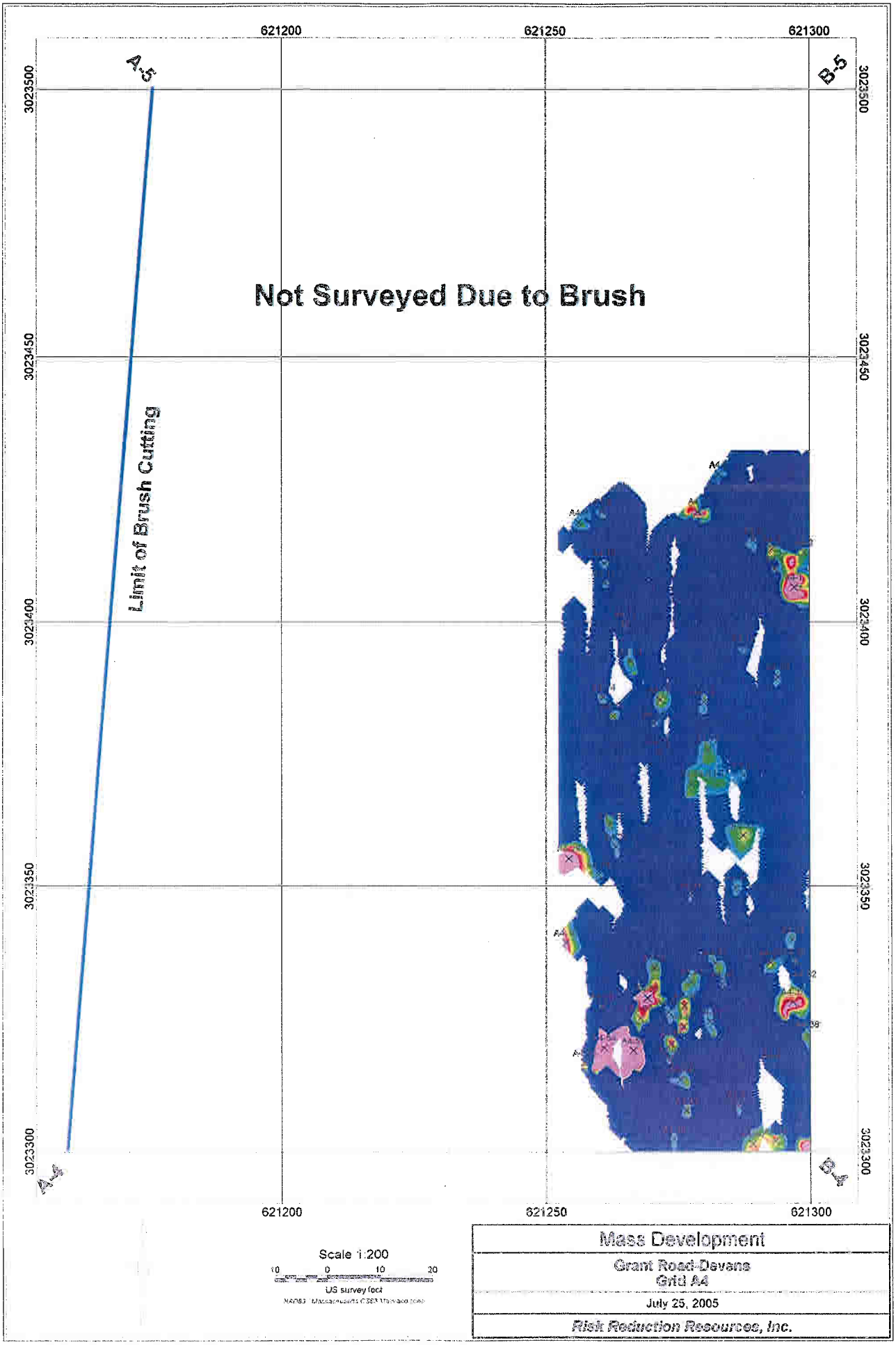
US survey foot

NAD83 / Massachusetts CS83 Mainland zone

Mass Development
Grant Road-Devens **Grid A-2**
June 22, 2005
Risk Reduction Resources, Inc.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Not Surveyed Due to Brush
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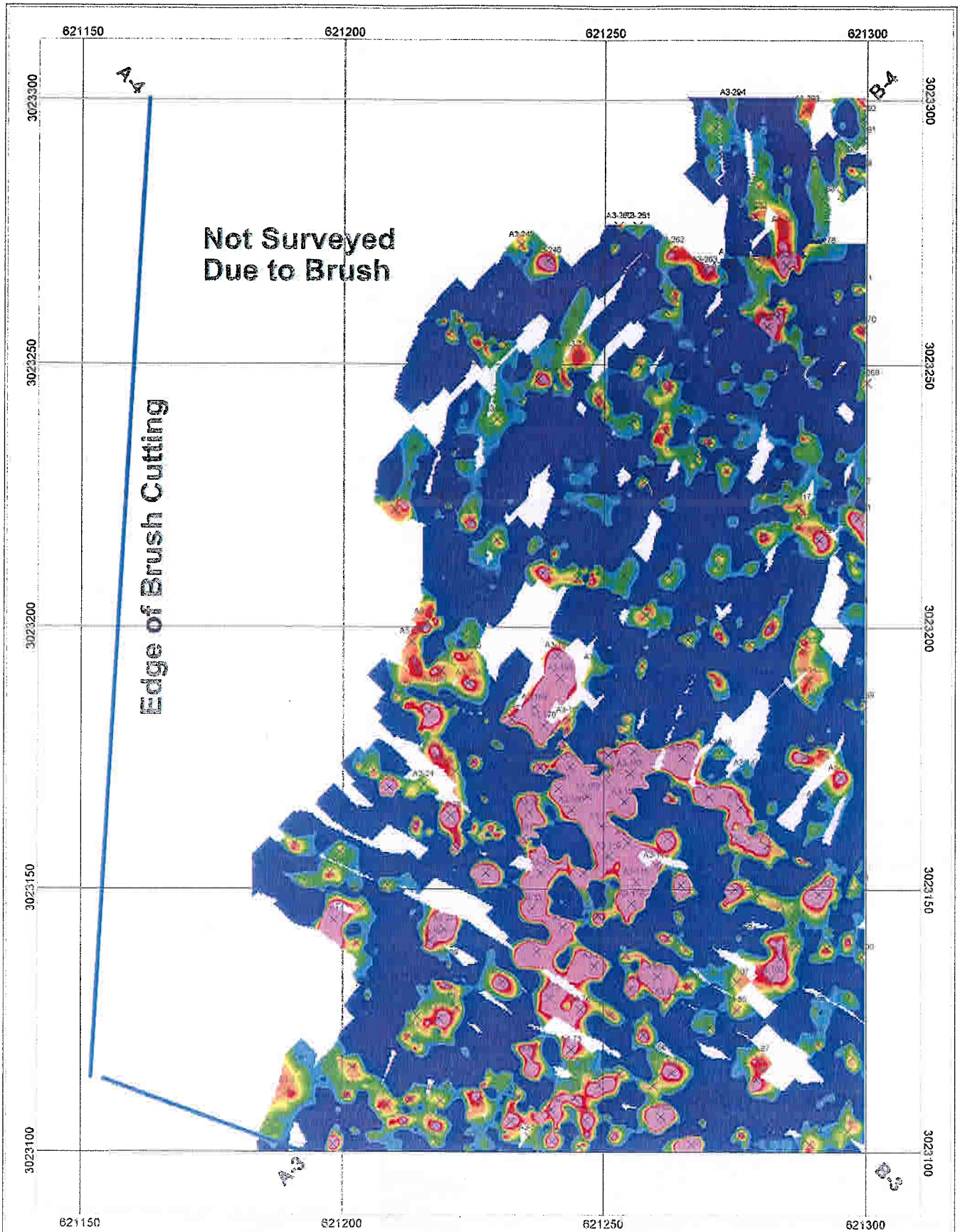
US survey foot
Mass Development
Grant Road-Devens
Grid A4
July 25, 2005
Risk Reduction Resources, Inc.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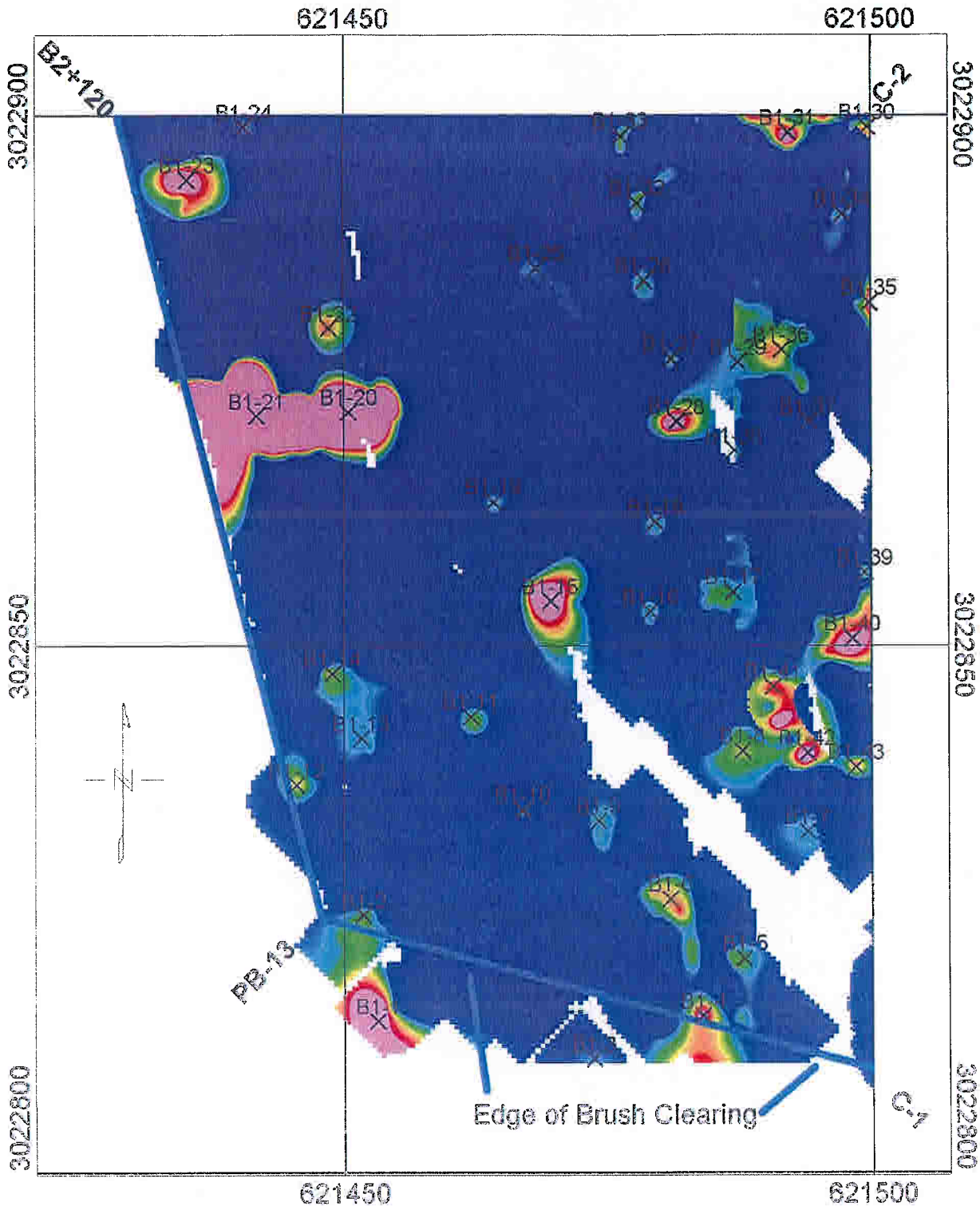
Mass Development
Grant Road-Devens
Grid A-3
June 22, 2005
Risk Reduction Resources, Inc.



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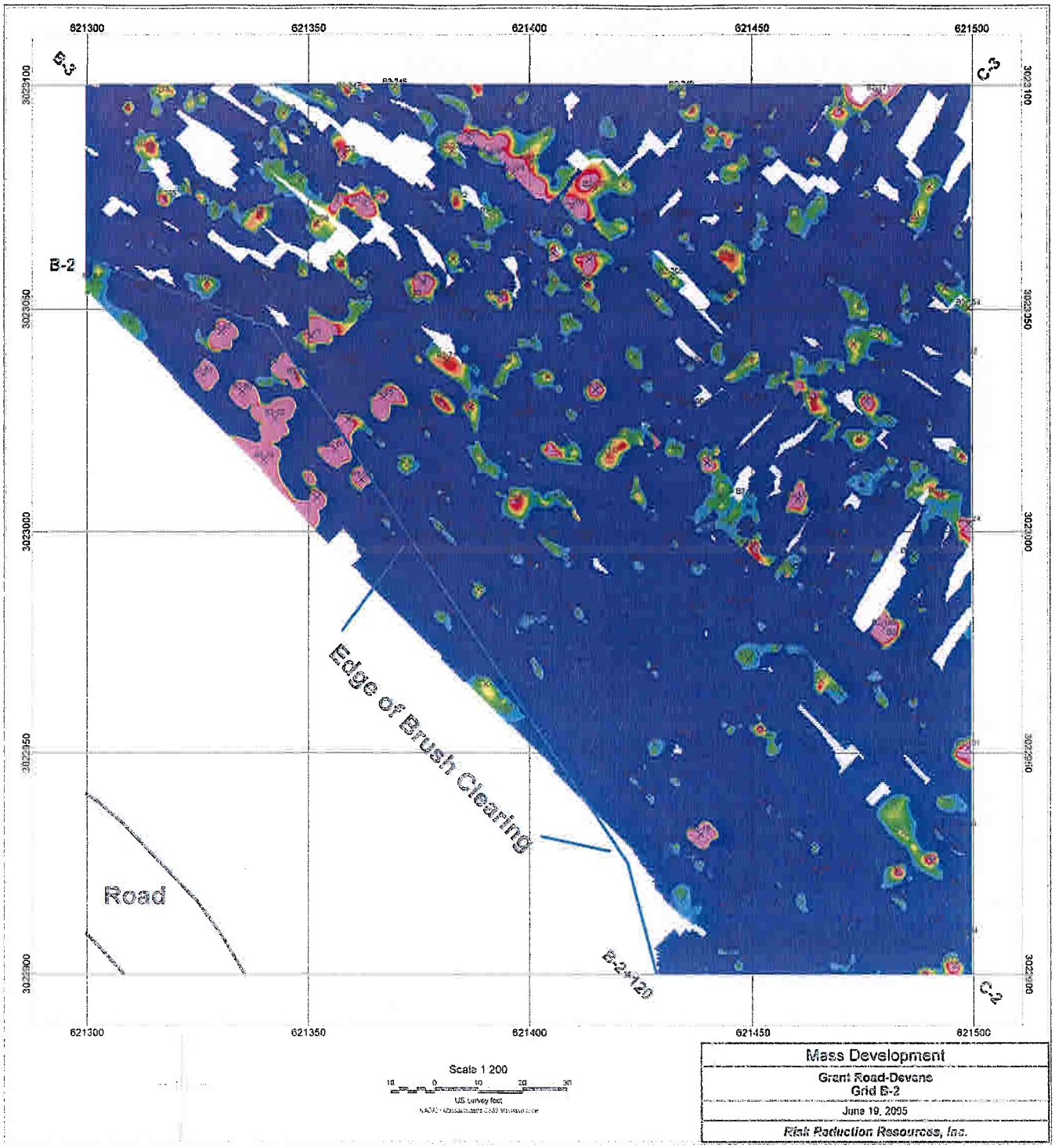
US survey foot

NAD83 / Massachusetts CS83 Mainland zone

Mass Development
Grant Road-Devens Grid B-1
June 16, 1005
Risk Reduction Resources, Inc.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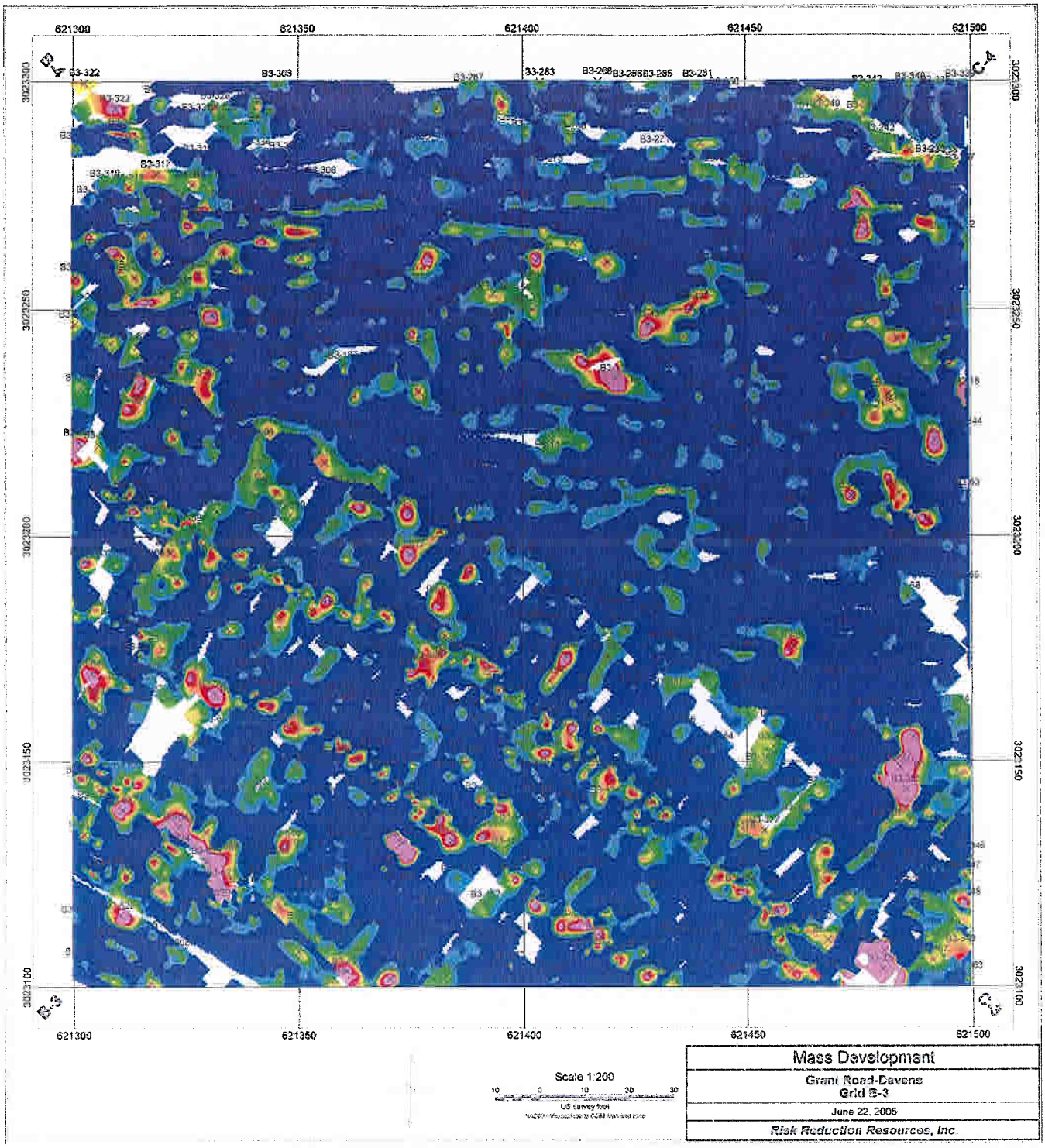
Grant Road-Devens
Grid B-2
June 19, 2005
Risk Reduction Resources, Inc.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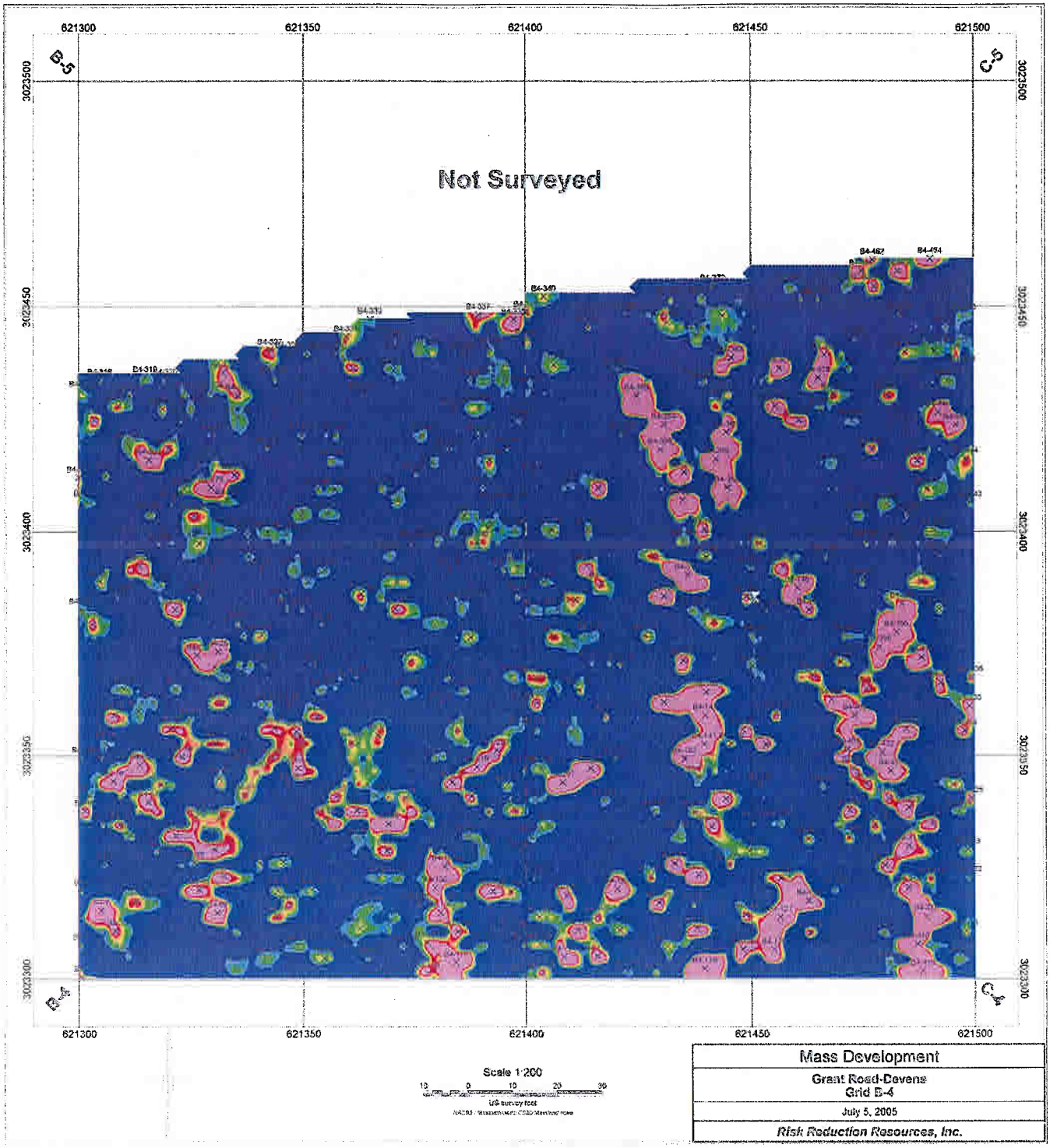
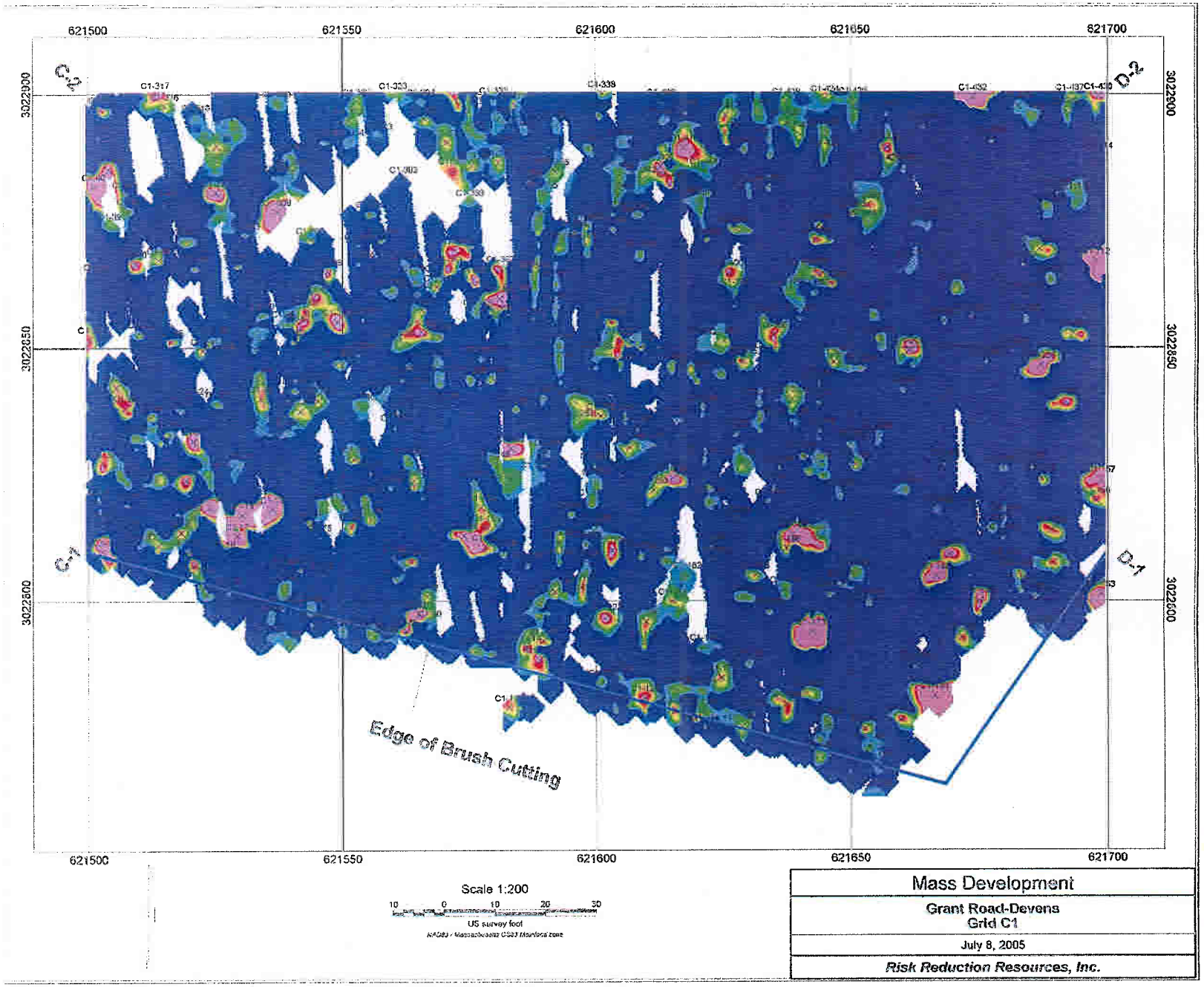
US survey foot
Mass Development
Grant Road-Devens
Grid B-3
June 22, 2005
Risk Reduction Resources, Inc



Mass Development
Grant Road-Devens Grid B-4
July 5, 2005
Risk Reduction Resources, Inc.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C-2
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Edge of Brush Cutting
Scale 1:200
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US survey foot
NAD83 / Massachusetts CS83 Mainland zone
Mass Development
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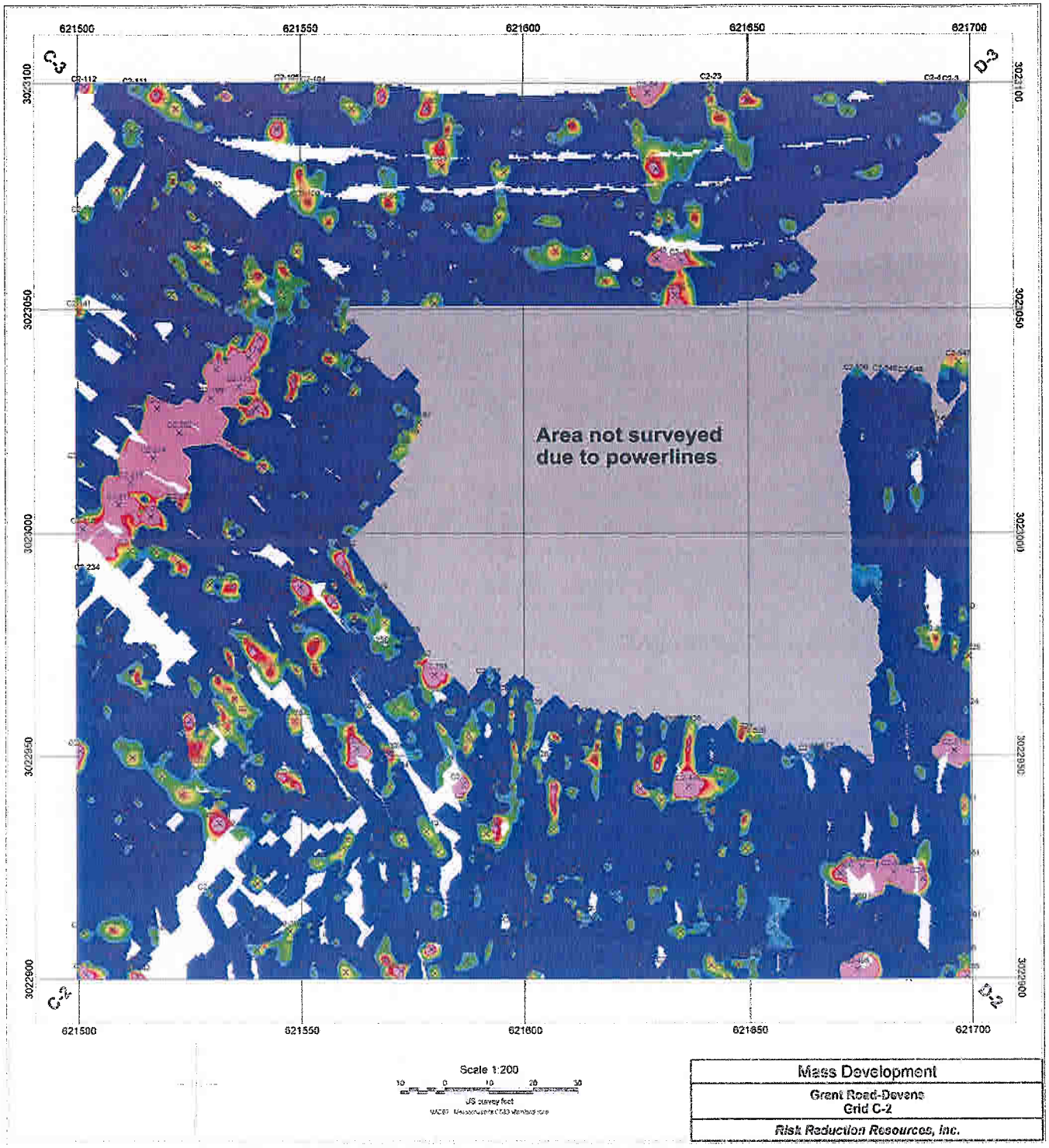
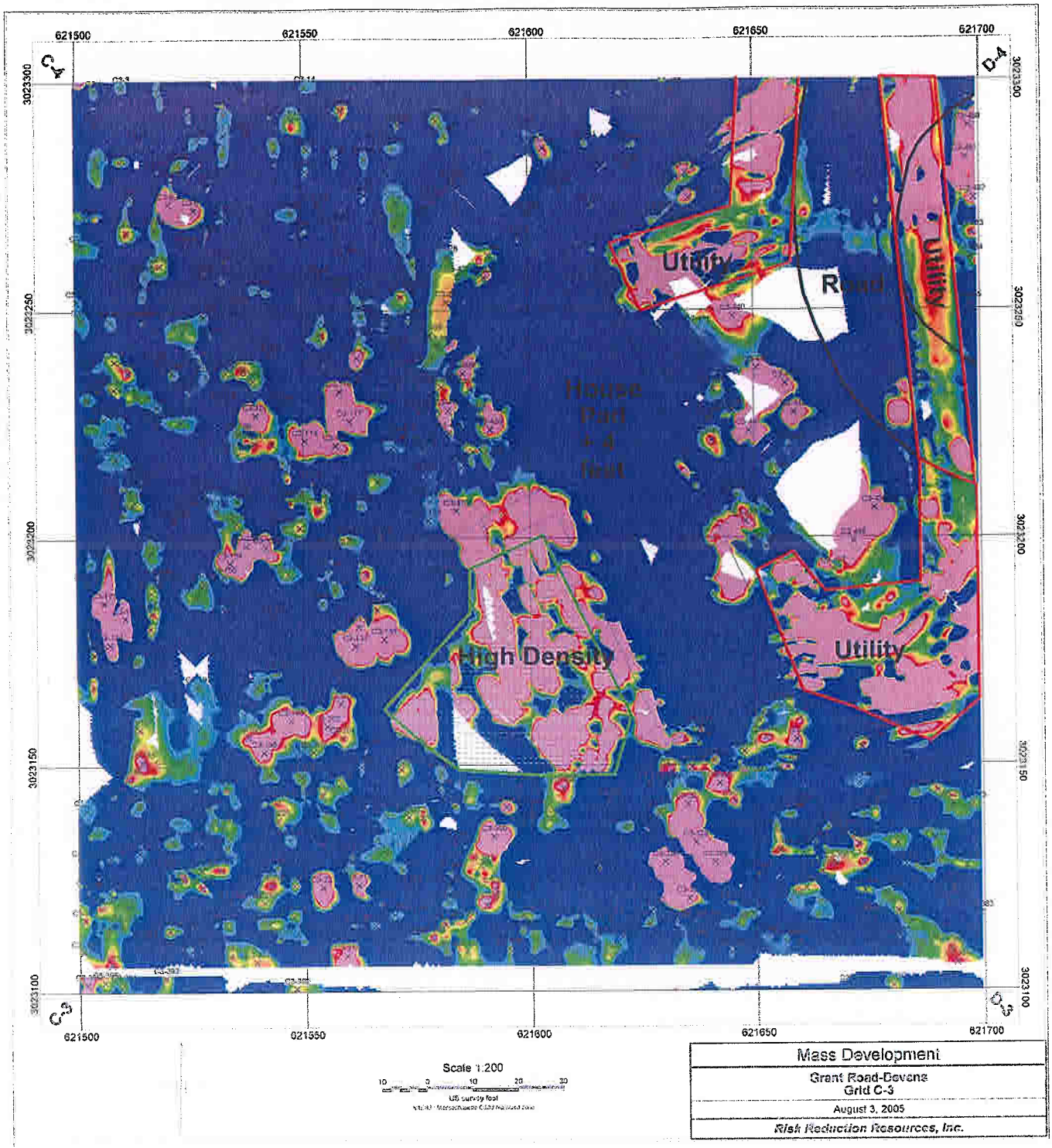
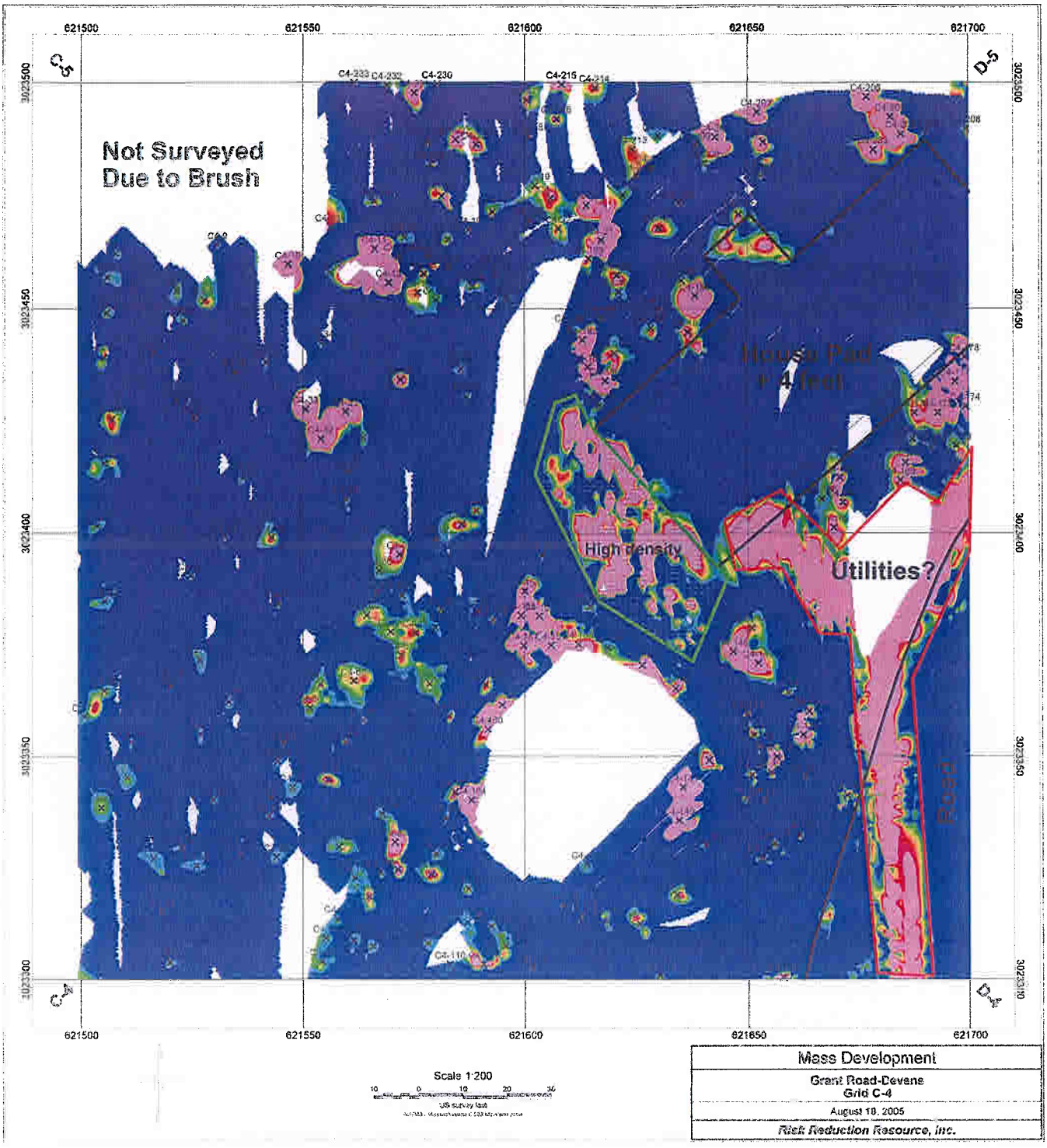
Grid C1
July 8, 2005
Risk Reduction Resources, Inc.



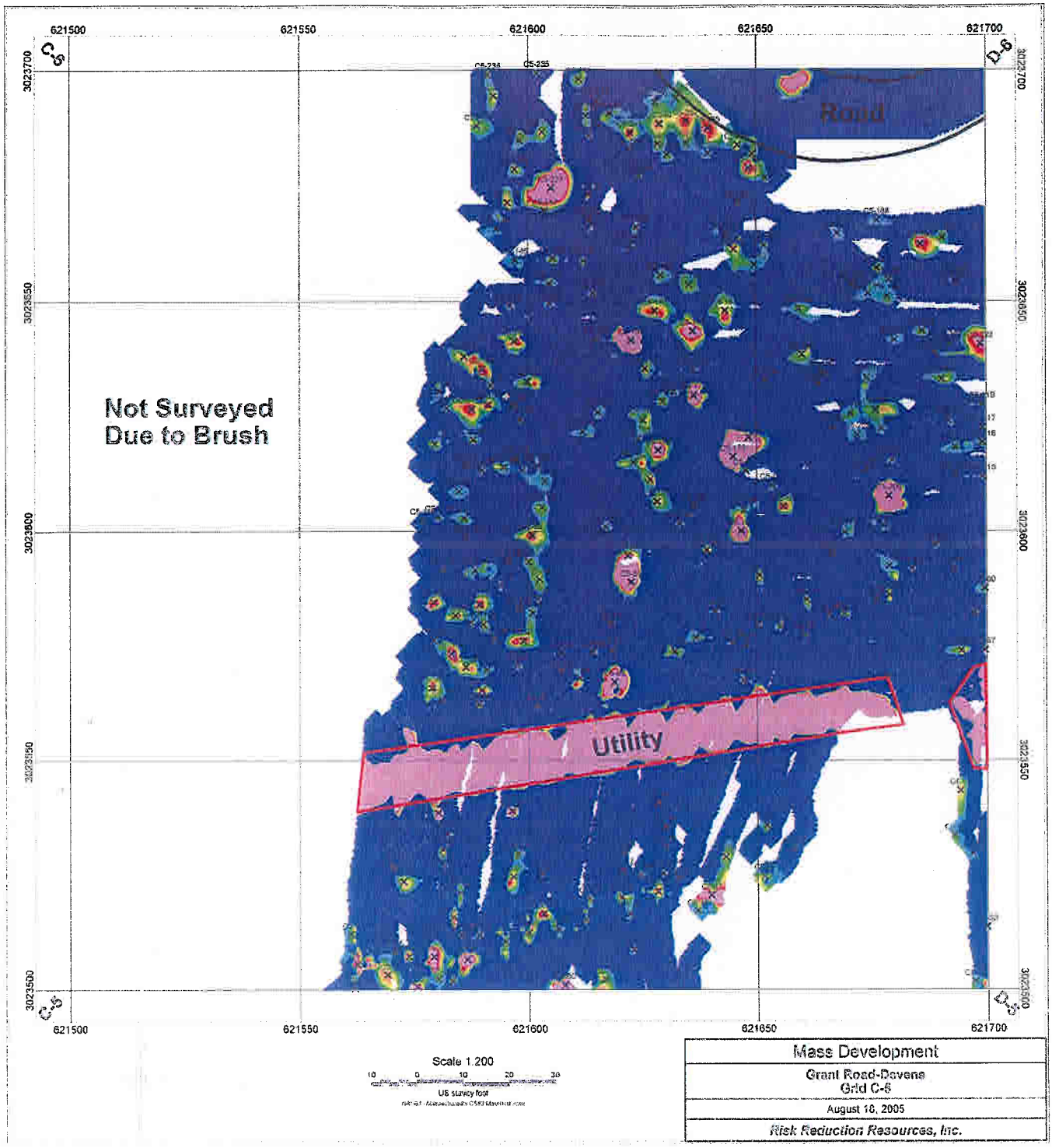
Mass Development
Grant Road-Devens Grid C-2
Risk Reduction Resources, Inc.



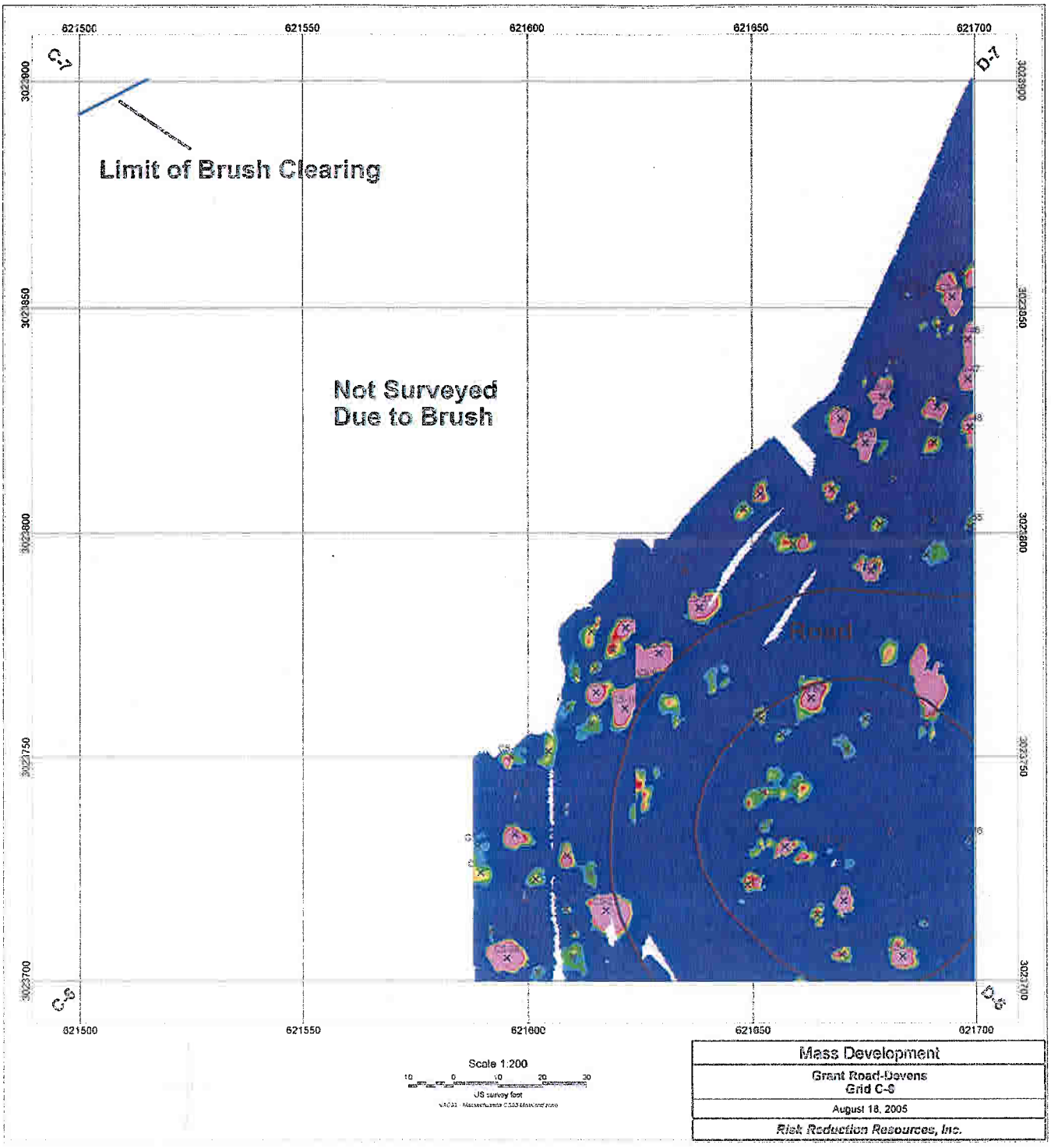
Mass Development
Grant Road-Devane Grid C-3
August 3, 2005
Risk Reduction Resources, Inc.

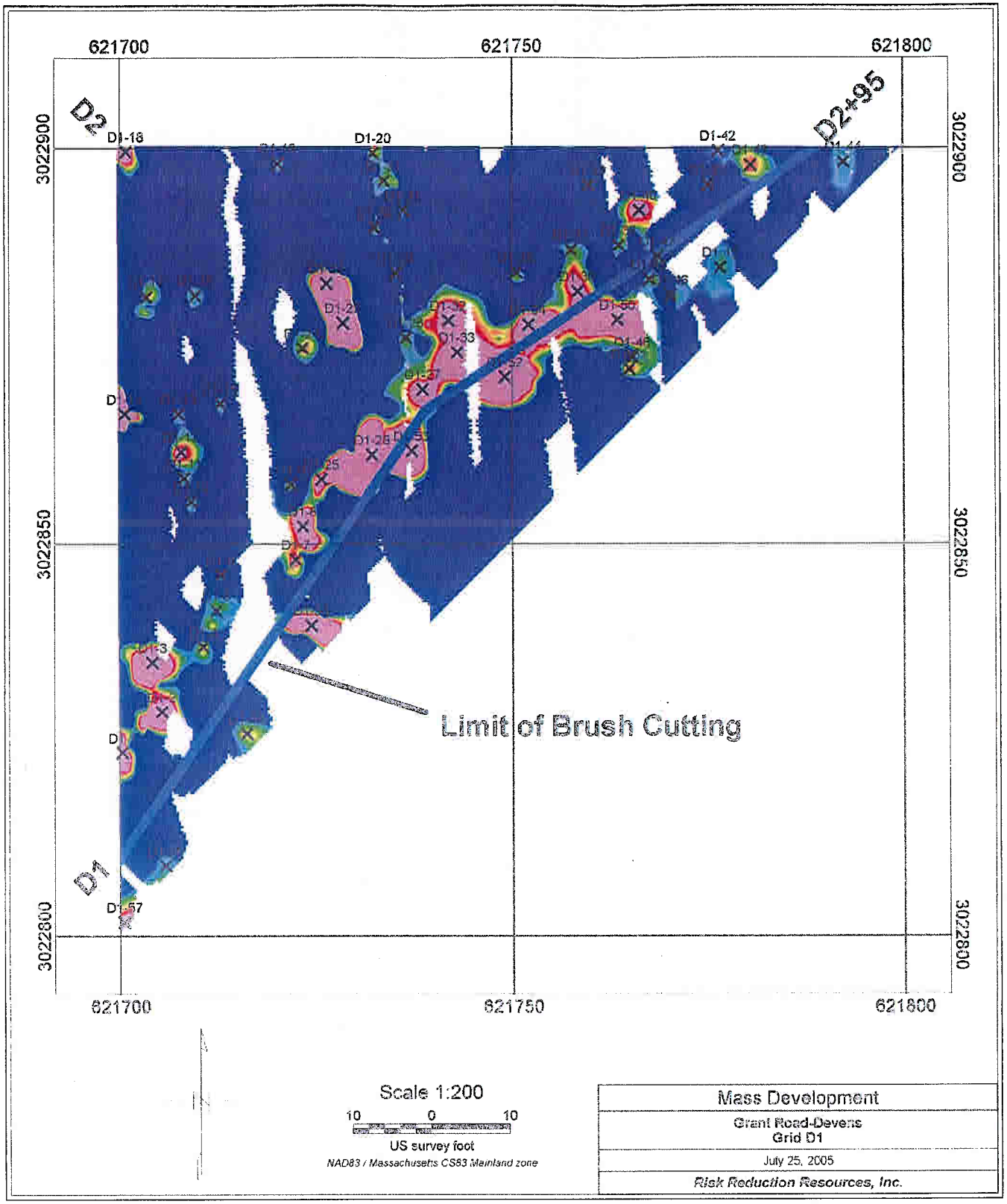


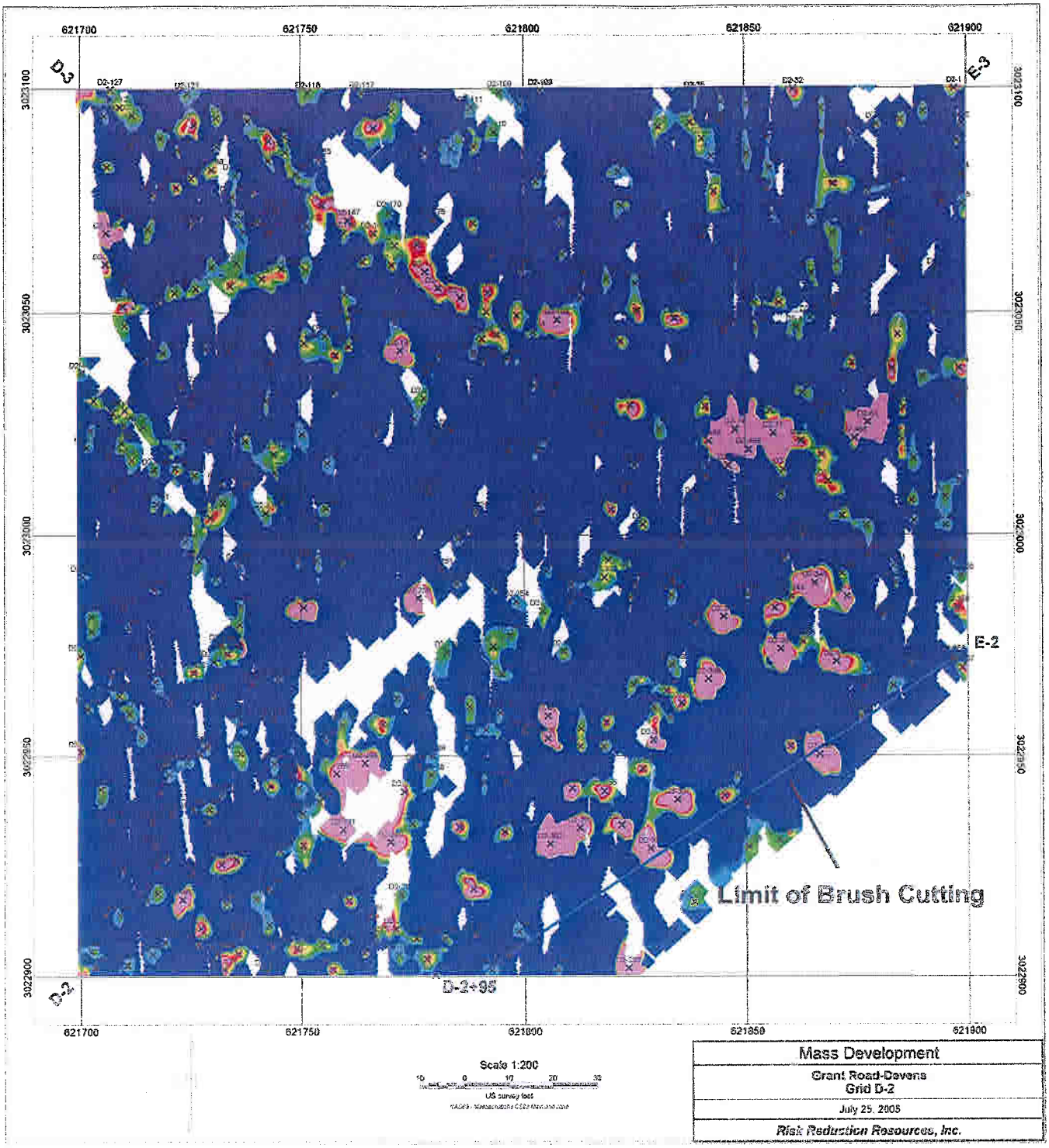
Mass Development
Grant Road-Devens Grid C-4
August 18, 2005
Risk Reduction Resource, Inc.



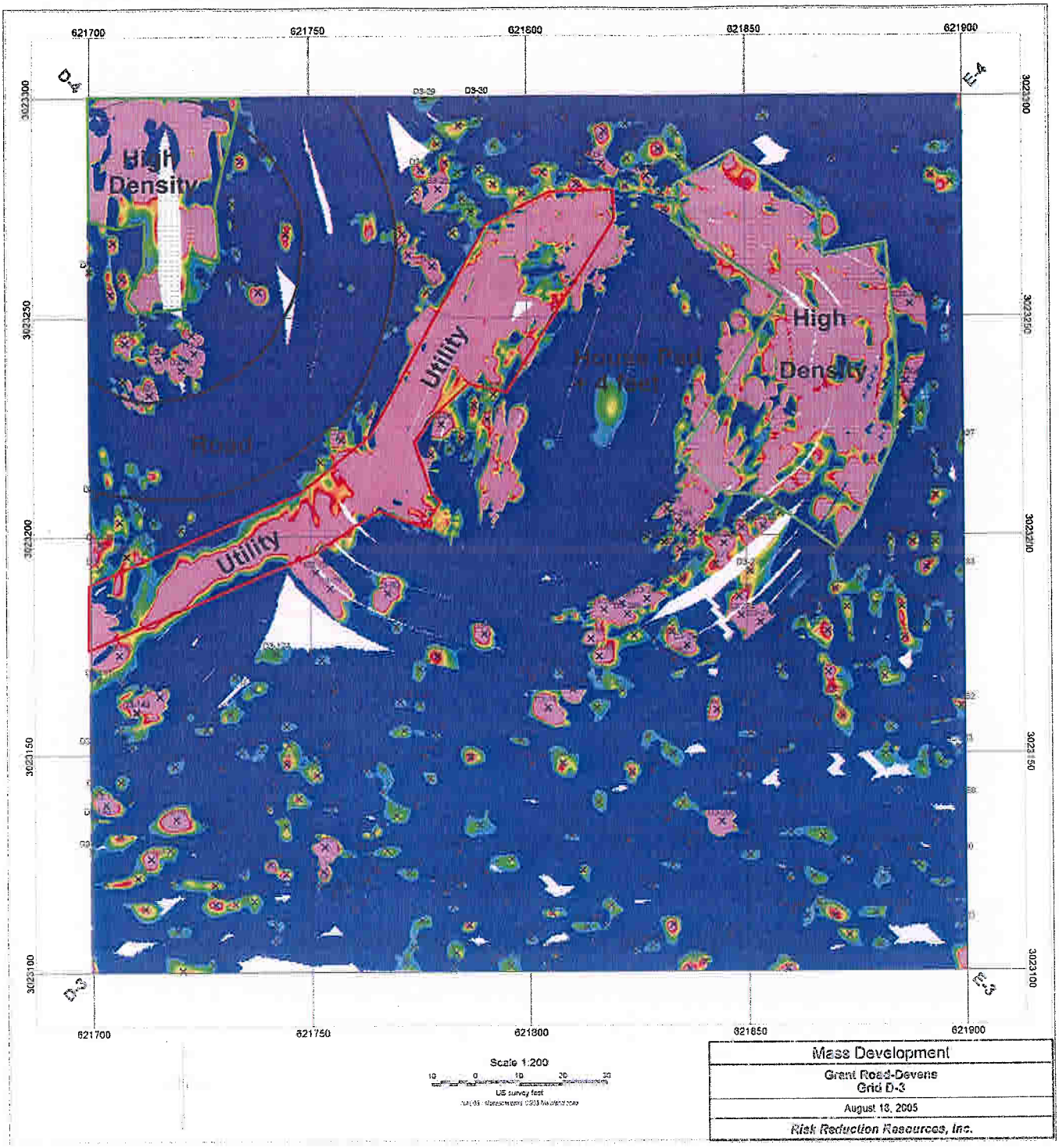
Mass Development
Grant Road-Devens Grid C-5
August 18, 2005
Risk Reduction Resources, Inc.


621500
621550
621600
621650
621700
C-7
D-7
C-6
D-6
3023900
3023850
3023800
3023750
3023700
Limit of Brush Clearing
Not Surveyed
Due to Brush
Road
Scale 1:200
10 0 10 20 30
US survey foot
Mass Development
Grant Road-Devens
Grid C-6
August 18, 2005
Risk Reduction Resources, Inc.

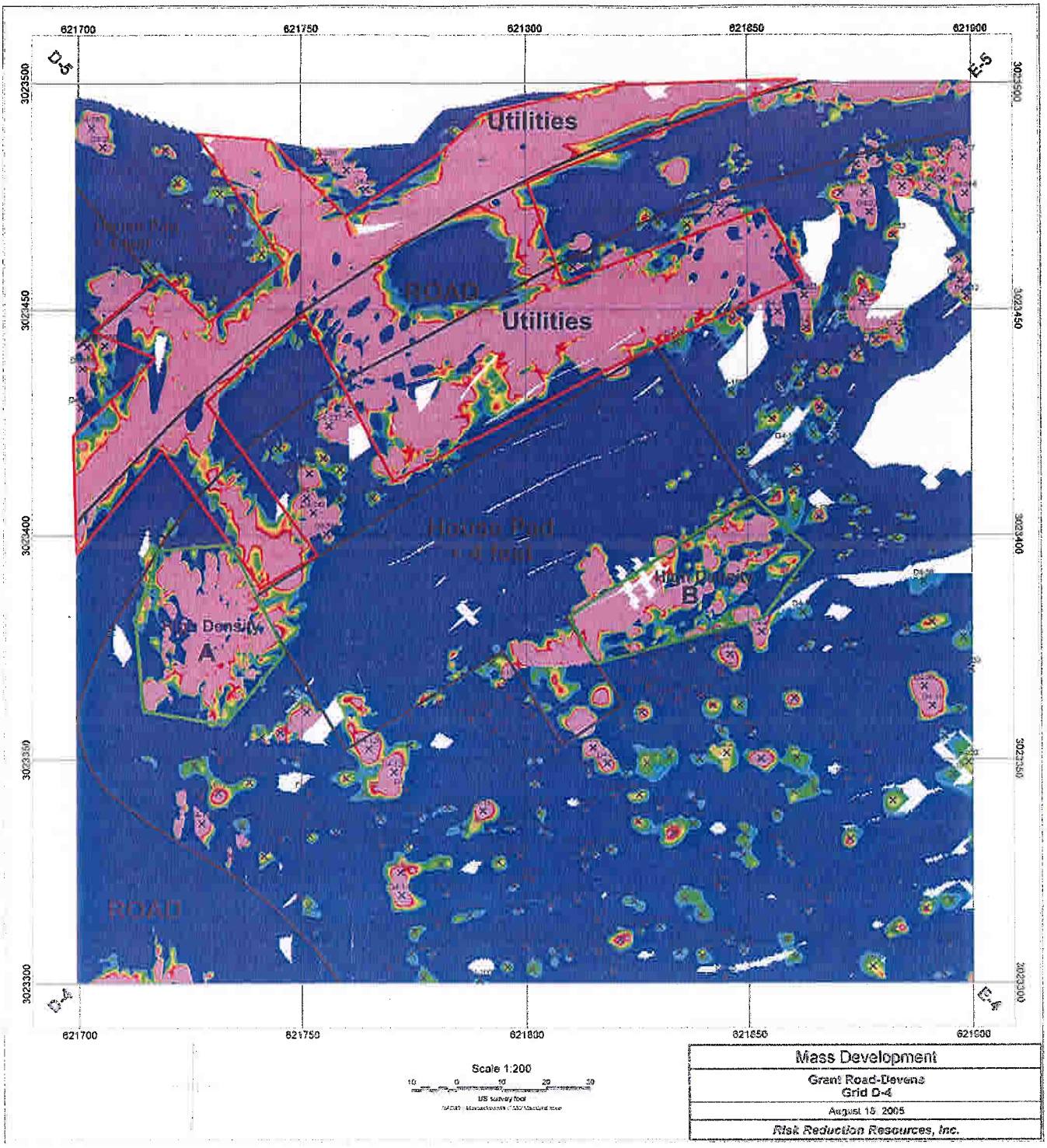

621700
621750
621800
3022900
3022850
3022800
D2
D2+95
D1
D1-18
D1-20
D1-42
D1-57
Limit of Brush Cutting
Scale 1:200
10 0 10
US survey foot
NAD83 / Massachusetts CS83 Mainland zone
Mass Development
Grant Road-Devens
Grid D1
July 25, 2005
Risk Reduction Resources, Inc.

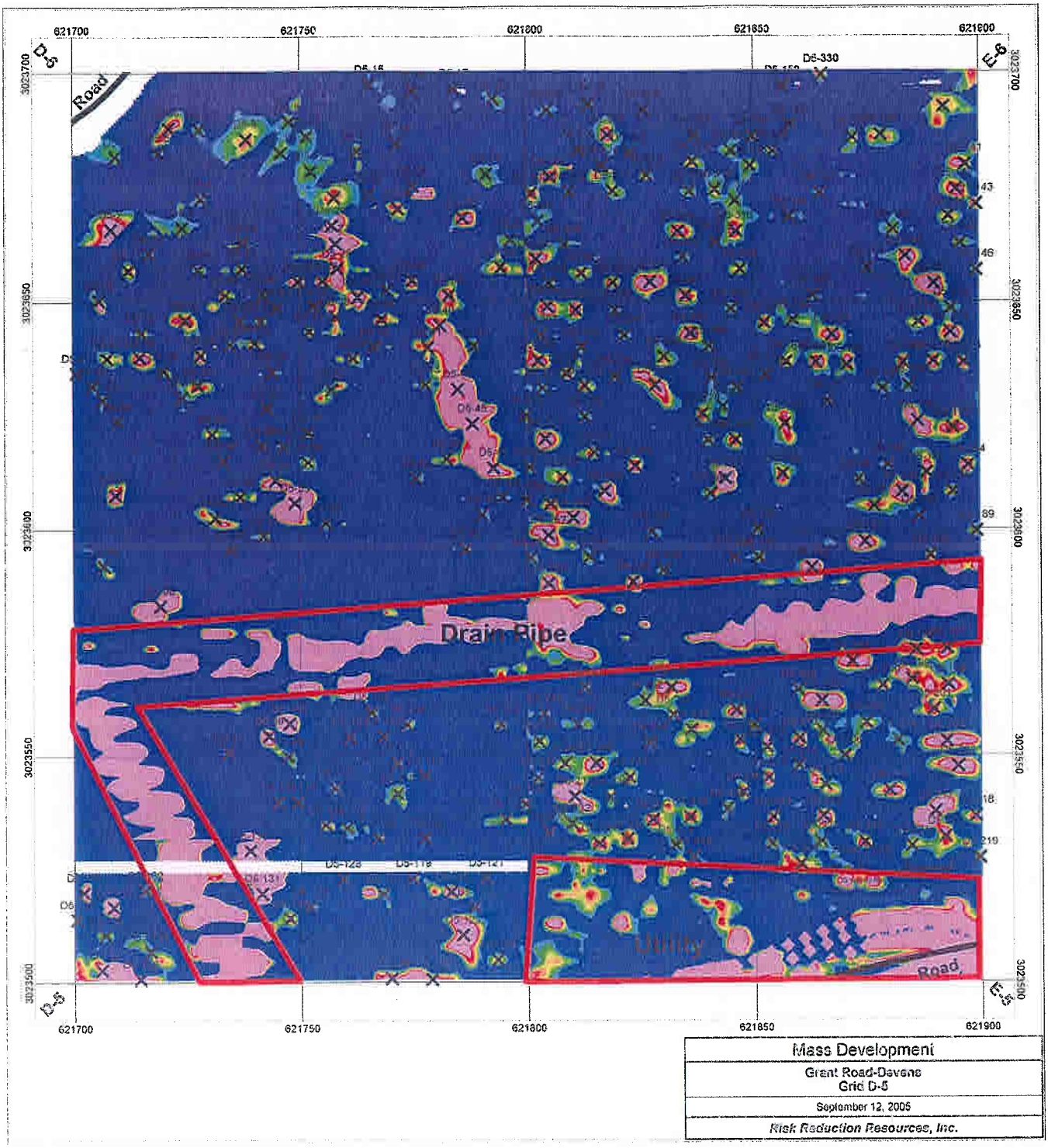


Mass Development
Grant Road-Devens Grid D-2
July 25, 2005
Risk Reduction Resources, Inc.

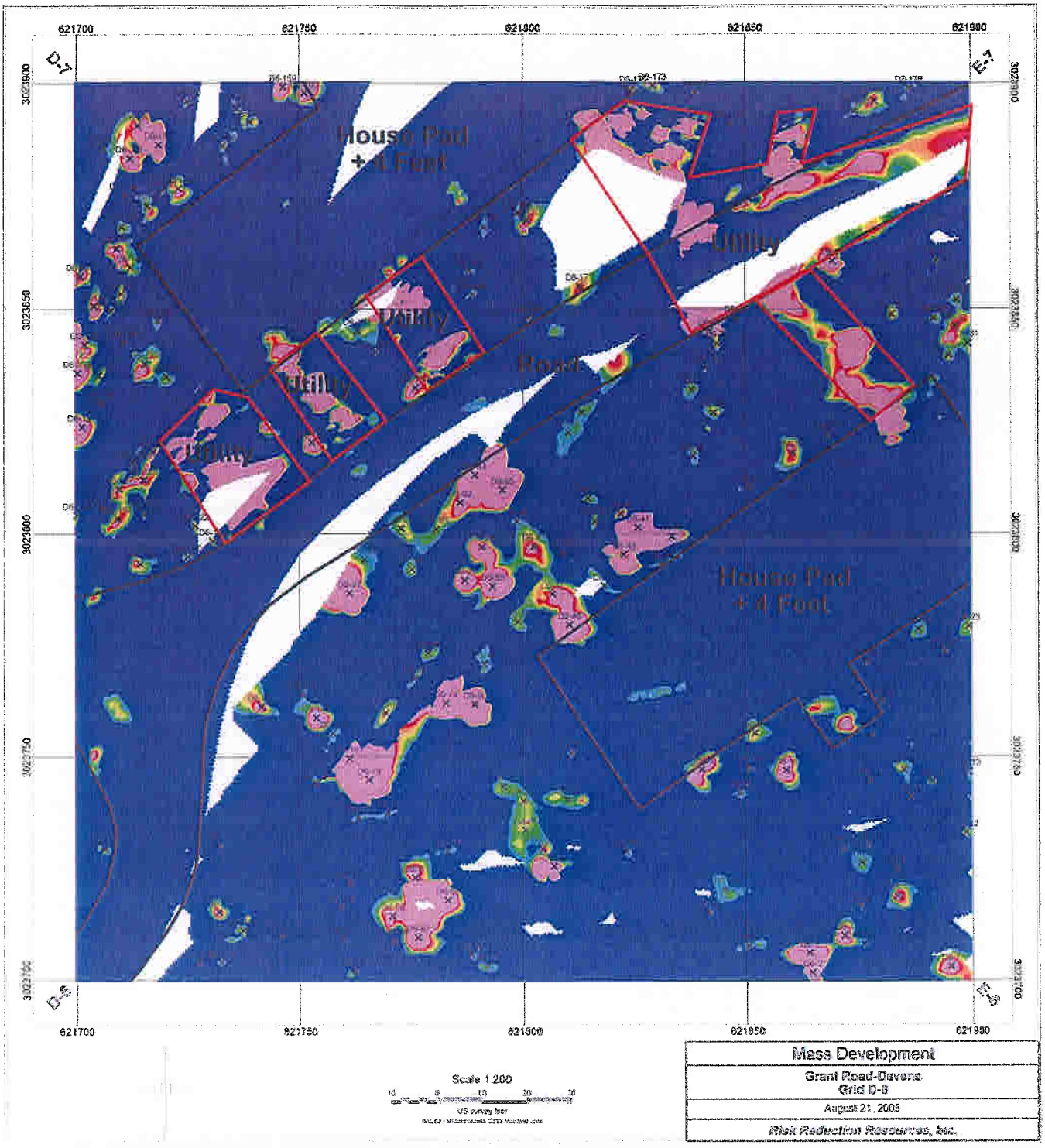


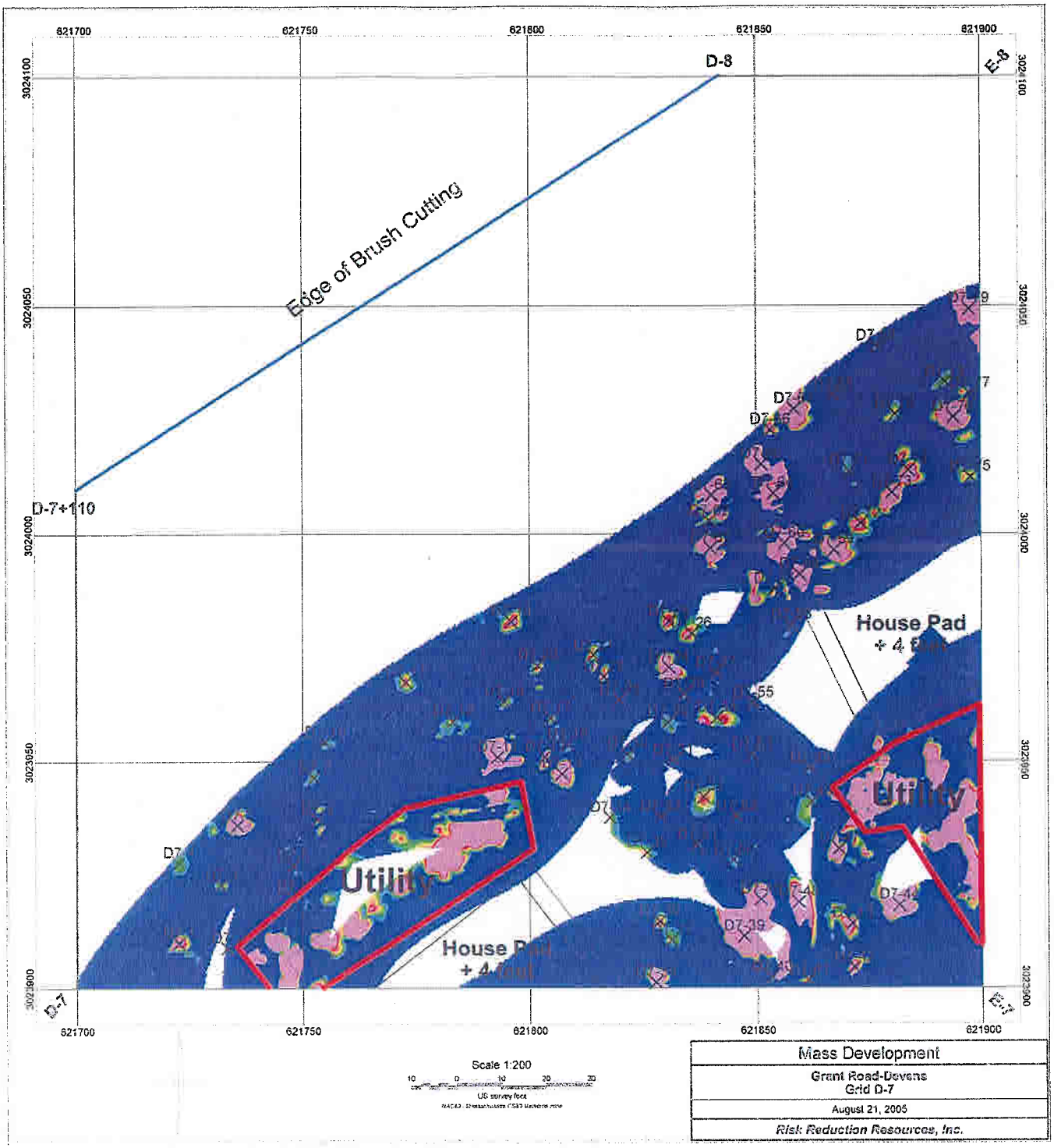
Mass Development
Grant Road-Devens Grid D-3
August 18, 2005
Risk Reduction Resources, Inc.


621700
621750
621800
621850
621900
3023500
3023450
3023400
3023350
3023300
D-5
E-5
D-4
E-4
Utilities
ROAD
Utilities
House Pad
+/- 4 feet
High Density
B
High Density
A
ROAD
Scale 1:200
10 0 10 20 30
US Survey Foot
Mass Development
Grant Road-Devens
Grid D-4
August 15, 2005
Risk Reduction Resources, Inc.

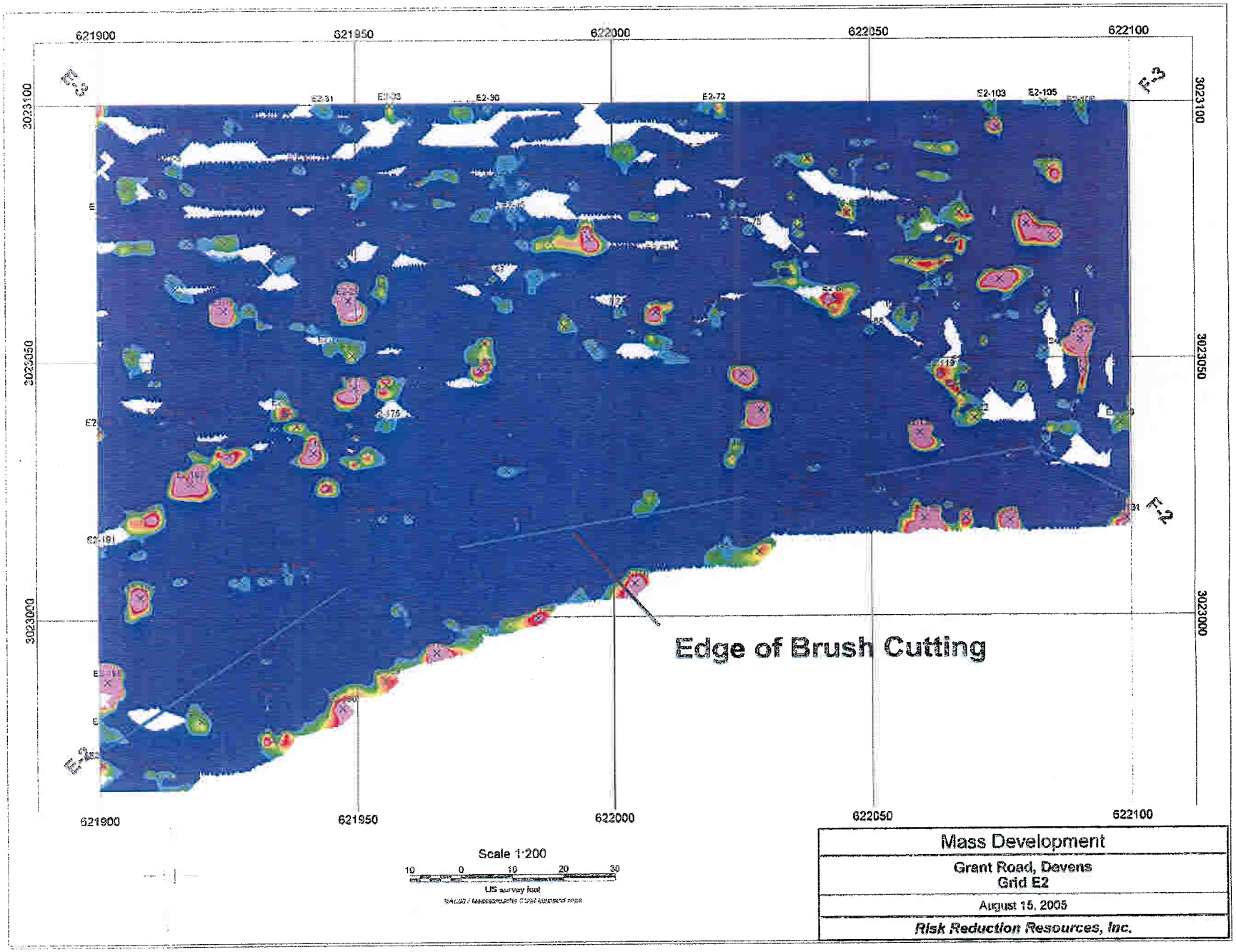


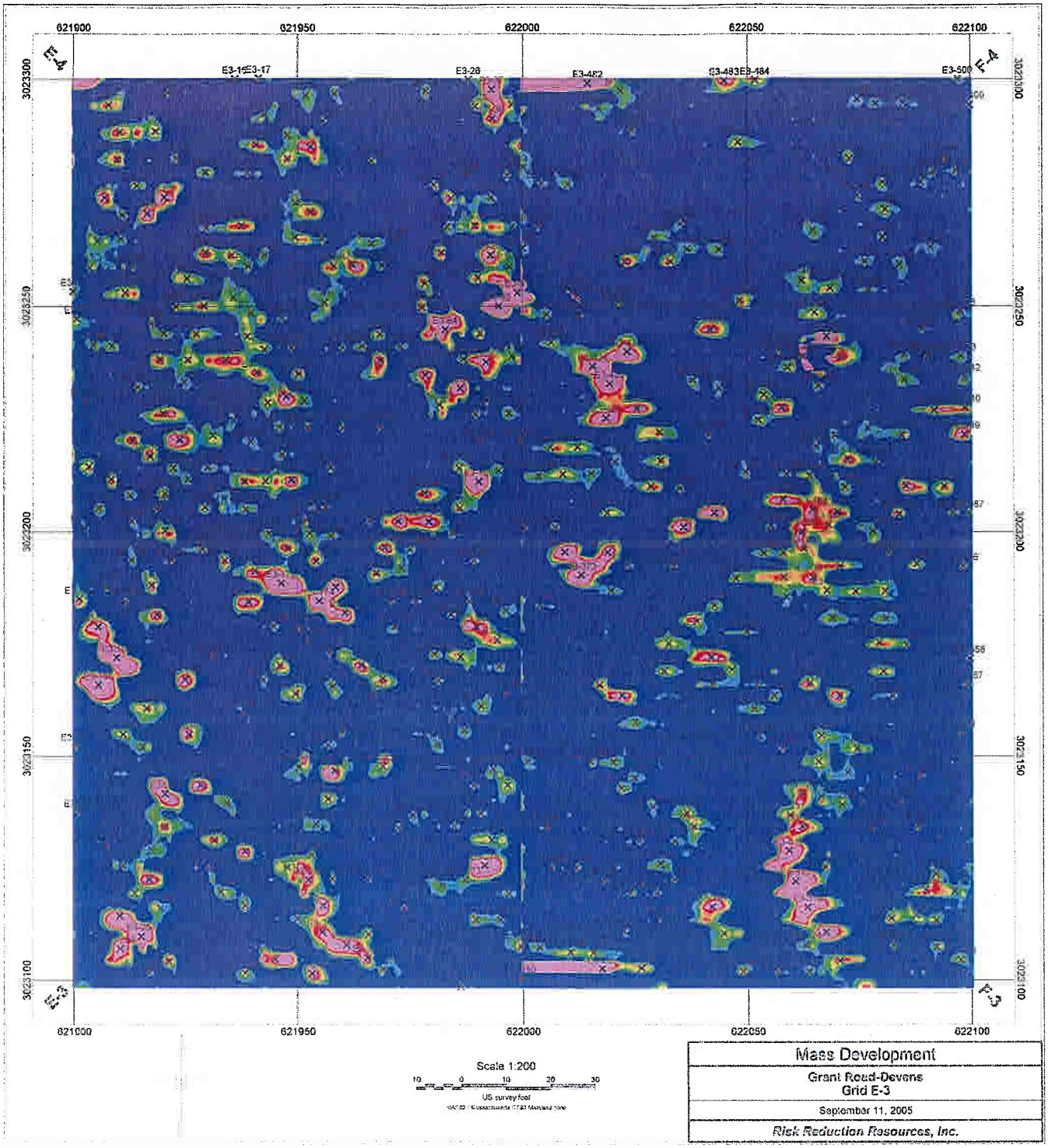
Mass Development
Grant Road-Devens Grid D-5
September 12, 2005
Risk Reduction Resources, Inc.

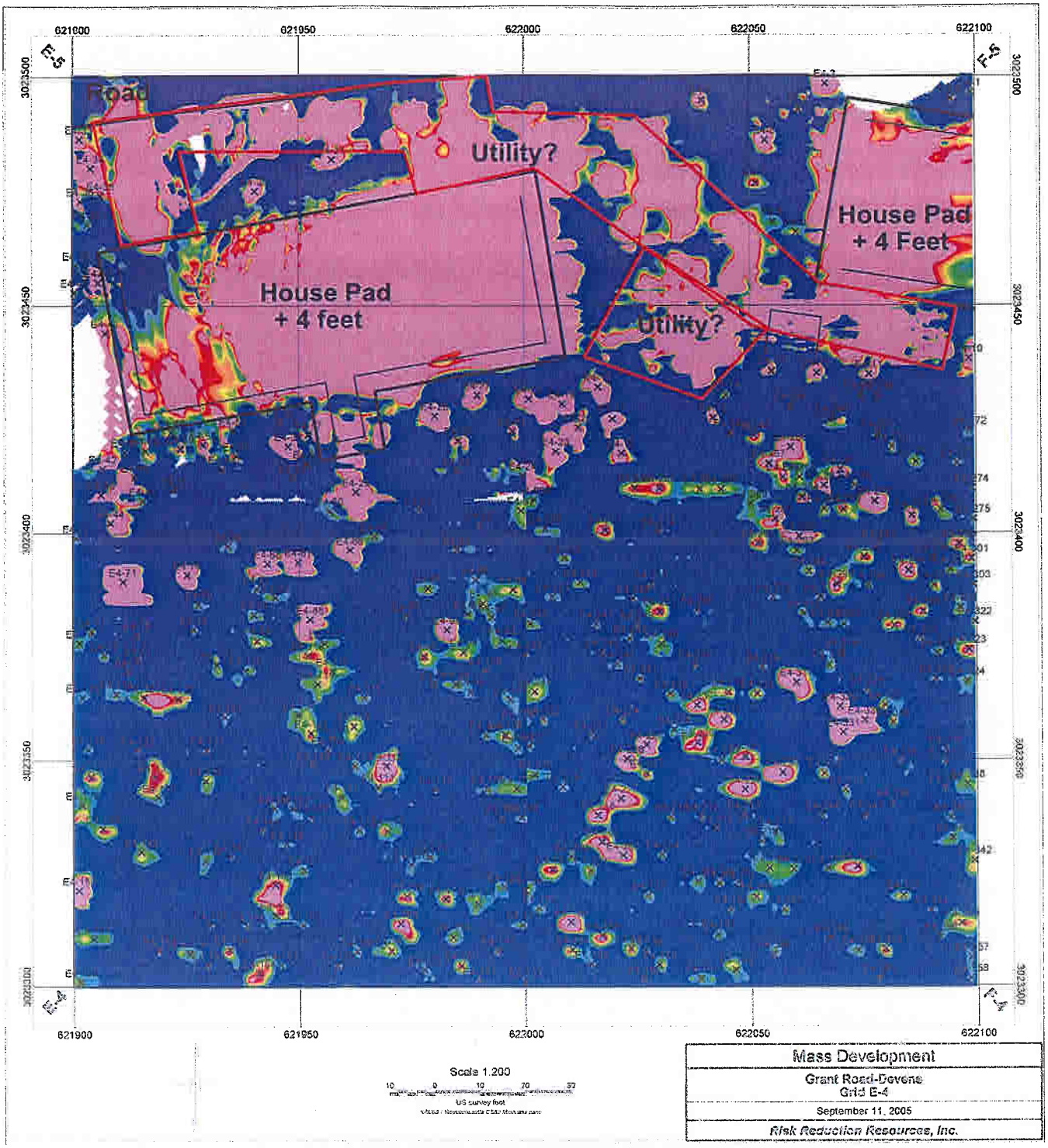

621700
621750
621800
621850
621900
3023900
3023850
3023800
3023750
3023700
D-1
E-1
D-5
E-5
House Pad
+4 Feet
Utility
Utility
Utility
Road
House Pad
+4 Feet
Scale 1:200
10 0 10 20 30
US survey feet
Mass Development
Grant Road-Devens
Grid D-6
August 21, 2003
Risk Reduction Resources, Inc.



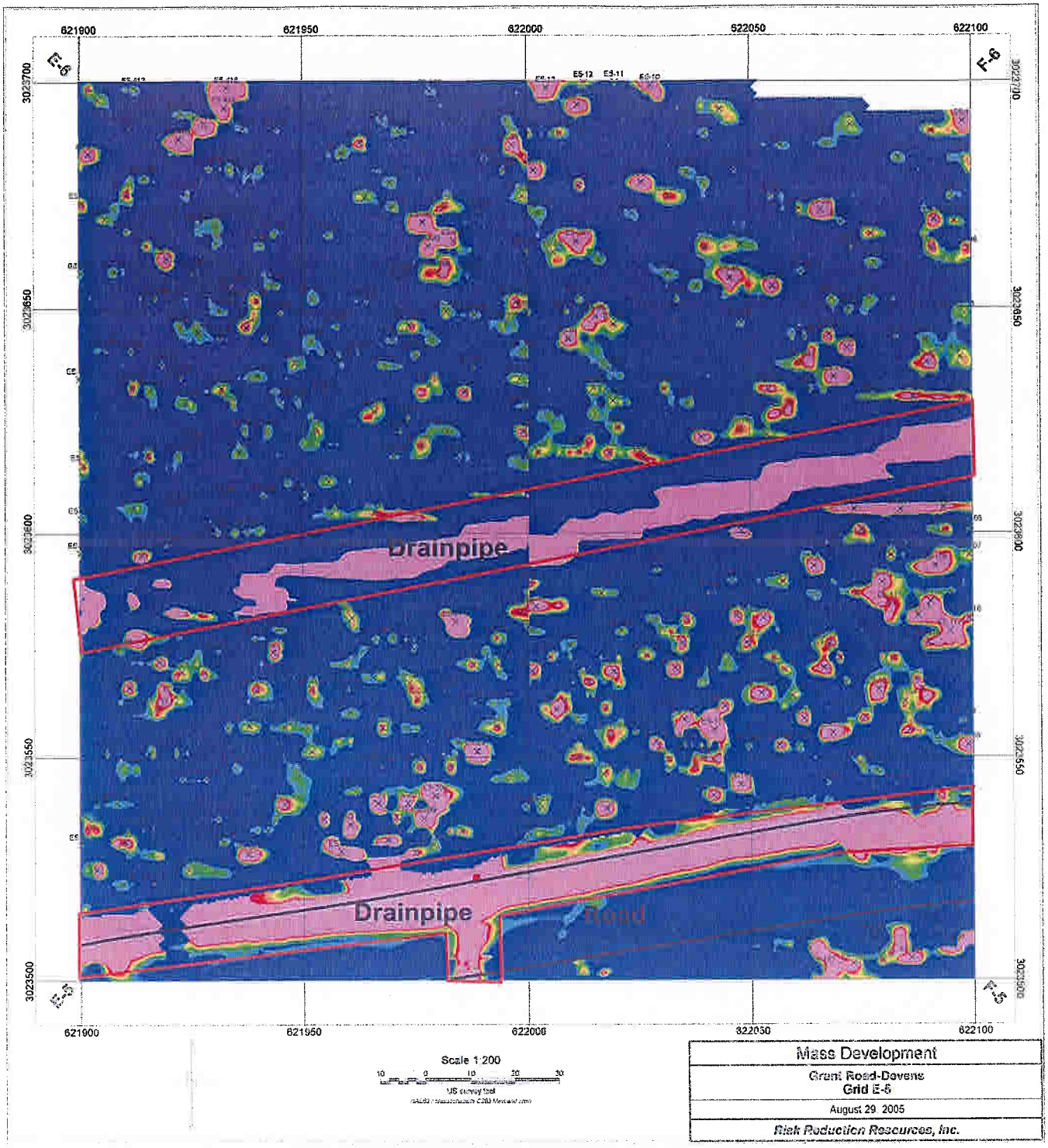
621700
621750
621800
621850
621900
3024100
3024050
3024000
3023950
3023900
D-8
E-8
Edge of Brush Cutting
D-7+110
D-7
E-7
House Pad
+ 4 ft
Utility
Utility
House Pad
+ 4 ft
D7-39
D7-44
Scale 1:200
US survey feet
Mass Development
Grant Road-Devens
Grid D-7
August 21, 2005
Risk Reduction Resources, Inc.


621900
621950
622000
622050
622100
3023100
3023050
3023000
F-3
F-2
E2-31
E2-30
E2-72
E2-103
E2-105
Edge of Brush Cutting
Scale 1:200
10 0 10 20 30
US survey foot
Mass Development
Grant Road, Devens
Grid E2
August 15, 2005
Risk Reduction Resources, Inc.

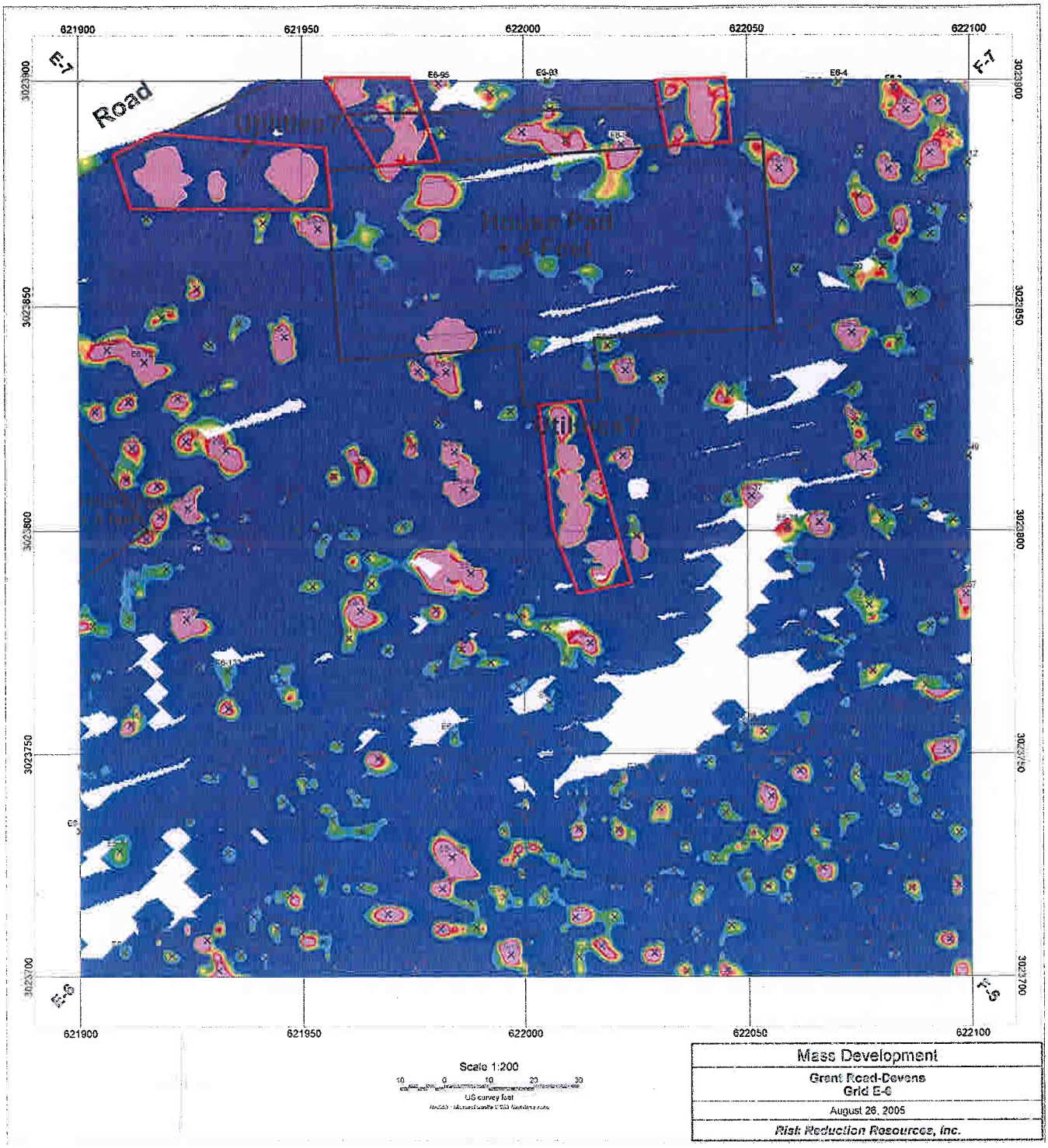

621900
621950
622000
622050
622100
E-4
E-3
E3-16
E3-17
E3-28
E3-482
E3-483
E3-484
E3-500
3023300
3023250
3023200
3023150
3023100
Scale 1:200
10 0 10 20 30
US survey foot
Mass Development
Grant Road-Devens
Grid E-3
September 11, 2005
Risk Reduction Resources, Inc.

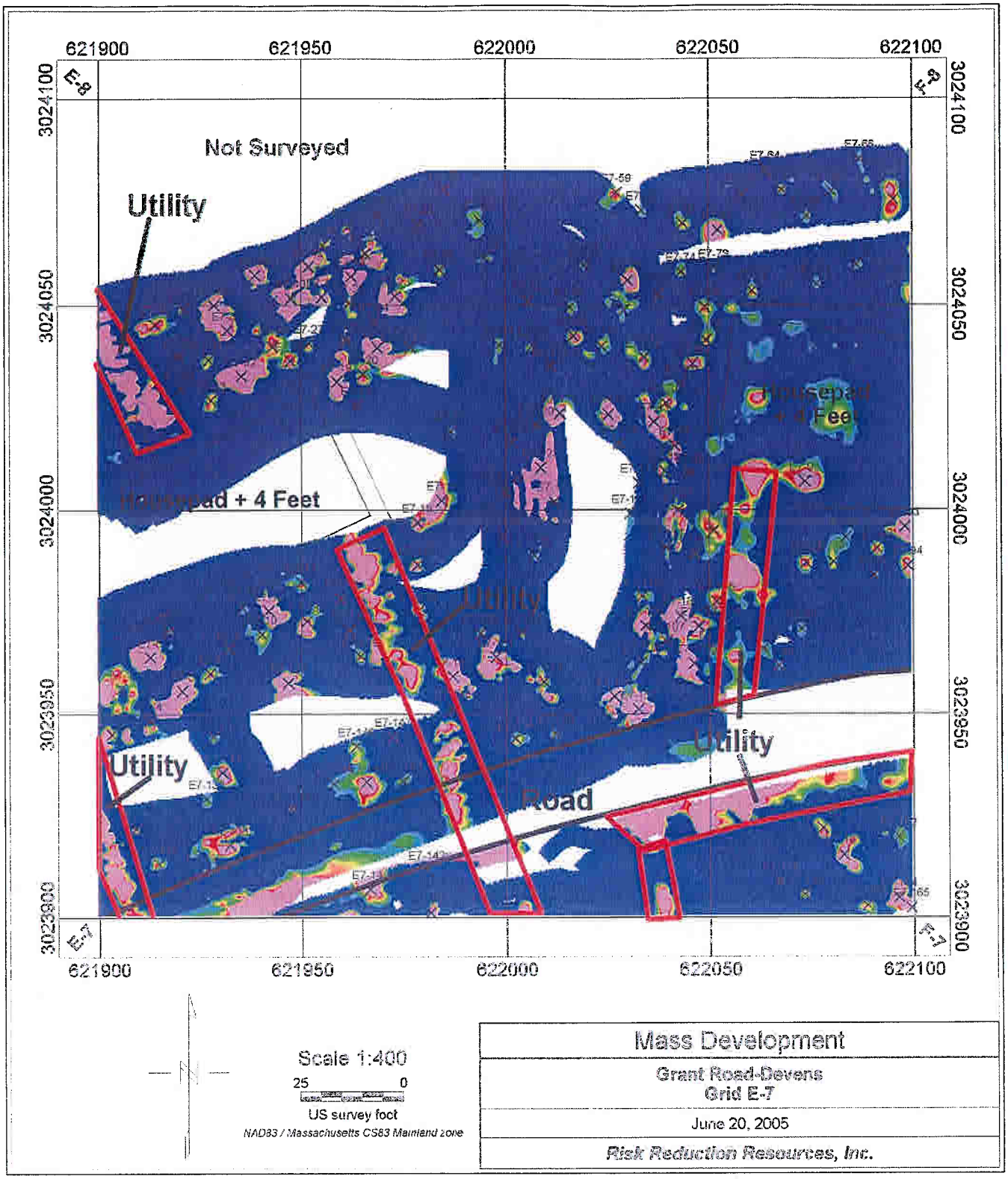


Mass Development
Grant Road-Devens Grid E-4
September 11, 2005
Risk Reduction Resources, Inc.



Mass Development
Grant Road-Devens Grid E-5
August 29, 2005
Risk Reduction Resources, Inc.


621900
621950
622000
622050
622100
3023900
3023850
3023800
3023750
3023700
E-7
E-6
E-5
Road
Utilities?
House Pad
+ 4 Feet
Utilities?
E6-95
E6-93
E6-4
Scale 1:200
US survey feet
Mass Development
Grant Road-Devens
Grid E-6
August 26, 2005
Risk Reduction Resources, Inc.



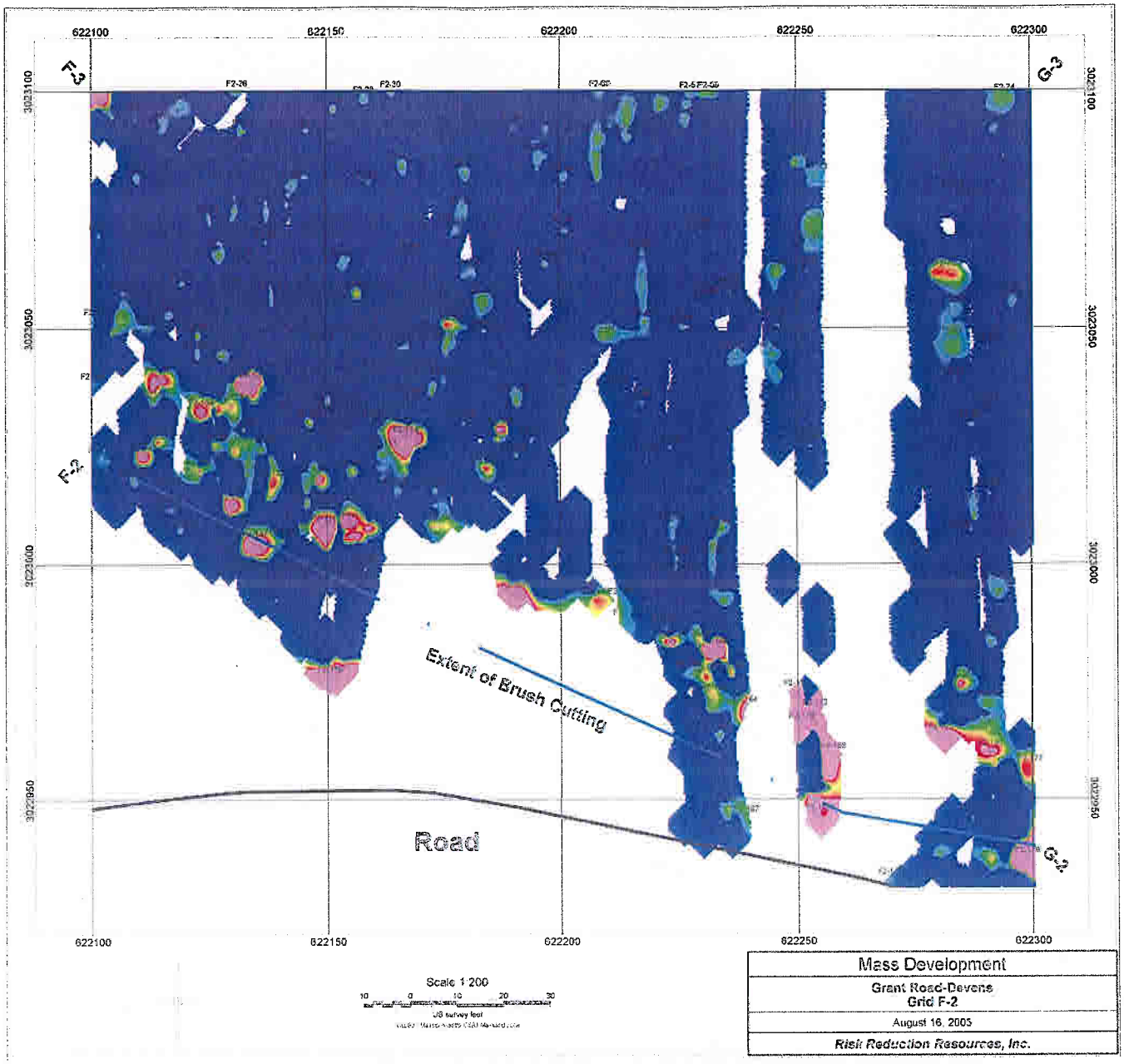
Scale 1:400

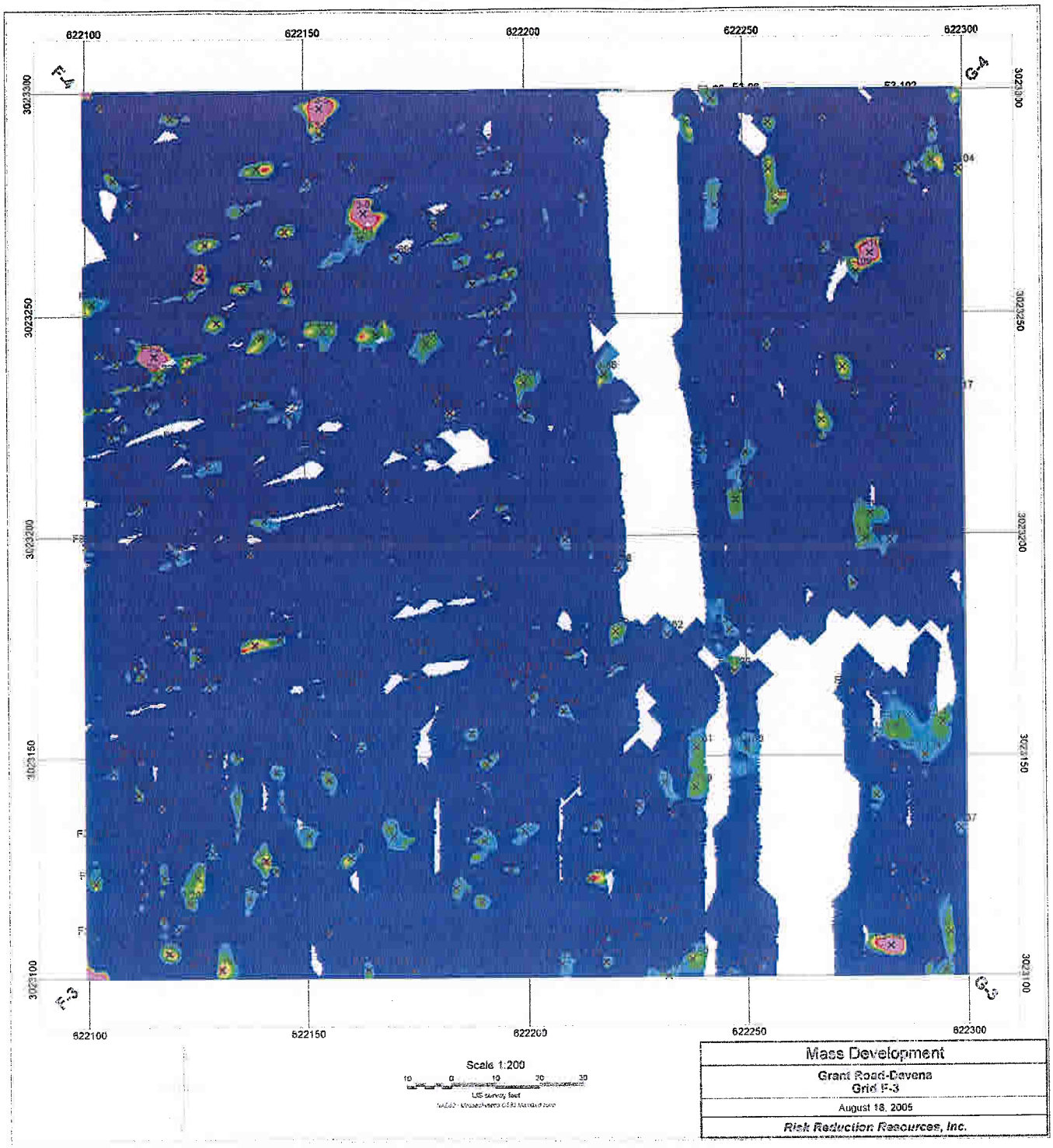
25 0

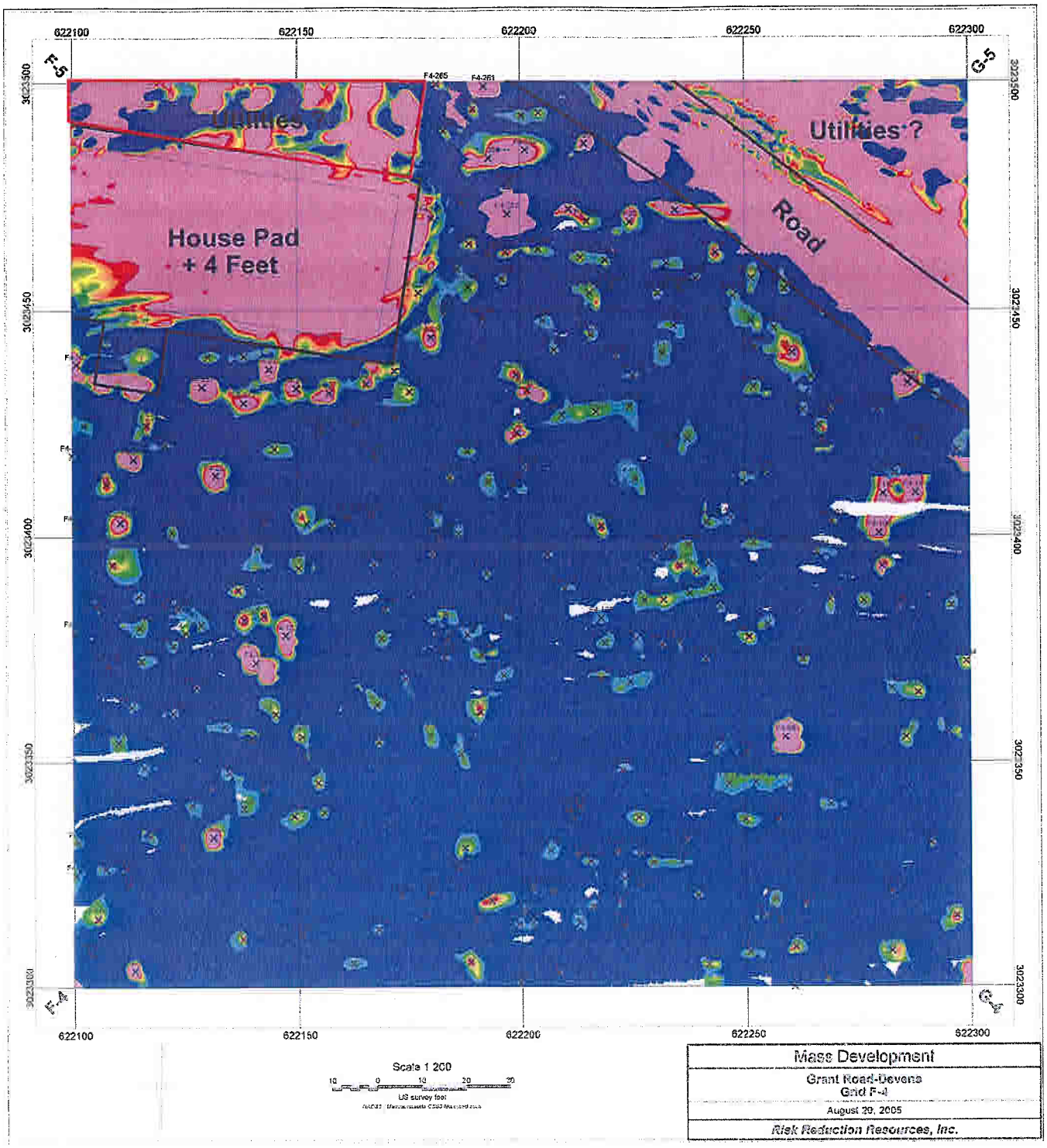
US survey foot

NAD83 / Massachusetts CS83 Mainland zone

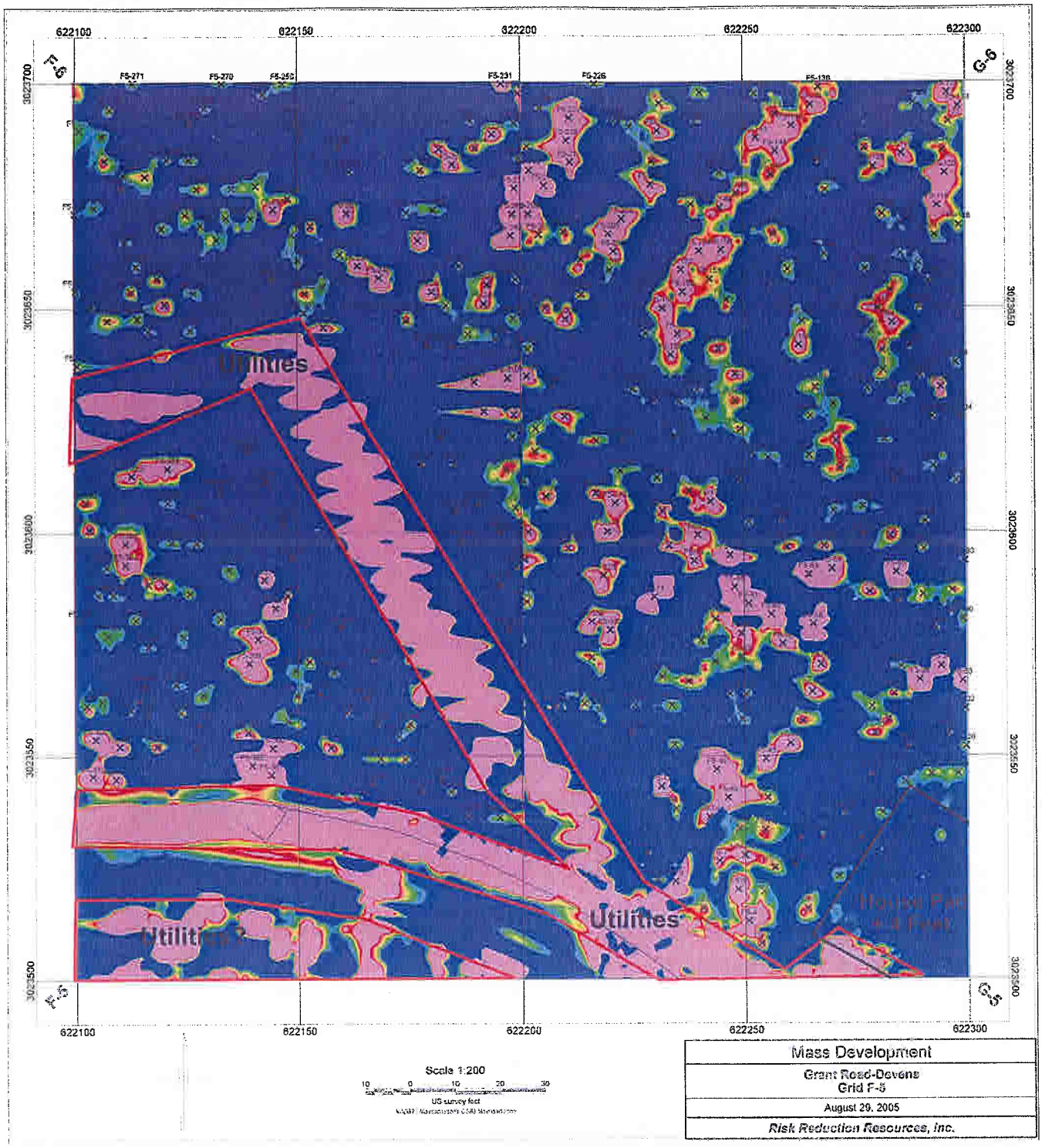
Mass Development
Grant Road-Devens Grid E-7
June 20, 2005
Risk Reduction Resources, Inc.


622100
622150
622200
622250
622300
3023100
3023050
3023000
3022950
F-3
G-3
F-2
G-2
F2-26
F2-30
F2-34
Extent of Brush Cutting
Road
Scale 1:200
10 0 10 20 30
US survey feet
Mass Development
Grant Road-Devens
Grid F-2
August 16, 2005
Risk Reduction Resources, Inc.

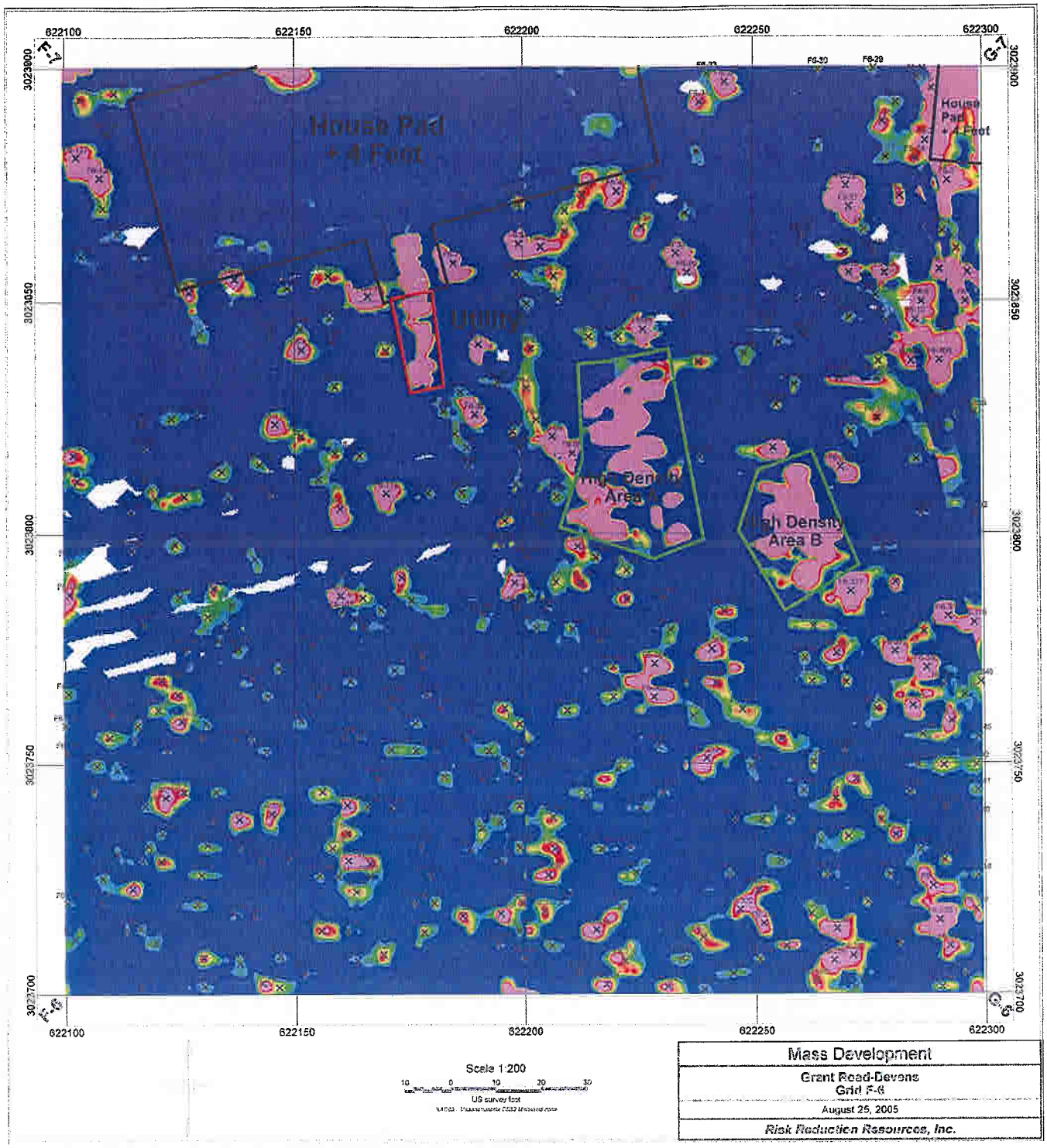

622100
622150
622200
622250
622300
3023300
3023250
3023200
3023150
3023100
F-4
G-4
F-3
G-3
Scale 1:200
10 0 10 20 30
US survey feet
Mass Development
Grant Road-Devena
Grid F-3
August 18, 2005
Risk Reduction Resources, Inc.



Mass Development
Grant Road-Devens Grid F-4
August 20, 2005
Risk Reduction Resources, Inc.



Mass Development
Grant Road-Devens Grid F-5
August 29, 2005
Risk Reduction Resources, Inc.

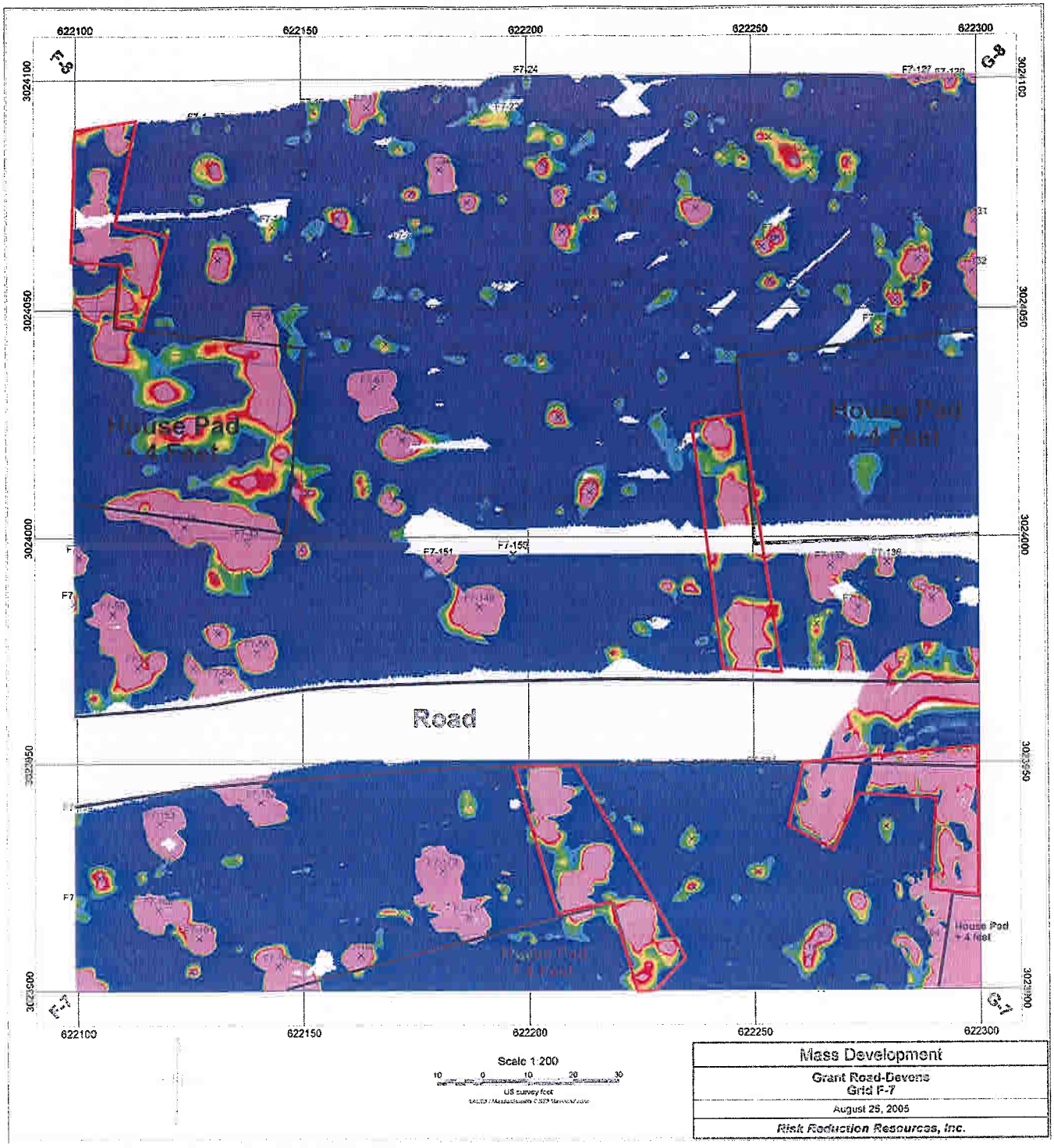


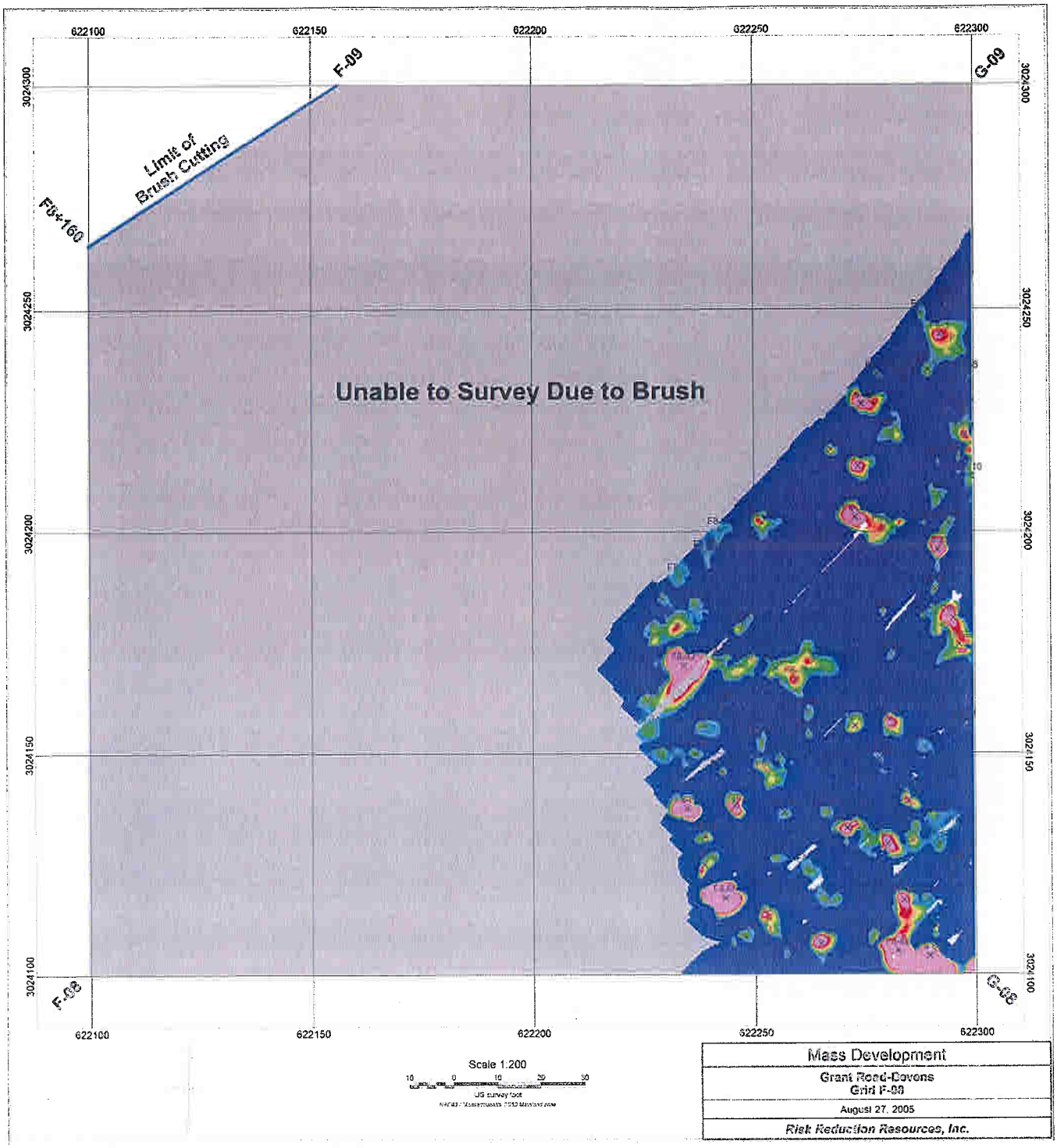
Scale 1:200

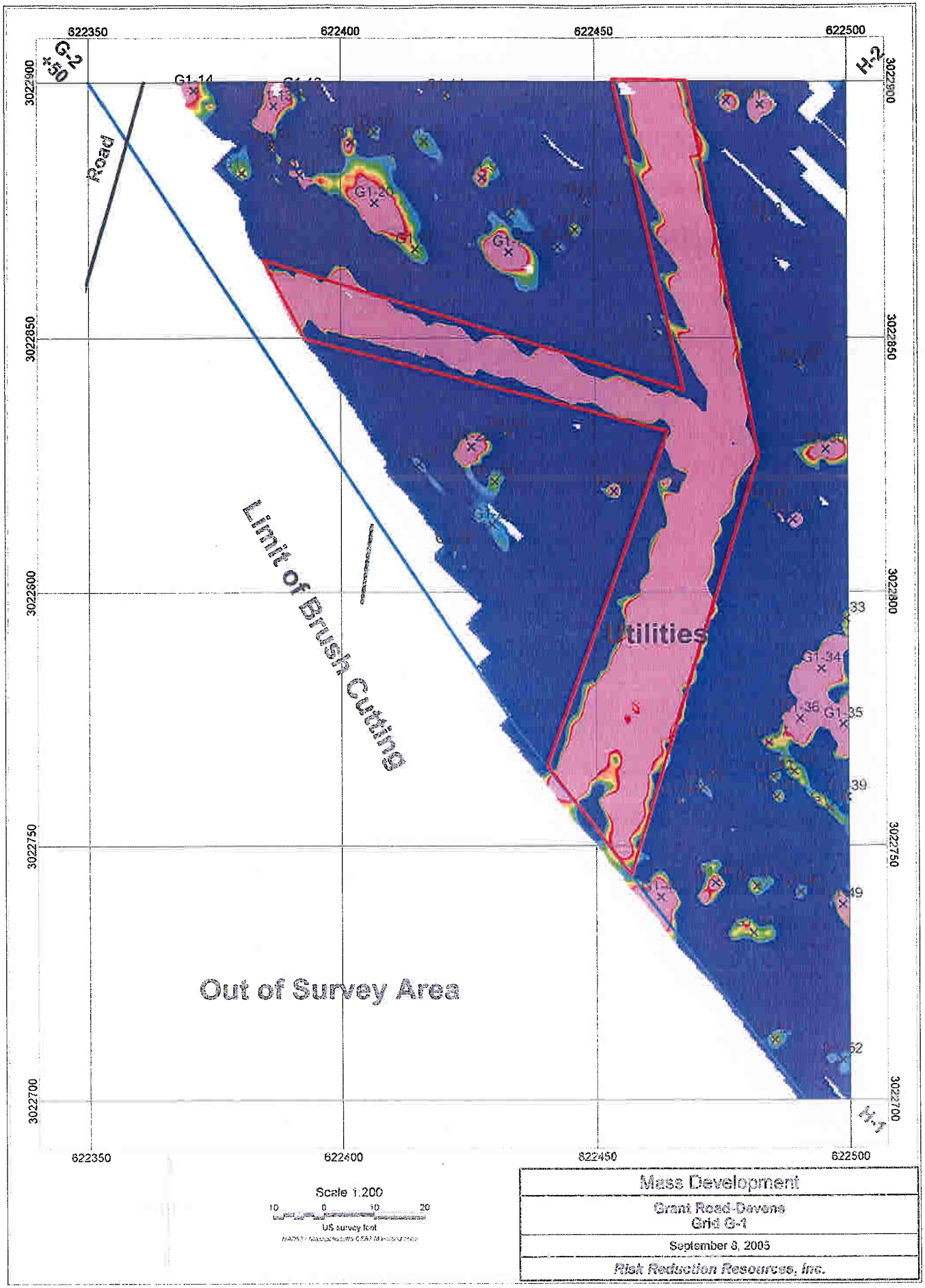
10 0 10 20 30

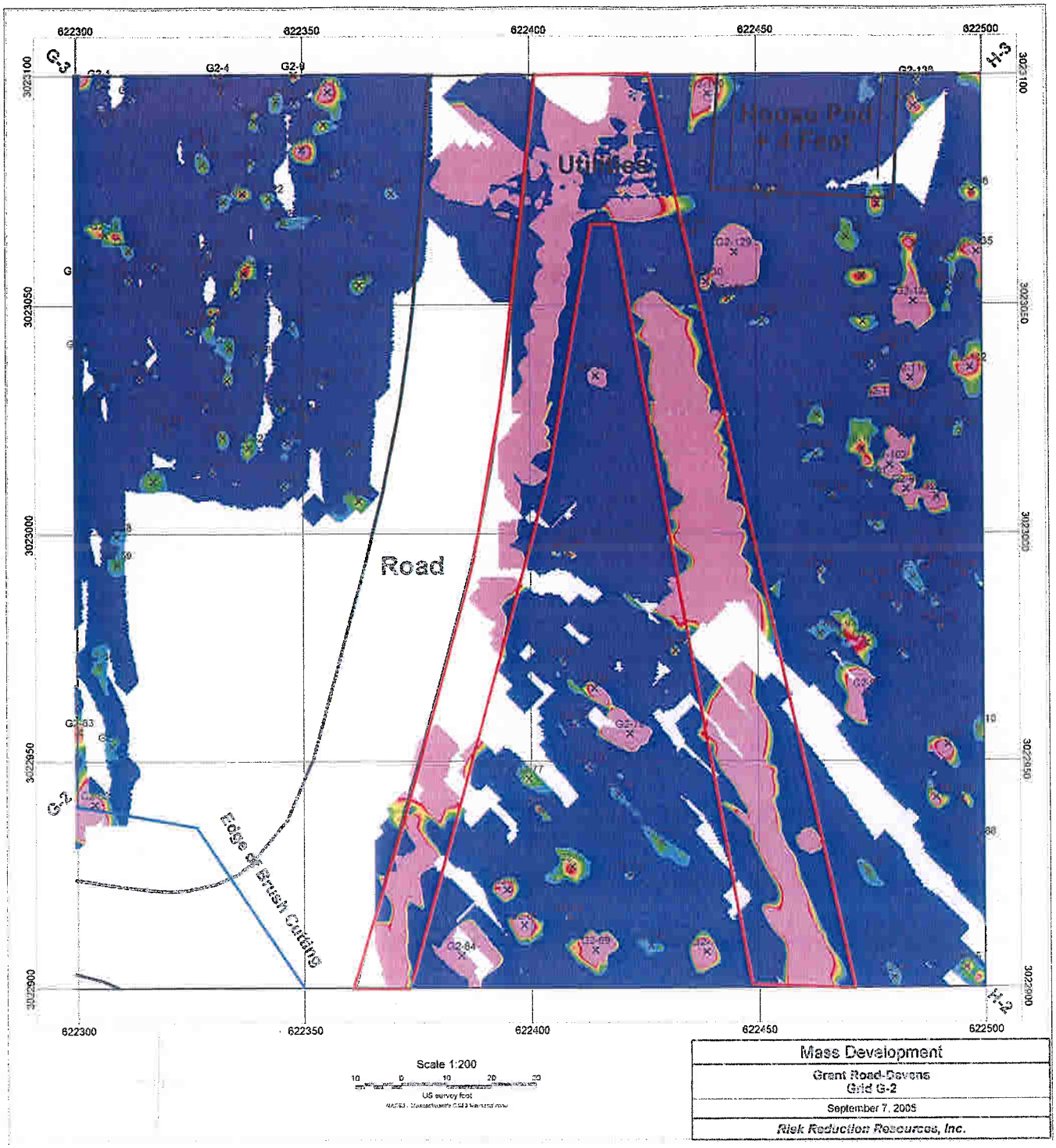
US survey foot

Mass Development
Grant Road-Devens Grid F-6
August 25, 2005
Risk Reduction Resources, Inc.

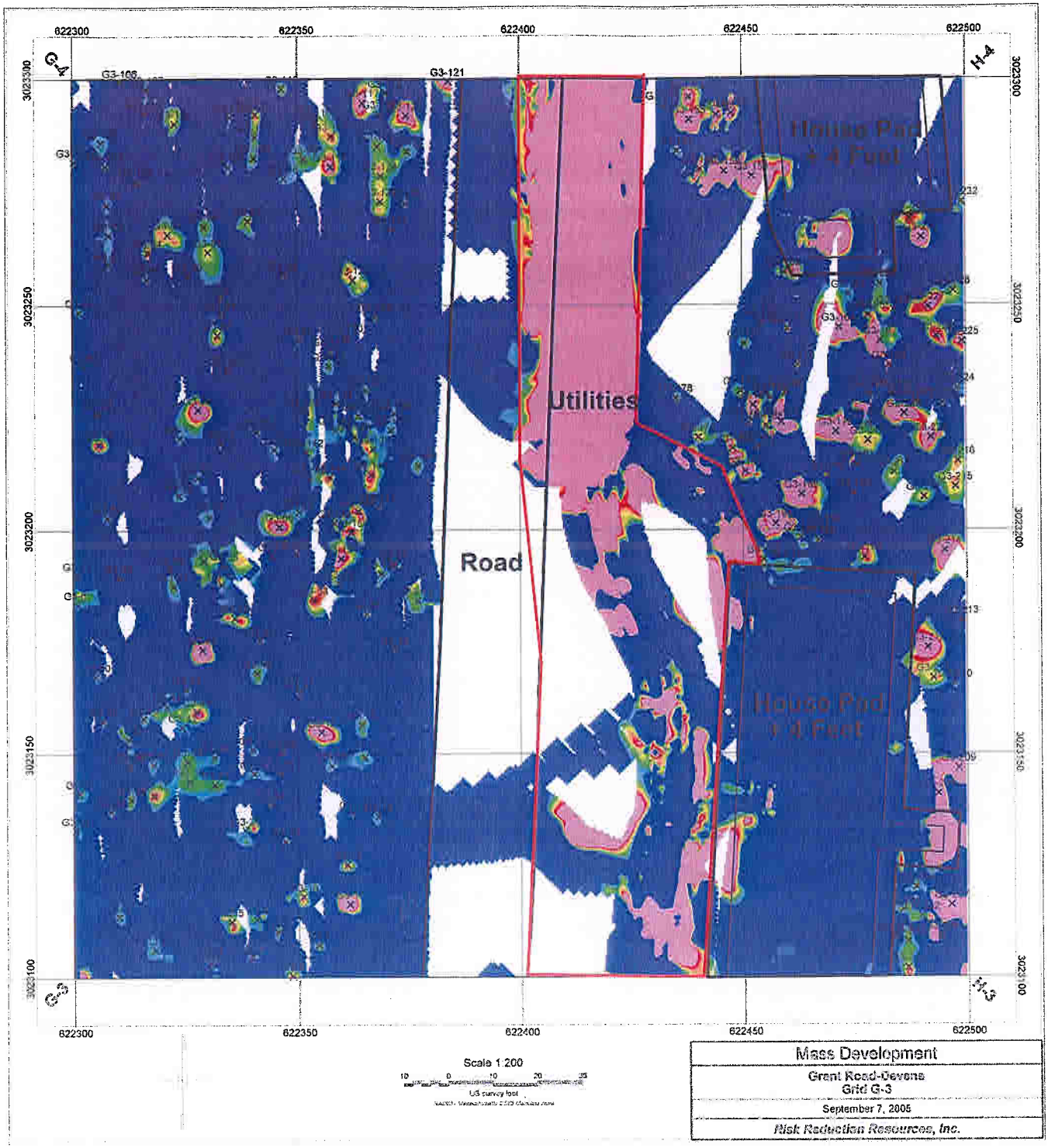

622100
622150
622200
622250
622300
3024100
3024050
3024000
3023950
3023900
F-8
G-8
F-7
G-7
House Pad
+4 Feet
House Pad
+4 Feet
Road
House Pad
+4 feet
Scale 1:200
10 0 10 20 30
US survey feet
Mass Development
Grant Road-Devens
Grid F-7
August 25, 2005
Risk Reduction Resources, Inc.


622100
622150
622200
622250
622300
3024300
3024250
3024200
3024150
3024100
F-09
G-09
F-08
G-08
Limit of
Brush Cutting
F5+160
Unable to Survey Due to Brush
Scale 1:200
10 0 10 20 30
US survey foot
Mass Development
Grant Road-Devens
Grid F-08
August 27, 2005
Risk Reduction Resources, Inc.


622350
622400
622450
622500
3022900
3022850
3022800
3022750
3022700
G2
+50
H2
H-1
Road
Limit of Brush Cutting
Utilities
Out of Survey Area
G1-14
G1-20
G1-34
G1-35
G1-36
Scale 1:200
10 0 10 20
US survey foot
Mass Development
Grant Road-Devens
Grid G-1
September 8, 2005
Risk Reduction Resources, Inc.



Mass Development
Grant Road-Devens Grid G-2
September 7, 2005
Risk Reduction Resources, Inc.

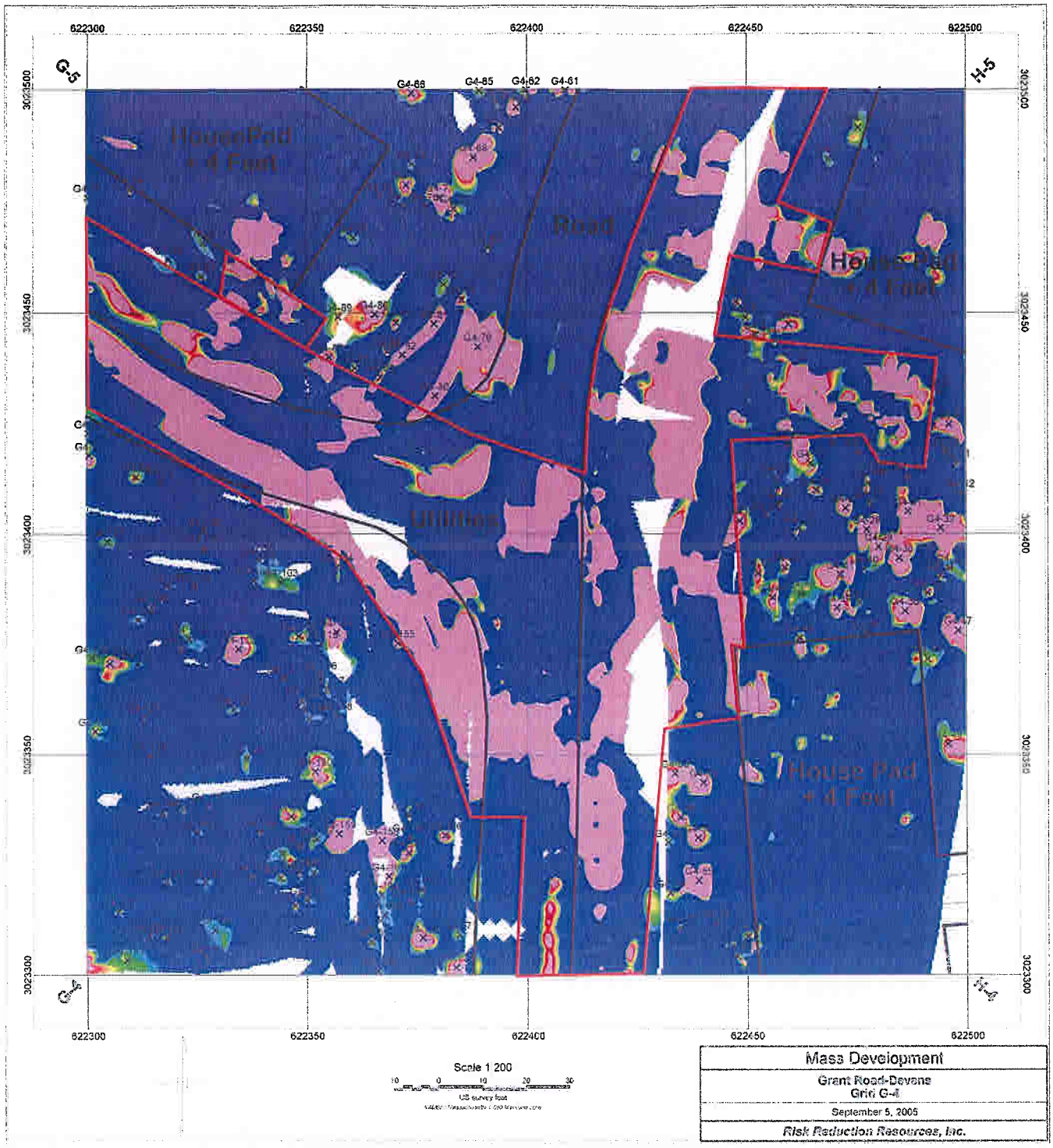


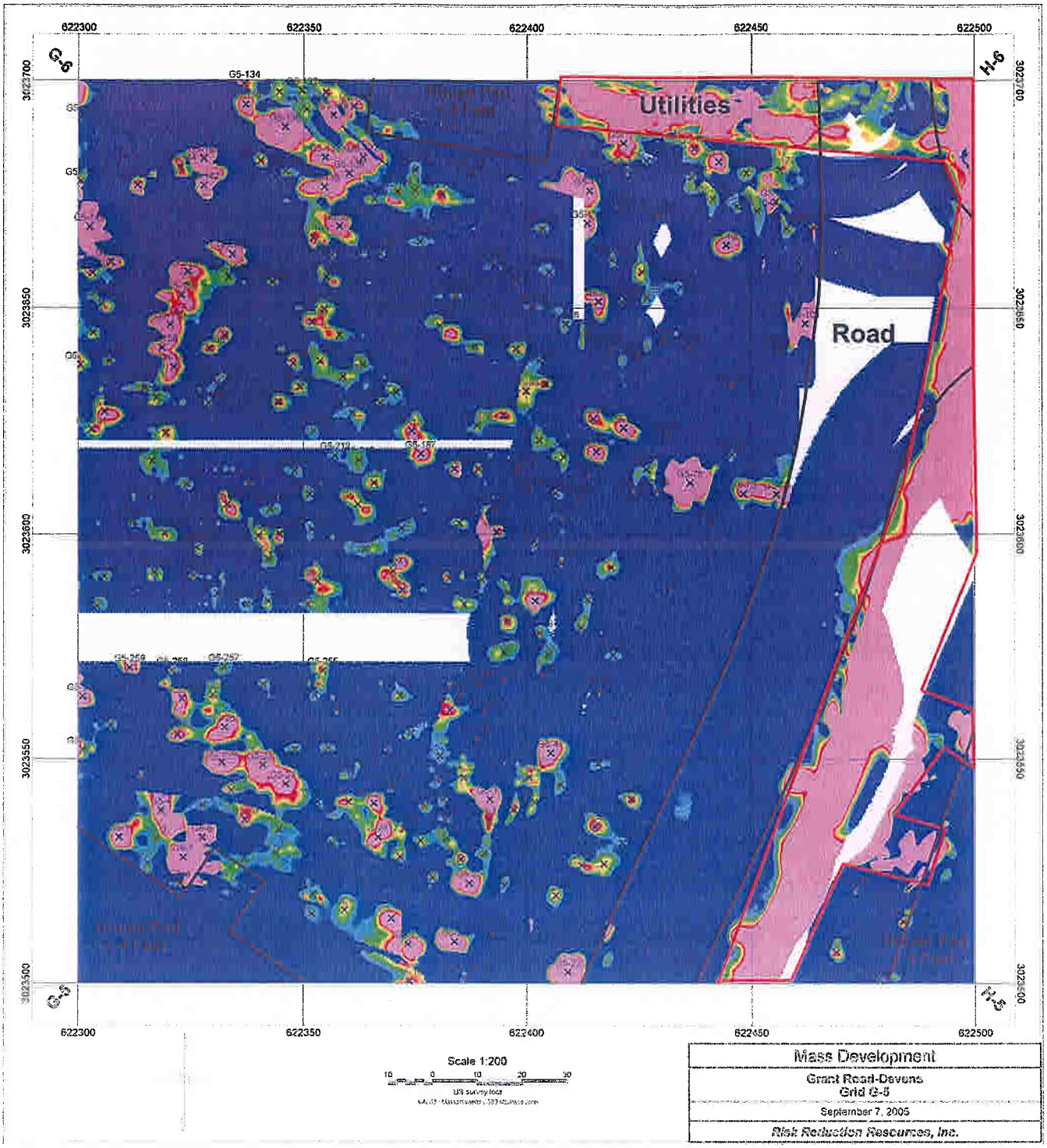
Scale 1:200

10 0 10 20 25

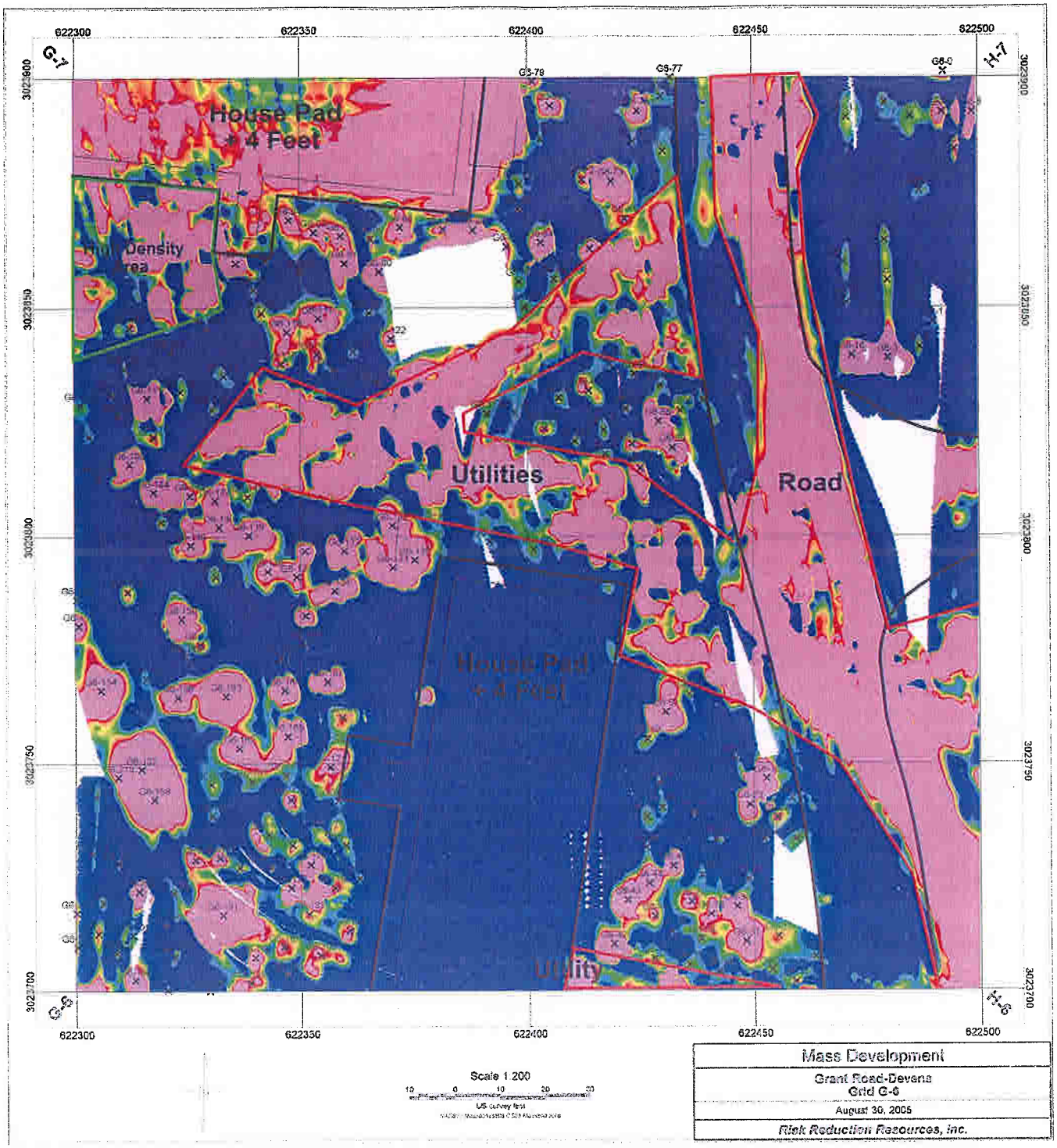
US survey foot

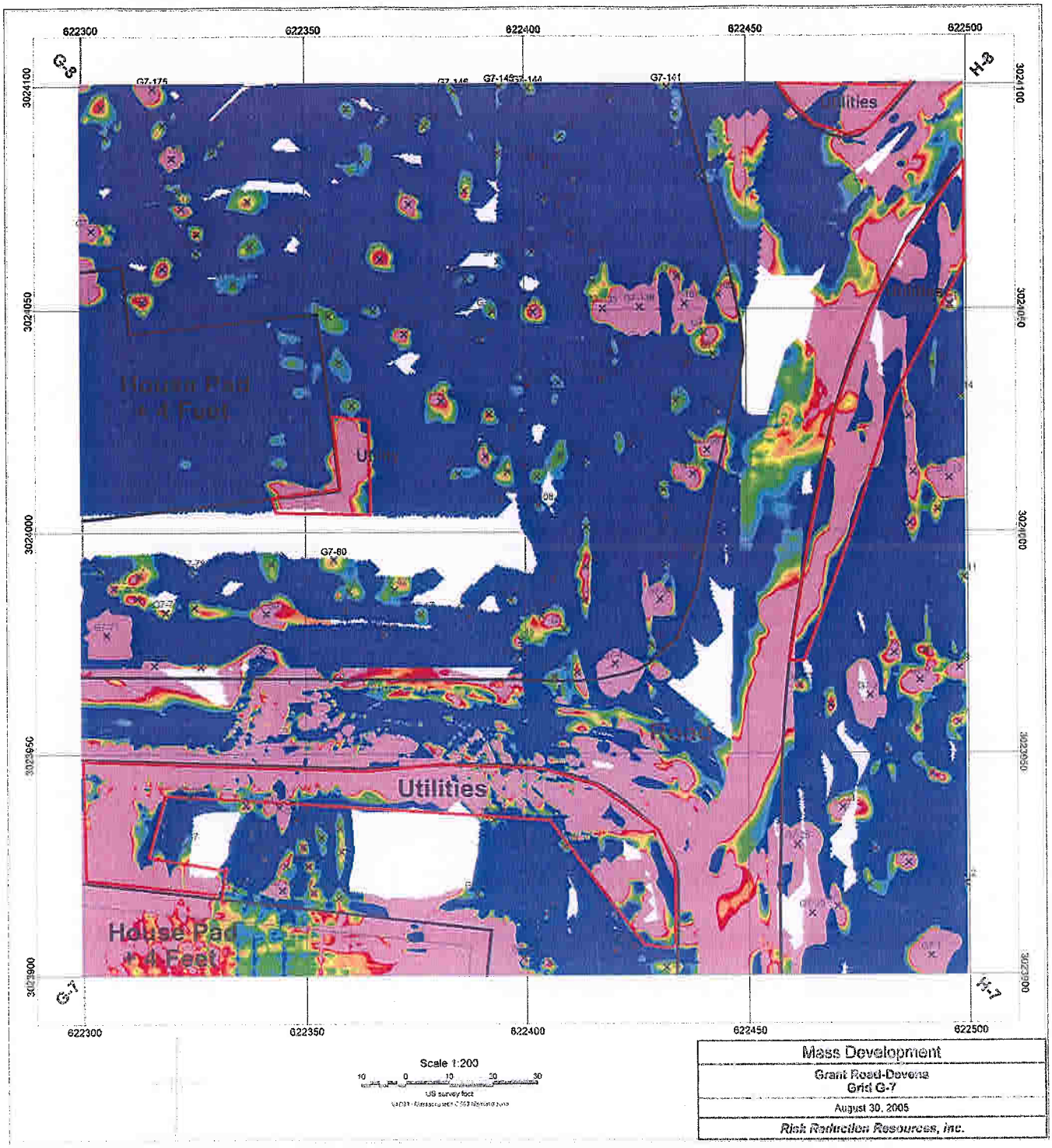
Mass Development
Grant Road-Devens Grid G-3
September 7, 2005
Risk Reduction Resources, Inc.


622300
622350
622400
622450
622500
G-5
H-5
G-4
H-4
G4-66
G4-65
G4-62
G4-61
HousePad
+4 Feet
Road
Utilities
House Pad
+4 Feet
3023500
3023450
3023400
3023350
3023300
Scale 1 200
10 0 10 20 30
US survey foot
Mass Development
Grant Road-Devens
Grid G-4
September 5, 2005
Risk Reduction Resources, Inc.

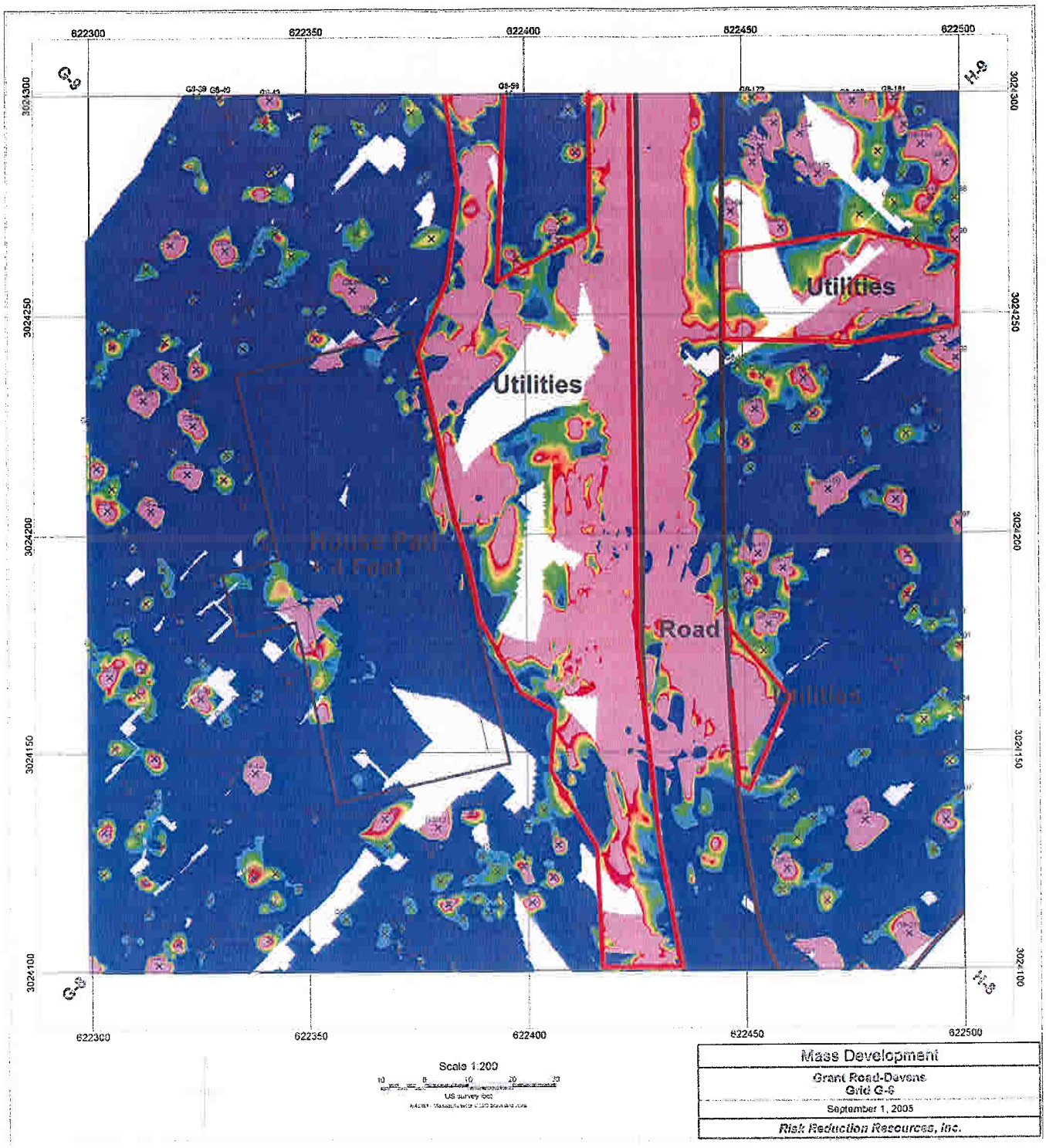


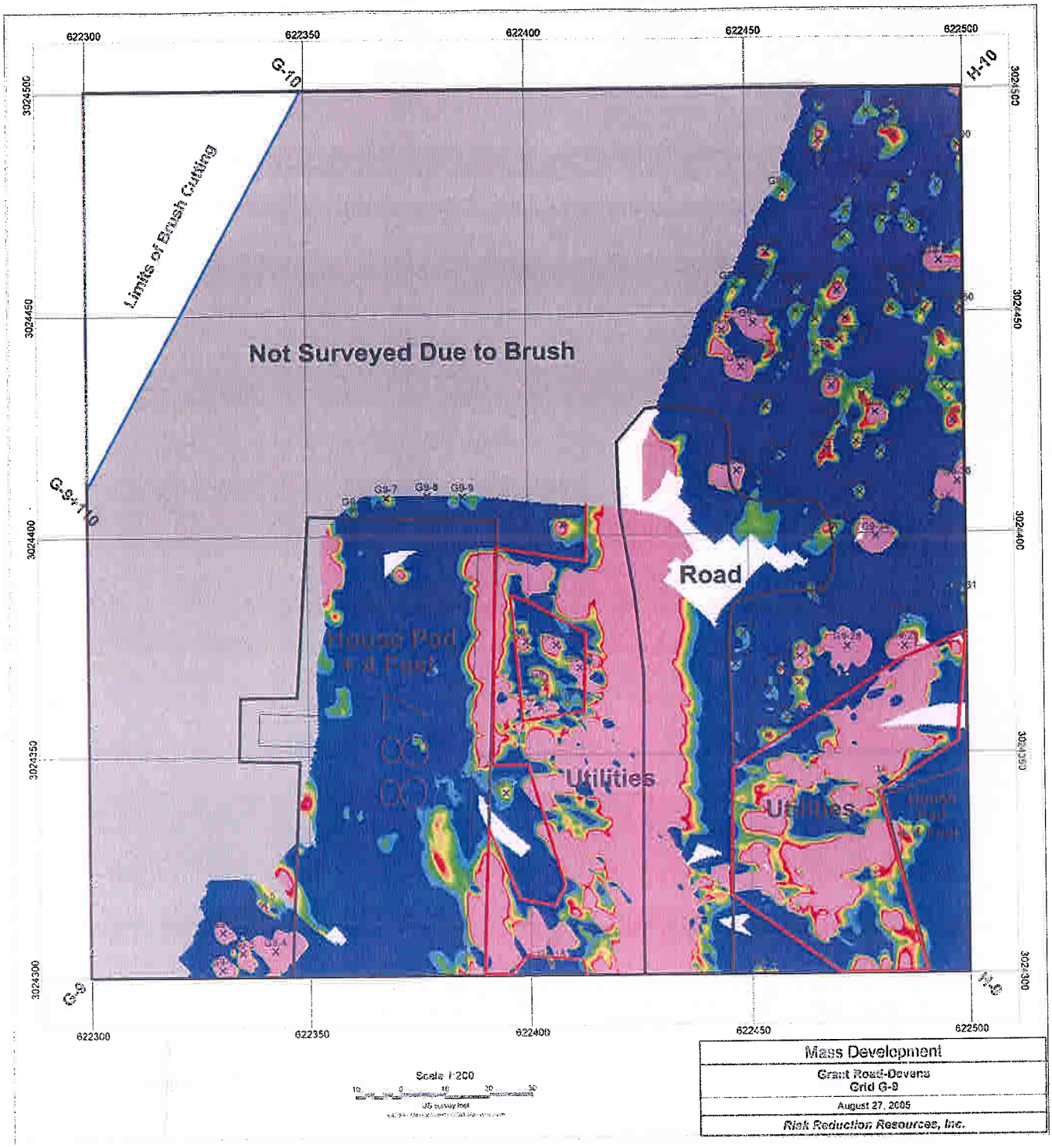
Mass Development
Grant Road-Devens Grid G-5
September 7, 2005
Risk Reduction Resources, Inc.

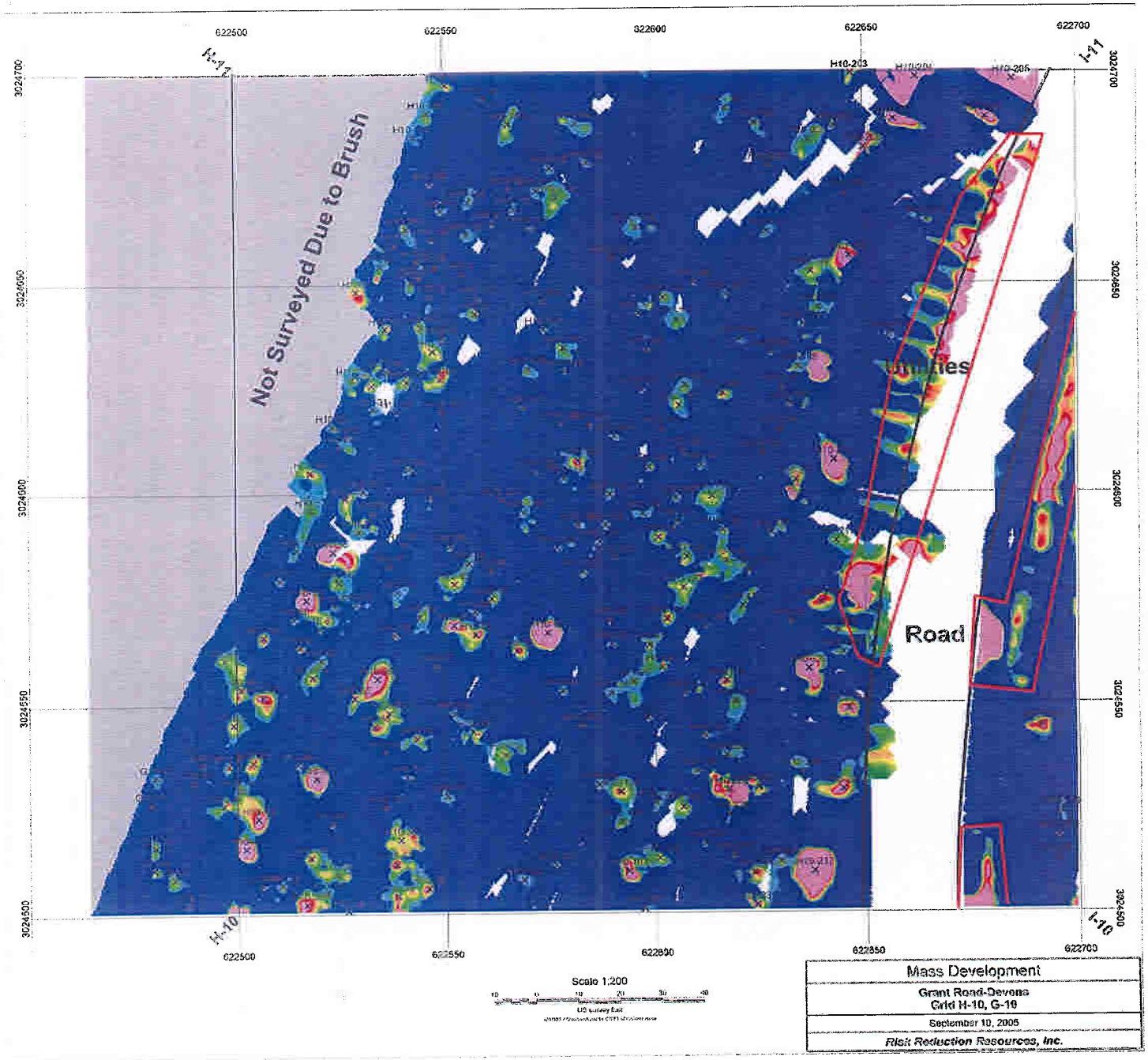

622300
622350
622400
622450
622500
G-1
H-7
G-6
H-6
3023900
3023850
3023800
3023750
3023700
House Pad
+ 4 Feet
Utilities
Road
House Pad
+ 4 Feet
Utility
Scale 1:200
US survey feet
Mass Development
Grant Road-Devens
Grid G-6
August 30, 2005
Risk Reduction Resources, Inc.

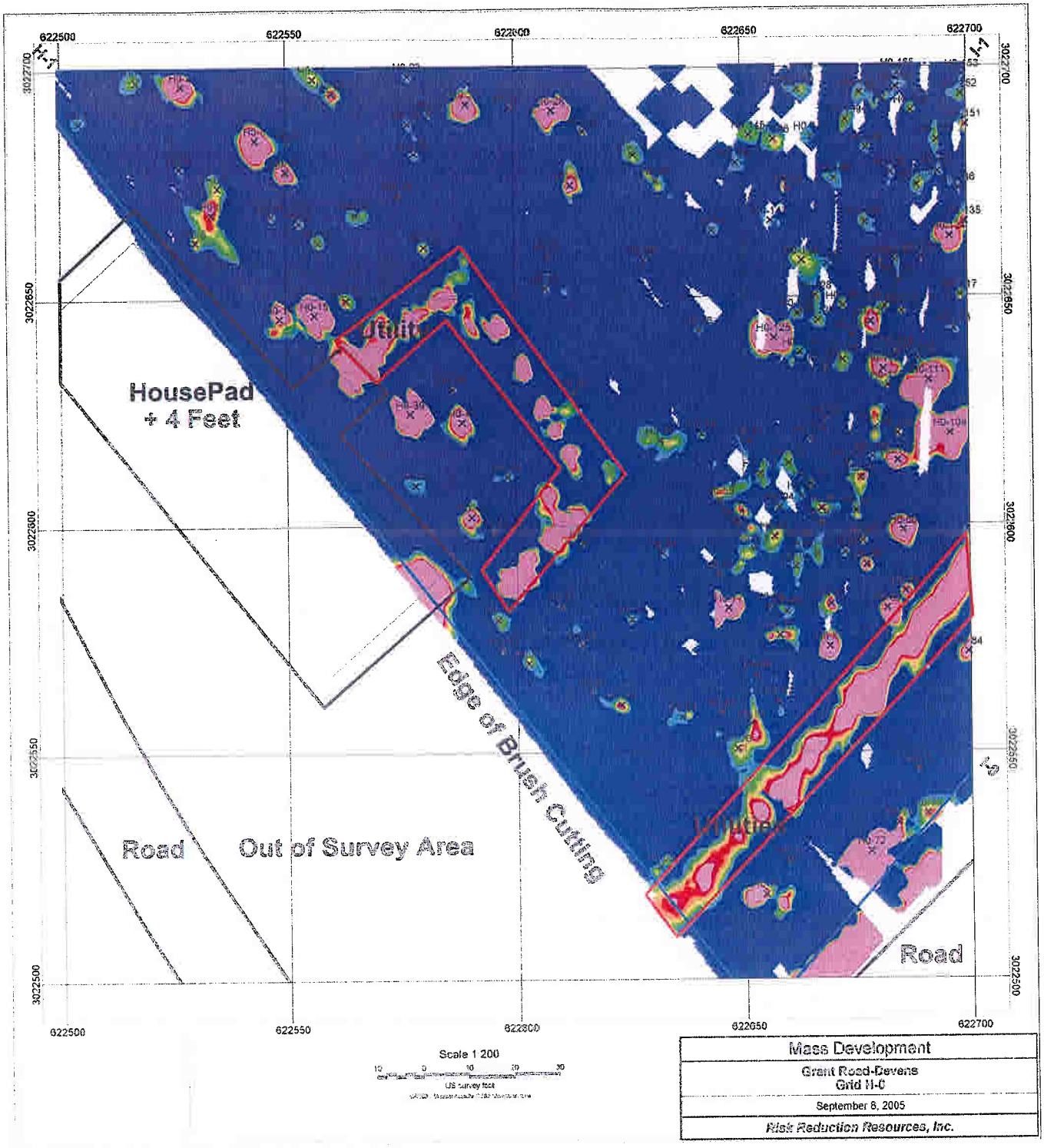


Mass Development
Grant Road-Devens Grid G-7
August 30, 2005
Risk Reduction Resources, Inc.

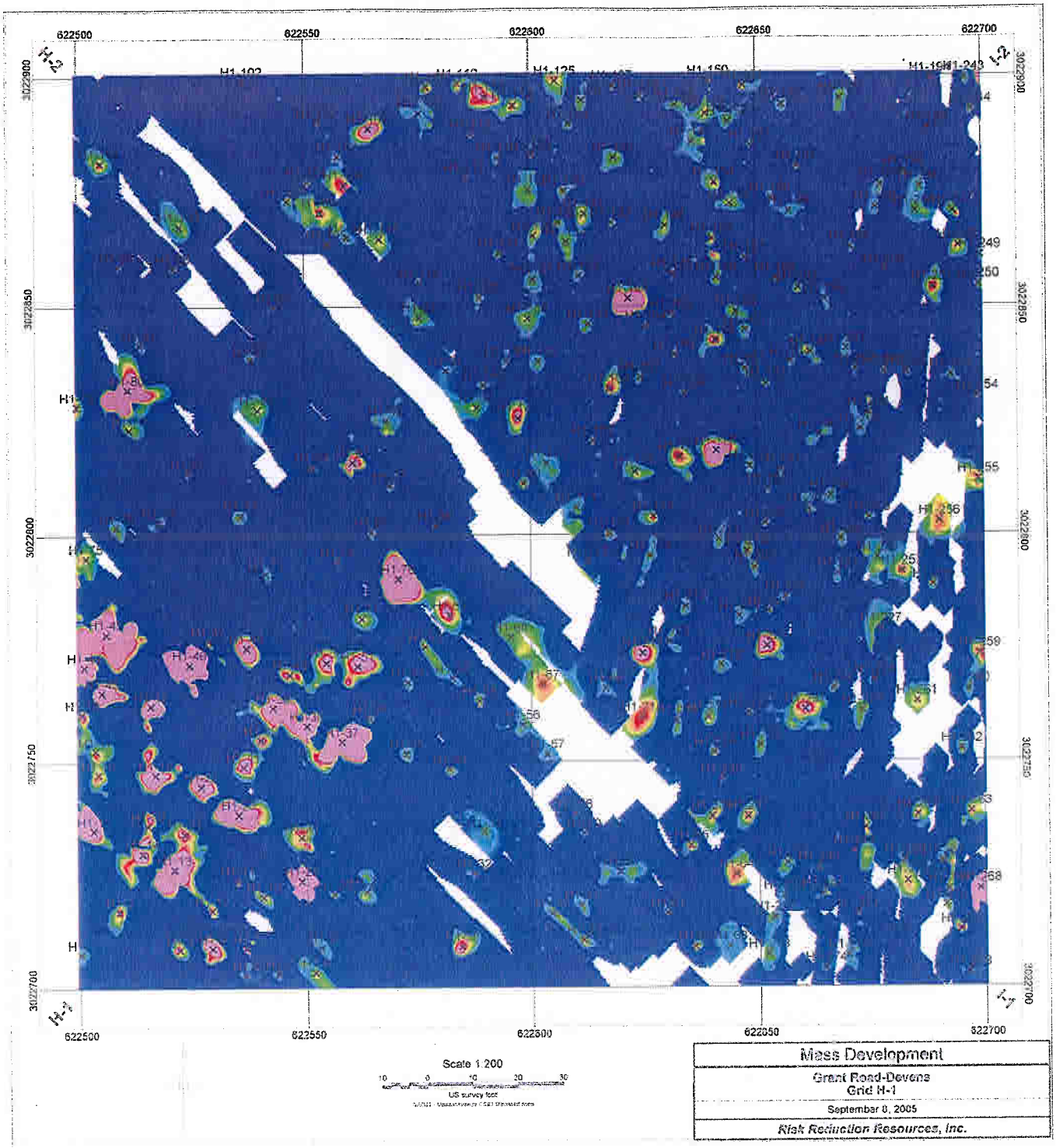

622300
622350
622400
622450
622500
3024300
3024250
3024200
3024150
3024100
G-5
H-5
Utilities
Utilities
House Path
Road
Utilities
Scale 1:200
US survey foot
Mass Development
Grant Road-Devens
Grid G-5
September 1, 2005
Risk Reduction Resources, Inc.

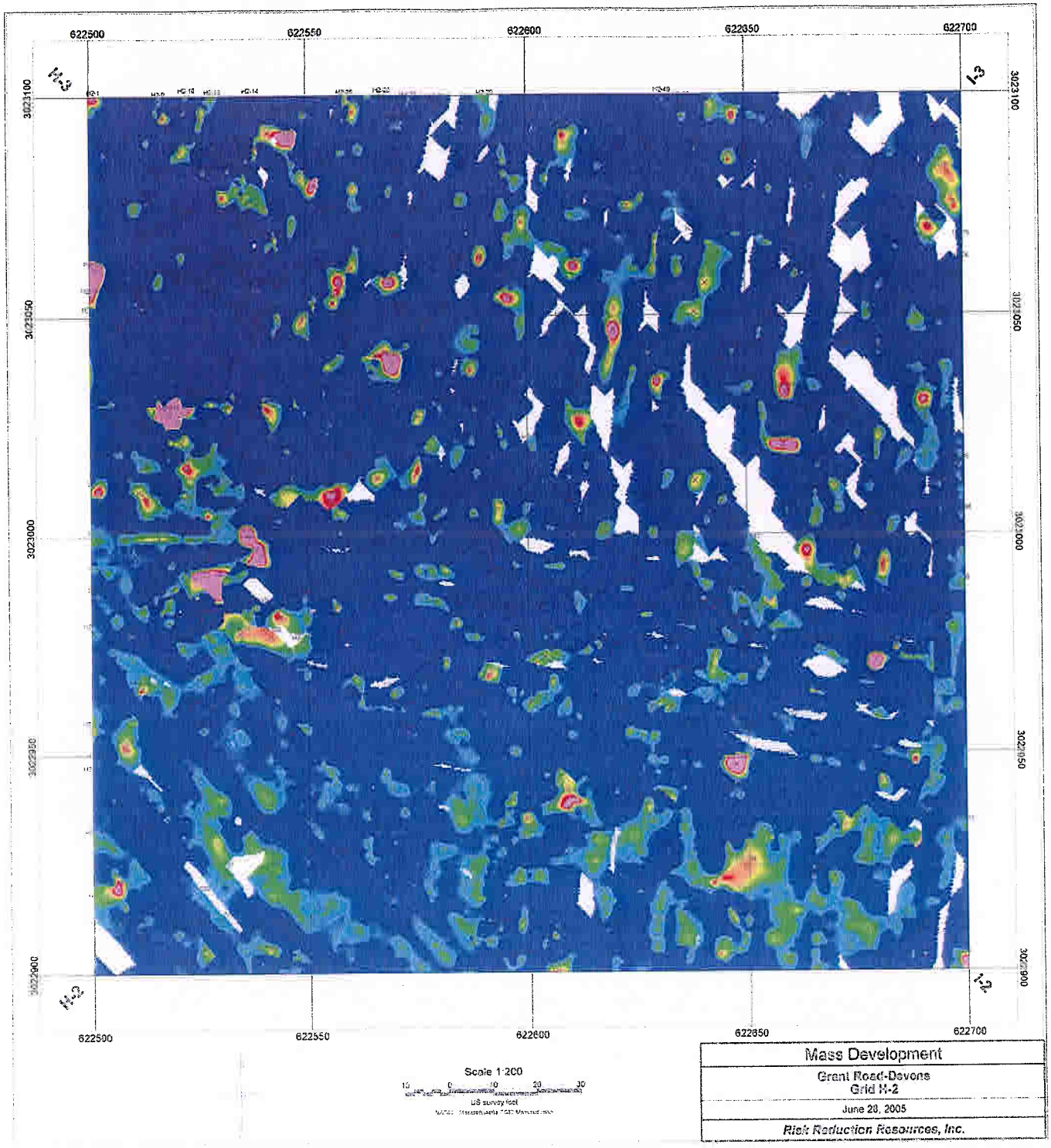

622300
622350
622400
622450
622500
3024500
3024450
3024400
3024350
3024300
G-10
H-10
G-9
A-9
Limits of Brush Cutting
Not Surveyed Due to Brush
Road
House Pad
+4 Feet
Utilities
Utilities
Scale 1:200
Mass Development
Grant Road-Devens
Grid G-9
August 27, 2005
Risk Reduction Resources, Inc.

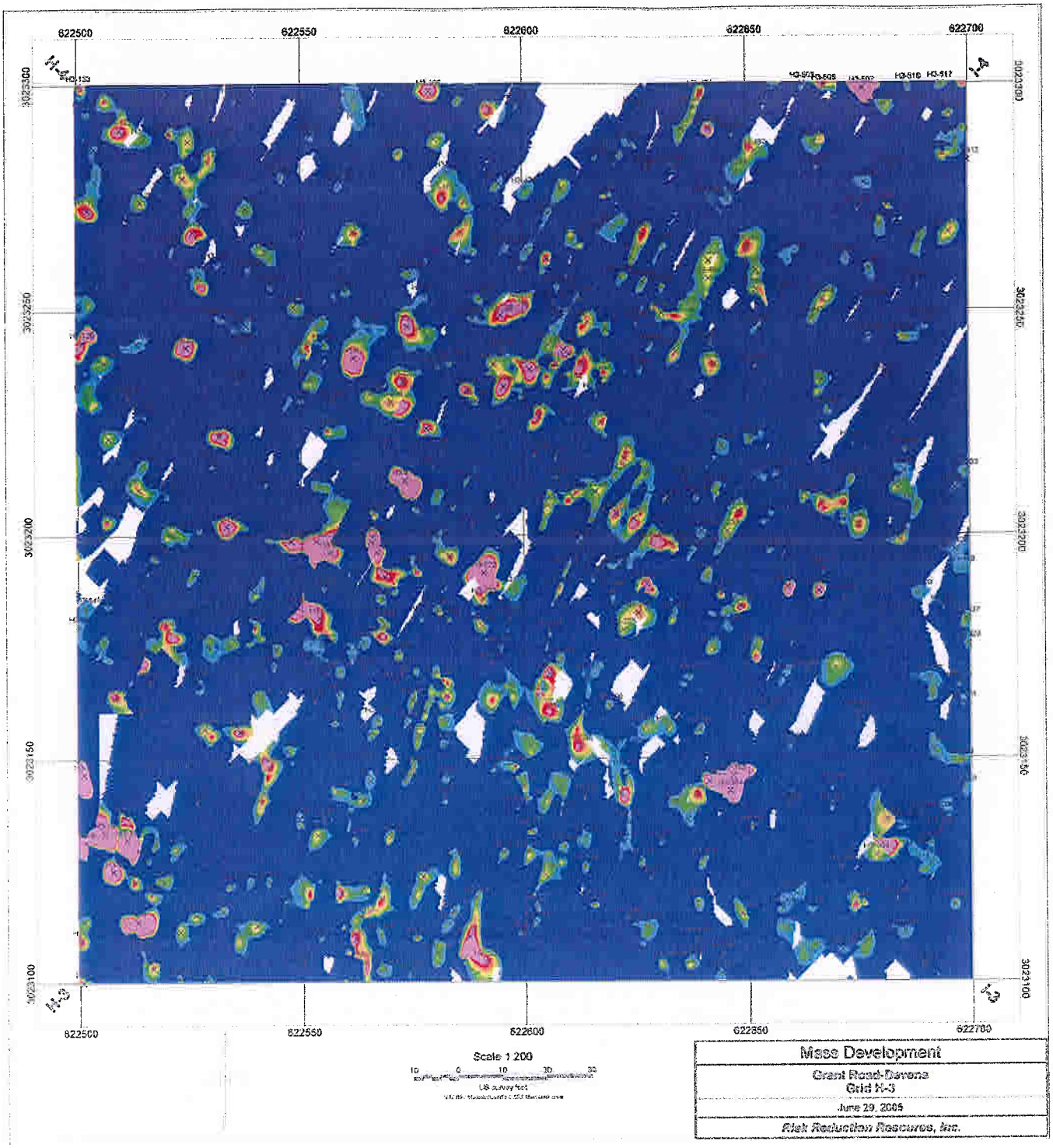

622500
622550
622600
622650
622700
3024700
3024650
3024600
3024550
3024500
H-11
H-10
H10-203
H10-205
Not Surveyed Due to Brush
Utilities
Road
Scale 1:200
Mass Development
Grant Road-Devens
Grid H-10, G-10
September 10, 2005
Risk Reduction Resources, Inc.



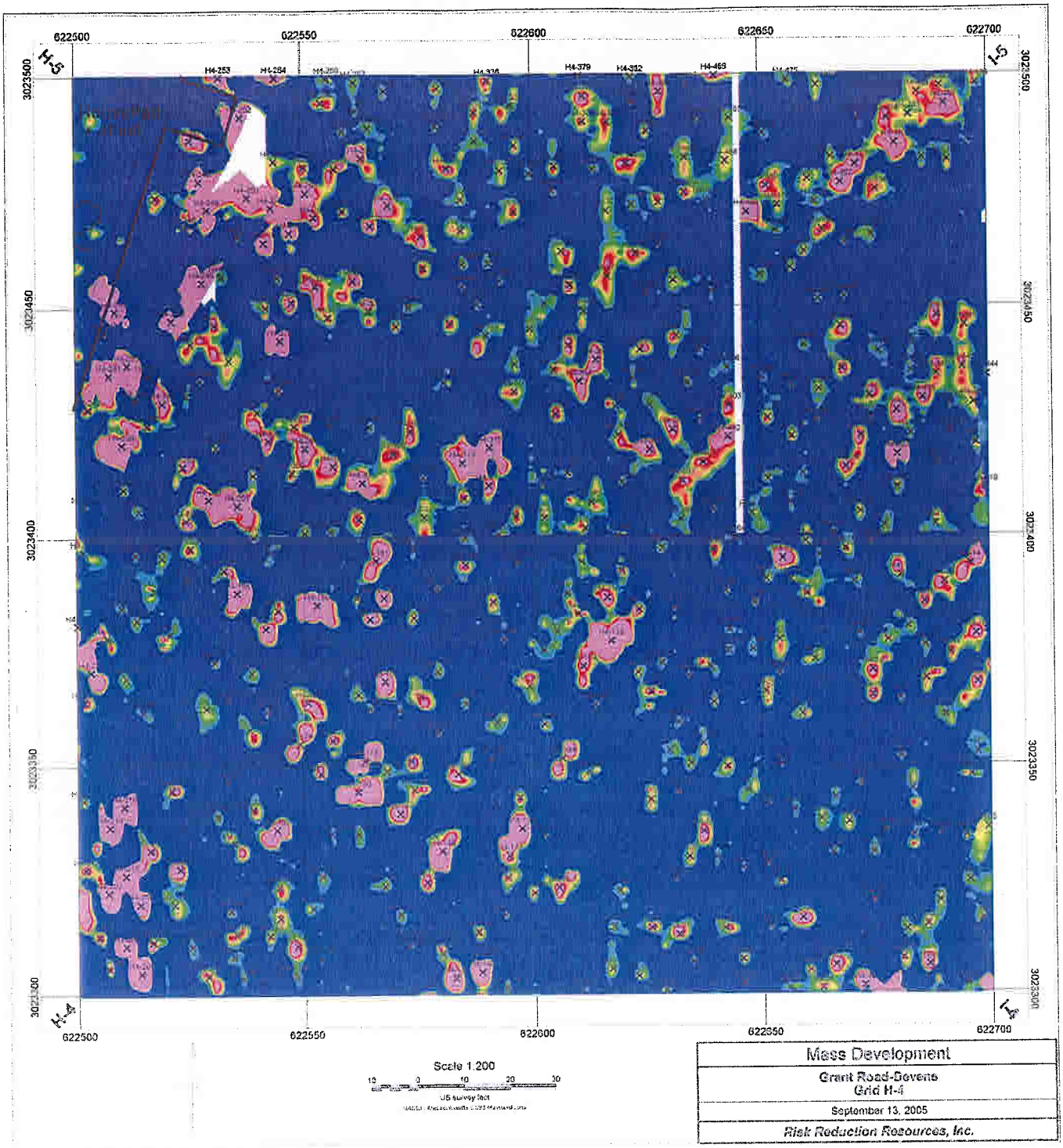
Mass Development
Grant Road-Devens Grid H-C
September 8, 2005
Risk Reduction Resources, Inc.

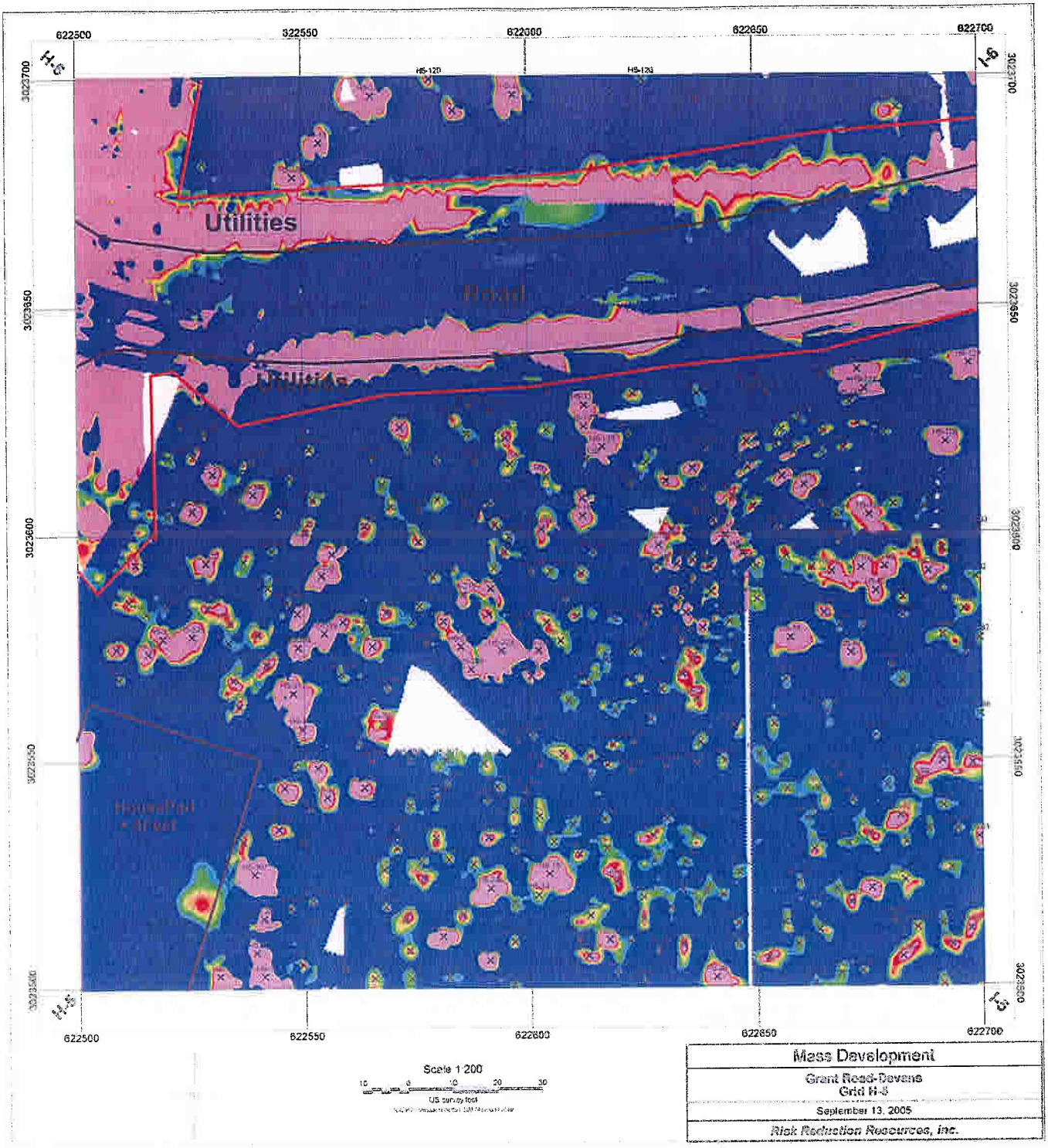

622500
622550
622600
622650
622700
3022900
3022850
3022800
3022750
3022700
H-2
H-1
Scale 1:200
10 0 10 20 30
US survey feet
Mass Development
Grant Road-Devens
Grid H-1
September 8, 2005
Risk Reduction Resources, Inc.


622500
622550
622600
622650
622700
3023100
3023050
3023000
3022950
3022900
H-2
I-2
Scale 1:200
10 0 10 20 30
US survey feet
Mass Development
Grant Road-Devons
Grid H-2
June 28, 2005
Risk Reduction Resources, Inc.

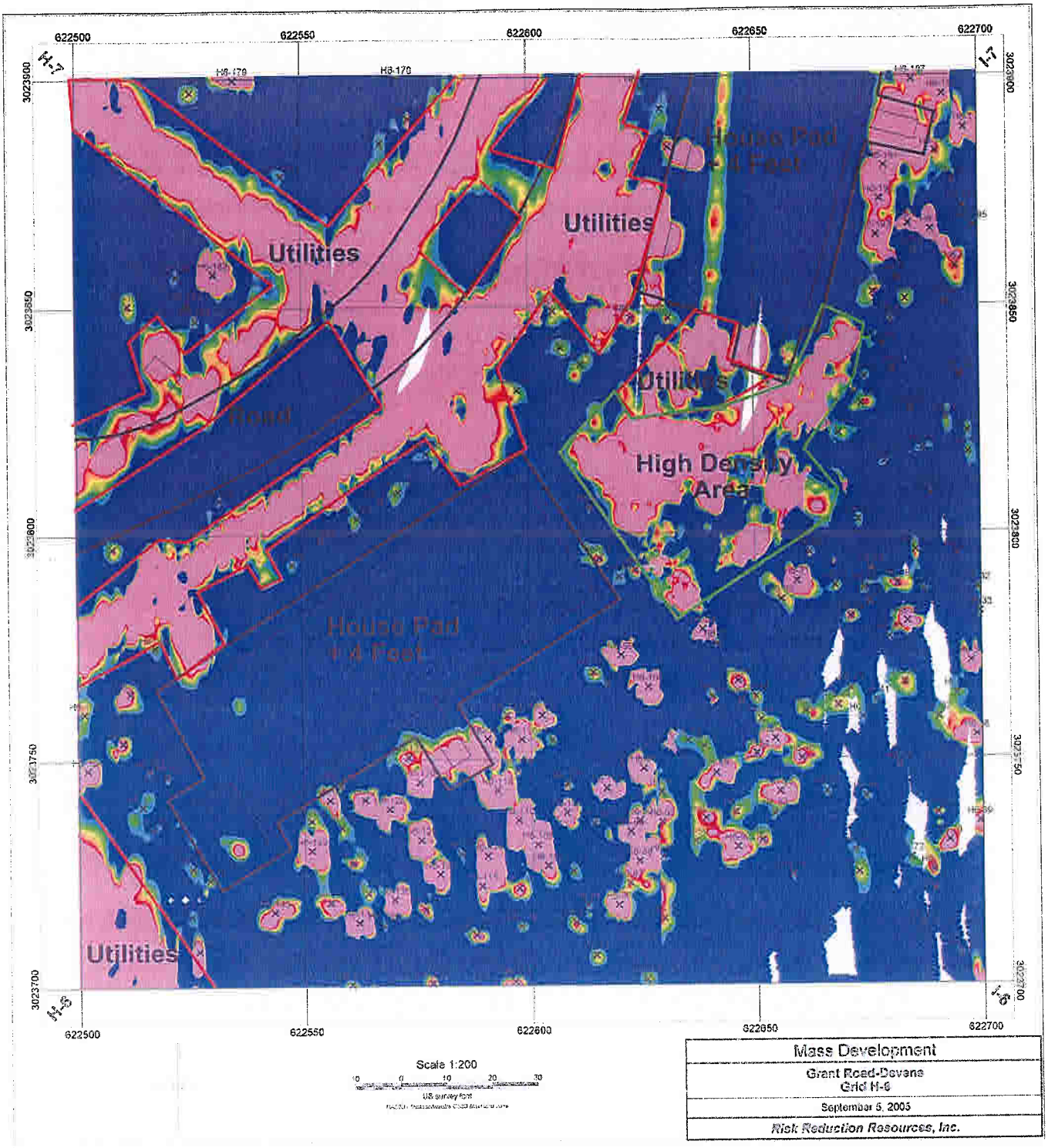


Mass Development
Grant Road-Devens Grid H-3
June 29, 2005
Risk Reduction Resources, Inc.

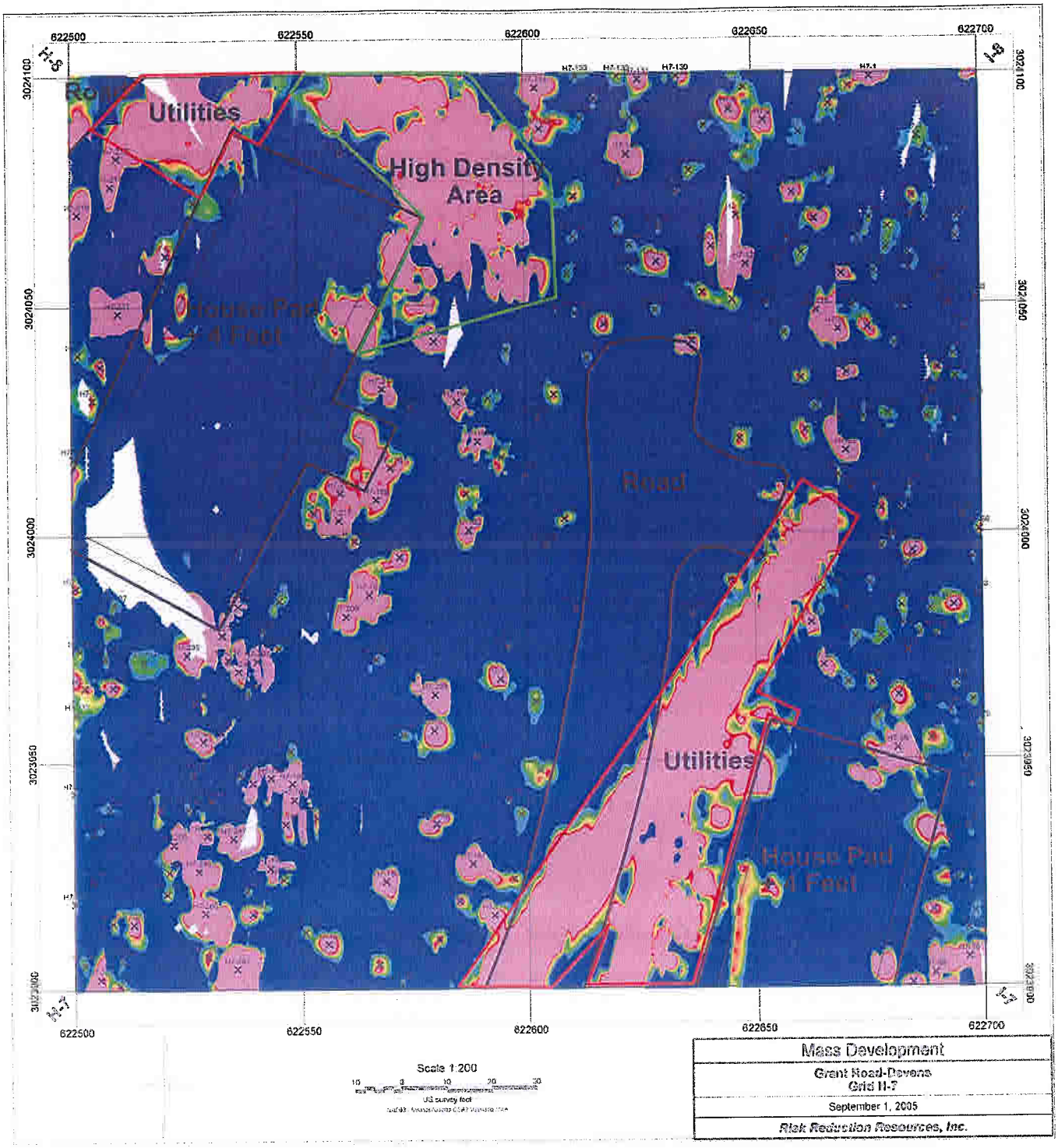

622500
622550
622600
622650
622700
H-5
I-5
H-4
I-4
H4-253
H4-284
H4-379
H4-312
H4-469
3023500
3023450
3023400
3023350
3023300
Scale 1:200
US Survey feet
Mass Development
Grant Road-Devens
Grid H-4
September 13, 2005
Risk Reduction Resources, Inc.



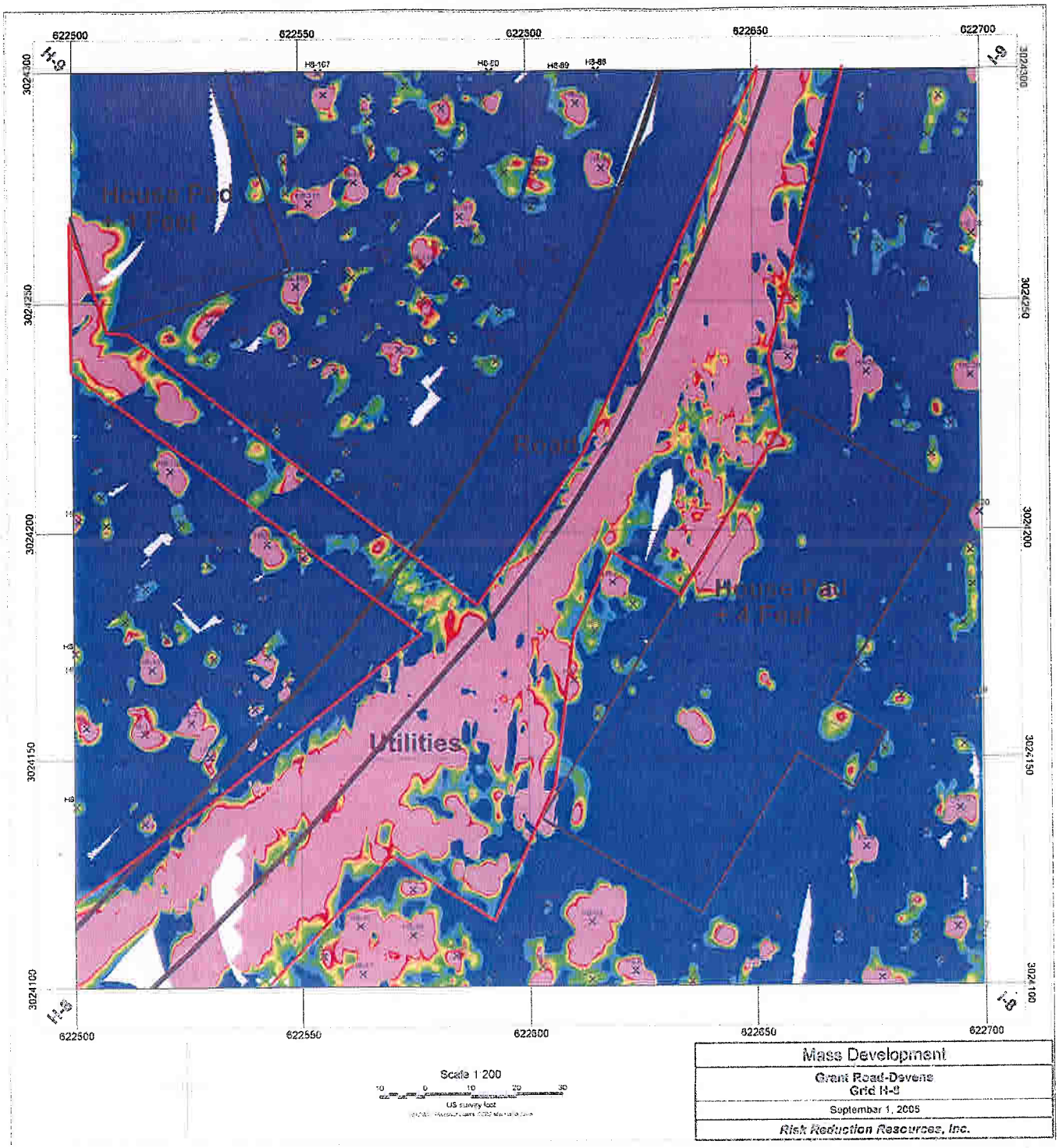
Mass Development
Grant Road-Devens Grid H-5
September 13, 2005
Risk Reduction Resources, Inc.

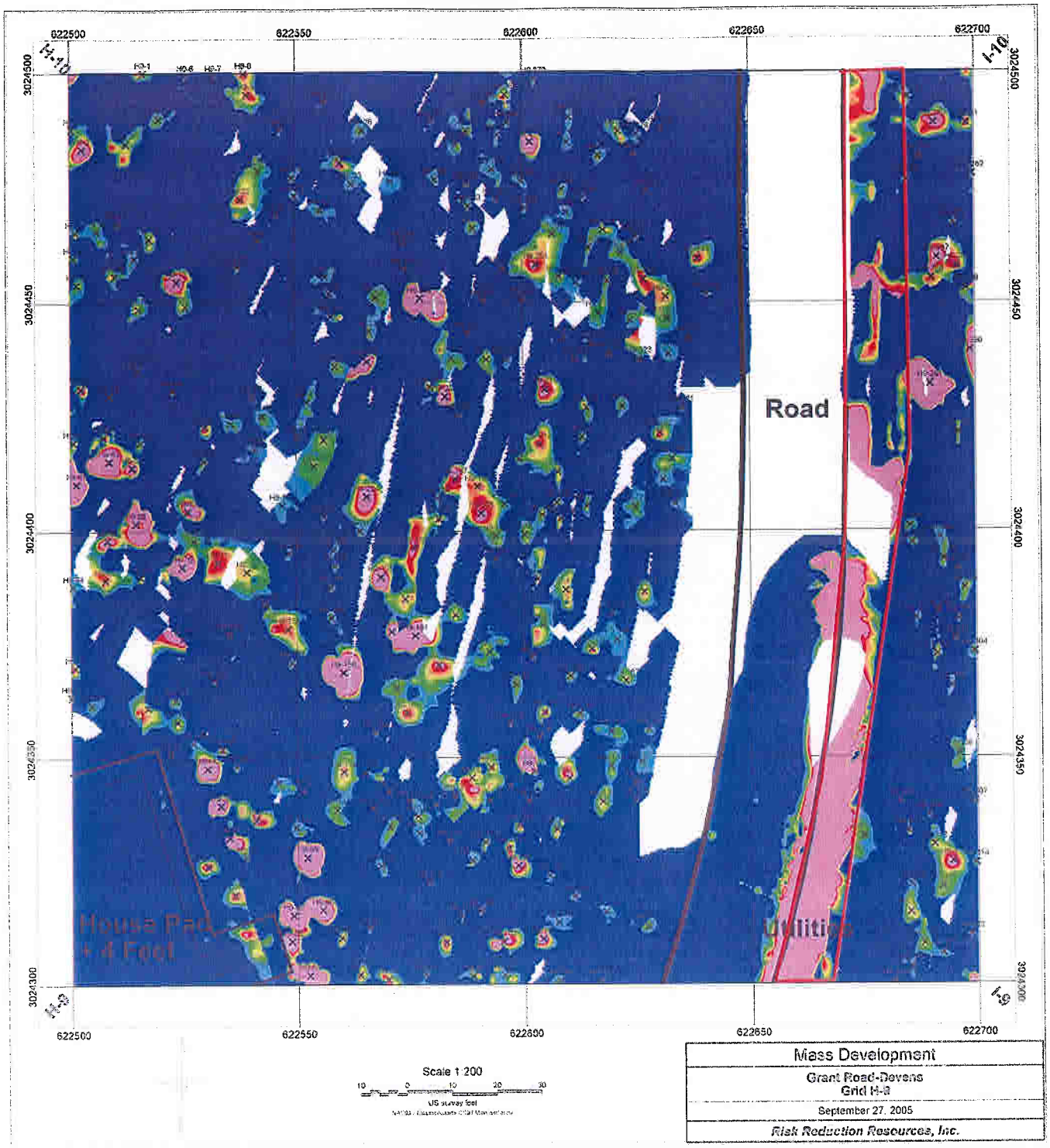


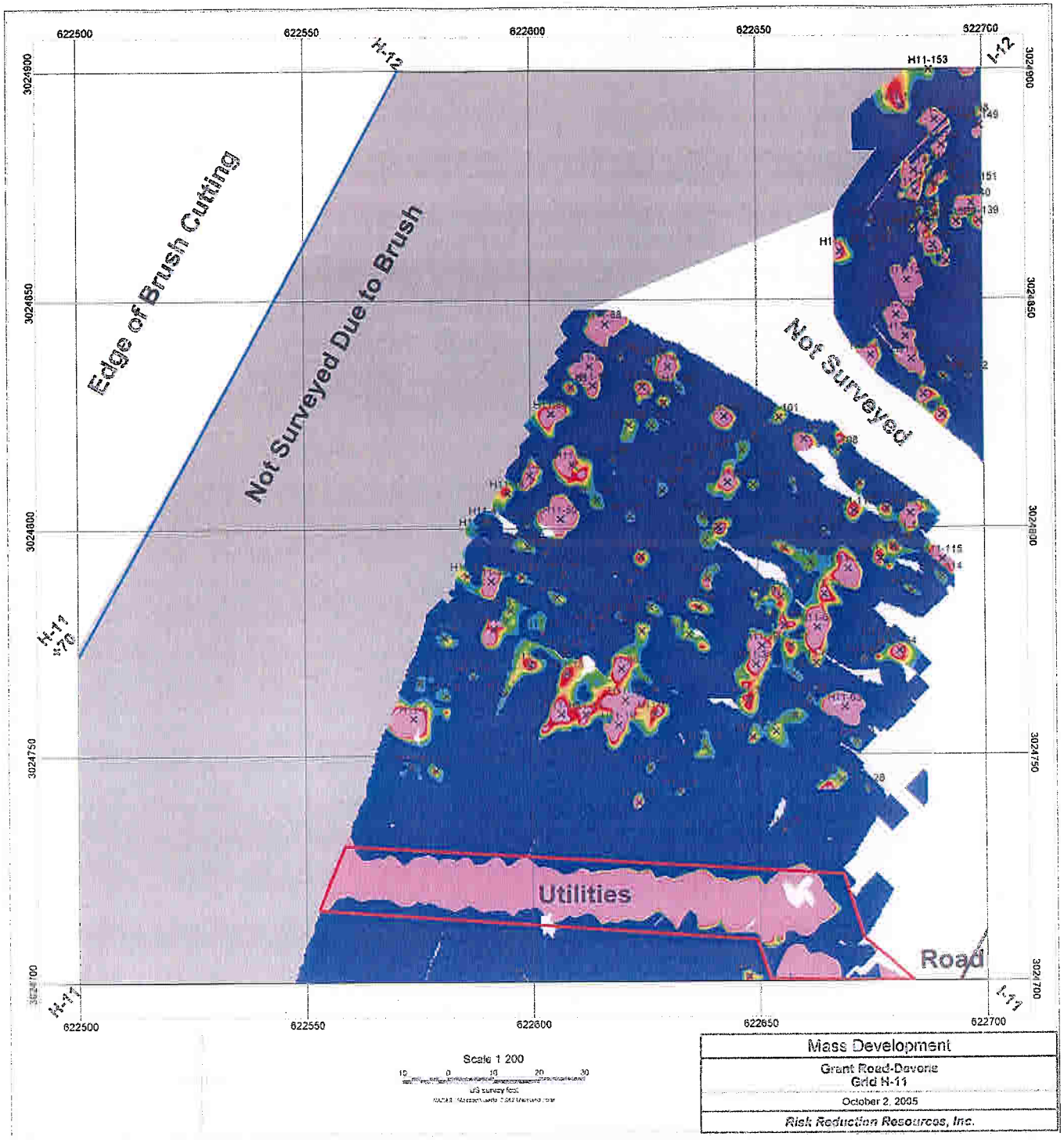
622500
622550
622600
622650
622700
3023900
3023850
3023800
3023750
3023700
H-7
I-7
H-8
I-8
Utilities
Utilities
Utilities
Utilities
Road
High Density Areas
House Pad + 4 Feet
House Pad + 4 Feet
Scale 1:200
US survey feet
Mass Development
Grant Road-Devens
Grid H-6
September 5, 2005
Risk Reduction Resources, Inc.

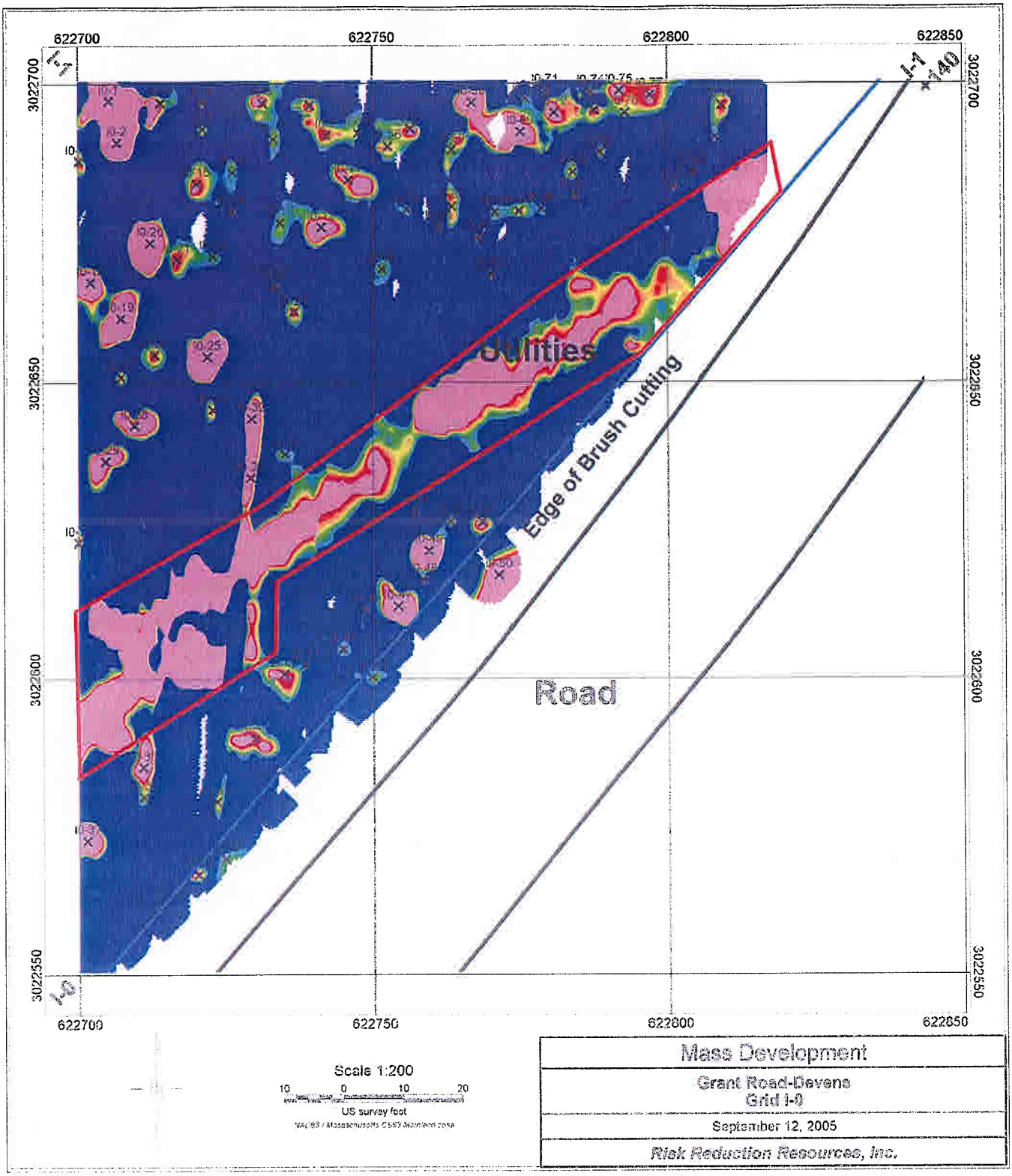


Mass Development
Grant Road-Devens Grid H-7
September 1, 2005
Risk Reduction Resources, Inc.

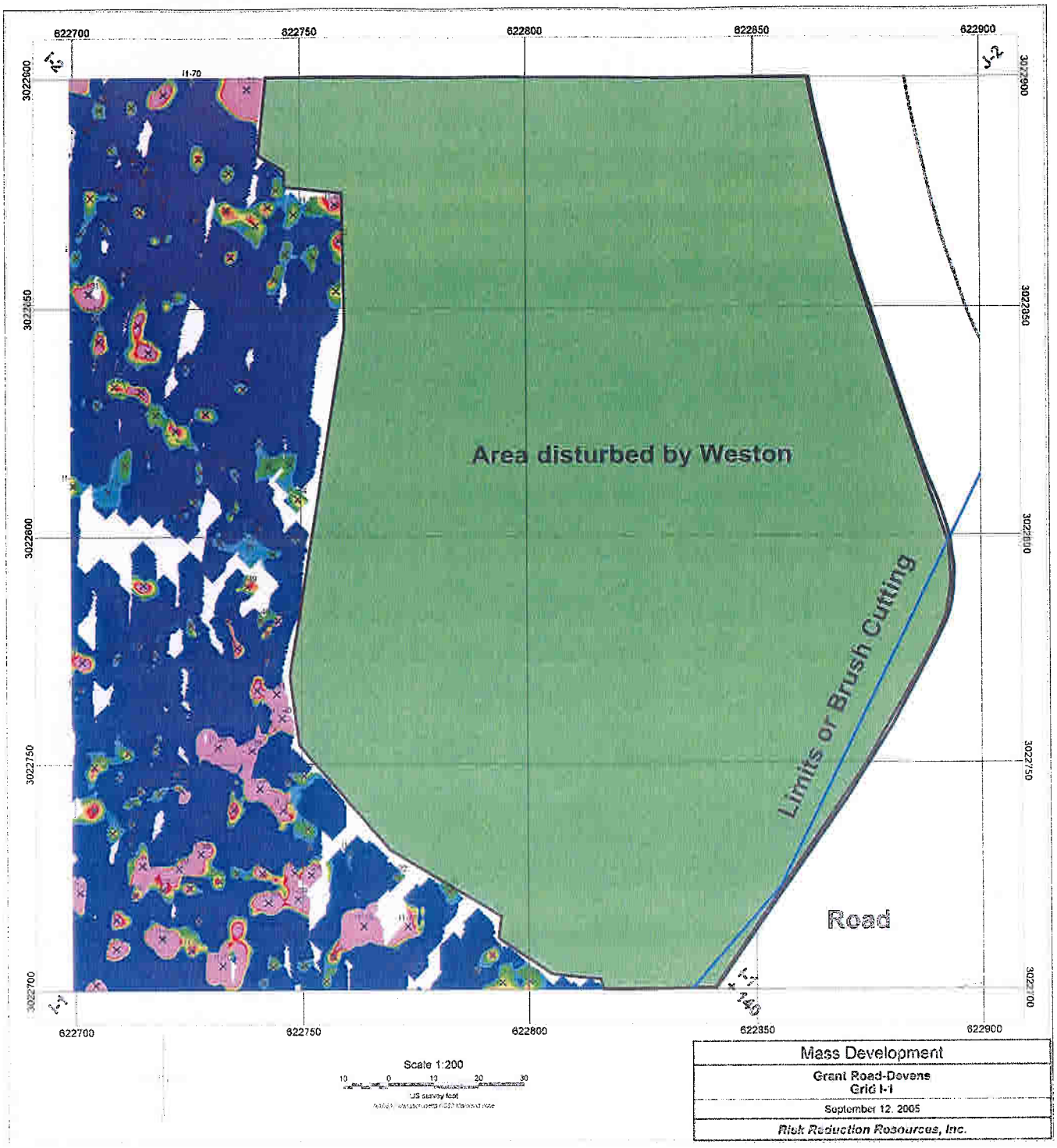

622500
622550
622600
622650
622700
3024300
3024250
3024200
3024150
3024100
H-9
House Pad
+ 1 Foot
Road
House Pad
+ 4 Foot
Utilities
Scale 1:200
10 0 10 20 30
US survey foot
Mass Development
Grant Road-Devens
Grid H-9
September 1, 2005
Risk Reduction Resources, Inc.


622500
622550
622600
622650
622700
3024500
3024450
3024400
3024350
3024300
I-10
I-9
Road
House Pad
+4 Foot
Utilities
Scale 1:200
US survey foot
Mass Development
Grant Road-Devens
Grid H-9
September 27, 2005
Risk Reduction Resources, Inc.

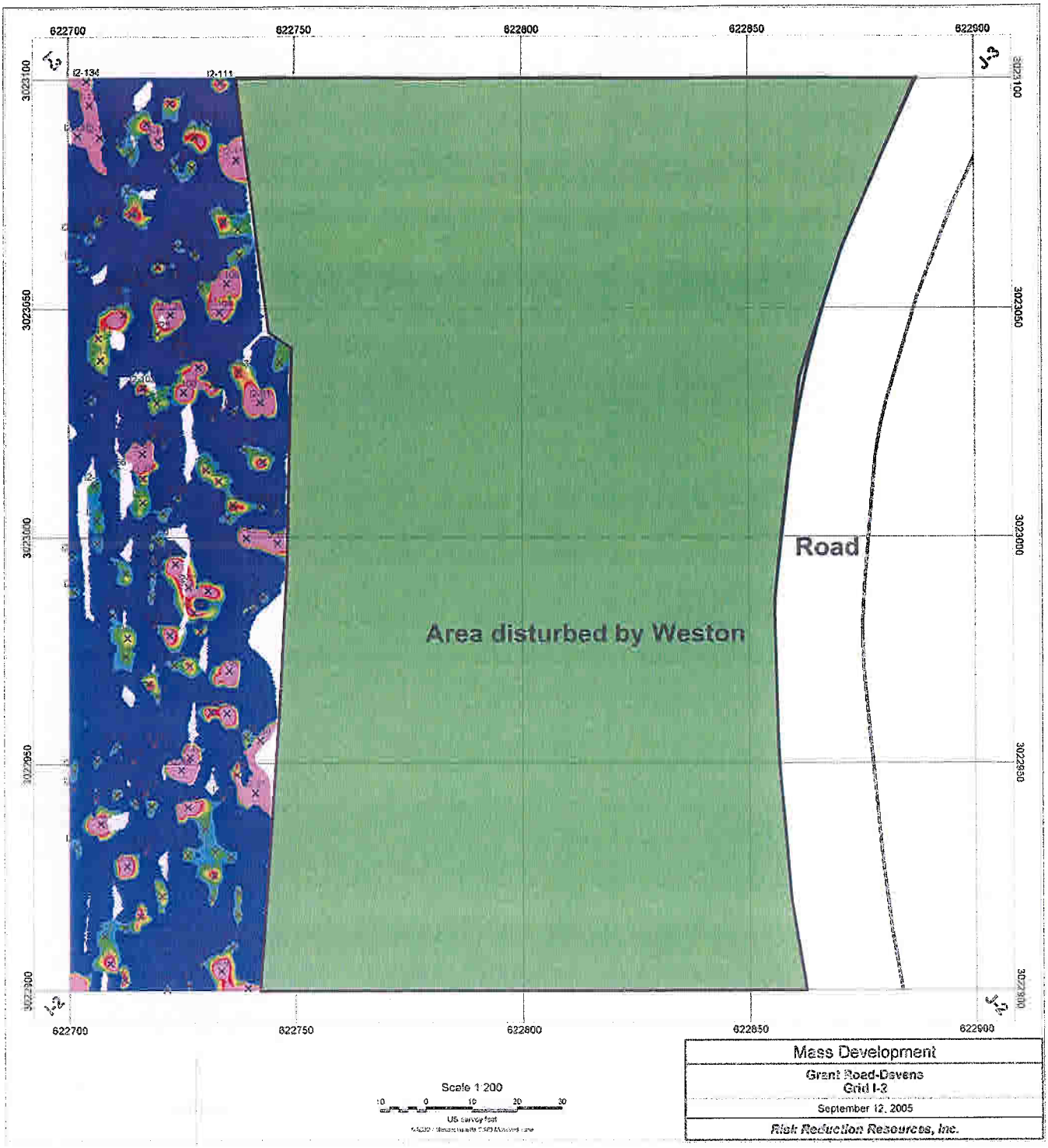

622500
622550
622600
622650
622700
3024900
3024850
3024800
3024750
3024700
H-12
I-12
H-11
I-11
H11-153
Edge of Brush Cutting
Not Surveyed Due to Brush
Not Surveyed
Utilities
Road
Scale 1 200
US survey feet
Mass Development
Grant Road-Devonie
Grid H-11
October 2, 2005
Risk Reduction Resources, Inc.

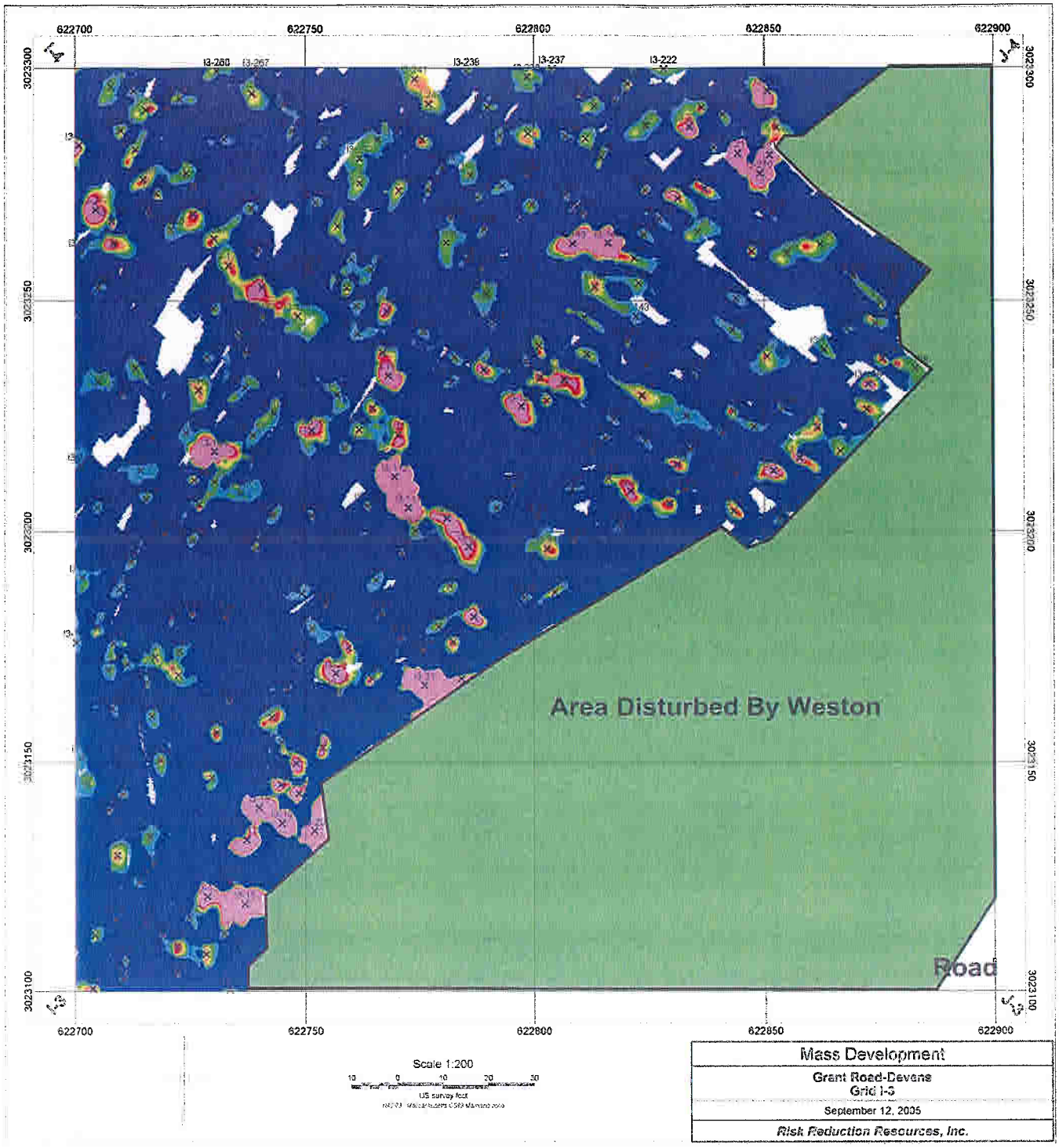


Mass Development
Grant Road-Devens Grid I-0
September 12, 2005
Risk Reduction Resources, Inc.

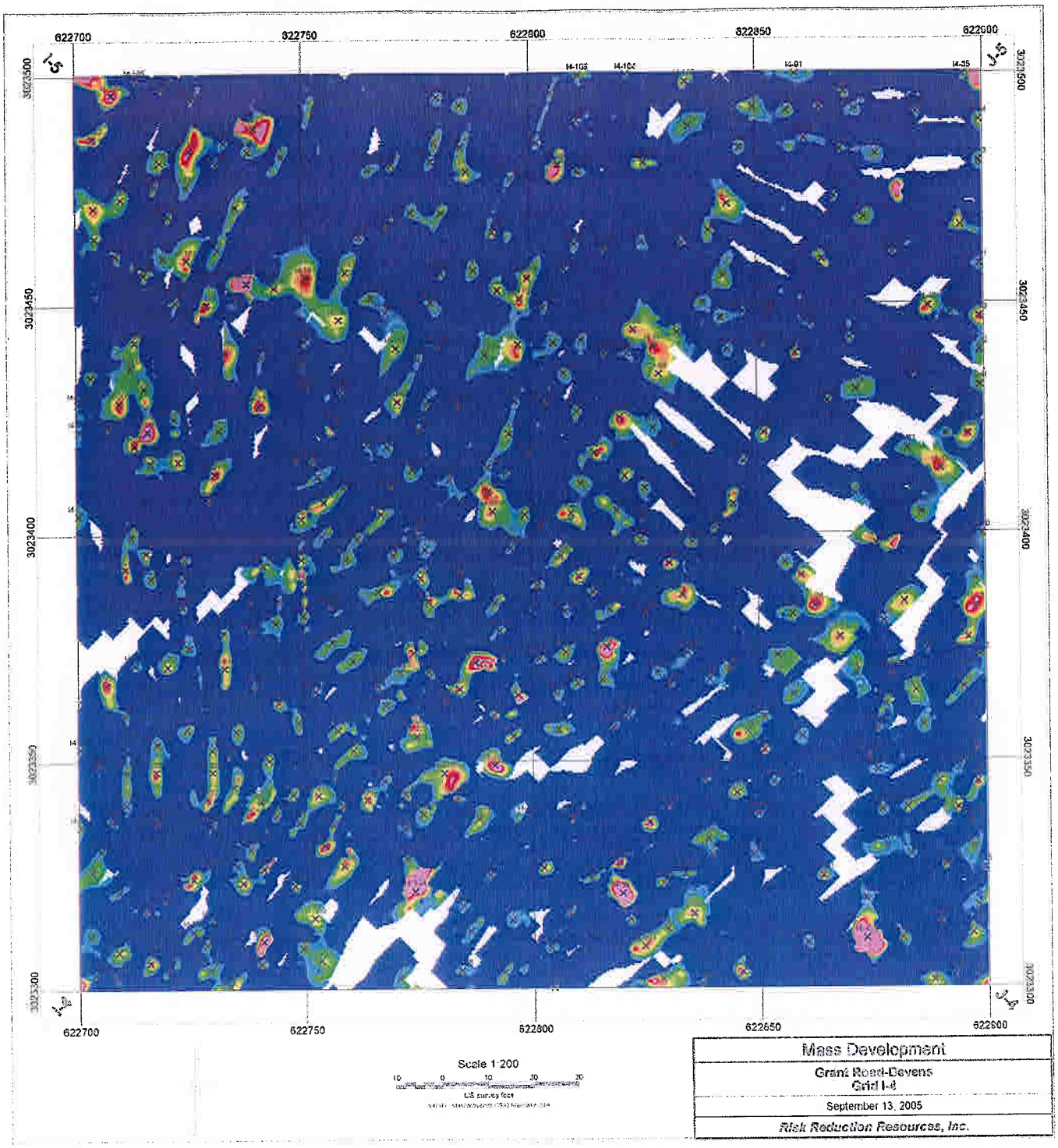


622700
622750
622800
622850
622900
3022900
3022850
3022800
3022750
3022700
I-2
I-1
I-70
Area disturbed by Weston
Limits or Brush Cutting
Road
Scale 1:200
US survey feet
Mass Development
Grant Road-Devens
Grid I-1
September 12, 2005
Risk Reduction Resources, Inc.

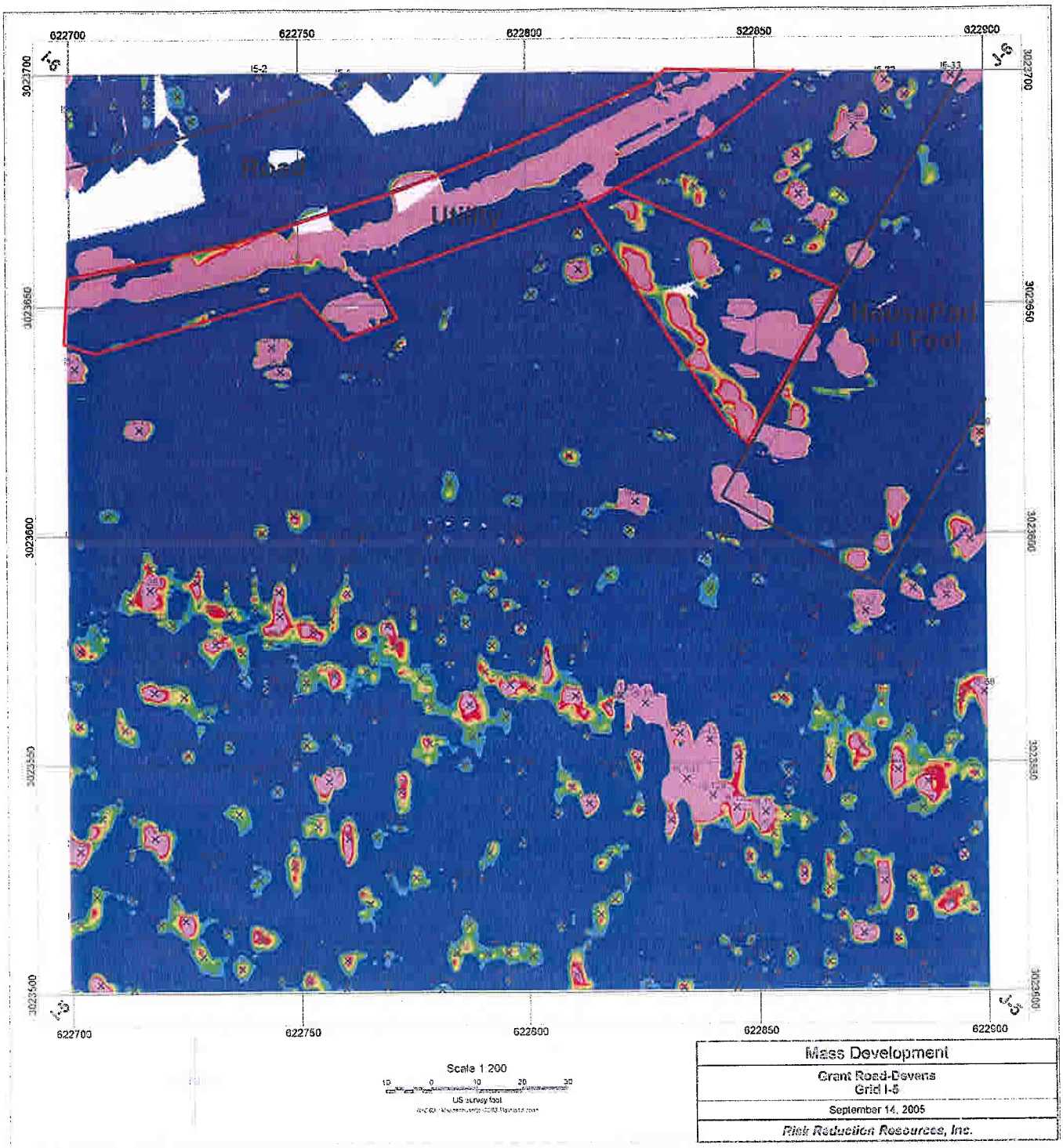

622700
622750
622800
622850
622900
3023100
3023050
3023000
3022950
3022900
I2-134
I2-111
I-2
I-3
Road
Area disturbed by Weston
Scale 1:200
10 0 10 20 30
US Survey Feet
Mass Development
Grant Road-Devens
Grid I-2
September 12, 2005
Risk Reduction Resources, Inc.



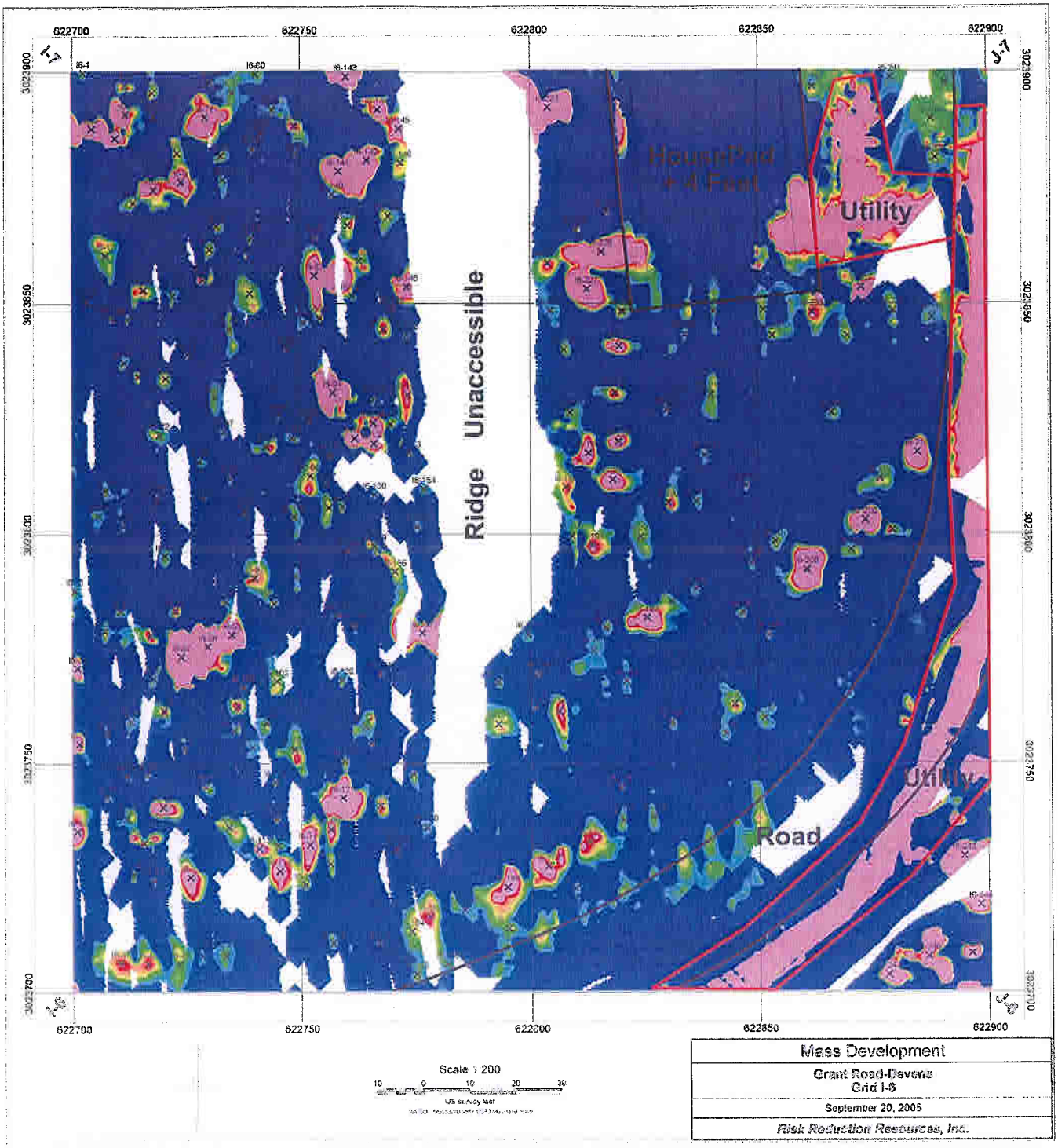
Mass Development
Grant Road-Devens Grid I-3
September 12, 2005
Risk Reduction Resources, Inc.



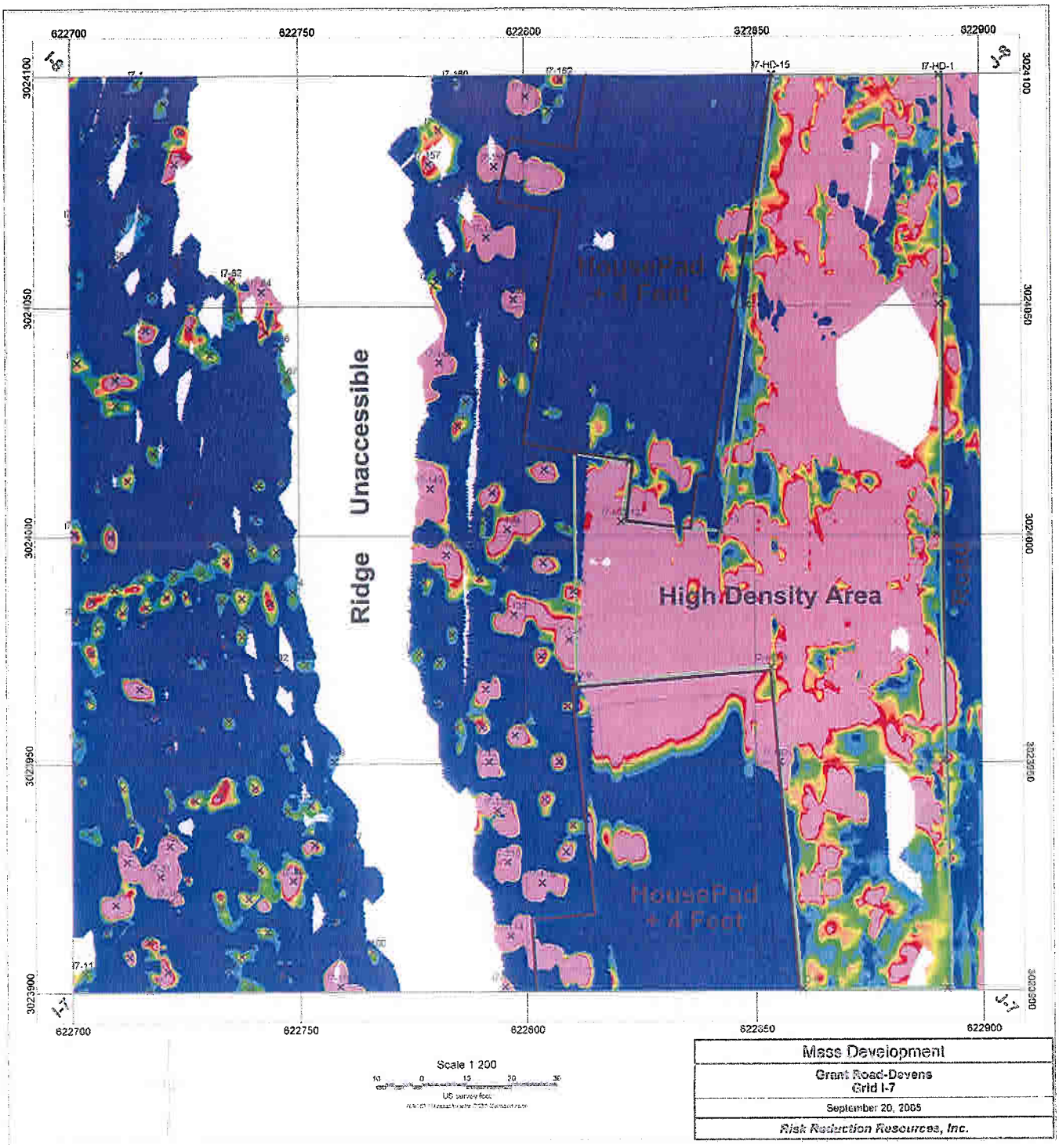
Mass Development
Grant Road-Devens Grid I-4
September 13, 2005
Risk Reduction Resources, Inc.



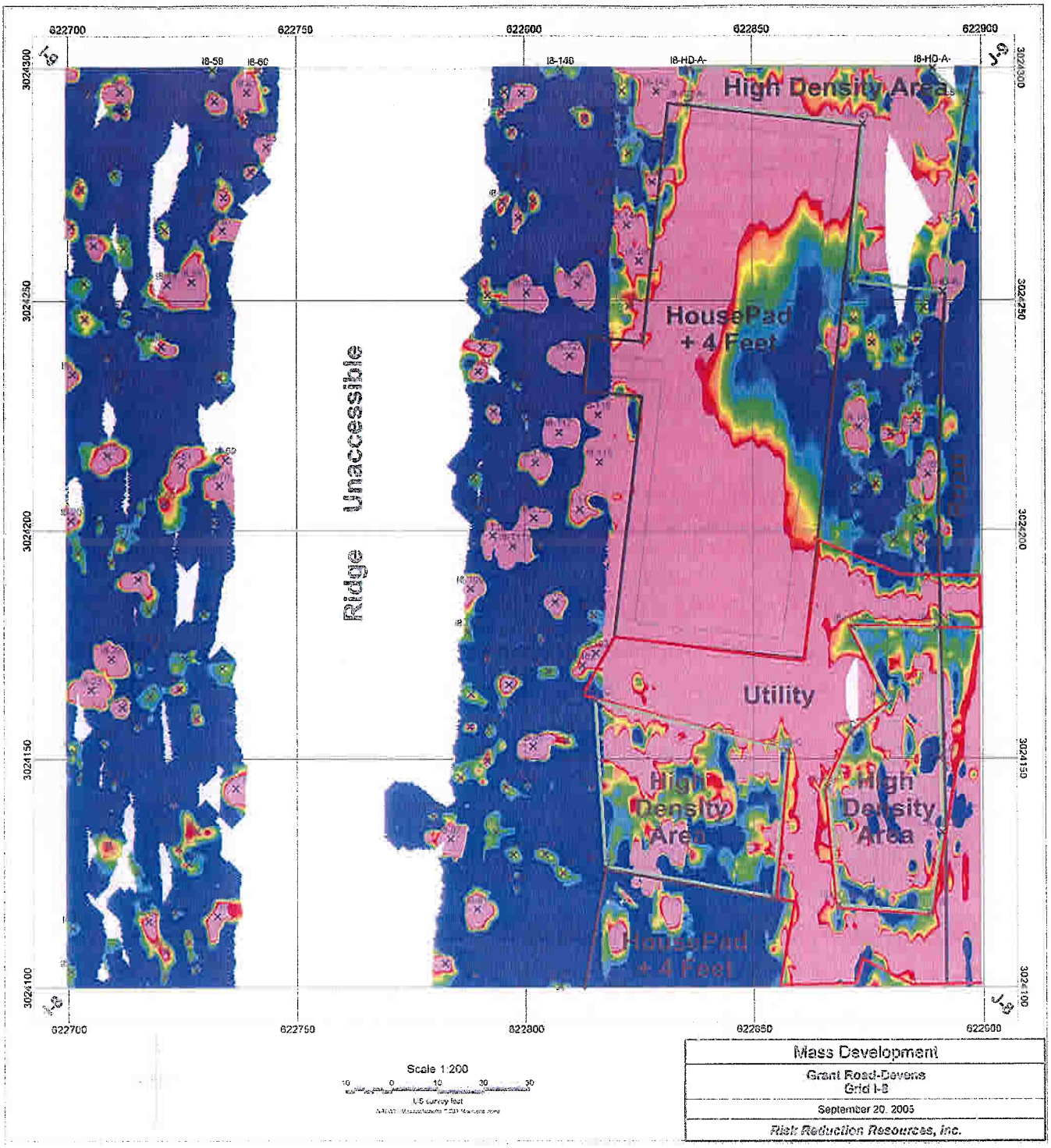
Mass Development
Grant Road-Devens Grid I-5
September 14, 2005
Risk Reduction Resources, Inc.

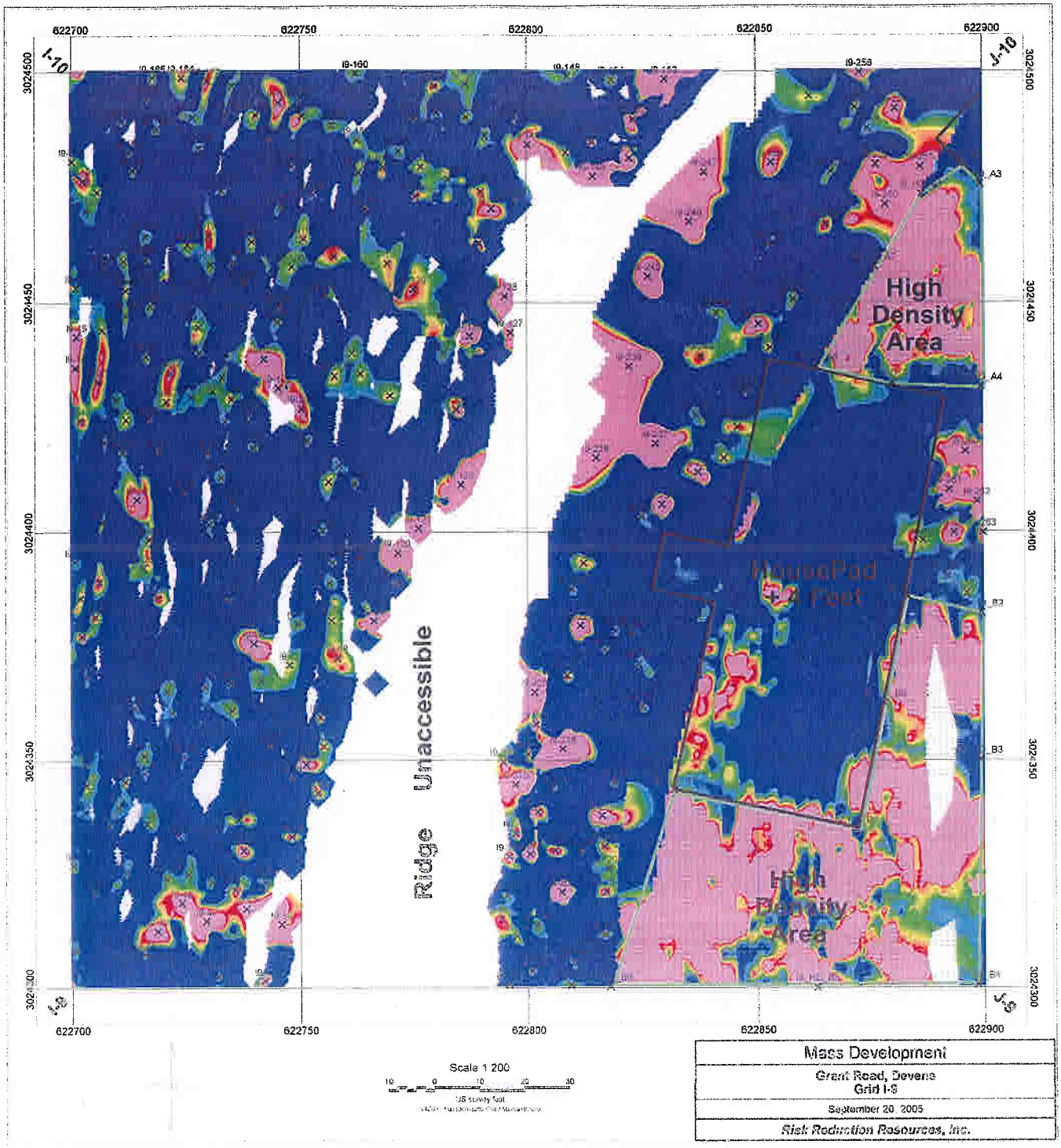


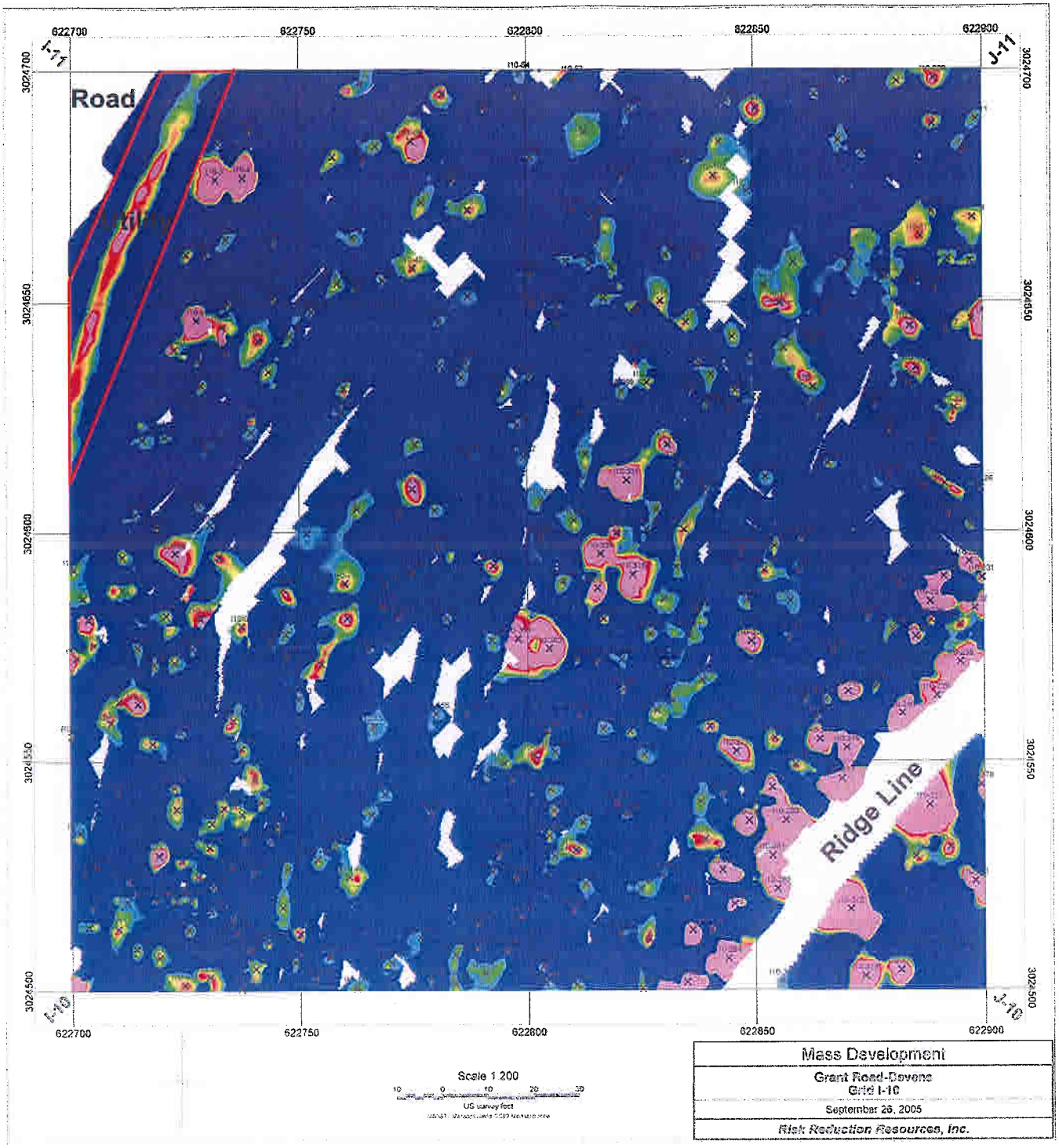
Mass Development
Grant Road-Stevens Grid I-8
September 20, 2005
Risk Reduction Resources, Inc.



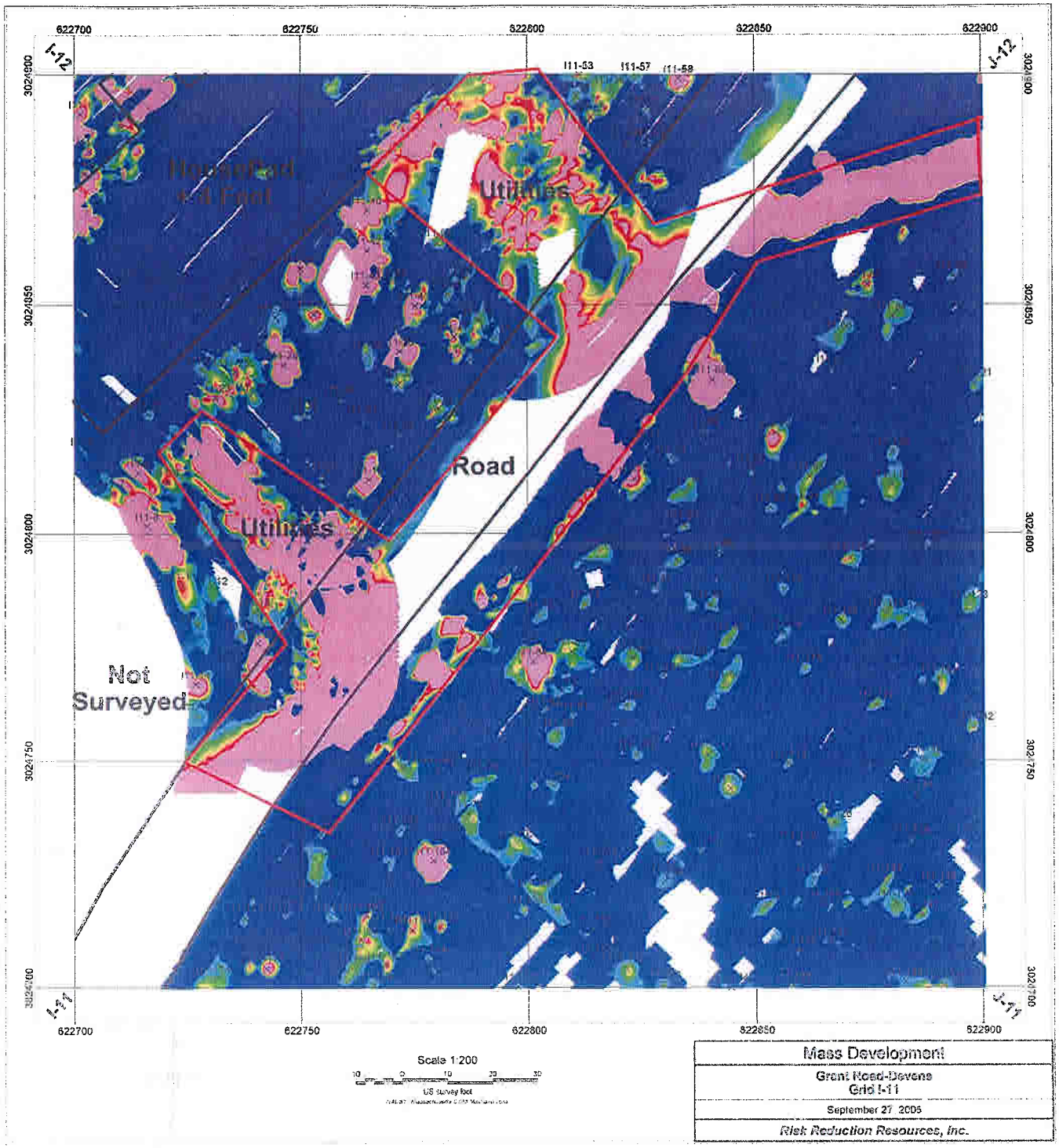
Mass Development
Grant Road-Devens Grid I-7
September 20, 2005
Risk Reduction Resources, Inc.

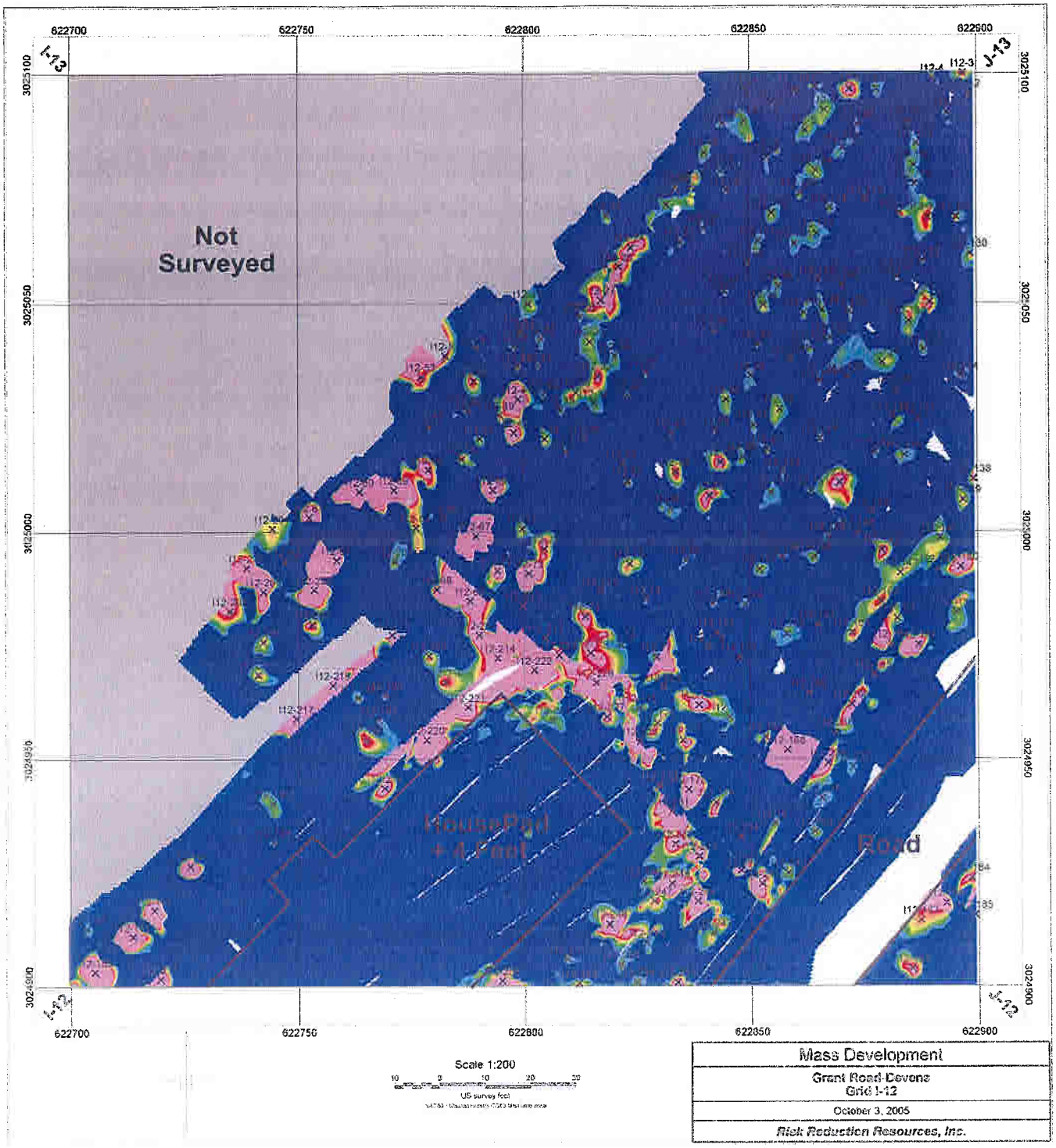

622700
622750
622800
622850
622900
3024300
3024250
3024200
3024150
3024100
I-9
J-9
I8-59
I8-60
I8-140
I8-HD-A-
I8-HD-A-
High Density Area
HousePad
+ 4 Feet
Ridge Unaccessible
Utility
High
Density
Area
High
Density
Area
HousePad
+ 4 Feet
Scale 1:200
10 0 10 30 30
US survey feet
Mass Development
Grant Road-Devens
Grid I-8
September 20, 2005
Risk Reduction Resources, Inc.


622700
622750
622800
622850
622900
I-10
J-10
I-9
J-9
3024500
3024450
3024400
3024350
3024300
I9-160
I9-148
I9-256
A3
A4
B2
B3
B4
High Density Area
HousePad ± 2 Feet
Ridge Unaccessible
High Density Area
Scale 1 200
10 0 10 20 30
US survey foot
Mass Development
Grant Road, Devens
Grid I-9
September 26, 2005
Risk Reduction Resources, Inc.

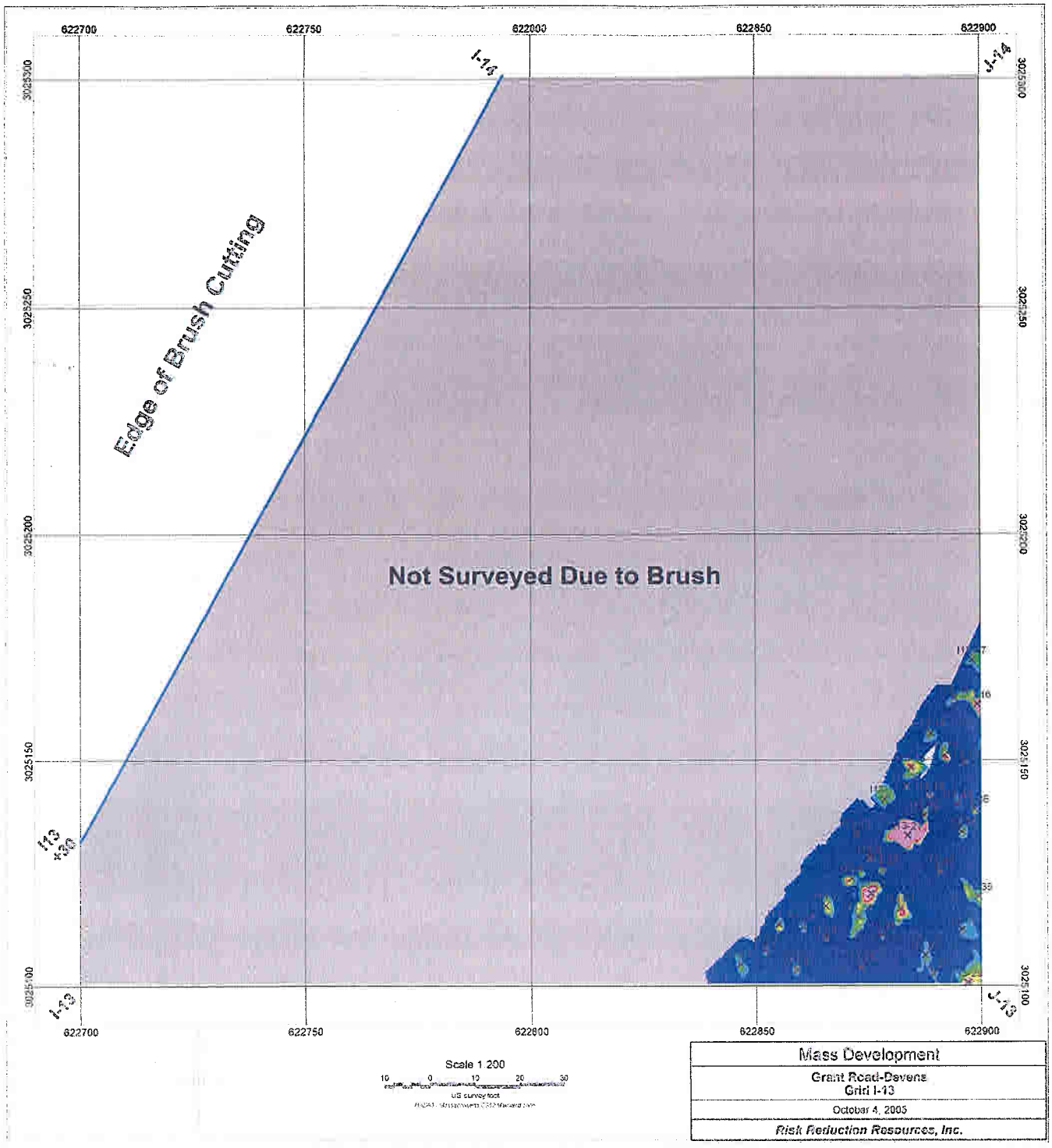


Mass Development
Grant Road-Devens Grid I-10
September 26, 2005
Risk Reduction Resources, Inc.

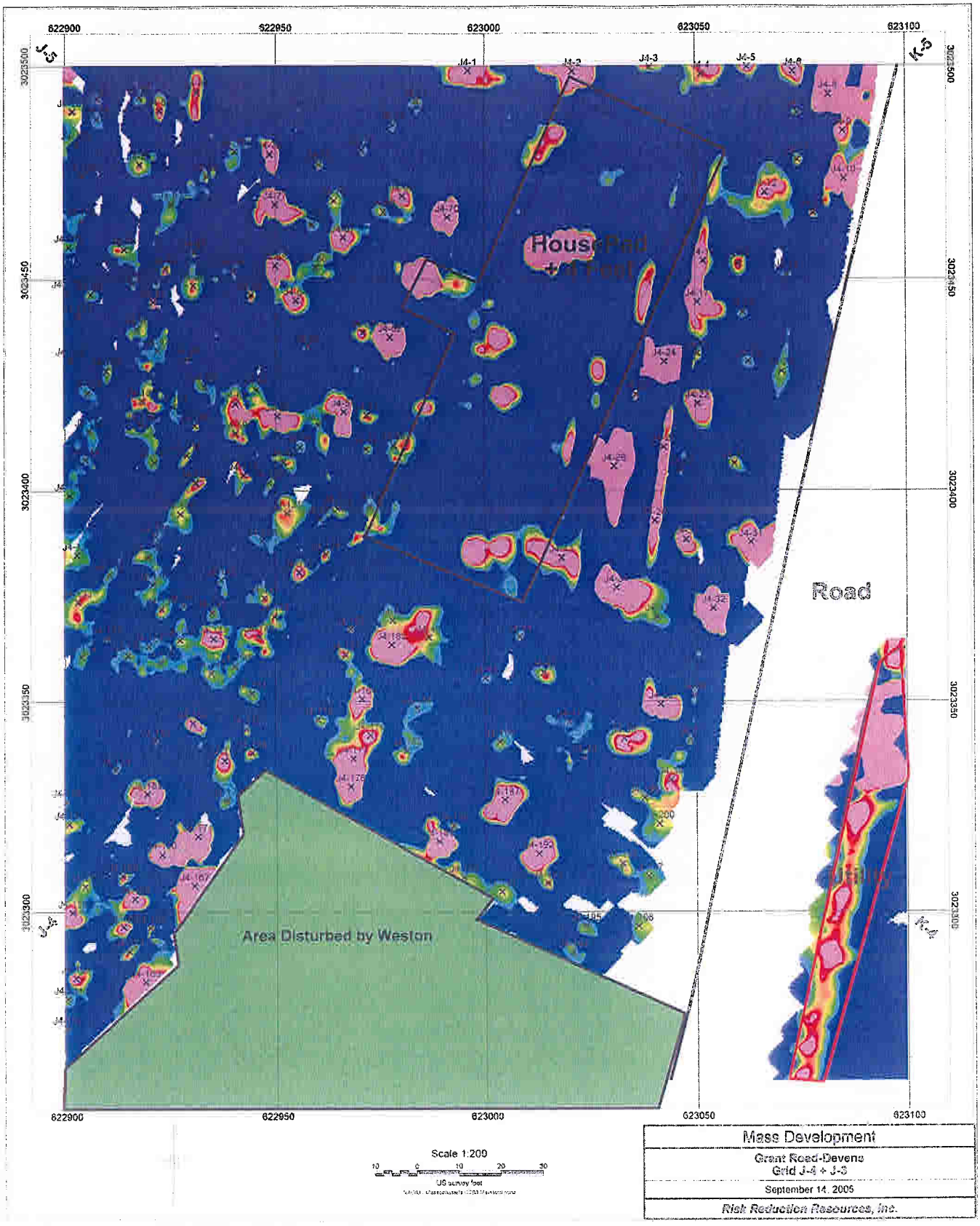

622700
622750
622800
622850
622900
I-12
I-11
3024900
3024850
3024800
3024750
3024700
111-53
111-57
111-58
Houseyard
+1 Foot
Utilities
Road
Utilities
Not
Surveyed
Scale 1:200
10 0 10 20 30
US survey feet
Mass Development
Grant Road-Devens
Grid I-11
September 27 2005
Risk Reduction Resources, Inc.

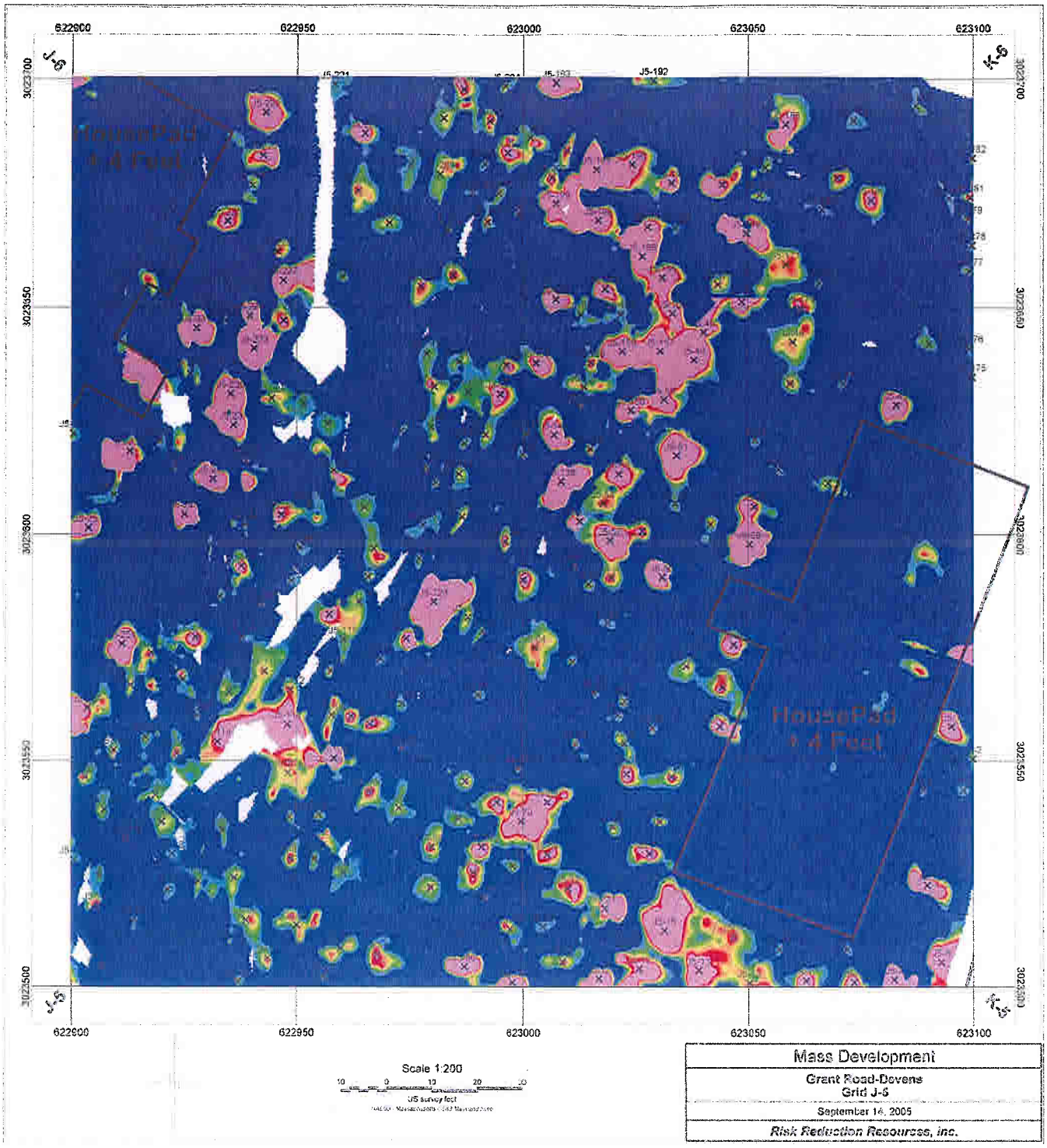


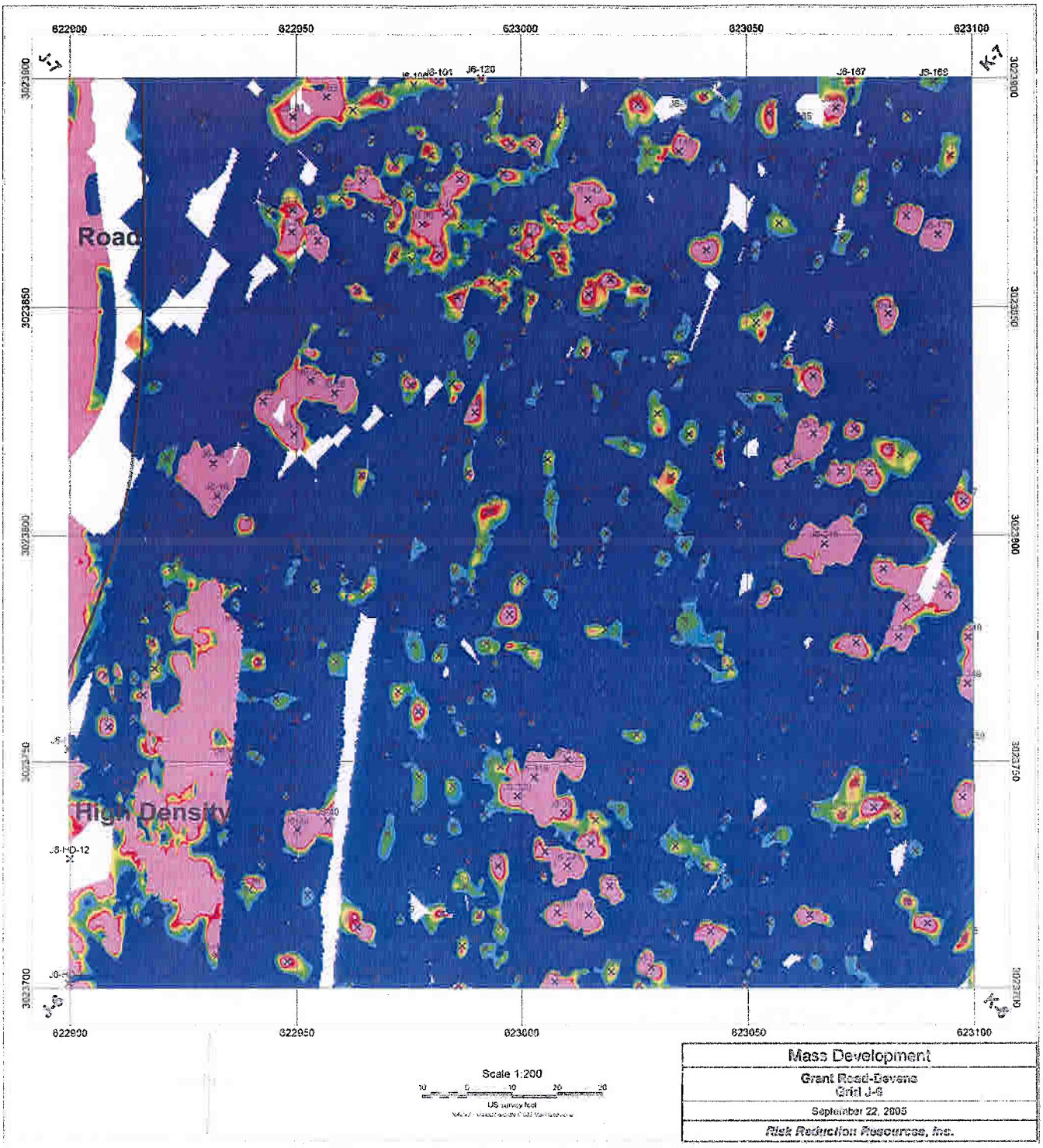
Mass Development
Grant Road-Devens Grid I-12
October 3, 2005
Risk Reduction Resources, Inc.



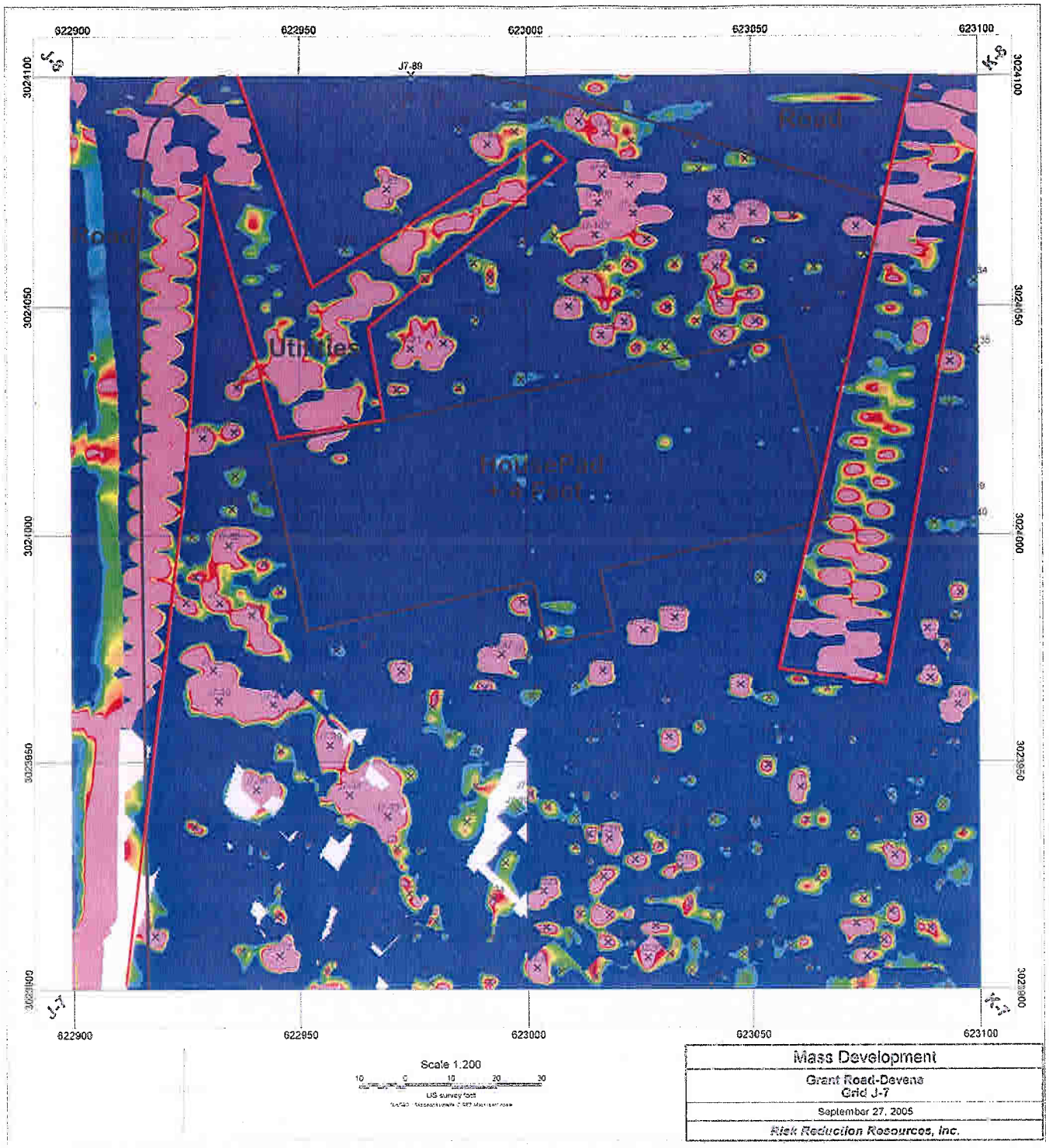
Mass Development
Grant Road-Devens Grid I-13
October 4, 2005
Risk Reduction Resources, Inc.


622900
622950
623000
623050
623100
3023500
3023450
3023400
3023350
3023300
K-5
J-5
J4-1
J4-2
J4-3
J4-5
J4-6
House Pad
+ Road
Road
Area Disturbed by Weston
Scale 1:200
10 0 10 20 30
US survey feet
Mass Development
Grant Road-Devens
Grid J-4 + J-3
September 14, 2005
Risk Reduction Resources, Inc.

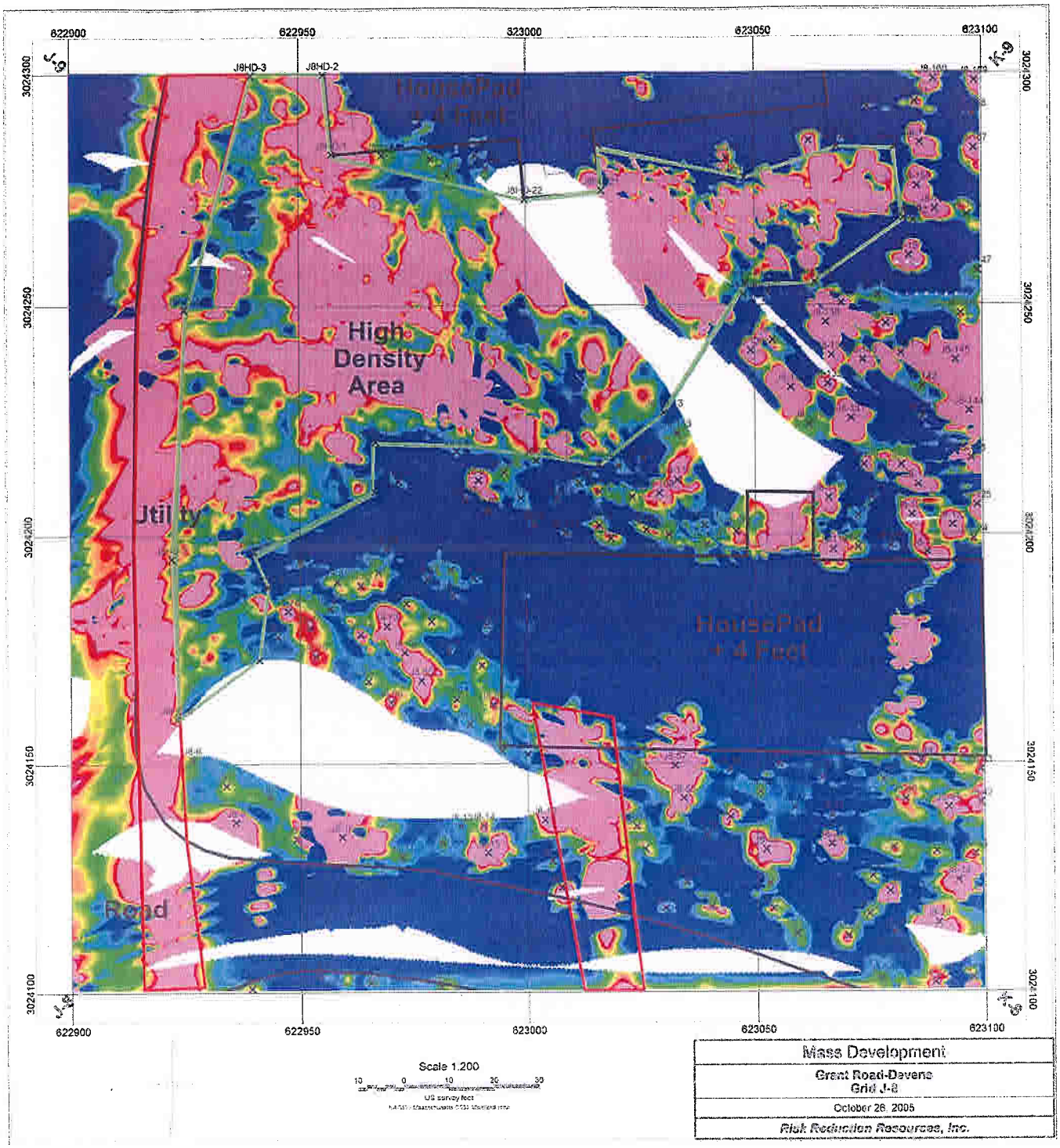

622900
622950
623000
623050
623100
J-5
K-5
J5-192
HousePad
+ 4 Feet
HousePad
+ 4 Feet
3023700
3023650
3023600
3023550
3023500
Scale 1:200
10 0 10 20
US survey feet
Mass Development
Grant Road-Devens
Grid J-5
September 16, 2005
Risk Reduction Resources, inc.

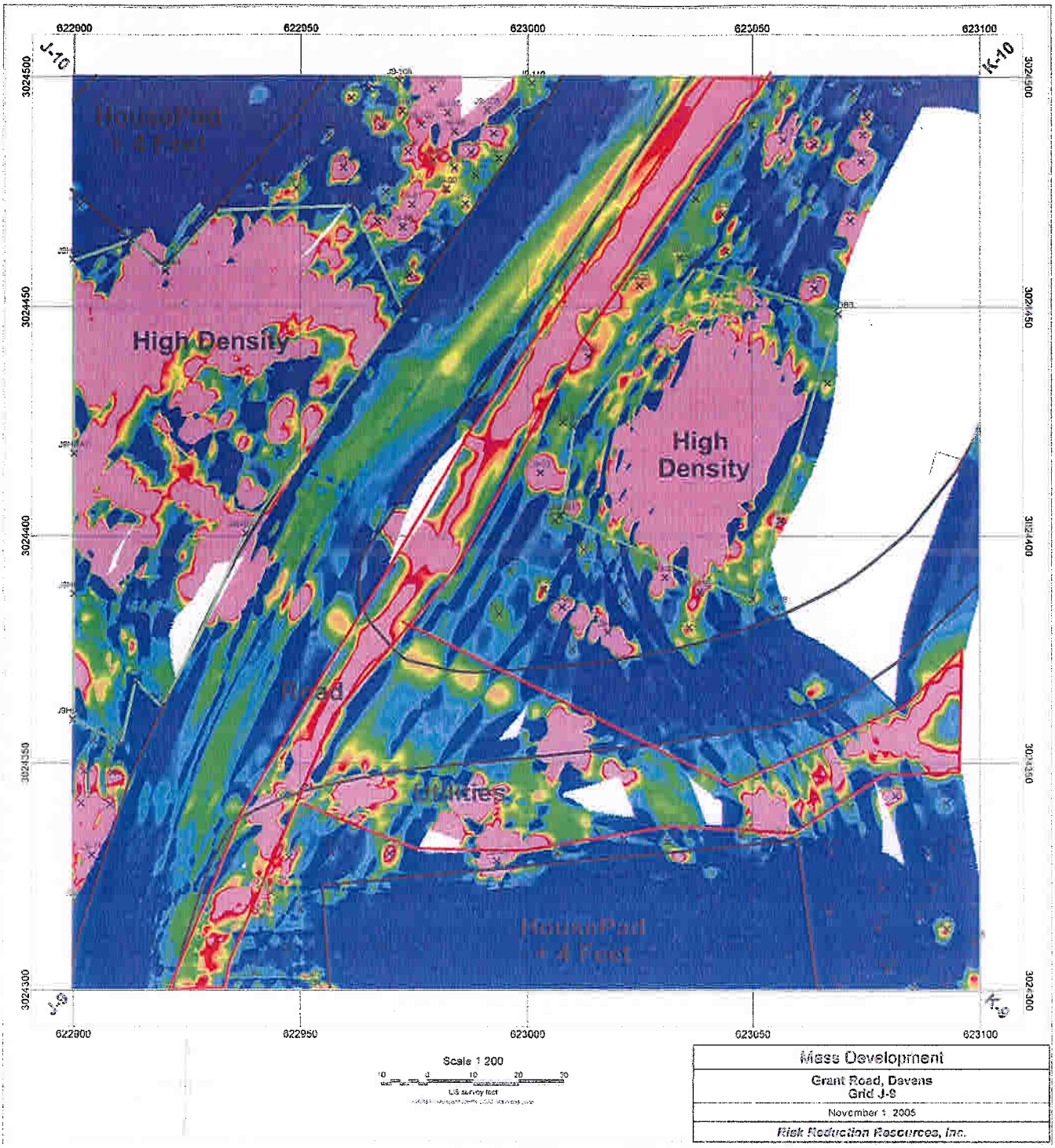


Mass Development
Grant Road-Devens Grid J-6
September 22, 2005
Risk Reduction Resources, Inc.

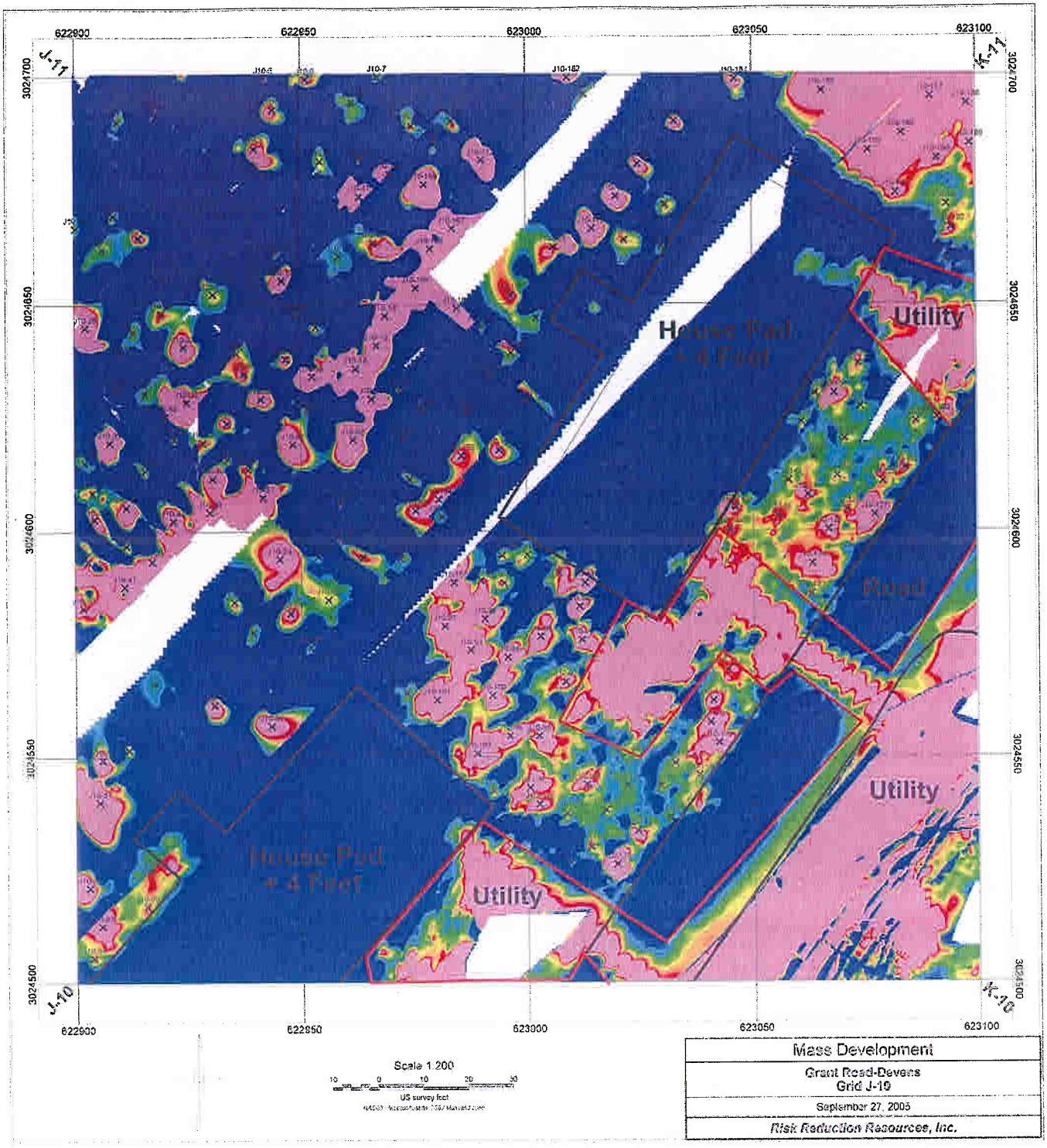


622900
622950
623000
623050
623100
3024100
3024050
3024000
3023950
3023900
J-8
K-8
J-7
K-7
J7-89
Road
Road
Utilities
HousePad
+ 4 Feet
Scale 1:200
10 0 10 20 30
US survey feet
Mass Development
Grant Road-Devena
Grid J-7
September 27, 2005
Risk Reduction Resources, Inc.

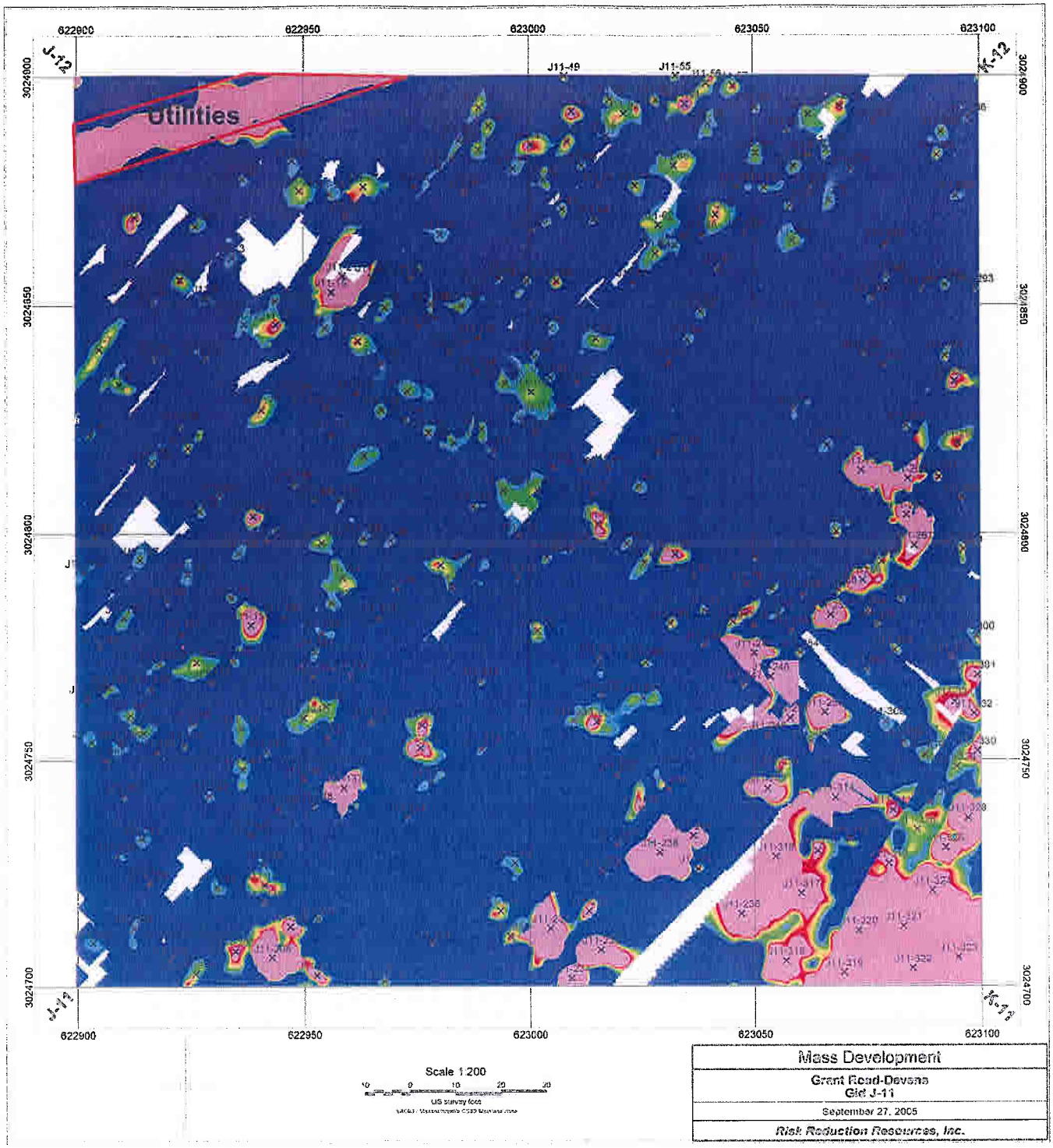

622900
622950
623000
623050
623100
3024300
3024250
3024200
3024150
3024100
J8HD-3
J8HD-2
J8HD-22
HousePad
+4 Feet
High
Density
Area
Jtility
HousePad
+4 Feet
Road
Scale 1:200
10 0 10 20 30
US survey feet
Mass Development
Grant Road-Davena
Grid J-8
October 26, 2005
Risk Reduction Resources, Inc.

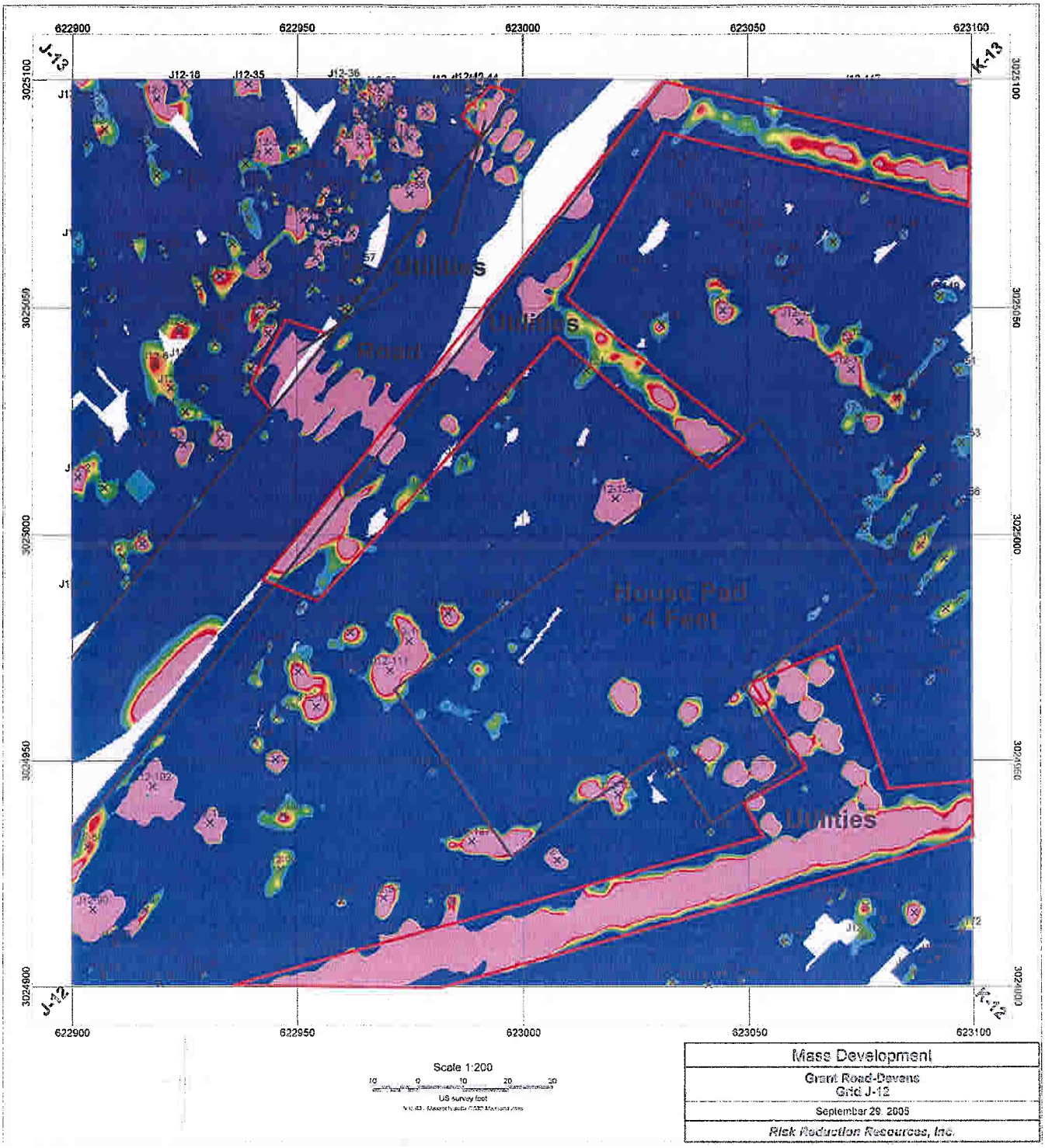


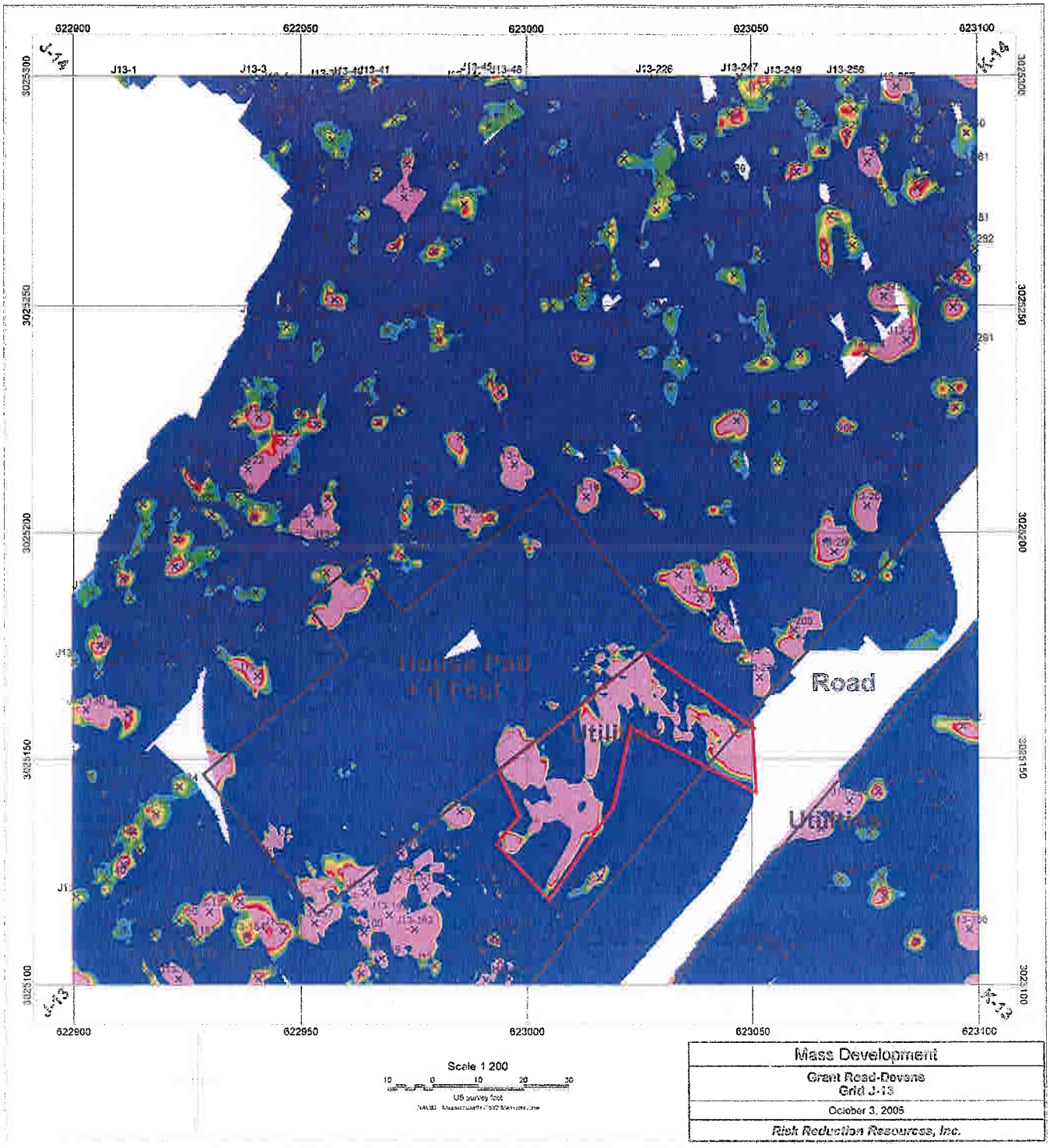
Mass Development
Grant Road, Devens Grid J-9
November 1 2005
Risk Reduction Resources, Inc.



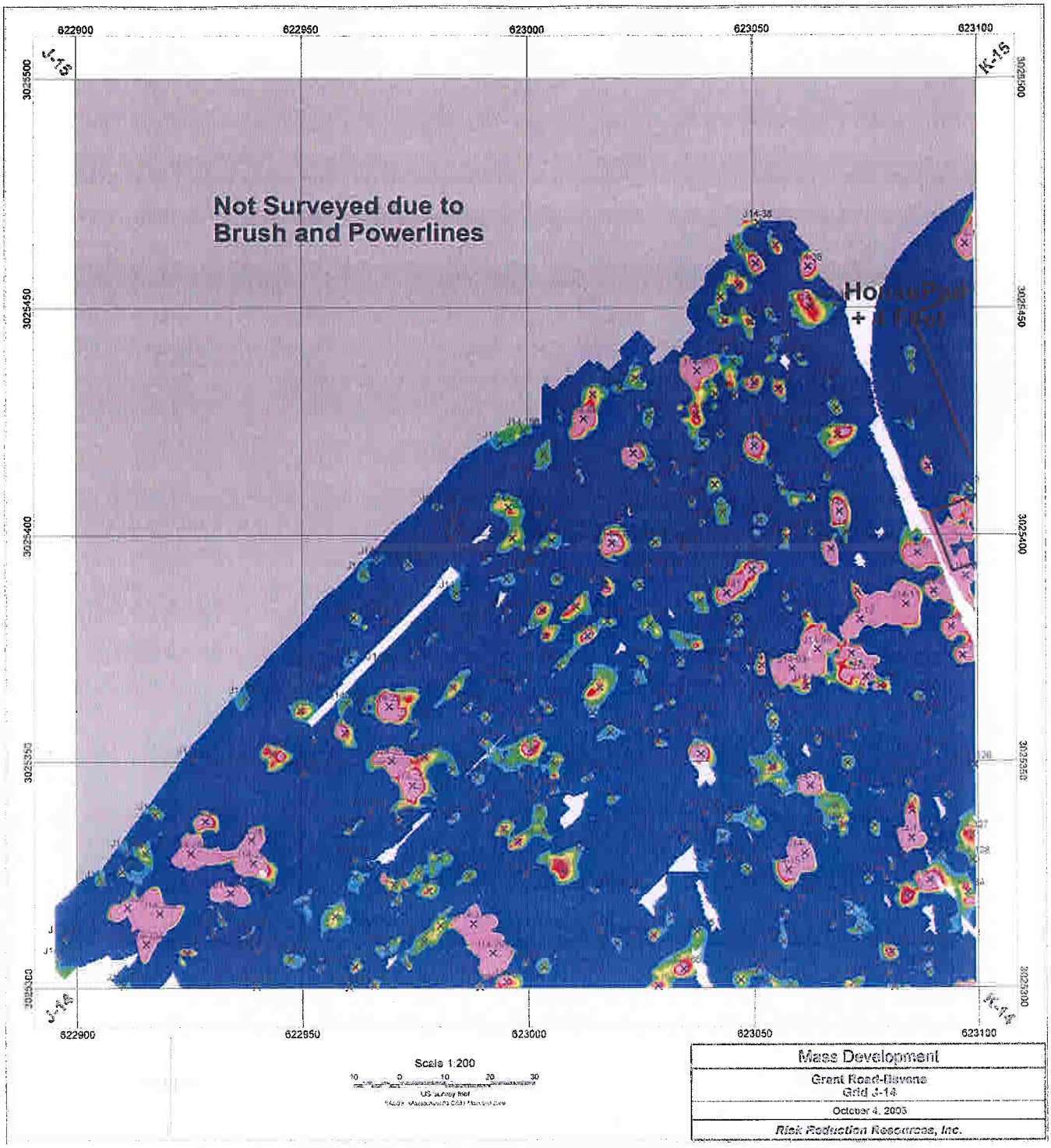
Mass Development
Grant Road-Devens Grid J-10
September 27, 2005
Risk Reduction Resources, Inc.


622900
622950
623000
623050
623100
3024900
3024850
3024800
3024750
3024700
J-12
K-12
J11-49
J11-55
Utilities
Scale 1:200
10 0 10 20 30
US survey foot
Mass Development
Grant Road-Devens
Gid J-11
September 27, 2005
Risk Reduction Resources, Inc.

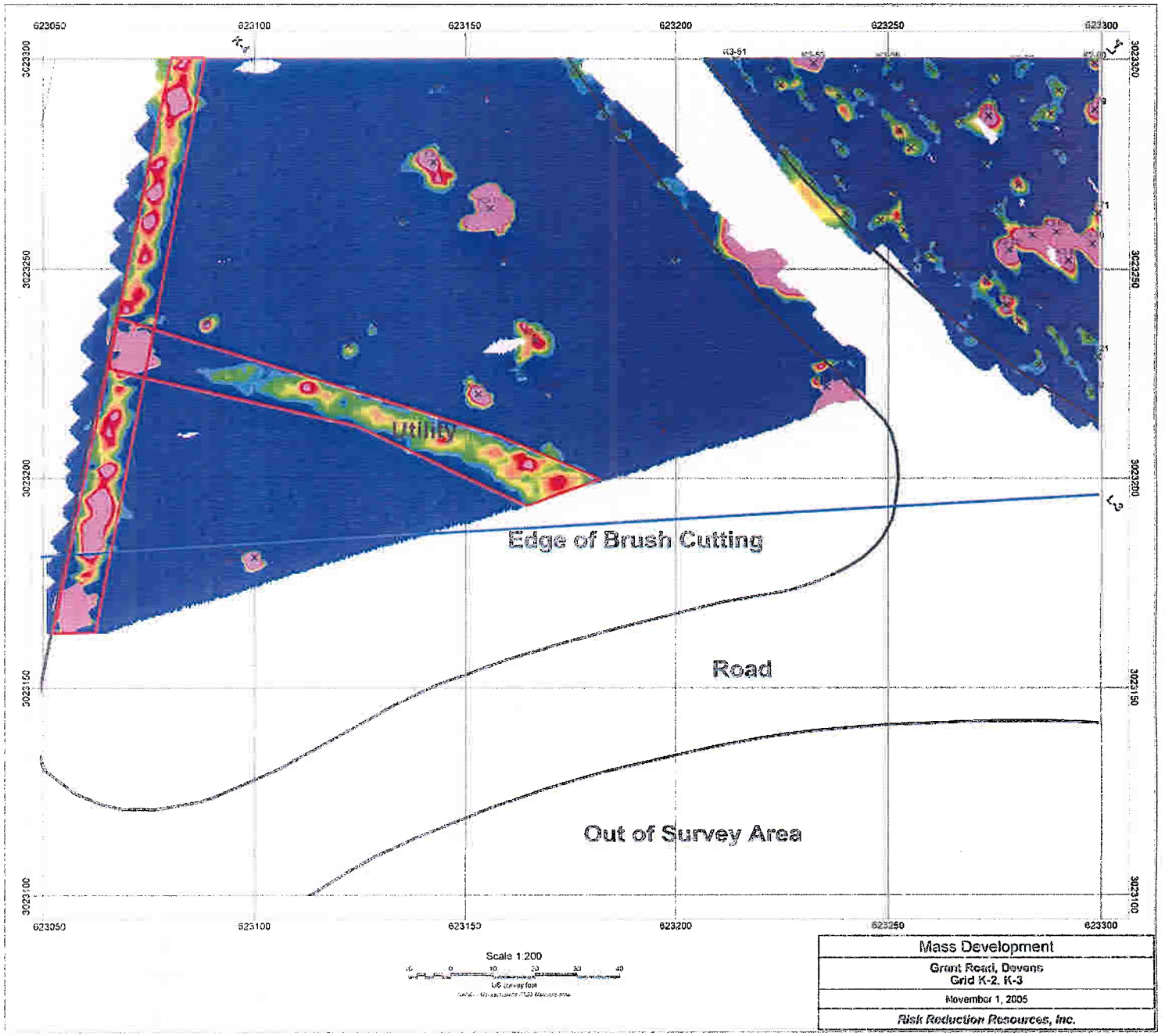

622900
622950
623000
623050
623100
J-13
K-13
J-12
K-12
3025100
3025050
3025000
3024950
3024900
J12-18
J12-35
J12-36
Utilities
Road
Utilities
House Pad
+ 4 Feet
Utilities
Scale 1:200
10 0 10 20 30
US survey feet
Mass Development
Grant Road-Devens
Grid J-12
September 29, 2005
Risk Reduction Resources, Inc.

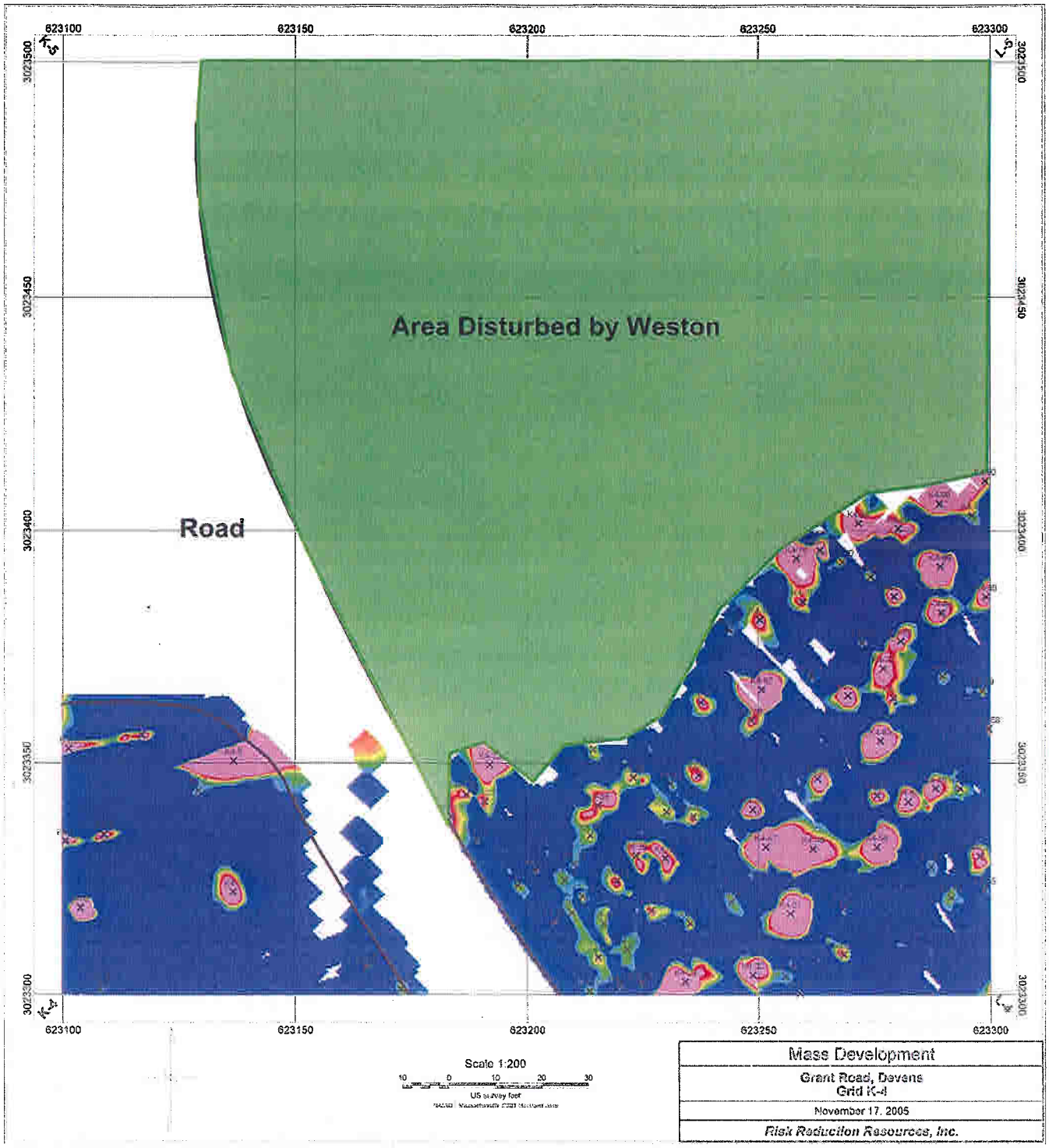


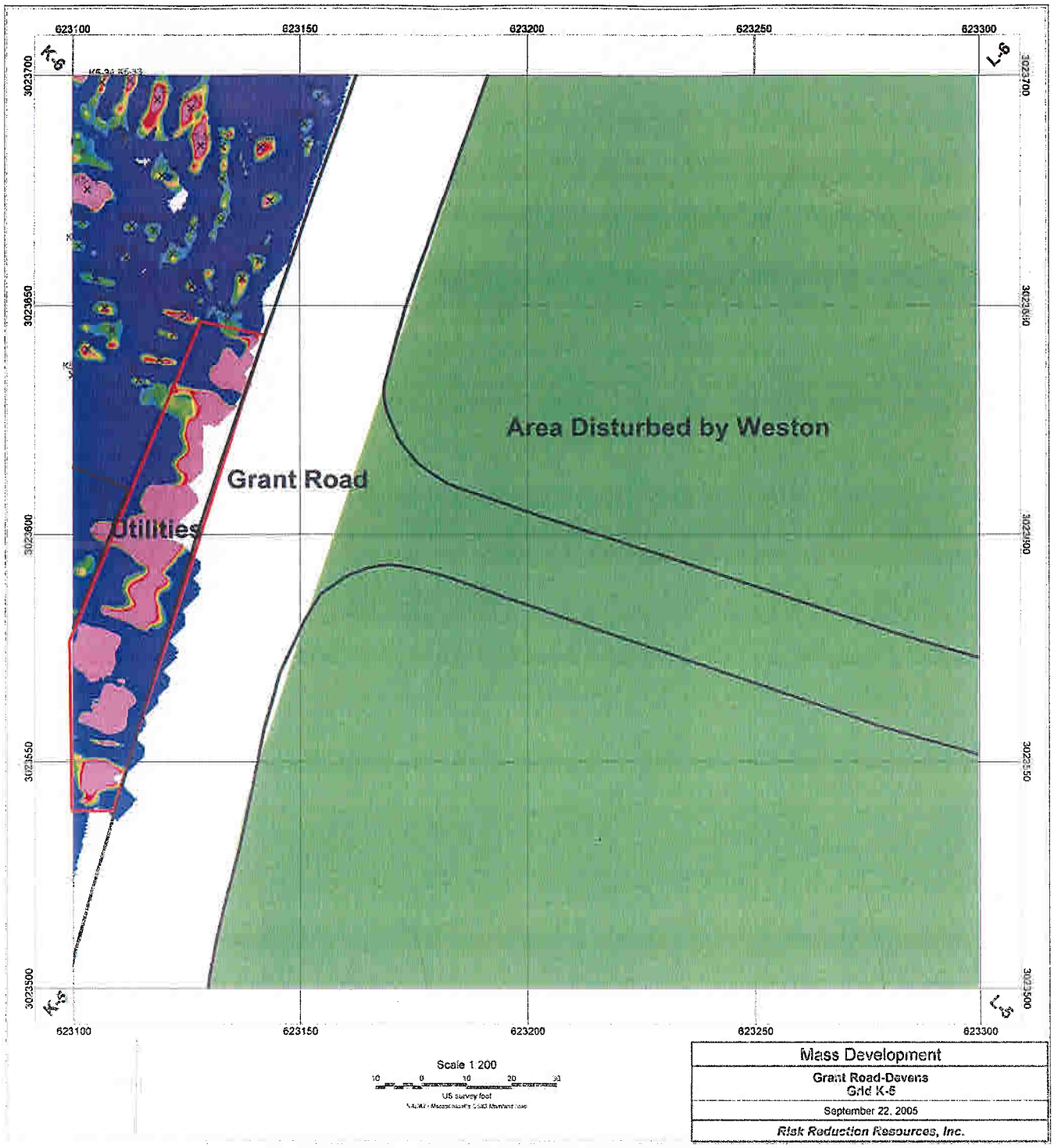
Mass Development
Grant Road-Devens Grid J-13
October 3, 2005
Risk Reduction Resources, Inc.



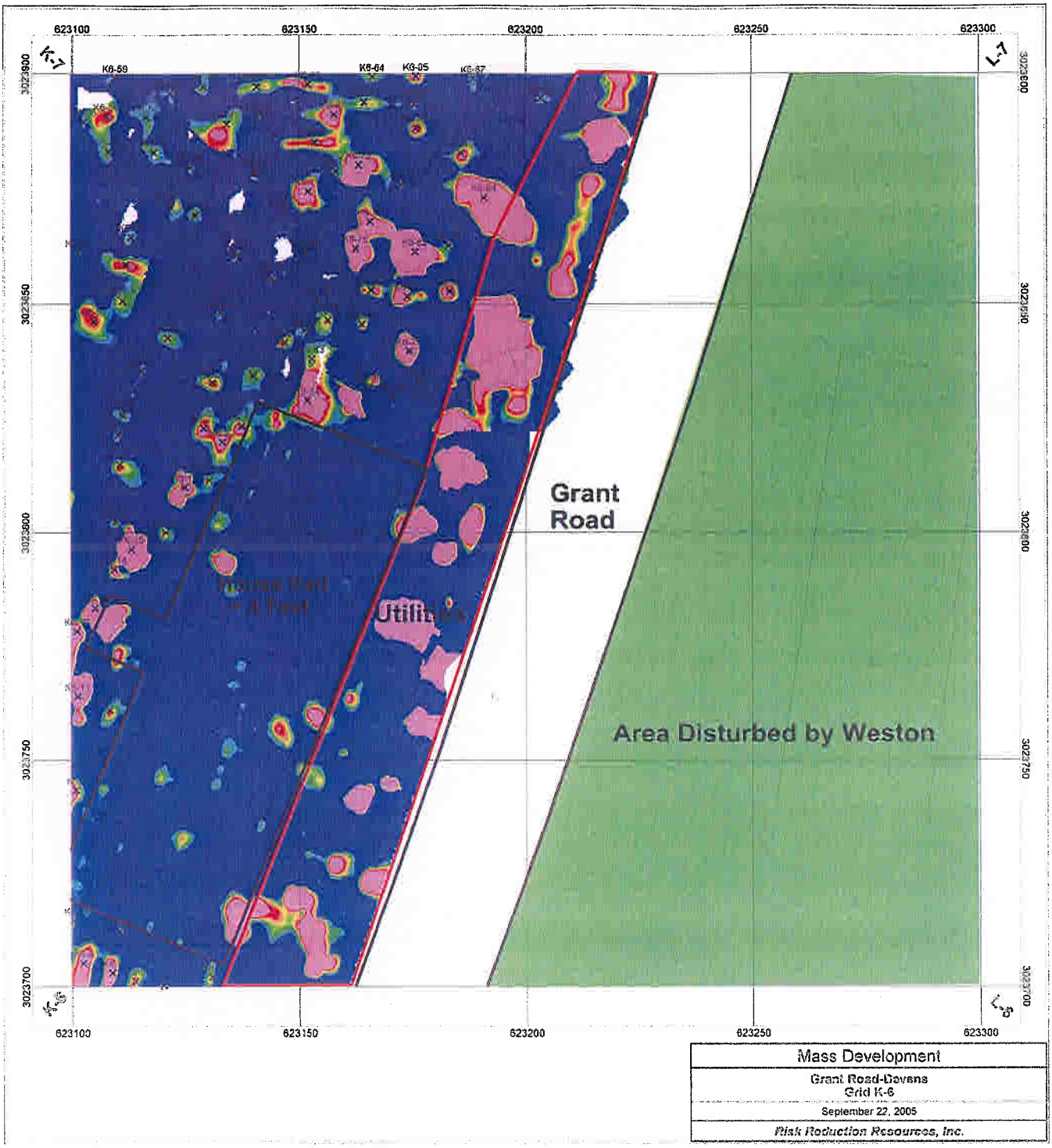
Mass Development
Grant Road-Revere Grid J-14
October 4, 2005
Risk Reduction Resources, Inc.


623050
623100
623150
623200
623250
623300
3023300
3023250
3023200
3023150
3023100
K-3
K-2
K3-51
Utility
Edge of Brush Cutting
Road
Out of Survey Area
Scale 1:200
Mass Development
Grant Road, Devens
Grid K-2, K-3
November 1, 2005
Risk Reduction Resources, Inc.


623100
623150
623200
623250
623300
3023500
3023450
3023400
3023350
3023300
Area Disturbed by Weston
Road
Scale 1:200
10 0 10 20 30
US survey feet
Mass Development
Grant Road, Devens
Grid K-4
November 17, 2005
Risk Reduction Resources, Inc.



Mass Development
Grant Road-Davens Grid K-5
September 22, 2005
Risk Reduction Resources, Inc.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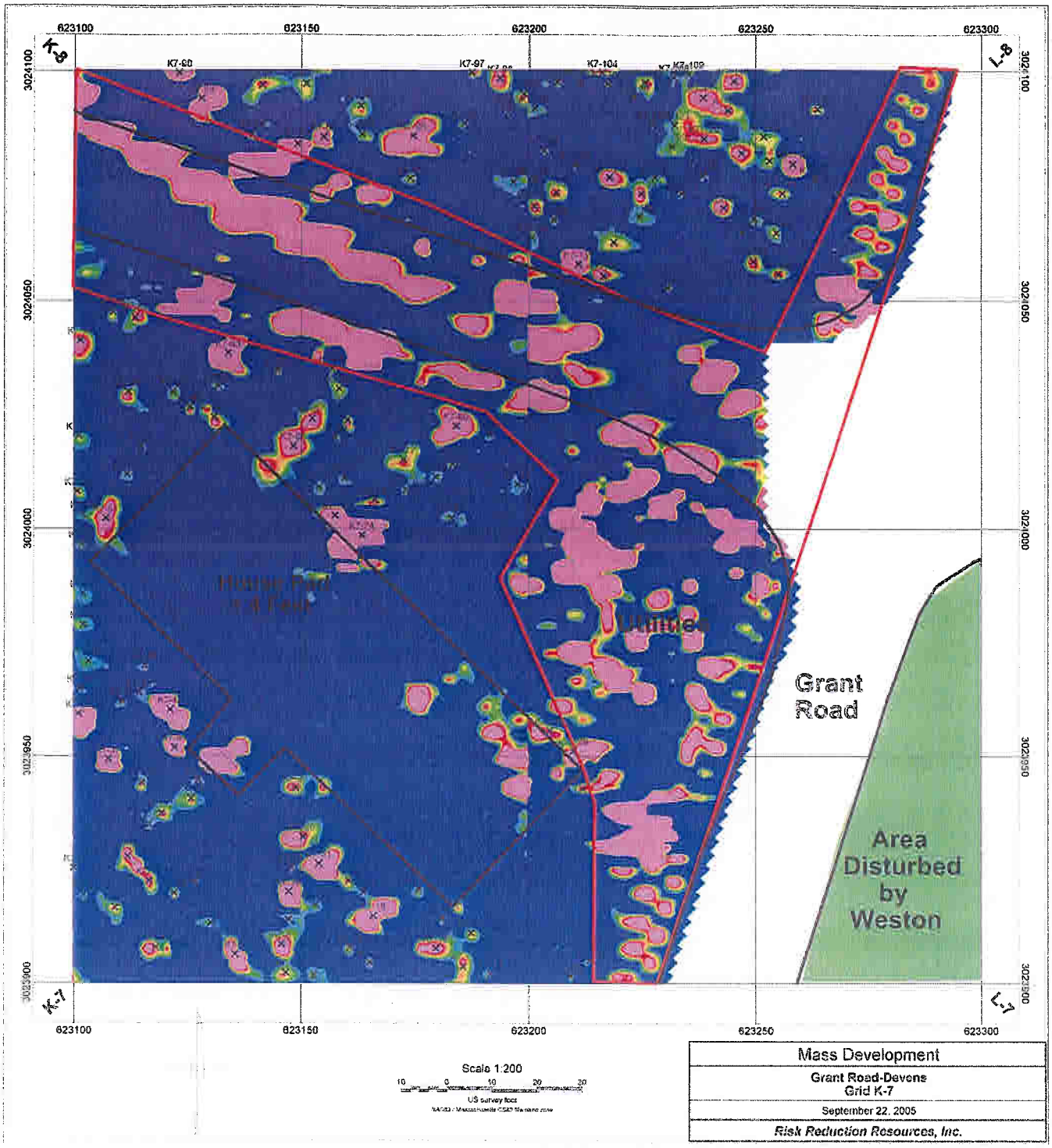
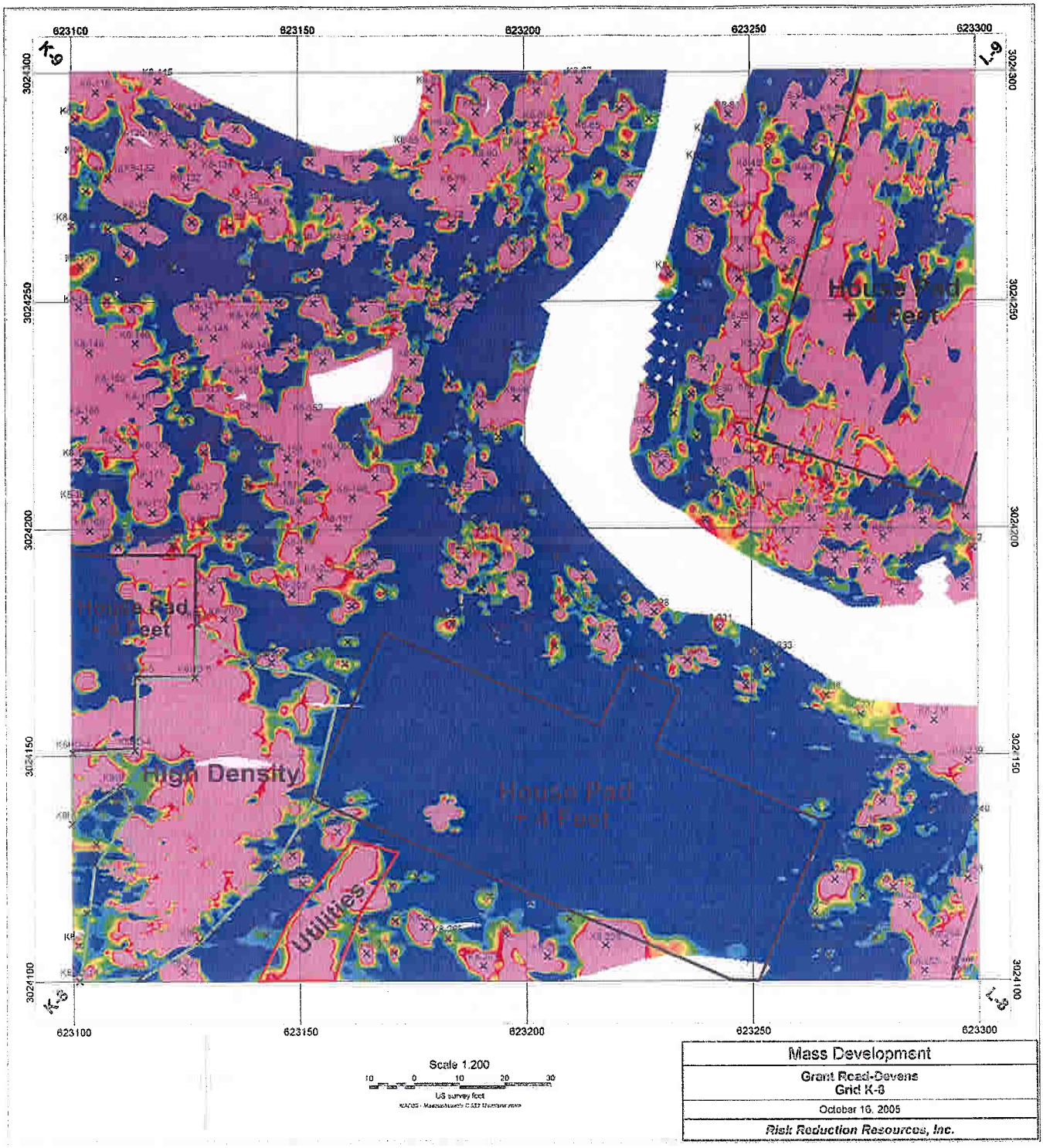
623150
623200
623250
623300
K-7
L-7
K-6
L-6
K6-59
K6-64
K6-65
K6-67
3023900
3023850
3023800
3023750
3023700
Grant
Road
Area Disturbed by Weston
Mass Development
Grant Road-Devens
Grid K-6
September 22, 2005
Risk Reduction Resources, Inc.



Mass Development
Grant Road-Devens Grid K-7
September 22, 2005
Risk Reduction Resources, Inc.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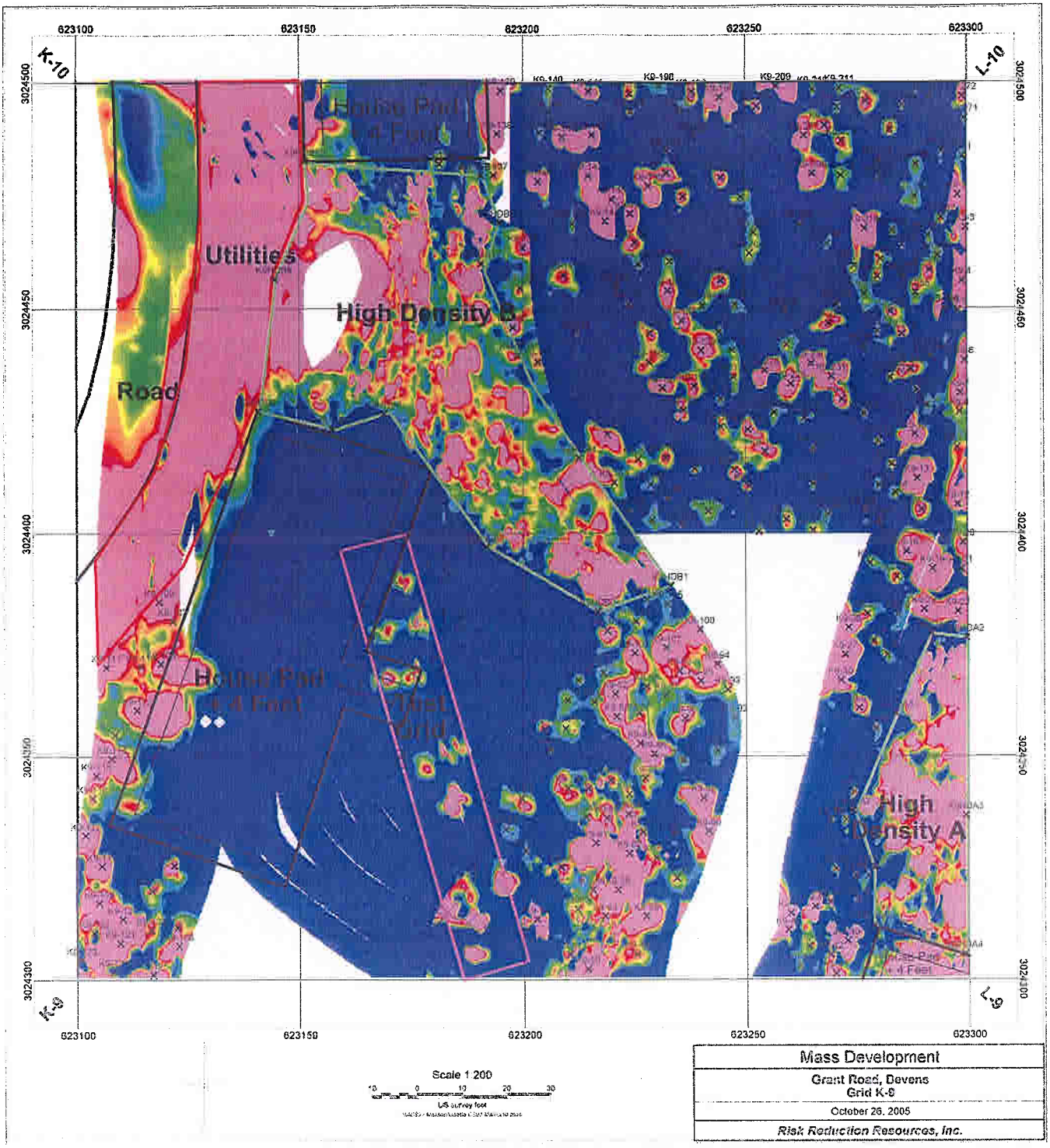
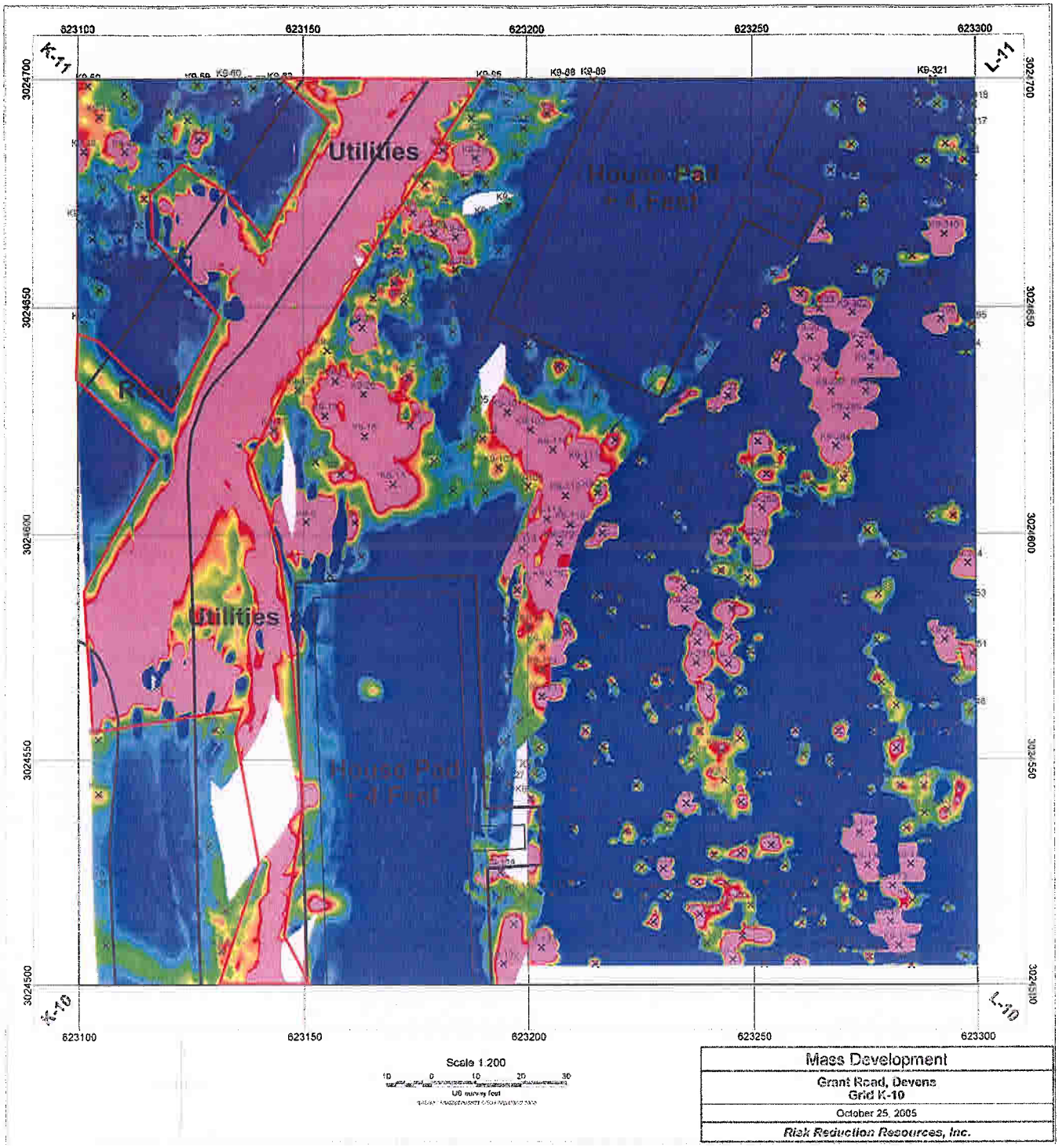
623150
623200
623250
623300
3024300
3024250
3024200
3024150
3024100
K-9
L-9
K-8
L-8
House Pad
+ 4 Feet
House Pad
+ 4 Feet
High Density
House Pad
+ 4 Feet
Utilities
Scale 1:200
10 0 10 20 30
US survey feet
NAD83 - Massachusetts ISS3 Mainland zone
Mass Development
Grant Road-Devens
Grid K-8
October 10, 2005
Risk Reduction Resources, Inc.



Mass Development
Grant Road, Devens Grid K-8
October 26, 2005
Risk Reduction Resources, Inc.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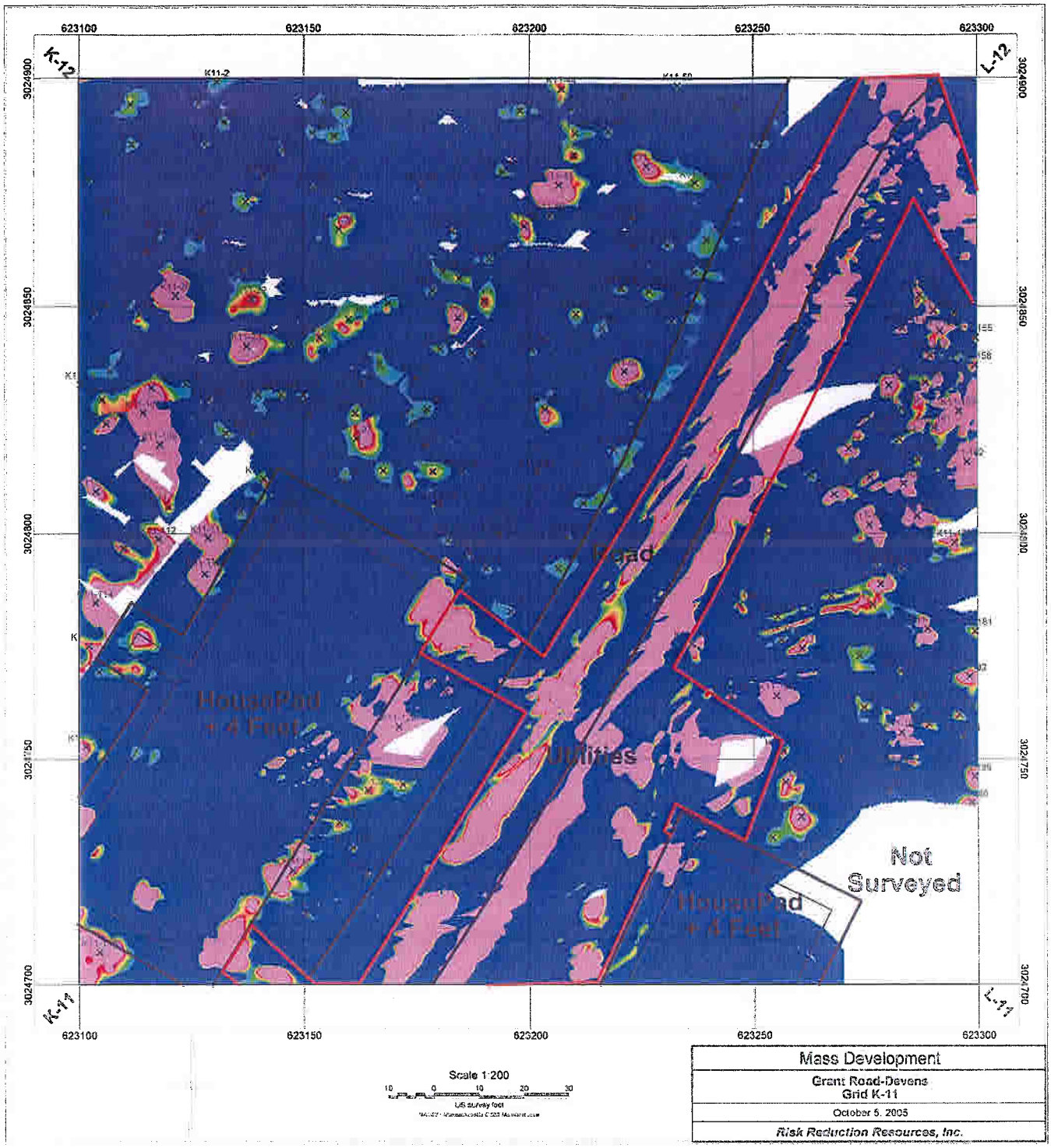
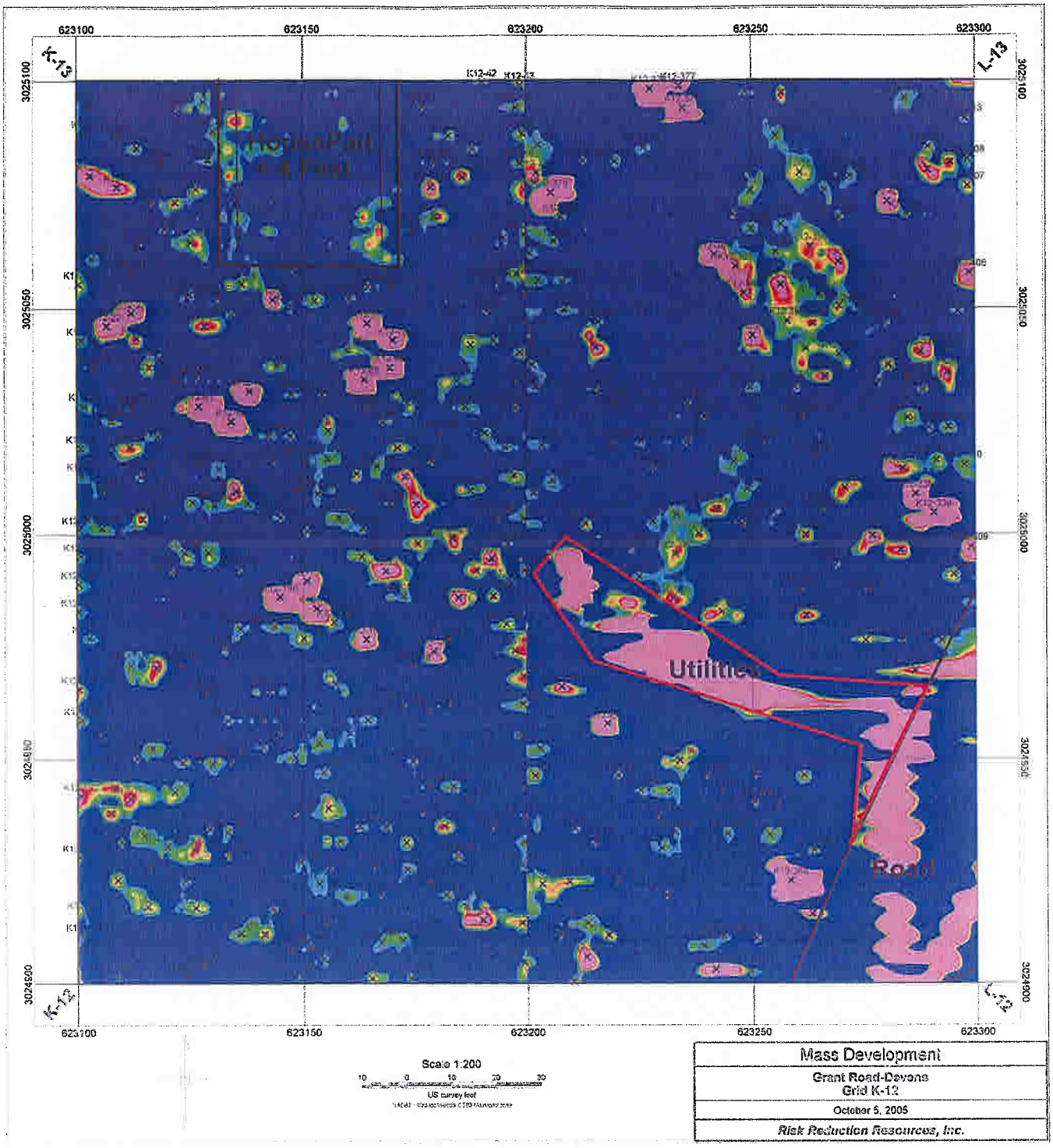
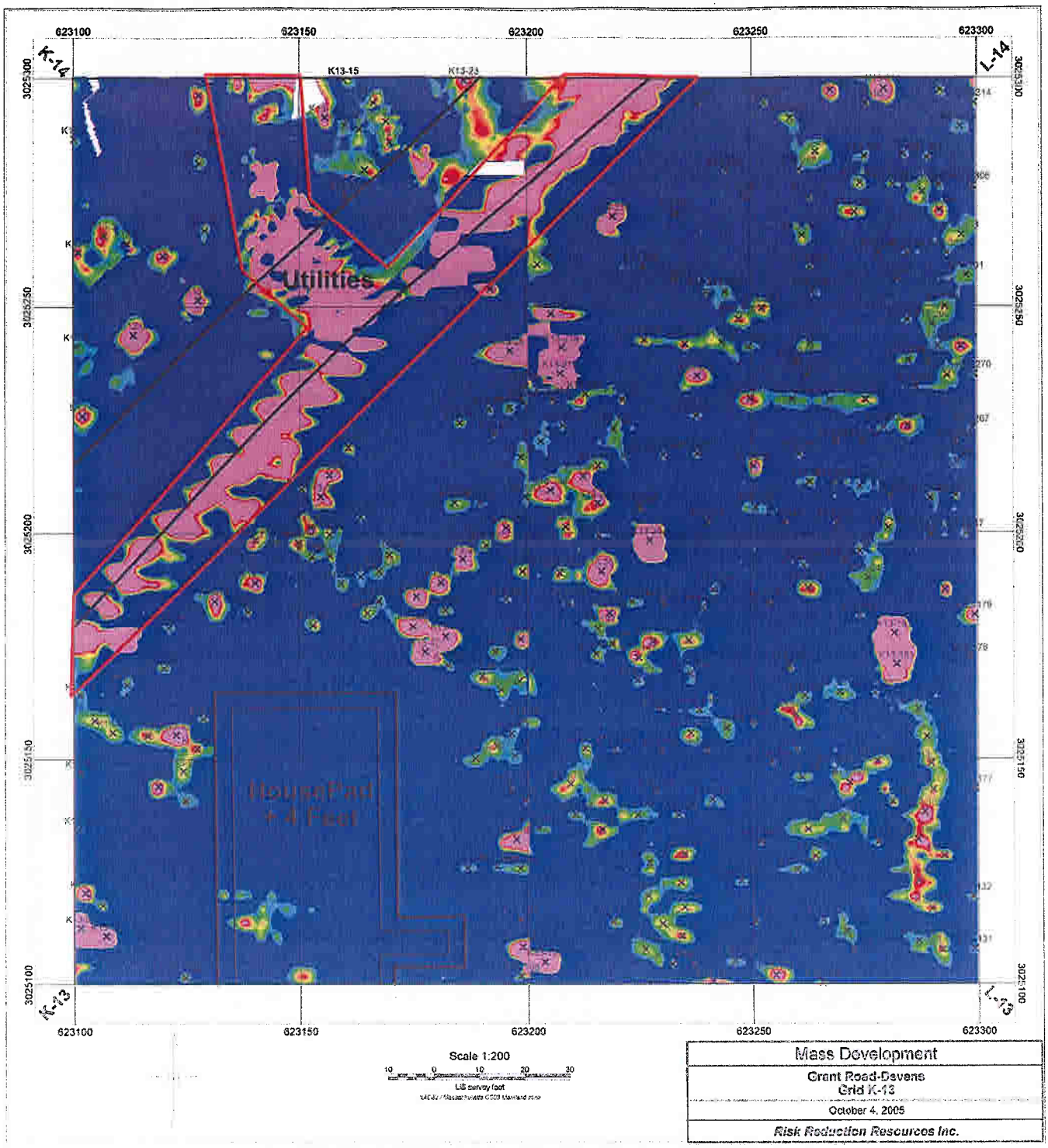
623150
623200
623250
623300
K-11
L-11
K-10
L-10
3024700
3024650
3024600
3024550
3024500
Utilities
House Pad
+ 4 Feet
Road
Utilities
House Pad
+ 4 Feet
K9-88
K9-89
K9-321
Scale 1:200
10 0 10 20 30
US survey feet
Mass Development
Grant Road, Devens
Grid K-10
October 25, 2005
Risk Reduction Resources, Inc.



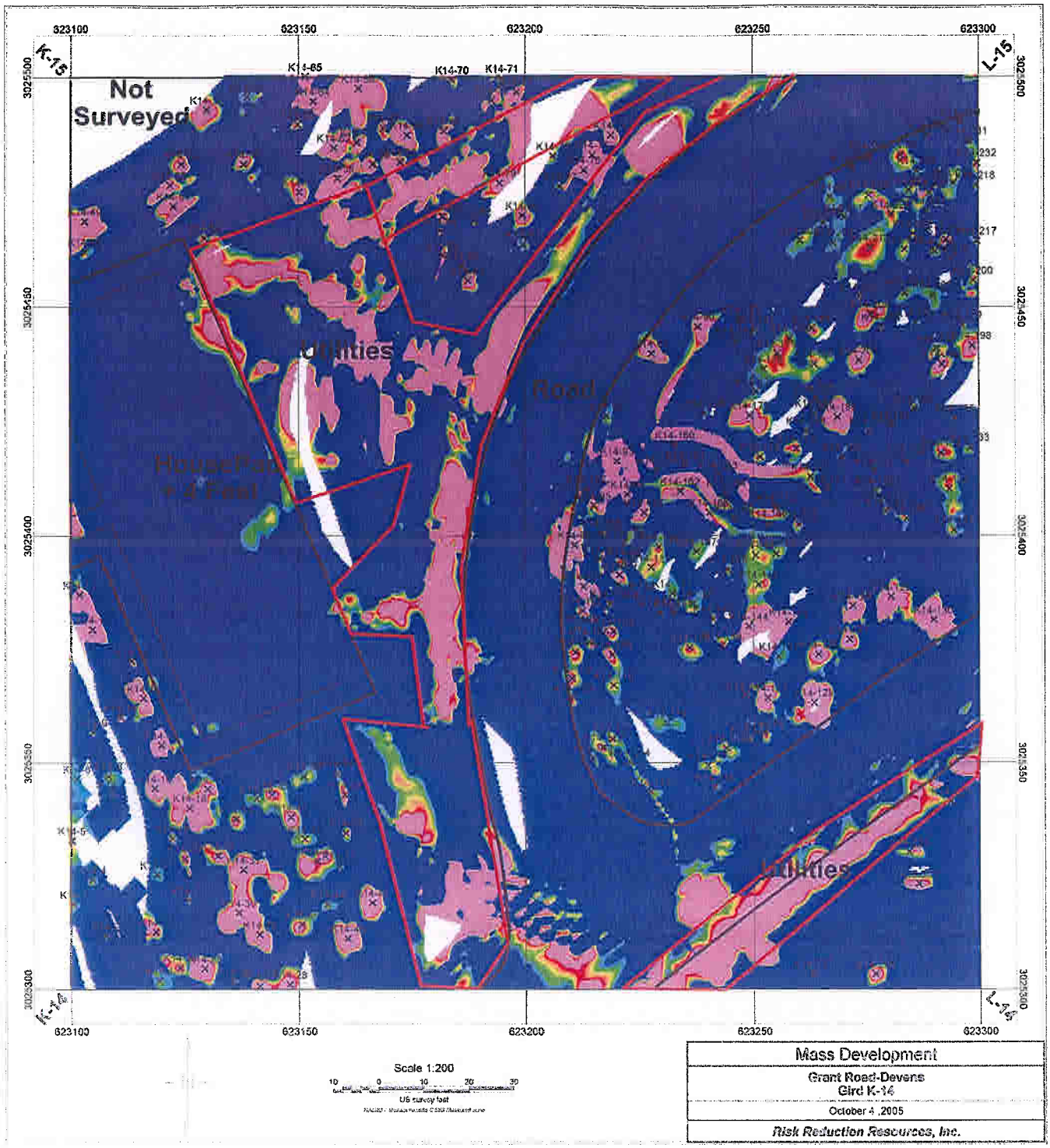
Mass Development
Grant Road-Devens Grid K-11
October 5, 2005
Risk Reduction Resources, Inc.



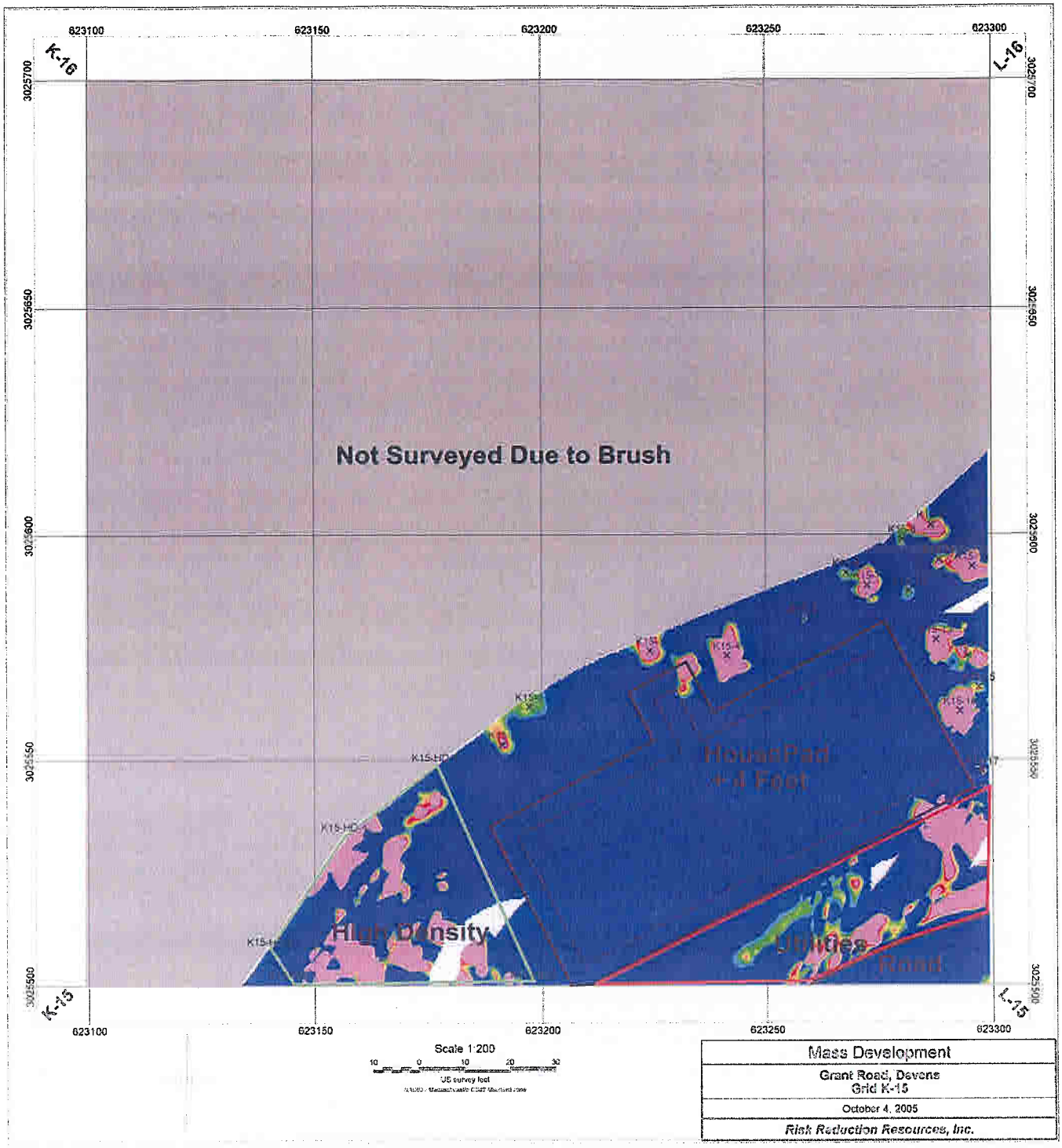
Mass Development
Grant Road-Devons Grid K-12
October 5, 2005
Risk Reduction Resources, Inc.



Mass Development
Grant Road-Devens Grid K-13
October 4, 2005
Risk Reduction Resources Inc.



Mass Development
Grant Road-Devens Grid K-14
October 4 ,2005
Risk Reduction Resources, Inc.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K-16
L-16
K-15
L-15
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3025500
Not Surveyed Due to Brush
K15-HD1
K15-HD2
K15-HD3
K15-HD4
K15-HD5
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K15-HD1894
K15-HD1895
K15-HD1896
K15-HD1897
K15-HD1898
K15-HD1899
K15-HD1900
K15-HD1901
K15-HD1902
K15-HD1903
K15-HD1904
K15-HD1905
K15-HD1906
K15-HD1907
K15-HD1908
K15-HD1909
K15-HD1910
K15-HD1911
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K15-HD1914
K15-HD1915
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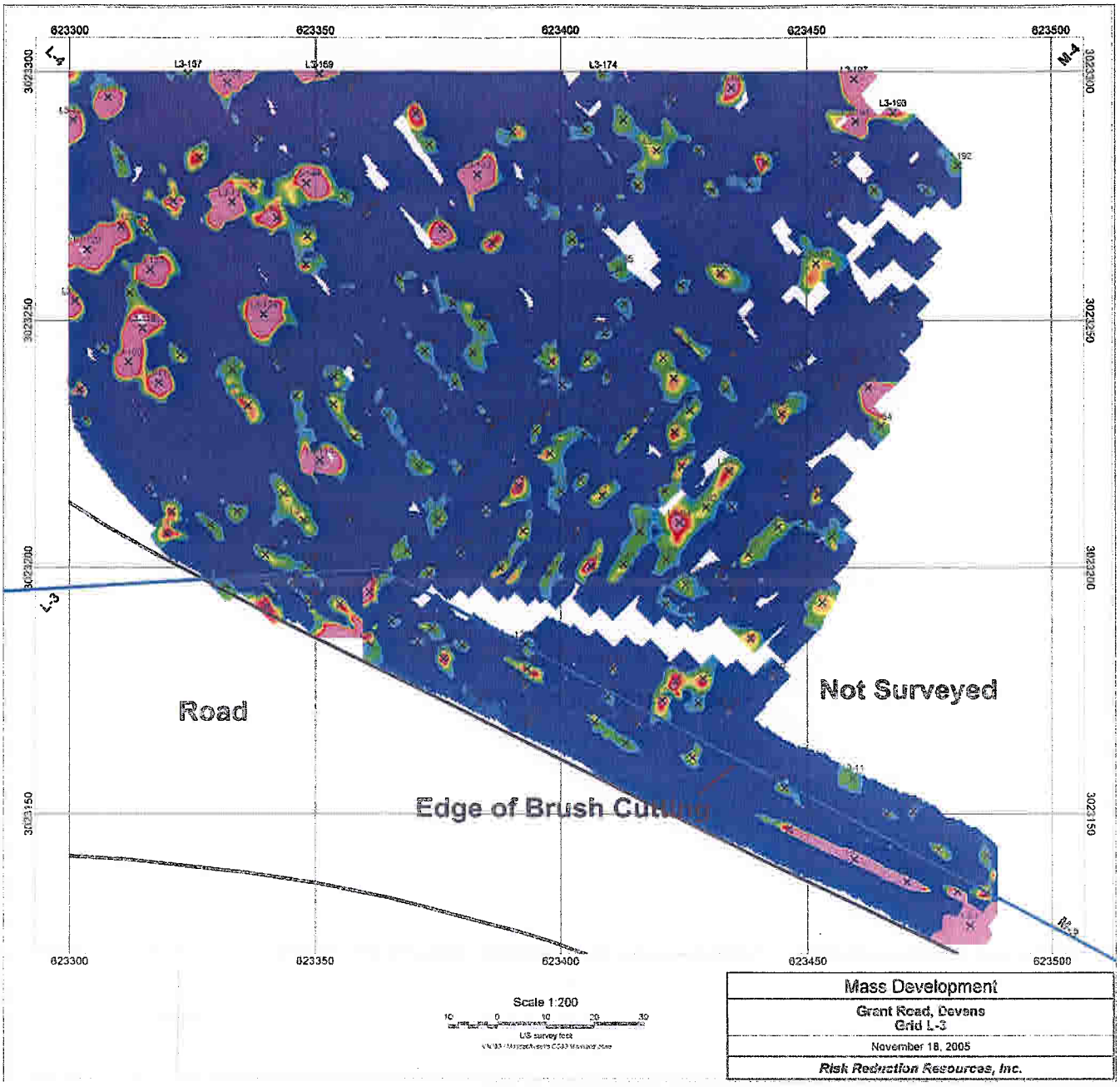
K15-HD1992
K15-HD1993
K15-HD1994
K15-HD1995
K15-HD1996
K15-HD1997
K15-HD1998
K15-HD1999
K15-HD2000
HousePad
+4 Foot
High Density
Utilities
Road
Scale 1:200
10 0 10 20 30
US survey foot
Mass Development
Grant Road, Devens
Grid K-15
October 4, 2005
Risk Reduction Resources, Inc.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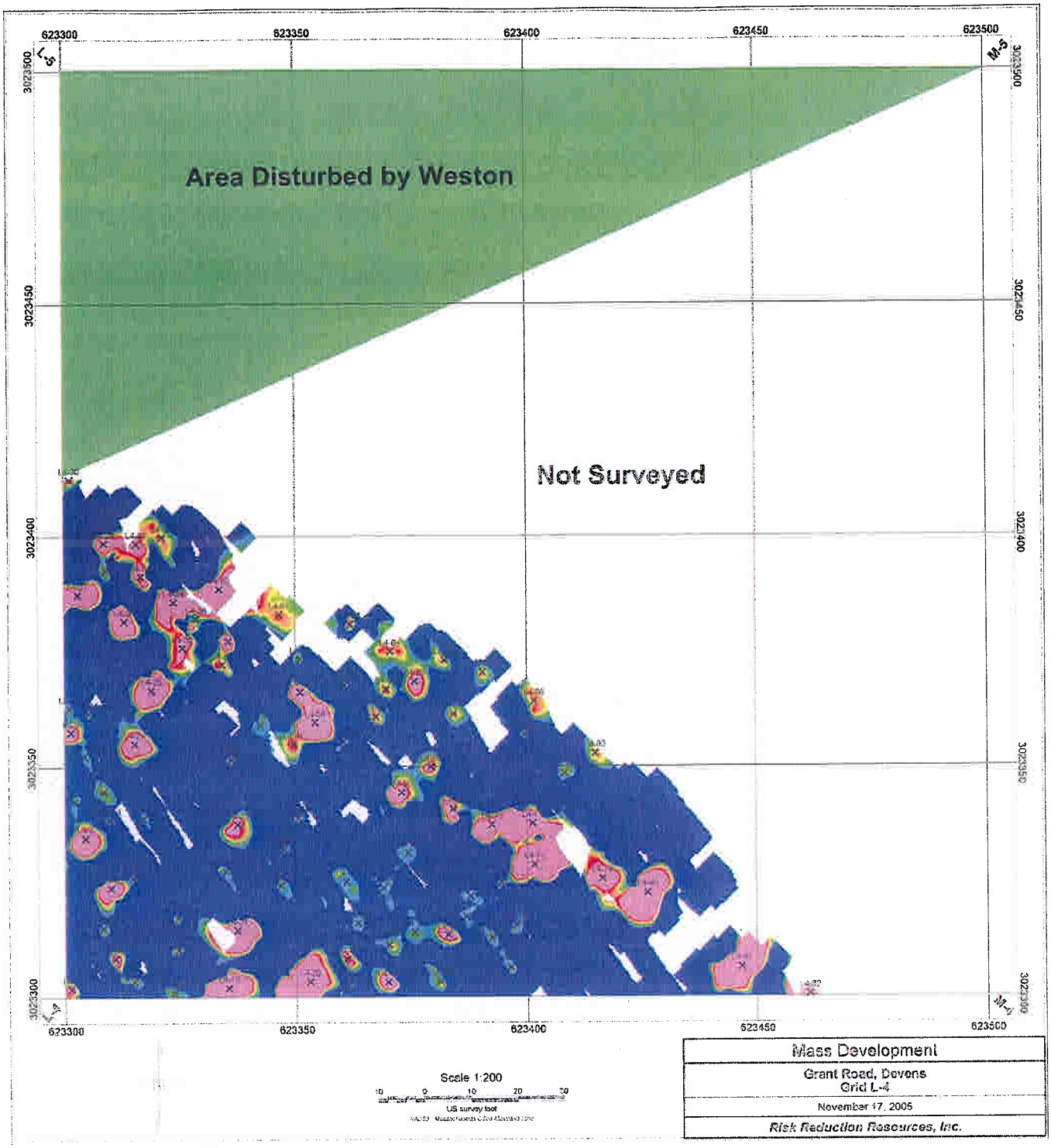
3023300
3023250
3023200
3023150
L-4
M-4
L-3
L3-157
L3-159
L3-174
L3-193
Road
Not Surveyed
Edge of Brush Cutting
Scale 1:200
10 0 10 20 30
US survey feet
Mass Development
Grant Road, Devens
Grid L-3
November 18, 2005
Risk Reduction Resources, Inc.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623350
623400
623450
623500
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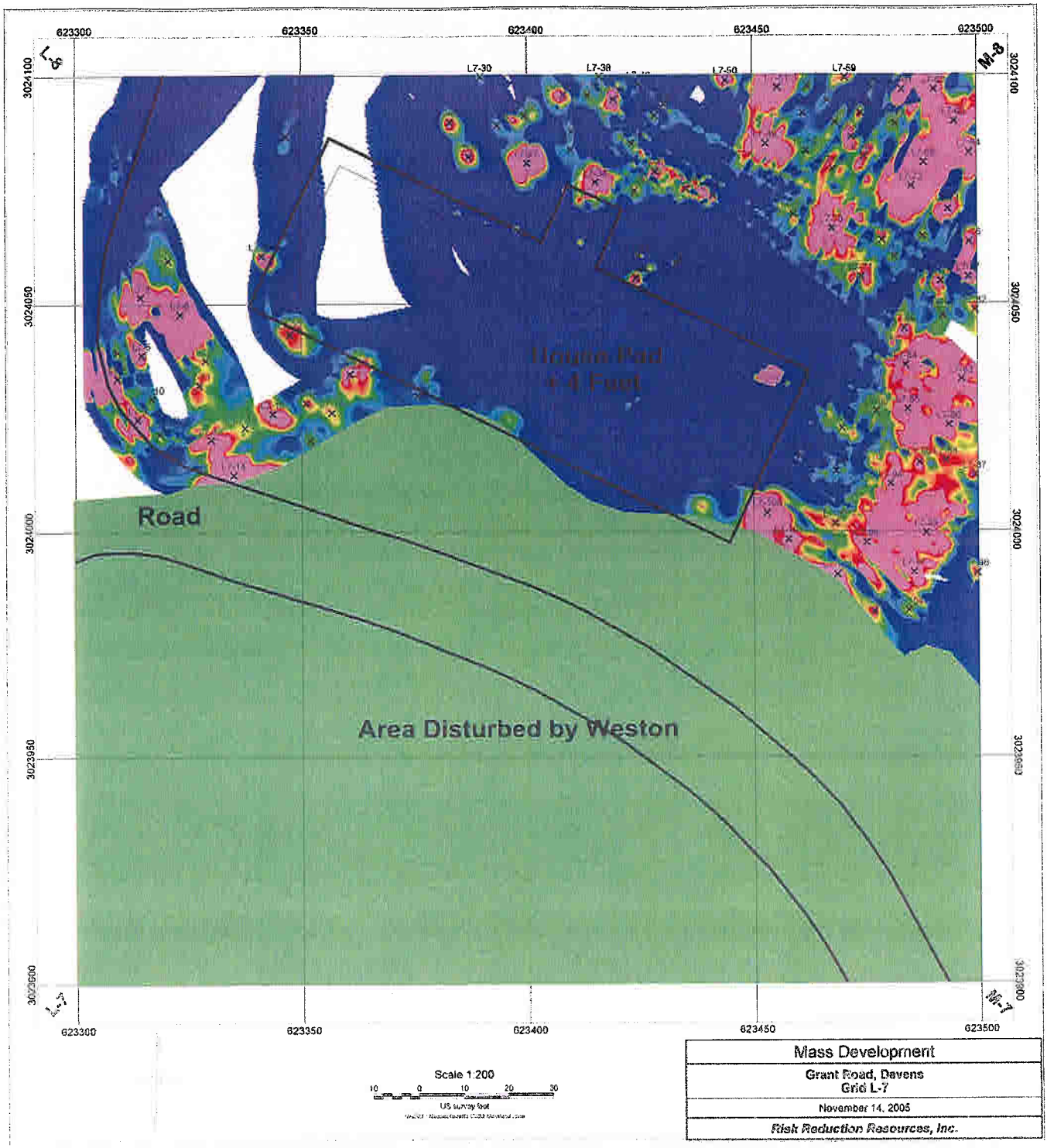
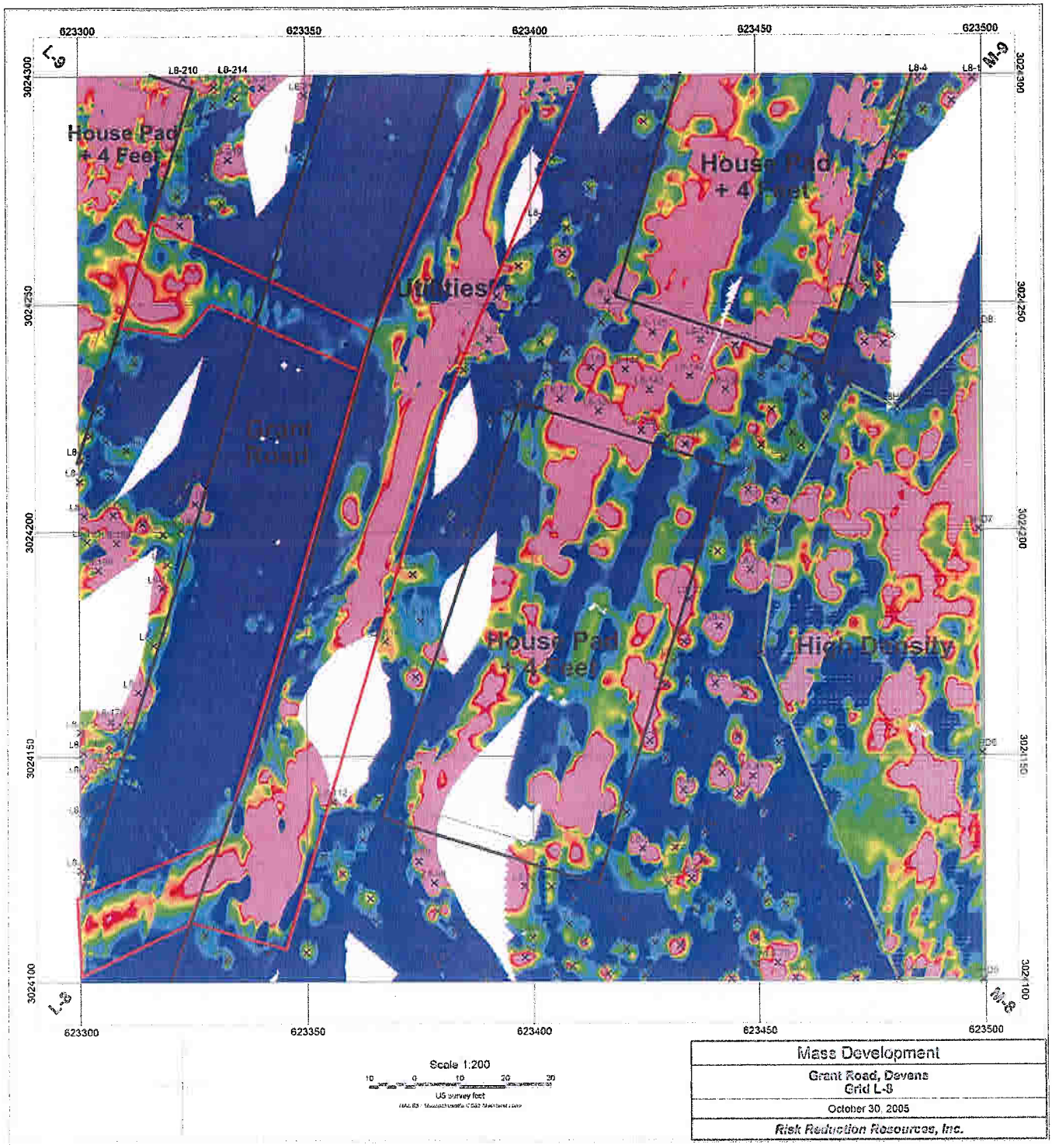
3023450
3023400
3023350
3023300
L-5
M-5
Area Disturbed by Weston
Not Surveyed
Scale 1:200
US survey foot
Mass Development
Grant Road, Devens
Grid L-4
November 17, 2005
Risk Reduction Resources, Inc.



Mass Development
Grant Road, Davens Grid L-7
November 14, 2005
Risk Reduction Resources, Inc.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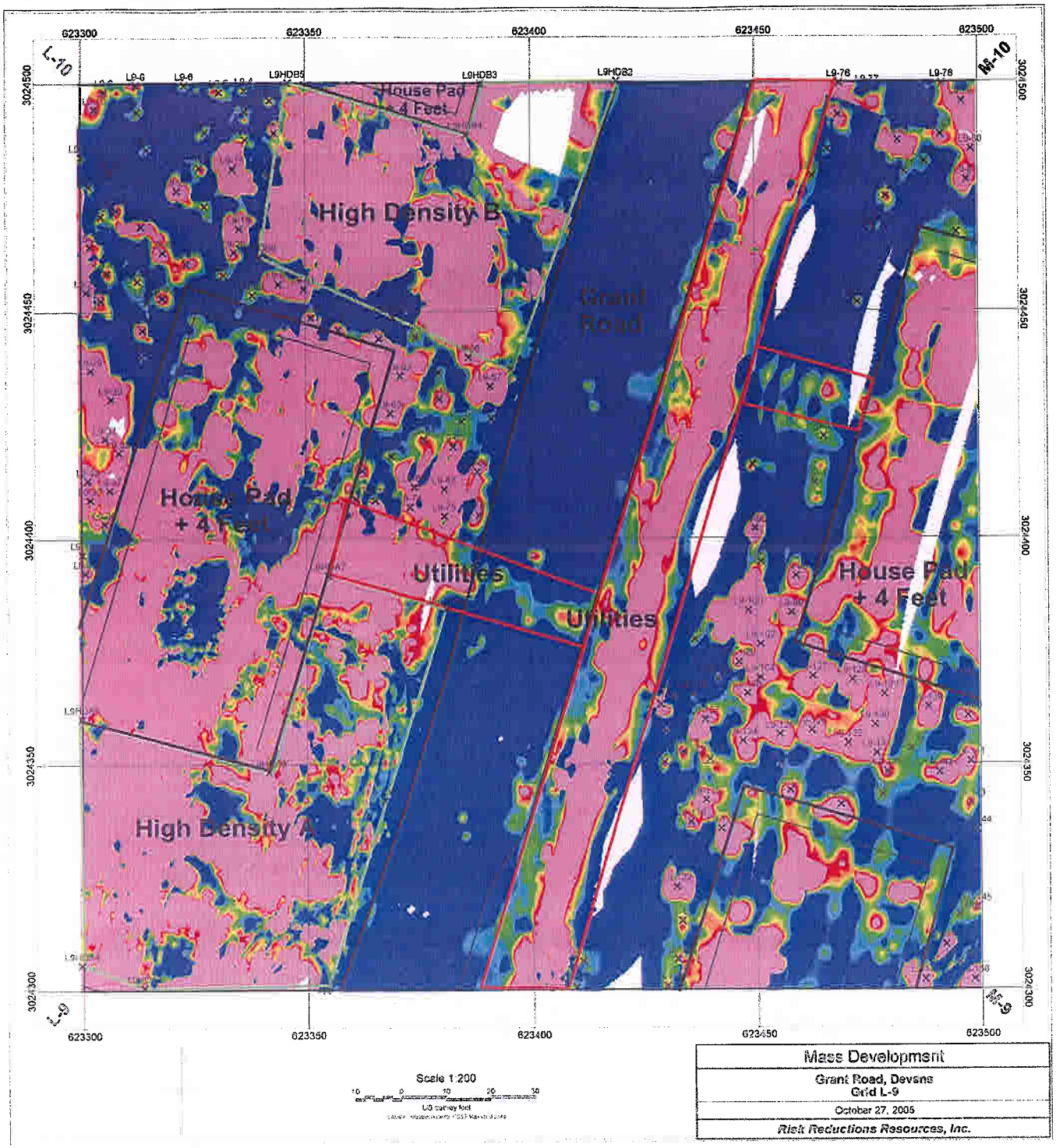
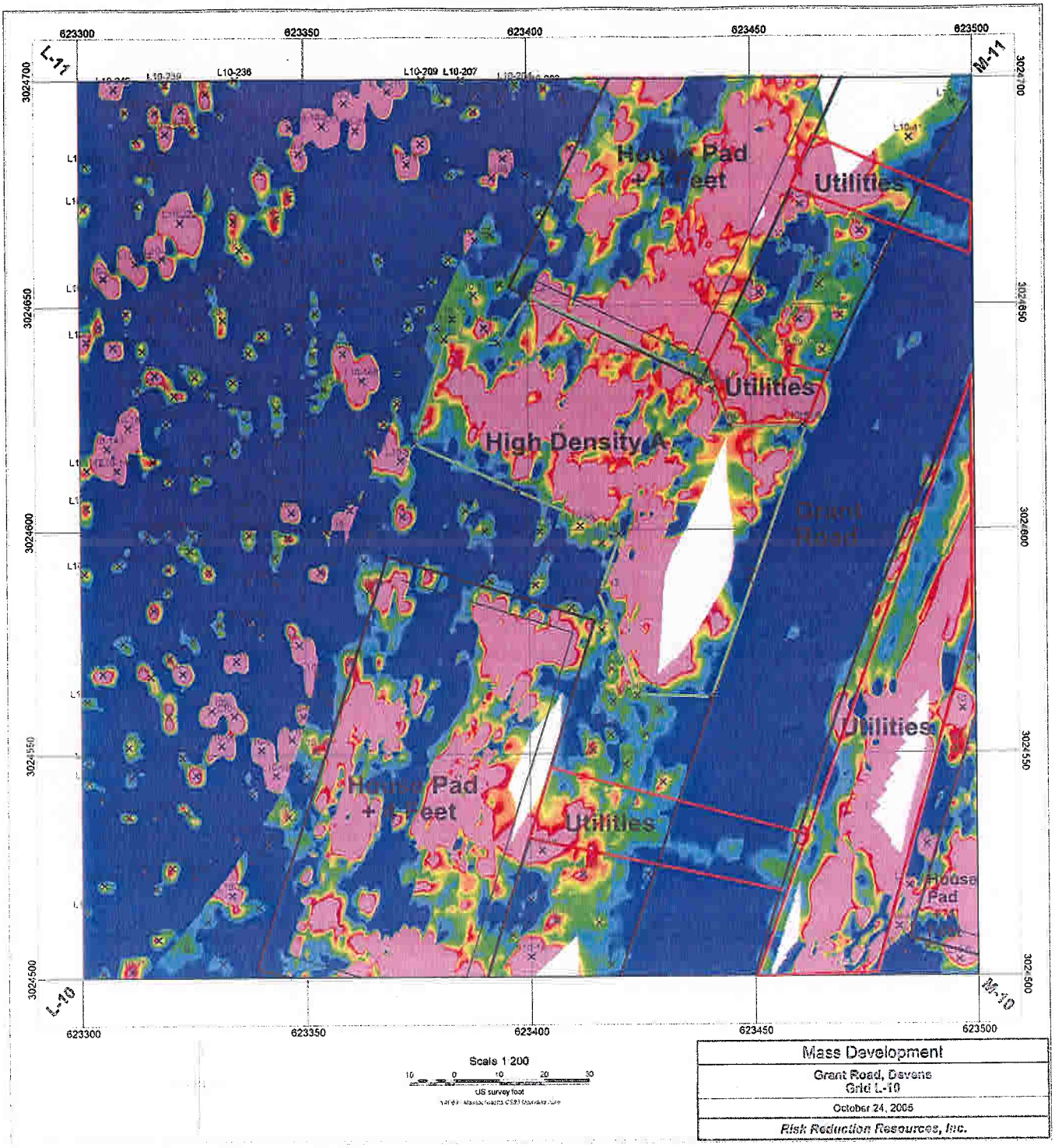
623350
623400
623450
623500
3024300
3024250
3024200
3024150
3024100
L-9
M-9
L-8
M-8
L8-210
L8-214
L8-4
House Pad
+ 4 Feet
Utilities
Grant
Road
House Pad
+ 4 Feet
House Pad
+ 4 Feet
High Density
Scale 1:200
10 0 10 20 30
US survey feet
Mass Development
Grant Road, Devens
Grid L-8
October 30, 2005
Risk Reduction Resources, Inc.



Mass Development
Grant Road, Devens Grid L-9
October 27, 2005
Risk Reductions Resources, Inc.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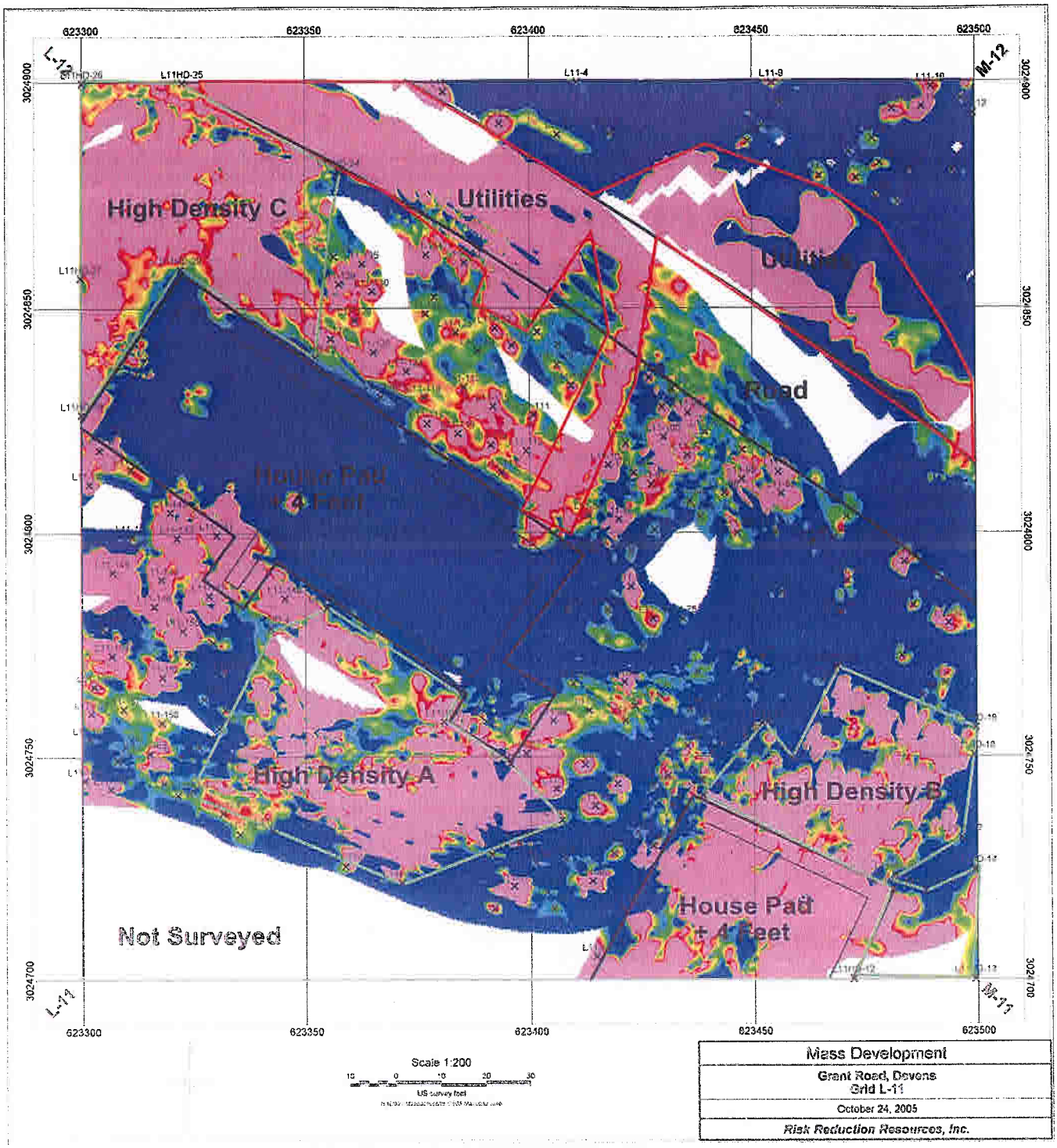
623450
623500
3024700
3024650
3024600
3024550
3024500
L-11
M-11
L-10
M-10
L10-236
L10-209
L10-207
House Pad
+4 Feet
Utilities
Utilities
High Density A
Grant
Road
Utilities
House Pad
+ Feet
Utilities
House
Pad
Scale 1:200
10 0 10 20 30
US survey foot
Mass Development
Grant Road, Devens
Grid L-10
October 24, 2005
Risk Reduction Resources, Inc.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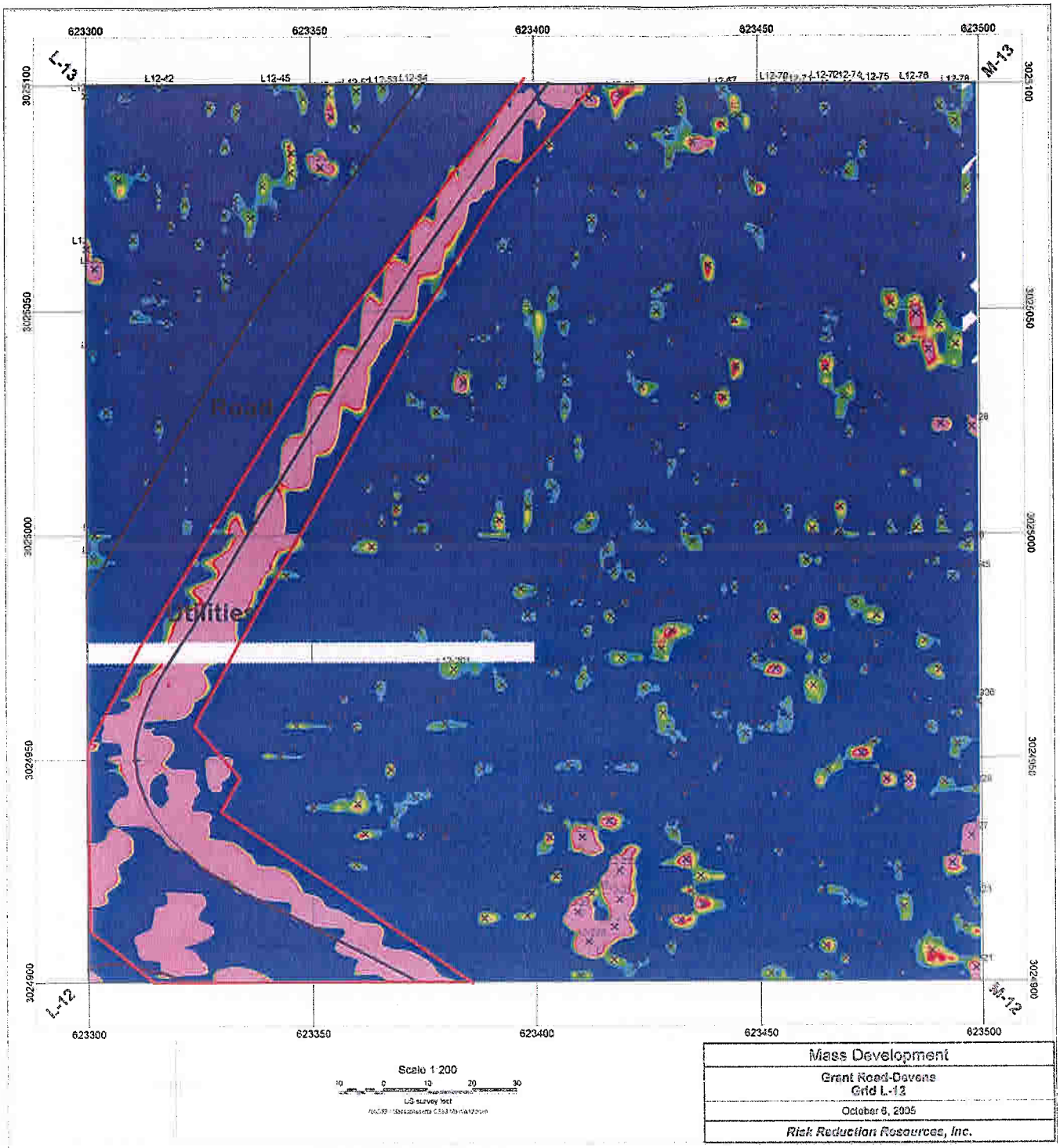
623400
623450
623500
L-12
M-12
L-11
M-11
L11HD-26
L11HD-25
L11-4
L11-9
3024900
3024850
3024800
3024750
3024700
High Density C
Utilities
Utilities
Road
House Pad
+4 Feet
High Density A
High Density B
House Pad
+4 Feet
Not Surveyed
Scale 1:200
10 0 10 20 30
US survey feet
Mass Development
Grant Road, Devens
Grid L-11
October 24, 2005
Risk Reduction Resources, Inc.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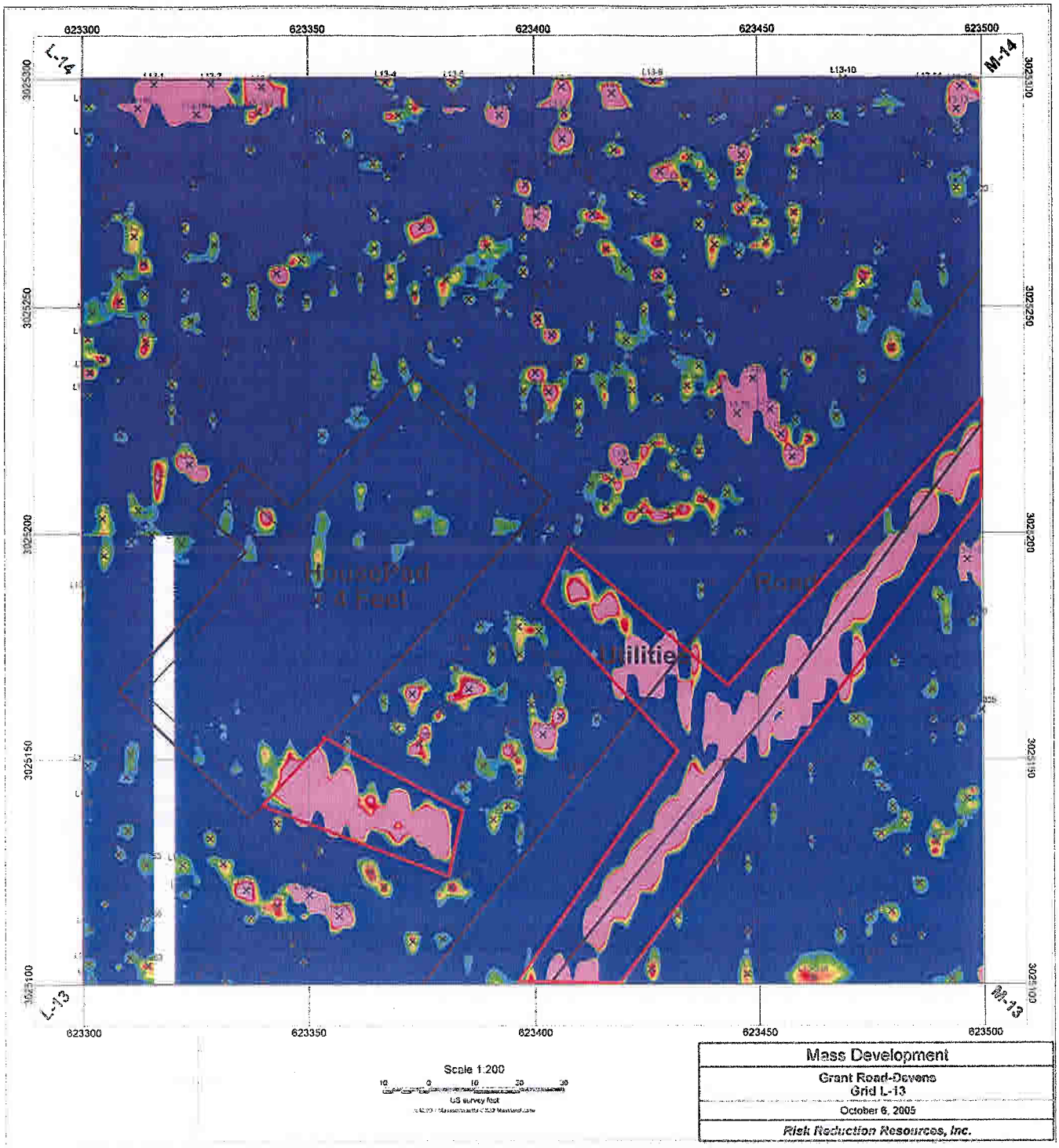
623450
623500
L-13
M-13
L-12
M-12
L12-42
L13-45
L12-75
L12-78
3025100
3025050
3025000
3024950
3024900
Road
Utilities
Scale 1:200
10 0 10 20 30
US survey feet
Mass Development
Grant Road-Devens
Grid L-12
October 6, 2005
Risk Reduction Resources, Inc.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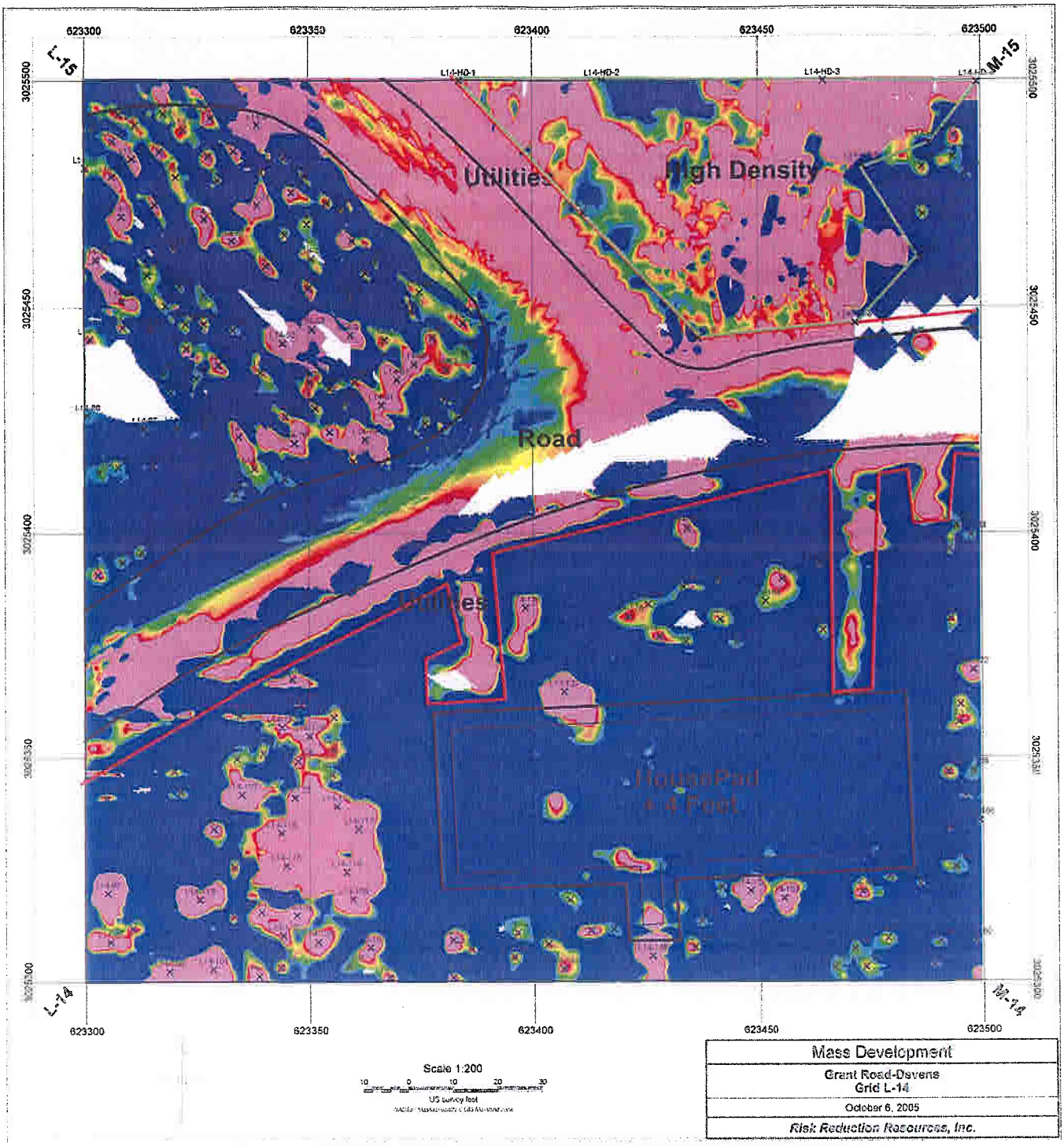
623450
623500
L-14
M-14
L-13
M-13
3025300
3025250
3025200
3025150
3025100
House Pad
+ 4 Feet
Road
Utilities
Scale 1:200
10 0 10 20 30
US survey foot
Mass Development
Grant Road-Devens
Grid L-13
October 6, 2005
Risk Reduction Resources, Inc.



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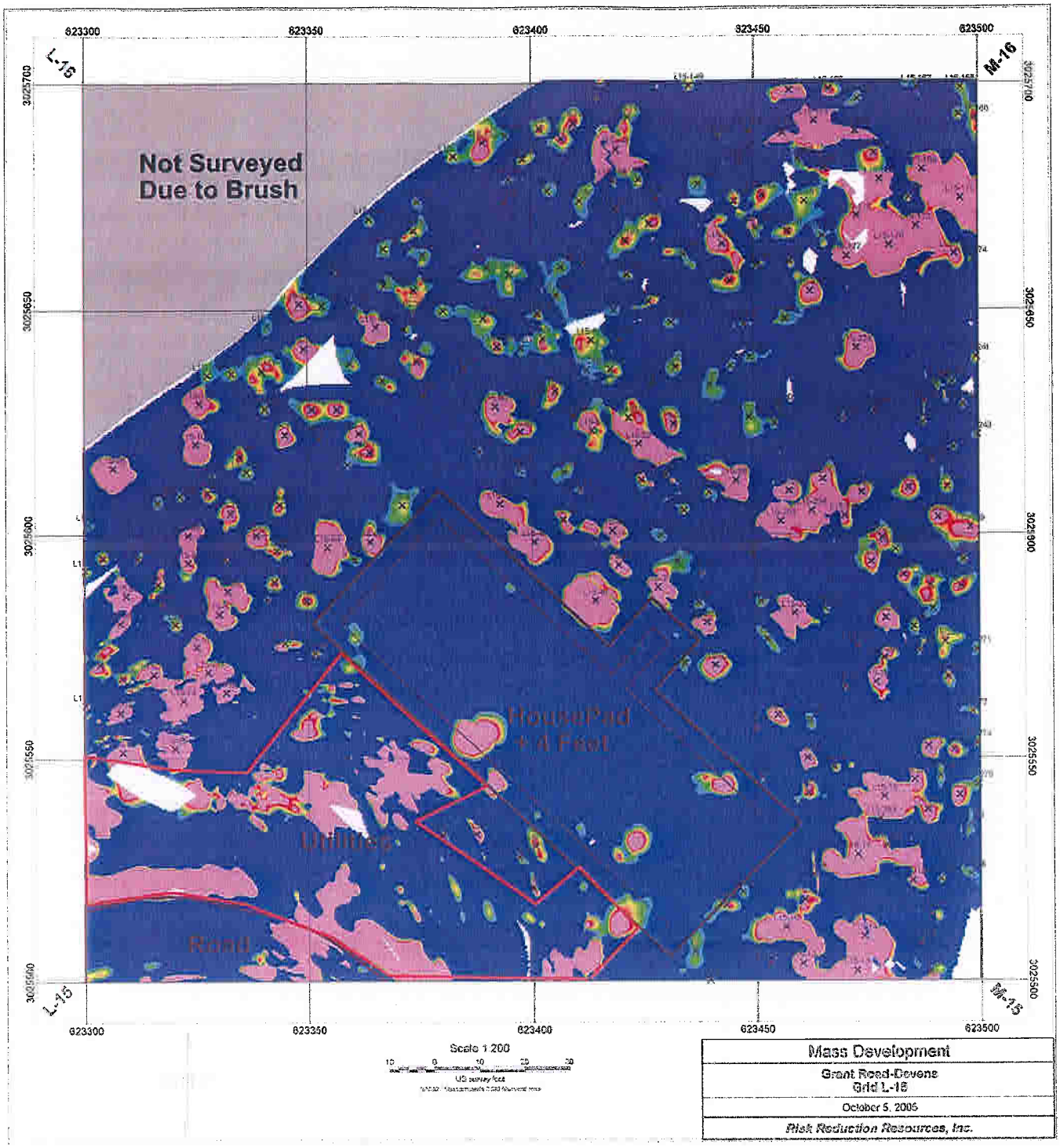
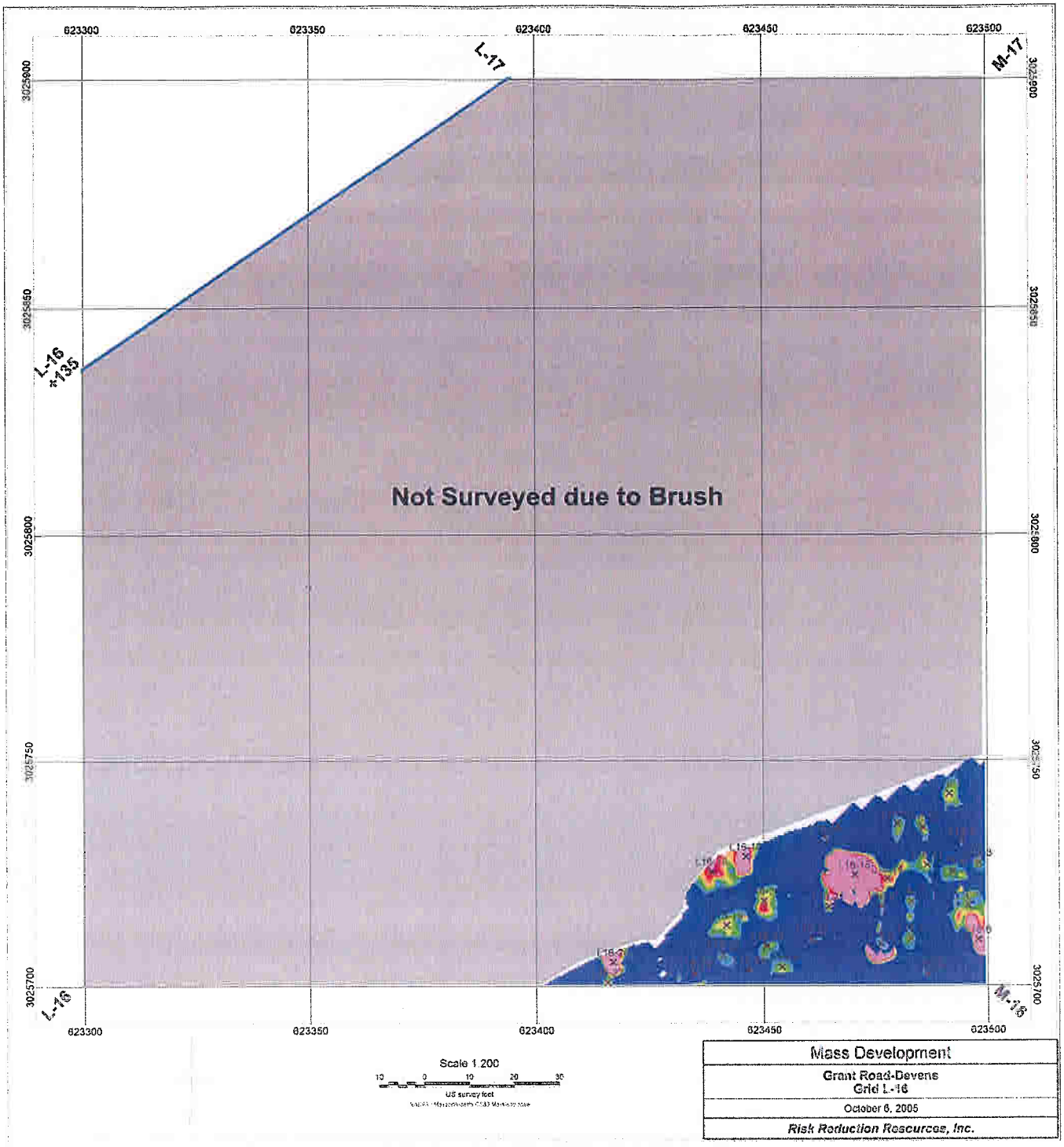
623350
623400
623450
623500
L-15
M-15
L14-HD-1
L14-HD-2
L14-HD-3
3025500
3025450
3025400
3025350
3025300
Utilities
High Density
Road
Utilities
HousePad
4 Feet
L-14
M-14
Scale 1:200
US survey feet
Mass Development
Grant Road-Devens
Grid L-14
October 6, 2005
Risk Reduction Resources, Inc.


623300
623350
623400
623450
623500
L-16
M-16
L-15
M-15
3025700
3025650
3025600
3025550
3025500
Not Surveyed
Due to Brush
HousePad
+ 4 Feet
Utilities
Road
Scale 1:200
10 0 10 20 30
US survey feet
Mass Development
Grant Road-Devens
Grid L-15
October 5, 2005
Risk Reduction Resources, Inc.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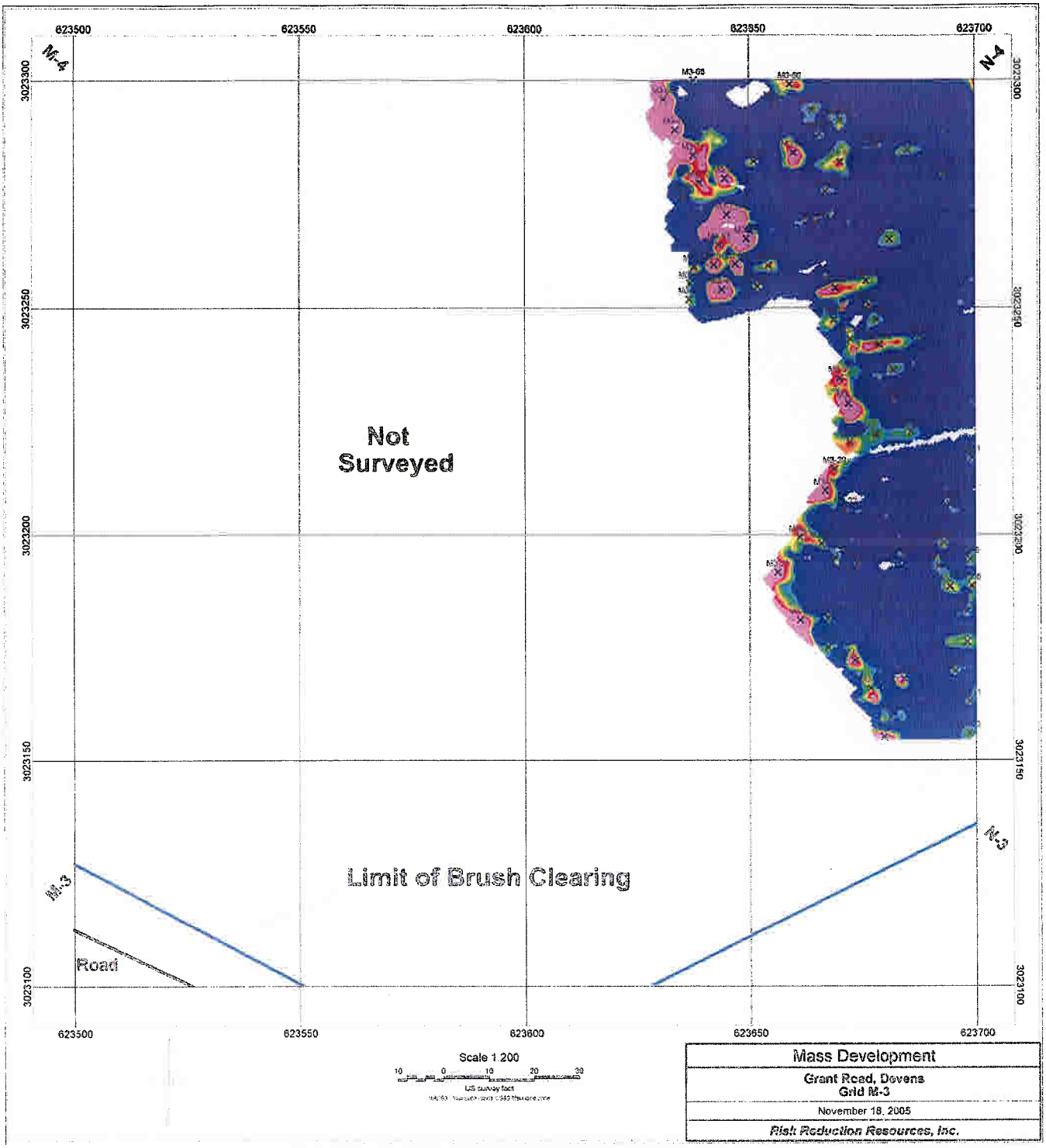
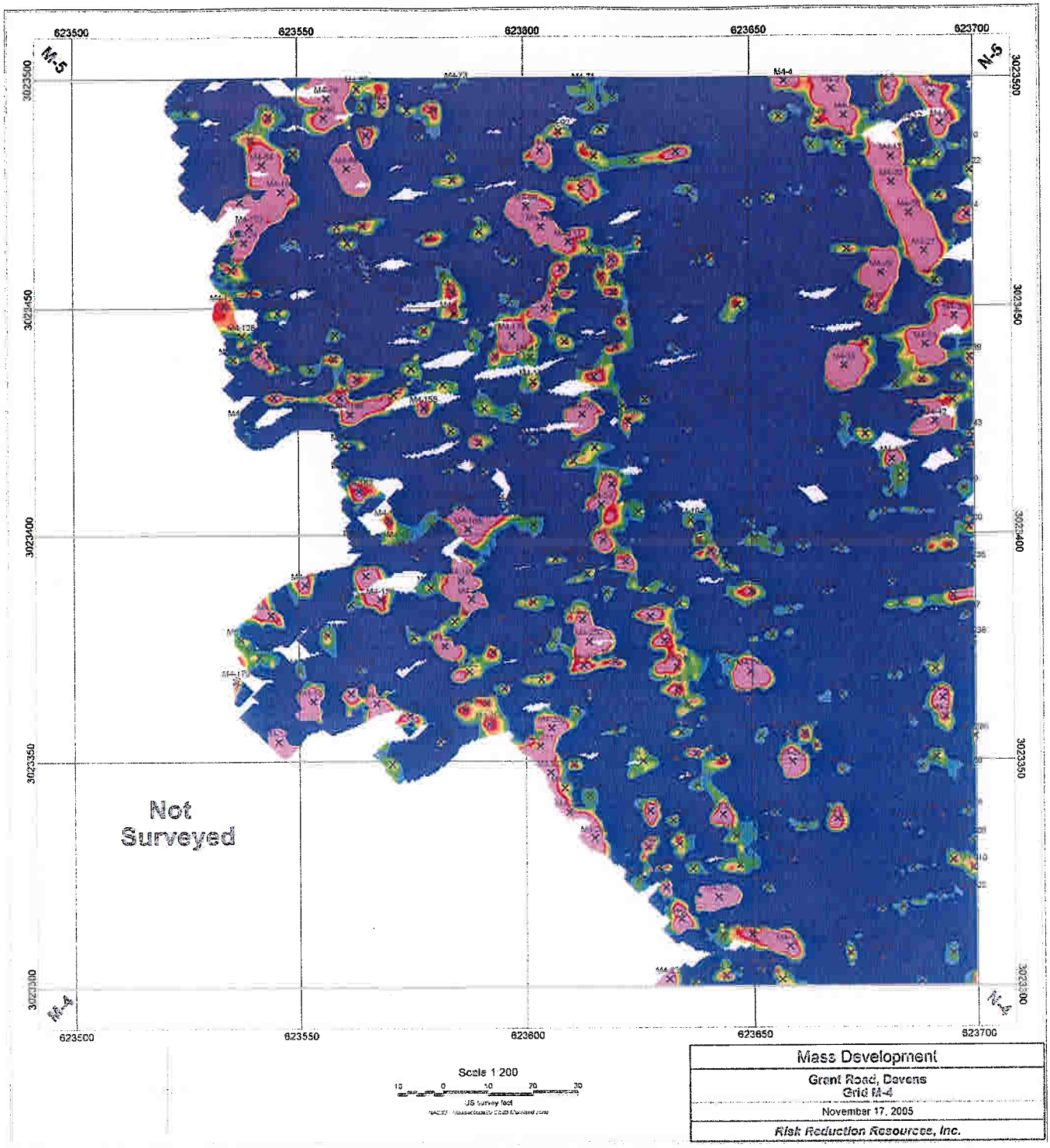
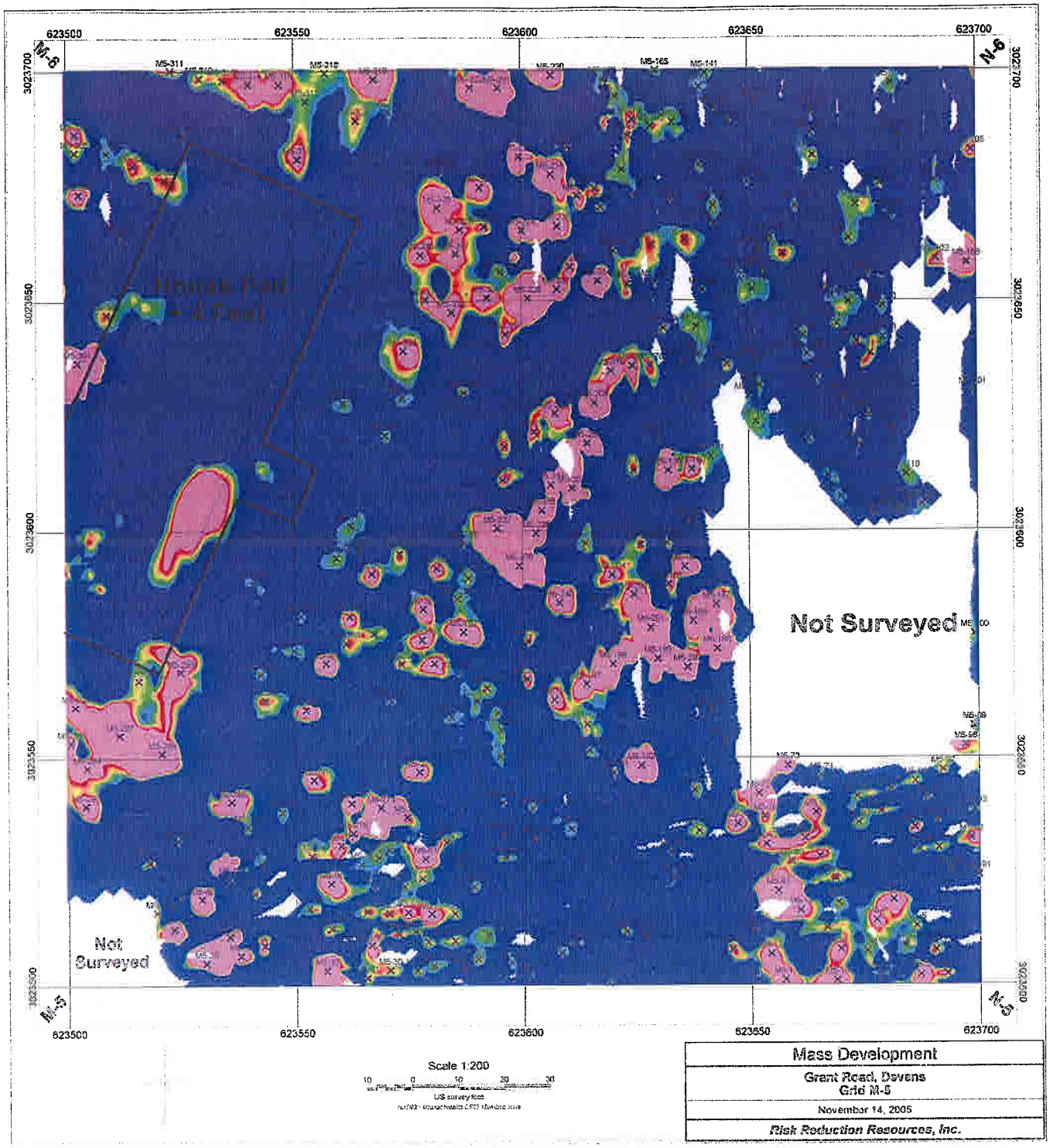
623350
623400
623450
623500
3025900
3025850
3025800
3025750
3025700
L-17
M-17
L-16
*135
Not Surveyed due to Brush
L-16
M-16
Scale 1:200
10 0 10 20 30
US survey foot
Mass Development
Grant Road-Devens
Grid L-16
October 6, 2005
Risk Reduction Resources, Inc.

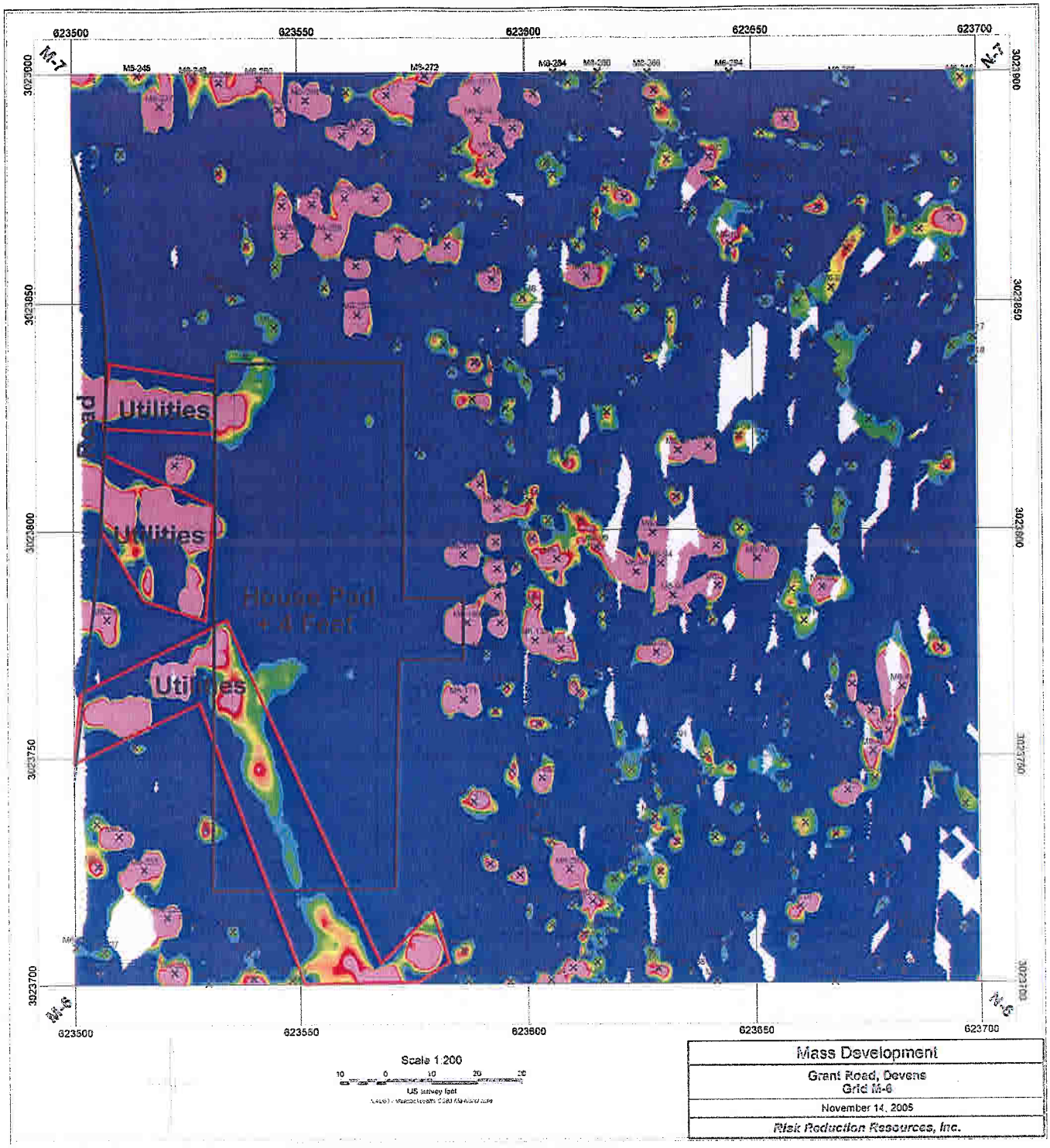

623500
623550
623600
623650
623700
3023300
3023250
3023200
3023150
3023100
M-4
N-4
M-3
N-3
Not
Surveyed
Limit of Brush Clearing
Road
Scale 1:200
10 0 10 20 30
US survey feet
Mass Development
Grant Road, Devens
Grid M-3
November 18, 2005
Risk Reduction Resources, Inc.



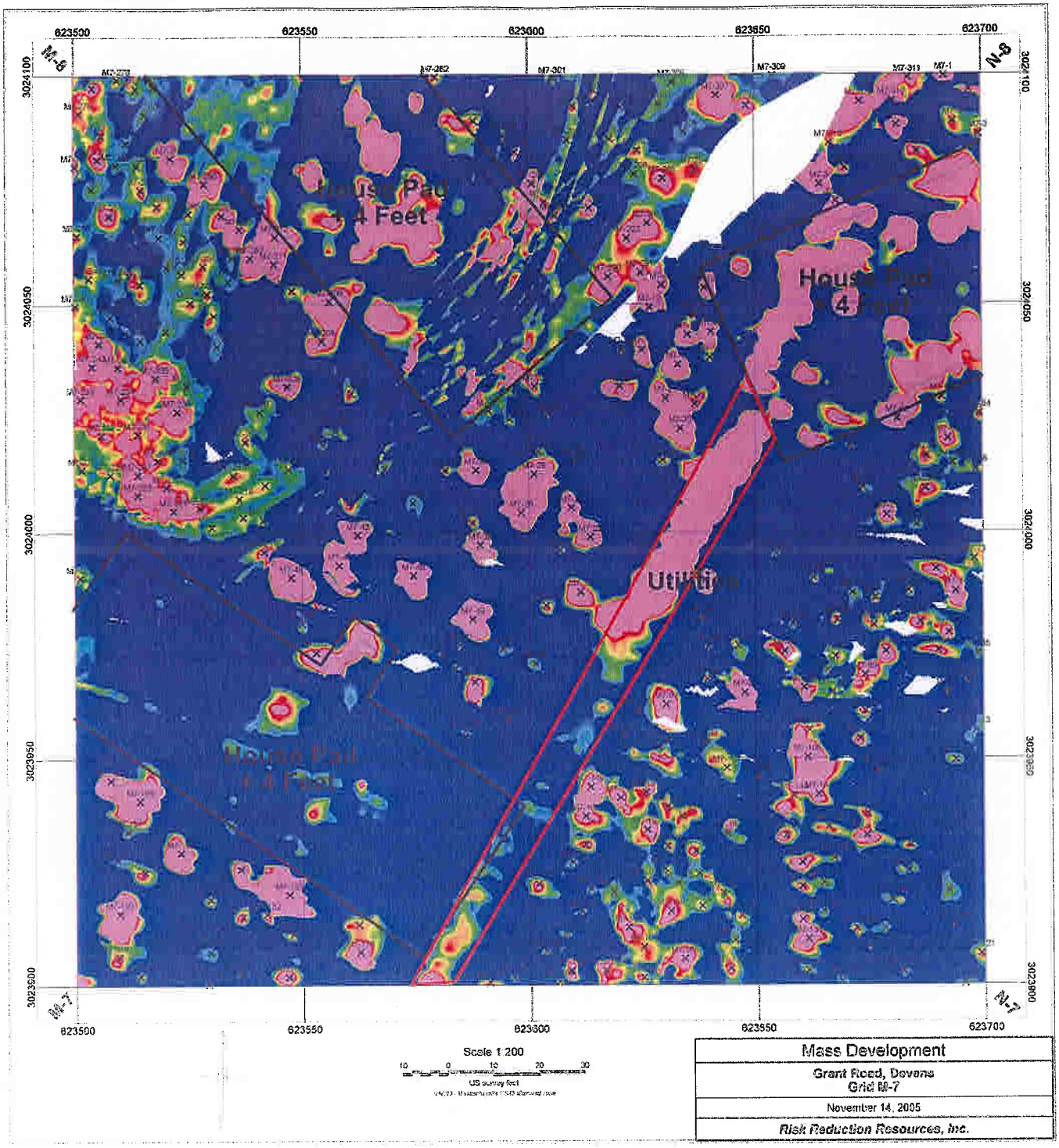
Mass Development
Grant Road, Devens Grid M-4
November 17, 2005
Risk Reduction Resources, Inc.



Mass Development
Grant Road, Devens Grid M-5
November 14, 2005
Risk Reduction Resources, Inc.



Mass Development
Grant Road, Devens Grid M-6
November 14, 2005
Risk Reduction Resources, Inc.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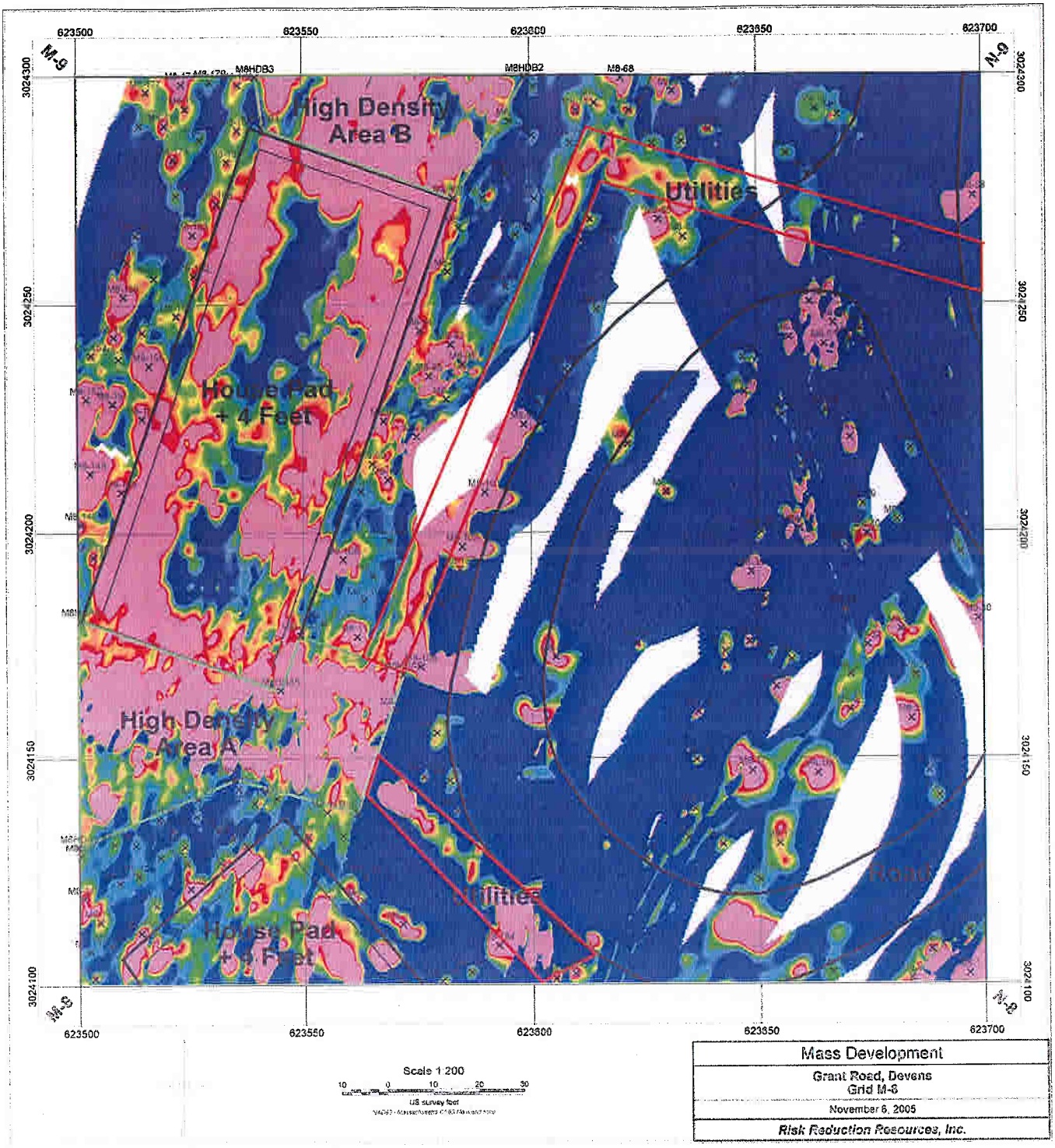
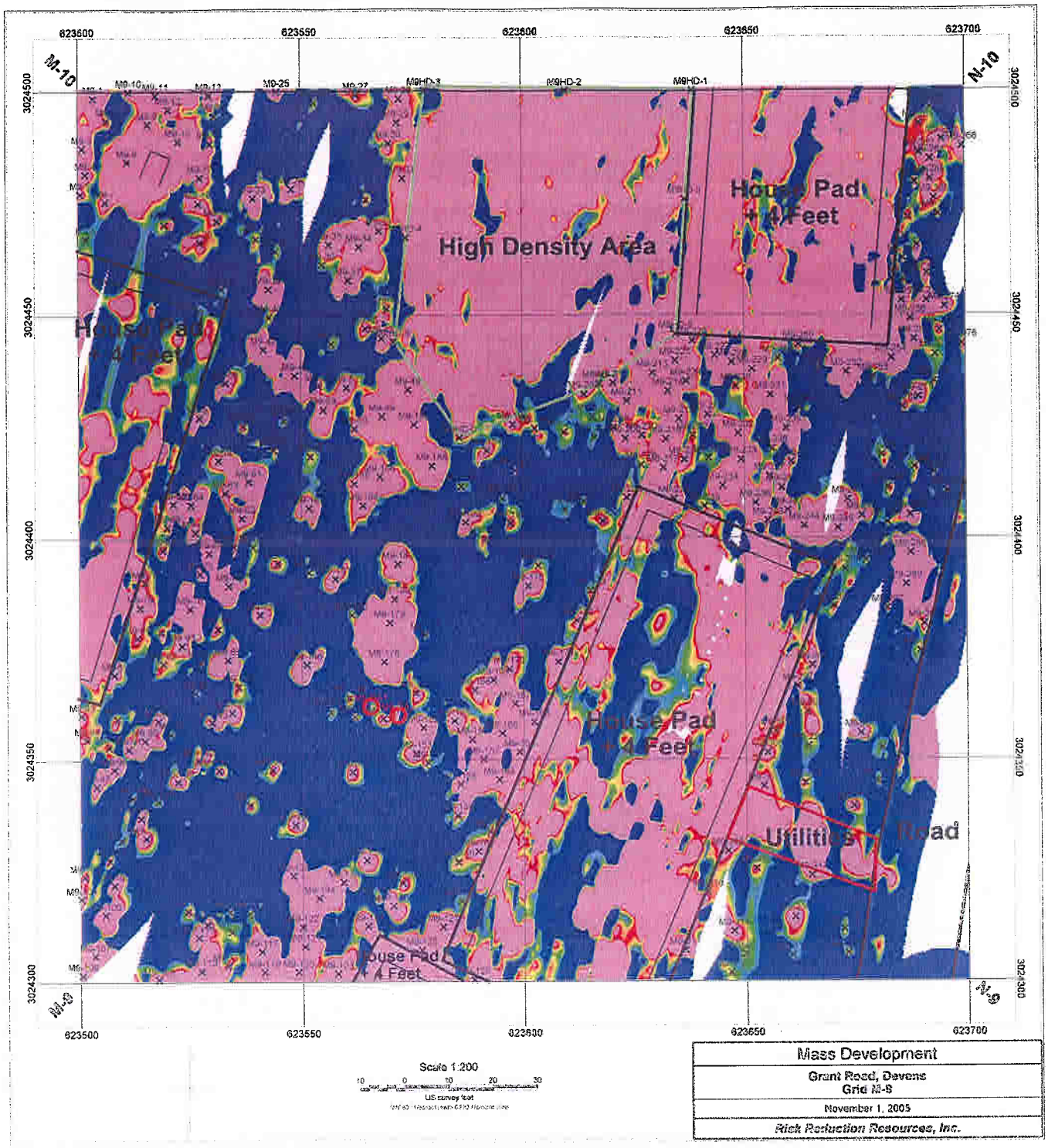
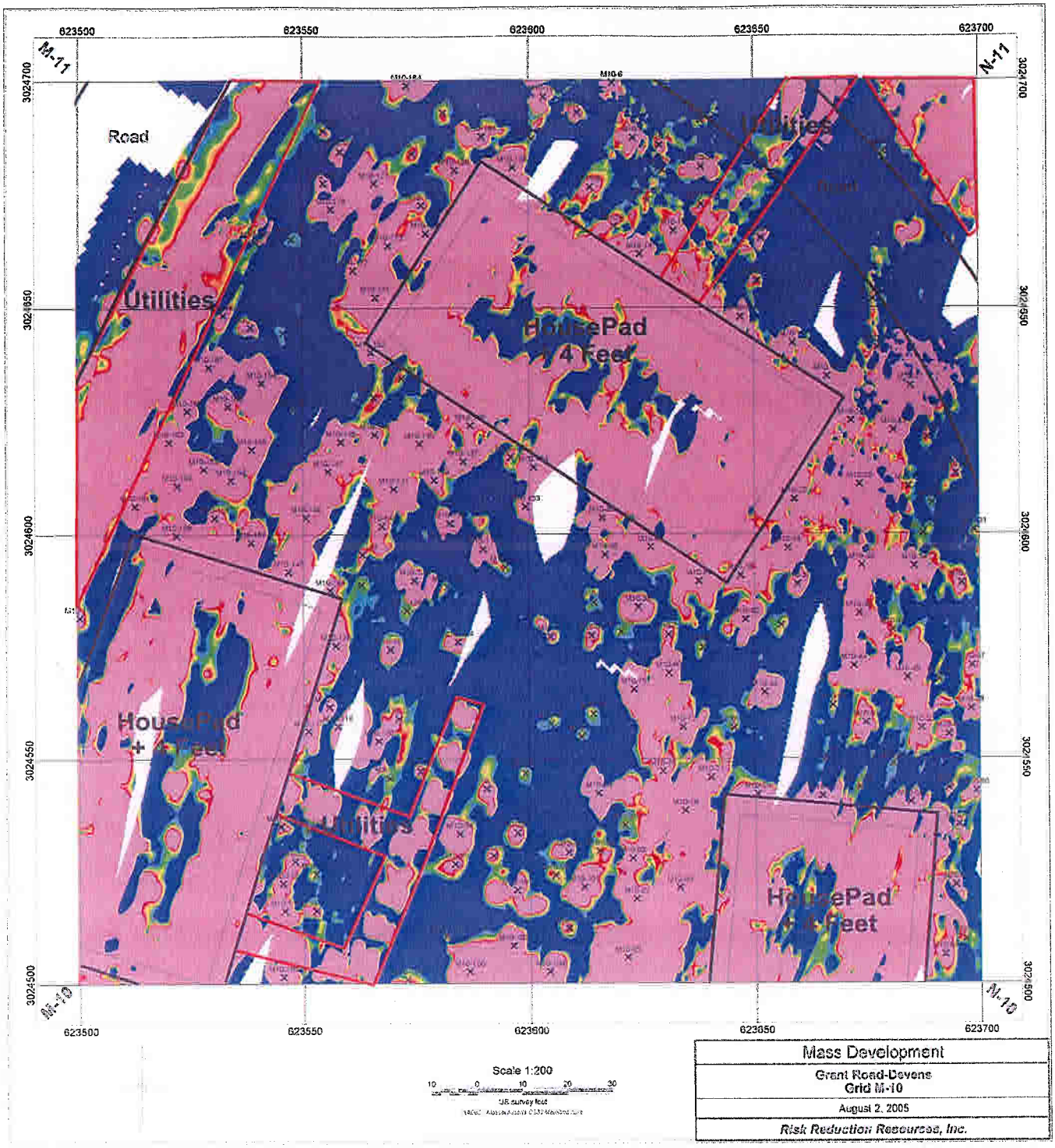
623550
623600
623650
623700
3024100
3024050
3024000
3023950
3023900
N-8
N-7
M7-262
M7-301
M7-309
M7-313
M7-1
House Pad
4 Feet
House Pad
4
Utility
House Pad
4 Feet
Scale 1:200
10 0 10 20 30
US survey feet
Mass Development
Grant Road, Devens
Grid M-7
November 14, 2005
Risk Reduction Resources, Inc.



Mass Development
Grant Road, Devens Grid M-6
November 6, 2005
Risk Reduction Resources, Inc.



Mass Development
Grant Road, Devens Grid M-9
November 1, 2005
Rick Reduction Resources, Inc.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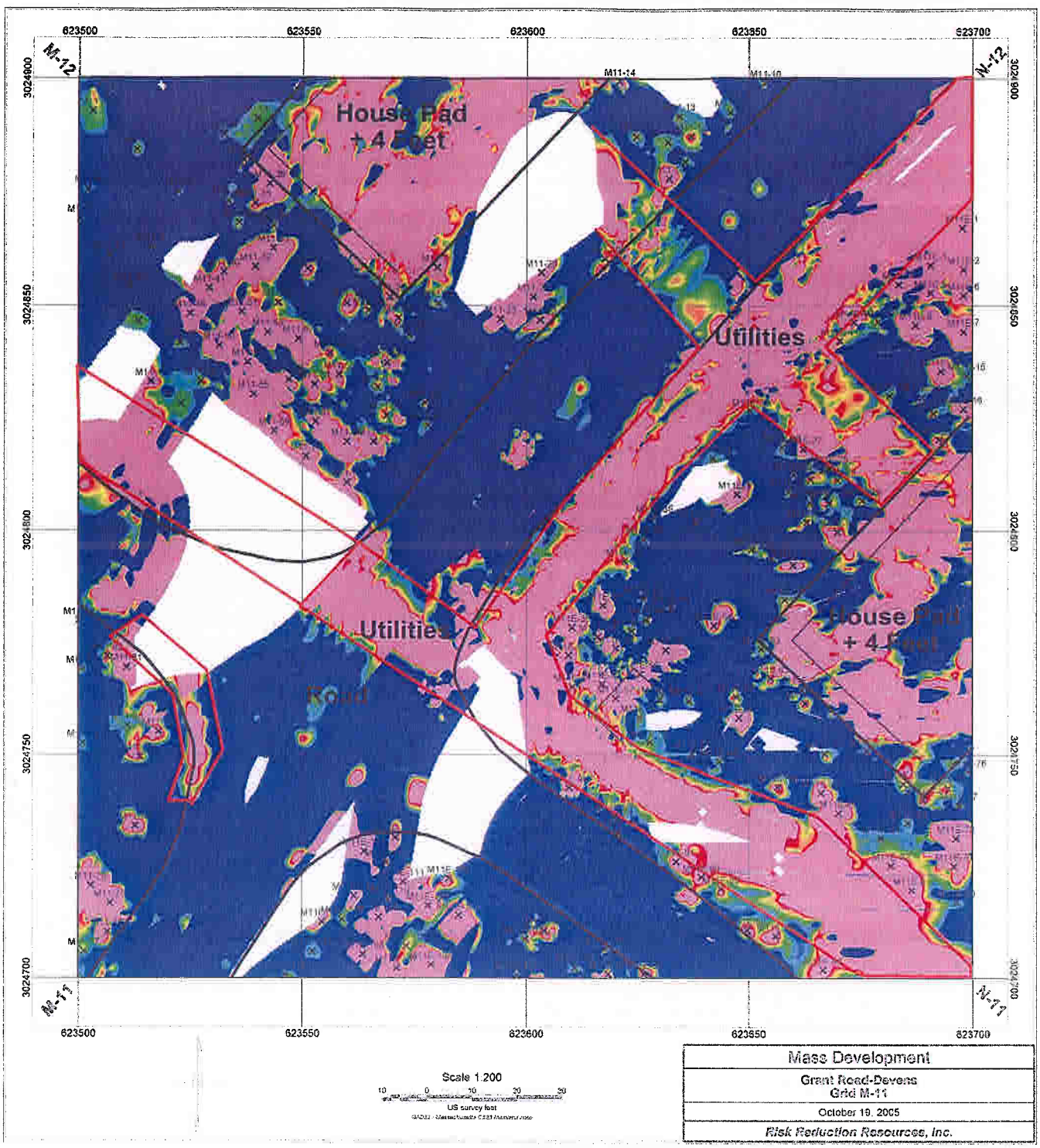
623550
623600
623650
623700
M-11
N-11
M-10
3024700
3024650
3024600
3024550
3024500
Road
Utilities
HousePad
4 Feet
Utilities
HousePad
4 Feet
Utilities
HousePad
4 Feet
Scale 1:200
10 0 10 20 30
US survey feet
Mass Development
Grant Road-Devens
Grid M-10
August 2, 2005
Risk Reduction Resources, Inc.

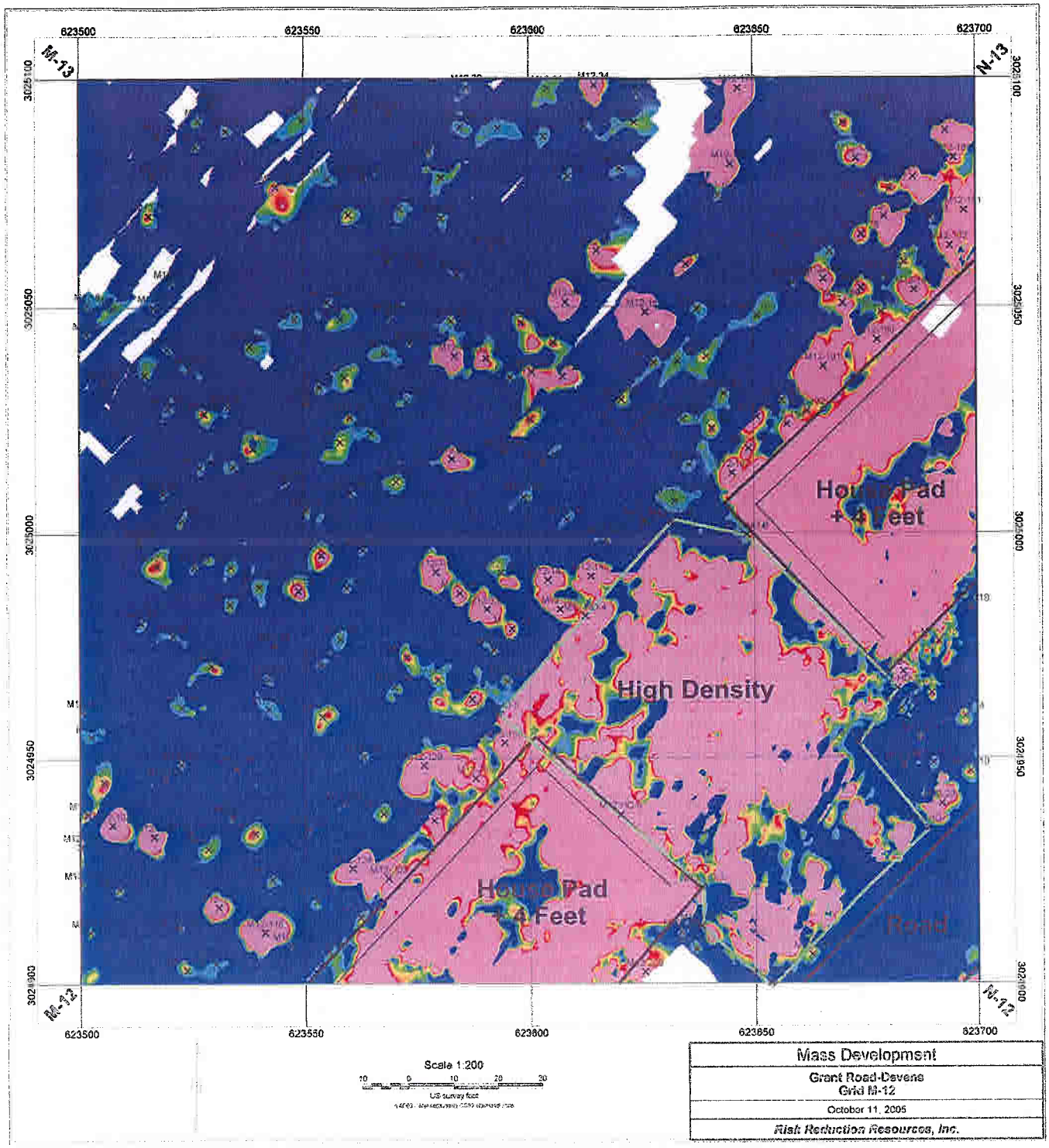


Scale 1:200

10 0 10 20 30

US survey feet

Mass Development
Grant Road-Devens Grid M-11
October 19, 2005
Risk Reduction Resources, Inc.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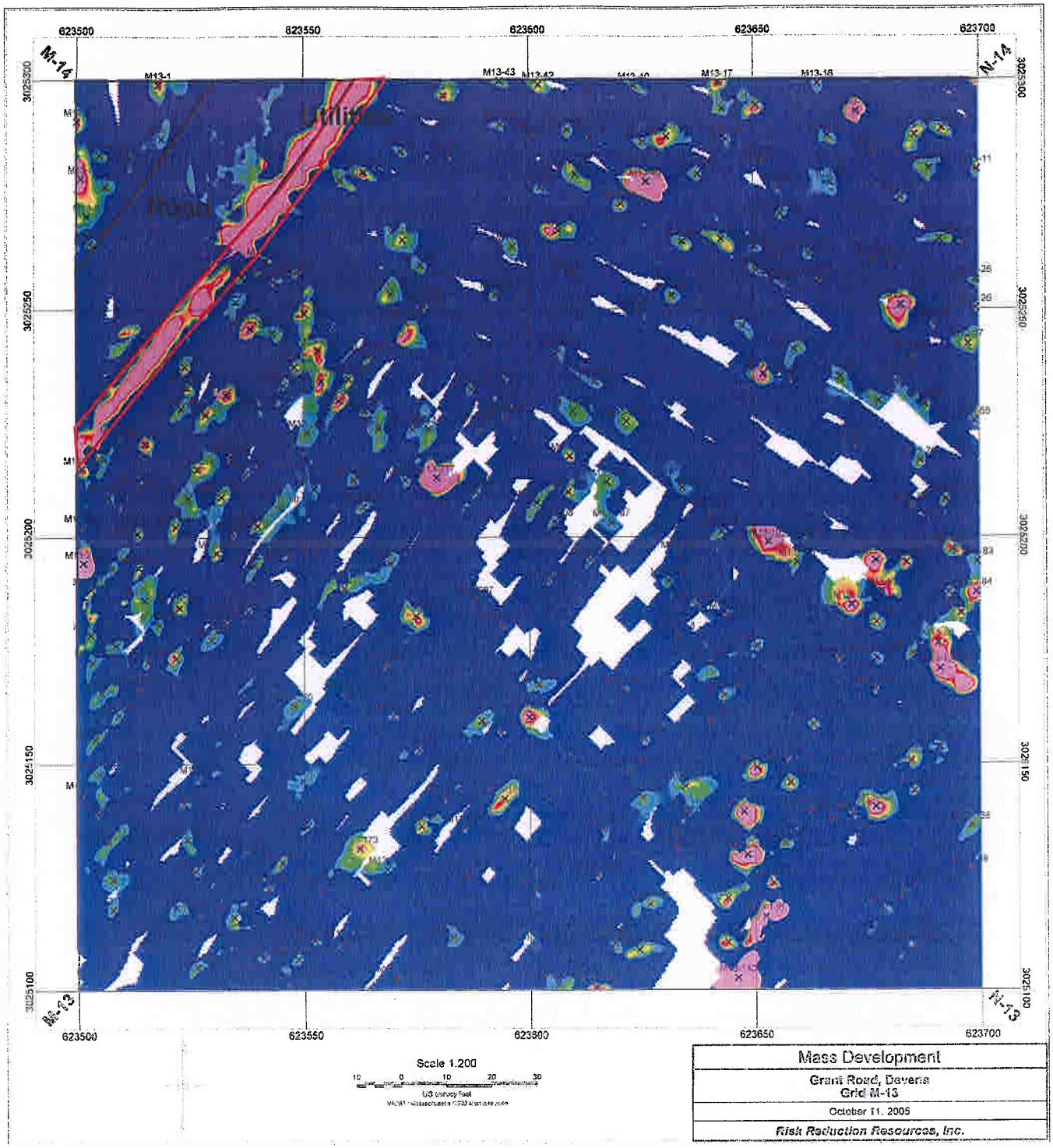
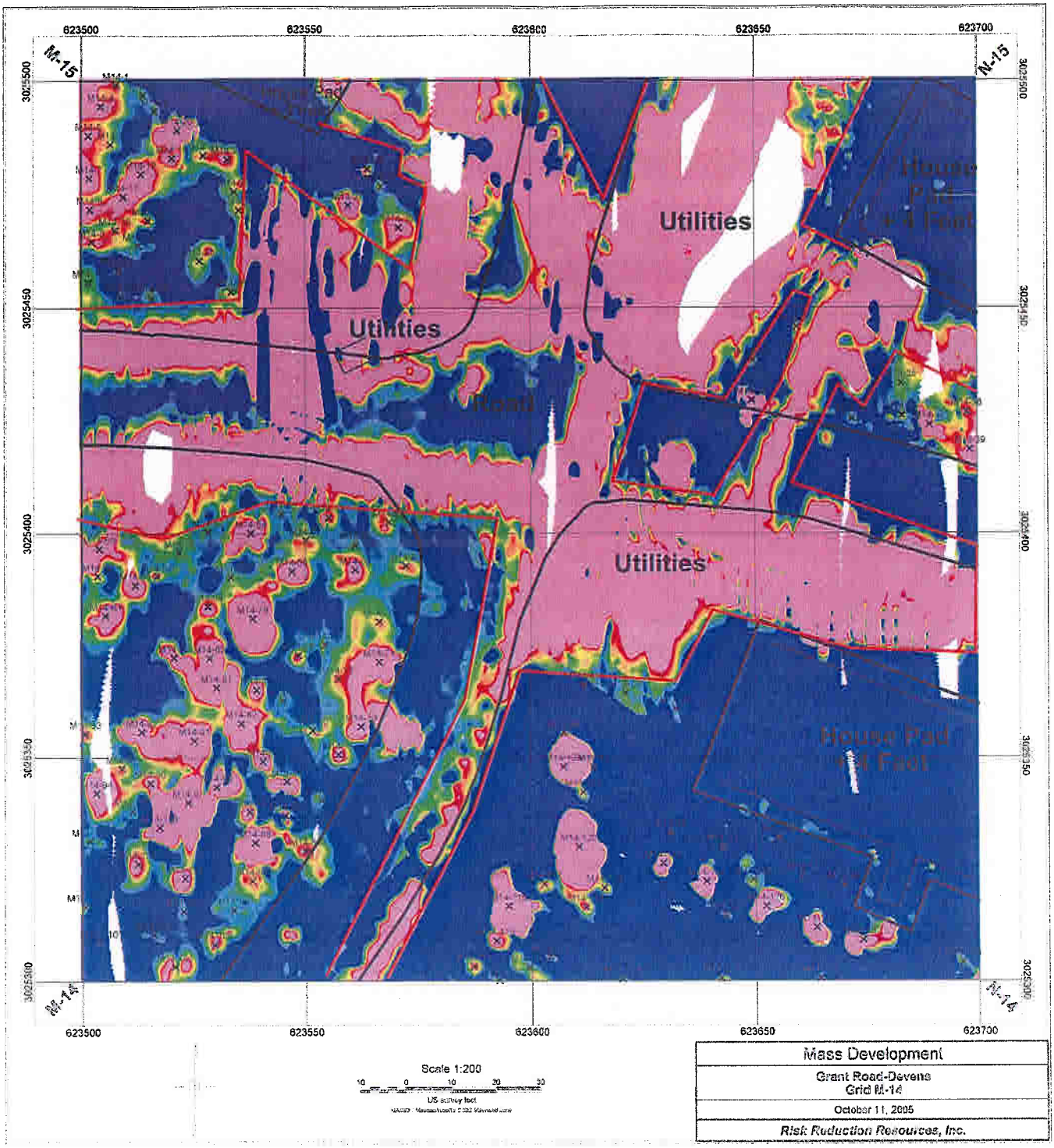
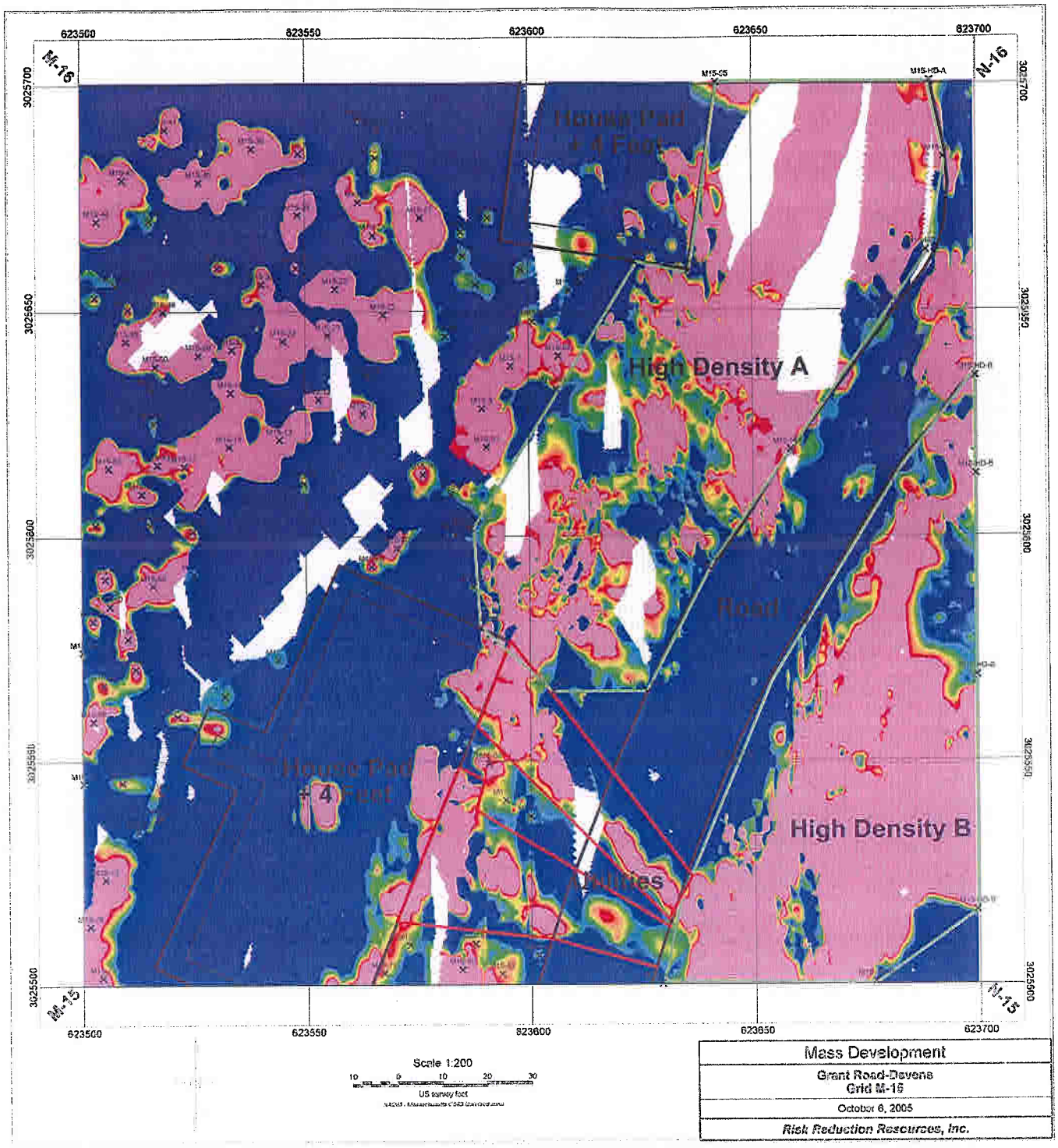
623550
623600
623650
623700
M-13
N-13
M-12
3025100
3025050
3025000
3024950
3024900
House Pad
+4 Feet
High Density
House Pad
+4 Feet
Road
Scale 1:200
10 0 10 20 30
US survey foot
Mass Development
Grant Road-Devens
Grid M-12
October 11, 2005
Risk Reduction Resources, Inc.

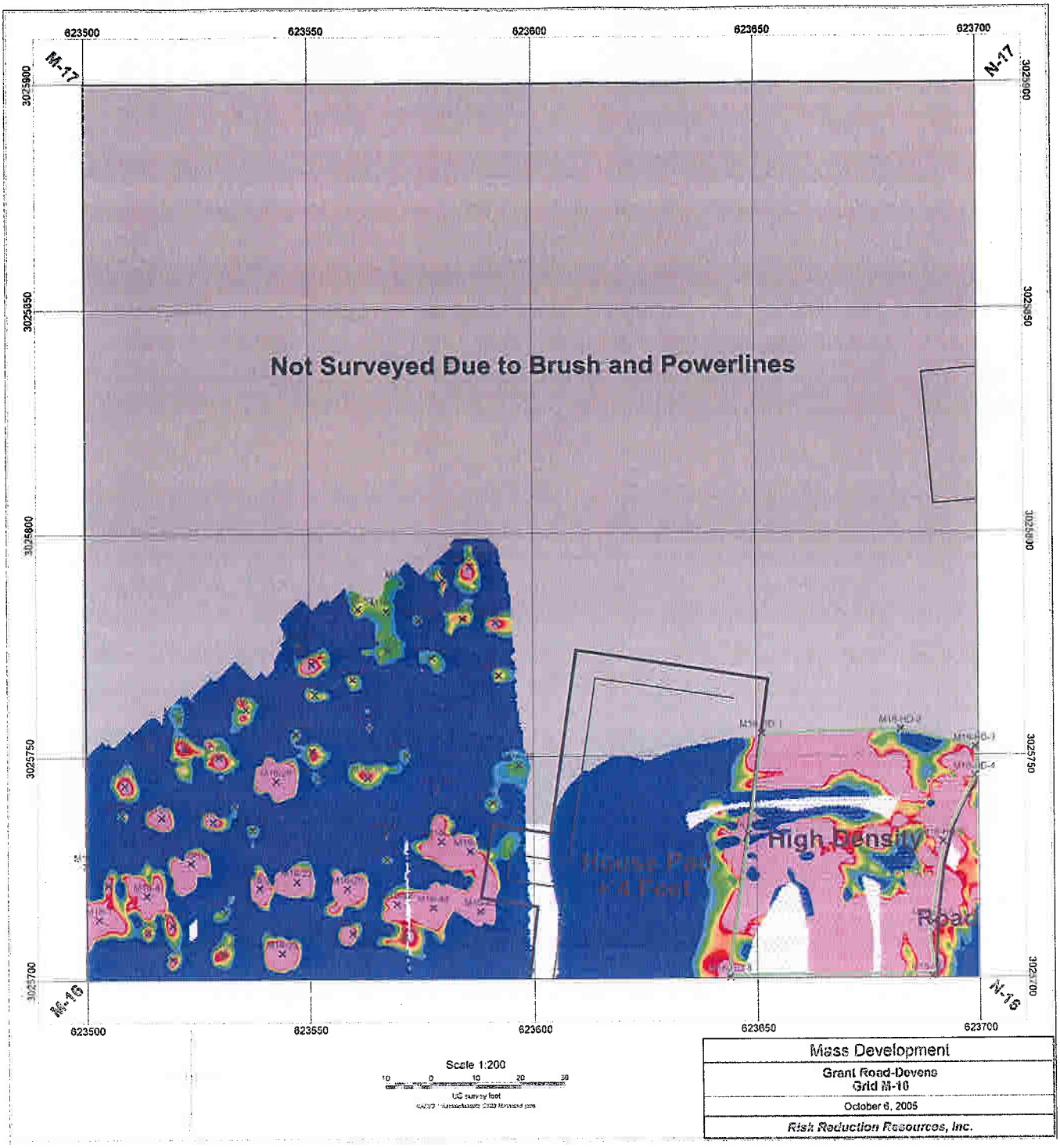


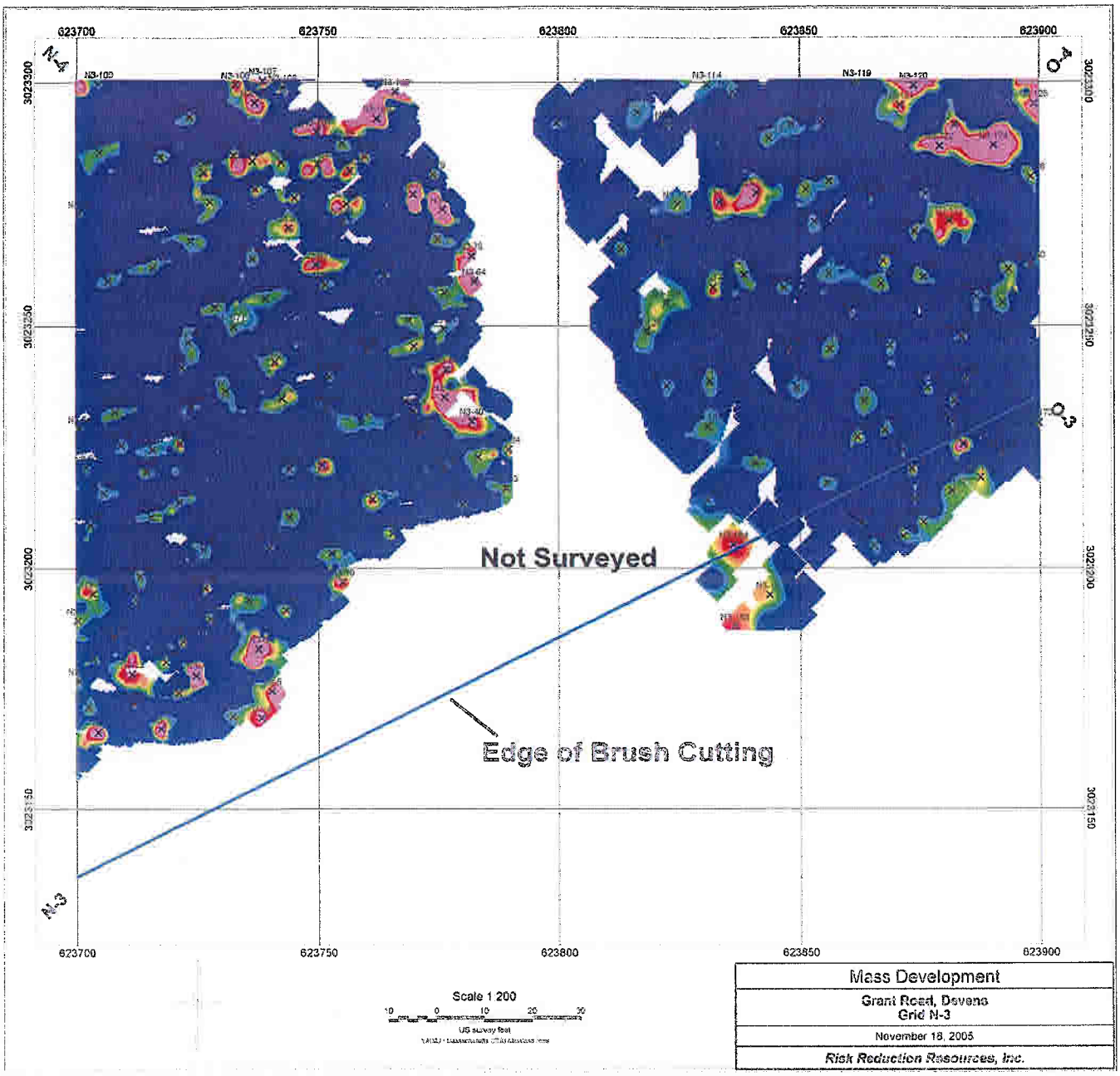
Mass Development
Grant Road, Devens Grid M-13
October 11, 2005
Risk Reduction Resources, Inc.

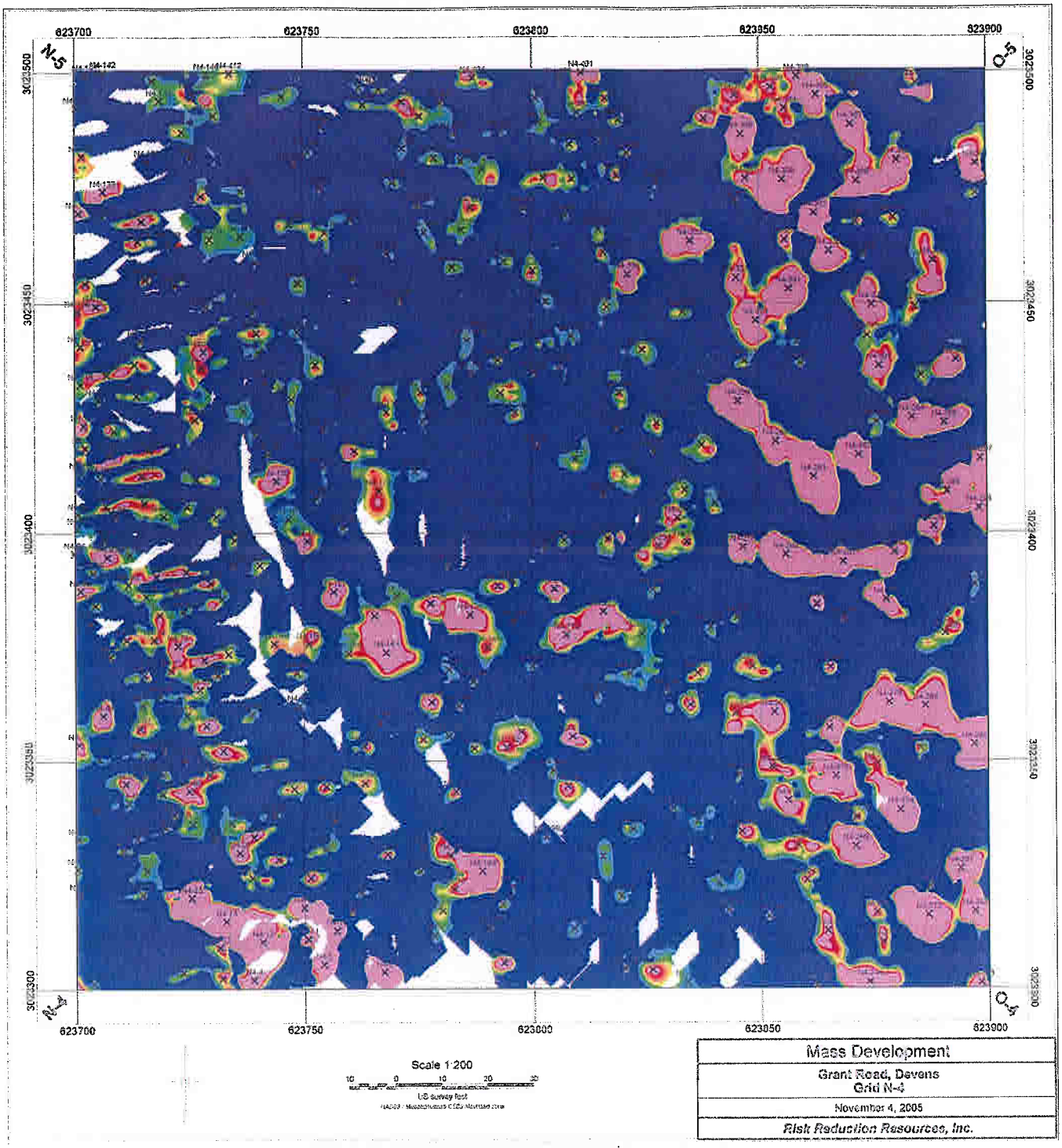


Mass Development
Grant Road-Devens Grid M-14
October 11, 2005
Risk Reduction Resources, Inc.

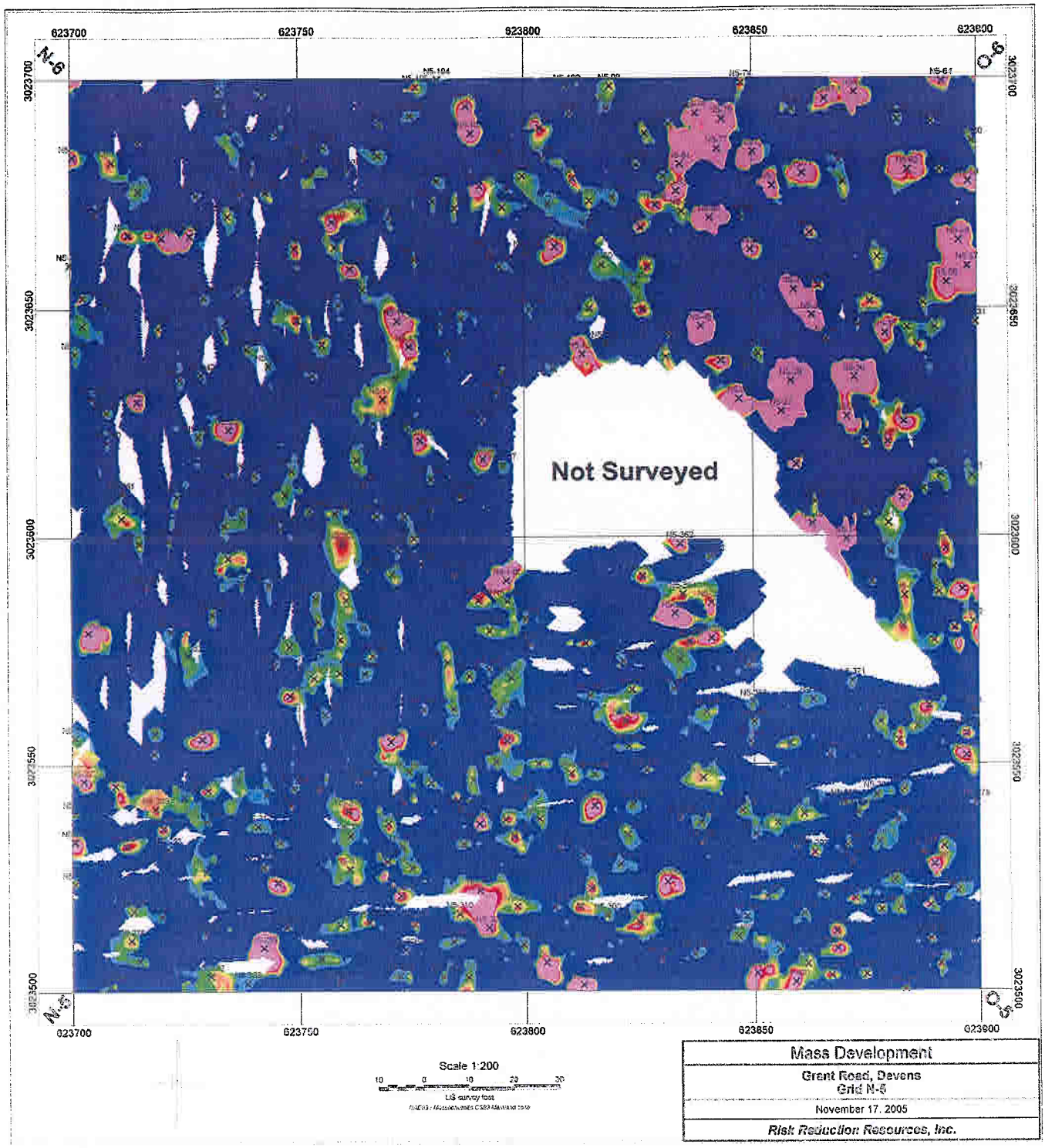

623500
623550
623600
623650
623700
M-16
M-15
3025700
3025650
3025600
3025550
3025500
House Pad
+ 4 Feet
High Density A
Road
House Pad
+ 4 Feet
High Density B
Utilities
Scale 1:200
10 0 10 20 30
US survey feet
Mass Development
Grant Road-Devens
Grid M-16
October 6, 2005
Risk Reduction Resources, Inc.


623500
623550
623600
623650
623700
M-17
N-17
M-16
N-16
3025900
3025850
3025800
3025750
3025700
Not Surveyed Due to Brush and Powerlines
High Density
House Pad
+ 4 Feet
Road
Scale 1:200
10 0 10 20 30
US survey foot
Mass Development
Grant Road-Devens
Grid M-16
October 6, 2005
Risk Reduction Resources, Inc.

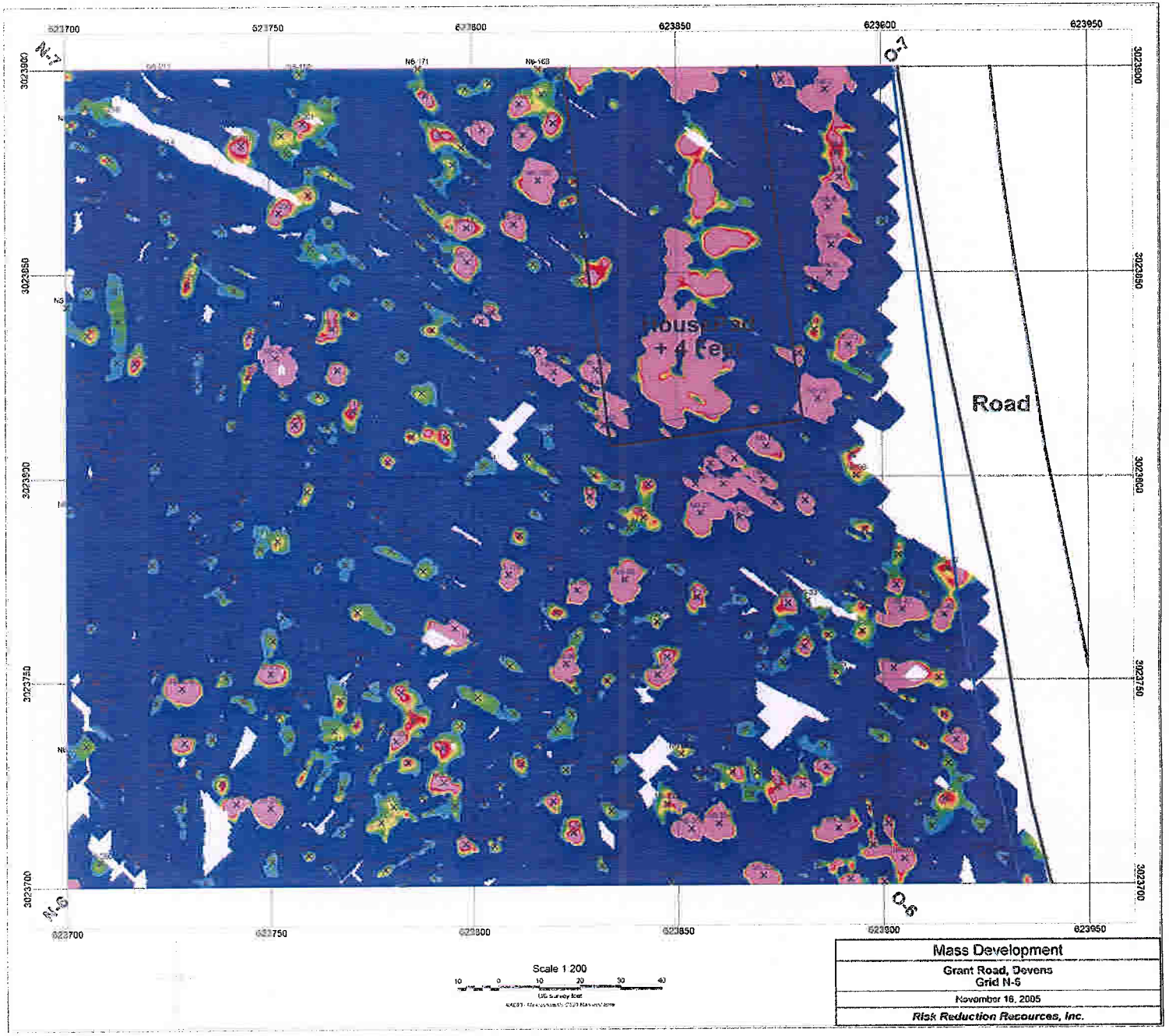

623700
623750
623800
623850
623900
3023300
3023250
3023200
3023150
N-4
O-4
O-3
N-3
Not Surveyed
Edge of Brush Cutting
Scale 1 200
10 0 10 20 30
US survey feet
Mass Development
Grant Road, Devens
Grid N-3
November 18, 2005
Risk Reduction Resources, Inc.



Mass Development
Grant Road, Devens Grid N-4
November 4, 2005
Risk Reduction Resources, Inc.



Mass Development
Grant Road, Devens Grid N-6
November 17, 2005
Risk Reduction Resources, Inc.


623700
623750
623800
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623950
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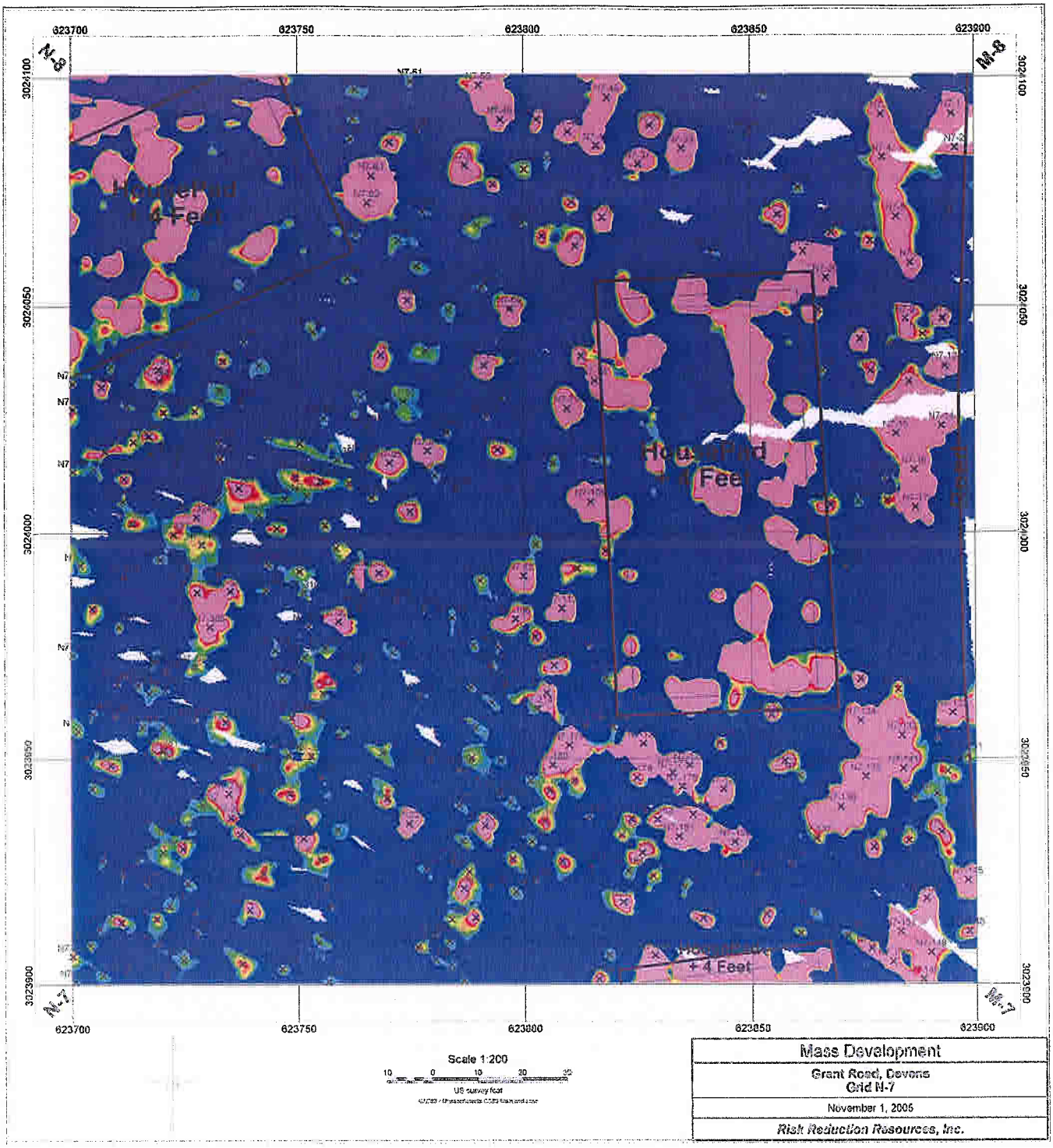
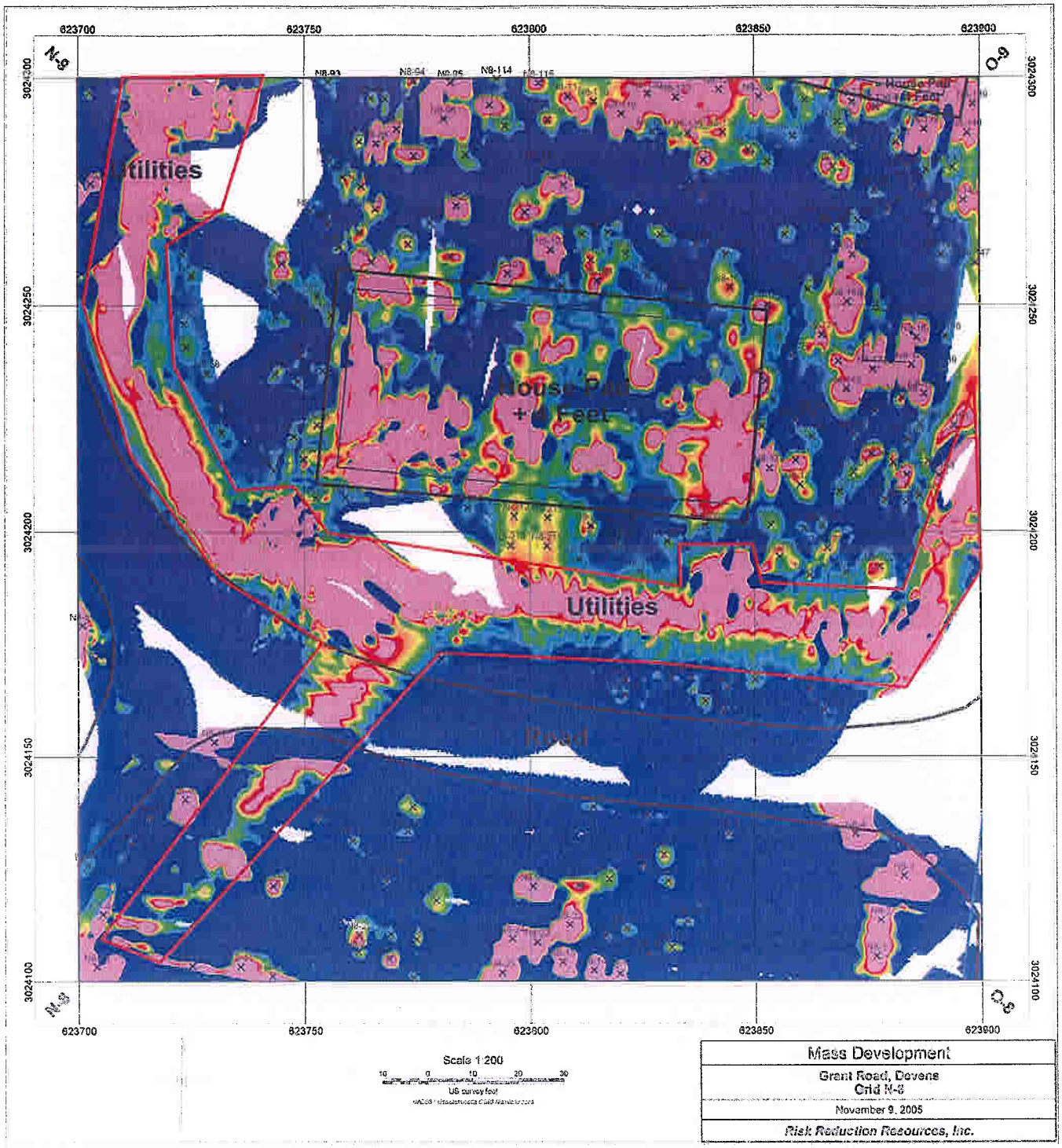
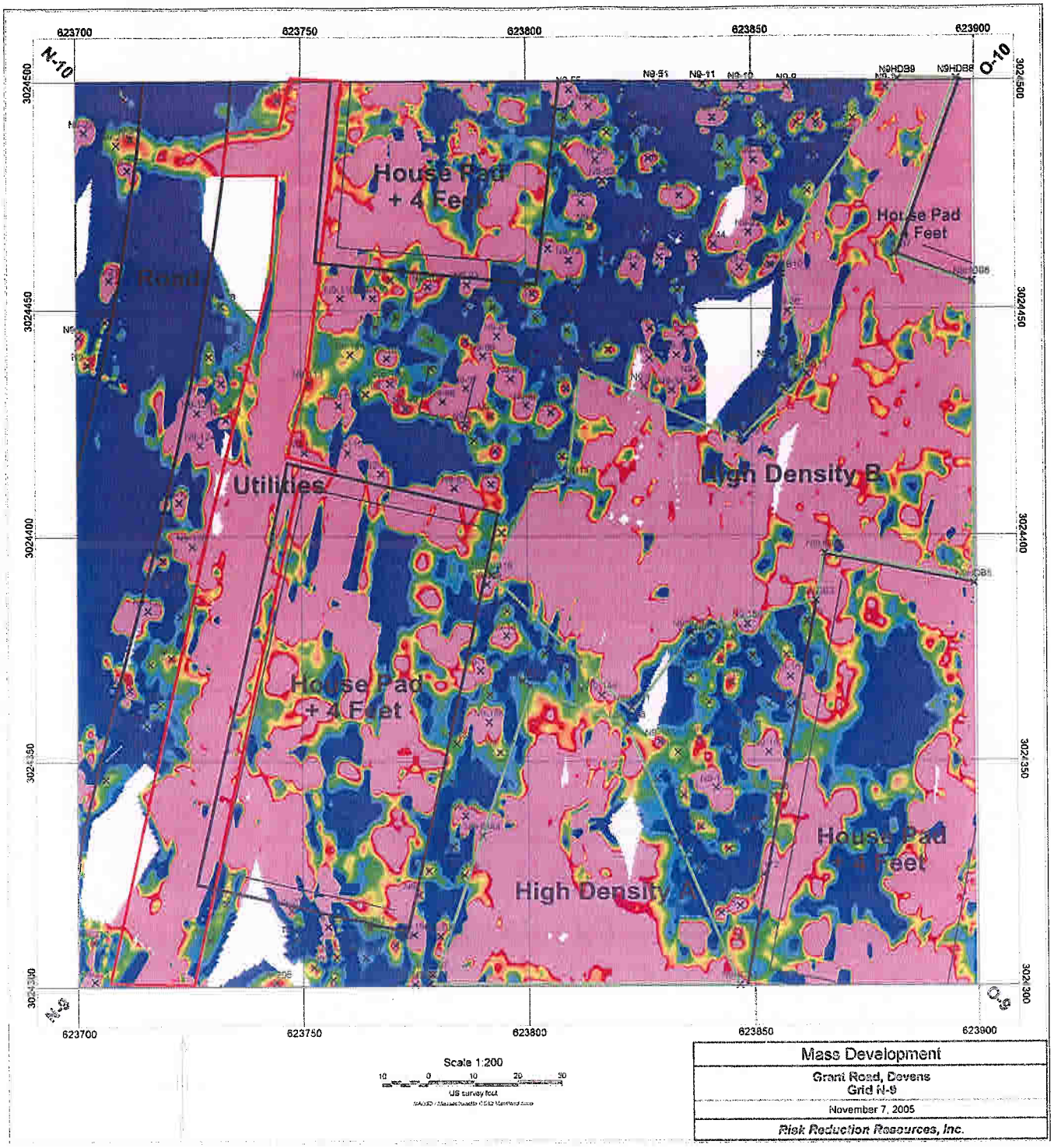
3023850
3023800
3023750
3023700
N-7
O-7
N-6
O-6
Road
Scale 1:200
10 0 10 20 30 40
Mass Development
Grant Road, Devens
Grid N-5
November 16, 2005
Risk Reduction Recources, Inc.

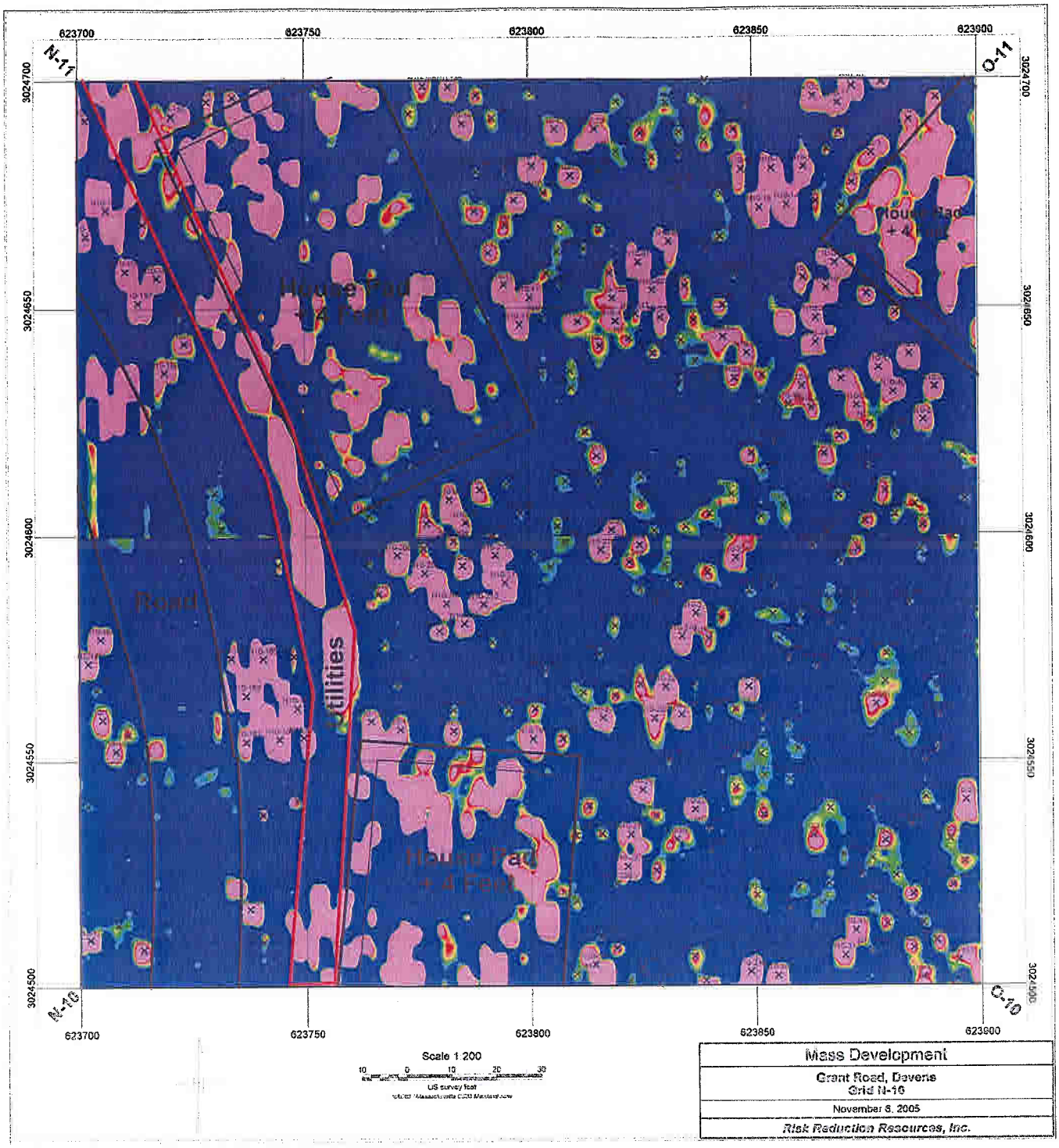


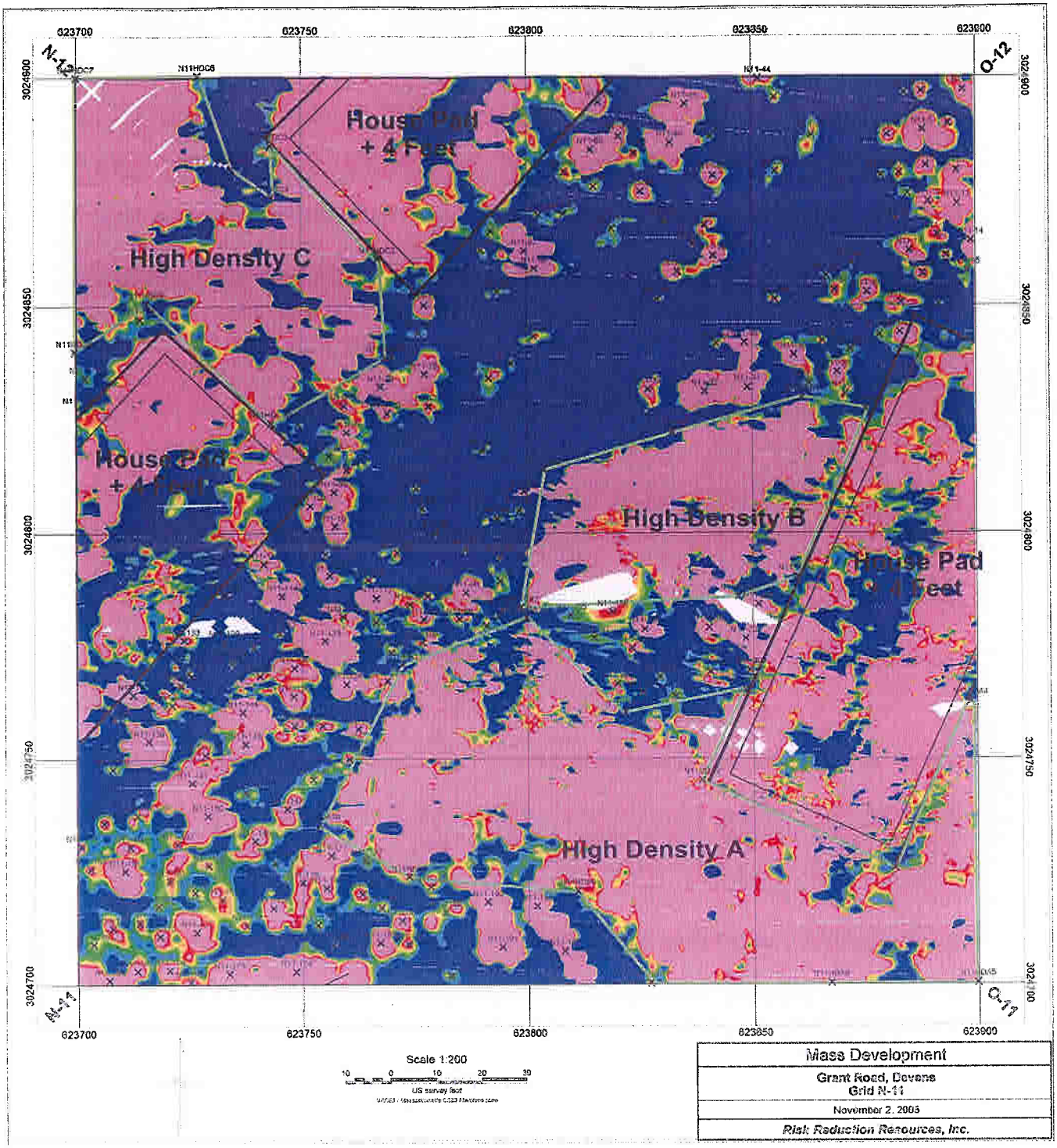
623700
623750
623800
623850
623900
3024100
3024050
3024000
3023950
3023900
N-8
M-8
N-7
M-7
Household
+4 Feet
Household
+4 Feet
+ 4 Feet
Scale 1:200
10 0 10 20 30
US survey feet
Mass Development
Grant Road, Devens
Grid N-7
November 1, 2005
Risk Reduction Resources, Inc.

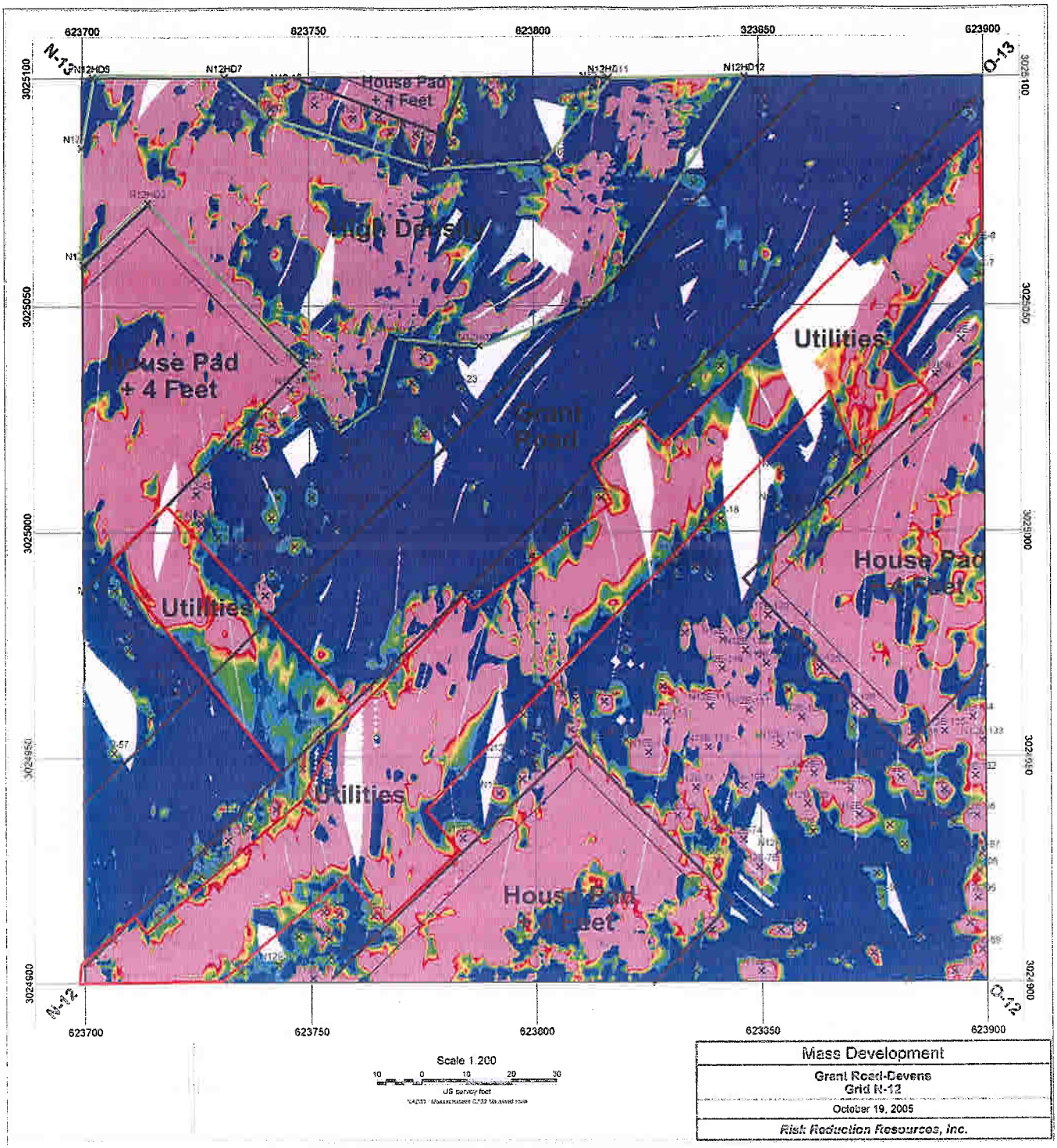


Mass Development
Grant Road, Devens Grid N-9
November 9, 2005
Risk Reduction Resources, Inc.

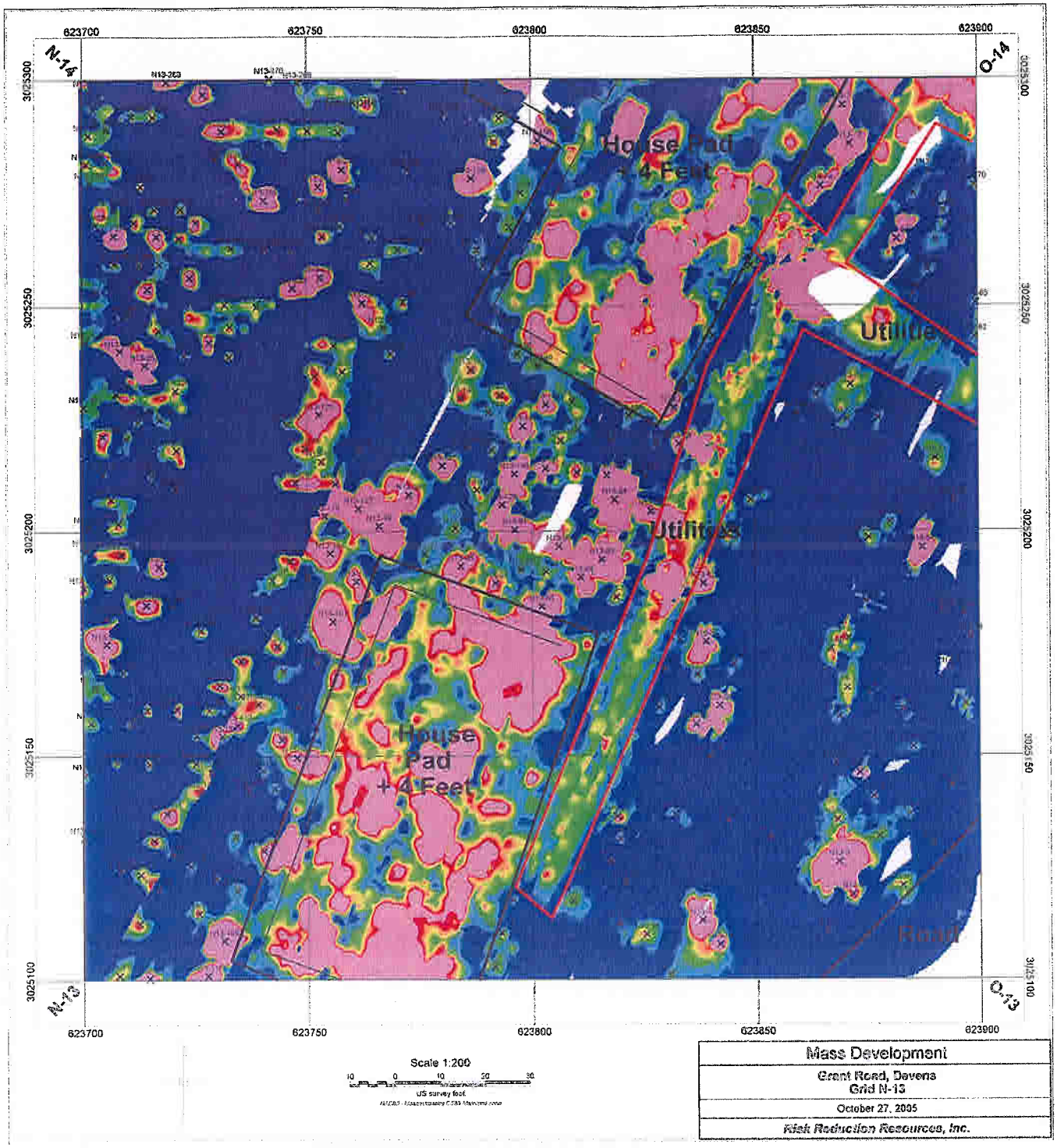

623700
623750
623800
623850
623900
N-10
O-10
3024500
3024450
3024400
3024350
3024300
House Pad
+ 4 Feet
Road
Utilities
High Density B
House Pad
+ 4 Feet
House Pad
+ 4 Feet
High Density A
Scale 1:200
10 0 10 20 30
US survey foot
Mass Development
Grant Road, Devens
Grid N-9
November 7, 2005
Risk Reduction Resources, Inc.


623700
623750
623800
623850
623900
N-11
O-11
N-10
O-10
3024700
3024650
3024600
3024550
3024500
House Pad
+ 4 Feet
Road
Utilities
Scale 1:200
10 0 10 20 30
US survey foot
Mass Development
Grant Road, Devens
Grid N-16
November 8, 2005
Risk Reduction Resources, Inc.

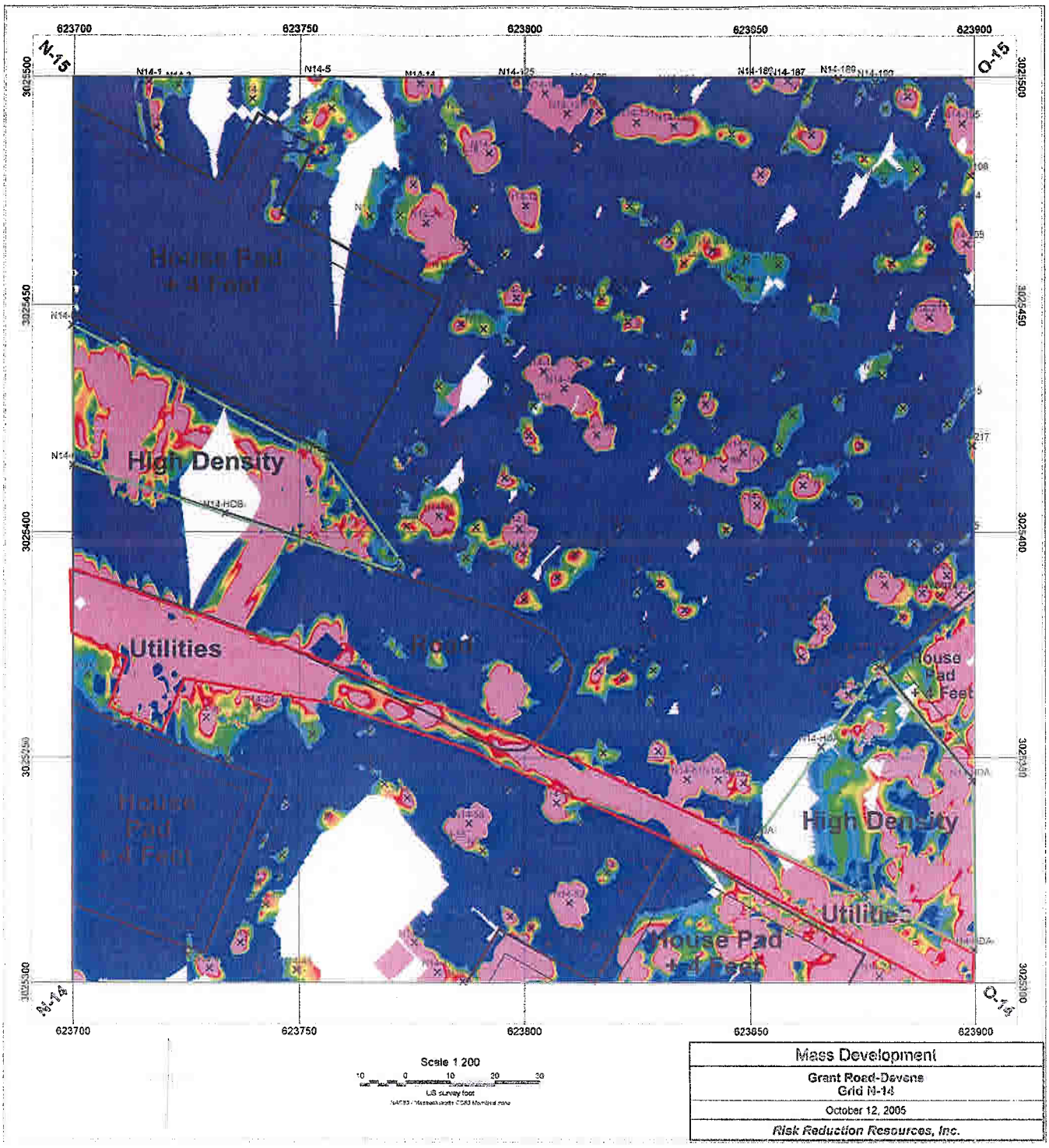

623700
623750
623800
623850
623900
3024900
3024850
3024800
3024750
3024700
N-12
O-12
N-11
O-11
N11HDC8
N11-44
House Pad
+ 4 Feet
High Density C
House Pad
+ 4 Feet
High Density B
House Pad
+ 4 Feet
High Density A
Scale 1:200
10 0 10 20 30
US survey feet
Mass Development
Grant Road, Devens
Grid N-11
November 2, 2005
Risk Reduction Resources, Inc.

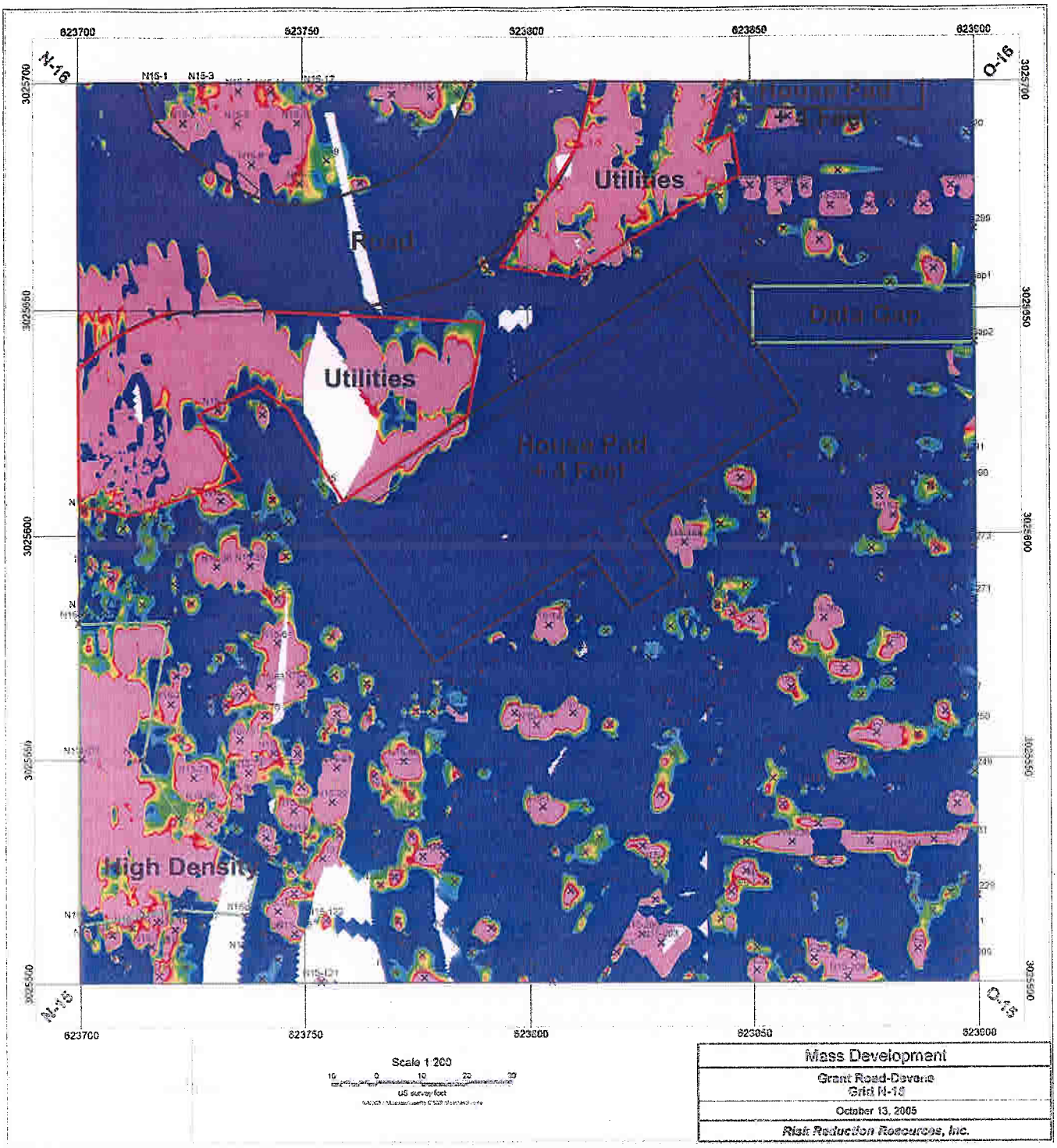


Mass Development
Grant Road-Devens Grid N-12
October 19, 2005
Risk Reduction Resources, Inc.

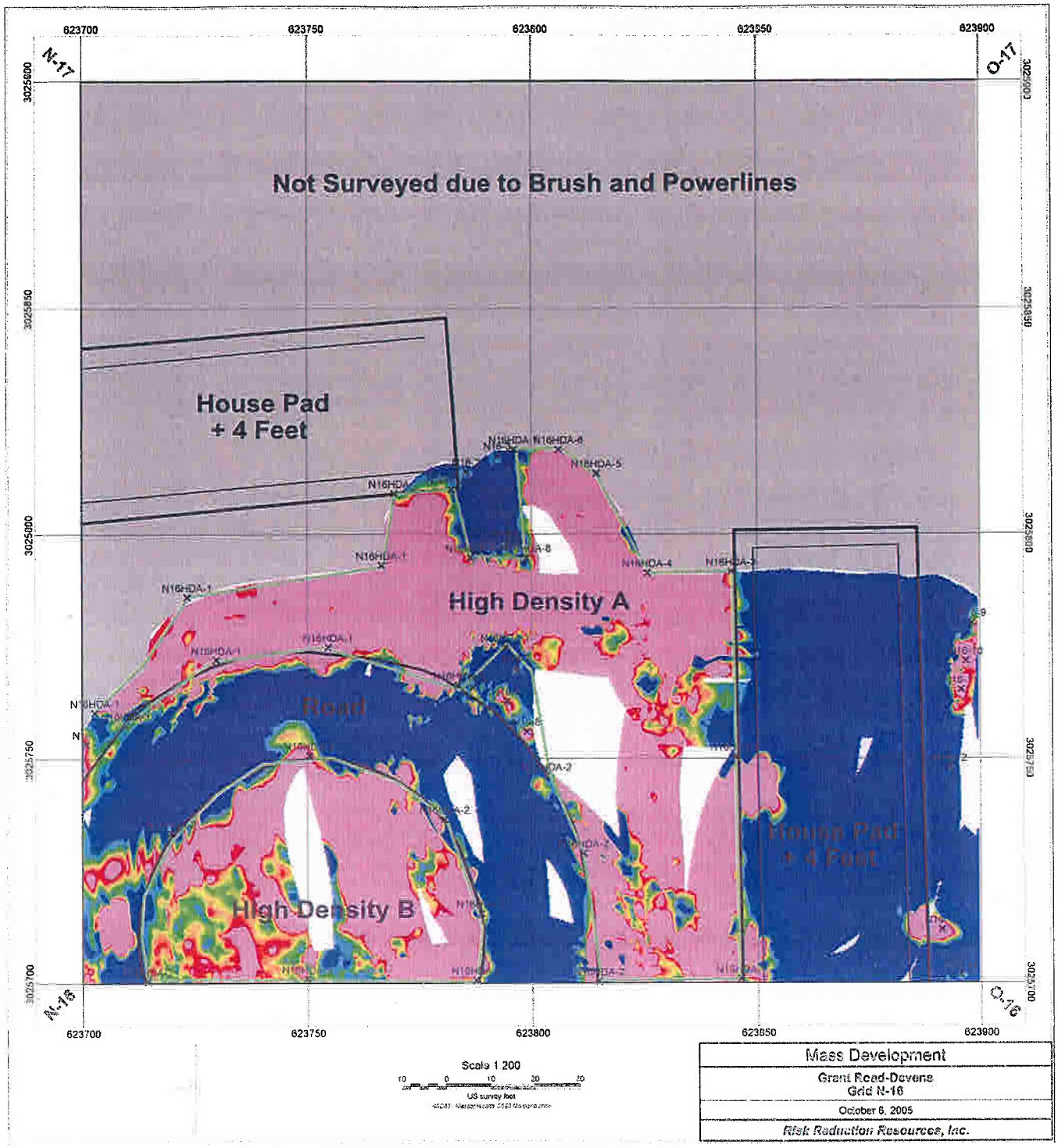


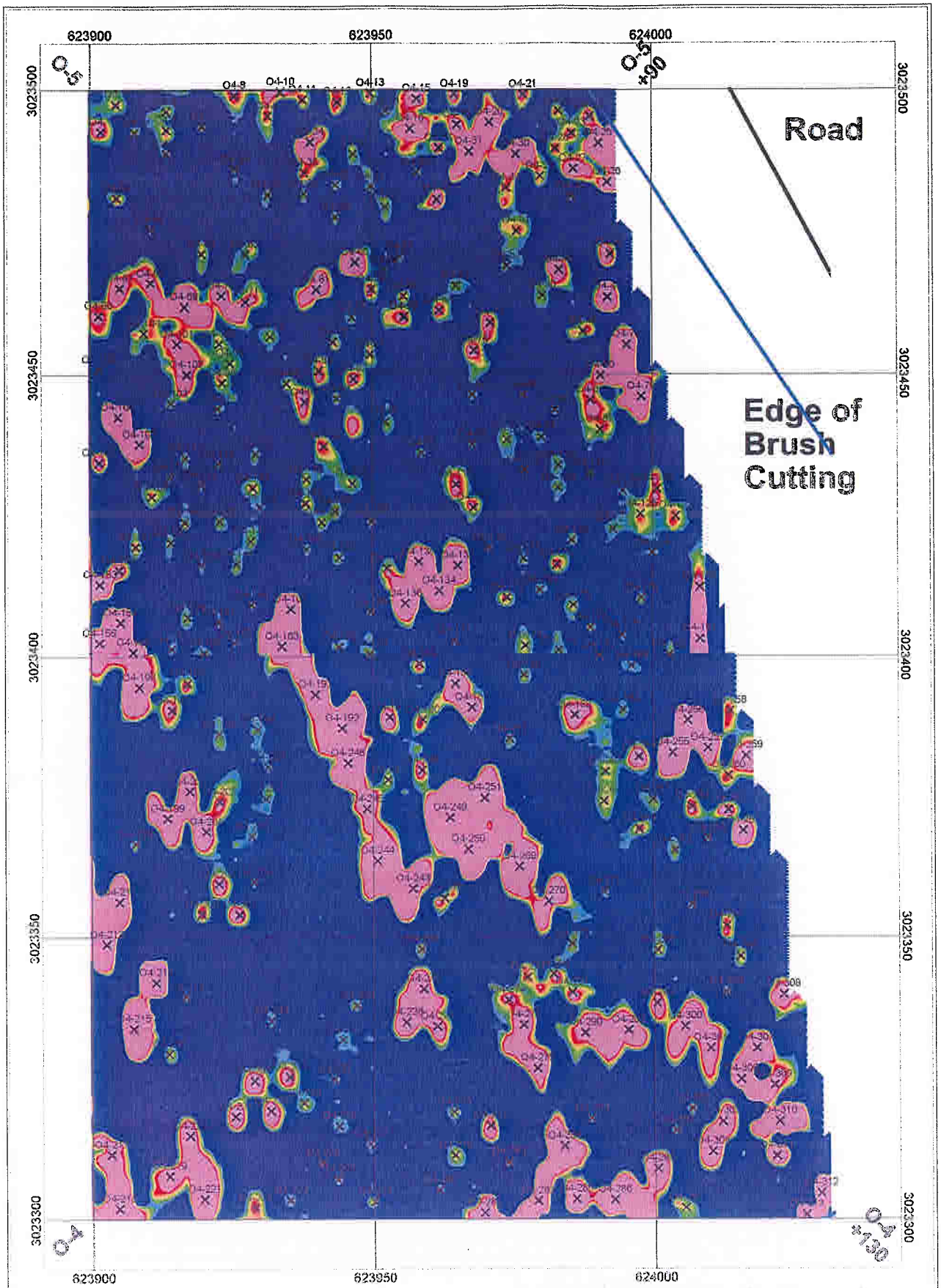
Mass Development
Grant Road, Devens Grid N-13
October 27, 2005
Risk Reduction Resources, Inc.

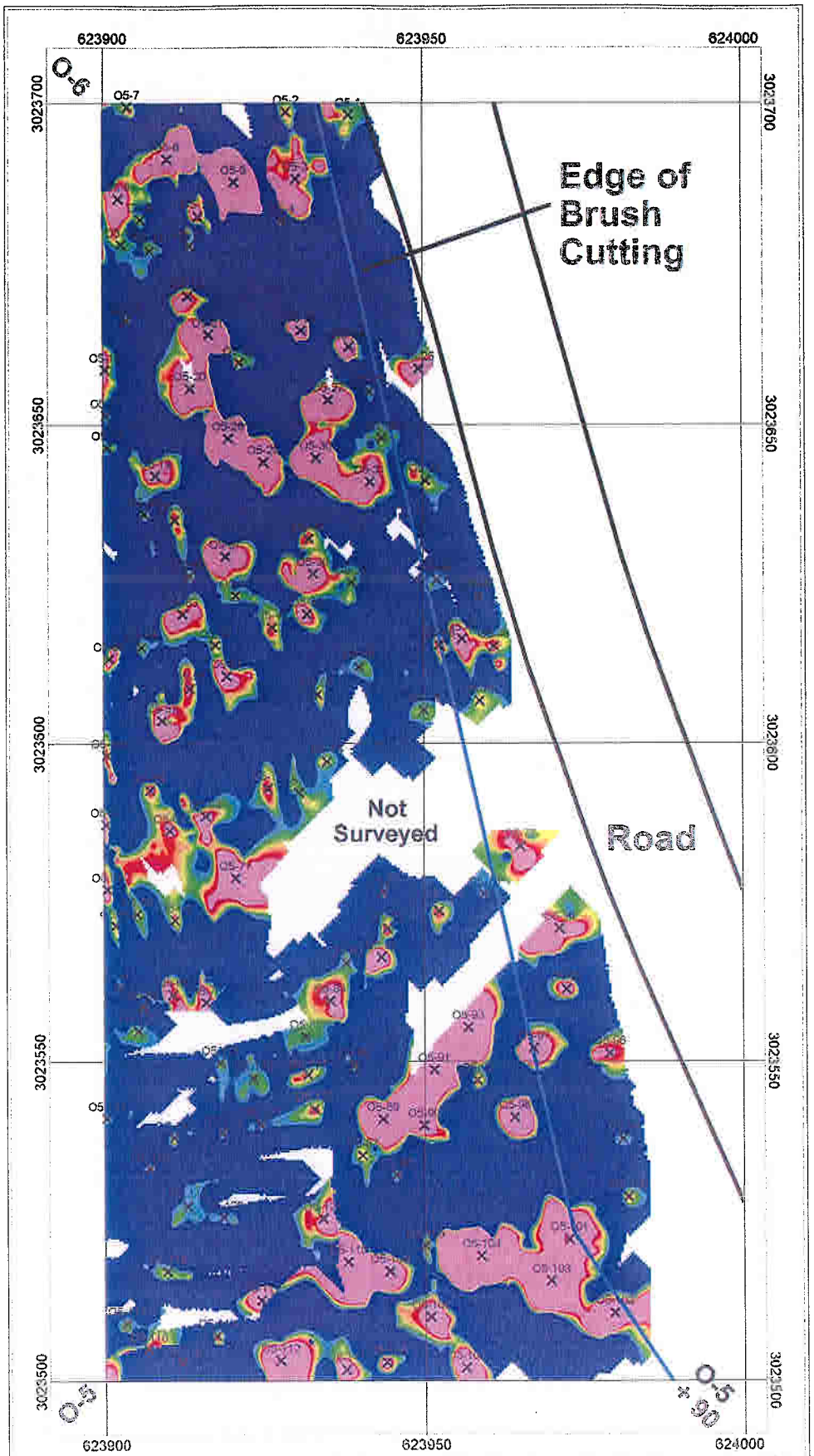

623700
623750
623800
623850
623900
N-15
O-15
M-14
O-14
3025500
3025450
3025400
3025350
3025300
House Pad
+4 Feet
High Density
Utilities
Road
House Pad
+4 Feet
High Density
Utilities
House Pad
+4 Feet
House Pad
+4 Feet
Scale 1 200
10 0 10 20 30
US survey foot
NAD83 / Massachusetts CS83 Mainland zone
Mass Development
Grant Road-Devens
Grid N-14
October 12, 2005
Risk Reduction Resources, Inc.



Mass Development
Grant Road-Devens Grid N-16
October 13, 2005
Risk Reduction Resources, Inc.


623700
623750
623800
623850
623900
N-17
O-17
N-16
O-16
3025900
3025850
3025800
3025750
3025700
Not Surveyed due to Brush and Powerlines
House Pad
+ 4 Feet
High Density A
Road
High Density B
House Pad
+ 4 Feet
N16HDA-1
N16HDA-2
N16HDA-4
N16HDA-5
N16HDA-6
Scale 1:200
10 0 10 20 30
US survey foot
Mass Development
Grant Road-Devens
Grid N-16
October 6, 2005
Risk Reduction Resources, Inc.


623900
623950
624000
3023500
3023450
3023400
3023350
3023300
O-5
O-5 +90
O-4
O-4 +90
Road
Edge of Brush Cutting
Scale 1:200
10 0 10 20
US survey foot
NAD83 / Massachusetts 0393 Mainland zone
Mass Development
Grant Road, Devens
Grid O-4
November 20, 2005
Risk Reduction Resources, Inc.



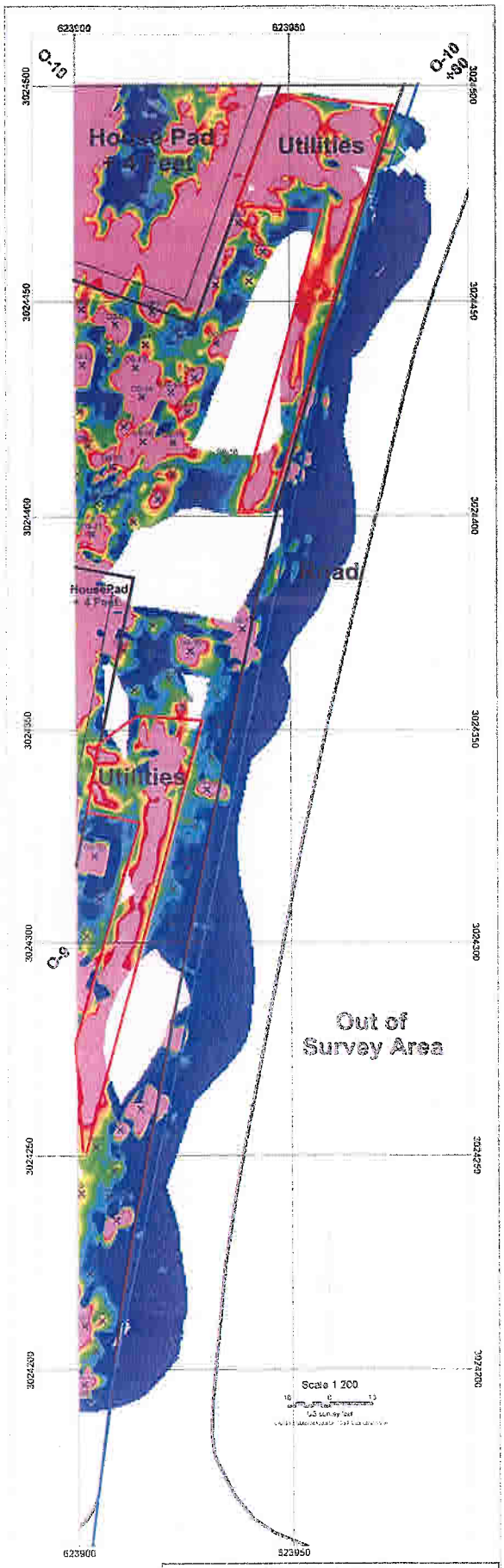
Scale 1:200

10 0 10

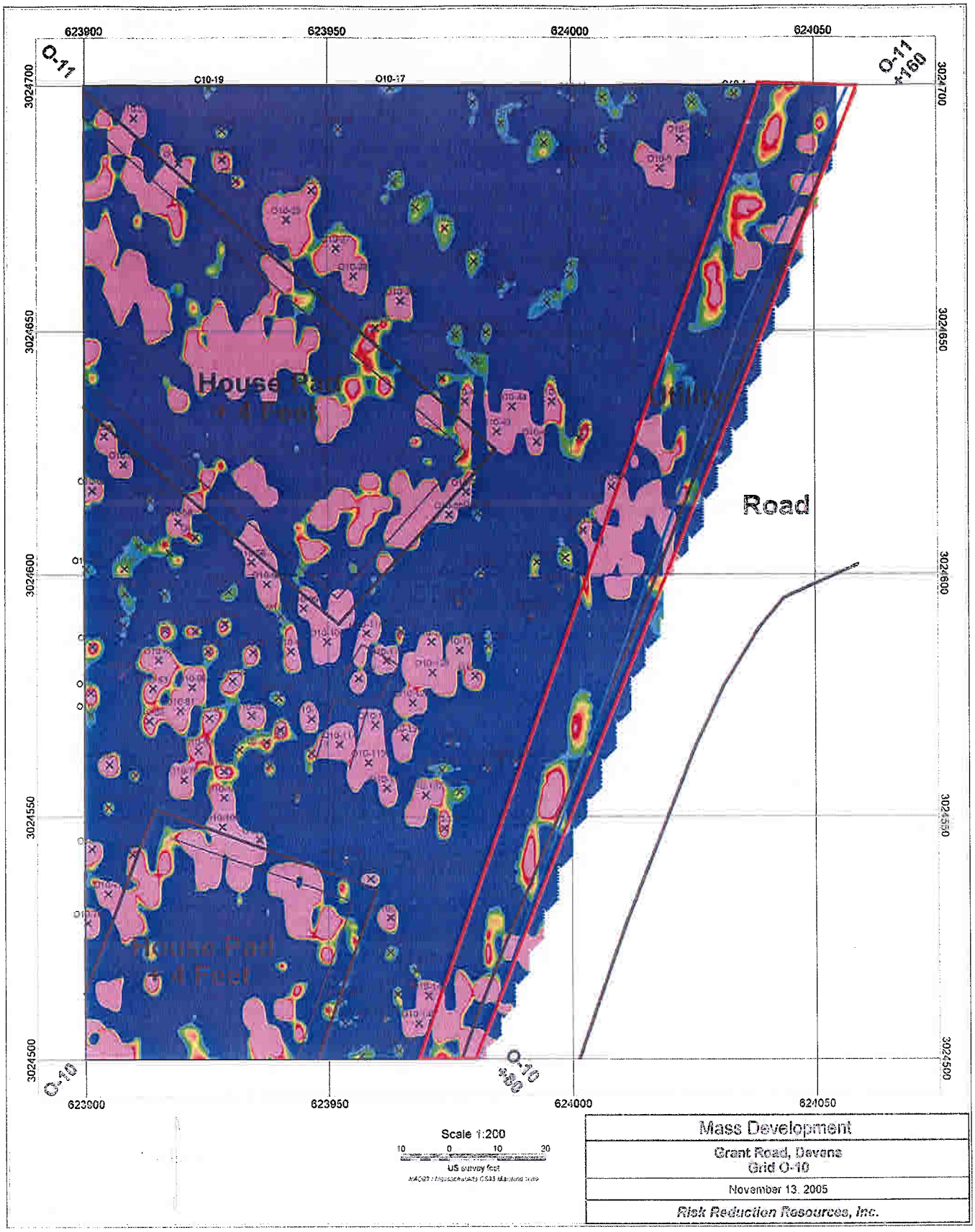
US survey foot

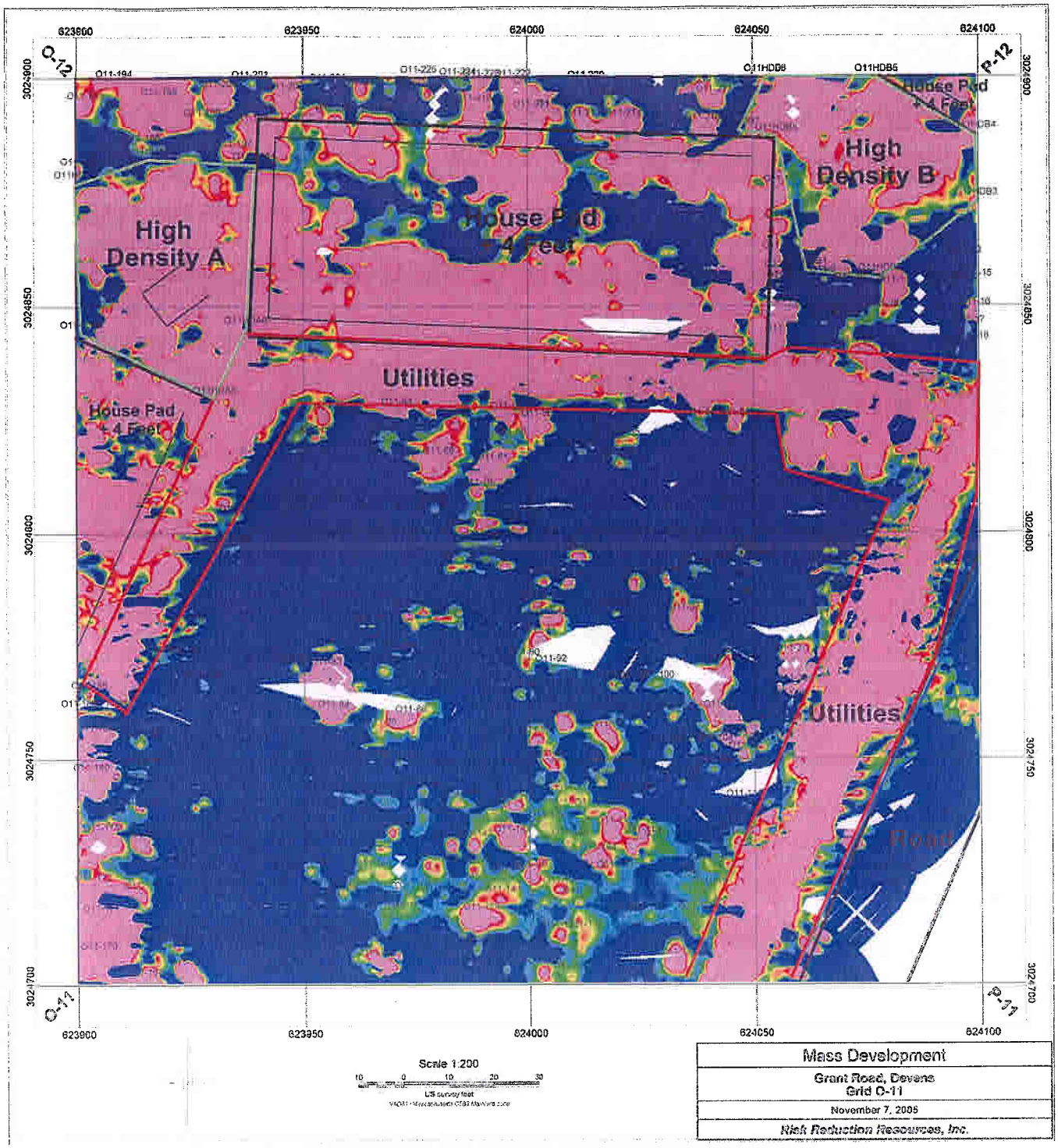
NAD83 - Massachusetts CS83 Mainland zone

Mass Development
Grant Road, Devens Grid O-5
November 17, 2005
Risk Reduction Resources, Inc.



Mass Development
Grant Road, Devens Grid O-8, O-9
November 16, 2005
Risk Reduction Resources, Inc.


623900
623950
624000
624050
O-11
O-11 +160
O10-19
O10-17
3024700
3024650
3024600
3024550
3024500
House Pad
+4 Feet
Utility
Road
House Pad
+4 Feet
O-10
O-10 +60
Scale 1:200
10 0 10 20
US survey feet
Mass Development
Grant Road, Devens
Grid O-10
November 13, 2005
Risk Reduction Resources, Inc.

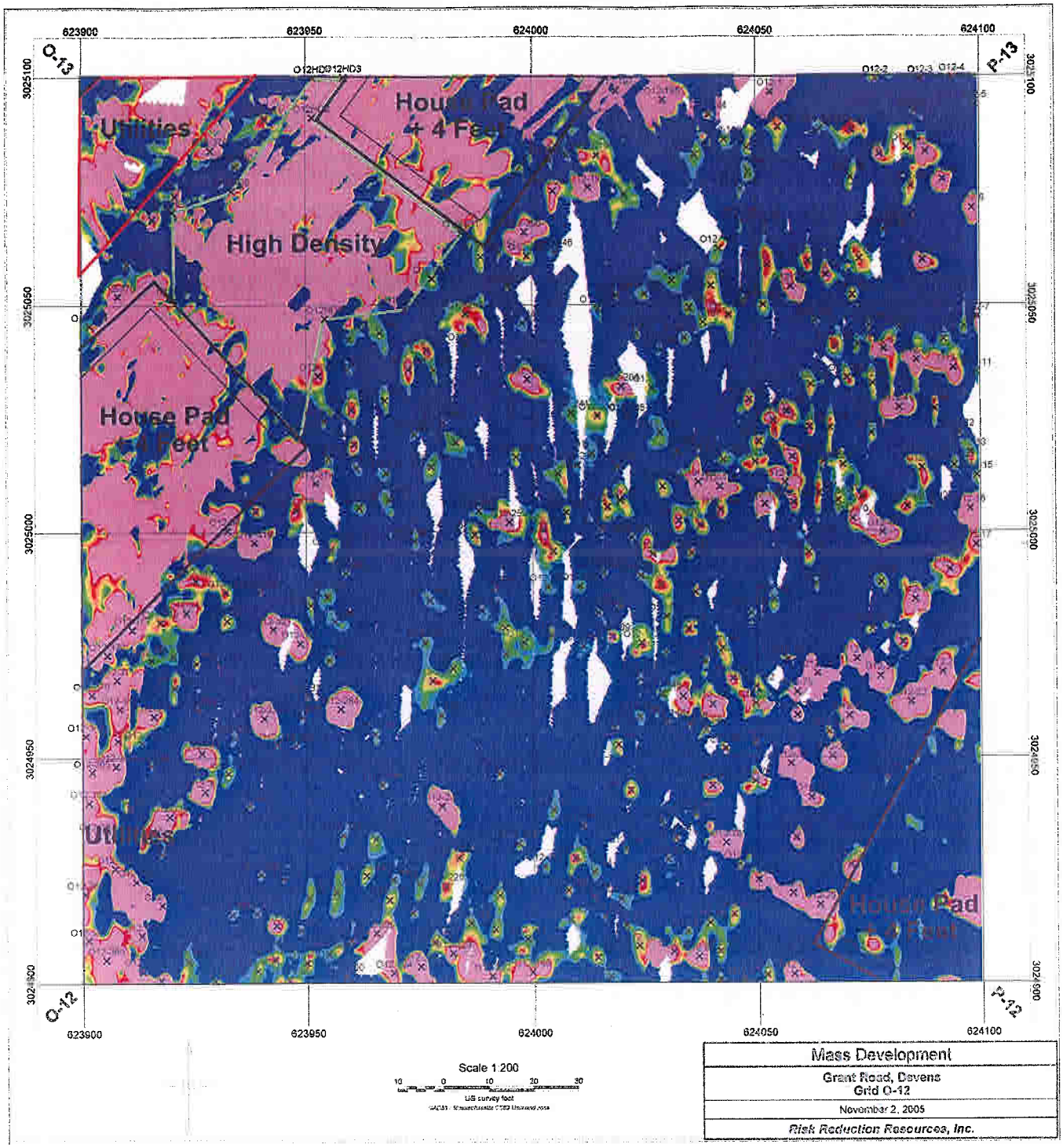


Mass Development

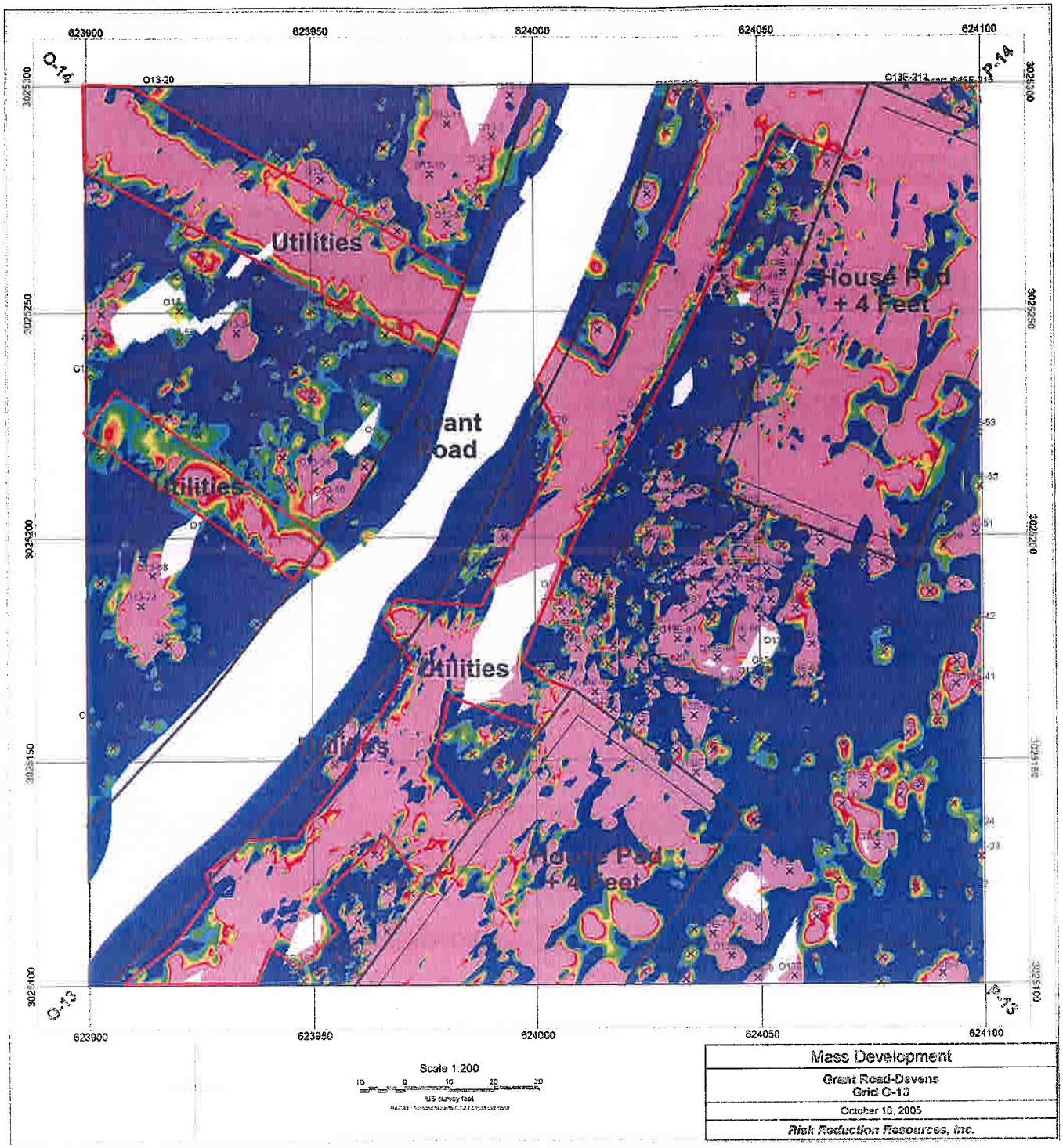
Grant Road, Devens
Grid O-11

November 7, 2005

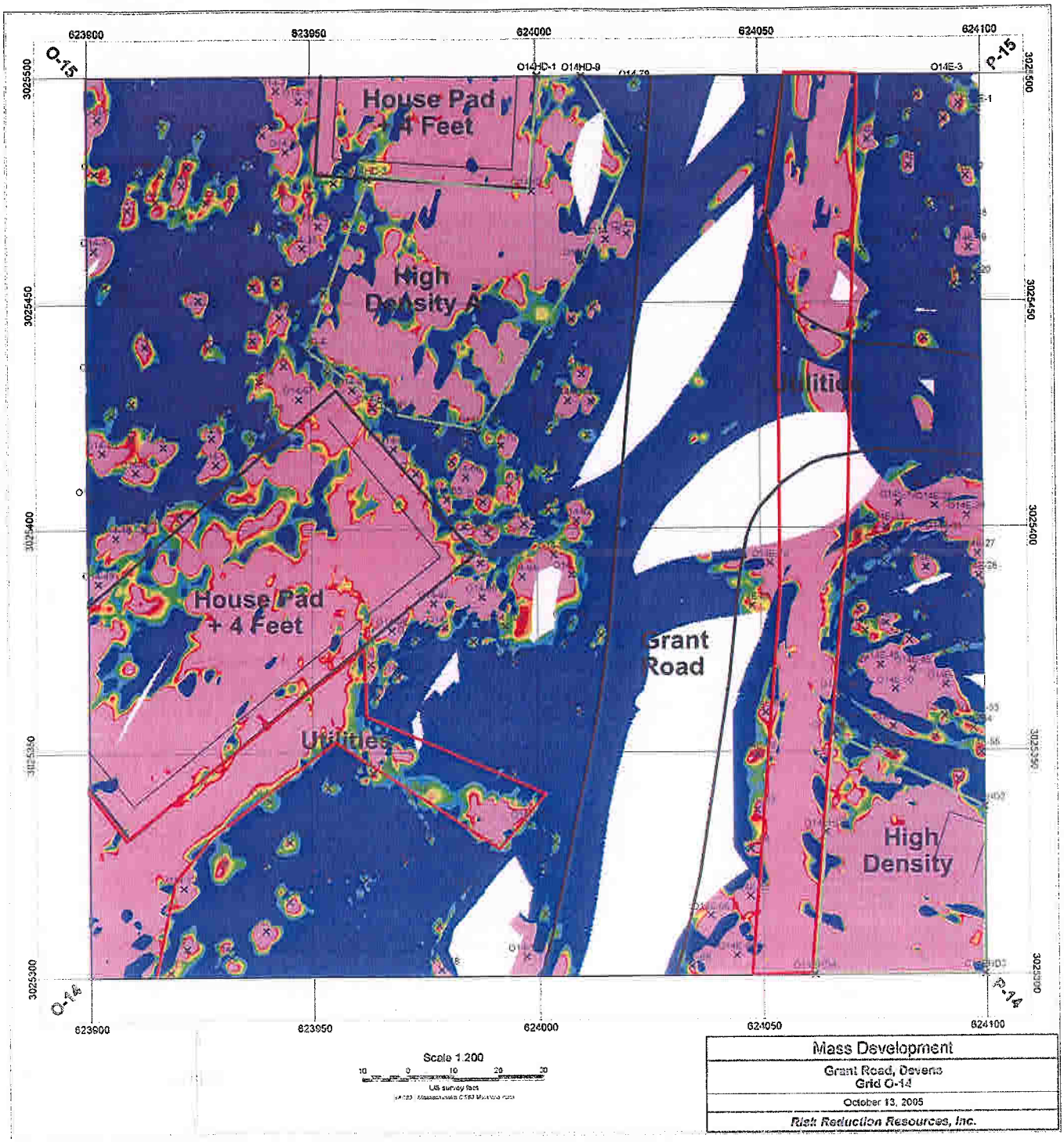
Risk Reduction Resources, Inc.

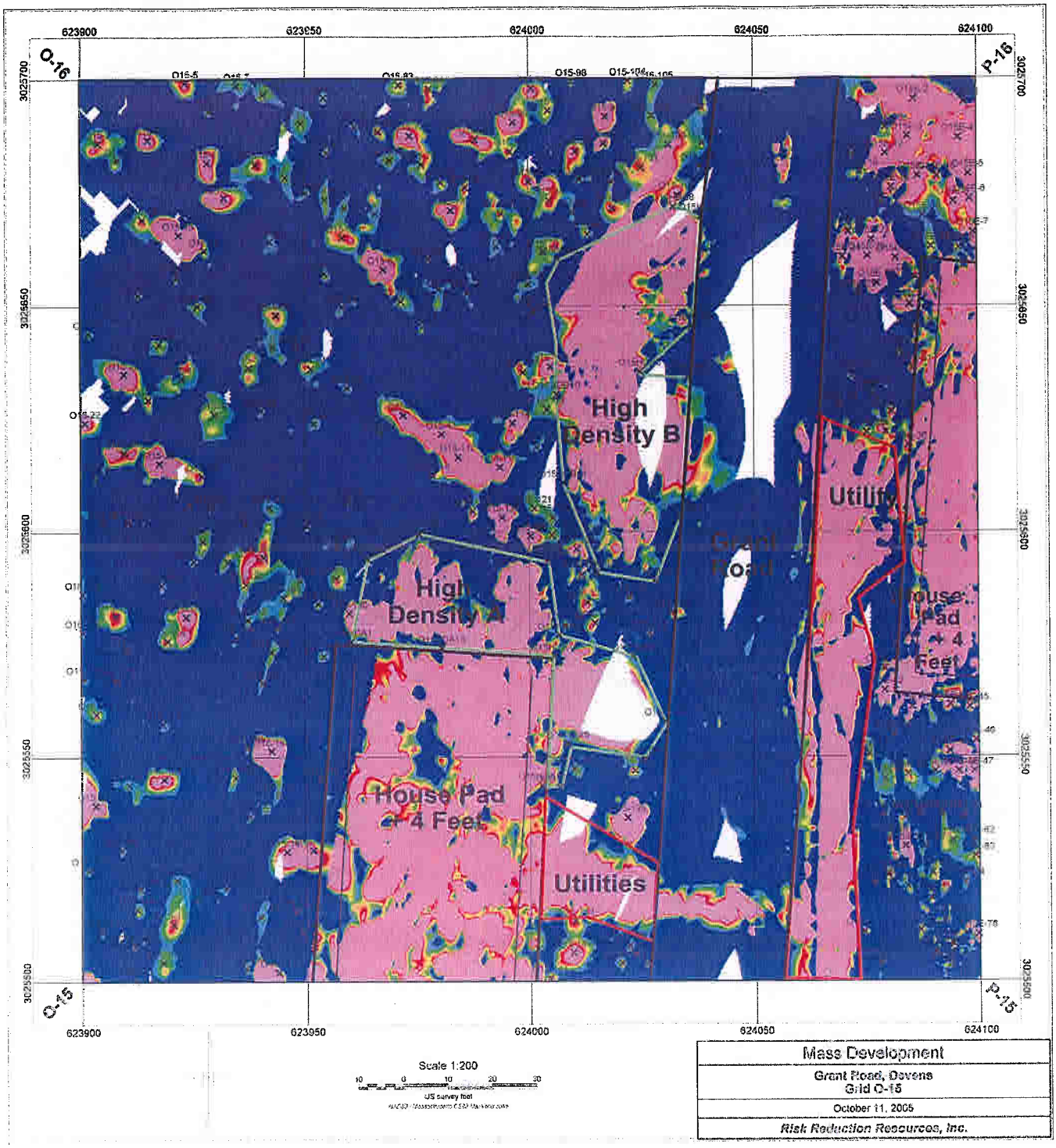


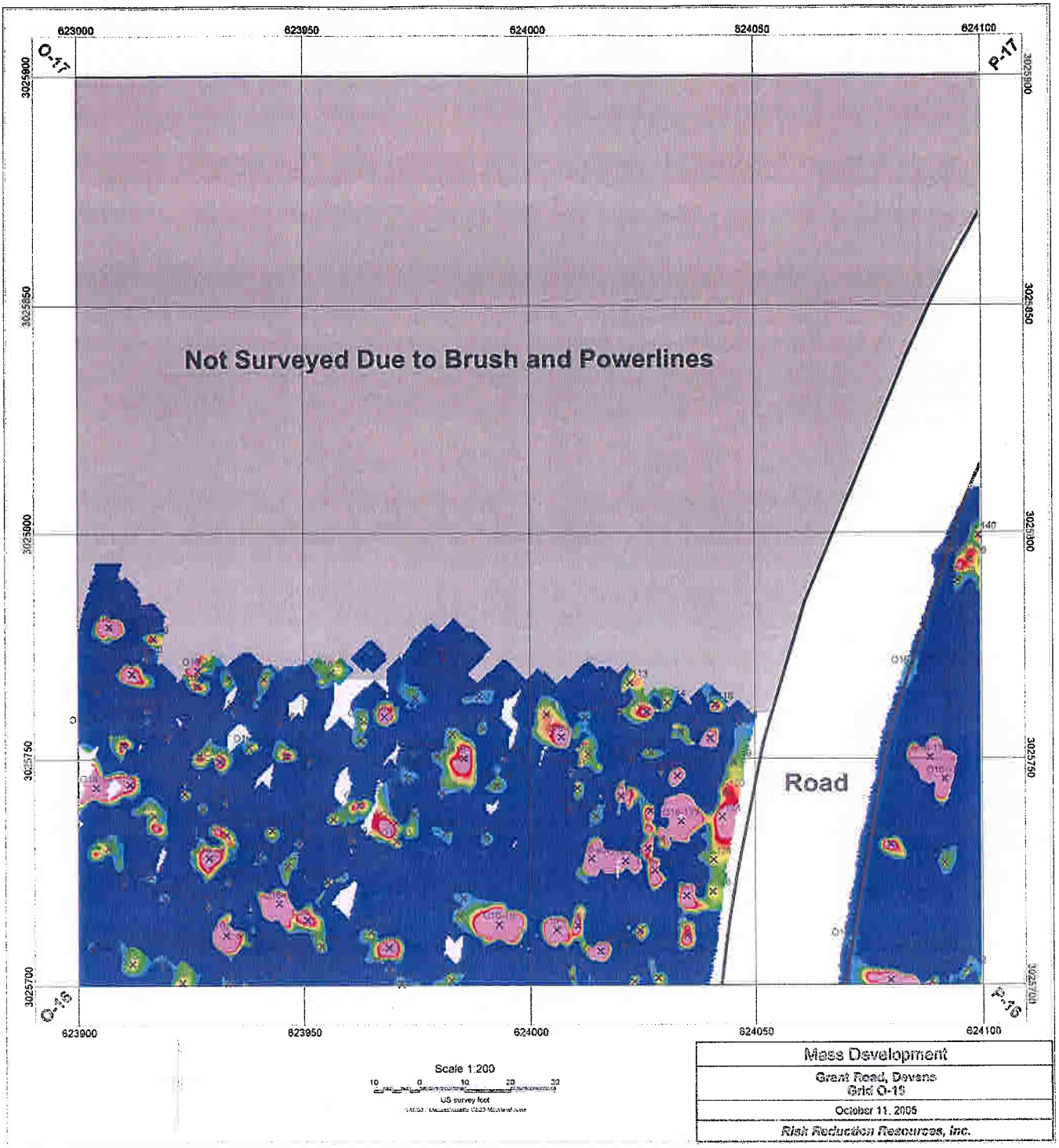
Mass Development
Grant Road, Devens Grid O-12
November 2, 2005
Risk Reduction Resources, Inc.

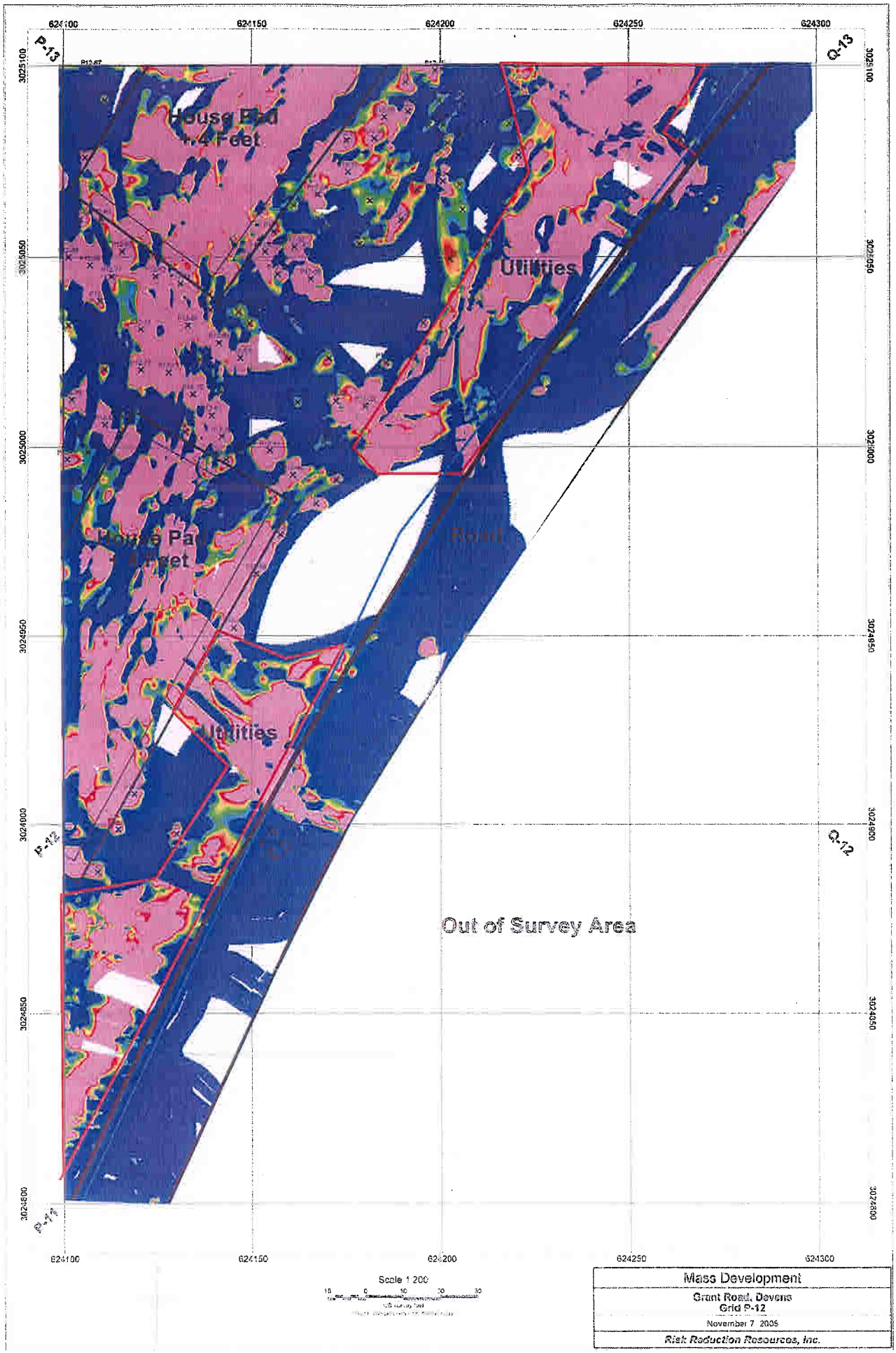


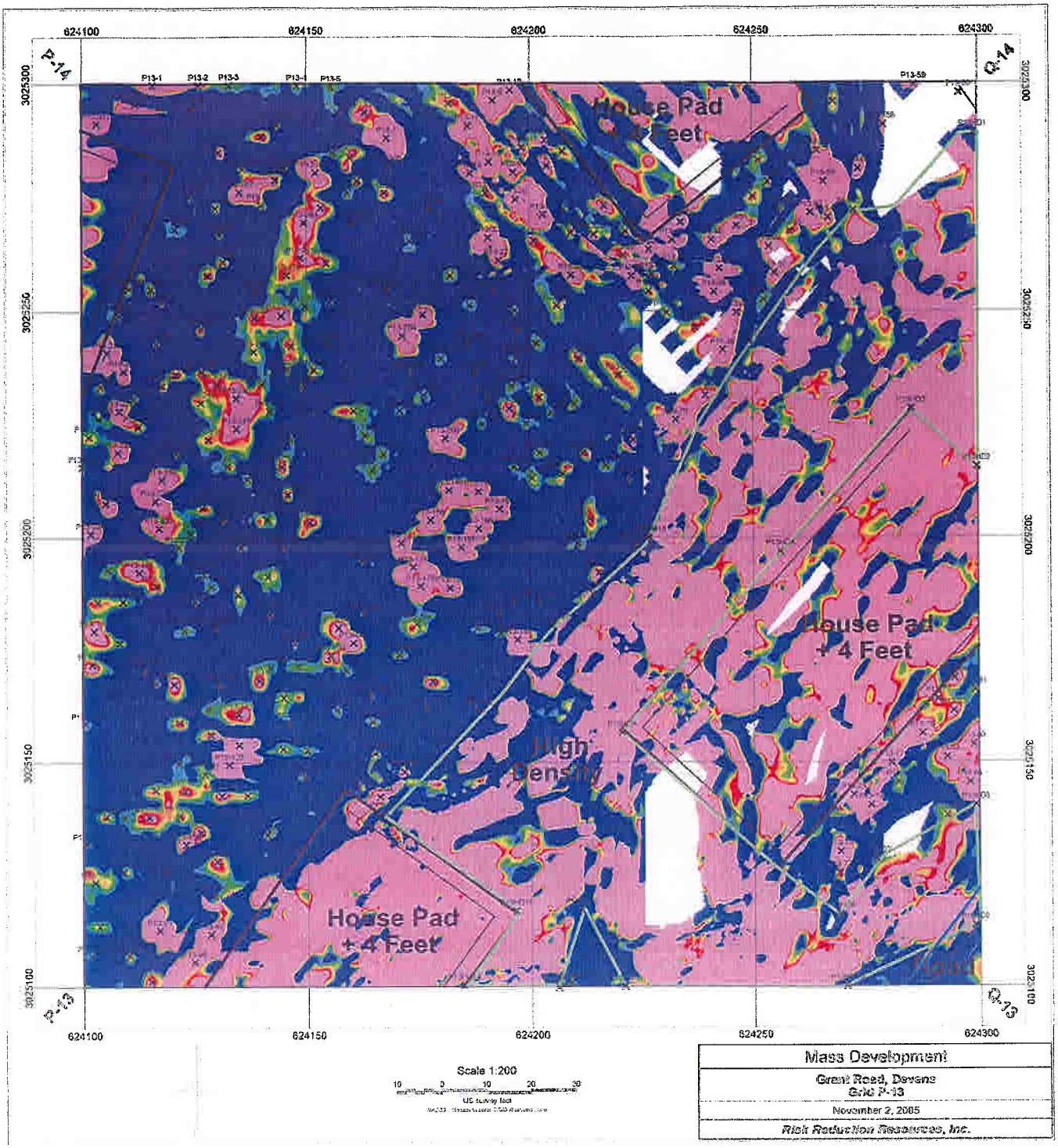
Mass Development
Grant Road-Devens Grid O-13
October 18, 2005
Risk Reduction Resources, Inc.

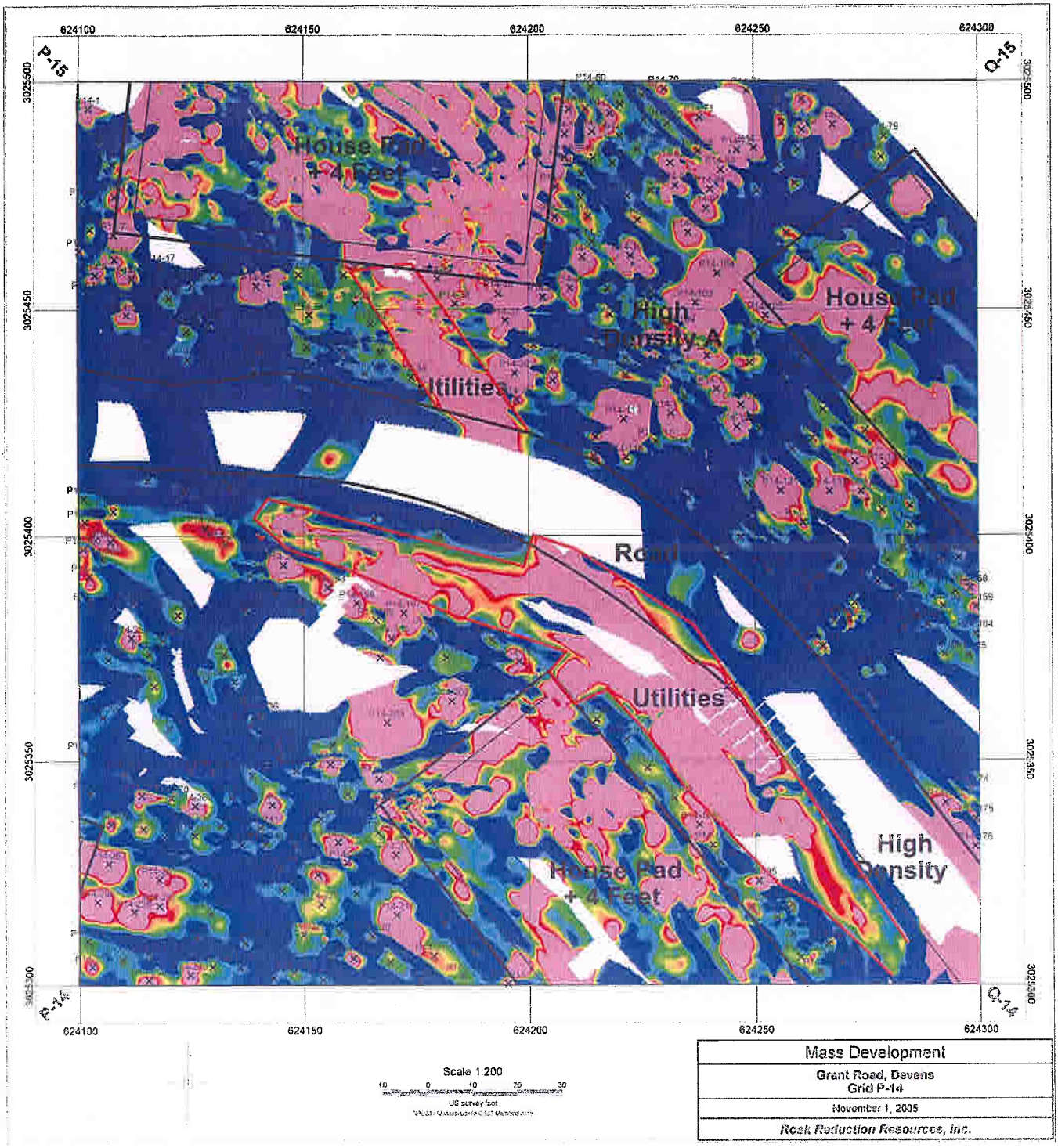

623900
623950
624000
624050
624100
O-15
P-15
O-14
P-14
3025500
3025450
3025400
3025350
3025300
O14HD-1
O14HD-9
O14E-3
House Pad
+ 4 Feet
High
Density A
Utilities
House Pad
+ 4 Feet
Grant
Road
Utilities
High
Density
Scale 1:200
10 0 10 20 30
US survey feet
Mass Development
Grant Road, Devens
Grid O-14
October 13, 2005
Risk Reduction Resources, Inc.


623900
623950
624000
624050
624100
O-16
P-16
O-15
P-15
3025700
3025650
3025600
3025550
3025500
High Density B
High Density A
Utilities
Grant Road
House Pad + 4 Feet
Scale 1:200
10 0 10 20 30
US survey feet
Mass Development
Grant Road, Devens
Grid O-15
October 11, 2005
Risk Reduction Resources, Inc.


623900
623950
624000
624050
624100
O-17
P-17
O-16
P-16
3025900
3025850
3025800
3025750
3025700
Not Surveyed Due to Brush and Powerlines
Road
Scale 1:200
10 0 10 20 30
US survey foot
Mass Development
Grant Road, Devens
Grid O-16
October 11, 2005
Risk Reduction Resources, Inc.


624100
624150
624200
624250
624300
P-13
Q-13
3025100
3025050
3025000
3024950
3024900
3024850
3024800
House Pad
1.4 Feet
Utilities
Road
Utilities
Out of Survey Area
P-12
Q-12
Scale 1:200
Mass Development
Grant Road, Devens
Grid P-12
November 7 2005
Risk Reduction Resources, Inc.


624100
624150
624200
624250
624300
P-14
Q-14
P-13
Q-13
3025300
3025250
3025200
3025150
3025100
P13-1
P13-2
P13-3
P13-4
P13-5
P13-59
House Pad
+4 Feet
House Pad
+4 Feet
High
Density
House Pad
+4 Feet
Scale 1:200
10 0 10 20 30
US survey feet
Mass Development
Grant Road, Devens
Grid P-13
November 2, 2005
Risk Reduction Resources, Inc.

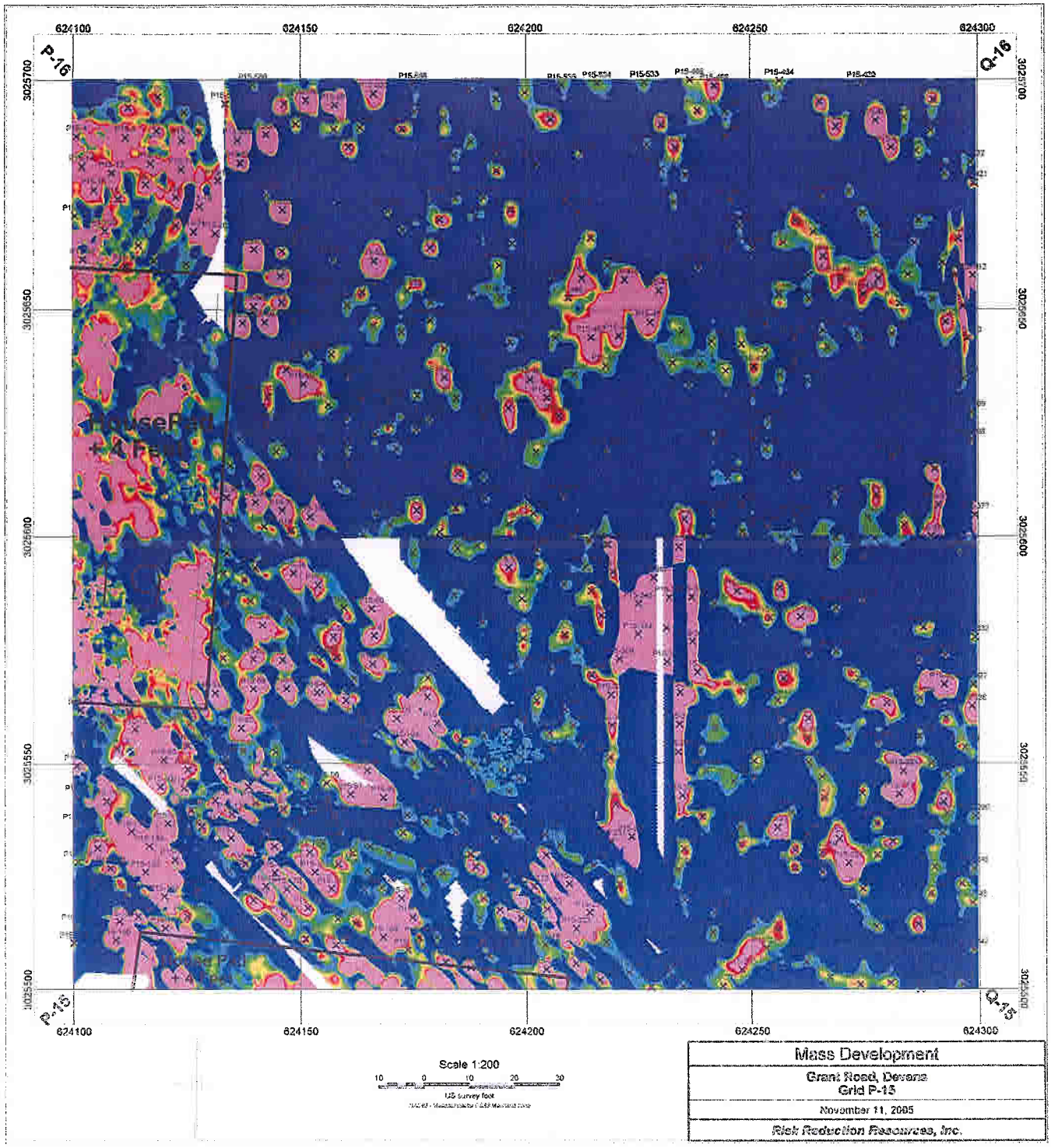


Scale 1:200

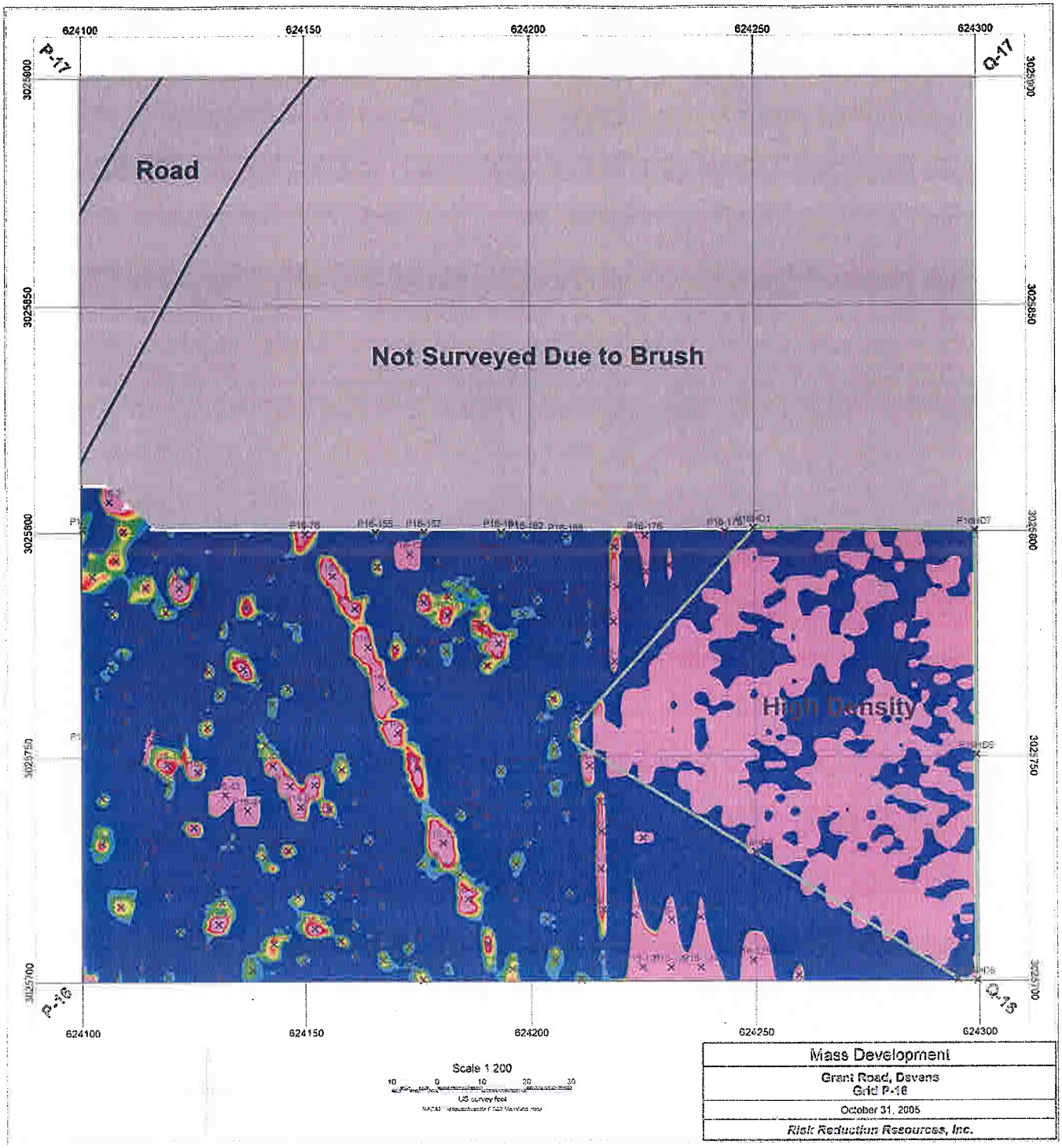
10 0 10 20 30

US survey foot

Mass Development
Grant Road, Devens Grid P-14
November 1, 2005
Rock Reduction Resources, Inc.



Mass Development
Grant Road, Devens Grid P-15
November 11, 2005
Risk Reduction Resources, Inc.


624100
624150
624200
624250
624300
P-17
Q-17
3025900
3025850
3025800
3025750
3025700
Road
Not Surveyed Due to Brush
High Density
P16-176
P16-155
P16-157
P16-182
P16-188
P16-178
P16-181
P16-179
P16-183
P16-184
P16-185
P16-186
P16-187
P16-189
P16-190
P16-191
P16-192
P16-193
P16-194
P16-195
P16-196
P16-197
P16-198
P16-199
P16-200
P16-201
P16-202
P16-203
P16-204
P16-205
P16-206
P16-207
P16-208
P16-209
P16-210
P16-211
P16-212
P16-213
P16-214
P16-215
P16-216
P16-217
P16-218
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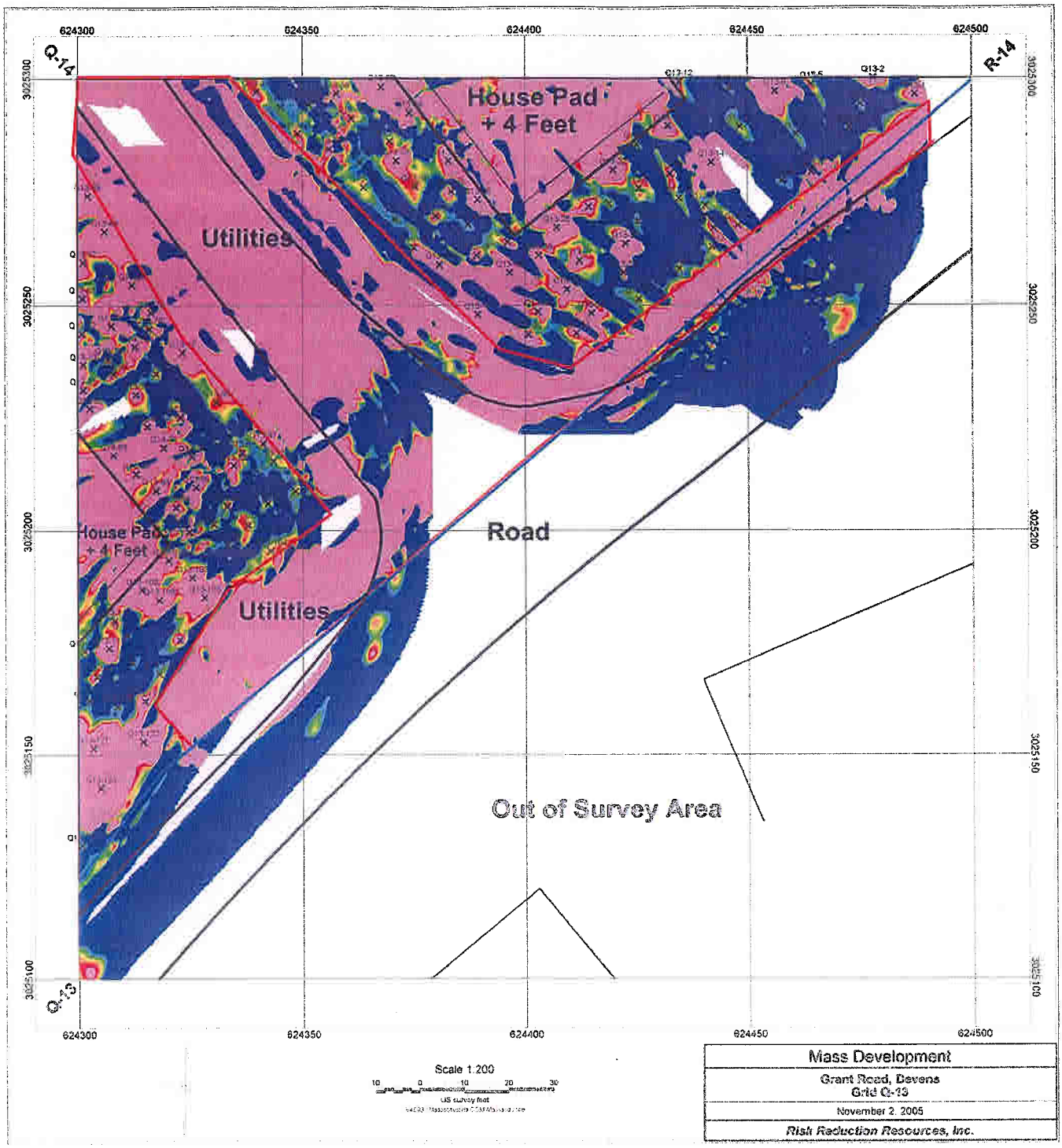
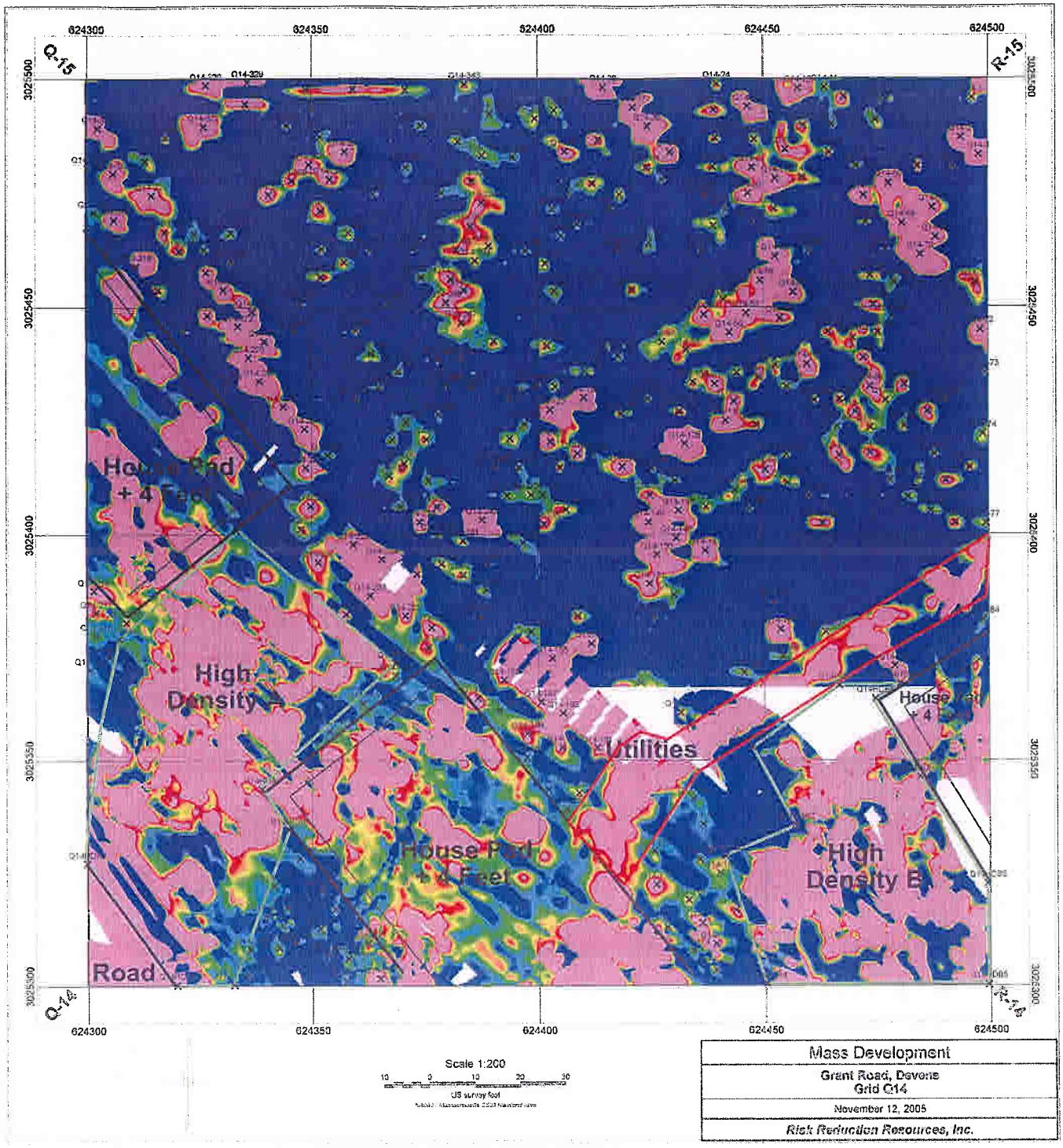
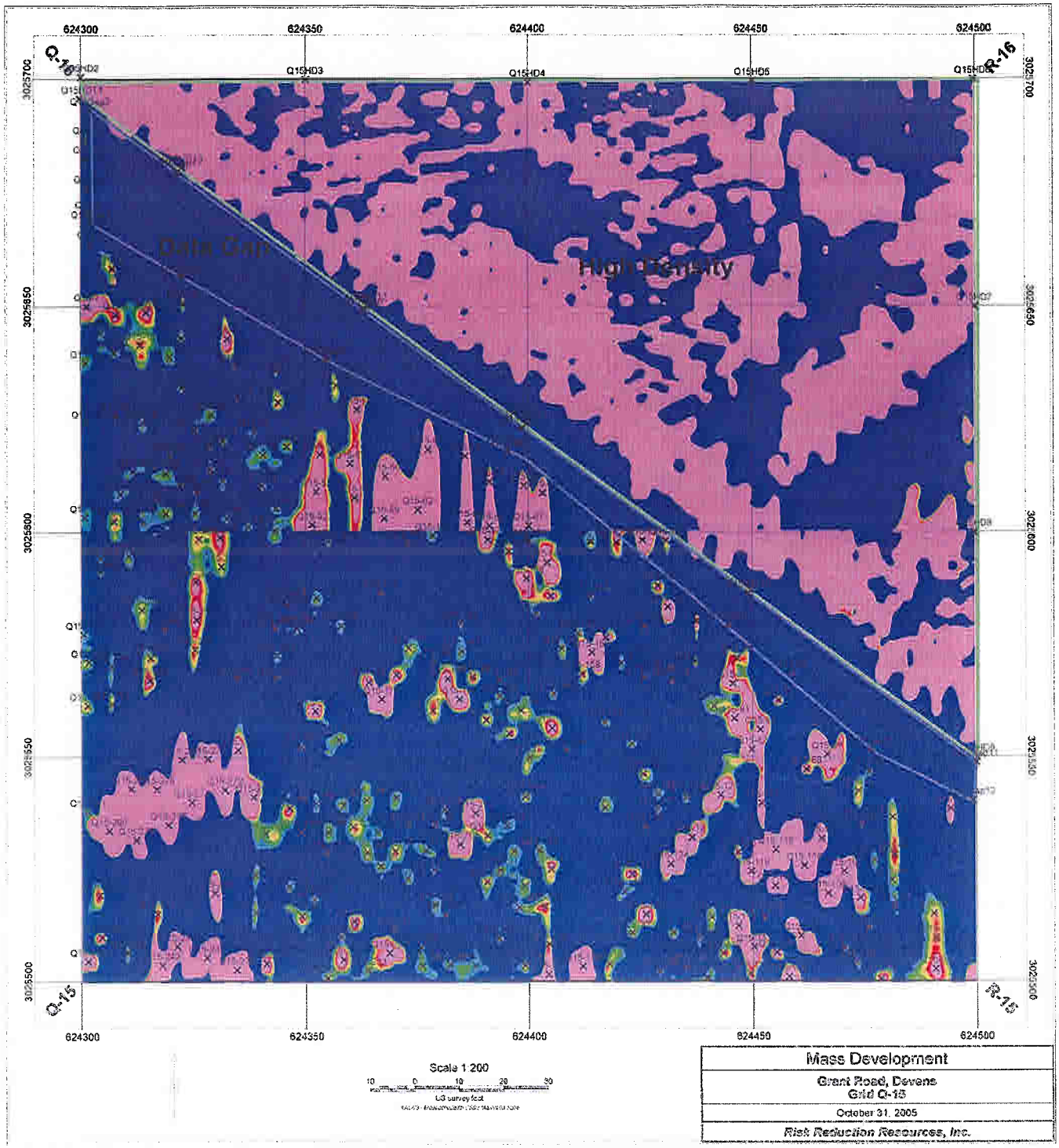
P16-226
P16-227
P16-228



Mass Development
Grant Road, Devens Grid Q-13
November 2, 2005
Risk Reduction Resources, Inc.



Mass Development
Grant Road, Devens Grid Q14
November 12, 2005
Risk Reduction Resources, Inc.

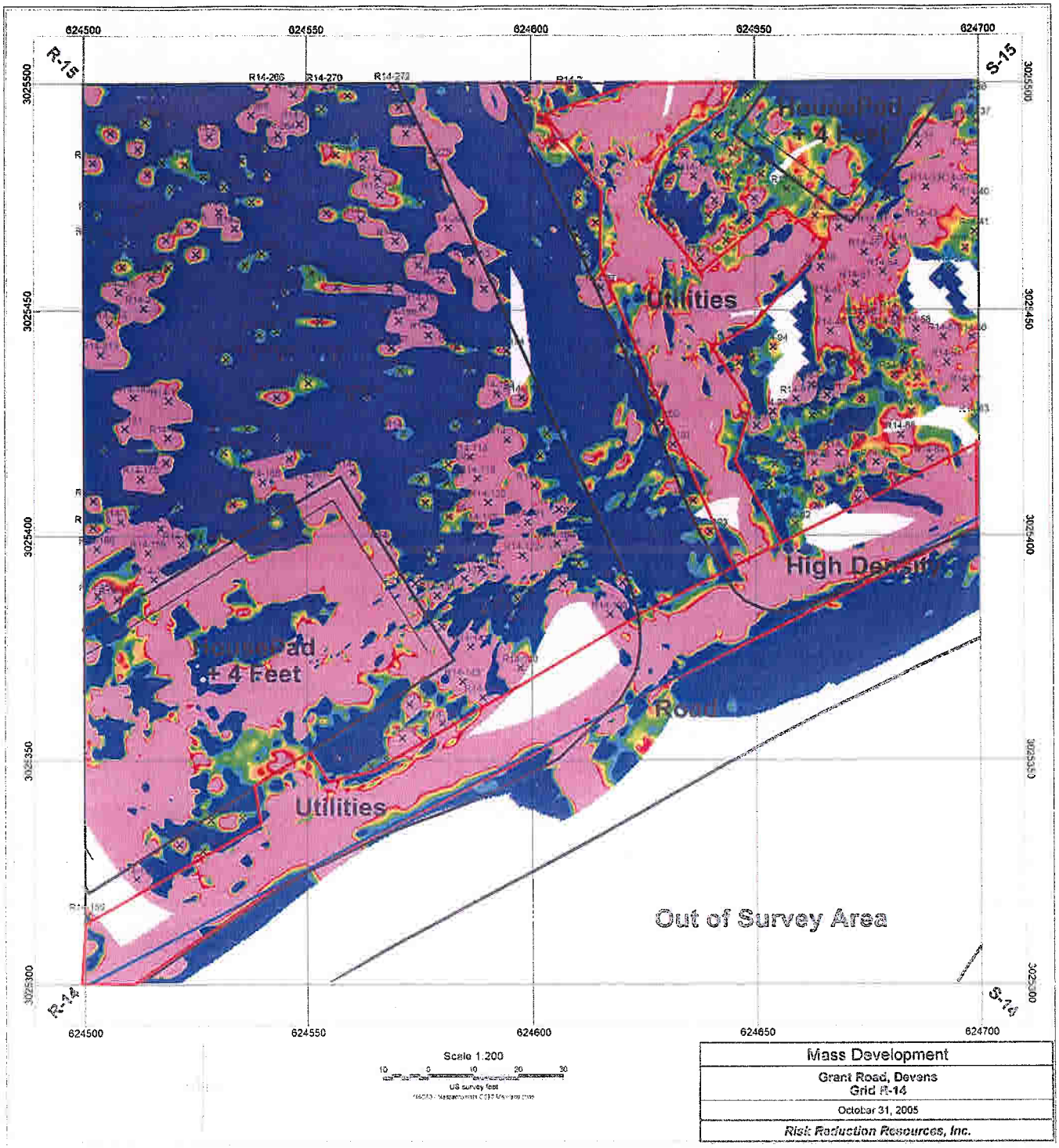


Scale 1:200

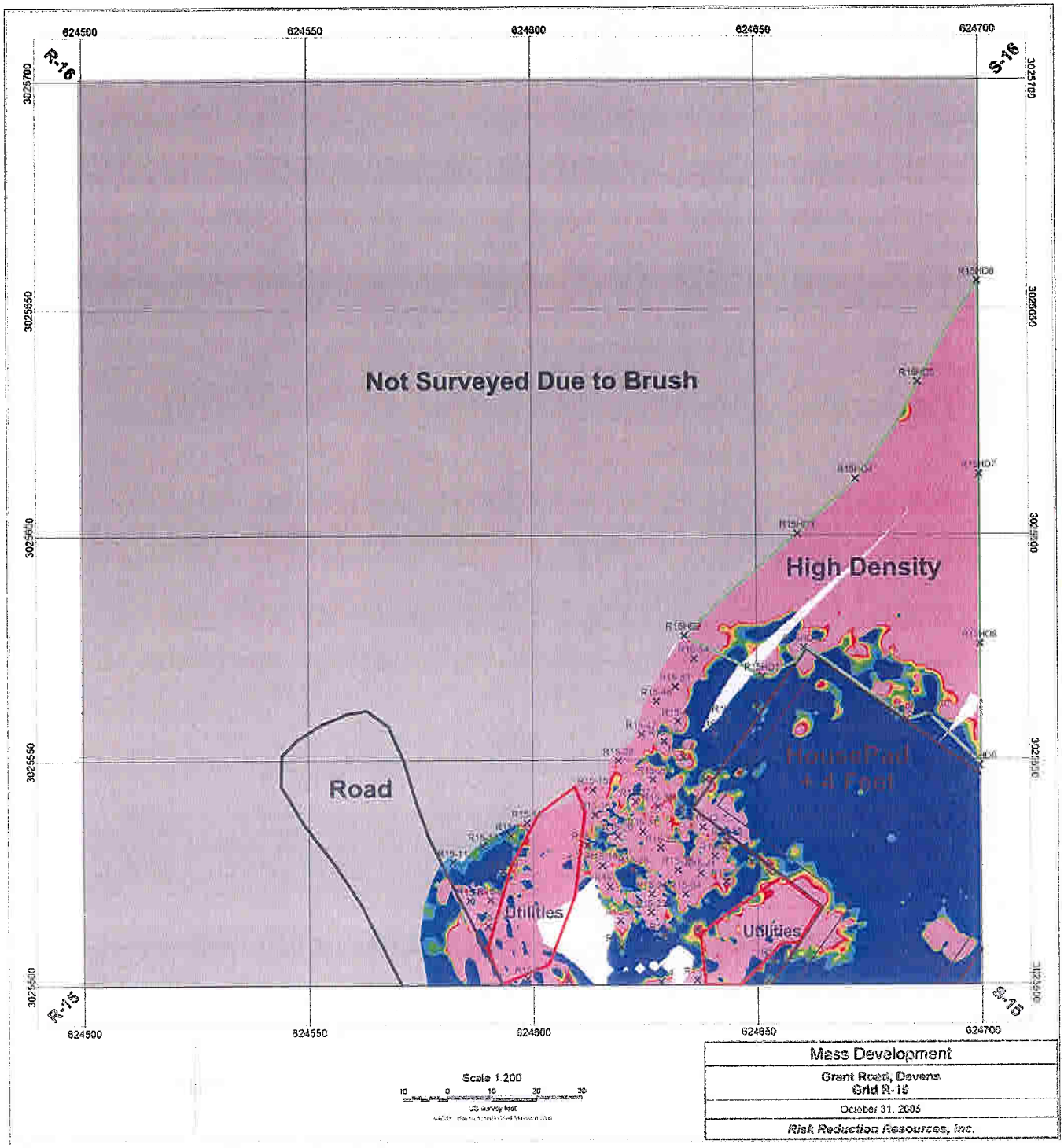
10 0 10 20 30

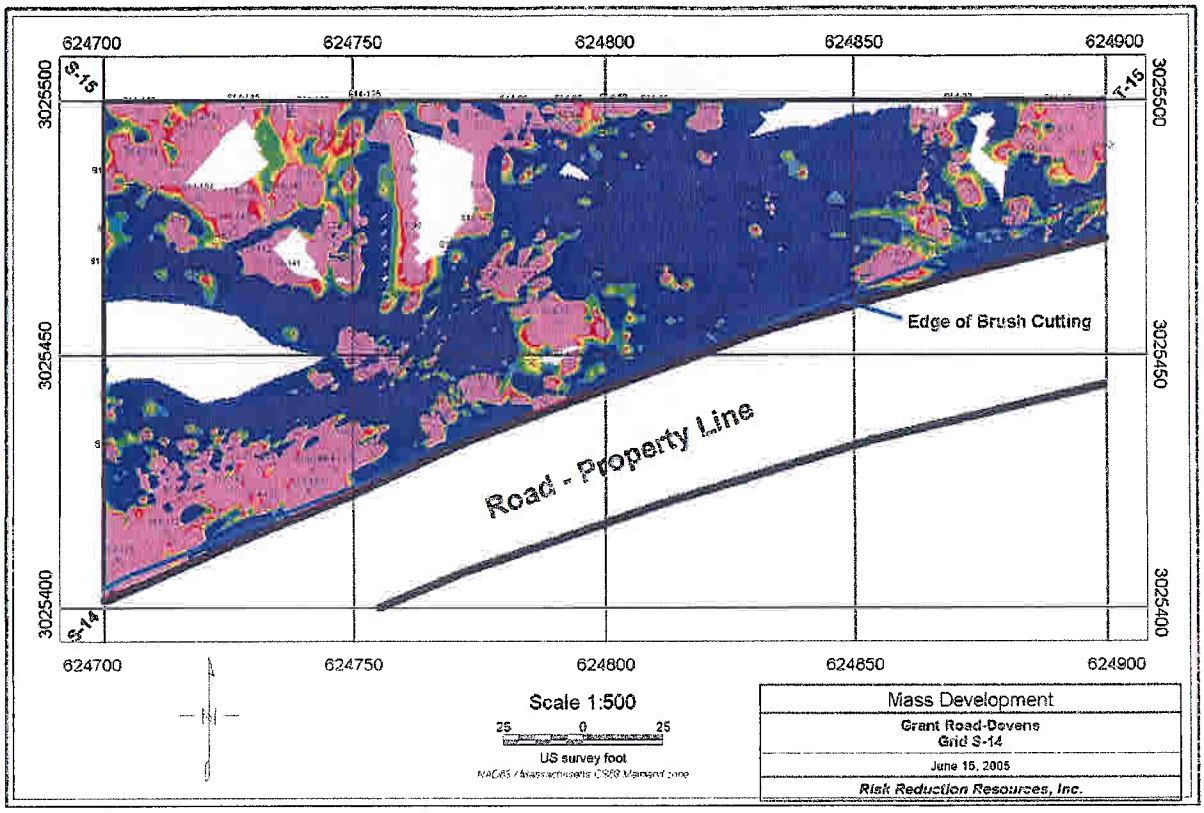
US survey feet

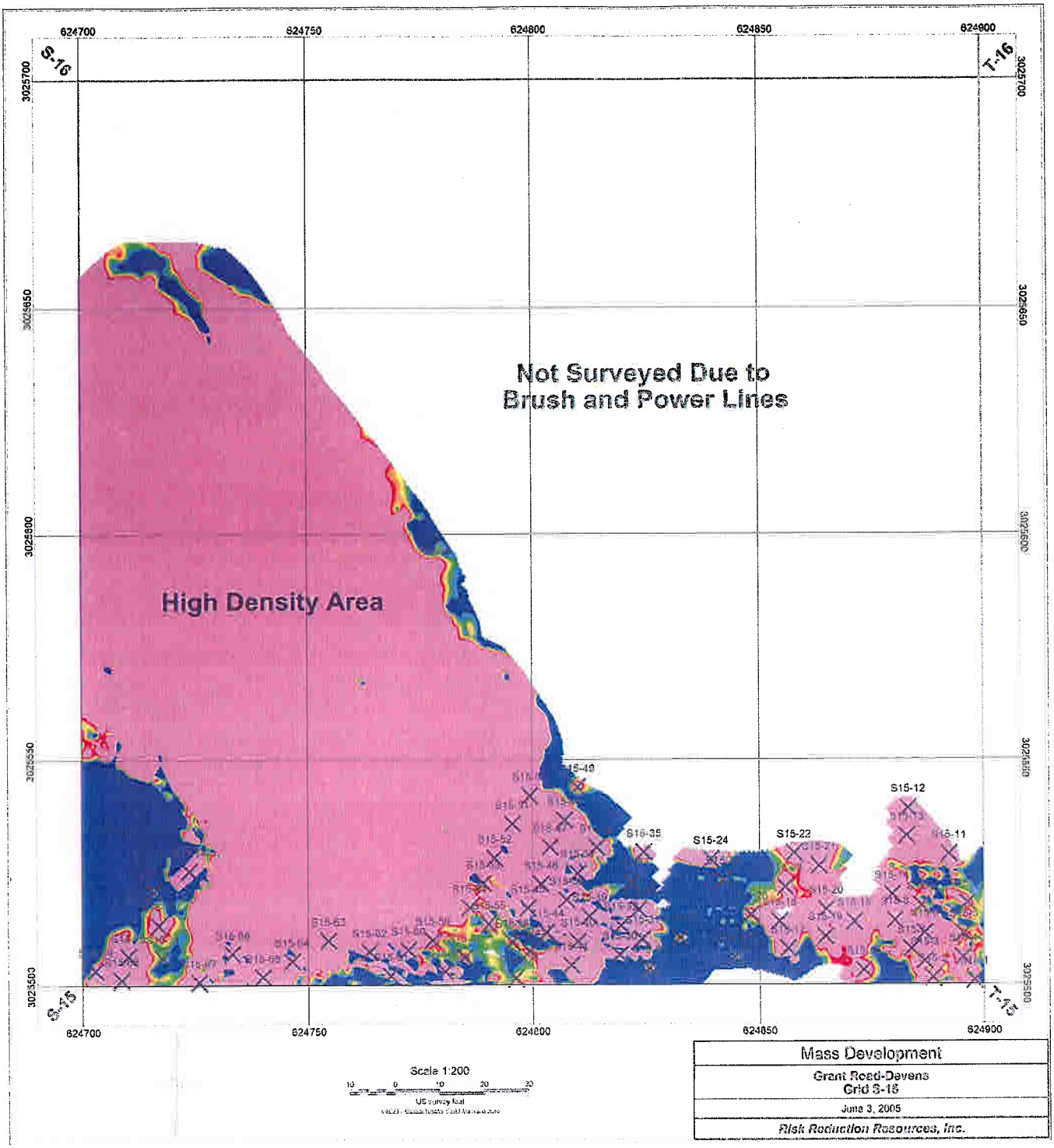
Mass Development
Grant Road, Devens Grid Q-15
October 31, 2005
Risk Reduction Resources, Inc.

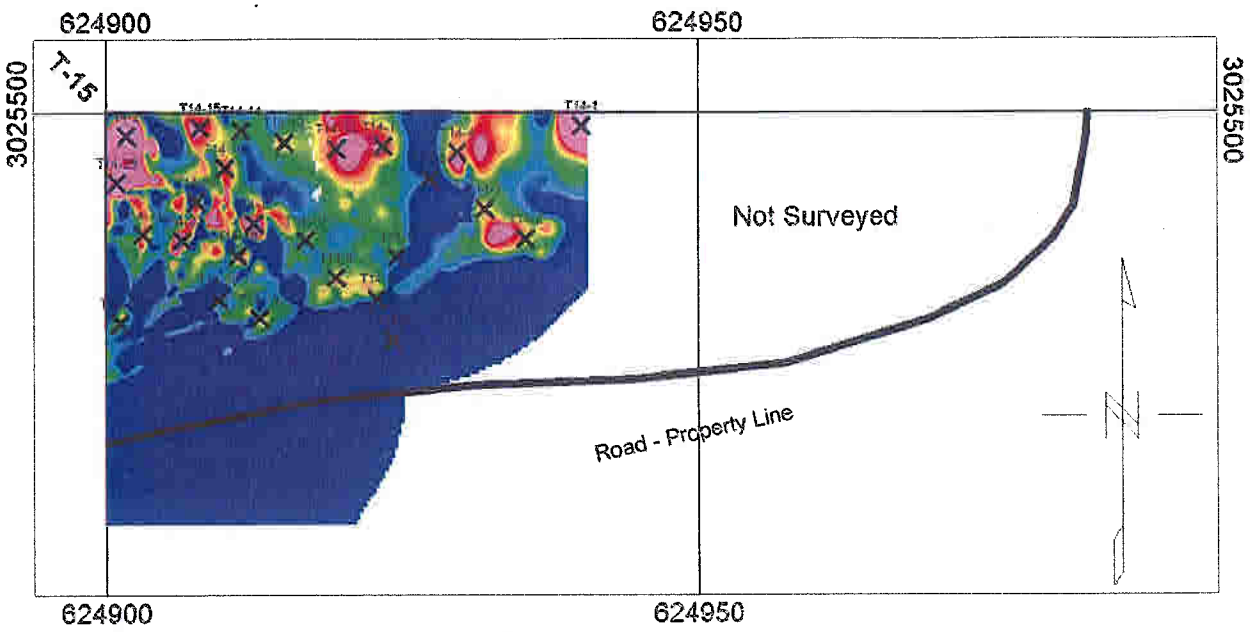


624500
624550
624600
624650
624700
R-15
S-15
R-14
S-14
3025500
3025450
3025400
3025350
3025300
R14-266
R14-270
R14-272
Utilities
High Density
Road
Utilities
Out of Survey Area
Scale 1:200
US survey feet
Mass Development
Grant Road, Devens
Grid R-14
October 31, 2005
Risk Reduction Resources, Inc.


624500
624550
624600
624650
624700
R-16
S-16
R-15
S-15
3025700
3025650
3025600
3025550
3025500
Not Surveyed Due to Brush
High Density
Road
HousePad
+ 4 Foot
Utilities
Utilities
Scale 1:200
10 0 10 20 30
US survey feet
Mass Development
Grant Road, Devens
Grid R-15
October 31, 2005
Risk Reduction Resources, Inc.


624700
624750
624800
624850
624900
3025500
3025450
3025400
S-15
T-15
S-14
Edge of Brush Cutting
Road - Property Line
Scale 1:500
25 0 25
US survey foot
NAD83 / Massachusetts (US) Mainland zone
Mass Development
Grant Road-Devens
Grid S-14
June 15, 2005
Risk Reduction Resources, Inc.


624700
624750
624800
624850
624900
S-16
T-16
S-15
T-15
3025700
3025650
3025600
3025550
3025500
Not Surveyed Due to
Brush and Power Lines
High Density Area
S15-12
S15-11
S15-22
S15-24
S15-35
Scale 1:200
10 0 10 20 30
US survey feet
Mass Development
Grant Road-Devens
Grid S-15
June 3, 2005
Risk Reduction Resources, Inc.



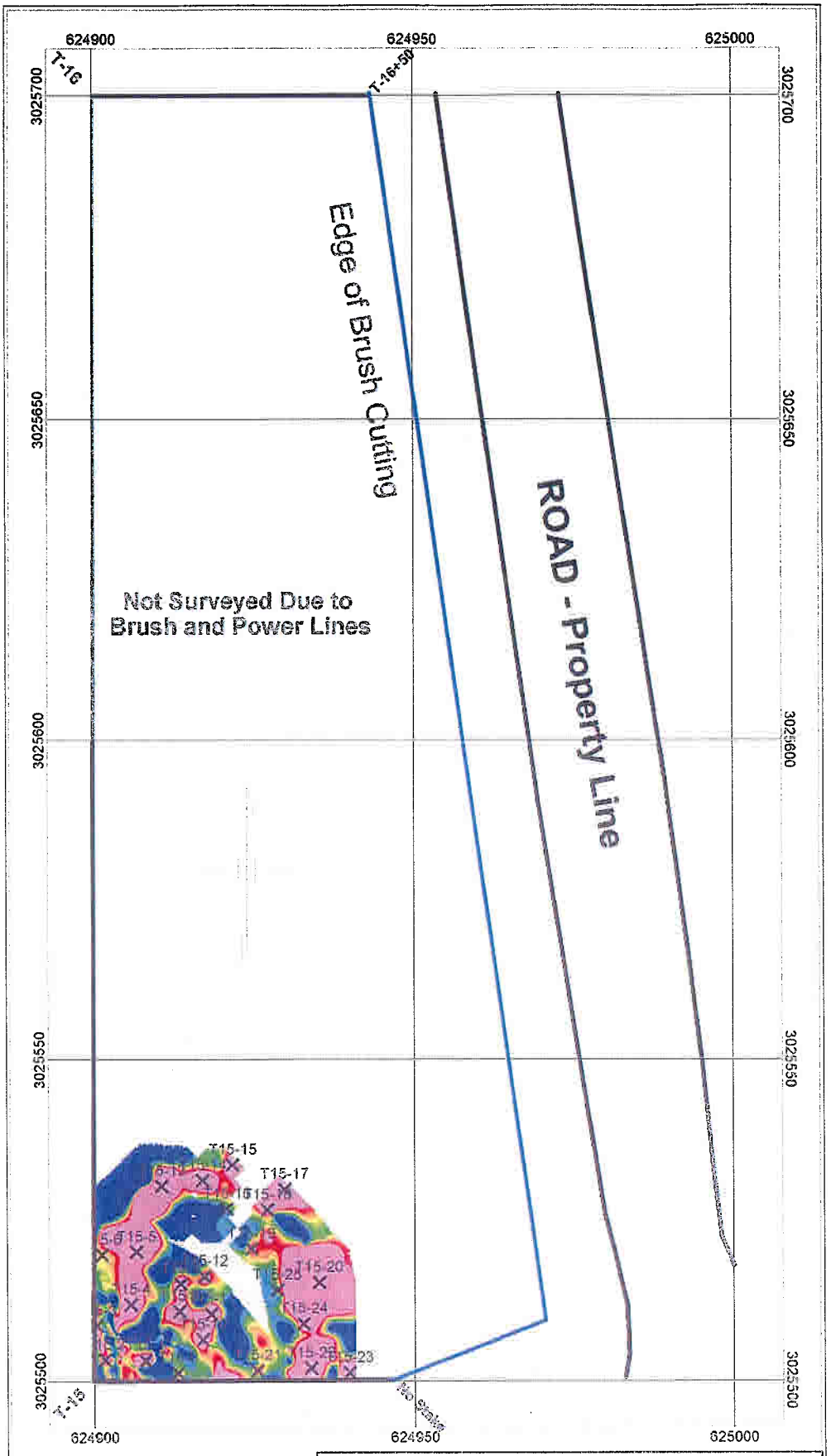
Scale 1:200

10 0 10

US survey foot

NAD83 / Massachusetts CS83 Mainland zone

Mass Development
Grant Road-Devens Grid T-14
June 3, 2005
Risk Reduction Resources, Inc.



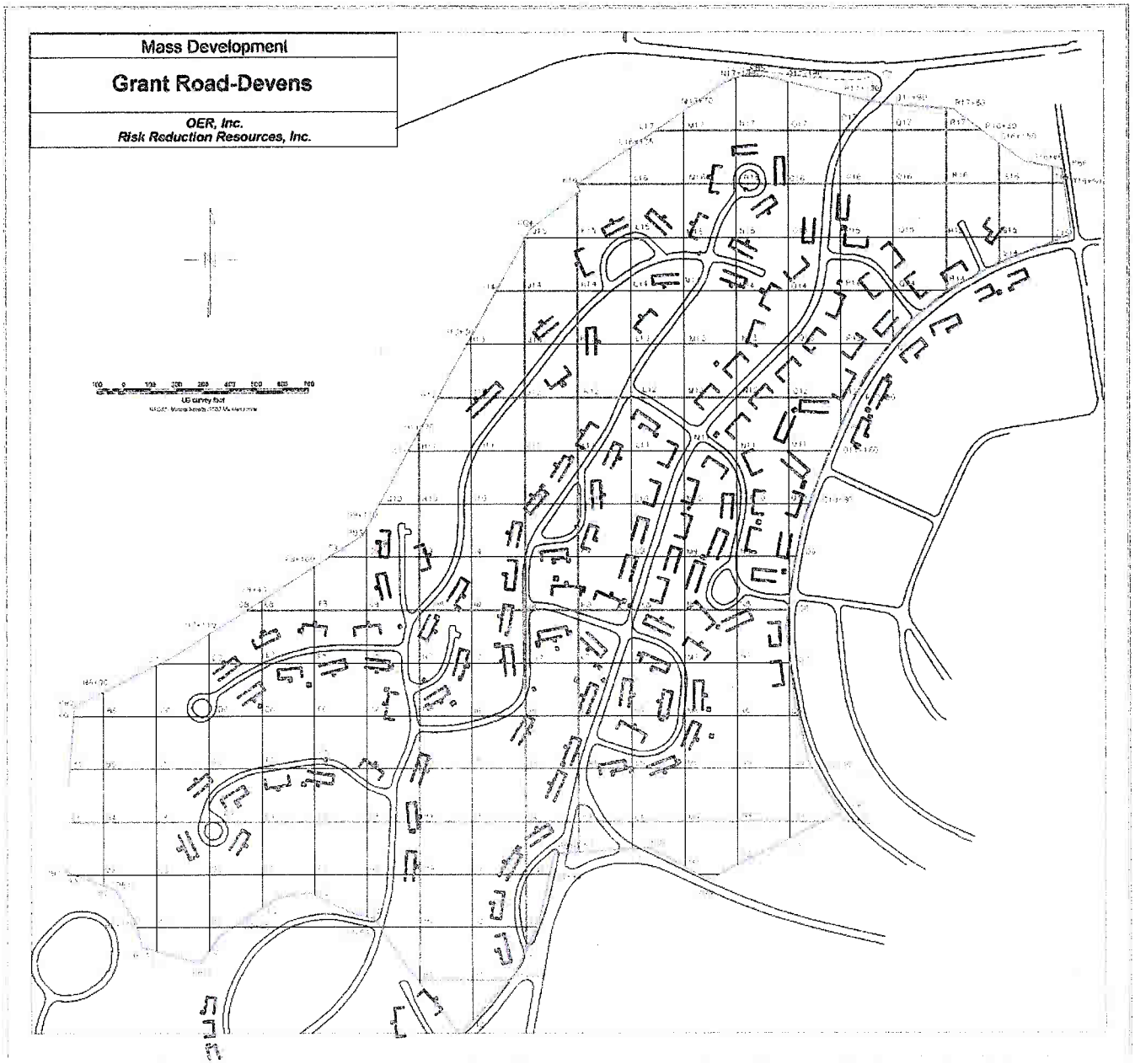
Scale 1:200

10 0 10

US survey foot

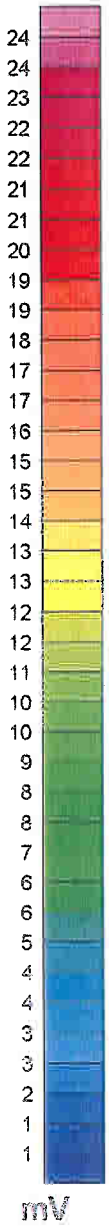
NAD83 Massachusetts Coast Mainland zone

Mass Development
Grant Road-Devens Grid T-15
June 3, 2005
Risk Reduction Resources, Inc.



Grid locations of maps in Map Appendix.

Scale Bar for all maps in Appendix



APPENDIX B

SUMMARY OF DAILY SITE ACTIVITIES

Appendix B: Summary of Daily Site Activity

November 14, 2004

- Mobilization of geophysical crew to the site

November 15, 2004

- Test grid instillation
- Grid survey
- Towed array trailer build

November 16, 2004

- Test grid instillation
- Grid survey
- Towed array trailer build

November 17, 2004

- Test grid instillation
- Grid survey
- Towed array trailer build

November 18, 2004

- Grid survey
- Towed array trailer build

November 19, 2004

- Equipment testing

November 22, 2004

- Equipment testing

November 23, 2004

- Towed array data collection in grids L5 and M7

November 24, 2004

- Towed array data collection in grid N9

November 25, 2004

- Thanksgiving

November 29, 2004

- Towed array data collection in grids N11 and N12

November 30, 2004

- Towed array data collection in grids J8, J10, and K9

December 1, 2004

- Towed array data collection in grids M14 and N13

December 2, 2004

- Towed array data collection in grids G6 and H6

December 6, 2004

- Towed array data collection in grids L10, M12, and N13

December 7, 2004

- Towed array data collection in grids K11, O13, P14, and P15

December 8, 2004

- Towed array data collection in grids P15 and R14

December 9, 2004

- Towed array data collection in grids D2, D3, D6, E4, G9, H11, J13, and K14

December 10, 2004

- Towed array data collection in grids H5 and J9

April 25, 2005

- work plan review
- site specific training
- started surface sweep on target hill
- started survey of grid locations

April 26, 2005

- continued surface sweep and grid location survey
- located one 37mm HE projectile which was turned over to the government representative (Frank Henderson, Weston Solutions)
- visited by Charles Duval (Mass Dev) and Devens Fire Chief Garrity
- demolition of 37mm was conducted by Mr. Henderson and Officer Sean Maloney (Mass State Police)
- removed and packaged soil from demolition site

April 27, 2005

- continued grid layout

April 28, 2005

- continued grid layout
- resumed surface sweep on target hill

May 2, 2005

- continued grid layout
- continued surface sweep
- located two 37mm projectiles (one broken in half). Items were secured and Mass Development was notified

May 3, 2005

- continued surface sweep
- continued grid layout
- another 37mm projectile found
- three 37mm projectiles turned over to Joe Kendal (government representative – Weston Solutions)
- demolition of 37mm projectiles conducted by government representative

May 4, 2005

- continued surface sweep, grids C1, C2, B2, C3
- continued grid layout
- located empty rifle grenade, placed in scrap area

May 5, 2005

- continued surface sweep, grids C3, C4, B4, D2
- continued grid layout
- OER Project Manager, Hugh Sease, visited site

May 9, 2005

- continued surface sweep, grids D2, E2, F2, D3
- continued grid layout
- conducted test of geophysical mapping equipment
- Mass Development picked up non-MEC scrap

May 10, 2005

- continued surface sweep, grids E3, E4, F3
- started geophysical mapping, grids B3, D3
- located one 37mm projectile, secured and notified Mass Development
- located two empty rifle grenades, placed in MEC scrap area
- State police arrived to secure site overnight

May 11, 2005

- continued surface sweep, grids E4, F4, F5, G3, G4, G5, G6
- continued geo mapping, grids B3, B4
- demolition of 37mm conducted by Navy EOD

May 12, 2005

- continued surface sweep, grids F5, E5, D5, C5, F6
- continued geo mapping, grid B4
- OER Project Manager visited site

May 16, 2005

- continued surface sweep, grids F6, E6, D6, E7, F7, G7
- continued geo mapping, grids H1, E3
- visited by Don Luciani of Mass Development
- met with Power Company to schedule shut down of power to facilitate geo mapping
- located belt of unfired blank 7.62 ammunition, stored in secure Conex awaiting disposition

May 17, 2005

- continued surface sweep, grids F8, G8, G9, H9, H10, H11, I12
- continued geo mapping, grid H1

May 18, 2005

- continued surface sweep, grids J13, J14, K14, K15, L15, M15, L16, M16, N16, N17
- continued geo mapping, grids B2, F3, E4, G4
- recovered staged piles of non-MEC scrap

May 19, 2005

- continued surface sweep, grids G2, H2, H3, I2
- continued geo mapping, grids B2, C1, C2, D6, D7, E6
- continued recovering piles of non-MEC scrap
- contacted Devens Public Works to schedule scrap pick-up

May 23, 2005

- continued surface sweep, grids O16, O17, P16, P17, H3, H4, I3
- continued geo mapping, grids C1, D2, C3, E7, F7, C4
- located two empty rifle grenades, placed in scrap holding area
- R. Smith went to the Medical Center for treatment of severe poison ivy
- continued pick-up of large piles of non-MEC scrap

May 24, 2005

- continued surface sweep, grids H5, I5, J5, J6, K6
- continued geo mapping, grids D2, G8, H3
- located empty training hand grenade, placed in holding area

May 25, 2005

- continued surface sweep, grids J7, K7, L12, M12, M13, N13, M14
- continued geo mapping, grids J13, H10
- DPW picked up non-MEC scrap
- located French VB2 Training rifle grenade, placed in MEC scrap holding area

May 26, 2005

- continued surface sweep, grids N14, O14, N15, D15
- continued geo mapping, grids J12, L14, H10, I12, M15
- contacted DPW to pick-up non-MEC scrap, will pick up tomorrow

May 31, 2005

- continued surface sweep, grids I6, I7, I8 (heavily contaminated with non-MEC scrap)
- continued geo mapping, grids C2, C5, J13, L15
- departed site in support of Mass Development to identify an item found at another site, could not locate item

June 1, 2005

- continued surface sweep, grids I9, J9, I10 (heavily contaminated with non-MEC scrap)
- continued geo mapping, grids J13, H1, C5
- picked up non-MEC scrap piles
- DPW picked up non-MEC scrap
- left site again (with escort) to identify item at the other site, item was a riot control grenade, M25A1 or A2, it was turned over to the State Police.

June 2, 2005

- continued surface sweep, grids J10, I11, J11, K11, J12, K112
- continued geo mapping, grids C5, H2, J13
- picked up non-MEC scrap piles
- OER Project Manager on site
- DPW picked up non-MEC scrap

June 3, 2005

- continued surface sweep, grids J12, K13, L13, L14, M14
- continued geo mapping, grids C1, I12, J13
- DPW picked up non-MEC scrap
- located fragmentation from a stokes mortar

June 4, 2005

- continued geo mapping, grid B3

June 6, 2005

- continued surface sweep, grids P14, P15, Q14, Q15, Q16, Q17
- continued geo mapping, grids B2, B3

June 7, 2005

- continued surface sweep, grids R14, R15, R16, R17, S15, S16, O12, P13, N10, O11
- continued geo mapping, grids B2, B3, C1, C2
- DPW picked up non-MEC scrap

June 8, 2005

- continued surface sweep, grids N7, M7, N6, M6
- continued geo mapping, grids B2, B3, C2

- personnel on site noted odd smell near storage area, Fire Department responded and determined it was a gas leak, but that it was safe to continue work in the area

June 9, 2005

- continued surface sweep, grids O5, N5, M5, L5, K5
- continued geo mapping, grids A3, C4, G2, G5, G6, H1, H2

June 13, 2005

- continued surface sweep, grid O4
- continued geo mapping, grid H3
- DPW picked up non-MEC scrap

June 14, 2005

- sorted scrap and staged for DPW pick-up
- training on Remote Tracking Station for reacquisition
- started anomaly reacquisition in grid T15
- continued geo mapping, grids D2, H3

June 15, 2005

- continued anomaly reacquisition and investigation, grids T15 and S15, nothing of interest found
- continued geo mapping, grids E2, D4

June 16, 2005

- continued reacquisition and investigation, grid S15
- located several fragments from stokes mortar
- continued geo mapping, grids D3, G2, H3, I0

June 20, 2005

- continued reacquisition and investigation, grids S14, B1, nothing of interest found
- continued geo mapping, grids H1, I1, I3

June 21, 2005

- continued reacquisition and investigation, grid B2, found some fragmentation from 37mm projectile
- continued geo mapping, grid I3

June 22, 2005

- continued reacquisition and investigation, grid B2
- continued geo mapping, grid I4

June 23, 2005

- continued reacquisition and investigation, grid B2
- conducted QC, grid B2
- continued geo mapping, grids !4, J4

June 27, 2005

- continued QC, grid B2
- continued geo mapping, grids J5, K6, J6

June 28, 2005

- continued reacquisition and investigation, grid H2
- continued geo mapping, grids G7, I11, J12

June 29, 2005

- continued reacquisition and investigation, grid H2
- continued geo mapping, grids J11, J12, K11
- one hour 30 minute delay for electrical storm

June 30, 2005

- continued reacquisition and investigation, grid H2
- continued geo mapping, grids J10, K11, J13, K6

July 6, 2005

- continued reacquisition and investigation, grid H2
- continued geo mapping, grids H8, J5, J6

July 7, 2005

- continued reacquisition and investigation, grid H3
- continued geo mapping, grids H8, H9, H10
- courtesy visit from Fire Chief

July 8, 2005

- continued reacquisition and investigation, grids H3, A2, some fragmentation found
- continued geo mapping, grids H10, I11, L12

July 9, 2005

- continued reacquisition and investigation, grids A2, A3
- conducted QC, grid A2
- continued geo mapping, grids K3, M6

July 11, 2005

- continued reacquisition and investigation, grid A3, significant amounts of 37mm fragmentation found
- continued geo mapping, grids H10, I10
- located 37mm HE projectile, notified Mass Development
- State Police officer on site to secure item overnight

July 12, 2005

- continued reacquisition and investigation, grid A3
- continued geo mapping, grids I7, I9
- located 37mm projectile, notified Mass Development
- State police officer on site to secure items overnight
- visited by OER Project Manager, Mr. Sease, and Mass Development Project Manager Meg Delorier

July 13, 2005

- continued reacquisition and investigation, grid A3
- continued geo mapping, grids I6, M13
- Government representative, Joe Kendal (Weston) on site, will dispose of MEC items on Jul 14
- Located a live detonator from pop-up flare, notified Mass Development
- State Police officer on site to secure items overnight

July 14, 2005

- continued reacquisition and investigation, grids A3, B3
- continued geo mapping, grids M12, M13
- located a 37mm Armor Piercing projectile (no hazard), placed in MEC holding area
- located live 37mm projectile, notified Mass Development
- turned three 37mm projectiles and flare detonator over to Mr. Kendel (government rep)

July 18, 2005

- continued reacquisition and investigation, grids B3, C1, H3, B2, A2
- continued geo mapping, grids M12, N14
- 37mm projectiles and flare detonator disposed of by government representatives
- removed and packaged soil from detonation hole

July 19, 2005

- continued reacquisition and investigation, grids A3, B3, H3
- continued geo mapping, grids O15, O16

July 20, 2005

- continued reacquisition and investigation, grids B3, C1, A3, tail booms from 3 inch Stokes mortars found
- continued geo mapping, grids N7, M7

July 21, 2005

- continued reacquisition and investigation, grids A3, B3
- continued geo mapping, grids M7, N6
- visited by Erin Kinney (Weston Project Manager) and Bob Simone, USACOE

July 25, 2005

- continued reacquisition and investigation, grids A3, B3
- started QC, grid B3
- continued geo mapping, grids N5, N6
- located two 37mm projectiles, notified Mass Development

July 26, 2005

- continued reacquisition and investigation, grid A3
- continued geo mapping, grids N4, M5
- continued QC, grid B3
- U.S. Navy EOD disposed of the two 37mm projectiles
- Fire Department on site
- removed and packaged soil from detonation holes
- visited by M. Delorier, Mass Development

July 27, 2005

- continued QC, grids A3, B3
- continued geo mapping, grids N4, M4
- reduced working time each hour due to high heat and humidity
- located one 37mm projectile, notified Mass Development
- State Police on site to secure item

July 28, 2005

- continued QC, grid A3
- U. S. Navy EOD disposes of 37mm projectile
- removed and packaged soil from detonation hole, stored all containers (36) in DPW fenced compound
- A. Gallerani taken to Emergency Room for bee stings

August 1, 2005

- continued QC, grid A3
- continued geo mapping, grids O12, O13
- established test grid using 37mm projectile halves to check detection capability of instruments

August 2, 2005

- continued reacquisition and investigation, grid C2
- continued geo mapping, grids L3, L4, H9, J10
- continued QC, grid A3
- T. Steelman stung by bees, no medical attention required
- Located three 37mm projectiles, notified Mass Development
- State Police on site to secure projectiles

August 3, 2005

- continued reacquisition and investigation, grids C2
- continued geo mapping, grids I6, I7, J11
- continued QC, grid A3
- located two 37mm projectiles, notified Mass Development
- M. Delorier, and Ron Ostrowski of Mass Development visit site
- OER Project Manager, H. Sease, visits site
- State Police on site to secure items

August 4, 2005

- continued reacquisition and investigation, grid C2
- continued geo mapping, grids I10, G5, G7
- continued QC, grid A3
- located two 37mm projectiles, notified Mass Development
- turned over custody of seven 37mm projectiles to Weston (government representative)

August 8, 2005

- continued reacquisition and investigation, grid C2
- removed and packaged soil from Weston's disposal sites
- located two 37mm projectiles, notified Mass Development
- Weston disposes of two 37mm projectiles
- Started brush cutting in overgrown areas

August 9, 2005

- continued reacquisition and investigation, grid C2
- removed and packaged soil from disposal shots
- continued brush cutting

August 10, 2005

- continued reacquisition and investigation, grid C2

August 11, 2005

- continued reacquisition and investigation, grids C2, C1
- located two 37mm projectiles, notified Mass Development
- Weston explosively disposed of two 37mm projectiles
- Removed 4 buckets of soil after the shot

August 15, 2005

- continued reacquisition and investigation, grid C2, C1
- located empty rifle grenade

August 16, 2005

- continued reacquisition and investigation, grids C1, A4, B4
- conducted QC, grid C2

August 17, 2005

- continued reacquisition and investigation, grids B4, D1, D2
- several people stung by bees, no medical attention required
- OER PM, H. Sease visits site

August 18, 2005

- continued reacquisition and investigation, grids D2, E2, found two trash pits from old military mess hall

August 22, 2005

- continued reacquisition and investigation, grids E2, F2, F3
- started brush cutting
- located three empty rifle grenades

August 23, 2005

- continued reacquisition and investigation, grid C3
- continued brush cutting

August 24, 2005

- continued reacquisition and investigation, grids D3, C4
- visited by J. Marc-Aurele, Mass Development

August 25, 2005

- continued reacquisition and investigation, grids D3, C4, C5, D4
- located one three inch stokes mortar, notified Mass Development
- State Police on site to secure item
- DPW picked up non-MEC scrap

August 29, 2005

- continued reacquisition and investigation, grids D4, C6, D6, E6,
- State Police on site to secure item

August 30, 2005

- continued reacquisition and investigation, grid E6, D7, E7
- turned custody of 3 inch Stokes over to Weston Solutions, W. Danjou
- Weston's explosive supplier on site

August 31, 2005

- continued reacquisition and investigation, gridF8, F7, F6
- visited by J Marc-Aurele, Mass Development
- removed and packaged soil from demolition shot, secured in DPW compound

September 1, 2005

- continued reacquisition and investigation, grids F6, F4, G7
- located a live star cluster rifle grenade, notified Mass Development
- visited by J. Marc-Aurele
- turned custody of rifle grenade over to Weston rep

September 6, 2005

- continued reacquisition and investigation, grids G7, F4, G6, F6
- removed and packaged soil from Weston demo shot
- OER Project Manager, H. Sease visited site

September 7, 2005

- continued reacquisition and investigation, grids G8, G7, G6, H8, H7, H6
- located empty mine flare body

September 8, 2005

- continued reacquisition and investigation, grids H6, G8, H7, F5

September 9, 2005

- continued reacquisition and investigation, grids F5, H6, E5
- OER Project Manager, H. Sease visited site

September 12, 2005

- continued reacquisition and investigation, grids E5, G5, G1, F5, G2
- located two live antitank mine fuzes, notified Mass Development
- located a 37mm round, with casing, appears to be a discarded military munition (DMM), believed to have been placed on site over the weekend, notified Mass Development
- DPW picked up non-MEC scrap
- State Police on site to secure items

September 13, 2005

- continued reacquisition and investigation, grids G2, E5, G5, G3, E3, G4, G1
- visited by J. Marc-Aurele, Mass Development
- Turned custody of two mine fuzes and 37mm over to Weston rep

September 14, 2005

- continued reacquisition and investigation, grids E3, E4
- removed and packaged soil from Weston demo shot

September 15, 2005

- continued reacquisition and investigation, grids E4, E3, D5, H5
- located a three inch Stokes Mortar, notified Mass Development, turned over to Weston rep
- J. Marc-Aurele, Mass Development visited site
- one hour delay for possible lightning and heavy rain

September 19, 2005

- continued reacquisition and investigation, grids H5, H0, H1, D5
- visited by J. Marc-Aurele, Mass Development
- removed and packaged soil from Weston demo shot
- located training hand grenade
- located empty rifle grenade

September 20, 2005

- continued reacquisition and investigation, grids H1, I0, I1, H4, H5
- visited by J. Marc-Aurele, Mass Development

September 21, 2005

- continued reacquisition and investigation, grids H4, I0, I1, I2, I3
- T. Horner stung by bees, no medical attention required
- DPW picked up non-MEC scrap

September 22, 2005

- continued reacquisition and investigation, grids I3, J4, J5
- J. Marc-Aurele, Mass Development, visited site
- individual who put 37mm in grid on 9/12 arrived on site, reported that he found it in grid I5, briefed him not to trespass on site, he would not give his name
- located empty rifle grenade

September 26, 2005

- continued reacquisition and investigation, grids J5, I2, I5, J4, I3, I4
- visited by J. Marc-Aurele, Mass Development, wanted to ensure we worked the west side of Grant Road first

September 27, 2005

- continued reacquisition and investigation, grids I4, K5, K6, I6
- visited again by the individual who found the 37mm, his name is Mike Edwards

September 28, 2005

- continued reacquisition and investigation, grids I6, J6, K7
- resumed brush cutting
- RRR and OER Project Managers, J. Baird and H. Sease, visit site

September 29, 2005

- continued reacquisition and investigation, grids K7, J7, I7
- responded at request of Devens fire dispatch to water tower, found a 3 inch Stokes Mortar without fuze, fire chief will contact State Police for disposal
- 1.5 hour delay for rain storm

October 3, 2005

- continued reacquisition and investigation, grids I6, I7, I8, I9, I10
- resumed brush cutting

October 4, 2005

- continued reacquisition and investigation, grids I10, J10, G9, G10, H10, J6, I7, I8, I9
- located training hand grenade
- unauthorized individual discovered digging in grid G9, Mark Cohen with Mass Development, looking for manhole cover, briefed not to dig in area without UXO support and to clear future entry with SUXOS

October 5, 2005

- continued reacquisition and investigation, gridH10, H9, H11
- resumed brush cutting

- visited by H. Sease, OER Project Manager and J. Baird, RRR Project Manager
- DPW picked up non-MEC scrap

October 6, 2005

- continued reacquisition and investigation, grids H11, I11, J11, G9
- located 37mm projectile, appears to be unfired, notified Mass Development
- Mass Development blocked Grant Road to traffic, we will use Oak Housing Area gate
- State Police Bomb Squad disposed of 37mm
- Removed and packaged soil from disposal hole

October 10, 2005

- continued reacquisition and investigation, grids J11, I12, J12
- located 37mm round with case, notified Mass Development
- located empty mine flare body
- located training hand grenade

October 11, 2005

- continued reacquisition and investigation, grids J12, K11, K12, J11
- J. Marc-Aurele, Mass Development requests access to G9, granted
- Weston personnel enter site to pick up equipment

October 12, 2005

- continued reacquisition and investigation, grids K12, J13, K13
- visited by E. Kinney, Weston Project Manager, J. Marc-Aurele, Mass Development, J. McCloskey, Weston demo supervisor
- DPW picked up non-MEC scrap

October 13, 2005

- continued reacquisition and investigation, grids K13, K12, L13, J13
- visited by J. Marc-Aurele, Mass Development, requesting access starting Oct 17th to work in G9 area, granted
- J. McCloskey, Weston, asked if we could store unfired 37mm over the weekend, okayed by OER Project Manager
- Fire Chief visited site to ask about demo plan

October 17, 2005

- continued reacquisition and investigation, grids L13, J14, K14
- J. Marc-Aurele attended Safety Brief

October 18, 2005

- continued reacquisition and investigation, grids L14, M13, L13, J14, K14, M14
- visited by Devens Fire Chief, asked about demo of unfired 37mm, we will hold until next item is found

October 19, 2005

- continued reacquisition and investigation, grids M14, L12, K15, M16, M15 L16

- located two French Training Rifle Grenades, no hazard
- located Anti-tank mine, unknown filler
- Weston conducted disposal of 37mm and anti-tank mine, post detonation investigation reveals it contained a live detonator
- removed and packaged soil from demo shot

October 20, 2005

- continued reacquisition and investigation, grids L15, N15
- J. McCloskey, Weston, on site
- Visited by M. Delorier and Bob Simone, Mass Development

October 24, 2005

- continued reacquisition and investigation, grids N15, N16, M15, M16, O16, O15, O114, O13
- located anti-personnel mine, empty with functioned fuze

October 25, 2005

- continued reacquisition and investigation, grids N14, L12, M12, K15, L15
- occasional delays for heavy rains

October 26, 2005

- continued reacquisition and investigation, grids M12, M14, N15, N16, O16, M11, M11E, N12, N12E, O12E,

October 27, 2005

- continued reacquisition and investigation, grids O13E, N15, O15, N14, O14E, K8, L11
- located one 3 inch Stokes Mortar, unfuzed

October 31, 2005

- continued reacquisition and investigation, grids J8, O14, K9, K10

November 1, 2005

- continued reacquisition and investigation, grids S14, L11, T14, S15, K10, L10, L9
- visited by M. Delorier, Mass Development

November 2, 2005

- continued reacquisition and investigation, grids L9, S15, P16, R14, P14, T15, K8

November 3, 2005

- continued reacquisition and investigation, grids P14, J8, Q15, K9, L9
- R. Simone of USACOE and a rep from ECC visited site

November 7, 2005

- continued reacquisition and investigation, grids O15E, S15, R15, N11, O12, R14

November 8, 2005

- continued reacquisition and investigation, grids O12, Q15, P12, P13
- visited by J. Marc-Aurele, Mass Development
- Hertz Rental maintenance on site

November 9, 2005

- continued reacquisition and investigation, grids P13, P16, Q13, M10, L10, K10
- OER Project Manager, H. Sease, visits site

November 10, 2005

- continued reacquisition and investigation, grids M10, O11, O12
- conducted QC, grids C4, C5, C6, D2, D3, D4, D5, D6, D7, E2
- turned custody of 3 inch Stokes to Navy EOD

November 14, 2005

- continued reacquisition and investigation, grids N9, P13, M8, L8
- conducted QC, grids E3, E4, E5, E6, E7, F4, F5, F6, F7, F8

November 15, 2005

- continued reacquisition and investigation, grids L8, P12, Q14, O10, Q13
- conducted QC, grids, F2, F3, G2, G3, G4, G5, G6, G7, G8, G9

November 16, 2005

- continued reacquisition and investigation, grids O10, O11, Q14, Q15, L7, N8
- conducted QC, grids H1, H2, H3, H4, H5, I1, I2, I3, I4, I5

November 17, 2005

- continued reacquisition and investigation, grids M6, Q14, M5
- conducted Qc, grids J3, J4, J5, J6, I6, H6, H7, J7, H0, I0

November 21, 2005

- continued reacquisition and investigation, grids M5, N10, M10, O8, O9
- conducted QC, grids H8, H9, H10, H11, I8, I9, I10, I11, I12, I13

November 22, 2005

- continued reacquisition and investigation, grids O9, M10, N9, N10, M9

November 23, 2005

- continued reacquisition and investigation, grids M9, P15
- OER Project Manager, H. Sease, visits site

November 28, 2005

- continued reacquisition and investigation, grids P15, N8, N10, N13
- conducted QC, grids J8, J10, J11, J12, J13, J14

- visited by J. Marc-Aurele, Mass Development
- located two unfuzed 3 inch Stokes Mortars, notified Mass Development

November 29, 2005

- continued reacquisition and investigation, grids N13, N10, O10, L8, M4
- conducted QC, grids A3, A4, B2, B3, B4, C1, C2, C3

November 30, 2005

- continued reacquisition and investigation, grids M4, L8, K3, K2, K4, L3, M9
- located unfuzed 3 inch Stokes Mortar, notified Mass Development
- DPW picked up non-MEC scrap
- J. Kendal, Weston, disposed of three 3 inch Stokes Mortars
- removed and packaged soil from demo hole
- visited by H. Sease, OER Project Manager

December 1, 2005

- continued reacquisition and investigation, grids L3, P15, M3, N7
- conducted QC, grids K6, K7, K8, K9, K10, K11, K12, K13, K14, K15

December 5, 2005

- continued reacquisition and investigation, grids N7, M8, N6, L4
- visited by J. Marc-Aurele, Mass Development

December 6, 2005

- continued reacquisition and investigation, grids L7, L4, O4
- conducted QC, grids L4, L7, L8, L9, L10, L11, L12, L13, O4
- moved storage Conex and cleared underneath

December 7, 2005

- continued reacquisition and investigation, grids N5, M7, N7
- visited by H. Sease, OER Project Manager
- identified boundaries of area heavily contaminated with copper wire

December 8, 2005

- continued reacquisition and investigation, grids O5, M6, N3, N4

December 12, 2005

- continued reacquisition and investigation, grids J9, N4, M5, N5
- approximately 12 inches of snow on ground slowed progress
- conducted QC, grids K3, K4, K5, K7
- DPW picked up non-MEC scrap

December 13, 2005

- continued reacquisition and investigation, grids N4, M4, J9
- conducted mag and dig operation on data gap in grids L3, L4, M3, M4, M5, N3

December 14, 2005

- continued reacquisition and investigation, grids J9, N13
- conducted QC, grids L3, L4, M3, M4, M5, N3, N4, N5, O4, O5
- conducted mag and dig of data gap in grid C2

December 15, 2005

- inspected and sorted remaining MEC scrap
- turned in backhoe
- packed equipment

December 19, 2005

- turned MEC scrap (19 buckets) over to DPW for storage awaiting scrap contractor
- conducted QC, grids L14, L15, L16, M14, M15, M16, N14, N15, N16, O14, O15, O16, P14, P15, P16, Q14, Q15, R14, R15, S14, S15, T14, T15, C2

December 20, 2005

- conducted QC, grids N6, N7, N8, N9, N10, N11, N12, N13, O8, O9, O10, O11, O12, O13, P13, P12, Q13, J9
- loaded equipment and demobilized

APPENDIX C

GRID DIG SHEET DATA
(ON CD ROM)

APPENDIX F

QUALITY ASSURANCE PROJECT PLAN

FINAL
QUALITY ASSURANCE PROJECT PLAN

RELEASE ABATEMENT MEASURES at the proposed SHIRLEY MIDDLE SCHOOL, and GRANT, LOCUST, AND CAVITE HOUSING AREAS and PESTICIDE SOIL REMEDIATION at the CHLORDANE CELL DEVENS, MASSACHUSETTS

Contract No. DACW33-00-D-0007
Task Order No. 0005
DCN: DVN2-021502-AAEI

Prepared for:

U.S. ARMY CORPS OF ENGINEERS
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February 2002

W.O. No. 20140.007.005

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LIST OF ACRONYMS

A2LA	Association for Laboratory Accreditation
ACM	asbestos-containing material
CAR	Corrective Action Report
CENAE	U.S. Army Corps of Engineers, New England District
CLP	contract laboratory protocol
COC	Contaminants of Concern
CoCs	chain of custody's
DQOs	data quality objectives
DRO	diesel range organics
EDD	electronic data deliverable
EPA	U.S. Environmental Protection Agency
FSP	Field Sampling Plan
GC	gas chromatography
GC/MS	gas chromatography/mass spectrometry
GPL	GPL Laboratory, LLLP
GRO	gasoline range organics
IDLs	Instrument Detection Limits
K	spike
LCS	Laboratory Control Sample
MCP	Massachusetts Contingency Plan
MDLs	Method Detection Limits
MS	Matrix Spike
MS/MSD	Matrix Spike/Matrix Spike Duplicate
MSD	Matrix Spike Duplicate
NIST	National Institute of Standards and Technology
PAHs	Petroleum Aromatic Hydrocarbons
PCB	polychlorinated biphenyl
PE	performance evaluation
PPE	Personal protective equipment
PQL	Practical Quantitation Limits
QA	Quality Assurance
QA/QC	Quality Assurance/Quality Control
QAPP	Quality Assurance Project Plan
R	rejected
RAM	Release Abatement Measure

LIST OF ACRONYMS
(continued)

RL	Reporting Limits
RPD	relative percent difference
SAP	Sampling and Analysis Plan
SARMs	Standard Analytical Reference Materials
SOPs	Standard Operating Procedures
SVOC	Semi-Volatile Organic Compounds
TAT	The turnaround time
TCL	target compound list
TCLP	Toxicity Characteristic Leaching Procedure
TOC	Total Organic Carbon
TPH	Total Petroleum Hydrocarbons
TWP	Task Work Plans
ug/L	micrograms per liter,
VOC	Volatile Organic Compounds
WESTON	Roy F. Weston, Inc.
XS	spiked sample
XU	unspiked sample

SECTION 1

PROJECT DESCRIPTION

1. PROJECT DESCRIPTION

This Quality Assurance Project Plan (QAPP) is intended to address sampling and analytical requirements for remedial actions described in three separate work plans as follows:

- Release Abatement Measure (RAM) Plan for the proposed Shirley Middle School, Devens, Massachusetts (WESTON, October 2001) (Shirley RAM Plan).
- RAM Plan for the Pesticide Soil Remedial Action at the Grant, Locust, and Cavite Housing Areas, Devens, Massachusetts (WESTON, October 2001) (Pesticide RAM Plan).
- Task Work Plan Addendum- Chlordane Cell- Devens, Massachusetts (WESTON, October 2001) (Chlordane Cell TWP).

Where appropriate, these documents are referred to collectively as the Work Plans.

Descriptions of work to be performed are provided in Section 1 of the Field Sampling Plan (FSP), and in the various Task Work Plans (TWP) named above. A copy of the Sampling and Analysis Plan (SAP), consisting of both this QAPP and the FSP, will be provided to the analytical laboratory and Quality Assurance (QA) laboratory prior to sample analysis.

SECTION 2

PROJECT ORGANIZATION AND RESPONSIBILITIES

2. PROJECT ORGANIZATION AND RESPONSIBILITIES

The Roy F. Weston, Inc. (WESTON®) project organization and personnel responsibilities are discussed in Section 2 of the Pesticide RAM Plan and Chlordane Cell TWP. Laboratory roles/responsibilities are presented in Section 2 of the FSP.

SECTION 3

DATA QUALITY OBJECTIVES

3. DATA QUALITY OBJECTIVES

This section describes the Quality Assurance (QA) objectives for the data relative to its intended use.

3.1 BACKGROUND

The primary objectives of this project are to: excavate and dispose/reuse of concrete slabs and frost walls and pesticide-contaminated soil from beneath former Buildings in the Grant, Locust, Cavite, (housing areas); excavate and dispose of asbestos, petroleum aromatic hydrocarbons (PAHs) and cadmium and lead contaminated soils in the Shirley Housing Areas; excavate and dispose of pesticide contaminated soils within the Chlordane Containment Cell. Sampling data will be collected to confirm that all pesticide-contaminated soils have been removed to applicable cleanup goals from the designated excavation areas.

Efforts to characterize the pesticide soil contamination at housing areas throughout Devens were undertaken by the Maguire Group in 1996, Gale Associates in the Fall of 2000 and by SEA Consultants in April 2001. Of the list of pesticides potentially detected by the analytical methods employed during the two efforts, only aldrin, chlordane, dieldrin, and heptachlor were detected at the housing areas. For the purposes of this QAPP, the Contaminants of Concern (COC) by work area are as follows:

Chlordane Cell

- Chlordane

Shirley Housing Area

- PAHs
- Cadmium
- Lead
- Asbestos

- Aldrin
- Dieldrin
- Heptachlor
- Chlordane
- Asbestos

(The on-site and off-site laboratories will report alpha-chlordane, gamma-chlordane and total chlordane. The total chlordane result will be compared to the MCP S-1 standard for total chlordane.) The on-site and off-site laboratories will analyze and report all compounds on the target compound list (TCL) for Method 8081A. WESTON and the U.S. Army Corps of Engineers, New England District (CENAE) have agreed that if the on-site laboratory analyst in performing the pesticide analysis identifies an Aroclor pattern present, WESTON will be notified and that sample will be sent to the off-site laboratory for pesticide and polychlorinated biphenyl (PCB) analysis (SW-846 Method 8082). The analyst will note his/her findings in the case narrative as well as the excel spreadsheet deliverable to WESTON.

As discussed in detail in the Shirley Housing TWP, the COCs for this area are asbestos, Petroleum Aromatic Hydrocarbons (PAHs), cadmium and lead. All asbestos sampling and analysis plans will be the responsibility of the asbestos subcontractor, Charter Environmental, Inc. and will be presented in an Asbestos Abatement Plan, (provided under separate cover).

In addition, based on recent sampling and analysis, asbestos-containing material (ACM) has been identified at the Cavite Site. WESTON anticipates that ACM will be encountered in the Cavite Street Housing Area as two separate materials during the remedial effort:

- Transite piping
- Waterproof mastic on the top three feet of frost walls below wood frame buildings.

See Subsection 1.2 of the TWP for more details. Because ACM has been identified at the Cavite Housing Area, as well as the Davao Housing (previously remediated), it is assumed that ACM-containing mastic will be found on 40% of the frost walls in the Grant and Locust Housing Areas as well. It is also assumed transite piping exists beneath 40% of the building foundations.

These assumptions will be verified by the licensed Asbestos Abatement Subcontractor, Charter Environmental, Inc. prior to removal of the slabs. Details of the verification program are provided in Section 4 of the TWP. Sampling and Analysis Plans for asbestos will be provide by the subcontractor in the Asbestos Abatement Plan.

The associated analytical methods, and the data quality objectives (DQOs) for all analyses at each location are presented in Table 3-1. Proposed locations of confirmation samples for the Devens Pesticide-Contaminated Soil project can be found in Figures 4-1 A through E of the FSP.

3.2 QA OBJECTIVES FOR CHEMICAL DATA MEASUREMENT

The Laboratory Analytical Methods and DQOs from GPL Laboratory, LLLP (GPL) are listed in Table 3-1A. The Laboratory Analytical Methods and DQOs from Alpha Analytical Laboratory are listed in Table 3-1B. Since it is unlikely that Mitkem will be used further on this project; only Mitkem's MDL study for the analyses already performed will be included in Attachment 1. Quality Assurance/Quality Control (QA/QC) samples are listed in Table 3-2.

Table 3-1A (GPL Laboratory)
Laboratory Analysis Methods and Data Quality Objectives

Analytes of Concern[1] and Methods[2]	CAS Number	Units	Project Action Limit	Project Quantitation Limit	Achievable Laboratory Limits	
					MDL	PQL
On-Site Analysis			ug/kg	ug/kg	ug/kg	ug/kg
4,4-DDD	72548		2000	1000	TBD	TBD
4,4-DDE	72559		2000	1000	TBD	TBD
4,4-DDT	50293		2000	1000	TBD	TBD
Aldrin	309002		30	15	TBD	TBD
Alpha-BHC	319846		NA	30	TBD	TBD
Alpha-Chlordane	5103719		NA	30	TBD	TBD
Beta-BHC	319857		NA	30	TBD	TBD
Chlordane, Total			NA	30	TBD	TBD
Chlordane	57749		1000	500	TBD	TBD
Delta-BHC	319868		NA	30	TBD	TBD
Dieldrin	60571		30	15	TBD	TBD
Endosulfan I	959988		200	1000	TBD	TBD
Endosulfan II	32213659		NA	30	TBD	TBD
Endosulfan Sulfate	1031078		NA	30	TBD	TBD
Endrin	72208		NA	30	TBD	TBD
Endrin Aldehyde	7421934		NA	30	TBD	TBD
Endrin Ketone	53494705		NA	30	TBD	TBD
Gamma-BHC (Lindane)	58899		NA	30	TBD	TBD
Gamma-Chlordane	5103742		NA	30	TBD	TBD
Heptachlor	76448		1000	500	TBD	TBD
Heptachlor Epoxide	1024573		60	30	TBD	TBD
Methoxychlor	72435		NA	30	TBD	TBD
Toxaphene	8011352		NA	30	TBD	TBD
VOCs - 5035 / 8260B					ug/kg	ug/kg
1,1,1-Trichloroethane	71556	ug/Kg	*	*	1.04	5
1,1,2,2-Tetrachloroethane	79345	ug/Kg	*	*	0.83	5
1,1,2-Trichloroethane	79005	ug/Kg	*	*	1.02	5
1,1-Dichloroethane	75343	ug/Kg	*	*	1.18	5
1,1-Dichloroethene	75354	ug/Kg	*	*	1.21	5
1,2-Dichloroethane	107062	ug/Kg	*	*	1.07	5
1,2-Dichloropropane	78875	ug/Kg	*	*	0.79	5
2-Chloroethyl Vinyl Ether	110758	ug/Kg	*	*	1.57	20
Acetonitrile	75058	ug/Kg	*	*	22.5	50
Acrylonitrile	107131	ug/Kg	*	*	8.25	25
Allyl Chloride	107051	ug/Kg	*	*	1.3	5
Benzene	71432	ug/Kg	*	*	0.79	5
Bromodichloromethane	75274	ug/Kg	*	*	0.98	5
Bromoform	75252	ug/Kg	*	*	0.77	5
Bromomethane	74839	ug/Kg	*	*	1	10
Carbon Disulfide	75150	ug/Kg	*	*	1.53	5
Carbon Tetrachloride	56235	ug/Kg	*	*	1.08	5
Chlorobenzene	108907	ug/Kg	*	*	1.06	5
Chloroethane	75003	ug/Kg	*	*	0.86	10
Chloroform	67663	ug/Kg	*	*	1.24	5
Chloromethane	74873	ug/Kg	*	*	0.56	10
cis-1,2-Dichloroethene		ug/Kg	*	*	1.08	5
cis-1,3-Dichloropropene	542756	ug/Kg	*	*	0.92	5
Dibromochloromethane	124481	ug/Kg	*	*	0.86	5
Ethylbenzene	100414	ug/Kg	*	*	1.05	5
Ethylene Dibromide	106934	ug/Kg	*	*	0.83	5
Methyl Methacrylate	80626	ug/Kg	*	*	1.14	5
Methylene Chloride	75092	ug/Kg	*	*	3.82	10
Styrene	100425	ug/Kg	*	*	0.97	5
Tetrachloroethene	127184	ug/Kg	*	*	1.23	5
Toluene	108883	ug/Kg	*	*	0.89	5

Table 3-1A (GPL Laboratory)
Laboratory Analysis Methods and Data Quality Objectives

Analytes of Concern[1] and Methods[2]	CAS Number	Units	Project Action Limit	Project Quantitation Limit	Achievable Laboratory Limits	
					MDL	PQL
trans-1,2-dichloroethene	156605	ug/Kg	*	*	1.31	5
trans-1,3-dichloropropene	542756	ug/Kg	*	*	0.86	5
Trichloroethene	79016	ug/Kg	*	*	1.13	5
Trichlorofluoromethane	75694	ug/Kg	*	*	1.27	5
Vinyl Acetate	108054	ug/Kg	*	*	0.88	5
Vinyl Chloride	75014	ug/Kg	*	*	1.02	10
Xylenes, Total	1330207	ug/Kg	*	*	3.24	15
SVOCs - 3540C / 8270C					ug/kg	ug/kg
1,2,4-Trichlorobenzene	120821	ug/Kg	**	**	49.3	330
1,2-Dichlorobenzene	95501	ug/Kg	**	**	42.9	330
1,2-Diphenylhydrazine	122667	ug/Kg	**	**	17.8	330
1,3-Dichlorobenzene	541731	ug/Kg	**	**	52.8	330
1,3-Dinitrobenzene	99650	ug/Kg	**	**	177	330
1,4-Dichlorobenzene	106467	ug/Kg	**	**	42.7	330
2,2-Oxybis(1-Chloropropane)		ug/Kg	**	**	70.6	330
2,4,5-Trichlorophenol	95954	ug/Kg	**	**	26	330
2,4,6-Trichlorophenol	88062	ug/Kg	**	**	19.6	330
2,4-Dichlorophenol	120832	ug/Kg	**	**	62.1	330
2,4-Dimethylphenol	105679	ug/Kg	**	**	162	330
2,4-Dinitrophenol	51285	ug/Kg	**	**	59.4	660
2,4-Dinitrotoluene	121142	ug/Kg	**	**	26	330
2,6-Dinitrotoluene	606202	ug/Kg	**	**	15.2	330
2-Chloronaphthalene	91587	ug/Kg	**	**	40.3	330
2-Chlorophenol	95578	ug/Kg	**	**	84	330
2-Methylnaphthalene	91576	ug/Kg	**	**	43.8	330
2-methylphenol	95487	ug/Kg	**	**	73.3	330
2-Nitroaniline		ug/Kg	**	**	9.3	330
2-Nitrophenol	88755	ug/Kg	**	**	89.4	330
3 & 4-Methylphenol		ug/Kg	**	**	74.8#	330#
3,3-Dichlorobenzidine	91941	ug/Kg	**	**	352.5	660
3-Nitroaniline		ug/Kg	**	**	105.5	330
4,6-dinitro-2-methyl phenol		ug/Kg	**	**	53	660
4-Bromophenyl-phenylether	101553	ug/Kg	**	**	16	330
4-chloro-3-methylphenol		ug/Kg	**	**	38.9	330
4-Chloroaniline	106478	ug/Kg	**	**	84	330
4-Chlorophenyl Phenyl Ether	7005723	ug/Kg	**	**	23.9	330
4-Nitroaniline		ug/Kg	**	**	87.6	330
4-Nitrophenol	100027	ug/Kg	**	**	33.4	660
Acenaphthene	83329	ug/Kg	**	**	26.3	330
Acenaphthylene	208968	ug/Kg	**	**	26.7	330
Aniline (Phenylamine, Aminobenzene)	62533	ug/Kg	**	**	389	660
Anthracene	120127	ug/Kg	**	**	22.7	330
Benzidine	92875	ug/Kg	**	**	187	330
Benzo(a)anthracene	56553	ug/Kg	**	**	9.1	330
Benzo(a)pyrene	50328	ug/Kg	**	**	13.9	330
Benzo(b)fluoranthene	205992	ug/Kg	**	**	35.2	330
Benzo(g,h,i)perylene	191242	ug/Kg	**	**	44.4	330
Benzo(k)fluoranthene	207089	ug/Kg	**	**	61.8	330
Benzyl Butyl Phthalate	85687	ug/Kg	**	**	12.5	330
bis(2-chloroethoxy) methane	111911	ug/Kg	**	**	37.7	330
bis(2-chloroethyl) ether	111444	ug/Kg	**	**	45.8	330
bis(2-ethylhexyl) phthalate	117817	ug/Kg	**	**	10.5	330
Chrysene	218019	ug/Kg	**	**	14.6	330
Dibenz(a,h)Anthracene	53703	ug/Kg	**	**	42.3	330
Dibenzofuran	132649	ug/Kg	**	**	22	330
Diethyl Phthalate	84662	ug/Kg	**	**	95.8	330
Dimethyl Phthalate	131113	ug/Kg	**	**	68.2	330
di-n-Butyl Phthalate	84742	ug/Kg	**	**	18.9	660
di-n-Octyl Phthalate	117840	ug/Kg	**	**	31.8	330
Fluoranthene	206440	ug/Kg	**	**	23.5	330
Fluorene	86737	ug/Kg	**	**	22.1	330

Table 3-1A (GPL Laboratory)
Laboratory Analysis Methods and Data Quality Objectives

Analytes of Concern[1] and Methods[2]	CAS Number	Units	Project Action Limit	Project Quantitation Limit	Achievable Laboratory Limits	
					MDL	PQL
Hexachlorobenzene	118741	ug/Kg	**	**	19.9	330
Hexachlorobutadiene	87683	ug/Kg	**	**	58.1	330
Hexachlorocyclopentadiene		ug/Kg	**	**	215.1	330
Hexachloroethane	67721	ug/Kg	**	**	37.4	330
Indeno(1,2,3-c,d)Pyrene	193395	ug/Kg	**	**	38.3	330
Isophorone	78591	ug/Kg	**	**	43	330
Naphthalene	91203	ug/Kg	**	**	37.6	330
Nitrobenzene		ug/Kg	**	**	43	330
n-Nitrosodimethylamine	62759	ug/Kg	**	**	49.3	330
n-Nitrosodi-n-Propylamine	621647	ug/Kg	**	**	36.8	330
n-Nitrosodiphenylamine	86306	ug/Kg	**	**	15.5	330
Pentachlorophenol	87865	ug/Kg	**	**	71.2	660
Phenanthrene	85018	ug/Kg	**	**	15.5	330
Phenol	108952	ug/Kg	**	**	82.4	330
Pyrene	129000	ug/Kg	**	**	15.6	330
Pyridine	110861	ug/Kg	**	**	307	660
Total Petroleum Hydrocarbons - 8015B						
DRO	N/A	mg/kg	2,500	1250	0.652+	1.7+
GRO						
Metals - 3050B / 6010B					mg/kg	mg/kg
Arsenic	7440382	mg/kg	30	15	1.06	4
Barium	7440393	mg/kg	1000	500	0.08	1
Cadmium	7440439	mg/kg	30	15	0.1	0.6
Chromium	7440473	mg/kg	1000	500	0.18	1
Lead	7439921	mg/kg	300	150	0.3	2
Selenium	7782492	mg/kg	300	150	0.48	4
Silver	7440224	mg/kg	100	50	0.46	0.6
Mercury - 7471A					mg/kg	mg/kg
Mercury	7439976	mg/kg	10	5	0.02	0.03
PCB - 8082					ug/Kg	ug/Kg
PCB-1016	N/A	ug/Kg	***	***	10.7	33
PCB-1221	N/A	ug/Kg	***	***	15.7	33
PCB-1232	N/A	ug/Kg	***	***	9.9	33
PCB-1242	N/A	ug/Kg	***	***	4.6	33
PCB-1248	N/A	ug/Kg	***	***	7	33
PCB-1254	N/A	ug/Kg	***	***	7.2	33
PCB-1260	N/A	ug/Kg	***	***	15.7	67
Pesticides - 3540C / 8081A					**ug/Kg**	**ug/Kg**
4,4-DDD	72548	ug/Kg	2000	1000	0.22	1.7
4,4-DDE	72559	ug/Kg	2000	1000	0.26	1.7
4,4-DDT	50293	ug/Kg	2000	1000	0.37	1.7
Aldrin	309002	ug/Kg	30	15	0.92	1.7
Alpha-BHC	319846	ug/Kg	50000	25000	0.21	1.7
Alpha-Chlordane	5103719	ug/Kg	1000	500	0.49	1.7
Beta-BHC	319857	ug/Kg	10000	5000	0.32	1.7
Chlordane, Total	57749	ug/Kg	1000	500	NA	NA
Chlordane	57749	ug/Kg	1000	500	1.54	33
Delta-BHC	319868	ug/Kg	10000	5000	0.2	1.7
Dieldrin	60571	ug/Kg	30	15	0.65	1.7
Endosulfan I	959988	ug/Kg	50	25	0.26	1.7
Endosulfan II	32213659	ug/Kg	50	25	0.44	1.7
Endosulfan Sulfate	1031078	ug/Kg	NA	NA	0.36	1.7
Endrin	72208	ug/Kg	600	300	0.3	1.7
Endrin Aldehyde	7421934	ug/Kg	10000	5000	0.32	1.7
Endrin Ketone	53494705	ug/Kg	NA	NA	0.3	1.7
Gamma-BHC (Lindane)	58899	ug/Kg	100	50	0.24	1.7
Gamma-Chlordane	5103742	ug/Kg	1000	500	0.22	1.7
Heptachlor	76448	ug/Kg	100	50	0.62	1.7
Heptachlor Epoxide	1024573	ug/Kg	60	30	0.39	1.7
Methoxychlor	72435	ug/Kg	30000	15000	0.38	1.7
Toxaphene	8011352	ug/Kg	10000	5000	13	33

Table 3-1A (GPL Laboratory)
Laboratory Analysis Methods and Data Quality Objectives

Analytes of Concern[1] and Methods[2]	CAS Number	Units	Project Action Limit	Project Quantitation Limit	Achievable Laboratory Limits	
					MDL	PQL
Other Parameters						
Flash Point - 1010	N/A	DC			N/A	N/A
Cyanide, reactive - 9014R		mg/kg	R/NR	R/NR	N/A	0.025
Sulfide, reactive - 9034R		mg/kg	R/NR	R/NR	N/A	10
Other Parameters (Cont.)						
Percent Solids	N/A	%	≥ 30%	≥ 30%	N/A	N/A
pH - 9045C	N/A	pH	NA	NA	N/A	N/A
TOC	N/A	mg/kg			44	100
PAH (3540C/8270C)					**ug/Kg**	**ug/Kg**
Acenaphthylene	208968	ug/Kg	100000	50000	26.7	330
Phenanthrene	85018	ug/Kg	700000	350000	15.5	330
Acenaphthene	83329	ug/Kg	20000	10000	26.3	330
Anthracene	120127	ug/Kg	1000000	500000	22.7	330
Benzo(a)athracene	56553	ug/Kg	700	350	9.1	330
Benzo(a)pyrene	50328	ug/Kg	700	350	13.9	330
Benzo(b)fluoranthrene	205992	ug/Kg	700	350	35.2	330
Benzo(g,h,i)Perylene	191242	ug/Kg	100000	50000	44.4	330
Benzo(k)fluoranthene	207089	ug/Kg	700	350	61.8	330
Chrysene	218019	ug/Kg	700	350	14.6	330
Dibenzo(a,h)Anthracene	53703	ug/Kg	700	350	42.3	330
Fluoranthrene	206440	ug/Kg	600000	300000	23.5	330
Fluorene	86737	ug/Kg	400000	200000	22.1	330
Ideno(1,2,3-cd)pyrene	193395	ug/Kg	700	350	38.3	330
Pyrene	129000	ug/Kg	500000	250000	15.6	330
2-Methylnapthalene	91576	ug/Kg	700	350	43.8	330
Napthalene	91203	ug/Kg	4000	2000	37.6	330
2-Chloronapthalene	91587	ug/Kg	1000000	500000	40.3	330
TCLP Pesticides 1311/8081A					**ug/L**	**ug/L**
Chlordane	57749	mg/L	Facility dependant		0.078	1
Endrin	72208	mg/L	Facility dependant		7.00E-03	0.05
Heptachlor	76448	mg/L	Facility dependant		3.00E-02	0.05
Heptachlor epoxide	76448	mg/L	Facility dependant		3.10E-02	0.05
Lindane	58899	mg/L	Facility dependant		1.90E-02	0.05
Methoxychlor	72435	mg/L	Facility dependant		5.00E-03	0.05
Toxaphene	801352	mg/L	Facility dependant		0.39	1

Note: DQO's listed above are from GPL Laboratories.

** Based on MADEP COMM-97-001, Action level is 100,000 ug/kg for Total SVOC. Project Quant. Limit is 50,000 ug/kg.

* Based on MADEP COMM-97-001, Action level is 4,000 ug/kg for Total VOC. Project Quant. Limit is 2,000 ug/kg.

*** Based on MADEP COMM-97-001, Action Level is 2,000 ug/kg for Total PCB. Project Quant. Limit is 1,000 ug/kg.

+ Based on 8015DRO

4-Methylphenol only

N/A Not Applicable- Lowest Possible Achievable Lab Quanitation Limit will be reported.

TBD To Be Determined once on-site lab is awarded and MDL study if performed: proposed MDLs and PQLs are listed in ESN's SOP

Table 3-1B (Alpha Analytical)
Laboratory Analysis Methods and Data Quality Objectives

Analytes of Concern[1] and Methods[2]	CAS Number	Units	Project Action Limit	Project Quantitation Limit	Achievable Laboratory Limits	
					PQL	MDL
On-Site Analysis						
4,4-DDD	72548					
4,4-DDE	72559					
4,4-DDT	50293					
Aldrin	309002					
Alpha-BHC	319846					
Alpha-Chlordane	5103719					
Beta-BHC	319857					
Chlordane, Total						
Chlordane	57749					
Delta-BHC	319868					
Dieldrin	60571					
Endosulfan I	959988					
Endosulfan II	32213659					
Endosulfan Sulfate	1031078					
Endrin	72208					
Endrin Aldehyde	7421934					
Endrin Ketone	53494705					
Gamma-BHC (Lindane)	58899					
Gamma-Chlordane	5103742					
Heptachlor	76448					
Heptachlor Epoxide	1024573					
Methoxychlor	72435					
Toxaphene	8011352					
VOCs - 5035 / 8260B						
1,1,1-Trichloroethane	71556	ug/kg	*	*	1.5	0.558
1,1,2,2-Tetrachloroethane	79345	ug/kg	*	*	3.0	0.85
1,1,2-Trichloroethane	79005	ug/kg	*	*	1.5	0.498
1,1-Dichloroethane	75343	ug/kg	*	*	1.0	0.189
1,1-Dichloroethene	75354	ug/kg	*	*	1.5	0.387
1,2-Dichloroethane	107062	ug/kg	*	*	1.5	0.364
1,2-Dichloropropane	78875	ug/kg	*	*	2.5	0.547
2-Chloroethyl Vinyl Ether	110758	ug/kg	*	*	NR	NR
2-propen-1-ol		ug/kg	*	*	NR	NR
Acetonitrile	75058	ug/kg	*	*	NR	NR
Acrylonitrile	107131	ug/kg	*	*	1.0	0.225
Allyl Chloride	107051	ug/kg	*	*	NR	NR
Benzene	71432	ug/kg	*	*	1.5	0.341
Bromodichloromethane	75274	ug/kg	*	*	1.5	0.342
Bromoform	75252	ug/kg	*	*	3.0	0.899
Bromomethane	74839	ug/kg	*	*	5.0	1.784
Carbon Disulfide	75150	ug/kg	*	*	2.0	0.466
Carbon Tetrachloride	56235	ug/kg	*	*	2.5	0.574
Chlorobenzene	108907	ug/kg	*	*	2.5	0.535
Chloroethane	75003	ug/kg	*	*	2.5	0.528
Chloroform	67663	ug/kg	*	*	1.0	0.243
Chloromethane	74873	ug/kg	*	*	3.0	0.827
cis-1,2-Dichloroethene		ug/kg	*	*	2.0	0.465
cis-1,3-Dichloropropene	542756	ug/kg	*	*	2.0	0.419
Dibromochloromethane	124481	ug/kg	*	*	2.5	0.678
Ethylbenzene	100414	ug/kg	*	*	2.5	0.502
Ethylene Dibromide	106934	ug/kg	*	*	2.5	0.542
Methyl Methacrylate	80626	ug/kg	*	*	NR	NR
Methylene Chloride	75092	ug/kg	*	*	5.0	1.466
Styrene	100425	ug/kg	*	*	2.5	0.753
Tetrachloroethene	127184	ug/kg	*	*	2.5	0.522
Toluene	108883	ug/kg	*	*	2.5	0.504
trans-1,2-dichloroethene	156605	ug/kg	*	*	2.0	0.452
trans-1,3-dichloropropene	542756	ug/kg	*	*	2.5	0.737
Trichloroethene	79016	ug/kg	*	*	2.5	0.735
Trichlorofluoromethane	75694	ug/kg	*	*	5.0	0.946
Vinyl Acetate	108054	ug/kg	*	*	1.0	0.284

Table 3-1B (Alpha Analytical)
Laboratory Analysis Methods and Data Quality Objectives

Analytes of Concern[1] and Methods[2]	CAS Number	Units	Project Action Limit	Project Quantitation Limit	Achievable Laboratory Limits	
					PQL	MDL
Vinyl Chloride	75014	ug/kg	*	*	2.5	0.729
Xylenes, Total	1330207	ug/kg	*	*	3.0	0.866
SVOCs - 3540C / 8270C						
1,2,4-Trichlorobenzene	120821	ug/kg	**	**	600	115
1,2-Dichlorobenzene	95501	ug/kg	**	**	600	120
1,2-Diphenylhydrazine	122667	ug/kg	**	**	600	134
1,3-Dichlorobenzene	541731	ug/kg	**	**	600	118
1,3-Dinitrobenzene	99650	ug/kg	**	**	700	210
1,4-Dichlorobenzene	106467	ug/kg	**	**	600	124
2,2-Oxybis(1-Chloropropane)		ug/kg	**	**	600	128
2,4,5-Trichlorophenol	95954	ug/kg	**	**	700	225
2,4,6-Trichlorophenol	88062	ug/kg	**	**	700	230
2,4-Dichlorophenol	120832	ug/kg	**	**	700	210
2,4-Dimethylphenol	105679	ug/kg	**	**	600	188
2,4-Dinitrophenol	51285	ug/kg	**	**	600	135
2,4-Dinitrotoluene	121142	ug/kg	**	**	600	156
2,6-Dinitrotoluene	606202	ug/kg	**	**	600	145
2-Chloronaphthalene	91587	ug/kg	**	**	600	130
2-Chlorophenol	95578	ug/kg	**	**	800	256
2-Methylnaphthalene	91576	ug/kg	**	**	600	192
2-methylphenol	95487	ug/kg	**	**	800	260
2-Nitroaniline		ug/kg	**	**	600	161
2-Nitrophenol	88755	ug/kg	**	**	600	175
3 & 4-Methylphenol		ug/kg	**	**	600	143
3,3-Dichlorobenzidine	91941	ug/kg	**	**	600	156
3-Nitroaniline		ug/kg	**	**	600	164
4,6-dinitro-2-methyl phenol		ug/kg	**	**	600	178
4-Bromophenyl-phenylether	101553	ug/kg	**	**	600	148
4-chloro-3-methylphenol		ug/kg	**	**	700	203
4-Chloroaniline	106478	ug/kg	**	**	600	176
4-Chlorophenyl Phenyl Ether	7005723	ug/kg	**	**	600	154
4-Nitroaniline		ug/kg	**	**	600	154
4-Nitrophenol	100027	ug/kg	**	**	700	218
Acenaphthene	83329	ug/kg	**	**	600	135
Acenaphthylene	208968	ug/kg	**	**	600	143
Aniline (Phenylamine, Aminobenzene)	62533	ug/kg	**	**	600	156
Anthracene	120127	ug/kg	**	**	600	118
Benzidine	92875	ug/kg	**	**	600	126
Benzo(a)anthracene	56553	ug/kg	**	**	600	120
Benzo(a)pyrene	50328	ug/kg	**	**	600	136
Benzo(b)fluoranthene	205992	ug/kg	**	**	600	143
Benzo(g,h,i)perylene	191242	ug/kg	**	**	600	139
Benzo(k)fluoranthene	207089	ug/kg	**	**	600	141
Benzyl Butyl Phthalate	85687	ug/kg	**	**	600	126
Benzyl Chloride	100447	ug/kg	**	**	600	131
bis(2-chloroethoxy) methane	111911	ug/kg	**	**	600	142
bis(2-chloroethyl) ether	111444	ug/kg	**	**	600	152
bis(2-ethylhexyl) phthalate	117817	ug/kg	**	**	600	147
Chrysene	218019	ug/kg	**	**	600	152
Dibenz(a,h)Anthracene	53703	ug/kg	**	**	600	143
Dibenzofuran	132649	ug/kg	**	**	600	153
Diethyl Phthalate	84662	ug/kg	**	**	600	185
Dimethyl Phthalate	131113	ug/kg	**	**	600	167
di-n-Butyl Phthalate	84742	ug/kg	**	**	600	156
di-n-Octyl Phthalate	117840	ug/kg	**	**	600	184
Fluoranthene	206440	ug/kg	**	**	600	142
Fluorene	86737	ug/kg	**	**	600	136
Hexachlorobenzene	118741	ug/kg	**	**	600	153
Hexachlorobutadiene	87683	ug/kg	**	**	600	174
Hexachlorocyclopentadiene		ug/kg	**	**	600	135
Hexachloroethane	67721	ug/kg	**	**	600	146
Indeno(1,2,3-c,d)Pyrene	193395	ug/kg	**	**	600	154
Isophorone	78591	ug/kg	**	**	600	125
Naphthalene	91203	ug/kg	**	**	600	149
Nitrobenzene		ug/kg	**	**	600	145
n-Nitrosodimethylamine	62759	ug/kg	**	**	600	134
n-Nitrosodi-n-Propylamine	621647	ug/kg	**	**	600	175

Table 3-1B (Alpha Analytical)
Laboratory Analysis Methods and Data Quality Objectives

Analytes of Concern[1] and Methods[2]	CAS Number	Units	Project Action Limit	Project Quantitation Limit	Achievable Laboratory Limits	
					PQL	MDL
n-Nitrosodiphenylamine	86306	ug/kg	**	**	600	157
Pentachlorophenol	87865	ug/kg	**	**	600	137
Phenanthrene	85018	ug/kg	**	**	600	142
Phenol	108952	ug/kg	**	**	600	135
Pyrene	129000	ug/kg	**	**	600	160
Pyridine		ug/kg	**	**	600	191
Total Petroleum Hydrocarbons - Modified 8015B						
DRO	N/A	mg/kg	2,500	1250	5	1.4
GRO	N/A	mg/kg			2.5	0.5
Metals - 3050B / 6010B						
Arsenic	7440382	mg/kg	30	15	1	0.207
Barium	7440393	mg/kg	1000	500	1	0.171
Cadmium	7440439	mg/kg	30	15	0.5	0.092
Chromium	7440473	mg/kg	1000	500	1	0.272
Lead	7439921	mg/kg	300	150	1.5	0.329
Selenium	7782492	mg/kg	300	150	0.5	0.109
Silver	7440224	mg/kg	100	50	1	0.159
Mercury - 7471A						
Mercury	7439976	mg/kg	10	5	0.15	0.031
PCB - 8082						
PCB-1016	N/A	ug/kg	***	***	55	17.6
PCB-1221	N/A	ug/kg	***	***	75	24.6
PCB-1232	N/A	ug/kg	***	***	55	18.2
PCB-1242	N/A	ug/kg	***	***	55	17.6
PCB-1248	N/A	ug/kg	***	***	55	14.3
PCB-1254	N/A	ug/kg	***	***	55	16.2
PCB-1260	N/A	ug/kg	***	***	25	6.26
Pesticides - 3540C / 8081A						
4,4-DDD	72548	ug/Kg	2000	1000	5.5	1.74
4,4-DDE	72559	ug/Kg	2000	1000	2.5	0.8
4,4-DDT	50293	ug/Kg	2000	1000	5	1.59
Aldrin	309002	ug/Kg	30	15	2	0.54
Alpha-BHC	319846	ug/Kg	50000	25000	1.5	0.49
Alpha-Chlordane	5103719	ug/Kg	1000	500	1.5	0.37
Beta-BHC	319857	ug/Kg	10000	5000	4	1.27
Chlordane, Total		ug/Kg	1000	500	10	2.32
Chlordane	57749	ug/Kg	1000	500	10	2.32
Delta-BHC	319868	ug/Kg	10000	5000	1.5	0.47
Dieldrin	60571	ug/Kg	30	15	2.5	0.7
Endosulfan I	959988	ug/Kg	50	25	2	0.54
Endosulfan II	32213659	ug/Kg	50	25	5.5	1.74
Endosulfan Sulfate	1031078	ug/Kg	NA	NA	3.5	1.05
Endrin	72208	ug/Kg	600	300	3	0.84
Endrin Aldehyde	7421934	ug/Kg	10000	5000	3	0.95
Endrin Ketone	53494705	ug/Kg	NA	NA	3	0.93
Gamma-BHC (Lindane)	58899	ug/Kg	100	50	1.5	0.43
Gamma-Chlordane	5103742	ug/Kg	1000	500	1.5	0.37
Heptachlor	76448	ug/Kg	100	50	2	0.54
Heptachlor Epoxide	1024573	ug/Kg	60	30	2	0.51
Methoxychlor	72435	ug/Kg	30000	15000	15	4.57
Toxaphene	8011352	ug/Kg	10000	5000	60	18.8
Other Parameters						
Flash Point - 1010	N/A	DC				
Cyanide, reactive - 9014R		mg/kg	R/NR		0.75	0.25
Sulfide, reactive - 9034R		mg/kg	R/NR		1.5	0.5
Other Parameters (Cont.)						
Percent Solids	N/A	%	> 30%	> 30%		
pH - 9045C	N/A	pH	NA	NA		
TOC (Lloyd Kahn)			Facility Dependent	Facility Dependent	0.10%	0.01%
PAH						
Acenaphthylene	208968	mg/kg	100	50	0.6	0.143
Phenanthrene	85018	mg/kg	700	350	0.6	0.142
Acenaphthene	83329	mg/kg	20	10	0.6	0.135
Anthracene	120127	mg/kg	1000	500	0.6	0.118
Benzo(a)athracene	56553	mg/kg	0.7	0.35	0.6	0.12
Benzo(a)pyrene	50328	mg/kg	0.7	0.35	0.6	0.13
Benzo(b)fluoranthrene	205992	mg/kg	0.7	0.35	0.6	0.143

Table 3-1B (Alpha Analytical)
Laboratory Analysis Methods and Data Quality Objectives

Analytes of Concern[1] and Methods[2]	CAS Number	Units	Project Action Limit	Project Quantitation Limit	Achievable Laboratory Limits	
					PQL	MDL
Benzo(g,h,i)Perylene	191242	mg/kg	100	50	0.6	0.139
Benzo(k)fluoranthene	207089	mg/kg	0.7	0.35	0.6	0.141
Chrysene	218019	mg/kg	0.7	0.35	0.6	0.152
Dibenzo(a,h)Anthracene	53703	mg/kg	0.7	0.35	0.6	0.143
Fluoranthrene	206440	mg/kg	600	300	0.6	0.142
Fluorene	86737	mg/kg	400	200	0.6	0.136
Ideno(1,2,3-cd)pyrene	193395	mg/kg	0.7	0.35	0.6	0.154
Pyrene	129000	mg/kg	500	250	0.6	0.16
1-Methylnapthalene		mg/kg	0.7	0.35	0.6	0.135
2-Methylnapthalene	91576	mg/kg	0.7	0.35	0.6	0.192
Napthalene	91203	mg/kg	4	2	0.6	0.149
2-Chloronapthalene	91587	mg/kg	1000	500	0.6	0.13
TCLP Pesticides 1311/8081A						
Chlordane	57749	mg/L	Facility dependant		0.0015	0.000395
Endrin	72208	mg/L	Facility dependant		0.0020	0.000555
Heptachlor	76448	mg/L	Facility dependant		0.0010	0.000195
Heptachlor epoxide	76448	mg/L	Facility dependant		0.0060	0.00012
Lindane	58899	mg/L	Facility dependant		0.0010	0.000245
Methoxychlor	72435	mg/L	Facility dependant		0.0150	0.003075
Toxaphene	801352	mg/L	Facility dependant		0.0100	0.002015

** Based on MADEP COMM-97-001, Action level is 100,000 ug/kg for Total SVOC. Project Quant. Limit is 50,000 ug/kg.
* Based on MADEP COMM-97-001, Action level is 4,000 ug/kg for Total VOC. Project Quant. Limit is 2,000 ug/kg.
*** Based on MADEP COMM-97-001, Action Level is 2,000 ug/kg for Total PCB. Project Quant. Limit is 1,000 ug/kg.
NR Not Reported as part of the 8260B target compound list.

TABLE 3-2
SAMPLE QA/QC
FORT DEVENS, MASSACHUSETTS

Sample Type	Area	Analysis	Method	Total Onsite Samples[4]	Onsite Duplicates	Onsite MS/MSD	Offsite[5] Verification/ Characterization	Offsite Field Duplicates	Offsite MS/MSD	CENAE QA
Post Excavation Confirmation and Depth Characterization	Grant, Locust, & Cavite Housing Areas	Pesticides[1]	8081A[2]	1759	176	0	352	35	18	35
	Chlordane Cell	Pesticides[1]	8081A				50	5	3	5
		TCLP Pest	1311/8081A							
	Shirley Housing Area	Asbestos[3]					250	NA	N/A	N/A
	Shirley Housing Area	PAH	3540C/ 8270C				25	10%	5%	10%
		Total Metals and Hg	3050B/6010B/7471A				25	10%	5%	10%
Additional Excavation Samples	Grant, Locust, & Cavite Housing Areas	Pesticides[1]	8081A[2]	528	53	0	106	11	5	11
Waste Characterization '- Pre-Excavation, and '- Stockpile	Chlordane Cell	VOC	5035/8260B				9	N/A	N/A	N/A
		SVOC	3540C/ 8270C				9	N/A	N/A	N/A
		TPH	8015B (DRO and GRO)				9	N/A	N/A	N/A
		Pesticides	3540C/8081A				9	N/A	N/A	N/A
		PCB	3540C/8082				9	N/A	N/A	N/A
		TCLP Pesticides	1311/8081A				9	N/A	N/A	N/A
		Herbicides	8151A				9	N/A	N/A	N/A
		TOC	9060A				9	N/A	N/A	N/A
		Ignitability	1010				9	N/A	N/A	N/A
		Corrosivity	9045A				9	N/A	N/A	N/A
		Cyanide/Sulfide Reactivity	7.3.4.1/7.3.4.2				9	N/A	N/A	N/A
		RCRA 8 Metals	3050B/6010B/7471A				9	N/A	N/A	N/A
	Shirley Housing Area	VOC	5035/8260B				2	N/A	N/A	N/A
		SVOC	3540C/ 8270C				7	N/A	N/A	N/A
		TPH	8015B (DRO and GRO)				7	N/A	N/A	N/A
		Pesticides	3540C/8081A				7	N/A	N/A	N/A
		PCB	3540C/8082				7	N/A	N/A	N/A
		Herbicides	8151A				7	N/A	N/A	N/A
		PAH	8270C				7	N/A	N/A	N/A
		Ignitability	1010				7	N/A	N/A	N/A
		Corrosivity	9045A				7	N/A	N/A	N/A
		Cyanide/Sulfide Reactivity	7.3.4.1/7.3.4.2				7	N/A	N/A	N/A
		TOC	9060A				160	N/A	N/A	N/A
		Total Metals and Hg	3050B/6010B/7471A				7	N/A	N/A	N/A
		Asbestos[3]					7	N/A	N/A	N/A
	Grant, Locust, & Cavite Housing Areas	Pesticides	3540C/8081				160	N/A	N/A	N/A
		VOC	5035/8260B				160	N/A	N/A	N/A
		SVOC	3540C/ 8270C				160	N/A	N/A	N/A
		PCB	8082				160	N/A	N/A	N/A
		TPH	8015B (DRO and GRO)				160	N/A	N/A	N/A
		RCRA 8 Metals	3050B/6010B/7471A				160	N/A	N/A	N/A
		Ignitability	1010				160	N/A	N/A	N/A
		Corrosivity	9045A				160	N/A	N/A	N/A
		Cyanide/Sulfide Reactivity	7.3.4.1/7.3.4.2				160	N/A	N/A	N/A
	Backfill	Pesticide	3540C/8081				1	N/A	N/A	N/A
		VOC	5035/8260B				1	N/A	N/A	N/A
		SVOC	3540C/ 8270C				1	N/A	N/A	N/A
		PCB	8082				1	N/A	N/A	N/A
		TPH	8015B (DRO and GRO)				1	N/A	N/A	N/A
		RCRA 8 Metals	3050B/6010B/7471A				1	N/A	N/A	N/A
		TOC	9060A				1	N/A	N/A	N/A
		Ignitability	1010				1	N/A	N/A	N/A
		Corrosivity	9045A				1	N/A	N/A	N/A
		Cyanide/Sulfide Reactivity	7.3.4.1/7.3.4.2				1	N/A	N/A	N/A
	Locust Concrete	TCLP Pest	1311/8081A				1	N/A	N/A	N/A
	Cavite Concrete	TCLP Pest	1311/8081A				1	N/A	N/A	N/A

[1] Full 8081A Pesticides will be analyzed and laboratory will report all TCL compounds and total chlordane.
[2] Extraction method 3540C must be used for offsite verification samples.
[3] See Asbestos Abatement Plan in Appendix B of the Work Plan for details on asbestos sampling.
[4] TAT is 24 hour for onsite analysis
[5] Off-site verification and waste diposal characterization sample analysis TAT = 5 days

SECTION 4

SAMPLING LOCATIONS AND PROCEDURES

4. SAMPLING LOCATIONS AND PROCEDURES

Sampling locations, rationale, and methods are discussed in Section 4 of the FSP. Figures 4-1A through E in the FSP provides a summary of the samples that are anticipated to be collected during this project.

Personal protective equipment (PPE) will not be sampled. PPE will be disposed of as solid waste.

SECTION 5

SAMPLE CUSTODY AND HOLDING TIMES

5. SAMPLE CUSTODY AND HOLDING TIMES

Sample holding times are listed along with the required preservatives and sample containers in Table 5-1 of this QAPP. Sample custody and documentation procedures are located in Section 5 of the FSP.

The on-site laboratory will receive each sample in an 8-ounce (oz.) clear glass jar along with a completed WESTON chain of custody. The samples will arrive at the on-site laboratory in a cooler (WESTON and CENAE have agreed that samples, due to the quick turnaround time and the need to have samples at room temperature to proceed with analysis, samples will not have to be delivered on ice) twice during the day (it is estimated that 20 to 40 samples will be collected each day). The on-site laboratory will analyze the samples for pesticides only and report result to WESTON's on-site data manager in the form of an electronic deliverable (excel spreadsheet) and hard-copy within 24 hours of sample receipt. The on-site analyst will also note chromatograms that exhibit an Aroclor pattern. Any such pattern will be noted on the enforcement decision document and the hard-copy. Upon receipt of these results, WESTON field personnel will decide which samples (20%) will be sent to the off-site laboratory for verification. Samples chosen will have analytical results below and above the project specific action limits. As part of the 20% sent off-site, samples yielding results which are within 10% of the regulatory action level will also be sent off-site for verification. If the on-site laboratory analyst detects a pattern resembling an Aroclor, that sample will be sent off-site for pesticide and PCB analysis (SW-846 Method 8082). The on-site laboratory must keep all samples cooled at 4 degrees centigrade plus or minus 2 degrees and must store samples for at least 7 days.

Table 5-1

Sample Containers, Preservation Methods, and Holding Times

Matrix	Parameter	Container	Preservation/ Solvents	Maximum Holding Times	
				Extraction	Analysis
CONFIRMATION SAMPLES					
Soil	On-site Total Pesticides	8 oz. clear jar	Ice to 4oC	14 days	40 days
Soil	Off-site Total Pesticides	8 oz. clear glass	Ice to 4oC	14 days	40 days
Soil	PAHs (Shirley only)	8 oz. clear glass	Ice to 4oC	14 days	40 days
Soil	Cadmium and Lead (Shirley only)	8 oz. clear glass	Ice to 4oC	180 days	180 days
WASTE CHARACTERIZATION SAMPLES					
Soil	Total VOCs	Two 30-ml glass vials with septum top	Methanol – 10 g soil to 25 ml methanol; ice to 4°C	---	14 days
Soil	Total SVOCs	8 oz clear glass	Ice to 4°C	14 Days	40 days
Soil	Total Pesticides	8 oz clear glass	Ice to 4°C	14 Days	40 days
Soil	Total PCBs	8 oz clear glass	Ice to 4°C	14 days	40 days
Soil	PAHs	8 oz. clear glass	Ice to 4°C	14 days	40 days
Soil	TOC	8 oz. clear glass	Ice to 4°C	14 days	40 days
Soil	RCRA 8 Metals Mercury	8 oz. clear glass	Ice to 4°C	---	180 days 28 days
Soil	TCLP VOCs	Two 30-ml glass vials with septum top	Ice to 4°C	---	14 days
Soil	TCLP SVOCs	8 oz clear glass	Ice to 4°C	14 days	40 days

Table 5-1
Sample Containers, Preservation Methods, and Holding Times
(continued)

Matrix	Parameter	Container	Preservation/ Solvents	Maximum Holding Times	
				Extraction	Analysis
WASTE CHARACTERIZATION SAMPLES					
Soil	TCLP Pesticides*	8 oz clear glass	Ice to 4°C	14 days	40 days
Soil	TCLP Herbicides	8 oz clear glass	Ice to 4°C	14 days	40 days
Soil	TCLP – Metals	8 oz. clear glass	Ice to 4°C	---	180 days
Soil	IRC	(combined w/TCLP)	Ice to 4°C	---	14 days

TCLP Holding Times: Metals (excluding mercury): TCLP – 180 days, Analysis – 180 days (from TCLP extraction). Mercury: TCLP – 28 days, Analysis – 28 days (following TCLP extraction).

SECTION 6

ANALYTICAL PROCEDURES

6. ANALYTICAL PROCEDURES

The following section summarizes the analytical procedures that will be used by the on-site and off-site laboratories for analysis of site contaminants. For complete details, laboratory Standard Operating Procedures (SOPs) for the following EPA Methods from the off-site laboratories, Alpha Analytical and GPL are provided in Attachment 1. ESN North Atlantic, the on-site mobile laboratory, has submitted a site specific SOP which is included in Attachment 3. At the start of the project all excavation confirmatory verification (pesticide verification sample submittal will start at 20 % for the first month and will be scaled down to 10% thereafter) and waste characterization samples (except for waste characterization samples from Shirley and the Chlordane Cell which were sent to Mitkem) will be sent to Alpha Analytical and GPL. Due to the large amount of samples anticipated and the duration of the project, WESTON has contracted Mitkem Corporation as a back-up laboratory to GPL and Alpha Analytical. Mitkem's SOPs are not provided in Attachment 1, but will be provided upon request should WESTON decide to utilize them. Mitkem's Method Detection Limits (MDLs) and Reporting Limits (RL) for all relative analyses are included in Attachment 1.

Post Excavation Confirmatory Sample Analysis

On-site Mobile Laboratory (ESN North Atlantic)

- Total Pesticides – modified SW-846 Method 8081A (The laboratory will analyze for the full target compound list of method 8081A – see ESN's SOP in Attachment 3 and Subsection 8.3 of QAPP for details of the method modification.)

Off-site Laboratories

- Total Pesticides – EPA Methods 3540C/8081A (Total PCBs-EPA Methods 3540C/8082, only if on-site analyst detected Aroclor pattern).
- Total Cadmium and Lead - EPA Methods 3050B/6010B (post-excavation confirmatory samples at Shirley Housing Area).

- Petroleum Aromatic Hydrocarbons (PAHs)- SW-846 Method 3540C/8270C (post-excavation confirmatory sampling at Shirley Housing Area).

- Asbestos – EPA Method 600 (for post-excavation confirmatory samples at Shirley Housing Area)

Waste Characterization Analysis

Off-site Laboratories

- Pesticides – EPA Methods 3540C/8081A (waste disposal characterization -inclusion in total Semi-Volatile Organic Compound (SVOC) concentration, per COMM-97-001).

- Toxicity Characteristic Leaching Procedure (TCLP) Pesticides – EPA Methods 1311/8081A, for waste characterization if indicated, based on totals.

- TCLP Herbicides– EPA Methods 1311/8151A/8150B, for waste characterization if indicated, based on totals.

- Total Herbicides – EPA Methods 3540C/8151A/8150B, for waste characterization (for TCLP analytes only).

- TCLP Metals – EPA Methods 1311/3050B/6010B/7471A, for waste characterization if indicated, based on totals.

- RCRA 8 Metals and Mercury – EPA Methods 3050B/6010B/7471A.

- TCLP Volatile Organic Compounds (VOC) - EPA Method 1311/5030A/8260B, for waste characterization if indicated, based on totals.

- Total Volatile Organic Compounds (VOC) - EPA Method 5035A/8260B.

- (TCLP) Semi-Volatile Organic Compounds (SVOC)- EPA Method 1311/8270C, for waste characterization if indicated, based on totals.

- Total Semi-Volatile Organic Compounds (SVOC)- EPA Method 3540C/8270C, include total pesticides in the total SVOC calculation.

- Total Polychlorinated Biphenyls (PCBs) - EPA Method 3540C/8082.

- Ignitability - EPA Method 1010.

- Corrosivity – EPA Method 9045A.

- Cyanide/Sulfide Reactivity – EPA Methods 7.3.4.1/7.3.4.2 for waste characterization.
- Total Organic Carbon (TOC) – EPA Method 9060A for waste characterization except for Shirley Housing Area where TOC was not required for disposal.
- Petroleum Aromatic Hydrocarbons (PAHs)- EPA Method 3540C/8270C (for post-excavation confirmatory sampling at Shirley and waste characterization).
- Total Petroleum Hydrocarbons (TPH)- EPA Method 5030B/8015B – gasoline range organics (GRO) and EPA Method 3540C/8015B – diesel range organics (DRO).

6.1 ANALYTICAL METHODS

GPL, Alpha Analytical and Mitkem maintains certification with CENAE for the analytical parameters required for this project. This certification is valid through September 2002 for GPL, through November, 2003 for Alpha Analytical and through November 10, 2001 for Mitkem (due to the expiration of Mitkem's certification, it is unlikely the WESTON will be utilizing them in the future on this project). GPL Laboratories, Alpha Analytical, and Mitkem Corporation's U.S. Army Corps of Engineers (USACE) validation letters are included as Attachment 2.

Routine analytical services are performed using standard Environmental Protection Agency (EPA)-approved methodologies subject to USACE approval, where applicable. In some cases, modification of standard methods may be necessary to provide accurate and precise analysis of particularly complex matrices. When modifications to standard analytical methods are performed, the specific alterations, as well as the reason for the change, will be communicated to the WESTON Project Manager who will inform the CENAE Project Manager. The modifications will be reported with the results of the analysis.

The laboratory's reporting limits are based on program requirements and sample matrix. Individual sample reporting limits may vary from the laboratory's routine reporting limits due to dilution requirements, variability in sample weight or volume used to perform the analysis, dry weight adjustment for solid samples, the presence of analytical background contaminants, or other sample- or analysis-related conditions. The selected analytical methods and reporting limits are shown in Table 3-1A for GPL and Table 3-1B for Alpha Analytical. The anticipated QA/QC

samples are shown in Table 3-2. The sample containers, preservation methods, and maximum holding times are detailed in Table 5-1.

SECTION 7

CALIBRATION PROCEDURES AND FREQUENCY

7. CALIBRATION PROCEDURES AND FREQUENCY

This section outlines the calibration procedures and frequency for equipment used by the off-site laboratories for the performance of this project.

Before any instrument is used as a measurement device on samples, the instrumental response to known reference materials must be determined. The manner in which various instruments are calibrated is dependent on the particular type of instrument and its intended use. All sample measurements will be made within the calibrated range of the instrument. Preparation of all reference materials used for calibration will be documented in a bound notebook.

Instrument calibration typically consists of two types: initial calibration and continuing calibration. Initial calibration procedures establish the calibration range of the instrument and determine instrument response over that range. Typically, three to five analyte concentrations are used to establish instrument response over a concentration range. The instrument response over the range is generally absorbance, peak height, etc., which can be expressed as a linear model with a correlation coefficient (e.g., for atomic absorption and inductively coupled plasma) or as a response factor or amount versus response plot (e.g., for gas chromatography/mass spectrometry).

Continuing calibration usually includes measurement of the instrument response to fewer calibration standards and requires instrument response to compare with certain limits (e.g., ± 10%) of the initial measured instrument response. Continuing calibration may be used within an analytical sequence to verify stable calibration throughout the sequence and/or to demonstrate that instrument response did not drift during a period of non-use of the instrument.

Instrument calibration will be conducted in accordance with procedures outlined in EPA Methods 3050B/6010B/7470A/7471A, 8260B, 8270C, 8082, 8081A, 8015B modified, 9020, 9060A, 1010, and 9045A.

7.1 ANALYTICAL SUPPORT AREAS

7.1.1 Standard and Reagent Preparation

Standards are obtained from commercial vendors as neat materials, single or multi-analyte stock solutions, or ready-to-use solutions. Actual preparation requirements vary with each analytical method, and are detailed in the respective analytical SOPs. Sources may vary depending on availability of mixes and solutions from vendors. Each production unit is responsible to ensure, when available, that all standards are traceable to EPA, National Institute of Standards and Technology (NIST), American Association for Laboratory Accreditation (A2LA), Standard Analytical Reference Materials (SARMs), or other equivalent certified material sources, or that an alternate source standard is used to verify reference materials.

7.1.2 Balances

Laboratory balances will be calibrated and serviced annually by a factory representative. In addition, the analyst will check the balance with three weightings before each use: one in the gram range, one in the milligram range and a combined reading of both weights. A record of calibrations and daily checks will be kept in the balance log.

The Class S weights used by the analysts for daily balance checks are re-calibrated annually.

7.1.3 Refrigerators, Freezers, and Ovens

Oven and refrigerator thermometers are calibrated annually against a NIST-certified thermometer in the range of interest. Annual calibrations are recorded in a calibration notebook. Daily readings are recorded with the respective oven or refrigerator.

7.1.4 Water Supply System

The laboratory's on-tap laboratory pure water supply is tested daily for pH and specific conductivity. Additionally, samples of the water supply are routinely collected and analyzed for metals.

7.2 LABORATORY INSTRUMENTS

Specific instrument calibration procedures for instruments used in EPA Methods 3050B/6010B/7471A, 8260B, 8270C, 8081A, 8082, 8015B, 9060A, 9020, 1010, and 9045A, are detailed in Laboratory SOPs, respectively. Alpha Analytical and GPL's SOPs are provided in Attachment 1. Mitkem's SOPs will be provided upon request.

SECTION 8

INTERNAL QC CHECKS

8. INTERNAL QC CHECKS

The daily quality of analytical data generated at the off-site laboratory is controlled by the implementation of a laboratory-specific QA/QC Plan. The types of internal QC checks are described in the following subsections.

8.1 BATCH QC

Sample preparation or pre-treatment is commonly required before analysis. Typical preparation steps include homogenization, grinding, soxhlet extraction, acid digestion, distillation, and concentration. During these pre-treatment steps, samples are arranged in discrete manageable groups referred to as Preparation (Prep) Batches. Prep batches provide a means to control variability in sample treatment.

QC indicators are added to each prep batch to monitor method performance. These QC Prep Batch Indicators are as follows:

- Method Blanks: Method blanks usually consist of laboratory reagent-grade water treated in the same manner as the sample (e.g., digested, extracted, distilled, etc.), which is then analyzed and reported as a standard sample would be.
- Laboratory Control Sample (LCS) (Organics/Inorganics): This is a standard solution with a certified concentration which is analyzed as a sample and is used to monitor analytical accuracy. (Equivalent to a method blank spike.)

8.2 MATRIX SPECIFIC QC

Matrix QC indicators help monitor for potential physical and chemical effects which may interfere with the precision and/or accuracy of the selected analytical method. Since interferences can enhance or mask the presence of target analytes, matrix QC indicators measure the degree of interference and are used to assist in the interpretation of the analytical results. The laboratory avoids performing matrix QC on known field blank samples, such as trip blanks and rinsates, since these samples are not indicative of the sample matrix. Matrix QC indicators are analyzed when requested by the client or specified by the method. No Matrix Spike/Matrix Spike

Duplicate (MS/MSD) will be provided for the waste characterization samples or for on-site sample analysis.

The matrix specific QC indicators are as follows:

- Laboratory Duplicate Sample (Inorganics): Duplicate samples are obtained by splitting a field sample into two separate aliquots and performing two separate analyses on the aliquots. The analysis of laboratory duplicates monitors sample precision; however, it may be affected by sample non-homogeneity, particularly in the case of non-aqueous samples.

- Matrix Spike (Inorganics): A matrix spike is an aliquot of an investigative sample which is fortified (spiked) with the analytes of interest and analyzed with an associated sample batch to monitor the effects of the investigative sample matrix (matrix effects) on the analytical method.

- Matrix Spike (MS)/MS Duplicate (MSD) (Organics): MS/MSD samples are an aliquot of an investigative sample which is fortified (spiked) with the analytes of interest and analyzed with an associated sample batch to monitor the effects of the investigative sample matrix (matrix effects) on the analytical method. MS/MSDs are performed for organic analysis and only in association with selected protocols. MS/MSD precision should fall within the limits specified in Attachment 1.

- Surrogates: Surrogates are used in all gas chromatography (GC) and gas chromatography/mass spectrometry (GC/MS) analyses. Every blank, standard and environmental sample will be spiked with surrogate compounds prior to purging volatiles or extracting semi-volatiles, pesticides and PCBs.

8.3 ON-SITE LABORATORY QC

The on-site mobile laboratory, ESN North Atlantic, performing post-excavation confirmatory soil analysis for pesticides only has provided to WESTON a project specific SOP included as Attachment 3. A method detection limit study (MDL study) for the modified SW-846 8081A method that they will be utilizing will be provided as an addendum to this QAPP. Reporting limits and method detection limits will ensure that Massachusetts Contingency Plan (MCP) S-1/GW-1 regulatory limits for the project are met. It is anticipated that a three to five point calibration curve will be run. A method blank and laboratory control spike sample (explained above) will be run with each batch of 20 samples. A single surrogate 2, 4, 5,

6-tetrachloro-meta-xylene (TCMX) will be utilized. All QC criteria and limits are stated in ESN's SOP included in Attachment 3.

WESTON will provide the on-site laboratory with a pesticide soil performance evaluation (PE) sample to be analyzed each week along with the field samples. The PE results from the laboratory must be within the acceptable criteria range established by the manufacturer of the PE sample. One field duplicate per 10 samples will be analyzed (precision will be evaluated by the performance of the field duplicate results). No MS/MSD samples will be analyzed by the on-site laboratory (accuracy will be evaluated by the performance of LCS results, the PE results and the surrogate recovery).

Field samples will be collected in 8-ounce clear glass jars and delivered by WESTON to the on-site laboratory twice per day (approximately noon and 4pm). WESTON will be providing the on-site laboratory with chain of custody's (CoCs). The laboratory will analyze the samples within 24 hours and deliver to WESTON preliminary hardcopy results as well as an electronic data deliverable (EDD) to the WESTON's on-site data manager within 24 hours of sample receipt. Preliminary results must include sample results in dry weight, percent solids results, method blank results, LCS and surrogate recoveries with an asterisk identifying any QC exceedances and a case narrative explaining any problems encountered must be included within 24 hours. The on-site laboratory will provide a full Tier III level hardcopy data package and EDD to Erik Hall at the WESTON, Manchester, New Hampshire office within 21 business days of sample collection.

The on-site laboratory will be required to provide corrective action should the batch QC such as method blank analyses, LCS or surrogate recoveries, or calibration fail to meet QC limits. If a target compound exceeds the calibration range of the instrument and the regulatory limit, no further dilution or reanalysis is required. The laboratory will flag the result with an "E".

SECTION 9

CALCULATION OF DATA QUALITY INDICATORS

9. CALCULATION OF DATA QUALITY INDICATORS

The objective of this QAPP is to provide a framework to ensure that all analytical data reported are of known quality. This section outlines methods for calculation of the data quality indicators that will be used by WESTON and the laboratories for analytical data generated for this project.

To assure that the data generated are of a known and acceptable level of quality, this plan establishes or makes provisions for:

- Developing performance standards related to various elements of the sampling plan.
- Monitoring actual performance in comparison to and in compliance with the established standards.
- Reporting the monitored performance.
- Rectifying performance not conforming to the established standards.

All QA/QC assessments made during this effort will be performed using a matrix representative of the sample matrix and conditions being measured whenever possible. The data will be calculated and reported in units consistent with standard reporting conventions to enable comparability to existing data, standards, and/or regulatory action limits. Alpha Analytical and GPL's data quality objectives are included in Attachment 1. The on-site laboratory, ESN's QC limits are stated in the project specific SOP included in Attachment 3.

9.1 PRECISION

Precision is a measure of mutual agreement among individual measurements of the same property, usually under prescribed similar conditions. Precision is best expressed in terms of the standard deviation. Various measures of precision exist depending on the "prescribed similar conditions".

Analytical precision is calculated by expressing, as a percentage, the difference between results of analyses of duplicate samples for a given analyte. Precision can be expressed as a relative percent difference (RPD) by the formula:

$$RPD = \frac{|X_1 - X_2|}{(X_1 - X_2)/2} \times 100\%$$

where:

X_1 = Concentration of analyte in sample.

X_2 = Concentration of analyte in replicate.

The results of field duplicate samples analyses will be a means for assessing precision..

9.2 ACCURACY

Accuracy is a measure of the bias in a system or the degree of agreement of the measurement of a spiked sample with the quantity of the spike. Accuracy is usually expressed as a percent of the difference between the spiked sample (XS) and unspiked sample (XU) divided by the quantity of the spike (K) as shown by the formula:

$$\text{Accuracy} = \text{Percent Recovery} = \frac{X_S - X_U}{K} \times 100\%$$

where:

X_S = Measured value of the spiked sample

X_U = Measured value of the unspiked sample

K = Known amount of the spike in the sample

Results of MS/MSD and LCSs analyses will be used as a means for assessing analytical accuracy. Surrogate compounds will be used to assess accuracy for organic analyses.

9.3 COMPLETENESS

Completeness is a measure of the relative number of analytical data points that meet all the acceptance criteria for accuracy, precision, and any other criteria required by the specific analytical methods used. The level of completeness can also be affected by loss or breakage of samples during transport, as well as external problems that prohibit collection of the sample.

The ability to meet or exceed completeness objectives is dependent on the nature of samples submitted for analysis. For example, if the analytical methods proposed for use (particularly for organics analyses) are intended for analysis of environmental samples of low and medium hazard, the applicability of these methods to non-routine matrices such as drum samples, wipes, air samples, etc., may result in poor method performance and, therefore, adversely impact achievement of the data completeness goal.

Laboratory completeness should be 95%. Completeness (%C) will be calculated by WESTON using the following formula:

$$\%C = \frac{V}{N} \times 100\%$$

where:

V = Number of sample measurements considered valid

N = Number of valid measurements needed to achieve a specified statistical level of confidence

9.4 REPRESENTATIVENESS

Representative ness expresses the degree to which data accurately and precisely represent a characteristic of a population, parameter, variation at a sampling point, a process condition, or an environmental condition. WESTON will ensure representativeness by following SOPs for sample collection and analysis and will ensure homogeneity of the environmental samples. Sample containers for matrices to be collected will be filled in the following order: VOCs, organic parameters, and inorganic parameters.

9.5 COMPARABILITY

Comparability expresses the confidence with which one data set can be compared to another. The comparability of the data is influenced by sampling and analytical procedures. By providing specific protocols to be used for obtaining and analyzing samples, data sets should be comparable, regardless of who obtained the sample or performed the analysis; however, WESTON will designate one person to be responsible for sample collection and handling so that introduction of errors will be kept to a minimum. Analytical comparability will be ensured by using standardized analytical procedures.

At the start of the project 20% of post-excavation confirmatory pesticide soil samples analyzed on-site will be sent off-site for verification. WESTON will have a data manager on-site who will receive an electronic deliverable from the on-site laboratory. As the off-site results are also received electronically, they will be downloaded into the same database. The WESTON data manager on-site will calculate the relative percent difference (%RPD) between the on-site and off-site analyses for post-excavation confirmatory soil samples. These results and the %RPD will be recorded on an excel spreadsheet. Any % RPD exceedance above 75% will be flagged. The excel spreadsheet will be updated weekly and submitted electronically to CENAE on a weekly basis. (Note: the on-site laboratory's turnaround time (TAT) is 24 hours while the off-site laboratory turnaround time is 5 days; therefore, there may be a time delay in reporting criteria exceedances). After an exceptable comparibility is achieved between on-site and off-site laboratory results, the frequency of the off-site verification samples will be reduced to 10%.

QA samples will also be collected at a frequency of 10 % of all samples going off-site for verification analyses of the excavation confirmatory samples (once comparibility has been established between the on-site and the off-site laboratory, the frequency of QA samples will be scaled back to 5%). CENAE will provide WESTON with QA results as soon as they receive them. WESTON will maintain those results in their database but CENAE will review those results against primary sample results and using CENAE established criteria, will direct WESTON if criteria are not met. No QA samples will be collected for waste characterization and disposal purposes.

9.6 DETECTION LIMITS

9.6.1 Method Detection Limits

The method detection limit (MDL) is the lowest concentration that can be measured for a given analytical method and sample matrix with a 99% confidence that the analyte is present. The MDL is determined according to Appendix B of 40 CFR 136, "Guidelines Establishing Test Procedures for the Analysis of Pollutants". MDLs reflect a calculated (statistical) value determined under ideal laboratory conditions in a clean matrix, and may not be achievable in all environmental matrices. The laboratory maintains MDL studies for analyses performed; these are verified at least annually.

9.6.2 Instrument Detection Limits

Instrument Detection Limits (IDLs) are generated for each element by the metals laboratory quarterly for each instrument specified in contract laboratory protocol (CLP). These limits are used to gauge instrument sensitivity and when routinely evaluated, instrument performance without the introduction of method variance can be determined.

9.6.3 Reporting Limits

Reporting limits are defined as the lowest concentration of an analyte determined by a given method in a given matrix that the laboratory feels can be reported with an acceptable quantitative error or client requirements, values specified by the EPA methods, or other project and client requirements. Because of the high level of quantitative error associated with determinations at the level of the MDL, reporting levels are usually higher than the MDL. Wherever possible, reporting is limited to values approximately 3 to 5 times the respective MDL to ensure confidence in the reported value.

9.6.4 Practical Quantitation Limit

The Practical Quantitation Limits (PQL) is the minimum concentration of a substance that can be reported based upon the analysis of a project specific matrix. Practical quantitation limit is

equivalent to the low level calibration standard. Laboratory PQLs for analyses are listed in Table 3-1A and 3-1B. Table 3-1A lists the data quality objectives (DQOs) of GPL Laboratories. Alpha Analytical's DQOs are listed in Table 3-1B. Mitkem's data quality objectives are included in Attachment 1. ESN's DQOs and PQLs are included in their SOP provided in Attachment 3.

SECTION 10

CORRECTIVE ACTIONS

10. CORRECTIVE ACTIONS

10.1 FIELD CORRECTIVE ACTION

Field personnel have initial responsibility for monitoring the quality of field measurements and observations. The Construction Superintendent/Site QC Officer will notify QC Management of any problems that occur that may jeopardize the integrity of the project or cause any project objective to not be met. An appropriate corrective action will be developed and implemented. The site QC officer will document the problem, including the cause, the corrective action, and results in the field logbook. Copies of the logbook will be provided to the Project Manager, Superintendent, and QC Management.

10.2 LABORATORY CORRECTIVE ACTION

The analyst has initial responsibility to monitor the quality of an analytical system. The analyst will verify that all laboratory-specific QC procedures are followed and results of an analysis of QC samples are within acceptance criteria. This requires that the analyst assess the correctness of all of the following items as appropriate:

- Sample preparation procedure
- Initial calibration
- Calibration verification
- Method blank result
- Laboratory control standard
- Duplicate analysis
- Fortified sample result
- MS/MSD and surrogate recoveries

If the assessment reveals that any of the laboratory-specific QC acceptance criteria are not met, the analyst must immediately assess the analytical system to correct the problem. The analyst will notify the appropriate supervisor and laboratory QA coordinator of the problem and, if possible will identify potential causes and corrective action.

The nature of the corrective action obviously depends on the nature of the problem. For example, if continuing calibration verification is determined to be "out of control," the corrective action

may require recalibration of the analytical system and reanalysis of all samples since the last acceptable continuing calibration standard.

When the appropriate corrective action measures have been defined and the analytical system is determined to be "in control," the analyst documents the problem and the corrective action. Data generated concurrently with an "out-of-control" system will be evaluated for usability in light of the nature of the deficiency. If the deficiency does not impair the usability of the results, data will be reported and the deficiency noted in the case narrative. Where sample results are impaired, the laboratory QA coordinator will be notified and appropriate corrective action (e.g., reanalysis, etc.) will be taken. If reanalysis cannot be conducted, re-sampling may be required.

Additional detail on laboratory corrective actions is provided in Laboratory SOPs that are included in Attachment 1.

SECTION 11

DATA REDUCTION, VALIDATION, AND REPORTING

11. DATA REDUCTION, VALIDATION, AND REPORTING

Analytical data are recorded on pre-formatted bench sheets or analysis run logs in bound laboratory notebooks. These bound notebooks are issued and controlled by the laboratory's Quality Assurance Section. A unique document control code is assigned to each book to assure that chronological record keeping is maintained.

Analytical data are referenced to a unique sample identification number (RFW Sample #) for internal tracking and reporting. Notebook pages contain the following information, as applicable: analytical method, analyst, date, sequential page number, associated RFW sample numbers, standard concentrations, instrument settings, and raw data. Entries for instrument logs are in chronological order and maintained so as to enable reconstruction of the analytical sequence.

The laboratory analyst is responsible for recording all appropriate information into analytical logs, and for signing and dating all analytical book entries daily. A supervisor or trained data reviewer reviews the notebook pages. Copies of instrument outputs (chromatograms, strip charts, etc.) are maintained on file with the analyst's signature/initials and date.

11.1 DATA REDUCTION

Data reduction is performed by the analyst and consists of calculating concentrations in samples from the raw data. The complexity of the data reduction depends on the analytical method and the number of discrete operations involved (e.g., extractions, dilutions, instrument readings and concentrations). The analyst calculates the final results from the raw data or uses appropriate computer programs to assist in the calculation of final reportable values. Copies of all raw data and the calculations used to generate the final results, such as bound laboratory notebooks, strip-charts, chromatograms, EXCEL spreadsheets and LIMS record files, are retained on file for a minimum of six years.

Calculations and data reduction steps for various methods are summarized in the laboratory SOPs or program requirements.

11.2 DATA REVIEW

11.2.1 Off-site Laboratory

System reviews are performed at all levels. The individual analyst continually reviews the quality of data through calibration checks, quality control sample results, and performance evaluation samples. Data review is initiated by the analyst during, immediately following, and after the completed analysis. The analyst uses a data review checklist to verify that all analytical criteria have been met. This checklist provides a list of items to verify that all analytical specifications have been achieved. Any out-of-control items are documented on the checklist and verbally communicated to the Unit Leader or Section Manager for review and response.

The supervisor, analyst, or data specialist performs a secondary review of the data. The peer reviewer is instructed by the QA Section, Section Manager, or Unit Leader to perform the data review. After these first two reviews are completed, the data is entered into the LIMS.

The Section Manager or designee reviews the data for precision and accuracy to assure that it meets all specifications. After approval by the Section Manager or designee, the analytical report is assembled. The Section Manager or the Laboratory Project Manager designee reviews the data to ensure consistency with laboratory QC requirements, to verify reasonableness with other generated data, and to determine if program requirements have been satisfied. Selected hard copy output of data (chromatograms, spectra, etc.) will be reviewed to ensure that results are interpreted correctly. The final report is signed by the Section Manager, Project Manager and Laboratory Manager.

Unusual or unexpected results will be reviewed and a resolution of the problem will be documented in a Corrective Action Report (CAR). If suspect data is reported, the out-of-control events will be addressed in a case narrative. Copies of the CARs may be included in a data package as needed.

Prior to final review/sign off by the Laboratory Manager or designee, the Report Generation Section will verify that the report is compiled in the proper format. The Laboratory Manager or designee provide the final laboratory review prior to reporting the results to the client. The

Laboratory Project Manager will do a final completeness check before submitting the data report to the client.

The Quality Assurance Section independently conducts a review of selected reports to determine if laboratory and client quality assurance/quality control requirements have been met. Discrepancies will be reported to the appropriate Section Manager and/or Laboratory Project Manager for resolution.

Data audits are also performed by regulatory agencies or client representatives. The frequency, level of detail, and the areas of concern during these reviews are dependent on the specific program requirements.

11.2.2 On-site Laboratory

Details of data review by the on-site laboratory, ESN, are provided in their SOP included in Attachment 3.

11.3 DATA VALIDATION

The on-site laboratory, ESN, will provide hardcopy internally reviewed data results to WESTON's on-site data manager. The on-site data manager will review results to ensure QC limits have been met. All field decisions will be made based on the on-site laboratory's preliminary results. PE results and field duplicate results will be reviewed by WESTON's on-site data manager to ensure QC criteria has been met. No formal data validation will take place. However, should any PE samples or field duplicate results fall outside QC acceptable criteria range, the on-site data manager will notify WESTON's chemist for further data review. The on-site laboratory will provide an EDD to WESTON's on-site database within 48 hours of sample receipt. WESTON will track and report weekly all sample results to CENAE.

WESTON will perform a modified Tier II level data validation of the post-excavation confirmation verification pesticide samples within 21 days of receipt of the final data packages and EDD from the off-site laboratory. The validation procedures to be employed will consist of the following activities:

- Review of chain-of-custody documents to verify sample identities; if a discrepancy is found, the sampler and/or laboratory will be contacted to resolve; details will be recorded in a telephone log; laboratory resubmittals will be requested if necessary;
- Review of sample log-in documents to verify any potential problems with custody seals, container integrity, sample preservation, labeling, etc. (see bullet above for corrective action);
- Review of trip blank data, if any, to identify any potential problems with sample container contamination, preservative contamination, laboratory reagent water contamination, or cross-contamination between samples during transport;
- Review of method blank data to determine the presence of any sources of contamination in the analytical process; The 5x action level will be applied for target compounds detected in method blank as stated in the Region I EPA Functional Guidelines for Data Validation (equipment blanks will not be used to qualify soil samples);
- Review the matrix spike (MS) data to evaluate the potential for matrix effects and as a measure of analytical accuracy. MS recoveries will be compared against laboratory acceptance criteria to determine if they are within or outside of warning and control limits for percent recoveries;
- Review of matrix spike/matrix spike duplicate (MS/MSD) data to evaluate sample homogeneity and as a measure of analytical precision. MS/MSD data will be compared to laboratory acceptance criteria for the maximum relative percent difference (RPD) $\leq$ 20%.
- If a sample has less than 30% solids but greater than 10%, all data will be estimated; if less than 10%, non-detected results will be rejected (R);
- Review of on-site laboratory versus off-site laboratory pesticide results for excavation confirmation samples (RPD must be less than or equal to 75%);
- Review of laboratory control sample (LCS) data (if available) as a measure of analytical accuracy. LCS data will be compared to the certified acceptable ranges of analytical values;
- Review of sample and sample duplicate data (if available) as a measure of sample homogeneity and as a measure of analytical precision.

- Review of surrogate recovery data to assess extraction efficiency, effectiveness of sample introduction, and possible loss during cleanup activities. Surrogate recoveries will be compared to laboratory acceptance criteria to determine if they are within or outside of acceptable limits.

- Review of sample dates, extraction/digestion dates, and analysis dates to determine if maximum holding times were met or exceeded; holding times are validated according to EPA Region I CLP Data Validation Functional Guidelines.

- Review of field duplicate: %RPD for soils must be less than or equal to 50%, %RPD for waters must be less than or equal to 30%.

- Review of QA sample results provided by CENAE. CENAE will provide WESTON with QA sample results as soon as they are received. These results will be entered into WESTON's on-site databases. However, CENAE will evaluate compariblity between QA samples and field samples based on CENAE criteria and provide WESTON with a report.

All post-excavation confirmation verification pesticide samples will be reviewed in accordance with the EPA Region 1 Data Validation Functional Guidelines, December 1996. If DQOs listed in Attachment 1 are not met, sample results will be qualified. Qualifiers will be added to the EDD file and will be explained in footnotes defined at the bottom of the table. Data for waste characterization and disposal samples will not be reviewed.

11.4 DATA REPORTING

Analytical reports comprise final results based on dry weight (uncorrected for blanks and recoveries unless specified), methods of extraction, methods of analysis, levels of reporting, surrogate recovery data, and method blank data. In addition, special analytical problems will be noted in the case narratives. The number of significant figures reported are consistent with the limits of uncertainty inherent in the analytical method. Consequently, most analytical results will be reported to no more than two (2) or three (3) significant figures. Data are normally reported in units commonly used for the analyses performed.

Concentrations in liquids are expressed in terms of weight per unit volume [e.g., micrograms per liter, (ug/L)]. Concentrations in solid or semi-solid matrices are expressed in terms of weight per unit weight of sample (e.g., ug/kg). Reporting limits take into account all appropriate

concentration, dilution, and/or extraction factors, unless otherwise specified by program requirements.

A client report is generated with various steps of approval prior to printing of the final version. If any analytical anomalies were encountered during the analyses, (e.g., an out-of-control matrix duplicate), it is documented in a case narrative. The case narrative is prepared by the respective operating unit and submitted to the Data Management Section to insert in the final report.

The final report forms are printed, data packages are organized, a glossary of flags and acronyms is added, and reports are paginated. The Laboratory Project Manager and/or the Laboratory Manager or designee will review and sign the report prior to delivery.

11.4.1 Reporting Format

The final data reports provided by the off-site laboratory are standard client reports and EDDs. These reports will be submitted with the final project report.

The standard client report contains a transmittal letter and the following:

- Case Narrative describing: data qualifiers, sample collection, sample preparation (e.g., extraction or digestion) and analysis dates, and a description of any technical problems encountered with the analysis.
- Sample data summaries to include appropriate QC result summaries.
- Five-peak library search report for GC/MS volatiles and semi-volatiles.
- Off-site laboratory will provide a EDD along with a level III type data package, which includes a GC chromatogram, within 15 business days of sample collection.

The on-site laboratory, ESN, has provided an example of its hardcopy report and EDD excel spreadsheet format (Appendix A) as part of its SOP provided in Attachment 3.

11.5 LABORATORY TURNAROUND TIME

The turnaround time (TAT) for preliminary raw data (hardcopy and electronic excel spreadsheet) for the on-site excavation confirmation samples will be 24 hours. The on-site laboratory will provide a full Tier III data package within 21 days of sample collection.

A 5-day TAT will be used for all off-site laboratory analytical data (electronic and Tier II hardcopy and an abbreviated EDD file). Because of the short duration of the project, a quick TAT will ensure that results are obtained prior to disposal from the site. A complete Tier III hardcopy of the off-site laboratory results and EDD will be provided within 15 days of sample collection.

SECTION 12

PREVENTATIVE MAINTENANCE

12. PREVENTATIVE MAINTENANCE

The ability to generate valid analytical data requires that all analytical instrumentation be properly and regularly maintained. The responsibility of routine care lies with the analysts using the instruments. Guidance on required routine maintenance, as well as troubleshooting information, is provided in the respective instrument manuals and laboratory SOPs. For more extensive preventative maintenance or emergency repair service, the laboratory maintains full service contracts on all major instruments or has accounts established with vendors. The elements of the maintenance program are discussed in Laboratory SOPs provided in Attachment 1. The on-site laboratory (ESN) SOP is provided in Attachment 3.

SECTION 13

PERFORMANCE AND SYSTEM AUDITS

13. PERFORMANCE AND SYSTEM AUDITS

Quality assurance audits and surveillances are conducted to assess the performance of laboratory systems in meeting technical, regulatory and client requirements. They provide a means for management to be apprised of, and to respond to, a potential problem before it actually impacts on laboratory operations. They also are a mechanism for ensuring closure of corrective actions resulting from external audits.

Performance audits test the laboratory's ability to assay an unknown sample correctly. They may be single blind or double blind. In a single blind study, the analyst is not provided with the acceptable result for the unknown sample until after the experimental result is reported; however, it is known that the sample is a performance test. In a double blind performance test, the analyst not only has no knowledge of the acceptable result, but the sample is disguised in such a manner as to maintain anonymity as a performance test sample. In some double-blind studies, even laboratory management is unaware that performance test samples are not actual samples.

Systems audits and surveillances are used to evaluate the operational details of the QA program. An audit is a systematic assessment of an area of laboratory operation. It may comprise evaluation of an operational unit, (e.g., Gas Chromatograph/Mass Spectrum (GC/MS) Analysis or Data Reporting), or it may have a more narrow focus, such as an assessment of adherence to chain-of-custody procedures. Audits are conducted by persons other than those who performed or directly supervised the work being inspected. A surveillance consists of inspection or monitoring of a specific targeted area for compliance with requirements, such as an evaluation of a single analytical method to ensure conformance with the written SOPs.

The on-site laboratory will be analyzing PE samples once per week for the first month and then once per month for successive months. Laboratory results of these PE samples must fall within the manufacturer's acceptance criteria.

13.1 EXTERNAL AUDITS

Performance audits, as well as on-site systems audits, by non-WESTON personnel and clients are an on-going, continual occurrence. Whether the audit is scheduled or unannounced, full cooperation with the audit team will be provided by the laboratory staff. A full response to any deficiencies cited as a result of a performance audit or on-site visit will be addressed within the schedule determined by the client. The QA Manager is responsible for coordinating all external audits and any resultant corrective actions.

On-site evaluation by agencies, clients, or designated third-party auditors (both government and non-government) are routinely conducted to assure program compliance. These audits are preferentially pre-scheduled with the client to ensure that appropriate personnel are available to answer questions. However, audits may also be unannounced. In either instance, full cooperation with audit team the laboratory staff during the on-site visit will be provided.

Program compliance may be defined as adherence to requirements for a specific certification or licensing program, e.g., state certifications, or adherence to specific project requirements.

13.2 PERFORMANCE/SYSTEM/DATA AUDITS AND SURVEILLENCES

Internal performance audits conducted at the bench level provide the analyst with a tool to evaluate the acceptability of a specific data set. This is accomplished through analysis of laboratory control samples or spiked blanks of known concentration to the analyst, which must meet minimum performance standards. When these QC checks are performed in duplicate, method accuracy and precision information can be generated to demonstrate the proper functioning of the total measurement system.

Procedures for system, performance, and data audits are included in the Laboratory SOPs.

SECTION 14

QC REPORTS TO MANAGEMENT

14. QC REPORTS TO MANAGEMENT

Quality assurance reports communicate quality status and needs to upper management. By providing summaries of quality data and analysis of relevant situations, these reports provide management a feedback loop to monitor the effectiveness of laboratory improvement activities. Quality assurance reports distinguish between major and minor issues, while minimizing false alarms. The reports emphasize objective quality measurements, but when subjective elements are reviewed, these are reported without blame.

APPENDIX G

SAMPLING AND ANALYSIS PLAN

FINAL
FIELD SAMPLING PLAN

RELEASE ABATEMENT MEASURES at the proposed SHIRLEY MIDDLE SCHOOL, and GRANT, LOCUST, AND CAVITE HOUSING AREAS and PESTICIDE SOIL REMEDIATION at the CHLORDANE CELL DEVENS, MASSACHUSETTS

Contract No. DACW33-00-D-0007
Task Order No. 0005
DCN: DVN2-021502-AAEI

Prepared for:

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February 2002

W.O. No. 20140.007.005

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LIST OF ACRONYMS

ACM	asbestos containing materials
ALPHA	Alpha Analytical Laboratories
ARARS	Applicable or Relevant and Appropriate Requirements
ARMY	United States Army
bgs	below ground surface
BRAC	Base Realignment And Closure Act
CENAE	U.S. Army Corps of Engineers
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
COC	Contaminants of Concern
CoC	Chain of Custodies
CQC	Construction Quality Control
DCQCRS	Daily Chemical Quality Control Reports
DDD	1,1 –Bis (4-Chlorophenyl)-2,2 Dichlorethane
DDE	1,1-dichloro-2,2-bis (4-chlorophenyl)ethane
DDT	Dichlorodiphenyltrichloroethane
DQOs	Data Quality Objectives
ESN	Environmental Services Network
EPA	U.S. Environmental Protection Agency
FEDEX	Federal Express
FSP	Field Sampling Plan
GPL	GPL Laboratories, LLLP
IDWs	investigation-derived wastes
LCS	laboratory control spike
MCP	Massachusetts Contingency Plan
MDEP	Massachusetts Department of Environmental Protection Agency
MDFA	Massachusetts Development and Finance Authority
MDL	method detection limits
MS/MSDs	matrix spike/matrix spike duplicates
NPL	National Priority List
NWD	U.S. Army Corps of Engineers Northwest Division
OCP	organochlorine pesticide
OSHA	Occupational Safety and Health Administration
PAH	polynuclear aromatic hydrocarbon
PCBs	Polychlorinated Biphenyls
PE	evaluation sample

LIST OF ACRONYMS
(continued)

PLM	Polarized Light Microscopy
PPE	Personal protective equipment
QA	Quality Assurance
QAPP	Quality Assurance Project Plan
QC	Quality Control
RAM	Release Abatement Measure
RAO	Response Action Outcome
RFTA	Reserve Forces Training Area
SAP	Sampling and Analysis Plan
SARA	Superfund Amendments and Reauthorization Act
SOPs	Standard Operating Procedures
SOW	Scope of Work
SSHASP	Site Specific Health and Safety Plan
SSHO	Site Safety and Health Officer
STL	Severn Trent Laboratory
SVOC	semi-volatile organic compounds
TAT	Turn around time
TB	Technical bulletin
TCLP	Toxicity Characteristic Leaching Procedure
TOC	Total Organic Carbon
TPH	Total Petroleum Hydrocarbons
TWP	Task Work Plans
UCL	Upper Concentration Limits
USACE	U.S. Army Corps of Engineers
VOC	Volatile Organic Compounds
WESTON	Roy F. Weston, Inc.

SECTION 1

PROJECT DESCRIPTION

1. PROJECT DESCRIPTION

Roy F. Weston, Inc. (WESTON®), under contract to the U.S. Army Corps of Engineers, New England District (CENAE), will perform remedial activities at three work areas within former Fort Devens in Devens, Massachusetts.

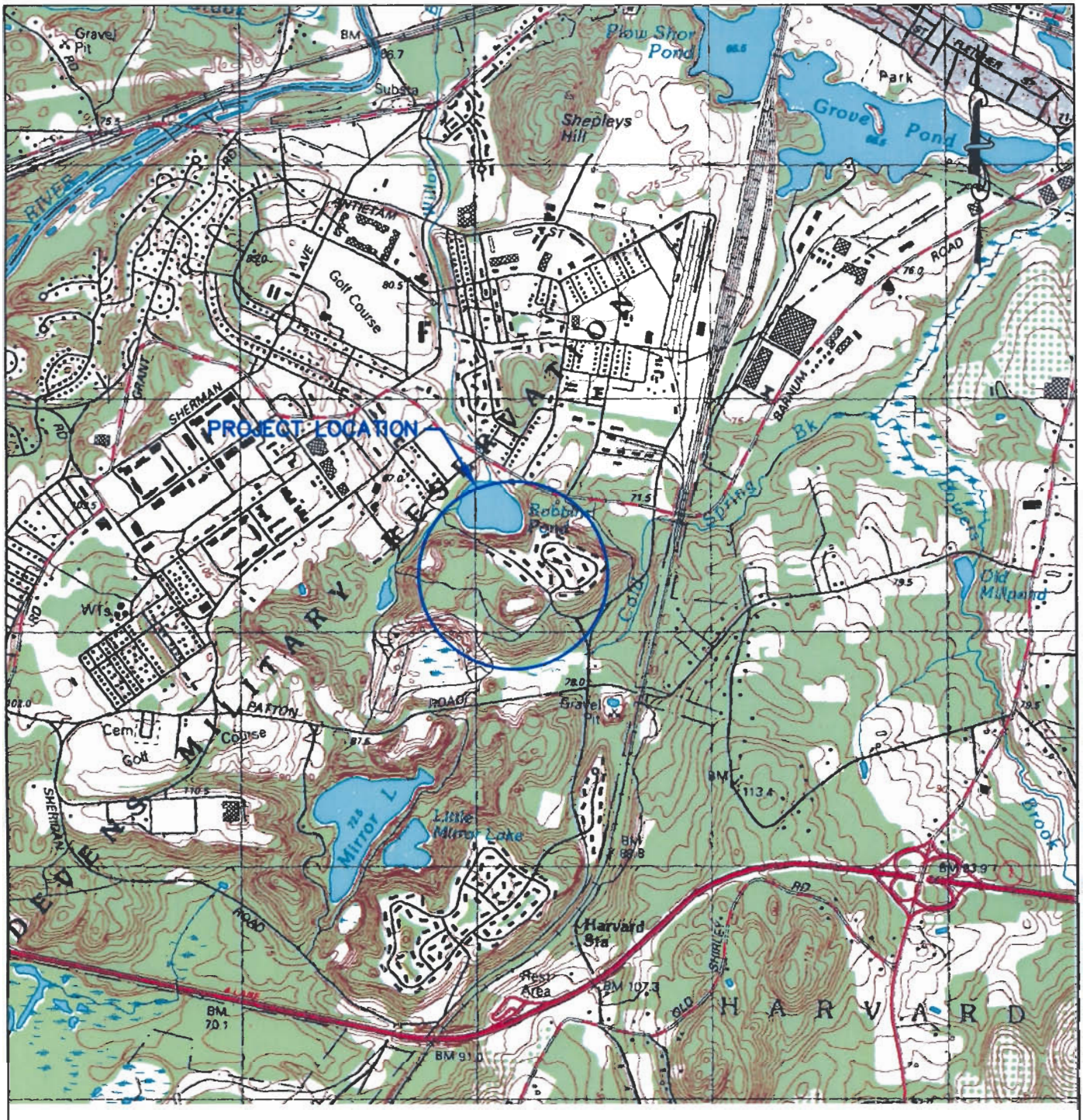
1.1 SITE HISTORY AND BACKGROUND

The former Fort Devens is located in the Commonwealth of Massachusetts, approximately 35 miles northwest of the city of Boston. Located in the towns of Ayer and Shirley (Middlesex County) and Harvard and Lancaster (Worcester County), it occupies approximately 9,400 acres of land (Figure 1-1).

The United States Army, hereafter referred to as Army, formed Fort Devens in 1917 as a temporary training area during World War I. In 1931 Fort Devens became a permanent installation with the primary mission to command, train, and provide logistical support for non-divisional troop units. The installation also supported the Army Readiness Region and National Guard units in the New England area. In 1991 the base was targeted for realignment and closure as a result of the Base Realignment And Closure Act (BRAC) and the installation was officially closed in September 1996.

Massachusetts Development and Finance Authority (MDFA) is the new owner of part of the transferred property and have plans to reuse or redevelop portions of the former base for future recreational, residential, and commercial uses.

Through an agreement between MDFA and the Army, the Army will perform remedial activities at several locations within the former Fort Devens. The Army has agreed to perform; a Pesticide Remedial Action at the former Grant, Locust and Cavite Housing Areas, a removal of asbestos, polynuclear aromatic hydrocarbons (PAHs), and/or metals impacted soils at the Shirley Housing Area, and a chlordane soil removal from the Chlordane Cell located in the former Cavite Housing Area. Further discussion on project objectives are presented in Subsection 3.1.



SOURCE
US DEPT. OF THE INTERIOR, GEOLOGICAL SURVEY
7.5 x 15 MINUTE SERIES (TOPOGRAPHIC) 1:25,000
AYER, MASSACHUSETTS, 1988

GRAPHIC SCALE
2000 1000 0 1000 2000
APPROXIMATE SCALE IN FEET

BUILDING 417 AND 422
PESTICIDE SOIL REMEDIAL ACTION
DEVENS, MASSACHUSETTS

DEPARTMENT OF THE ARMY
OMAHA DISTRICT
CORPS OF ENGINEERS
OFFUTT AFB, NEBRASKA

SITE LOCATION MAP

WESTON
MANAGERS DESIGNERS/CONSULTANTS
MANCHESTER NEW HAMPSHIRE

DRAWN	BEG
DATE	JUL 2001
FIGURE NO.	1-1

M:\Design\DWG\ACOE\FTDEVENS\PEST_SOIL\FIG1-1.DWG, Layout1, 01/09/2002 10:13:05 AM, GIRARDEB, 1:1

1.2 EXISTING SITE INFORMATION

On 21 December 1989, Fort Devens was placed on the National Priority List (NPL), in accordance with the Comprehensive Environmental Recovery, Compensation, and Liability Act (CERCLA) as amended by the Superfund Amendments and Reauthorization Act (SARA).

In 1990, Fort Devens was identified for cessation of operations and closure under Public Law 101-510, the Defense Base Realignment and Closure Act, and was officially closed in September 1996. The Army, for reserve forces training, retained sections of the former Fort Devens property renaming it the Devens Reserve Forces Training Area (RFTA). Areas not retained as part of the Devens RFTA were, or are in the process of being, transferred to MDFA for reuse and redevelopment.

In July of 2000, Haley and Aldrich, at the direction of MDFA, developed a *General Excavated Soil Management Plan* for contaminated soil excavated from the former Fort Devens Army installation in accordance with Massachusetts Department of Environmental Protection Agency (MDEP) Administrative Consent Order # ACO-CE-96-300. As part of this report (Appendix titled *Procedures for Management of Pesticide-Contaminated Soil*), risk-based standards were developed for on-site reuse of soils containing pesticide Contaminants of Concern (COCs). This analysis was based on existing site data and a number of potential soil reuse and exposure scenarios using the Massachusetts Contingency Plan (MCP) Method 3 risk assessment approach. The pesticide COCs evaluated included Aldrin, Alpha-chlordane, Gamma-chlordane, Chlordane (total), Dieldrin, 1,1 –Bis (4-Chlorophenyl)-2,2 Dichlorethane (DDD), 1,1-dichloro-2,2-bis (4-chlorophenyl)ethane (DDE), Dichlorodiphenyltrichloroethane (DDT), and Heptachlor.

In a letter dated 11 October 2000, MDEP approved the beneficial reuse of Devens pesticide-contaminated soils at Massachusetts Landfills, provided that such reuse was in compliance with MDEP Policy COMM-97-001 *Reuse and Disposal of Contaminated Soil at Massachusetts Landfills.*

Table 1-1 of the Release Abatement Measure (RAM) Plan lists the primary Applicable or Relevant and Appropriate Requirements (ARARS) for the actions to be performed for the project. WESTON shall follow all required federal, state and local regulations. Regulations to be followed are cited throughout this Sampling Analysis Plan (SAP) Addendum, the RAM Plan and the Site-Specific Health and Safety Plan (SSHASP) Addendum.

In accordance with the August 13, 2001 CENAE Scope of Work (SOW), the Army has agreed to remove the concrete slabs and frost walls and contaminated soil from beneath 149 buildings located in the Grant, Locust, and Cavite Housing Areas, and will manage the excavated soil in accordance with COMM-97-001 (for off-site disposal or reuse for Grant, Locust and Cavite). In addition, the Army agree to remove chlordane contaminated soils temporarily stockpiled in a cell within the Cavite Housing Area (CENAE SOW, August 8, 2001) and to remediate soils impacted by the release of asbestos, PAH and metals from the demolition of a former Army Hospital formerly located in the Shirley Housing Area (CENAE SOW, September 5, 2001).

1.3 CONTAMINANTS OF CONCERN (COCs)

Specific constituents were selected as constituents of concern based on historical background information and existing soils analysis data. Constituents were selected as COCs by work area as follows:

Chlordane Cell

- Chlordane

Shirley Housing Area

- PAHs
- Cadmium
- Lead
- Asbestos

Pesticide Remedial Action – Grant, Locust and Cavite Housing Areas

- Aldrin
- Dieldrin

- Heptachlor
- Chlordane
- Asbestos

1.4 PROJECT CLEANUP CRITERIA

Project cleanup criteria will comply with the MCP Method 1 S-1/GW-1 or S-3/GW-1 Standards (310 CMR 40.0000). Confirmatory soil sample laboratory analytical results will be compared to the Method 1 S-1/GW-1 or S-3/GW-1 Standards provided in Tables 2 and 4 of the MCP ((310 CMR 40.0975(6)(a) and (c)) to assess whether a release has occurred at a given location within an excavation and may require additional sampling and/or soil excavation.

Method 1 S-1/GW-1 standards shall be applied to all the buildings in the Grant Housing Area, the excavation scheduled for the Shirley Housing Areas, Buildings #137, 138, 146 and 147 in the Cavite Housing Area and the Chlordane Removal Action (Chlordane Cell). The Method 1 S-3/GW-1 standards shall apply to the Buildings #144 and 145 in the Cavite Housing Area and all the buildings Locust Housing Areas.

Project cleanup criteria for asbestos remedial activities has been set to a "non-detectable level" as specified by the MDEP Bureau of Solid Waste.

1.5 ANALYTICAL RESULTS EVALUATION

On-site analytical results will be compared to the project cleanup criteria on an excavation-by-excavation basis using the following steps.

Step 1. Exceedance Evaluation: Determine if any sample(s) within an excavation has a constituent that exceeds a Method 1 S-1/GW-1 or S-3/GW-1 criteria, whichever applies. If an exceedance is detected then continue to Step 2. If no exceedances are present then the remedial activities are completed for that excavation.

Step 2. MCP Method 1 Exposure Point Evaluation (i.e. the "75/10 Rule"- 310 CMR 40.0926(3)(b)). No exceedance exist if all of the following criteria are met:

a. The average of the individual analytical constituents of all sample points is below the applicable Method 1 standard.

b. No single constituent can be more than 10X the applicable Method 1 standard.

c. At least 75 % of the results for individual analytical constituents must be below the applicable Method 1 standard.

If either Step 1 or 2 determine a "no exceedance" then additional remedial action is not required.

Analytical evaluations will be based on the on-site laboratory results for the Pesticide Remedial Action – Grant, Locust and Cavite Housing Areas. Evaluation for the Chlordane Soil Removal and Removal Action - Shirley Housing Area will be based on off-site laboratory results.

Asbestos sample results will be evaluated against the project cleanup criteria of "**non-detectable**" using Polarized Light and/or Transmission Light Microscopy analysis.

Further assessment, investigation, and/or remediation will be performed to address any location that exceeds project cleanup criteria.

SECTION 2

PROJECT ORGANIZATION AND RESPONSIBILITIES

2. PROJECT ORGANIZATION AND RESPONSIBILITIES

2.1 PROJECT PERSONNEL

WESTON will provide a staff of experienced administrative and technical professionals to serve as the key personnel for this project. These personnel were selected for their management and technical abilities.

Individual responsible for implementing the quality assurance (QA) aspects of the Field Sampling Plan (FSP) are identified in Figure 2-1 of the Draft RAM Plan for the Pesticide Soil Remedial Action – Grant, Locust & Cavite Housing Devens (WESTON, February 2002). The responsibilities of these individual are discussed in Subsection 2.2 of the RAM Plan.

2.2 LABORATORY RESPONSIBILITIES

2.2.1 On-site Analytical Laboratory

The on-site analytical laboratory will be used to perform confirmatory sample organochlorine pesticide (OCP) analysis during the Pesticide Remedial Action. ESN North Atlantic (ESN) will perform on-site OCP analysis using a mobile laboratory. ESN's Standard Operating Procedures (SOPs) for the analysis anticipated to be performed as part of this SOW is provided in Attachment 3 of the Quality Assurance Project Plan (QAPP). U.S. Army Corps of Engineers Northwest Division (NWD) analytical laboratory certification is not required for the on-site laboratory. The points of contact for ESN North Atlantic are:

Environmental Services Network (ESN) North Atlantic
PO Box 6752
Scarborough, Maine
Contacts: Robert Burger, David B. Dionne
Phone: (207)-883-0860 or (800)-880-0533;
Fax: 207-883-1912

2.2.2 Off-site Analytical Laboratory

Three off-site laboratories, GPL Laboratories (GPL), MITKEM Corporation, and Alpha Analytical Laboratories (ALPHA) will provide fixed laboratory analytical services. All three laboratories are NWD certified analytical laboratory. The points of contact are:

Marty Sadoughi, Project Manager
GPL Laboratories, LLLP
202 Perry Parkway
Gaithersburg, MD 20877
Phone: (301) 926-6802
Fax: (301) 840-1209

Glen Breland
Alpha Analytical
Eight Walkup Drive
Westborough, MA 01581
Phone: (508) 898-9220
Fax: (508) 898-9193

Ben Dodge
MITKEM
175 Metro Center Boulevard
Warwick, RI
Phone: 401-732-3400
Fax: 401-732-3499

SOPs for all analyses anticipated to be performed as part of this SOW for GPL and ALPHA are provided in Attachment 1 of the QAPP. Since it is unlikely at this time that MITKEM will be utilized further on this project, MITKEM's SOPs are not included in Attachment 1, but can be provided upon request. MITKEM's method detection limits (MDLs) for all analyses are included in Attachment 1.

Off-site laboratory Quality Control (QC) procedures will be performed in accordance with the analytical laboratory's CENAE-approved QAPP.

Roles and responsibilities of laboratory personnel are outlined below:

2.2.2.1 Laboratory Director

The Laboratory Director is responsible for ensuring that all analytical tasks for this project are conducted according to the requirements of the SAP.

2.2.2.2 Laboratory Project Manager

The Laboratory Project Manager is responsible for scheduling project analytical requirements, monitoring analytical status/deadlines, approving laboratory reports, and coordinating data revisions/corrections and resubmitting packages to project staff. The Laboratory Project Manager will prepare/review analytical work and ensure that laboratory personnel understand and conform to the elements of the SAP that are related to their activities.

2.2.2.3 Laboratory QA Manager

The Laboratory Quality Assurance (QA) Manager will ensure conformance with authorized policies, procedures, and sound practices, and will recommend improvements as necessary. The Laboratory QA Manager will inform the Laboratory Project Manager of nonconformance to the SAP. In addition, the Laboratory QA Manager may approve laboratory data before reporting or transferring data to permanent storage and be responsible for maintaining supporting information and other performance indicators to demonstrate that the systems that produced the data were in control. The Laboratory QA Manager will also review results of internal QA audits and recommend corrective actions and schedules for their implementation.

2.2.2.4 Laboratory Chemists/Technicians

An effective laboratory QA program depends on the performance of all laboratory staff performing analyses. The responsibilities of laboratory chemists and technicians include:

- Performing initial review of QC data for acceptability.
- Recording data in bound laboratory notebooks.
- Informing direct supervisors of any problems with instruments or methods to ensure that prompt and effective corrective action is taken.

2.2.3 QA Laboratory

In accordance with CENAE direction, QA samples will only be collected as part of the excavation/confirmation effort. QA samples will not be collected for the soil waste

characterization, backfill confirmation, or asbestos confirmation phases of this work effort. QA samples will be collected as part of the excavation/confirmation phase and analyzed for pesticides, PAHs, and/or metals, as needed. The QA laboratory for this project is:

Severn Trent Laboratory (STL)
208 South Park Drive, Suite 1
Colchester, VT
Phone: (802) 655-1203
Fax: (802) 655-1248

The STL point of contact for this project is Ron Pentkowski.

The QA Number for the Grant, Locust, and Cavite Housing Area and the Chlordane Cell project is E0878 and the CENAE QA chemist is Mark Koenig. The QA Number for the Shirley Housing Area project is E0896 and the CENAE QA chemist is David Lubianez. This project-specific reference number will be included on all sample Chain of Custodies (CoC) documents and other submittals to the QA laboratory.

A copy of the QA Chain of Custody (CoC) form will be faxed to Mark Koenig or Dave Lubianez at CENAE within 24 hours of the shipment of samples to the QA Laboratory.

US Army Corps of Engineers, New England District, CENAE-EP-HC
696 Virginia Road
Concord, MA 01742-2751
Phone: (978) 318-8312 (M. Koenig): (978) 318-8311 (D. Lubianez)
Fax: (978) 318-8663

Questions regarding sample collection, shipment, analysis, and evaluation may be directed to Diane Quigley (WESTON) at (603) 656-5400, to Mr. Koenig or D. Lubianez at the numbers provided above, or to Marie Wojtas (CENAE) at (978) 318-8175.

SECTION 3

SCOPE AND OBJECTIVES

3. SCOPE AND OBJECTIVES

3.1 PROJECT PURPOSE

The purpose of these projects is to prepare the work areas for eventual reuse or redevelopment into residential, commercial or industrial properties. The work in each area will consist of the following:

Chlordane Cell

- Removal of cap material from the cell area.
- Excavate, load and transport chlordane contaminated soil and dispose of at the Devens Consolidated Landfill.
- Collect post-excavation confirmation soil samples to assess the effectiveness of the remedial effort in comparison to the project cleanup criteria MCP Method 1 S-1/GW-1 Standards).
- Following confirmation of cleanup criteria, backfill and regrade the excavation.

Shirley Housing Area

- Conduct pre-excavation waste characterization soil sample collection and off-site laboratory analysis.
- Complete soil waste profiles and submit to the off-site disposal facility for approval.
- Excavate soils from the former Building Debris Area and former Hospital Area to remove PAH, lead, cadmium and/or asbestos contamination.
- Collect post-excavation confirmation soil samples to assess the effectiveness of the remedial effort in comparison to the project cleanup criteria (MCP (MCP) Method 1 S-1/GW-1 Standards for PAHs, lead and cadmium and "non-detect" for asbestos).
- Backfill the excavations following confirmation that the remaining soil meets the project cleanup criteria.

Pesticide Remedial Action – Grant, Locust and Cavite Housing Areas

- Conduct preliminary asbestos containing materials (ACM) assessment and testing.

- Conduct pre-excavation waste characterization soil sample collection and off-site laboratory analysis.
- Complete soil waste profiles and submit to the off-site disposal facility for approval.
- Remove concrete building slabs with typical sizes and quantities as stated below, and remove concrete frost walls. The concrete will be temporarily staged, processed and reused as on-site backfill.

Building Size	Grant Housing	Locust Housing	Cavite Street
27"W x 110' L	64	14	
33'W x 85'L	64		
29'W x 63'L	1		
32'W x 151'L			3
25'W x 193'L			3
Total	129	14	6

- Abate and dispose of asbestos containing material (ACM) in accordance with the Asbestos Abatement Plan (Charter Environmental Inc., September 2001).
- Excavate the pesticide-contaminated soil beneath the pads at Grant, Locust and Cavite Housing to a pre-determined depth.
- Load and transport excavated soils to an approved off-site disposal facility or to the Stockpile Management Area for eventual off-site disposal.
- Perform confirmatory sampling to verify that remaining soils are below project cleanup criteria [MCP Method 1 S-1/GW-1 at Grant and four of the Cavite buildings, S-3/GW-1 at Locust and two of the Cavite buildings (Buildings #144 and #145)].
- Backfill the excavations following confirmation that remaining soil meets the project cleanup criteria.

The actions outlined above are explained in more detail in the Draft RAM Plan for the Pesticide Soil Remedial Action – Grant, Locust & Cavite Housing Devens (WESTON, February 2002), and the Draft RAM Plan for Proposed Shirley Middle School Devens, Massachusetts (WESTON, October 2001).

Further details regarding the scope items delineated above are presented in the RAM Plan, SSHASP Addendum and the Asbestos Abatement Plan (Charter Environmental Inc., September 2001), which are provided under separate cover.

3.2 GENERAL QA/QC PROCEDURES

Quality Control (QC) samples will be collected, and will include field duplicates, matrix spike/matrix spike duplicates (MS/MSDs), trip blanks [one per cooler if Volatile Organic Compounds (VOC) analysis is requested] and equipment blanks (one per 20 samples). For on-site post-excavation confirmatory samples, for each matrix and analytical parameter, one (1) field duplicate sample will be collected for every ten (10) field samples. At the start of the project 20% of post-excavation confirmation samples analyzed by the on-site laboratory will be sent to one of the three off-site laboratories as pesticide analysis verification samples. It is anticipated that if after one month correlation is within QC limits (Relative Percent Difference $\leq$ 75%) between on-site and off-site laboratory results, off-site verification sample submittal will be reduced to 10%. No MS/MSD samples will be sent to the on-site laboratory since the expected high concentrations of pesticides may cause calibration exceedances. The on-site laboratory will perform laboratory control spike (LCS) samples. The on-site laboratory will also be given a performance evaluation sample (PE) to analyze once per week for the first month and then once per month thereafter. One (1) MS/MSD sample will be collected for every twenty (20) confirmation samples sent to the off-site laboratory. QC (excluding trip blanks) samples will not be collected for any samples used for waste characterization or waste profiling at an off-site facility. Temperature blanks will be prepared and submitted with each cooler of samples.

Quality Assurance (QA) split samples will be collected at a rate of 10 % of those samples that are sent off site for confirmatory sample analysis. For the Grant, Locust, and Cavite Housing Area and the Chlordane Cell phase, after the on-site laboratory is mobilized and operational the QA split samples will be collected at a frequency of 5 %. See Table 3-1 for QA/QC information.

TABLE 3-1
SAMPLE QA/QC
FORT DEVENS, MASSACHUSETTS

Type	Area	Analysis	Method	Total Onsite Samples[4]	Onsite Duplicates	Onsite MS/MSD	Offsite[5] Verification/ Characterization	Offsite Field Duplicates	Offsite MS/MSD	CENAE QA
Post excavation Confirmation	D-149	Pesticides[1]	8081A[2]	1759	177	89	353	36	19	36
	Chlordane cell	Total Pesticides + Chlordane	8081A							
		TCLP Pest	1311/8081A							
	Shirley	Asbestos[3]					60	12		
	Shirley (BDA)	PAH	3540C/ 8270C	(TBD)	10%	5%				10%
		Total Metals and Hg	3050B/6010B/7471A	(TBD)	10%	5%				10%
Post Excavation Additional	D-149	Pesticides[1]	8081A[2]	(725)						
Waste Characterization	Chlordane cell	VOC	5035/8260B				9	N/A	N/A	N/A
		SVOC	3540C/ 8270C				9	N/A	N/A	N/A
		TPH	8015B (DRO and GRO)				9	N/A	N/A	N/A
		Pest/PCB	3540C/8081A/8082				9	N/A	N/A	N/A
		TCLP Pesticides					9	N/A	N/A	N/A
		Herbicides	8151A				9	N/A	N/A	N/A
		PAH	8270C				9	N/A	N/A	N/A
		Ignitability	1010				9	N/A	N/A	N/A
		Corrosivity	9045A				9	N/A	N/A	N/A
		Cyanide/Sulfide Reactivity	7.3.4.1/7.3.4.2				9	N/A	N/A	N/A
		Total Metals and Hg	3050B/6010B/7471A				9	N/A	N/A	N/A
	Shirley	VOC	5035/8260B				1	N/A	N/A	N/A
		SVOC	3540C/ 8270C				3	N/A	N/A	N/A
		TPH	8015B (DRO and GRO)				3	N/A	N/A	N/A
		Pest/PCB	3540C/8081A/8082				3	N/A	N/A	N/A
		Herbicides	8151A				3	N/A	N/A	N/A
		PAH	8270C				3	N/A	N/A	N/A
		Ignitability	1010				3	N/A	N/A	N/A
		Corrosivity	9045A				3	N/A	N/A	N/A
		Cyanide/Sulfide Reactivity	7.3.4.1/7.3.4.2				3	N/A	N/A	N/A
		Total Metals and Hg	3050B/6010B/7471A				3	N/A	N/A	N/A
		Asbestos[3]					3	N/A	N/A	N/A
	D-149	Total Pest	3540C/8081				160	N/A	N/A	N/A
		VOC	5035/8260B				160	N/A	N/A	N/A
		SVOC	3540C/ 8270C				160	N/A	N/A	N/A
		PCB	8082				160	N/A	N/A	N/A
		TPH	8015B (DRO and GRO)				160	N/A	N/A	N/A
		Total Metals and Hg	3050B/6010B/7471A				160	N/A	N/A	N/A
		TOC	9060A				160	N/A	N/A	N/A
		Ignitability	1010				160	N/A	N/A	N/A
		Corrosivity	9045A				160	N/A	N/A	N/A
		Cyanide/Sulfide Reactivity	7.3.4.1/7.3.4.2				160	N/A	N/A	N/A
	Locust concrete	TCLP Pest	1311/8081A				1	N/A	N/A	N/A
	Cavite Concrete	TCLP Pest	1311/8081A				1	N/A	N/A	N/A

[1] Full 8081A Pesticides will be analyzed, but laboratory will only report aldrin, dieldrin and chlordane and total chlordane.
[2] Extraction method 3540C must be used for offsite verification samples.
[3] See Asbestos Abatement Plan in Appendix B of the Work Plan for details on asbestos sampling.
[4] Turn around time (TAT) is 24 hour for onsite analysis
[5] Off-site verification and waste diposal characterization sample analysis TAT = 5 days

SECTION 4

FIELD ACTIVITIES

4. FIELD ACTIVITIES

The information contained in this portion of the SAP, the FSP, documents procedures that will be used by WESTON for collection of soil samples for chemical analysis. This FSP also addresses disposal and treatment characterization of the excavation soils to be removed from the site.

4.1 PRELIMINARY ASBESTOS ABATEMENT

4.1.1 Sampling Rationale

Prior to the removal of the building slabs an assessment will be conducted to determine the need for asbestos abatement activities at each building or within groups of buildings with similar construction (determine by building dimensions). The primary asbestos containing materials (ACM) of concern are 1) Transite piping, and 2) waterproof mastic on the top three feet of the building frost walls.

4.1.2 Sample Collection and Analysis

The assessment will be conducted by penetrating the concrete in several locations across the slab. Rubble concrete will be removed and the heating duct will be visually inspected for the presence of transite piping. If mastic is present on the building frost walls, up to four samples (one from each wall) will be collected and submitted to an off-site certified asbestos testing laboratory for Polarized Light Microscopy (PLM) analysis. Certified personnel will conduct asbestos sampling.

4.2 "PRE-DETERMINED DEPTH OF EXCAVATION" EVALUATION

4.2.1 Sampling Rationale

A "pre-determined depth of excavation" within each building foundation for the Pesticide Remedial Action – Grant, Locust and Cavite Housing Area has been established as four feet bgs. The depth is based on data collected as part of previous investigations and remedial actions at housing areas outside of those included in this remedial action.

As part of this remedial action an evaluation of the "pre-determined depth of excavation" will be conducted to determine if the 4 feet bgs depth is the appropriate depth interval based on an assessment of COC concentrations within building foundations associated with the Pesticide Remedial Action.

An assessment will be conducted in the first 10 building excavations by excavating to an initial depth of 2 feet bgs followed by the collection of evaluation samples in the same manner as confirmatory samples. These samples will be submitted to the on-site laboratory for analysis. Following the evaluation sample collection, soils between 2-4 feet bgs will be removed to obtain the approved "pre-determined depth of excavation". Confirmatory samples will be collected from the 4 feet bgs depth and submitted for analysis in accordance with the approved excavation program.

WESTON will review the evaluation sample results and will provide CENAE with a summary and recommendations for a revised "pre-determined depth of excavation". CENAE will discuss the results with concerned parties to determine that most appropriate action.

Additional "pre-determined depth of excavation" evaluations may be conducted throughout the duration of the project to ensure that the proper depth is being applied to the remedial action.

4.2.2 Sample Collection and Analysis

Sample collection will be conducted in accordance with the Excavation Confirmation Sampling protocols (see following sections). Samples will be analyzed for pesticides (Method 8081A) at the on-site analytical laboratory.

4.3 EXCAVATION CONFIRMATION SAMPLING

4.3.1 Sampling Rationale

In order to ensure that the project cleanup criteria are met at the Grant, Locust and Cavite Housing and the Shirley Housing Building Debris Area, confirmation soil samples will be collected from the floor and along the walls of the excavation. Floor samples will be collected at

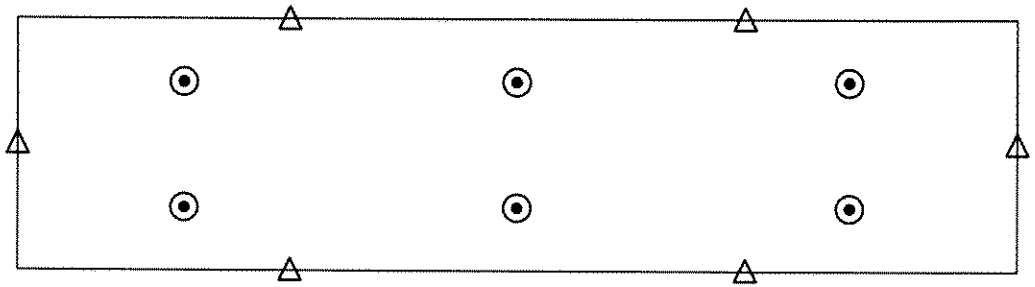
a rate of one composite sample per 500 square ft². Wall samples will be collected at a rate of one composite sample for every 50 linear feet of excavation sidewall. Figures 4-1A, 4-1B, 4-1C, 4-1D and 4-1E provide sampling scenarios for the typical building sizes described in Subsection 3.1

4.3.2 Discrete/Composite Sampling Requirements

Confirmation samples from the excavation floor and sidewalls will be taken as five-point composites. Floor samples will be collected as discrete sub samples from the four corners and the center of each 500 square-foot section and composited. Sidewall samples will be collected as discrete sidewall scrapes from the base to the top of each wall from five locations equi-distance apart over the length of the excavation sidewall and composited. A minimum of one sidewall sample shall be collected from each sidewall of an excavation.

FILE NAME: M:\DESIGN\DWG\ACOE\FTDEVENS\PEST_SOIL\FIG4-1A.DWG (PLOT 1=1)

TYPICAL 110'x27'



LEGEND

- BUILDING FOUNDATION/PROPOSED EXCAVATION BOUNDARY
- △ WALL COMPOSITE (5-POINT COMPOSITE EVERY 50 LINEAR FEET)
- ⊙ FLOOR COMPOSITE (5-POINT COMPOSITE EVERY 500 SQUARE FEET)

GRAPHIC SCALE

20 10 0 10 20

APPROXIMATE SCALE IN FEET

PROPOSED TYPICAL CONFIRMATION SAMPLING LOCATIONS

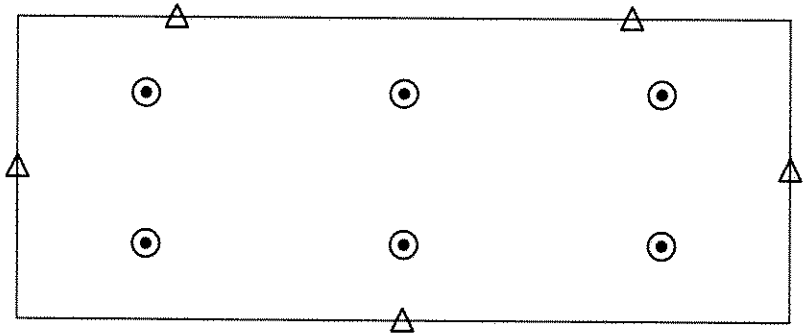
PESTICIDE SOIL REMEDIAL ACTION
GRANT, LOCUST, & CAVITE HOUSING
DEVENS, MASSACHESETTS

ROY F. WESTON, INC.
WESTON MANAGERS DESIGNERS/CONSULTANTS

DRAWN	DATE	DES. ENG.	DATE	W. O. NO.
BEG	SEPT 2001			20140 007 005
CHECKED		APPROVED		DWG. NO. 4-1A

FILE NAME: M:\DESIGN\DWG\ACOE\FTDEVENS\PEST_SOIL\FIG4-1B.DWG (PLOT 1=1)

TYPICAL 85'x33'



LEGEND

BUILDING FOUNDATION/PROPOSED EXCAVATION BOUNDARY

WALL COMPOSITE (5-POINT COMPOSITE EVERY 50 LINEAR FEET)

FLOOR COMPOSITE (5-POINT COMPOSITE EVERY 500 SQUARE FEET)

GRAPHIC SCALE

20 10 0 10 20

APPROXIMATE SCALE IN FEET

PROPOSED TYPICAL CONFIRMATION SAMPLING LOCATIONS

PESTICIDE SOIL REMEDIAL ACTION
GRANT, LOCUST, & CAVITE HOUSING
DEVENS, MASSACHESETTS

ROY F. WESTON, INC.
WESTON MANAGERS DESIGNERS/CONSULTANTS

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BEG	SEPT 2001			20140 007 005
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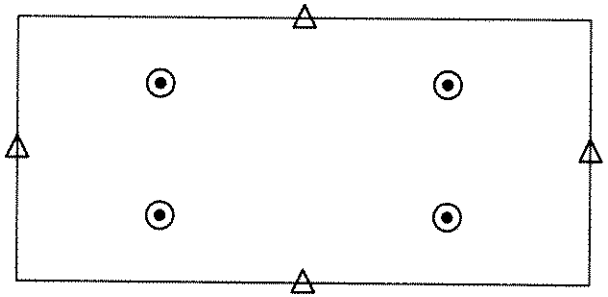
				4-1B

FILE NAME: M:\DESIGN\DWG\ACOE\FTDEVENS\PEST_SOIL\FIG4-1C.DWG (PLOT 1=1)

TYPICAL 63'x29'



LEGEND

- BUILDING FOUNDATION/PROPOSED EXCAVATION BOUNDARY
- △ WALL COMPOSITE (5-POINT COMPOSITE EVERY 50 LINEAR FEET)
- ⊙ FLOOR COMPOSITE (5-POINT COMPOSITE EVERY 500 SQUARE FEET)

GRAPHIC SCALE

20 10 0 10 20

APPROXIMATE SCALE IN FEET

PROPOSED TYPICAL CONFIRMATION SAMPLING LOCATIONS

PESTICIDE SOIL REMEDIAL ACTION
GRANT, LOCUST, & CAVITE HOUSING
DEVENS, MASSACHESETTS

ROY F. WESTON, INC.
WESTON MANAGERS DESIGNERS/CONSULTANTS

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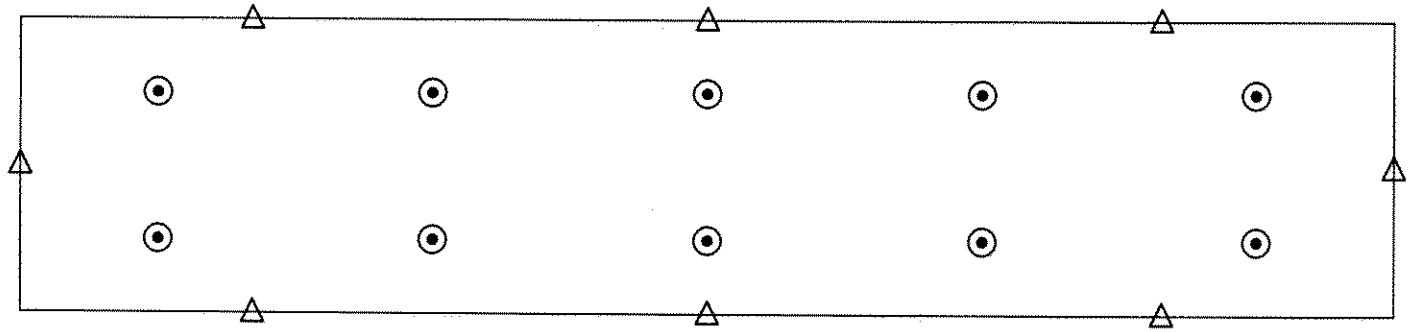
FILE NAME: M:\DESIGN\DWG\ACOE\FTDEVENS\PEST_SOIL\FIG4-1D.DWG (PLOT 1=1)

TYPICAL 151'x32'



LEGEND

- BUILDING FOUNDATION/PROPOSED EXCAVATION BOUNDARY
- △ WALL COMPOSITE (5-POINT COMPOSITE EVERY 50 LINEAR FEET)
- ⊙ FLOOR COMPOSITE (5-POINT COMPOSITE EVERY 500 SQUARE FEET)

GRAPHIC SCALE

20 10 0 10 20

APPROXIMATE SCALE IN FEET

PROPOSED TYPICAL CONFIRMATION SAMPLING LOCATIONS

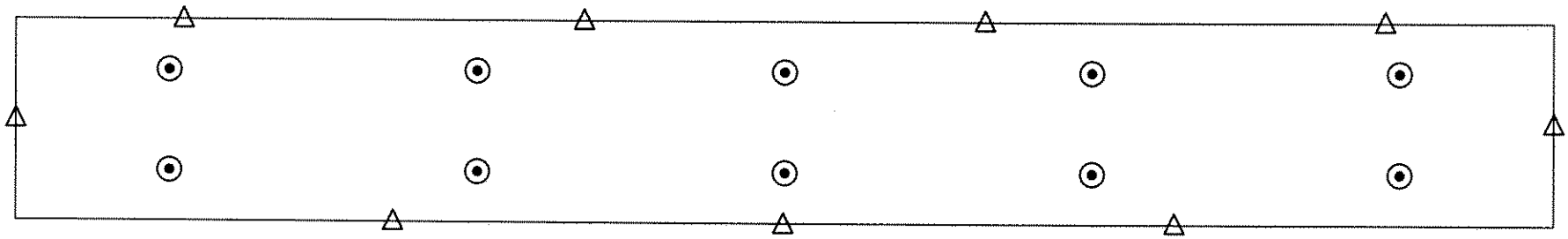
PESTICIDE SOIL REMEDIAL ACTION
GRANT, LOCUST, & CAVITE HOUSING
DEVENS, MASSACHESETTS

ROY F. WESTON, INC.
WESTON MANAGERS DESIGNERS/CONSULTANTS

DRAWN	DATE	DES. ENG.	DATE	W. O. NO.
BEG	SEPT 2001			20140 007 005
CHECKED		APPROVED		DWG. NO. 4-1D

FILE NAME: M:\DESIGN\DWG\ACOE\FTDEVENS\PEST_SOIL\FIG4-1E.DWG (PLOT 1=1)

TYPICAL 192'x25'



LEGEND

- BUILDING FOUNDATION/PROPOSED EXCAVATION BOUNDARY
- △ WALL COMPOSITE (5-POINT COMPOSITE EVERY 50 LINEAR FEET)
- ⊙ FLOOR COMPOSITE (5-POINT COMPOSITE EVERY 500 SQUARE FEET)

GRAPHIC SCALE

20 10 0 10 20

APPROXIMATE SCALE IN FEET

PROPOSED TYPICAL CONFIRMATION SAMPLING LOCATIONS

PESTICIDE SOIL REMEDIAL ACTION
GRANT, LOCUST, & CAVITE HOUSING
DEVENS, MASSACHESETTS

ROY F. WESTON, INC.
WESTON MANAGERS DESIGNERS/CONSULTANTS

DRAWN	DATE	DES. ENG.	DATE	W. O. NO.
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4.3.3 Sample Collection and Analysis

Soil samples from the excavation sidewalls and floor will be collected and sent to an on-site mobile laboratory and 20% will go to one of three off-site laboratories as verification samples for pesticide analysis. It is anticipated that if after one month correlation is within QC limits (Relative Percent Difference $\leq$ 75%) between on-site and off-site laboratory results, off-site verification sample submittal will be reduced to 10%. Sample analysis will be conducted as follows:

On-site Mobile Laboratory (ESN North Atlantic)

- Total Pesticides – modified SW-846 Method 8081A (The laboratory will analyze for the full target compound list of Method 8081A, including total chlordane.)

Off-site Laboratories

- Total Pesticides – EPA Methods 3540C/8081A (for confirmatory sampling at the Chlordane Cell and the Pesticide Remedial Action – Grant, Locust and Cavite Housing Areas)
- Petroleum Aromatic Hydrocarbons (PAHs)- EPA Methods 3540C/8270C (for post-excavation confirmatory sampling at Shirley)
- Total Cadmium and Lead – EPA Methods 3050B/6010B (for post-excavation confirmatory samples at Shirley)
- Asbestos – EPA Method 600 (for post-excavation confirmatory samples at Shirley)

4.4 SAMPLING FOR WASTE CHARACTERIZATION

4.4.1 Rationale

Waste characterization samples will be used as the basis for determining if; soils meet MDEP COMM-97-001 or other facility permit requirements for landfill reuse/disposal prior to shipment, or concrete is suitable for on-site reuse. Sampling results will be sent to the disposal facility for review and confirmation of acceptance.

It is anticipated that waste characterization samples will be collected both in situ, prior to excavation activities, and from stockpiled soils/concrete. Samples will be collected at a frequency of one representative sample per 500 yd^3 of material. Characterization analysis will comply with MDEP COMM-97-001 and the disposal facility acceptance requirements. Each sample will be analyzed for TCLP analyses, if indicated based on total results using the 20X rule, and various other analyses specific to the requirements of MDEP COMM-97-001. No QC samples will be collected for waste characterization work. Concrete characterization will address potential pesticide contamination. It is assumed that all asbestos containing materials (ACM) has been removed from the surface of the concrete.

4.4.2 Pre-Excavation Sample Collection and Analysis

Waste characterization sampling prior to excavation activities within the work areas will be conducted either as part of the preliminary asbestos assessment program or as a stand-alone task. In the housing areas, soils sampling shall be conducted at each building following the removal of small sections of the building slab. Sample locations shall be selected by the field personnel at locations that are representative and provide areal coverage of the foundation. Samples shall be collected from 0-2 feet bgs from a minimum of four locations within a foundation and composited. A discrete sample will be collected from one of composite sampling locations within the foundation and submitted for VOC analysis.

In the Shirley Housing Area and Chlordane Cell, soils samples shall be conducted by excavating test holes at several location that are representative of the material to be disposed. Samples will be collected from a minimum of three test pits and composited. A discrete sample will be collected from one of composite sampling locations within the test holes and submitted for VOC analysis.

4.4.3 Stockpile Sample Collection and Analysis

Soil samples of stockpiled soils will be obtained by compositing a number of soil samples. The number and location of discrete excavated soil samples to be collected will be selected based on

the judgment of the field personnel. Samples to be composited (except for VOCs) will be collected from the excavated soil pile(s) at locations that:

- Represent the greatest likelihood of contamination based on field observations.
- Represent and provide areal coverage within the soil pile.
- Represent and provide coverage of the difference soil types observed.

Discrete samples will be collected from one or more depths to adequately characterize the vertical profile of the soil pile(s) to be sampled and composited. One discrete VOC sample will be collected for each 500 yd^3 of stockpiled soil.

4.4.4 Concrete Characterization

Concrete waste characterization samples will be collected as a composite from a minimum of 4 locations within a building foundation or from a concrete rubble stockpile. One composite sample will be collected for every 500 yd^3 of concrete. At a minimum, one sample will be collected from each of the housing areas (Grant, Locust, and Cavite) and submitted for pesticide analysis (Method 8081A).

4.4.5 Analytical Methods

Waste characterization samples will be submitted to one of the three off-site laboratories for analysis. Samples will be analyzed using approved methods as outlined below:

Waste Characterization Analysis

Off-site Laboratories

- Pesticides – EPA Methods 3540C/8081A (waste disposal characterization -inclusion in total Semi-volatile organic compounds (SVOC) concentration, per COMM-97-001).
- TCLP Pesticides – EPA Methods 1311/8081A, if necessary based on Total Pesticide results.
- Total Herbicides – EPA Methods 3540C/8151A/8150B, Not required for disposal of pesticide contaminated soils under Comm-97-001.

- TCLP Herbicides– EPA Methods 1311/8151A/8150B, if necessary based on Total Herbicide results.
- RCRA 8 Metals and Mercury – EPA Methods 3050B/6010B/7471A.
- TCLP Metals – EPA Methods 1311/3050B/6010B/7471A, if necessary based on Total metals results.
- Total Volatile Organic Compounds (VOC) - EPA Method 5035A/8260B.
- TCLP Volatile Organic Compounds (VOC) - EPA Method 1311/5030A/8260B, if necessary based on Total VOC results.
- Total Semi-Volatile Organic Compounds (SVOC)- EPA Method 3540C/8270C.
- TCLP Semi-Volatile Organic Compounds (SVOC)- EPA Method 1311/8270C, if necessary based on Total SVOC results.
- Total Polychlorinated Biphenyls (PCBs) - EPA Method 3540C/8082.
- Ignitability - EPA Method 1010.
- Corrosivity – EPA Method 9045A.
- Cyanide/Sulfide Reactivity – EPA Methods 7.3.4.1/7.3.4.2.
- Total Organic Carbon (TOC) – EPA Method 9060A. COMM-97-001 requirement, not required for Shirley Housing Area characterization sampling.
- Total Petroleum Hydrocarbons (TPH)- EPA Method 5030B/8015B – GRO and EPA Method 3540C/8015B – DRO.

Actual waste characterization analytical requirements are dependent on the disposal facility.

4.5 DEPTH CHARACTERIZATION

4.5.1 Sampling Rationale

Upon determination that excavation activities within an excavation have achieved project cleanup criteria levels as addressed in Subsection 1.5, depth characterization sampling will be conducted as a final assessment confirm the removal of pesticide-contaminated soils from within the footprint of the former building. Depth characterization will continue until MDFA and CENAE indicate that sufficient data has been collected through the depth characterization

program to ensure that remedial activities have addressed MDFAs concerns regarding the existence of contaminated soils at depths greater than the pre-determine excavation depths.

4.5.2 Sample Collection and Analysis

One test pit will be excavated per 50 lineal feet of the original foundation in the direction of its longest dimension. Example, an excavation under a building footprint 40 feet wide by 150 feet long, three test pits, one at either end of the excavation, and one in the middle, would be excavated. Based on the building dimensions included in this scope of work, in no case would there be less than 2 test pits in any foundation. The test pits would be located along the centerline of the excavation, roughly in the center of each 50-foot span. Test pits will be approximately 4 to 6 feet long by 2 feet wide, and will be advanced to a total depth of 10 feet bgs in two-foot lifts. At the bottom of each two-foot lift, up to a depth of 10 feet bgs, a discrete soil sample will be collected and submitted to the on-site laboratory for pesticide analysis via EPA Method 8081A. Soil samples will either be collected directly from the open test pit or from the bucket of the excavator if access into the test pit by sampling personnel is in violation of Occupational Safety and Health Administration (OSHA) regulations.

QC samples will be submitted to an off-site laboratory, in accordance with Subsection 4.11, and in accordance with the *Sampling and Analysis Plan for Release Abatement Measures at the Proposed Shirley Middle School, and Grant, Locust and Cavite Housing Areas and Pesticide Soil Remediation at the Chlordane Cell, Devens, Massachusetts* (SAP-WESTON, November 2001).

4.6 BACKGROUND SAMPLING

Background sample collection and analysis is not anticipated for this project.

4.7 SAMPLING PROCEDURES

This section outlines specific procedures that will be used when collecting samples for excavation confirmation sampling and for disposal characterization of soil stockpiles.

4.7.1 Sampling Methods

Confirmation samples:

Samples will be manually collected using either decontaminated stainless steel or disposable scoops or spades. A decontaminated stainless steel bowl (or equivalent) will be used for sample homogenization.

Waste Characterization samples:

Samples will be manually collected using either decontaminated stainless steel or disposable scoops or spades. A decontaminated stainless steel bowl (or equivalent) will be used for sample homogenization.

4.7.2 Field Measurement Procedures and Criteria

No field measurements will be required for confirmatory or waste characterization soil samples.

4.7.3 Sampling for Chemical Analysis

In general, all environmental samples will be collected in accordance with WESTON SOPs and with USACE documents ER-110-1-263 and EM-200-1-3. All soil samples will be manually collected using either decontaminated stainless steel or disposable scoops or spades.

Soils will be collected and placed into clean and labeled sample containers. Photographs of, or measurements to, the sample locations will be taken as necessary.

Confirmation samples, other than those collected as CENAE QA laboratory split samples, will not be cooled prior to being relinquished to the on-site laboratory. Samples designated for

submittal to the CENAE QA laboratory will be taken from the field preserved at 4°C and prepared for shipment.

Waste characterization samples will be preserved at 4°C following sample collection and prepared for shipment.

4.7.4 Sample Containers and Preservation Techniques

Specific sample containers and preservations will be performed according to Appendix I of USACE Guidance Document EM 200-1-3 and analytical method requirements. Table 5-1 in the QAPP details the required sample containers and preservation techniques for all of the analyses to be performed during this project.

4.7.5 Field Quality Control Procedures

Checks of field sampling operations will be made by the Site QC officer to ensure compliance with this FSP, and with the overall program quality control plan. Deficiencies, if any, will be noted and tracked.

4.7.6 Decontamination Procedures

Should decontamination of sampling equipment be required, the method is defined in EM 200-1-3. Sampling equipment decontamination will consist of an initial detergent wash, tap rinse, 10% nitric acid rinse (metals sampling only), deionized water rinse, and a methanol rinse. The equipment will be allowed to air dry and will be placed into plastic bags or wrapped in aluminum foil (shiny side out) to avoid re-contamination during storage. However, in general, it is anticipated that disposable sampling equipment and materials will be used and that these materials will be properly disposed off-site.

SECTION 5

SAMPLE CHAIN OF CUSTODY/DOCUMENTATION

5. SAMPLE CHAIN OF CUSTODY/DOCUMENTATION

This section documents chain-of-custody (CoC) and documentation procedures.

5.1 FIELD LOGBOOK

The field logbook should enable the sampling activity to be reconstructed without relying on the collector's memory. Logbooks should be kept in the possession of the field member responsible for sampling activities, or in a secure place during fieldwork. The following information should be recorded in the field logbook:

- Name and title of author, and date and time of entry.
- Name and address of field contact.
- Names and responsibilities of field crewmembers.
- Names and titles of any site visitors.
- Sample collection method.
- Number and volume of sample(s) taken.
- Information concerning sampling changes, scheduling modifications, and change orders.
- Details/Sketch of sampling location, including depth.
- Date and time of collection.
- Weather conditions.
- Field observations.
- Any field measurements made.
- Sample identification number(s).
- Information from containers, labels of reagents used, water type (i.e., deionized) used for blanks, etc.
- Sampling methodology.

- Sample preservation.
- Analytical method to be performed.
- Sample distribution and transportation.
- Sample documentation (e.g., CoC record numbers).
- Decontamination procedures.
- Documentation for investigation-derived wastes (IDWs) (e.g., contents and approximate volume of waste, disposal method).
- Documentation of any SOW changes required by field conditions.
- Signature and date (entered by personnel responsible for observations).

5.2 PHOTOGRAPHS

Photographs will be taken as necessary to document field activities.

5.3 SAMPLE NUMBERING PROCEDURES

The system for identifying and tracking the samples, associated field data, and the method of relating the data to the proper samples will be recorded in permanently bound and weatherproof notebooks and also in computer spread sheet format maintained by the field team. Team members will record all information related to sampling procedures, time, field and weather conditions, unusual events, sample descriptions (including sample depth), instrument readings, and CoC data. Field documentation will be done in indelible ink.

Additional sample types, areas of origin, and sub sample types will be allocated as necessary.

5.3.1 Soil Excavation Sample Numbering System

Samples collected during this project will be uniquely identified using the following scheme:

AA-BBB-CCC-DD-E-F

The codes A through F are as defined as below:

AA: Work Area:

AA = GR- Grant Housing

LO- Locust Housing

SH- Shirley Area

CT- Cavite Housing

CC- Chlordane Cell

BBB: Building Number or Excavation Location:

Ex: 417

Note: For Chlordane Cell and Shirley Housing Area use "XXX".

CCC: Sample Location Within Excavation

Sample Number (000, 001, 002, 003.....):

These sample numbers will be used sequentially and not be repeated within the each Building or Excavation.

DD: Location type and sampling round

FX = Floor of Excavation

WX = Wall of Excavation

X = Round of Excavations

E: Laboratory Type

0 = On-site Laboratory

1 = Off-site Laboratory

F: QA/QC Type

D = Field Duplicate

Q = QA Split Sample

Examples:

GR-510-011-F1-0-D

Grant Housing Area, Building #510, Sample #11, Floor sample first sample collected at that sampling location, on-site laboratory analysis, duplicate.

GR-510-011-F2-1

Grant Housing Area, Building #510, Sample location 011, Floor sample second sample collected from that sample location, off-site analysis, not a duplicate or QA sample.

5.3.2 Waste Characterization Sample Numbering System

AA-BBB

AA: Work Area & Material Type

SH = Shirley Area

CC = Chlordane Cell

PS = Pre-Excavation Waste Characterization (Grant, Locust and Cavite Housing Areas)

LC = Locust Concrete

GC = Grant Concrete

TC = Cavite Concrete

SM = Stockpile – Stockpile Management Area

SC = Stockpile – Cavite

BF = Backfill

BBB: Sample Number

Sample Number (000, 001, 002, 003.....):

These sample numbers will be used sequentially and not repeated.

SH-002 Shirley Area Waste Characterization Sample No. 2.

PS-003 Pre-Excavation Waste Characterization Sample No.3.

5.3.3 Other Sample Numbering System

AA-BBBBBB -CC

AA: TB = Trip Blank

EB = Equipment Blank

BBBBBB: Date sampled.

Ex. 101002 was taken on October 10, 2002.

CC: Sequential numbering of each type of blank submitted on a daily basis

Ex. Two trip blanks are submitted on October 10, 2002, insert "01" for first technical bulletin (TB) and "02" for second TB

5.4 SAMPLE DOCUMENTATION

5.4.1 Sample Labels

Sample labels and/or tags will be consistent with the requirements of Appendix F of EM 200-1-3.

Field personnel will be responsible for identifying, labeling, providing proper preservation, and packaging samples to prevent breakage during shipment.

Each sample will be labeled with the following information:

- Project number and site name
- Unique sample number
- Sampling date and time
- Initials of sampling technician
- Method of sample preservation/conditioning
- Analytical method to be performed

5.4.2 Sample Field Sheets and/or Logbook

The system for identifying and tracking the samples and associated field data will be recorded on both a computer generated spreadsheet and a permanently bound and weatherproof logbook maintained by the field team. Team members will record all information related to sampling procedures as specified in Subsection 5.1. Field documentation will be written in indelible ink.

5.4.3 Chain-of-Custody Records

Chain of custody (CoC) records provides documentation of the handling of each sample from the time of its collection to its destruction. WESTON will initiate sample custody upon collection of samples. CoC forms will be placed in weatherproof plastic bags and taped to the inside lid of the cooler. The cooler will be sealed with custody seals. CoC forms will be used for recording pertinent information about the types and numbers of samples collected and shipped for analysis. Sample identification numbers will be included on the CoC form to ensure that no error in identification is made during shipment. CoC procedures shall be performed in accordance with Appendix F of EM 200-1-3.

A sample is considered "in custody" if it:

- Is in a person's actual possession
- Is in view after being in physical possession
- Is locked up so that no one can tamper with it after having been in physical custody
- Is in a secured area, restricted to authorized site personnel only.

5.5 DOCUMENTATION PROCEDURES

Prior to sample collection, labels will be affixed to sample containers using either transparent tape or self-adhesive labels. Indelible ink will be used for all logbooks, CoC, and sample label entries. Documentation will conform to Appendix F of EM 200-1-3.

5.6 CORRECTIONS TO DOCUMENTATION

All original data recorded in field logbooks, sample labels, CoC records, and receipt for sample forms will be written in indelible ink. If an error is made, a single line should be drawn through the entry and the entry initialed and dated. The erroneous information should not be obliterated. The person who wrote the entry should correct any errors found in documentation.

SECTION 6

SAMPLE SHIPMENT

6. SAMPLE SHIPMENT

Sample Shipment via Contracted Courier

If samples are to be transported to via Federal Express (FEDEX) or similar shipping each sealed container will need to comply with the following shipping requirements. Samples will be placed in a leak-proof plastic bag and placed in containers compatible with the intended analysis and properly preserved prior to relinquishment/shipment to the laboratory. Strong thermal ice chests will be filled approximately 3 inches with inert material, such as asbestos-free vermiculite. Samples will be placed on top of the vermiculite and then ice/gel packs will be placed adjacent to the bagged samples to maintain the sample temperature at 4°C. Vermiculite will then be used to fill the interstices around the samples and to fill the remaining space in the cooler. A CoC form will be placed in a waterproof plastic bag and taped to the inside lid of the cooler. Ice chests will be taped shut with strapping tape, wrapped around the cooler in at least two places. Tape will also be put over the drain plug (if present) to prevent leaking. Ice chests will be sealed with numbered and signed custody seals. Custody seal numbers should be included on the CoC and logged in the field team sample logbook. This packaging and shipment is in accordance with EPA protocol. Prior to shipment, a QC check will be performed to ensure samples have been properly identified and packaged, and that appropriate documentation (CoC) will accompany them.

Sample delivery to on-site laboratory or contract laboratory courier

Samples that are delivered to the on-site or off-site laboratory or relinquished to a laboratory courier shall be placed in appropriate transportation containers and preserved as required. Samples should be packed in such a manner as to minimize the possibility of sample container breakage. Samples provided to an off-site laboratory courier must be sealed with a numbered and signed custody seal. Custody seal numbers should be included on the CoC and logged in the field team sample logbook. CoCs should be transferred to the laboratory using the appropriate relinquishment procedures, but do not need to be placed in the transportation container. Prior to shipment, a QC check will be performed to ensure samples have been properly identified and packaged, and that appropriate documentation (CoC) will accompany them.

SECTION 7

INVESTIGATION-DERIVED WASTES (IDW)

7. INVESTIGATION-DERIVED WASTES (IDW)

Waste materials generated during site activities (e.g., decontamination fluids, personal protective equipment (PPE), and construction debris) will be containerized. Disposal options will be determined pending receipt of soil waste characterization results.

If potentially hazardous materials generated during field activities they will be placed in labeled drums and/or roll-off containers. Soil sampling results will be used for IDW characterization purposes to the extent possible. Containerized IDW that is determined to be non-hazardous based on analytical results will be disposed of as solid waste. IDW, characterized or listed as hazardous waste, will be disposed of in a manner consistent with all local, state, and federal guidelines.

SECTION 8

CONTRACTOR QUALITY CONTROL

8. CONTRACTOR QUALITY CONTROL

WESTON is required to ensure that quality is maintained throughout all fieldwork. WESTON will utilize experienced field personnel to perform soil sampling.

8.1 PREPARATORY PHASE

The Site CQC Officer will review all pertinent sections of the plans and specifications during the preparatory meeting to ensure that field personnel are cognizant of Data Quality Objectives (DQOs). The Site Manager, in conjunction with the WESTON Project Manager and sampling team(s), will also review all work requirements, examine all materials and equipment, examine work areas, and demonstrate all field activities. If new sampling personnel arrive on-site during the work effort, the Site CQC Officer must repeat this phase before new personnel begin work. The Site CQC Officer is also responsible for overseeing each step of work as it is initiated and for continued daily contract compliance throughout completion of the project.

8.1.1 Project-Specific Checklist

The field equipment list includes the following:

- Sampling and Analysis Plan (SAP)
- Field Logbook
- Example tables for recording all data
- QA sample table for matching QC and QA samples
- Decontamination materials (if needed)
- Personal protective equipment
- Sample collection equipment
- Sample containers labels
- Examples of completed sample shipping documents
- Sample containers
- Chain-of-custody forms
- Custody seals
- Sample shipping containers
- Sample packing materials
- Sample preservatives
- Laboratory information
- Copy of a phone log showing that QA samples have been scheduled

Checklist of activities:

- Review DQOs and specific analytical method, including required sampling, sample holding, and analysis requirements.
- Review SAP.
- Review decontamination procedures.
- Review sample custody forms.
- Review sample numbering system.
- Review field logbook documentation requirements.
- Discuss analytical test methods.
- Review sampling techniques.
- Review sampling activities for compliance with this SAP.
- Review sample labels and CoC forms for accuracy, completeness, and consistency.
- Oversee sample packaging and shipping.
- Inspect field notes.

SECTION 9

DAILY CHEMICAL QUALITY CONTROL REPORTS (DCQCRS)

9. DAILY CHEMICAL QUALITY CONTROL REPORTS (DCQCRS)

9.1 DAILY QUALITY CONTROL REPORTS

9.1.1 Field Activities

DCQCRs will be incorporated into the daily inspection and daily construction quality control reports. These reports will be completed and submitted to CENAE as required.

9.1.2 Laboratory

The QC reporting requirements for laboratory reporting are addressed in Subsections 11 and 14 of the QAPP. The QC information will be submitted together with the analytical data packages. No additional QC reports will be required.

9.2 DEPARTURE FROM APPROVED PLANS

WESTON will document and report all major departures, if any, from approved plans. The report will address the following:

- Reasons for departures
- Problems identified
- Corrective actions
- Effect of the departure on scope and results
- Instructions from CENAE personnel for resampling and/or reanalysis

These reports of major departures from approved plans will be sent to the contracting officer's representative within 48 hours of the occurrence.

9.3 DATA REPORT TO THE QUALITY ASSURANCE LABORATORY

WESTON will collect and ship QA samples to the QA Laboratory listed in Subsection 2.2.3. A report will be submitted to CENAE that will include the contractor's analytical laboratory data and a table that matches primary (field, QC) samples with their corresponding QA samples. The

data reporting will also include a discussion of any problems that occurred during analyses, the effects of those problems, and recommendations for further analyses, if required.

SECTION 10

CORRECTIVE ACTIONS

10. CORRECTIVE ACTIONS

10.1 FIELD CORRECTIVE ACTION

Field personnel have initial responsibility for monitoring the quality of field measurements and observations. The Site Manager will notify the QC Management of any problems that occur that may jeopardize the integrity of the project or cause any project objective to not be met. An appropriate corrective action will be developed and implemented. The Site Manager will document the problem, including the cause, the corrective action, and results in the field logbook. Copies of the logbook will be provided to the Project Manager, Site CQC Officer, and QC Management.

10.2 LABORATORY CORRECTIVE ACTION

The laboratory analyst has initial responsibility to monitor the quality of an analytical system. The analyst will verify that all laboratory-specific QC procedures are followed and that results of an analysis of QC samples are within acceptance criteria. This requires that the analyst assess the correctness of all of the following items as appropriate:

- Sample preparation procedure
- Initial calibration
- Calibration verification
- Method blank result
- Laboratory control standard
- Duplicate analysis
- Fortified sample result
- MS/MSD and surrogate recoveries

If the assessment reveals that any of the laboratory-specific QC acceptance criteria are not met, the analyst must immediately assess the analytical system to correct the problem. The analyst notifies the appropriate supervisor and laboratory QA coordinator of the problem and, if possible, identifies potential causes and corrective action.

The nature of the corrective action depends on the nature of the problem. For example, if continuing calibration verification is determined to be "out of control," the corrective action may

require recalibration of the analytical system and reanalysis of all samples since the last acceptable continuing calibration standard.

When the appropriate corrective action measures have been defined and the analytical system is determined to be "in control," the analyst documents the problem and the corrective action. Data generated concurrently with an "out-of-control" system will be evaluated for usability in light of the nature of the deficiency. If the deficiency does not impair the usability of the results, data will be reported and the deficiency noted in the case narrative. Where sample results are impaired, the laboratory QA coordinator is notified and appropriate corrective action (e.g., reanalysis, etc.) is taken. If reanalysis cannot be conducted, re-sampling may be required. Other laboratory corrective actions are discussed in Section 10 of the QAPP.

SECTION 11

PROJECT SCHEDULE

11. PROJECT SCHEDULE

The project schedule is presented and discussed in Subsection 2.3 of the Draft RAM Plan for the Pesticide Soil Remedial Action – Grant, Locust & Cavite Housing Devens (WESTON, February 2002).

SECTION 12

SAMPLING APPARATUS AND FIELD INSTRUMENTATION

12. SAMPLING APPARATUS AND FIELD INSTRUMENTATION

A list of the expected field equipment, containers, and supplies anticipated for this project is provided below. Not all equipment may be used.

Field Equipment:

- First aid kit
- Fire extinguisher
- Eyewash station
- Caution tape
- Hazard signs
- Camera
- Duct tape
- Film
- Garbage bags
- Indelible ink pens
- Pda Dust Meter
- Paper towels
- Razor knife
- Sample containers provided by laboratory
- Polyethylene sheeting

Decontamination Equipment: None anticipated

Personal Protective Equipment:

- Safety goggles
- Surgical gloves
- Nitrile gloves
- Plastic booties
- Tyvek suits
- Level C protective gear (as necessary)
- Level D (and Level D modified) protective gear

Sampling Equipment:

- Stainless steel bowls
- Vermiculite
- Spades
- Scoopulas

- Tape measures
- Folding ruler
- Hazard shipping labels
- Cooler
- Strapping tape
- Shovel
- Ice
- Measuring tape
- Site plans
- Weatherproof notebook
- Sample log forms
- Sample containers, including labels
- Chisel
- Sledge hammer
- Utility knife

SECTION 13

REFERENCES

13. REFERENCES

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ATTACHMENT 1

REUSE AND DISPOSAL OF CONTAMINATED SOIL AT MASSACHUSETTS LANDFILLS
DEP POLICY #COMM-97-001

COMMONWEALTH OF MASSACHUSETTS
EXECUTIVE OFFICE OF ENVIRONMENTAL AFFAIRS
DEPARTMENT OF ENVIRONMENTAL PROTECTION
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REUSE AND DISPOSAL OF CONTAMINATED SOIL

AT MASSACHUSETTS LANDFILLS

DEPARTMENT OF ENVIRONMENTAL PROTECTION

POLICY # COMM-97-001

(SUPERSEDES POLICY # BWP-94-037)

This Policy provides guidance to the regulated community about the Department of Environmental Protection's requirements, standards, and approvals for testing, tracking, transport, and reuse or disposal of contaminated soil at Massachusetts permitted landfills. This Policy supersedes Department Policy BWP-94-037.

[15 Aug 97]

Date

[Signature on Original]

Edward Kunce
Deputy Commissioner

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1.0 Policy Statement and Scope

This Policy provides information to the regulated community about the Massachusetts Department of Environmental Protection's (the Department) requirements, standards, management practices and approvals for the testing, tracking, transport, and reuse or disposal of Contaminated Soil at Massachusetts landfills. This Policy is effective immediately and supersedes the Department Policy # BWP-94-037. The Department is updating Policy # BWP-94-037 with this Policy in order to:

- update the standards for management of Contaminated Soil by Massachusetts landfills;
- maintain consistency with Policy # COMM-94-007, Interim Policy for Sampling, Analysis, Handling and Tracking Requirements for Dredged Sediment Reused or Disposed at Massachusetts Permitted Landfills, February 15, 1995;
- reflect changes to Table 1 Contaminant Levels for Soil Reuse at Landfills, and to include contaminant levels for the reuse of Contaminated Soil at unlined landfills;
- maintain consistency with revisions in 310 CMR 30.000, Massachusetts Hazardous Waste Regulations, November 18, 1994;
- describe the procedures and requirements lined landfills must meet to reuse or dispose of Treated TCLP Soil (including Treated TCLP-Lead Soil);
- prohibit the reuse or disposal of Treated TCLP Soil at unlined landfills; and
- maintain consistency with EPA's 1995 Household Hazardous Waste Exemption for Residential Lead Soil.

Landfills which intend to reuse or dispose of Contaminated Soil must have a prior approval from the Department under 310 CMR 19.000 unless: the soil **does not exceed** the contaminant levels of Table 1; meets the other acceptance criteria of this Policy; and the landfill complies with the management, technical and procedural requirements of this Policy.

This Policy is not meant to be, and shall not be relied upon to be, a complete list of all the regulatory requirements for managing Contaminated Soil. Parties managing Contaminated Soil shall consult 310 CMR 40.0000 (the Massachusetts Contingency Plan), 310 CMR 30.000 (the Massachusetts Hazardous Waste Regulations), and 310 CMR 19.000 (the Massachusetts Solid Waste Management Regulations) for other applicable requirements.

The information contained in this Policy is intended solely for guidance. This Policy does not create any substantive or procedural rights, enforceable by any party in any administrative proceeding with the Commonwealth.

Additional copies of this Policy, and other policies and forms referenced throughout this Policy can be obtained by calling the Department's InfoLine at (617) 338-2255 or 1-800-462-0444 (Outside of Area Code 617) and on the World Wide Web at http://www.state.ma.us/dep. The 21E Bill of Lading and Material Shipment Record forms and instructions can also be obtained through the Regional Service Centers located in each Department Regional Office.

2.0 Applicability

This Policy provides information to the regulated community on the reuse and disposal of Contaminated Soil at Massachusetts landfills. This Policy applies to Contaminated Soil generated from 21E disposal sites; Contaminated Soil which exhibits concentrations of oil and/or hazardous material below the applicable notification thresholds specified in 310 CMR 40.0300 and 310 CMR 40.1600; Contaminated Soil generated at out-of-state locations; Treated TCLP Soil (including Treated TCLP-Lead Soil); Residential Lead Soil; and soil contaminated with used or unused waste oil (see 310 CMR 30.252(2)).

This Policy does not apply to soil that is either a listed or characteristic hazardous waste, except Treated TCLP Soil as described in **Section 8.0, *Reuse and Disposal of Treated TCLP Soil***, nor does it apply to the management of wastes such as industrial waste, sludge, street sweepings[1], catch basin sediments or Municipal Solid Waste (MSW).

3.0 Terminology

This section contains definitions of the important terms and acronyms used in this Policy.

Contaminated Soil means soil that contains oil and/or hazardous materials as a result of a release to the environment. This includes anthropogenic contaminants, regardless of whether the contaminant levels exceed the applicable Reportable Concentration (RC) under section 310 CMR 40.1600 of the MCP. This definition of Contaminated Soil is broader than that in 310 CMR 40.0006 since it includes soil contaminated at less than the RCs.

Department means the Massachusetts Department of Environmental Protection.

Hazardous Waste Treatment, Storage, or Disposal Facilities (TSDFs) as used in this Policy means facilities which treat, store, or dispose of hazardous waste as an ongoing operation. These are distinguishable from facilities which generate hazardous waste and may engage in discrete storage or treatment activities; (e.g., tank and containers treatment or storage on-site by generators for less than ninety days). It does not include treatment that occurs at 21E sites under the MCP or licensed hazardous waste treatment facilities that only treat only waste generated on-site as part of the facilities' manufacturing operations.

Treatment, storage, or disposal facilities, unlike generators, are required by federal and/or state law to be permitted or licensed either as an Interim Status Facility or as a Permitted Hazardous Waste Facility.

[1] Guidance on the management of street sweepings is provide in DEP Policy BWP-94-092, ***Reuse and Disposal of Street Sweepings, Department of Environmental Protection Bureau of Waste Prevention, Final Policy # BWP-94-092***, April 15, 1997.

Interim Status Facilities, defined and regulated by Title 40 Code of Federal Regulations Part 265 (or Authorized State Hazardous Waste Regulations), and Permitted Hazardous Waste Facilities, defined and regulated by Title 40 Code of Federal Regulations Part 264 and Part 270 (or Authorized State Hazardous Waste Regulations), are required to comply with a series of ongoing requirements for waste analysis, facility inspection, record keeping, employee training, siting, environmental monitoring, closure/post-closure planning, and financial assurance, that do not apply to generators.

Household means, for purposes of 310 CMR 30.000 and the household hazardous waste exemption, single and multiple residences, hotels and motels, bunkhouses, ranger stations, crew quarters, campgrounds, picnic grounds, and day-use recreation areas (310 CMR 30.104(6)).

Land Disposal Restrictions (LDRs) each means the federal hazardous waste land disposal restrictions found at Title 40, Chapter I, Part 268 of the Code of Federal Regulations.

Licensed Site Professional (LSP) each means a hazardous waste site cleanup professional, as defined in M.G.L. 21A, § 19, holding a valid license issued by the Board of Registration of Hazardous Waste Site Cleanup Professionals pursuant to M.G.L. c. 21A§§ 19 through 19J.

Lined Landfill is a landfill that has a liner system complying with 310 CMR 19.110, and a leachate collection system complying with 310 CMR 19.110(9).

Massachusetts Contingency Plan (MCP) each mean 310 CMR 40.0000.

Qualified Environmental Professional (QEP) each means an individual who: is knowledgeable about the procedures and methods for characterizing wastes and contaminated media; is familiar with the receiving state, Massachusetts, and federal regulations applicable to the management of such materials; performs or oversees the management of Contaminated Soil as an integral part of his or her professional duties; and is professionally licensed or certified in a discipline related to environmental assessment (i.e., engineering, geology, soil science, LSP, or environmental science) by a state or recognized professional organization.

RCRA means the Federal Hazardous Waste statute: 42 U.S.C. Sections 6901 et. seq and federal regulations issued there under.

Residential Lead Soil means lead Contaminated Soil, originating from household locations, defined at 310 CMR 30.104(6) of the Massachusetts Hazardous Waste Regulations and which is being managed as a solid waste under EPA's application of the household hazardous waste exemption[2]

Soil means any unconsolidated mineral and organic matter overlying bedrock that has been subjected to and influenced by geologic and other environmental factors, excluding sediment as defined in 310 CMR 40.006.

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[2] United States Environmental Protection Agency - Region I, Letter to Mr. Philip O'Brien, Ph.D., New Hampshire Department of Environmental Services, ***Applicability of the Household Hazardous Waste Exclusion to Lead Contaminated Residential Soil***, April 21, 1995.

Toxicity Characteristic (TC) Waste means a waste that is a hazardous waste if the extract from a representative sample of the waste contains any of the materials listed in 310 CMR 30.125B at a concentration equal to or greater than the respective value given in that table. The extract is obtained using the Toxicity Characteristic test described in 310 CMR 30.155B. Where the waste contains less than 0.5% filterable solids, the waste itself, after filtering, is considered to be the extract for purposes of 310 CMR 30.125B.

Toxicity Characteristic Leaching Procedure (TCLP) means the Toxicity Characteristic test for determining whether a waste is a hazardous waste because of a Toxicity Characteristic defined in 310 CMR 30.125B.

Treated TCLP Soil includes both Treated TCLP Non-Lead and Treated TCLP-Lead Soil.

Treated TCLP Non-Lead Soil means Contaminated Soil that: originally failed the TCLP under 310 CMR 30.155B for a TC contaminant other than lead D008 (e.g. Hazardous Waste Codes: D004 Arsenic, D005 Barium, D006 Cadmium, D007 Chromium, D009 Mercury, D010 Selenium, and D011 Silver and the TC Organic Constituents D012-D043); and that has been treated in compliance with Title 40, Code of Federal Regulations Part 268 to the LDRs (e.g., passes the TCLP); and under the LDRs no longer requires management as a TC characteristic hazardous waste (e.g., may be managed as a solid waste).

Treated TCLP-Lead Soil means Contaminated Soil that: originally failed the Toxicity Characteristic Leaching Procedure (TCLP) under 310 CMR 30.155B for lead; has been treated in compliance with Title 40, Code of Federal Regulations Part 268 to the LDRs (e.g., passes the TCLP); and no longer requires management as a D008 TC characteristic hazardous waste (310 CMR 30.125B).

4.0 Contaminant Levels, and Approval Procedures for the Reuse and Disposal of Contaminated Soil at Massachusetts Landfills

4.1 Contaminant Levels for Reuse

Table 1 lists the allowable contaminant levels for reuse of soil at Massachusetts landfills. The Department has determined that Contaminated Soil which **does not exceed** the contaminant levels in **Table 1** may be reused as daily cover, intermediate cover and pre-capping contour material at Massachusetts landfills provided it is managed consistent with all the provisions of this Policy, the facility's permit and 310 CMR 19.000.

With respect to the contaminant levels and reuses identified in section 4.1, compliance with this Policy may constitute compliance with the requirements to obtain a Department approval for the handling of special waste at 310 CMR 19.061 and the requirements at 310 CMR 19.130(15) regarding cover material, for the categories of Contaminated Soil identified in this Policy.
A list of Massachusetts lined and unlined landfills may be obtained from the DEP InfoLine at (617) 338-2255. This list may be updated by the Department from time to time. These landfills shall be contacted by the generator, LSP or Qualified Environmental Professional to determine whether the operator has an interest in receiving Contaminated Soil for landfill reuse. It is the responsibility of the generator, and the LSP or QEP to determine whether a specific landfill may accept Contaminated Soil as described in this Policy.

4.2 Reuse of Contaminated Soil at Lined Landfills

Contaminated Soil that **does not exceed** the contaminant levels listed in **Table 1** for lined landfills and that is managed as described in this Policy may be reused at lined landfills as daily cover, intermediate cover and pre-capping contour material (e.g., grading and shaping material) without obtaining a prior Department approval. A Landfill - Minor Modification, BWP SW 22permit or other approval under 310 CMR 19.000 by the Department shall be obtained prior to the reuse at a lined landfill of any Contaminated Soil which:

- **exceeds** the contaminant levels in**Table 1**, or;
- may not be managed consistent with the guidelines in **Section 7.0, *Landfill Operation Practices***, or;
- contains oil and/or hazardous materials for which no threshold is provided in **Table 1**

4.3 Reuse of Contaminated Soil at Unlined Landfills

Unlined landfills may accept Contaminated Soil for reuse as: daily cover, intermediate cover, and pre-capping contour material without prior approval by the Department, provided such use is not in conflict with any consent order, consent degree, court judgment, or Department-approved closure plan or conceptual grading plan, and provided that: the Contaminated Soil **does not exceed**he contaminant levels for unlined landfills in **Table 1**; the soil is managed in accordance with the provisions of this Policy; the landfill has either a Department approved closure plan, or an approved permit or Administrative Consent Order with a Department approved closure schedule and has a Department approved conceptual grading plan. The closure plan and/or conceptual grading plan shall also have:

- an erosion control/sedimentation plan;
- an excavate (e.g., Contaminated Soil) placement plan; and
- for landfills that reuse the soil as daily cover, a Department approved limitation on the amount of Contaminated Soil which may be stockpiled for daily cover.

A Landfill - Minor Modification, BWP SW 22 permit or other approval by the Department shall be obtained prior to the reuse at an unlined landfill of any Contaminated Soil which:

- **exceeds** the contaminant levels in**Table 1**, or;
- may not be managed consistent with the guidelines of **Section 7.0,*Landfill Operation Practices***, or;
- contains oil and/or hazardous materials for which no threshold is provided in **Table 1**

4.4 Disposal of Contaminated Soil at Lined or Unlined Landfills

A Special Waste Determination (BWP SW 14 or BWP SW 31) or Other Department approval pursuant to 310 CMR 19.000 shall be obtained prior to the disposal of Contaminated Soil at a **lined or unlined landfill**. An **unlined landfill** must also have either a Department approved closure plan or have entered into an agreed upon closure schedule with the Department (e.g., Administrative Consent Order, permit).

Contaminated Soil which does not require notification under the MCP shall not be disposed of at landfills if a cost effective alternative exists that involves the reuse, recycling, destruction, and/or detoxification of such Contaminated Soil. Applicants seeking to dispose of Contaminated Soil at a Massachusetts landfill shall demonstrate the infeasibility of alternatives to such disposal. Feasibility determinations performed under 310 CMR 40.0032(5) and M.G.L. c. 21E will be considered sufficient for this purpose.

5.0 Testing and Characterization

5.1 General

This Section describes the type and level of information, data, and documentation the generator shall provide to the landfill operator when proposing the management of Contaminated Soil at a Massachusetts landfill. This information is consistent with that required under EPA's RCRA "due diligence" policy, for determining when environmental media (e.g., Contaminated Soil) is a hazardous waste (Federal Register, 53 FR 51444).

310 CMR 40.0000, 310 CMR 30.000 and Department Policies #WSC-94-400, #WSC-310-91, and #WSC-91-401[3] contain additional information applicable to the characterization of Contaminated Soil. Other federal requirements under the Toxic Substance Control Act (TSCA) or RCRA may also apply to the characterization of Contaminated Soil.

The landfill operator and the generator shall obtain sufficient information to demonstrate that the soil may be accepted by the landfill. It is the landfill operator's responsibility to obtain sufficient information to determine and document: the type and quantity of contaminated soil it receives and that it meets the Policy's acceptance criteria. This does not relieve the generator of the responsibility to appropriately and adequately characterize its waste and to send it only to facilities that may legally accept it.

[3] MDEP, BWSC Policy #WSC-91-401, ***Policy for the Investigation, Assessment, and Remediation of Petroleum Releases: Interim Site Investigation Protocol Document***, April 9, 1991.

CONTAMINANT	Reuse Levels (mg/kg)[a]	
	Lined Landfills	Unlined Landfill
Total Arsenic	40	40
Total Cadmium	80	30
Total Chromium	1,000	1,000
Total Lead	2,000	1,000
Total Mercury	10	10
Total Petroleum Hydrocarbons (TPH)	5,000	2,500
Total PCBs[b]	< 2	< 2
Total SVOCs[c]	100	100
Total VOCs[d]	10	4
Conductivity[e] (umhos/cm)	8,000 umhos/cm	4,000 umhos/cm
Listed or Characteristic Hazardous Waste (TCLP[f]	NONE	NONE

TABLE 1 NOTES:

a The reuse levels are expressed as total levels in mg/kg and apply to reuse of soil as daily cover, intermediate cover, and pre-capping contour material at lined landfills and unlined landfills as described in this Policy.

b Total concentrations of polychlorinated biphenyls EPA Method 8080.

c Total concentrations of compounds listed in EPA Method 8270.

d Total concentration of compounds listed in EPA Method 8260.

e For soil which may be expected to contain elevated NaCl.

f TCLP testing shall be performed for metals or organic compounds when the total concentrations in the soil are above the theoretical levels at which the TCLP criteria may be exceeded. For guidance parties shall consult United States Environmental Protection Agency, Memorandum #36, "Notes on RCRA Methods and QA Activities", pp. 19-21, Gail Hanson, January 12, 1993.

[Please note that the methods specified in footnotes d, e, and f indicate the universe of chemicals to be added up in calculating the total concentrations for these classes of contaminants. Section 5.0 of this Policy provides guidance for determining which specific chemicals must be considered chemicals of concern (e.g., contaminants) within the soil. This Policy does not specify the analytical test methods to be used to quantify the specific contaminants. Readers can consult 310 CMR 40.0017 Environmental Sample Collection and Analysis, 310 CMR 30.110 Criteria, Procedures for Determining Which Wastes are to be Regulated as Hazardous Waste or Non-Hazardous Waste and 310 CMR 30.151 Representative Sampling Methods for additional information which may be applicable to the selection of appropriate sampling and analytical methods.]

5.2 Testing

Contaminated Soil shall be sampled at sufficient and adequately distributed locations so that the concentrations of the contaminants of concern in the soil are adequately characterized. The factors listed below shall be considered when developing and implementing such a sampling plan. Evaluation of release, source, and site specific conditions assist in developing the basis for the selection of field screening techniques, sampling methodologies, sampling frequencies, and the contaminants of concern (e.g., analytical parameters) used to characterize Contaminated Soil. These include, but are not necessarily limited to the following:

- the type(s) and likely constituents of the petroleum oil (e.g., unused waste oil, used waste oil, or mixtures) or hazardous material known or suspected to be the source of the contaminants;
- the presence or likelihood of any other oil and/or hazardous materials (e.g., chlorinated solvents, metals, polychlorinated biphenyls (PCBs), semi-volatile organic compounds (SVOCs) , halogenated volatile organic compounds (VOCs));
- current and former site uses, past incidents involving the spill or release of oil and/or hazardous material, and past and present management practices of oil and/or hazardous materials at the site;
- the potential for the soil to contain listed hazardous waste or to be a characteristic hazardous waste;
- visual/olfactory observations, field screening, analytical data, and/or in-situ pre-characterization data;
- soil matrix type - naturally occurring soil or fill/soil mixtures (e.g., homogeneous or heterogeneous soil conditions);
- the identification and segregation of discrete "hot spots";
- soil volume; and
- the presence of anthropogenic contaminants (e.g., arsenic, lead).

5.3 Treated TCLP Soil

Generators of Treated TCLP Soil shall also comply with the characterization, waste analysis, notification, reporting and licensing requirements of the applicable federal and state Hazardous Waste Regulations. These requirements may include, but are not limited to, the provisions of Title 40 Code of Federal Regulations Parts: 262.11, 264, 265, and 268.

5.4 Residential Lead Soil

Residential Lead Soil shall be characterized as described in this Policy to determine whether it meets **all** the acceptance criteria, contaminant levels and guidelines of this Policy. The characterization shall include ascertaining whether the Contaminated Soil: exceeds the contaminant levels in**Table 1**; contains other oil and/or hazardous materials or listed hazardous waste; or if it is a characteristic hazardous waste other than lead (i.e., D001-D007, or D009-D043 Hazardous Waste).

Residential Lead Soil intended for reuse or disposal at a lined landfill need not be tested to determine if it is D008 TC Waste (e.g., lead). Residential Lead Soil intended for reuse at an unlined landfill that does not contain total lead **in excess** of 1000 mg/kg also does not require TCLP testing to determine if it is a D008 TC Waste (e.g., lead). However, the Department may require TCLP testing for Residential Lead Soil intended for reuse at an unlined fill if the total lead level exceeds 1000 mg/kg.

5.5 Documentation

When accepting Contaminated Soil a landfill operator shall obtain sufficient information and documentation to determine whether the Contaminated Soil has been adequately characterized, meets the Policy's acceptance criteria, and may be reused by the landfill, as provided in this Policy. The documentation shall include, but not necessarily be limited to, the following types of information:

- quantity of Contaminated Soil;
- a description of the source and type of the release and the contaminants;
- a description of current and former site usage;
- chemical characterization of the soil including any laboratory analytical data used to support the determination;
- any field screening analytical data used to support the determination;
- a physical description of the soil including the soil classification method used;
- a statement from the generator as to whether any other releases or spills have occurred in the vicinity of the site which may have affected the site, including the types of oil and hazardous material spilled/released;
- a statement that the generator has used due diligence, as described in the Department's Policy HW93-01 in characterizing the soil and as to whether or not the soil contains a listed hazardous waste and/or is itself a characteristic hazardous waste; and
- in addition, for TCLP-Treated Soil, from the treater, a description of the treatment process and a copy of the waste analysis plan complying with Title 40 Code of Federal Regulations Part 264, 265, or 268, as applicable.

Section 6.0 Transportation, Shipping Documentation, Record Keeping and Reporting

6.1 General

The transportation of Contaminated Soil to Massachusetts landfills shall be conducted in accordance with the 21E Bill of Lading (21E BOL) provisions of 310 CMR 40.0030 (**Section 6.2, *21E Bill of Lading***), if applicable, or, if not applicable, the Material Shipping Record (MSR) (**Section 6.3, *Material Shipping Record***) procedures described in this Policy. Contaminated Soil generated at out-of-state locations and transported to Massachusetts landfills shall use a Material Shipping Record.

Soil may be transported by common carrier, provided that this method of transport is protective of the public health, safety, welfare and the environment. All soil shall be covered by a tarpaulin or other means during transport to prevent the soil from escaping the truck during transport (310 CMR 40.0036(5) Management Requirements for Storing Remediation Waste and M.G.L. c.85 Sec.36 Construction and loading of vehicles to prevent dropping of load on way).

Nothing in this Section is intended to prohibit the voluntary use of the 21E Bill of Lading process to document the transport of soil with contamination below the applicable 120 day notification threshold, specified in 310 CMR 40.0300 and 310 CMR 40.1600.

6.2 21E Bill of Lading

Contaminated Soil generated and transported within Massachusetts shall comply with the MCP, as applicable. The MCP requires that Contaminated Soil containing oil and/or hazardous material at concentrations equal to or greater than a release notification threshold established by 310 CMR 40.0300 and 310 CMR 40.1600 shall be transported in compliance with the 21E Bill of Lading requirements of 310 CMR 40.0034 and 40.0035 of the MCP.

6.3 Material Shipping Record

Contaminated Soil, containing oil and/or hazardous material at concentrations **less** than an applicable release notification threshold established by 310 CMR 40.0300 and 310 CMR 40.1600, need not be transported in accordance with the 21E BOL provisions. Contaminated Soil generated from out-of-state locations also is not subject to the 21E BOL requirements of the MCP. Therefore, for these classes of Contaminated Soil, a Material Shipping Record (MSR) shall be submitted to the landfill by the generator with the certification of a Qualified Environmental Professional (QEP). **Attachment III, *Material Shipping Record and Instructions***, includes a description of the qualifications of the QEP and a copy of the MSR form.

Treated TCLP-Lead Soil that has been treated at and is generated from a licensed Commercial Hazardous Waste Treatment, Storage or Disposal Facility (TSDF, see Section 3), shall be shipped from the TSDF to the landfill using a Material Shipping Record. The QEP for purposes of the MSR may be the individual at the TSDF responsible for implementing the TSDF's waste analysis plan.

6.4 Facility Record Keeping

All record keeping shall be in compliance with 310 CMR 19.009 of the Solid Waste Management Regulations. Copies of the 21E BOLs, MSRs and all supporting documentation submitted by the generator to the landfill shall be kept by the landfill operator for review by Department staff. All 21E BOLs, MSRs and supporting documentation shall be kept by the landfill permittee at the facility, unless an alternate location has been approved by the Department, for at least three (3) years. This period shall be automatically extended for the duration of any enforcement action. This period may also be extended by the Department.

6.5 Reporting

Landfills that use Contaminated Soil as daily or intermediate cover, or pre-capping contour material or for disposal shall send 21E BOL and MSR summary reports as part of the landfill's regular annual operational reports to the appropriate Department Regional Office (See Attachment I for the Department Regional Office addresses). The summary reports shall include the source of the Contaminated Soil, volumes, dates received, use and reference the 21E BOL or BWP MSR Tracking Numbers.

7.0 Landfill Operation Practices

The reuse of Contaminated Soil, containing contaminants at concentrations which **do not exceed** the contaminant levels in **Table 1**, as daily cover, intermediate cover or pre-capping contour material at landfills, is based in part on the results of a risk assessment by the Department's Office of Research and Standards. This risk assessment was predicated on adherence to the landfill operating procedures listed below. Therefore, these procedures shall be followed when managing Contaminated Soil at a Massachusetts landfill.

1. When it is used for daily cover the standards in daily cover in 310 CMR 19.130(15) shall be met, including the requirement that the cover material be substantially odor free.

2. Contaminated Soil applied as daily cover shall not exceed 25% of the total volume of solid waste disposed in any single day.

3. When Contaminated Soil is proposed for use as intermediate cover, the standards in 310 CMR 19.130(15)(c) shall be met including the requirement that the material meet the following Unified Soil Classification System categories: G.C.; S.C.; C.H.; C.L.; or O.H.

4. Unlined landfills that accept Contaminated Soil for use as daily cover, intermediate cover and pre-capping contour material shall have in place Department approved erosion control and excavate placement plans. In addition, unlined landfills that accept Contaminated Soil for use as daily cover shall have a Department approval specifying the quantity of Contaminated Soil to be stockpiled for use as daily cover.

5. Daily cover or other reuse materials which contain Contaminated Soil shall be applied within 90 days of receipt at the facility.

6. Preventative maintenance shall be employed to ensure that the Contaminated Soil, whether stockpiled or applied to the landfill, does not erode into the area between the operating footprint of the landfill and the property boundary.

7. Fugitive dust levels shall be kept to a minimum through the use of Best Management Practices such as chemical addition or other Department-approved method. Contaminated Soil shall be prohibited from use on haul roads or other areas used for vehicle or truck traffic.

8. Stockpiling of Contaminated Soil intended for use at lined landfills shall be limited to portions of the landfill which are lined. Stockpiling of Contaminated Soil at unlined landfills shall be restricted to areas above the existing landfill footprint.

9. Storage of Contaminated Soil shall not take place on areas of the landfill which have received final cover.

10. Contaminated Soil shall not be applied or placed in contact with the landfill liner.

11. Contaminated Soil shall have no free draining liquids. Visual inspection based on the source of excavate shall be sufficient to determine whether there are free draining liquids in most

cases. When there is a question whether this standard is met, EPA Method 9095 shall be used to determine the presence of free liquids in a representative sample of the Contaminated Soil.

12. The Contaminated Soil shall be free of solid waste (e.g., construction and demolition debris or other putrescible matter). See 310 CMR 16.05(3)(i) for conditionally exempted rubble processing (crushing) operations.

8.0 Reuse and Disposal of Treated TCLP Soil at Massachusetts Landfills

8.1 General

This Section provides guidance on the reuse and disposal of Treated TCLP Soil (see Section 3) by Massachusetts landfills. The guidance provided by this Policy does not waive, relieve, or limit the responsibility of the generator, treatment facility and landfill owner/operator to comply with all applicable laws and regulations, including but not limited to 310 CMR 16.000, 310 CMR 19.000, 310 CMR 30.000, 310 CMR 40.0000 and Title 40 Code of Federal Regulations Parts 260 through 271 (Federal Hazardous Waste Regulations). This includes, but is not limited to, the certification, treatment, characterization, notification, and other requirements of 40 CFR Part 268 Land Disposal Restrictions (LDRs or Land Ban Restrictions).

The landfill operator and the TSDF shall obtain sufficient information to demonstrate that the Contaminated Soil may be accepted by the landfill. It is the landfill operator's responsibility to obtain sufficient information from the TSDF to determine and document: the type and quantity of Contaminated Soil it receives, that it meets the Policy's acceptance criteria, and the landfill has complied with 310 CMR 19.130(5). This does not relieve the TSDF of its responsibility to appropriately and adequately characterize its waste and to send it only to facilities that may legally accept it.

8.2 Reuse and Disposal of Treated TCLP-Lead Soil at Lined Landfills

Treated TCLP-Lead Soil (see Section 3.0) may be reused or disposed at Massachusetts lined landfills provided that it is managed consistent with the acceptance criteria, contaminant levels, and the operational and procedural guidelines of this Policy and 310 CMR 19.000. The ***Treated TCLP-Lead Soil*** also shall comply with the characterization (testing,etc.), procedural and treatment requirements of 310 CMR 30.000 and the provisions of the RCRA Hazardous Waste Regulations, Title 40 Code of Federal Regulations Parts 260 through 271. This includes, but is not limited to the requirements of Title 40 Code of Federal Regulations Parts: 262.11, and 268. Title 40 Code of Federal Regulations Part 268 Subpart D - Treatment Standards specifies the applicable Land Disposal treatment standards.

8.3 Reuse and Disposal of Treated TCLP-Lead Soil at Unlined Landfills

The reuse and disposal of Treated TCLP-Lead Soil is prohibited at unlined landfills.

8.4 Treated TCLP-Lead Soil Generated at Commercial Hazardous Waste Treatment, Storage and Disposal Facilities (TSDFs)

TCLP-Lead Soil that has been treated by a TSDF operating as either a Part 265 Interim Status Facility or as a Part 264/Part 270 Permitted Hazardous Waste Facility, may be reused or disposed at Massachusetts landfills provided that it is managed consistent with the acceptance criteria, operational, and procedural guidelines of this Policy. The TSDF shall provide the landfill operator receiving the treated Contaminated Soil with sufficient documentation, including the original source and site of the spill or release of the Contaminated soil, to demonstrate that the reuse or disposal of the treated Contaminated Soil at the Massachusetts landfill is in accordance with this Policy.

The landfill operator shall utilize the guidance provided in**Section 5.0, *Testing and Characterization*** in evaluating the adequacy of the information submitted to it by a TSDF. Documentation by the TSDF that the Contaminated Soil no longer fails the TCLP test for lead is not sufficient for demonstrating the Contaminated Soil may be managed under this Policy. The documentation submitted by the TSDF shall be consistent with that described in **Section 5.5, *Documentation***.

The landfill operator in evaluating the adequacy of the post treatment analytical testing by the TSDF, may consider the degree to which the TSDF's waste analysis plan sufficiently documents that the Contaminated Soil meets the acceptance criteria of this Policy. The level of post-treatment analytical testing necessary beyond that required in a TSDF's waste analysis plan shall be a function of the degree to which the TSDF's waste analysis plan reflects and provides the information described in **Section 5.0**.

Treated TCLP-Lead Soil that has been treated at and is generated from a TSDF (see Section 3) shall be shipped from the TSDF to a Massachusetts lined landfill using a Material Shipping Record. The QEP for purposes of the MSR may be the individual at the TSDF responsible for implementation of the TSDF's waste analysis plan.

8.5 Management of Treated TCLP Non-Lead Soil at Massachusetts Landfills

Treated TCLP Non-Lead Soil, as defined in Section 3, is Contaminated Soil that failed the TCLP for a TC constituent other than lead and that has subsequently been treated to remove the characteristic (e.g., pass TCLP) and meets the **LDRs**, and as a result under RCRA may be managed as a solid waste. Treated TCLP Non-Lead Soil may be accepted by Massachusetts lined landfills for reuse or disposal only if the Department has issued the landfill a Special Waste Determination (BWP SW 14 or BWP SW 31 permit), Beneficial Use Determination (BWP SW 13 or BWP SW 30 permit), Landfill Minor Modification (BWP SW 22 permit) or Other Approval under 310 CMR 19.000, regardless of whether or not the contaminant levels **do not exceed** those in Table 1. Treated TCLP Non-Lead Soil is **prohibited** from reuse or disposal in unlined Massachusetts landfills.

9.0 Reuse and Disposal of Residential Lead Soil at Massachusetts Landfills

Section 9.1 General

Residential Lead Soil, as defined in Section 3, is lead-Contaminated Soil originating from a location which qualifies as a household under Section 310 CMR 30.104(6), of the Massachusetts Hazardous Waste Regulations, and for which the generator has also determined, using due diligence as discussed in **Department Policy HW93-01**, that there is no affirmative evidence that the lead contamination results from an industrial source (e.g., lead paint). Such Contaminated Soil may be managed, under EPA's application of the household hazardous waste exemption (see Section 3), as a solid waste.

Section 9.2 Reuse of Residential Lead Soil at Lined Landfills

Residential Lead Soil may be accepted for reuse by Massachusetts **lined landfills** in accordance with the procedures described in **Section 4.2, *Reuse of Contaminated Soil at Lined Landfills*** providing it is managed in accordance with and meets **all** the other requirements of this Policy. As described in **Section 5.4, *Residential Lead Soil***, Residential Lead Soil intended for reuse at a lined landfill **need not** be tested using the TCLP to determine if it is a D008 (lead) TC Waste.

Section 9.3 Reuse of Residential Lead Soil at Unlined Landfills

Residential Lead Soil may be accepted for reuse by Massachusetts **unlined landfills** in accordance with the procedures described in **Section 4.3, *Reuse of Contaminated Soil at Unlined Landfills*** providing it is managed in accordance with and meets **all** the other requirements of this Policy. As described in **Section 5.4, *Residential Lead Soil***, Residential Lead Soil intended for reuse at a unlined landfill **need not** be tested using the TCLP to determine if it is a D008 (lead) TC Waste if the total lead level **does not exceed** 1000 mg/kg. The Department may require TCLP testing for Residential Lead Soil containing lead at total levels **exceeding** 1000 mg/kg when reviewing requests for the reuse of such soil at unlined landfills.

9.4 Disposal of Residential Lead Soil at Lined and Unlined Landfills

A Special Waste Determination (BWP SW 14 or BWP SW 31) or Other Department approval shall be obtained prior to the disposal of Residential Lead Soil at a lined or unlined landfill. An unlined landfill shall also have either a Department approved closure plan or have entered into an agreed upon closure schedule with the Department (e.g., Administrative Consent Order).

ATTACHMENT I: ADDRESSES OF DEPARTMENT REGIONAL OFFICES

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436 Dwight Street, Suite 402
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Attn: Mark Schleeweis

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ATTACHMENT II: BIBLIOGRAPHY OF RELATED DOCUMENTS

1. Massachusetts Department of Environmental Protection, Policy BWP-94-092, ***Reuse and Disposal of Street Sweepings Department of Environmental Protection Bureau of Waste Prevention, Final Policy # BWP-94-092***, April 15, 1997.

2. Massachusetts Department of Environmental Protection, 310 CMR 30.000, ***Hazardous Waste Regulations***, August 23, 1996.

3. Massachusetts Department of Environmental Protection, 310 CMR 40.0000, ***Massachusetts Contingency Plan***, April 5, 1996.

4. Massachusetts Department of Environmental Protection, 310 CMR 4.00, ***Timely Action Schedule and Fee Provisions***, November 3, 1995.

5. United States Environmental Protection Agency - Region I, Letter to Mr. Philip O'Brien, Ph.D., New Hampshire Department of Environmental Services, ***Applicability of the Household Hazardous Waste Exclusion to Lead Contaminated Residential Soil***, April 21, 1995.

6. Massachusetts Department of Environmental Protection, Policy # WSC-94-400, ***Interim Remediation Waste Management Policy for Petroleum Contaminated Soils*** April 21, 1994.

7. Massachusetts Department of Environmental Protection, ***Interim Policy HW 93-01, Regarding the Regulatory Status of Soil Contaminated with Waste Oil of Unknown Origin*** Memorandum from Thomas Powers, Deputy Commissioner, January 11, 1993.

8. Massachusetts Department of Environmental Protection, 310 CMR 16.000, ***Site Assignment Regulations for Solid Waste Facilities***, July 3, 1992.

9. Massachusetts Department of Environmental Protection, 310 CMR 19.000, ***Solid Waste Management Facility Regulations***, July 3, 1992.

10. Massachusetts Department of Environmental Protection, Policy # WSC-91-401, ***Policy for the Investigation, Assessment, and Remediation of Petroleum Releases: Interim Site Investigation Protocol Document***, April 9, 1991.

11. Massachusetts Department of Environmental Protection, Policy # WSC-310-91, ***Standard References for Monitoring Wells***, April 1991.

COMMONWEALTH OF MASSACHUSETTS
EXECUTIVE OFFICE OF ENVIRONMENTAL AFFAIRS
DEPARTMENT OF ENVIRONMENTAL PROTECTION
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Governor

JANE SWIFT
Lieutenant Governor

BOB DURAND
Secretary

LAUREN A. LISS
Commissioner

October 11, 2000

Mr. Ron Ostrowski
Devens Commerce Center
43 Buena Vista Street
Devens, MA 01432

RE: Reuse of Pesticide Contaminated Soil at Massachusetts' landfills - **Approval.**

Dear Mr. Ostrowski:

The Massachusetts Department of Environmental Protection (the "Department") has reviewed "Appendix A of General Excavated Soil Management Plan - Procedures for Management of Pesticide Contaminated Soil" (the "Plan") dated July 2000 for the Fort Devens site. The Plan was prepared by Haley & Aldrich, Inc. of Boston, Massachusetts as required by Department's Administrative Consent Order number ACO-CE-96-300. The Plan presents options for the management of pesticide contaminated soil generated at the Fort Devens site, including transporting pesticide contaminated soil to Massachusetts landfills for reuse in accordance with Department guidance document COMM-97-001 The Reuse and Disposal of Contaminated Soil at Massachusetts Landfills (the "Policy"). The Plan recognizes that pesticides are not listed as a contaminant in Table 1 of the Policy and notes that the Department intends to issue guidance on the management of pesticide contaminated soil at Massachusetts' landfills.

The Department is in the process of developing guidance for the reuse and disposal of pesticide contaminated soil at Massachusetts's landfills and has reviewed the appropriateness of including pesticides in the SVOC criteria for the purposes of Table 1: *Contaminant Levels for Soil Reuse at Landfills,* of the Policy. However, the final guidance document for the management of pesticide contaminated soil will not likely be available until later this fall.

Therefore, as provided by Department Policy COMM-97-001 the Department **approves** the use of pesticide contaminated soil from the Fort Devens site at Massachusetts' landfills provided:

- the concentration of the organochlorine pesticides are determined using EPA Method 8081A,

Enclosure 2

- the pesticides have been applied to the soil in accordance with the manufacturer's instructions,
- the pesticides do not cause the soil to be either a listed or characteristic hazardous waste under 310 CMR 30.000 (the Massachusetts Hazardous Waste Regulations) or Title 40 Part 261 of the Code of Federal Regulations Identification and Listing of Hazardous Waste (40 CFR 261),
- the concentrations of those pesticides listed as analytes under EPA Test Methods 8270C and 8081A are included in the total SVOC concentration for the purposes of Table 1 of Department Policy COMM-97-001, and
- the pesticide containing soil is managed and reused in accordance with the guidance provided in COMM-97-001.

Please be advised this approval may be modified as necessary in the future after the Department issues new guidance for the management of pesticide contaminated soil.

Should you have any questions regarding this letter please do not hesitate to contact John Regan at (508) 767-2840.

Sincerely,

Robert Bois
Section Chief
BWP CERO

P:/JREGAN/LFCVR

Cc: Ed MacDonald, DEP/BWP/NERO
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Purna Rao, DEP/BWP/CERO
John Carrigan,DEP/BWP/BC
Carol Keating, EPA
James Chambers, Devens BRAC

APPENDIX H

OBSERVATIONS FROM PRELIMINARY ASSESSMENT SITE INSPECTION FIELD RECONNAISSANCE



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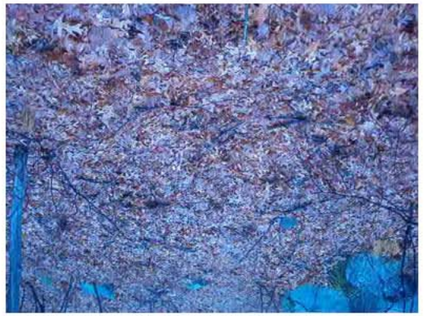

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APPENDIX I

SUPPLEMENTAL SITE INVESTIGATION WORK PLAN

U.S. Army Corps of Engineers

New England District
Concord, Massachusetts

STUDY AREAS - GRANT, LOCUST, AND CAVITE HOUSING AREAS
FORMER FORT DEVENS ARMY INSTALLATION
DEVENS, MASSACHUSETTS

RTN: 2-0662
Contract No. DACA31-00-D-0023
Task Order No. 0046

DCN: DVNPASI-050605-AAQV

FINAL
SUPPLEMENTAL SITE INVESTIGATION
WORK PLAN

MAY 2005

01M-0007

WESTON SOLUTIONS

FINAL

SUPPLEMENTAL SITE INVESTIGATION WORK PLAN
STUDY AREA – GRANT, LOCUST, AND CAVITE HOUSING AREAS
FORMER FORT DEVENS ARMY INSTALLATION
DEVENS, MASSACHUSETTS

Contract No. DACA31-00-D-0023
Delivery Order No. 0046
DCN: DVNPASI-050605-AAQV

Prepared for:

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May 2005

W.O. No. 03886.518.045

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LIST OF ACRONYMS

Army	United States Army
ASR	*Archive Search Report*
AST	aboveground storage tank
ASTM	American Society for Testing and Materials
bgs	below ground surface
BRAC	Base Realignment and Closure
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CFR	Code of Federal Regulations
CoCs	constituents of concern
COC	chain-of-custody
CRZ	Contamination reduction (decontamination) zone
DNAPL	dense non-aqueous phase liquid
DO	dissolved oxygen
DOT	Department of Transportation
DQO	data quality objectives
DRFTA	Devens Reserve Forces Training Area
EPA	U.S. Environmental Protection Agency
EPH	Extractable Petroleum Hydrocarbons
ESCA	Environmental Services Cooperative Agreement
EZ	Exclusion zone
FID	Flame Ionization Detector
ft	foot/feet
GPS	Geographic Positioning System
HSA	Hollow-stem auger
IA	Investigation Area
ID	inside diameter
IDW	investigation-derived wastes
MassDevelopment	Massachusetts Development Finance Agency
MCP	Massachusetts Contingency Plan
MDEP	Massachusetts Department of Environmental Protection
MEC	Munitions and Explosives of Concern
mg/kg	milligrams per kilogram
ml	milliliter
mm	millimeter

LIST OF ACRONYMS (continued)

MS/MSD	Matrix Spike/Matrix Spike Duplicate
NAPL	non-aqueous phase liquid
NTP	Notice to Proceed
NTU	nephelometric turbidity unit
ORP	oxidation-reduction potential
OSHA	Occupational Safety and Health Administration
PA/SI	Preliminary Assessment/Site Inspection
PAH	Polycyclic Aromatic Hydrocarbons
PCBs	polychlorinated biphenyls
PID	photoionization detector
PPE	personal protective equipment
PVC	polyvinyl chloride
QAPP	Quality Assurance Project Plan
QA	Quality Assurance
QC	Quality Control
RAM	Release Abatement Measure
RCRA	Resource Conservation and Recovery Act
RPD	relative percent difference
SAP	Sampling and Analysis Plan
SMA	Stockpile Management Area
SOP	Standard Operating Procedure
SSI	Supplemental Site Investigation
SVOCs	semi-volatile organic compounds
SZ	support zone
TAL	Target Analyte List
TCL	Target Compound List
TCLP	Toxicity Characteristic Leaching Procedure
TSCA	Toxic Substance Control Act
USACE	U.S. Army Corps of Engineers, New England District
USCS	Unified Soil Classification System
USDA	United States Department of Agriculture
USGS	United States Geological Survey
UV	Ultraviolet

LIST OF ACRONYMS
(concluded)

UXO	unexploded ordnance
VOCs	volatile organic compounds
WESTON®	Weston Solutions, Inc.

EXECUTIVE SUMMARY

EXECUTIVE SUMMARY

This Work Plan (WP) outlines the sampling activities for a Supplemental Site Investigation (SSI) of the Study Area - Grant, Locust, and Cavite Housing Areas. This SSI WP was prepared with consideration of input provided by the United States Environmental Protection Agency (EPA), Massachusetts Department of Environmental Protection (MDEP), MassDevelopment, U.S. Army Corps of Engineers, New England District, and the Army during Base Realignment and Closure Team meetings and conference calls between October 2003 and April 2004.

The SSI is a continuation of investigation activities conducted within the housing areas based on the results of findings from the Massachusetts Contingency Plan (MCP)-regulated Pesticide Soil Remedial Action (2002) and EPA-regulated Preliminary Assessment and Site Inspection (PASI) of 2003.

During the course of pesticide remediation activities conducted at the Former Grant, Locust, Cavite, Housing Areas in 2002, several constituents including Total Petroleum Hydrocarbon, polycyclic aromatic hydrocarbons, arsenic, and polychlorinated biphenyls (PCBs) were detected during characterization and confirmation sampling. These compounds were not initially site Constituents of Concern (CoCs) based on existing site data and site usage as housing areas.

On 13 March 2003 (as modified in e-mail message dated 17 September 2003), EPA forwarded a letter to the Army notifying that the Grant, Locust, and Cavite Housing Areas should become a Study Area and that a PASI should also be performed to determine whether a release or potential releases of Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA)-regulated compounds existed and to assess the nature of any threats to human health and the environment associated with any releases.

The PASI field activities were initiated in October 2003 and completed in December 2003. During the first phase of PASI efforts, historical site information and existing analytical databases were reviewed to establish if a CERCLA release or potential release of arsenic, lead, explosives, and/or PCBs existed within the Study Area. Follow-up sampling activities focused on areas of previously detected contaminants and historical training areas and firing ranges to determine if additional action was warranted at these locations. In addition, an assessment to

determine if the presence of arsenic resulted from an anthropogenic release or natural occurrence was conducted. The results of the PASI activities are addressed in the *Draft Preliminary Assessment/Site Inspection (PA/SI) Report* (WESTON, 2004).

The results of the PASI effort and follow-up discussions between the EPA, MDEP, and Army concluded that additional data was required to address data gaps and to evaluate groundwater within the Study Area. The intent of this SSI effort is to provide for additional data for the evaluation of Investigation Areas (IAs) within the Study Area - Grant, Locust, and Cavite Housing Areas. The CoC list has been expanded to include: volatile organic compounds, semi-volatile organic compounds, PCBs, pesticides, Extractable Petroleum Hydrocarbons, and Target Analyte List metals (including earth metals), perchlorate, dioxins/furans, and explosives analysis.

SSI field activities will include the following tasks:

- Field Reconnaissance and Mapping
- Soil Borings and Sampling
- Test Pit Sampling
- Monitoring Well Installation
- Piezometer Installation
- Groundwater Sampling

This SSI WP is divided into 6 sections as follows:

Section 1 – Introduction – Provides a brief use history and regulatory background for the Former Fort Devens; establishes the objectives of the SSI, and provides and overview of the approach for achieving those objectives.

Section 2 – Description of the Former Fort Devens Installation – Provides a more in depth use history for the Former Fort Devens Study Area, based on the PA/SI work conducted to date. Discusses site features and site uses for the Former Grant, Locust, and Cavite Housing Areas. Also provides a discussion of the physical setting of the Study Area.

Section 3 – Supplemental Site Investigation Activities – Discusses sampling locations and rationale for each of the Study Areas and IAs that are to be addressed in this SSI. The IAs to be addressed are:

- IA-1 Former Training Area (circa 1922)
- IA-2 Former Training Area and/or Range (circa 1922)
- IA-3 Former Rifle Range
- IA-5 Sub-Caliber Anti-Tank Range

- IA-7 Sub-Caliber Anti-Tank Range
- IA-8 Former Base Laundry Buildings
- IA-9 Cavite Housing Area
- IA-10 Grant Housing Area
- IA-11 Locust Housing Area

Section 4 – Sample Collection/Analysis Procedures – Provides the pertinent elements of a Sampling and Analysis Plan and serves as an addendum to the *Sampling and Analysis Plan for the Release Abatement Measures for the Shirley, Grant, Locust, and Cavite Housing Areas, and Pesticide Remediation at the Chlordane Cell – Devens, Massachusetts* (WESTON, April 2002).

Section 5 – Quality Assurance Procedures – Provides the pertinent elements of a Quality Assurance Project Plan and serves as the second half of an addendum to *the Sampling and Analysis Plan for the Release Abatement Measures for the Shirley, Grant, Locust, and Cavite Housing Areas, and Pesticide Remediation at the Chlordane Cell – Devens, Massachusetts* (WESTON, April 2002)

Section 6 – Schedule – Provides and schedule for completion of the SSI activities described in this WP.

Section 7 - References

SECTION 1

INTRODUCTION

1. INTRODUCTION

This document outlines the sampling activities for a Supplemental Site Investigation (SSI) of the Study Area (Grant, Locust, and Cavite Housing Areas) in accordance with the United States Army (Army)-U.S. Environmental Protection Agency (EPA) Federal Facilities Agreement, and the Army-Massachusetts Development Finance Agency (MassDevelopment) Environmental Services Cooperative Agreement (ESCA). The SSI Work Plan addresses the potential for data gaps associated with the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) of 1980, as amended, assessment for potential regulated contaminants in the Study Areas during 2002. This SSI Work Plan (WP) was also prepared in consideration of input provided by EPA, Massachusetts Department of Environmental Protection (MDEP), MassDevelopment, U.S. Army Corps of Engineers (USACE), New England District, and the Base Realignment and Closure (BRAC) Environmental Coordinator during BRAC Closure Team meetings and conference calls between October 2003 and April 2004.

1.1 BACKGROUND

The Army established Fort Devens in 1917 as a temporary training area for soldiers during World War I. In 1931, Fort Devens became a permanent installation with the primary mission of commanding, training, and providing logistical support for non-divisional troop units. The installation also supported the Army Readiness Regional and National Guard units in the New England area.

In 1982, an *Installation Assessment of Headquarters Report* (Environmental Science & Engineering, Inc., 1982) for the Fort Devens site (EPA ID MA7210025154) was completed. Subsequent to the report, Fort Devens was designated as a CERCLA site as amended by the Superfund Amendments and Reauthorization Act. Fort Devens was placed on the National Priorities List on 21 November 1989. Subsequently, an *Enhanced Preliminary Assessment Report* (Roy F. Weston, Inc., 1992) and a *Final Site Inspection Report* (Arthur D. Little, 1993) were completed to assess impacts at 69 Areas Requiring Environmental Evaluation and Study Areas.

Fort Devens was identified for cessation of operations and closure under Public Law 101-510, the BRAC Act of 1990, and officially closed in September 1996. Portions of the property formerly occupied by Fort Devens were retained by the Army for reserve forces training and renamed the Devens Reserve Forces Training Area (DRFTA). Areas not retained as part of the DRFTA were, or are in the process of being, transferred to new owners for reuse and redevelopment.

In 2002, a Release Abatement Measure (RAM) to remediate pesticide-impacted soils was performed by Weston Solutions, Inc. (WESTON®) at 150 former building locations within the Study Areas (Figure 1-1). The work was performed under Contract No. DACW33-00-D-0007, Task Order No. 0005 with USACE. The remedial action was regulated under the MDEP Release Tracking Number 2-0662 and the Massachusetts Contingency Plan (MCP).

It had been previously determined through evaluation of historical information and soil analyses that the Army had applied pesticides to the soil (in a manner approved at the time of application) at the site, during and possibly after construction of the buildings, as part of periodic pest control procedures. Under an ESCA between the Army and MassDevelopment, the BRAC office (representing the Army) agreed to implement RAM activities at the Study Areas. The BRAC office engaged USACE to implement RAM activities. USACE subsequently retained the services of WESTON to perform the RAM activities.

The primary objectives of the remedial action were: removal and disposal or reuse of concrete slabs and frost walls; removal and disposal of asbestos-containing materials; and excavation and disposal of pesticide-impacted soil from beneath former building slabs to meet established project clean-up goals.

Prior to the initiation of remedial activities, a pre-remedial characterization sampling program was conducted to determine the concentrations of constituents of concern (CoCs) in soils below the existing building slabs for the purposes of waste disposal characterization and profiling.

Characterization results indicated a high rate of arsenic detections within soils below the building foundations in all three housing areas in excess of the established base background concentration of 19 milligrams per kilogram (mg/kg). Because of the high rate of arsenic occurrences at

concentrations greater than 19 mg/kg, an assessment to determine if the presence of arsenic resulted from an anthropogenic release or natural occurrence was conducted. The results of the assessment are addressed in the *Draft Preliminary Assessment/Site Inspection (PA/SI) Report* (WESTON, 2004).

Following the completion and evaluation of the pre-remedial characterization results, WESTON initiated remedial activities at the site. Pesticide-impacted soils were excavated and disposed off-site; post-excavation confirmatory sampling and analysis was conducted; and the excavations were backfilled in accordance with the project work plans.

During the course of pesticide remediation activities, Polycyclic Aromatic Hydrocarbons (PAH), Total Petroleum Hydrocarbon (TPH), and Polychlorinated Biphenyl (PCB) compounds were detected during the characterization sampling program at a at concentrations above the EPA standard of 1 mg/kg in 12 buildings and one Stockpile Management Area (SMA) at the Grant Housing Area (Buildings 838, 857, 858, 861, 862, 863, 864, 865, 866, 869, 874, 877), and Poplar Circle SMA.

Polycyclic aromatic hydrocarbons and TPH data collected during the characterization process and follow-up remedial activities appears to indicate that any release at these buildings was very limited extent. The data indicates that although the PAH and TPH impacted soils coexisted with pesticide impacted soil, there was no discernable association with the application of pesticides. Further sample analysis indicated that the PAH- and TPH-impacted soils were remediated as part of the activities associated with the pesticide removal action.

The presence of PCBs in soil samples at concentrations above the EPA standard of 1 mg/kg in 12 buildings and one Stockpile Management Area (SMA) at the Grant Housing Area (Buildings 838, 857, 858, 861, 862, 863, 864, 865, 866, 869, 874, 877, and Poplar Street SMA) was discovered during the on-site laboratory analyses for pesticides. When PCBs were detected in the screened samples, the samples were submitted to an off-site laboratory for verification. Polychlorinated biphenyls were not detected in samples collected from the Locust or Cavite Housing Areas.

A *RAM Modification* (WESTON, 2002), detailing PCB remedial action measures, was submitted to MDEP in November 2002. MDEP approved the modification on 22 January 2003. Remedial activities at the buildings where PCBs were detected were carried out in the same manner as those employed for pesticide remediation, and the requirement of a 1 part per million remedial action level was established.

At two buildings (Buildings 863 and 877), PCBs were detected at concentrations above 50 mg/kg, which mandated Toxic Substance Control Act (TSCA) disposal of remedial waste (soil) associated with releases at these buildings. These buildings are currently in the process of being remediated in accordance with a TSCA Subpart O.

On 13 March 2003 (as modified in e-mail message dated 17 September 2003), EPA forwarded a letter to the Army notifying that the Grant, Locust, and Cavite Housing Areas should become a Study Area and that a PA/SI should also be performed to determine whether a release or potential release of arsenic and/or PCBs exists and to assess the nature of the associated threats to human health and the environment.

The PA/SI field activities were initiated in October 2003 and completed in December 2003. During the first phase of PA/SI efforts, historical site information and existing analytical databases were reviewed to establish if a CERCLA release or release of arsenic, lead, explosives, and/or PCBs existed within the Study Areas. Sampling activities focused on areas of previously detected contaminants and historical training areas and firing ranges to determine if additional action was warranted at these locations.

1.2 PROJECT OBJECTIVES

The intent of this SSI effort is to provide a more comprehensive analysis of the Study Areas and the associated Investigation Areas (IAs) within the Study Area (Figure 1-2). The SSI effort will provide additional data to determine if a CERCLA release exists and whether any further action is necessary. The CoC list will be expanded to include volatile organic compounds (VOCs), semi-volatile organic compounds (SVOCs), PCBs, pesticides, Extractable Petroleum Hydrocarbons (EPH), and Target Analyte List (TAL) metals (including earth metals) as well as a

smaller subset of perchlorate (sampling and analysis of perchlorate in soil and groundwater will be performed by MassDevelopment), dioxins/furans, and explosives analysis.

1.3 PROJECT APPROACH

WESTON will conduct field sampling and analysis within the Study Areas to: assess historical training activities; assess potential CERCLA releases; evaluate the source of elevated arsenic concentrations at previously sampled locations; and to evaluate the potential impact to local shallow overburden groundwater by former site activities. Therefore, SSI activities will include the following tasks:

1. **Field Reconnaissance and Mapping:** WESTON has performed a field reconnaissance of approximately 166 acres of the Grant (137 acres), Locust (17 acres), and Cavite (12 acres) Housing Areas for potential training areas to document possible military features such as trenches, foxholes, impact craters, burn pits, etc. A Global Positioning System (GPS) and digital photography was used to document the location of each reconnaissance finding. This task is described in further detail in Subsection 3.1 and Appendix A

2. **Soil Sampling:** WESTON will perform soil sampling at multiple depth intervals to confirm the absence/presence of concentrations of CoCs and to determine the source of elevated arsenic concentrations at specific locations. This task is described in further detail in Subsection 3.2.3.

3. **Groundwater Monitoring and Well Installation:** WESTON will install a minimum of two overburden wells and two piezometers in IAs 2 and 8 to determine the direction of groundwater flow and to support the collection of groundwater samples to assess if potential releases associated with historical activities at each IA has impacted on shallow overburden groundwater. This task is described in further detail in Subsection 3.3.

Following the SSI field activities, a Revised PA/SI Report will be prepared which will summarize the findings of the SSI and PA/SI investigative activities.

SECTION 2

DESCRIPTION OF FORMER FORT DEVENS INSTALLATION

2. DESCRIPTION OF FORMER FORT DEVENS INSTALLATION

2.1 SITE HISTORY

The Army established Fort Devens in 1917 as a temporary training area for soldiers during World War I. In 1931, Fort Devens became a permanent installation with the primary mission of commanding, training, and providing logistical support for non-divisional troop units. The installation also supported the Army Readiness Regional and National Guard units in the New England area.

A review of historical aerial photographs [from the *Archives Search Report* (*ASR*) (Years 1922, 1943, 1951, 1965, 1980, and 1994) and the Middlesex County U.S. Department of Agriculture (USDA) office (Years 1938, 1952, and 1985)], historical United States Geological Survey (USGS) topographical maps [Ayer (Years 1939, 1945, and 1951) and Shirley (Years 1939 and 1951) 7.5 minute series quadrangles], and facility base maps and plans indicates that within five years after the base was established, most of the central base area was already developed with roads and buildings. Based on the historical data, the Grant, Locust, and Cavite Housing Areas appear substantially undeveloped prior to the construction of the existing housing areas during the late 1950s and early 1960s. Evidence indicates that these areas were used for a variety of training purposes prior to their development. Historical aerial photographs and base documents indicate dirt roads, cleared and/or excavated areas, and firing ranges were present within the housing areas and that several areas were being used as "Training Areas" and "Ranges". Except for the interpretations noted on these aerial photographs in the *ASR*, the specific uses of the identified Training Areas or Ranges are not known.

The only buildings present within any of the housing areas prior to the construction of the Grant, Locust, and Cavite housing units include several buildings of unknown use in the Cavite Housing Area that appear to date back to at least 1922; several small buildings of unknown use in the far northern portion of the Grant Housing area between 1919 and 1938; and a facility designated as the "Base Laundry" in the Grant Housing Area. Very limited information is readily available for these former structures. The laundry facility was constructed in the present day area of Poplar Street between 1943 and 1952. The duration of the laundry facility at

this site has not been established, but it was demolished prior to 1963. The buildings located at the northern end of the Grant Housing Area are present on a 1919 base map in the vicinity of Grant Housing Unit No. 830. These buildings are visible on aerial photographs until 1938. No structures were identified in the Locust Housing Area prior to the construction of the housing units. According to aerial photographs and base maps, the former buildings in the Cavite Housing Area were present until at least 1952. The construction date of the former Cavite Housing Area could not be determined from base records, plans, or available aerial photographs.

Fort Devens was officially closed in September 1996 under the Defense BRAC of 1990, Public Law 101-510. The Army retained certain portions of the installation for reserve forces training and renamed those areas the DRFTA. Ownership of the majority of the former installation, including the Grant Housing Area, was conveyed to MassDevelopment following the base closure. Redevelopment of the Grant, Locust, and Cavite Housing Areas is planned for 2004.

2.1.1 Grant Housing Area

By 1938, cleared/excavated areas were present in much of the Grant Housing Area and the area was criss-crossed with trails and roads. Some of the cleared areas appear to be associated with previously localized “high spots” on the historic USGS topographical quadrangle maps (USGS: Ayer Quad., 1939, 1945, and 1951) and are most likely related to overburden mining activities. Other cleared areas (e.g., long linear areas cleared of trees, smaller cleared or excavated areas) appear to be associated with some unspecified training. Figures 2-1 depicts the locations of former training areas and areas which appear to have had significant overburden mining within the Study Area.

A 1941 General Plan of Fort Devens indicates the construction of a former laundry facility in the current location of Poplar Street. A 1943 aerial photograph of this area indicates that some clearing and soil disturbance has occurred in the same area; however, the poor quality of the photograph does not provide sufficient clarity to confirm the presence of the laundry building. A 1951 aerial clearly depicts the former Base Laundry facility, but no housing units. A 1952 Topographic Survey of Fort Devens indicates that several of the housing units in the northern

portion of the Grant Housing Area along Grant Avenue had been built and identifies planned locations for the remaining housing units throughout the housing area.

Historically, it appears that the Grant Housing Area was used primarily for a variety of training purposes from 1917 through the early 1950s when the Base Laundry and the early housing units were constructed. After the early 1960s, the area was primarily used as a housing area.

The areas within this housing area that will be investigated further during the SSI include; the Former Training Area/Rifle Range (IA-1), Former 37-millimeter (mm) Range (IA-2), Former Rifle Range (IA-3), Sub-Caliber Anti-Tank Range (IA-5), Former Bryant Range (IA-6), the area around the former Base Laundry facility (IA-8), and the Grant Housing Area (IA-10) which includes further delineation of two potentially elevated arsenic sample locations. Further details are provided in Section 3.

2.1.2 Locust Housing Area

The Locust Housing Area is adjacent to three former Training Areas and/or Ranges (IA-3 and IA-6, Rifle and Machine Gun Range, and IA-7, Sub-Caliber Anti-Tank Range) as shown on Figure 1-2. No specific features or past use for the area prior to its development for base housing has been identified. Based on aerial photographs, the houses appear to have been built sometime between 1952 and 1965. The area has been identified as IA-11 and further investigation activities will be conducted to determine if CoCs remain in the area. Further details are provided in Section 3. Further investigation activities at IA-7 are discussed in Subsection 3.2.3.5. Further investigation activities at IA-6 will be performed under a separate work plan and reported along with the PA/SI and SSI results.

2.1.3 Cavite Housing Area

Various buildings and structures, many of unknown use, are visible on portions of the Cavite Housing Area (Figure 1-2) in photographs from 1922 to the present. Based on aerial photographs, the former housing units were built sometime after 1952. The area has been identified as IA-9 and further investigation activities will be conducted if CoCs remain in the area. Further details are provided in Section 3. Investigation Area 4, Possible Trench Warfare

Training Area, which was identified as being located within and adjacent to the south boundary of the housing area in the *Draft PA/SI Report* (WESTON, 2004), was incorrectly located. Based on a review of the aerial photographs and supporting data, it was determined that the IA-4 was incorrectly located on the aerial and when corrected, IA-4 is actually located approximately 0.5-mile south of the housing area. Therefore, no further action associated with this IA-4 will be conducted under this SSI. Investigation Area 4 will be addressed concurrently with any future remedial action in the Former Davao Housing Area.

2.2 PHYSICAL SETTING

The former Fort Devens is located in the Commonwealth of Massachusetts, approximately 35 miles northwest of the city of Boston. Located within the towns of Ayer and Shirley (Middlesex County) and Harvard and Lancaster (Worcester County), it occupies approximately 9,300 acres of land.

The Study Area is the former Grant, Locust, and Cavite Housing Areas at Fort Devens. The former Grant and Locust Housing Areas are located in the northwest portion of the Main Base and included 144 housing units located on Plum Street, Beech Street, Spruce Street, Poplar Street, Hospital Road, El Caney Street, Antietam Street, Birch Circle, Grant Road and on the Locust Street cul-de-sac. The former Cavite Housing Area is located on the eastern portion of the Main Base on Cavite Street and includes six housing units on Cavite Street and Bates Service Road, between MacArthur Avenue and Saratoga Road.

The soils in the former Grant and Cavite Housing Areas comprise somewhat excessively drained Quonset loamy sands, formed on glacial outwash stratified drift deposits. The soils in the Cavite Housing Area comprise somewhat excessively drained Chatfield-Hollis complex soils, formed on either bedrock outcrops or Quonset loamy sands.

The Study Area generally slopes gently westward, draining via storm drains and overland flow, to the Nashua River. The Nashua River is located approximately 400 feet (ft) to the west of the western boundary of the Grant and Locust Housing Areas. The Study Area is located above the 500-year flood elevation of the Nashua River.

Depth to groundwater beneath the Study Area has not been measured. Borings conducted in the Maple Housing Area, located between Grant and Locust Housing Areas, indicate that groundwater was encountered at approximately 31 ft below grade. Based on this information and mapping of contribution zones of local public drinking water wells, groundwater flow beneath the former Grant and Locust Housing Area is up to 60 ft below grade and flows in a northwesterly direction, toward the Nashua River, where groundwater is presumed to discharge. Published information indicates that the western portion of the Study Area is underlain by a stratified drift aquifer with a transmissivity estimated at up to 1,400 square feet per day. Groundwater flow beneath the former Cavite Housing Area portion of the Study Area is not documented. The area is located at the top of an apparent groundwater divide between Cold Spring Brook to the east and Robbins Pond Brook to the west. Based on past excavation activities conducted and the presence of bedrock outcrops in the Cavite Housing Area, groundwater beneath the former Cavite Housing Area is likely present only in bedrock fractures.

SECTION 3

SUPPLEMENTAL SITE INVESTIGATION ACTIVITIES

3. SUPPLEMENTAL SITE INVESTIGATION ACTIVITIES

Based on a review of the historical information and existing databases, BRAC, EPA, MDEP, and USACE have agreed that additional data is required to fully characterize the potential for releases that may have occurred within the Study Area. A review of the past historical uses and small arms training in the Study Area has indicated the potential presence of impacts at several IAs (Figure 1-2). A site reconnaissance and soil sampling evaluation will be performed in support of this SSI. The specific SSI tasks are described in the following text. A description of each IA, prior investigations and removal actions, and proposed sampling outline are also provided below.

3.1 SITE RECONNAISANCE

In order to assist in the identification of past potential small arms training and range activities within the Study Area, additional site reconnaissance was conducted. The reconnaissance assessed approximately 166 acres (Figures 3-1 and 3-2) that the SSI is intended to investigate. While the reconnaissance focused on identifying site features that may indicate historic training activities (i.e., former foxholes, trenches, or impact craters), areas of significant alteration of the surface topography (i.e., areas of cut and fill), monuments, subgrade utility structures, old foundations, old roads, and walls were also noted. General features information, including relative location within the landscape, size, orientation and probable origin/use, were also recorded in field logbooks.

3.1.1 Reconnaissance Methods

The site reconnaissance effort utilized a digital camera and a GPS unit (Trimble XRS) as the primary means of recording an image and identifying the feature's location, respectively. The GPS unit has an accuracy that ranges from $\pm$ 3 ft up to $\pm$ 20 ft, depending on the over-story cover.

3.1.2 Reconnaissance Findings

The reconnaissance effort identified the following types of features:

- **Fill:** Three different types of fill were identified during this field effort: berms, piles, and mounds. Berms were characterized as generally linear areas of fill. Piles were typically small, comprised of debris, rock or earth, and appeared to have been discarded or dumped. Mounds were typically larger than piles and were comprised of primarily earthen materials.

- **Depressions:** Three different types of depressions were identified during this field effort: trenches, borrow pits, and excavations. Trenches were generally narrow, linear features ranging up to a few feet in depth. Borrow pits were located against a hill slope and were constructed with at least one side designed to allow easy egress into the pit. Excavations ranged in size from a few feet up to several tens of feet in diameter and typically had either a sharp, acute edge (as opposed to the more convex curvature of a depression's natural margin).

- **Structures:** Three different structures were identified within the Study Area: foundations, concrete features, and various miscellaneous structures collectively categorized as "Other". Features identified as foundations contained either a wall or footing of a former above-grade building or structure. Concrete features included pads, blocks, vaults or other type of small, ground level structures made out of concrete. "Other" structures included obstacle course components, anchors/tie rods and stone, metal, concrete, or wooden monuments or markers.

The reconnaissance effort did not identify any features inconsistent with the known uses of the Study Area as general Training Areas and/or Firing Ranges between 1917 and approximately 1960. The identified features are depicted on Figures 3-1 and 3-2 and presented in Appendix A.

While numerous depressions were identified within the Study Area, most appeared to have bermed edges characteristic of "foxholes" or trenches dug for training purposes. No burn pits, impact craters, or detonation craters were identified within the Study Area. No munitions and explosives of concern were identified during this reconnaissance field effort. The results of the reconnaissance effort were obtained through visual inspection of site features and are subject to the judgment and experience of the personnel conducting the survey. Based on feedback from the EPA and MDEP the evidence obtained during the reconnaissance should be supported by additional sampling and analysis data. Based on this feedback and considering the reality that historic site features have degraded from their original conditions and could be identified under

several features (i.e., a depression resulting from historical 37 mm training versus a depression resulting from a foxhole excavation) it is appropriate that evaluation of several areas of the Study Area be reviewed by the BCT and sampling be conducted at select locations.

3.2 SOIL SAMPLING AND ANALYSIS

3.2.1 Rationale/Sampling Locations

Soil sampling will be performed to collect the additional data required to determine if a release of CERCLA-regulated CoCs have occurred within the Study Area - Grant, Locust, and Cavite Housing Areas. A review of the past historical uses of the Study Area has indicated several IAs where CoCs are potentially present. Each of the IAs are summarized in the following subsections, which include a description of the IA, a brief summary of any past sampling activities, the rationale for any additional sampling, and the proposed sampling locations. The analytical requirements proposed for each IA is summarized in Table 3-1. Proposed sampling locations are shown on Figures 3-3 through 3-7 and 3-9 through 3-12.

The position of soil boring and shallow soil sample locations at IA-1, -3, -5, and -8 may be adjusted prior to sampling activities, based on the results of a preliminary survey of the general vicinity with a metal detector. An all-metal detector will be used in an attempt to identify potential areas with high concentrations of small arms projectiles, shell casings or other range related materials (e.g., ammunition clips). If such areas are identified by the all-metal detector, sampling locations will be adjusted to include those locations. Conversely, soil boring, monitoring well, and piezometer locations at IA-2 will be adjusted prior to sampling activities based on the results of a survey in the general vicinity with a Schonstedt Meter. In the case that the meter detects the presence of a ferrous material, safety procedures will require that the sampling location is offset to a location where ferrous materials are not present as part of Munitions and Explosives of Concern (MEC) avoidance procedures.

Soil sample collection procedures are presented in Section 4 of this WP.

3.2.2 Soil Sampling Requirements

The samples will be collected utilizing either hollow stem auger drilling and split-spoon sample collection techniques or hand tools (as in the case of samples collected from the sidewalls of test pits excavated by a backhoe). Test pits and soil borings will be logged to their totals depths.

Surficial soil samples will be collected from depths of 0 to 1.5 ft below ground surface (bgs), using a, backhoe, shovel or a hand auger.

Test pits will be excavated using a backhoe. Side wall soil samples will be collected using hand tools at 0- to 2 ft, 2- to 4 ft, and 4- to 6 ft depth intervals from each sidewall of each test pit for a total of 12 samples per test pit.

Soil borings will be advanced to 10 ft-bgs using a hollow-stem auger with 3-inch split-spoon samplers. Samples will be collected from the 0- to 3 ft and 3- to 10 ft bgs depth intervals for a total of two samples per borehole.

All soil samples will be submitted to an off-site analytical laboratory for the analysis specified on Table 3-1. Mass Development will collect and analyze perchlorate samples .

Detailed field procedures for shallow soil sampling, test pit sampling, borehole drilling, split-spoon sampling, borehole logging, field screening, documentation, quality assurance (QA)/quality control (QC) samples, sample preparation, custody and shipment, data evaluation, and validation, are provided in Sections 4 and 5.

3.2.3 Soil Sampling by Investigation Area

The following subsections define the soil sampling requirements for each Investigation Area (IA).

3.2.3.1 IA-1 - Former Training Area (circa 1922)

Investigation Area 1 (IA-1) is located in the northern portion of the Grant Housing Area along Grant Road and centered at the Chance Street intersection (Figure 3-3). This area has been identified as a possible former Training Area based on a 1922 map contained in the *ASR*

document. Although no specific activities have been identified for this area, the possibility exists that the area was utilized as a former small arms firing range and that past uses may have impacted the area. The IA exists in the area of significant overburden soils mining (Figure 2-1) and remnant features such as impact berm no longer exist. Based on historical documentation, it is presumed that the impact berm would have been located in the southwestern end of the IA and the firing point(s) would have been located to the northeast of the impact berm.

Previous soil sampling conducted as part of the Pesticide Soil Remedial Action (WESTON, 2003) in the area (Figure 3-3) focused on investigating potential arsenic and PCB releases in the vicinity of the disturbed soils surrounding the former housing units. Investigation results indicated that neither arsenic nor PCB releases were detected in this area.

To evaluate the IA, an additional four soil borings will be completed as shown on Figure 3-3, unless otherwise relocated by the results of a preliminary all-metal detector survey or the location of subsurface utilities. Based on the presumed orientation of the range, the three soil borings will be completed within the area of the presumed impact berm and one soil borings will be completed at the presumed firing point. Representative soil samples will be collected from 0- to 3 and 3- to 10 ft bgs at each sample locations. At one location within the impact berm area, samples will be submitted for full suite analysis (VOCs, SVOCs, PCBs, pesticides, TAL metals, and EPH). Samples collected from the remaining borings will be submitted for TAL metals analysis. A summary of soil sample analysis is provided on Table 3-1.

3.2.3.2 IA-2 - Possible Training Area and/or Range (circa 1922)

Investigation Area 2 is located in the northernmost portion of the Grant Housing Area along Birch Circle (Figure 1-2). This area has been identified as a possible former Training Area and/or Range and is one of three areas where PCBs have been detected. Although several small buildings of unknown use were identified in the vicinity of the presumed firing point before 1934, no specific training or range activities were identified for this area in the *ASR* documents. The *Draft Final Expanded Conceptual Site Model Report* (USACE, June 2004) identifies this area as a 37-mm range based on aerial photographs and the discovery of more than 50 unexploded 37 mm munitions. In addition to the 37 mm rounds, more than 2,700 pounds of ordnance scrap was removed from the area.

The northern portion of this area contains the localized PCB detections that were previously remediated by WESTON as part of the Pesticide Soil Remedial Action. Although this area of PCB impact was subsequently removed and the resulting verification soil samples of this removal action did not detect any additional PCB impact, additional soil samples were collected in this area to confirm that the extent and source of the previously detected PCBs had been identified and to screen the remainder of the area for arsenic and PCBs.

In the fall of 2003, a total of nine composite samples were collected and analyzed for PCBs, and six composite samples were analyzed for arsenic and PCBs. The results showed no hits above background for arsenic and no hits above the CERCLA action level for PCBs. In addition, since IA-2 is the location for the presumed 37-mm direct fire range, a total of ten discrete soil samples were collected to assess this area for residual explosives. All results for explosive analysis were non-detect.

To further assess the IA, an additional 26 soil borings, two monitoring wells, and two or more piezometers will be completed in this IA as shown on Figures 3-4A, 3-4B, and 3-4C. Munitions and Explosives of Concern avoidance measures will be conducted prior to the initiation of soils boring activities. If necessary, boring locations will be relocated to avoid potential contact with MEC and to ensure the safety of the sampling crews. Soil borings, monitoring wells, and piezometers will be located and sampled within the Impact Berm, the Intermediate Area and Firing Point as described below:

- **Impact Berm (Figure 3-4A):** A total of 12 soil borings, two monitoring wells, and two or more piezometers will be completed in the area of the impact berm. Ten soil borings will be placed throughout the impact berm area. Final locations will be selected in the field where historical impacts are likely to have occurred. These locations could include, but are not limited to areas that have potential for being remnant range features (i.e., demolition or impact craters); areas where pockets of fragmentation or MEC were encountered during the unexploded ordnance (UXO) Removal Actions completed in the mid-1990s; and areas that appear to be undisturbed (and therefore, may contain MEC as yet undiscovered). The two monitoring well borings will be placed as follows: one at the toe-of-slope and one in the downgradient groundwater flow direction from the toe-of-slope, as determined from piezometer groundwater elevation measurements. If necessary, additional soil borings or piezometers will be completed to groundwater to support the assessment of groundwater flow direction. Representative soil samples will be collected from 0- to 3 and 3- to 10 ft-bgs at each soil boring location and at each monitoring well location.

Samples collected from one boring placed within a UXO removal action area and each of the monitoring well borings will be submitted for full suite, perchlorate and explosive analysis. Samples from the nine remaining locations will be collected from the same intervals and submitted for TAL metals, perchlorate, and explosives analysis. A summary of sample analysis requirements is provided on Table 3-1. No analytical samples will be collected from the piezometer borings. As indicated above, MEC avoidance measures will be initiated at all sample locations.

- **Intermediate Area (Figure 3-4B):** A total of eight soil borings will be completed throughout the intermediate area. The sampling locations will be placed in areas of potential remnant range features identified during the site reconnaissance and in locations that would provide the most likely location for "short shots" (i.e., along line of flight between firing point and pockets of fragmentation/UXO removal during 1996 UXO removal action). Representative soil samples will be collected from 0- to 3 and 3- to 10 ft-bgs at each soil boring location. Samples from two randomly selected borings will be submitted for full suite, perchlorate and explosive analysis. A summary of sample analysis requirements is provided on Table 3-1. Samples from the eight remaining locations will be collected from the same intervals and submitted for TAL metals and explosives analysis. As indicated above, MEC avoidance measures will be initiated at all sample locations.

- **Firing Point (Figure 3-4C):** A total of six soil borings and one shallow soil sample will be completed in the area. One boring will be placed in the center of the Birch Circle cul-de-sac and the remaining borings will be placed in the vicinity and downrange of the cul-de-sac. The shallow soil sample will be placed in a remnant training feature (foxhole or defensive training position) located to the north of the cul-de-sac. This sampling approach assumes that the cul-de-sac was the primary firing point for 37-mm artillery. Representative soil samples will be collected from 0- to 3 and 3- to 10 ft-bgs at each soil boring location and from 0-18 inches at the shallow soil sample location. Samples from the soil boring to the southwest of the cul-de-sac will be submitted for full suite and explosive analysis. Samples from the five remaining locations and shallow soil sample will be collected and submitted for TAL metals and explosives analyses. A summary of soil sample analysis is provided on Table 3-1. As indicated above, MEC avoidance measures will be initiated at all sample locations.

3.2.3.3 IA-3 - Possible Rifle Range

Investigation Area 3 is located along Hospital Road north of the Locust Housing Area (Figure 3-5). A 1922 map in the *ASR* document indicates the past use of this IA as a possible rifle range. The physical features of this area provide for at least two possible locations of firing and target stations.

In the fall of 2003, a total of 30 samples were collected from the potential impact areas to focus on potential lead impacts. Based on the results, lead impacts above the MCP Reportable Concentration Standard-1 standard of 300 mg/kg at the two potential targeting berms were not identified.

To further evaluate the IA, an additional four soil borings and 22 shallow soil samples will be completed as shown on Figure 3-5, unless otherwise relocated by the results of a preliminary all-metal detector survey. Based on the presumed orientation of the potential range, the soil borings will be completed within the area of the presumed impact berms and at points located in the hill slopes to the north and south of the berms. Representative soil boring samples will be collected from 0- to 3 and 3- to 10 ft-bgs at each sample location. The samples collected from one boring location at the northern and southern impact berms will be submitted for full suite analysis. Samples collected from the remaining boring location at the northern and southern impact berms will be collected from the same sampling intervals, but will only be submitted for TAL metals analysis. Representative shallow soil samples will be collected from 0- to 1.5 ft-bgs at each shallow soil sample location. The shallow soil samples will be submitted for TAL metals analysis. A summary of soil sample analysis is provided on Table 3-1.

3.2.3.4 IA-5 – Sub-Caliber Anti-Tank Range

Investigation Area 5 is located in the eastern portion of the Grant Housing Area, west of Grant Street (Figure 3-6). This area, which has been identified as a possible former Sub-Caliber Anti-Tank Range, is one of two areas where PCBs have been detected and is an area where significant quantities of fill material was identified during the PCB removal action.

In the fall of 2003, soil investigation activities conducted in this area focused on potential lead, arsenic and PCB impacts. While PCB impacts have been identified and are currently being remediated, no arsenic or lead impacts were detected during this work.

To further evaluate the IA, an additional nine soil borings and six shallow soil samples will be completed as shown on Figure 3-6, unless otherwise relocated by the results of a preliminary all-metal detector survey or to avoid subsurface utilities. Based on the presumed orientation of the potential range, the soil borings will be completed within the area of the presumed impact

berm and firing points. Representative soil samples will be collected from 0- to 3 and 3- to 10 ft bgs at each sample locations. The samples collected from one boring location within the berm will be submitted for full suite analysis. Samples collected from the remaining borings will be collected from the same sampling intervals and submitted for TAL metals analysis. Representative shallow soil samples will be collected from 0- to 1.5 ft-bgs at each location. The shallow soil samples will be submitted for TAL metals analysis. A summary of soil sample analysis is provided on Table 3-1.

3.2.3.5 IA-7 – Sub-Caliber Anti-Tank Range

Investigation Area 7 is located to the south of the former Sports Arena and to the west of the Grant Road and Sherman Avenue intersection (Figure 3-7). The area has been identified as a former 1,000-inch Sub-Caliber Anti-Tank Range on historical Target Range Area Maps (1942 and 1948). Earthen berms are located on the western and south/southwestern boundaries of the area. The firing point area is relatively flat. The range appears to have been constructed by the mining of overburden from a former hill. Access is from the east side of the site via Sherman Avenue.

No previously identified soil investigation activities have been conducted at this IA.

To further evaluate the IA, an additional four soil borings and six shallow soil samples will be completed as shown on Figure 3-7, unless otherwise relocated by the results of a preliminary all-metal detector survey or to avoid subsurface utilities. Based on the presumed orientation of the potential range, the soil borings will be completed within the area of the presumed impact berm and at firing points which will be presumed to be 1,000 inches (87 ft) from the berm. Samples will be collected from 0- to 3 and 3- to 10 ft-bgs at each soil boring and from 0- to 18 inches bgs at each of the shallow soil sample locations. Soil boring and shallow soil samples will be submitted for TAL metals analysis. A summary of soil sample analysis is provided on Table 3-1.

3.2.3.6 IA-8 - Former Base Laundry Buildings

Investigation Area 8 is located in the eastern portion of the Grant Housing Area, east of Grant Street and just north of the Poplar Street loop (Figures 3-8 and 3-9). This area has been identified as a former base dry cleaner facility and is located within one of three areas of known PCB impact. Figure 3-8 provides an overlay of the former Grant Housing Area features on a 1953 aerial of the site when the Base Laundry and dry cleaner buildings existed at the site.

In the fall of 2003, soil investigation activities conducted in this area focused on potential arsenic and PCB impacts. While PCB impacts have been identified and are currently being remediated, no arsenic impacts were detected during this investigation effort.

To further evaluate this IA, an additional six soil borings, three piezometers, and two monitoring wells will be completed to assess impacts associated with the former dry cleaner facility. The soil borings will be located within or adjacent to the former facility foundation to determine potential source areas associated with former dry cleaner activities. Borings for each of the monitoring wells (2), piezometers (3), and two soil borings within the former dry cleaner foundation will be drilled and continually sampled at 2-ft intervals to bedrock or a confining layer. Representative soil samples will be collected from the remaining borings at 2-ft intervals to 10 ft bgs. Soil from every 2-ft sample interval will be headspace screened. The sample interval with the highest headspace result will be submitted to an off-site laboratory for VOC analysis. The groundwater elevations measured following the piezometer installations, coupled with observations of the depth of saturated soils in the source area soil borings will be evaluated to determine an appropriate location for the source area monitoring well. Two monitoring well borings will be completed, one within the former building foundation area or source area and another in the downgradient groundwater flow direction. Representative soil samples will be collected from 0- to 3 and 3- to 10 ft-bgs at each boring location. Samples collected from each boring will be submitted for full suite, perchlorate and explosive analysis. MassDevelopment will be responsible for collection and analysis analysis of the all perchlorate samples. No analytical samples will be collected from the piezometer borings. A summary of soil sample analysis is provided on Table 3-1.

3.2.3.7 IA-9 - Cavite Housing Area

Investigation Area 9 includes the entire Cavite Housing Area, which has been historically identified as a former Training Area (Figure 3-10). In the fall of 2003, investigation activities focused on potential arsenic and PCB impacts in this area. Potential arsenic impacts have been identified, but no PCB impacts were identified during this investigation effort.

To further evaluate this IA, an additional soil boring and test pit will be completed in this IA as shown in Figure 3-10. The location of the soil boring will be selected in a location of likely fill that has not been assessed as part of previous investigation activities. Representative soil samples will be collected from 0- to 3 and 3- to 10 ft-bgs at the boring location. Samples will be submitted for full suite and dioxin/furan analysis. A test pit will be completed to assess a potential arsenic impact associated with previous PASI Investigation soil sample CT-502-2. Representative soil samples will be collected from each side of the pit at 0- to 2, 2- to 4 and 4- to 6 ft-bgs intervals. A total of 12 samples will be submitted for TAL metals analysis. A summary of soil sample analysis is provided on Table 3-1.

3.2.3.8 IA-10 - Grant Housing Area

Investigation Area 10 consists of the entire Grant Housing Area (Figure 3-11) and has been identified as a former Training Area.

In the fall of 2003, soil investigation activities conducted in this area focused on potential arsenic and PCB impacts. Polychlorinated biphenyl impacts identified in two areas of the site and are currently being remediated. Arsenic was detected in two sample locations at elevated levels and requires further evaluation.

To further evaluate this IA, an additional four soil borings and two test pits will be completed as shown in Figure 3-11. The location of three soil borings will be selected in likely fill areas that have not been assessed as part of previous investigation activities. The final boring will be placed in the location of the former Base Laundry facility to evaluate potential releases associated with the laundry operations. Historical aerial photographs (see Figure 3-8) and site plans indicate the laundry facility operations included former boiler house and aboveground storage tank (AST). It

is unclear at this time what was contained within the AST (water, fuel or other liquid). Representative soil samples will be collected from 0- to 3 and 3- to 10 ft-bgs at each boring location. Samples will be submitted for full suite and dioxin/furan analysis. Test pits will be completed to assess a potential arsenic impact associated with previous soil samples GR-3-01 and GR-3-09. Representative soil samples will be collected from each side of the pit at 0- to 2, 2-to 4 and 4- to 6 ft-bgs intervals. A total of 24 samples will be submitted for TAL metals analysis. A summary of soil sample analysis is provided on Table 3-1.

3.2.3.9 IA-11 - Locust Housing Area

Investigation Area 11 comprises the entire Locust Housing Area and has been identified as a former Training Area. Past use of this area as a training area may indicate the potential for arsenic and PCB impacts.

In the fall of 2003, soil investigation activities conducted in this area focused on potential arsenic and PCB impacts. While no arsenic or PCB impacts have been identified, one additional soil boring will be completed within this IA as shown on Figure 3-12. The soil boring location will be placed just southeast of the housing area in an area with a high concentration of apparent man-made features. Representative soil samples will be collected from 0- to 3 and 3- to 10 ft-bgs at each boring location. Samples will be submitted for full suite and dioxin/furan analysis. A summary of soil sample analysis is provided on Table 3-1.

3.3 GROUNDWATER SAMPLING

3.3.1 Rationale/Sampling Locations

A total of five or more piezometers and four overburden groundwater monitoring wells will be installed in order to assess the potential for groundwater impact associated with IA-2 (Possible Training Area and/or Range) and IA-8 (former Base Laundry Buildings). The final depths of each piezometer/monitoring well will be determined by the particular geology and hydraulic conditions encountered at each boring location. The locations and rationale for each piezometer and monitoring well are presented in the following subsections. The proposed well locations are shown on Figures 3-4A and 3-9. One round of groundwater sampling is included in this scope of work to evaluate groundwater quality. Groundwater levels will be measured upon installation of

the source area monitoring wells and piezometers, following installation of the downgradient well, and during the groundwater sampling event.

3.3.2 Groundwater Sample Collection and Analysis

Groundwater samples will be collected and field screened for temperature, turbidity, pH, dissolved oxygen (DO), oxidation-reduction potential (ORP), and specific conductivity using EPA low-flow techniques. Groundwater samples will be submitted for off-site laboratory analysis for VOCs, SVOCs, PCBs, pesticides, TAL metals, dioxins/furans, explosives and perchlorate (Table 3-1).

Detailed field procedures for sampling of monitoring wells and piezometers, well development, water level measurement, purging, low-flow sampling, field measurements, documentation, QA/QC samples, sample preparation, custody and shipment, data evaluation, and validation are provided in Sections 4 and 5.

3.3.3 Groundwater Sampling by Investigation Area

The following subsections describe the groundwater sampling requirements for each IA.

3.3.3.1 IA-2 – Possible Training Area and/or Range (circa 1922)

Groundwater investigative activities will be completed in the area of the impact berm located in the southern end of this IA. These activities will include the completion of two piezometers and two monitoring wells utilizing hollow stem auger drilling techniques. One water table monitoring well will be installed at the toe-of-slope that comprises the target area for the former 37-mm firing range, directly b elow the presumed location of the former range targets. Subsequently, two piezometers will be installed approximately 50- to 200 ft to the west and north-northwest of the former target area. The well and piezometers will be used to determine groundwater flow direction. Once the piezometers have been surveyed and the static water levels measured, one additional water table monitoring well will be installed approximately 100- to 200 ft downgradient from the toe-of-slope monitoring well location. Figure 3-5A provides the approximate piezometer and monitoring well locations.

All piezometers and monitoring wells will be installed utilizing hollow-stem auger drilling techniques. General well construction details are outlined in the following table:

Objective	Exploration	Estimated Depth	Quantity	Total Linear Feet
Determine groundwater quality in potential source area	Shallow water table monitoring well with continuous soil sampling; 2-inch polyvinyl chloride (PVC), 10-ft screen, bottom set 5 ft below water table	30 ft	1	30
Determine groundwater flow direction	Piezometers with continuous sampling to 5 ft below water table; 2-inch PVC, 10-ft screen, bottom set 5 ft below water table.	30 ft	2	60
Determine downgradient groundwater quality	Shallow water table monitoring well with continuous soil sampling, 2-inch PVC, 10-ft screen, bottom set at 5 ft below water table surface	30 ft	1	30

3.3.3.2 IA-8 – Former Base Laundry Buildings

Groundwater investigative activities will be completed within the general area of the former Base dry cleaning facility building located just north of Poplar Street (Figures 3-8 and 3-9) at the southeastern end of the former Grant Housing Area. These activities will include the installation of two shallow overburden groundwater monitoring wells and three shallow overburden piezometers. One monitoring well will be installed within the former dry cleaner facility foundation. The location will be determined by data collected during the soil boring sample collection activities. The monitoring well installed at the location of a source for groundwater impact associated with a potential release from the dry cleaner operations. If there is no evidence of a release based on the soil boring sampling activities, the source area well will be installed within the footprint of the foundation on the presumed downgradient side (to the west) of the facility. Three piezometers will be installed approximately 100- to 200 ft to the north, northwest and southwest of the former dry cleaner facility to support determination of groundwater flow direction. Once the piezometers and source well have been installed and surveyed, and the static water levels measured, a final overburden monitoring well will be installed no more than 200 ft downgradient from the potential source well location.

All piezometers and monitoring wells will be installed utilizing hollow stem auger drilling techniques. General well construction details are outlined in the following table:

Objective	Exploration	Depth	Quantity.	Total Linear Feet
Determine groundwater quality in potential source area, shallow	Shallow water table monitoring well, 2-inch PVC, 10-ft screen set 5 ft below water table	70 ft	1	70
Determine groundwater flow direction	Piezometers with continuous sampling to 5 ft below water table, 2-inch PVC, set 5 ft below water table surface	70 ft	3	210
Determine groundwater quality, downgradient, shallow	Shallow water table monitoring well with no sampling, 2-inch PVC, 10-ft screen, set 5 ft below water table	70 ft	1	70

SECTION 4

SAMPLE COLLECTION AND ANALYSIS PROCEDURES

4. SAMPLE COLLECTION AND ANALYSIS PROCEDURES

This section provides the pertinent elements of the first half of a Sampling and Analysis Plan (SAP) –the Field Sampling Plan and serves as part of an addendum to the *Sampling and Analysis Plan for the Release Abatement Measures for the Shirley, Grant, Locust, and Cavite Housing Areas, and Pesticide Remediation at the Chlordane Cell – Devens, Massachusetts* (WESTON, April 2002). Standards referenced throughout Section 4 have been provided in Appendix B. Section 5 will serve as the Quality Assurance Project Plan (QAPP) portion of the SAP Addendum.

4.1 MOBILIZATION AND SITE PREPARATION

4.1.1 Personnel and Equipment

WESTON will mobilize all necessary personnel, equipment, materials, and subcontractors to the former Fort Devens in order to implement specific tasks as outlined in this SSI WP. Mobilization of staff and equipment will begin in accordance the projected schedule. SSI WP field tasks include:

- Test pit sampling
- Shallow soil sampling
- Soil borings
- Monitoring well and piezometer installation
- Groundwater sampling
- MEC avoidance

A general list of equipment, materials, and supplies required for the performance of field activities by WESTON is provided below:

- Communication equipment including portable cellular phones, radios, and computers (lap-tops).
- Air monitoring instruments [e.g., Photo-Ionization Detector (PID), Flame Ionization Detector (FID), Miniram].
- Sample bottles, coolers, etc. as specified in SAP.

- Safety equipment including a first aid kit, fire extinguisher, Personal Protective Equipment (PPE), safety signs, caution tape, etc.
- Miscellaneous tools, sampling equipment, etc.

Subcontractors will complete/perform test pit excavations, soil borings, well installation, equipment decontamination, and other sampling associated tasks under the supervision of experienced field personnel. On-site support activities required for these activities include the following:

- Secure all necessary permits and/or agreements, and make all required notifications required for the transport or delivery of any necessary materials to the site.
- Set-up and maintain equipment/materials laydown areas.
- Provide proper PPE for site personnel.

4.1.2 Utilities

Prior to groundbreaking activities, DigSafe (minimum 72-hour notification) will be notified and utility clearance will be requested. DigSafe will contact local utility companies for each service to mark out any subsurface utilities. Should it be necessary to obtain additional utility information not supplied by DigSafe for water, sewer, and other utilities information, WESTON will contact MassDevelopment and request this information.

Overhead utilities (e.g., electrical, telephone, etc.) exist in the immediate vicinity of most buildings and will need to be protected; de-energized, or sampling locations will need to be modified to protect workers and utilities from injury or damage.

4.1.3 Clearing and Grubbing

Most sampling areas are sparsely vegetated with overgrown weeds and field grass. Shrubs and small trees, which restrict access to sampling locations within each IA, will be removed. WESTON does not anticipate the need to remove large trees from the vicinity of the IAs. A final decision on large tree removal will be determined by site activities. It is WESTON's intention to limit the removal of large trees to a minimum.

4.1.4 Staging Areas, Access Roads, and Traffic Control

It is anticipated that soil not placed back into the borehole or test pit will be containerized into Department of Transportation (DOT)-approved 55-gallon drums and transported to a staging area for eventual sampling and if necessary, off-site disposal. Separate staging areas will be established at each housing area. Drummed soil which exceeds the project cleanup criteria will be transported and disposed in accordance with applicable laws and regulations.

Laydown areas for equipment and supplies required to complete investigation activities will be staged within the Grant Housing area. The exact location will be coordinated with MassDevelopment through USACE.

Grant Housing Area will be closed to non-project traffic, except for Grant Road, which will be open to local traffic. Traffic control at the housing areas is not anticipated. Any traffic control issues will be coordinated with MassDevelopment through USACE, as appropriate. Construction of access roads is not anticipated. There will be no restrictions to access for fire, rescue and police services throughout the proposed activities.

Due to the short duration of sampling efforts at each sampling location, the erection of high visibility construction fence will not be utilized to block access to the area in the vicinity of the existing roadways. Barricade tape will be used in those areas where potential pedestrian traffic may cross the exclusion zone. Additional security fencing will be installed as needed at each the area to meet Site-Specific Health and Safety Plan requirements or if directed by USACE.

4.1.5 Work Zones and Support Areas

To prevent both exposure of unprotected personnel and migration of contamination due to tracking by personnel or equipment, work areas and PPE requirements will be clearly identified. The proposed limits of intrusive activities will be delineated on site drawings based on current site knowledge and proposed sampling locations.

WESTON will designate work areas or zones as suggested in *Occupational Safety and Health Guidance Manual for Hazardous Waste Site Activities*, National Institute for Occupational Safety and Health/Occupational Safety and Health Administration (OSHA)/U.S. Coast Guard/EPA,

dated November 1995. The areas surrounding the work area will be divided into the following zones:

- Exclusion zone (EZ)
- Contamination reduction (decontamination) zone (CRZ)
- Support zone (SZ)

For the purpose of this project, each IA will be considered the SZ and within each IA will be a designated CRZ and EZ.

WESTON's subcontractors will be responsible for performing decontamination of equipment and materials leaving each work area. A staging area for decontamination will be laid out during site preparation activities in order to support site activities. It is anticipated that vehicles and trucks leaving the site will not require decontamination since the SZ is assumed to be clean. Limited decontamination will be necessary for equipment that is utilized within the EZ. This will include heavy equipment, sampling equipment, and miscellaneous tools. Currently, only dry decontamination of heavy equipment is anticipated. Wherever possible, disposable sampling equipment will be used. Personal protective equipment will be collected for off-site disposal, as necessary. Where decontamination is required, it will be performed in accordance with protocols set forth in Subsection 4.3.13.

4.1.6 Erosion Control

Due to the short duration and limited soil disturbance associated with soil boring installation and test pit excavation activities, no erosion control measures are planned. If activities are expanded or the effort results in sufficient surficial soil disturbance such that surficial soils are eroding during storm events, then erosion control measures will be conducted. Erosion control measures include the installation/placement of silt fence and/or hay bales, staked approximately every 3 - to 4 linear feet along the border of the impacted area in an effort to eliminate soil runoff. Exposed eroding soils should be covered with hay, a filter fabric or plastic as needed to assist in erosion control, when needed.

4.1.7 Munitions and Explosives of Concern (MEC) Avoidance

Wherever possible, the WESTON Team will seek to avoid MEC. This effort will be particularly important at the IA-2 firing points, IA-2 intermediate areas and IA-2 impact area, where the presence of MEC is a possibility. This will be accomplished by access and subsurface surveys as described below.

Munitions and explosives of concern avoidance personnel at IA-2 will consist of at least one Project Leader/MEC Site Safety Officer. No intrusive excavation of anomalies will be performed during any MEC marking or support operation.

4.1.7.1 Access Survey

Overland access/egress will be required for personnel, clearing and grubbing equipment, site trucks, and drilling/well installation rig(s) to access IA-2. Investigation Area 2 is an area designated as a historic firing range and has not as yet been fully cleared of MEC. Therefore, an access survey will precede all other mobilization activities at IA-2. The MEC Project Leader, in consultation with the Site Geologist, will locate an access route and sampling locations that are free of anomalies using an "all metals detector" White's Spectrum XLT, Schonstedt magnetometer, or similar detection equipment to ensure that the access route is clear of detectable MEC. The access route will be at least 1.5 times as wide as the widest vehicle that will use the route. If surface anomalies or MEC are encountered, they will be marked with flagging and the access route or sampling location site will be relocated to avoid contact. Any surface contact determined to be a hazardous MEC will be properly identified, marked, and reported to the appropriate personnel/agency. The MEC Project Leader will ensure that all personnel adhere to all appropriate safety precautions. Work will continue at a safe distance from the discovered MEC.

4.1.7.2 Subsurface Surveys

Subsequent to the access survey and other mobilization activities, avoidance surveys will be used at the location of intrusive work. A White's Spectrum XLT, Schonstedt magnetometer, and/or Ebinger MAGNEX 120 with downhole cable, or similar device will be used to locate subsurface

metal contacts. If anomalies are detected at depth during intrusive activities, such as borehole drilling, the site will be evacuated by all non-MEC personnel and an MEC determination will be conducted to evaluate whether the anomaly represents a hazardous MEC. If the anomaly cannot be easily accessed without further intrusion, such as excavation, all work will stop, and appropriate personnel/agency will be notified. Work will recommence once approval is obtained from the appropriate personnel/agency.

If the anomaly can be easily accessed, the determination will be made by the MEC Project Leader via:

- Visual inspection
- Photographing of the anomaly
- Measurements
- X-rays, if required

Once the data described above have been evaluated, on-site MEC personnel will either:

- Make a determination as to whether the anomaly represents hazardous-MEC, non-UXO or UXO scrap, or
- Determine that further consultation is needed and send data and photos to the WESTON Identification Center for review.

Those items determined to be non-UXO or UXO scrap will be disposed properly off-site. If it is determined that the anomaly is live MEC, appropriate personnel/agency will be notified immediately. Live MEC will be properly segregated for detonation or demilling by appropriate personnel/agency at a later date.

Drilling or sampling activities will be relocated a safe distance and sampling activities will continue.

If visual inspection indicates that the item is smoking or that it is a possible CWM-related item, all work will stop, and emergency evacuation and notification procedures will be followed.

4.2 FIELD AND QUALITY ASSURANCE/QUALITY CONTROL SAMPLES

Table 4-1 provides a summary of the field samples and QA/QC samples to be colleted and the analyses required. The paragraphs that follow provide descriptions of the samples to be collected and the analytical methods to be performed.

4.2.1 Supplemental Site Investigation Site Characterization Samples

Based on the rationale established in Subsection 4.3, the following numbers of sample locations are planned:

- Sixty-eight (68) soil borings with soil samples collected at two depth intervals (0 – to 3 ft bgs and 3- to 10 ft bgs). Samples from all of the 68 soil borings will be analyzed by Alpha Analytical Laboratory of Westborough, Massachusetts, for TAL metals via EPA SW 846 Method 6010B/7471A or VOCs via Method 8260B at a minimum. In addition, select soil boring samples within each investigation area will also be analyzed for full suite Target Compound List (TCL) compounds, which incorporates the following:

  - VOC - EPA Method 5035A/8260B
  - SVOC - EPA Method 3540C/8270C
  - PCBs - EPA Method 3540C/8082
  - Pesticides –EPA Methods 3540C/8081A
  - EPH via the MDEP published method

  Select locations will also be analyzed for the following:

  - Perchlorate – EPA Method 8321A
  - Explosives – EPA Method 8330
  - Dioxins/Furans – EPA Method 8290

- Six (6) soil borings with soil samples screened via PID/FID every 2 ft, and one sample per boring collected, based upon the highest PID/FID reading. These samples will be analyzed at Alpha Analytical Laboratory for VOCs via EPA Method 8260B.

- Three (3) test pits with soil samples collected at three depths (0- to 2 ft, 2- to 4 ft, and 4- to 6 ft bgs) from each of the walls of the pits. These samples will be analyzed for TAL metals via EPA Methods 3050B/6010B/7471A.

- Four (4) monitoring wells with soil samples collected at two depth intervals (0- to 3 ft bgs and 3- to 0 ft bgs) and groundwater samples collected from each well. Soil samples will be analyzed for Full Suite TCL Compounds/TAL analytes, as specified above, as well as explosives via EPA SW 846 Method 8330 and perchlorate via EPA

Method 8321A. Groundwater samples will be analyzed for the same constituents as soil plus dioxins/furans via EPA SW 846 Method 8290.

- Five (5) piezometers with no analytical samples collected – depth to groundwater measurements only.

4.2.2 Waste Disposal Characterization Samples

In addition to analytical samples collected to characterize environmental media in the various IAs as part of the SSI effort, it may be necessary to characterize investigation derived wastes (IDW), such as purge water from monitoring wells and drill cuttings from borings for off-site disposal, presumable at a Resource Conservation and Recovery Act (RCRA) Subtitle D (non-hazardous waste) facility. It is also possible, though unlikely that some of the investigative waste would qualify as a RCRA hazardous waste via toxicity characteristic (there are at present no known listed wastes at any of the IAs). Should any of the environmental media be classified as hazardous, PPE associated with sampling and/or otherwise handling the hazardous material, will also be disposed as hazardous, without analytical sampling of the PPE.

Generally, wastes are tested for toxic hazardous characteristics via the Toxicity Characteristic Leaching Procedure (TCLP) and via analysis for ignitability, corrosivity, and reactivity. In accordance with standard practice, because the residuals generated from SSI activities are not expected to be RCRA-hazardous, initially total soil concentrations will be analyzed. Then the total concentrations in milligrams per kilogram will divided by 20 to account for the leaching of contaminants from the soil in a typical landfill setting. The resulting concentrations, now in milligrams per liter will be compared with the maximum concentrations for the toxicity characteristic found at 40 Code of Federal Regulations (CFR) 261.24 (TCLP "allowable" concentrations). Should any of the concentrations exceed the "allowable" concentrations; the sample will be re-extracted and reanalyzed using the TCLP procedure. The typical analytical methods for these tests are as follows:

- Total VOC - EPA Method 5035A/8260B
- Total SVOC - EPA Method 3540C/8270C, include total pesticides in the total SVOC calculation
- RCRA 8 Metals and Mercury – EPA Methods 3050B/6010B/7471A

- PCBs - EPA Method 3540C/8082
- Pesticides –EPA Methods 3540C/8081A
- Total Herbicides –EPA Methods 3540C/8151A/8150B
- TCLP VOC - EPA Method 1311/5030A/8260B
- TCLP SVOC - EPA Method 1311/8270C
- TCLP Metals – EPA Methods 1311/3050B/6010B/7471A
- TCLP Pesticides - EPA Methods 1311/8081A
- TCLP Herbicides– EPA Methods 1311/8151A/8150B
- Ignitability - EPA Method 1010
- Corrosivity – EPA Method 9045A
- Cyanide/Sulfide Reactivity – EPA Methods 7.3.4.1/7.3.4.2 for waste characterization
- Total Organic Carbon – EPA Method 9060A
- TPH - EPA Method 5030B/8015B – gasoline range organics and EPA Method 3540C/8015B – diesel range organics

4.2.3 Quality Assurance/Quality Control Samples

Table 4-1 provides a summary of the QA/QC samples to be collected as part of the SSI field activities described in this WP. The following subsections provide details on the types of QA/QC samples anticipated and their collection frequencies.

4.2.3.1 Soil Quality Assurance/Quality Control Samples

Equipment Blank/Rinsate Blanks

Equipment/rinsate blanks will be collected at the rate of 1 in 20 samples for each parameter or at a minimum one sample per day for an analysis being submitted on that day.

Duplicates

Field duplicate soil samples will be collected at a rate of 1 in 20 per parameter. The duplicate samples will be analyzed for the same parameters as the field samples.

Matrix Spikes/Matrix Spike Duplicates Samples

Matrix Spikes/Matrix Spike Duplicate (MS/MSD) samples will be collected with triple the sample volume at a frequency of 1 in 20 per parameter, per matrix. Double the sample volume is required for MS/MSD soil samples.

Trip Blanks

One trip blank will be submitted for each cooler of samples submitted for VOC analysis. The trip blank samples will be prepared in the laboratory or other off-site location by pouring laboratory grade deionized water into two 40-milliliter (ml) vials and securing the caps. Trip blanks are transported with empty sample containers to the site and remain sealed until analyzed with collected environmental samples.

Quality Assurance Samples

As mentioned previously, QA split samples will be collected at a frequency of 5% of total per analysis, and sent to the USACE contracted QA laboratory, Severn Trent Laboratory-Vermont under contract number E0914 for the following analysis.

- Full Suite – two soil samples and one groundwater sample plus a trip blank
- TAL Metals – 10 soil samples
- Explosives – four soil samples and one groundwater sample

4.2.3.2 Groundwater Quality Assurance/Quality Control Samples

Equipment Rinsate Blank Samples

One equipment blank sample will be collected from new sample tubing prior to the use of the tubing for sample collection. The sample will be collected by pumping laboratory supplied deionized water through a section of supplied tubing into the appropriate sample containers. One

sample for each of the analytes will be collected and submitted to the off-site laboratory for full suite analysis.

Duplicates

One duplicate sample will be collected from a monitoring well and analyzed for the same parameter list. Duplicates will be collected sequentially on an aliquot-by-aliquot basis.

Matrix Spikes/Matrix Spike Duplicates

One MS/MSD sample will be collected and analyzed for the same parameter list.

Trip Blanks

One trip blank per cooler will be submitted on each day that VOC samples are collected and submitted during the groundwater sampling event and analyzed for VOCs. Trip blank samples will be prepared in the laboratory or other off-site location by pouring laboratory grade deionized water into two 40-ml vials. Preservatives are added to the blank, and the containers are sealed. Trip blanks are transported with empty sample containers to the site and remain sealed until analyzed with collected environmental samples.

Quality Assurance Samples

As mentioned in Section 4.2.3.1, QA split samples will be collected and submitted as requested by USACE.

4.3 SAMPLE COLLECTION PROCEDURES

4.3.1 Soil Borings

Hollow-stem auger (HSA) drilling techniques will be employed to advance the subsurface soil borings. The following subsections contain a Standard Operating Procedure (SOP) for advancement of HSA borings as part of this SSI. The SOP uses American Society for Testing and Materials (ASTM) Standards D1452-80 *(re-approved in 2000) - Standard Practice for Soil Investigation and Sampling by Auger Boring and* D5784-95, *Standard Guide for Use of Hollow-*

Stem Augers for Geoenvironmental Exploration and the Installation of Subsurface Water Quality Monitoring Devices as guidelines for boring procedures..

4.3.1.1 Sampling Equipment

The following list of equipment is expected to be required for HSA soil borings:

- Tape measure or folding rule
- Electronic water level indicators
- Field logbook
- PPE
- PID and/or FID and calibration standard
- GPS survey equipment

4.3.1.2 Procedures

The following procedures will be used when performing soil borings using HSA:

1. Once the rig is in place, ensure that it is level

2. The first split-spoon is generally taken outside the augers. Standard blow count procedures, including the ASTM prescribed hammer weight and fall distances, must be followed and documented. Samples within the first 1 to 2 ft of the surface are often compressed by the split-spoon advancement process, resulting in what appears to be reduced recoveries.

3. After the first 2-ft sample is collected, the augers will be advanced 2 ft, and the next split-spoon sample is collected from 2 to 4 ft, and so on, adding 5-ft auger flights to the drill string as needed. Do not allow the driller to "*double spoon"* during sampling.

   This is done by sampling an interval (e.g., 5 to 7 ft bgs) and, without auguring over that interval, immediately sampling the next interval (e.g., 7 to 9 ft bgs) using the previous split-spoon's hole for guidance. This usually results in soil from the upper hole collecting in the second spoon, thereby compromising the sample.

4. A center plug, which prevents earthen materials from moving up into the augers, should be used in all but the hardest of sediments. The center plug is connected to the drive head of the rig by rods to ensure that the plug and rods rotate with the auger flights.

5. The rods used to lower the split-spoon into the augers are also used, along with the auger count, to measure the relative position of the spoon from the surface. Inspect the rods prior to use to ensure that they are the lengths the drillers perceive them to be.

6. Carefully watch the progression of the spoon while recording blow counts and note irregularities in the penetration rate. The use of "fingers" or sand catchers in the sampler may help produce better retrieval volumes in non-cohesive soils.

7. Record observations of:

   - Auger penetration rates.

   - Characteristics of auger cuttings (i.e., moisture content, color, and texture), including changes in the nature (behavior) of the cuttings. For example, if the soil begins to form balls or *rope*, moisture in the soil has probably increased at that depth.

   - Gravel, boulders, and competent bedrock will make the rig bounce, vibrate, or *dance* as well as chatter.

   - Steam coming off the augers. Slow the auger rotation speed to prevent baking.

8. The cuttings appear at the surface after a time lag, and that this lag increases with the depth of the hole; therefore, it is not possible to correlate cuttings with the exact depth being drilled.

9. Running, heaving, or flowing sands occur when augers intercept a saturated soil unit whose fluid or formational pressure pushes its materials out into the boring and up the augers. The use of a center plug can help prevent this from happening, but not after the fact. If running sands are encountered, the following techniques may be used:

   - Remove augers and continue the hole using the rotary-flush (case-and-wash or drive-and-wash) technique (this technique will be used unless directed otherwise; see Subsection 4.4).

   - Fill the augers with potable water to apply a reverse/positive pressure against that of the sands.

   - Drill down below the running sand unit and muck out the augers using a sand pump, dart bailer, and/or roller bit wash.

10. Drilling into or through sand (flowing and non-flowing), gravel, or expanding clay (i.e., clay units that, because of overburden pressures, expand into the hole) can lock up and bind the augers. Avoid leaving the augers in the hole for any prolonged period (e.g., overnight) if any of these conditions are encountered. This may be difficult when rock coring is required.

11. Record on a routine basis the levels of any fluids (depth to water and/or product) in the auger string.

12. Depth to bedrock is based on a combination of both split-spoon and auger refusal. If spoon refusal (50 blows with no penetration) is met and the recovered sample does

not verify bedrock, attempt to auger deeper. A boulder may have stopped the spoon. Continuing the hole using the augers may push the obstruction aside. If the augers advance, continue to the next scheduled sampling interval and attempt to collect another spoon sample. Continue this process until both the spoon and augers have met refusal. Document all refusals (being careful to label them as being either spoon or auger refusal), rig gyrations, and physical conditions of spoons. The only sure way to determine bedrock refusal is to take a core.

13. If a boulder is struck with the augers and the target depth has not been achieved, move approximately 5 feet away from the hole if you are installing a well (10 ft away if you are not) and begin drilling a new borehole. Ensure that the original borehole is properly abandoned.

14. The 6-inch inside diameter (ID) augers used for 2-inch-diameter groundwater monitoring well placement can generally be used to a depth of 50 ft. At locations where the overburden is greater than 50 or where heaving sands are expected, HSA methods may be replaced with the case-and-wash drilling method.

15. Coordinates of each soil boring and test pits will be established utilizing a GPS unit. The accuracy of GPS unit measurements should be less than $\pm$ 20 ft with less than 5 ft accuracy preferred. This will be dependent on the over-story coverage at each sampling point.

4.3.2 Subsurface Soil Sampling Using Split-Spoons

Subsurface soil will be sampled using clean split spoon samplers. Sampling will be conducted as described below. Standard Operating Procedures ASTM D1452-80, *Soil Investigation and Sampling by Auger Borings* and ASTM D6640-01 *Collection and Handling of Soils Obtained in Core Barrel Samplers for Environmental Investigation* will be used a guidance documents during subsurface soil sampling activities.

4.3.2.1 Sampling Equipment

The split-spoon sampling will conducted with a 3-inch-diameter, thick-walled, steel tube that is split lengthwise. For each 3-inch-diameter split spoon sampler used, standard penetration tests will be conducted to determine the density of the soil by utilizing a 300-pound drop hammer with a 30-inch fall. A cutting shoe is attached to the lower end; the upper end contains a check valve and is connected to the drill rods. When a boring is advanced to the point that a sample is to be taken, drill tools are removed, and the sampler is lowered into the hole on the bottom of the drill

rods. The sampler is driven into the ground in accordance with the standard penetration test. The following list of equipment is expected to be required for HSA soil borings:

- Tape measure or folding rule
- Stainless steel mixing bowl
- Stainless steel mixing spoon
- Plastic sheeting
- Field logbook
- PPE
- PID and/or FID and calibration standard

4.3.2.2 Sampling Procedure

1. Place plastic sheeting on the ground around the sampling location to prevent cross contamination.

2. Assemble the sampler by aligning both sides of the barrel and then screwing the drive shoe on the bottom and the heavier headpiece on top.

3. Place the sampler in a perpendicular position on the material to be sampled.

4. Drive the tube utilizing the drill rig drop hammer if available. Do not drive past the bottom of the headpiece because this will result in compression of the sample.

5. Record the length of the tube that penetrated the material being sampled and the number of blows required to obtain this depth. The number of blows per 6 inch of depth shall be recorded.

6. Withdraw the sampler and open it by unscrewing the drive shoe and head, and splitting the barrel. Use caution not to agitate the sample excessively during the opening process. If split samples are desired, a decontaminated stainless steel knife should be utilized to split the tube contents in half longitudinally.

7. Begin sampling with the acquisition of any grab VOC samples, conducting the sampling with as little disturbance as is possible to the media. Undisturbed aliquots of soil from the 0- to 3-ft and 3- to 10 ft depth intervals will be added to VOC sample jars as sampling progresses downward. For the 0- to 3-ft sample, approximately 67% of the soil volume should come from the 0- to 2-ft split spoon, and 33% from the top half of the 2 - 4-ft split spoon. For the 3- to 10-ft sample, approximately 16% should come from the bottom half of the 2- 4-ft split spoon, and 28% of the soil volume should come from the 4- to 6-ft, 6- to 8-ft, and 8- to 10-ft split spoons. When soil aliquots from the entire sample interval have been added to the VOC sample container, sampling is complete. For VOC samples collected from IA-8, one aliquot will be added to the sample jar from the 2-foot interval with the highest PID/FID reading.

8. Homogenization of the sample from the above depth intervals will be required for the remaining analytical parameters. As sampling progresses downward, the recovered soil sample, following soil description and VOC sampling, will be transferred to a stainless steel bowl for mixing. When soil aliquots from the entire sample interval have been added to the stainless steel bowl, sampling is complete, and the soil will be homogenized and placed in the required sample containers.

9. Transfer sample into an appropriate sample bottle with a stainless steel lab spoon or equivalent.

10. Remove any soil clinging to the bottle threads or rim, and secure the cap tightly.

11. Label the sample bottle with the appropriate sample label. Be sure to label the bottle carefully and clearly, addressing all the categories or parameters.

12. Place filled sample containers on ice immediately.

13. Complete all chain-of-custody documents and record in the field.

14. Prepare samples for shipping.

15. Decontaminate sampling equipment after use and between sampling locations.

4.3.3 Subsurface Soil Sampling in Test Pits

During excavation activities, decontamination and containment materials will be supplied by the excavation subcontractor, in accordance with decontamination procedures provided in ASTM 5088-02 - *Standard Practices for Decontamination of Field Equipment Used at Waste Sites*, and Subsection 4.3.13.

Following sampling equipment decontamination, representative soil samples will be collected from each side of the pit at 0- to 2, 2- to 4 and 4- to 6 ft-bgs intervals as follows:

The excavation subcontractor, under the direction of WESTON, will excavate a test pit approximately 9 ft wide by 9 ft in length by approximately 6 ft in depth. Test pits will be logged to their total depth in accordance with relevant portions of ASTM Practice D2488-00 - *Standard Practice for Description and Identification of Soils (Visual-Manual Procedure)*. A complete copy of ASTM D2488-00 is included in Appendix B for reference.

A WESTON geologist or other qualified person will then enter the test pit and collect samples from each of the four sidewalls at three depths (0- to 2, 2- to 4, and 4- to 6 ft-bgs) from each wall

of the test pit. Each sidewall will be given a letter designation (A, B, C, or D) and each sample interval will be given a sequential number designation (1, 2, or 3). The samples will be collected using a stainless steel scoop. Currently, only TAL metals analysis is anticipated for test pit soil samples. In order to represent the depth interval, each sample will be collected by removing soil from the entire length of the targeted depth interval. The soil collected will then be homogenized. Homogenized soil will be placed in an appropriate laboratory container, logged and stored in a cooler for ultimate shipment to the laboratory.

Samples to be collected from the 4- to 6-ft depth interval will be collected in much the same way as the shallower ones, except that, for health and safety reasons, and in compliance with the OSHA Excavation requirements at 29 CFR 1910.126 Subpart P, the sides of the excavation will be sloped above the 4 ft-bgs level to allow site personnel to enter the excavation safely.

All sampled soil will be screened using a PID/FID, and soil descriptions will be entered into the field notebook by the geologist or other qualified person.

Sample preparation, packaging, preservation and shipment will proceed as discussed in Subsections 4.4 and 4.5, and in compliance with ASTM D6640 - Guide *for Collection and Handling of Soils Obtained in Core Barrel Samplers for Environmental Investigation* and ASTM 4547-98 - *Standard Guide for Sampling Waste and Soils for Volatile Organic Compounds*.

4.3.4 Shallow Soil Sampling

Surficial soil samples will be collected from depths of 0 to 1.5 ft-bgs, using a backhoe, shovel or a hand auger. Currently, only TAL metals analysis is planned for surficial soil sampling. If a backhoe is to be used, then the backhoe bucket will be used to excavate soil to a total depth of 1.5 ft bgs. Samples will then be collected directly from the backhoe bucket using a stainless steel scoop and homogenized in a stainless steel bowl prior to placement in the appropriate sample jar and storage on ice in a cooler for ultimate shipment to the laboratory.

For sample collection using a hand auger or a shovel, soil will be excavated to a total depth of 1.5 ft bgs, homogenized and prepared for shipment as described for sampling using a backhoe bucket.

Soil will be screened using a PID/FID and soil descriptions will be entered into the field notebook by the geologist or other qualified person.

Sample preparation, packaging, preservation and shipment will proceed as discussed in Subsections 4.4 and 4.5, and in compliance with ASTM D6640 - *Guide for Collection and Handling of Soils Obtained in Core Barrel Samplers for Environmental Investigation* and ASTM 4547-98 - *Standard Guide for Sampling Waste and Soils for Volatile Organic Compounds*.

4.3.5 Soil Logging

Soils samples will be characterized and logged in a field logbook. ASTM Standards D-5434 *Standard Guide for Field Logging of Subsurface Soil and Rock*, and D-2488-03 *Standard Practice for Description and Identification of Soils* (Visual-Manual Procedure) provide the guidelines for this procedure. Text descriptions of soil characteristics will follow the Burmister Classification System.

4.3.5.1 Equipment

The following list of equipment is expected to be required for HSA soil borings:

- Tape measure or folding rule
- Stainless steel knife or spatula
- Hand lens
- Dropper bottle of dilute hydrochloric acid
- Munsell Color Chart
- Field logbook
- PPE
- PID and/or FID and calibration standard

4.3.5.2 Procedure

The following procedures will be used when describing soil:

1. For soil cores recovered by split-spoons, use a decontaminated stainless steel knife to split the tube contents in half longitudinally. For soils in test pits, use a clean shovel to remove any smearing from the sidewall.

2. Screen the soil for headspace readings using a photoionization detector or equivalent instrument and in accordance with Subsection 4.6. Note any elevated headspace readings, and their specific locations within the soil.

3. Soil samples will be classified using the Unified Soil Classification System (USCS). USCS classifications comprise a two-letter code, related to the primary and secondary grain sizes. Details of USCS nomenclature and test methods are included in ASTM 2488-03 *Standard Practice for Description and Identification of Soils (Visual-Manual Procedure).* However, to provide better descriptive detail, the soil descriptions will be recorded in the field logbook using the Burmister Classification System. Each soil type will be described as follows: *Color, Primary grain size, secondary grain size, tertiary grain size, etc., density, plasticity/cohesiveness, moisture content.* Each grain size should be modified with its roundness. The fractions of the minor grain sizes are indicated using the following modifiers: trace (<5%), little (5% to 20%), some (20% to 35%), with (35% to 50%), and (approximately 50%). An example would be: *Olive brown, SILT, little subangular gravel, trace fine to coarse subangular sand, trace clay, dense, cohesive, saturated.*

4. Record observations of:

   - Angularity of the grains (i.e., rounded, subrounded, subangular, or angular).
   - Shape of the grains (i.e., flat, elongated).
   - Unusual odors.
   - Moisture content (i.e, dry, moist, wet, or saturated).
   - HCl reaction.
   - Consistency (i.e., very soft, soft, firm, hard, or very hard).
   - Cementation.
   - Note any apparent soil structure, such as layering or bedding.

5. Test a representative portion of the soil for dry strength, dilatency, toughness, and plasticity.

6. Record observations immediately into the field logbook. If different layers within the soil core have different characteristics, describe them separately, noting the depth at which the soil characteristics change.

7. The field geologist should attempt to interpret the depositional environment (i.e., fill, lacustrine, fluvial, subglacial) of the soil observed. If possible, descriptive terms such

as till, bar deposit, etc. may be added to the soil description in parentheses following the description.

8. Commence headspace and/or analytical sample collection, as required.

4.3.6 Field Screening

Soil samples will be screened for headspace using a PID and/or FID. Field screening will be performed by filling a polyethylene bag with an aliquot of soil sample from each sampling location. A minimum of approximately 1 inch of headspace will be maintained in the bag. The bag will be sealed, kneaded for 10 seconds, and allowed to equilibrate for a minimum of 15 minutes but for not more than 1 hour. During the equilibration period, the bag should be allowed to warm to approximately 60 to 70°F, either by leaving it out during warm weather or placing it inside a warm vehicle during cold weather. To screen the sample, the PID/FID probe will be inserted into the bag, and an organic vapor reading will be taken using the instrument. Contact between the probe tip and the soil in the bag will be avoided. Results will be recorded in the field logbook.

4.3.7 Design, Construction, and Installation of Groundwater Monitoring Wells/Piezometers

Groundwater monitoring wells are used to collect groundwater elevation data and groundwater samples for analytical screening purposes. Piezometers are installed where additional information is needed to more accurately evaluate the groundwater flow direction in a given aquifer. Piezometers can also be used to collect groundwater samples for analytical screening purposes, but may be subject to low recovery rate, due to their relatively small radius. Groundwater monitoring wells and piezometers will be designed and installed in accordance with applicable sections of ASTM D5092-04, *Standard Practice for Design and Installation of Ground Water Monitoring Wells*.

4.3.7.1 Monitoring Well/Piezometer Design

Schedule 40 polyvinyl chloride (PVC) will be used for all well screens and risers. All well materials will be as chemically inert as technically practical with respect to the site environment. All well screens will be commercially fabricated, slotted or continuously wound, and have an ID

equal to or greater than the ID of the well casing. All screens, casings, and fittings will be new. Screens will have the largest open area per unit length that is practical for the adjacent aquifer and available filter pack.

Couplings within the casing and between the casing and screen will be compatibly threaded. Thermal or solvent welded couplings on plastic pipe will not be used. This also applies to threaded or slip-joint couplings thermally welded to the casing by the manufacturer or in the field.

Each well cap will be constructed to preclude binding to the well casing due to tightness of fit, unclean surface, or frost, and secure enough to preclude debris and insects from entering the well. Caps and risers may be threaded; however, sufficient annular space will be allowed between the well and protective casing to enable one to thaw any frosted shut caps. Caps will be loose enough to allow equilibration between hydrostatic and atmospheric pressures or have filtered vents.

All granular filter pack materials will be approved prior to drilling. The actual gradation of the filter pack will be determined during drilling, so more than one filter pack gradation will be on hand so that well installation will not be unnecessarily delayed.

Granular filter packs will be visually free of material that would pass through a No. 200 (75-micrometer (µm)) sieve, inert, siliceous, composed of rounded grains, and of appropriate size for the well screen and host environment, according to ASTM D5092-04, *Standard Practice for Design and Installation of Ground Water Monitoring Wells*, Section 6.33. The filter material will be packaged in bags by the supplier and therein delivered to the site.

Bentonite is the only material that is allowed for sealing or as drilling mud under normal circumstances. This includes any form of bentonite (powders, granules, or pellets) intended for drilling mud, grout, seals, etc. Chips or pellets of an appropriate size depending on the annular space available will be used to form the well seal. If chips are used, they should be sieved to remove fine-grained material.

Grout, when used in monitor well construction or borehole/well abandonment, will be composed of Portland cement, bentonite (0- to 10% dry bentonite per 94 pound sack of dry cement), and a maximum 6 to 7 gallons of approved water per sack of cement. The amount of water per sack of cement required for a pumpable mix will vary with the amount of bentonite used. The amount of water used will be kept to a minimum. Neither additives nor borehole cuttings will be mixed with the grout.

All grout materials will be combined in an aboveground rigid container or mixer, and mechanically (not manually) blended on-site to produce a thick, lump-free mixture throughout the mixing vessel. The mixed grout will be re-circulated through the grout pump prior to placement. Grout will be placed using a grout pump and pipe/tremie. The grout pipe will be of rigid construction for vertical control of pipe placement. Drill rods, rigid PVC, or metal pipes are suggested stock for tremie pipes. If hoses or flexible plastics must be used, they may have to be fitted with a length of steel pipe at the downhole end to keep the flexible material from curling and embedding itself into the borehole wall. This is especially true in cold weather when the coiled material resists straightening. Grout pipes will have side discharge. The side discharge will help to maintain the integrity of the underlying material (especially the bentonite seal).

To the extent practical, the use of drilling water will be held to a minimum. When water usage is deemed necessary, the water source used in drilling, grouting, sealing, filter placement, well installation, well decommissioning/abandonment, equipment washing, etc. will be approved prior to arrival of the drilling equipment on-site and specified in the work plans. Desirable characteristics for the source include:

- An uncontaminated aquifer origin.
- Wellhead upgradient of potential contaminant sources.
- Source is free of survey-related contaminants by virtue of pretesting.
- The water is untreated and unfiltered.
- The tap has accessibility and capacity [greater than 10 gallons per minute (gpm)] compatible with project schedules and equipment.

- Only one designated tap for access.
- Surface water bodies will not be used, if at all practical.

If a suitable source exists on-site, that source will be used. The drilling subcontractor will have the responsibility to procure, transport, and store the water required for project needs in a manner to avoid the chemical contamination or degradation of the water once obtained. The drilling subcontractor will also be responsible for any heating, thermal insulation, or agitation of the water to maintain the water as a fluid for its intended uses.

Materials will be delivered to the site and stored in a secure area. Subcontractors are generally responsible for scheduling delivery and ordering those supplies pertaining to the installation of wells. An inventory will be kept to track the materials. Perishable materials will be covered with tarps and secured to prevent water damage. All materials will be handled in a safe manner and in accordance with health and safety protocols.

4.3.7.2 Monitoring Well/Piezometer Construction

Drilling and monitoring well installation materials will be kept away from fuel and generators used in drilling. The actual well screen lengths and depths will be determined in the field based on the actual depth of the water table. Screen interval placement will be dependent upon the season. During the dryer seasons the base of the well screen will be installed approximately 5 ft below the observed water table. During the wet seasons the base of the well screens will be installed approximately 7 ft below the observed water table.

During any activities pertaining to well construction, abandonment, or development, the field geologist will note in the field logbook the following information:

- Length of time required to perform all drill rig activities (e.g., overdrilling, well construction, abandonment/grouting, development times, and pumping rates).
- All well construction/abandonment supplies used (e.g., bentonite, Portland cement, filter sand, and screen/riser footage).
- Any difficulties in well construction, development, or abandonment. This information may be used to substantiate a change of scope or explain anomalous sampling data.

- Exact measurements (using a tape measure) of screen, end cap trap, and riser lengths.
- A completed well construction diagram.
- A tally of water gain/loss during monitor well/piezometer installation.

Piezometer Construction

The following materials will be used to install piezometers:

- Piezometers will generally be constructed in boreholes advanced with 4.25-inch ID, hollow-stem augers.
- Piezometers will be constructed within the augers as the augers are pulled back and will be constructed using 2-inch-diameter PVC with a 10-foot screen length and a threaded bottom cap with a drain hole drilled in the bottom cap to allow drainage if the water table drops below the total depth of the piezometer. The well screen will be machine-slotted with No. 10 slots (0.010 inch). The screened section will be threaded to attach to the PVC riser pipe. Sections will never use PVC cement.
- Place decontaminated PVC screen and riser into the auger.
- Use Moiré No. 1 or finer sand to create a filter pack that will extend from total depth to approximately 1 to 2 ft above the top of the screen as the augers are withdrawn from the borehole.
- Place a 2- to 3-ft-thick bentonite pellet seal above the filter pack. Add pellets slowly to minimize the risk of *bridging* that could result in inadequate sealing properties. Allow pellets to hydrate for 10 to 15 minutes. If the seal is located above the water table (dry), use pure bentonite slurry or pour potable water on the pellets to cause them to hydrate. Depending on the hydrogeologic conditions encountered in the borehole and/or intended use, actual screen and filter pack lengths may vary (e.g., 1- to or 2-ft-screens may be used). The PM is responsible for approving any nonstandard construction details based on intended use and lithologic constraints.
- Tremie grout cement/bentonite grout slurry from the top of the seal to 4 ft bgs. The grout slurry will consist of the following ratio of components:
  - 94 pounds of Type I Portland cement
  - 4 pounds of pure sodium bentonite powder
  - No more than 6.5 gallons of potable water

Proper grouting techniques are required to prevent cross-contamination. Thus, it is imperative that the field team closely supervise all grouting operations.

Two piezometers may be installed in the same borehole if logistics warrant this type of procedure (i.e., difficult access or thick concrete at the ground surface). Nested piezometer installation will be conducted as described previously, except that a bentonite seal will be installed as an impermeable layer between the screened intervals. Specifically, the lower screen's bentonite seal will extend to 1 ft below the proposed depth of the upper screen. A minimum 1-ft-thick filter pack base (normally 2 ft thick) will be added to avoid possible contact of the upper screen with the bentonite seal.

Monitoring Well Construction

The following materials will be used to install monitoring wells:

Overburden monitoring wells will monitor 10-foot intervals; however, screen length may be modified by the field geologist to accommodate specific data needs. Proposed screened intervals may be changed based on the results of soil screening with a PID/FID, or when highly permeable zones are encountered. Wells installed to monitor the water table will be screened from approximately 5 ft above the existing water level in the borehole to approximately 7 ft below this level to allow for seasonal groundwater table fluctuations. Depth of well screens may be modified by the field geologist to accommodate seasonal fluctuations in groundwater elevation. Where floating product is suspected to exist, screens will be installed to extend 5 ft above the water table.

After completion of the borehole, the monitor well will be constructed using Schedule 40 PVC riser and machine-slotted well screen. Well screen slot sizes for both PVC and stainless steel wells will be No. 10 or 20 (0.010 or 0.020 inch), depending on the grain size of the formation outside the screen. Filter pack and well slot size will be selected based on the mean grain size of the most finely grained geologic deposits in the screened interval, and should be designed to retain most of the formation.

Moiré or equivalent sand, used for the sand pack, should not extend less than 2 ft above the top of the screen. The mean grain size of the filter pack should be twice the mean grain size of the formation material based on lithologic information. A seal consisting of pure sodium bentonite pellets or chips, approximately 3 ft thick will be placed above the filter pack. If the seal is above

the water table, the pellets will be hydrated with potable water. Cement/bentonite grout will be tremied into place from the top of the bentonite seal to within 4 ft of the ground surface. The protective casing will then be installed, and grout will be added to the annulus between the borehole and the exterior wall of the protective casing. To prevent frost heaving, pure bentonite slurry will be added to the annulus between the well casing and the interior of the protective casing.

Each batch of grout will be mixed to consist of 94 pounds of Type I Portland cement or equivalent, 4 pounds of pure sodium bentonite powder, and not more than 6.5 gallons of potable water. The bentonite pellets and grout seal should be a minimum of 5 ft thick (2 ft of pellets and at least 3 ft of cement/bentonite grout).

Monitoring Well/Piezometer Installation

The following installation procedures will be followed when installing monitoring wells and piezometers:

1. Lower screen and riser into the augers or temporary casing to the bottom of the borehole. If the well exceeds 50 feet in depth, centralizers may be needed.

2. Add the appropriate grade of Moiré or equivalent sand to the annulus around the screen to 2 ft above the screen as the augers are pulled back. If case-and wash methods are used, the sand will be added while the temporary casing is pulled back.

3. Add a 3-ft-thick seal consisting of pure sodium bentonite pellets or chips. If the seal will be above the water table, potable water will be poured on the pellets to cause them to hydrate.

4. Pellets will be tamped down to the top of the sand pack and allowed to hydrate for 10 to 15 minutes before the rest of the annulus is grouted.

5. Tremie grout (above the bentonite seal).

6. The bentonite and grout seal should be a minimum of 5 ft thick (2 ft of pellets or bentonite slurry and at least 3 feet of cement/bentonite grout).

7. Deviations from these procedures are sometimes necessary because of field conditions. Project Manager notification is required before deviating from the approved installation procedure.

8. Erosion and/or ponding in the immediate vicinity of the monitoring well may be prevented by assuring that the ground surface slopes away from the monitor well protective casing by the installation of a 2-ft by 2-ft concrete pad around the well.

9. Wells will contain a locking cover on the protective casing. The cover will be hinged or telescoped, but not threaded. All locks on these covers should be opened by a single key, if possible.

10. Extend the well casing 2 to 3 ft above ground surface.

11. Provide an end plug or casing cap for each well. Use a filtered vented cap or drill a small (0.125-inch) hole into the PVC riser just below the PVC cap or into the PVC cap to allow air circulation in the well.

12. Shield the extended well casing with a carbon steel protective casing that is set over the well casing and cap and extends to a depth of 3 ft bgs.

13. Grout the annular space between the borehole and the protective casing with cement/bentonite grout to a depth of 4 ft bgs.

14. Construct a 2- by 2-ft by 4-inch concrete pad at the surface, sloped away from the protective casing.

15. Drill a small diameter hole (0.25- to 0.375-inch) in the protective casing (weep hole) near the top of the concrete pad to allow for drainage, and mark a survey location on the inner casing (mark with an indelible marker or cut a small notch in the PVC on the side toward the hinge).

16. Install a lockable cap or lid on the protective casing.

17. Mark the well number clearly on the protective casing cap using impact lettering.

18. Install three 3-inch-diameter, concrete-filled steel guard posts, if necessary.

19. All wells will be secured as soon as possible after drilling. Corrosion-resistant locks will be used for both flush and aboveground well assemblies. The locks must have extended shanks.

20. Groundwater monitoring wells will be completed aboveground at most locations. Where wells are completed flush with ground surface, the methods described in ASTM D 5787 – *Practice for Monitoring Well Protection* - should be used for installation of a manhole or vault at the surface for well protection. An internal cap should be fitted on top of the riser within the manhole or vault. This cap should be leak-proof so that if the vault or manhole should fill with water, the water will not enter the well casing. Ideally, the manhole cover cap should also be leak-proof.

21. Coordinates and elevations will be established for each new piezometer and monitoring well. A state-certified land surveyor will be subcontracted to perform the

survey work. The coordinates will be to the closest 1.0 ft and referenced to existing on-site control. The ground surface, top of outer casing, and top of inner casing (measuring point) elevations will be determined to the closest 0.01 ft.

4.3.8 Well Development

Well development is the process by which foreign materials and solids are removed from the screen filter pack or open hole, allowing water to flow freely into the well. This process is accomplished by moving water through the well screen or borehole into and out of the surrounding material. Well development serves four principal purposes:

1. Removes materials that have built up in the openings of the screen or borehole during the well drilling and installation process.
2. Removes fine materials from the side of the borehole that result from the drilling procedures (e.g., drilling mud).
3. Increases hydraulic conductivity of the filter pack and adjacent geologic materials by removing fine materials.
4. Stabilizes the fine materials that remain in the vicinity of the well, thereby retarding their entry into the well.

The benefits are increased yield and reduced suspended solids.

The well will be developed using mechanical surging and over-pumping. In this method (surge blocking), a surge block is pushed in and pulled out of the well in a plunger-like fashion. As fines are flushed into the well, they are pumped out or bailed out. This method is the most effective method of development, but is only used to develop screened wells because it may cause collapse in an open borehole.

All materials placed in the wells must be decontaminated prior to their use. All submersible pumps must be equipped with clean wiring (no electrical or duct tape), and have either PVC or polyethylene tubing.

4.3.8.1 Equipment

- De-ionized water and decontamination supplies
- Stopwatch/wristwatch

- Electronic water level measurement device
- Flow rate/volume measurement devices
- Turbidity meter
- Thermometer
- pH meter
- Electrical conductivity meter
- Organic vapor detector (PID/FID)
- DO meter (optional)
- Eh meter (optional)
- 1,000-ml Imhoff cone (optional)

4.3.8.2 Well Development Procedures

Overburden wells are developed as follows:

Development should not be performed sooner than 48 hours after installation to ensure that the grout has had ample time to cure, unless grout is above the depth of the water table.

Overburden well development will be performed using surge block techniques.

Depending on well construction design, the surging will either be performed manually using a surge block connected to a tremie pipe (or equivalent) or operated mechanically from the drilling rig. The entire length of the saturated well screen will be surged. Surging will alternate with pumping for a minimum of 1 hour up to 4 hours, until sediment production nearly ceases.

The wells will then be pumped (if yields are high enough: >0.5 gpm) using a decontaminated submersible pump (low-yielding wells should be pumped with a 2-inch outside diameter adjustable rate pump or manually bailed). All pumps will be equipped with clean wiring and PVC or polyethylene tubing. The submersible pumps should be capable of operating at a range of pumping rates (generally from 1 to 10 gpm); either by use of different pumps or throttling back on pump flow to meet well yield conditions.

At regular intervals, such as every 15 minutes during development, purge rate; depth to water; and groundwater pH, temperature, electrical conductivity, PID/FID readings, turbidity, incremental, and total volume purged will be recorded. All purge water will be containerized. Well development will continue until turbidity measurements are 5 nephelometric turbidity unit (NTUs) or less, and readings stabilize over three successive 5-minute intervals, or for a minimum

of 1 hour or a maximum of 4 hours. After 4 hours, if a turbidity of 5 NTU cannot be achieved, well development will discontinue, and the final turbidity will be noted in the log.

Because one of the objectives during well development is the determination of well yield in gallons per minute, the depth to water will be measured at the same time as the other parameters, and the flow of the submersible pump (if used) will be adjusted so that the water level stabilizes. At that point, flow rate should be approximately equal to well yield. If the well goes dry during development, water levels should be recorded during a 10-minute recovery test that will be run to determine the rate that groundwater is entering the well. Water levels are taken at intervals of 0 seconds, 15 seconds, 30 seconds, 1 minute, 2 minutes, 5 minutes, and 10 minutes. At the end of development, an estimation of yield will be recorded.

4.3.9 Water Level Measurements

Water level measurements will be collected in accordance with WESTON SOP GW-8 - *Water Level and Well Depth Measurements*. The SOP provides detail on the handling of well measurement equipment as well as on procedural differences between measurements in the presence of non-aqueous phase liquid (NAPL) and those measurements taken in the absence of NAPL. The following text summarizes the SOP.

In addition to wells designated for water quality monitoring, water level measurements will be collected at piezometers designated for water level monitoring only. The well/piezometer identification numbers and locations are described in Subsection 4.5.2.1.

At a minimum, the following equipment will be used:

- Electronic water level indicator
- PID and calibration standard
- Decontamination supplies including non-phosphate detergent, tap water, deionized water, brushes, decon tubs, and sprayers.

The general procedure for measurement of water levels in wells and piezometers at for SSI activities Devens is as follows:

a. Unlock the protective casing on the well.

b. Scan the headspace in the wellhead for organic vapors using a PID/FID and record the measurements.

c. Using a decontaminated water level indicator, measure and record the static groundwater level in the well. Measurements will be taken from the highest point of the inner riser pipe of all wells and from a surveyor mark, such as a groove filed into the riser, whenever possible. Record the measurement from the water surface to the top of the well casing to the nearest 0.01 ft. Record measurement time.

d. Following completion of water level measurement activities, measure and record the water level in the first well measured to identify any regional fluctuations in water levels.

4.3.10 Low-Flow Groundwater Sampling

Groundwater samples will be collected from monitoring wells only after the wells have been properly developed and no earlier than 7 calendar days after development has been completed. Drilling and well construction may disrupt the natural groundwater system; the delay allows the groundwater system to return to equilibrium before sampling. Wells will be sampled in the order of least contaminated to most contaminated, to the extent possible.

4.3.10.1 Sampling Equipment

Monitoring wells will be sampled using dedicated Teflon tubing and low flow purging and sampling methods. ASTM D6771-02, *Low-Flow Purging and Sampling for Wells and Devices Used for Ground-Water Quality Investigations* and EPA *Low-Flow (Minimal Drawdown) Ground-Water Sampling Procedures* are used as guidelines for the procedures. The following list of equipment is expected to be required for monitoring well sampling:

- Peristaltic sampling pumps
- 2-inch submersible pumps with controllers
- Electronic water level indicators

- Dedicated Teflon tubing for each monitoring well
- Disposable Teflon bailers
- Surficial grade silicon tubing for peristaltic pumps
- 250 ml graduated cylinders
- Stop watches to check/adjust purge rates
- Dedicated nylon rope
- Calibrated bucket
- Sample containers and preservatives
- Flow-through polyethylene containers for monitoring groundwater parameters during purging
- Wide range pH test paper to ensure proper sample preservation
- Generator to supply electricity at remote sampling locations
- Extension cords
- Large pipe wrenches to remove well caps
- Polyethylene sheeting
- Coolers for sample shipment
- Conductivity meter and KCl calibration standard solutions
- Turbidity meter and calibration standards
- Thermometer
- pH meter with standard pH buffer solutions of pH 4, 7, and 10
- DO meter
- ORP meter
- PID or FID and calibration standard
- Decontamination supplies including non-phosphate detergent, tap water, deionized water, brushes, decon tubs, and sprayers.

4.3.10.2 Sampling Procedures

The following procedures will be used for sampling monitoring wells:

1. Unlock the protective casing on the well.

2. Scan the headspace in the wellhead for organic vapors using a PID/FID and record the measurements.

3. Water levels will be measured using an electronic water level meter and will be measured from a designated location at the top of the inner well casing. The designated location will be the highest point on the inner well casing and will be clearly marked with a permanent marker for future reference. Record the measurement from the water surface to the top of the well casing to the nearest 0.01 ft. Measurements will be taken from the surveyor's mark on the well casing to ensure they are taken from the same location each time. A single water level meter, which is decontaminated between wells, will be used for all measurements. The date and time of water level observation will be recorded along with the water level measurement. An electronic interface probe will be used to monitor NAPL in monitoring wells, if warranted.

4. Using the well diameter, the measured depth of the standing water, and the screened interval, calculate the volume of the standing water in the well and the screened volume. Record these volumes.

5. If the depth to groundwater is less than approximately 25 ft bgs, use a peristaltic pump for purging. If the depth to groundwater exceeds 25 ft bgs, use a submersible pump. Set the Teflon tubing at the middle of the saturated screened interval for existing overburden wells, at the depth corresponding to the highest VOC soil screening result (as indicated on the well installation logs) for the new overburden monitoring wells, and at the mid-point of the open bedrock interval or screened interval for all bedrock wells. In the absence of any VOC concentrations from the well installation logs for the new overburden wells, the sample intake will be located at a point one-third up from the bottom of the entire screened length. Begin purging at a flow rate no greater than 500 ml per minute. During purging, water levels and pumping rates will be measured every 3 to 5 minutes. Drawdown must be monitored and the purge rate adjusted so that the drawdown is minimized and does not exceed 0.3 ft. If drawdown of 0.3 ft is exceeded, the flow should be adjusted to the lowest stable flow (approximately 100 ml per minute). Prior to screening groundwater, field personnel will calibrate screening instruments and document the calibration in a field logbook. Monitor the pH, turbidity, specific conductance, dissolved oxygen, oxidation reduction potential, and temperature every 3 to 5 minutes during purging

using a flow-through container. Purging will continue until stabilization has been reached, as defined by three consecutive readings within the following limits:

- pH: ±0.1 standard unit,
- turbidity: 10% or is less than one nephelometric turbidity unit (NTU),
- ORP ±10 millivolts
- dissolved oxygen: 10%
- specific conductance: 3%
- temperature: 3%

The pumping rate, drawdown, indicator parameter values, and clock time will be recorded at appropriate time intervals. A maximum purge time of four hours will be set at each well. If the parameters have not stabilized to within the limits listed above after four hours, this will be noted in the field logbook, and the sampling will begin. If the sampling pumps should fail, a Teflon bailer will be used to complete the purging and to collect the samples, and the total volume of water purged. Purged water will be staged in drums for future sampling and disposal.

6. Once purging is complete (as described above), sampling may begin. Samples will be collected before water has passed through the flow-through cell by disconnecting the flow-through cell from the discharge line or by using a by-pass assembly.

7. If dense non-aqueous phase liquid (DNAPL) is encountered during purging or sampling, a sample of the DNAPL will be collected. The DNAPL sample will be submitted to the laboratory for analysis (TBD).

8. Samples for VOC analysis will be collected first. Following the collection of a sample in a volatile organic analysis vial, ensure that there are no air bubbles in the vial by turning the vial upside down and tapping it lightly. All other sample containers should be filled to approximately 3/4 full. The metals sample will be for total metals and as such should be unfiltered.

9. Once sampling has been completed, a final set of pH, temperature, turbidity, DO, ORP, and conductivity readings will be obtained and recorded.

10. Immediately label, preserve (if necessary), refrigerate/ice, and log the samples in the field logbook.

11. Measure and record the standing water level in the well and the depth of the well following sampling

12. Replace the protective cap on the well and lock it securely.

4.3.10.3 Sample Preservation

Table 4-2 identifies sample matrices, analytical parameters, required containers, specified preservatives, and maximum holding times for samples collected for analysis at the off-site laboratory.

All samples will be immediately preserved following collection. Sample collection, preservation and handling must be in accordance with the analytical method. If preservative is added to the bottles prior to shipment to the field, care must be taken not to overfill the containers, and pH must be measured on samples where a value is specified.

4.3.11 Non-aqueous Phase Liquid Testing

The general procedure for screening/sampling of NAPL in wells and piezometers for SSI activities is as follows:

4.3.11.1 NAPL Screening

NAPL screening will be performed on every soil sample that produces an OVA response greater than 10 units (10 parts per million methane equivalent in air) during the headspace screening.

At a minimum, the following equipment will be used:

- Stainless steel spoons, spatulas, or scoops
- Stainless steel bowls
- Sample containers
- Ultraviolet (UV) fluorescent light
- Hydrophobic, non-volatile dye (SUDAN IV)

Non-aqueous phase liquid screening will include visual examination, a fluorescence test, dye test, and a jar shake test. Each sample (while still in the sample jar) will be visually examined for the presence of NAPL. The senior geologist to be used on this project has previously drilled at sites containing NAPL and is therefore familiar with its visual characteristics. Drill cuttings that come to the surface during drilling will also be periodically examined for signs of NAPL.

Once the results of the visual examination have been recorded in the field log book, the sample will be exposed to a portable UV light source in a darkened location on-site. Any milky-white fluorescent areas on a sample will be noted in the logbook.

After the fluorescence test has been completed, SUDAN IV dye will be added to the sample jar and the jar will be shaken. SUDAN IV is known to turn NAPL red. The sample will be examined for signs of red and then placed under the UV light source again. Any reddish areas will be noted in the logbook.

4.3.11.2 NAPL Sampling

NAPL sampling will be conducted only if screening indicates the potential presence of NAPL within the groundwater. At a minimum, the equipment used for sampling of NAPL includes:

- Oil/water interface probe
- Heavy string
- PID/FID
- Bottom filling bailer-LNAPL
- Dual check value bailer-DNAPL
- Bacon Bomb Sampler-DNAPL (Optional)

The sampling procedure for NAPL is summarized as follows:

LNAPL

Prior to the purging of groundwater from the well, a sample of the floating layer may be obtained using a bailer that fills from the bottom. Care should be taken to lower the bailer just through the floating layer, but not significantly into the underlying groundwater. A sample jar may also be used to sample the floating product, but it must be well secured to avoid being dropped down the well.

If more than one distinct LNAPL layer is present in a well, each layer should be sampled. Samples should be analyzed for chemical composition and physical parameters (e.g., specific gravity, water solubility, etc.).

DNAPL

A DNAPL sample may be obtained by lowering a dual check value bailer or a Bacon Bomb Sampler to the bottom of the well. Samples should be analyzed for chemical composition and physical parameters (e.g., specific gravity, water solubility, etc.).

The Bacon Bomb Sampler is a widely used, commercially available sampler, designed for sampling petroleum products and viscous liquids. The Bacon Bomb Sampler is equipped with a trigger that is spring loaded. When opened, the trigger allows liquid to enter the collection chamber. When the trigger is released, liquid is prevented from flowing into the collection chamber or out of the collection chamber. Sampling of DNAPL with a Bacon Bomb sampler should proceed as follows:

1. Spread new plastic sheeting on the ground at each sampling location to keep sampling equipment decontaminated and to prevent cross-contamination.
2. Measure and mark the sampler line at the desired sampling depth.
3. Lower the Bacon Bomb Sampler carefully to the desired sampling depth, allowing the line for the trigger to remain slack at all times. When the desired depth is reached, pull the trigger line until taut.
4. Release the trigger line and retrieve the sampler.
5. Transfer the sample to the sample bottles by pulling on the trigger. Allow the sample to flow down the side of the sample bottle with minimal disturbance.
6. Preserve the sample as necessary, and verify that the pH is sufficient for the criteria.
7. Check that a PTFE liner is present in the cap. Secure the cap tightly.
8. Label the sample bottle with an appropriate label. Be sure to complete the label with all necessary information.
9. Place filled sample containers on ice immediately, along with the required trip blank, if analyzing for VOCs.
10. Record the information in the field logbook and complete all chain-of-custody records and field sheets.
11. Decontaminate the sampler.

4.3.12 Equipment Operation and Calibration

The field measurement equipment anticipated to be on-site during SSI activities includes:

- Schoenstedt Magnetometer
- White's Spectrum XLT
- Ebinger MAGNEX 120 with downhole cable
- Turbidity Meter (YSI Model 63 or equivalent) and calibration standards
- pH Meter (YSI Model 63 or equivalent) and calibration standards
- Conductivity Meter (YSI Model 63 or equivalent) and calibration standards
- Electronic water level indicator
- PID and/or FID and calibration standards

Manufacturer's instructions for proper use, calibration and care of the equipment will be followed in the field. Calibration of equipment will be performed at the start of each sampling day, with calibration checks performed at a minimum at the end of each sampling day. The equipment will be used by qualified field personnel, experienced in their use, or by personnel under the direct supervision of qualified, experienced persons.

Calibration and calibration checks shall be recorded in the field logbooks.

4.3.13 Decontamination Procedures

All sampling equipment must be properly decontaminated prior to sample collection, between sampling locations, and following a sampling event. Decontamination of equipment is necessary in order to prevent cross-contamination between samples. In addition, rust should be removed from any part of the sampling equipment that may contact the sample. Dry decontamination will be employed for the backhoe equipment while all HSA, split-spoons and direct-push equipment will be wet decontaminated. Decontamination will occur between individual sampling locations, but not within composite sampling locations.

ASTM standard D5088-02 *Standard Practices for Decontamination of Field Equipment Used at Waste Sites* is used as a guideline for this procedure.

The water level probe and flow-through cell will be thoroughly rinsed with deionized water between sampling locations. The drilling rig and all downhole drilling equipment (casing, auger flights, drill rods, etc.) will be decontaminated between borings by high temperature pressure

washing with a steam cleaner. The decontamination will be conducted on a temporary decontamination pad. Any decontamination fluids not lost to evaporation will be collected and containerized.

Dedicated tubing will be used during groundwater sampling events on this project. This tubing will be properly disposed of following collection of a groundwater sample.

Procedures for decontamination of all other sampling equipment are as follows:

1. Wash the equipment thoroughly with phosphate-free laboratory detergent and tap water. Use a brush to remove any particulate matter or surface film. If the sampling equipment was used to collect samples that contained oil, grease, or similar materials, it may be necessary to steam clean the equipment prior to washing with the detergent solution. If the field equipment cannot be cleaned using these procedures, it should be properly disposed.

2. Rinse the equipment thoroughly with tap water.

3. If the sampling equipment (Teflon, polyethylene, or glass equipment only) is being used to collect samples for metals analysis, rinse the equipment with a nitric acid solution.

4. If the sampling equipment (stainless steel equipment only) is being used to collect samples for PCB analysis, rinse the equipment initially with alcohol (methanol or isopropanol), and then with a hexane solution. Follow with an alcohol rinse (methanol or isopropanol) to remove residual hexane.

5. Rinse the equipment (Teflon, glass, or stainless steel equipment only) with pesticide-grade isopropanol.

6. Alternative decontamination procedures for Steps 3, 4, and 5 includes steam cleaning steel sampling equipment (i.e., split-spoons).

7. Rinse the equipment with deionized water and allow to air dry.

8. Wrap the equipment completely with aluminum foil to prevent contamination during storage and/or transport to the field.

Decontamination of electronic water level measurement tape and probe will be conducted by rinsing with deionized water prior to use in each well. If gross contamination is present on the water level measurement tape or probe, it may be washed with phosphate-free laboratory detergent and tap water and rinsed with tap water and deionized water.

The drilling rig will be decontaminated between wells by steam cleaning at a temporary decontamination pad. The decontamination fluids will be contained and pumped into drums along with drilling fluids and well development water for subsequent testing, and appropriate disposal.

4.4 SAMPLE HANDLING, PRESERVATION, AND HOLDING TIMES

Table 4-2 provides a summary of sample containers, preservatives, and maximum holding times for the samples to be analyzed in support of the SSI. All samples will be immediately preserved following collection. Sample collection, preservation and handling must be in accordance with the analytical method. If preservative is added to the bottles prior to shipment to the field, care must be taken not to overfill the containers, and pH must be measured on samples where a value is specified.

4.5 SAMPLE CHAIN OF CUSTODY AND SAMPLE DOCUMENTATION

4.5.1 Chain of Custody

Evidence of collection, shipment, laboratory receipt, and laboratory custody until disposal will be documented to ensure maintenance of sample integrity. Documentation will be accomplished through a chain-of-custody (COC) record that records each sample and the individuals responsible for sample collection, shipment, and receipt. Sample custody will be initiated by WESTON upon collection of samples. A unique sample identification label will be attached to each sample container. The samples will be packed for until shipping in appropriate coolers. Chain-of-custody forms will be placed in waterproof plastic bags and taped to the inside lid of the cooler. The cooler will be sealed with chain of custody seals.

A COC form will be completed for each sampling event. COC forms will be used for recording pertinent information about the sampling locations, types and numbers of samples collected and shipped for analysis, the sampling data and time, signatures of the sampling team, the project name and number, and the name of the laboratory where the samples are being sent. Sample identification numbers will be included on the COC form to ensure that no error in identification is made during shipment.

4.5.2 Documentation

Field documentation procedures will be employed to provide consistency of documentation between field crews during on-site activities. The field logbook should enable the field activities to be reconstructed without relying on the field personnel memory. The system for identifying and tracking the field activities and associated field data will be recorded in a permanently bound and weatherproof logbooks maintained by each field team. Field documentation will be done in indelible ink. The front of the logbook will be labeled with the project name and number, the types of field activities recorded in the logbook, and the dates of use.

The field logbook should enable the sampling activity to be reconstructed without relying on the memory of the field team. Logbooks should be kept in the possession of a field member or in a secure place during field work. If an error is made in a logbook, a single line should be drawn through the entry and the entry initialed and dated. The following topics should be recorded in the field logbook on a daily basis or at pertinent time intervals.

- Name and title of author, date and time of entry.
- Names and responsibilities of field crew members.
- Names and responsibilities of any subcontractors present.
- Names and titles of any site visitors.
- Weather conditions.
- Sample collection method.
- Number and volume of sample(s) taken.
- Information concerning sampling changes, scheduling modifications and change orders.
- Details of sampling location, including descriptions of the locations in reference to permanent landmarks. A basic drawing of the sample location in reference (distance to and north arrow) to the permanent landmarks should be included for each sample location or group of sample locations.
- Date and time of sample collection.
- Field observations.

- Any field measurements (e.g., headspace readings) made.
- Sample identification number(s).
- Information from containers, labels of reagents used, de-ionized water used for blanks, etc.
- Equipment and instrument identification numbers, if available.
- Sample preservation.
- Sample distribution and transportation.
- Sample documentation (e.g. chain-of-custody record numbers).
- QC samples associated with the samples collected.
- QC sample collection.
- Instrument calibration logs.
- Air monitoring data (FID or PID).
- Level of personal protection used by site workers and the time spent in each level of protection.
- Decontamination procedures.
- Documentation for IDWs (e.g., contents and approximate volume of waste, disposal method).
- Documentation of any scope of work changes required by field conditions.
- Signature and date (entered by personnel responsible for observations).

Error corrections should be completed by drawing a single line through the error, inserting the correct information above or following the original error, and initialing and dating the error. Errors only need be initialized and dated if there is a change in the information being presented. Corrections of simple errors such as misspellings do not require initializing.

4.5.2.1 Borehole and test pit logs and Well Installation Diagrams

Soil lithology from each soil boring and test pit will be thoroughly described, classified, and recorded in a field logbook by a WESTON geoscientist. Soil boring logs detailing drilling observations and geologic descriptions will be compiled from the field logbook data.

In addition, the soil headspace screening results will be noted in the logbook. Soil boring and well construction logs detailing the soil and well construction will be compiled from the field logbook data. In addition, the following information will also be logged on a daily basis in field logs:

- Names of personnel on-site (including subcontractors).
- Date and time of arrivals.
- Weather conditions.
- Site sketch with description and measurements to sample locations.
- Field calibration notes.
- Decontamination procedures.
- Sample identification numbers.
- Sample collection procedures.
- Sample preservation used.
- Notes on conversations with site personnel, observers and subcontractors, and general observations.

4.5.2.2 Well Development Record

The following data will be recorded as part of development and documented in field notes:

- Project name, location.
- Well designation, location.
- Date(s) and time(s) of well installation.
- Date(s) and time(s) of well development.

- Static water level from top of well casing before and 24 hours after development.
- Field measurement of pH, conductivity, temperature, turbidity, ORP, and DO.
- Depth from top of well casing to bottom of well.
- Screen length.
- Physical character of removed water, to include changes during development in clarity, color, particulates and any noted odor.
- Type and size/capacity of pump and/or bailer used.
- Description of surge technique, if used.
- Height of well casing above ground surface.
- Typical pumping rate.
- Estimated recharge rate.

Quantity of fluid/water removed and time for removal.

4.5.2.3 Soil Sample Identification

Soil sample identification for soil borings and shallow soil samples will be as follows:

AA-BBBB-CCDD-E-F
The codes A through F are as defined as below:

AA: Housing Area:
GR - Grant Housing Area
LO – Locust Housing Area
CA – Cavite Housing Area

BBBB: Investigation Area
IA## – Investigation Area (e.g., IA01, IA02,… IA10),
(Note: use a two digit area identifier)

CC: Sample Type:
SB – Soil Boring
SS – Shallow Soil

DD: Location identifier
Number (01, 02, 03, 04,…10, 11,….):

These sample numbers will be used sequentially for each well type and not be repeated.

E: Laboratory Type
1 = Off-site Laboratory

F: QA/QC Type
D = Field Duplicate
M = MS/MSD
E = Equipment (Rinsate) Blank
Q = QA Split Sample

Examples:

GR-*IA01-SB01-1-D*
Grant Housing Area, Investigation Area 1, soil boring, location #1, 0- to 3 ft-bgs, off-site laboratory analysis, duplicate.

GR-*IA05-SS12-1-Q*
Grant Housing Area, Investigation Area 5, shallow soil sample, Location 5, 0- to 1.5 ft-bgs, off-site lab, QA Split Sample.

Note: Sample depth intervals shall be documented in the logbook and on the Chain-of-custody form for all samples submitted to the analytical laboratory.

4.5.2.4 Test Pit Sample Identification

Soil sample identification for test pit samples will be as follows:

AA-BBBB-CCDD-EE-F-G
The codes A through F are as defined as below:

AA: Housing Area:
GR - Grant Housing Area
LO – Locust Housing Area
CA – Cavite Housing Area

BBBB: Investigation Area
IA## – Investigation Area (e.g., IA01, IA02,…IA10),
(Note: use a two digit area identifier)

CC: Sample Type:
TP – Test Pit

DD: Location identifier
Number (01, 02, 03, ….):
These sample numbers will be used sequentially for each test pit location within each housing area and shall not be repeated.

EE Sidewall location and depth interval
A1 – Sidewall A, depth interval 0- to 2 ft-bgs
A2 – Sidewall A, depth interval 2- to 4 ft-bgs
A3 – Sidewall A, depth interval 4- to 6 ft-bgs
B3 – Sidewall B, depth interval 4- to 6 ft-bgs

Sidewalls should include sides A, B, C, D with sequential numbering for each sampling depth.

F: Laboratory Type
1 = Off-site Laboratory

G QA/QC Type
D = Field Duplicate
M = MS/MSD
E = Equipment (Rinsate) Blank
Q = QA Split Sample

Examples:

GR-IA10-*TP01-D3-1-D*
Grant Housing Area, Investigation Area 10, test pit, location #1, sidewall "D", sampling interval 4- to 6 ft-bgs, off-site laboratory analysis, duplicate.

GR-*IA09-TP01-C1 -1-Q*
Cavite Housing Area, Investigation Area 9, test pit, location #1, sidewall "C", 0- to 2 ft-bgs, off-site lab, QA Split Sample.

4.5.2.5 Monitoring Well Sample Identification

Well identification will be as follows:

AA-BB-CD-E-F
The codes A through F are as defined as below:

AA: Work Area:
GR - Grant Housing

BB: Well Type:
MW – monitoring well
PZ – piezometer

C: Location identifier
Number (1, 2, 3, 4,…..):

These sample numbers will be used sequentially for each well type and not be repeated.

D: Location type and sampling round
S = water table
I = intermediate depth
D = deep
B = bedrock

E: **Laboratory Type**
1 = Off-site Laboratory

F: QA/QC Type
D = Field Duplicate
M = MS/MSD
E = Equipment (Rinsate) Blank
Q = QA Split Sample

Examples:

GR-MW-1S-1-D
Grant Housing Area, monitoring well, location #1, water table well, off-site laboratory analysis, duplicate.

GR-PZ-3S
Grant Housing Area, Piezometer, Location 3, water table piezometer, no sampling.

4.5.2.6 Trip and Equipment Blank Identification

Trip and Equipment **blank samples will be identified with sequential** numbers and numbers will not repeat for the duration of the field effort.

Trip Blanks: TB01, TB02,…..
Equipment Blanks: EB01, EB02,…..

4.6 SAMPLE SHIPMENT

Field personnel will be responsible for identifying, labeling, providing proper preservation, and packaging samples to preclude breakage and leakage during shipment. Shipping containers will be labeled in accordance with DOT regulations. Prior to shipment, a QC check will be performed to ensure samples have been properly identified and packaged, and that appropriate documentation (COC) will accompany them.

Every sample will be labeled with a unique identifier. All labeling will be completed in indelible/water proof ink and will include:

- Project number and site name
- Unique sample number
- Type of analysis to be performed
- Sampling date and time
- Initials of sampling technician
- Method of sample preservation

Samples will be placed in containers compatible with the intended analysis and properly preserved prior to shipment to the laboratory. Each sealed container will be placed in a self-sealing plastic bag. Glass containers will be wrapped with bubble wrap prior to being placed in the plastic bag. Strong thermal ice chests will be filled approximately three inches with inert material, such as vermiculite. The bagged sample containers will be placed in the ice chests and vermiculite will be added to nearly fill the ice chest.

Bagged ice/gel packs or equivalent will be placed on top of the vermiculite to ensure samples are cooled to at least 4°C. A COC form will be placed in a waterproof plastic bag and taped to the inside of the cooler. Ice chests will be taped shut with strapping tape, wrapped around the cooler in at least two places. Ice chests will be sealed with numbered and signed chain-of-custody seals.

Samples will be considered potentially hazardous for DOT shipping purposes. It is anticipated that all samples, with the exception of DNAPL samples, will be shipped as non-hazardous materials. The packaging and shipping of environmental samples will be in accordance with DOT regulations as described in 49 CFR parts 172 and 173. As such, packing procedures will include:

- Proper identification and classification of the hazardous materials
- Proper description and shipping name of the materials
- The use of DOT approved shipping containers
- Proper marking of the shipping container to include:
    - Commodity description and DOT labeling

- "This End Up" labels for shipping containers of liquid samples
- Name and address of shipper
- Characteristics of hazardous materials such as corrosivity, ignitability, or flammability (if applicable)

- Sample container labeling consistent with shipping papers
- Inclusion of proper shipping papers listing the name and classification of the hazardous material and assurance that the labeling is consistent with the shipping papers

Samples of highly toxic hazardous materials and samples of pure product such as gas, fuel, oil, PCB-oil, or DNAPL, must be sealed in a paint can prior to shipment to the laboratory.

SECTION 5

QUALITY ASSURANCE

5. QUALITY ASSURANCE

This section provides the pertinent elements of a QAPP and serves as the second half of an addendum to the *Sampling and Analysis Plan for the Release Abatement Measures for the Shirley, Grant, Locust, and Cavite Housing Areas, and Pesticide Remediation at the Chlordane Cell – Devens, Massachusetts* (WESTON, April 2002). Laboratory Standard Operating Procedures for the analyses being conducted as part of the SSI WP effort have been provided in Appendix C.

5.1 DATA QUALITY OBJECTIVES

This section describes the QA objectives for the data relative to its intended use.

5.1.1 Background

The primary objectives of this project are as follows:

- Collect and analyze soil and groundwater samples from various Investigation Areas (IAs) at the Devens Study Area in support of completion of a Supplemental Site Investigation (SSI) performed in compliance with CERCLA.
- Produce legally defensible analytical data and field documentation of a sufficient level of detail and accuracy, to be used to support remedial action decisions under CERCLA at each IA.
- Collect data which are of sufficient quality to ensure compliance with CERCLA and other Applicable and/or Relevant and Appropriate Requirements and regulations/policies which are "To Be Considered".

Efforts to characterize the pesticide the IAs at Devens have been undertaken by numerous parties. The results of the investigation have laid the groundwork for determination of Contaminants of Concern (CoC) for the various IAs. The CoCs for each IA addressed in this SSI are as follows:

- IA-1 – VOCs, SVOCs, Metals, Pesticides, PCBs, EPH
- IA-2 – VOCs, SVOCs, Metals, Pesticides, PCBs, EPH, Perchlorate, Explosives, Dioxin/Furan

- IA-3 - VOCs, SVOCs, Metals, Pesticides, PCBs, EPH
- IA-5 - VOCs, SVOCs, Metals, Pesticides, PCBs, EPH
- IA-7 – Metals
- IA-8 - VOCs, SVOCs, Metals, Pesticides, PCBs, EPH, Perchlorate, Explosives, Dioxin/Furan
- IA-9 - VOCs, SVOCs, Metals, Pesticides, PCBs, EPH, Dioxin/Furan
- IA-10 - VOCs, SVOCs, Metals, Pesticides, PCBs, EPH, Dioxin/Furan
- IA-11 - VOCs, SVOCs, Metals, Pesticides, PCBs, EPH, Dioxin/Furan

Proposed locations of samples for the SSI can be found in Figures 3-4 through 3-12.

5.1.2 QA Objectives for Chemical Data Management

The USACE-QA laboratory assigned to this SSI is Severn Trent Laboratory in Vermont. The project QA reference number is E0914. Quality Assurance samples will be sent to the QA laboratory as specified in Subsection 4.2.3.1.

The laboratory analytical methods and data quality objectives (DQOs) for Alpha Analytical Laboratory are listed in Tables 5-1a through 5-1g and 5-2a through 5-2g for soils and groundwater, respectively. Quality Assurance/QC samples are listed in Table 4-1. Quality Assurance/QC samples are discussed in Subsection 4.2.3.

5.2 DATA REDUCTION, VALIDATION, AND REPORTING

Analytical data are recorded on pre-formatted bench sheets or analysis run logs in bound laboratory notebooks. These bound notebooks are issued and controlled by the laboratory's QA Section. A unique document control code is assigned to each book to assure that chronological record keeping is maintained.

Analytical data are referenced to a unique sample identification number (RFW Sample #) for internal tracking and reporting. Notebook pages contain the following information, as applicable:

- Analytical method
- Analyst

- Date
- Sequential page number
- Associated RFW sample numbers
- Standard concentrations
- Instrument settings
- Raw data

Entries for instrument logs are in chronological order and maintained so as to enable reconstruction of the analytical sequence.

The laboratory analyst is responsible for recording all appropriate information into analytical logs, and for signing and dating all analytical book entries daily. A supervisor or trained data reviewer reviews the notebook pages. Copies of instrument outputs (chromatograms, strip charts, etc.) are maintained on file with the analyst's signature/initials and date.

5.2.1 Data Reduction

Data reduction is performed by the analyst and consists of calculating concentrations in samples from the raw data. The complexity of the data reduction depends on the analytical method and the number of discrete operations involved (e.g., extractions, dilutions, instrument readings and concentrations). The analyst calculates the final results from the raw data or uses appropriate computer programs to assist in the calculation of final reportable values. Copies of all raw data and the calculations used to generate the final results, such as bound laboratory notebooks, strip-charts, chromatograms, EXCEL spreadsheets and LIMS record files, are retained on file for a minimum of six years.

Calculations and data reduction steps for various methods are summarized in the laboratory SOPs or program requirements.

5.2.2 Data Review

System reviews are performed at all levels. The individual analyst continually reviews the quality of data through calibration checks, QC sample results, and performance evaluation samples. Data review is initiated by the analyst during, immediately following, and after the completed analysis. The analyst uses a data review checklist to verify that all analytical criteria have been met. This checklist provides a list of items to verify that all analytical specifications

have been achieved. Any out-of-control items are documented on the checklist and verbally communicated to the Unit Leader or Section Manager for review and response.

The supervisor, analyst, or data specialist performs a secondary review of the data. The peer reviewer is instructed by the QA Section, Section Manager, or Unit Leader to perform the data review. After these first two reviews are completed, the data is entered into the LIMS.

The Section Manager or designee reviews the data for precision and accuracy to assure that it meets all specifications. After approval by the Section Manager or designee, the analytical report is assembled. The Section Manager or the Laboratory Project Manager designee reviews the data to ensure consistency with laboratory QC requirements, to verify reasonableness with other generated data, and to determine if program requirements have been satisfied. Selected hard copy output of data (chromatograms, spectra, etc.) will be reviewed to ensure that results are interpreted correctly. The final report is signed by the Section Manager, Project Manager, and Laboratory Manager.

Unusual or unexpected results will be reviewed, and a resolution of the problem will be documented in a Corrective Action Report. If suspect data is reported, the out-of-control events will be addressed in a case narrative. Copies of the Corrective Action Reports may be included in a data package as needed.

Prior to final review/sign-off by the Laboratory Manager or designee, the Report Generation Section will verify that the report is compiled in the proper format. The Laboratory Manager or designee provides the final laboratory review prior to reporting the results to the client. The Laboratory Project Manager will do a final completeness check before submitting the data report to the client.

The QA Section independently conducts a review of selected reports to determine if laboratory and client QA/QC requirements have been met. Discrepancies will be reported to the appropriate Section Manager and/or Laboratory Project Manager for resolution.

Data audits are also performed by regulatory agencies or client representatives. The frequency, level of detail, and the areas of concern during these reviews are dependent on the specific program requirements.

5.2.3 Data Validation

WESTON will perform a modified Tier II level data validation of the samples within 21 days of receipt of the final data packages and EDD from the off-site laboratory. The validation procedures to be employed will consist of the following activities:

- Review of COC documents to verify sample identities. If a discrepancy is found, the sampler and/or laboratory will be contacted to resolve. Details will be recorded in a telephone log. Laboratory resubmittals will be requested, if necessary.
- Review of sample log-in documents to verify any potential problems with custody seals, container integrity, sample preservation, labeling, etc. (see bullet above for corrective action).
- Review of trip blank data, if any, to identify any potential problems with sample container contamination, preservative contamination, laboratory reagent water contamination, or cross-contamination between samples during transport.
- Review of method blank data to determine the presence of any sources of contamination in the analytical process; the 5x action level will be applied for target compounds detected in method blank as stated in the Region I EPA Functional Guidelines for Data Validation (equipment blanks will not be used to qualify soil samples.
- Review the matrix spike (MS) data to evaluate the potential for matrix effects and as a measure of analytical accuracy. Matrix spike recoveries will be compared against laboratory acceptance criteria to determine if they are within or outside of warning and control limits for percent recoveries.
- Review of matrix spike/matrix spike duplicate (MS/MSD) data to evaluate sample homogeneity and as a measure of analytical precision. Matrix spike/matrix spike duplicate data will be compared to laboratory acceptance criteria for the maximum relative percent difference (RPD) $\leq$ 20%.
- If a sample has less than 30% solids but greater than 10%, all data will be estimated; if less than 10%, non-detected results will be rejected (R).
- Review of laboratory control sample data (if available) as a measure of analytical accuracy. Laboratory control sample data will be compared to the certified acceptable ranges of analytical values;

- Review of sample and sample duplicate data (if available) as a measure of sample homogeneity and as a measure of analytical precision.

- Review of surrogate recovery data to assess extraction efficiency, effectiveness of sample introduction, and possible loss during cleanup activities. Surrogate recoveries will be compared to laboratory acceptance criteria to determine if they are within or outside of acceptable limits.

- Review of sample dates, extraction/digestion dates, and analysis dates to determine if maximum holding times were met or exceeded. Holding times are validated according to EPA Region I CLP Data Validation Functional Guidelines.

- Review of field duplicate: %RPD for soils must be less than or equal to 50%, %RPD for waters must be less than or equal to 30%.

- Review of QA sample results provided by USACE. USACE will provide WESTON with QA sample results as soon as they are received. USACE will evaluate comparability between QA samples and field samples based on USACE criteria and provide WESTON with a report.

All samples will be reviewed in accordance with the EPA Region 1 Data Validation Functional Guidelines, December 1996. If DQOs listed in Attachment 1 are not met, sample results will be qualified. Qualifiers will be added by hand to hard copy and will be explained in handwritten footnotes defined at the bottom of the table. Daily Quality Objectives that are outside of QC limits will be evaluated as to the impact on data usability. Any negative impacts will be reported to USACE immediately. Data for waste characterization and disposal samples will not be reviewed.

5.2.4 Data Reporting

Analytical reports comprise final results based on the following:

- Dry weight (uncorrected for blanks and recoveries unless specified)
- Methods of extraction
- Methods of analysis
- Levels of reporting
- Surrogate recovery data
- Method blank data

In addition, special analytical problems will be noted in the case narratives. The number of significant figures reported is consistent with the limits of uncertainty inherent in the analytical

method. Consequently, most analytical results will be reported to no more than two (2) or three (3) significant figures. Data are normally reported in units commonly used for the analyses performed.

Concentrations in liquids are expressed in terms of weight per unit volume [e.g., micrograms per liter,]. Concentrations in solid or semi-solid matrices are expressed in terms of weight per unit weight of sample (e.g., micrograms per kilogram). Reporting limits take into account all appropriate concentration, dilution, and/or extraction factors, unless otherwise specified by program requirements.

A client report is generated with various steps of approval prior to printing of the final version. If any analytical anomalies were encountered during the analyses, (e.g., an out-of-control matrix duplicate), it is documented in a case narrative. The case narrative is prepared by the respective operating unit and submitted to the Data Management Section to insert in the final report.

The final report forms are printed, data packages are organized, a glossary of flags and acronyms is added, and reports are paginated. The Laboratory Project Manager, the Laboratory Manager and/or designee will review and sign the report prior to delivery.

5.2.4.1 Reporting Format

The final data reports provided by the off-site laboratory are standard client reports and EDDs. These reports will be submitted with the final project report.

The standard client report contains a transmittal letter and the following:

- Case Narrative describing: data qualifiers, sample collection, sample preparation (e.g., extraction or digestion), analysis dates, and a description of any technical problems encountered with the analysis.
- Sample data summaries to include appropriate QC result summaries.
- Five-peak library search report for gas chromatography/MS volatiles and semi-volatiles.
- Off-site laboratory will provide an EDD along with a Level III type data package, which includes raw data, within 15 business days of sample collection.

SECTION 6

SCHEDULE

6. SCHEDULE

Figure 6-1 presents a proposed schedule for implementation of the work elements described in this SSI WP. The start date is assumed and may change depending upon receipt of Notice to Proceed (NTP) from CENAE. However, regardless of NTP, the task durations will remain approximately the same, with the exception of possible delays resulting from the winter holidays or the increasing likelihood of inclement weather from delays in the NTP.

SECTION 7

REFERENCES

7. REFERENCES

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South Post – 1943 Aerial Photo
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North Post – 1951 Aerial Photo
South Post – 1951 Aerial Photo
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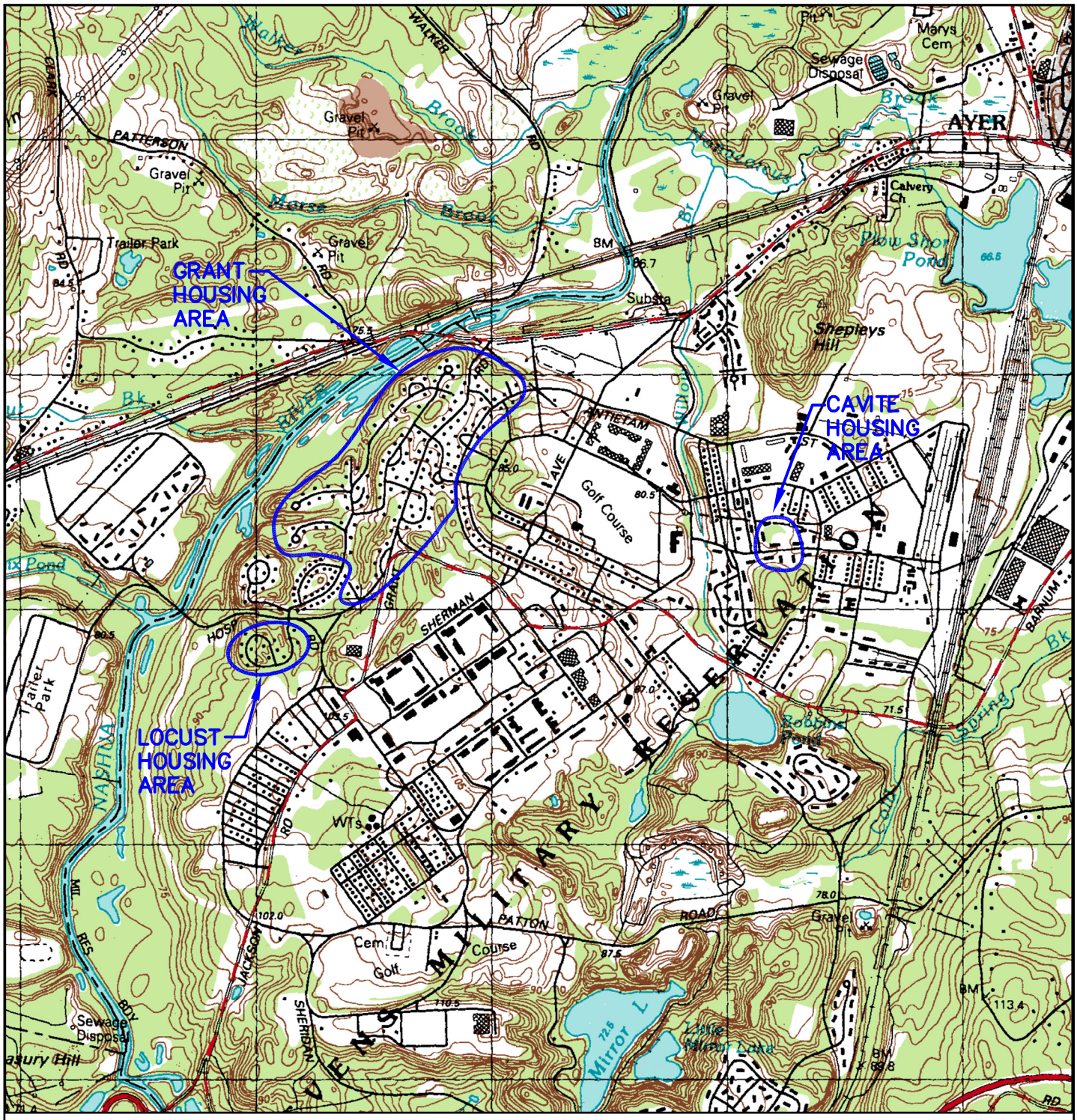
FIGURES



SOURCE
US DEPT. OF THE INTERIOR, GEOLOGICAL SURVEY
7.5 x 15 MINUTE SERIES (TOPOGRAPHIC)
AYER, MA., 1988

GRAPHIC SCALE
2000 1000 0 1000 2000
APPROXIMATE SCALE IN FEET

SUPPLEMENTAL SITE INVESTIGATION (SSI)
STUDY AREA – GRANT, LOCUST, AND CAVITE HOUSING AREAS
DEVENS, MASSACHUSETTS

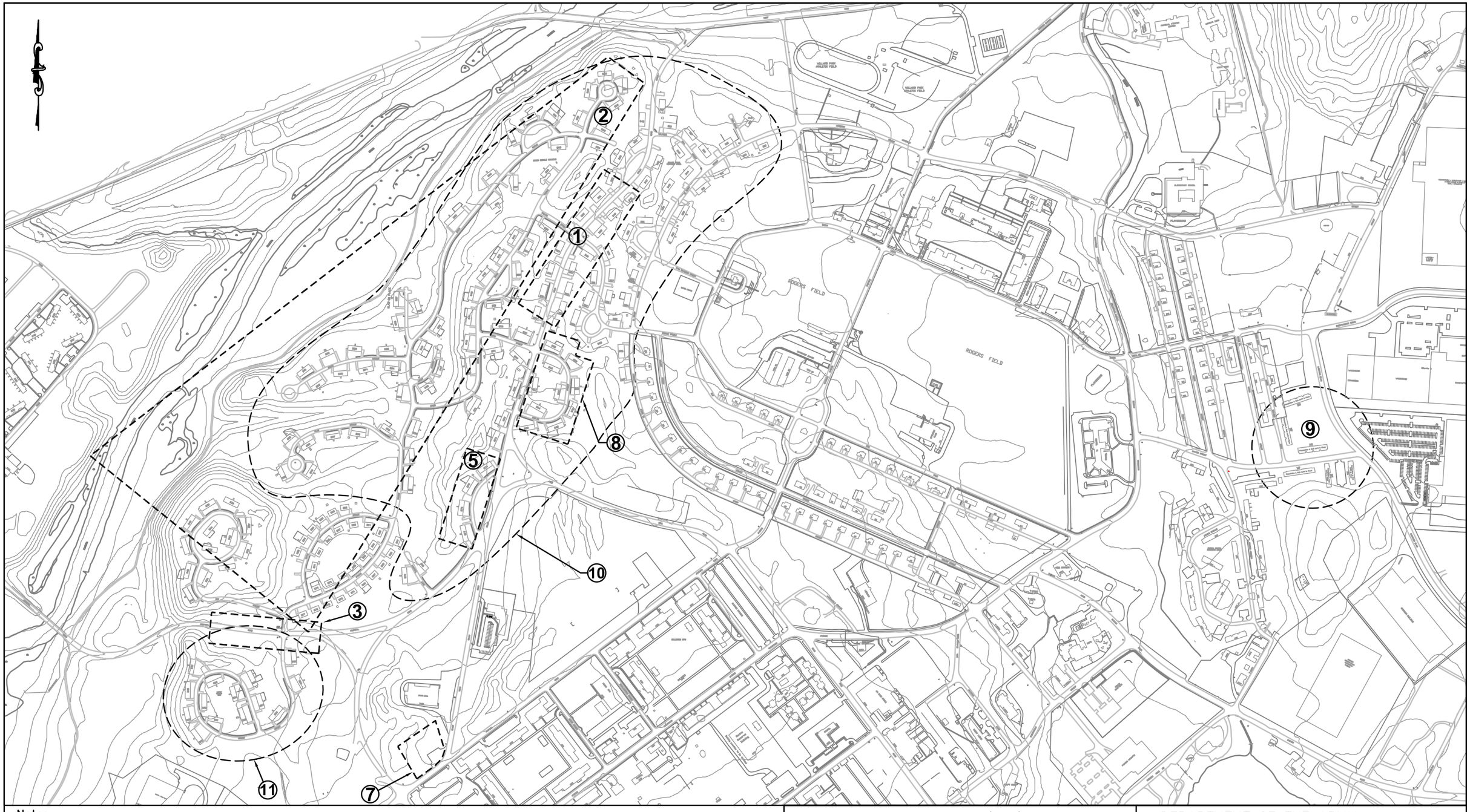
DEPARTMENT OF THE ARMY
NEW ENGLAND DISTRICT
CORPS OF ENGINEERS
CONCORD, MASSACHUSETTS

FORMER GRANT, LOCUST, & CAVITE HOUSING AREAS

WESTON SOLUTIONS
MANCHESTER NEW HAMPSHIRE

DRAWN	BEG
DATE	JAN 2005
FIGURE NO.	1–1

M:\Design\DWG\ACOE\FTDEVENS\SSI\Work Plan\FINAL REVISIONS – OCT 2004\fig 1-1.dwg, Site Location Map, 1/21/2005 2:57:08 PM, girardeb, 1:1



Notes

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1. 1922 – Possible Training Area
2. 1922 – Possible Training Area and/or Range
3. 1922 – Possible Rifle Range
5. 1943 & 1951 – Anti-tank Range
7. 1943 & 1951 – Anti-tank Range
8. Former Laundry Facility
9. Entire Cavite Housing Area referred to as a Training Area – 1954, 1957, 1961.
10. Entire Grant Housing Area west of Grant Road is referred to as a Training Area – 1954, 1957.
11. Entire Locust Housing Area is referred to as a Training Area – 1954, 1957, 1961.

Legend

———— Investigation Area (IA) Boundary

GRAPHIC SCALE

600 300 0 300 600

APPROXIMATE SCALE IN FEET

INVESTIGATION AREAS (IAs) WITHIN THE GRANT, LOCUST, & CAVITE HOUSING AREAS

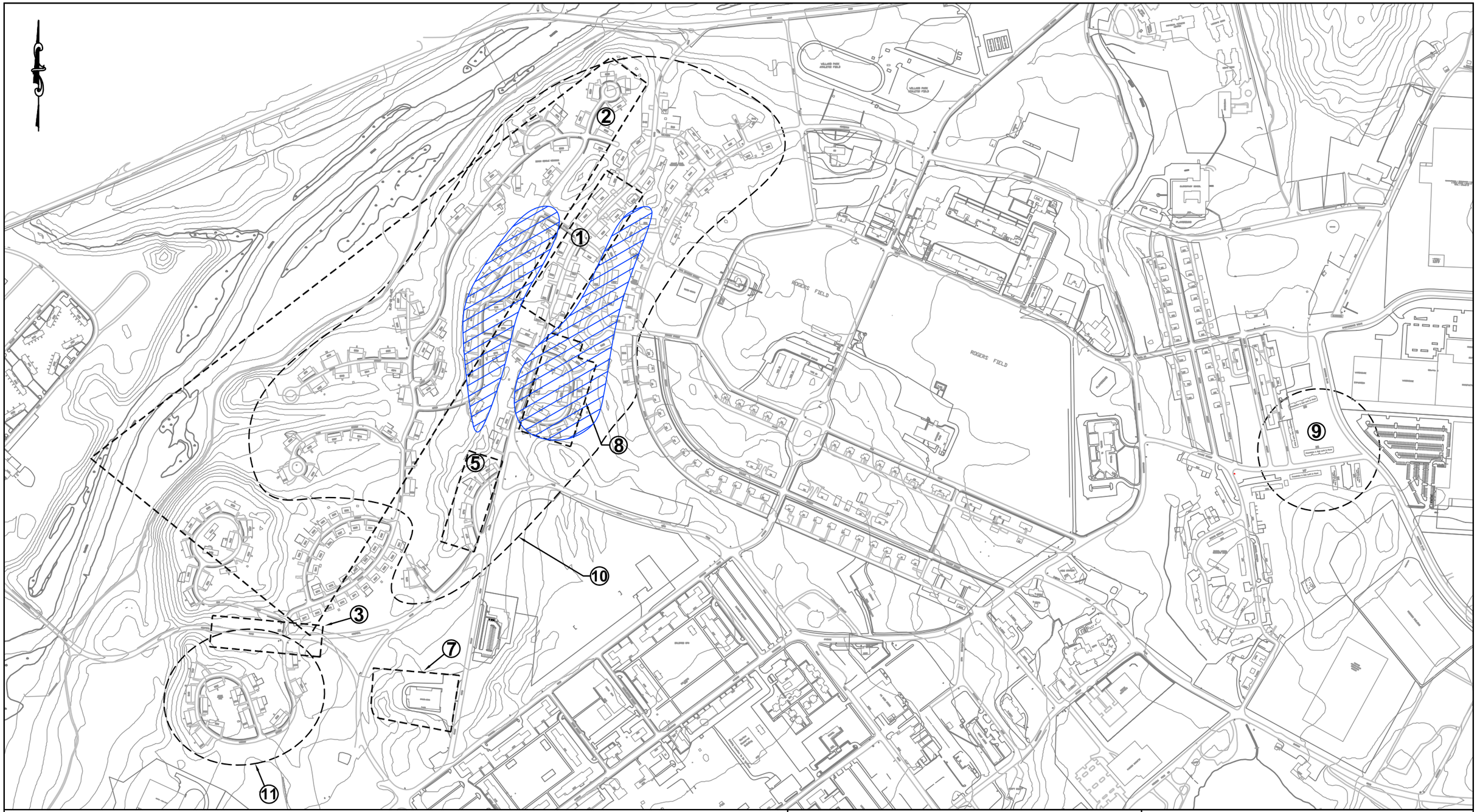
SUPPLEMENTAL SITE INVESTIGATION (SSI)
STUDY AREA – GRANT, LOCUST, AND CAVITE HOUSING AREAS
DEVENS, MASSACHUSETTS

DEPARTMENT OF THE ARMY
NEW ENGLAND DISTRICT
CORPS OF ENGINEERS
CONCORD, MASSACHUSETTS

WESTON SOLUTIONS
MANCHESTER NEW HAMPSHIRE

DRAWN BEG
DATE JAN 2005
FIGURE NO. 1-2

M:\Design\DWG\ACOE\FTDEVENS\SSI\Work Plan\FINAL REVISIONS - OCT 2004\FIG 1-2.dwg, LAYOUT1, 1/21/2005 3:00:15 PM, girardeb, 1:1



Notes

** Based on information gathered from the Archives Search Report – (Findings, Maps, Conclusions and Recommendations), Fort Devens, U.S. Army Corps of Engineers, St. Louis District, US Dept. of Defense BRAC, Ordnance, Ammunition and Explosives, May 1995.

1. 1922 – Possible Training Area
2. 1922 – Possible Training Area and/or Range
3. 1922 – Possible Rifle Range
5. 1943 & 1951 – Anti-tank Range
7. 1943 & 1951 – Anti-tank Range
8. Former Laundry Facility
9. Entire Cavite Housing Area referred to as a Training Area – 1954, 1957, 1961.
10. Entire Grant Housing Area west of Grant Road is referred to as a Training Area – 1954, 1957.
11. Entire Locust Housing Area is referred to as a Training Area – 1954, 1957, 1961.

Legend

– – – – Investigation Area (IA) Boundary

Area of Significant Mining of Sand and Gravel

GRAPHIC SCALE

600 300 0 300 600

APPROXIMATE SCALE IN FEET

AREAS OF SIGNIFICANT OVERBURDEN MINING ACTIVITIES

SUPPLEMENTAL SITE INVESTIGATION (SSI)
STUDY AREA – GRANT, LOCUST, AND CAVITE HOUSING AREAS
DEVENS, MASSACHUSETTS

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DRAWN BEG
DATE JAN 2005
FIGURE NO. 2-1

M:\Design\DWG\ACOE\FTDEVENS\SSI\Work Plan\FINAL REVISIONS – OCT 2004\FIG 2-1.dwg, LAYOUT1, 1/21/2005 2:59:34 PM, girardeb, 1:1



Legend

- STREAM
- TOPO LINE (3m/10ft)
- OLD ROAD
- INSTALLATION BOUNDARY
- FILL AREA
- CUT AREA
- OPEN WATER
- WETLAND

EXCAVATIONS

- PESTICIDE REMEDIAL ACTION
- PCB EXCAVATION
- RECON BOUNDARIES

STRUCTURE

- CONCRETE
- FOUNDATION
- OTHER

FILL

- BERM
- PILE

DEPRESSION

- EXCAVATION
- TRENCH

N

0 400 800 Feet

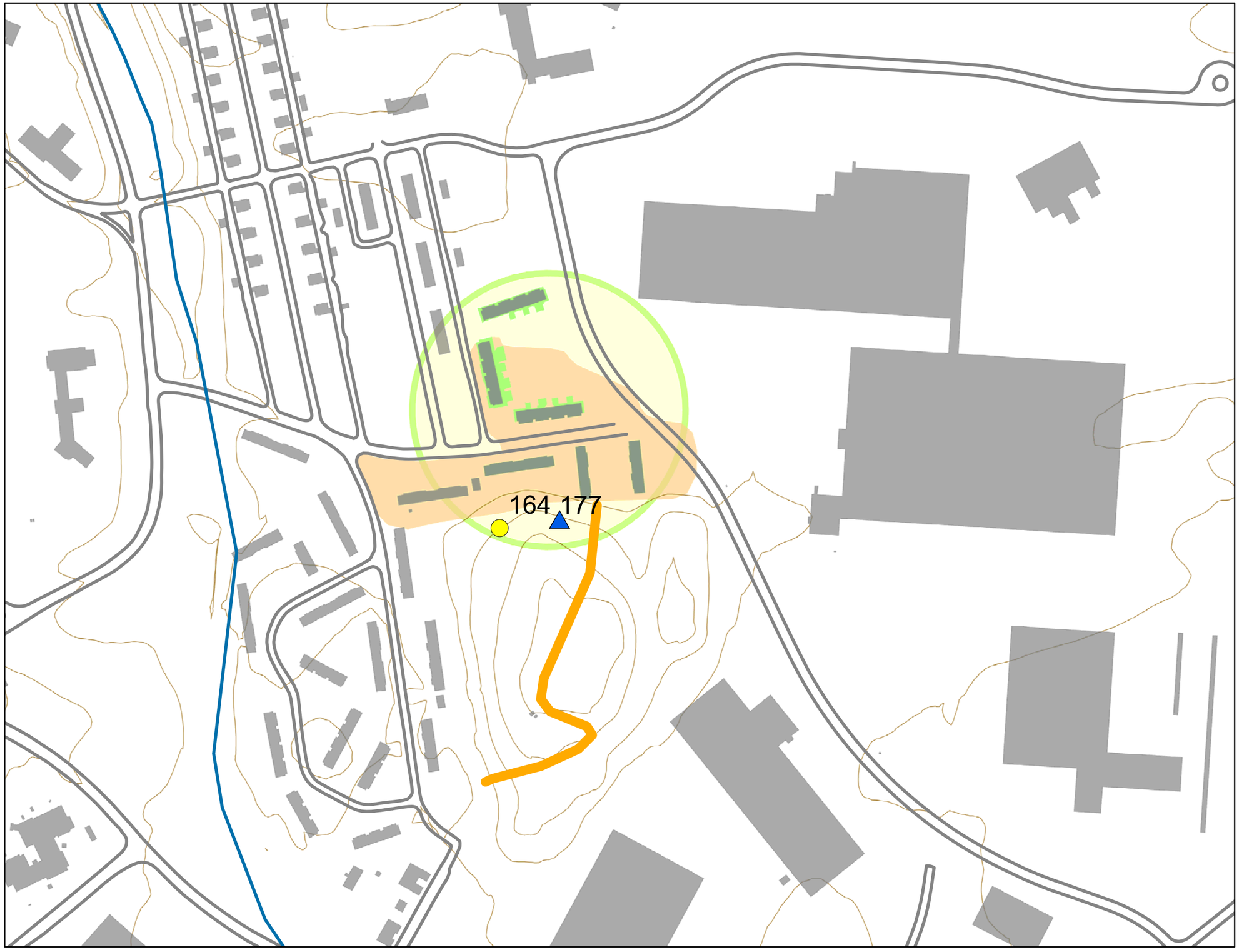
CULTURAL FEATURES WITHIN THE STUDY AREA GRANT AND LOCUST HOUSING AREAS

SUPPLEMENTAL SITE INVESTIGATION (SSI)
STUDY AREA - GRANT, LOCUST, & CAVITE HOUSING AREAS
DEVENS, MASSACHUSETTS

FIGURE 3-1

US Army Corps of Engineers®

JANUARY 2005



Legend

- STREAM
- TOPO LINE (3m/10ft)
- OLD ROAD
- INSTALLATION BOUNDARY
- FILL AREA
- CUT AREA
- OPEN WATER
- WETLAND

EXCAVATIONS

- PESTICIDE REMEDIAL ACTION
- PCB EXCAVATION
- RECON BOUNDARIES

STRUCTURE

- CONCRETE
- FOUNDATION
- OTHER

FILL

- BERM
- PILE

DEPRESSION

- EXCAVATION
- TRENCH

N

0 200 400 Feet

CULTURAL FEATURES WITHIN THE STUDY AREA CAVITE HOUSING AREA

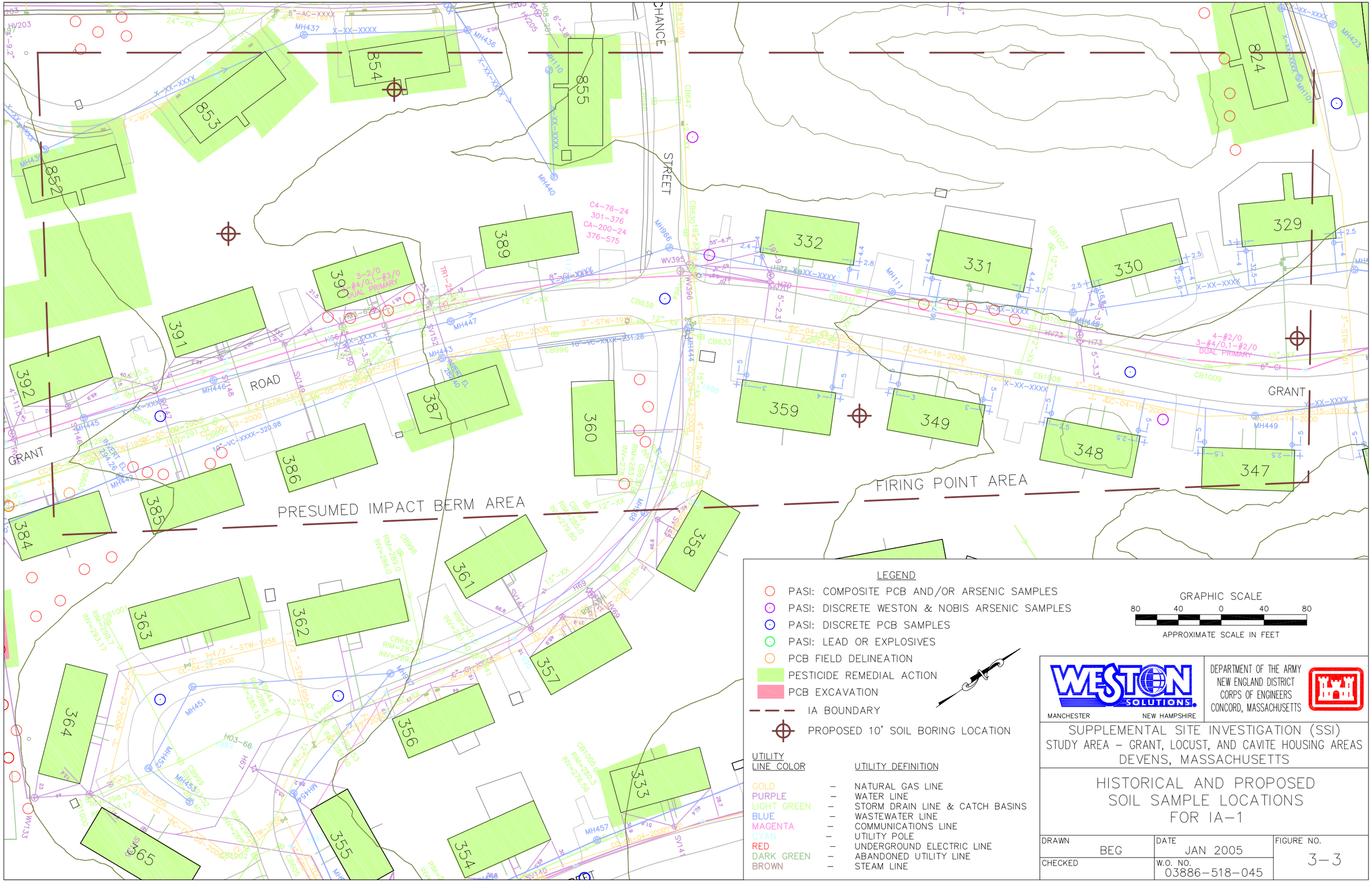
SUPPLEMENTAL SITE INVESTIGATION (SSI)
STUDY AREA - GRANT, LOCUST, & CAVITE HOUSING AREAS
DEVENS, MASSACHUSETTS

FIGURE 3-2

US Army Corps of Engineers®

JANUARY 2005

M:\Design\DWG\ACOE\FTDEVENS\SSI\Work Plan\FINAL REVISIONS - OCT 2004\fig 3-3.dwg, IA-1, 1/21/2005 3:01:29 PM, girardeb, 1:1



LEGEND

- PASI: COMPOSITE PCB AND/OR ARSENIC SAMPLES
- PASI: DISCRETE WESTON & NOBIS ARSENIC SAMPLES
- PASI: DISCRETE PCB SAMPLES
- PASI: LEAD OR EXPLOSIVES
- PCB FIELD DELINEATION
- PESTICIDE REMEDIAL ACTION
- PCB EXCAVATION
- IA BOUNDARY
- PROPOSED 10' SOIL BORING LOCATION

UTILITY LINE COLOR		UTILITY DEFINITION
GOLD	–	NATURAL GAS LINE
PURPLE	–	WATER LINE
LIGHT GREEN	–	STORM DRAIN LINE & CATCH BASINS
BLUE	–	WASTEWATER LINE
MAGENTA	–	COMMUNICATIONS LINE
CYAN	–	UTILITY POLE
RED	–	UNDERGROUND ELECTRIC LINE
DARK GREEN	–	ABANDONED UTILITY LINE
BROWN	–	STEAM LINE

GRAPHIC SCALE

80 40 0 40 80

APPROXIMATE SCALE IN FEET

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SUPPLEMENTAL SITE INVESTIGATION (SSI)
STUDY AREA – GRANT, LOCUST, AND CAVITE HOUSING AREAS
DEVENS, MASSACHUSETTS

HISTORICAL AND PROPOSED SOIL SAMPLE LOCATIONS FOR IA-1

DRAWN	DATE	FIGURE NO.
BEG	JAN 2005	3-3
CHECKED	W.O. NO. 03886-518-045	

INTERMEDIATE AREA

PRESUMED OVERBURDEN GROUNDWATER FLOW

IMPACT BERM

PLUM

STREET

MAPLE

822 823 882 895 896 897 898 899

538 539 540 542 543 544 545 534 535 536 537

570 572 574 579 580 581 582 583 584 585 586 587 588 590 592

GRAPHIC SCALE

120 60 0 60 120

APPROXIMATE SCALE IN FEET

LEGEND

- IA BOUNDARY
- PROPOSED MONITORING WELL LOCATION
- PROPOSED PIEZOMETER LOCATION
- PROPOSED 10' SOIL BORING LOCATION
- PASI: COMPOSITE PCB AND/OR ARSENIC SAMPLES
- PASI: DISCRETE WESTON & NOBIS ARSENIC SAMPLES
- PASI: DISCRETE PCB SAMPLES
- PASI: LEAD OR EXPLOSIVES
- PCB FIELD DELINEATION
- PESTICIDE REMEDIAL ACTION
- PCB EXCAVATION

UTILITY LINE COLOR		UTILITY DEFINITION
GOLD	–	NATURAL GAS LINE
PURPLE	–	WATER LINE
LIGHT GREEN	–	STORM DRAIN LINE & CATCH BASINS
BLUE	–	WASTEWATER LINE
MAGENTA	–	COMMUNICATIONS LINE
CYAN	–	UTILITY POLE
RED	–	UNDERGROUND ELECTRIC LINE
DARK GREEN	–	ABANDONED UTILITY LINE
BROWN	–	STEAM LINE

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SUPPLEMENTAL SITE INVESTIGATION (SSI)
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HISTORIC AND PROPOSED SOIL SAMPLE LOCATIONS FOR IA–2 – IMPACT BERM

DRAWN	DATE	FIGURE NO.
BEG	MAY 2005	3–4A
CHECKED	W.O. NO. 03886.518.045	

INTERMEDIATE AREA

STREET

BEECH

PLUM

BIRCH

LUNDY

AVENUE

GRAPHIC SCALE

120 60 0 60 120

APPROXIMATE SCALE IN FEET

LEGEND

- IA BOUNDARY
- PROPOSED 10' SOIL BORING LOCATION
- PASI: COMPOSITE PCB AND/OR ARSENIC SAMPLES
- PASI: DISCRETE WESTON & NOBIS ARSENIC SAMPLES
- PASI: DISCRETE PCB SAMPLES
- PASI: LEAD OR EXPLOSIVES
- PCB FIELD DELINEATION
- PESTICIDE REMEDIAL ACTION
- PCB EXCAVATION

UTILITY LINE COLOR		UTILITY DEFINITION
GOLD	–	NATURAL GAS LINE
PURPLE	–	WATER LINE
LIGHT GREEN	–	STORM DRAIN LINE & CATCH BASINS
BLUE	–	WASTEWATER LINE
MAGENTA	–	COMMUNICATIONS LINE
CYAN	–	UTILITY POLE
RED	–	UNDERGROUND ELECTRIC LINE
DARK GREEN	–	ABANDONED UTILITY LINE
BROWN	–	STEAM LINE

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SUPPLEMENTAL SITE INVESTIGATION (SSI)
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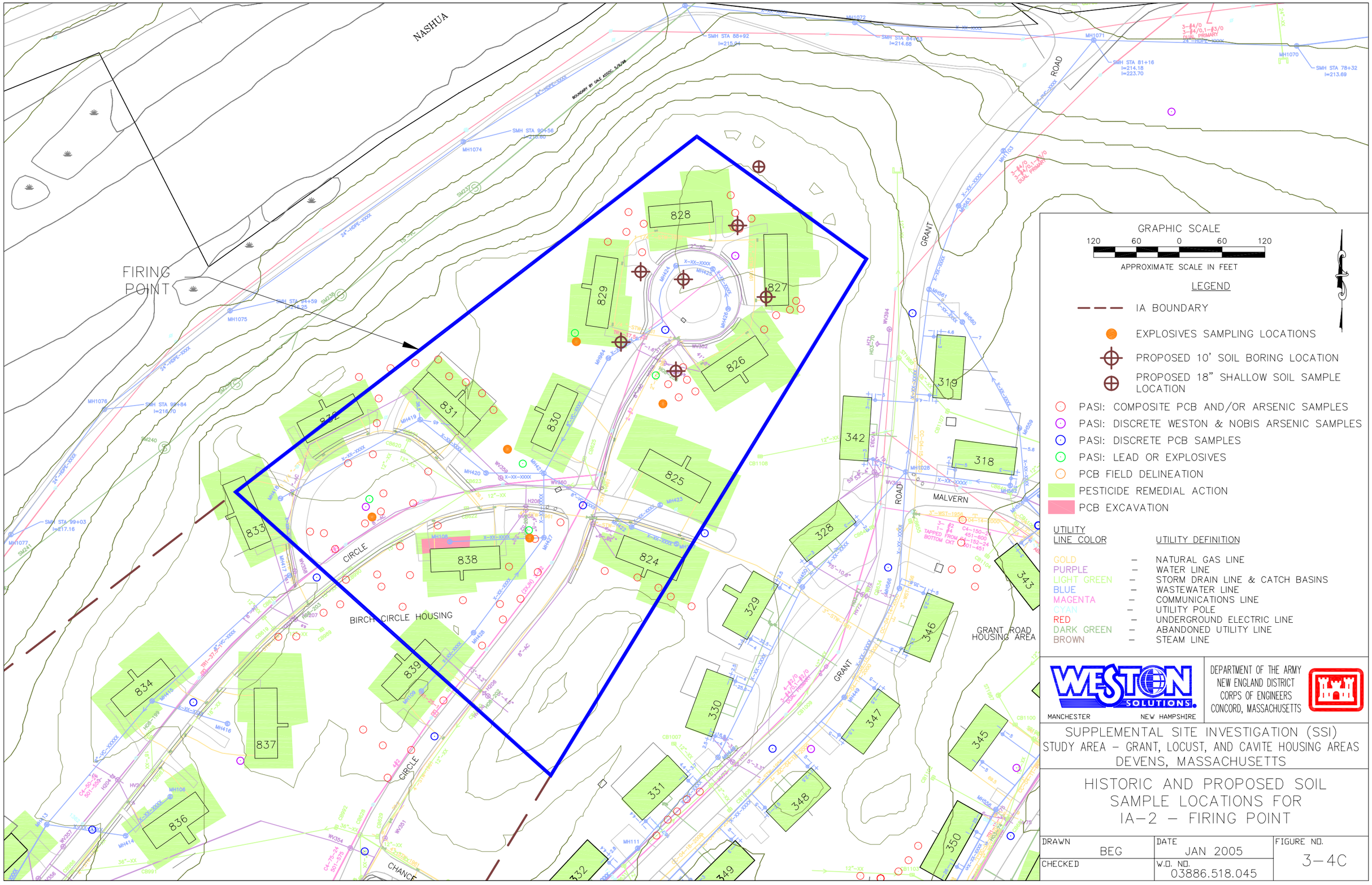
HISTORIC AND PROPOSED SOIL SAMPLE LOCATIONS FOR IA–2 – INTERMEDIATE AREA

DRAWN	DATE	FIGURE NO.
BEG	JAN 2005	3–4B
CHECKED	W.O. NO. 03886.518.045	

M:\Design\DWG\ACOE\FTDEVENS\SSI\Work Plan\FINAL REVISIONS – OCT 2004\fig 3-4.dwg, IA-2 (b), 1/21/2005 3:04:57 PM, girardeb, 1:1



GRAPHIC SCALE

120 60 0 60 120

APPROXIMATE SCALE IN FEET

LEGEND

- IA BOUNDARY
- EXPLOSIVES SAMPLING LOCATIONS
- PROPOSED 10' SOIL BORING LOCATION
- PROPOSED 18" SHALLOW SOIL SAMPLE LOCATION
- PASI: COMPOSITE PCB AND/OR ARSENIC SAMPLES
- PASI: DISCRETE WESTON & NOBIS ARSENIC SAMPLES
- PASI: DISCRETE PCB SAMPLES
- PASI: LEAD OR EXPLOSIVES
- PCB FIELD DELINEATION
- PESTICIDE REMEDIAL ACTION
- PCB EXCAVATION

UTILITY LINE COLOR		UTILITY DEFINITION
GOLD	–	NATURAL GAS LINE
PURPLE	–	WATER LINE
LIGHT GREEN	–	STORM DRAIN LINE & CATCH BASINS
BLUE	–	WASTEWATER LINE
MAGENTA	–	COMMUNICATIONS LINE
CYAN	–	UTILITY POLE
RED	–	UNDERGROUND ELECTRIC LINE
DARK GREEN	–	ABANDONED UTILITY LINE
BROWN	–	STEAM LINE

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HISTORIC AND PROPOSED SOIL SAMPLE LOCATIONS FOR IA–2 – FIRING POINT

DRAWN	DATE	FIGURE NO.
BEG	JAN 2005	3–4C
CHECKED	W.O. NO. 03886.518.045	

M:\Design\DWG\ACOE\FTDEVENS\SSI\Work Plan\FINAL REVISIONS – OCT 2004\fig 3-4.dwg, IA-2 (c), 1/24/2005 1:04:08 PM, girardeb, 1:1

M:\Design\DWG\ACOE\FTDEVENS\SSI\Work Plan\FINAL REVISIONS - OCT 2004\fig 3-5.dwg, IA 3, 1/21/2005 3:02:35 PM, girardeb, 1:1

HOSPITAL ROAD

SPRUCE STREET

GRAPHIC SCALE
80 40 0 40 80
APPROXIMATE SCALE IN FEET

LEGEND

- PROPOSED 10' SOIL BORING LOCATION
- PROPOSED 18" SHALLOW SOIL SAMPLE LOCATION
- IA3-002A PREVIOUS LEAD SAMPLING (0-6")

UTILITY LINE COLOR		UTILITY DEFINITION
GOLD	–	NATURAL GAS LINE
PURPLE	–	WATER LINE
LIGHT GREEN	–	STORM DRAIN LINE & CATCH BASINS
BLUE	–	WASTEWATER LINE
MAGENTA	–	COMMUNICATIONS LINE
CYAN	–	UTILITY POLE
RED	–	UNDERGROUND ELECTRIC LINE
DARK GREEN	–	ABANDONED UTILITY LINE
BROWN	–	STEAM LINE

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STUDY AREA – GRANT, LOCUST, AND CAVITE HOUSING AREAS
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HISTORIC AND PROPOSED SOIL SAMPLE LOCATIONS FOR IA-3

DRAWN	DATE	FIGURE NO.
BEG	JAN 2005	3-5
CHECKED	W.O. NO. 03886.518.045	

IA5–001A
IA5–001B
IA5–001C
IA5–001D
IA5–001E
IA5–002A
IA5–002B
IA5–002C
IA5–002D
IA5–002E
IA5–003A
IA5–003B
IA5–003C
IA5–003D
IA5–003E
IA5–004A
IA5–004B
IA5–004C
IA5–004D
IA5–004E
IA5–005A
IA5–005B
IA5–005C
IA5–005D
IA5–005E
874
875
876
877
CB966
CB965
CB341
CB339
MH350
MH349
MH357
WV340
WV339
HV59
HV121
H112
H106–122
DUAL PRIMARY
GRANT
ABS(OP)
P–1035
AB–05
TAPPED BOTTOM
1832
1093
1157
1159
1082
1035
1034
GRAPHIC SCALE
50 25 0 25 50
APPROXIMATE SCALE IN FEET

LEGEND

- IA BOUNDARY
- PROPOSED 10' SOIL BORING LOCATION
- PROPOSED 18" SHALLOW SOIL SAMPLE LOCATION
- PASI: COMPOSITE PCB AND/OR ARSENIC SAMPLES
- PASI: DISCRETE WESTON & NOBIS ARSENIC SAMPLES
- PASI: DISCRETE PCB SAMPLES
- PASI: LEAD SAMPLE (0–6")
- PCB FIELD DELINEATION
- PESTICIDE REMEDIAL ACTION
- PCB EXCAVATION

UTILITY LINE COLOR		UTILITY DEFINITION
GOLD	–	NATURAL GAS LINE
PURPLE	–	WATER LINE
LIGHT GREEN	–	STORM DRAIN LINE & CATCH BASINS
BLUE	–	WASTEWATER LINE
MAGENTA	–	COMMUNICATIONS LINE
CYAN	–	UTILITY POLE
RED	–	UNDERGROUND ELECTRIC LINE
DARK GREEN	–	ABANDONED UTILITY LINE
BROWN	–	STEAM LINE

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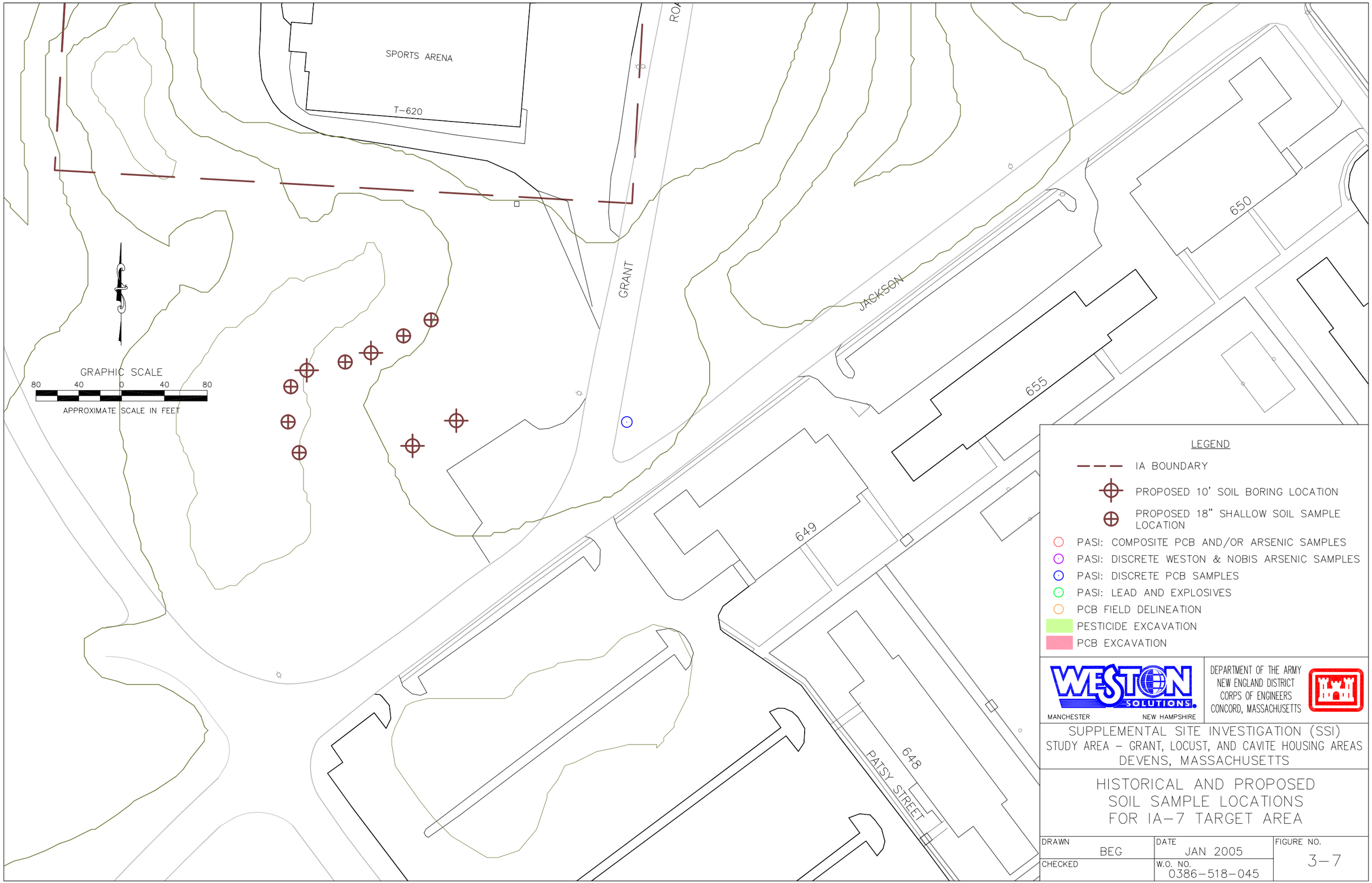
SUPPLEMENTAL SITE INVESTIGATION (SSI)
STUDY AREA – GRANT, LOCUST, AND CAVITE HOUSING AREAS
DEVENS, MASSACHUSETTS

HISTORIC AND PROPOSED SOIL SAMPLE LOCATIONS FOR IA–5

DRAWN	DATE	FIGURE NO.
BEG	JAN 2005	3–6
CHECKED	W.O. NO. 03886.518.045	

M:\Design\DWG\ACOE\FTDEVENS\SSI\Work Plan\FINAL REVISIONS – OCT 2004\fig 3–6.dwg, IA 5, 1/21/2005 3:25:50 PM, girardeb, 1:1



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SUPPLEMENTAL SITE INVESTIGATION (SSI)
STUDY AREA – GRANT, LOCUST, AND CAVITE HOUSING AREAS
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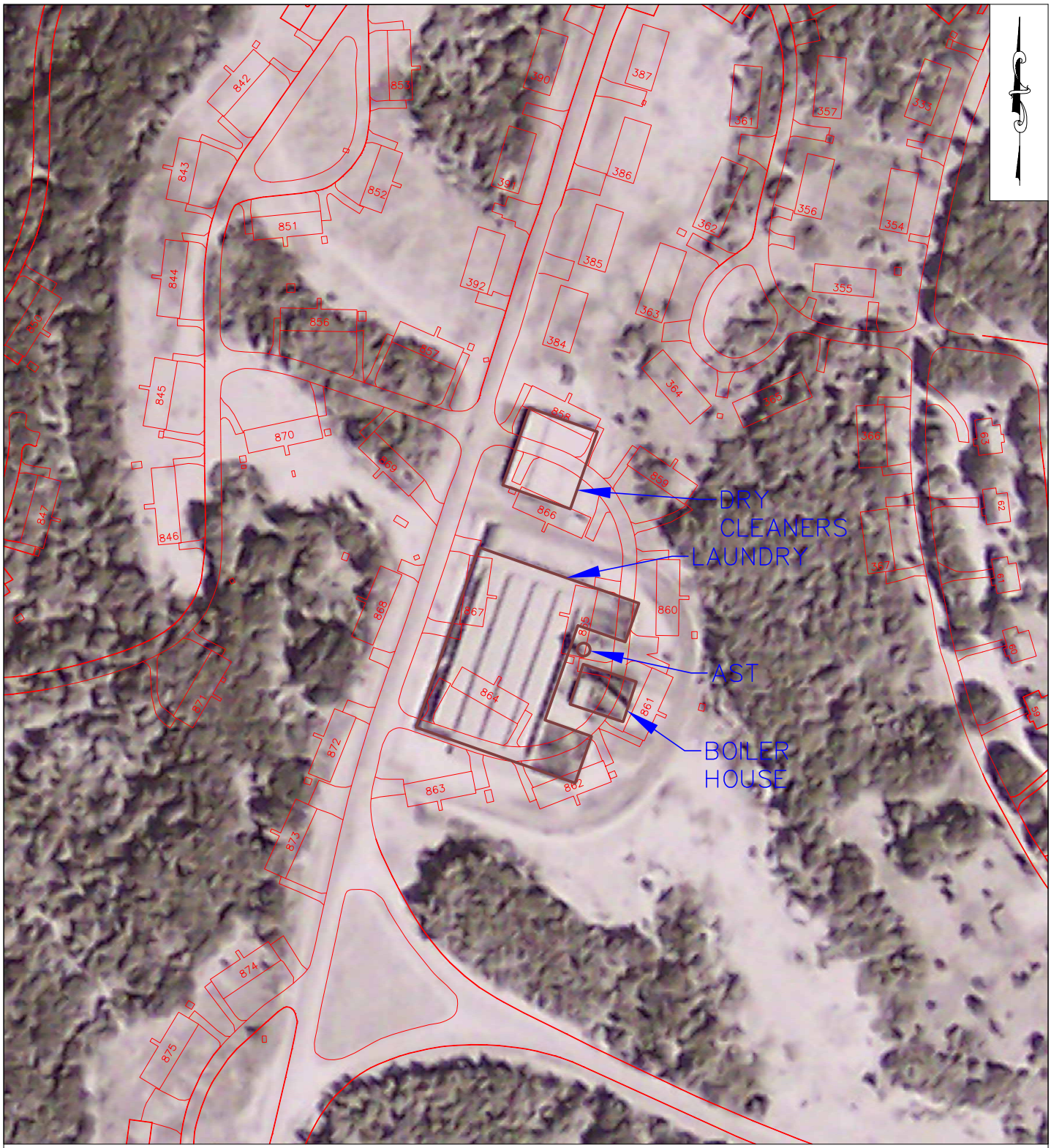
HISTORICAL AND PROPOSED SOIL SAMPLE LOCATIONS FOR IA-7 TARGET AREA

DRAWN	DATE	FIGURE NO.
BEG	JAN 2005	3-7
CHECKED	W.O. NO. 0386-518-045	

M:\Design\DWG\ACOE\FTDEVENS\SSI\Work Plan\FINAL REVISIONS - OCT 2004\fig 3-7.dwg, IA-7, 1/21/2005 3:08:04 PM, girardeb, 1:1



GRAPHIC SCALE

200 100 0 100 200

APPROXIMATE SCALE IN FEET

GRANT HOUSING AREA
POPLAR STREET
DEVENS, MASSACHUSETTS

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CONCORD, MASSACHUSETTS

1952 AERIAL PHOTO

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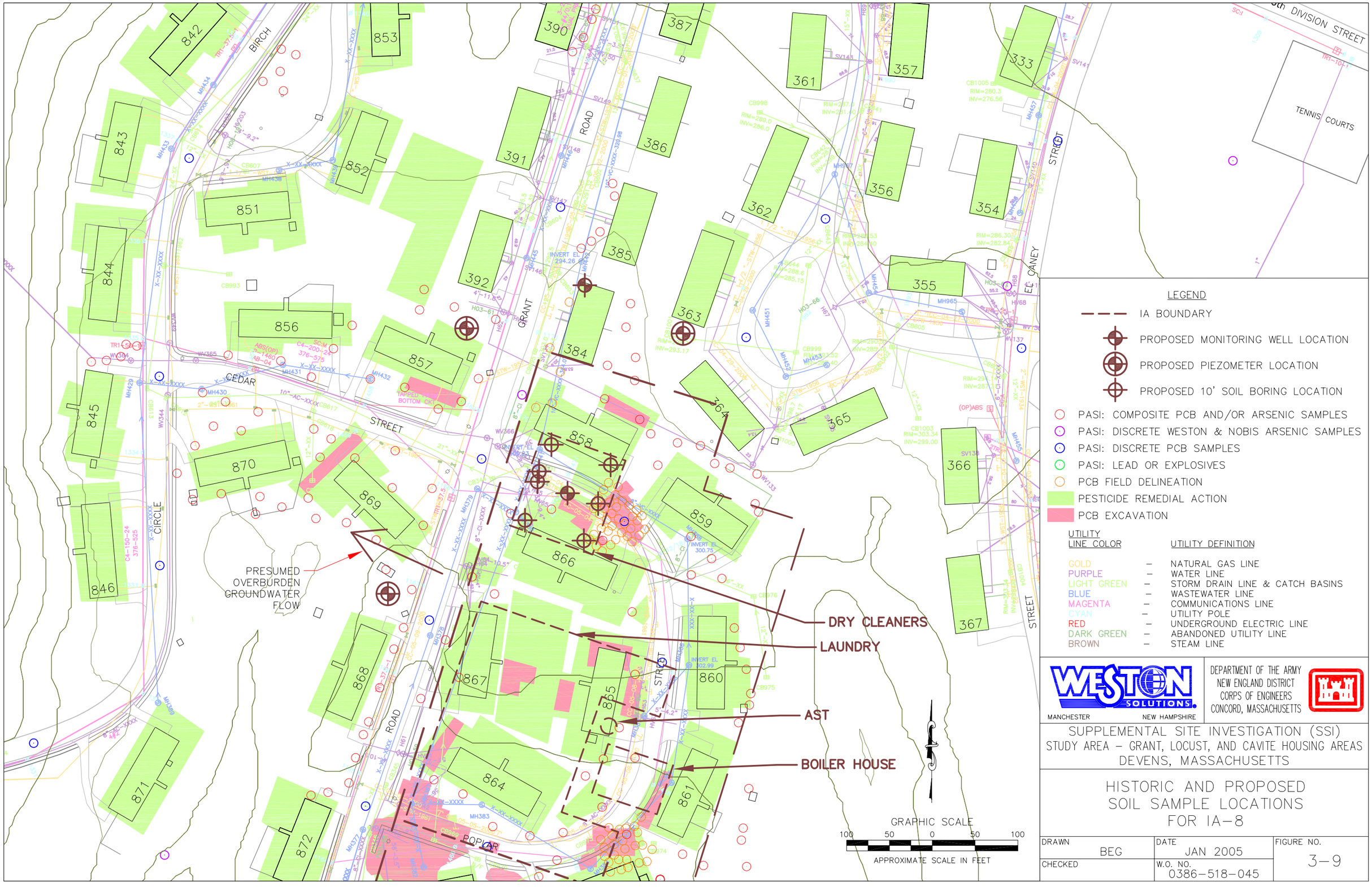
DRAWN BEG
DATE JAN 2005
FIGURE NO. 3-8

M:\Design\DWG\ACOE\FTDEVENS\SSI\Work Plan\FINAL REVISIONS - OCT 2004\fig 3-8.dwg, poplar circle, 1/21/2005 3:11:08 PM, girardeb, 1:1



LEGEND

- IA BOUNDARY
- PROPOSED MONITORING WELL LOCATION
- PROPOSED PIEZOMETER LOCATION
- PROPOSED 10' SOIL BORING LOCATION
- PASI: COMPOSITE PCB AND/OR ARSENIC SAMPLES
- PASI: DISCRETE WESTON & NOBIS ARSENIC SAMPLES
- PASI: DISCRETE PCB SAMPLES
- PASI: LEAD OR EXPLOSIVES
- PCB FIELD DELINEATION
- PESTICIDE REMEDIAL ACTION
- PCB EXCAVATION

UTILITY LINE COLOR		UTILITY DEFINITION
GOLD	–	NATURAL GAS LINE
PURPLE	–	WATER LINE
LIGHT GREEN	–	STORM DRAIN LINE & CATCH BASINS
BLUE	–	WASTEWATER LINE
MAGENTA	–	COMMUNICATIONS LINE
CYAN	–	UTILITY POLE
RED	–	UNDERGROUND ELECTRIC LINE
DARK GREEN	–	ABANDONED UTILITY LINE
BROWN	–	STEAM LINE

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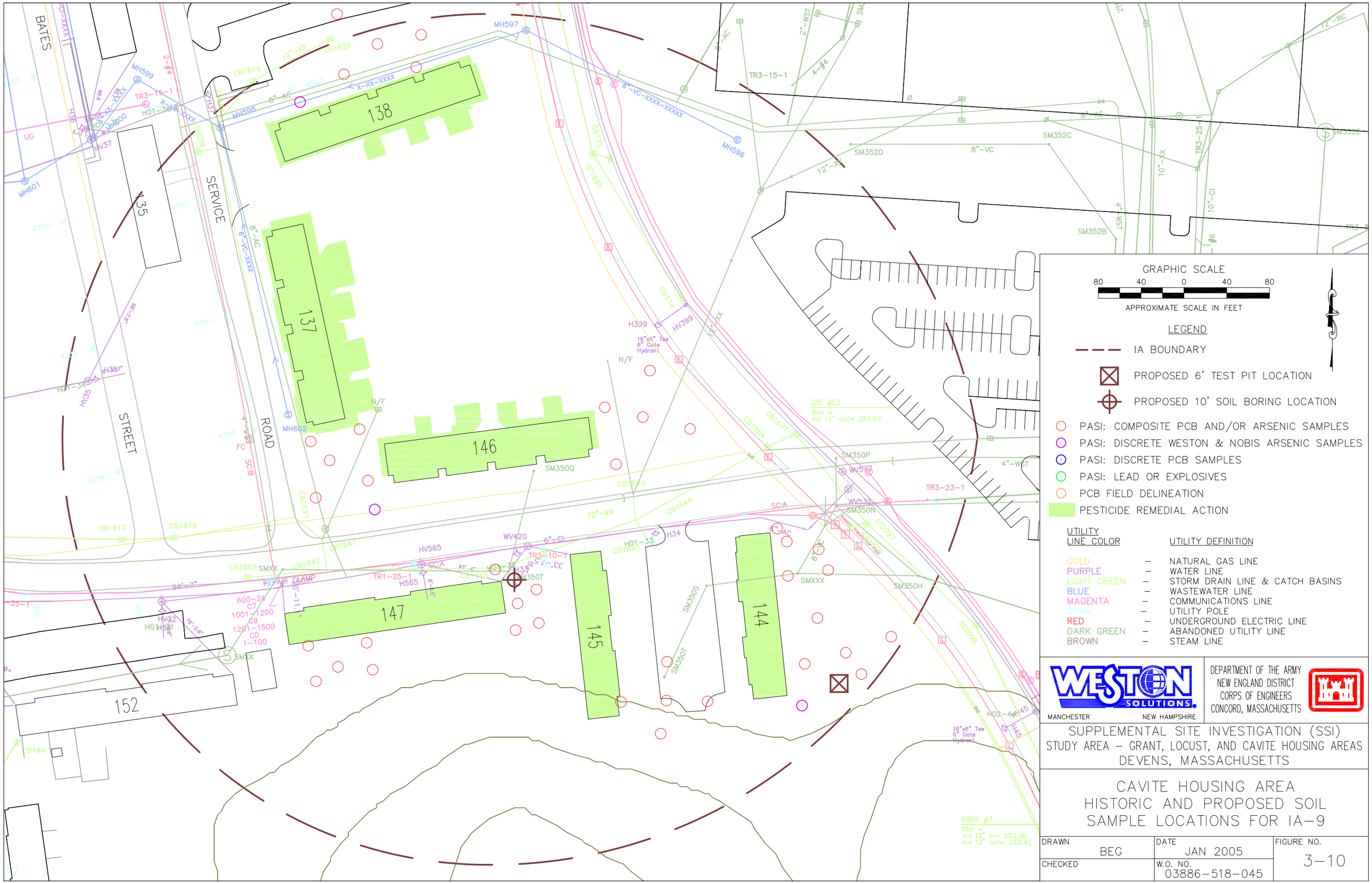
SUPPLEMENTAL SITE INVESTIGATION (SSI)
STUDY AREA – GRANT, LOCUST, AND CAVITE HOUSING AREAS
DEVENS, MASSACHUSETTS

HISTORIC AND PROPOSED SOIL SAMPLE LOCATIONS FOR IA–8

DRAWN	DATE	FIGURE NO.
BEG	JAN 2005	3–9
CHECKED	W.O. NO. 0386–518–045	

M:\Design\DWG\ACOE\FTDEVENS\SSI\Work Plan\FINAL REVISIONS – OCT 2004\fig 3–9.dwg, IA–8, 1/24/2005 1:06:56 PM, girardeb, 1:1



M:\Design\DWG\ACOE\FTDEVENS\SSI\Work Plan\FINAL REVISIONS – OCT 2004\fig 3-10.dwg, IA-9, 1/21/2005 3:15:37 PM, girardeb, 1:1

GRAPHIC SCALE

400 200 0 200 400

APPROXIMATE SCALE IN FEET

WILLARD PARK ATHLETIC FIELD

ROGERS FIELD

BIRCH CIRCLE HOUSING

LEGEND

- IA BOUNDARY
- PROPOSED 6' TEST PIT LOCATION
- PROPOSED 10' SOIL BORING LOCATION
- PASI: COMPOSITE PCB AND/OR ARSENIC SAMPLES
- PASI: DISCRETE WESTON & NOBIS ARSENIC SAMPLES
- PASI: DISCRETE PCB SAMPLES
- PASI: LEAD AND EXPLOSIVES
- PCB FIELD DELINEATION
- PESTICIDE EXCAVATION
- PCB EXCAVATION

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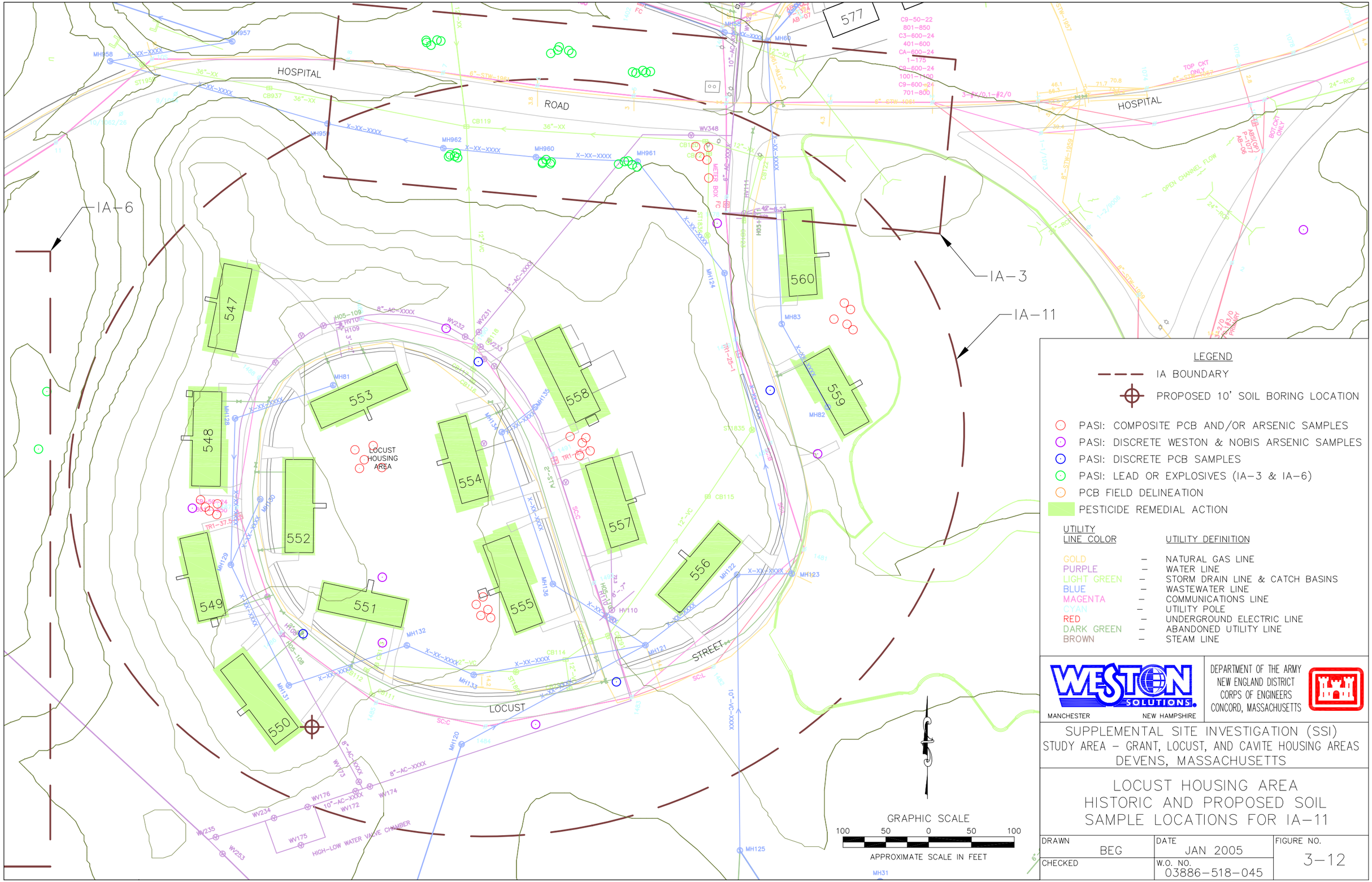
SUPPLEMENTAL SITE INVESTIGATION (SSI)
STUDY AREA - GRANT, LOCUST, AND CAVITE HOUSING AREAS
DEVENS, MASSACHUSETTS

HISTORICAL AND PROPOSED SOIL SAMPLE LOCATIONS FOR IA-10 TARGET AREA

DRAWN	DATE	FIGURE NO.
BEG	JAN 2005	3-11
CHECKED	W.O. NO. 03886.518.045	

M:\Design\DWG\ACOE\FTDEVENS\SSI\Work Plan\FINAL REVISIONS - OCT 2004\fig 3-11.dwg, IA-10, 1/21/2005 3:14:26 PM, girardeb, 1:1



LEGEND

IA BOUNDARY

PROPOSED 10' SOIL BORING LOCATION

PASI: COMPOSITE PCB AND/OR ARSENIC SAMPLES

PASI: DISCRETE WESTON & NOBIS ARSENIC SAMPLES

PASI: DISCRETE PCB SAMPLES

PASI: LEAD OR EXPLOSIVES (IA-3 & IA-6)

PCB FIELD DELINEATION

PESTICIDE REMEDIAL ACTION

UTILITY LINE COLOR		UTILITY DEFINITION
GOLD	–	NATURAL GAS LINE
PURPLE	–	WATER LINE
LIGHT GREEN	–	STORM DRAIN LINE & CATCH BASINS
BLUE	–	WASTEWATER LINE
MAGENTA	–	COMMUNICATIONS LINE
CYAN	–	UTILITY POLE
RED	–	UNDERGROUND ELECTRIC LINE
DARK GREEN	–	ABANDONED UTILITY LINE
BROWN	–	STEAM LINE

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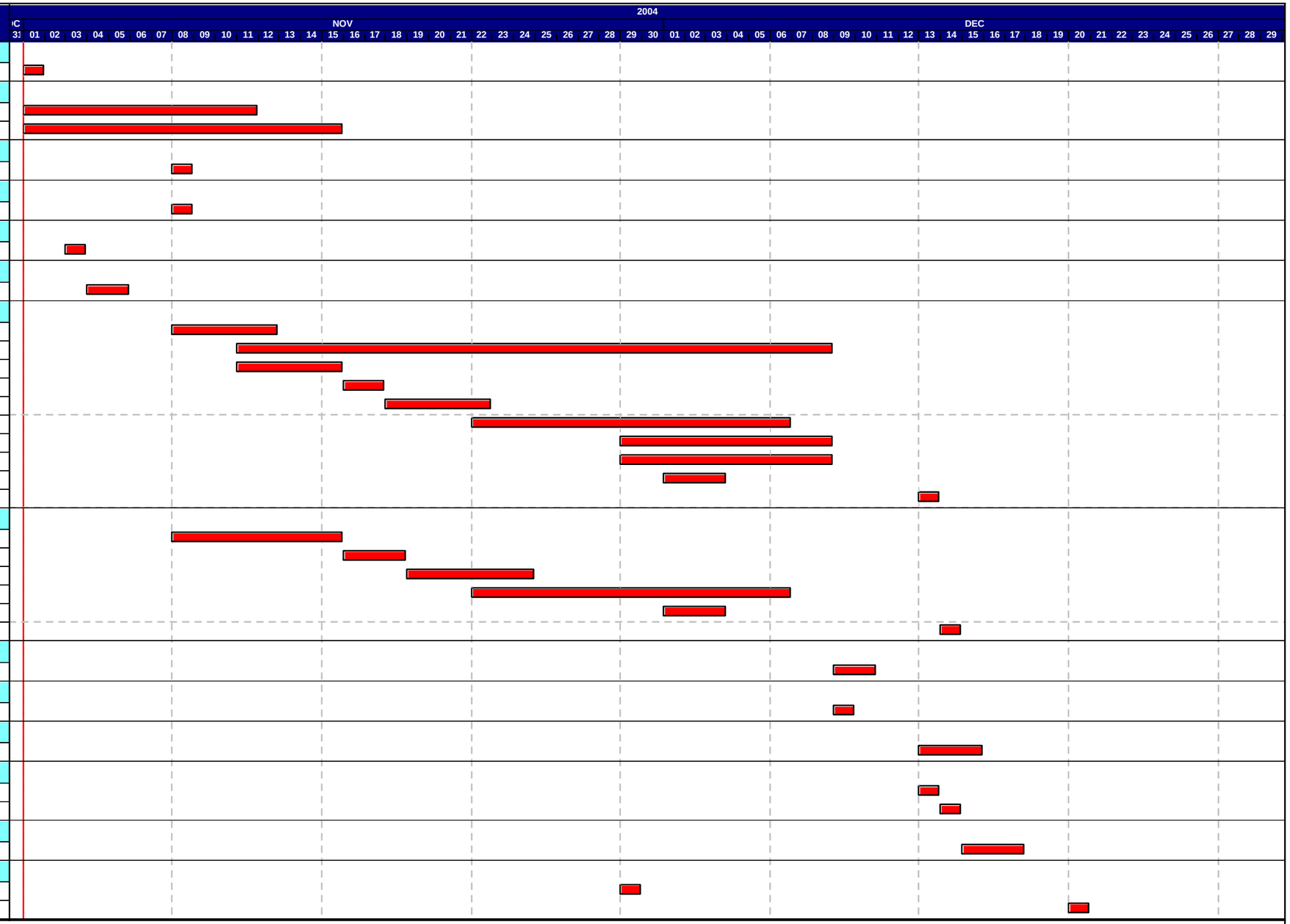
SUPPLEMENTAL SITE INVESTIGATION (SSI)
STUDY AREA – GRANT, LOCUST, AND CAVITE HOUSING AREAS
DEVENS, MASSACHUSETTS

LOCUST HOUSING AREA
HISTORIC AND PROPOSED SOIL
SAMPLE LOCATIONS FOR IA-11

DRAWN	DATE	FIGURE NO.
BEG	JAN 2005	3-12
CHECKED	W.O. NO. 03886-518-045	

M:\Design\DWG\ACOE\FTDEVENS\SSI\Work Plan\FINAL REVISIONS – OCT 2004\fig 3-12.dwg, IA-11, 1/21/2005 3:23:02 PM, girardeb, 1:1

Description	Rem Dur	Early Start	Early Finish
Site Walk			
Site Walk	1	11/01/04	11/01/04
Mobilization			
Mobilization	9	11/01/04	11/11/04
Clearing & Grubbing IAs as needed	11	11/01/04	11/15/04
IA-9 Cavite Housing Area			
Soil Borings (1)	1	11/08/04	11/08/04
IA-11 Locust Housing Area			
Soil Borings (1)	1	11/08/04	11/08/04
Test Pits			
Test Pits at IA-9(1), IA-10(2)	1	11/03/04	11/03/04
Shallow Soil Sampling			
Shallow Soils IA-3(6), IA-5(6), IA-7(6)	2	11/04/04	11/05/04
IA-2 Former Training Area/Range			
MEC Access Survey	5	11/08/04	11/12/04
MEC Subsurface Avoidance	20	11/11/04	12/08/04
Firing Point Soil Borings (6)	3	11/11/04	11/15/04
Install Impact Berm Source Area Monitor Well (1)	2	11/16/04	11/17/04
Install Impact Berm Piezometers (2)	3	11/18/04	11/22/04
Develop Monitor Wells	11	11/22/04	12/06/04
Impact Area Soil Borings (10)	8	11/29/04	12/08/04
Intermediate Area Soil Borings (10)	8	11/29/04	12/08/04
Inst. Impact Berm Downgradient Monitor Well (1)	3	12/01/04	12/03/04
Sample Monitor Wells	1	12/13/04	12/13/04
IA-8 Former Base Laundry Buildings			
Soil Borings (6)	6	11/08/04	11/15/04
Install Source Area Monitor Well (1)	3	11/16/04	11/18/04
Install Piezometers (2)	4	11/19/04	11/24/04
Develop Monitor Wells	11	11/22/04	12/06/04
Install Downgradient Monitor Well (1)	3	12/01/04	12/03/04
Sample Monitor Wells	1	12/14/04	12/14/04
IA-10 Grant Housing Area			
Soil Borings (4)	2	12/09/04	12/10/04
IA-1 Former Training Area			
Soil Borings (6)	1	12/09/04	12/09/04
IA-5 Anti-Tank Range			
Soil Borings (9)	3	12/13/04	12/15/04
IA-7 Anti-Tank Range			
Impact Berm Borings (2)	1	12/13/04	12/13/04
Firing Position Borings (2)	1	12/14/04	12/14/04
IA-3 Rifle Range			
Soil Borings (7)	3	12/15/04	12/17/04
Survey			
Initial Survey	1	11/29/04	11/29/04
Final Survey	1	12/20/04	12/20/04



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Finish date	12/20/04 4:59PM
Data date	11/01/04 7:00AM
Run date	10/20/04 7:00AM
Page number	1A

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FIGURE 6-1

Former Fort Devens SSI Schedule

TABLES

Table 3-1
Summary of Analytical Requirements for Phase 2 of the PA/SI Effort
Supplemental Site Investigation Work Plan
Study Areas - Grant, Locust, and Cavite Housing Areas
Devens, Massachusetts

Location	Sample Type	Soil Sample Type			Full SuiteTCL/ TAL*	TAL Metals 6010	Perchlorate 8321A**	Explosives 8330***	VOC 8260B	Dioxin / Furan	Sample Intervals	Other Requirements
		Test Pits	Soil Borings	Surface Samples								
Investigation Areas					Total numbers of samples (excluding QA/QC)							
IA-1 Impact Berm	Soil		3		2	4					0'-3' & 3'-10'	Metal Detector
IA-1 Firing Positions	Soil		1			2					0'-3' & 3'-10'	Metal Detector
IA-1 Totals		0	4	0	2	6	0	0	0	0		
IA-2 Impact Berm	Soil		10		2	18	20	20			0'-3' & 3'-10'	Metal Detector, focused on locations of previous removal actions and demolition craters.
IA-2 Impact Berm Well	Soil		1		2		2	2			0'-3' & 3'-10'	Source Well, Metal detector
	Aqueous				1		1	1		1		
IA-2 Intermediate Area	Soil		10		4	16	4	20			0'-3' & 3'-10'	Metal Detector
IA-2 Firing Position	Soil		6		2	10		12			0'-3' & 3'-10'	Metal Detector
IA-2 Firing Position	Soil			1		1		1			0-18"	Metal Detector
IA-2 Piezometers	na		2									2 piezomenters, no sampling
IA-2 Well (downgradient)	Soil		1		2		2	2			0'-3' & 3'-10'	Downgradient of Impact Area
	Aqueous				1		1	1		1		
IA-2 Totals		0	30	1	14	45	30	59	0	2		
IA-3 Impact Berm-N	Soil		2		2	2					0'-3' & 3'-10'	Metal Detector Extend vertically from toe of slope
	Soil			3		3					0"-18"	Extend horizontally into berm Metal Detector
IA-3 Impact Berm-S	Soil		2		2	2					0'-3' & 3'-10'	Metal Detector Extend vertically from toe of slope
	Soil			3		3					0"-18"	Extend horizontally into berm Metal Detector

Table 3-1
Summary of Analytical Requirements for Phase 2 of the PA/SI Effort
Supplemental Site Investigation Work Plan
Study Areas - Grant, Locust, and Cavite Housing Areas
Devens, Massachusetts

Location	Sample Type	Soil Sample Type			Full SuiteTCL/ TAL*	TAL Metals 6010	Perchlorate 8321A**	Explosives 8330***	VOC 8260B	Dioxin / Furan	Sample Intervals	Other Requirements
		Test Pits	Soil Borings	Surface Samples								
Investigation Areas					Total numbers of samples (excluding QA/QC)							
IA-3 Hillslope-N	Soil			8		8					0'-3' & 3'-10'	Metal Detector
IA-3 Hillslope-S	Soil			8		8					0'-3' & 3'-10'	Metal Detector
IA-3 Totals		0	4	22	4	26	0	0	0	0		
IA-5 Impact Berm - Lower	Soil		4		2	6					0'-3' & 3'-10'	Metal Detector Extend vertically from toe of slope
	Soil			6		6					0"-18"	Extend horizontally into berm, Metals detector, and at two locations with Lead concentrations exceeding 200 mg/kg.
IA-5 Impact Berm - Upper	Soil		3			6					0'-3' & 3'-10'	Metal Detector
IA-5 Firing Position	Soil		2			4					0'-3' & 3'-10'	Metal Detector
IA-5 Totals		0	9	6	2	22	0	0	0	0		
IA-7 Firing Position	Soil		2			4					0'-3', 3'-10'	Metal Detector
IA-7 Impact Berm	Soil		2			4					0'-3', 3'-10'	Metal Detector
IA-7 Impact Berm	Soil			6		6					0"-18"	
IA-7 Totals	Soil	0	4	6	0	14	0	0	0	0	0'-3' & 3'-10'	Metal Detector
IA-8 Source Area Well	Soil		1		2		2	2			0'-3' & 3'-10'	Within footprint of former Dry Cleaner foundation
	Aqueous				1		1	1		1		
IA-8 Piezometers	na		3									3 piezometers, no sampling
IA-8 Well (downgradient)	Soil		1		2		2	2			0'-3' & 3'-10'	Downgradient of former Dry Cleaner foundation
	Aqueous				1		1	1		1		
IA-8 Soil Borings	Soil		6						6		2' intervals	
IA-8 Totals		0	11	0	6	0	6	6	6	2		

Table 3-1
Summary of Analytical Requirements for Phase 2 of the PA/SI Effort
Supplemental Site Investigation Work Plan
Study Areas - Grant, Locust, and Cavite Housing Areas
Devens, Massachusetts

Location	Sample Type	Soil Sample Type			Full SuiteTCL/ TAL*	TAL Metals 6010	Perchlorate 8321A**	Explosives 8330***	VOC 8260B	Dioxin / Furan	Sample Intervals	Other Requirements
		Test Pits	Soil Borings	Surface Samples								
Investigation Areas					Total numbers of samples (excluding QA/QC)							
Housing Areas												
Former Cavite Housing Area (IA-9)	Soil		1		2					2	0'-3' & 3'-10'	Randomly located
	Soil	1				12					0'-2', 2'-4' & 4'-	Test pit around arsenic hit - sidewall samples
IA-9 Totals		1	1	0	2	12	0	0	0	2		
Former Grant Housing Area (IA-10)	Soil		4		8					8	0'-3' & 3'-10'	4 randomly located
	Soil	2				24					0'-2', 2'-4' & 4'-	Test pits around 2 arsenic hits - sidewall samples
IA-10 Totals		2	4	0	8	24	0	0	0	8		
Former Locust Housing Area (IA-11)	Soil		1		2					2	0'-3' & 3'-10'	Randomly located
IA-11 Totals		0	1	0	2	0	0	0	0	2		
Total Samples		**3**	**68**	**35**	**40**	**149**	**36**	**65**	**6**	**16**		Total number of borings
QA/QC Samples (Dups & Ebs & TBs)					9	17	9	12	4	3	51	
Total samples					**49**	**166**	**45**	**77**	**10**	**19**	**366**	Total Locations:

NOTES

*Full Suite TCL/TAL	Method	Reporting Limits - need to confirm acceptable RL based on DQOs	
VOC = volatile organic compound	8260B	std	
SVOC = semi-volatile organic compound	8270C	std	includes PAHs
PCB = polychlorinated biphenyl	8082	std	
Pesticides	8081A	std	
TAL Metals = Target Analyte List Metals	6010B/7471A	std	
EPH = Extractable Petroleum Hydrocarbon	MADEP-EPH-98-1	std	
µg/kg = micrograms per kilogram			
mg/kg = milligrams per kilogram			
TB = trip blanks			
QA/QC = quality assurance/quality control			

Other analysis		
Dioxin/Furans	8290	std
Perchlorate	8321A**	std
Explosives	8330***	µg/kg

Table 4-1
QA/QC Sample Requirements - Supplemental Site Investigation Sampling
Study Area - Grant, Locust, and Cavite Housing Areas
Devens, Massachusetts

Sample Type	Areas	Analysis	Method	Total Routine Samples	Duplicates	MS/MSD	Equipment Blanks	Trip Blanks	CENAE QA
Soil from soil borings	IA-1, IA-2, IA-3, IA-5, IA-7, IA-8, IA-9, IA-10, IA-11	VOC	5035/8260B	34	2	2	20 (1/day)	2	2
		SVOCs	3540C/ 8270C	28	2	2	20 (1/day)	0	2
		TAL Metals	3050B/6010C/7471A	106	6	7	20 (1/day)	0	6
		Pesticides	8081A	28	2	2	20 (1/day)	0	2
		PCB	3540C/8082	28	2	2	20 (1/day)	0	2
		EPH	MADEP Method	28	2	2	20 (1/day)	0	2
		Dioxins/Furans	3540C/8290	12	1	1	20 (1/day)	0	1
		Explosives	3540C/8330	52	3	3	20 (1/day)	0	3
		Perchlorates	314	24	2	2	20 (1/day)	0	1
Soil from monitoring well boreholes	IA-2, IA-8	VOC	5035/8260B	8	1	1	4 (1/day)	1	1
		SVOCs	3540C/ 8270C	8	1	1	4 (1/day)	0	1
		TAL Metals	3050B/6010C/7471A	8	1	1	4 (1/day)	0	1
		Pesticides	8081A	8	1	1	4 (1/day)	0	1
		PCB	3540C/8082	8	1	1	4 (1/day)	0	1
		EPH	MADEP Method	8	1	1	4 (1/day)	0	1
		Dioxins/Furans	3540C/8290	0	0	0	0	0	0
		Explosives	3540C/8330	8	1	1	4 (1/day)	0	1
		Perchlorates	314	8	1	1	4 (1/day)	0	1
Surficial Soil	IA-2, IA-3, IA-5, IA-7	VOC	5035/8260B	0	0	0	0	0	0
		SVOCs	3540C/ 8270C	0	0	0	0	0	0
		TAL Metals	3050B/6010C/7471A	35	2	1	2 (1/day)	0	2
		Pesticides	8081A	0	0	0	0	0	0
		PCB	3540C/8082	0	0	0	0	0	0
		EPH	MADEP Method	0	0	0	0	0	0
		Dioxins/Furans	3540C/8290	0	0	0	0	0	0
		Explosives	3540C/8330	1	0	0	0	0	0
		Perchlorates	314	0	0	0	0	0	0
Soil From Test Pits	IA-9, IA-10	VOC	5035/8260B	0	0	0	0	0	0
		SVOCs	3540C/ 8270C	0	0	0	0	0	0
		TAL Metals	3050B/6010C/7471A	36	4	1	2 (1/day)	0	2
		Pesticides	8081A	0	0	0	0	0	0
		PCB	3540C/8082	0	0	0	0	0	0
		EPH	MADEP Method	0	0	0	0	0	0
		Dioxins/Furans	3540C/8290	0	0	0	0	0	0
		Explosives	3540C/8330	0	0	0	0	0	0
		Perchlorates	314	0	0	0	0	0	0

Table 4-1
QA/QC Sample Requirements - Supplemental Site Investigation Sampling
Study Area - Grant, Locust, and Cavite Housing Areas
Devens, Massachusetts

Groundwater	IA-2, IA-8	VOC	5035/8260B	4	1	1	2 (1/day)	1	0
		SVOCs	3540C/ 8270C	4	1	1	2 (1/day)	0	0
		TAL Metals	3050B/6010C/7471A	4	1	1	2 (1/day)	0	0
		Pesticides	8081A	4	1	1	2 (1/day)	0	0
		PCB	3540C/8082	4	1	1	2 (1/day)	0	0
		EPH	MADEP Method	4	1	1	2 (1/day)	0	0
		Dioxins/Furans	3540C/8290	4	1	1	2 (1/day)	0	0
		Explosives	3540C/8330	4	1	1	2 (1/day)	0	0
		Perchlorates	314	4	1	1	2 (1/day)	0	0
Investigation-Derived Waste	Drill Cuttings from IA-2 a Purge Water from IA-2 a	Ignitability	1010	2	0	0	0	0	0
		Corrosivity	9045A	2	0	0	0	0	0
		Cyanide/Sulfide F	7.3.4.1/7.3.4.2	2	0	0	0	0	0
		TCLP VOC	1311/5035/8260B	1	0	0	0	0	0
		TCLP SVOC	1311/3540C/ 8270C	1	0	0	0	0	0
		PCB	8082	2	0	0	0	0	0
		TCLP Pesticide	1311/3540C/8081	1	0	0	0	0	0
		TCLP Metals	1311/3050B/6010B/7471A	1	0	0	0	0	0
		TCLP Herbicides	1311/3540C/8151A	1	0	0	0	0	0
		VOC	5035/8260B	2	0	0	0	0	0
		SVOC	3540C/ 8270C	2	0	0	0	0	0
		Pesticides	3540C/8081	2	0	0	0	0	0
		RCRA 8 Metals	3050B/6010B/7471A	2	0	0	0	0	0
		Herbicides	3540C/8151A	2	0	0	0	0	0
		TPH	8015B (DRO and GRO)	2	0	0	0	0	0
		TOC	9060A	2	0	0	0	0	0

Notes:
DRO = diesel range organics
EPH = Extractable Petroleum Hydrocarbons
GRO = Gasoline Range Organics
MS/MSD = Matrix Spike/Matrix Spike Duplicate
PCB = polychlorinated biphenyl
QA = Quality Assurance
QC = Quality Control
SVOC = semi-volatile organic compound
TAL = Target Analyte List
TCLP = Toxic Characteristic Leaching Procedure
VOC = volatile organic compound

Table 4-2

Sample Containers, Preservation Methods, and Holding Times

Matrix	Parameter	Container	Preservation/Solvents	Maximum Holding Times	
				Extraction	Analysis
IA Characterization Samples					
Soil	Total VOCs	Two 30-ml glass vials with septum top	Methanol – 10 g soil to 25 ml methanol; ice to 4°C	---	14 days
Soil	EPH	8 oz. clear jar	Hand delivered in coolers without ice; Ice to 4°C after analysis	14 days	40 days
Soil	SVOCs	8 oz. clear glass	Ice to 4°C	14 days	40 days
Soil	Pesticides	8 oz. clear glass	Ice to 4°C	14 days	40 days
Soil	TAL Metals	8 oz. clear glass	Ice to 4°C	180 days	180 days
Soil	Explosives	8 oz. clear glass	Ice to 4°C	14 days	40 days
Soil	Perchlorate	8 oz. clear glass	Ice to 4°C	14 days	40 days
Soil	PCBs	8 oz. clear glass	Ice to 4°C	14 days	40 days
Soil	Dioxin/Furan	8 oz. clear glass	Ice to 4°C	14 days	40 days
Soil	Hydrazine	8 oz. clear glass	Ice to 4°C	14 days	40 days
Waste Characterization Samples					
Soil	Total VOCs	Two 30-ml glass vials with septum top	Methanol – 10 g soil to 25 ml methanol; ice to 4°C	---	14 days
Soil	Total SVOCs	8 oz clear glass	Ice to 4°C	14 Days	40 days
Soil	Total Pesticides	8 oz clear glass	Ice to 4°C	14 Days	40 days
Soil	Total PCBs	8 oz clear glass	Ice to 4°C	14 days	40 days
Soil	PAHs	8 oz. clear glass	Ice to 4°C	14 days	40 days
Soil	TOC	8 oz. clear glass	Ice to 4°C	14 days	40 days
Soil	RCRA 8 Metals Mercury	8 oz. clear glass	Ice to 4°C	---	180 days 28 days
Soil	TCLP VOCs	Two 30-ml glass vials with septum top	Ice to 4°C	---	14 days

Sample Containers, Preservation Methods, and Holding Times (concluded)

Matrix	Parameter	Container	Preservation/Solvents	Maximum Holding Times	
				Extraction	Analysis
Waste Characterization Samples (con't)					
Soil	TCLP SVOCs	8 oz clear glass	Ice to 4°C	14 days	40 days
Soil	TCLP Pesticides*	8 oz clear glass	Ice to 4°C	14 days	40 days
Soil	TCLP Herbicides	8 oz clear glass	Ice to 4°C	14 days	40 days
Soil	TCLP – Metals	8 oz. clear glass	Ice to 4°C	---	180 days
Soil	IRC	(combined w/TCLP)	Ice to 4°C	---	14 days
Groundwater Characterization Samples and Liquid Waste Characterization Samples					
Water/ liquid	Total VOCs	3 X 40-ml glass vials with Teflon septum caps	HCL to pH<2. Ice to 4°C.		14 days
Water/ liquid	EPH	2.5 L Amber Glass Bottle	Ice to 4°C.	7 days	40 days
Water/ liquid	SVOCs	2.5 L Amber Glass Bottle	Ice to 4°C.	7 days	40 days
Water/ liquid	Pesticides	2.5 L Amber Glass Bottle	Ice to 4°C.	7 days	40 days
Water/ liquid	TAL Metals/RCRA 8 Metals	500 ml HDPE	HNO_3 to pH<2. Ice to 4°C.	--	6 months to analyze/ 28 days for Hg
Water/ liquid	Explosives	2.5 L Amber Glass Bottle	Ice to 4°C.	7 days	40 days
Water/ liquid	Perchlorate	2.5 L Amber Glass Bottle	Ice to 4°C.	7 days	40 days
Water/ Liquid	PCBs	2.5 L Amber Glass Bottle	Ice to 4°C.	7 days	40 days
Water/ liquid	Dioxin/Furan	2.5 L Amber Glass Bottle	Ice to 4°C.	7 days	40 days
Water/ liquid	Hydrazine	2.5 L Amber Glass Bottle	Ice to 4°C.	7 days	40 days
Water/ liquid	IRC	(combined w/TCLP)	Ice to 4°C	---	14 days

TCLP Holding Times: Metals (excluding mercury): Extraction within 180 days, analysis must follow within 180 days from extraction.
Mercury: Extraction within 28 days, analysis must follow within 28 days from extraction.

Sample Containers, Preservation Methods, and Holding Times (concluded)

Notes:

EPH = Extractable Petroleum Hydrocarbons
Hg = mercury
HNO_3 = Nitric Acid
L = liter
ml = milliliter
oz. = ounce
PAH = polycyclic aromatic hydrocarbons
PCB = polychlorinated biphenyl
RCRA = Resource Conservation and Recovery Act
SVOC = semi-volatile organic compound
TAL = Target Analyte List
TCLP = Toxic Characteristics Leaching Procedure
VOC = volatile organic compound

Table 5-1a
Project Action Limits - Volatiles in Soil (mg/kg)
Supplemental Site Investigation Work Plan
Study Area - Grant, Locust, and Cavite Housing Areas
Devens, Massachusetts

Analyte	CAS Number	MCP Cleanup Standards	EPA Region 3 RBCs	EPA Region 9 PRGs	Project Action Limit	Lab MDLs	Lab PQLs
Volatiles (MCP) Soil 5035/8260B							
Acetone	67641	**3**	70000	1,600	**3**	0.002841	0.010
Amyl Methyl Ether (TAME), *tert-*	994058					NA	0.004
Benzene	71432	10	12	**0.6**	**0.6**	0.00021	0.001
Bromobenzene	108861	100		**28**	**28**	0.000204	0.005
Bromochloromethane	74975					0.000165	0.005
Bromodichloromethane	75274	**0.1**	10	0.82	**0.1**	0.000305	0.001
Bromoform	75252	**0.1**	81	62	**0.1**	0.000219	0.004
Bromomethane	74839	**3**	110	3.9	**3**	0.000564	0.002
Butylbenzene, *sec-*	135988	**100**		220	**100**	0.000195	0.001
Butylbenzene	104518	**100**		240	**100**	0.000222	0.001
Butylbenzene, *tert-*	98066	**100**		390	**100**	0.000186	0.005
Carbon Disulfide	75150	**100**	7800	360	**100**	0.000245	0.010
Carbon Tetrachloride	56235	1	4.9	**0.25**	**0.25**	0.000234	0.001
Chlorobenzene	108907	**8**	1600	150	**8**	0.000159	0.001
Chlorodibromomethane	124481	**0.09**	7.6	1.1	**0.09**	0.000227	0.001
Chloroethane	75003	**100**	220	3	**3**	0.000638	0.002
Chloroform	67663	**0.1**	780	3.6	**0.1**	0.000482	0.0015
Chloromethane	74873	100		**1.2**	**1.2**	0.000649	0.005
2-Chlorotoluene	95498	**100**	1600	1600	**100**	0.000161	0.005
4-Chlorotoluene	106434					0.000145	0.005
1,2-Dibromo-3-chloropropane	96128	10	0.46	0.45	**0.45**	0.000356	0.005
1,2-Dibromoethane (EDB)	106934	**0.005**	0.0075	0.0069	**0.005**	0.000253	0.004
Dibromomethane	74953	500	782	**67**	**67**	0.000261	0.010
1,3-Dichlorobenzene (m-DCB)	541731	100	2300	**16**	**16**	0.000507	0.005
1,2-Dichlorobenzene (o-DCB)	95501	**100**	7000	370	**100**	0.000156	0.005
1,4-Dichlorobenzene (p-DCB)	106467	**2**	27	3.4	**2**	0.000143	0.005
Dichlorodifluoromethane	75718	**1000**	16000	**94**	**94**	0.000431	0.010
1,1-Dichloroethane	75343	**3**	7800	510	**3**	0.000204	0.0015
1,2-Dichloroethane	107062	**0.05**	7	0.28	**0.05**	0.000132	0.001

Table 5-1a
Project Action Limits - Volatiles in Soil (mg/kg)
Supplemental Site Investigation Work Plan
Study Area - Grant, Locust, and Cavite Housing Areas
Devens, Massachusetts

Analyte	CAS Number	MCP Cleanup Standards	EPA Region 3 RBCs	EPA Region 9 PRGs	Project Action Limit	Lab MDLs	Lab PQLs
1,1-Dichloroethylene	75354	**0.1**	3900	120	**0.1**	0.000159	0.001
1,2-Dichloroethylene, *cis-*	156592	**2**	780	43	**2**	0.000233	0.001
1,2-Dichloroethylene, *trans-*	156605	**4**	1600	69	**4**	0.000161	0.0015
1,2-Dichloropropane	78875	**0.1**	9.4	0.34	**0.1**	0.000147	0.0035
1,3-Dichloropropane	142289	500	1600	**0.78**	**0.78**	0.000187	0.005
2,2-Dichloropropane	594207					0.000255	0.005
1,1-Dichloropropene	563586					0.000194	0.005
Dichloropropene, *cis-1,3-*	10061015	**0.01**			**0.01**	0.000202	0.001
Dichloropropene, *trans-1,3-*	10061026	**0.01**			**0.01**	0.000306	0.001
Diethyl Ether	60297	**100**	16000		**100**	0.000305	0.005
Diisopropyl Ether (DIPE)	108203	**100**			**100**	NA	0.004
1,4-Dioxane	123911	100	58	**44**	**44**	NA	0.500
Ethyl Tertiary Butyl Ether (ETBE)	637923					NA	0.004
Ethylbenzene	100414	80	7800	**8.9**	**8.9**	0.000125	0.001
Hexachlorobutadiene	87683	**3**	8.2	6.2	**3**	0.000402	0.005
Hexanone (MNBK)	591786	**100**			**100**	0.002945	0.010
Isopropylbenzene (Cumene)	98828	1000	7800	**570**	**570**	0.000196	0.001
Isopropyltoluene, p-	99876	**100**			**100**	0.000155	0.001
Methyl Ethyl Ketone (MEK)	78933	**0.3**	47000	**7300**	**0.3**	0.000196	0.010
Methyl Isobutyl Ketone (MIBK)	108101	**0.5**		790	**0.5**	0.000162	0.010
Methyl Tertiary Butyl Ether (MTBE)	1634044	**0.3**	160	62	**0.3**	0.000141	0.002
Methylene Chloride	75092	**0.1**	82	9.1	**0.1**	0.003274	0.010
Naphthalene	91203	**4**	1600		**4**	0.00064	0.005
Propylbenzene, n-	103651	**100**		240	**100**	0.000121	0.001
Styrene	100425	**2**	16000	1700	**2**	0.000453	0.002
1,1,1,2-Tetrachloroethane	630206	**0.4**	25	3.2	**0.4**	0.000153	0.001
1,1,2,2-Tetrachloroethane	79345	**0.02**	3.2	0.41	**0.02**	0.000248	0.001
Tetrachloroethylene	127184	**0.5**	1.2	1.5	**0.5**	0.000198	0.001
Tetrahydrofuran (THF)	109999	500	84	**9.4**	**9.4**	0.000525	0.020
Toluene	108883	**90**	15000	520	**90**	0.000154	0.0015

Table 5-1a
Project Action Limits - Volatiles in Soil (mg/kg)
Supplemental Site Investigation Work Plan
Study Area - Grant, Locust, and Cavite Housing Areas
Devens, Massachusetts

Analyte	CAS Number	MCP Cleanup Standards	EPA Region 3 RBCs	EPA Region 9 PRGs	Project Action Limit	Lab MDLs	Lab PQLs
1,2,4-Trichlorobenzene	120821	**100**	780	650	**100**	0.000478	0.005
1,2,3-Trichlorobenzene	87616					0.000718	0.005
1,1,1-Trichloroethane	71556	**30**	22000	1200	**30**	0.000234	0.001
1,1,2-Trichloroethane	79005	**0.3**	11	0.73	**0.3**	0.000171	0.0015
Trichloroethylene (TCE)	79016	0.4	1.6	**0.053**	**0.053**	0.000142	0.001
Trichlorofluoromethane	75694	1000	23000	**390**	**390**	0.001	0.005
1,2,3-Trichloropropane	96184	100	0.32	**0.005**	**0.005**	0.000234	0.010
1,2,4-Trimethylbenzene	95636		3900	**52**	**52**	0.000405	0.005
1,3,5-Trimethylbenzene	108678	**10**	3900	21	**10**	0.000406	0.005
Vinyl Chloride	75014	0.3	0.09	**0.079**	**0.079**	0.00064	0.002
Xylene, o-	95476	**500**			**500**	0.000301	0.001
Xylene, m- (1)	108383	**500**			**500**	0.000272	0.001
Xylene, p- (1)	106423	**500**			**500**	0.000272	0.001

Notes:
EPA = U.S. Environmental Protection Agency
MCP = Massachusetts Contingency Plan
MDL = Maximum Detectable Limit
mg/kg = milligrams per kilogram
PQL = Practical Quantitation Limits
PRGs = Preliminary Remediation Goals
RBCs = risk-based concentrations
(1) Due to co-elusion, m-Xylene and p-Xylene are reported as m/p-Xylene.
Lab MDLs and PQLs are on a wet weight basis and are based on 5035 low-level method.

Table 5-1b
Project Action Limits - Semi-volatiles in Soil (mg/kg)
Supplemental Site Investigation Work Plan
Study Area - Grant, Locust, and Cavite Housing Areas
Devens, Massachusetts

Analyte	CAS Number	MCP Cleanup Standards	EPA Region 3 RBCs	EPA Region 9 PRGs	Project Action Limit	Lab MDLs	Lab PQLs
Semi-volatiles (MCP) Soils 3540C/3545/8270C/8270C-SIM							
Acenaphthene	83-32-9	**20**	4700	3700	**20**	0.03466	0.333
Acenaphthylene	208-96-8	**100**			**100**	0.03857	0.333
Acetophenone	98-86-2		**7800**		**7800**	0.04902	1.333
Aniline	62-53-3	1000	**11**	85	**11**	0.03317	0.667
Anthracene	120-12-7	**1000**	23000	22000	**1000**	0.07444	0.333
Azobenzene	103-33-3		5.8	**4.4**	**4.4**	0.05448	0.333
Benzo(a)anthracene	56-55-3	0.7	0.87	**0.62**	**0.62**	0.0341	0.333
Benzo(a)pyrene (3)	50-32-8	0.7	0.087	**0.062**	**0.062**	0.00232	0.01334
Benzo(b)fluoranthene	205-99-2	0.7	0.87	**0.62**	**0.62**	0.08925	0.333
Benzo(k)fluoranthene	207-08-9	7	8.7	**6.2**	**6.2**	0.04087	0.333
Benzo(g,h,i)perylene	191-24-2	**1000**			**1000**	0.02529	0.333
Bromophenyl phenyl ether, 4-	101-55-3	**100**			**100**	0.03295	0.333
Butyl benzyl phthalate	85-68-7	**100**	16000	12000	**100**	0.02702	0.333
Butyl phthalate, Di-n-	84-74-2	**50**	7800	6100	**50**	0.0284	0.333
Chloroaniline, 4-	106-47-8	**1**	310	150	**1**	0.05268	0.333
bis (Chloroethoxy)methane	111-91-1					0.02642	0.333
bis (2-Chloroethyl)ether	111-44-4	0.7	**0.58**		**0.58**	0.02453	0.333
bis (2-Chloroisopropyl) ether	39638-32-9	**0.7**	9.1	2.9	**0.7**	0.02555	0.333
Chloronaphthalene, 2-	91-58-7	1000	6300	**4900**	**4900**	0.02317	0.333
Chlorophenol, 2-	95-57-8	**0.7**	390	63	**0.7**	0.03781	0.400
Chrysene	218-01-9	**7**	87	62	**7**	0.03562	0.333
Dibenz(a,h)anthracene (3)	53-70-3	0.7	0.087	**0.062**	**0.062**	0.00261	0.01334
Dibenzofuran	132-64-9	**100**	160	290	**100**	0.0292	0.333
Dichlorobenzene, 1,2-	95-50-1	**100**	7000	370	**100**	0.07201	0.333
Dichlorobenzene, 1,3-	541-73-1	100	2300	**16**	**16**	0.01837	0.333
Dichlorobenzene, 1,4-	106-46-7	**2**	27	3.4	**2**	0.06286	0.333
Dichlorobenzidine, 3,3'-	91-94-1	**1**	1.4	1.1	**1**	1.32429	3.334
Dichlorophenol, 2,4-	120-83-2	**10**	230	180	**10**	0.0413	0.667
Diethyl phthalate	84-66-2	**0.7**	63000	49000	**0.7**	0.03172	0.333
Dimethyl phthalate	131-11-3	**0.7**	780000	100000	**0.7**	0.02458	0.333
Dimethylphenol, 2,4-	105-67-9	**0.7**	1600	1200	**0.7**	0.05258	0.667
Dinitrophenol, 2,4-	51-28-5	**3**	160	120	**3**	0.11087	1.333
Dinitrotoluene, 2,4-	121-14-2	**0.7**	160	120	**0.7**	0.02125	0.400
Dinitrotoluene, 2,6-	606-20-2	100	78	**61**	**61**	0.0265	0.333
bis (2-Ethylhexyl)phthalate	117-81-7	100	46	**35**	**35**	0.10512	0.667

Table 5-1b
Project Action Limits - Semi-volatiles in Soil (mg/kg)
Supplemental Site Investigation Work Plan
Study Area - Grant, Locust, and Cavite Housing Areas
Devens, Massachusetts

Analyte	CAS Number	MCP Cleanup Standards	EPA Region 3 RBCs	EPA Region 9 PRGs	Project Action Limit	Lab MDLs	Lab PQLs
Fluoranthene	206-44-0	**1000**	3100	2300	**1000**	0.07247	0.333
Fluorene	86-73-7	**400**	3100	2700	**400**	0.0246	0.333
Hexachlorobenzene	118-74-1	0.7	**0.4**	30	**0.4**	0.01647	0.333
Hexachlorobutadiene	87-68-3	**3**	8.2	6.2	**3**	0.04182	0.667
Hexachloroethane	67-72-1	**6**	46	35	**6**	0.02809	0.333
Indeno (1,2,3-cd) pyrene	193-39-5	0.7	0.81	**0.62**	**0.62**	0.02813	0.467
Isophorone	78-59-1	**100**	670	510	**100**	0.0468	0.333
Methylnaphthalene, 2-	91-57-6	**4**	31		**4**	0.03018	0.533
Methylphenol, 2-	95-48-7		3900	**3100**	**3100**	0.03275	0.400
Methylphenol, 3- (2)	108-39-4		3900	**3100**	**3100**	0.04751	0.400
Methylphenol, 4- (2)	106-44-5		390	**310**	**310**	0.04751	0.400
Naphthalene	91-20-3	**4**	1600		**4**	0.039	0.333
Nitrobenzene	98-95-3	500	39	**20**	**20**	0.02261	0.333
Nitrophenol, 2-	88-75-5	**100**			**100**	0.02026	1.333
Nitrophenol, 4-	100-02-7	**100**			**100**	0.07822	0.667
Octyl phthalate, di-n-	117-84-0		**2100**	2400	**2100**	0.02083	0.333
Pentachlorophenol	87-86-5	5	5.3	**3**	**3**	0.08771	1.333
Phenanthrene	85-01-8	**100**			**100**	0.0579	0.333
Phenol	108-95-2	**60**	23000	37000	**60**	0.02976	0.467
Pyrene	129-00-0	**700**	2300	2300	**700**	0.06415	0.333
Trichlorobenzene, 1,2,4-	120-82-1	**100**	780	650	**100**	0.07572	0.333
Trichlorophenol, 2,4,5-	95-95-4	**2**	7800	6100	**2**	0.03439	0.333
Trichlorophenol, 2,4,6-	88-06-2	**3**	58	6.1	**3**	0.03619	0.333

Notes:
EPA = U.S. Environmental Protection Agency
MCP = Massachusetts Contingency Plan
MDL = Maximum Detectable Limit
mg/kg = milligrams per kilogram
PQL = Practical Quantitation Limits
PRGs = Preliminary Remediation Goals
RBCs = risk-based concentrations
(1) Lab MDLs and PQLs are on a wet weight basis.
(2) Due to co-elusion, 3-Methylphenol and 4-Methylphenol are reported as 3-Methylphenol/4-Methylphenol.
(3) Compounds to be analyzed by EPA 8270C-SIM.

Table 5-1c
Project Action Limits - Pesticides in Soil (mg/kg)
Supplemental Site Investigation Work Plan
Study Area - Grant, Locust, and Cavite Housing Areas
Devens, Massachusetts

Analyte	CAS Number	MCP Cleanup Standards	EPA Region 3 RBCs	EPA Region 9 PRGs	Project Action Limit	Lab MDLs	Lab PQLs
Pesticides Soil 3540C/3545/8081A							
Aldrin	309-00-2	0.03	0.038	**0.029**	**0.029**	0.000547	0.00333
alpha-BHC	319-84-6	50	0.1	**0.09**	**0.09**	0.000915	0.00333
beta-BHC	319-85-7	10	0.35	**0.32**	**0.32**	0.000511	0.00333
gamma-BHC	58-89-9	0.1	0.49	**0.44**	**0.44**	0.000546	0.00333
delta-BHC	319-86-8	**10**			**10**	0.000539	0.00333
Chlorodane (nos), multicomponent mixture	57-74-9	**1**	1.8		**1**	0.003838	0.0133
alpha-chlordane	5103-71-9	**0.002**			**0.002**	0.000363	0.00133
gamma-chlordane	5103-74-2	**0.002**			**0.002**	0.000189	0.00133
4,4'-DDD	72-54-8	**2**	2.7	2.4	**2**	0.000643	0.00333
4,4'-DDE	72-55-9	2	1.9	**1.7**	**1.7**	0.000466	0.00333
4,4'-DDT	50-29-3	2	1.9	**1.7**	**1.7**	0.000696	0.00333
Diedrin	60-57-1	0.03	0.04	**0.03**	**0.03**	0.000495	0.00333
Endosulfan I	959-98-8	**0.05**			**0.05**	0.000462	0.00333
Endosufan II	33213-65-9	**0.05**			**0.05**	0.000318	0.00333
Endosulfan Sulfate	1031-07-8					0.000311	0.00333
Endrin	72-20-8	**0.6**	23	18	**0.6**	0.000403	0.00333
Endrin Ketone	53494-70-5					0.000267	0.00333
Heptachlor	76-44-8	**0.1**	0.14	0.11	**0.1**	0.000443	0.00333
Heptachlor epoxide	1024-57-3	0.06	0.07	**0.053**	**0.053**	0.000533	0.00333
Hexachlorobenzene	118-74-1	0.7	0.4	**0.3**	**0.3**	0.000384	0.00333
Methoxychlor	72-43-5	**30**	390	310	**30**	0.001196	0.0133

Notes:
EPA = U.S. Environmental Protection Agency
MCP = Massachusetts Contingency Plan
MDL = Maximum Detectable Limit
mg/kg = milligrams per kilogram
PQL = Practical Quantitation Limits
PRGs = Preliminary Remediation Goals
RBCs = risk-based concentrations
(1) Lab MDLs and PQLs are on a wet weight basis.

Table 5-1d
Project Action Limits - PCBs in Soil (mg/kg)
Supplemental Site Investigation Work Plan
Study Area - Grant, Locust, and Cavite Housing Areas
Devens, Massachusetts

Analyte	CAS Number	MCP Cleanup Standards	EPA Region 3 RBCs	EPA Region 9 PRGs	Project Action Limit[3]	Lab MDLs	Lab PQLs
PCBs Soil 3540C/3545/8082							
Aroclor Mixtures:							
Aroclor 1016 (2)	12674-11-2	**2**	5.5	3.9	**1**	0.00159	0.033
Aroclor 1221	11104-28-2	2	0.32	**0.22**	**1**	0.00657	0.033
Aroclor 1232	11141-16-5	2	0.32	**0.22**	**1**	0.00213	0.033
Aroclor 1242 (2)	53469-21-9	2	0.32	**0.22**	**1**	0.00159	0.033
Aroclor 1248	12672-29-6	2	0.32	**0.22**	**1**	0.00217	0.033
Aroclor 1254	11097-69-1	2	0.32	**0.22**	**1**	0.00217	0.033
Aroclor 1260	11096-82-5	2	0.32	**0.22**	**1**	0.00192	0.033
Aroclor 1262	37324-23-5					0.00290	0.033
Aroclor 1268	11100-14-4					0.00185	0.033

Notes:
EPA = U.S. Environmental Protection Agency
MCP = Massachusetts Contingency Plan
MDL = Maximum Detectable Limit
mg/kg = milligrams per kilogram
PCB = polychlorinated biphenyl
PQL = Practical Quantitation Limits
PRGs = Preliminary Remediation Goals
RBCs = risk-based concentrations
(1) Lab MDLs and PQLs are on a wet weight basis.
(2) Due to co-elusion of target peaks, Aroclor 1016 and 1242 are reported as 1016/1242.
(3) Project Action Limit established by Base Cleanup Team.

Table 5-1e
Project Action Limits - Dioxins/furans in Soil (mg/kg)
Supplemental Site Investigation Work Plan
Study Area - Grant, Locust, and Cavite Housing Areas
Devens, Massachusetts

Analyte	CAS Number	MCP Cleanup Standards	EPA Region 3 RBCs	EPA Region 9 PRGs	Project Action Limit	Lab MDLs	Lab PQLs
Dioxins Soils Method 8290							
2,3,7,8-Tetrachlorodibenzo-p-dioxin (TCDD)	1746-01-6	0.000004	0.0000043	**0.0000039**	0.0000039	0.0000000002	0.000000001
1,2,3,7,8-Pentachlorodibenzo-p-dioxin (PeCDD)	40321-76-4					0.0000000003	0.000000005
1,2,3,6,7,8-Hexachlorodibenzo-p-dioxin (HxCDD)	57653-85-7					0.0000000003	0.000000005
1,2,3,4,7,8-Hexachlorodibenzo-p-dioxin (HxCDD)	39227-28-6					0.0000000004	0.000000005
1,2,3,7,8,9-Hexachlorodibenzo-p-dioxin (HxCDD)	19408-74-3					0.0000000006	0.000000005
1,2,3,4,6,7,8-Heptachlorodibenzo-p-dioxin (HpCDD)	35822-39-4					0.0000000005	0.000000005
1,2,3,4,6,7,8,9-Octachlorodibenzo-p-dioxin (OCDD)	3268-87-9					0.000000001	0.00000001
2,3,7,8-Tetrachlorodibenzofuran (TCDF)	51207-31-9					0.0000000002	0.000000001
1,2,3,7,8-Pentachlorodibenzofuran (PeCDF)	57117-41-6					0.0000000004	0.000000005
2,3,4,7,8-Pentachlorodibenzofuran (PeCDF)	57117-31-4					0.0000000005	0.000000005
1,2,3,6,7,8-Hexachlorodibenzofuran (HxCDF)	57117-44-9					0.0000000003	0.000000005
1,2,3,7,8,9-Hexachlorodibenzofuran (HxCDF)	72918-21-9					0.0000000003	0.000000005
1,2,3,4,7,8-Hexachlorodibenzofuran (HxCDF)	70648-26-9					0.0000000003	0.000000005
2,3,4,6,7,8-Hexachlorodibenzofuran (HxCDF)	60851-34-5					0.0000000003	0.000000005
1,2,3,4,6,7,8-Heptachlorodibenzofuran (HpCDF)	67562-39-4					0.0000000003	0.000000005
1,2,3,4,7,8,9-Heptachlorodibenzofuran (HpCDF)	55673-89-7					0.0000000008	0.000000005
1,2,3,4,6,7,8,9-Octachlorodibenzofuran (OCDF)	39001-02-0					0.0000000008	0.00000001

Notes:
EPA = U.S. Environmental Protection Agency
MCP = Massachusetts Contingency Plan
MDL = Maximum Detectable Limit
mg/kg = milligrams per kilogram
PQL = Practical Quantitation Limits
PRGs = Preliminary Remediation Goals
RBCs = risk-based concentrations

Table 5-1f
Project Action Limits - Metals in Soil (mg/kg)
Supplemental Site Investigation Work Plan
Study Area - Grant, Locust, and Cavite Housing Areas
Devens, Massachusetts

Analyte	CAS Number	MCP Cleanup Standards	EPA Region 3 RBCs	EPA Region 9 PRGs	Project Action Limit	Lab MDLs	Lab PQLs
Metals Soils 6010B							
Aluminum	7429905		78000	**76000**	**76000**	0.508	4.0
Antimony	7440360	**10**	31	31	**10**	0.32	2.0
Arsenic	7440382	30	**0.43**	22	**0.43**	0.12	0.4
Barium	7440393	**1000**	5500	5400	**1000**	0.008	0.4
Beryllium	7440417	**0.7**	160	150	**0.7**	0.008	0.2
Cadmium	7440439	**30**	39	37	**30**	0.064	0.4
Calcium	7440702	NA				1.096	4.0
Chromium	7440473	**1000**			**1000**	0.036	0.4
Cobalt	7440484	**500**	1600	900	**500**	0.052	0.8
Copper	7440508	**1000**	3100	3100	**1000**	0.044	0.4
Iron	7439896		**23000**	**23000**	**23000**	0.604	2.0
Lead	7439921	**300**		400	**300**	0.06	2.0
Magnesium	7439954	NA				0.324	4.0
Manganese	7439965		11000	**1800**	**1800**	0.008	0.4
Mercury(7470)	7439976	**20**			**20**	0.004	0.08
Nickel	7440020	**300**	1600	1600	**300**	0.04	1.0
Potassium	7440097	NA				4.18	100.0
Selenium	7782492	400	**390**	**390**	**390**	0.104	0.8
Silver	7440224	**100**	390	390	**100**	0.052	0.4
Sodium	7440235	NA				4.752	100.0
Thallium	7440280	8	5.5	**5.2**	**5.2**	0.156	0.4
Vanadium	7440622	400	**78**	550	**78**	0.032	0.4
Zinc	7440666	**2500**	23000	23000	**2500**	0.284	2.0

Notes:
EPA = U.S. Environmental Protection Agency
MCP = Massachusetts Contingency Plan
MDL = Maximum Detectable Limit
mg/kg = milligrams per kilogram
PQL = Practical Quantitation Limits
PRGs = Preliminary Remediation Goals
RBCs = risk-based concentrations
(1) Lab MDLs and PQLs are on a wet weight basis.

Table 5-1g
Project Action Limits - Explosives in Soil (mg/kg)
Supplemental Site Investigation Work Plan
Study Area - Grant, Locust, and Cavite Housing Areas
Devens, Massachusetts

Analyte	CAS Number	MCP Cleanup Standards	EPA Region 3 RBCs	EPA Region 9 PRGs	Project Action Limit	Lab MDLs	Lab PQLs
Explosives Soils 8330/PDA						*ug/Kg*	*ug/Kg*
1,3,5-Trinitrobenzene (1,3,5-TNB)	99354	**50**	2300	1800	**50**	63.448	200
1,3-Dinitrobenzene (1,3-DNB)	99650	100	7.8	**6.1**	**6.1**	38.896	200
2,4,6-Trinitrotoluene (TNT)	118967	100	21	**16**	**16**	73.999	200
2,4-Diamino-6-nitrotoluene (2,4-Dam-6NT)	6629294						
2,4-Dinitrotoluene (2,4-DNT)	121142	**0.7**	160	120	**0.7**	45.33	200
2,6-Diamino-4-nitrotoluene (2,6-DAm-4NT)	59299753						
2,6-Dinitrotoluene (2,6-DNT)	606202	100	78	**61**	**61**	118.589	200
2-Amino-4,6-dinitrotoluene (2-Am-DNT)	35572782						
2-Nitrotoluene (2-NT)	88722	500	**2.8**		**2.8**	235.037	780
3-Nitrotoluene (3-NT)	99081	500	1600	**370**	**370**	211.461	780
4-Amino-2,6-dinitrotoluene (4-Am-DNT)	1946510						
4-Nitrotoluene (4-NT)	99990	500	**38**	370	**38**	531.291	2340
HMX	2691410	**2**	3900		**2**	81.33	1700
Nitrobenzene (NB)	98953	500	39	**20**	**20**	174.943	210
Nitroglycerin	55630	50	46	**35**	**35**		
PETN	78115						
Picric Acid (trinitrophenol)	88891	**100**			**100**		
RDX (Cyclonite)	121824	100	5.8	**4.4**	**4.4**	45.919	880
Tetryl	479458	**100**	780		**100**	121.355	710

Notes:
EPA = U.S. Environmental Protection Agency
MCP = Massachusetts Contingency Plan
MDL = Maximum Detectable Limit
mg/kg = milligrams per kilogram
PQL = Practical Quantitation Limits
PRGs = Preliminary Remediation Goals
RBCs = risk-based concentrations

Table 5-2a
Project Action Limits - Volatiles in Groundwater (mg/L)
Supplemental Site Investigation Work Plan
Study Area - Grant, Locust, and Cavite Housing Areas
Devens, Massachusetts

Analyte	CAS Number	MCP Cleanup Standards	EPA Region 3 RBCs	EPA Region 9 PRGs	EPA Drinking Water Standards MCL (mg/L)	Project Action Limit	Lab MDLs	Lab PQLs
Volatiles (MCP) Waters 5030/8260B								
Acetone	67641	**3**				**3**	0.0674	0.005
Amyl Methyl Ether (TAME), *tert-*	994058						NA	0.002
Benzene	71432	**0.005**			**0.005**	**0.005**	0.00006	0.0005
Bromobenzene	108861	**1**				**1**	0.00033	0.0025
Bromochloromethane	74975						0.00019	0.0025
Bromodichloromethane	75274	**0.005**			0.08	**0.005**	0.00009	0.0005
Bromoform	75252	**0.005**			0.08	**0.005**	0.0006	0.002
Bromomethane	74839	**0.002**				**0.002**	0.00011	0.001
Butylbenzene, *sec-*	135988	**200**				**200**	0.00006	0.0005
Butylbenzene	104518	**200**				**200**	0.00013	0.0005
Butylbenzene, *tert-*	98066	**200**				**200**	0.00006	0.0025
Carbon Disulfide	75150	**1**				**1**	0.000097	0.005
Carbon Tetrachloride	56235	**0.005**			**0.005**	**0.005**	0.00009	0.0005
Chlorobenzene	108907	**0.1**				**0.1**	0.00006	0.0005
Chlorodibromomethane	124481	**0.005**				**0.005**	0.00007	0.0005
Chloroethane	75003	**1**				**1**	0.00006	0.001
Chloroform	67663	**0.005**				**0.005**	0.00011	0.00075
Chloromethane	74873	**1**				**1**	0.00007	0.0025
2-Chlorotoluene	95498	**1**				**1**	0.00023	0.0025
4-Chlorotoluene	106434						0.0002	0.0025
Dibromo-3-chloropropane	96128	**0.1**				**0.1**	0.00132	0.005
1,2-Dibromomethane (EDB)	106934	**0.00002**			0.0002	**0.00002**	0.00011	0.002
Dibromomethane	74953	**5**				**5**	0.00016	0.005
1,3-Dichlorobenzene (m-DCB)	541731	**0.6**				**0.6**	0.0002	0.0025
1,2-Dichlorobenzene (o-DCB)	95501	**0.6**			**0.6**	**0.6**	0.00022	0.0025
1,4-Dichlorobenzene (p-DCB)	106467	**0.005**			0.075	**0.005**	0.0002	0.0025
Dichlorodifluoromethane	75718	**10**				**10**	0.00148	0.005
1,1-Dichloroethane	75343	**0.07**				**0.07**	0.00005	0.00075
1,2-Dichloroethane	107062	**0.005**			**0.005**	**0.005**	0.00011	0.0005
1,1-Dichloroethylene	75354	**0.001**			0.007	**0.001**	0.00009	0.0005
Dichloroethylene, *cis-*	156592	**0.07**			**0.07**	**0.07**	0.00006	0.0005
Dichloroethylene, *trans-*	156605	**0.1**			**0.1**	**0.1**	0.00008	0.00075
1,2-Dichloropropane	78875	**0.005**			**0.005**	**0.005**	0.00021	0.00175
1,3-Dichloropropane	142289	**5**				**5**	0.0002	0.0025
2,2-Dichloropropane	594207						0.00009	0.0025
1,1-Dichloropropene	563586						0.00007	0.0025
Dichloropropene, *cis-1,3-*	10061015	**0.0005**				**0.0005**	0.00007	0.0005
Dichloropropene, *trans-1,3-*	10061026	**0.0005**				**0.0005**	0.00008	0.0005
Diethyl Ether	60297	**1**				**1**	0.00063	0.0025
Diisopropyl Ether (DIPE)	108203	**1**				**1**	NA	0.002
1,4-Dioxane	123911	**1**				**1**	NA	0.25

Table 5-2a
Project Action Limits - Volatiles in Groundwater (mg/L)
Supplemental Site Investigation Work Plan
Study Area - Grant, Locust, and Cavite Housing Areas
Devens, Massachusetts

Analyte	CAS Number	MCP Cleanup Standards	EPA Region 3 RBCs	EPA Region 9 PRGs	EPA Drinking Water Standards MCL (mg/L)	Project Action Limit	Lab MDLs	Lab PQLs
Ethyl Tertiary Butyl Ether (ETBE)	637923						NA	0.002
Ethylbenzene	100414	**0.7**			**0.7**	**0.7**	0.00005	0.0005
Hexachlorobutadiene	87683	**0.0006**				**0.0006**	0.00018	0.0025
Hexanone (MNBK)	591786	**1**				**1**	0.00093	0.005
Isopropylbenzene (Cumene)	98828	**10**				**10**	0.0001	0.0005
Isopropyltoluene, p-	99876						0.00009	0.0005
Methyl Ethyl Ketone (MEK)	78933	**0.4**				**0.4**	0.00014	0.005
Methyl Isobutyl Ketone (MIBK)	108101	**0.4**				**0.4**	0.00106	0.005
Methyl Tertiary Butyl Ether (MTBE)	1634044	**0.07**				**0.07**	0.00007	0.001
Methylene Chloride	75092	**0.005**				**0.005**	0.00009	0.005
Naphthalene	91203	**0.02**				**0.02**	0.00083	0.0025
Propylbenzene, n-	103651	**1**				**1**	0.00006	0.0005
Styrene	100425	**0.1**			**0.1**	**0.1**	0.00038	0.0015
1,1,1,2-Tetrachloroethane	630206	**0.005**				**0.005**	0.00006	0.0005
1,1,2,2-Tetrachloroethane	79345	**0.002**				**0.002**	0.00011	0.0005
Tetrachloroethylene	127184	**0.005**			**0.005**	**0.005**	0.00012	0.0005
Tetrahydrofuran (THF)	109999	**5**				**5**	0.0009	0.01
Toluene	108883	**1**			**1**	**1**	0.00022	0.0008
1,2,4-Trichlorobenzene	120821	**0.07**			**0.07**	**0.07**	0.00015	0.0025
1,2,3-Trichlorobenzene	87616						0.00014	0.0025
1,1,1-Trichloroethane	71556	**0.2**			**0.2**	**0.2**	0.00007	0.0005
1,1,2-Trichloroethane	79005	**0.005**			**0.005**	**0.005**	0.00013	0.0008
Trichloroethylene (TCE)	79016	**0.005**			**0.005**	**0.005**	0.0001	0.0005
Trichlorofluoromethane	75694	**10**				**10**	0.00008	0.0025
1,2,3-Trichloropropane	96184	**1**				**1**	0.00018	0.005
1,2,4-Trimethylbenzene	95636						0.0002	0.0025
1,3,5-Trimethylbenzene	108678	**0.1**				**0.1**	0.00022	0.0025
Vinyl Chloride	75014	**0.002**			**0.002**	**0.002**	0.00009	0.001
Xylene, o-	95476	**6**			10	**6**	0.00013	0.0005
Xylene, m-	108383	**6**			10	**6**	0.00015	0.0005
Xylene, p-	106423	**6**			10	**6**	0.00015	0.0005

Notes:
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MCL = Maximum Contaminant Level
MDL = Maximum Detectable Limit
mg/L = milligrams per liter
PQL = Practical Quantitation Limits
PRGs = Preliminary Remediation Goals
RBCs = risk-based concentrations

Table 5-2b
Project Action Limits - Semi-volatiles in Groundwater (mg/L)
Supplemental Site Investigation Work Plan
Study Area - Grant, Locust, and Cavite Housing Areas
Devens, Massachusetts

Analyte	CAS Number	MCP Cleanup Standards	EPA Region 3 RBCs	EPA Region 9 PRGs	EPA Drinking Water Standards MCL (mg/L)	Project Action Limit	Lab MDLs	Lab PQLs
Semi-volatiles (MCP) Waters 3510,3520/8270C								
Acenaphthene	83-32-9	**0.02**				**0.02**	0.00048	0.005
Acenaphthylene	208-96-8	**0.3**				**0.3**	0.00037	0.005
Acetophenone	98-86-2						0.00044	0.02
Aniline	62-53-3	**10**				**10**	0.00042	0.01
Anthacene	120-12-7	**0.6**				**0.6**	0.00023	0.005
Azobenzene	103-33-3						0.00058	0.005
Benzo(a)anthracene	56-55-3	**0.001**				**0.001**	0.000038	0.0002
Benzo(a)pyrene	50-32-8	**0.0002**			**0.0002**	**0.0002**	0.000040	0.0002
Benzo(b)fluoranthene	205-99-2	**0.001**				**0.001**	0.000050	0.0002
Benzo(k)fluoranthene	207-08-9	**0.0001**				**0.0001**	0.000036	0.0002
Benzo(g,h,i)perylene	191-24-2	**0.3**				**0.3**	0.00075	0.005
Bromophenyl phenyl ether, 4-	101-55-3	**1**				**1**	0.00051	0.005
Butyl benzyl phthalate	85-68-7	**1**				**1**	0.00039	0.005
Butyl phthalate, Di-n-	84-74-2	**0.5**				**0.5**	0.00034	0.005
Chloroaniline, 4-	106-47-8	**0.03**				**0.03**	0.00028	0.005
bis (Chloroethoxy)methane	111-91-1						0.00037	0.005
bis (2-Chloroethyl)ether	111-44-4	**0.03**				**0.03**	0.00027	0.005
bis (2-Chloroisopropyl) ether	108-60-1	**0.03**				**0.03**	0.00049	0.005
Chloronaphthalene, 2-	91-58-7	**0.01**				**0.01**	0.00043	0.005
Chlorophenol, 2-	95-57-8	**0.01**				**0.01**	0.00048	0.006
Chrysene	218-01-9	**0.002**				**0.002**	0.000024	0.0002
Dibenz(a,h)anthracene	53-70-3	**0.0005**				**0.0005**	0.000017	0.0002
Dibenzofuran	132-64-9	**1**				**1**	0.00042	0.005
Dichlorobenzene, 1,2-	95-50-1	**0.6**			**0.6**	**0.6**	0.0003	0.005
Dichlorobenzene, 1,3-	541-73-1	**0.6**				**0.6**	0.00037	0.005
Dichlorobenzene, 1,4-	106-46-7	**0.005**			0.075	**0.005**	0.00035	0.005
Dichlorobenzidine, 3,3'-	91-94-1	**0.08**				**0.08**	0.0034	0.05
Dichlorophenol, 2,4-	120-83-2	**0.01**				**0.01**	0.00062	0.01
Diethyl phthalate	84-66-2	**0.03**				**0.03**	0.00068	0.005
Dimethyl phthalate	131-11-3	**0.03**				**0.03**	0.00043	0.005
Dimethylphenol, 2,4-	105-67-9	**0.1**				**0.1**	0.00057	0.01
Dinitrotoluene, 2,4-	51-28-5	**0.03**				**0.03**	0.00243	0.02
Dinitrotoluene, 2,4-	121-14-2	**0.03**				**0.03**	0.00034	0.006
Dinitrotoluene, 2,6-	606-20-2	**1**				**1**	0.00034	0.005
bis (2-Ethylhexyl)phthalate	117-81-7	**0.006**			**0.006**	**0.006**	0.00048	0.01
Fluoranthene	206-44-0	**0.2**				**0.2**	0.00031	0.005
Fluorene	86-73-7	**0.3**				**0.3**	0.00039	0.005

Table 5-2b
Project Action Limits - Semi-volatiles in Groundwater (mg/L)
Supplemental Site Investigation Work Plan
Study Area - Grant, Locust, and Cavite Housing Areas
Devens, Massachusetts

Analyte	CAS Number	MCP Cleanup Standards	EPA Region 3 RBCs	EPA Region 9 PRGs	EPA Drinking Water Standards MCL (mg/L)	Project Action Limit	Lab MDLs	Lab PQLs
Hexachlorobenzene	118-74-1	0.001			**0.0002**	**0.0002**	0.000031	0.0008
Hexachlorobutadiene	87-68-3	**0.0006**			0.001	**0.0006**	0.000034	0.0005
Hexachloroethane	67-72-1	**0.008**				**0.008**	0.00024	0.005
Indeno (1,2,3-cd) pyrene	193-39-5	**0.0005**				**0.0005**	0.000026	0.0002
Isophorone	78-59-1	**1**				**1**	0.00048	0.005
Methylnaphthalene, 2-	91-57-6	**0.01**				**0.01**	0.00075	0.008
Methylphenol, 2-	95-48-7						0.00044	0.006
Methylphenol, 3-	108-39-4						0.0005	0.006
Methylphenol, 4-	106-44-5						0.0005	0.006
Naphthalene	91-20-3	**0.02**				**0.02**	0.00037	0.005
Nitrobenzene	98-95-3	**5**				**5**	0.00073	0.005
Nitrophenol, 2-	88-75-5	**1**				**1**	0.00065	0.02
Nitrophenol, 4-	100-02-7	**1**				**1**	0.00059	0.01
Octyl phthalate, di-n-	117-84-0						0.00045	0.005
Pentachlorophenol	87-86-5	**0.001**			**0.001**	**0.001**	0.000074	0.0008
Phenanthrene	85-01-8	**0.05**				**0.05**	0.00037	0.005
Phenol	108-95-2	**4**				**4**	0.00024	0.007
Pyrene	129-00-0	**0.2**				**0.2**	0.00025	0.005
Trichlorobenzene, 1,2,4-	120-82-1	**0.07**			**0.07**	**0.07**	0.00039	0.005
Trichlorophenol, 2,4,5-	95-95-4	**0.1**				**0.1**	0.0005	0.005
Trichlorophenol, 2,4,6-	88-06-2	**0.01**				**0.01**	0.00041	0.005

Notes:
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MCL = Maximum Contaminant Level
MDL = Maximum Detectable Limit
mg/L = milligrams per liter
PQL = Practical Quantitation Limits
PRGs = Preliminary Remediation Goals
RBCs = risk-based concentrations

Table 5-2c
Project Action Limits - Pesticides in Groundwater (mg/L)
Supplemental Site Investigation Work Plan
Study Area - Grant, Locust, and Cavite Housing Areas
Devens, Massachusetts

Analyte	CAS Number	MCP Cleanup Standards	EPA Region 3 RBCs	EPA Region 9 PRGs	EPA Drinking Water Standards MCL	Project Action Limit	Lab MDLs	Lab PQLs
Pesticides Waters 3510,3520/8081								
Aldrin	309-00-2	**0.0005**				**0.0005**	0.000003	0.00002
alpha-BHC	319-84-6	**0.5**				**0.5**	0.000001	0.00002
beta-BHC	319-85-7	**0.1**				**0.1**	0.000002	0.00002
gamma-BHC	58-89-9	**0.0002**			**0.0002**	**0.0002**	0.000006	0.00002
delta-BHC	319-86-8	**0.1**				**0.1**	0.000002	0.00002
Chlorodane (nos), multicomponent mixture	57-74-9	**0.002**			**0.002**	**0.002**	0.00002	0.0002
alpha-chlordane	5103-71-9	**0.002**			**0.002**	**0.002**	0.000003	0.00002
gamma-chlordane	5103-74-2	**0.002**			**0.002**	**0.002**	0.000002	0.00002
4,4'-DDD	72-54-8	**0.0001**				**0.0001**	0.000003	0.00004
4,4'-DDE	72-55-9	**0.0001**				**0.0001**	0.000005	0.00004
4,4'-DDT	50-29-3	**0.0003**				**0.0003**	0.000005	0.00004
Diedrin	60-57-1	**0.0001**				**0.0001**	0.000004	0.00004
Endosulfan I	959-98-8	**0.0001**				**0.0001**	0.000004	0.00002
Endosufan II	33213-65-9	**0.0001**				**0.0001**	0.000004	0.00004
Endosulfan Sulfate	1031-07-8						0.000006	0.00004
Endrin	72-20-8	**0.002**			**0.002**	**0.002**	0.000004	0.00004
Endrin Ketone	53494-70-5						0.000004	0.00004
Heptachlor	76-44-8	**0.0004**			**0.0004**	**0.0004**	0.000002	0.00002
Heptachlor epoxide	1024-57-3	**0.0002**			**0.0002**	**0.0002**	0.000005	0.00002
Hexachlorobenzene	118-74-1	**0.001**			**0.001**	**0.001**	0.000002	0.00002
Methoxychlor	72-43-5	**0.002**			0.04	**0.002**	0.000016	0.0002

Notes:
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MDL = Maximum Detectable Limit
mg/L = milligrams per liter
PQL = Practical Quantitation Limits
PRGs = Preliminary Remediation Goals
RBCs = risk-based concentrations

Table 5-2d
Project Action Limits - PCBs in Groundwater (mg/L)
Supplemental Site Investigation Work Plan
Study Area - Grant, Locust, and Cavite Housing Areas
Devens, Massachusetts

Analyte	CAS Number	MCP Cleanup Standards	EPA Region 3 RBCs	EPA Region 9 PRGs	EPA Drinking Water Standards MCL	Project Action Limit	Lab MDLs	Lab PQLs
PCBs Water 3510,3520/8082								
Aroclor Mixtures (TOTAL PCBs):	1336-36-3				**0.0005**	**0.0005**		
Aroclor 1016	12674-11-2	**0.0003**				**0.0003**	0.000012	0.0003
Aroclor 1221	11104-28-2	**0.0003**				**0.0003**	0.000036	0.0003
Aroclor 1232	11141-16-5	**0.0003**				**0.0003**	0.000015	0.0003
Aroclor 1242	53469-21-9	**0.0003**				**0.0003**	0.000012	0.0003
Aroclor 1248	12672-29-6	**0.0003**				**0.0003**	0.000025	0.0003
Aroclor 1254	11097-69-1	**0.0003**				**0.0003**	0.000023	0.0003
Aroclor 1260	11096-82-5	**0.0003**				**0.0003**	0.000019	0.0003
Aroclor 1262	37324-23-5						0.000024	0.0003
Aroclor 1268	11100-14-4						0.000016	0.0003

Notes:
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MCL = Maximum Contaminant Level
MDL = Maximum Detectable Limit
mg/L = milligrams per liter
PCB = polychlorinated biphenyl
PQL = Practical Quantitation Limits
PRGs = Preliminary Remediation Goals
RBCs = risk-based concentrations

Table 5-2e
Project Action Limits - Dioxins/furan in Groundwater (mg/L)
Supplemental Site Investigation Work Plan
Study Area - Grant, Locust, and Cavite Housing Areas
Devens, Massachusetts

Analyte	CAS Number	MCP Cleanup Standards	EPA Region 3 RBCs	EPA Region 9 PRGs	EPA Drinking Water Standards MCL	Project Action Limit	Lab MDLs	Lab PQLs
Dioxins Waters Method 8290								
2,3,7,8-Tetrachlorodibenzo-p-dioxin (TCDD)	1746-01-6	**0.00000003**			**0.00000003**	**0.00000003**	0.00000000	0.00000001
1,2,3,7,8-Pentachlorodibenzo-p-dioxin (PeCDD)	40321-76-4						0.00000000	0.00000005
1,2,3,6,7,8-Hexachlorodibenzo-p-dioxin (HxCDD)	57653-85-7						0.00000001	0.00000005
1,2,3,4,7,8-Hexachlorodibenzo-p-dioxin (HxCDD)	39227-28-6						0.00000001	0.00000005
1,2,3,7,8,9-Hexachlorodibenzo-p-dioxin (HxCDD)	19408-74-3						0.00000002	0.00000005
1,2,3,4,6,7,8-Heptachlorodibenzo-p-dioxin (HpCDD)	35822-39-4						0.00000001	0.00000005
1,2,3,4,6,7,8,9-Octachlorodibenzo-p-dioxin (OCDD)	3268-87-9						0.000000039	0.0000001
2,3,7,8-Tetrachlorodibenzofuran (TCDF)	51207-31-9						0.00000000	0.00000001
1,2,3,7,8-Pentachlorodibenzofuran (PeCDF)	57117-41-6						0.00000001	0.00000005
2,3,4,7,8-Pentachlorodibenzofuran (PeCDF)	57117-31-4						0.00000001	0.00000005
1,2,3,6,7,8-Hexachlorodibenzofuran (HxCDF)	57117-44-9						0.000000008	0.00000005
1,2,3,7,8,9-Hexachlorodibenzofuran (HxCDF)	72918-21-9						0.00000003	0.00000005
1,2,3,4,7,8-Hexachlorodibenzofuran (HxCDF)	70648-26-9						0.00000001	0.00000005
2,3,4,6,7,8-Hexachlorodibenzofuran (HxCDF)	60851-34-5						0.00000001	0.00000005
1,2,3,4,6,7,8-Heptachlorodibenzofuran (HpCDF)	67562-39-4						0.00000001	0.00000005
1,2,3,4,7,8,9-Heptachlorodibenzofuran (HpCDF)	55673-89-7						0.000000017	0.00000005
1,2,3,4,6,7,8,9-Octachlorodibenzofuran (OCDF)	39001-02-0						0.00000002	0.0000001

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RBCs = risk-based concentrations

Table 5-2f
Project Action Limits - Metals in Groundwater (mg/L)
Supplemental Site Investigation Work Plan
Study Area - Grant, Locust, and Cavite Housing Areas
Devens, Massachusetts

Analyte	CAS Number	MCP Cleanup Standards	EPA Region 3 RBCs	EPA Region 9 PRGs	EPA Drinking Water Standards MCL	Project Action Limit	Lab MDLs	Lab PQLs
Metals Waters 6010B								
Aluminum	7429905				**0.05 to 0.2 (Secondary)**	**0.05 to 0.2**	0.0127	0.10
Antimony	7440360	**0.006**			**0.006**	**0.006**	0.00005	0.0002
Arsenic	7440382	0.05			**0.01**	**0.01**	0.00008	0.0004
Barium	7440393	**2**			**2**	**2**	0.00007	0.0002
Beryllium	7440417	**0.004**			**0.004**	**0.004**	0.00014	0.0005
Cadmium	7440439	**0.005**			**0.005**	**0.005**	0.00011	0.0004
Calcium	7440702	NA					0.0274	0.10
Chromium	7440473	**0.1**			**0.1 (total)**	**0.1**	0.00006	0.0002
Cobalt	7440484	**5**				**5**	0.00003	0.0001
Copper	7440508	10			**1 (secondary)**	**1**	0.00007	0.0005
Iron	7439896				**0.3 (secondary)**	**0.3**	0.0151	0.05
Lead	7439921	0.02			**0.015 (action level)**	**0.015**	0.00005	0.0002
Magnesium	7439954	NA					0.0081	0.10
Manganese	7439965				**0.05 (secondary)**	**0.05**	0.00005	0.0002
Mercury (7471)	7439976	**0.001**			**0.002**	**0.001**	0.00001	0.0002
Nickel	7440020	**0.08**				**0.08**	0.00014	0.0005
Potassium	7440097	NA					0.1045	2.50
Selenium	7782492	**0.05**			**0.05**	**0.05**	0.00017	0.0010
Silver	7440224	**0.007**			0.1 (secondary)	**0.007**	0.00002	0.0001
Sodium	7440235	NA					0.1188	2.00
Thallium	7440280	**0.002**			**0.002**	**0.002**	0.00002	0.0001
Vanadium	7440622	**0.05**				**0.05**	0.00005	0.0002
Zinc	7440666	**0.9**			5 (secondary)	**0.9**	0.00053	0.0020

Notes:
EPA = U.S. Environmental Protection Agency
MCP = Massachusetts Contingency Plan
MCL = Maximum Contaminant Level
MDL = Maximum Detectable Limit
mg/L = milligrams per liter
PQL = Practical Quantitation Limits
PRGs = Preliminary Remediation Goals
RBCs = risk-based concentrations

Table 5-2g
Project Action Limits - Explosives in Groundwater (mg/L)
Supplemental Site Investigation Work Plan
Study Area - Grant, Locust, and Cavite Housing Areas
Devens, Massachusetts

Analyte	CAS Number	MCP Cleanup Standards	EPA Region 3 RBCs	EPA Region 9 PRGs	EPA Drinking Water Standards MCL	Project Action Limit	Lab MDLs	Lab PQLs
Explosives Waters 8330/PDA								
1,3,5-Trinitrobenzene (1,3,5-TNB)	99354	**0.5**				**0.5**	0.071	0.2
1,3-Dinitrobenzene (1,3-DNB)	99650	**1**				**1**	0.101	0.2
2,4,6-Trinitrotoluene (TNT)	118967	**1**				**1**	0.048	0.2
2,4-Diamino-6-nitrotoluene (2,4-Dam-6NT)	6629294							
2,4-Dinitrotoluene (2,4-DNT)	121142	**0.03**				**0.03**	0.089	0.2
2,6-Diamino-4-nitrotoluene (2,6-DAm-4NT)	59299753							
2,6-Dinitrotoluene (2,6-DNT)	606202	**1**				**1**	0.188	0.2
2-Amino-4,6-dinitrotoluene (2-Am-DNT)	35572782							
2-Nitrotoluene (2-NT)	88722	**5**				**5**	0.25	0.78
3-Nitrotoluene (3-NT)	99081	**5**				**5**	0.263	0.78
4-Amino-2,6-dinitrotoluene (4-Am-DNT)	1946510							
4-Nitrotoluene (4-NT)	99990	**5**				**5**	0.234	2.34
HMX	2691410	**0.2**				**0.2**	0.088	1.7
Nitrobenzene (NB)	98953	**5**				**5**	0.114	0.2
Nitroglycerin	55630	**0.5**				**0.5**		
PETN	78115							
Picric Acid (trinitrophenol)	88891	**1**				**1**		
RDX (Cyclonite)	121824	**1**				**1**	0.11	0.88
Tetryl	479458	**1**				**1**	0.123	0.71

Notes:
EPA = U.S. Environmental Protection Agency
MCP = Massachusetts Contingency Plan
MCL = Maximum Contaminant Level
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APPENDICES

APPENDIX A

SUMMARY OF UXO FIELD RECONNAISSANCE OBSERVATIONS

(click here to open Appendix A)

APPENDIX B

FIELD OPERATION STANDARDS

Designation: D 1452 – 80 (Reapproved 2000)

Standard Practice for Soil Investigation and Sampling by Auger Borings[1]

This standard is issued under the fixed designation D 1452; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval. A superscript epsilon (ε) indicates an editorial change since the last revision or reapproval.

This standard has been approved for use by agencies of the Department of Defense.

1. Scope

1.1 This practice covers equipment and procedures for the use of earth augers in shallow geotechnical exploration. This practice does not apply to sectional continuous flight augers.

1.2 *This standard does not purport to address all of the safety concerns, if any, associated with its use. It is the responsibility of the user of this standard to establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.*

1.3 *This practice offers a set of instructions for performing one or more specific operations. This document cannot replace education or experience and should be used in conjunction with professional judgment. Not all aspects of this practice may be applicable in all circumstances. This ASTM standard is not intended to represent or replace the standard of care by which the adequacy of a given professional service must be judged, nor should this document be applied without consideration of a project's many unique aspects. The word "Standard" in the title of this document means only that the document has been approved through the ASTM concensus process.*

2. Significance and Use

2.1 Auger borings often provide the simplest method of soil investigation and sampling. They may be used for any purpose where disturbed samples can be used and are valuable in connection with ground water level determination and indication of changes in strata and advancement of hole for spoon and tube sampling. Equipment required is simple and readily available. Depths of auger investigations are, however, limited by ground water conditions, soil characteristics, and the equipment used.

3. Apparatus

3.1 *Hand-Operated Augers*:

3.1.1 *Helical Augers*—Small lightweight augers generally available in sizes from 1 through 3 in. (25.4 through 76.2 mm).

3.1.1.1 *Spiral-Type Auger*, consisting of a flat thin metal strip, machine twisted to a spiral configuration of uniform pitch; having at one end, a sharpened or hardened point, with a means of attaching a shaft or extension at the opposite end.

3.1.1.2 *Ship-Type Auger*—Similar to a carpenter's wood bit. It is generally forged from steel and machined to the desired size and configuration. It is normally provided with sharpened and hardened nibs at the point end and with an integral shaft extending through its length for attachment of a handle or extension at the opposite end.

3.1.2 *Open Tubular Augers*, ranging in size from 1.5 through 8 in. (38.1 through 203.2 mm) and having the common characteristic of appearing essentially tubular when viewed from the digging end.

3.1.2.1 *Orchard-Barrel Type*, consisting essentially of a tube having cutting lips or nibs hardened and sharpened to penetrate the formation on one end and an adaptor fitting for an extension or handle on the opposite end.

3.1.2.2 *Open-Spiral Type*, consisting of a flat thin metal strip that has been helically wound around a circular mandrel to form a spiral in which the flat faces of the strip are parallel to the axis of the augered hole. The lower helix edges are hard-faced to improve wear characteristics. The opposite end is fitted with an adaptor for extension.

3.1.2.3 *Closed-Spiral Type*—Nearly identical to the open-spiral type except the pitch of the helically wound spiral is much less than that of the open-spiral type.

3.1.3 *Post-Hole Augers*, generally 2 through 8 in. (50.8 through 203.2 mm), and having in common a means of blocking the escape of soil from the auger.

3.1.3.1 *Clam-Shell Type*, consisting of two halves, hinged to allow opening and closing for alternately digging and retrieving. It is not usable deeper than about 3.5 ft (1.07 m).

3.1.3.2 *Iwan Type*, consisting of two tubular steel segments, connected at the top to a common member to form a nearly complete tube, but with diametrically opposed openings. It is connected at the bottom by two radial blades pitched to serve as cutters which also block the escape of contained soil. Attachment of handle or extension is at the top connector.

3.2 *Machine-Operated Augers*:

3.2.1 *Helical Augers*, generally 8 through 48 in. (203.2 through 1219 mm), consisting essentially of a center shaft fitted with a shank or socket for application of power, and having one to three complete 360° (6.28-rad) spirals for conveyance and storage of cut soil. Cutter bits and pilot bits are available in moderate and hard formation types and normally replaceable in the field. They are normally operated by

[1] This practice is under the jurisdiction of ASTM Committee D18 on Soil and Rock and is the direct responsibility of Subcommittee D18.02 on Sampling and Related Field Testing for Soil Investigations.

Current edition approved June 12, 1980. Published August 1980. Originally published as D 1452 – 57 T. Last previous edition D 1452 – 65 (1972).

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heavy-duty, high-torque machines, designed for heavy construction work.

3.2.2 *Stinger Augers*, generally 6 through 30 in. (152.4 through 762 mm), are similar to the helical auger in 3.2.1, but lighter and generally smaller. They are commonly operated by light-duty machines for post and power pole holes.

3.2.3 *Disk Augers*, generally 10 through 30 in. (254 through 762 mm), consisting essentially of a flat, steel disk with diametrically opposed segments removed and having a shank or socket located centrally for application of power. Replaceable cutter bits, located downward from the leading edges of the remaining disk, dig and load soil that is held on the disk by valves or shutters hinged at the disk in order to close the removed segments. The disk auger is specifically designed to be operated by machines having limited vertical clearance between spindle and ground surface.

3.2.4 *Bucket Auger*, generally 12 through 48 in. (304.8 through 1219 mm), consisting essentially of a disk auger, without shank or socket, but hinge-mounted to the bottom of a steel tube or bucket of approximately the same diameter as the disk auger. A socket or shank for power application is located in the top center of the bucket diametral cross piece provided for the purpose.

3.3 *Casing* (when needed), consisting of pipe of slightly larger diameter than the auger used.

3.4 *Accessory Equipment*—Labels, field log sheets, sample jars, sealing wax, sample bags, and other necessary tools and supplies.

4. Procedure

4.1 Make the auger boring by rotating and advancing the desired distance into the soil. Withdraw the auger from the hole and remove the soil for examination and test. Return the empty auger to the hole and repeat the procedure. Continue the sequence until the required depth is reached.

4.2 Casing is required in unstable soil in which the bore hole fails to stay open and especially when the boring is extended below the ground-water level. The inside diameter of the casing must be slightly larger than the diameter of the auger used. The casing shall be driven to a depth not greater than the top of the next sample and shall be cleaned out by means of the auger. The auger can then be inserted into the bore hole and turned below the bottom of the casing to obtain a sample.

4.3 The soil auger can be used both for boring the hole and for bringing up disturbed samples of the soil encountered. The structure of a cohesive soil is completely destroyed and the moisture may be changed by the auger. Seal all samples in a jar or other airtight container and label appropriately. If more than one type of soil is picked up in the sample, prepare a separate container for each type of soil.

4.4 *Field Observations*—Record complete ground water information in the field logs. Where casing is used, measure ground water levels both before and after the casing is pulled. In sands, determine the water level at least 30 min after the boring is completed; in silts, at least 24 h. In clays, no accurate water level determination is possible unless pervious seams are present. As a precaution, however, water levels in clays shall be taken after at least 24 h.

5. Report

5.1 The data obtained in boring shall be recorded in the field logs and shall include the following:

5.1.1 Date of start and completion of boring,

5.1.2 Identifying number of boring,

5.1.3 Reference datum including direction and distance of boring relative to reference line of project or other suitable reference points,

5.1.4 Type and size of auger used in boring,

5.1.5 Depth of changes in strata,

5.1.6 Description of soil in each major stratum,

5.1.7 Ground water elevation and location of seepage zones, when found, and

5.1.8 Condition of augered hole upon removal of auger, that is, whether the hole remains open or the sides cave, when such can be observed.

6. Keywords

6.1 auger borings; sampling; soil investigations

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Designation: D 1586 – 99

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Standard Test Method for Penetration Test and Split-Barrel Sampling of Soils[1]

This standard is issued under the fixed designation D 1586; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval. A superscript epsilon (ε) indicates an editorial change since the last revision or reapproval.

This standard has been approved for use by agencies of the Department of Defense.

1. Scope *

1.1 This test method describes the procedure, generally known as the Standard Penetration Test (SPT), for driving a split-barrel sampler to obtain a representative soil sample and a measure of the resistance of the soil to penetration of the sampler.

1.2 *This standard does not purport to address all of the safety problems, if any, associated with its use. It is the responsibility of the user of this standard to establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.* For a specific precautionary statement, see 5.4.1.

1.3 The values stated in inch-pound units are to be regarded as the standard.

NOTE 1—Practice D 6066 can be used when testing loose sands below the water table for liquefaction studies or when a higher level of care is required when drilling these soils. This practice provides information on drilling methods, equipment variables, energy corrections, and blow-count normalization.

2. Referenced Documents

2.1 *ASTM Standards:*

D 2487 Practice for Classification of Soils for Engineering Purposes (Unified Soil Classification System)[2]

D 2488 Practice for Description and Identification of Soils (Visual-Manual Procedure)[2]

D 4220 Practices for Preserving and Transporting Soil Samples[2]

D 4633 Test Method for Stress Wave Energy Measurement for Dynamic Penetrometer Testing Systems[2]

D 6066 Practice for Determining the Normalized Penetration Resistance Testing of Sands for Evaluation of Liquefaction Potential[3]

3. Terminology

3.1 *Definitions of Terms Specific to This Standard:*

3.1.1 *anvil*—that portion of the drive-weight assembly which the hammer strikes and through which the hammer energy passes into the drill rods.

3.1.2 *cathead*—the rotating drum or windlass in the rope-cathead lift system around which the operator wraps a rope to lift and drop the hammer by successively tightening and loosening the rope turns around the drum.

3.1.3 *drill rods*—rods used to transmit downward force and torque to the drill bit while drilling a borehole.

3.1.4 *drive-weight assembly*—a device consisting of the hammer, hammer fall guide, the anvil, and any hammer drop system.

3.1.5 *hammer*—that portion of the drive-weight assembly consisting of the 140 ± 2 lb (63.5 ± 1 kg) impact weight which is successively lifted and dropped to provide the energy that accomplishes the sampling and penetration.

3.1.6 *hammer drop system*—that portion of the drive-weight assembly by which the operator accomplishes the lifting and dropping of the hammer to produce the blow.

3.1.7 *hammer fall guide*—that part of the drive-weight assembly used to guide the fall of the hammer.

3.1.8 *N-value*—the blowcount representation of the penetration resistance of the soil. The *N*-value, reported in blows per foot, equals the sum of the number of blows required to drive the sampler over the depth interval of 6 to 18 in. (150 to 450 mm) (see 7.3).

3.1.9 Δ*N*—the number of blows obtained from each of the 6-in. (150-mm) intervals of sampler penetration (see 7.3).

3.1.10 *number of rope turns*—the total contact angle between the rope and the cathead at the beginning of the operator's rope slackening to drop the hammer, divided by 360° (see Fig. 1).

3.1.11 *sampling rods*—rods that connect the drive-weight assembly to the sampler. Drill rods are often used for this purpose.

3.1.12 *SPT*—abbreviation for standard penetration test, a term by which engineers commonly refer to this method.

4. Significance and Use

4.1 This test method provides a soil sample for identification purposes and for laboratory tests appropriate for soil obtained from a sampler that may produce large shear strain disturbance in the sample.

4.2 This test method is used extensively in a great variety of geotechnical exploration projects. Many local correlations and

[1] This method is under the jurisdiction of ASTM Committee D-18 on Soil and Rock and is the direct responsibility of Subcommittee D18.02 on Sampling and Related Field Testing for Soil Investigations.

Current edition approved Jan. 10, 1999. Published March 1999. Originally published as D 1586 – 58 T. Last previous edition D 1586 – 98.

[2] *Annual Book of ASTM Standards*, Vol 04.08.

[3] *Annual Book of ASTM Standards*, Vol 04.09.

***A Summary of Changes section appears at the end of this standard.**

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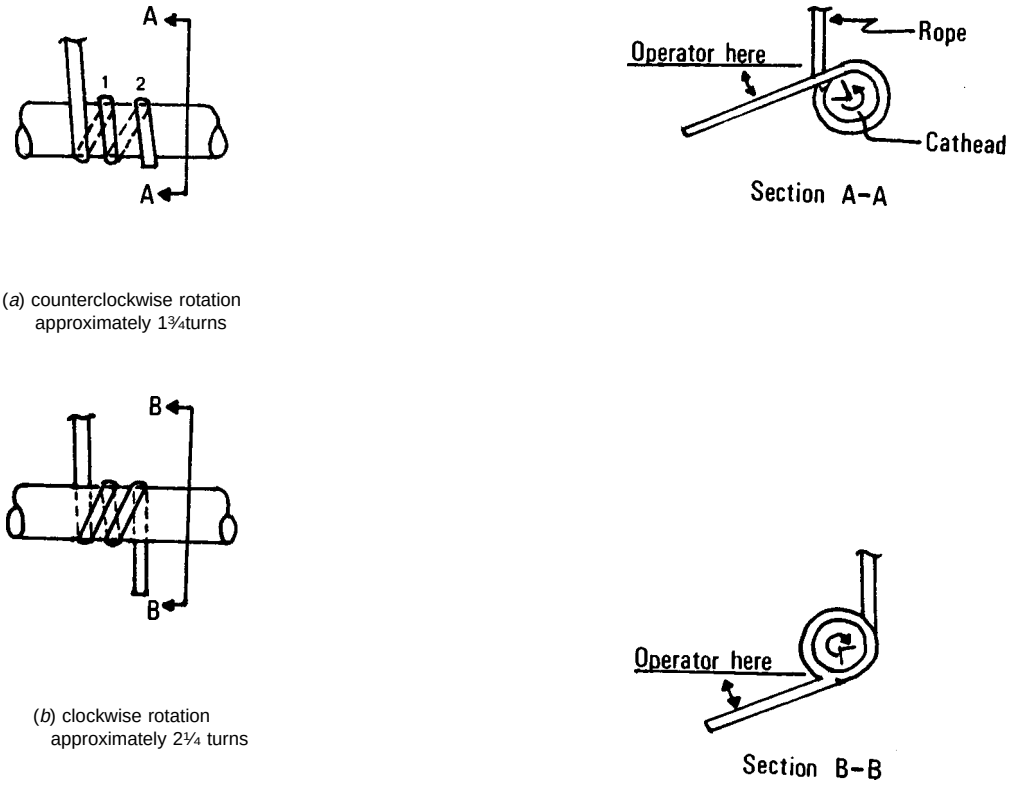

(*a*) counterclockwise rotation approximately 1¾turns

(*b*) clockwise rotation approximately 2¼ turns

FIG. 1 Definitions of the Number of Rope Turns and the Angle for (*a*) Counterclockwise Rotation and (*b*) Clockwise Rotation of the Cathead

widely published correlations which relate SPT blowcount, or *N*-value, and the engineering behavior of earthworks and foundations are available.

5. Apparatus

5.1 *Drilling Equipment*—Any drilling equipment that provides at the time of sampling a suitably clean open hole before insertion of the sampler and ensures that the penetration test is performed on undisturbed soil shall be acceptable. The following pieces of equipment have proven to be suitable for advancing a borehole in some subsurface conditions.

5.1.1 *Drag, Chopping, and Fishtail Bits*, less than 6.5 in. (162 mm) and greater than 2.2 in. (56 mm) in diameter may be used in conjuction with open-hole rotary drilling or casing-advancement drilling methods. To avoid disturbance of the underlying soil, bottom discharge bits are not permitted; only side discharge bits are permitted.

5.1.2 *Roller-Cone Bits*, less than 6.5 in. (162 mm) and greater than 2.2 in. (56 mm) in diameter may be used in conjunction with open-hole rotary drilling or casing-advancement drilling methods if the drilling fluid discharge is deflected.

5.1.3 *Hollow-Stem Continuous Flight Augers*, with or without a center bit assembly, may be used to drill the boring. The inside diameter of the hollow-stem augers shall be less than 6.5 in. (162 mm) and greater than 2.2 in. (56 mm).

5.1.4 *Solid, Continuous Flight, Bucket and Hand Augers*, less than 6.5 in. (162 mm) and greater than 2.2 in. (56 mm) in diameter may be used if the soil on the side of the boring does not cave onto the sampler or sampling rods during sampling.

5.2 *Sampling Rods*—Flush-joint steel drill rods shall be used to connect the split-barrel sampler to the drive-weight assembly. The sampling rod shall have a stiffness (moment of inertia) equal to or greater than that of parallel wall "A" rod (a steel rod which has an outside diameter of 1⅝ in. (41.2 mm) and an inside diameter of 1⅛ in. (28.5 mm).

NOTE 2—Recent research and comparative testing indicates the type rod used, with stiffness ranging from "A" size rod to "N" size rod, will usually have a negligible effect on the *N*-values to depths of at least 100 ft (30 m).

5.3 *Split-Barrel Sampler*—The sampler shall be constructed with the dimensions indicated in Fig. 2. The driving shoe shall be of hardened steel and shall be replaced or repaired when it becomes dented or distorted. The use of liners to produce a constant inside diameter of 1⅜ in. (35 mm) is permitted, but shall be noted on the penetration record if used. The use of a sample retainer basket is permitted, and should also be noted on the penetration record if used.

NOTE 3—Both theory and available test data suggest that *N*-values may increase between 10 to 30 % when liners are used.

5.4 *Drive-Weight Assembly*:

5.4.1 *Hammer and Anvil*—The hammer shall weigh 140 ± 2 lb (63.5 ± 1 kg) and shall be a solid rigid metallic mass. The hammer shall strike the anvil and make steel on steel contact when it is dropped. A hammer fall guide permitting a free fall

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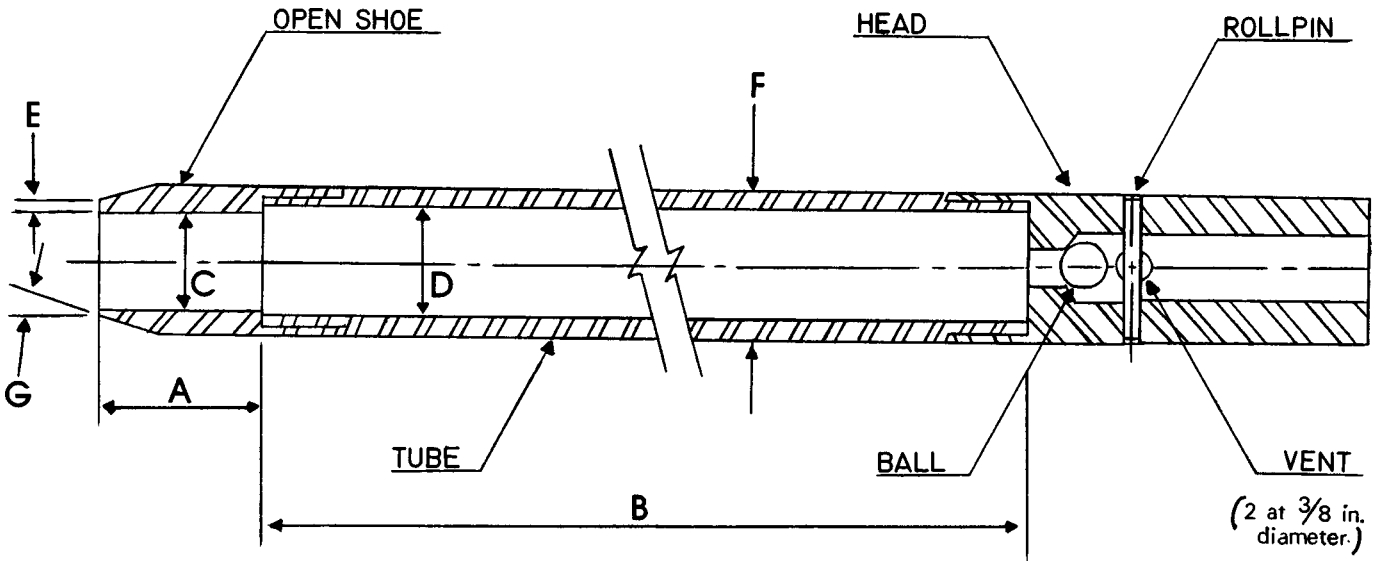

A = 1.0 to 2.0 in. (25 to 50 mm)
B = 18.0 to 30.0 in. (0.457 to 0.762 m)
C = 1.375± 0.005 in. (34.93 ± 0.13 mm)
D = 1.50 ± 0.05 − 0.00 in. (38.1 ± 1.3 − 0.0 mm)
E = 0.10 ± 0.02 in. (2.54 ± 0.25 mm)
F = 2.00 ± 0.05 − 0.00 in. (50.8 ± 1.3 − 0.0 mm)
G = 16.0° to 23.0°

The 1½ in. (38 mm) inside diameter split barrel may be used with a 16-gage wall thickness split liner. The penetrating end of the drive shoe may be slightly rounded. Metal or plastic retainers may be used to retain soil samples.

FIG. 2 Split-Barrel Sampler

shall be used. Hammers used with the cathead and rope method shall have an unimpeded overlift capacity of at least 4 in. (100 mm). For safety reasons, the use of a hammer assembly with an internal anvil is encouraged.

NOTE 4—It is suggested that the hammer fall guide be permanently marked to enable the operator or inspector to judge the hammer drop height.

5.4.2 *Hammer Drop System*—Rope-cathead, trip, semi-automatic, or automatic hammer drop systems may be used, providing the lifting apparatus will not cause penetration of the sampler while re-engaging and lifting the hammer.

5.5 *Accessory Equipment*—Accessories such as labels, sample containers, data sheets, and groundwater level measuring devices shall be provided in accordance with the requirements of the project and other ASTM standards.

6. Drilling Procedure

6.1 The boring shall be advanced incrementally to permit intermittent or continuous sampling. Test intervals and locations are normally stipulated by the project engineer or geologist. Typically, the intervals selected are 5 ft (1.5 mm) or less in homogeneous strata with test and sampling locations at every change of strata.

6.2 Any drilling procedure that provides a suitably clean and stable hole before insertion of the sampler and assures that the penetration test is performed on essentially undisturbed soil shall be acceptable. Each of the following procedures have proven to be acceptable for some subsurface conditions. The subsurface conditions anticipated should be considered when selecting the drilling method to be used.

6.2.1 Open-hole rotary drilling method.

6.2.2 Continuous flight hollow-stem auger method.

6.2.3 Wash boring method.

6.2.4 Continuous flight solid auger method.

6.3 Several drilling methods produce unacceptable borings. The process of jetting through an open tube sampler and then sampling when the desired depth is reached shall not be permitted. The continuous flight solid auger method shall not be used for advancing the boring below a water table or below the upper confining bed of a confined non-cohesive stratum that is under artesian pressure. Casing may not be advanced below the sampling elevation prior to sampling. Advancing a boring with bottom discharge bits is not permissible. It is not permissible to advance the boring for subsequent insertion of the sampler solely by means of previous sampling with the SPT sampler.

6.4 The drilling fluid level within the boring or hollow-stem augers shall be maintained at or above the in situ groundwater level at all times during drilling, removal of drill rods, and sampling.

7. Sampling and Testing Procedure

7.1 After the boring has been advanced to the desired sampling elevation and excessive cuttings have been removed, prepare for the test with the following sequence of operations.

7.1.1 Attach the split-barrel sampler to the sampling rods and lower into the borehole. Do not allow the sampler to drop onto the soil to be sampled.

7.1.2 Position the hammer above and attach the anvil to the top of the sampling rods. This may be done before the sampling

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rods and sampler are lowered into the borehole.

7.1.3 Rest the dead weight of the sampler, rods, anvil, and drive weight on the bottom of the boring and apply a seating blow. If excessive cuttings are encountered at the bottom of the boring, remove the sampler and sampling rods from the boring and remove the cuttings.

7.1.4 Mark the drill rods in three successive 6-in. (0.15-m) increments so that the advance of the sampler under the impact of the hammer can be easily observed for each 6-in. (0.15-m) increment.

7.2 Drive the sampler with blows from the 140-lb (63.5-kg) hammer and count the number of blows applied in each 6-in. (0.15-m) increment until one of the following occurs:

7.2.1 A total of 50 blows have been applied during any one of the three 6-in. (0.15-m) increments described in 7.1.4.

7.2.2 A total of 100 blows have been applied.

7.2.3 There is no observed advance of the sampler during the application of 10 successive blows of the hammer.

7.2.4 The sampler is advanced the complete 18 in. (0.45 m) without the limiting blow counts occurring as described in 7.2.1, 7.2.2, or 7.2.3.

7.3 Record the number of blows required to effect each 6 in. (0.15 m) of penetration or fraction thereof. The first 6 in. is considered to be a seating drive. The sum of the number of blows required for the second and third 6 in. of penetration is termed the "standard penetration resistance," or the "*N*-value." If the sampler is driven less than 18 in. (0.45 m), as permitted in 7.2.1, 7.2.2, or 7.2.3, the number of blows per each complete 6-in. (0.15-m) increment and per each partial increment shall be recorded on the boring log. For partial increments, the depth of penetration shall be reported to the nearest 1 in. (25 mm), in addition to the number of blows. If the sampler advances below the bottom of the boring under the static weight of the drill rods or the weight of the drill rods plus the static weight of the hammer, this information should be noted on the boring log.

7.4 The raising and dropping of the 140-lb (63.5-kg) hammer shall be accomplished using either of the following two methods:

7.4.1 By using a trip, automatic, or semi-automatic hammer drop system which lifts the 140-lb (63.5-kg) hammer and allows it to drop 30 ± 1.0 in. (0.76 m ± 25 mm) unimpeded.

7.4.2 By using a cathead to pull a rope attached to the hammer. When the cathead and rope method is used the system and operation shall conform to the following:

7.4.2.1 The cathead shall be essentially free of rust, oil, or grease and have a diameter in the range of 6 to 10 in. (150 to 250 mm).

7.4.2.2 The cathead should be operated at a minimum speed of rotation of 100 RPM, or the approximate speed of rotation shall be reported on the boring log.

7.4.2.3 No more than 2¼ rope turns on the cathead may be used during the performance of the penetration test, as shown in Fig. 1.

NOTE 5—The operator should generally use either 1¾ or 2¼ rope turns, depending upon whether or not the rope comes off the top (1¾ turns) or the bottom (2¼ turns) of the cathead. It is generally known and accepted that 2¾or more rope turns considerably impedes the fall of the hammer and should not be used to perform the test. The cathead rope should be maintained in a relatively dry, clean, and unfrayed condition.

7.4.2.4 For each hammer blow, a 30-in. (0.76-m) lift and drop shall be employed by the operator. The operation of pulling and throwing the rope shall be performed rhythmically without holding the rope at the top of the stroke.

7.5 Bring the sampler to the surface and open. Record the percent recovery or the length of sample recovered. Describe the soil samples recovered as to composition, color, stratification, and condition, then place one or more representative portions of the sample into sealable moisture-proof containers (jars) without ramming or distorting any apparent stratification. Seal each container to prevent evaporation of soil moisture. Affix labels to the containers bearing job designation, boring number, sample depth, and the blow count per 6-in. (0.15-m) increment. Protect the samples against extreme temperature changes. If there is a soil change within the sampler, make a jar for each stratum and note its location in the sampler barrel.

8. Report

8.1 Drilling information shall be recorded in the field and shall include the following:

8.1.1 Name and location of job,

8.1.2 Names of crew,

8.1.3 Type and make of drilling machine,

8.1.4 Weather conditions,

8.1.5 Date and time of start and finish of boring,

8.1.6 Boring number and location (station and coordinates, if available and applicable),

8.1.7 Surface elevation, if available,

8.1.8 Method of advancing and cleaning the boring,

8.1.9 Method of keeping boring open,

8.1.10 Depth of water surface and drilling depth at the time of a noted loss of drilling fluid, and time and date when reading or notation was made,

8.1.11 Location of strata changes,

8.1.12 Size of casing, depth of cased portion of boring,

8.1.13 Equipment and method of driving sampler,

8.1.14 Type sampler and length and inside diameter of barrel (note use of liners),

8.1.15 Size, type, and section length of the sampling rods, and

8.1.16 Remarks.

8.2 Data obtained for each sample shall be recorded in the field and shall include the following:

8.2.1 Sample depth and, if utilized, the sample number,

8.2.2 Description of soil,

8.2.3 Strata changes within sample,

8.2.4 Sampler penetration and recovery lengths, and

8.2.5 Number of blows per 6-in. (0.15-m) or partial increment.

9. Precision and Bias

9.1 *Precision*—A valid estimate of test precision has not been determined because it is too costly to conduct the necessary inter-laboratory (field) tests. Subcommittee D18.02 welcomes proposals to allow development of a valid precision statement.

9.2 *Bias*—Because there is no reference material for this test method, there can be no bias statement.

9.3 Variations in *N*-values of 100 % or more have been

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observed when using different standard penetration test apparatus and drillers for adjacent borings in the same soil formation. Current opinion, based on field experience, indicates that when using the same apparatus and driller, *N*-values in the same soil can be reproduced with a coefficient of variation of about 10 %.

9.4 The use of faulty equipment, such as an extremely massive or damaged anvil, a rusty cathead, a low speed cathead, an old, oily rope, or massive or poorly lubricated rope sheaves can significantly contribute to differences in *N*-values obtained between operator-drill rig systems.

9.5 The variability in *N*-values produced by different drill rigs and operators may be reduced by measuring that part of the hammer energy delivered into the drill rods from the sampler and adjusting *N* on the basis of comparative energies. A method for energy measurement and *N*-value adjustment is given in Test Method D 4633.

10. Keywords

10.1 blow count; in-situ test; penetration resistance; split-barrel sampling; standard penetration test

SUMMARY OF CHANGES

(1) Added note to Section 1, Scope. The note refers to a related standard, Practice D 6066.

(2) Added Practice D 6066 to Section 2 on Referenced Documents.

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Designation: D 2488 – 00

Standard Practice for Description and Identification of Soils (Visual-Manual Procedure)[1]

This standard is issued under the fixed designation D 2488; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval. A superscript epsilon (ε) indicates an editorial change since the last revision or reapproval.

This standard has been approved for use by agencies of the Department of Defense.

1. Scope *

1.1 This practice covers procedures for the description of soils for engineering purposes.

1.2 This practice also describes a procedure for identifying soils, at the option of the user, based on the classification system described in Test Method D 2487. The identification is based on visual examination and manual tests. It must be clearly stated in reporting an identification that it is based on visual-manual procedures.

1.2.1 When precise classification of soils for engineering purposes is required, the procedures prescribed in Test Method D 2487 shall be used.

1.2.2 In this practice, the identification portion assigning a group symbol and name is limited to soil particles smaller than 3 in. (75 mm).

1.2.3 The identification portion of this practice is limited to naturally occurring soils (disturbed and undisturbed).

NOTE 1—This practice may be used as a descriptive system applied to such materials as shale, claystone, shells, crushed rock, etc. (see Appendix X2).

1.3 The descriptive information in this practice may be used with other soil classification systems or for materials other than naturally occurring soils.

1.4 The values stated in inch-pound units are to be regarded as the standard.

1.5 *This standard does not purport to address all of the safety problems, if any, associated with its use. It is the responsibility of the user of this standard to establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.* For specific precautionary statements see Section 8.

1.6 *This practice offers a set of instructions for performing one or more specific operations. This document cannot replace education or experience and should be used in conjunction with professional judgment. Not all aspects of this practice may be applicable in all circumstances. This ASTM standard is not intended to represent or replace the standard of care by which the adequacy of a given professional service must be judged, nor should this document be applied without consideration of a project's many unique aspects. The word "Standard" in the title of this document means only that the document has been approved through the ASTM consensus process.*

2. Referenced Documents

2.1 *ASTM Standards:*

D 653 Terminology Relating to Soil, Rock, and Contained Fluids[2]

D 1452 Practice for Soil Investigation and Sampling by Auger Borings[2]

D 1586 Test Method for Penetration Test and Split-Barrel Sampling of Soils[2]

D 1587 Practice for Thin-Walled Tube Sampling of Soils[2]

D 2113 Practice for Diamond Core Drilling for Site Investigation[2]

D 2487 Classification of Soils for Engineering Purposes (Unified Soil Classification System)[2]

D 3740 Practice for Minimum Requirements for Agencies Engaged in the Testing and/or Inspection of Soil and rock as Used in Engineering Design and Construction[3]

D 4083 Practice for Description of Frozen Soils (Visual-Manual Procedure)[2]

3. Terminology

3.1 *Definitions*—Except as listed below, all definitions are in accordance with Terminology D 653.

NOTE 2—For particles retained on a 3-in. (75-mm) US standard sieve, the following definitions are suggested:
Cobbles—particles of rock that will pass a 12-in. (300-mm) square opening and be retained on a 3-in. (75-mm) sieve, and
Boulders—particles of rock that will not pass a 12-in. (300-mm) square opening.

3.1.1 *clay*—soil passing a No. 200 (75-µm) sieve that can be made to exhibit plasticity (putty-like properties) within a range of water contents, and that exhibits considerable strength when air-dry. For classification, a clay is a fine-grained soil, or the

[1] This practice is under the jurisdiction of ASTM Committee D-18 on Soil and Rock and is the direct responsibility of Subcommittee D18.07 on Identification and Classification of Soils.

Current edition approved Feb. 10, 2000. Published May 2000. Originally published as D 2488 – 66 T. Last previous edition D 2488 – 93$^{\epsilon 1}$.

[2] *Annual Book of ASTM Standards*, Vol 04.08.

[3] *Annual Book of ASTM Standards*, Vol 04.09.

***A Summary of Changes section appears at the end of this standard.**

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fine-grained portion of a soil, with a plasticity index equal to or greater than 4, and the plot of plasticity index versus liquid limit falls on or above the "A" line (see Fig. 3 of Test Method D 2487).

3.1.2 *gravel*—particles of rock that will pass a 3-in. (75-mm) sieve and be retained on a No. 4 (4.75-mm) sieve with the following subdivisions:

coarse—passes a 3-in. (75-mm) sieve and is retained on a ¾-in. (19-mm) sieve.

fine—passes a ¾-in. (19-mm) sieve and is retained on a No. 4 (4.75-mm) sieve.

3.1.3 *organic clay*—a clay with sufficient organic content to influence the soil properties. For classification, an organic clay is a soil that would be classified as a clay, except that its liquid limit value after oven drying is less than 75 % of its liquid limit value before oven drying.

3.1.4 *organic silt*—a silt with sufficient organic content to influence the soil properties. For classification, an organic silt is a soil that would be classified as a silt except that its liquid limit value after oven drying is less than 75 % of its liquid limit value before oven drying.

3.1.5 *peat*—a soil composed primarily of vegetable tissue in various stages of decomposition usually with an organic odor, a dark brown to black color, a spongy consistency, and a texture ranging from fibrous to amorphous.

3.1.6 *sand*—particles of rock that will pass a No. 4 (4.75-mm) sieve and be retained on a No. 200 (75-µm) sieve with the following subdivisions:

coarse—passes a No. 4 (4.75-mm) sieve and is retained on a No. 10 (2.00-mm) sieve.

medium—passes a No. 10 (2.00-mm) sieve and is retained on a No. 40 (425-µm) sieve.

fine—passes a No. 40 (425-µm) sieve and is retained on a No. 200 (75-µm) sieve.

3.1.7 *silt*—soil passing a No. 200 (75-µm) sieve that is nonplastic or very slightly plastic and that exhibits little or no strength when air dry. For classification, a silt is a fine-grained soil, or the fine-grained portion of a soil, with a plasticity index less than 4, or the plot of plasticity index versus liquid limit falls below the "A" line (see Fig. 3 of Test Method D 2487).

4. Summary of Practice

4.1 Using visual examination and simple manual tests, this practice gives standardized criteria and procedures for describing and identifying soils.

4.2 The soil can be given an identification by assigning a group symbol(s) and name. The flow charts, Fig. 1a and Fig. 1b for fine-grained soils, and Fig. 2, for coarse-grained soils, can be used to assign the appropriate group symbol(s) and name. If the soil has properties which do not distinctly place it into a specific group, borderline symbols may be used, see Appendix X3.

NOTE 3—It is suggested that a distinction be made between *dual symbols* and *borderline symbols.*

Dual Symbol—A dual symbol is two symbols separated by a hyphen, for example, GP-GM, SW-SC, CL-ML used to indicate that the soil has been identified as having the properties of a classification in accordance with Test Method D 2487 where two symbols are required. Two symbols are required when the soil has between 5 and 12 % fines or when the liquid limit and plasticity index values plot in the CL-ML area of the plasticity chart.

Borderline Symbol—A borderline symbol is two symbols separated by a slash, for example, CL/CH, GM/SM, CL/ML. A borderline symbol should be used to indicate that the soil has been identified as having properties that do not distinctly place the soil into a specific group (see Appendix X3).

5. Significance and Use

5.1 The descriptive information required in this practice can be used to describe a soil to aid in the evaluation of its significant properties for engineering use.

5.2 The descriptive information required in this practice should be used to supplement the classification of a soil as determined by Test Method D 2487.

5.3 This practice may be used in identifying soils using the classification group symbols and names as prescribed in Test Method D 2487. Since the names and symbols used in this practice to identify the soils are the same as those used in Test Method D 2487, it shall be clearly stated in reports and all other appropriate documents, that the classification symbol and name are based on visual-manual procedures.

5.4 This practice is to be used not only for identification of soils in the field, but also in the office, laboratory, or wherever soil samples are inspected and described.

5.5 This practice has particular value in grouping similar soil samples so that only a minimum number of laboratory tests need be run for positive soil classification.

NOTE 4—The ability to describe and identify soils correctly is learned more readily under the guidance of experienced personnel, but it may also be acquired systematically by comparing numerical laboratory test results for typical soils of each type with their visual and manual characteristics.

5.6 When describing and identifying soil samples from a given boring, test pit, or group of borings or pits, it is not necessary to follow all of the procedures in this practice for every sample. Soils which appear to be similar can be grouped together; one sample completely described and identified with the others referred to as similar based on performing only a few of the descriptive and identification procedures described in this practice.

5.7 This practice may be used in combination with Practice D 4083 when working with frozen soils.

NOTE 5—Notwithstanding the statements on precision and bias contained in this standard: The precision of this test method is dependent on the competence of the personnel performing it and the suitability of the equipment and facilities used. Agencies that meet the criteria of Practice D 3740 are generally considered capable of competent and objective testing. Users of this test method are cautioned that compliance with Practice D 3740 does not in itself assure reliable testing. Reliable testing depends on several factors; Practice D 3740 provides a means for evaluating some of those factors.

6. Apparatus

6.1 *Required Apparatus*:

6.1.1 *Pocket Knife or Small Spatula*.

6.2 *Useful Auxiliary Apparatus*:

6.2.1 *Small Test Tube and Stopper* (or jar with a lid).

6.2.2 *Small Hand Lens*.

7. Reagents

7.1 *Purity of Water*—Unless otherwise indicated, references

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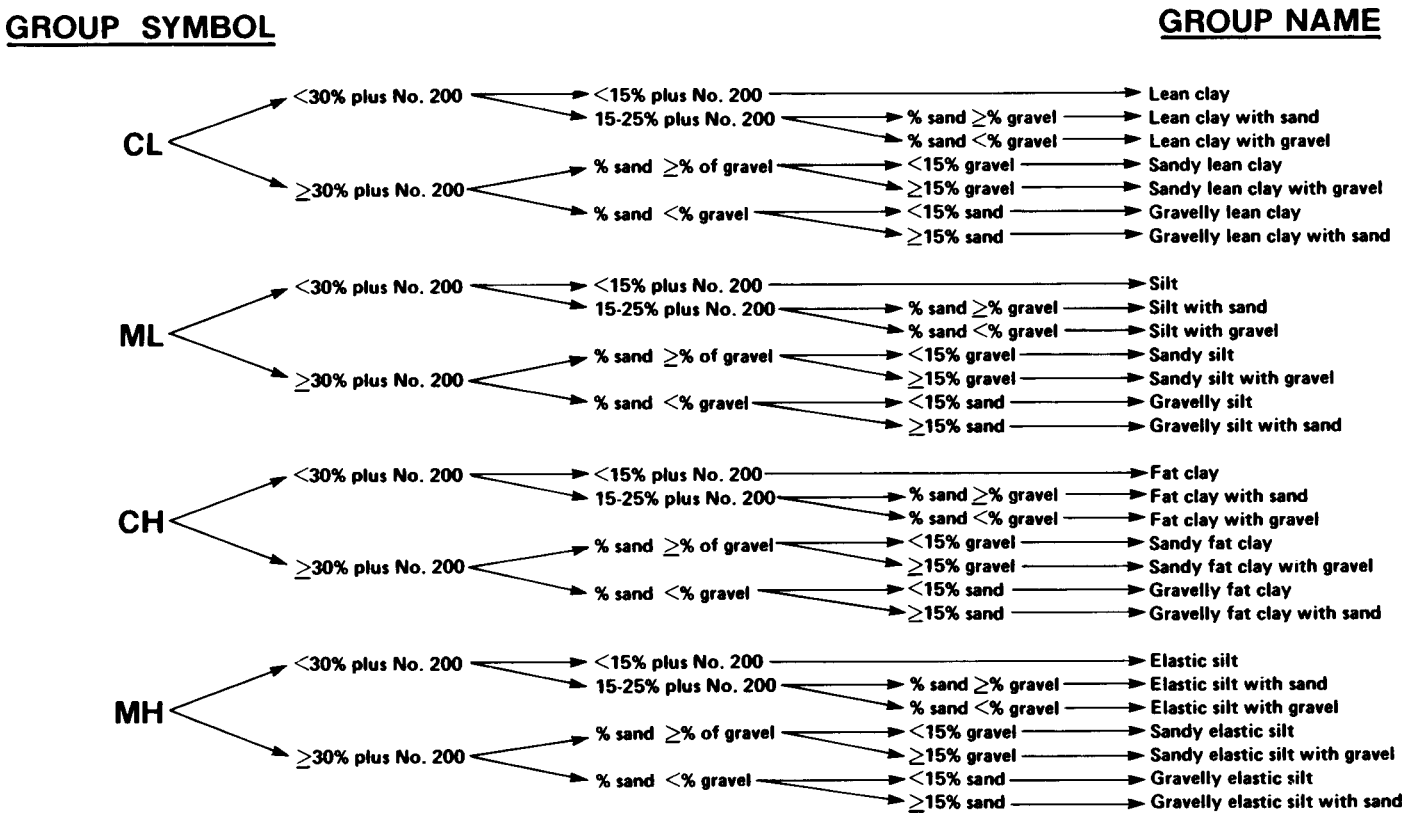
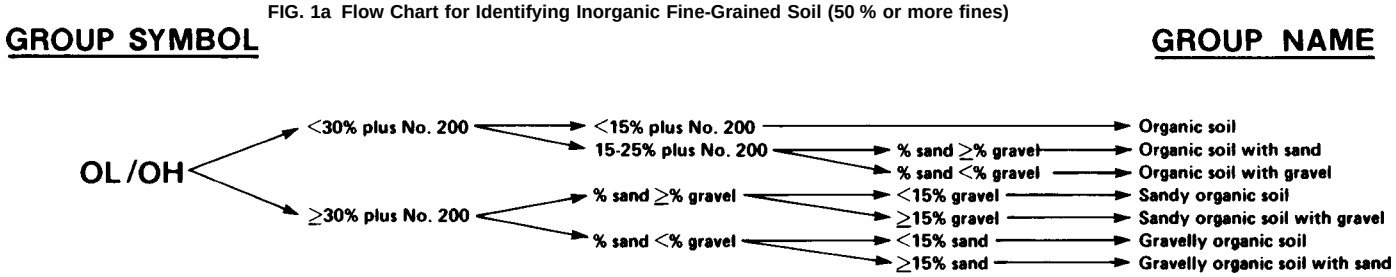


NOTE 1—Percentages are based on estimating amounts of fines, sand, and gravel to the nearest 5 %.

FIG. 1a Flow Chart for Identifying Inorganic Fine-Grained Soil (50 % or more fines)



NOTE 1—Percentages are based on estimating amounts of fines, sand, and gravel to the nearest 5 %.

FIG. 1 b Flow Chart for Identifying Organic Fine-Grained Soil (50 % or more fines)

to water shall be understood to mean water from a city water supply or natural source, including non-potable water.

7.2 *Hydrochloric Acid*—A small bottle of dilute hydrochloric acid, HCl, one part HCl (10 *N*) to three parts water (This reagent is optional for use with this practice). See Section 8.

8. Safety Precautions

8.1 When preparing the dilute HCl solution of one part concentrated hydrochloric acid (10 *N*) to three parts of distilled water, slowly add acid into water following necessary safety precautions. Handle with caution and store safely. If solution comes into contact with the skin, rinse thoroughly with water.

8.2 **Caution**—Do not add water to acid.

9. Sampling

9.1 The sample shall be considered to be representative of the stratum from which it was obtained by an appropriate, accepted, or standard procedure.

NOTE 6—Preferably, the sampling procedure should be identified as having been conducted in accordance with Practices D 1452, D 1587, or D 2113, or Test Method D 1586.

9.2 The sample shall be carefully identified as to origin.

NOTE 7—Remarks as to the origin may take the form of a boring number and sample number in conjunction with a job number, a geologic stratum, a pedologic horizon or a location description with respect to a permanent monument, a grid system or a station number and offset with respect to a stated centerline and a depth or elevation.

9.3 For accurate description and identification, the minimum amount of the specimen to be examined shall be in accordance with the following schedule:

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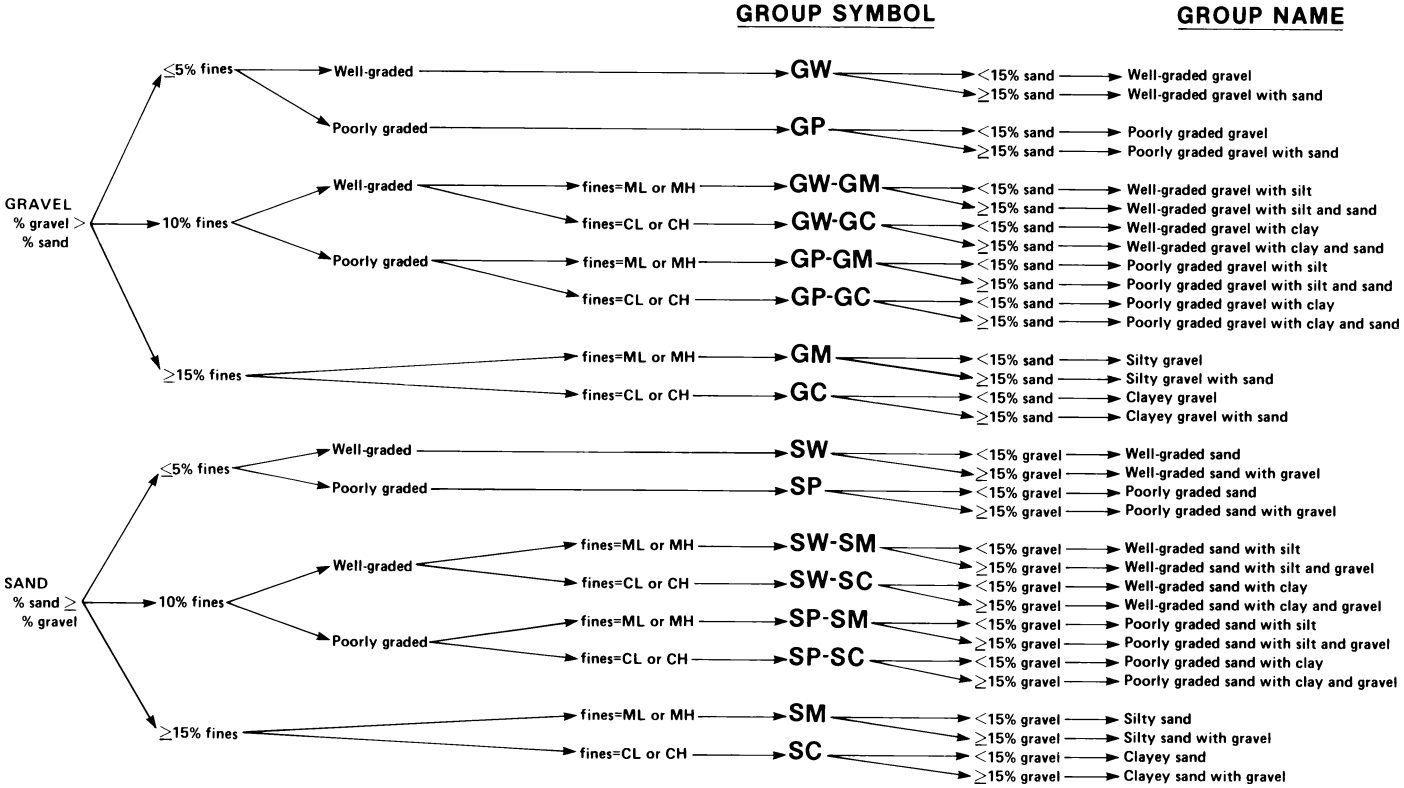

NOTE 1—Percentages are based on estimating amounts of fines, sand, and gravel to the nearest 5 %.

FIG. 2 Flow Chart for Identifying Coarse-Grained Soils (less than 50 % fines)

Maximum Particle Size, Sieve Opening	Minimum Specimen Size, Dry Weight
4.75 mm (No. 4)	100 g (0.25 lb)
9.5 mm (⅜ in.)	200 g (0.5 lb)
19.0 mm (¾ in.)	1.0 kg (2.2 lb)
38.1 mm (1½ in.)	8.0 kg (18 lb)
75.0 mm (3 in.)	60.0 kg (132 lb)

NOTE 8—If random isolated particles are encountered that are significantly larger than the particles in the soil matrix, the soil matrix can be accurately described and identified in accordance with the preceeding schedule.

9.4 If the field sample or specimen being examined is smaller than the minimum recommended amount, the report shall include an appropriate remark.

10. Descriptive Information for Soils

10.1 *Angularity*—Describe the angularity of the sand (coarse sizes only), gravel, cobbles, and boulders, as angular, subangular, subrounded, or rounded in accordance with the criteria in Table 1 and Fig. 3. A range of angularity may be stated, such as: subrounded to rounded.

10.2 *Shape*—Describe the shape of the gravel, cobbles, and boulders as flat, elongated, or flat and elongated if they meet the criteria in Table 2 and Fig. 4. Otherwise, do not mention the shape. Indicate the fraction of the particles that have the shape, such as: one-third of the gravel particles are flat.

10.3 *Color*—Describe the color. Color is an important property in identifying organic soils, and within a given locality it may also be useful in identifying materials of similar geologic origin. If the sample contains layers or patches of varying colors, this shall be noted and all representative colors shall be described. The color shall be described for moist samples. If the color represents a dry condition, this shall be stated in the report.

TABLE 1 Criteria for Describing Angularity of Coarse-Grained Particles (see Fig. 3)

Description	Criteria
Angular	Particles have sharp edges and relatively plane sides with unpolished surfaces
Subangular	Particles are similar to angular description but have rounded edges
Subrounded	Particles have nearly plane sides but have well-rounded corners and edges
Rounded	Particles have smoothly curved sides and no edges

10.4 *Odor*—Describe the odor if organic or unusual. Soils containing a significant amount of organic material usually have a distinctive odor of decaying vegetation. This is especially apparent in fresh samples, but if the samples are dried, the odor may often be revived by heating a moistened sample. If the odor is unusual (petroleum product, chemical, and the like), it shall be described.

10.5 *Moisture Condition*—Describe the moisture condition as dry, moist, or wet, in accordance with the criteria in Table 3.

10.6 *HCl Reaction*—Describe the reaction with HCl as none, weak, or strong, in accordance with the critera in Table 4. Since calcium carbonate is a common cementing agent, a report of its presence on the basis of the reaction with dilute hydrochloric acid is important.

10.7 *Consistency*—For intact fine-grained soil, describe the

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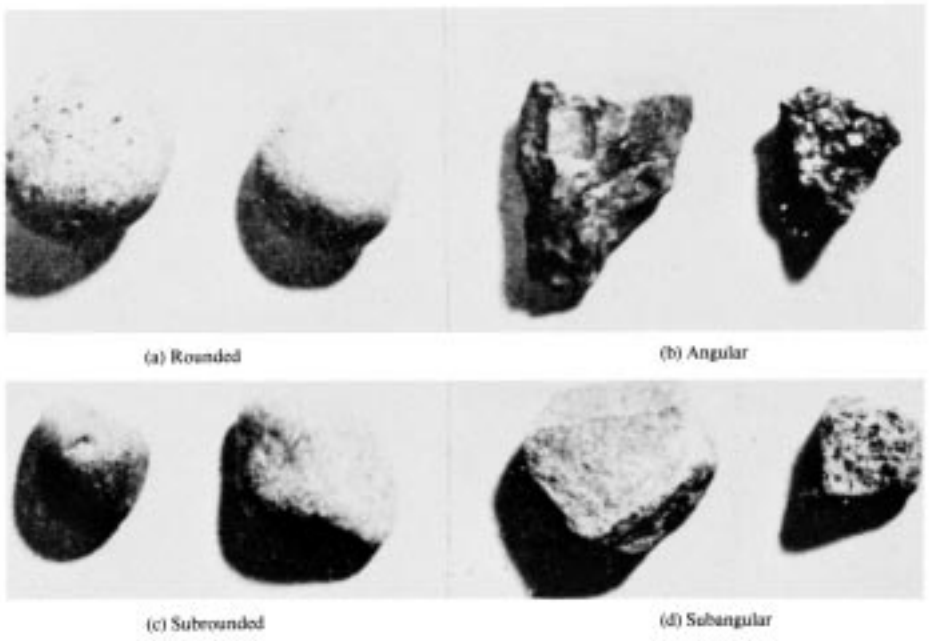

FIG. 3 Typical Angularity of Bulky Grains

TABLE 2 Criteria for Describing Particle Shape (see Fig. 4)

The particle shape shall be described as follows where length, width, and thickness refer to the greatest, intermediate, and least dimensions of a particle, respectively.	
Flat	Particles with width/thickness > 3
Elongated	Particles with length/width > 3
Flat and elongated	Particles meet criteria for both flat and elongated

consistency as very soft, soft, firm, hard, or very hard, in accordance with the criteria in Table 5. This observation is inappropriate for soils with significant amounts of gravel.

10.8 *Cementation*—Describe the cementation of intact coarse-grained soils as weak, moderate, or strong, in accordance with the criteria in Table 6.

10.9 *Structure*—Describe the structure of intact soils in accordance with the criteria in Table 7.

10.10 *Range of Particle Sizes*—For gravel and sand components, describe the range of particle sizes within each component as defined in 3.1.2 and 3.1.6. For example, about 20 % fine to coarse gravel, about 40 % fine to coarse sand.

10.11 *Maximum Particle Size*—Describe the maximum particle size found in the sample in accordance with the following information:

10.11.1 *Sand Size*—If the maximum particle size is a sand size, describe as fine, medium, or coarse as defined in 3.1.6. For example: maximum particle size, medium sand.

10.11.2 *Gravel Size*—If the maximum particle size is a gravel size, describe the maximum particle size as the smallest sieve opening that the particle will pass. For example, maximum particle size, 1½ in. (will pass a 1½-in. square opening but not a ¾-in. square opening).

10.11.3 *Cobble or Boulder Size*—If the maximum particle size is a cobble or boulder size, describe the maximum dimension of the largest particle. For example: maximum dimension, 18 in. (450 mm).

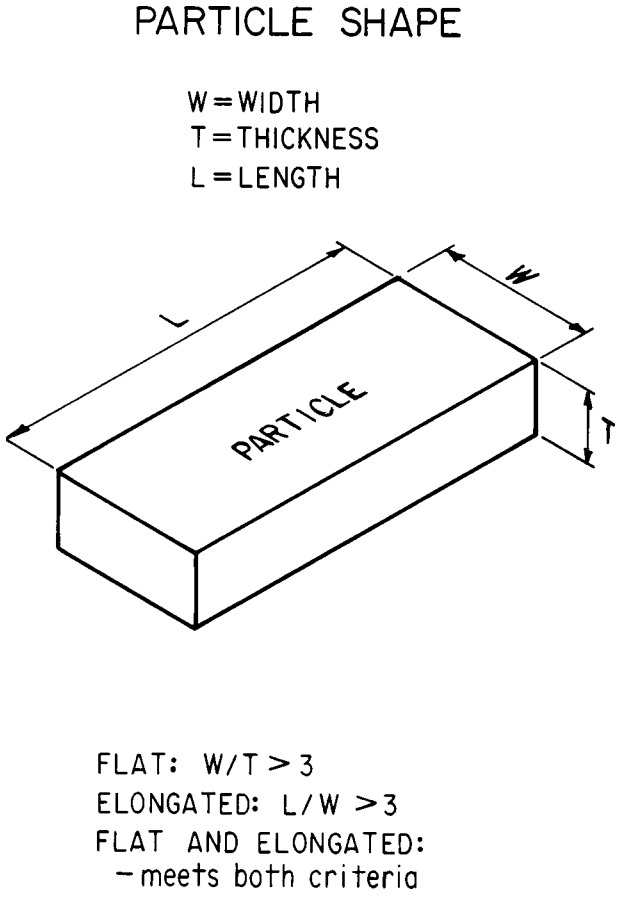

FIG. 4 Criteria for Particle Shape

10.12 *Hardness*—Describe the hardness of coarse sand and larger particles as hard, or state what happens when the

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TABLE 3 Criteria for Describing Moisture Condition

Description	Criteria
Dry	Absence of moisture, dusty, dry to the touch
Moist	Damp but no visible water
Wet	Visible free water, usually soil is below water table

TABLE 4 Criteria for Describing the Reaction With HCl

Description	Criteria
None	No visible reaction
Weak	Some reaction, with bubbles forming slowly
Strong	Violent reaction, with bubbles forming immediately

TABLE 5 Criteria for Describing Consistency

Description	Criteria
Very soft	Thumb will penetrate soil more than 1 in. (25 mm)
Soft	Thumb will penetrate soil about 1 in. (25 mm)
Firm	Thumb will indent soil about ¼in. (6 mm)
Hard	Thumb will not indent soil but readily indented with thumbnail
Very hard	Thumbnail will not indent soil

TABLE 6 Criteria for Describing Cementation

Description	Criteria
Weak	Crumbles or breaks with handling or little finger pressure
Moderate	Crumbles or breaks with considerable finger pressure
Strong	Will not crumble or break with finger pressure

TABLE 7 Criteria for Describing Structure

Description	Criteria
Stratified	Alternating layers of varying material or color with layers at least 6 mm thick; note thickness
Laminated	Alternating layers of varying material or color with the layers less than 6 mm thick; note thickness
Fissured	Breaks along definite planes of fracture with little resistance to fracturing
Slickensided	Fracture planes appear polished or glossy, sometimes striated
Blocky	Cohesive soil that can be broken down into small angular lumps which resist further breakdown
Lensed	Inclusion of small pockets of different soils, such as small lenses of sand scattered through a mass of clay; note thickness
Homogeneous	Same color and appearance throughout

particles are hit by a hammer, for example, gravel-size particles fracture with considerable hammer blow, some gravel-size particles crumble with hammer blow. "Hard" means particles do not crack, fracture, or crumble under a hammer blow.

10.13 Additional comments shall be noted, such as the presence of roots or root holes, difficulty in drilling or augering hole, caving of trench or hole, or the presence of mica.

10.14 A local or commercial name or a geologic interpretation of the soil, or both, may be added if identified as such.

10.15 A classification or identification of the soil in accordance with other classification systems may be added if identified as such.

11. Identification of Peat

11.1 A sample composed primarily of vegetable tissue in various stages of decomposition that has a fibrous to amorphous texture, usually a dark brown to black color, and an organic odor, shall be designated as a highly organic soil and shall be identified as peat, PT, and not subjected to the identification procedures described hereafter.

12. Preparation for Identification

12.1 The soil identification portion of this practice is based on the portion of the soil sample that will pass a 3-in. (75-mm) sieve. The larger than 3-in. (75-mm) particles must be removed, manually, for a loose sample, or mentally, for an intact sample before classifying the soil.

12.2 Estimate and note the percentage of cobbles and the percentage of boulders. Performed visually, these estimates will be on the basis of volume percentage.

NOTE 9—Since the percentages of the particle-size distribution in Test Method D 2487 are by dry weight, and the estimates of percentages for gravel, sand, and fines in this practice are by dry weight, it is recommended that the report state that the percentages of cobbles and boulders are by volume.

12.3 Of the fraction of the soil smaller than 3 in. (75 mm), estimate and note the percentage, by dry weight, of the gravel, sand, and fines (see Appendix X4 for suggested procedures).

NOTE 10—Since the particle-size components appear visually on the basis of volume, considerable experience is required to estimate the percentages on the basis of dry weight. Frequent comparisons with laboratory particle-size analyses should be made.

12.3.1 The percentages shall be estimated to the closest 5 %. The percentages of gravel, sand, and fines must add up to 100 %.

12.3.2 If one of the components is present but not in sufficient quantity to be considered 5 % of the smaller than 3-in. (75-mm) portion, indicate its presence by the term *trace*, for example, trace of fines. A trace is not to be considered in the total of 100 % for the components.

13. Preliminary Identification

13.1 The soil is *fine grained* if it contains 50 % or more fines. Follow the procedures for identifying fine-grained soils of Section 14.

13.2 The soil is *coarse grained* if it contains less than 50 % fines. Follow the procedures for identifying coarse-grained soils of Section 15.

14. Procedure for Identifying Fine-Grained Soils

14.1 Select a representative sample of the material for examination. Remove particles larger than the No. 40 sieve (medium sand and larger) until a specimen equivalent to about a handful of material is available. Use this specimen for performing the dry strength, dilatancy, and toughness tests.

14.2 *Dry Strength*:

14.2.1 From the specimen, select enough material to mold into a ball about 1 in. (25 mm) in diameter. Mold the material until it has the consistency of putty, adding water if necessary.

14.2.2 From the molded material, make at least three test specimens. A test specimen shall be a ball of material about ½ in. (12 mm) in diameter. Allow the test specimens to dry in air, or sun, or by artificial means, as long as the temperature does not exceed 60°C.

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14.2.3 If the test specimen contains natural dry lumps, those that are about ½ in. (12 mm) in diameter may be used in place of the molded balls.

NOTE 11—The process of molding and drying usually produces higher strengths than are found in natural dry lumps of soil.

14.2.4 Test the strength of the dry balls or lumps by crushing between the fingers. Note the strength as none, low, medium, high, or very high in accorance with the criteria in Table 8. If natural dry lumps are used, do not use the results of any of the lumps that are found to contain particles of coarse sand.

14.2.5 The presence of high-strength water-soluble cementing materials, such as calcium carbonate, may cause exceptionally high dry strengths. The presence of calcium carbonate can usually be detected from the intensity of the reaction with dilute hydrochloric acid (see 10.6).

14.3 *Dilatancy*:

14.3.1 From the specimen, select enough material to mold into a ball about ½ in. (12 mm) in diameter. Mold the material, adding water if necessary, until it has a soft, but not sticky, consistency.

14.3.2 Smooth the soil ball in the palm of one hand with the blade of a knife or small spatula. Shake horizontally, striking the side of the hand vigorously against the other hand several times. Note the reaction of water appearing on the surface of the soil. Squeeze the sample by closing the hand or pinching the soil between the fingers, and note the reaction as none, slow, or rapid in accordance with the criteria in Table 9. The reaction is the speed with which water appears while shaking, and disappears while squeezing.

14.4 *Toughness*:

14.4.1 Following the completion of the dilatancy test, the test specimen is shaped into an elongated pat and rolled by hand on a smooth surface or between the palms into a thread about ⅛ in. (3 mm) in diameter. (If the sample is too wet to roll easily, it should be spread into a thin layer and allowed to lose some water by evaporation.) Fold the sample threads and reroll repeatedly until the thread crumbles at a diameter of about ⅛ in. The thread will crumble at a diameter of ⅛ in. when the soil is near the plastic limit. Note the pressure required to roll the thread near the plastic limit. Also, note the strength of the thread. After the thread crumbles, the pieces should be lumped together and kneaded until the lump crumbles. Note the toughness of the material during kneading.

14.4.2 Describe the toughness of the thread and lump as low, medium, or high in accordance with the criteria in Table 10.

TABLE 8 Criteria for Describing Dry Strength

Description	Criteria
None	The dry specimen crumbles into powder with mere pressure of handling
Low	The dry specimen crumbles into powder with some finger pressure
Medium	The dry specimen breaks into pieces or crumbles with considerable finger pressure
High	The dry specimen cannot be broken with finger pressure. Specimen will break into pieces between thumb and a hard surface
Very high	The dry specimen cannot be broken between the thumb and a hard surface

TABLE 9 Criteria for Describing Dilatancy

Description	Criteria
None	No visible change in the specimen
Slow	Water appears slowly on the surface of the specimen during shaking and does not disappear or disappears slowly upon squeezing
Rapid	Water appears quickly on the surface of the specimen during shaking and disappears quickly upon squeezing

14.5 *Plasticity*—On the basis of observations made during the toughness test, describe the plasticity of the material in accordance with the criteria given in Table 11.

14.6 Decide whether the soil is an *inorganic* or an *organic* fine-grained soil (see 14.8). If inorganic, follow the steps given in 14.7.

14.7 *Identification of Inorganic Fine-Grained Soils*:

14.7.1 Identify the soil as a *lean clay*, CL, if the soil has medium to high dry strength, no or slow dilatancy, and medium toughness and plasticity (see Table 12).

14.7.2 Identify the soil as a *fat clay*, CH, if the soil has high to very high dry strength, no dilatancy, and high toughness and plasticity (see Table 12).

14.7.3 Identify the soil as a *silt*, ML, if the soil has no to low dry strength, slow to rapid dilatancy, and low toughness and plasticity, or is nonplastic (see Table 12).

14.7.4 Identify the soil as an *elastic silt*, MH, if the soil has low to medium dry strength, no to slow dilatancy, and low to medium toughness and plasticity (see Table 12).

NOTE 12—These properties are similar to those for a lean clay. However, the silt will dry quickly on the hand and have a smooth, silky feel when dry. Some soils that would classify as MH in accordance with the criteria in Test Method D 2487 are visually difficult to distinguish from lean clays, CL. It may be necessary to perform laboratory testing for proper identification.

14.8 *Identification of Organic Fine-Grained Soils*:

14.8.1 Identify the soil as an *organic soil*, OL/OH, if the soil contains enough organic particles to influence the soil properties. Organic soils usually have a dark brown to black color and may have an organic odor. Often, organic soils will change color, for example, black to brown, when exposed to the air. Some organic soils will lighten in color significantly when air dried. Organic soils normally will not have a high toughness or plasticity. The thread for the toughness test will be spongy.

NOTE 13—In some cases, through practice and experience, it may be possible to further identify the organic soils as organic silts or organic clays, OL or OH. Correlations between the dilatancy, dry strength, toughness tests, and laboratory tests can be made to identify organic soils in certain deposits of similar materials of known geologic origin.

TABLE 10 Criteria for Describing Toughness

Description	Criteria
Low	Only slight pressure is required to roll the thread near the plastic limit. The thread and the lump are weak and soft
Medium	Medium pressure is required to roll the thread to near the plastic limit. The thread and the lump have medium stiffness
High	Considerable pressure is required to roll the thread to near the plastic limit. The thread and the lump have very high stiffness

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TABLE 11 Criteria for Describing Plasticity

Description	Criteria
Nonplastic	A ⅛-in. (3-mm) thread cannot be rolled at any water content
Low	The thread can barely be rolled and the lump cannot be formed when drier than the plastic limit
Medium	The thread is easy to roll and not much time is required to reach the plastic limit. The thread cannot be rerolled after reaching the plastic limit. The lump crumbles when drier than the plastic limit
High	It takes considerable time rolling and kneading to reach the plastic limit. The thread can be rerolled several times after reaching the plastic limit. The lump can be formed without crumbling when drier than the plastic limit

TABLE 12 Identification of Inorganic Fine-Grained Soils from Manual Tests

Soil Symbol	Dry Strength	Dilatancy	Toughness
ML	None to low	Slow to rapid	Low or thread cannot be formed
CL	Medium to high	None to slow	Medium
MH	Low to medium	None to slow	Low to medium
CH	High to very high	None	High

14.9 If the soil is estimated to have 15 to 25 % sand or gravel, or both, the words “with sand” or “with gravel” (whichever is more predominant) shall be added to the group name. For example: “lean clay with sand, CL” or “silt with gravel, ML” (see Fig. 1a and Fig. 1b). If the percentage of sand is equal to the percentage of gravel, use “with sand.”

14.10 If the soil is estimated to have 30 % or more sand or gravel, or both, the words “sandy” or “gravelly” shall be added to the group name. Add the word “sandy” if there appears to be more sand than gravel. Add the word “gravelly” if there appears to be more gravel than sand. For example: “sandy lean clay, CL”, “gravelly fat clay, CH”, or “sandy silt, ML” (see Fig. 1a and Fig. 1b). If the percentage of sand is equal to the percent of gravel, use “sandy.”

15. Procedure for Identifying Coarse-Grained Soils

(Contains less than 50 % fines)

15.1 The soil is a *gravel* if the percentage of gravel is estimated to be more than the percentage of sand.

15.2 The soil is a *sand* if the percentage of gravel is estimated to be equal to or less than the percentage of sand.

15.3 The soil is a *clean gravel* or *clean sand* if the percentage of fines is estimated to be 5 % or less.

15.3.1 Identify the soil as a *well-graded gravel*, GW, or as a *well-graded sand*, SW, if it has a wide range of particle sizes and substantial amounts of the intermediate particle sizes.

15.3.2 Identify the soil as a *poorly graded gravel*, GP, or as a *poorly graded sand*, SP, if it consists predominantly of one size (uniformly graded), or it has a wide range of sizes with some intermediate sizes obviously missing (gap or skip graded).

15.4 The soil is either a *gravel with fines* or a *sand with fines* if the percentage of fines is estimated to be 15 % or more.

15.4.1 Identify the soil as a *clayey gravel*, GC, or a *clayey sand*, SC, if the fines are clayey as determined by the procedures in Section 14.

15.4.2 Identify the soil as a *silty gravel*, GM, or a *silty sand*, SM, if the fines are silty as determined by the procedures in Section 14.

15.5 If the soil is estimated to contain 10 % fines, give the soil a dual identification using two group symbols.

15.5.1 The first group symbol shall correspond to a clean gravel or sand (GW, GP, SW, SP) and the second symbol shall correspond to a gravel or sand with fines (GC, GM, SC, SM).

15.5.2 The group name shall correspond to the first group symbol plus the words “with clay” or “with silt” to indicate the plasticity characteristics of the fines. For example: “well-graded gravel with clay, GW-GC” or “poorly graded sand with silt, SP-SM” (see Fig. 2).

15.6 If the specimen is predominantly sand or gravel but contains an estimated 15 % or more of the other coarse-grained constituent, the words “with gravel” or “with sand” shall be added to the group name. For example: “poorly graded gravel with sand, GP” or “clayey sand with gravel, SC” (see Fig. 2).

15.7 If the field sample contains any cobbles or boulders, or both, the words “with cobbles” or “with cobbles and boulders” shall be added to the group name. For example: “silty gravel with cobbles, GM.”

16. Report

16.1 The report shall include the information as to origin, and the items indicated in Table 13.

NOTE 14—*Example: Clayey Gravel with Sand and Cobbles, GC*—About 50 % fine to coarse, subrounded to subangular gravel; about 30 % fine to coarse, subrounded sand; about 20 % fines with medium plasticity, high dry strength, no dilatancy, medium toughness; weak reaction with HCl; original field sample had about 5 % (by volume) subrounded cobbles, maximum dimension, 150 mm.

In-Place Conditions—Firm, homogeneous, dry, brown

Geologic Interpretation—Alluvial fan

TABLE 13 Checklist for Description of Soils

1. Group name
2. Group symbol
3. Percent of cobbles or boulders, or both (by volume)
4. Percent of gravel, sand, or fines, or all three (by dry weight)
5. Particle-size range:
   Gravel—fine, coarse
   Sand—fine, medium, coarse
6. Particle angularity: angular, subangular, subrounded, rounded
7. Particle shape: (if appropriate) flat, elongated, flat and elongated
8. Maximum particle size or dimension
9. Hardness of coarse sand and larger particles
10. Plasticity of fines: nonplastic, low, medium, high
11. Dry strength: none, low, medium, high, very high
12. Dilatancy: none, slow, rapid
13. Toughness: low, medium, high
14. Color (in moist condition)
15. Odor (mention only if organic or unusual)
16. Moisture: dry, moist, wet
17. Reaction with HCl: none, weak, strong

For intact samples:

18. Consistency (fine-grained soils only): very soft, soft, firm, hard, very hard
19. Structure: stratified, laminated, fissured, slickensided, lensed, homogeneous
20. Cementation: weak, moderate, strong
21. Local name
22. Geologic interpretation
23. Additional comments: presence of roots or root holes, presence of mica, gypsum, etc., surface coatings on coarse-grained particles, caving or sloughing of auger hole or trench sides, difficulty in augering or excavating, etc.

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NOTE 15—Other examples of soil descriptions and identification are given in Appendix X1 and Appendix X2.

NOTE 16—If desired, the percentages of gravel, sand, and fines may be stated in terms indicating a range of percentages, as follows:

Trace—Particles are present but estimated to be less than 5 %
Few—5 to 10 %
Little—15 to 25 %
Some—30 to 45 %
Mostly—50 to 100 %

16.2 If, in the soil description, the soil is identified using a classification group symbol and name as described in Test Method D 2487, it must be distinctly and clearly stated in log forms, summary tables, reports, and the like, that the symbol and name are based on visual-manual procedures.

17. Precision and Bias

17.1 This practice provides qualitative information only, therefore, a precision and bias statement is not applicable.

18. Keywords

18.1 classification; clay; gravel; organic soils; sand; silt; soil classification; soil description; visual classification

APPENDIXES

(Nonmandatory Information)

X1. EXAMPLES OF VISUAL SOIL DESCRIPTIONS

X1.1 The following examples show how the information required in 16.1 can be reported. The information that is included in descriptions should be based on individual circumstances and need.

X1.1.1 *Well-Graded Gravel with Sand (GW)*—About 75 % fine to coarse, hard, subangular gravel; about 25 % fine to coarse, hard, subangular sand; trace of fines; maximum size, 75 mm, brown, dry; no reaction with HCl.

X1.1.2 *Silty Sand with Gravel (SM)*—About 60 % predominantly fine sand; about 25 % silty fines with low plasticity, low dry strength, rapid dilatancy, and low toughness; about 15 % fine, hard, subrounded gravel, a few gravel-size particles fractured with hammer blow; maximum size, 25 mm; no reaction with HCl (Note—Field sample size smaller than recommended).

In-Place Conditions—Firm, stratified and contains lenses of silt 1 to 2 in. (25 to 50 mm) thick, moist, brown to gray; in-place density 106 lb/ft^3; in-place moisture 9 %.

X1.1.3 *Organic Soil (OL/OH)*—About 100 % fines with low plasticity, slow dilatancy, low dry strength, and low toughness; wet, dark brown, organic odor; weak reaction with HCl.

X1.1.4 *Silty Sand with Organic Fines (SM)*—About 75 % fine to coarse, hard, subangular reddish sand; about 25 % organic and silty dark brown nonplastic fines with no dry strength and slow dilatancy; wet; maximum size, coarse sand; weak reaction with HCl.

X1.1.5 *Poorly Graded Gravel with Silt, Sand, Cobbles and Boulders (GP-GM)*—About 75 % fine to coarse, hard, subrounded to subangular gravel; about 15 % fine, hard, subrounded to subangular sand; about 10 % silty nonplastic fines; moist, brown; no reaction with HCl; original field sample had about 5 % (by volume) hard, subrounded cobbles and a trace of hard, subrounded boulders, with a maximum dimension of 18 in. (450 mm).

X2. USING THE IDENTIFICATION PROCEDURE AS A DESCRIPTIVE SYSTEM FOR SHALE, CLAYSTONE, SHELLS, SLAG, CRUSHED ROCK, AND THE LIKE

X2.1 The identification procedure may be used as a descriptive system applied to materials that exist in-situ as shale, claystone, sandstone, siltstone, mudstone, etc., but convert to soils after field or laboratory processing (crushing, slaking, and the like).

X2.2 Materials such as shells, crushed rock, slag, and the like, should be identified as such. However, the procedures used in this practice for describing the particle size and plasticity characteristics may be used in the description of the material. If desired, an identification using a group name and symbol according to this practice may be assigned to aid in describing the material.

X2.3 The group symbol(s) and group names should be placed in quotation marks or noted with some type of distinguishing symbol. See examples.

X2.4 Examples of how group names and symbols can be incororated into a descriptive system for materials that are not naturally occurring soils are as follows:

X2.4.1 *Shale Chunks*—Retrieved as 2 to 4-in. (50 to 100-mm) pieces of shale from power auger hole, dry, brown, no reaction with HCl. After slaking in water for 24 h, material identified as "Sandy Lean Clay (CL)"; about 60 % fines with medium plasticity, high dry strength, no dilatancy, and medium toughness; about 35 % fine to medium, hard sand; about 5 % gravel-size pieces of shale.

X2.4.2 *Crushed Sandstone*—Product of commercial crushing operation; "Poorly Graded Sand with Silt (SP-SM)"; about 90 % fine to medium sand; about 10 % nonplastic fines; dry, reddish-brown, strong reaction with HCl.

X2.4.3 *Broken Shells*—About 60 % gravel-size broken

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shells; about 30 % sand and sand-size shell pieces; about 10 % fines; "Poorly Graded Gravel with Sand (GP)."

X2.4.4 *Crushed Rock*—Processed from gravel and cobbles in Pit No. 7; "Poorly Graded Gravel (GP)"; about 90 % fine, hard, angular gravel-size particles; about 10 % coarse, hard, angular sand-size particles; dry, tan; no reaction with HCl.

X3. SUGGESTED PROCEDURE FOR USING A BORDERLINE SYMBOL FOR SOILS WITH TWO POSSIBLE IDENTIFICATIONS.

X3.1 Since this practice is based on estimates of particle size distribution and plasticity characteristics, it may be difficult to clearly identify the soil as belonging to one category. To indicate that the soil may fall into one of two possible basic groups, a borderline symbol may be used with the two symbols separated by a slash. For example: SC/CL or CL/CH.

X3.1.1 A borderline symbol may be used when the percentage of fines is estimated to be between 45 and 55 %. One symbol should be for a coarse-grained soil with fines and the other for a fine-grained soil. For example: GM/ML or CL/SC.

X3.1.2 A borderline symbol may be used when the percentage of sand and the percentage of gravel are estimated to be about the same. For example: GP/SP, SC/GC, GM/SM. It is practically impossible to have a soil that would have a borderline symbol of GW/SW.

X3.1.3 A borderline symbol may be used when the soil could be either well graded or poorly graded. For example: GW/GP, SW/SP.

X3.1.4 A borderline symbol may be used when the soil could either be a silt or a clay. For example: CL/ML, CH/MH, SC/SM.

X3.1.5 A borderline symbol may be used when a fine-grained soil has properties that indicate that it is at the boundary between a soil of low compressibility and a soil of high compressibility. For example: CL/CH, MH/ML.

X3.2 The order of the borderline symbols should reflect similarity to surrounding or adjacent soils. For example: soils in a borrow area have been identified as CH. One sample is considered to have a borderline symbol of CL and CH. To show similarity, the borderline symbol should be CH/CL.

X3.3 The group name for a soil with a borderline symbol should be the group name for the first symbol, except for:

CL/CH lean to fat clay
ML/CL clayey silt
CL/ML silty clay

X3.4 The use of a borderline symbol should not be used indiscriminately. Every effort shall be made to first place the soil into a single group.

X4. SUGGESTED PROCEDURES FOR ESTIMATING THE PERCENTAGES OF GRAVEL, SAND, AND FINES IN A SOIL SAMPLE

X4.1 *Jar Method*—The relative percentage of coarse- and fine-grained material may be estimated by thoroughly shaking a mixture of soil and water in a test tube or jar, and then allowing the mixture to settle. The coarse particles will fall to the bottom and successively finer particles will be deposited with increasing time; the sand sizes will fall out of suspension in 20 to 30 s. The relative proportions can be estimated from the relative volume of each size separate. This method should be correlated to particle-size laboratory determinations.

X4.2 *Visual Method*—Mentally visualize the gravel size particles placed in a sack (or other container) or sacks. Then, do the same with the sand size particles and the fines. Then, mentally compare the number of sacks to estimate the percentage of plus No. 4 sieve size and minus No. 4 sieve size present. The percentages of sand and fines in the minus sieve size No. 4 material can then be estimated from the wash test (X4.3).

X4.3 *Wash Test (for relative percentages of sand and fines)*—Select and moisten enough minus No. 4 sieve size material to form a 1-in (25-mm) cube of soil. Cut the cube in half, set one-half to the side, and place the other half in a small dish. Wash and decant the fines out of the material in the dish until the wash water is clear and then compare the two samples and estimate the percentage of sand and fines. Remember that the percentage is based on weight, not volume. However, the volume comparison will provide a reasonable indication of grain size percentages.

X4.3.1 While washing, it may be necessary to break down lumps of fines with the finger to get the correct percentages.

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X5. ABBREVIATED SOIL CLASSIFICATION SYMBOLS

X5.1 In some cases, because of lack of space, an abbreviated system may be useful to indicate the soil classification symbol and name. Examples of such cases would be graphical logs, databases, tables, etc.

X5.2 This abbreviated system is not a substitute for the full name and descriptive information but can be used in supplementary presentations when the complete description is referenced.

X5.3 The abbreviated system should consist of the soil classification symbol based on this standard with appropriate lower case letter prefixes and suffixes as:

Prefix:	Suffix:
s = sandy	s = with sand
g = gravelly	g = with gravel
	c = with cobbles
	b = with boulders

X5.4 The soil classification symbol is to be enclosed in parenthesis. Some examples would be:

Group Symbol and Full Name	Abbreviated
CL, Sandy lean clay	s(CL)
SP-SM, Poorly graded sand with silt and gravel	(SP-SM)g
GP, poorly graded gravel with sand, cobbles, and boulders	(GP)scb
ML, gravelly silt with sand and cobbles	g(ML)sc

SUMMARY OF CHANGES

In accordance with Committee D18 policy, this section identifies the location of changes to this standard since the last edition (1993$^{\epsilon 1}$) that may impact the use of this standard.

(1) Added Practice D 3740 to Section 2.

(2) Added Note 5 under 5.7 and renumbered subsequent notes.

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Designation: D 4547 – 03

Standard Guide for Sampling Waste and Soils for Volatile Organic Compounds[1]

This standard is issued under the fixed designation D 4547; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval. A superscript epsilon (ε) indicates an editorial change since the last revision or reapproval.

1. Scope

1.1 This guide describes recommended procedures for the collection, handling, and preparation of solid waste, soil, and sediment samples for subsequent determination of volatile organic compounds (VOCs). This class of compounds includes low molecular weight aromatics, hydrocarbons, halogenated hydrocarbons, ketones, acetates, nitriles, acrylates, ethers, and sulfides with boiling points below 200° Celsius (C) that are insoluble or slightly soluble in water.

1.2 Methods of sample collection, handling, storage, and preparation for analysis are described.

1.3 This guide does not cover the details of sampling design, laboratory preparation of containers, and the analysis of the samples.

1.4 It is recommended that this guide be used in conjunction with Guide D 4687.

1.5 *This standard does not purport to address all of the safety concerns, if any, associated with its use. It is the responsibility of the user of this standard to establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.* See 7.2 and 8.1.1 for specific warnings.

2. Referenced Documents

2.1 *ASTM Standards:*

D 3550 Practice for Thick Wall Ring-Lined, Split Barrel, Drive Sampling of Soils[2]

D 4687 Guide for General Planning of Waste Sampling[3]

D 4700 Guide for Soil Sampling from the Vadose Zone[2]

D 5058 Test Methods for Compatibility of Screening Analysis of Waste[3]

D 5792 Practice for Generation of Environmental Data Related to Waste Management Activities: Development of Data Quality Objectives[3]

D 6051 Guide for Composite Sampling and Field Subsampling for Environmental Waste Management Activities[3]

D 6418 Practice for Using the Disposable En Core Sampler for Sampling and Storing Soil for Volatile Organic Analysis[3]

D 6640 Practice for Collection and Handling of Soils Obtained in Core Barrel Samplers for Enviromental Investigations[3]

E 856 Definitions of Terms and Abbreviations Relating to Physical and Chemical Characteristics of Refuse-Derived Fuel[3]

2.2 *Federal Standard:*

Title 49 Transportation, Code of Federal Regulations (CFR), Part 172, List of Hazardous Substances and Reportable Quantities[4]

3. Terminology

3.1 *sample*, *n*—a portion of material taken from a larger quantity for the purpose of estimating properties or composition of the larger quantity. **(E 856)**

3.2 *subsample*, *n*—a portion of a sample taken for the purpose of estimating properties or composition of the whole sample. **(D 6051)**

3.2.1 *Discussion*—A subsample, by definition, is also a sample.

4. Summary of Guide

4.1 This guide addresses the use of tools for sample collection and transfer, conditions for sample storage, sample preservation, and two common means of sample preparation for analysis. Special attention is given to each step from sample collection to analysis to limit the loss of VOCs by volatilization and biodegradation. The sample collected and analyzed should be representative of the matrix material sampled. The two methods cited for the preparation of samples for VOC analysis are methanol extraction and vapor partitioning (that is, purge-and-trap and headspace). The method of sample preparation for VOC analysis should be consistent with the data quality objectives (see Practice D 5792).

5. Significance and Use

5.1 This guide describes sample collection and handling procedures designed to minimize losses of VOCs. The principal mechanisms for the loss of VOCs from materials during

[1] This guide is under the jurisdiction of ASTM Committee D34 on Waste Management and is the direct responsibility of Subcommittee D34.01.02 on Monitoring.

Current edition approved June 10, 2003. Published August 2003. Originally approved in 1991. Last previous edition approved in 1998 as D 4547 - 98.

[2] *Annual Book of ASTM Standards*, Vol 04.08.

[3] *Annual Book of ASTM Standards*, Vol 11.04.

[4] Available from Superintendent of Documents, U.S. Government Printing Office, Washington, DC 20402.

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collection, handling and storage are volatilization and biodegradation. Susceptibility of various VOCs to these two loss mechanisms is both compound and matrix specific. In general, compounds with higher vapor pressures are more susceptible to volatilization than compounds with lower vapor pressures. Also, aerobically degradable compounds are generally more susceptible to biodegradation than anaerobically degradable compounds. In some cases, the formation of other compounds not originally present in the material can occur. Loss or gain of VOCs leads to analytical results that are unrepresentative of field conditions.

5.2 Ancillary information concerning sample collection, handling and storage for VOC analysis is provided in Appendix X1 and Appendix X2. These appendixes and cited references are recommended reading for those unfamiliar with the many challenges presented during the collection, handling and storage of samples for VOC analysis.

6. Selection of Sample Preparation Method for VOC Analysis

6.1 *Introduction*:

6.1.1 Sample collection, handling, and preservation methods should be compatible with the method used to prepare the sample for VOC analysis, and meet the project's data quality objectives (see Practice D 5792). Preparation of a sample for instrumental analysis can be initiated either in the field or laboratory. In either case, prior to analysis, the sample should be placed into a tared volatile organic analysis (VOA) vial or bottle meeting the specifications given in 7.3. When working with an uncharacterized solid waste, it is advisable to perform compatibility tests (see Test Methods D 5058) between the sample material and the solution (see 6.2 and 6.3) into which it will be transferred in preparation for analysis. For instance, when collecting highly contaminated soils or waste of unknown composition, it is strongly recommended that preliminary testing be performed to adequately characterize the waste materials so that when the user applies the procedures cited in this guide, there will be no chemical reaction which may jeopardize the user's safety.

6.1.2 Figs. 1 and 2 are flow diagrams showing some different options for combining sample collection, handling and preparation methods for instrumental analysis.

6.2 *Methanol Extraction*:

6.2.1 This method involves the extraction of VOCs from a sample with methanol and the subsequent transfer of an aliquot of the extract to water for either purge-and-trap or headspace analysis.

6.2.2 Advantages of methanol extraction are (*1*) large samples or composite samples, or both, can be collected to enhance representatives (see Guide D 6051), (*2*) biodegradation is inhibited, (*3*) an efficient extraction of VOCs from the matrix materials can be achieved with methanol due to its strong affinity for these compounds and favorable wetting properties, (*4*) a subsample can be analyzed several times, and

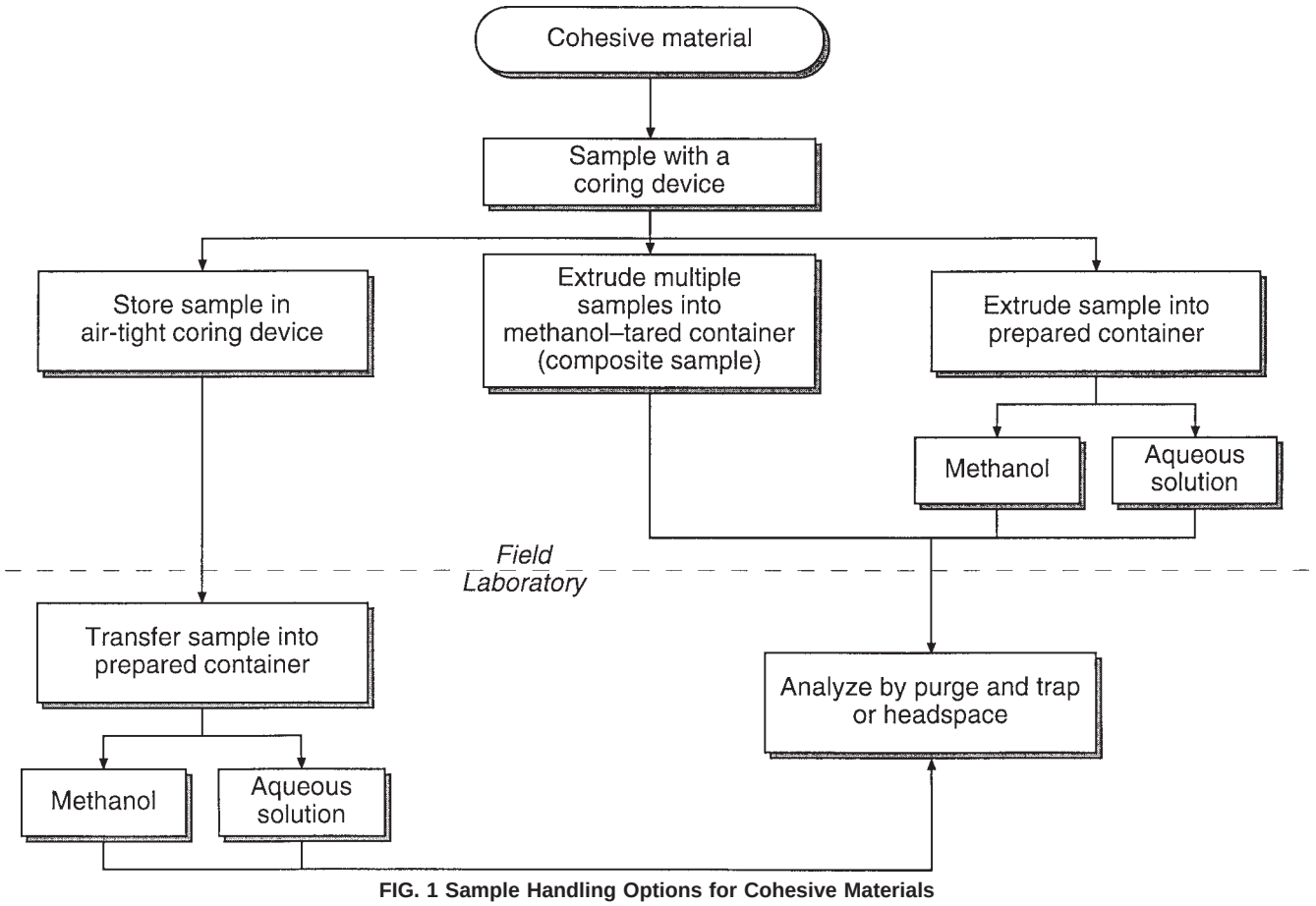

FIG. 1 Sample Handling Options for Cohesive Materials

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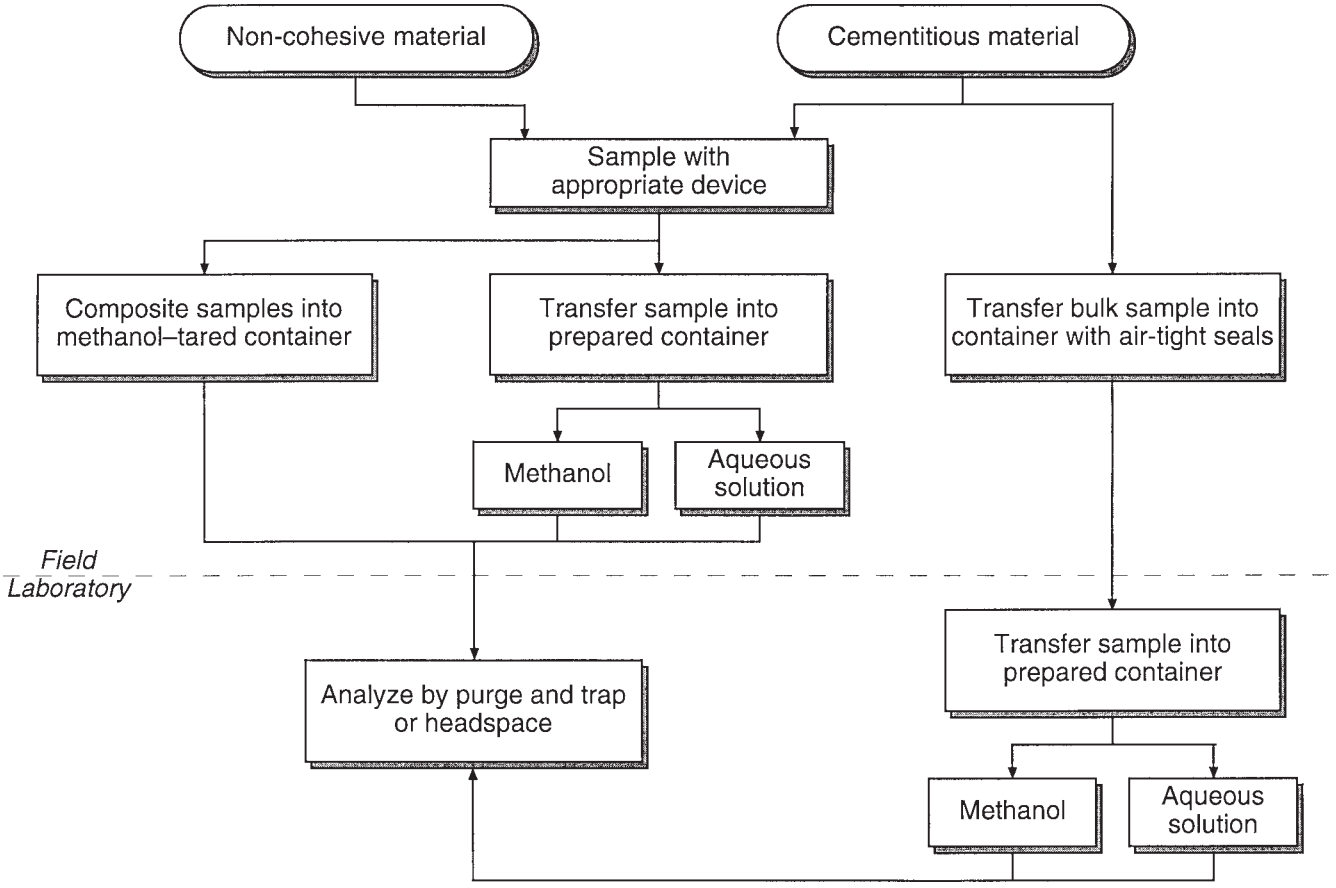

FIG. 2 Sample Handling Options for Non-Cohesive and Cementitious Materials

(*5*) sample extracts can be archived, if verified that VOC losses have not occurred (see 10.1.1)).

6.2.3 The primary disadvantages of methanol extraction are (*1*) samples may have to be shipped as a flammable liquid depending on the amount of methanol present (for example, U.S. DOT reg. 49CFR§172.101), (*2*) hazards to personnel due to methanol's toxicity and flammability, (*3*) detection limits are elevated due to analyte dilution, (*4*) possible interference of the methanol peak with VOCs of interest, (*5*) potential adverse impact of methanol on the performance of certain gas chromatograph/detector systems, and (*6*) samples extracted with methanol must be disposed of as a regulated waste.

6.2.4 Logistical challenges of performing these tasks in the field can be overcome by extracting samples with methanol once they have been received in a laboratory, provided that the samples are transported in an airtight container (see 7.3.2, 9.1 and 9.2). Furthermore, if VOC levels are unknown, a replicate sample can be obtained and screened to determine if methanol extraction is appropriate for the expected contaminant concentrations.

6.3 *Vapor Partitioning*:

6.3.1 Vapor partitioning involves the direct analysis of a sample by either purge-and-trap or headspace. In both cases, the sample is placed into a tared volatile analysis (VOA) vial containing water or a preservative solution (for example, acidified water) from which the vapor is removed for analysis without the container being opened.

6.3.2 The principal advantages of this method are (*1*) it can offer lower detection limits than methanol extraction because no dilution is involved, (*2*) there are no organic solvent interferences, and (*3*) there is no use of regulated organic solvents, which may require special shipment, disposal, and field handling practices.

6.3.3 The disadvantages associated with vapor partitioning are (*1*) the VOA vial (VOA vials are different sizes for automated purge-and-trap and headspace instrumentation) or adapter used in conjunction with a VOA vial, or both, often are instrument specific, (*2*) sample size is limited (<10 g) by automated systems, (*3*) a matrix-appropriate method of preservation may be necessary (see Appendix X2), (*4*) vapor partitioning is less efficient at recovering VOCs from some materials than methanol extraction, and (*5*) when using purge-and-trap, only a single analysis of the same sample can be made; similarly only a single analysis may be possible with headspace analysis unless concentrations allow for the use of a small injection volume.

6.3.4 Limitations imposed by vapor phase partitioning methods with regard to number of analyses that can be performed on a single sample can be addressed by taking replicate samples.

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6.3.5 When employing vapor phase partitioning methods, the logistical challenges of performing sample preparation in the field (see 7.3.3) can be avoided by performing the preparation step in the laboratory, so long as the sample is transported to the laboratory in an airtight container (see 7.2.1). If VOC levels are unknown, a replicate sample can be obtained and screened to determine if it is appropriate to use a vapor partitioning method of sample preparation.

7. Sampling Tools and Containers

7.1 All sample handling devices and vessels used to collect and store samples for analysis should be constructed of nonreactive materials that will not sorb, leach or diffuse constituents of interest. Examples of materials that meet these criteria are glass, stainless steel, steel, and brass. Materials, such as polytetrafluorethylene (PTFE) and many rigid plastics also can be used, however, it should be recognized that they may have some limited adsorptive properties or allow slow diffusive passage of some VOCs. Materials which show limited reactivity can be used when they have a very short period of contact with the sample or when they are necessary for making airtight (hermetic) seals. Collection tools and storage containers made of materials other than those cited in this section should only be used after they have demonstrated equivalency. All collection tools and storage containers should be cleaned in a manner consistent with their intended use.

7.2 *Tools*—There are often several steps to sampling, particularly if it involves obtaining bulk materials from subsurface regions. Most of the equipment used to obtain samples from the subsurface was originally developed for the geotechnical industry. These subsurface bulk sample retrieval systems are designed to obtain intact cylindrical cores of material, ranging anywhere from 1 to 4 in. in diameter, and 1 to several ft in length. Two commonly used collection devices for subsurface sample collection are the split-spoon corer that opens to expose the entire length of the material obtained for subsampling and core barrel liners (that is, ring-lined barrel sampling, see Practice D 3550) that typically are subsampled through the open ends. Core barrel liners fit snugly within a corer and come in a variety of lengths and materials (stainless steel, brass, PTFE, rigid plastics, etc.). Several liners, or a single long liner, can be placed within the core barrel, depending on the sampling plan (See **Warning** at the end of this paragraph). Additional information on the application and design of different types of subsurface collection systems available can be found in Guide D 4700. Subsurface materials retrieved for VOC characterization should be obtained (sampling tubes filled and brought to the surface) as quickly as possible and remain intact and undisturbed until they are subsampled (see Practice D6640). Subsampling of a bulk sample should occur within a couple minutes of its being brought to the surface (see 8.1 through 8.3 for additional sampling guidance). (**Warning**—Core barrel liners are not recommended for storage of samples intended for VOC analysis because they do not have airtight seals (see Appendix X1).)

7.2.1 In addition to the coring devices which retrieve bulk quantities of material, there are smaller hand operated coring tools for obtaining samples of the appropriate size (for example, coring devices capable of collecting 3- and 15-cm^3 volumes, for collection of approximately 5- and 25-g samples, respectively) for analysis (see Fig. 3). If one of these smaller coring devices is used to store the sample (see 9.1.1) for more than a few seconds, the main body should be constructed of materials that are nonreactive and have airtight seals that show limited sorption and penetration of VOCs. When the coring device is only used to rapidly transfer the sample to a VOA vial, corer material requirements are less stringent.

7.3 *Containers*—VOA vials and bottles used for storage and preparation of samples for analysis should be made of glass and have airtight seals. To achieve an airtight seal, these containers should have a thick septum cushion between the sealing material (PTFE) and cap (rigid plastic screw cap or aluminum crimp top). PTFE-lined caps that do not have flexible septum backing often fail to achieve a liquid or airtight seal. Furthermore, the thickness of the PTFE used for a lined septum, should be at least 10 mil.

7.3.1 *Preparation of VOA Vial or Bottle*—Record the tared weight of the VOA vial or bottle and cap prior to the sampling event. Moreover, depending on the method of sample preparation and analysis, the vessel may also contain a solvent, or VOC free water, and if required a PTFE or glass coated stir bar at the time of sample collection (see Section 9).

7.3.2 *Preparation of Containers for Methanol Extraction*—Container preparation applies to both field and laboratory sample preparation. The appropriate volume of analytical-grade methanol (high performance liquid chromatography, spectrographic or purge and trap) is added to the organic-free container by the laboratory that supplies the container, by the sample collector, or by a third party. The party that adds the methanol to the container should also be responsible for providing trip blanks (see Guide D 4687). If methanol is present in the sample container in the field, this container should be opened only to add the sample(s). The tared weight of the container with methanol should be recorded prior to adding the sample to the container. A predetermined volume of sample that corresponds to a weight in grams (g) that is equivalent to or less than the volume (mL) of methanol can then be introduced. The ratio (typically 1:1 to 10:1, methanol to material) between the two constituents should allow for formation of a clear layer of methanol over the sample after thorough mixing. The difference in weight of the container and cap, measured before and after the sample is introduced, is used to establish the sample's wet weight. Because of the water (moisture) present in most samples, calculation of the recovery of sample analyte concentrations should account for this source of dilution.

7.3.3 *Preparation of Containers for Vapor Partitioning*—Container preparation applies to both field and laboratory sample preparation. This method allows for the direct analysis of a sample by either purge-and-trap or headspace techniques. In both cases, the sample is placed into a VOA vial from which the vapor (only a portion for headspace analysis) is removed for analysis without the container being opened. Moreover, water that contains no detectable levels of VOCs and if required a PTFE or glass coated stir bar should be present in the VOA vial prior to introducing the sample. Current automated equipment for purge-and-trap and headspace systems

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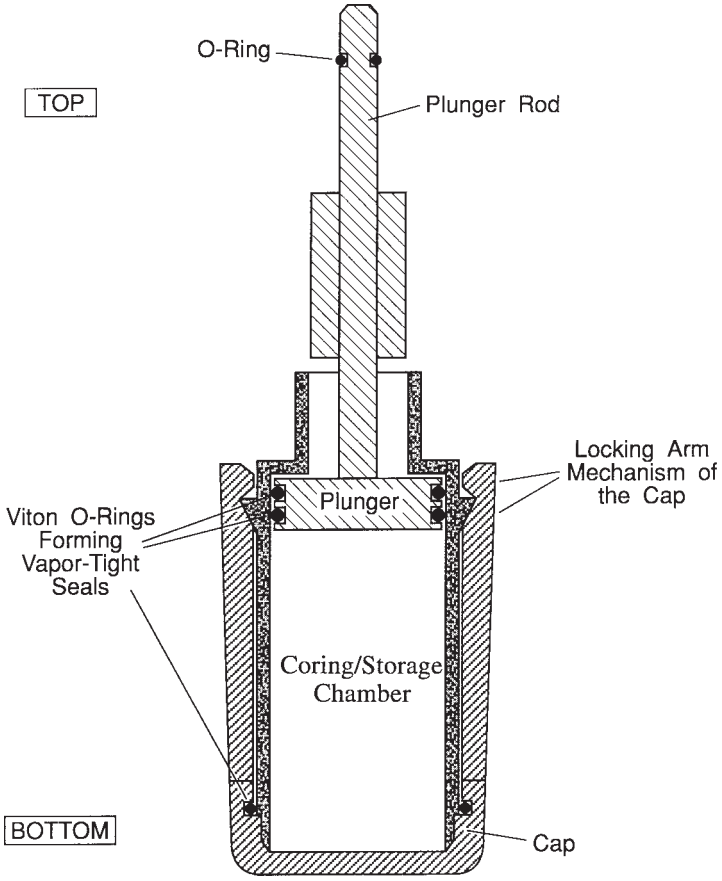

FIG. 3 Components of the En Core Sampler

use 44- (or 40-) and 22-mL VOA vials, respectively. The volume of water used for these two different systems is typically 10 mL or less. Furthermore, the tared weight of the container should be recorded prior to adding the sample. The difference in weight of the container, measured before and after the sample is added, is used to determine the sample's wet weight.

7.3.4 *Preparation of Samples Transported and Stored in Solventless VOA Vials or Bottles*—When samples are held in a VOA vial or bottle, methanol can be added to the container by piercing the septum. In the case of a 5-g sample contained in a 40-mL VOA vial, 5.0 mL of methonal can be added without over pressurization. When larger samples and bottles, or both, are used, experimental trials should be performed to establish what volume of solution can be added. If performed manually, a 23-gage or smaller needle should be used to add the methanol. After the methanol is introduced, the soil sample should be dispersed. If the sample is held beyond the laboratory-prescribed extraction and analysis period (typically 24 h or less), it is recommended that either the pierced septum be replaced with one that is intact or that an aliquot of the methanol be transferred to an appropriate vessel for storage. If the pierced septum is replaced, it should be replaced with one that is intact by replacing the cap of the vial or bottle with a cap having an intact septum. When the laboratory prescribed extraction method uses elevated temperatures, or sonication, or both, it is recommended that the pierced septum be replaced prior to this treament. To limit the loss of VOCs when replacing the cap or transferring an aliquot of methanol, the container should be cooled to 4 ± 2°C, and these functions should be performed as quickly as possible. Cooling the sample lowers the vapor pressure of the analytes of interest and reduces the pressure created by adding the methanol. By having methanol present in the collection vessel prior to introducing the sample, the additional precautions associated with a pierced septum can be avoided. In addition, having methanol present in the collection vessel reduces the possibility of VOCs being lost during the transfer step (that is, extrusion of a plug of soil from the sampling tool into the empty vessel.)

8. Sample Collection

8.1 *General Sampling Guidance*—Using an appropriate sized coring tool (see below), collect samples from freshly exposed surfaces of the soil or waste with minimal disturbance. The soil or waste to be sampled may be an intact pit face or the relatively undisturbed contents of a split-barrel sampler or a core barrel liner. Before sampling, remove several centimeters of material to expose a fresh surface. Obtain a sample by pressing (or hammering in a few cases) the end of the coring tool into the pit face or into the end or side of a larger core sample. Remove the coring tool. The optimum diameter of the coring tool depends on the following: size of the opening on the collection vial or bottle (tool should fit inside mouth), particle size of the solid materials (for example, gravel-size

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particles would require larger samplers), and volume of sample required for analysis. For example when a 5-g sample of soil is specified, only a single 3-cm^3 volume would need to be collected (assuming the soil has density of 1.7 g/cm^3). Larger sample masses or composite samples may be preferred as the heterogeneity of the material increases.

8.1.1 *Sampling of Cohesive but Uncemented Materials Using Devices Designed to Obtain a Sample Appropriate for Analysis*—Collect appropriate size sample for analysis using a metal or rigid plastic coring tool (Figs. 3 and 4). For example, coring tools for the purpose of transferring a sample can be made from disposable plastic syringes by cutting off the tapered front end and removing the rubber cap from the plunger (see **Warning** at the end of this paragraph). These smaller coring devices help maintain the sample structure during collection and transfer to the VOA vial or a larger bottle. When inserting a clean coring tool into a fresh surface for sample collection, air should not be trapped behind the sample. If air is trapped, it could either pass through the sampled material causing VOCs to be lost or cause the sample to be pushed prematurely from the coring tool. For greater ease in pushing coring tools into the solid matrix, their front edge can be sharpened. (**Warning**—This type of coring device is not appropriate for sample storage.)

8.1.2 Obtain an undisturbed sample by pushing the barrel of the coring tool into a freshly exposed surface and removing the corer once filled. Clean the exterior of the barrel by wiping with a clean disposable towel. If the coring tool is an En Core[5] sampler and it is used as a storage container, cap the open end after ensuring that the sealing surfaces are cleaned (see 9.1.1). If the device is solely used for collection and not storage, immediately extrude the sample into a tared VOA vial or bottle by gently pushing the plunger. During transfer of the sample into the container, care should be taken to prevent the sample from contacting the sealing surfaces which can comprise these surfaces and prevent an airtight seal. The volume of material collected should not cause excessive stress on the coring tool during intrusion into the material, or be so large that the sample easily falls apart during extrusion. Obtaining and transferring a sample should be done rapidly (<10 s) to reduce volatilization losses. If the vial or bottle contains methanol or another liquid,

[5] En Core sampler, En Novative Technologies, Inc., 1241 Bellevue St, Green Bay, WI 54302. The En Core sampler is covered by a patent. Interested parties are invited to submit information regarding the identification of an alternative(s) to this patented item to the ASTM Headquarters. Your comments will receive careful consideration at a meeting of the responsible technical committee, which you may attend.

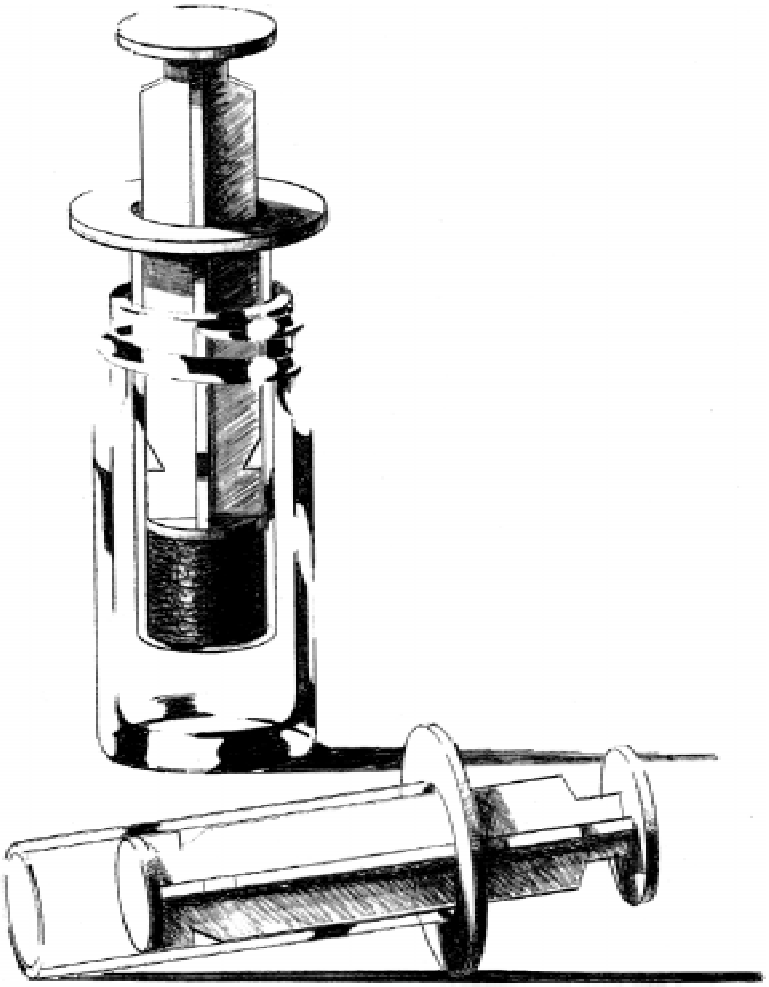

FIG. 4 A Coring Tool Made by Cutting the Tip Off a Plastic Syringe

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it should be held at an angle when extruding the sample into the container to minimize splashing. Just before capping, a visual inspection of the lip and threads of the sample vessel should be made, and any foreign debris should be removed with a clean towel, allowing an airtight seal to form.

8.2 *Devices That Can be Used for Sampling a Cemented Material*—Samples of hard or cementitious material may be obtained by fragmenting a larger portion of the material using a clean chisel to generate aggregate(s) of a size that can be placed into a tared VOA vial or bottle. When transferring the aggregate(s), precautions must be taken to prevent compromising the sealing surfaces and threads of the container. Losses of VOCs by using this procedure are dependent on the location of the contaminant relative to the surface of the material being sampled. Therefore, caution should be taken in the interpretation of the data obtained from materials that fit this description. As a last resort when this task can not be performed on-site, a large sample can be collected in a vapor-tight container and transported to the laboratory for further processing (see 9.1 and 9.2). Collecting, fragmenting, and adding the sample to a container should be accomplished as quickly as possible.

8.3 *Devices That Can be Used for Sampling a Noncohesive Material*—When sampling gravel, or a mixture of gravel and fines, that can not be easily obtained or transferred using coring tools, as a last resort, a sample can be quickly transferred using a spatula or scoop (see discussion concerning the use of a spatula or scoop to collect samples for VOC analysis, in Appendix X1). If the tared collection vial or bottle contains methanol or an aqueous solution, transfer the sample to the vial or bottle with minimal splashing and without the spatula or scoop contacting the liquid contents. For some solids, a wide-bottom funnel or similar channeling device may be necessary to facilitate transfer to the container and prevent compromising of the sealing surfaces of the container. Caution should be taken in the interpretation of the data obtained from materials that fit this description. Losses of VOCs are likely because of the nature of the sampling method and the noncohesive nature of the material exposes more surface area to the atmosphere than for other types of samples. Another potential source of error during the sampling process, is the separation of coarser materials from fines, which can bias the concentration data if the different particle sizes, which have different surface areas, are not properly represented in the sample.

8.4 *Sampling Location Physical Characteristics*—Collect a separate co-located sample within a couple of centimeters and from the same stratum and place in a suitable container for the determination of percent moisture content of the waste or soil. This sample should be collected in a container suitable for the retention of soil moisture. The location adjacent to where the sample for VOC analysis was collected should be inspected visually and its characteristics logged. This adjacent material can also be retained for determining other relevant properties, such as general appearance, color, presence of oils, other visible signs of contamination, grain-size distribution, organic carbon content, etc. Collection of these ancillary samples should be performed after the collection of samples for VOC analysis.

9. Sample Storage, Transportation, and Preservation

9.1 *Sample Storage and Transportation*:

9.1.1 *General Considerations*—During an initial 48 h storage and transportation period, all samples for VOC analysis should be held in air-tight containers and cooled to at least 4 ± 2°C.[6] For storage periods beyond 48 h, these air-tight containers (for example, VOA vial or En Core sampler [see Note 1]), should contain a chemical preservative or be held under conditions that ensure retention of the analytes of concern (see 9.2).

NOTE 1—The disposable En Core sampler is a coring device for collection, storage, and transfer of soil samples. This device meets the specifications discussed in 7.2.1 and 8.1.1. Guidance on the use of the En Core sampler is given in Practice D 6418.

9.2 *Sample Preservation Beyond 48 Hours*:

9.2.1 Currently, it is recommended that samples stored in an air-tight container should be held for no longer than 48 h at 4 ± 2°C prior to analysis or preservation. Longer storage times at 4 ± 2°C can be applied if it can be demonstrated that the VOC concentrations are not affected or that the data generated at the time of analysis meets the data quality objectives. Extended sample storage can be achieved by using either physical or chemical methods of preservation. Sample preservation can be initiated at the time of sample collection or after arrival in a laboratory.

9.2.2 *Physical Preservation*—Samples contained in a VOA vial, a bottle, or coring device are physically preserved by low temperature storage (for example, preferably in a freezer set for -12 ± 5°C, or by using a temporary refrigerant, for example, a mixture of salt and ice or dry ice, see Appendix X2). Under this condition, sample storage (total time period starting at collection) can be extended up to 14 days. Longer periods of low temperature storage can be used provided it can be demonstrated that the VOC concentrations are not affected or that the data generated at the time of analysis meets the data quality objective. When low temperature storage is used for samples intended for analysis by vapor partitioning, VOC free water and if required a PTFE or glass coated stir bar should be present prior to adding the sample in the field (see 7.3.3). Special precautions may be necessary, for example, positioning the sample vessel on its side, when using a low temperature condition with VOA vials smaller than 40 mL, or when more than 5 mL of water is present, because of the potential for breakage caused by the formation of ice. When the sample is intended to be prepared by methanol extraction, this solvent can be introduced through the septa of the storage vessel after low temperature storage (see 7.3.4). In either case, immediately following low temperature storage of samples in VOA vials or bottles, the caps should be checked and tightened, if necessary. For the En Core sampler, the sample is extruded into a prepared VOA vial after low-temperature storage (see Practice D 6418).

9.2.3 *Chemical Preservation*—Samples immersed in methanol are chemically preserved. Under this condition, storage (total time period starting at collection) at 4 ± 2°C can be extended for up to 14 days. Longer periods of methanol

[6] SW-846, Method 5035, 3rd Update.

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preservation can be used provided if it can be demonstrated that the VOC concentrations are not affected or that the data generated at the time of analysis meets the data quality objectives. A chemical preservation method for samples intended to be analyzed by vapor partitioning, is acidification to a pH of 2 or less with either sodium bisulfate or hydrochloric acid. However, VOC samples containing carbonates should not be added to an acidic solution because of effervescence (for guidance on testing for carbonates and the use of these acids to preserve samples, see Appendix X3). Precautions must also be taken when preserving by acidification because certain compounds within the following classes; olefins, ketones, esters, ethers, and sulfides, will react under a low pH condition (see Appendix X2 for other potential problems). Acidified sample storage (total time period starting at collection) can be extended for up to 14 days at 4 ± 2°C. Longer periods of acidified sample storage can be used provided it can be demonstrated that the VOC concentrations are not affected or that the data generated at the time of analysis meets the data quality objectives.

10. Sample Preparation

10.1 *Methanol Extraction*—Completely disperse samples in methanol, if possible, by shaking, vortexing or by sonication. Allow suspended particulates to settle so that an aliquot of clear supernatant can be removed for analysis. Some materials will show a slow release of VOCs to methanol; therefore, the dissolved VOC concentration may increase with increasing extraction time (see Appendix X1). This increased extraction of VOCs over time may be particularly pronounced with cementitious materials or materials that strongly adsorb VOCs. Transfer of an aliquot for analysis should be performed using a clean liquid-tight syringe (composed of glass and metal) to withdraw the aliquot through the septum of the sample container. If necessary, the cap of the sample container can be removed, and an aliquot can be collected with either a clean syringe or pipette. However, the time that the cap is off the sample container should be minimized as much as possible to limit volatilization losses of solvent and VOCs. For purge-and-trap analysis, methanol aliquot volumes of less than 0.2 mL are typically transferred to a vessel containing 5 mL of organic-free water. For headspace analysis, methanol aliquot volumes as large as 1.0 mL, depending on the detector and analytes of concern, can be transferred to VOA vials containing 10 mL of organic-free water. When the re-analysis of the sample extract is a possibility, an aliquot of the extract should be archived by transferring it to an airtight vial (for example, 2 mL) with a PTFE-lined cap.

10.1.1 Periodic weighing of the sample container can be used to determine if a hermetic seal is being maintained, that is, no weight loss of methanol.

10.2 *Vapor Partitioning*—Completely disperse samples in water, if possible, by shaking, vortexing or by sonication. This mixing of the solid material with the aqueous solution not only helps prevent the plugging of the sparging needle used by purge-and-trap systems but also assists in attaining an equilibrium state by completely exposing the sample to the partitioning solution. To enhance partitioning into the vapor phase, automated purge-and-trap and headspace analysis systems warm the sample to a selected temperature (typically 40°C for purge-and-trap, this temperature or higher for headspace) prior to removing vapors for analysis.

11. Keywords

11.1 field sampling; methanol extraction; sample collection; sample handling; soil; solid wastes; vapor phase partitioning; volatile organic compounds

APPENDIXES

(Nonmandatory Information)

X1. ADDITIONAL INFORMATION CONCERNING SAMPLE COLLECTION AND HANDLING FOR VOC ANALYSIS.

X1.1 Volatile organic compounds (VOCs) are among the most frequently identified soil contaminants at Superfund and other hazardous waste sites. Because some VOCs are potentially mutagenic, carcinogenic, and teratogenic, they often are key factors in the risk assessment process at these sites. These risk assessments and other remedial decisions depend upon an accurate understanding of the levels and extent of VOC contamination in soils and other materials.

X1.2 In most materials, VOCs coexist as gaseous, liquid, and solid (sorbed) phases. The VOC equilibrium that exists among these phases is controlled by physiochemical properties, material properties, and environmental variables (**1, 2**).[7] Unaccounted loss of analytes from any phase may result in rendering the sample unrepresentative of the material from which it was taken. For this reason, sample collection, handling, and analysis must be performed under conditions that maintain the accountability of all phases present (**3**).

X1.3 In general, uncontrolled losses of VOCs from materials occur through two mechanisms: volatilization and biodegradation. Volatilization losses occur whenever gaseous molecules, which have diffusion coefficients up to four orders of magnitude greater than liquid diffusion coefficients, are allowed to move freely. Therefore, whenever a new surface is exposed, VOC losses are incurred. The extent to which VOCs are lost depends on the vapor phase concentration (analyte vapor pressure), surface area exposed, duration of exposure, porosity of matrix, and perhaps meteorological conditions (**4**).

[7] The boldface numbers in parentheses refer to a list of references at the end of this standard.

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X1.4 Biological degradation of VOCs in samples is usually dominated by aerobic processes because many conventional intrusive collection methods expose the sample to the atmosphere. The rate of this biological degradation is dependent on several factors, including the indigenous microbiological population, chemical properties of the VOC, and temperature. Provided that sufficient quantities of electron acceptors, nutrients, and moisture are present, indigenous microbes continue to aerobically degrade compounds even when stored at 4°C (**5**). Non-halogenated aromatic compounds are quite susceptible to this loss mechanism. To inhibit biodegradation of these compounds, the sample can be immersed in methanol, frozen (see Appendix X2), or acidified to a pH of 2 or less.

X1.5 One sampling procedure that fails to achieve accountability of all VOC phases is the collection of a bulk sample by using a spatula-type device to completely fill a bottle for sample storage and transportation (**4, 6-10**). Samples collected and transferred with spatula-type devices fail to control surface area exposure. Moreover, in the process of filling a bulk sample bottle to capacity, the sealing surfaces often become compromised (dirty), preventing a vapor-tight seal during storage. For these reasons this procedure has been shown to result in concentrations that are less than 10 % of the in-situ contamination (**6-9**).

X1.6 Another procedure that often performs poorly is the use of core barrel liners covered with either PTFE or aluminum foil for sample transportation and storage, because these barriers fail to serve as air-tight seals (**3, 11**). Sheets of PTFE that are only 2 or 3 mil (mil = 0.001 in.) thick are easily penetrated by VOC vapors. Elastic formulations of PTFE (for example, white plumber's tape) show much greater rates of VOC penetration than non-elastic semi-translucent formulations. Aluminum foil fails because an airtight seal is often not achieved when this material is folded over the end of a core barrel liner and it sometimes corrodes allowing small holes to form. The addition of plastic caps and sealing tape does not improve the performance of either PTFE or aluminum foil, since pliable plastics sorb VOCs and sealing tapes often contain VOCs in the adhesive, which serves as a potential artifact source.

X1.7 The procedures discussed in this guide are designed to limit VOC losses by volatilization and biodegradation. This is accomplished by stressing that (*1*) samples be collected only from freshly exposes surfaces, (*2*) collection and transfer of a sample be performed quickly and with minimal disruption to its physical state, (*3*) samples be held under conditions that ensure retention of the analytes of interest, and, (*4*) in the case of samples collected for vapor partitioning methods of analysis (purge-and-trap or headspace), the VOA vial's airtight seal never be broken prior to analysis.

X1.8 An additional source of inaccuracy in VOC analyses is their incomplete extraction from the sampled material (**12-17**). This source of error can either be due to differences between sample preparation methods (that is, methanol extraction versus vapor partitioning) or the kinetics of the desorption processes. In general, as the indigenous total organic carbon content increases in a matrix, recoveries using vapor partitioning methods would be expected to decrease compared to methanol extraction, particularly for the more hydrophobic analytes (**17**). Heat or sonication, or both, have been shown to speed up desorption processes (that is, mass transfer of analyte from the sampled matrix to the vapor phase or methanol); therefore, these more aggressive extraction steps should be considered when a total VOC concentration is needed. In some instances, incomplete extraction due to either the method used or the kinetics associated with the release of VOCs from a given matrix can result in an under estimation (perhaps as much as an order of magnitude) of the total VOC concentration present in a sample (**12, 14, 16, 17**).

X2. INFORMATION ON THE PRESERVATION OF SAMPLES BY STORAGE UNDER LOW TEMPERATURE CONDITIONS

X2.1 Losses of VOCs due to biological degradation can be abated by storing samples at low temperatures, for example, in a freezer set at -12 ± 5°C (D 6418, **18**, **19**). This method of preservation offers several advantages over the recommended in-field chemical preservation option: no prior knowledge of the VOC concentrations is necessary, fewer Department of Transportation (DOT) regulatory requirements must be met, and field personnel don't have to handle chemical solutions or weigh samples. Moreover, freezing, rather than acidification, can be used to preserve VOCs in carbonaceous soils. An additional concern with sample acidification is that with some soil matrices, the formation of acetone, a regulated compound itself, has been observed.

X2.2 Low temperatures that will freeze a soil sample can be achieved with a freezer, by mixing table salt and ice together, or by using dry ice. It is recommended that a freezer be used in preference to these other temporary refrigerants, whenever possible. These other methods of achieving low temperatures that will freeze soil are intended for short term use (1 to 3 days), and should only be used when the following precautions are taken. When using salt and ice, this mixture should be contained in plastic bags, a high quality cooler should be used, and this refrigerant should be replaced when the cooler temperature reaches -5°C. Use a thick walled Styrofoam cooler packed so that about two thirds of its volume is filled with bags containing a 1:3.6 weight ratio of NaCl to ice; initially establish a temperature of -14 ± 3°C, and keep below -5°C for up to 20 h (**18**). However, a shorter period of refrigeration below -5°C would most likely have resulted if the cooler had been opened frequently for adding or removing samples. If dry ice is used it should be placed below and above the sample containers while not coming into direct contact with them. This can be accomplished by placing the sample containers inside a cardboard box that is then placed inside the cooler with dry ice packed around the sample box. This precaution is necessary

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because when dry ice comes into direct contact with some plastic materials it can cause them to crack, or may cause the seal on a bottle to fail because materials (that is, glass and plastic) have different contractile properties. The temperature inside a cooler packed with dry ice usually can not be measured with conventional thermometers, since it is often below -20°C. This extreme low temperature may affect the integrity of the seals of the sample container. There are also some special shipping concerns with the use of these two temporary refrigerants. For the salt and ice mixture, the shipping period and conditions should be closely tracked so that the cooler temperature remains below -5°C. When dry ice is used as a refrigerant, a placard must be placed on the outside of the cooler identifying the presence of this refrigerant and its weight.

X3. TESTING FOR CARBONATES

X3.1 Soil or waste samples may contain carbonates that will generate carbon dioxide gas (CO_2) when in contact with acid preservatives. The generation of CO_2 may drive off VOCs and cause sample containers to fail due to increased pressures within the container. To determine whether carbonates are present in waste or soil, the following test should be performed.

X3.1.1 Moisten approximately 1 g of sample material that has been placed on a watch glass or similar surface with water, than stir to remove any trapped air.

X3.1.2 Add drop-wise a cold solution of 4N HC1 to the moistened material while observing for effervescence using a hand lens. If effervescence (rapid formation of bubbles) is observed, then preservation by acidification is not appropriate. If effervescence is not observed samples can be preserved by acidification. To determine the amount of hydrochloric acid or sodium bisulfate required to give a pH of 2 or less add the prescribed (usually 5 g) amount of sample material to a vessel containing 5 mL of water, mix thoroughly, then slowly add one of these acids while monitoring that pH. The volume or weight of acid determined to be necessary to achieve a pH of 2 or less should then be added to vials containing 5 mL of water, prior to adding samples of similar materials.

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Designation: D 5088 – 02

Standard Practices for Decontamination of Field Equipment Used at Waste Sites[1]

This standard is issued under the fixed designation D 5088; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval. A superscript epsilon (ε) indicates an editorial change since the last revision or reapproval.

1. Scope *

1.1 This practice covers the decontamination of field equipment used in the sampling of soils, soil gas, sludges, surface water, and ground water at waste sites which are to undergo both physical and chemical analyses.

1.2 These practices are applicable only at sites where chemical (organic and inorganic) wastes are a concern. It is not intended for use at radiological, mixed (chemical and radiological), or biohazard sites.

1.3 Procedures are included for the decontamination of equipment which comes into contact with the sample matrix (sample contacting equipment) and for ancillary equipment that has not contacted the portion of sample to be analyzed (non-sample contacting equipment).

1.4 These practices are based on commonly recognized methods by which equipment may be decontaminated. The procedures described for sample contacting equipment are commonly prescribed, however there is a minimum of scientific data that supports these methods (Mickam et al. 1989[2], Parker[3,4], 1995). Therefore the user is reminded of the importance of QA/QC samples that document decontamination effectiveness and that these samples can be used to modify or enhance decontamination techniques. Decontamination at radiologically contaminated sites should refer to Practice D 5608.

1.5 This practice is applicable to most conventional sampling equipment constructed of metallic and synthetic materials. The manufacturer of a specific sampling apparatus should be contacted if there is concern regarding the reactivity of a decontamination rinsing agent with the equipment.

1.6 *This practice offers an organized collection of information or a series of options and does not recommend a specific course of action. This document cannot replace education or experience and should be used in conjunction with professional judgement. Not all aspects of this practice may be applicable in all circumstances. This ASTM standard is not intended to represent or replace the standard of care by which the adequacy of a given professional service must be judged, nor should this document be applied without consideration of a project's many unique aspects. The word "Standard" in the title of this document means only that the documents has been approved through the ASTM consensus process..*

1.7 *This standard does not purport to address the safety problems associated with its use. It is the responsibility of the user of this standard to establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.*

2. Referenced Documents

2.1 *ASTM Standards:*

D 653 Terminology Relating to Soil, Rock, and Contained Fluids[5]

D 5608 Practice for Decontamination of Field Equipment Used at Low Level Radioactive Waste Sites[5]

3. Terminology

3.1 *Definitions:*

3.1.1 *contaminant*—an undesirable substance not normally present or an unusually high concentration of a naturally occurring substance in water or soil.

3.1.2 *control rinse water*—water used for equipment washing and rinsing having a known chemistry.

3.1.3 *decontamination*—the process of removing or reducing to a known level undesirable physical or chemical constituents, or both, from a sampling apparatus to maximize the representativeness of physical or chemical analyses proposed for a given sample.

3.1.4 *non-sample contacting equipment*—related equipment associated with the sampling effort, but that does not directly contact the sample (for example, augers, drilling rods, excavations machinery).

3.1.5 *quality assurance/quality control (QA/QC)*—the efforts completed to evaluate the accuracy and precision of a sampling or testing procedure, or both.

[1] This practice is under the jurisdiction of ASTM Committee D18 on Soil and Rock and is the direct responsibility of Subcommittee D18.14 on Geotechnics of Waste Management.

Current edition approved Jan. 10, 2002. Published April 2002.. Originally published as D 5088–90. Last previous edition D 5088–90.

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[5] *Annual Book of ASTM Standards*, Vol 04.08.

***A Summary of Changes section appears at the end of this standard.**

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3.1.6 *sample contacting equipment*—equpiment that comes in direct contact with the sample or portion of sample that will undergo chemical analyses or physical testing (for example, ground water well bailer, split-spoon sampler, soil gas sampling probe).

3.1.7 For definitions of other terms used in this practice, see Terminology D 653.

4. Summary of Practice

4.1 Two different procedures are presented for the decontamination of sample-contacting and non-sample contacting equipment. The procedures have been developed based on a review of current state and federal guidelines, as well as a summary of commonly employed procedures. In general, sample contacting equipment should be washed with a detergent solution followed by a series of control water, desorbing agents and deionized water rinses. Nonsample contacting equipment should be washed with a detergent solution and rinsed with control water. Although such techniques may be difficult to perform in the field, they may be necessary to most accurately evaluate low concentrations of the chemical constituent(s) of interest.

4.2 Prior to initiating a field program that will involve equipment decontamination, a site specific equipment decontamination protocol should be prepared for distribution to the individuals involved with the particular sampling program. Information to be presented in the protocol should include:

4.2.1 Site location and description,

4.2.2 Statement of the sampling program objective and desired precision and accuracy, that is, is sampling effort for gross qualitative evaluation or for trace concentration, parameter specific evaluations,

4.2.3 Summary of available information regarding soil types, hydrogeology and anticipated chemistry of the materials to be sampled,

4.2.4 Listing of equipment to be used for sampling and materials needed for decontamination,

4.2.5 Detailed step by step procedure for equipment decontamination for each piece or type of equipment to be utilized and procedures for rinse fluids containment and disposal as appropriate,

4.2.6 Summary of QA/QC procedures and QA/QC samples to be collected to document decontamination completeness including specific type of chemical analyses and their associated detection limit, and

4.2.7 Outline of equipment decontamination verification report.

5. Significance and Use

5.1 An appropriately developed, executed and documented equipment decontamination procedure is an integral and essential part of waste site investigations. The benefits of its use include:

5.1.1 Minimizing the spread of contaminants within a study area and from site to site,

5.1.2 Reducing the potential for worker exposure by means of contact with contaminated sampling equipment, and

5.1.3 Improved data quality and reliability.

5.2 This practice is not a substitute for a well-documented Quality Assurance/Quality Control (QA/QC) program. Because the ultimate test of a decontamination procedure is its ability to minimize erroneous data, a reasonable QA/QC program must be implemented.

5.3 This practice may not be applicable to all waste sites. When a sampling effort is completed to determine only the general range of chemical concentrations of interest less rigorous decontamination procedures can be adequate. Investigators should have the flexibility to modify the decontamination procedures with due consideration for the sampling objective or if QA/QC documentation supports alternative decontamination methods.

5.4 At sites where the reactivity of sampling equipment to decontamination washes creates concern for the generation of undesirable chemical by-products, the use of dedicated sampling equipment should be considered.

5.5 This practice, where applicable, should be used before, between, and after the completion of sampling events.

5.6 These practices are appropriate for use at sites where chemical (organic and inorganic) contamination is known or expected. The application of these practices to other types of sites radiological, mixed (radiological and chemical), or biohazard contaminated sites may not be applicable. The application of these practices to these types of sites should be undertaken with care and consideration, along with QA/QC documentation that supports the effectiveness of these decontamination techniques.

6. Reagents

6.1 *Detergent*, non-phosphate detergent solution.[6]

6.2 *Acid rinse (inorganic desorbing agent)*, 10 % nitric or hydrochloric acid solution-made from reagent grade nitric or hydrochloric acid and deionized water (1 % is to be applied to low-carbon steel equipment).

6.3 *Solvent rinse (organic desorbing agent)*, isopropanol, acetone, or methanol; pesticide grade.

6.4 *Control rinse water*, preferably from a water system of known chemical composition.

6.5 *Deionized water*, organic-free reagent grade.

7. Procedure for Sample Contacting Equipment

7.1 At a minimum, sample contacting equipment should be washed with a detergent solution and rinsed with control water.

7.2 For programs requiring more rigorous decontamination to meet the sampling or QA/QC objectives, the following procedures are indicated+. Table 1 provides applications of various solutions for decontamination of field equipment and materials. Table 2 provides commonly recommended decontamination procedures for various equipment and materials,

7.2.1 Wash with detergent solution, using a brush made of inert material to remove any particles or surface film.

7.2.1.1 For equipment that, because of internal mechanism or tubing cannot be adequately cleaned with a brush, the decontamination solutions should be circulated through the equipment.

[6] Liquinox or Detergent 8 or similar solution has been found suitable for this purpose. Detergent 8 is recommended for spray cleaning.

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TABLE 1 Applications of Various Solutions for Decontamination of Field Equipment and Materials[A,B,C]

Solution	Concentrations	Remarks
Portable Water	Tap water (demonstrated to be analyte free)	Used under high pressure or steam to remove heavy mud and dirt, or to rinse off other solutions
Laboratory-grade water	Distilled Deionized Reagengrade distilled and deionized water	
Low sudsing non-phosphate detergents (Liquinox, Detergent 8)	Typical concentrations are 0.5 to 2% solution by volume	General all-purpose cleaner. Detergent 8 is recommended for spray cleaning.
Sodium carbonate (baking soda)	5 to 15% aqueous solution	Used to neutralize either acidic or strongly basic contaminants
Sodium carbonate (washing soda)	10 to 20% aqueous solution	Effective for neutralizing inorganic acids, organic acids, heavy metals, metal processing wastes.
Trisodium phosphate (TSP Oakite)	10% aqueous solution	Similar to sodium carbonate. Good rinsing solution for organic compounds (such as toluene, chloroform, TCE, PBBs, and PCBs).
Calcium hypochlorite (HTH)	10% aqueous solution	Disinfectant, bleaching, and oxidizing agent for pesticides, fungicides, chlorinated phenols, dioxins, cyanides, ammonia and other non-acidic inorganic wastes.
Hydrochloric acid, nitric acid	10% nitric 10% to 20% hydrochloric	Used for inorganic bases, alkali and caustic wastes
Citric, tartaric, oxalic acids or their respective salts	5% solution	Used to clean heavy-metal contaminants
Organic solvents	Concentrated	Used to remove organic compounds that have poor solubility in water, such as oil and grease. do not use a solvent that is one of the analytes of interest or interferes with analyses. Porous materials such as polymers can absorb these solvents.

[A] Examples of commonly recommended cleaning solvents include pesticide-grade" isopropanol, acetone, methanol, hexane, heptane, and ethanol.

[B] Adapted for Mickam et al. (1989), Moberly (1985), and Richter and Collentine (1983).

[C] Many of the solvents listed are themselves hazardous materials. Care should be taken in both use and disposal of these materials.

7.2.2 Rinse thoroughly with control water.

7.2.3 Rinse with an inorganic desorbing agent (may be deleted if samples will not undergo inorganic chemical analysis). This rinse is effective only on non-metal surfaces.

7.2.4 Rinse with control water.

7.2.5 Rinse with organic desorbing agent (may be deleted if samples will not undergo organic chemical analyses).

7.2.6 Rinse with deionized water.

7.2.7 Allow equipment to air dry prior to next use.

7.2.8 Wrap equipment for transport with inert material (aluminum foil or plastic wrap) to direct contact with potentially contaminated material.

7.3 *Nonsample Contact Equipment*:

7.3.1 Clean the equipment with portable power washer or steam cleaning machine. Alternatively, hand wash with brush using detergent solution.

7.3.2 Rinse with control water.

7.3.3 The more rigorous decontamination procedures may be employed if necessary to meet sampling or QA/QC objectives.

7.4 Depending on site conditions, it may be appropriate to contain spent decontamination rinse fluids. If this is the case the appropriate vessel[7] for fluid containment should be used depending on the ultimate disposition of the material.

7.5 Depending on site conditions, it may be desirable to perform all equipment decontamination at a centralized location as opposed to the location where the equipment was used. If this is the case, care must be taken to transport the equipment to the decontamination area such that the spread of contaminants is minimized.

8. Quality Assurance/Quality Control

8.1 It is important to document the effectiveness of the decontamination procedure. To that end the projects QA/QC program should include provisions for the collection of samples to evaluate the completeness of a specific decontamination procedure. This could include:

8.1.1 Collection of rinse or wipe samples before the initial equipment decontamination prior to its use for sampling to establish a base line level of contaminants residing on or in the equipment,

[7] A drum approved by the Department of Transportation or similar container has been found suitable for this purpose.

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TABLE 2 Commonly Recommended Decontamination Procedures for Different Equipment and Different Materials of Construction[A,B]

NOTE—

	Soapy Water Wash	Tap Water Rinse	10% Nitric Acid Rinse[C]	Organic-Free Water Rinse	Rinse with Solvent	Air Dry for 24h	Oven Dry	Store in Aluminum Foil or Polyethylene	Discard After Use
Glass	1	2,4	3	5	6[D]	7		8	
Teflon	1	2,4	3	5	6[E]	7		8	
Metals and Stainless Steel	1	2		3	4[D]	5		6	
Teflon Tubing	1	2			3[E]		4[F]	5	
PVC Tubing				Use Only New PVC Tubing					1
Stainless Tubing	1	2		3	4[D]	5		6	
Glass Tubing	1	2,4	3	5	6[D]	7		3	
Well Sounders	1	2		3					
Submersible Pumps	1	2		3					

[A]These procedures are based on commonly recommended practices. It should be noted that there is not a lot of experimental data to support some of these practices. Mickam et al., 1989, Parker 1995, Parker and Ranney 1997a, 1997b in press.

[B]Sampling equipment that employs a process whereby potentially contaminated material passes through internal mechanical workings (pump, houisng, impellers, etc.) can be very difficult to decontaminate. This should be considered when identifying an appropriate decontamination procedure for equipment with internal sample contacting parts.

[C]This step is used in removing inorganic contaminants and can be eliminated if they are not of concern.

[D]Data by Parker and Ranney (in press, 1997a, 1997b) should show that solvent rinsing may not be needed.

[E]Data by Parker and Ranney (in press, 1997a, 1997b), show that oven drying may be more effective than an organic solvent rinse for removing sorbed organic contaminants.

[F]Excessive heat that could damage the polymer should not be used. Check manufacturer's recommendations for heat tolerance.

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8.1.2 Collection of final rinse or wipe samples after equipment decontamination following its use, and

8.1.3 The frequency of sampling to demonstrate the completeness of equipment decontamination is dependent upon objectives of the project as they relate to QA/QC. At a minimum it is recommended after every ten decontamination washings.

9. Report

9.1 The activities completed for each equipment decontamination should be documented in writing. Included in this report should be the following information:

9.1.1 Site location, date, time, and weather,

9.1.2 Sample location where equipment was employed,

9.1.3 Location where decontamination was performed,

9.1.4 Individuals performing the decontamination,

9.1.5 Decontamination procedures,

9.1.6 Source of materials (solutions) used for decontamination,

9.1.7 Handling of rinse fluids and accumulates solids, if any, and

9.1.8 QA/QC sampling performed and analytical results of QA/QC samples whether completed in the field or laboratory subsequent to sampling event.

10. Keywords

10.1 contaminant; decontamination; sampling; waste

SUMMARY OF CHANGES

In accordance with Committee D18 policy, this section identifies the location of changes to this standard since the 90 edition that may impact the use of this standard.

(1) Revised title to reflect that radiological contamination exists at some level at all sites.

(2) Revised Section 1.2 to reflect that this practice may not be appropriate for radiological, mixed or biologically contaminated sites.

(3) Editorial changes to comply with current ASTM form and styleand D18 procedures.

(4) Added information on the importance of QA/QC process and samples.

(5) Added new section 5.6 to Significance and Use regarding applicability to radiological, mixed, and biologically contaminated sites.

(6)Added professional care caveat to Section 1.

(7) Removed Alquinox from footnote to section 6 as it is not a non-phosphate detergent. Added Detergent 8 as a replacement and information on its application.

(8) Section 7.2 added additional information on decontamination procedures and materials and Tables 1 and 2.

(9) Section 7.2.3 added that this rinse is only effective on non-metal components.

(10) Added Summary of Changes section.

(11)Added footnotes in 1.4.

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Designation: D 5092 – 04ε1

Standard Practice for Design and Installation of Ground Water Monitoring Wells[1]

This standard is issued under the fixed designation D 5092; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval. A superscript epsilon (ε) indicates an editorial change since the last revision or reapproval.

ε[1] NOTE—Editorial changes were made throughout in June 2004.

1. Scope

1.1 This practice describes a methodology for designing and installing conventional (screened and filter-packed) ground-water monitoring wells suitable for formations ranging from unconsolidated aquifers (i.e., sands and gravels) to granular materials having grain-size distributions with up to 50 % passing a #200 sieve and as much as 20 % clay-sized material (i.e., silty fine sands with some clay). Formations finer than this (i.e., silts, clays, silty clays, clayey silts) should not be monitored using conventional monitoring wells, as representative ground-water samples, free of artifactual turbidity, cannot be assured using currently available technology. Alternative monitoring technologies (not described in this practice) should be used in these formations

1.2 The recommended monitoring well design and installation procedures presented in this practice are based on the assumption that the objectives of the program are to obtain representative ground-water samples and other representative ground-water data from a targeted zone of interest in the subsurface defined by site characterization.

1.3 This practice, in combination with proper well development (D 5521), proper ground-water sampling procedures (D 4448), and proper well maintenance and rehabilitation (D 5978), will permit acquisition of ground-water samples free of artifactual turbidity, eliminate siltation of wells between sampling events, and permit acquisition of accurate ground-water levels and hydraulic conductivity test data from the zone screened by the well. For wells installed in fine-grained formation materials (up to 50 % passing a #200 sieve), it is generally necessary to use low-flow purging and sampling techniques (D 6771) in combination with proper well design to collect turbidity-free samples.

1.4 This practice applies primarily to well design and installation methods used in drilled boreholes. Other Standards, including Guide D 6724 and Practice D 6725, cover installation of monitoring wells using direct-push methods.

1.5 The values stated in inch-pound units are to be regarded as standard. The values in parentheses are for information only.

1.6 *This standard does not purport to address all of the safety concerns, if any, associated with its use. It is the responsibility of the user of this standard to establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.*

1.7 *This practice offers a set of instructions for performing one or more specific operations. This document cannot replace education or experience and should be used in conjunction with professional judgment. Nat all aspects of this practice may be applicable in all circumstances. This ASTM standard is not intended to represent or replace the standard of care by which the adequacy of a given professional service must be judged, nor should this document be applied without consideration of a project's many unique aspects. The word "Standard" in the title of this document means only that the document has been approved through the ASTM consensus process.*

2. Referenced Documents

2.1 *ASTM Standards:* [2]

C 150 Specification for Portland Cement

C 294 Descriptive Nomenclature of Constituents of Natural Mineral Aggregates

D 421 Practice for Dry Preparation of Soil Samples for Particle Size Analysis and Determination of Soil Constants

D 422 Test Method for Particle Size Analysis of Soils

D 653 Terminology Relating to Soil, Rock, and Contained Fluids

D 1452 Practice for Soil Investigation and Sampling by Auger Borings

D 1586 Method for Penetration Test and Split-Barrel Sampling of Soils

D 1587 Practice for Thin-Walled Tube Sampling of Soils

D 2113 Practice for Rock Core Drilling and Sampling of Rock for Site Investigation

D 2217 Practice for Wet Preparation of Soil Samples for Particle Size Analysis and Determination of Soil Constants

[1] This practice is under the jurisdiction of ASTM Committee D18 on Soil and Rock and is the direct responsibility of Subcommittee D18.21.05 on Design and Installation of Ground-Water Monitoring Wells.

Current edition approved Jan. 1, 2004. Published March 2004. Originally approved in 1990. Last previous edition approved in 2002 as D 5092 – 02.

[2] For referenced ASTM standards, visit the ASTM website, www.astm.org, or contact ASTM Customer Service at service@astm.org. For *Annual Book of ASTM Standards* volume information, refer to the standard's Document Summary page on the ASTM website.

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D 2487 Practice for Classification of Soils for Engineering Purposes (Unified Soil Classification System)
D 2488 Practice for Description and Identification of Soils (Visual-Manual Procedure)
D 3282 Practice for Classification of Soils and Soil Aggregate Mixtures for Highway Construction Purposes
D 3441 Test Method for Deep, Quasi-Static, Cone and Friction Cone Penetration Tests of Soil
D 3550 Practice for Ring Lined Barrel Sampling of Soils
D 4220 Practice for Preserving and Transporting Soil Samples
D 4700 Guide for Soil Sampling from the Vadose Zone
D 4750 Test Method for Determining Subsurface Liquid Levels in a Borehole or Monitoring Well (Observation Well)
D 5079 Practices for Preserving and Transporting Rock Core Samples
D 5088 Practice for Decontamination of Field Equipment Used at Nonradioactive Waste Sites
D 5254 Practice for Minimum Set of Data Elements to Identify a Ground-Water Site
D 5299 Guide for Decommissioning of Ground-Water Wells, Vadose Zone Monitoring Devices, Boreholes, and Other Devices for Environmental Activities
D 5434 Guide for Field Logging of Subsurface Explorations of Soil and Rock
D 5518 Guide for Acquisition of File Aerial Photography and Imagery for Establishing Historic Site Use and Surficial Conditions
D 5521 Guide for Development of Ground-Water Monitoring Wells in Granular Aquifers
D 5608 Practice for Decontamination of Field Equipment Used at Low-Level Radioactive Waste Sites
D 5730 Guide to Site Characterization for Environmental Purposes with Emphasis on Soil, Rock, the Vadose Zone, and Ground Water
D 5753 Guide for Planning and Conducting Borehole Geophysical Logging
D 5777 Guide for Using the Seismic Refraction Method for Subsurface Investigation
D 5781 Guide for Use of Dual-Wall Reverse-Circulation Drilling for Geoenvironmental Exploration and Installation of Subsurface Water-Quality Monitoring Devices
D 5782 Guide for Use of Direct Air-Rotary Drilling for Geoenvironmental Exploration and Installation of Subsurface Water-Quality Monitoring Devices
D 5783 Guide for Use of Direct Rotary Drilling with Water-Based Drilling Fluid for Geoenvironmental Exploration and Installation of Subsurface Water-Quality Monitoring Devices
D 5784 Guide for Use of Hollow Stem Augers for Geoenvironmental Exploration and Installation of Subsurface Water-Quality Monitoring Devices
D 5787 Practice for Monitoring Well Protection
D 5872 Guide for the Use of Casing Advancement Drilling Methods for Geoenvironmental Exploration and Installation of Subsurface Water-Quality Monitoring Devices
D 5875 Guide for the Use of Cable Tool Drilling and Sampling Methods for Geoenvironmental Exploration and Installation of Subsurface Water-Quality Monitoring Devices
D 5876 Guide for the Use of Direct Rotary Wireline Casing Advancement Drilling Methods for Geoenvironmental Exploration and the Installation of Subsurface Water-Quality Monitoring Devices
D 5978 Guide for Maintenance and Rehabilitation of Ground-Water Monitoring Wells
D 5979 Guide for Conceptualization and Characterization of Ground-Water Systems
D 6001 Guide for Direct-Push Water Sampling for Geoenvironmental Investigations
D 6067 Guide for Using the Electronic Cone Penetrometer for Environmental Site Characterization
D 6167 Guide for Conducting Borehole Geophysical Logging
D 6169 Guide to the Selection of Soil and Rock Sampling Devices Used With Drilling Rigs for Environmental Investigations
D 6235 Practice for Expedited Site Characterization of Vadose Zone and Ground-Water Contamination at Hazardous Waste Contaminated Sites
D 6274 Guide for Conducting Borehole Geophysical Logging—Gamma
D 6282 Guide for Direct-Push Soil Sampling for Environmental Site Characterization
D 6286 Guide to the Selection of Drilling Methods for Environmental Site Characterization
D 6429 Guide for Selecting Surface Geophysical Methods
D 6430 Guide for Using the Gravity Method for Subsurface Investigation
D 6431 Guide for Using the Direct Current Resistivity Method for Subsurface Investigation
D 6432 Guide for Using the Surface Ground Penetrating Radar Method for Subsurface Investigation
D 6519 Practice for Sampling of Soil Using the Hydraulically Operated Stationary Piston Sampler
D 6639 Guide for Using the Frequency Domain Electromagnetic Method for Subsurface Investigations
D 6640 Guide for Collection and Handling of Soils Obtained in Core Barrel Samplers for Environmental Investigations
D 6724 Guide for the Installation of Direct-Push Ground-Water Monitoring Wells
D 6725 Practice for the Installation of Prepacked Screen Monitoring Wells in Unconsolidated Aquifers
D 6771 Practice for Low-Flow Purging and Sampling for Wells and Devices Used for Ground-Water Quality Investigations
F 480 Specification for Thermoplastic Well Casing and Couplings Made in Standard Dimension Ratios (SDR), Schedule 40 and Schedule 80

3. Terminology

3.1 *Definitions:*

3.1.1 *annular space; annulus*—the space between two concentric strings of casing, or between the casing and the

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borehole wall. This includes the space(s) between multiple strings of casing in a borehole installed either concentrically or adjacent to one another.

3.1.2 *artifactual turbidity*—particulate matter that is not naturally mobile in the ground-water system and that is produced in some way by the ground-water sampling process. May consist of particles introduced to the subsurface during drilling or well construction, sheared from the target monitoring zone during pumping or bailing the well, or produced by exposure of ground water to atmospheric conditions.

3.1.3 *assessment monitoring*—an investigative monitoring program that is initiated after the presence of a contaminant in ground water has been detected. The objective of this program is to determine the concentration of constituents that have contaminated the ground water and to quantify the rate and extent of migration of these constituents.

3.1.4 *ballast*—materials used to provide stability to a buoyant object (such as casing within a water-filled borehole).

3.1.5 *borehole*—an open or uncased subsurface hole, generally circular in plan view, created by drilling.

3.1.6 *borehole log*—the record of geologic units penetrated, drilling progress, depth, water level, sample recovery, volumes, and types of materials used, and other significant facts regarding the drilling and/or installation of an exploratory borehole or well.

3.1.7 *bridge*—an obstruction within the annulus that may prevent circulation or proper placement of annular fill materials.

3.1.8 *casing*—pipe, finished in sections with either threaded connections or beveled edges to be field welded, which is installed temporarily or permanently either to counteract caving, to advance the borehole, or to isolate the zone being monitored, or any combination of these.

3.1.9 *casing, protective*—a section of larger diameter pipe that is placed over the upper end of a smaller diameter monitoring well riser or casing to provide structural protection to the well, to prevent damage to the well, and to restrict unauthorized access into the well.

3.1.10 *casing, surface*—pipe used to stabilize a borehole near the surface during the drilling of a borehole that may be left in place or removed once drilling is completed.

3.1.11 *caving; sloughing*—the inflow of unconsolidated material into a borehole that occurs when the borehole walls lose their cohesiveness.

3.1.12 *cement*—commonly known as Portland cement. A mixture that consists of calcareous, argillaceous, or other silica-, alumina-, and iron-oxide-bearing materials that is manufactured and formulated to produce various types which are defined in Specification C 150. Portland cement is considered a hydraulic cement because it must be mixed with water to form a cement-water paste that has the ability to harden and develop strength even if cured under water.

3.1.13 *centralizer*—a device that assists in the centering of a casing or riser within a borehole or another casing.

3.1.14 *confining unit*—a body of relatively low hydraulic conductivity formation material stratigraphically adjacent to one or more aquifers. Synonymous with “aquiclude,”“ aquitard,” and “aquifuge.”

3.1.15 *detection monitoring*—a program of monitoring for the express purpose of determining whether or not there has been a contaminant release to ground water.

3.1.16 *d-10*—the diameter of a soil particle (preferably in mm) at which 10 % by weight (dry) of the particles of a particular sample are finer. Synonymous with the effective size or effective grain size.

3.1.17 *d-60*—the diameter of a soil particle (preferably in mm) at which 60 % by weight (dry) of the particles of a particular sample are finer.

3.1.18 *flush joint or flush coupled*—casing or riser with ends threaded such that a consistent inside and outside diameter is maintained across the threaded joints or couplings.

3.1.19 *gravel pack*—common term used to refer to the primary filter pack of a well (see *primary filter pack*).

3.1.20 *grout (monitoring wells)*—a low-permeability material placed in the annulus between the well casing or riser and the borehole wall (in a single-cased monitoring well), or between the riser and casing (in a multi-cased monitoring well), to prevent movement of ground water or surface water within the annular space.

3.1.21 *hydrologic unit*—geologic strata that can be distinguished on the basis of capacity to yield and transmit fluids. Aquifers and confining units are types of hydrologic units. Boundaries of a hydrologic unit may not necessarily correspond either laterally or vertically to lithostratigraphic formations.

3.1.22 *multi-cased well*—a well constructed by using successively smaller diameter casings with depth.

3.1.23 *neat cement*—a mixture of Portland cement (Specification C 150) and water.

3.1.24 *packer (monitoring wells)*—a transient or dedicated device placed in a well that isolates or seals a portion of the well, annulus, or borehole at a specific level.

3.1.25 *piezometer*—a small-diameter well with a very short screen that is used to measure changes in hydraulic head, usually in response to pumping a nearby well. Synonymous with observation well.

3.1.26 *primary filter pack*—a clean silica sand or sand and gravel mixture of selected grain size and gradation that is installed in the annular space between the borehole wall and the well screen, extending an appropriate distance above the screen, for the purpose of retaining and stabilizing the particles from the adjacent formation(s). The term is used in place of *gravel pack.*

3.1.27 *PTFE tape*—joint sealing tape composed of polytetrafluoroethylene.

3.1.28 *riser*—the pipe or well casing extending from the well screen to just above or below the ground surface.

3.1.29 *secondary filter pack*—a clean, uniformly graded sand that is placed in the annulus between the primary filter pack and the overlying seal, or between the seal and overlying grout backfill, or both, to prevent intrusion of the seal or grout, or both, into the primary filter pack.

3.1.30 *sediment sump*—a blank extension of pipe or well casing, closed at the bottom, beneath the well screen used to collect fine-grained material from the filter pack and adjacent

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formation materials during the process of well development. Synonymous with rat trap or tail pipe.

3.1.31 *single-cased well*—a monitoring well constructed with a riser but without an exterior casing.

3.1.32 *static water level*—the elevation of the top of a column of water in a monitoring well or piezometer that is not influenced by pumping or conditions related to well installation, or hydraulic testing.

3.1.33 *tamper*—a heavy cylindrical metal section of tubing that is operated on a wire rope or cable. It either slips over the riser and fits inside the casing or borehole annulus, or fits between the riser and annulus. It is generally used to tamp annular sealants or filter pack materials into place and to prevent bridging or break bridges that form in the annular space.

3.1.34 *target monitoring zone*—the ground-water flow path from a particular area or facility in which monitoring wells will be screened. The target monitoring zone should be an interval in subsurface materials in which there is a reasonable expectation that a monitoring well will intercept ground water moving beneath an area or facility and any migrating contaminants that may be present.

3.1.35 *tremie pipe*—a small-diameter pipe or tube that is used to transport filter pack materials and annular seal materials from the ground surface into an annular space.

3.1.36 *uniformity coefficient*—the ratio of d-60/d-10, where d-60 and d-10 are particle diameters corresponding to 60 % and 10 % finer on the cumulative particle size curve, respectively.

3.1.37 *uniformly graded*—a quantitative definition of the particle size distribution of a soil that consists of a majority of particles being of approximately the same diameter. A granular material is considered uniformly graded when the uniformity coefficient is less than about five (Test Method D 2487). Comparable to the geologic term *well sorted*.

3.1.38 *vented cap*—a cap with a small hole that is installed on top of the riser.

3.1.39 *weep hole*—a small-diameter hole (usually ¼ in.) drilled into the protective casing above the ground surface that serves to drain out water that may enter the annulus between the riser and the protective casing.

3.1.40 *well completion diagram*—a record that illustrates the details of a well installation.

3.1.41 *well screen*—a device used to retain the primary or natural filter pack; usually a cylindrical pipe with openings of a uniform width, orientation, and spacing.

4. Significance and Use

4.1 This practice for the design and installation of ground-water monitoring wells will promote *(1)* efficient and effective site hydrogeological characterization; *(2)* durable and reliable well construction; and *(3)* acquisition of representative ground-water quality samples, ground-water levels, and hydraulic conductivity testing data from monitoring wells. The practices established herein are affected by governmental regulations and by site-specific geological, hydrogeological, climatological, topographical, and subsurface geochemical conditions. To meet these geoenvironmental challenges, this practice promotes the development of a conceptual hydrogeologic model prior to monitoring well design and installation.

4.2 A properly designed and installed ground water monitoring well provides essential information on one or more of the following subjects:

4.2.1 Formation geologic and hydraulic properties;

4.2.2 Potentiometric surface of a particular hydrologic unit(s);

4.2.3 Water quality with respect to various indicator parameters; and

4.2.4 Water chemistry with respect to a contaminant release.

5. Site Characterization

5.1 *General*—A thorough knowledge of site-specific geologic, hydrologic and geochemical conditions is necessary to properly apply the monitoring well design and installation procedures contained within this practice. Development of a conceptual site model, that identifies potential flow paths and the target monitoring zone(s), and generates a 3-D picture of contaminant distribution and contaminant movement pathways, is recommended prior to monitoring well design and installation. Development of the conceptual site model is accomplished in two phases -- an initial reconnaissance, after which a preliminary conceptual model is created, and a field investigation, after which a revised conceptual model is formulated. When the hydrogeology of a project area is relatively uncomplicated and well documented in the literature, the initial reconnaissance may provide sufficient information to identify flow paths and the target monitoring zone(s). However, where limited or no background data are available or where the geology is complex, a field investigation will be required to develop the necessary conceptual site model.

5.2 *Initial Reconnaissance of Project Area*—The goal of the initial reconnaissance of the project area is to identify and locate those zones or preferential flow pathways with the greatest potential to transmit fluids from the project area. Identifying these flow pathways is the first step in selecting the target ground-water monitoring zone(s).

5.2.1 *Literature Search*—Every effort should be made to collect and review all applicable field and laboratory data from previous investigations of the project area. Information such as, but not limited to, topographic maps, aerial imagery (see Guide D 5518), site ownership and utilization records, geologic and hydrogeologic maps and reports, mineral resource surveys, water well logs, information from local well drillers, agricultural soil reports, geotechnical engineering reports, and other engineering maps and reports related to the project area should be reviewed to locate relevant site information.

5.2.2 *Field Reconnaissance*—Early in the investigation, the soil and rocks in open cut areas (e.g., roadcuts, streamcuts) in the vicinity of the project should be studied, and various soil and rock profiles noted. Special consideration should be given to soil color and textural changes, landslides, seeps, and springs within or near the project area.

5.2.3 *Preliminary Conceptual Model*—The distribution of the predominant soil and rock units likely to be found during subsurface exploration may be hypothesized at this time in a preliminary conceptual site model using information obtained in the literature search and field reconnaissance. In areas where

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the geology is relatively uniform, well documented in the literature, and substantiated by the field reconnaissance, further refinement of the conceptual model may not be necessary unless anomalies are discovered in the well drilling stage.

5.3 *Field Investigation*—The goal of the field investigation is to refine the preliminary conceptual site model so that the target monitoring zone(s) is (are) identified prior to monitoring well installation.

5.3.1 *Exploratory Borings and Direct-Push Methods*—Characterization of the flow paths conceptualized in the initial reconnaissance involves defining the porosity (type and amount), hydraulic conductivity, stratigraphy, lithology, gradation and structure of each hydrologic unit encountered beneath the site. These characteristics are defined by conducting an exploratory program which may include drilled soil borings (see Guide D 6286 for selection of drilling methods) and direct-push methods (e.g., cone penetrometers [see Test Method D 3441 or Guide D 6067] or direct-push machines using soil sampling, ground-water sampling and/or electrical conductivity measurement tools [see Guides D 6282 and D 6001]). Exploratory soil borings and direct-push holes should be deep enough to develop the required engineering and hydrogeologic data for determining the preferential flow pathway(s), target monitoring zone(s), or both.

5.3.1.1 *Sampling*—Soil and rock properties should not be predicted wholly on field description or classification, but should be confirmed by laboratory and/or field tests made on samples or in boreholes or wells. Representative soil or rock samples of each material that is significant to the design of the monitoring well system should be obtained and evaluated by a geologist, hydrogeologist, soil scientist or engineer trained and experienced in soil and rock analysis. Soil sample collection should be conducted according to Practice D 1452, Test Method D 1586, Practice D 3550, Practice D 6519 or Practice D 1587, whichever is appropriate given the anticipated characteristics of the soil samples (see Guide D 6169 for selection of soil sampling methods). Rock samples should be collected according to Practice D 2113. Soil samples obtained for evaluation of hydraulic properties should be containerized and identified for shipment to a laboratory. Special measures to preserve either the continuity of the sample or the natural moisture are not usually required. However, soil and rock samples obtained for evaluation of chemical properties often require special field preparation and preservation to prevent significant alteration of the chemical constituents during transportation to a laboratory (see Practice D 6640). Rock samples for evaluation of hydraulic properties are usually obtained using a split-inner-tube core barrel. Evaluation and logging of the core samples is usually done in the field before the core is removed from the core barrel.

5.3.1.2 *Boring Logs*—Care should be taken to prepare and retain a complete boring log and sampling record for each exploratory soil boring or direct-push hole (see Guide D 5434).

NOTE 1—Site investigations conducted for the purpose of generating data for the installation of ground-water monitoring wells can vary greatly due to the availability of reliable site data or the lack thereof. The general procedure would be as follows: *(1)* gather factual data regarding the surficial and subsurface conditions, *(2)* analyze the data, *(3)* develop a conceptual model of the site conditions, *(4)* locate the monitoring wells based on the first three steps. Monitoring wells should only be installed with sufficient understanding of the geologic, and hydrologic and geochemical conditions present at the site. Monitoring wells often serve as part of an overall site investigation for a specific purpose, such as determining the extent of contamination present, or for predicting the effectiveness of aquifer remediation. In these cases, extensive additional geotechnical and hydrogeologic information may be required that would go beyond the Section 5 Site Characterization description.

Boring logs should include the location, geotechnical data (that is, penetration rates or blow counts), and sample description information for each material identified in the borehole either by symbol or word description, or both. Description and identification of soils should be in accordance with Practice D 2488; classification of soils should be in accordance with either Practice D 2487 or Practice D 3282. Identification of rock material should be based on Nomenclature C 294 or by an appropriate geologic classification system. Observations of seepage, free water, and water levels should also be noted. The boring logs should be accompanied by a report that includes a description of the area investigated; a map illustrating the vertical and horizontal location (with reference to either North American Vertical Datum of 1988 [NAVD 88] or to a standardized survey grid) of each exploratory soil boring or test pit, or both; and color photographs of rock cores, soil samples, and exposed strata labeled with a date and identification.

5.3.2 *Geophysical Exploration*—Geophysical surveys may be used to supplement soil boring and outcrop observation data and to aid in interpretation between soil borings. Appropriate surface and borehole geophysical methods for meeting site-specific project objectives can be selected by consulting Guides D 6429 and D 5753 respectively. Surface geophysical methods such as seismic (Guide D 5777), electrical-resistivity (Guide D 6431), ground-penetrating radar (Guide D 6432), gravity (Guide D 6430) and electromagnetic conductance surveys (Guide D 6639) can be particularly valuable when distinct differences in the properties of contiguous subsurface materials are indicated. Borehole methods such as resistivity, gamma, gamma-gamma, neutron, and caliper logs (see Guide D 6167) can be useful to confirm specific subsurface geologic conditions. Gamma logs (Guide D 6274) are particularly useful in existing cased wells.

5.3.3 *Ground-Water Flow Direction*—Ground-water flow direction is generally determined by measuring the vertical and horizontal hydraulic gradient within each conceptualized flow pathway. However, because water will flow along the pathways of least resistance (within the highest hydraulic conductivity formation materials at the site), actual flow direction may be oblique to the hydraulic gradient (within buried stream channels or glacial valleys, for example). Flow direction is determined by first installing piezometers in the exploratory soil borings that penetrate the zone(s) of interest at the site. The depth and location of the piezometers will depend upon anticipated hydraulic connections between conceptualized flow pathways and their respective lateral direction of flow. Following careful evaluation, it may be possible to utilize existing private or public wells to obtain water-level data. The construction integrity of such wells should be verified to ensure that the water levels obtained from the wells are representative only of the zone(s) of interest. Following water-level data acquisition,

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a potentiometric surface map should be prepared. Flow pathways are ordinarily determined to be at right angles, or nearly so, to the equipotential lines, though consideration of complex geology can result in more complex interpretations of flow

5.4 *Completing the Conceptual Model*—A series of geologic and hydrogeologic cross sections should be developed to refine the conceptual model. This is accomplished by first plotting logs of soil and rock observed in the exploratory soil borings or test pits, and interpreting between these logs using the geologic and engineering interrelationships between other soil and rock data observed in the initial reconnaissance or with geophysical techniques. Extrapolation of data into adjacent areas should be done only where geologically uniform subsurface conditions are known to exist. The next step is to integrate the geologic profile data with the potentiometric data for both vertical and horizontal hydraulic gradients. Plan view and cross-sectional flow nets should be constructed. Following the analysis of these data, conclusions can be made as to which flow pathway(s) is (are) the appropriate target monitoring zone(s).

NOTE 2—UUse of ground-water monitoring wells is difficult and may not be a reliable technology in fine-grained, low hydraulic conductivity formation materials with primary porosity because of *(1)* the disproportionate influence that microstratigraphy has on ground-water flow in fine-grained strata; *(2)* the proportionally higher vertical flow component in low hydraulic conductivity strata; and *(3)* the presence of indigenous metallic and inorganic constituents in the matrix that make water-quality data evaluation difficult.

6. Monitoring Well Construction Materials

6.1 *General*—The materials that are used in the construction of a monitoring well that come in contact with water samples should not alter the chemical quality of the sample for the constituents being examined. The riser, well screen, and annular seal installation equipment should be cleaned immediately prior to well installation (see either Practice D 5088 or D 5608) or certified clean from the manufacturer and delivered to the site in a protective wrapping. Samples of the riser and screen material, cleaning water, filter pack, annular seal, bentonite, and mixed grout should be retained to serve as quality control until the completion of at least one round of ground- water quality sampling and analysis has been completed.

6.2 *Water*—Water used in the drilling process, to prepare grout mixtures and to decontaminate the well screen, riser, and annular sealant injection equipment, should be obtained from a source of known chemistry that does not contain constituents that could compromise the integrity of the well installation.

6.3 *Primary Filter Pack*:

6.3.1 *General*—The purposes of the primary filter pack are to act as a filter that retains formation material while allowing ground water to enter the well, and to stabilize the formation to keep it from collapsing on the well. The design of the primary filter pack is based on the grain-size distribution of the formation material (as determined by sieve analysis—see Test Method D 422) to be retained. The grain size distribution of the primary filter pack must be fine enough to retain the formation, but coarse enough to allow for unrestricted movement of ground water into and through the monitoring well. The design of the well screen (see 6.4.3) must be done in concert with the design of the filter pack. After development, a monitoring well with a correctly designed and installed filter pack and screen combination should produce samples free of artifactual turbidity.

6.3.2 *Materials*—The primary filter pack should consist of an inert granular material (generally ranging from gravel to very fine sand, depending on formation grain size distribution) of selected grain size and gradation that is installed in the annulus between the well screen and the borehole wall. Washed and screened silica sands and gravels, with less than 5 % non-siliceous materials, should be specified.

6.3.3 *Design*—The design theory of filter pack gradation is based on mechanical retention of formation materials.

6.3.3.1 1 For formation materials that are relatively coarse-grained (i.e., fine, medium and coarse sands and gravels), the grain size distribution of the primary filter pack is determined by calculating the d-30 (30 % finer) size, the d-60 (60 % finer) size, and the d-10 (10 % finer) size of the filter pack. The first point on the filter pack grain-size distribution curve is the d-30 size. The primary filter pack is usually selected to have a d-30 grain size that is about 4 to 6 times greater than the d-30 grain size of the formation material being retained (see Fig. 1). A multiplication factor of 4 is used if the formation material is relatively fine-grained and well sorted or uniform (small range in grain sizes); a multiplication factor of 6 is used if the formation is relatively coarse grained and poorly sorted or non-uniform (large range in grain sizes). Thus, 70 % of the filter pack will have a grain size that is 4 to 6 times larger than the d-30 size of the formation materials. This ensures that the filter pack is coarser (with a higher hydraulic conductivity) than the formation material, and allows for unrestricted ground-water flow from the formation into the monitoring well.

The next 2 points on the filter pack grain-size distribution curve are the d-60 and d-10 grain sizes. These are chosen so that the ratio between the two grain sizes (the uniformity coefficient) is less than 2.5. This ensures that the filter pack has a small range in grain sizes and is uniform (see technical Note 5). The d-60 and d-10 grain sizes of the filter pack are calculated by a trial and error method using grain sizes that are close to the d-30 size of the filter pack. After the d-30, d-60 and d-10 sizes of the filter pack are determined, a smooth curve is drawn through these points. The final step in filter pack design is to specify the limits of the grain size envelope, which defines the permissible range in grain sizes for the filter pack. The permissible range on either side of the grain size curve is 8 %. The boundaries of the grain size envelope are drawn on either side of the filter pack grain-size distribution curve, and filter pack design is complete. A filter medium having a grain-size distribution as close as possible to this curve is then obtained from a local sand supplier.

6.3.3.2 In formation materials that are predominantly fine-grained (finer than fine to very fine sands), soil piping can occur when a hydraulic gradient exists between the formation and the well (as would be the case during well development and sampling). To prevent soil piping in these materials, the following criteria are used for designing granular filter packs:

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d-15 of filter / d-85 of formation </= 4 to 5 and d-15 of filter / d-15 of formation >/= 4 to 5

The left half of this equation is the fundamental criterion for the prevention of soil piping through a granular filter, while the right half of the equation is the hydraulic conductivity criterion. This latter criterion serves the same purpose as multiplying the d-30 grain size of the formation by a factor of between 4 and 6 for coarser formation materials. Filter pack materials suitable for retaining formation materials in formations that are predominantly fine-grained are themselves, by necessity, relatively fine-grained (e.g., fine to very fine sands), presenting several problems for well designers and installers. First, well screen slot sizes suitable for retaining such fine-grained filter pack materials are not widely available (the smallest commercially available slotted well casing is 0.006 in. [6 slot]; the smallest commercially available continuous-slot wire-wound screen is 0.004 in. [4 slot]). Second, the finest filter pack material practical for conventional (tremie tube) installation is a 40 by 70 (0.008 by 0.018 in.) sand, which can be used with a well screen slot as small as 0.008-in. (8 slot). Finer grained filter pack materials cannot be placed practically by either tremie tubes or pouring down the annular space or down augers. Thus, the best method for ensuring proper installation of filter packs in predominantly fine-grained formation materials is to use pre-packed or sleeved screens, which are described in detail in Practice D 6725. A 50 by 100 (0.011 by 0.006 in.) filter-pack sand can be used with a 0.006-in. slot size pre-packed or sleeved screen, and a 60 by 120 (0.0097 by 0.0045 in.) filter-pack sand can be used with a 0.004-in. (4 slot) slot size pre-packed or sleeved screen. Filter packs that are finer than these (e.g., sands as fine as 100 by 120 [0.006 by 0.0045 in.], or silica flour as fine as 200 mesh [0.003 in.]) can only be installed within stainless steel mesh sleeves that can be placed over pipe-based screens. While these sleeves, or the space between internal and external screens in a pre-packed well screen may be as thin as 1/2-in. (1.27 cm), the basis for mechanical retention dictates that a filter-pack thickness of only two or three grain diameters is needed to contain and control formation materials. Laboratory tests have demonstrated that a properly sized filter pack material with a thickness of less than 1/2-in. (1.27 cm) successfully retains formation particles regardless of the velocity of water passing through the filter pack [3].

[3] (1) Driscoll, F.G., 1986, Groundwater and Wells, Johnson Division, St. Paul, MN, pg.443

6.3.3.3 The limit of mechanical filtration for monitoring wells is defined by the finest filter pack material that can be practically installed via a pre-packed or sleeved screen—silica flour with a grain size of 0.003 in. (200 mesh), encased within a very fine mesh screen of stainless steel or other suitable material. This fine a filter pack material will retain formation material as fine as silt, but not clay. Formations with a small fraction of clay (up to about 20 %) can be successfully monitored, as long as the wells installed in these formations are properly developed (see Guide D 5521). For mechanical filtration to be effective in formations with more than 50 % fines, the filter pack design would have to include silt-sized particles in the filter pack in order to meet the design criteria, which is impractical, as placement would be impossible and screen mesh fine enough to retain the material is not commercially available. Therefore, formations with more than 50 % passing a #200 sieve, and having more than 20 % clay-sized material, should not be monitored using conventional well designs. Alternative monitoring technologies should be used in these formations..

NOTE 3—When installing a monitoring well in solution-channeled limestone or highly fractured bedrock, the borehole configuration of void spaces within the formation surrounding the borehole is often unknown. Therefore, the installation of a filter pack becomes difficult and may not be possible.

NOTE 4—This practice presents a design for monitoring wells that will be effective in the majority of formations. Applicable state guidance may differ from the designs contained in this practice.

NOTE 5—Because the well screen slots have uniform openings, the filter pack should be composed of particles that are as uniform in size as is practical. Ideally, the uniformity coefficient (the quotient of the 60 % passing, D-60 size divided by the 10 % passing D-10 size [effective size]) of the filter pack should be 1.0 (that is, the D-60 % and the D-10 % sizes should be identical). However, a more practical and consistently achievable uniformity coefficient for all ranges of filter pack sizes is 2.5. This value of 2.5 should represent a maximum value, not an ideal.

NOTE 6—Although not recommended as standard practice, often a project requires drilling and installing the well in one phase of work. Therefore, the filter pack materials must be ordered and delivered to the drill site before soil samples can be collected. In these cases, the suggested well screen slot size and filter pack material combinations are presented in Table 1.

NOTE 7—Silica flour can alter water chemistry, particularly for transuranics, and its use should be evaluated against the monitoring program analytes

6.4 *Well Screen*:

6.4.1 *General*—The purposes of the well screen are to provide designed openings for ground-water flow through the well, and to prevent migration of filter pack and formation

TABLE 1 Recommended (Achievable) Filter Pack Characteristics for Common Screen Slot Sizes

Size of Screen Opening, mm (in.)	Slot No.	Sand Pack Mesh Size Name(s)	1 % Passing Size (D-1), mm	Effective Size, (D-10), mm	30 % Passing Size (D-30), mm	Range of Uniformity Coefficient	Roundness (Powers Scale)
0.125 (0.005)	5[A]	100	0.09 to 0.12	0.14 to 0.17	0.17 to 0.21	1.3 to 2.0	2 to 5
0.25 (0.010)	10	20 to 40	0.25 to 0.35	0.4 to 0.5	0.5 to 0.6	1.1 to 1.6	3 to 5
0.50 (0.020)	20	10 to 20	0.7 to 0.9	1.0 to 1.2	1.2 to 1.5	1.1 to 1.6	3 to 6
0.75 (0.030)	30	10 to 20	0.7 to 0.9	1.0 to 1.2	1.2 to 1.5	1.1 to 1.6	3 to 6
1.0 (0.040)	40	8 to 12	1.2 to 1.4	1.6 to 1.8	1.7 to 2.0	1.1 to 1.6	4 to 6
1.5 (0.060)	60	6 to 9	1.5 to 1.8	2.3 to 2.8	2.5 to 3.0	1.1 to 1.7	4 to 6
2.0 (0.080)	80	4 to 8	2.0 to 2.4	2.4 to 3.0	2.6 to 3.1	1.1 to 1.7	4 to 6

[A] A 5-slot (0.152-mm) opening is not currently available in slotted PVC but is available in Vee wire PVC and Stainless; 6-slot opening may be substituted in these cases.

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material into the well. The well screen design is based on either the grain-size distribution of the formation (in the case of a well with a naturally developed filter pack), or the grain-size distribution of the primary filter pack material (in the case of a filter-packed well). The screen openings must be small enough to retain most if not all of the formation or filter-pack materials, yet large enough to maintain ground-water flow velocities, from the well screen/filter pack interface back to the natural formation materials, of less than 0.10 ft/s (0.03 m/s). If well screen entrance velocities exceed 0.10 ft/s (0.03 m/s), turbulent flow conditions can occur, resulting in mobilization of sediment from the formation and reductions in well efficiency.

6.4.2 *Materials*—TThe well screen should be new, machine-slotted casing or continuous wrapped wire-wound screen composed of materials compatible with the monitoring environment, as determined by the site characterization program. The screen should be plugged at the bottom (unless a sediment sump is used), and the plug should generally be of the same material as the well screen. This assembly must have the capability to withstand well installation and development stresses without becoming dislodged or damaged. The length of the well screen open area should reflect the thickness of the target monitoring zone. Immediately prior to installation, the well screen should be cleaned (see either Practice D 5088 or Practice D 5608) with water from a source of known chemistry, if it is not certified clean by the manufacturer, and delivered, and maintained in a clean environment at the site.

NOTE 8—Well screens are most commonly composed of PVC or stainless steel. Stainless steel may be specified based on knowledge of the occurrence of microbially influenced corrosion in formations (specifically reducing or acid-producing conditions).

6.4.3 *Diameter*—TThe minimum nominal internal diameter of the well screen should be chosen based on factors specific to the particular application (such as the outside diameter of the purging and sampling device(s) to be used in the well). Well screens as small as 1/2-in. (1.27 cm) nominal diameter are available for use in monitoring well applications.

6.4.4 *Design*—The design of the well screen should be determined based on the grain size analysis (per Test Method D 422) of the interval to be monitored and the gradation of the primary filter pack material. In granular, non-cohesive formation materials that will fall in easily around the screen, filter packs can be developed from the native formation materials—filter pack materials foreign to the formation are not necessary. In these cases of naturally developed filter packs, the slot size of the well screen is determined using the grain size of the materials in the surrounding formation. The well screen slot size selected for this type of well completion should retain at least 70 % of formation materials—the finest 30 % of formation materials will be brought into the well during development, and the objectives of filter packing (to increase hydraulic conductivity immediately surrounding the well screen, and to promote easy flow of ground water into and through the screen) will be met. In wells in which a filter pack material of a selected grain size distribution is introduced from the surface, the screen slot size selected should retain at least 90 %, and preferably 99 %, of the primary filter pack materials. The method for determining the primary filter pack design is described in 6.3.3.

6.4.5 *Prepacked or Sleeved Well Screens*—An alternative to designing and installing filter pack and well screens separately is to use a pre-packed or sleeved screen assembly. A pre-packed well screen consists of an internal well screen, an external screen or filter medium support structure, and the filter medium contained between the screens, which together comprise an integrated structure. The internal and external screens are constructed of materials compatible with the monitored environment, and are usually of a common slot size specified by the well designer to retain the filter pack material. The filter pack is normally an inert (e.g., siliceous) granular material that has a grain-size distribution chosen to retain formation materials. A sleeved screen consists of a slotted pipe base over which a sleeve of stainless steel mesh filled with selected filter media is installed. Pre-packed or sleeved screens may be used for any formation conditions, but they are most often used where heaving, running or blowing sands make accurate placement of conventional well screens and filter packs difficult, or where predominantly fine-grained formation materials are encountered. In the latter case, using pre-packed or sleeved screens is the only practical means of ensuring that filter pack materials of the selected grain-size distribution (generally fine to very fine sands) are installed to completely surround the screen.

NOTE 9—The practice of using a single well screen/filter pack combination (e.g., 0.010 in. [0.254 mm]) well screen slot size with a 20/40 sand) for all wells, regardless of formation grain-size distribution, will result in siltation of the well and significant turbidity in samples when applied to formations finer than the recommended design. It will also result in the loss of filter pack, possible collapse of the screen, and invasion of overlying well construction materials (e.g., secondary filter pack, annular seal materials, grout) when applied to formations coarser than the recommended design. For these reasons, the universal application of a single well screen/filter pack combination to all formations is not recommended, and should be avoided.

6.5 *Riser*:

6.5.1 *Materials*—TThe riser should be new pipe composed of materials that will not alter the quality of water samples for the constituents of concern and that will stand up to long-term exposure to the monitoring environment, including potential contaminants. The riser should have adequate wall thickness and coupling strength to withstand the stresses imposed on it during well installation and development. Each section of riser should be cleaned (see either Practice D 5088 or Practice D 5608) using water from a source of known chemistry immediately prior to installation.

NOTE 10—Risers are generally constructed of PVC, galvanized steel or stainless steel.

6.5.2 *Diameter*—The minimum nominal internal diameter of the riser should be chosen based on the particular application. Risers as small as ½-in. (1.25-cm) in diameter are available for applications in monitoring wells.

6.5.3 *Joints (Couplings)*—Threaded joints are recommended. Glued or solvent-welded joints of any type are not recommended because glues and solvents may alter the chemistry of water samples. Because square profile flush joint

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threads (Specification F 480) are designed to be accompanied by O-ring seals at the joints, they do not require PTFE taping. However, tapered threaded joints should be PTFE taped to prevent leakage of water into the riser.

6.6 *Casing*—Where conditions warrant, the use of permanent casing installed to prevent communication between water-bearing zones is encouraged. The following subsections address both temporary and permanent casings.

6.6.1 *Materials*—The material type and minimum wall thickness of the casing should be adequate to withstand the forces of installation. All casing that is to remain as a permanent part of the installation (that is, in multi-cased wells) should be new and cleaned to be free of interior and exterior protective coatings.

NOTE 11—The exterior casing (temporary or permanent multi-cased) is generally composed of steel, although other appropriate materials may be used.

6.6.2 *Diameter*—Several different casing sizes may be required depending on the geologic formations penetrated. The diameter of the borehole and the well casing for conventionally filter packed wells should be selected so that a minimum annular space of 2 in. (5 cm) is maintained between the inside diameter of the casing and outside diameter of the riser to provide working space for a tremie pipe. For naturally developed wells and pre-packed or sleeved screen completions, this annular space requirement need not be met. In addition, the diameter of the casings in multi-cased wells should be selected so that a minimum annular space of 2 in. (5 cm) is maintained between the casing and the borehole (that is, a 2-in. [5 cm] diameter screen will require first setting a 6-in. [15.2 cm] diameter casing in a 10-in. [25.4 cm] diameter boring).

NOTE 12—Under difficult drilling conditions (collapsing soils, rock, or cobbles), it may be necessary to advance temporary casing. Under these conditions, a smaller annular space may be maintained.

6.6.3 *Joints (Couplings)*—The ends of each casing section should be either flush-threaded or beveled for welding.

6.7 *Sediment Sump*—A sediment sump, a length of blank pipe, generally of the same diameter and made of the same material as the riser and well screen -- may be affixed to the bottom of the screen, and capped with a bottom plug, to collect fine-grained material brought into the well by the process of well development. A drainage hole may be drilled in the bottom of the sump to prevent the sump from retaining water in the event that the water level outside the well falls below the bottom of the well screen. Because the sediment that collects in the sump may harbor geochemistry-altering microflora and reactive metal oxides, this sediment must be removed periodically to minimize the potential for sample chemical alteration.

6.8 *Protective Casing*:

6.8.1 *Materials*—Protective casings may be made of aluminum, mild steel, galvanized steel, stainless steel, cast iron, or structural plastic pipe. The protective casing should have a lid capable of being locked shut by a locking device or mechanism.

6.8.2 *Diameter*—The inside dimensions of the protective casing should be a minimum of 2 in. (5 cm) and preferably 4 in. (10 cm) larger than the nominal diameter of the riser to facilitate the installation and operation of sampling equipment.

6.9 *Annular Sealants*—TThe materials used to seal the annulus may be prepared as a slurry or used un-mixed in a dry pellet, granular, or chip form. Sealants should be selected to be compatible with ambient geologic, hydrogeologic, geochemical and climatic conditions and any man-induced conditions (e.g., subsurface contamination) anticipated during the life of the well.

6.9.1 *Bentonite*—Bentonite should be powdered, granular, pelletized, or chipped sodium montmorillonite from a commercial source, free of impurities that may adversely impact the water quality in the well. Pellets consist of roughly spherical units of moistened, compressed bentonite powder. Chips are large, irregularly shaped, and coarse granular units of bentonite free of additives. The diameter of pellets or chips selected for monitoring well construction should be less than one fifth the width of the annular space into which they are placed to reduce the potential for bridging. Granules consist of coarse to fine particles of unaltered bentonite, typically smaller than 0.2 in. (5.0 mm). It is recommended that the water chemistry of the formation in which the bentonite is intended for installation be evaluated to ensure that it is suitable to hydrate the bentonite. Some water-quality conditions (e.g., high chloride content, high concentrations of certain organic solvents or petroleum hydrocarbons) may inhibit the hydration of bentonite and result in an ineffective seal.

6.9.2 *Cement*—Each type of cement has slightly different characteristics that may be appropriate under various physical and chemical conditions. Cement should be one of the five Portland cement types that are specified in Specification C 150. The use of quick-setting cements containing additives is not recommended for use in monitoring well installation. Additives may leach from the cement and influence the chemistry of water samples collected from the monitoring well.

6.9.3 *Grout*—The grout backfill that is placed above the bentonite annular seal and secondary filters (see Fig. 1) is ordinarily a thick liquid slurry consisting of either a bentonite (powder or granules, or both) base and water, or a Portland cement base and water. Often, bentonite-based grouts are used when it is desired that the grout remain workable for extended periods of time during well construction or flexible (that is, to accommodate freeze-thaw cycles) during the life of the well. Cement-based grouts are often used when filling cracks in the surrounding geologic material, adherence to rock units, or a rigid setting is desired.

6.9.3.1 *Mixing*—The mixing (and placing) of a grout backfill should be performed with precisely recorded weights and volumes of materials, and according to procedures stipulated by the manufacturer that often include the order of component mixing. The grout should be thoroughly mixed with a paddle-type mechanical mixer or by recirculating the mix through a pump until all lumps are disintegrated. Lumpy grout should not be used in the construction of a monitoring well to prevent bridging within the tremie pipe.

NOTE 13—Lumps do not include lost circulation materials that may be added to the grout if excessive grout losses occur.

6.9.3.2 *Typical Bentonite-Based Grout*—When a bentonite-based grout is used, bentonite, usually unaltered, should be placed in the water through a venturi device. A typical

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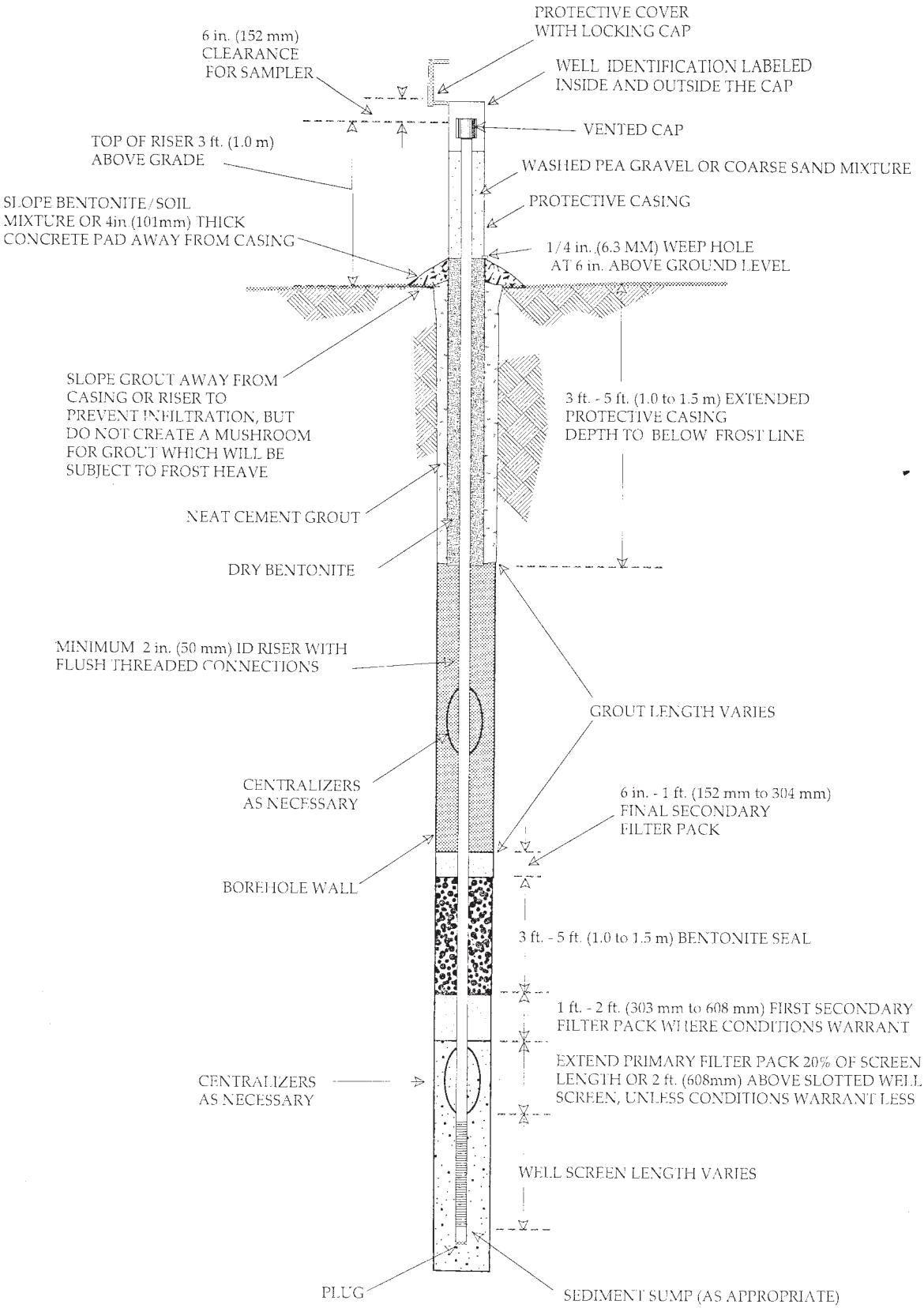

FIG. 1 Monitoring Well Design—Single–Cased Well

unbeneficiated bentonite-based grout consists of about 1 to 1.25 lb (0.57 kg) of unaltered bentonite to each 1 gal (3.8 L) of

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water. 100 % bentonite grouts should not be used for monitoring well annular sealants in the vadose zone of arid regions because of the possibility that they may desiccate. This could result in migration of water into the screened portion of the well from zones above the target monitoring zone.

NOTE 14—High solids bentonite grouts (minimum 20 % by weight with water) and other bentonite-based grouts may contain granular bentonite to increase the solids content and other components added under manufacturer's directions to either stiffen or retard stiffening of the mix. All additives to grouts should be evaluated for their effects on subsequent water samples.

6.9.3.3 *Typical Cement-Based Grout*—A typical cement-based grout consists of about 6 gal. (23 L) of water per 94-lb. (43-kg) bag of Type I Portland cement. Though not recommended because of the chemical incompatability of bentonite with cement (2, 3), from 3 to 8 % (by dry weight) of unaltered bentonite powder is often added after the initial mixing of cement and water to retard shrinkage and provide plasticity..

6.10 *Secondary Filter Packs*:

6.10.1 *Materials*—A secondary filter pack is a layer of material placed in the annulus between the primary filter pack and the bentonite seal, and/or between the bentonite seal and the grout backfill (see Fig. 1 and Fig. 2).

6.10.2 *Gradation*—The secondary filter pack should be uniformly graded fine sand with 100 % by weight passing the #30 U.S. Standard sieve, and less than 2 % by weight passing the #200 U.S. Standard sieve.

6.11 *Annular Seal and Filter Pack Installation Equipment*—The equipment used to install the annular seals and filter pack materials should be cleaned (if appropriate for the selected material) using water from a source of known quality prior to use. This procedure is performed to prevent the introduction of materials that may ultimately alter water quality samples.

7. Drilling Methods

7.1 The type of equipment required to create a stable, open, vertical borehole for installation of a monitoring well depends upon the site geology, hydrology, and the intended use of the data. Engineering and geological judgment and some knowledge of subsurface geological conditions at the site is required for the selection of the appropriate drilling method(s) utilized for drilling the exploratory soil borings and monitoring wells (see Guide D 6286). Appropriate drilling methods for investigating and installing monitoring wells at a site may include any one or a combination of several of the following methods: hollow-stem auger (Guide D 5784); direct (mud) rotary (Guide D 5783); direct air-rotary (Guide D 5782); direct rotary wireline casing advancement (Guide D 5876); dual-wall reverse-circulation rotary (Guide D 5781); cable-tool (Guide D 5875); or various casing advancement methods (Guide D 5872). Whenever feasible, it is advisable to utilize drilling procedures that do not require the introduction of water or drilling fluids into the borehole, and that optimize cuttings control at ground surface. Where the use of water or drilling fluid is unavoidable, the selected fluid should have as little impact as possible on the water samples for the constituents of interest. The chemistry of the fluid to be used should be evaluated to determine the potential for water quality sample alteration. In addition, care should be taken to remove as much drilling fluid as possible from the well and the surrounding formation during the well development process. It is recommended that if an air compressor is used, it should be equipped with an oil air filter or oil trap to minimize the potential for chemical alteration of ground-water samples collected after the well is installed. 8. Monitoring Well Installation

8. Monitoring Well Installation

8.1 *Stable Borehole*—A stable borehole must be constructed prior to attempting the installation of monitoring well screen and riser. Steps must be taken to stabilize the borehole before attempting installation if the borehole tends to cave or blow in, or both. Boreholes that are not straight or are partially obstructed should be corrected prior to attempting the installation procedures described herein.

8.2 *Assembly of Well Screen and Riser*:

8.2.1 *Handling*—TThe well screen, sediment sump, bottom plug and riser should be either certified clean from the manufacturer or steam-cleaned or high-pressure hot-water washed (whichever is appropriate for the selected material) using water from a source of known chemistry immediately prior to assembly. Personnel should take precautions to assure that grease, oil, or other contaminants that may ultimately alter the water sample do not contact any portion of the well screen and riser assembly. As one precaution, for example, personnel should wear a clean pair of cotton, nitrile or powder-free PVC (or equivalent) gloves while handling the assembly..

8.2.2 *Riser Joints (Couplings)*—Flush joint risers with square profile (Specification F 480) threads do not require PTFE taping to achieve a water tight seal; these joints should not be taped. O-rings made of a material of known chemistry, selected on the basis of compatibility with contaminants of concern and prevailing environmental conditions, should be used to assure a tight seal of flush-joint couplings. Couplings are often tightened by hand; however, if necessary, steam-cleaned or high-pressure water-cleaned wrenches may be utilized. Precautions should be taken to prevent damage to the threaded joints during installation, as such damage may promote leakage past the threads.

8.3 *Setting the Well Screen and Riser Assembly*—When the well screen and riser assembly is lowered to the predetermined level in the borehole and held in position, the assembly may require ballast to counteract the tendency to float in the borehole. Ballasting may be accomplished by filling the riser with water from a source of known and acceptable chemistry or, preferably, using water that was previously removed from the borehole. Alternatively, the riser may be slowly pushed into the fluid in the borehole with the aid of hydraulic rams on the drill rig and held in place as additional sections of riser are added to the column. Care must be taken to secure the riser assembly so that personnel safety is assured during the installation. The assembly must be installed straight and plumb, with centralizers installed at appropriate locations (typically every 20 to 30 ft [6 to 9 m]). Difficulty in maintaining a straight installation may be encountered where the weight of the well screen and riser assembly is significantly less than the buoyant force of the fluid in the borehole. The riser should extend above grade and be capped temporarily to deter entrance of foreign materials during final completion.

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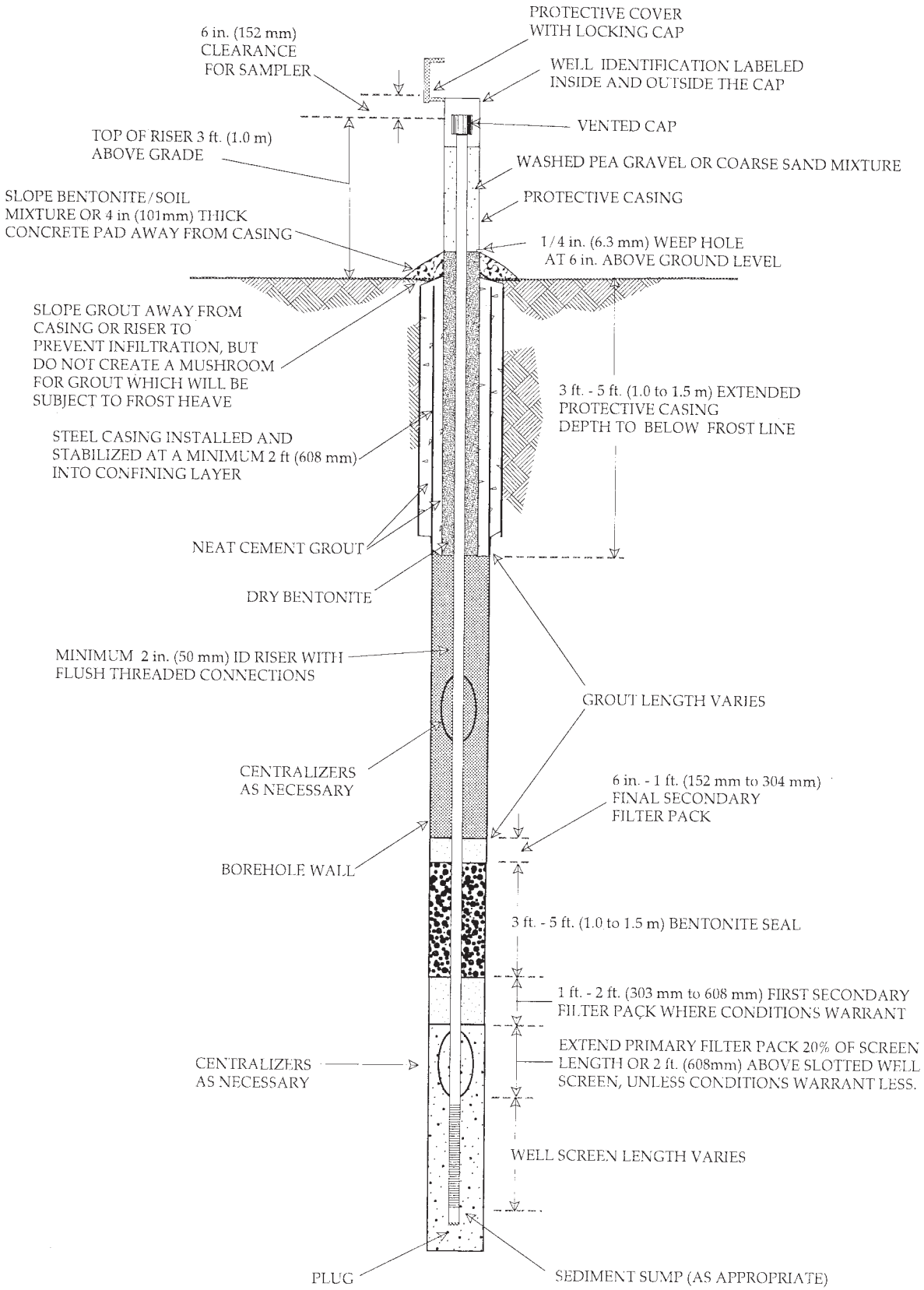

FIG. 2 Monitoring Well Design—Multi–Cased Well

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8.4 *Installation of the Primary Filter Pack*:

8.4.1 *Volume of Filter Pack*—TThe volume of filter pack required to fill the annular space between the well screen and borehole should be calculated, measured, and recorded on the well completion diagram during installation. To be effective, the filter pack should extend above the screen for a distance of about 20 % of the length of the well screen but not less than 2 ft. (0.6 m) (see Figs. 1 and 2). Where there is hydraulic connection between the zone to be monitored and the overlying strata, this upward extension should be gauged to prevent seepage from overlying hydrologic units into the filter pack. Seepage from other units may alter hydraulic head measurements or the chemistry of water samples collected from the well.

8.4.2 *Placement of Primary Filter Pack*—Placement of the well screen is preceded by placing no less than 2 % and no more than 10 % of the primary filter pack into the bottom of the borehole using a decontaminated, flush threaded, 1-in. (25-mm) minimum internal diameter tremie pipe. Alternatively, the filter pack may be added directly between the riser pipe and the auger or drive/temporary casing and the top of the filter pack located using a tamper or a weighted line. The well screen and riser assembly is then centered in the borehole. This can be done using one or more centralizer(s) or alternative centering devices located not more than 10 ft (3 m) above the bottom of the well screen (see Figs. 1 and 2). Centralizers should not be located in the well screen. The remaining primary filter pack is then placed in increments as the tremie is gradually raised or as the auger or drive/temporary casing is removed from the borehole. As primary filter pack material is poured into the tremie pipe, water from a source of known and acceptable chemistry may be added to help deliver the filter pack to the intended interval in the borehole. The tremie pipe or a weighed line can be used to measure the top of the primary filter pack as work progresses. If bridging of the primary filter pack material occurs, the bridged material should be broken mechanically prior to proceeding with the addition of more filter pack material. The elevation (or depth below ground surface), volume, and gradation of primary filter pack should be recorded on the well completion diagram (see Fig. 2 for an example).

8.4.3 *Withdrawal of the Temporary Casing/Augers*—If used, the drive/temporary casing or hollow stem auger is withdrawn, usually in stipulated increments. Care should be taken to avoid lifting the riser with the withdrawal of the temporary casing/augers. To limit borehole collapse in stable formations, the temporary casing or hollow stem auger is usually withdrawn until the lower-most point on the temporary casing or hollow stem auger is at least 2 ft (0.6 m), but no more than 5 ft (1.5 m) above the filter pack for unconsolidated materials; or at least 5 ft (1.5 m), but no more than 10 ft (3.0 m), for consolidated materials. In highly unstable formations, withdrawal intervals may be much less. After each increment, it should be ascertained that the primary filter pack has not been displaced during the withdrawal operation (using a weighed measuring device).

8.5 *Placement of First Secondary Filter*—A secondary filter pack may be installed above the primary filter pack to prevent the intrusion of the bentonite grout seal into the primary filter pack (see Figs. 1 and 2). To be effective, a measured and recorded volume of secondary filter material should be added to extend 1 to 2 ft (0.3 to 0.6 m) above the primary filter pack. As with the primary filter, a secondary filter must not extend into an overlying hydrologic unit (see 8.4.1). The well designer should evaluate the need for this filter pack by considering the gradation of the primary filter pack, the hydraulic heads between adjacent units, and the potential for grout intrusion into the primary filter pack. The secondary filter material is poured into the annular space through a decontaminated, flush threaded, 1-in. (25-mm) minimum internal diameter tremie pipe lowered to within 3 ft (1.0 m) of the placement interval. Water from a source of known and acceptable chemistry may be added to help deliver the filter pack to its intended location. The tremie pipe or a weighed line can be used to measure the top of the secondary filter pack as work progresses. The elevation (or depth below ground surface), volume, and gradation of the secondary filter pack should be recorded on the well completion diagram.

8.6 *Installation of the Bentonite Seal*—A bentonite pellet or a slurry seal is placed in the annulus between the borehole and the riser pipe on top of the secondary or primary filter pack (see Figs. 1 and 2). This seal retards the movement of cement-based grout backfill into the primary or secondary filter packs. To be effective, the bentonite seal should extend above the filter packs approximately 3 to 5 ft (1.0 to 1.5 m), depending on local conditions. The bentonite slurry seal should be installed using a positive displacement pump and a side-discharge tremie pipe lowered to the top of the filter pack. The tremie pipe should be raised slowly as the bentonite slurry fills the annular space. Bentonite pellets or chips may be poured from the surface and allowed to free-fall into the borehole. As a bentonite pellet or chip seal is poured into the borehole, a tamper may be necessary to tamp pellets or chips into place or to break bridges formed as the pellets or chips stick to the riser or the walls of the water-filled portion of the borehole. If the bentonite seal is installed above the water level in the borehole, granular bentonite should be used as the seal material – *bentonite pellets or chips should not be used in the unsaturated zone.* Granular bentonite should be poured into the borehole and installed in lifts of 2 in., then hydrated with water from a source of known chemistry. The tremie pipe or a weighed line can be used to measure the top of the bentonite seal as the work progresses. Sufficient time should be allowed for the bentonite pellet seal to hydrate or the slurry annular seal to expand prior to grouting the remaining annulus. The volume and elevation (or depth below ground surface) of the bentonite seal material should be measured and recorded on the well completion diagram.

8.7 *Final Secondary Filter Pack*—A 6-in. to 1-ft (0.15 to 0.3-m) secondary filter may be placed above the bentonite seal in the same manner described in 8.5 (see Figs. 1 and 2). This secondary filter pack will provide a layer over the bentonite seal to limit the downward movement of cement-based grout backfill into the bentonite seal. The volume, elevation (or depth

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below ground surface), and gradation of this final secondary filter pack should be documented on the well completion diagram.

8.8 *Grouting the Annular Space*:

8.8.1 *General*—Grouting procedures vary with the type of well design. The following procedures will apply to both single- and multi-cased monitoring wells. Paragraphs 8.8.2 and 8.8.3 detail those procedures unique to single- and multi-cased installations, respectively.

8.8.1.1 *Volume of Grout*—An ample volume of grout should be mixed on site to compensate for unexpected losses to the formation. The use of alternate grout materials, including grout containing gravel, may be necessary to control zones of high grout loss. The volume and location of grout used to backfill the remaining annular space is recorded on the well completion diagram.

8.8.1.2 *Grout Installation Procedures*—The grout should be pumped down hole through a side-discharge tremie pipe using a positive displacement pump (e.g., a diaphragm pump, moyno pump, or similar pump) to reduce the chance of leaving voids in the grout, and to displace any liquids and drill cuttings that may remain in the annulus. In very shallow wells, grouting may be accomplished by gravity feeding grout through a tremie pipe. With either method, grout should be introduced in one continuous operation until full-strength grout flows out of the borehole at the ground surface without evidence of drill cuttings, drilling fluid, or water.

8.8.1.3 *Grout Setting and Curing*—The riser should not be disturbed until the grout sets and cures for the amount of time necessary to prevent a break in the seal between the grout and riser. The amount of time required for the grout to set or cure will vary with the grout mix and ambient temperature and should be documented on the well completion diagram.

8.8.2 *Specific Procedures for Single-Cased Wells*—Grouting should begin at a level directly above the final secondary filter pack (see Fig. 1) if used, or above the bentonite pellet, chip or slurry seal. Grout should be pumped using a side-discharge tremie pipe to dissipate the fluid-pumping energy against the borehole wall and riser, reducing the potential for infiltration of grout into the primary filter pack. The tremie pipe should be kept full of grout from start to finish, with the discharge end of the pipe completely submerged as it is slowly and continuously lifted. Approximately 5 to 10 ft (1.5 to 3.0 m) of tremie pipe should remain submerged until grouting is complete. For deep installations or where the joints or couplings of the selected riser cannot withstand the collapse stress exerted by a full column of grout as it is installed, a staged grouting procedure may be used. If used, the drive/temporary casing or hollow-stem auger should be removed in increments immediately following each increment of grout installation and before the grout begins to set. If casing removal does not commence until grout pumping is completed, then, after the casing is removed, additional grout may be periodically pumped into the annular space to maintain a continuous column of grout up to the ground surface.

8.8.3 *Specific Procedures for Multi-Cased Wells*—If the outer casing of a multi-cased well cannot be driven to form a tight seal between the surrounding stratum (strata) and the casing, it should be installed in a pre-drilled borehole. After the borehole has penetrated not less than 2 ft. (0.6 m) of the first targeted confining stratum, the outer casing should be lowered to the bottom of the boring and the annular space pressure grouted. Pressure grouting requires the use of a grout shoe or packer installed at the end of the outer casing to prevent grout from moving up into the casing. The grout must be allowed to cure and form a seal between the casing and the borehole prior to advancing the hole to the next hydrologic unit. This procedure is repeated as necessary to advance the borehole to the desired depth. Upon reaching the final depth, the riser and screen should be set through the inner casing. After placement of the filter packs and bentonite seal, the remaining annular space is grouted as described in 8.8.2 (see Fig. 2).

NOTE 15—When using a packer, pressure may build up during grout injection and force grout up the sides of the packer and into the casing.

8.9 *Well Protection*—Well protection refers specifically to installations made at the ground surface to deter unauthorized entry to the monitoring well, to prevent damage to or destruction of the well, and to prevent surface water from entering the annulus. The methods described in Practice D 5787 should be used for well protection.

8.9.1 *Protective Casing*—Protective casing should be used for all monitoring well installations. In areas that experience frost heaving, the protective casing should extend from below the depth of frost penetration (3 to 5 ft [1.0 to 1.5 m] below grade, depending on local conditions), to slightly above the top of the well casing. The protective casing should be initially placed before final set of the grout. The protective casing should be sealed and immobilized in concrete placed around the outside of the protective casing above the set grout. The protective casing should be stabilized in a position concentric with the riser (see Figs. 3 and 1). Sufficient clearance, usually 6 in. (0.15 m) should be maintained between the lid of the protective casing and the top of the riser to accommodate sampling equipment. A ¼-in. (6.3-mm) ddiameter weep hole should be drilled in the protective casing approximately 6 in. (15 cm) above ground surface to permit water to drain out of the annular space between the protective casing and the riser. In cold climates, this hole will also prevent water freezing between the protective casing and the well casing. Dry bentonite pellets, granules, or chips should then be placed in the

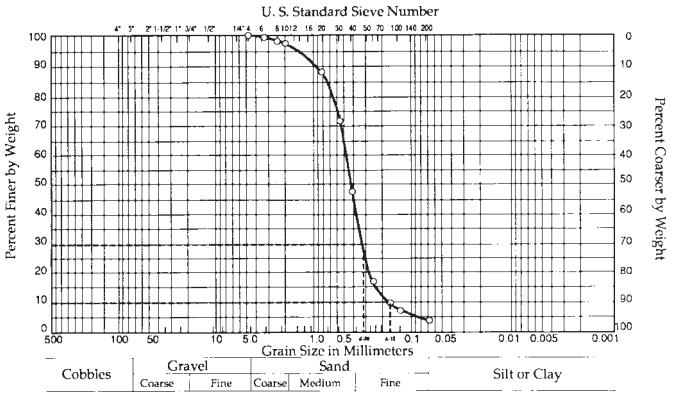

FIG. 3 Example Grading Curve for Design of Monitoring Well Screens

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annular space below ground level within the protective casing. Coarse sand or pea gravel or both should be placed in the annular space above the dry bentonite pellets and to just above the weep hole to prevent entry of insects. All materials chosen should be documented on the well completion diagram. The monitoring well identification number should be clearly visible on the inside and outside of the protective casing.

8.9.2 *Completion of Surface Installation*—The well protection installation may be completed in one of three ways:

8.9.2.1 In areas subject to frost heave, place a soil or bentonite/sand layer adjacent to the protective casing sloped to direct water drainage away from the well.

8.9.2.2 In regions not subject to frost heave, a concrete pad, sloped slightly to provide water drainage away from the well, should be placed around the installation.

8.9.2.3 Where monitoring well protection must be installed flush with the ground, an internal cap should be fitted on top of the riser within the manhole or vault. This cap should be leak-proof so that if the vault or manhole should fill with water, the water will not enter the well casing. Ideally, the manhole cover cap should also be leak-proof..

8.9.3 *Additional Protection*—In areas where there is a high probability of damaging the well (high traffic, heavy equipment, poor visibility), it may be necessary to enhance the normal protection of the monitoring well through the use of posts, markers, signs, or other means, as described in Practice D 5787. The level of protection should meet the damage threat posed by the location of the well.

9. Well Development

9.1 *General*—Well development serves to remove fine-grained material from the well screen and filter pack that may otherwise interfere with water quality analyses, to restore the formation properties disturbed during the drilling process, and to improve the hydraulic characteristics of the filter pack and hydraulic communication between the well and the hydrologic unit adjacent to the well screen. Methods of well development vary with the physical characteristics of hydrologic units in which the monitoring well is screened and with the drilling method used.

9.2 *Development Methods and Procedures*—The methods and procedures for well development described in Guide D 5521 should be followed to ensure a proper well completion.

9.3 *Timing and Duration of Well Development*—Well development should begin either after the riser, well screen and filter pack are installed and before the bentonite seal and grout are installed (the preferred time), or after the monitoring well is completely installed and the grout has cured or set. In the former case, the installer may add filter pack material to the borehole before the bentonite seal is installed to compensate for settlement that typically occurs during the development process. This allows the installer to maintain the desired separation between the top of the screen and the bentonite seal. In the latter case, the possibility exists that settlement of the filter pack may result in the bentonite seal settling into the top of the screen. Development should be continued until representative water, free of the drilling fluids, cuttings, or other materials introduced or produced during well construction, is obtained. Representative water is assumed to have been obtained when turbidity readings stabilize and the water is visually clear of suspended solids. The minimum duration of well development will vary with the method used to develop the well. The timing and duration of well development and the turbidity measurements should be recorded on the well completion diagram.

9.4 *Well Recovery Test*—A well recovery test should be performed immediately after and in conjunction with well development. The well recovery test provides an indication of well performance and provides data for estimating the hydraulic conductivity of the screened hydrologic unit. Readings should be taken at intervals suggested in Table 2 until the well has recovered to 90 % of its static water level.

NOTE 16—If a monitoring well does not recover sufficiently for sampling within a 24-hr period and the well has been properly developed, the installation should not generally be used as a monitoring well for detecting or assessing low level organic constituents or trace metals. The installation may, however, be used for long-term water-level monitoring if measurements of short-frequency water-level changes are not required.

10. Installation Survey

10.1 *General*—The vertical and horizontal position of each monitoring well in the monitoring system should be surveyed and subsequently mapped by a licensed surveyor. The well location map should include the location of all monitoring wells in the system and their respective identification numbers, elevations of the top of riser position to be used as the reference point for water-level measurements, and the elevations of the ground surface protective installations. The locations and elevations of all permanent benchmark(s) and pertinent boundary marker(s) located on-site or used in the survey should also be noted on the map.

10.2 *Water-Level Measurement Reference*—The water-level measurement reference point should be permanently marked, for example, by cutting a V-notch into the top edge of the riser pipe. This reference point should be surveyed in reference to the nearest NAVD reference point.

10.3 *Location Coordinates*—The horizontal location of all monitoring wells (active or decommissioned) should be surveyed by reference to a standardized survey grid or by metes and bounds.

10.4 *Borehole Deviation Survey*—A borehole deviation survey, to determine the direction and distance of the bottom of the well relative to the top of the well and points in between, should be completed in wells deeper than 100 feet and in wells installed in dipping formations.

11. Monitoring Well Network Report

11.1 TTo demonstrate that the goals set forth in the Scope have been met, a monitoring well network report should be prepared. This report should:

TABLE 2 Suggested Recording Intervals for Well Recovery Tests

Time Since Starting Test	Time Interval
0 to 15 min	1 min
15 to 50 min	5 min
50 to 100 min	10 min
100 to 300 min (5 h)	30 min
300 to 1440 min (24 h)	60 min

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11.1.1 Locate the area investigated in terms pertinent to the project. This should include sketch maps or aerial photos on which the exploratory borings, piezometers, sample areas, and monitoring wells are located, as well as topographic items relevant to the determination of the various soil and rock types, such as contours, streambeds, etc. Where feasible, include a geologic map and geologic cross sections of the area being investigated.

11.1.2 Include copies of all well boring test pits and exploratory borehole logs, initial and post-completion water levels, all laboratory test results, and all well completion diagrams.

11.1.3 Include the well installation survey.

11.1.4 Describe and relate the findings obtained in the initial reconnaissance and field investigation (Section 5) to the design and installation procedures selected (Sections 7-9) and the surveyed locations (Section 10).

11.1.5 This report should include a recommended decommissioning procedure that is consistent with those described in Guide D 5299 and/or with applicable regulatory requirements.

12. Keywords

12.1 aquifer; borehole drilling; geophysical exploration; ground water; monitoring well; site investigation

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Designation: D 5299 – 99

Standard Guide for Decommissioning of Ground Water Wells, Vadose Zone Monitoring Devices, Boreholes, and Other Devices for Environmental Activities[1]

This standard is issued under the fixed designation D 5299; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval. A superscript epsilon (ε) indicates an editorial change since the last revision or reapproval.

1. Scope

1.1 This guide covers procedures that are specifically related to permanent decommissioning (closure) of the following as applied to environmental activities. It is intended for use where solid or hazardous materials or wastes are found, or where conditions occur requiring the need for decommissioning. The following devices are considered in this guide:

1.1.1 A borehole used for geoenvironmental purposes (see Note 1),

1.1.2 Monitoring wells,

1.1.3 Observation wells,

1.1.4 Injection wells (see Note 2),

1.1.5 Piezometers,

1.1.6 Wells used for the extraction of contaminated ground water, the removal of floating or submerged materials other than water such as gasoline or tetrachloroethylene, or other devices used for the extraction of soil gas,

1.1.7 A borehole used to construct a monitoring well, and

1.1.8 Any other vadose zone monitoring device.

1.2 Temporary decommissioning of the above is not covered in this guide.

NOTE 1—This guide may be used to decommission boreholes where no contamination is observed at a site (see Practice D 420 for details); however, the primary use of the guide is to decommission boreholes and wells where solid or hazardous waste have been identified. Methods identified in this guide can also be used in other situations such as the decommissioning of water supply wells and boreholes where water contaminated with nonhazardous pollutants (such as nitrates or sulfates) are present. This guide should be consulted in the event that a routine geotechnical investigation indicates the presence of contamination at a site.

NOTE 2—The term "well" is used in this guide to denote monitoring wells, piezometers, or other devices constructed in a manner similar to a well. Some of the devices listed such as injection and extraction wells can be decommissioned using this guide for information, but are not specifically covered in the text.

NOTE 3—Details on the decommissioning of multiple-screened wells are not provided in this guide due to the many methods used to construct these types of wells and the numerous types of commercially available multiple-screened well systems. However, in some instances, the methods presented in this guide may be used with few changes. An example of how this guide may be used is the complete removal of the multiple-screened wells by overdrilling.

1.3 Most monitoring wells and piezometers are intended primarily for water quality sampling, water level observation, or soil gas sampling, or combination thereof, to determine quality. Many wells are relatively small in diameter and are used to monitor for hazardous chemicals in ground water. Decommissioning of monitoring wells is necessary to:

1.3.1 Eliminate the possibility that the well is used for purposes other than intended,

1.3.2 Prevent migration of contaminants into an aquifer or between aquifers,

1.3.3 Prevent migration of contaminants in the vadose zone,

1.3.4 Reduce the potential for vertical or horizontal migration of fluids in the well or adjacent to the well, and

1.3.5 Remove the well from active use when the well is no longer capable of rehabilitation, or has failed structurally; no longer required for monitoring; no longer capable of providing representative samples or is providing unreliable samples; or required to be decommissioned; or to meet regulatory requirements.

NOTE 4—The determination of whether a well is providing a representative water quality sample is not defined in this guide. Examples of when a representative water quality sample may not be collected include the biological or chemical clogging of well screens, a drop in water level to below the base of the well screen, or complete silting of a tail pipe. These conditions may indicate that a well is not functioning properly.

1.4 This guide is intended to provide information for effective permanent closure of wells so that the physical structure of the well does not provide a means of hydraulic communication between aquifers or react chemically in a detrimental way with the environment.

1.5 The intent of this guide is to provide procedures that when followed result in a reasonable level of confidence in the integrity of the decommissioning activity. However, it may not be possible to verify the integrity of the decommissioning procedure. At this time, methods are not available to substantially determine the integrity of the decommissioning activity.

1.6 The values stated in inch-pound units are to be regarded as the standard. The SI units given in parentheses are for information only.

[1] This guide is under the jurisdiction of ASTM Committee D-18 on Soil and Rock and is the direct responsibility of Subcommittee D18.21 on Ground Water and Vadose Zone Investigations.

Current edition approved Dec. 10, 1999. Published March 2000. Originally published as D 5299 – 92. Last previous edition D 5299 – 92ε1.

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1.7 *This standard does not purport to address all of the safety problems, if any, associated with its use. It is the responsibility of the user of this standard to establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.*

1.8 *This guide offers an organized collection of information or a series of options and does not recommend a specific course of action. This document cannot replace education or experience and should be used in conjunction with professional judgment. Not all aspects of this guide may be applicable in all circumstances. This ASTM standard is not intended to represent or replace the standard of care by which the adequacy of a given professional service must be judged, nor should this document be applied without consideration of a project's many unique aspects. The word" Standard" in the title of this document means only that the document has been approved through the ASTM consensus process.*

NOTE 5—If state and local regulations are in effect where the decommissioning is to occur, the regulations take precedence over this guide.

2. Referenced Documents

2.1 *ASTM Standards:*

C 150 Specification for Portland Cement[2]

C 618 Specification for Coal Fly Ash and Raw or Calcined Natural Pozzolan for Use as a Mineral Admixture in Portland Concrete Cement[3]

D 420 Guide to Site Characterization for Engineering, Design and Construction Purposes[4]

D 4380 Test Method for Density of Bentonitic Slurries[4]

D 5088 Practice for Decontamination of Field Equipment Used at Nonradioactive Waste Sites[4]

D 5092 Practice for Design and Installation of Ground Water Monitoring Wells in Aquifers[5]

D 6001 Guide for Direct-Push Water Sampling for Geoenvironmental Investigations[4]

D 6282 Guide for Direct-Push Soil Sampling for Environmental Site Characterization[5]

3. Terminology

3.1 *Definitions of Terms Specific to This Standard:*

3.1.1 **abandonment**—see *decommissioning*.

3.1.2 *attapulgite clay*—a chain-lattice clay mineral. The term also applies to a group of clay minerals that are lightweight, tough, matted, and fibrous.

3.1.3 *borehole television log*—a borehole or well video record produced by lowering a television camera into the borehole or well. This record is useful in visually observing downhole conditions such as collapsed casing or a blocked screen.

3.1.4 *blowout*—a sudden or violent uncontrolled escape of fluids or gas, or both, from a borehole.

3.1.5 *caliper log*—a geophysical borehole log that shows to scale the variations with depth in the mean diameter of a cased or uncased borehole.

3.1.6 *cement, API, Class A*—a cement intended for use from the surface to a depth of 6000 ft (1828 m). This cement is similar to ASTM Type I cement.

3.1.7 *cement, API, Class B*—a cement intended for use from the surface to a depth of 6000 ft (1828 m) when conditions require moderate- to high-sulfate resistance. This cement is similar to ASTM Type II cement.

3.1.8 *cement, API, Class C*—this cement is intended for use from the surface to a depth of 6000 ft (1828 m) when conditions require high early strength. This cement is similar to ASTM Type III cement. Also available as a high sulfate resistant type.

3.1.9 *cement, API, Class G*—this cement is intended for use from the surface to a depth of 8000 ft (2438 m). It can be used with accelerators or retarders to cover a wide range of well depths and temperatures. No additions other than calcium sulfate or water, or both, can be interground or blended with the clinker during manufacture of the cement. Also available as several sulfate-resistant types.

3.1.10 *cement, API, Class H*—this cement is intended for use from the surface to a depth of 8000 ft (2438 m). It can be used with accelerators or retarders to cover a wide range of well depths and temperatures. No additions other than calcium sulfate or water, or both, can be interground or blended with the clinker during manufacture of the cement. Also available as a sulfate-resistant type.

3.1.11 *cement, API, Class J*—this cement is intended for use from depths of 12 000 to 16 000 ft (3658 to 4877 m) under conditions of extremely high temperatures and pressures. It can be used with accelerators and retarders to cover a range of well depths and temperatures. No additions of retarders other than calcium sulfate, or water, or both, can be interground or blended with the clinker during manufacture of the cement.

3.1.12 *cement bond (sonic) log*—a borehole geophysical log that can be used to determine the effectiveness of a cement seal of the annular space of a well.

3.1.13 *channeling*—the process of forming a vertical cavity resulting from a faulty cement job in the annular space.

3.1.14 *curing accelerator*—a material added to cement to decrease the time for curing. Examples are sodium chloride, calcium sulfate (gypsum), and aluminum powder.

3.1.15 *curing retarder*—a material added to cement to increase the time for curing. Sodium chloride in high concentrations is an example.

3.1.16 *decommissioning (closure)*—the engineered closure of a well, borehole, or other subsurface monitoring device sealed with plugging materials. Decommissioning also includes the planning and documenting of all associated activities. A synonym is abandonment.

3.1.17 *decontamination*—the process of removing undesirable physical or chemical constituents, or both, from equipment to reduce the potential for cross-contamination.

3.1.18 *fallback*—shrinkage, settlement, or loss of plugging material placed in a borehole or well.

3.1.19 *fire clay*—a silicious clay rich in hydrous aluminum silicates.

3.1.20 *flow log*—a borehole geophysical log used to record vertical movement of ground water and movement of water

[2] *Annual Book of ASTM Standards*, Vol 04.01.
[3] *Annual Book of ASTM Standards*, Vol 04.02.
[4] *Annual Book of ASTM Standards*, Vol 04.08.
[5] *Annual Book of ASTM Standards*, Vol 04.09.

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into or out of a well or borehole and between formations within a well.

3.1.21 *geophysical borehole log*—a log obtained by lowering an instrument into a borehole and continuously recording a physical property of native or backfill material and contained fluids. Examples include resistivity, induction, caliper, sonic, and natural gamma logs.

3.1.22 *grout*—material consisting of bentonite, cement, or a cement-bentonite mixture.

3.1.23 *grout pipe*—a pipe or tube that is used to transport cement, bentonite, or other plugging materials from the ground surface to a specified depth in a well or borehole. The material may be allowed to flow freely or it may be injected under pressure. The term tremie pipe is frequently used interchangeably.

3.1.24 *hydraulic communication*—the migration of fluids from one zone to another, with reference to this guide; especially along a casing, grout plug, or through backfill materials.

3.1.25 *multiple-screened wells*—two or more monitoring wells situated in the same borehole. These devices can be either individual casing strings and screen set at a specific depth, a well with screens in more than one zone, or can consist of devices with screens with tubing or other collecting devices attached that can collect a discrete sample.

3.1.26 *native material*—in place geologic (or soil) materials encountered at a site.

3.1.27 *overdrilling*—the process of drilling out a well casing and any material placed in the annular space.

3.1.28 *perforation*—a slot or hole made in well casing to allow for communication of fluids between the well and the annular space.

3.1.29 *permanent plugging*—a seal that has a hydraulic conductivity that is equivalent or less than the hydraulic conductivity of the geologic formation. This term is often used with uncased boreholes.

3.1.30 *plow layer*—the depth typically reached by a plow or other commonly used earth turning device used in agriculture. This depth is commonly one to two feet (.3 m to .61 m) below land surface.

3.1.31 *plugging material*—a material that has a hydraulic conductivity equal to or less than that of the geologic formation(s) to be sealed. Typical materials include portland cement and bentonite.

3.1.32 *pre-conditioning*—an activity conducted prior to placing plugging material into a borehole in order to stabilize the hole.

3.1.33 *temporary decommissioning*—the engineered closure of a well intended to be returned to service at some later date (generally no more than six months). Temporary plugging should not damage the structural integrity of the well. Plugging materials consist of sand, bentonite, or other easily removed materials.

4. Summary of Guide

4.1 Information is provided on the significance of properly decommissioning boreholes and wells at sites containing or formerly containing solid or hazardous waste or hazardous materials or their byproducts, or that may be affected by solid or hazardous waste materials or their byproducts in the future. This guide may be used in situations where water quality in one aquifer may be detrimental to another aquifer either above or below the aquifer. The primary purpose of decommissioning activities is to permanently decommission the borehole or monitoring device so that the natural migration of ground water or soil vapor is not significantly influenced. Decommissioned boreholes and wells should have no adverse influence on the local environment than the original geologic setting.

4.2 It is important to have a good understanding of the geology, hydrogeology, well construction, historic and future land use, chemicals encountered, and the regulatory environment for successful decommissioning to occur.

4.3 Various materials suitable for decommissioning boreholes and wells are discussed, including their positive and negative attributes for decommissioning. A generalized procedure is provided that discusses the process from planning through implementation and documentation. Examples of typical practices are provided in the appendix.

5. Significance and Use

5.1 Decommissioning of boreholes and monitoring wells, and other devices requires that the specific characteristics of each site be considered. The wide variety of geological, biological, and physical conditions, construction practices, and chemical composition of the surrounding soil, rock, waste, and ground water precludes the use of a single decommissioning practice. The procedures discussed in this guide are intended to aid the geologist or engineer in selecting the tasks required to plan, choose materials for, and carry out an effective permanent decommissioning operation. Each individual situation should be evaluated separately and the appropriate technology applied to best meet site conditions. Considerations for selection of appropriate procedures are presented in this guide, but other considerations based on site specific conditions should also be taken into account.

NOTE 6—Ideally, decommissioning should be considered as an integral part of the design of the monitoring well. Planning at this early stage can make the decommissioning activity easier to accomplish. See Practice D 5092 for details on monitoring well construction.

5.2 This guide is intended to provide technical information and is not intended to supplant statutes or regulations. Approval of the appropriate regulatory authorities should be an important consideration during the decommissioning process.

6. Materials

6.1 The materials used for construction of a monitoring well or other monitoring device to be decommissioned in part determines how it is decommissioned. Various materials are available for use in plugging boreholes and monitoring wells. This section provides information on these materials.

6.2 *Casing and Screen Materials*:

6.2.1 Various materials are used for well casing and screen. The most common materials used are: PVC, PTFE, fiberglass, carbon steel, stainless steel, and aluminum. Typically, the same material is used for casing and screen in a well, however, in some instances different materials may be used in a well to achieve a particular purpose such as corrosion protection, reduction of material costs, or improving the integrity of

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ground water or soil vapor samples. This guide does not specifically address the use of more than one type of casing or screen material used in a well, however, the same decommissioning methods can frequently be used when more than one material is used (for example, PVC and PTFE, or stainless steel and carbon steel) in a well.

6.2.2 In selecting a well decommissioning method, PVC, PTFE, and fiberglass wells can be decommissioned using similar methods as all three types of materials tend to be low in tensile strength and easy to drill out or perforate. Appendix X1 provides a discussion on various procedures that can be used for the decommissioning of PVC wells and by reference PTFE and fiberglass wells.

6.2.3 Wells constructed of carbon steel, stainless steel, and heavy walled aluminum can be decommissioned using similar methods as these materials tend to have a higher tensile strength that allows for the casing to be removed. Appendix X1 provides a discussion on various procedures that can be used for the decommissioning of steel wells and by reference stainless steel and aluminum wells.

6.3 *Plugging Materials*:

6.3.1 Plugging materials should be carefully chosen for well closure to be permanent. Basic material characteristics are listed as follows:

6.3.1.1 Plugging materials should not react with contaminants or adversely react with ground water or geologic materials.

6.3.1.2 Plugging materials used in decommissioning wells, borings, etc. should have hydraulic conductivity (saturated condition) that is comparable to or lower than that of the lowest hydraulic conductivity of the geologic material being sealed.

6.3.1.3 Plugging materials must have sufficient structural strength to withstand pressures expected from native conditions.

6.3.1.4 Plugging materials must maintain sealing capabilities and not degrade due to chemical interaction, corrosion, dehydration, or other physical or chemical processes. Materials should maintain their design characteristics for the length of time contamination is present at the site.

6.3.1.5 Plugging materials should not be readily susceptible to cracking or shrinkage, or both.

6.3.1.6 Plugging materials must be capable of being placed at the position in the well or borehole in which they are needed and must have properties that reduce their unintended movement vertically and horizontally.

6.3.1.7 Plugging materials must be capable of forming a tight bond and seal with well casing and the formation.

6.3.1.8 Plugging materials must have properties that eliminate leaching or erosion of the material, under the conditions the material will be subjected. These include vertical or horizontal movement, or both, or contact with ground water or other existing conditions.

NOTE 7—The grain size of plugging material used in decommissioning operations conducted in areas where thick vadose zones occur should be coarser than materials used in areas where thin vadose zones or shallow saturated conditions occur. This is necessary as water is not transported effectively in coarse-grained materials under negative pore pressures. Coarse-grained materials should not be used where saturated conditions are likely to exist during the period of time that hazardous materials can be expected to occur at the site. It is important to determine the lithology and grain size distribution of materials adjacent to the borehole or well prior to selection of plugging materials.

NOTE 8—If coarse-grained materials are used to decommission the borehole or well, a layer of fine-grained material (such as cement or bentonite, or both) 1 or 2 ft (.3 or .61 m) thick should be placed at 10 ft (3 m) intervals in the borehole in the saturated zone. This layer should extend 2 to 3 ft (.61 to .91 m) above the highest expected level saturation is expected based on historical information on the water table for unconfined aquifers. A similar thickness of these materials should be used for confined aquifers. A similar 5-ft (1.5-m) seal of a low-permeability material should be placed near the ground surface to reduce the potential for entrance of fluids at the ground surface.

6.4 *Commonly Used Materials*—Subsections 6.2 and 6.3 introduced the general criteria that must be evaluated during the process of selecting the appropriate procedure and material for plugging a specific well. Because well construction and local geological conditions are site specific, a wide variety of materials and procedures may be used to complete the closure.

6.4.1 Section 6.4 presents a review of the plugging materials most commonly used to decommission monitoring wells. Table 1 summarizes these materials and lists the most important considerations (positive and negative) for their use. A detailed discussion of each material is presented in the following subsections.

6.4.2 *Portland Cement*—Portland cement may be used in any of its various forms to meet placement, strength, and durability criteria listed in 6.1. The amount of shrinkage or settling of neat cement is dependent on the amount of water used. Higher water to cement ratios tend to increase shrinkage **(1)**.[6]

6.5 *Specification C 150*:

6.5.1 *Type 1*—Type 1 cement, a general-purpose material, is the most commonly used cement. This material has a tendency to develop a relatively high heat of hydration when used in confined situations and has relatively low-sulfate resistance.

6.5.2 *Type II*—Somewhat slower strength development than Type I; however, Type II cement has moderate heat of hydration and moderate sulfate resistance.

6.5.3 *Type III*—Type III cement is used when high early strength is desired. This material is not commonly used in decommissioning activities because of its ability to quickly set. Care must be used in working with this material.

6.5.4 *Type IV*—Type IV cement is used where a low heat of hydration is desired. It is not commonly used in decommissioning activities.

6.5.5 *Type V*—Type V cement has high resistance to sulfate, and brine solutions. This material has ultimate strength development somewhat less than either Types I or II.

6.5.6 Type K cement is expansive and can be used to compensate for shrinkage. This cement is essentially Type I or more commonly Type II Portland Cement with additives to produce expansion. It can be of use in plugging situations where water-tightness is important. Type K cement contains calcium sulfoaluminate. When mixed with water, the hydration causes an expansion ranging from approximately 0.05 to 0.20 % **(2)**.

[6] The boldface numbers in parentheses refer to a list of references at the end of the text.

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6.6 *API Cements* **(3)**:

6.6.1 *Class A*—Class A cement corresponds closely to ASTM Type 1. This cement is intended to be used from the surface to a depth of 6000 ft (1828 m).

6.6.2 *Class B*—Class B cement corresponds closely to ASTM Type II. It is intended for use from the surface to a depth of 6000 ft (1828 m) and is also available as a high-sulfate resistant variety.

6.6.3 *Class C*—Class C cement corresponds closely to ASTM Type III. It is intended for use from the surface to a depth of 6000 ft (1828 m). It is also available as a high-sulfate resistant variety.

6.6.4 *Class G*—Class G cement is intended for use from the surface to a depth of 8000 ft (2438 m) and can be used with accelerators or retarders to cover a wide range of depths and temperatures. The cement is also available as a high-sulfate resistant variety.

TABLE 1 Properties of Common Plugging Materials

Plugging Material	Description	Positive Attributes	Negative Attributes
ASTM C-50 Portland Cement			
Type I	Most commonly used type of cement for plugging	Forms a good seal when used with bentonite in 3 to 5 % concentration. Commonly available and can be purchased premixed on-site.	High heats of hydration may be a problem in PVC-cased wells. Can shrink and crack; low-sulfate resistance. Should not be used in the presence of strong acids or in low-pH environments.
Type II	Similar to Type I, but with a moderate heat of hydration.	Moderate heat of hydration. Moderate resistance to sulfate.	Somewhat slower strength development than Type I; expensive. Can shrink and crack. Can be difficult to use. Should not be used in the presence of strong acids or in low-pH environments.
Type III	High early strength.	May prove useful in situations where high early strength is needed, such as borehole walls that have a tendency to collapse.	Not a common cement. Can set very quickly before decommissioning is completed. Should not be used in the presence of strong acids or in low-pH environments.
Type IV	Low heat of hydration.	May prove useful in situations where a low heat of hydration is required	Not a common cement. Should not be used in the presence of strong acids or in low-pH environments.
Type V	Similar to Type I, with high resistance to sulfate and brine.	High resistance to sulfate and brine. Low heat of hydration.	Ultimate strength is less than Types I and III. Expensive; should not be used in the presence of strong acids or in low-pH environments. Can be difficult to use. Can shrink or crack.
K	Expansive cement.	Basically Type I or Type II Portland Cement with additions (tricalcium sulfo aluminate for example) to provide for expansion. Expansion is generally in the range from 0.05 to 0.20 % Good resistance to sulfate attack.	
API 10			
Class A	Similar to ASTM Type I.	Can be used to a depth of 6000 ft (1828 m). Forms a good seal when used with bentonite in 3 to 5 % concentration. Commonly available and can be purchased premixed on-site.	High heats of hydration may be a problem in PVC-cased wells. Can shrink and crack; low-sulfate resistance. Should not be used in the presence of strong acids or in low-pH environments.
Class B	Similar to ASTM Type II.	Can be used to depth of 6000 ft (1828 m). Moderate heat of hydration. Moderate resistance to sulfate. Available as a high-sulfate resistant variety.	Somewhat slower strength development than Type I; expensive. Can shrink and crack. Can be difficult to use. Should not be used in the presence of strong acids or in low-pH environments.
Class C	Similar to ASTM Type III.	Can be used to a depth of 6000 ft (1828 m).	Can set very quickly before decommissioning is completed. Should not be used in the presence of strong acids or in low-pH environments. Can shrink and crack.
Class G	Useful in a wide range of temperatures and depths through the use of accelerators or retarders.	Can be used to a depth of 8000 ft (2438 m). Available as a sulfate-resistant variety.	Should not be used in the presence of strong acids or in low-pH environments. Can shrink and crack.
Class H	Useful in a wide range of depths and temperatures through the use of accelerators or retarders.	Can be used to a depth of 8000 ft (2438 m). Available only as a moderate sulfate type.	Should not be used in the presence of strong acids or in low-pH environments. Can shrink and crack.
Class J	Intended for use from a depth 12 000 to 16 000 ft (3658 to 4877 m).	Has use where extremely high temperatures and pressures occur.	Should not be used in the presence of strong acids or in low-pH environments. Can shrink and crack.
Pozzolanic cement	Addition of silicious materials to ASTM Type V or API Class A cement.	Good resistance to corrosive conditions and in reducing the permeability of cement.	Many types of materials can be used that can result in variable results.
Epoxy cements	Vinyl ester resins.	Good chemical resistance to acids and bases. Can use available equipment to place cement.	Very expensive. Poor chemical resistance to chlorinated hydrocarbons and acetic aid. Should be used only by experienced personnel. Water accelerates curing, must use diesel oil to precondition hole (diesel may increase contamination of site if hydrocarbons are a concern).
Bentonite Pellets	Granular bentonite compressed into a tablet	Uniform in size. Easy to use. Produces a low permeability seal.	Must be hydrated after placement. Shrinkage may occur when desiccated or when in contact with high concentrations of organic compounds (greater than 2 %) or materials that are strongly acidic or alkaline. Expensive.

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TABLE 1 *Continued*

Plugging Material	Description	Positive Attributes	Negative Attributes
Chips	Raw mined montmorillonite in the form of chunks ¼ to ¾in. (.64 to 1.91 m) in size.	Inexpensive. No mixing equipment required. Forms a low-permeability seal.	Difficult to place. Must be hydrated after placement. Less swelling than beneficiated bentonite. Shrinkage may occur when desiccated when in contact with high concentrations of organic compounds (greater than 2 %) or materials that are strongly acidic or alkaline.
Granular	Raw mined montmorillonite crushed and seared to an 8 to 20-mesh size.	Can be placed at depth in dry holes. Forms a low- permeability seal.	Difficult to place in holes containing water as it quickly hydrates. Can bridge in hole. May desiccate when in contact with high concentrations of organic compounds (greater than 2 %) or materials that are strongly acidic or alkaline causing shrinkage.
Powdered	Pulverized and seared bentonite that passes a 200-mesh screen. Used as drilling mud or as an additive to cement.	Used with cement to compensate for shrinkage (under saturated conditions). Other additives can be used to inhibit swelling, etc. Retards cement set; lowers heat of hydration.	May not be a desirable plugging material in deep vadose zones due to the drying out of the material, resulting in cracking. Difficult to place in holes containing water, as it quickly hydrates. Can bridge in hole. May desiccate when in contact with high concentrations of organic compounds (greater than 2 %) or materials that are strongly acidic or alkaline causing shrinkage.
High solids clay grout	Powdered bentonite (200 mesh) mixed with fresh water to form a slurry with a minimum of 20 % solids and a density of 9.4 lb/gal (1126 Kg/m^3 g/L).	Does not shrink during curing. Low density reduces formation losses. Forms a low-permeability seal that stays flexible as long as it is hydrated.	May not be a desirable plugging material in deep vadose zones due to the drying out of the material, resulting in cracking. May desiccate when in contact with high concentrations of organic compounds (greater than 2 %) or materials that are strongly acidic or alkaline causing shrinkage. A low-strength material subject to expansion under low-pressure differentials such as artesian conditions.

6.6.5 *Class H*—Class H cement is intended for use from the surface to a depth of 8000 ft (2438 m). It can be used with a wide variety of accelerators and retarders to cover a wide range of depths and temperatures. It is available only as a moderate-sulfate resistant type.

6.6.6 *Class J*—This cement is intended for use from a depth of 12 000 to 16 000 ft (3658 to 4877 m) where extremely high temperatures and pressures can be expected to occur.

6.6.7 *Other Cements*—Other cements have been developed that may have applicability in decommissioning activities. These include the following:

6.6.7.1 Ultralight cements with a slurry density that can be as low as 6 lb/gal (719 cm Kg/L). This material can be made by foaming the cement with nitrogen or through the addition of hollow glass microspheres between 60 and 315 µm in diameter. The latter forms a slurry of between 9 and 12 lb/gal (1078 and 1438 Kg/L). Ultralight cements and microspheres have been reported **(4)** for cement unconsolidated sands and for plugging cavernous formations and lost circulation zones. Reference **(5)** provided similar information on microspheres. Microspheres can also be used in high-pressure applications when it may be desirable to limit density increases. Another advantage is the low water/cement ratio due to the low water absorbency and low density **(5)**.

6.6.7.2 *Pozzolanic-Portland Cements*—These cements consist of silicious materials that develop into a cement in the presence of lime and water. Both natural materials of volcanic origin such as perlites (volcanic ashes), heat-treated clays, shales, tuffs, opaline cherts, diatomaceous earth and artificial materials consisting of byproducts from glass factories, furnace slag, and fly ash have been used **(2, 4, 6)**. The large variety of materials that can be used as a source for pozzolans may result in variable results.

6.6.7.3 Pozzolans act to extend cement and decrease density. The specific gravity of fly ash ranges from 2.3 to 2.7 (depending upon the source) while portland cement is 3.1 to 3.2 **(2)**. These materials can also provide improved resistance to corrosive fluids. Table 2 provides a comparison of sulfate resistance between ASTM Type V cement with and without pozzolans.

6.6.7.4 The improved resistance to corrosive materials is accomplished in part as many pozzolans contain zeolites which have the ability for ion exchange between the corrosive material and the alkaline component in the cement **(7)**. Secondly, the use of pozzolans also decreases cement permeability over time. This occurs as a result of the increased percentage in hydrated cement containing materials resulting from the release of calcium hydroxide and the silica combining with lime from the cement to form a stable material **(8)**.

6.6.7.5 Pozzolans are added to portland cement by adding 74 lb (33.6 Kg) (as fly ash) per sack of cement. If perlites are used, 2 to 6 % of bentonite by weight is needed to keep the perlite from floating **(9)**.

6.6.8 Gypsum cements can be used for high early strength development and their ability to set rapidly. These cements expand approximately 0.3 %. This cement may have use in plugging highly permeable formations. Care should be taken in using gypsum cements due to the solubility of gypsum.

6.6.9 *Epoxy Resin Cements*—Epoxy (vinyl ester resins) cements may have applicability in decommissioning wells and boreholes where corrosive materials may be present **(5)**.

6.6.9.1 Epoxy cement consists of an epoxy base, hardener, accelerator, and inert filler. Resin viscosity is reduced by the addition of a nonreactive liquid diluent that also controls exothermic heat during polymerization. An inert solid filler such as very fine silica or barite is added to further reduce

TABLE 2 Comparison of ASTM Type V Cement With and Without Pozzolan Materials[A]

Cement Type	Relative Degree of Sulfate Attack	Percentage of Water Soluble Sulfate (as SO_4) in Soil, ppm	Sulfate (as SO_4) in Water Samples, ppm
V	Severe	0.20 to 2.00	1 500 to 10 000
V (plus pozzolan)	Very severe	2.00 or more	10 000 or more

[A] See Ref **(4)**.

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reaction heat and increase strength **(10)**.

6.6.9.2 There are several advantages of using epoxy cements. Reference **(11)** reports that a stronger bond occurred between the casing and the formation. Cole also reported resistance to various chemicals (see Table 3). The cement is highly resistant to high concentrations of hydrochloric and sulfuric acid, but is not suitable for use in environments where acetic acid, chlorinated hydrocarbons, or toluene are present.

6.6.9.3 This cement is expensive and requires removal of water (that reduces settling time) through the use of gelled and weighted diesel oil to precondition the hole. The use of this material may increase contamination at the site, if diesel oil (hydrocarbons) are a concern at the site.

6.6.10 *Cement Additives*—A number of materials can be added to cement to modify properties to meet a specific need. Cement additives can be used to extend, accelerate, retard, increase density, control fluid losses, control circulation losses, or reduce friction **(4)**. Several of these materials have more than one use; for example, sodium chloride can be used to accelerate or retard cement. The most common cement additives are discussed in the following subsections. Fig. 1 lists these additives and presents the relative impact of their use on selected performance criteria.

6.7 *Extenders*:

6.7.1 Bentonite is the most commonly used material in modifying cement properties. It can be added to most ASTM and API cements. In decommissioning activities, the percentage of bentonite added is generally no more than 4 %. It has the following effects when added to cement **(4)**:

6.7.1.1 Lowers the hydraulic conductivity of the cement;

6.7.1.2 Increases slurry viscosity;

6.7.1.3 Reduces fluid loss to the formation;

6.7.1.4 Provides for a longer pumpability at normal pressures as a result of delaying strength development;

6.7.1.5 Reduces compressive strength; and

6.7.1.6 Lowers resistance to chemical attack.

6.7.2 Bentonite increases shrinkage as it ties up large volumes of water that would normally be in the cement. A second common extender are pozzolans which have already been addressed in 6.6.7.2.

6.8 *Accelerators*:

6.8.1 Accelerators hasten the settling of cement and are useful when voids occur, or when cement plugs are to be used in the first pour. Two common materials are used; calcium chloride and sodium chloride.

6.8.2 Calcium chloride is available as a powder or flake. Flakes are the most commonly used form, as it is easy to store and can absorb some moisture without becoming lumpy **(2)**. Two to four % of calcium chloride by weight is used to achieve maximum acceleration. The use of calcium chloride should be considered when a rapid set, a decrease in viscosity, and early strength are desired.

6.8.3 Sodium chloride can be added between 1.5 to 5 % by weight of cement to reduce setting time. Maximum acceleration occurs at a concentration of 2 to 2.5 % except when higher water ratios are used **(2)**.

6.9 *Retarders*:

6.9.1 Sodium chloride can be used to retard the settling of cement as well as accelerate the setting of cement. Fifteen to seventeen % salt (14 to 16 lb (6.35 to 7.26 Kg) of salt per sack) by weight is added to retard cement **(2)**.

6.9.2 Other chemicals (cellulose, lignosulfates) have been used as retarders, but are not appropriate for decommissioning activities without additional information on their compatibility with waste and their effect on water quality. Reference **(12)** indicates that sugar-derived retarders such as cellulose lignosulfates are destructive to cement strength and should not be used where strength is important. Organic retarders should not be used for decommissioning activities.

6.10 *Density Improvers*—The density of cement can be improved to increase hydrostatic pressure. Sand can be used to increase density without affecting the cement chemically although additional water is required. Barite has been used, but may interact with waste and should not be used.

6.11 *Fluid Loss Controllers*:

6.11.1 Various organic materials such as cellulose can be used to produce a constant water to solids ratio that may have applicability when a grout is placed under pressure and water loss can occur. However, these materials may not be suitable for decommissioning activities, as they may contribute to contamination.

6.11.2 These organic materials (fibrous materials, cellophane flakes) act to block the movement of the grout into the formation. It is not desirable to use these materials in decommissioning activities due to their organic content that may adversely affect water quality and also may not result in a good plug.

6.12 *Friction Reducers (Dispersants)*:

6.12.1 These materials reduce friction to improve flow and can be effective when the water cement ratio is reduced. Reduction of the water cement ratio is a method to decrease cement friction. (It is possible to reduce the amount of water added by using a dispersant **(5)**. These materials (sodium chloride, polymers, and calcium lignosulfonate) also help to reduce the energy required to pump the grout. Polymers and calcium lignosulfonate may not be appropriate materials for decommissioning activity as they may affect water quality.

6.13 *Bentonite*—Bentonite is predominantly composed of the clay mineral sodium montmorillonite. It has the ability to absorb large quantities of water and swell to many times its original size when hydrated, and the material remains flexible. Bentonite clay may be used in any of its various forms to meet placement, strength, and sealing criteria listed in 6.3. The amount of shrinkage or settling of a bentonite seal is dependent on the percent solids of bentonite, composition of surrounding formation and its soil moisture. Higher water to bentonite ratios increase the likelihood of dehydration.

TABLE 3 List of Chemicals Reported Not to Affect Epoxy Cement[A]

Chemical	Concentration, %
Hydrochloric acid	30
Sulfuric acid	25
Chromic acid	up to 10
Nitric acid	5
Hydroxide	up to 20
Hypochlorite	up to 6

[A] See Ref **(11)**.

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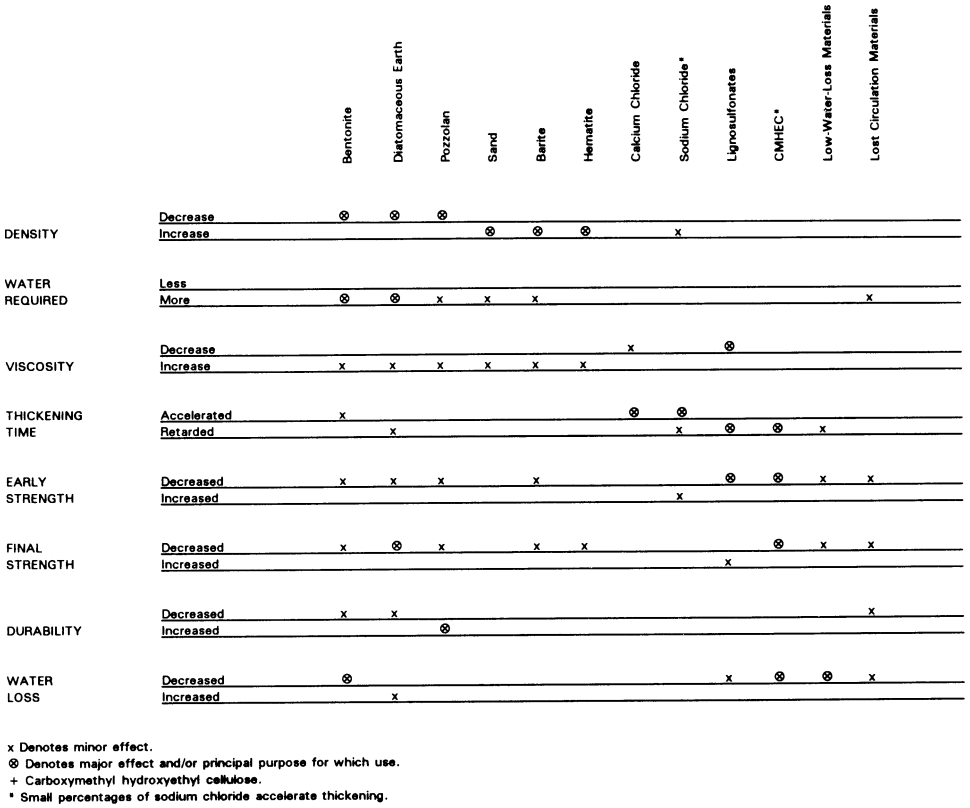

NOTE 1—See Ref **(3)**.

FIG. 1 Effects of Some Additives on the Physical Properties of Cement

6.13.1 The permeability of bentonite is very low; hydraulic conductivities of 1×10^{-6} cm/s or less can be achieved. However, bentonite may desiccate in the presence of high concentrations of some organic chemicals, strong acids or bases, saline ground water, or when allowed to dry, thereby increasing its hydraulic conductivity. Bentonite is commercially available in the following forms:

6.13.1.1 *Pellets*—Pellets are made from granular powdered bentonite that has been compressed into tablets, commonly ¼ to ¾ in. (.64 cm to 1.91 cm) in diameter. Pellets have a low-moisture content, high density, and uniform size. Pellets should be composed of additive-free, high-swelling granular sodium bentonite. Properly placed in a well or borehole, pellets hydrate and expand creating a low permeability (1×10^{-6} cm/s) plug. Pellets can be used in the saturated zone provided the length of the water column is short. The rate of pour into the hole should not be more than 50 lb (22.7 Kg) of bentonite in 5 min **(1)**.

6.13.1.2 *Preformed Donuts*—Commercial preformed donuts consist of compressed bentonite and may have use in decommissioning activities.

6.13.2 *Chips*—Raw mined sodium montmorillonite in the form of chunks that are ¼to ¾ in. (6.4 to 1.91 cm) in diameter. Their angular shape can make it difficult to place chips to the desired depth in a small-diameter well or borehole without bridging.

6.13.2.1 Fine-grained material resulting from the mechanical breakdown during shipping may cause a problem in the placement of chips due to clumping. Fines should be screened through a ¼-in. (6.4-mm) mesh screen before use.

6.13.2.2 The lower affinity for water that chips have allow them to fall through a water column without rapid hydration.

6.13.2.3 Chips have applicability in large-diameter boreholes and when carefully dropped into the hole to reduce bridging.

6.13.3 *Granular*—Raw-mined sodium montmorillonite without any additives that has been crushed and seared to an 8 to 20-mesh size. This material can be placed at depth in dry holes but hydrates quickly when placed into water. It often sticks to wet borehole walls and bridges when placed through water. Granular material is best suited for use in the unsaturated zone with enough water added to provide adequate hydration.

6.13.3.1 Fines can clump when in contact with water **(1)**. Fines result from mechanical breakdown of the material during shipping. Granular bentonite should be poured slowly to reduce the potential for bridging. In some situations, a pour rate not exceeding 50 lb (227 Kg) in 5 min has been used successfully **(1)**.

6.13.4 *Powdered*—Untreated, seared, and ground bentonite that passes through a 200-mesh screen. It is designed to be used in drilling fluids (muds) and as an additive to other plugging materials such as cement. Bentonite powder slurry can become an effective grout material when combined with density-increasing additives and swelling inhibitors. Powdered bentonite should not be placed in dry form through water as it can bridge and stick to the borehole walls.

6.13.5 *High Solids Clay Grout*—This material is a blend of

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powdered polymer-free bentonite clays mixed with fresh water that forms a slurry with a minimum 20 % solids by weight and a density of 9.4 lb/gal (1126m^3 Kg/L). The slurry sets to a low-permeable plastic grout that generates no heat of hydration and does not shrink during curing in the presence of moisture. High solids clay grouts are commonly used for borehole plugging.

6.14 *Other Materials*:

6.14.1 A number of other materials have been used for plugging:

6.14.1.1 Attapulgite clay (may have applicability when used with a salt cement grout),[7]

6.14.1.2 Fire clay,

6.14.1.3 Commercial packing materials, and

6.14.1.4 Packers.

6.14.2 These materials are either inappropriate for use in decommissioning wells or boreholes where hazardous waste are encountered, or are not well studied for decommissioning wells in hazardous waste situations. Therefore, they are not discussed in this guide.

6.14.3 Other materials have been used in the past for plugging wells and boreholes. Such materials as wooden or lead plugs should not be used because wood plugs may decay and lead is a potentially hazardous material. Mechanical packers composed of steel, plastic, or other materials can be used to assist in plugging.

7. Procedure

7.1 The primary purpose of most boreholes and monitoring wells is to monitor chemical compounds in the soil and ground water; however, there are other uses for subsurface monitoring including the measurement of temperature, soil gas sampling, or measurement of geophysical parameters. Use significant care in planning and implementing the decommissioning activity. It is important to obtain any required approvals from regulatory agencies, land owners, responsible parties, and other parties involved with the site. The following subsections present a recommended list of tasks in order that the decommissioning activity is successfully completed. Several of the steps outlined below do not pertain to boreholes and may be omitted.

7.2 *Planning*:

7.2.1 *Records Review*—Carefully review all available records and information relating to use of the monitoring well, borehole, etc. This review may include the following information:

7.2.1.1 Review applicable Federal, state, and local regulations relating to decommissioning activities. This may include contacting the applicable state or local agency having jurisdiction over drilling activities and preparation of the necessary documentation to drill (start card),

7.2.1.2 Collection of drillers' logs, geophysical logs, well construction, or geologic logs, including stratigraphy, structural geology, subsurface information, construction materials, screened interval, depth, hydraulic gradients (if water levels are available from other wells for its determination), legal location, date of installation, and photographs of the well,

7.2.1.3 Review of analytical chemical data for soil and ground water over the life of the well, and variations in water levels over time,

7.2.1.4 Review of records of the repairs, modifications, or other changes made to the well during the lifetime of the well,

7.2.1.5 Evaluation of historic, current, and planned land use,

7.2.1.6 Interviews with local workers and collection of other pertinent data such as discussing site conditions with local drillers, and

7.2.1.7 While not directly part of the decommissioning activity, proper disposal of displaced fluids and other materials (such as pulled or drilled out casing and cement seals) should be considered. Some of these materials may be classified as a hazardous waste under Federal, state, or local regulations. Conduct a review of these regulations and appropriate analytical documentation prior to classifying a material as a hazardous waste.

NOTE 9—This information may be summarized in a work plan. A work plan would also include a description of the site geology and hydrogeology and the decommissioning method to be used.

7.2.2 *Verification of Field Data*—The variety and quality of field practices and reporting require that the well be inspected to verify the actual field situation prior to decommissioning the well. The following list of procedures is recommended so that the actual condition of the well is known. Some of the borehole geophysical logs may not be applicable or may not be available for small diameter (2 in. (5.08 cm) or less) holes or wells.

7.2.2.1 Inspection of well head installation for integrity,

7.2.2.2 Current depth measurement of the casing and well. (The original depth of the borehole may be different than the well.),

7.2.2.3 *Water Quality Sampling and Analysis*—A final water quality sample taken from the well may be required for regulatory purposes;

7.2.2.4 *Downhole Inspections*—Including caliper logs to measure inside diameter; television logs to determine in-well conditions such as casing breaks, screen size, etc.; gamma logs to verify geologic information, if not already available; cement bond logs (sonic) to determine if the casing is firmly attached to grout (presently available for holes 2½ in. (6.35 cm) or larger in diameter); flow logs (flow meter or spinners) to determine if vertical flow occurs within the casing; and hydraulic integrity test to determine if the well casing is intact.

NOTE 10—Care should be taken in running any of these tools in a well with a collapsed or broken casing, or in boreholes that may collapse on the tool. Tools with active radioactive sources should not be used under these circumstances. Conduct downhole inspections only after obstructions are removed from the well casing or borehole.

7.2.2.5 Contact local owner, resident operator/observer to verify operations at the site.

7.2.2.6 Verification of field data is an ongoing responsibility. Use verified information to modify plans in order that the decommissioning activity is correctly conducted. Continue this activity during the field phase and change specifications as needed.

7.2.3 *Review of Decommissioning Options*—After the records have been thoroughly reviewed and verified in the

[7] Sutton, Fred, Personal Communication, 1990.

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field, select an appropriate decommissioning procedure. Evaluate each possible option to determine the most appropriate method for the selection. The following list of evaluation criteria is recommended:

7.2.3.1 The potential for fluid movement from one aquifer into another by means of the borehole or well should be eliminated.

7.2.3.2 Materials to be used in plugging must be compatible with well casing and screen (if left in place), and with subsurface formation and ground water, etc. over the period of time hazardous materials are found at these sites.

7.2.3.3 Future land use (as is known at the time of decommissioning) should be compatible with decommissioning plans.

7.2.3.4 Closure options should be compatible with applicable federal, state, and local requirements.

7.3 *Implementation*:

7.3.1 *Field Procedure*:

7.3.1.1 Satisfactory completion of decommissioning is the primary purpose of this guide. All work performed on the borehole or well should be completed by competently trained drillers, equipped with appropriate tools, under the direction of a geological or engineering professional who is qualified to certify that the decommissioning is completed according to the planned procedures and is consistent with applicable regulations.

7.3.1.2 Approve any modifications to the proposed work plan and record in writing by the on-site geologist or engineer (or their representatives) prior to implementation.

7.3.1.3 The geologist or engineer should be on-site during the field activities to verify that the activities are completed as planned. Decommissioning operations can be successfully accomplished by careful planning and documentation (see 7.5). Maintain documentation of decommissioning activities for the post-closure period or period required by regulations (if specified). While regulations may require documentation for a period of 30 years, it is advisable to continue this activity for a period lasting as long as hazardous materials occur at the site.

7.3.1.4 Remove casing from the ground by either pulling or overdrilling (see 7.3.7). Depending upon construction, it may be necessary to leave the casing in place and produce suitable perforations in the screen and blank casing to allow for the plugging material to penetrate the annular space and formation (see 7.3.7). If grout in the annular space can be verified to be in good condition, the well can be decommissioned by cutting the blank casing and filling the screened interval with grout. Verifying the integrity of grout may be difficult to impossible. If a filter pack is present, it may be necessary to remove the filter pack after perforating the casing by washing or overdrilling. Several of the methods identified in this subsection are briefly discussed in the Appendix X1.

7.3.1.5 If well construction conditions are not adequately known and the well site contains hazardous materials, it may not be appropriate to remove the casing and screen, as this may increase the mobility of hazardous materials.

7.3.1.6 The borehole or well, or both, may require preconditioning for decommissioning to be successful. Preconditioning can reduce the potential for sloughing of the borehole wall if for example, a sodium montmorillonite clay occurs naturally in the formation and cement is used as the plugging material. The calcium contained in Portland cement exchanges with the sodium cation in bentonite clay decreasing the water contained in the clay and inducing sloughing. This problem can be significant in sediments or rocks that are under considerable pressure, causing a loss in part of the hole, thereby not completely plugging the borehole and possibly causing loss of all downhole equipment. These conditions are usually known by local drilling and well servicing contractors who should be contacted prior to the start of field operations.

7.3.1.7 Preconditioning consists of removing mud from borehole walls (when mud is used for drilling the borehole), or stabilizing a borehole prior to placement of the plugging material. If a drilling mud has been used to drill a borehole, preconditioning can involve the circulation of a high-quality, low-solids drilling fluid to remove gelled mud from the borehole and borehole walls prior to plugging. For the above situation, a high-quality bentonite or drilling fluid can be used. If a drilling mud is used as the plugging material, prepare fresh mud. The mud used in drilling contains cuttings and may also not have suitable properties **(13)**. The selection and use of material(s) should meet the requirements specified in Section 6.

7.3.2 *Volume of Plugging Material Required*:

7.3.2.1 The geologist or engineer should calculate the volume of plugging material required for the borehole or well after first taking into consideration applicable loss of material to the formation, voids intersecting the borehole, changes in borehole diameter, washout zones, and swelling or shrinkage of material. An approximation of the volume of material that may be required can frequently be provided by contacting local drillers or professionals.

7.3.2.2 Loss of plugging material into the formation may occur rapidly (within minutes) or after several hours or days. The volume of plugging material required to be on-site should be at a minimum, enough to fill one borehole volume, however, it is advisable to have available a minimum of 25 to 50 % in excess of the calculated borehole volume **(1, 2)**. Additional plugging material should be readily available to site personnel under short notice, especially if it is common to lose plugging material into the formation or the material is required for clearing a hole (see 7.3.8.2).

7.3.2.3 A caliper log is helpful in boreholes or overdrilled holes to define hole diameter. If this information is not available, use an estimate of borehole diameter from the available well construction specifications. Calculate the volume of the borehole using the following:

$$v = \pi r^2 L \quad (1)$$

where:

v = volume,
L = length of borehole or well to be plugged, and
r = radius of hole.

7.3.2.4 Manuals listing the volume of a hole per linear foot (metre) such as Ref **(3)** can also be used. These manuals are available through major deep well cementing service companies. Assume in the calculations or table used that the derived

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volume is the minimum required for actual conditions due to possible loss of plugging material into the formation. Verify grout emplaced through estimating the volume of material leaving the hole for holes filled with mud or water. For all boreholes, measure the volume of material emplaced and check for the appearance of the material at the top of the interval grouted or land's surface, whichever is applicable.

7.3.2.5 Location of the grout at depth can be difficult because the top of the grout may not be able to be distinguished from water or other fluids in the borehole. One field procedure that has been applied to measure the level of the grout is to use a wooden sounding block with a weight attached to the block. The weight should be slightly denser than the grout.

NOTE 11—Location of the depth of plugging material in a borehole or well does not confirm that the plug has performed its intended purpose. Plugging materials may not have adhered to the walls of the borehole or well or may have been bypassed from the target zone. Therefore, placement of plugging materials is highly dependent upon proper preparation of the hole.

7.3.2.6 In areas where coarse materials are encountered, or considerable fracturing or solution openings occur, two or three times the calculated volume of material may be required to fill the hole. In extreme cases such as in some karst terrains where large conduits may exist, it may be difficult to plug a well or borehole. In these situations, packers can be used to isolate critical intervals for filling with plugged materials above or below the karstic formations. Packers may also be used to isolate critical intervals within a well or borehole throughout the entire depth.

7.3.3 *Quality of Water Used for Grout*—Grout must be carefully mixed using water of a known chemical quality. The quality of the water must be compatible with the grouting material and not introduce contamination into the subsurface. For cement, water used should be free of silt, organic matter, alkali compounds, and have a total solids content of 500 mg/L or less **(14)**. The grout should be weighed using a mud balance.

NOTE 12—Thicker grout mixtures may have greater effectiveness in plugging highly permeable materials or materials with large voids, but may be very difficult to pump through a grout pipe. Less viscous mixtures are easy to pump, but may be too mobile, have greater shrinkage, and take longer to set if additives to compensate these problems are not added.

7.3.4 *Mixing of Cement and Bentonite On-Site*—Both cement and bentonite can be mixed on site. Cement can also be purchased from a contractor and delivered premixed on site, provided the water used is of known and acceptable quality.

7.3.5 *Use of Curing Accelerators*—Curing accelerators can be used to hasten the initial set time for cement from 6 to 8 h to perhaps 2 or 3 h, provided the accelerator (typically calcium chloride, sodium chloride, aluminum powder, or gypsum) does not degrade the cement or react with the environment. The use of these materials may also require approval by regulatory authorities.

7.3.6 *Decommissioning of Boreholes*:

7.3.6.1 To achieve an effective seal, the borehole should be free of debris and foreign matter that may restrict the adhesion of the plugging materials to the borehole wall. Clear boreholes of excessive mud filtercake, or gelled mud (if used) and any bridges resulting from the removal of temporary casing, or when noncohesive materials (such as sand and gravel) are encountered that can lead to a collapsed borehole during decommissioning activities.

7.3.6.2 One method commonly used for effective removal of these materials is to advance a small grout pipe to the bottom of the borehole by use of water or a high-quality bentonite slurry and flush the hole. Flushing is continued until the blockage is removed, or noncohesive formations are stabilized. Use at least two borehole volume of materials. If the flushing fluid returning to the surface contains potentially hazardous materials, it may be necessary to place this material into containers for proper disposal.

7.3.6.3 As soon as the borehole is prepared, pump plugging material slowly through a grout pipe to displace the flushing fluid. Inject grout starting from the bottom of the hole, forcing other fluids upward. Complete grouting slowly to prevent channeling of the grout around any undesirable material remaining in the hole. Complete this operation in one continuous operation. Raise the grout pipe when pumping pressure increases significantly, or when undiluted grout reaches the surface. Regularly sample and evaluate overflowing grout for weight, presence of foreign material, or other changes. When the overflowing grout is similar to that being pumped down the hole, the plugging is considered complete.

7.3.6.4 Grout pipes should be the largest diameter that is practical for field operations to reduce the required pumping pressure. Cut the lower end of the pipe at an angle to allow for the side discharge of the grout. Side discharge reduces the potential for erosion of the borehole wall. Typically, heavy-walled PVC (Schedule 40 or greater) or thin-walled steel pipe is used for grouting purposes. Use caution while grouting deeper holes in order that downhole pressure does not exceed the rupture strength of the grout pipe.

7.3.6.5 Grouting of shallow auger holes or other boreholes where grout pumping equipment is not readily available may be accomplished by placing grout through a side discharge grout pipe that has a funnel attached to the top. As the grouting progresses, slowly raise the pipe. Take care when using this procedure, as the low placement pressure may not completely fill or flush undesirable materials from the borehole. This procedure is only recommended when the entire borehole depth is 10 to 15 ft (3 to 4.6 m) or less.

7.3.6.6 Small diameter (<2-in. (5.08 cm-mm)) holes are difficult to plug. A small diameter (¾-in. (1.9 cm-mm)) grout pipe can be used, however, high-pumping pressures may be required or less viscous plugging materials may be necessary.

NOTE 13—It is important to avoid hydrofracturing or blowout in shallow holes in unconsolidated materials when pressure grouting. A general rule to avoid hydrofracturing is to restrict pumping pressure to about 0.6 lb/in.^{2}(0.42 Kg/cm^2) of hydraulic pressure for each foot (metre) of overburden. In some instances, the pressure used must be reduced further.

7.3.6.7 A conservative method **(15)** of calculating maximum pressure is as follows:

$$Pm = (0.733 - 0.433\,Sg)d \quad (2)$$

where:

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Pm = pressure of fluid injected at wellhead, lb/in.^{2}(Kg/cm^2),
Sg = density (specific gravity) of the plugging material (grout) (unitless), and
d = depth measured for the surface to the opening of the grout pipe (metres) feet.

Hydrofracturing typically occurs during start-up or restart of grouting.

7.3.6.8 Inject grout at the bottom of the hole, displacing grout, loose formation materials, and borehole fluids upward. Slowly pump grout to avoid channeling. Do this in one continuous operation. Raise the grout pipe when grout can no longer be easily forced from the pipe into the hole or when undiluted grout reaches the top of the hole and flows out. Sample and weigh this material. The weight of the grout returning to the surface should be the same as the grout pumped into the hole.

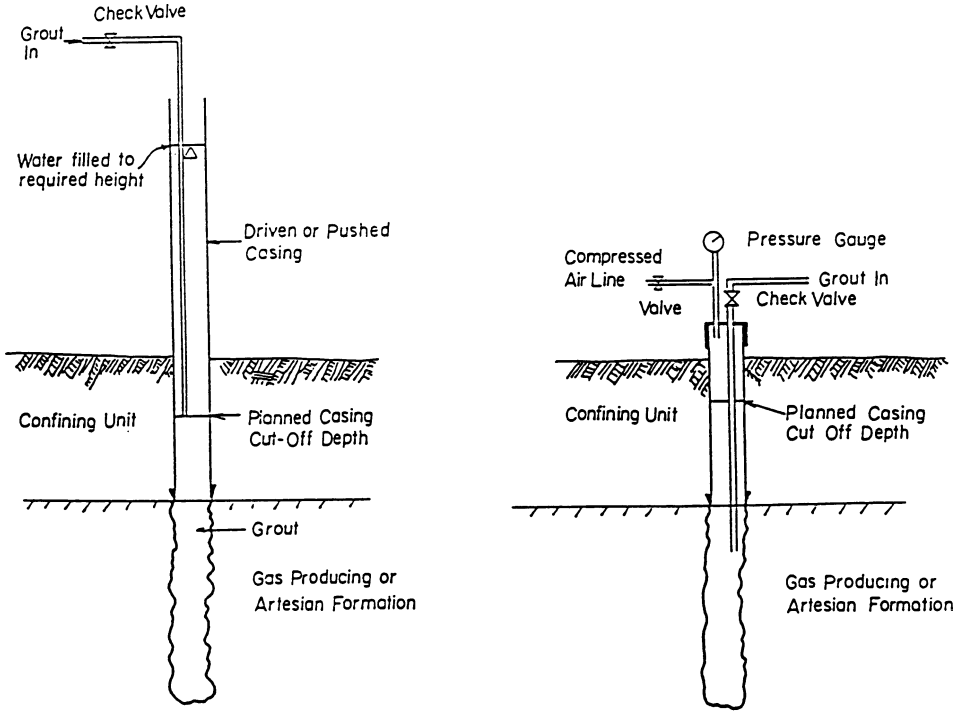
7.3.7 *Control of Elevated Formation Pressures*—Occasionally, a borehole or well may penetrate a formation that is under confined conditions (artesian head), or from which a gas is being released, under pressure. (Gas bubbling upward through the grout may result in open channels, or increase the permeability of the grout.) When this condition is encountered, sealing of the borehole requires that the grout pressure be maintained greater than the formation pressure until initial grout set occurs. The "shut-in-pressure" of the formation can usually be determined by use of pressure gages attached to a casing that has been pushed or driven into the confining unit. This casing must be tightly sealed to prevent leakage around its annulus. (Separate packers or casing grout, or both, may be required to prevent leakage around the casing.)

7.3.7.1 Several procedures may be used to balance the formation pressure until the initial set of the grout has occurred. (See Fig. 2.) The procedure most often used to contain the pressure is to use a sufficient column of grout. If additional head pressure is required, increase the unit weight of the grout by the addition of sand, densifying additives (barite, or hematite) or decreasing the water cement ratio. Another alternative commonly used is to pump the grout through a check valve into the casing until the top of grout reaches the desired elevation. Maintain pressure above the grout by use of compressed air, or by use of a simple standpipe filled with water. If the standpipe procedure is used, pump grout through a tremie pipe extending through the water to prevent dilution.

7.3.7.2 After the initial grout set has occurred (minimum 24 h), the sustaining pressure (above atmospheric pressure) may be released. However, record the air pressure (or fluid level) in the air filled casing above the grout frequently for several days to verify that no leakage is occurring. If gas (of any variety) is present in the formation, analyze a sample of the air from the casing above the grout. Care should be taken under these conditions, as explosive or hazardous conditions may be present. Methane, the most commonly produced gas, is odorless, colorless, toxic, and extremely flammable. Safety precautions are advised.

7.3.7.3 Only after testing results confirm that the seal is effective, is it advisable to complete the permanent closure or removal of the near (or above) surface casing.

7.3.7.4 Measure any fallback or settlement of the grout surface (whether by gravity or under pressure) that occurs after grout emplacement to the nearest foot and record. Correct any fallback with native or imported materials to grade, or to a



Stand Pipe To Contain Excess Formation Pressure

Compressed Air To Contain Excess Formation Pressure

FIG. 2 Two Procedures That Can Be Used to Overcome Elevated Formation Pressure

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specified depth below grade, such as below the plow layer. The depth is based on existing and proposed land use and regulatory requirements.

7.3.8 *Decommissioning of Wells and Other Monitoring Devices*:

7.3.8.1 This discussion has applicability in decommissioning ground water monitoring and injection wells and soil gas monitoring wells, neutron probe access tubes, lysimeter and tensiometer and installations, and similar devices. Appendix X1 should be consulted for additional information.

7.3.8.2 It is desirable to remove all existing well construction materials such as screen, casing, filter pack, seal, and grout from the hole to reduce the potential for the formation of a vertical conduit to occur at the contact between casing and annular seal; reduce the potential of these materials interfering with the decommissioning operation; decrease the potential of a reaction between the materials used; or to minimize the reaction with the native materials or ground water. In situations where well materials are removed and borehole collapse occurs, redrill the borehole following the guidance provided in 7.3.6.

7.3.8.3 Steel casing may be removed using jacks to free casing from the hole followed by lifting the casing out by using a drill rig, backhoe, cranes, etc. of sufficient capacity. If the annular space has been cemented over a long distance, this method may not be readily used unless a poor contact occurs between the casing and borehole. Small lengths of cement (typically less than 10 ft (3 m)) can be removed along with the casing if the drill rig has sufficient lifting capacity. When the casing cannot be removed, perforate the casing and screen using a suitable tool. This is necessary as encrustation or corrosion of the screen can block or completely close openings. A wide variety of commercial equipment is available for perforating casings and screens. Due to the diversity of application, consult an experienced contractor prior to selection of the technique. A minimum of four rows of perforations several inches (millimetres) long and a minimum of five perforations per linear foot (metre) of casing or screen is recommended.

7.3.8.4 Remove steel casing by overdrilling (overreaming) the casing. Overreaming can be done using an overreaming tool (see Fig. 3). Select a pilot bit that is nearly the same size as the inside diameter of the casing. The reaming bit should be slightly larger than the borehole diameter to remove all well construction materials and a small amount of native material. As drilling proceeds, the casing, grout, bentonite seal, filter pack, and other well materials are destroyed and returned to the surface. In situations when the grout in the annular space can be verified to be in good condition, it may be very difficult to remove casing and grout and grout can be left in place by pressure grouting the screened interval and casing. Verifying the integrity of the grout can be difficult.

7.3.8.5 PVC and other low tensile strength materials generally cannot be removed by pulling if they have been properly cemented into place. Overdrilling is necessary to remove these casing and screen materials.

7.3.8.6 A hollow stem auger equipped with outward facing carbide cutting teeth with a diameter 2 to 4 in. (50.8 to 1016 cm) larger than the casing may be used for overdrilling. Place the lead auger over the casing and rotate downward (see Fig. 4). The casing guides the cutting head and remains inside the auger. When the full diameter and length of the well has been penetrated, the casing and screen can be retrieved from the center of the auger. It is important to use outward facing cutting teeth in order that the cutting tool does not sever the casing and drift off center. An alternative is to install a steel guide pipe inside the well casing so that the augers can be centered.[8] Firmly attach this temporary working pipe to the inside of the casing by use of a packer, or other type of expansion or friction device. When the auger reaches full depth and the well materials have been removed, pump plugging materials through the hollow stem as the augers are withdrawn.

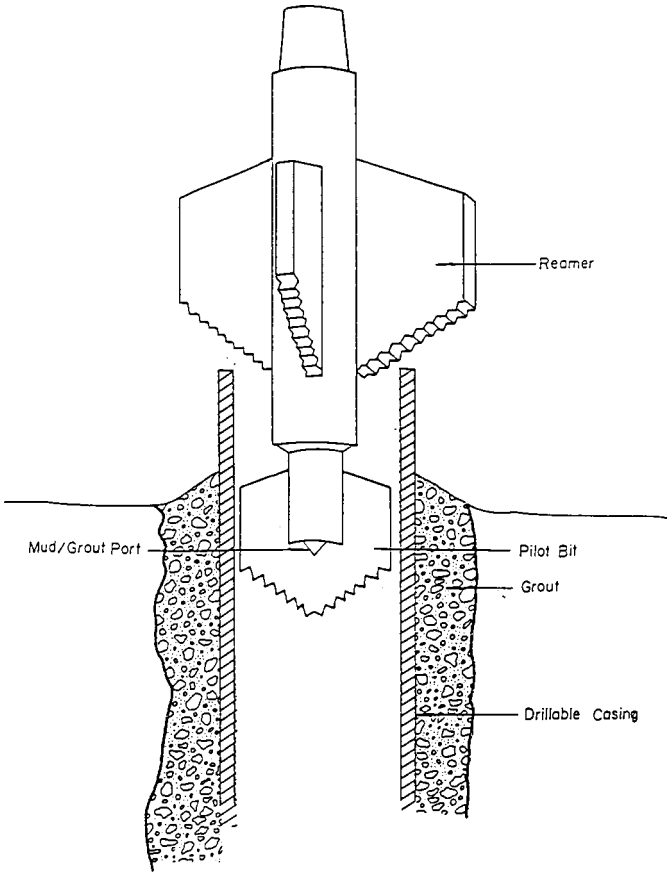

FIG. 3 Over Drilling by Mud Rotary Procedure

NOTE 14—Local regulations may allow leaving the PVC casing in place, if a good annular seal exists, or just removing blank casing if the integrity of the annular seal can be documented. It is generally difficult to document a good annular seal (tight fit, no fractures or channels) without the use of a cement bond log or similar method. A cement bond log cannot be run in small diameter wells (less than 2.5 in. (6.35 cm) in diameter) because a small diameter tool is not currently available. Also, this method is not reliable for PVC casings.

7.3.8.7 After removal of the casing, decommissioning can be completed in accordance with 7.3.6.

NOTE 15—Wells with a maximum depth of 10 to 15 ft (3 to 4.6 m) can be removed by overdrilling, or when possible by pulling the casing out of

[8] Baker, Robert, Personal Communication, Layne Environmental, 1990.

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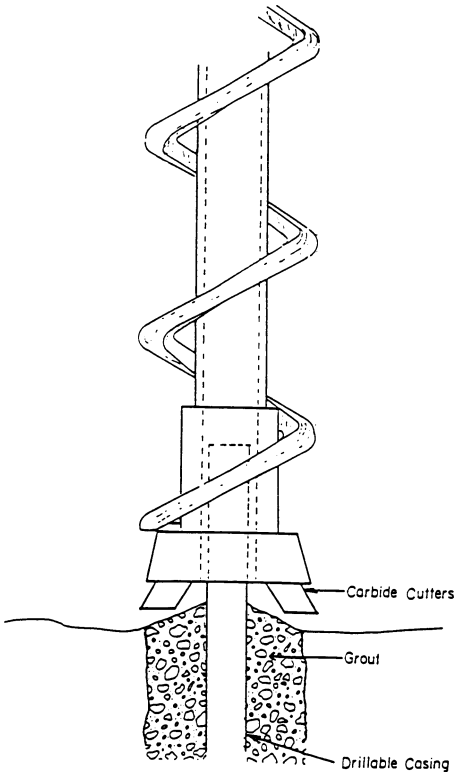

FIG. 4 Over Drilling by Hollow Stem Auger Procedure

the ground. The open hole is then filled with grout or other suitable plugging materials. A tamping rod can be used to tamp the material into place.

7.4 *Decontamination of Downhole Equipment*:

7.4.1 If hazardous waste or other contaminants occur at the site, decontaminate all tools placed into the borehole or well prior to entry (see Practice D 5088). Follow state and local regulations, if applicable. A hot water pressure wash or steam cleaning are examples of two typical decontamination methods. Other methods such as the use of solvents followed by rinsing with clean tap water and allowing equipment to air dry may also be acceptable. Also contain water and other materials used for decontamination for chemical analysis to determine proper disposal methods.

7.4.2 Do not flush grout pipes out with water while in or above the hole. Conduct all cleaning operations aboveground and manage appropriately as a hazardous or nonhazardous situation depending upon chemical analytical data on the site.

7.5 *Documentation*:

7.5.1 *Inspection Records*—The primary purpose of records of field work is to provide that appropriate measures have been taken so that the borehole or monitoring well is permanently decommissioned in a manner that minimizes it from being a conduit for fluid, water, or vapor migration. Properly decommissioned boreholes and wells should have no adverse influence on the local environment than the original geological setting.

7.5.2 *Narrative Report*—Maintain the narrative report of activities as a permanent record of the decommissioning activities and include the full set of field activities including:

7.5.2.1 Decommissioning date,

7.5.2.2 Personnel (with listing of company representation, including phone number and address),

7.5.2.3 Source of decommissioning method,

7.5.2.4 Step-by-step procedures used in the field,

7.5.2.5 Record of all measurements made, depths encountered, types and volume of fluids pumped and photographs before and after, and

7.5.2.6 All other pertinent information that is required based on site conditions or regulatory requirements. Any problems encountered should also be documented in detail.

8. Report

8.1 At the completion of field work, present a formal report to document the entire procedure used in the decommissioning process for the borehole or well. Additional information or requirements may be specified in government regulations and should also be included in this report. Report in detail the following items as a minimum:

8.1.1 *Background Information*:

8.1.1.1 Location of the borehole/well,

8.1.1.2 Purpose of the borehole/well,

8.1.1.3 History of the borehole/well,

8.1.1.4 Chemical parameters and concentrations present during the active life of the well and at the time of plugging; and

8.1.1.5 Information collected prior to the inspection record.

8.1.2 *Testing Prior to Decommissioning*:

8.1.2.1 Site characterization (if applicable),

8.1.2.2 Physical testing (depth, structural condition, etc.),

8.1.2.3 Chemical testing results (last chemical analysis for record), and

8.1.2.4 Geophysical logging results (if any).

8.1.3 *Decommissioning Design Procedure*:

8.1.3.1 Rationale for selection of method used, and

8.1.3.2 Presentation of a decommissioning plan.

8.1.4 *Field Implementation*:

8.1.4.1 Description of activities,

8.1.4.2 Variance from plan, and

8.1.4.3 Result of testing and measurements.

8.1.5 *Confirmation*—Statement of regulatory compliance.

9. Keywords

9.1 abandonment; decommissioning; ground water monitoring wells; hazardous waste; plugging

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APPENDIX

(Nonmandatory Information)

X1. EXAMPLES OF SUCCESSFUL MONITORING WELL DECOMMISSIONING PRACTICES

X1.1 This appendix covers a general discussion of field procedures that have been used to decommission monitoring wells. These procedures are presented to provide technical guidance to assist in the development of decommissioning wells or boreholes. Local regulations may not allow implementation of some procedures. Two subsets of procedures are outlined, one for rigid steel casing and the second for lower tensile strength casing materials (plastic).

X1.2 *Steel Casing:*

X1.2.1 *Condition*—Properly grouted steel casing and screen, difficult to pull casing:

X1.2.1.1 *Suggestion*—Pressure pump plugging materials into well to above aquifer, place 3-ft (.91-mm) plug of plastic material (bentonite plug) above rigid plug then complete with rigid plugging material to surface. Place a PVC or neoprene plug or packer, located at the base of the rigid (cement) material to reduce the co-mingling of fluids due to different specific gravities. Complete decommissioning at surface according to local regulations.

X1.2.1.2 *Alternative*—Perforate steel casing and screen to allow plugging material to come into contact with the annular space and formation.

X1.2.1.3 *Advantage*—If (when) casing material corrodes, the continually plastic bentonite plug will continue to provide a suitable sealing zone.

X1.2.2 *Condition*—Steel well materials, that are removable:

X1.2.2.1 *Suggestion*—Pull screen and casing, then redrill borehole to original depth using slightly larger diameter drill bit than the borehole. Complete closure by pressure sealing the borehole by grout pipe from bottom to top.

X1.2.2.2 *Advantage*—Casing and annular materials are completely removed and replaced with sealing material of equal or lower permeability (saturated zone) than the native geologic materials.

X1.2.3 *Condition*—Shallow screened well completed into permeable sand or gravel aquifer:

X1.2.3.1 *Suggestion*—Pull the casing and screen (grout also, if possible) then redrill the borehole to original depth. Completion should be by pressure sealing to the surface.

X1.2.3.2 *Advantage*—The possibility of hydraulic connections with the surface is greatly reduced.

X1.2.4 *Condition*—Steel casing and screen set into highly permeable formation (such as fractured limestone) that results in lost fluid circulation during drilling or decommissioning procedures:

X1.2.4.1 *Suggestion*—Fill highly permeable section with quick setting cement grout (addition of calcium chloride), or coarse gravel to base of casing, or hang "cement basket" at base of casing. Complete decommissioning with plugging materials pumped into place, including at least one section of permanent plastic seal.

X1.2.4.2 *Advantage*—Extremely permeable or highly cavernous materials may not be able to be filled sufficiently to allow closure similar to other cases. In such situations, prevention of vertical migration of fluids to or from that zone is the primary purpose of decommissioning.

X1.3 *Low-Tensile Strength Materials (that is, PVC, ABS, PTFE):*

X1.3.1 *Condition*—Properly constructed well that has a sealed annulus from the surface to the top of screen:

X1.3.1.1 *Suggestions*—Pressure grout in place after perforating the entire casing so that the screen and gravel pack are filled with grout; or over-ream the well using a drill bit diameter that is a minimum or slightly larger than the diameter of the annular space.

X1.3.2 *Condition*—Annulus is not permanently sealed and casing/screen cannot be pulled:

X1.3.2.1 *Suggestion*—Overdrill casing, screen and filter pack with a hollow stemmed auger or other suitable drilling method. Remove casing from bottom to top as augers are removed.

X1.3.2.2 *Advantage*—Complete well structure is removed. Grouting materials provide no avenue of fluid or gas migration after decommissioning.

X1.3.3 *Condition*—Annulus seal questionable; casing screen cannot be pulled:

X1.3.3.1 *Suggestion*—Use rotary tools equipped with pilot bit. Large portion of bit must be equal to or larger than diameter of original borehole. Drill out casing, annular material, to depth of well. Pressure seal after tools are removed.

X1.3.3.2 *Advantage*—Complete well structure is removed. Grouting materials do not provide pathways for fluid or gas migration after decommissioning.

X1.3.4 *Condition*—Annulus seal questionable, casing and screen may be pulled from firm clay soils:

X1.3.4.1 *Suggestion*—Use pulling rig equipped with down hole casing latch tool. Anchor tool at bottom of well and lift casing and screen. Pressure grout open hole from bottom to top. (This method may have applicability for shallow wells.)

X1.3.4.2 *Advantage*—This method is often possible in firm clay soils. Requires less expensive equipment than other procedures.

X1.3.5 *Condition*—Vadose zone monitoring devices such as lysimeters, tensiometers, neutron access holes, and similar devices installed vertically:

X1.3.5.1 *Suggestion*—Drill out the device and backfill as suggested in 7.3.8.5 and 7.3.8.6. (See also Note 15 in the text.)

X1.3.5.2 *Advantage*—The device and materials used to construct the device are removed reducing the potential for fluid movement from the surface to underlying materials and ground water.

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Designation: D 5434 – 03

Standard Guide for Field Logging of Subsurface Explorations of Soil and Rock[1]

This standard is issued under the fixed designation D 5434; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval. A superscript epsilon (ε) indicates an editorial change since the last revision or reapproval.

1. Scope*

1.1 This guide describes the type of information that should be recorded during field subsurface explorations in soil and rock.

1.2 This guide is not intended to specify all of the information required for preparing field logs. Such requirements will vary depending on the purpose of the investigation, the intended use of the field log, and particular needs of the client or user.

1.3 This guide is applicable to boreholes, auger holes, excavated pits, or other subsurface exposures such as road side cuts or stream banks. This guide may serve as a supplement to Guide D 420.

1.4 This guide may not be suited to all types of subsurface exploration such as mining, agricultural, geologic hazardous waste, or other special types of exploration.

1.5 *This standard does not purport to address all of the safety concerns, if any, associated with its use. It is the responsibility of the user of this standard to establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.*

1.6 *This guide offers an organized collection of information or a series of options and does not recommend a specific course of action. This document cannot replace education or experience and should be used in conjunction with professional judgment. Not all aspects of this guide may be applicable in all circumstances. This ASTM standard is not intended to represent or replace the standard of care of which the adequacy of a given professional service must be judged, nor should this document be applied without consideration of a project's many unique aspects. The word "Standard" in the title of this document means only that the document has been approved through the ASTM consensus process.*

2. Referenced Documents

2.1 *ASTM Standards:* [2]

D 420 Guide to Site Characterization for Engineering, Design, and Construction Purposes
D 653 Terminology Relating to Soil, Rock, and Contained Fluids
D 1452 Practice for Soil Investigation and Sampling by Auger Borings
D 1586 Method for Penetration Test and Split-Barrel Sampling of Soils
D 1587 Practice for Thin-Walled Tube Geotechnical Sampling of Soils
D 2113 Practice for Diamond Core Drilling for Site Investigation
D 2488 Practice for Description and Identification of Soils (Visual-Manual Procedure)
D 2573 Test Method for Field Vane Shear Test in Cohesive Soil
D 3441 Test Method for Deep, Quasi-Static, Cone and Friction/Cone Penetration Tests of Soil
D 3550 Practice for Ring-Lined Barrel Sampling of Soils
D 3740 Practice for Minimum Requirements for Agencies Engaged in the Testing and/or Inspection of Soil and Rock as Used in Engineering Design and Construction
D 4083 Practice for Description of Frozen Soils (Visual-Manual Procedure)
D 4220 Practices for Preserving and Transporting Soil Samples
D 4403 Practice for Extensometers Used in Rock
D 4544 Practice for Estimating Peat Deposit Thickness
D 4622 Test Method for Rock Mass Monitoring Using Inclinometers
D 4623 Test Method for Determination of In Situ Stress in Rock Mass by Overcoring Method—USBM Borehole Deformation Gage
D 4633 Test Method for Stress Wave Energy Measurement for Dynamic Penetrometer Testing Systems
D 4645 Test Method for Determination of the In-Situ Stress in Rock Using the Hydraulic Fracturing Method
D 4719 Test Method for Pressuremeter Testing in Soils
D 4750 Test Method for Determining Subsurface Liquid Levels in a Borehole or Monitoring Well (Observation Well)
D 4879 Guide for Geotechnical Mapping of Large Underground Openings in Rock

[1] This guide is under the jurisdiction of ASTM Committee D18 on Soil and Rock and is the direct responsibility of D18.07 onIdentification and Classification of Soils.

Current edition approved Nov. 1, 2003. Published December 2003. Originally approved in 1993. Last previous edition approved in 2003 as D 5434 – 97(2003).

[2] For referenced ASTM standard, visit the ASTM website, www.astm.org, or contact ASTM Customer Service at service@astm.org. For *Annual Book of ASTM Standards*volume information, refer to the standard's Document Summary page of the ASTM website.

***A Summary of Changes section appears at the end of this standard.**

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D 5079 Practices for Preserving and Transporting Rock Core Samples

3. Terminology

3.1 *Definitions:*

3.1.1 Except as listed below, all definitions are in accordance with Terminology D 653.

3.2 *Description of Term Specific to This Standard:*

3.2.1 *field log*—a record prepared during subsurface explorations of soil and rock to document procedures used, test data, descriptions of materials and depths where encountered, ground water conditions, and other information.

4. Summary of Guide

4.1 This guide describes the type of information that should be recorded during the execution of field subsurface explorations in soil and rock. The information described relates to the project, personnel, methods of investigation and equipment used, visual description of subsurface materials and ground water conditions, in-situ testing, installation of monitoring equipment, and other data that may be appropriate.

5. Significance and Use

5.1 The preparation of field logs provides documentation of field exploration procedures and findings for geotechnical, geologic, hydrogeologic, and other investigations of subsurface site conditions. This guide may be used for a broad range of investigations.

5.2 The recorded information in a field log will depend on the specific purpose of the site investigation. All of the information given in this guide need not appear in all field logs.

NOTE 1—- The quality of the result produced by this standard is dependent on the competence of the personnel performing it, and the suitability of the equipment and facilities used. Agencies that meet the criteria of Practice D 3740 are generally considered capable of competent and objective sampling. Users of this practice are cautioned that compliance with Practice D 3740 does not in itself assure reliable results. Reliable results depend on many factors; Practice D 3740 provides a means of evaluating some of those factors.

6. Summary of Work

6.1 Soil and rock field logs should include the following written information:

6.1.1 Project information should include:

6.1.1.1 Name and location of the project or project number, or both,

6.1.1.2 Name of personnel onsite during the exploration, such as drilling crew, supervisor, geologist, engineer, and technicians,

6.1.1.3 Names and addresses of organizations involved,

6.1.1.4 Name of person(s) preparing log,

6.1.1.5 Reference datum for project if available and description of datum, and

6.1.1.6 General remarks as appropriate.

6.1.2 Exploration information should include:

6.1.2.1 Exploration number and location (station and coordinates if available and applicable, position relative to a local permanent reference which is identified, or markings of exploration location),

6.1.2.2 Type of exploration, such as drill hole, auger hole, test pit, or road cut,

6.1.2.3 Date and time of start and finish,

6.1.2.4 Weather conditions including recent rain or other events that could affect subsurface conditions,

6.1.2.5 Depth and size of completed exploration,

6.1.2.6 The condition of exploration prior to and after backfilling or sealing, or both, and

6.1.2.7 Method of backfilling or sealing exploration, or both.

6.1.3 Explorations by drill hole or auger hole should include the following drilling information:

6.1.3.1 Type and make (manufacture and model if known) of drilling machine or description and name of contractor,

6.1.3.2 Method of drilling or advancing and cleaning the borehole. State if air, water, or drilling fluid is used. Describe type, source of water and additives, concentration, and tests performed on fluid,

6.1.3.3 Size, type, and section length of drilling rods (rod designations should conform with Table 3 of Method D 2113) and drilling bits used.

6.1.3.4 Dates and times of each stage of operation and time to complete intervals,

6.1.3.5 Size of hole (diameter and depth),

6.1.3.6 Ground elevation at top of borehole,

6.1.3.7 Orientation of drill hole, if not vertical (azimuth or bearing and angle),

NOTE 2—Even with careful drilling, the actual subsurface path of both vertical and inclined drill holes may be different from the intended direction of drilling. Deflection of the drill bit due to inclined bedding and hard boulders are some of the many reasons a drill hole might deviate from the intended direction. Drill holes that deviate from the intended direction can give erroneous data if not corrected. This can lead to significant interpretation errors of subsurface conditions and geologic structure. Depending on intended use of the data, it may be prudent to perform a borehole survey so the borehole spatial data can be corrected.

6.1.3.8 Size and description of casing, if appropriate, method of casing installation (driven, drilled, or pushed) and depth of cased portion of boring (casing size designations should conform with Table 2 of Method D 2113), hollow-stem augers,

6.1.3.9 Methods used for cleaning equipment or drilling tools, or both, when required, and

6.1.3.10 Describe and state depth of any drilling problems such as borehole instability (cave in, squeezing hole, flowing sands), cobbles, lost drilling fluid, lost ground, obstruction, fluid return color changes, and equipment problems.

6.1.4 Exploration by test pit, road cut, stream cut, etc., should include:

6.1.4.1 Method of exploration,

6.1.4.2 Equipment used for excavation,

6.1.4.3 Type of shoring used, and

6.1.4.4 Excavation problems: instability of cut (sloughing, caving, etc.), depth of refusal, difficulty of excavating, etc.

6.1.5 Subsurface information should include:

6.1.5.1 Depth of changes and discontinuities in geologic material and method used to establish change (such as Practice D 4544).

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6.1.5.2 Description of material encountered with origin or formation name, if possible, and type of samples used for description. The system or method of soil (such as Practices D 2488 and D 4083) or rock description should be referenced.

6.1.5.3 Description of nature of boundary between strata (gradual or abrupt, as appropriate) and other relevant structural features such as breccia, slickensides, solution zones, discolorations by weathering or hydrothermal fluids, and other stratigraphic information.

6.1.6 Soil or rock sampling and testing information should include:

6.1.6.1 Depth of each sample and number (if used),

6.1.6.2 Method of sampling (reference to appropriate ASTM standard, for example, Practice D 1452, Test Method D 1586, Method D 1587, Practice D 3550, or other method).

6.1.6.3 Description of sampler: inside and outside dimensions, length, type of metal, type of coating, and type of liner,

6.1.6.4 Method of sampler insertion: pushed, cored, or driven,

6.1.6.5 Sampler penetration and recovery lengths of samples (rock quality designation (RQD) and rate of coring in the case of rock),

6.1.6.6 Method of sample extrusion. Mark direction of extrusion,

6.1.6.7 Method of preserving samples and preparing for transport (refer to Practices D 4220 or D 5079),

6.1.6.8 Mark top and bottom of samples and orientation, if possible,

6.1.6.9 Depth and description of any in-situ test performed (reference to applicable ASTM standard, for example, Test Methods D 1586, D 2573, D 3441, D 4623, D 4633, D 4645, D 4719, or other tests if applicable),

6.1.6.10 Description of any other field tests conducted on soil and rock during the exploration such as pH, hydraulic conductivity, pressuremeter geophysical, pocket penetrometer, soil gas/vapor analysis, or other tests, and

6.1.6.11 Destination or recipient of samples and method of transportation.

6.1.7 Ground water information should include:

6.1.7.1 Depths and times at which ground water is encountered, including seepage zones, if appropriate,

6.1.7.2 In the case of drilling using drilling fluid, depth of fluid surface in boring and drilling depth at the time of a noted loss or gain in drilling fluid,

6.1.7.3 Depth to ground water level at the completion of drilling and removal of drill steel and description of datum (note condition of borehole, for example, cased or uncased). Date and time measured,

6.1.7.4 Depth to ground water level at some reported time period following completion of drilling and description of datum, when possible.

6.1.7.5 Method or equipment used to determine depth of ground water level, such as Test Method D 4750,

6.1.7.6 Method and depth of ground water samples obtained, including size of samples taken and description of sampler, and

6.1.7.7 Description of any field tests conducted on ground water samples such as pH, temperature, conductivity, turbidity, or odor.

6.1.8 Information regarding installation of instrumentation or monitoring equipment should include:

6.1.8.1 Type of equipment installed, for example, piezometers, monitoring well screens, inclinometer, including sizes and types of materials,

6.1.8.2 Depth and description of equipment installed (reference to applicable ASTM standard, for example, Test Method D 4622, Practice D 4403, or other standards or procedures),

6.1.8.3 Methods used for installation of equipment and method used for sealing annular space, and

6.1.8.4 Methods used to protect equipment (casing cap or locks).

6.2 Soil and rock field logs should include the following pictorial information:

6.2.1 Maps, drawings, or sketches of area of exploration and subsurface surfaces observed. Include pertinent surface information such as neighboring outcrops, as appropriate. Describe system of mapping, such as Guide D 4879 for rock, or legend for symbols of materials. Include dimensions, directions, and slopes, and

6.2.2 Photographs of activities, surfaces, or core. Describe sequence, dates and time, direction, objects used for scale, and subject.

7. Keywords

7.1 drilling; explorations; geologic investigations; ground water; logging; preliminary investigations; sampling; soil investigations; subsurface investigations

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SUMMARY OF CHANGES

In accordance with Committee D18 policy, this section identifies the location of changes to this standard since the last edition (D5434–97(03)) that may impact the use of this standard.

(1) Section 2 — Added Practice D 3740 to the Referenced Documents Section.

(2) Section 5 — Added Note 1 on the use of Practice D 3740.

(2) Section 6— Added Note 2 after Section 6.1.3.7.

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Designation: D 5784 – 95 (Reapproved 2000)

Standard Guide for Use of Hollow-Stem Augers for Geoenvironmental Exploration and the Installation of Subsurface Water-Quality Monitoring Devices[1]

This standard is issued under the fixed designation D 5784; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval. A superscript epsilon (ε) indicates an editorial change since the last revision or reapproval.

1. Scope

1.1 This guide covers how hollow-stem auger-drilling systems may be used for geoenvironmental exploration and installation of subsurface water-quality monitoring devices.

1.2 Hollow-stem auger drilling for geoenvironmental exploration and monitoring device installations often involves safety planning, administration, and documentation. This guide does not purport to specifically address exploration and site safety.

NOTE 1—This guide does not include considerations for geotechnical site that are addressed in a separate Guide.

1.3 The values stated in SI units are to be regarded as the standard. The inch-pound units given in parentheses are for information only.

1.4 *This standard does not purport to address all of the safety concerns, if any, associated with its use. It is the responsibility of the user of this standard to establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.*

1.5 *This guide offers an organized collection of information or a series of options and does not recommend a specific course of action. This document cannot replace education or experience and should be used in conjunction with professional judgment. Not all aspects of this guide may be applicable in all circumstances. This ASTM standard is not intended to represent or replace the standard of care by which the adequacy of a given professional service must be judged, nor should this document be applied without consideration of a project's many unique aspects. The word "Standard" in the title of this document means only that the document has been approved through the ASTM consensus process.*

2. Referenced Documents

2.1 *ASTM Standards:*

D 653 Terminology Relating to Soil, Rock, and Contained Fluids[2]

D 1452 Practice for Soil Investigation and Sampling by Auger Borings[2]

D 1586 Test Method for Penetration Test and Split-Barrel Sampling of Soils[2]

D 1587 Test Method for Thin-Walled Tube Sampling of Soils[2]

D 2113 Test Method for Diamond Core Drilling for Site Investigation[2]

D 2487 Test Method for Classification of Soils for Engineering Purposes[2]

D 2488 Practice for Description and Identification of Soils (Visual-Manual Procedure)[2]

D 3550 Practice for Ring-Lined Barrel Sampling of Soils[2]

D 4220 Practices for Preserving and Transporting Soil Samples[2]

D 4428/D4428M Test Methods for Crosshole Seismic Testing[2]

D 4700 Guide for Soil Sampling from the Vadose Zone[2]

D 4750 Test Method for Determining Subsurface Liquid Levels in a Borehole or Monitoring Well (Observation Well)[2]

D 5079 Practices for Preserving and Transporting of Rock Core Samples[3]

D 5088 Practice for Decontamination of Field Equipment Used at Non-Radioactive Waste Sites[3]

D 5092 Practice for Design and Installation of Ground Water Monitoring Wells in Aquifers[3]

D 5099 Test Method for Rubber—Measurement of Processing Properties Using Capillary Rheometry[4]

D 5254 Practice for Minimum Set of Data Elements to Identify a Ground-Water Site[3]

3. Terminology

3.1 *Definitions:*

3.1.1 Terminology used within this guide is in accordance with Terminology D 653. Definitions of additional terms may be found in Terminology D 653.

3.2 *Definitions of Terms Specific to This Standard:*

3.2.1 *bentonite*—the common name for drilling fluid additives and well-construction products consisting mostly of naturally occurring montmorillonite. Some bentonite products have chemical additives that may affect water-quality analyses.

[1] This guide is under the jurisdiction of ASTM Committee D18 on Soil and Rock and is the direct responsibility of Subcommittee D18.21 on Ground Water and Vadose Zone Investigations.

Current edition approved Oct. 10, 1995. Published December 1995.

[2] *Annual Book of ASTM Standards*, Vol 04.08.

[3] *Annual Book of ASTM Standards*, Vol 04.09.

[4] *Annual Book of ASTM Standards*, Vol 09.01.

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3.2.2 *bentonite granules and chips*—irregularly shaped particles of bentonite (free from additives) that have been dried and separated into a specific size range.

3.2.3 *bentonite pellets*—roughly spherical- or disk-shaped units of compressed bentonite powder (some pellet manufacturers coat the bentonite with chemicals that may affect the water-quality analysis).

3.2.4 *coefficient of uniformity— C_u (D)*, the ratio D_{60}/D_{10}, where D_{60} is the particle diameter corresponding to 60 % finer on the cumulative particle-size distribution curve, and D_{10} is the particle diameter corresponding to 10 % finer on the cumulative particle-size distribution curve.

3.2.5 *continuous-sampling devices*—barrel-type samplers that fit within the lead auger of the hollow-auger column. The sampler barrel fills with material as the augers advance.

3.2.6 *drill hole*—a cylindrical hole advanced into the subsurface by mechanical means. Also known as borehole or boring.

3.2.7 *drawworks*—a power-driven winch, or several winches, usually equipped with a clutch and brake system(s) for hoisting or lowering a drilling string.

3.2.8 *filter pack*—also known as a gravel pack or a primary filter pack in the practice of monitoring-well installations. The gravel pack is usually granular material, having specified grain-size characteristics, that is placed between a monitoring device and the borehole wall. The basic purpose of the filter pack or gravel envelope is to act as: (*1*) a nonclogging filter when the aquifer is not suited to natural development or, (*2*) act as a formation stabilizer when the aquifer is suitable for natural development.

3.2.8.1 *Discussion*—Under most circumstances a clean, quartz sand or gravel should be used. In some cases a pre-packed screen may be used.

3.2.9 *fluid-injection devices*—usually consist of various auger components or drill-rig attachments that may be used to inject a fluid within a hollow-auger column during drilling.

3.2.10 *grout packer*—an inflatable or expandable annular plug that is attached to a tremie pipe, usually positioned immediately above the discharge end of the pipe.

3.2.11 *grout shoe*—a drillable plug containing a check valve that is positioned within the lowermost section of a casing column. Grout is injected through the check valve to fill the annular space between the casing and the borehole wall or another casing.

3.2.11.1 *Discussion*—The composition of the drillable plug should be known and documented.

3.2.12 *hoisting line*—or drilling line, is wire rope used on the drawworks to hoist and lower the drill string.

3.2.13 *in situ testing devices*—sensors or probes, used to obtain mechanical or chemical-test data, that are typically pushed, rotated, or driven below the bottom of a borehole following completion of an increment of drilling. However, some in situ testing devices (such as electronic pressure transducers, gas-lift samplers, tensiometers, and and so forth) may require lowering and setting of the device(s) in a preexisting borehole by means of a suspension line or a string of lowering rods or pipe. Centralizers may be required to correctly position the device(s) in the borehole.

3.2.14 *intermittent-sampling devices*—usually barrel-type samplers that may be rotated, driven, or pushed below the bottom of a borehole with drill rods or with a wireline system to lower, drive, and retrieve the sampler following completion of an increment of drilling. The user is referred to the following ASTM standards relating to suggested sampling methods and procedures: Practice D 1452, Test Method D 1586, Practice D 3550, and Practice D 1587.

3.2.15 *mast*—or derrick, on a drilling rig is used for supporting the crown block, top drive, pulldown chains, hoisting lines, and so forth. It must be constructed to safely carry the expected loads encountered in drilling and completion of wells of the diameter and depth for which the rig manufacturer specifies the equipment.

3.2.16 *Discussion*—To allow for contingencies, it is recommended that the rated capacity of the mast should be at least twice the anticipated weight load or normal pulling load.

3.2.17 *piezometer*—an instrument for measuring pressure head.

3.2.18 *subsurface water-quality monitoring device*— an instrument placed below ground surface to obtain a sample for analyses of the chemical, biological, or radiological characteristics of subsurface pore water or to make in-situ measurements.

4. Significance and Use

4.1 Hollow-stem auger drilling may be used in support of geoenvironmental exploration (Practice D 3550, Test Method D 4428) and for installation of subsurface water-quality monitoring devices in unconsolidated materials. Hollow-stem auger drilling may be selected over other methods based on the advantages over other methods. These advantages include: the ability to drill without the addition of drilling fluid(s) to the subsurface, and hole stability for sampling purposes (see Test Methods D 1586, D 1587, D 2487, and D 2488) and monitor-well construction in unconsolidated to poorly indurated materials. This drilling method is generally restricted to the drilling of shallow, unconsolidated materials or softer rocks. The hollow-stem drilling method is a favorable method to be used for obtaining cores and samples and for the installation of monitoring devices in many, but not all geologic environments.

NOTE 2—In many geologic environments the hollow-stem auger drilling method can be used for drilling, sampling, and monitoring-device installations without the addition of fluids to the borehole. However, in cases where heaving water-bearing sands or silts are encountered, the addition of water or drilling mud to the hollow-auger column may become necessary to inhibit the piping of these fluid-like materials into the augers. These drilling conditions, if encountered, should be documented.

4.1.1 The application of hollow-stem augers to geoenvironmental exploration may involve ground water and soil sampling, in-situ or pore-fluid testing, or utilization of the hollow-auger column as a casing for subsequent drilling activities in unconsolidated or consolidated materials (Test Method D 2113).

NOTE 3—The user may install a monitoring device within the same auger borehole wherein sampling or in-situ or pore-fluid testing was performed.

4.1.2 The hollow-stem auger column may be used as a temporary casing for installation of a subsurface water-quality

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monitoring device. The monitoring device is usually installed as the hollow-auger column is removed from the borehole.

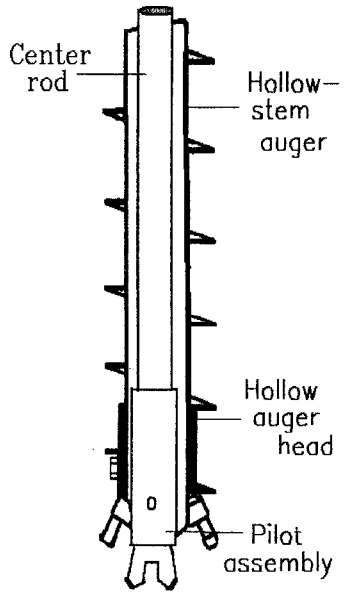
4.2 The subsurface water-quality monitoring devices that are addressed in this guide consist generally of a screened or porous intake device and riser pipe(s) that are usually installed with a filter pack to enhance the longevity of the intake unit, and with isolation seals and low-permeability backfill to deter the movement of fluids or infiltration of surface water between hydrologic units penetrated by the borehole (see Practice D 5092). Inasmuch as a piezometer is primarily a device used for measuring subsurface hydraulic heads, the conversion of a piezometer to a water-quality monitoring device should be made only after consideration of the overall quality and integrity of the installation, to include the quality of materials that will contact sampled water or gas.

NOTE 4—Both water-quality monitoring devices and piezometers should have adequate casing seals, annular isolation seals, and backfills to deter the movement of fluids between hydrologic units.

5. Apparatus

5.1 Each auger section of the hollow-stem auger-column assembly consists of a cylindrical tube with continuous helical flighting rigidly attached to the outer surface of the tube (see Fig. 1). The hollow-auger section has a coupling at each end for attachment of a hollow-auger head to the bottom end of the lead auger section and for attachment of additional auger sections at the top end to make up the articulated hollow-stem auger column.

NOTE 5—The inside diameter of the hollow-stem auger column is usually selected to provide an opening large enough for insertion of monitoring-device components such as the screened intake and filter pack and installation devices such as a tremie pipe. When media sampling is required, the optimum opening should permit easy insertion and retraction of a sampler or core barrel. When a monitoring device is installed, the annular opening should provide easy insertion of a pipe with an inside diameter large enough for placing completion materials adjacent to the riser.



NOTE 1—Various pilot assemblies not shown here may vary.

FIG. 1 Sketch Showing Basic Hollow-Stem Auger Components

5.1.1 *Hollow-Auger Head*, attached to the lead auger of the hollow-auger column and usually contains replaceable, abrasion-resistant cutters or teeth (see Fig. 1). As the hollow-auger head is rotated, it cuts and directs the cuttings to the auger flights which convey the cuttings to the surface.

5.1.2 *Auger-Drive Assembly*, attaches to the uppermost hollow-auger section and transfers rotary power and axial force from the drill rig to the auger-column assembly.

5.1.3 *Pilot Assembly*, may consist of: (*1*) an auger head aperture-plugging device with or without a center cutting head, or (*2*) a sampling device that is used to sample simultaneously with advancement of the auger column.

5.1.4 *Auxiliary Components of a Hollow-Auger Drilling System*, consist of various devices such as auger-connector wrenches, auger forks, hoisting hooks, and fluid-injection swivels or adapters.

5.2 *Drill Rig*, used to rotate and advance the auger column. The drill rig should be capable of applying the rated power at a rotary velocity of 50 to 100 r/min. The drill rig should have a feed stroke of at least the effective length of the auger sections plus the effective length of the auger couplings plus about 100 mm (4 in.).

6. Drilling Procedures

6.1 As a prelude to and throughout the drilling process stabilize the drill rig and raise the drill-rig mast. Attach an initial assembly of hollow-auger components (see Fig. 1) to the rotary drive of the drill rig.

NOTE 6—The drill rig, drilling and sampling tools, the rotary gear or chain case, the spindle, and all components of the rotary drive above the auger column should be cleaned and decontaminated prior to drilling according to Practice D 5088. All lubricated rotary gear or chain cases should be monitored for leaks during drilling. Any lubricants used should be documented. Lubricants with organic or metallic constituents that could be interpreted as contaminants if detected in a soil or water sample should not be used on auger couplings. Any instances of possible contamination should be documented.

6.2 Push the auger-column assembly below the ground surface and initiate rotation at a low velocity.

NOTE 7—If surface contamination is suspected, special drilling procedures may be required to deter transport of contaminated materials downhole. For example, the augers and auger head may be removed and cleaned according to Practice D 5088 following drilling of the initial increments. Complete removal of the augers from a boring may allow caving and cross contamination of materials (especially below the water table). When augers are reinserted, attempts should be made to note if caving or sloughing, or both, has occurred in the borehole and the information documented.

6.3 Then continue drilling, usually at a rotary velocity of about 50 to 100 r/min, and to a depth where intermittent sampling or in situ testing is required, or until the drive assembly is advanced to within about 0.15 to 0.45 m (6 to 18 in.) of the ground surface. Soil sampling is usually accomplished by either of two methods: (*1*) removing the pilot assembly, if being used, and inserting and driving a sampler through the hollow stem of the auger column, or (*2*) using a continuous sampling device within the lead auger section. In the latter case the sampler barrel fills with material as the hollow-auger column is advanced. It should be noted that the pilot assembly and any sampling devices should be cleaned and

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decontaminated according to Practice D 5088 after each use and prior to reinsertion in the hollow-auger column. Water sampling can also be done through the hollow-stem augers when using augers with watertight connections to prevent fluid leakage from occurring at the connections: (*1*) by allowing the auger column to fill with water through the use of a screened lead auger section; (*2*) by allowing the auger column to fill from the bottom; (*3*) by using a soil-penetrating water sampling device that can be lowered into the hollow-auger column and either driven, rotated, or pushed out through the bottom or lead auger into the undisturbed material below the auger head.

NOTE 8—Under some circumstances it may be effective to drill without using a pilot assembly. If a pilot assembly is not used, however, and water is not injected into the auger column simultaneously with advancement, material will often enter the hollow stem of the auger column. The addition of water to the auger column during drilling may deter material entrance but, on the other hand, may also affect both the mechanical and chemical characteristics of soil samples and the quality of water samples. Therefore, if water is added and the chemistry determined, the approximate volume(s) added over specific intervals and the water chemistry should be documented.

6.4 Accomplish drilling at greater depths by attaching additional hollow-auger sections to the top of the previously advanced hollow-auger column assembly.

NOTE 9—Cuttings are removed periodically from around the top of the auger column. Soil cuttings above the ground water may be representative of deposits being penetrated if proper cuttings-return rates are maintained. Cuttings from below the ground water surface are likely to be mixed from varying formations in the hole and are usually not representative of deposits at the end of the auger if cuttings are sampled for classification (see Practice D 2488) and relation to lithology report and document the intervals sampled. If drilling is performed in contaminated soil and cuttings control is required, drilling through a hole in a sheet of plywood or similar material held securely above the borehole by the stabilizing jacks of the drill rig will usually facilitate cuttings control. Containment and disposal of contaminated and potentially contaminated drilling fluids and associated cuttings should be in accordance with applicable regulations.

6.5 When drilling must progress through material suspected of being contaminated, installation of single or multiple (nested) casings may be required to isolate zones of suspected contamination. Install isolation casings in a predrilled borehole or by using a casing advancement method. However, when attempting to auger inside the casing, the column of cuttings return may cause the augers to bind in the casing. Then install a grout seal usually by applying the grout at the bottom of the annulus with the aid of a tremie pipe, and a grout shoe or a grout packer. Allow the grout to set before drilling activities are continued.

7. Installation of Monitoring Devices

7.1 Subsurface water-quality monitoring devices are generally installed using hollow-stem augers following the three-step procedure shown in Fig. 2. The three steps are: (*1*) drilling, with or without sampling, (*2*) removal of the pilot assembly, if being used, and insertion of the monitoring device, and (*3*) incremental removal of the hollow-auger column as completion materials such as filter pack, annular seals, and backfill are installed as required.

NOTE 10—Removal of the pilot assembly following an increment of drilling or prior to installation of a monitoring device should be performed so that the entrance of material into the bottom of the hollowauger stem is minimized. The efficacy of pilot assembly removal will depend upon several principal factors: (*1*) the character of the soil at the auger head, (*2*)

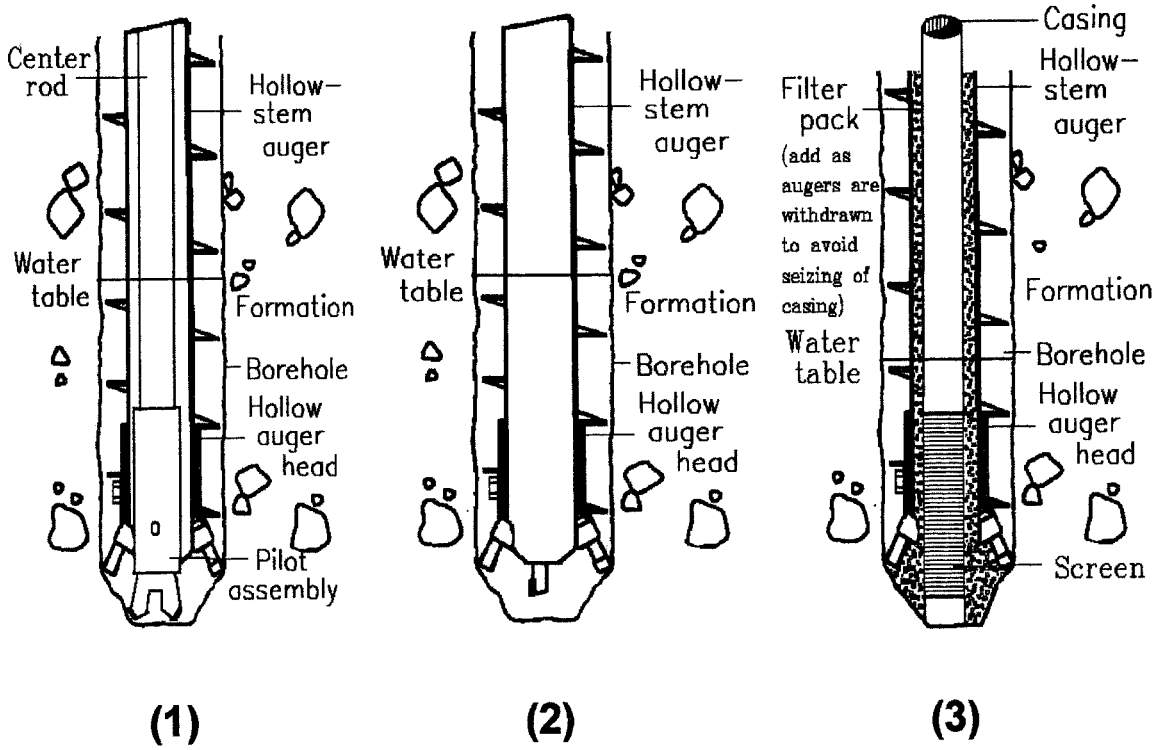

FIG. 2 Sketch Showing Basic Three-Step Procedure for Installation of Subsurface Water-Quality Monitoring Device Using the Hollow-Stem Auger Drilling Method

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the water levels inside and outside the auger prior to removal of the pilot assembly, (*3*) the type of pilot assembly used (special designs of pilot assemblies can be used to reduce the suction effect of removing the pilot bit), and (*4*) the speed of removal. As drilling progresses in saturated, granular materials, it usually becomes progressively more difficult to maintain the stability of the material below the auger column because of unbalanced hydraulic heads. The stability of the material below the auger head may be enhanced by using special pilot assemblies or injecting water of known chemistry into the hollow auger during drilling. The injection of water into a borehole usually requires consideration and documentation of the effects of injected water on (*1*) quality of subsequent chemical analyses of sampled water, and (*2*) the possible addition of moisture or contaminants to sampled materials.

7.1.1 If materials enter the bottom of the auger hollow stem during removal of the pilot assembly, remove it with a bailer, drive sampler, or other device.

NOTE 11—If heaving occurs, the amount of material entering the hollow-stem auger column should be documented. The effective use of a bailer may require the addition of a fluid to the auger stem.

7.1.2 If sampling or in situ testing is not required during drilling for installation of a monitoring device, advance the boring (for some geologic conditions) by using an expendable knockout plate or plug of known chemistry instead of a pilot assembly.

NOTE 12—Knockout plates or plugs usually remain in the ground close to the monitoring device. Therefore, the material components for knockout plates or plugs should be selected based on their possible effects on subsequent measurements or analyses and the information documented. It may be necessary to fill or partially fill the auger stem with water of known chemistry to prevent blow-in, piping, or sanding in at the time of the plate or plug removal. Refer to Note 7 for considerations regarding adding water to the hollow-auger stem.

7.1.3 Use an auger head with an integral, hinged aperture cover to deter entrance of materials into the auger stem.

7.2 Assemble water-quality monitoring devices, with attached fluid conductors (risers), and suspend in tension prior to placement of filter pack and during placement of filter pack in the borehole (with the least possible addition of contaminants).

7.2.1 Some materials, such as screens and risers, may require cleaning or decontamination, or both, at the job site (see Practice D 5088).

7.2.2 Prior to installation, store all monitoring device materials under cover and place upwind and well away from the drill rig and other sources of potential contamination such as electrical generators, air compressors, or industrial machinery.

7.2.3 Clean hoisting tools, particularly wire rope and hoisting swivels, and decontaminate according to Practice D 5088 before using.

7.3 Select filter materials, bentonite pellets, granules and chips, and grouts and install to specific subsurface monitoring requirements. The thickness of the emplaced materials and extension of the materials above the top of the screen should be sufficient to adequately seal the well and monitoring device(s) against contamination effects of fluid movement between hydrologic units and infiltration of surface contaminants.

7.3.1 Filter packs for monitoring devices are typically installed by withdrawing the hollow augers in small increments, while simultaneously adding small increments of filter material. Record the total volume of filter materials installed and the depth to the upper surface of the filter pack and compare to calculated volumes of material required for completion. Consider any discrepancies occurring between the actual volume of material used and the calculated volume required prior to proceeding to ensure proper completion. If filter material bridges within the hollow auger-riser annulus during installation, use tamping rods or other tamping devices to dislodge the bridge.

NOTE 13—Filter packs for monitoring devices installed in a saturated zone are typically selected on the basis of the grain size characteristics of the hydrologic unit adjacent to the screened intake (screen size should be less than the grain size of the formation adjacent to the screened intake). Filter-pack material is often inserted from above ground surface within the annulus of the hollow auger and the riser and is distributed by gravity around the screened intake. Filter-pack material with a uniformity coefficient of less than 2.5 is ordinarily selected to minimize in-place segregation of grain sizes. For some circumstances, such as installations under water in uniform, fine to very fine sand soils, the filter should be installed with a tremie pipe to minimize segregation of particle sizes. Filter packs for vadose-zone monitoring devices may be predominantly silt sized. These filter materials are often mixed with water of known quality, inserted through a tremie pipe, and tamped into place around the device.

NOTE 14—Effective installation of the filter pack, the seal above the filter pack, and the grout above the seal may be difficult to achieve. Consideration should be given to allow for sufficient annular space between the monitoring device and the hollow-stem auger to accommodate the tremie pipe. Under some circumstances, the filter pack may be more successfully installed by injecting or inserting water of known chemistry into the hollow-auger annulus either before or during incremental pull-back of the auger column. Enough water should be injected to both fill the space previously occupied by the auger flights and to maintain or slightly increase the head within the auger-hollow stem. This additional head within the auger-hollow stem provides an outward seepage force on the wall of the borehole as the augers are retracted. The additional head deters caving prior to installation of filter or seal materials. Approximate volumes of water used and water losses should be documented.

7.4 Usually place sealing materials consisting of either bentonite pellets, chips, or granules directly above the filter pack.

NOTE 15—It may be effective, when granular filters are used, to install a thin, fine sand, secondary filter either below the annular seal or both above and below the seal. These secondary filters are installed to protect the monitoring device, primary filter pack, and seal from intrusion of grout installed above the seal.

NOTE 16—A measured volume of water of known chemistry is often placed in the annulus on top of a dry bentonite seal to initiate hydration; however, hydration of a seal may require from 6 to 24 h.

7.5 The backfill that is placed above the annular seal is usually a bentonite- or cement-base grout.

NOTE 17—Grouts should be designed and installed in consideration of the ambient hydrogeologic conditions. The constituents should be selected and documented according to specific performance requirements. Typical grout mixtures are given in Practice D 5092 and Test Method D 4428.

NOTE 18—Grouting equipment and pipes should be cleaned and decontaminated according to Practice D 5088 prior to use and should be constructed of materials that do not “leach” significant amounts of contaminants to the grout.

7.5.1 When a tremie pipe is used, control its initial position and grouting pressures to prevent materials from being jetted into underlying seal(s) and filter(s) (use of a tremie pipe having a plugged bottom and side-discharge ports should be considered to minimize bottom-jetting problems).

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7.5.2 After placement of the initial 1.5 to 3 m (5 to 10 ft) of grout above the underlying filter or seal, discharge additional grout at a depth of about 1.5 to 3 m below the grout surface.

NOTE 19—The need for chemical analysis of samples of each grout component and the final mixture should be considered and documented.

7.5.3 Install the grout from the bottom of the borehole to the top of the borehole so as to displace fluids in the borehole.

8. Development

8.1 Most monitoring device installations should be developed to remove suspended solids from disturbance of geologic materials during installation and to improve the hydraulic characteristics of the filter pack and the hydrologic unit adjacent to the intake. The method(s) selected and time expended to develop the installation and changes in quality of water discharged at the surface should be observed and recorded.

NOTE 20—Under most circumstances, development should be initiated as soon as possible following grouting and well completion operations. For suggested well-development methods and techniques, the user is referred to Test Method D 5099. However, time should be allowed for setting of grout.

9. Field Report and Project Control

9.1 The field report should include information recommended under Guide D 5434, and identified as necessary and pertinent to the needs of the exploration program.

9.2 Other information in addition to Guide D 5434 should be considered if deemed appropriate and necessary to the requirements of the exploration program. Additional information should be considered as follows:

9.2.1 *Drilling Methods*:

9.2.1.1 Description of the hollow-stem auger system,

9.2.1.2 Type, quantities, and locations in the borehole of use of water or additives added,

9.2.1.3 Description of cuttings return, including quantities, and

9.2.1.4 Descriptions of drilling conditions related to rotation rates, and general ease of drilling as related to subsurface materials encountered.

9.2.2 *Sampling*—Document conditions of the bottom of the borehole prior to sampling and report any slough or cuttings present in the recovered sample.

9.2.3 *In Situ Testing*:

9.2.3.1 For devices inserted below the bottom of the borehole, document the depths below the bottom of the hole and any unusual conditions during testing, and

9.2.3.2 For devices testing or seating at the borehole wall, report any unusual conditions of the borehole wall.

9.2.4 *Installations*—A description of well-completion materials and placement methods, approximate volumes placed, depth intervals of placement, methods of confirming placement, and areas of difficulty of material placement or unusual occurrences.

10. Keywords

10.1 drilling; geoenvironmental exploration; ground water; vadose zone

APPENDIX

(Nonmandatory Information)

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Designation: D 5787 – 95 (Reapproved 2000)

Standard Practice for Monitoring Well Protection[1]

This standard is issued under the fixed designation D 5787; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval. A superscript epsilon (ε) indicates an editorial change since the last revision or reapproval.

INTRODUCTION

This practice for monitoring well protection is provided to promote durable and reliable protection of installed monitoring wells against natural and man caused damage. The practices contained promote the development and planning of monitoring well protection during the design and installation stage.

1. Scope

1.1 This practice identifies design and construction considerations to be applied to monitoring wells for protection from natural and man caused damage or impacts.

1.2 The installation and development of a well is a costly and detailed activity with the goal of providing representative samples and data throughout the design life of the well. Damages to the well at the surface frequently result in loss of the well or changes in the data. This standard provides for access control so that tampering with the installation should be evident. The design and installation of appropriate surface protection will mitigate the likelihood of damage or loss.

1.3 This practice may be applied to other surface or subsurface monitoring device locations, such as piezometers, permeameters, temperature or moisture monitors, or seismic devices to provide protection.

1.4 *This practice offers a set of instructions for performing one or more specific operations. This document cannot replace education or experience and should be used in conjunction with professional judgment. Not all aspects of this practice may be applicable in all circumstances. This ASTM standard is not intended to represent or replace the standard of care by which the adequacy of a given professional service must be judged, nor should this document be applied without consideration of a project's many unique aspects. The word "Standard" in the title of this document means only that the document has been approved through the ASTM consensus process.*

2. Referenced Documents

2.1 *ASTM Standards:*

C 150 Specification for Portland Cement[2]

C 294 Descriptive Nomenclature of Constituents of Natural Mineral Aggregates[3]

D 5092 Design and Installation of Ground Water Monitoring Wells in Aquifers[4]

3. Terminology

3.1 *Definitions:*

3.1.1 *barrier*—any device that physically prevents access or damage to an area.

3.1.2 *barrier markers*—plastic, or metal posts, often in bright colors, placed around a monitoring well to aid in identifying or locating the well.

3.1.3 *barrier posts*—steel pipe, typically from 4 to 12 inches in diameter and normally filled with concrete or grout that are placed around a well location to protect the well from physical damage, such as from vehicles.

3.1.4 *borehole*—a circular open or uncased subsurface hole created by drilling.

3.1.5 *casing*—pipe, finished in sections with either threaded connections or bevelled edges to be field welded, which is installed temporarily or permanently to counteract caving, to advance the borehole, or to isolate the zone being monitored, or a combination thereof.

3.1.6 *casing, protective*—a section of larger diameter pipe that is emplaced over the upper end of a smaller diameter monitoring well riser or casing to provide structural protection to the well and restrict unauthorized access into the well.

3.1.7 *riser*—the pipe extending from the well screen to or above the ground surface.

3.1.8 *sealed cap*—a sealable riser cap, normally gasketed or sealed, that is designed to prevent water or other substances from entering into, or out of the well riser.

3.1.9 *vented cap*—a cap with a small hole that is installed on top of the riser.

4. Significance and Use

4.1 An adequately designed and installed surface protection

[1] This practice is under the jurisdiction of ASTM Committee D18 on Soil and Rock and is the direct responsibility of Subcommittee D18.21 on Ground Water and Vadose Zone Investigations.

Current edition approved Sept. 10, 1995. Published January 1996.

[2] *Annual Book of ASTM Standards,* Vol 04.01.

[3] *Annual Book of ASTM Standards,* Vol 04.02.

[4] *Annual Book of ASTM Standards,* Vol 04.08.

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system will mitigate the consequences of naturally or man caused damages which could otherwise occur and result in either changes to the data, or complete loss of the monitoring well.

4.2 The extent of application of this practice may depend upon the importance of the monitoring data, cost of monitoring well replacement, expected or design life of the monitoring well, the presence or absence of potential risks, and setting or location of the well.

4.3 Monitoring well surface protection should be a part of the well design process, and installation of the protective system should be completed at the time of monitoring well installation and development.

4.4 Information determined at the time of installation of the protective system will form a baseline for future monitoring well inspection and maintenance. Additionally, elements of the protection system will satisfy some regulatory requirements such as for protection of near surface ground water and well identification.

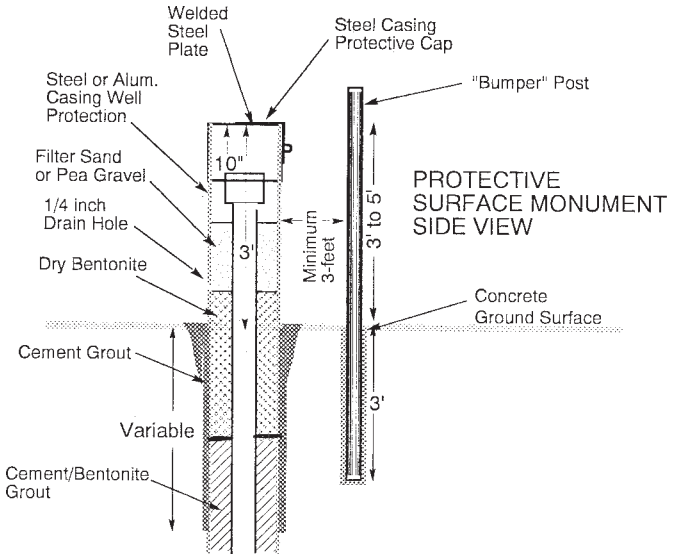

FIG. 1 Example of Protective Design

5. Design Considerations

5.1 The design of a monitoring well protective system is like other design processes, where the input considerations are determined and the design output seeks to remedy or mitigate the negative possibilities, while taking advantage of the site characteristics.

5.2 The factors identified in this practice should be considered during the design of the monitoring well protective system. The final design should be included in the monitoring well design and installation documentation and be completed and verified during the final completion and development of the well.

5.3 In determining the level or degree of protection required, the costs and consequences, such as loss of data or replacement of the well, must be weighed against the probability of occurrence and the desired life of the well. For monitoring wells which will be used to obtain data over a short time period, the protection system may be minimal. For wells which are expected to be used for an indefinite period, are in a vulnerable location, and for which the costs of lost data could be high, the protective system should be extensive. Factors to consider and methods of mitigating them are presented in the following sections.

5.3.1 *Impact Damages*—Physical damages resulting from construction equipment, livestock, or vehicles striking the monitoring well casing frequently occur. Protective devices and approaches include:

5.3.1.1 Extra heavy protective casings with a reinforced concrete apron extending several feet around the casing may be an acceptable design in those areas where frost heave is not a problem. The principle behind this is to design the protective casing so that it will be able to withstand the impact of vehicles without damage to the riser within.

5.3.1.2 Barrier Posts placed in an array such that any anticipated vehicle can not pass between them to strike the protective casing. Barrier posts are typically filled with concrete and set in post holes several feet deep which are backfilled with concrete. Barrier posts typically extend from 3 to 5 feet above the ground surface. Barrier posts are frequently used in and around industrial or high vehicle traffic areas. Costs for installation can be substantial however they provide a high degree of protection for exposed wells. Cost of removal at decommissioning can also be substantial.

NOTE 1—Cattle frequently rub against above ground completions leading to damage of unprotected casings. Concrete filled posts or driven T-posts, wrapped with barbed wire, are frequently used.

5.3.1.3 Barrier Markers are relatively lightweight metal or often plastic posts which provide minimal impact resistance but which by their color, location, and height, warn individuals of the well presence. The use of barrier markers is effective in areas that are well protected from impact type damage by other features, such as surrounding structures or fences. They are relatively inexpensive to install.

5.3.1.4 *Signs*—An inexpensive means of identifying the presence of a monitoring well. Signs provide protection only by warning of the well presence. Signs may be required in some circumstances and appropriate in others. Wells known to contain hazardous, radioactive, or explosive compounds should be marked to warn sampling personnel of potential dangers. When a potential exists for water usage, signage indicating that the water is non-potable and is utilized strictly as a monitoring well, and not for any other purpose, may be appropriate. Disadvantages of signs are that they may be ignored, are often difficult to maintain, and may invite vandalism to the well.

5.3.1.5 Recessed or Subsurface casings may be used to mitigate impact damage by allowing the vehicles to pass over.

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Frequently used techniques include recessing the casing below ground level, using commercially available covers. These may take the form of valve pits or manholes, as examples. Advantages include both protecting the well while minimizing the interference to surface traffic, such as in parking lots or urban areas and screening the well from view. Using this technique, wells may be located in the most desired locations from a ground-water monitoring perspective. Disadvantages include the need to assure surface drainage does not enter the well riser, either by maintaining positive drainage or by using a sealed riser cap (or both). When the risk is from the influx of surface water, drains below the level of the riser should be installed. In extreme cases, such as in location with high ground-water levels or potential drainage from surrounding areas, automatic sump pumps may be required. Consideration should be given to the sampling personnel who will require adequate space to perform sampling, particularly in manhole situations. Additionally, personnel protection requirements from working in a confined space should be considered.

5.3.1.6 Fencing, such as commercial chainlink type fences may provide adequate protection in areas with light risk from vehicles, but where people or animals may interfere or affect the well. Advantages are relative minimal costs, ease of removal or opening. Disadvantages include maintenance, adequacy of protection from hard vehicle impacts, and visual and traffic interference.

5.3.2 *Vandalism*—Damage from vandals can take two forms, those which seek to damage or destroy the well itself, and those which intend to damage the data that the well may provide. Theft of sampling pumps, loss of access to the riser, plugging of the well with foreign debris, or injection of foreign materials or chemicals are potential results of vandalism.

5.3.2.1 Physical damage to the well can be minimized with many of the same techniques as used to protect the well from impact damages. Generally two techniques can be used to protect a well from physical damage, one, by hiding or camouflaging the well, the other by constructing the surface protection of the well with multiple physical barriers. Hiding or camouflaging the well utilizes the philosophy that what can't be found can't be damaged. Camouflage techniques include enclosing the well in manholes or sumps, planting shrubs or vegetation to shield the well from view, enclosing the well in another structure, such as inside a raised planter or a small shed. Color characteristics of the above ground can be used to disguise the well or to assist in making it blend into the surroundings. Costs for camouflage can vary widely, but are generally minimal when included with other protections. Disadvantages are that if found, the well is still susceptible to damage by vandals, that damage may be undetected, and that sampling personnel not familiar with the well may have difficulty locating it.

5.3.2.2 Protection from vandalism is generally achieved by constructing multiple physical barriers. The first barrier should always include a rugged protective casing with a locking cap or lid. The lock quality can vary from relatively inexpensive and easily broken types to more costly high security type locks. Locks used on wells are subject to weather, dirt and deterioration. Frequently locks must be cut if not regularly maintained and the design and selection of the cap and lock should include this consideration. Construction of the hasps, locking lugs, or other mechanisms should be rugged, made of metal and welded to prevent access to the casing by prying, hammering or other typical vandalism. The casing should be heavy enough to resist penetration by bullets in areas where shooting may occur. A concrete apron or grout collar around the casing will provide mass to defeat attempts to pull the casing upwards, or sideways. Additional physical barriers should be added in consideration of the location and likelihood of vandalism. These include locked chainlink fences, use of barbed or concertina wire, concrete walls, or enclosure inside of buildings or other fenced or enclosed areas. When placed in below ground level structures, such as sumps or manholes, the access covers can be equipped with a lock. Access to keys should be controlled to prevent unauthorized use and entry.

5.3.2.3 Protection of the well and the data, (for example, ground-water level elevations), that the well will provide can be generally achieved by the physical barriers previously described. Detection of access to a well should also be considered. While not protecting the well and the sample data directly, it will be valuable in evaluating the data derived from the well samples. Sampling personnel should be alert and inspect the well and the protective devices for signs of vandalism. Foil or paper seals can be applied to the riser and cap at the end of each sampling to allow visual verification that the riser cap has not been disturbed between samplings. Seals are inexpensive and provide assurance of the well integrity and should be considered for use on all wells.

5.3.3 *Landslides*—Movement of the surface layers of soil due to seismic activity or other changes can result in lateral movement with the riser being bent or ultimately sheared. The primary protection against this type of damage is location. Whenever possible, the well should be located outside of the slide area. When relocation is not possible and the moving soil layer is relatively thin, limited protection may be achieved by extending the protective casing several feet below the shear line. Additional protection may be gained by driving piling or posts through the surface layer and below the shear line to anchor the surface. Protection and maintenance of wells in slide areas can be expensive and may result in only delaying the loss of the well.

5.3.4 *Freeze Damage*—Freezing of the ground surrounding a well riser can result in heaving which can sever the riser resulting in the loss of the well. In areas where extended freezing temperatures are expected, the well protective casing should be constructed to minimize the possibility of damage. The protective casing should extend several feet below the frost line and the space between the well riser and the protective casing should be filled with a granular, free draining fine gravel down to the ground surface elevation and the bentonite below the gravel. Alternative designs in frost heave problem areas use a tapered concrete collar preferable to a 4-in. concrete pad. This will allow vertical movement of the protective casing and apron or collar without placing stress on the riser. The casing should have drain holes at several locations and heights to allow any water that may accumulate to drain freely. In areas where freezing occurs, the top of riser

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elevation and casing or concrete apron should be periodically checked to verify if movement has occurred. This will also allow for correction of ground water levels measured from the surface reference points.

5.3.5 *Floods*—Flood waters provide opportunities for physical damage to the well and to the integrity of the data that the well may provide. Wells located in low areas, floodplains, or areas where there is a potential for ponding of water should consider protection from physical damage and infiltration. Physical damage is generally mitigated by the protective devices described previously. Infiltration of water into the well from flooding can affect the data that will be derived from the well samples. It can also serve as a pathway for surface contaminants to reach the ground water. When flood or ponding surface waters are a possibility, the riser should be extended above an anticipated water level, such as the 100 year flood level. Additionally, a sealed cap capable of preventing leakage should be considered. If extending the riser is not possible or desirable, the riser cap should be sealable and capable of withstanding the anticipated head pressures that the site may experience.

NOTE 2—Where a sealed cap is used to prevent surface water from entering a well, it can also impede the vertical movement of water in the well casing, thus affecting the accuracy of the water level measurements.

5.3.6 *Elevation Changes*—Frequently wells are placed in locations where the surface elevations are expected to change, such as in landfills, borrow areas, or construction fill areas. Design of the well surface protection should take these changes into consideration. In areas where the surface elevation will be raised to a known level, the riser and casing should be extended to above the expected level. A second concrete collar and surface protection system can be put into place at that time. When the elevation change was not anticipated or known, the protection of the well and casing during the change should be carefully planned to protect the well riser from damage. Damage can occur due to equipment impacts, shearing of slopes, having the riser and casing buried, or falling over when surrounding soils are removed. Elevations before the change should be known. Elevations should be re-established at the completion and included in the well history records. Costs for protecting a well during elevation changes are minimal and less than the cost of replacing a well that was badly damaged or lost.

5.4 *Signage*—External signs provide a means of economical administrative control. Signs can protect the well from damage or accidental extraction by informing personnel of the well's purpose for providing ground-water data. Signs also have the negative aspect of informing vandals and others of the well's presence. The use of signs should consider the benefits and disadvantages of identifying the well. Signs may be required by regulation, to identify the owner, permit identifications, location identification, date of installation, and other information.

5.4.1 Internal signs or tagging may also be placed inside the protective casing, an attached locking cap, or other structures to provide information to the sampling personnel and to prevent inadvertent errors, such as sampling the wrong wells. Signs, or tags may also inform the samplers of relevant information or requirements, such as recording the total volume of water extracted, or other information such as the well elevation, chemical or other hazards, explosive potential, or required safety precautions. Signs or tags used for identification should be positively attached inside the individual well protective casing. When several well risers are clustered inside a single protective casing, the identification should be affixed to the riser, rather than the cap to prevent inadvertent misidentification.

5.5 *Decommissioning*—If the well is to be used only for a limited period, the ease or difficulty and costs of removing the surface protective devices should be considered along with the need to protect the well while in use. In cases where the surface or surrounding soils may become contaminated by materials extracted from the well, preventative protection should be considered, such as placing liners below the soil surface, and concrete cap, using raised berms, and protective coatings on the metal and concrete surfaces. These will prevent the spread of contamination, should it occur, and will minimize the amount of material that must be decontaminated or removed at the time of cleanup or decommissioning.

6. Records and Reports

6.1 *Well Design Considerations*—Surface protection, including signs, labeling, barriers, and other details should be included in the well design documentation. Other information, such as the initial survey elevations at the time of well completion and asbuilt configuration should also be included as baseline information that can be referred to during the life of the well and for use during the decommissioning. The design information should be updated as new information becomes available. Such information may include periodic elevation surveys, records or changes to the surface devices, changes in surrounding grade or land uses, and the like.

6.2 *Well Condition Checklists*—Checklists for use during the life of the well should be developed during the design stage to insure that the well protective devices are maintained throughout the life of the well. These checklists should be completed whenever the well is sampled or in a predefined inspection schedule. Needed repairs to the surface protective devices should be recorded and accomplished to maintain the well protection. Any damage, or suspected intrusions into the well should be recorded. This information may be useful during evaluation of the well sample data, particularly when unauthorized spiking or tampering is suspected.

6.3 *Repair/Maintenance History*—Any maintenance performed, including the costs, should be included in the well documentation.

7. Keywords

7.1 ground water; surface protection; well damage; well protection; well vandalism

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Designation: D 6282 – 98

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Standard Guide for Direct Push Soil Sampling for Environmental Site Characterizations[1]

This standard is issued under the fixed designation D 6282; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval. A superscript epsilon (ε) indicates an editorial change since the last revision or reapproval.

1. Scope

1.1 This guide addresses direct push soil samplers, which also may be driven into the ground from the surface or through prebored holes. The samplers can be continuous or discrete interval units. Samplers are advanced by a combination of static push, or impacts from hammers, or vibratory methods, or a combination thereof, to the depth of interest. The guide does not cover open chambered samplers operated by hand such as augers, agricultural samplers operated at shallow depths, or side wall samplers. This guide does not address single sampling events in the immediate base of the drill hole using rotary drilling equipment with incremental drill hole excavation. Other sampling standards, such as Test Methods D 1586 and D 1587 and Practice D 3550 apply to rotary drilling activities. This guide does not address advancement of sampler barrel systems with methods that employ cuttings removal as the sampler is advanced. Other drilling and sampling methods may apply for samples needed for engineering and construction applications.

1.2 Guidance on preservation and transport of samples, as given in Guide D 4220, may or may not apply. Samples for chemical analysis often must be subsampled and preserved for chemical analysis using special techniques. Practice D 3694 provides information on some of the special techniques required. Additional information on environmental sample preservation and transportation is available in other references **(1, 2).**[2] Samples for classification may be preserved using procedures similar to Class A. In most cases, a direct push sample is considered as Class B in Practice D 4220 but is protected, representative, and suitable for chemical analysis. The samples taken with this practice do not usually produce Class C and D (with exception of thin wall samples of standard size) samples for testing for engineering properties, such as shear strength and compressibility. Guide D 4700 has some information on mechanical soil sampling devices similar to direct push techniques, however, it does not address most direct push sampling methods. If sampling is for chemical evaluation in the Vadose Zone, consult Guide D 4700 for any special considerations.

1.3 Field methods described in this guide, include the use of discreet and continuous sampling tools, split and solid barrel samplers and thin walled tubes with or without fixed piston style apparatus.

1.4 Insertion methods described include static push, impact, percussion, other vibratory/sonic driving, and combinations of these methods using direct push equipment adapted to drilling rigs, cone penetrometer units, and specially designed percussion/direct push combination machines. Hammers providing the force for insertion include drop style, hydraulically activated, air activated and mechanical lift devices.

1.5 Direct push soil sampling is limited to soils and unconsolidated materials that can be penetrated with the available equipment. The ability to penetrate strata is based on hammer energy, carrying vehicle weight, compactness of soil, and consistency of soil. Penetration may be limited or damage to samplers and conveying devices can occur in certain subsurface conditions, some of which are discussed in 5.5. Successful sample recovery also may be limited by the ability to retrieve tools from the borehole. Sufficient retract force must be available when attempting difficult or deep investigations.

1.6 This guide does not address the installation of any temporary or permanent soil, ground water, vapor monitoring, or remediation devices.

1.7 The practicing of direct push techniques may be controlled by local regulations governing subsurface penetration. Certification, or licensing requirements, or both, may need to be considered in establishing criteria for field activities.

1.8 The values stated in SI units are to be regarded as standard: however, dimensions used in the drilling industry are given in inch-pound units by convention. Inch-pound units are used where necessary in this guide.

1.9 *This standard does not purport to address all of the safety concerns, if any, associated with its use. It is the responsibility of the user of this standard to establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.*

1.10 *This guide offers an organized collection of information or a series of options and does not recommend a specific course of action. This document cannot replace education or experience and should be used in conjunction with professional judgment. Not all aspects of this guide may be applicable in all circumstances. This ASTM standard is not intended to represent or replace the standard of care by which the adequacy of*

[1] This guide is under the jurisdiction of ASTM Committee D-18 on Soil and Rock and is the direct responsibility of Subcommittee D18.21 on Ground Water and Vadose Zone Investigation.

Current edition approved July 10, 1998. Published February 1999.

[2] The boldface numbers in parentheses refer to the list of references at the end of this standard.

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a given professional service must be judged, nor should this document be applied without consideration of a projects's many unique aspects. The word "Standard" in the title of this document means only that the document has been approved through the ASTM consensus process.

2. Referenced Documents

2.1 *ASTM Standards:*

D 420 Guide to Site Characterization for Engineering, Design and Construction Purposes[3]

D 653 Terminology Relating to Soil, Rock and Contained Fluids[3]

D 1452 Practice for Soil Investigation and Sampling by Auger Boring[3]

D 1586 Test Method for Penetration Test and Split-Barrel Sampling of Soils[3]

D 1587 Practice for Thin-Wall Tube Sampling of Soils[3]

D 2488 Practice for Description and Identification of Soils (Visual-Manual Method)[3]

D 3550 Practice for Ring-Lined Barrel Sampling of Soils[3]

D 3694 Practices for Preparation of Sample Containers and for Preservation of Organic Constituents[4]

D 4220 Practices for Preserving and Transporting Soil Samples[3]

D 4700 Guide for Soil Sampling from the Vadose Zone[3]

D 4750 Test Method for Determining Subsurface Liquid Levels in a Borehole or Monitor Well (Observation Well)[3]

D 5088 Practice for Decontamination of Field Equipment Used at Nonradioactive Waste Sites[5]

D 5092 Practice for Design and Installation of Ground Water Monitoring Wells in Acquifers[5]

D 5299 Guide for Decommisioning of Ground Water Wells, Vadose Zone Monitoring Devices, Boreholes, and Other Devices for Environmental Activities[5]

D 5314 Guide for Soil Gas Sampling in the Vadose Zone[5]

D 5434 Guide for Field Logging of Subsurface Explorations of Soil and Rock[5]

D 5730 Guide to Site Characterization for Environmental Purposes with Emphasis on Soil, Rock, the Vadose Zone, and Ground Water[5]

D 5778 Test Method for Performing Electronic Friction Cone and Piezocone Penetration Testing of Soils[5]

D 5783 Guide for Use of Direct Rotary Drilling with Water-Based Drilling Fluid for Geoenvironmental Exploration and the Installation of Subsurface Water-Quality Monitoring Devices[5]

D 5784 Guide for Use of Hollow-stem Augers for Geoenvironmental Exploration and the Installation of Subsurface Water-Quality and Monitoring Devices[5]

D 6001 Guide for Direct-Push Water Sampling for Geoenvironmental Investigations[5]

3. Terminology

3.1 *Definitions*—General definitions for terminology used in this guide are in accordance with Terminology D 653. Definitions for terms related to direct push water sampling for geoenvironmental investigations are in accordance with Guide D 6001.

3.1.1 *assembly length*, *n*—length of sampler body and riser pipes.

3.1.2 *borehole*, *n*—a hole of circular cross-section made in soil or rock.

3.1.3 *casing*, *n*—pipe furnished in sections with either threaded connections or bevelled edges to be field-welded, which is installed temporarily or permanently to counteract caving, to advance the borehole, or to isolate the interval being monitored, or combination thereof.

3.1.4 *caving/sloughing*, *n*—the inflow of unconsolidated material into an unsupported borehole that occurs when the borehole walls lose their cohesive strength.

3.1.5 *decontamination*, *n*—the process of removing undesirable physical or chemical constituents, or both, from equipment to reduce the potential for cross-contamination.

3.1.6 *direct push sampling*, *n*—sampling devices that are advanced into the soil to be sampled without drilling or borehole excavation.

3.1.7 *extension rod*, *n*—hollow steel rod, threaded, in various lengths, used to advance and remove samplers and other devices during direct pushing boring. Also known as *drive rod*. In some applications, small diameter solid extension rods are used through hollow drive rods to activate closed samples at depth.

3.1.8 *incremental drilling and sampling*, *n*—insertion method where rotary drilling and sampling events are alternated for incremental sampling. Incremental drilling often is needed to penetrate harder or deeper formations.

3.1.9 *percussion driving*, *n*—insertion method where rapid hammer impacts are performed to advance the sampling device. The percussion normally is accompanied with the application of a static down-force.

3.1.10 *push depth*, *n*—the depth below a ground surface datum to which the lower end, or tip, of the direct-push sampling device is inserted.

3.1.11 *sample interval*, *n*—defined zone within a subsurface strata from which a sample is gathered.

3.1.12 *sample recovery*, *n*—the length of material recovered divided by the length of sampler advancement and stated as a percentage.

3.1.13 *soil core*, *n*—cylindrical shaped specimen of sediments or other unconsolidated accumulations of solid particles produced by the physical and chemical disintegration of rocks and which may or may not contain organic matter recovered from a soil sampler.

3.2 *Definitions of Terms Specific to This Standard:*

3.2.1 *closed barrel sampler*, *n*—a sampling device with a piston or other secured device that is held to block the movement of material into the barrel until the blocking device is removed or released. Liners are required in closed barrel samplers. Also may be referred to as a *protected type sampler.*

3.2.2 *impact heads/drive heads*, *n*—pieces or assemblies that fit to top of the above ground portion of the direct push tool assembly to receive the impact of the hammering device and transfer the impact energy to sampler extensions.

[3] *Annual Book of ASTM Standards*, Vol 04.08.
[4] *Annual Book of ASTM Standards*, Vol 11.02.
[5] *Annual Book of ASTM Standards*, Vol 04.09.

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3.2.3 *open barrel sampler, n*—sampling barrel with open end allowing material to enter at any time or depth. Also may be referred to as an *unprotected type sampler.*

3.2.4 *piston lock, n*—device to lock the sampler piston in place to prevent any entry of a foreign substance into the sampler chamber prior to sampling.

3.2.5 *single tube system, n*—a system whereby single extension/drive rods with samplers attached are advanced into the subsurface strata to collect a soil sample.

3.2.6 *solid barrel sampler, n*—a soil sampling device consisting of a continuous or segmented tube with a wall thickness sufficient to withstand the forces necessary to penetrate the strata desired and gather a sample. A cutting shoe and a connecting head are attached to the barrel.

3.2.7 *split barrel sampler, n*—a soil sampling device consisting of the two half circle tubes manufactured to matching alignment, held together on one end by a shoe and on the other by a connecting head.

3.2.8 *two tube systems, n*—a system whereby inner and outer tubes are advanced simultaneously into the subsurface strata to collect a soil sample. The outer tube is used for borehole stabilization. The inner tube for sampler recovery and insertion.

4. Summary of Guide

4.1 Direct push soil sampling consists of advancing a sampling device into subsurface soils by applying static pressure, by applying impacts, or by applying vibration, or any combination thereof, to the above ground portion of the sampler extensions until the sampler has been advanced to the desired sampling depth. The sampler is recovered from the borehole and the sample removed from the sampler. The sampler is cleaned and the procedure repeated for the next desired sampling interval. Sampling can be continuous for full depth borehole logging or incremental for specific interval sampling. Samplers used can be protected type for controlled specimen gathering or unprotected for general soil specimen collection.

5. Significance and Use

5.1 Direct push methods of soil sampling are used for geologic investigations, soil chemical composition studies, and water quality investigations. Examples of a few types of investigations in which direct push sampling may be used include site assessments, underground storage tank investigations, and hazardous waste site investigations. Continuous sampling is used to provide a lithological detail of the subsurface strata and to gather samples for classification and index or for chemical testing. These investigations frequently are required in the characterization of hazardous waste sites. Samples, gathered by direct push methods, provide specimens necessary to determine the chemical composition of soils, and in most circumstances, contained pore fluids **(3)**.

5.2 Direct push methods can provide accurate information on the characteristics of the soils encountered and of the chemical composition if provisions are made to ensure that discrete samples are collected, that sample recovery is maximized, and that clean decontaminated tools are used in the sample gathering procedure. For purposes of this guide, "soil" shall be defined in accordance with Terminology D 653. Using sealed or protected sampling tools, cased boreholes, and proper advancement techniques can assure good representative samples. Direct push boreholes may be considered as a supplementary part of the overall site investigation or may be used for the full site investigation if site conditions permit. As such, they should be directed by the same procedural review and quality assurance standards that apply to other types of subsurface borings. A general knowledge of subsurface conditions at the site is beneficial.

5.3 Soil strata profiling to shallow depths may be accomplished over large areas in less time than with conventional drilling methods because of the rapid sample gathering potential of the direct push method. More site time is available for actual productive investigation as the time required for ancillary activities, such as decontamination, rig setup, tool handling, borehole backfill, and site clean-up is reduced over conventional drilling techniques. Direct push soil sampling has benefits of smaller size tooling, smaller diameter boreholes, and minimal investigative derived waste.

5.4 The direct push soil sampling method may be used as a site characterization tool for subsurface investigation and for remedial investigation and corrective action. The initial direct push investigation program can provide good soil stratigraphic information depending on the soil density and particle size, determine ground water depth, and provide samples for field screening and for formal laboratory analysis to determine the chemical composition of soil and contained pore fluids. Use of this method, results in minimum site disturbance and no cuttings are generated.

5.5 This guide may not be the correct method for investigations in all cases. As with all drilling methods, subsurface conditions affect the performance of the sample gathering equipment and methods used. Direct push methods are not effective for solid rock and are marginally effective in partially weathered rock or very dense soils. These methods can be utilized to determine the rock surface depth. The presence or absence of ground water can affect the performance of the sampling tools. Compact gravelly tills containing boulders and cobbles, stiff clay, compacted gravel, and cemented soil may cause refusal to penetration. Certain cohesive soils, depending on their water content, can create friction on the sampling tools which can exceed the static delivery force, or the impact energy applied, or both, resulting in penetration refusal. Some or all of these conditions may complicate removal of the sampling tools from the borehole as well. Sufficient retract force should be available to ensure tool recovery. As with all borehole advancement methods, precautions must be taken to prevent cross contamination of aquifers through migration of contaminants up or down the borehole. Regardless of the tool size, the moving of drilling and sampling tools through contaminated strata carries risks. Minimization of this risk should be a controlling factor in selecting sampling methods and drilling procedures. The user should take into account the possible chemical reaction between the sample and the sampling tool itself, sample liners, or other items that may come into contact with the sample **(3, 4)**.

5.6 In some cases this guide may combine water sampling,

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or vapor sampling, or both, with soil sampling in the same investigation. Guides D 6001 and D 4700 can provide additional information on procedures to be used in such combined efforts.

6. Criteria for Selection

6.1 Important criteria to consider when selecting sampling tools include the following:

6.1.1 Size of sample.

6.1.2 Sample quality (Class A,B,C,D) for physical testing. Refer to Practice D 4220.

6.1.3 Sample handling requirements, such as containers, preservation requirements.

6.1.4 Soil conditions anticipated.

6.1.5 Ground water depth anticipated.

6.1.6 Boring depth required.

6.1.7 Chemical composition of soil and contained pore fluids.

6.1.8 Probability of cross contamination.

6.1.9 Available funds.

6.1.10 Estimated cost.

6.1.11 Time constraints.

6.1.12 History of tool performance under anticipated conditions (consult experienced users and manufacturers).

6.2 Important criteria to consider when selecting direct push equipment include the following:

6.2.1 Site accessibility.

6.2.2 Site visibility.

6.2.3 Soil conditions anticipated.

6.2.4 Boring depth required.

6.2.5 Borehole sealing requirements.

6.2.6 Equipment performance history.

6.2.7 Personnel requirements.

6.2.8 Decontamination requirements.

6.2.9 Equipment grouting capability.

6.2.10 Local regulatory requirements.

7. Apparatus

7.1 *General*—A direct push soil sampling system consists of a sample collection tool, hollow extension rods for advancement, retrieval, and transmission of energy to the sampler, and an energy source to force sampler penetration. Auxiliary tools are required to handle, assemble and disassemble, clean, and repair the sample collection tools and impact surfaces. Necessary expendable supplies are sample containers, sample container caps, sample liners, sample retainers, appropriate lubricants, and personal safety gear.

7.2 *Direct Push Tool Systems*:

7.2.1 *Two Tube System*—An outer casing and an inner extension rod with a sampler attached (see Fig. 1) are advanced simultaneously into the soil for the length capacity of the sampler. The sampler is removed from the borehole and a new sampler barrel or plug bit is inserted for each increment of depth. Two-tube sampling systems also may incorporate sample gathering chambers that are fitted into the outer casing shoe. These sample barrels are designed to create a minimum of sample disturbance while gathering high quality specimens (see Fig. 2). Samplers are held in the proper position by different methods, such as extension rods, pneumatic or mechanical packers, spring activated latches, or other devices (see Figs. 1 and 2). Locking devices must be strong enough to hold the sampler while penetrating the sample strata. The outer casing supports the borehole wall. Sample retrieval is expedited by the cased hole and continuous sampling is simplified. Continuous sampling may be a benefit to lithological logging. A cased borehole can be sealed from the bottom up as the casing is extracted (see Section 10). A cased hole may reduce the risk of contamination migration down the borehole and sample cross contamination. The two-tube system is more susceptible to soil friction because of its larger diameter and may require larger direct push energy than single-tube systems. An oversized drive shoe is sometimes used to reduce friction and buckling but may increase the risk of contamination migration down the borehole.

7.2.2 *Single Tube System*—The single tube system (see Fig. 3), uses a hollow extension/drive rod to advance and retrieve the sampler. The sampler is attached to the bottom of the extension/drive rod. A drive cap is added to the top of the extension/drive rod and the sampler is pushed into the soil. Extension/drive rods generally are smaller in diameter than the sampler. The single tube system minimizes effort for discrete interval sampling under many subsurface conditions. Tool connection time per interval is reduced. Time of removal and reinsertion of samplers into the borehole is affected by soil conditions. Repeated movement of the sampler through contaminated subsurface strata may increase the risk of contamination migration down the borehole. Bottom up borehole sealing may require re-entry in soil formations that collapse (see Section 10).

7.3 *Samplers*:

7.3.1 *Split Barrel Samplers*—Split barrel samplers (see Fig. 4) are available for use with direct push drilling methods and are available in various sizes up to 3.0 in. (76.2-mm) inside diameter. The inside tolerance should allow for use of liners. Split barrel sampler shoes used in two tube systems must be of sufficient diameter to prevent the intrusion of soil between the outer diameter of the shoe and the inside wall of the outer tube. Split barrel shoes should be replaced when the leading edge is damaged. Damaged shoes can negatively affect sample recovery. Samplers can be used with or without ball check value fitted split barrel heads. The ball check prevents uphole fluids from flowing down through the sample. Where soil sampling will be performed below the water table, the split barrel head, equipped with a ball check, should be used. The open split barrel is best used with the two tube system because the outer casing protects the borehole against cave-in or sloughing, or in soils in which the borehole wall will not collapse. Split barrel sealing systems are available. Split barrel sections can be joined to create a sampler with a nominal sample length capacity of 48 in. (1.22 m). It is understood that samplers with usable lengths beyond 24 in. (0.61 m) are used to advantage in certain soil types; however, the added weight of the soil sample in the chamber and the added friction within the sampler may prevent loose soils from entering the sampler, affecting sample recovery and representativeness. Split barrel samplers can be fitted with a basket to improve recovery in cohesionless soils. Retainers are available in many styles and materials. Retainers

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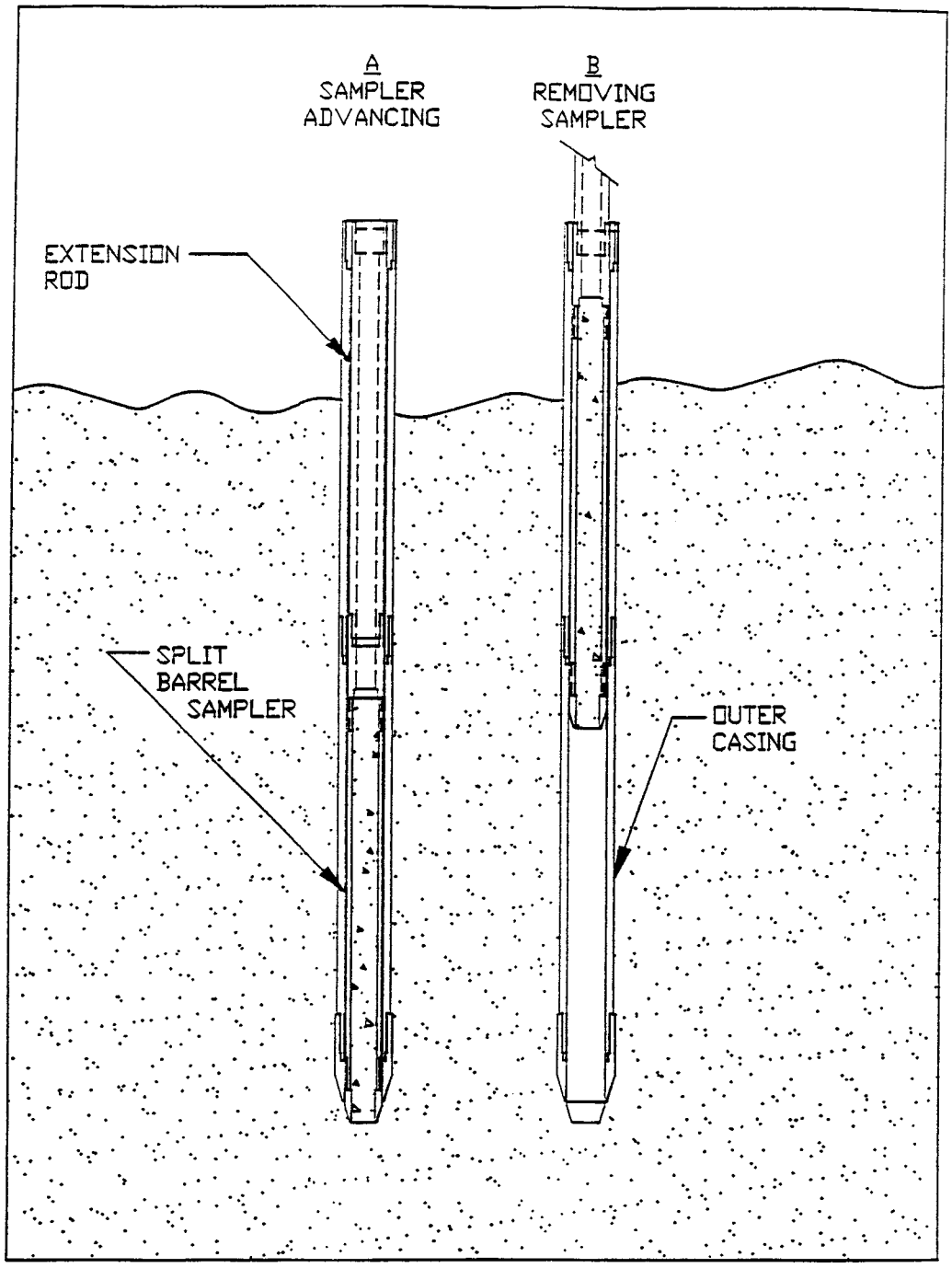

FIG. 1 Split Spoon Sampling, Two Tube System

should allow the passage of softer soils. Stiff retainers can reduce specimen recovery in soft soils.

7.3.2 *Solid Barrel Samplers*:

7.3.2.1 *Open Solid Barrel Samplers*—Open solid barrel (see Fig. 5) samplers are used with all types of direct push sampling systems. Solid barrels can have inside diameters ranging up to 3 in. (76.2 mm). Barrel lengths range from 6 in. (152.4 mm) to 5 ft (1.53 m). Solid barrel samplers may be one piece or segmented. Sample liners should be used to facilitate removal of the sample from the solid barrel. Without the use of liners, samples are extruded mechanically. Liner lengths should fit sampler barrel lengths. Solid barrel samplers are generally assembled with a removable cutting shoe and a drive head (see Fig. 6). The head provides a backing to hold the liner stationary while the sampler is advanced and serves as a connector to the extension/drive rods. The shoe is manufactured to hold the liner stationary during the soil collection procedure. The liner should be slightly larger than the inner diameter of the cutting shoe. It may be slipped over the cutting shoe (see Fig. 6) or nested inside of the cutting shoe (see Fig. 7). The shoe is manufactured to cut the sample to a slightly undersized diameter allowing it to pass into the sample liner with a minimum of side friction to reduce sample disturbance. The amount of specimen contact with the inside of the shoe should

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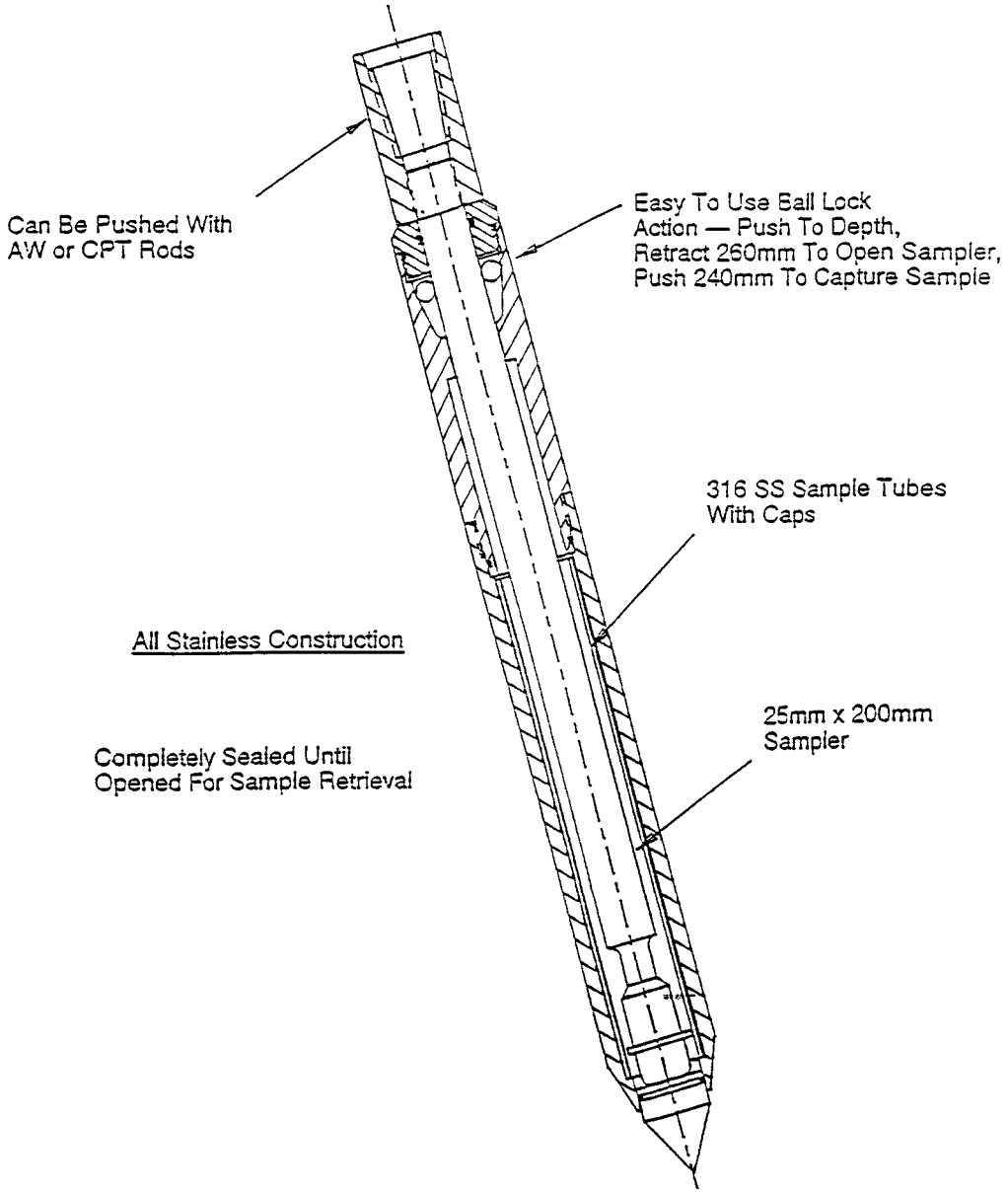

FIG. 2 Sealed Sample Barrel, Single Tube System

be held to the minimum distance possible to aid in achieving the maximum amount of recovery.

7.3.3 *Closed Barrel Sampler*—Closed barrel samplers (see Figs. 2 and 3, Figs. 5-8) are devices, which remain sealed shut until an action is taken to open the sample receiving chamber. These samplers are used most often for single events (discrete point sampling) where a sealed sampler is required to avoid cross contamination or in circumstances where borehole wall stability cannot be assured. The shoe sealing device generally is a point designed to allow the continuous flow of soil around and past the sampler until such time as it is removed or released. The piston point can be fitted with seals, such as "O" rings at top and bottom to hold fluid out until sampling the desired interval. The piston rod extends through the sample retaining liner and must be released or removed for the soil to enter (see Fig. 3, Fig. 5, Fig. 7). The piston can be removed manually before sampling or be displaced by the soil entering the sampler chamber. Using the displacement method can result in reduced recovery if sampled soils do not have sufficient strength to displace the piston. Pistons are locked in place by several methods, such as a spring loaded latch. The latch holds several balls (see Fig. 2, Fig. 7, Fig. 8) into a groove in the latch coupling. When the latch is released by lifting up on the latch stem, the balls slip back into the latch chamber allowing the piston to be removed. Another method uses a locking screw. A reverse thread pin (Fig. 3, Fig. 6) is positioned in the sampler head to prevent the piston from being displaced by the soil when advancing the sampler. At the sampling interval, small diameter extension rods are inserted through the sampler extension/drive rods and rotated clockwise to unscrew the locking pin. A third method uses an inflated packer. An inflated packer (see Fig. 9) is attached to the top of the sampler barrel. The sample barrel is lowered into position in the drive casing and the packer inflated. The packer is deflated to release

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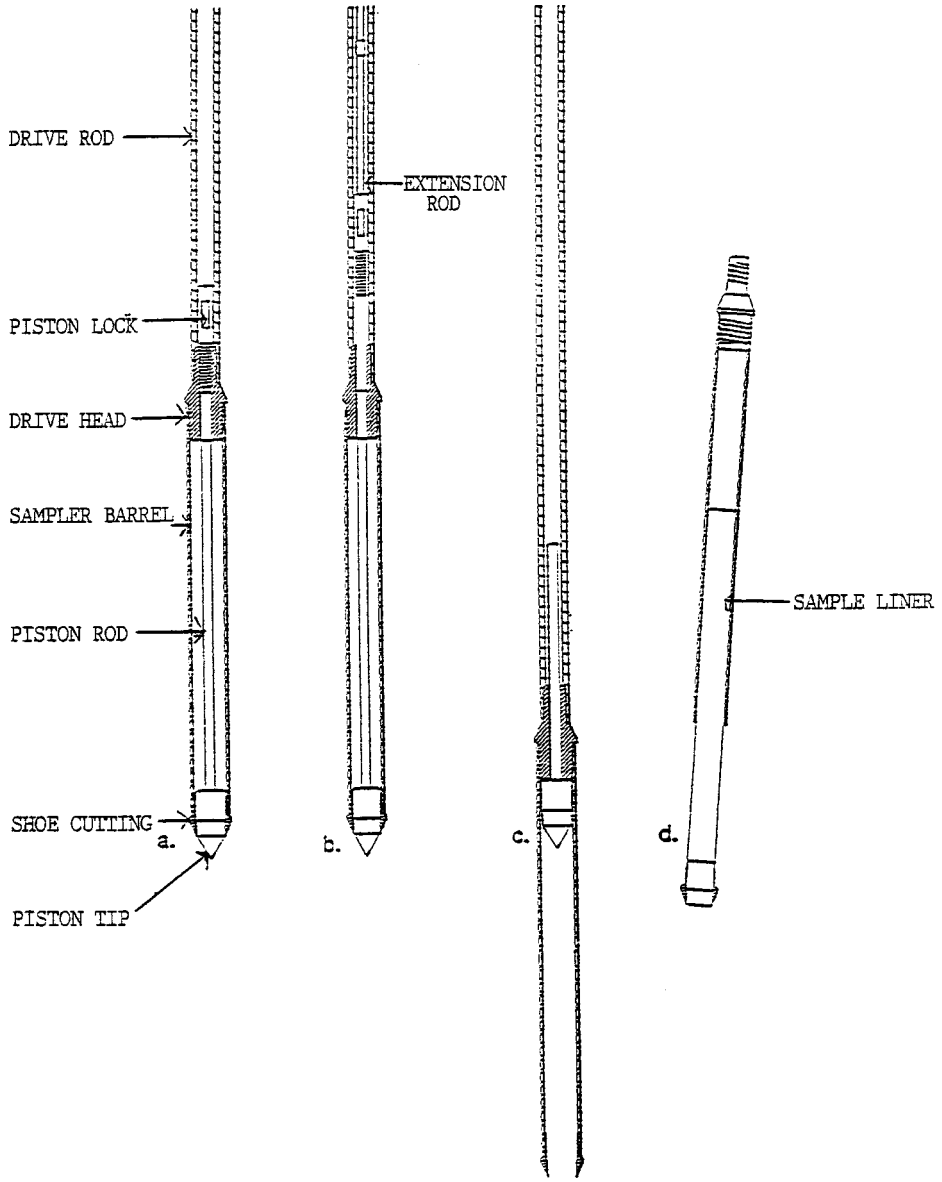

FIG. 3 Driving and Sampling, Single Tube System

(a) Driving the sealed sampler. (b) Removing the stop-pin.
(c) Collecting a sample (d) Recovering sample in liner.

and the sample barrel is recovered after being advanced the sampling interval.

7.3.4 *Thin Wall Tube*—A 1.0-in. (25.4-mm) diameter thin wall tube (see Fig. 10) is available for use with direct push equipment and is manufactured according to Practice D 1587. Thin wall tubes can be effective when used with dual tube direct push systems as the borehole must be kept clear of disturbed soil prior to gathering a sample. Thin wall tubes may be effective in cohesive soils with single tube systems when the borehole can be kept clear of disturbed soil. Thin wall tubes must have an outside diameter that will allow passage through the outer casing. The thin wall tube can be operated in accordance with Practice D 1587, or it can be advanced using the percussion hammer of the direct push equipment. The primary use of the thin wall tube is to gather relatively undisturbed samples in cohesive soils. Sealing of thin wall tube ends should be completed in accordance with Practice D 4220. Fixed piston apparatus (see Fig. 10) also is available for use with thin walled tubes. The fixed piston action allows the sampling of very soft formations, which may not be retained in conventional samplers. In certain soil formations, the thin wall tube provides the best method to collect an undisturbed sample.

7.3.5 *Sampler Extension/Drive Rods*—Sampler extension/drive rods are lengths of rod or tube generally constructed of steel to withstand the pushing or percussion forces applied. Extension drive rods are available in various lengths. Rod lengths should be mated with casing and sampling equipment used. Thread types and classes vary between equipment manufacturers. Rod joints can be sealed to prevent fluid intrusion with "O" rings. Teflon™ washers or Teflon™ tape. Because of the percussive effort, joint seals should be checked for each sampling effort. Extension/drive rods should have

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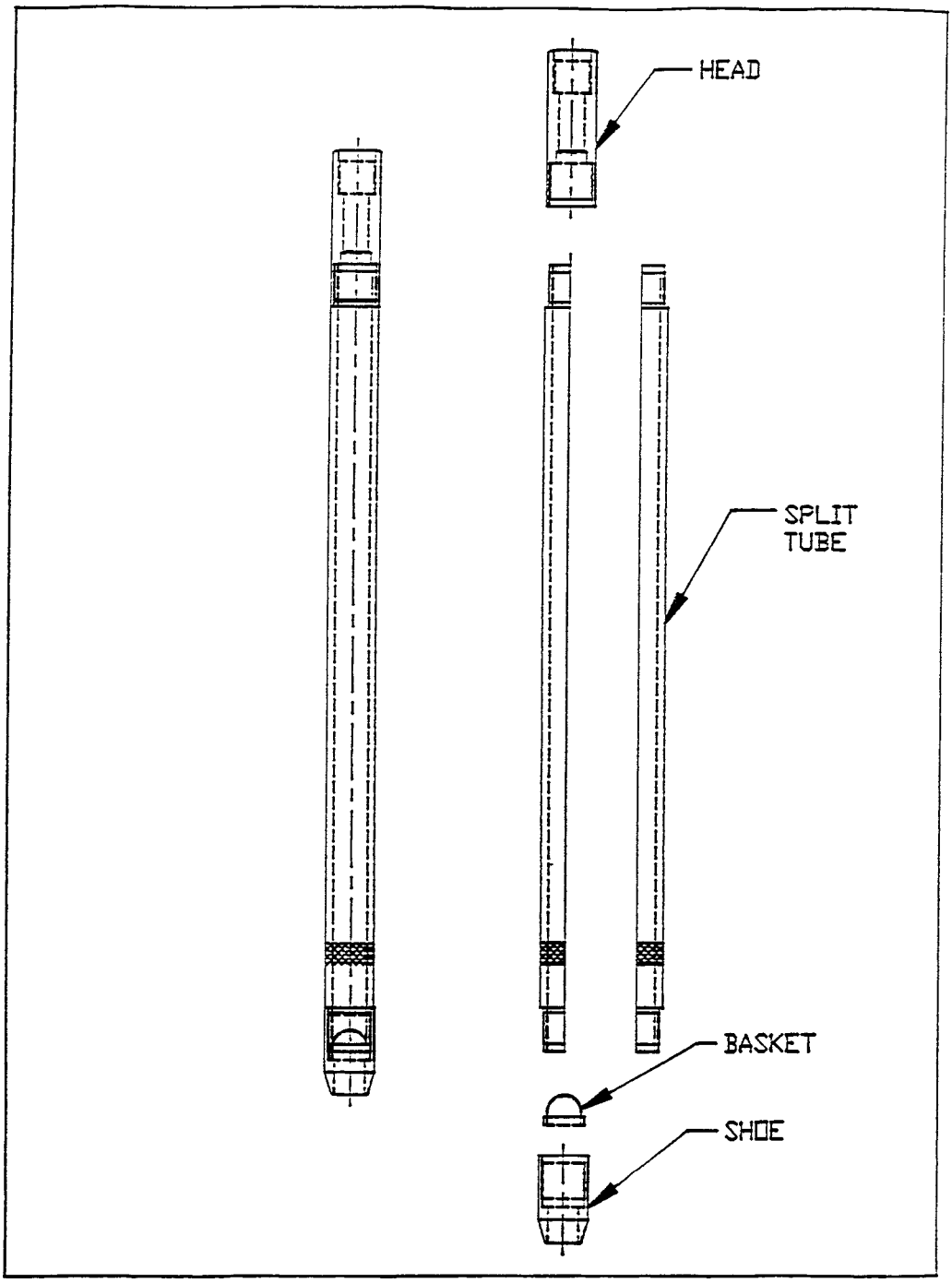

FIG. 4 Split Barrel Sampler, Two Tube System

sufficient inside diameter to accommodate the equipment necessary to perform the desired action.

7.3.6 *Sampler Liners*—Sampler liners are used to collect and store samples for shipment to laboratories, for field index testing of samples and for removing samples from solid barrel type samplers. Liners are available in plastics, Teflon™, brass, and stainless steel. Other materials can be used as testing needs dictate. Liners are available in lengths from 6 in. (152.4 mm) to 5.0 ft (1.53 m). Liner material selection often is based on the chemical composition of liner/soil to minimize sample reaction with liner. Most liner use is short term as samples are subsampled and preserved immediately on site. A general rule for liner selection is stainless steel for organic compounds and plastic for metals. Teflon™ may be required for mixed wastes and for long time storage. Liners should be sealed in accordance with Practice D 4220 when samples are collected for physical testing. Other appropriate procedures must be used when samples are collected for environmental analysis (see Practices D 3694) **(1, 2)**. Liners generally are split in the field for subsampling. Individually split liners are available in some sizes for field use. The liner should have a slightly larger inside diameter than the soil specimen to reduce soil friction and

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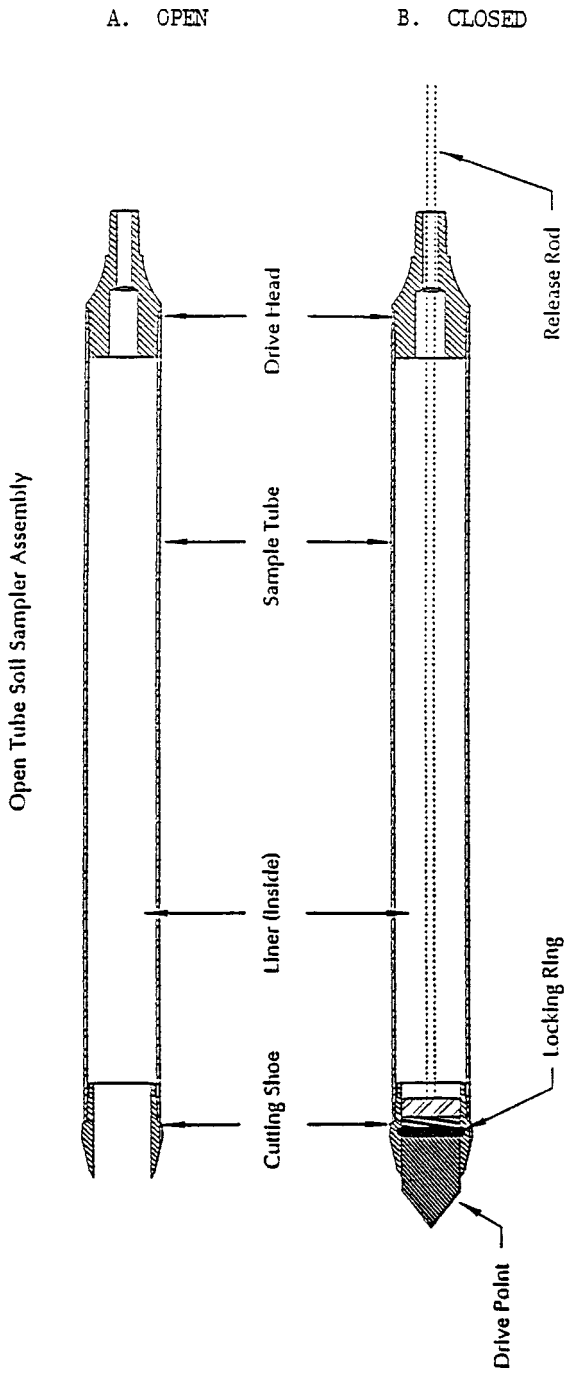

FIG. 5 (A) Open and (B) Closed Piston Sampler Assembly, Single Tube System

enhance recovery. When a slightly oversized liner is used, the potential for air space exists around the sample. Certain chemical samples may be affected by the enclosed air. Liners having less tolerance may be required and a shortened sampled interval used to reduce friction in the liner. Metal liners can be reused after proper cleaning and decontamination. Plastic liners should be disposed of properly after use.

7.3.7 *Sample Containers*—Sample containers should be prescribed according to the anticipated use of the sample specimen. Samples taken for chemical testing may require decontaminated containers with specific preservatives. Practice D 3694 provides information on some of the special containers and preservation techniques required **(1, 2)**. These containers generally will be decontaminated to specific criteria. Samples for geotechnical testing require certain minimum volumes and specific handling techniques. Practice D 4220 offers guidance for sample handling of samples submitted for physical testing.

7.4 *Direct Push Power Sources*—Soil probing percussion driving systems, penetrometer drive systems, and rotary drilling equipment may be used to drive casings and direct push soil sampling devices. The equipment should be capable of applying sufficient static force, or dynamic force, or both, to advance the sampler to the required depth to gather the desired sample. The system must have adequate retraction force to

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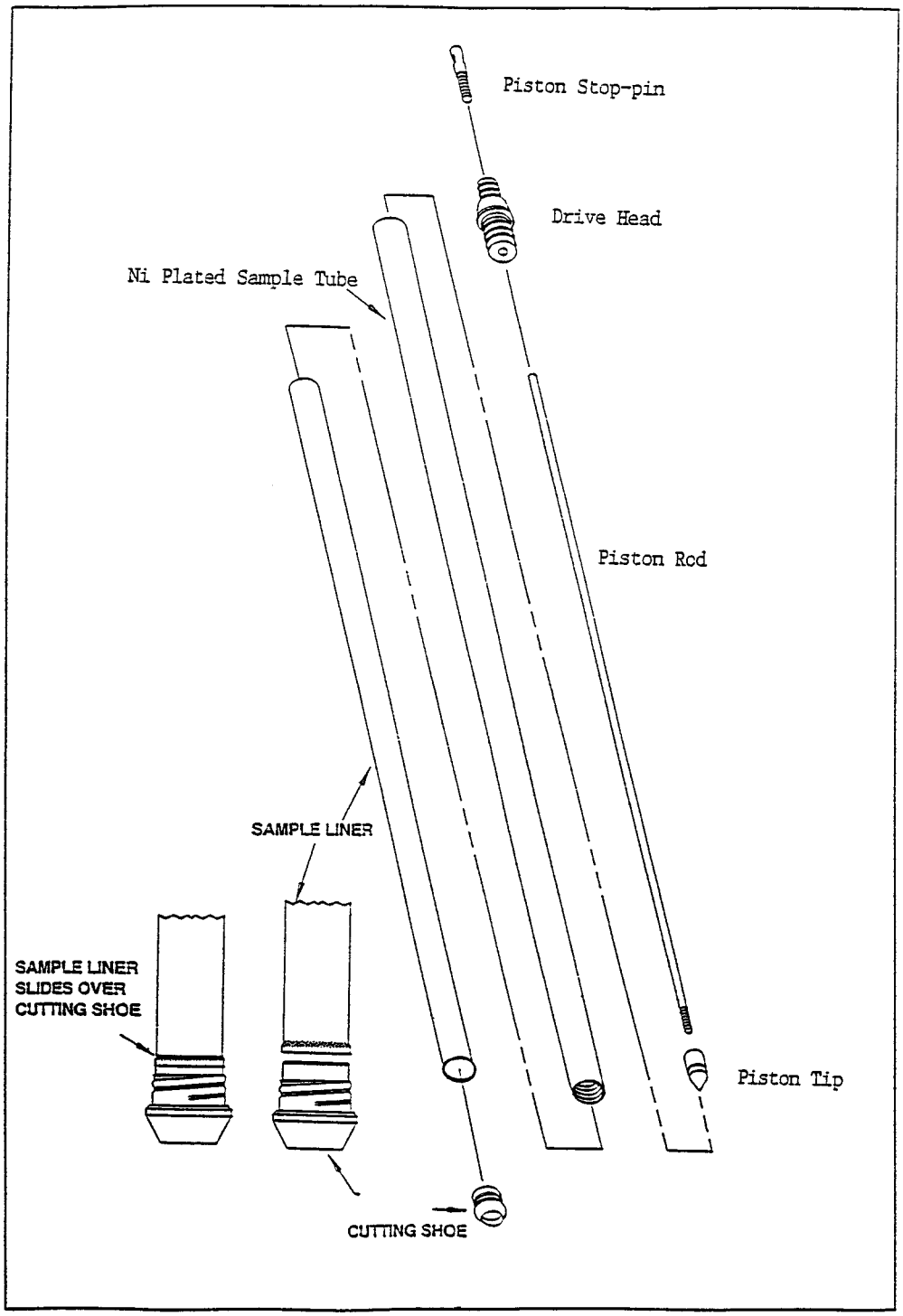

FIG. 6 Sampler Parts, Single Tube System

remove the sampler and extension/drive rods once the selected strata has been penetrated. Rotation of the drill string can be added during insertion, as well as during retraction if the drive system can impart rotation.

7.4.1 *Retraction Force*—The retraction force can be applied by direct mechanical pull back using the hydraulic system of the power source; line pull methods using mechanical or hydraulic powered winches, or cathead and rope windlass type devices. Winches used with direct push technology should have a minimum of 2000 lb (907 kg) top layer rating capacity and a line speed of 400 ft (121.96 m)/min to provide effective tool handling. Direct push sampling tools can be retracted by back pounding using weights similar to those of standard penetration testing practices. Backpounding to recover samples can affect recovery and cause disturbances to the sample. Other forms of extraction, such as jacking, that do not cause undue disturbance to the sample, are preferable.

7.4.2 *Percussion Devices*—Percussion devices for use with

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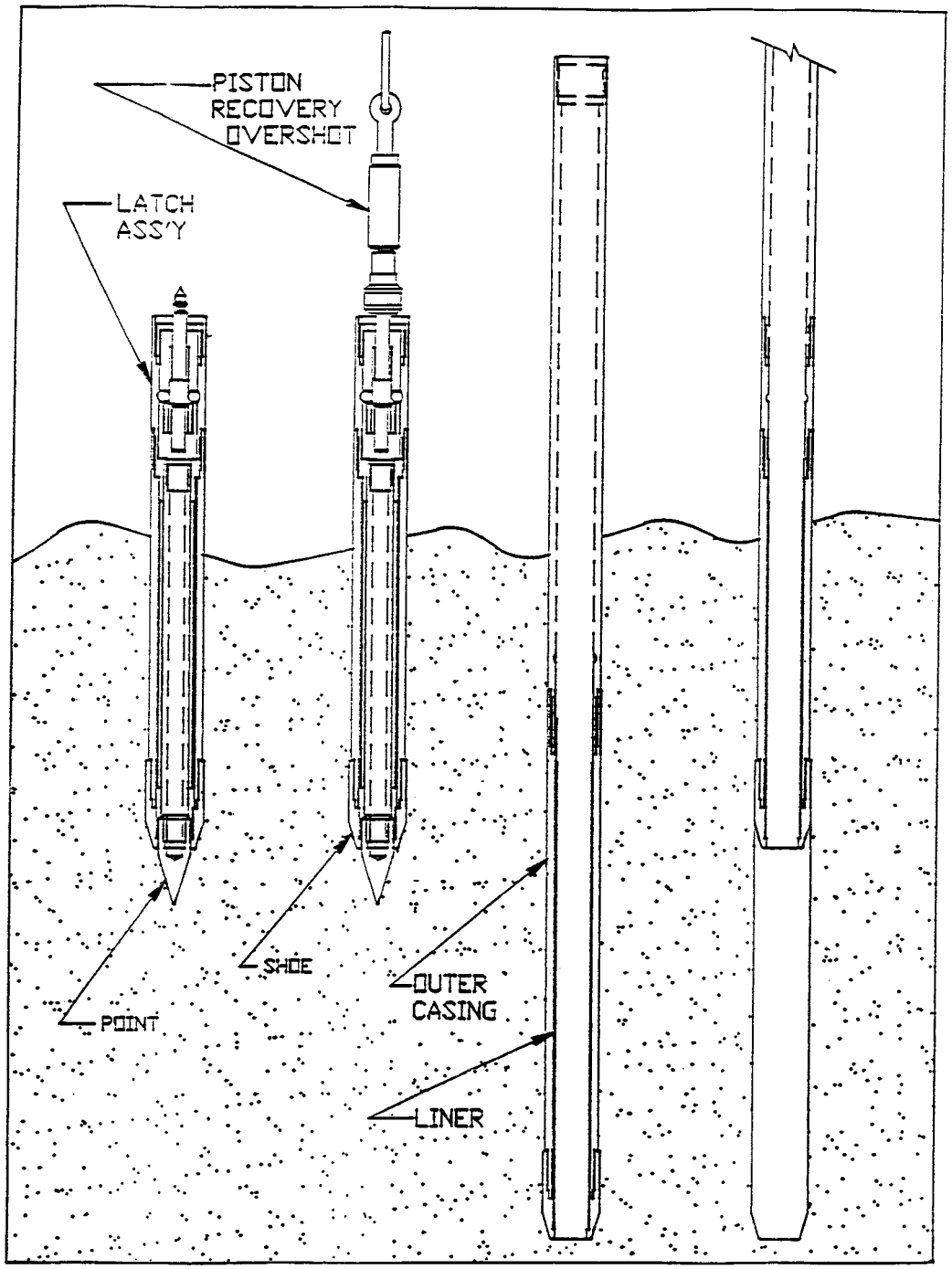

FIG. 7 Closed Solid Barrel Sampler, Single Tube System

direct push methods are hydraulically-operated hammers, air-operated hammers, and mechanically-operated hammers. Hydraulically-operated hammers should have sufficient energy to be effective in moving the samplers through the subsurface strata. The maximum energy application is dependent on the tools used. Hammer energy that exceeds tool tolerance will result in tool damage or loss and will not achieve the goal of collecting high quality samples. Air-operated hammers should be capable of delivering sufficient energy, as well. Hammer systems utilizing hydraulic oil or air should be operated in the range specified by the manufacturer. Manually-operated hammers can be used to advance direct push tools. These hammers can be operated mechanically or manually using cathead and rope. These systems generally involve using 140 lb, standard penetration (see Test Method D 1586) hammers, which can work well for direct push sampling. In operation, these hammers tend to be slower than hydraulic hammers and can cause tool damage if direct push tools are not designed to take the heavy blows associated with these hammers. The hydraulic- and air-operated hammers strike up to 2000 blows/min. In addition to the energy transferred, the rapid hammer action sets up a vibratory effect, which also aids in penetration.

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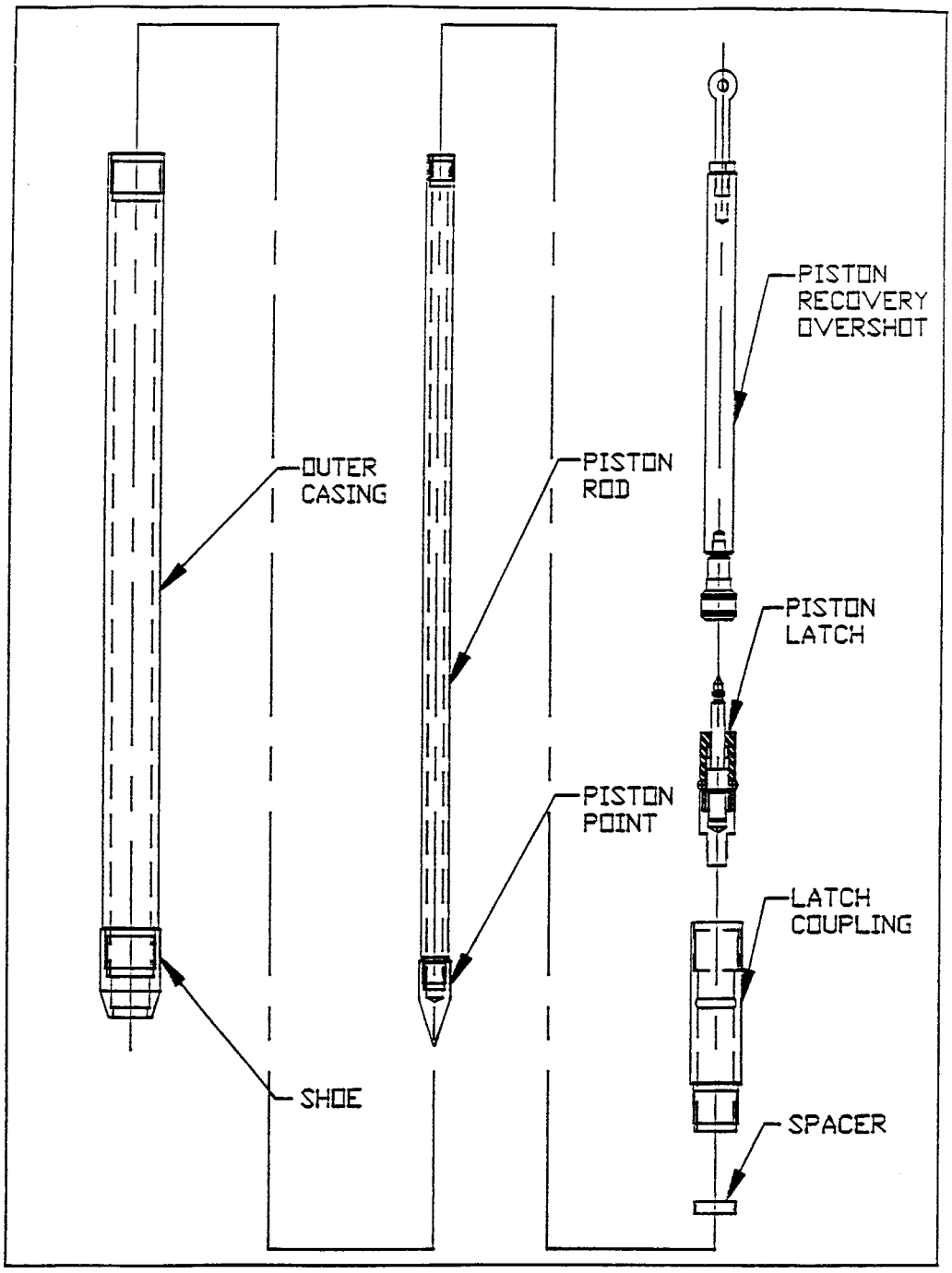

FIG. 8 Closed Solid Barrel Sampler, Single Tube System

This vibratory effect, along with the percussive effort, may disturb some soil samples.

7.4.3 *Static Push Systems*—Cone penetrometer systems are an example of static push systems. They impart energy to the sampler and extension rods by using hydraulic rams to apply pressure. The pressure applied is limited to the reactive weight of the drive vehicle. Retraction of the sampler and extension rods is by static pull from the hydraulic rams.

7.4.4 *Vibratory/Sonic Systems*—These systems utilize a vibratory device, which is attached to the top of the sampler extension rods. Reactive pressure and vibratory action are applied to the sampler extensions moving the sampler into the formation. In certain formations, sample recovery and formation penetration is expedited; however, all formations do not react the same to vibratory penetration methods.

7.4.4.1 *Sonic or Resonance Drilling Systems*—These are high powered vibratory systems that can be effective in advancing large diameter single or dual tube systems. They generally have depth capabilities beyond the smaller direct push systems.

7.4.5 *Rotary Drilling Equipment*—Direct push systems are readily adaptable to rotary drill units. The drill units offer a ready hydraulic system to operate percussion hammers, as well as reactive weight for static push. Because most drills are

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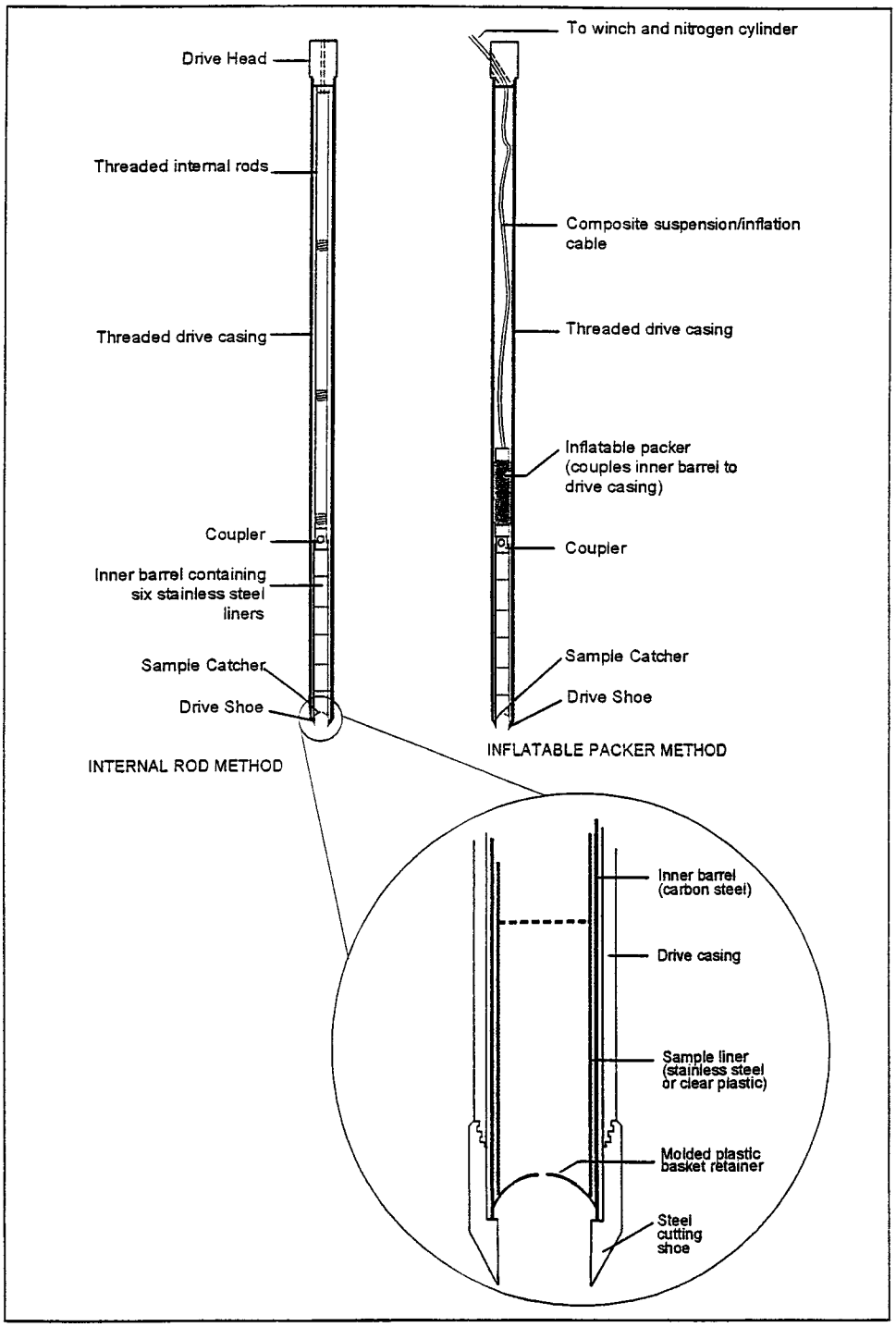

FIG. 9 Sampler Holding Methods, Two Tube System

equipped with leveling jacks, better weight application is achieved. Vertical pushing is improved because of the ability to level the machine. Tool handling is facilitated by high speed winches common to drilling rigs, extended masts for long tool pulls, and longer feed stroke length. Drill units with direct push adaptations also offer drilling techniques should obstacles be encountered while using direct push technology. Large drill units may have reactive weights that can exceed the tool capacity, thereby resulting in damaged tools.

8. Conditioning

8.1 *Decontamination*—Sampling equipment that will contact the soil to be sampled should be cleaned and decontaminated before and after the sampling event. Extension rods should be cleaned prior to each boring to avoid the transfer of contaminants and to ease the connecting of joints. Thread maintenance is necessary to ensure long service life of the tools. Sample liners should be kept in a sealed or clean

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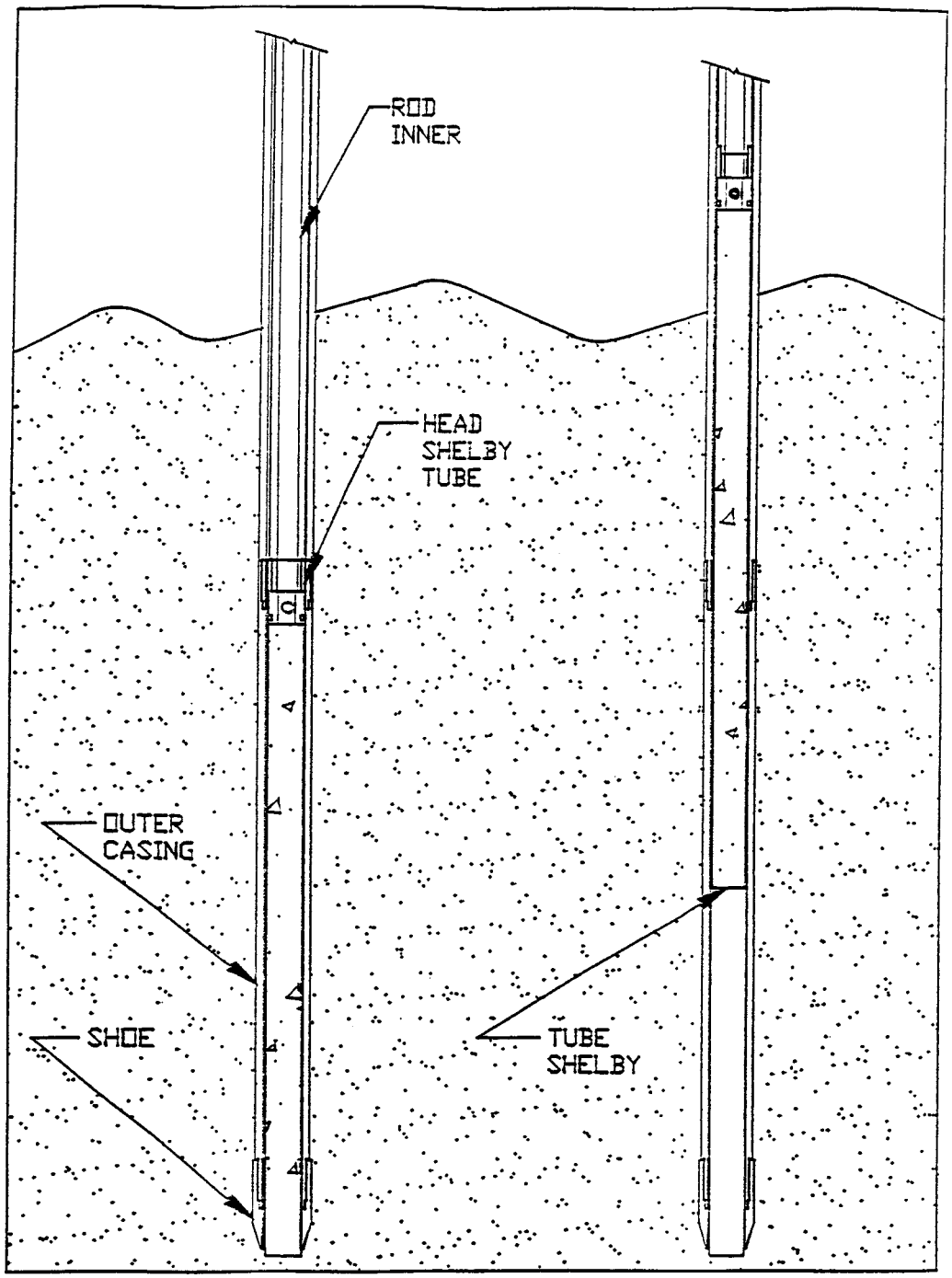

FIG. 10 Thin Wall Tube Sampler, Two Tube System

environment prior to use. Reusable liners should be decontaminated between each use. All ancillary tools used in the sampling process should be cleaned thoroughly, and if contaminants are encountered, decontaminated before leaving the site. It should not be assumed that new tools are clean. They should be cleaned and decontaminated before use. Decontamination should be performed following procedures outlined in Practice D 5088 along with any site safety plans, sampling protocols, or regulatory requirements.

8.2 *Tool Selection*—Prior to dispatch to the project site an inventory of the necessary sampling tools should be made. Sample liners, containers, sampling tools, and ancillary equipment should be checked to ensure its proper operation for the work program prescribed. Sampling is expedited by having two or more samplers on site. Since samples can be recovered quite fast, a supply of samplers will allow a boring to be completed so other functions can be performed while samples are being processed. A backup tool system adaptable to and within the capabilities of the power source should be available should the original planned method prove unworkable. Materials for proper sealing of boreholes should always be available at the site **(5-7)**.

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9. Procedure

9.1 While procedures for direct push soil sampling with two common direct push methods are outlined here, other systems may be available. As long as the basic principles of practice relating to sampler construction and use are followed, other systems may be acceptable.

9.2 *General Set-Up*—Select the boring location and check for underground and overhead utilities and other site obstructions. Establish a reference point on the site for datum measurements, and set the direct push unit over the boring location. Stabilize and level the unit, raise the drill mast or frame into the drilling position, and attach the hammer assembly to the drill head if not permanently attached. Attach the anvil assembly in the prescribed manner, slide the direct push unit into position over the borehole, save a portion of the sliding distance for alignment during tool advancement, and ready the tools for insertion.

9.2.1 *Tool Preparation*—Inspect the direct push tools before using, and clean and decontaminate as necessary. Inspect drive shoes for damaged cutting edges, dents, or thread failures as these conditions can cause loss of sample recovery and slow the advancement rate. Where permissible, lubricate rod joints with appropriate safe products, and check impact surfaces for cracks or other damage that could result in failure during operations. Assemble samples and install where required, install sample retainers where needed, and install and secure sampler pistons to ensure proper operation where needed.

9.2.2 *Sample Processing*—Sample processing should follow a standard procedure to ensure quality control procedures are completed. View sample in the original sampling device, if possible. Open the sampling device with care to keep disturbance to a minimum. When using liners or thin wall tubes, protect ends to prevent samples from falling out or being disturbed by movement within the liner. Measure recovery accurately, containerize as specified in the work plan or applicable ASTM procedures, and label recovered samples with sufficient information for proper identification. When collecting samples for volatile chemical analysis, sample specimens must be contained and preserved as soon as possible to prevent loss of these components. Follow work plan instructions or other appropriate documents (see Practice D 3694) when processing samples collected for chemical analysis.

9.3 *Two Tube System*:

9.3.1 *Split Barrel Sampling (see Fig. 1)*—Assemble the outer casing with the drive shoe on the bottom, attach the drive head to the top of the outer casing, and attach the sampler to the extension rods. Connect the drive head to the top of the sampler extension rods, and insert the sampler assembly into the outer casing. The sampler cutting shoe should contact the soil ahead of the outer casing to prevent unnecessary sample disturbance. The split spoon cutting shoe should extend a minimum of 0.25 in. (6.25 mm) ahead of the outer casing. Greater extensions may improve recovery in soft formations. Mark the outer casing to designate the required drive length, position the outer casing and sampler assembly under the drill head, and move the drill head downward to bring pressure on the tool string. If soil conditions allow, advance the sampler/casing assembly into the soil at a steady rate slow enough to allow the soil to be cut by the shoe and move up inside the sample barrel. If advancement is too rapid, it can result in loss of recovery because of soil friction in the shoe. Occasional hammer action during the push may help recovery by agitating the sample surface. If soil conditions prevent smooth static push advancement, activate the hammer to advance the sampler. Apply a continuous pressure while hammering to expedite soil penetration. The pressure required is controlled by subsurface conditions. Applications of excessive down pressure may result in the direct push unit being shifted off the borehole causing misalignment with possible tool damage. Stop the hammer at completion of advancement of the measured sampling barrel length. Release the pressure and move the drill head off the drive head. Attach a pulling device to the extension rods or position the hammer bail and retrieve the sampler from the borehole. At the surface remove the sampler from the extension rods and process. Soil classification is accomplished easily using split barrel samplers as the specimen is available readily for viewing, physical inspection and subsampling when the barrel is opened. Clean, decontaminate, and reassemble the sampler. Reattach the sampler to the extension rod, add the necessary extension rod and outer casing to reach the next sampling interval, and sound the borehole for free water before each sample interval. If water is present, it may be necessary to change sampling tools. Unequal pressure inside the casing may result in blow-in of material disturbing the soil immediately below the casing. Lower the sampler to its proper position, add the drive heads, and repeat the procedure. If it is desired that the pass through certain strata without sampling, install an extension rod point in lieu of the sampler. When the sampling interval is reached, remove the point and install the sampler. Advance the sampler as described. Upon completion of the borehole, remove the outer casing after instrumentation has been set or as the borehole is sealed as described in Section 10 **(6)**.

9.3.2 *Two Tube System—Other Samplers*:

9.3.2.1 *Thin Wall Tubes*—Thin wall tubes (see Fig. 10) can be used with the dual tube system. Attach the tube to the tube head using removable screws. Attach the tube assembly to the extension rods and position at the base of the outer casing shoe protruding a minimum of 0.25 in. (6.25 mm) to contact the soil ahead of the outer casing. Advance the tube, with or without the outer casing, at a steady rate similar to the requirements of Practice D 1587. At completion of the advancement interval, let the tube remain stationary for 1 min. Rotate the tube slowly two revolutions to shear off the sample. Remove the tube from the borehole, measure recovery, and classify soil. The thin wall tube can be field extruded for on-site analysis or sealed in accordance with Practice D 4220 and sent to the laboratory for processing. Samples for environmental testing generally require the subsampling and preservation of samples in controlled containers. Soil samples generally are removed from the sampling device for storage and shipping. Thin wall tubes should be cleaned and decontaminated before and after use.

9.3.2.2 *Thin Wall Tube Piston Sampler (see Fig. 11)*—Check the fixed piston sampling equipment for proper operation of the cone clamping assembly and the condition of the

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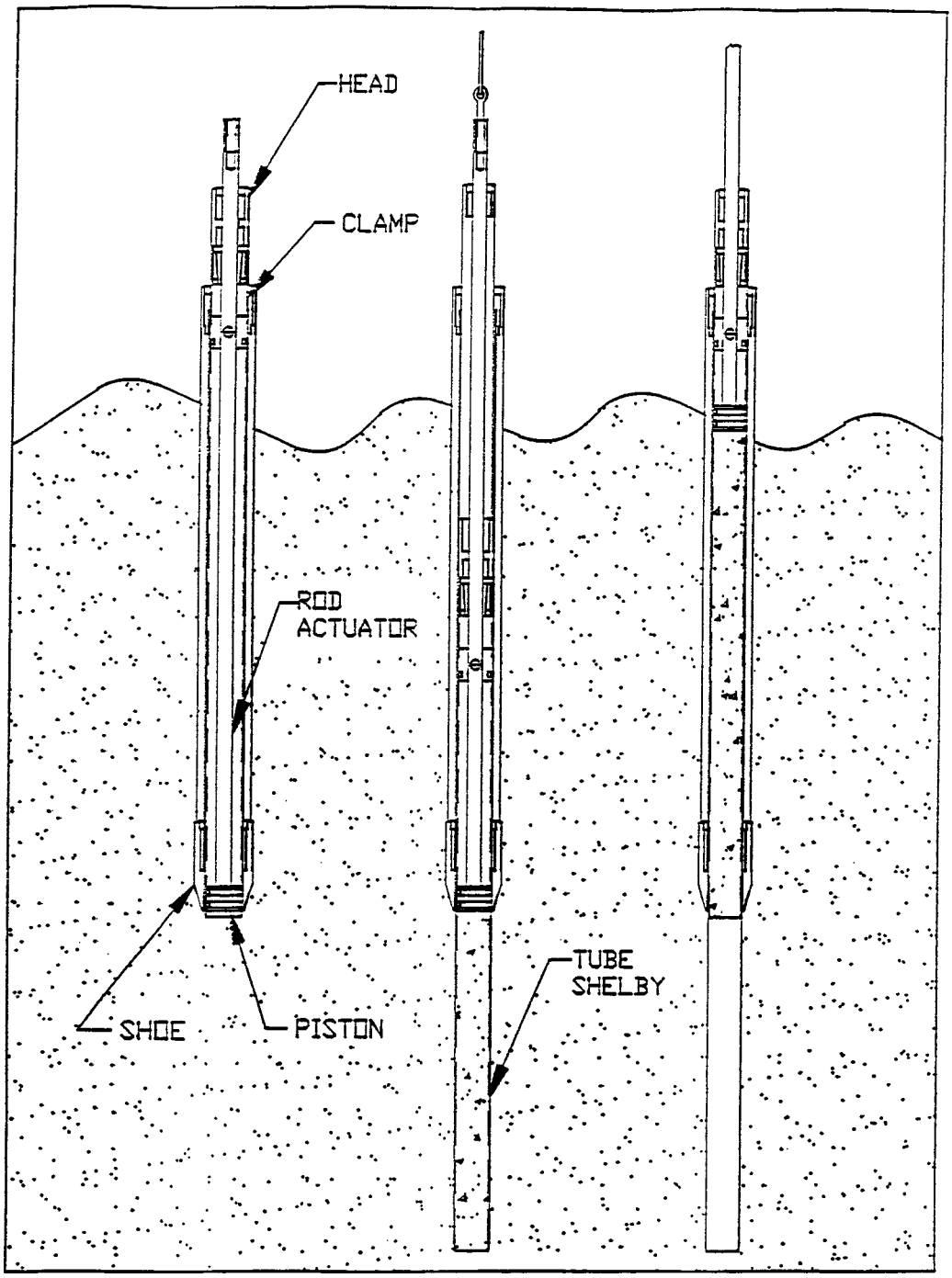

FIG. 11 Fixed Piston Sampler, Two Tube System

sealing "O" rings. Slide the thin wall tube over the piston, and attach it to the tube head. Position the piston at the sharpened end of the thin wall tube just above the sample relief bend. Attach the sampler assembly to the extension rods, and lower the sampler into position through the outer casing. Install the actuator rods through the extension rod, and attach to the actuator rod in the sampler assembly. Attach a holding ring to the top of the actuator rod string, and hook the winch cable or other hook to the holding ring to hold the actuator rods in a fixed position. Attach the pushing fork to the drill head/probe hammer, and slowly apply downward pressure to the extension rods advancing the thin wall tube over the fixed piston into the soil for the sample increment. Rest sampler 1 min to allow sample to conform to tube. Rotate tube one revolution to shear off sample. Remove sampler assembly from borehole and process sample **(6)**.

9.3.2.3 *Open Solid Barrel Samplers*—Use solid barrel samplers in advance of the outer casing where the soil conditions could cause swelling of split barrel samplers, or where friction against the outer casing precludes its advancement and sampling must still be accomplished. The solid, single, or segmented barrel sampler requires the use of liners for removal of

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the sample. The sampler must be cleaned and decontaminated before use. Use of the sampler follows the procedure described in 9.3.1.

9.4 *Single Tube System*:

9.4.1 *Open Solid Barrel Sampler (see Figs. 5 and 6)*—Attached the required liner to the cutting shoe by insertion into the machined receptacle area or by sliding over the machined tube. Insert the liner and shoe into the solid barrel, and attach the shoe **(6, 8-11)**. Attach the sampler head to the sampler barrel providing a backing plate for the liner. Attach the sampler assembly to the drive rod and the drive head to the drive rod. Position the assembly under the hammer anvil and advanced as described in 9.3.1. At completion of the sampling increment, remove the sampler from the borehole. Remove the filled sample liner from the barrel by unscrewing the shoe, cap the liner for laboratory testing or spit open for field processing, and advance the borehole by repeating the procedure. Because the solid barrel cannot be opened for cleaning, it may require more effort for cleaning and decontamination. The open solid barrel sampler is used in soil formations that have sufficient wall strength to maintain a borehole wall without sloughing or cave-in. In soil formations not affording such structure, other sampling methods may be required or the opening sealed. To enhance recovery in some soil strata, it may be necessary to vary the length of the sampling increment. Shorter increments generally improve recovery because of lower sample friction and compression inside the sampler chamber. Sample recovery can be enhanced in some formations by intermittent use of the percussion hammer **(6, 8, 10, 11)**.

9.4.2 *Closed Solid Barrel Sampler (see Figs. 5-7, Fig. 11)*—Insert or attach the sample liner to the shoe, and insert the assembly into the solid barrel sampler. Install sample retaining basket if desired. Attach the latch coupling or sampler head to the sampler barrel, and attach the piston assembly with point and“ O” rings if free water is present, to the latching mechanism or holder. Insert the piston or packer into the liner to its proper position so the point leads the sampler shoe. Set latch, charge packer, or install locking pin, and attach assembled sampler to drive rod. Add drive head and position under the hammer anvil. Apply down pressure, hammer if needed, to penetrate soil strata above the sampling zone. When the sampling zone is reached, insert the piston latch release and recovery tool, removing the piston, or insert the locking pin removal/extension rods through the drive rods, turn counterclockwise, and remove the piston locking pin so the piston can float on top of the sample, or release any other piston holding device. Direct push or activate the hammer to advance the sampler the desired increment. Retrieve the sampler from the borehole by withdrawing the extension/drive rods. Remove the shoe, and withdraw the sample liner with sample for processing. Clean and decontaminate the sampler, reload as described, and repeat the procedure. Extreme stress is applied to the piston when driving through dense soils. If the piston releases prematurely, the sample will not be recovered from the correct interval, and a resample attempt must be made. The piston sampler can be used as a re-entry grouting tool for sealing boreholes on completion if it is equipped with a removable piston **(5, 6, 7, 10, 11)**.

9.4.3 *Standard Split Barrel Sampler*—Attach the split spoon to an extension rod or drill rod. Using a mechanical or hydraulic hammer drive the sampler into the soil the desired increment, as long as that increment does not exceed the sampler chamber length. Remove the sampler from the borehole, disassemble, and process sample. Standard split barrel samplers can be used, as long as borehole wall integrity can be maintained and the additional friction can be overcome. If caving or sloughing occurs, the sampler tip should be sealed or other sampling tools used **(9)**.

9.5 *Quality Control*:

9.5.1 *Quality Control*—Quality control measures are necessary to ensure that sample integrity is maintained and that project data quality objectives are accomplished. By following good engineering principles and applying common sense, reliable site characterizations can be accomplished.

9.5.2 *Water Checks*—Water seeping into the direct push casing or connecting rods from contaminated zones may influence testing results. Periodically check for ground water before inserting samplers into borehole or into outer casings in the two tube system. If water is encountered, it may be necessary to switch to the sealed piston type samplers to protect sample integrity. Sealed piston type samples may not always be water tight. Sealing of rod or casing joints can prevent ground water from entering through the joints.

9.5.3 *Datum Points*—Establishment of a good datum reference is essential to providing reliable sample interval depths and elevators. Select datum reference points that are sufficiently protected from the work effort, and that can be located for future reference. Field measurements should be to 0.1 ft (3.05 mm). Measure extension rods as the bore advances to locate sample depth. Mark rods before driving each sample interval to determine accurate measurement of sample recovery and to accurately log borehole depth.

9.5.4 *Sample Recovery*—Sample recovery should be monitored closely and results documented. Poor recovery could indicate a change in sampling method is needed, that improper sampling practices are being conducted, or that sampling tools are incorrect. Sample recovery involves both volume and condition. Poor sample recovery should cause an immediate review of the sampling program.

9.5.5 *Decontamination*—Follow established decontamination procedures. Taking shortcuts may result in erroneous or suspect data.

10. Completion and Sealing

10.1 *Completion*—For boreholes receiving permanent monitoring devices, completion should be in accordance with Practice D 5092, site work plan, or regulatory requirements.

10.2 *Borehole Sealing*—Seal direct push boreholes to minimize preferential pathways for containment migration. Additional information and guidance on borehole sealing can be found in Guide D 6001 and in Guide D 5299. State or local regulations may control both the method and the materials for borehole sealing. Regulations generally direct bottom up borehole sealing as it is the surest and most permanent method for complete sealing. High pressure grouting is available for use with direct push technology for bottom up borehole sealing.

10.2.1 *Sealing by Slurry, Two Tube System*—Sound the

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borehole for free water. If water exists in the casing, place the extension rods, open-ended, to the bottom of the outer casing, as a tremie. Mix the slurry to standard specifications prescribed by regulation or work plan. Pump slurry through the extension/drive rod until it appears at the surface of the outer casing. Remove the extension rods. If no free water exists in the borehole, the slurry can be placed by gravity. Top off the outer casing as it is removed from the borehole.

10.2.1.1 *Slurry Mixes*—Slurry mixes used for slurry grouting of direct push boreholes generally are of lower viscosity because of the small diameter tremie pipes required. Usable mixes are 6 to 8 gal (22.7 to 30.28 L) of water/94-lb (42.64-kg) bag of cement with 5 lb (2.27 kg) of bentonite or 24 to 36 gal (90.84 to 136.28 L) of water to 50 lb (22.68 kg) of bentonite.

10.2.2 *Sealing by Gravity—Two Tube System*—Measure the cased hole to ensure it is open to depth. Slowly add bentonite chips or granular bentonite to fill the casing approximately 2 ft. Withdraw the casing 2 ft and recheck depth. Hydrate the bentonite by adding water. Repeat this procedure as the outer casing is withdrawn. The bentonite must be below the bottom of the casing during hydration. Wetness inside the rods may affect the flow of granular bentonite to the bottom of the casing. Fill the top foot of the borehole with material that is the same as exists in that zone.

10.2.3 *Borehole Sealing Single Tube System*:

10.2.3.1 *Gravity Sealing from Surface*—If the soil strata penetrated has sufficient wall strength to maintain an open hole, then it may be possible to add sealing materials from the surface. Dry bentonite chips or granular bentonite can be placed by gravity. The borehole volume should be determined and the borehole sounded every 10 ft (3 m) to ensure bridging has not occurred. The bentonite should be hydrated by adding approximately 1 pt (0.57 L) of water for each 5 ft of filled borehole. Seal the surface with native material.

10.2.3.2 *Wet Grout Mix Tremie Sealing*—Tremie sealing methods can be used with single tube systems when borehole wall strength is sufficient to maintain an open hole or when extension rods with an expendable point are used to reenter the borehole. The grout pipe should be inserted immediately after the direct push tools are withdrawn or through the annulus of the extension rods that have been reinserted down the borehole for grouting. Care must be taken to not plug the end of the grout pipe. Side discharge grout pipes also can be used to prevent plugging.

10.2.4 *Re-Entry Grouting*—If the borehole walls are not stable, the borehole can be re-entered by static pushing grouting tools, such as an expendable point attached to the extension/drive rods to the bottom of the original borehole. Pump a slurry through the rods as they are withdrawn. High pressure grouting equipment may be beneficial in pumping standard slurry mixes through small diameter gravity pipes. Care must be taken to ensure the original borehole is being sealed.

11. Record Keeping

11.1 *Field Report*—The field report may consist of boring log or a report of the sampling event and a description of the sample. Soil samples can be classified in accordance with Practice D 2488 or other methods as required for the investigation **(12)**. Prepare the log in accordance with standards set in Guide D 5434 listing the parameters required for the field investigation program. List all contaminants identified, instrument readings taken, and comments on sampler advancement. Record any special field tests performed and sample processing procedures beyond those normally used in the defined investigation. Record borehole sealing procedures, materials used, and mix formulas on the boring log. Survey or otherwise locate the boring site to provide a permanent record of its replacement.

11.2 *Backfilling Record*—Record the method of sealing, materials used, and volume of materials placed in each borehole. This information can be added to the field boring log or recorded on a separate abandonment form.

12. Keywords

12.1 decontamination; direct push; ground water; sealing; soil sampling

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Designation: D 6640 – 01

Standard Practice for Collection and Handling of Soils Obtained in Core Barrel Samplers for Environmental Investigations[1]

This standard is issued under the fixed designation D 6640; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval. A superscript epsilon (ε) indicates an editorial change since the last revision or reapproval.

1. Scope

1.1 This practice covers procedures for obtaining soils from core barrel samplers for chemical and physical analysis, with an emphasis on the collection and handling procedures that maintain the representativeness of the chemical contaminants of concern. Core barrel samplers are initially empty (hollow) until they are pushed into the ground to collect and retrieve a cylindrical soil sample with minimal disturbance. The selection of equipment and the sample handling procedures are dependent on the soil properties, the depth of sampling, and the general properties of the chemical contaminants of concern, that is, volatile organic compounds, semi-volatile organic compounds, and inorganic constituents. The sampling procedures described are designed to maintain representative concentrations of the contaminants regardless of their physical state(s), that is, solid, liquid or gas.

1.2 Four general types of core barrel samplers are discussed in this practice: split-barrel, ring-lined barrel, thin-walled tube, and solid-barrel samplers.

1.3 This document does not cover all the core barrel devices that are available for the collection of soil samples.

1.4 The procedures described may or may not be applicable to handling of samples for assessing certain geotechnical properties, for example, soil porosity.

1.5 *This standard does not purport to address all of the safety concerns, if any, associated with its use. It is the responsibility of the user of this standard to establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.*

2. Referenced Documents

2.1 *ASTM Standards:*

D 653 Terminology Relating to Soil, Rock, and Contained Fluids[2]

D 1586 Standard Test Method for Penetration Test and Split-Barrel Sampling of Soils[3]

D 1587 Standard Practice for Thin-Walled Tube Geotechnical Sampling of Soils[3]

D 3550 Standard Practice for Ring-Lined Barrel Sampling of Soils[3]

D 3694 Standard Practices for Preparation of Sample Containers and for Preservation of Organic Constituents[4]

D 4547 Standard Guide for Sampling Waste and Soils for Volatile Organic Compounds[5]

D 4687 Guide for General Planning of Sampling[5]

D 4700 Standard Guide for Soil Sampling from the Vadose Zone[3]

D 5088 Standard Practice for Decontamination of Field Equipment Used at Nonradioactive Waste Sites[3]

D 5784 Standard Guide for Use of Hollow-Stem Augers for Geoenvironmental Exploration and the Installation of Subsurface Water-Quality Monitoring Devices[2]

D 5792 Standard Practice for Generation of Environmental Data Related to Waste Management Activities: Development of Data Quality Objectives[5]

D 5875 Standard Guide for Use of Cable-Tool Drilling and Sampling Methods for Geoenvironmental Exploration and the Installation of Subsurface Water-Quality Monitoring Devices[2]

D 5876 Standard Guide for Use of Direct Rotary Wireline Casing Advancement Drilling Methods for Geoenvironmental Exploration and the Installation of Subsurface Water-Quality Monitoring Devices[2]

D 6051 Standard Guide for Composite Sampling and Field Subsampling for Environmental Waste Management Activities[5]

D 6151 Standard Practice for Using Hollow-Stem Augers for Geotechnical Exploration and Soil Sampling[2]

D 6169 Standard Guide for Selection of Soil and Rock Sampling Used With Drill Rigs for Environmental Investigations[2]

D 6232 Standard Guide for Selection of Sampling Equipment for Waste and Contaminated Media Data Collection Activities[5]

D 6282 Standard Guide for Direct Push Soil Samplings for Environmental Site Characterization[2]

D 6286 Standard Guide for Selection of Drilling Methods

[1] This practice is under the jurisdiction of ASTM Committee D34 on Waste Management and is the direct responsibility of Subcommittee D34.01.03 on Sampling Equipment.

Current edition approved Feb. 10, 2001. Published April 2001.

[2] *Annual Book of ASTM Standards*, Vol 04.09.

[3] *Annual Book of ASTM Standards*, Vol 04.08.

[4] *Annual Book of ASTM Standards*, Vol 11.02.

[5] *Annual Book of ASTM Standards*, Vol 11.04.

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for Environmental Site Characterization[2]

3. Summary of Practice

3.1 Obtaining soil samples from the surface and subsurface for chemical and physical analysis often involves the advancement of a core barrel sampler into the ground. A core barrel sampler can be operated by hand or mechanically, and it may be of a closed or open design (D 6282). Once the core barrel has been filled, the sampler is recovered from the bore hole and the soil sample is handled appropriately for the chemical constituents of concern.

3.2 This practice describes collection and handling procedures used with four types of core barrel samplers. The standards related to data quality objectives (D 5792), equipment specifications (D 6232, D 6169 and D 4700), their limitations and advantages (D 6282), and the site-specific geological and hydrological data should be reviewed to determine the soil coring equipment that is best suited for a specific project.

4. Significance and Use

4.1 Often during environmental investigations, soils are analyzed after being collected from the surface, the vadose zone (D 653) and sometimes from below the ground water table to identify and quantify the presence of a chemical contaminant. A contaminant is a substance that is typically hazardous and either is not normally present or that occurs naturally but is of an uncharacteristically high concentration (D 4687). A three-dimensional spatial array of samples can often provide information as to the source and route(s) of migration of the contaminant. The resultant information is used to direct remedial and corrective actions or can be used for monitoring purposes. Obtaining a soil sample with a core barrel sampler involves driving this device into the ground and then retrieving it for sample processing. Several methods for advancing a core barrel are generally acceptable (e.g., D 1586, D 1587, D 3550, D 4700, D 5784, D 5875, D 5876, D 6151, D 6282, and D 6286). Drilling methods that use drilling fluids (liquids or air) should be avoided because they are more susceptible to cross-contamination (See section 5.1.6).

5. Equipment Selection Criteria

5.1 Important criteria to consider when selecting a core barrel sampler for soil sampling are:

5.1.1 The materials that come into direct contact with the soil sample (barrel or barrel liner) should be compatible with the chemical or physical properties of the contaminant(s) of concern and the chemical properties of the soil. As a general rule samples obtained for semi-volatile organic compound analysis can be obtained within a core barrel or core barrel liner that is composed of stainless steel, steel, or brass. When only inorganic constituents are of concern, a plastic core barrel liner would be more appropriate than the previously cited materials. All of these materials are suitable for volatile organic compounds as long as the contact time is minimized. Often all of the above samples (semi-volatile organic, inorganic, and volatile organic compounds) are obtained from a single soil core. In this situation, soils should be taken from the interior of the soil core to avoid potential interferences between the contaminants of concern and the surface of the core barrel that is in direct contact with the sample.

5.1.2 The design of the core barrel sampler should allow for easy access to the sampled substrate for all subsequent handling procedures.

5.1.3 Core barrel size requirements depend on the type and number of chemical constituents of concern. For example, more soil is needed for the collection of samples intended for semi-volatile organic compound analysis than for the analysis of volatile organic compounds or inorganic constituents or both. Typically, a 250-mL (8-oz) bottle is filled for the analysis of semi-volatile organic compounds, a 125-mL (4-oz) bottle for inorganic constituents, and only 5-g subsamples are taken for volatile organic compounds.

5.1.4 Sampling depth (see D 6286, for selection of drilling method).

5.1.5 Suitability for soil type, that is, grain size, cohesion properties, and moisture content. For example, when sampling non-cohesive materials or when sampling below the water table, a core catcher (basket) should be used to limit the loss of sample and ground water during retrieval (D 4700 and D 6282).

5.1.6 The spreading of contamination between sampling depths should be minimized. Sealed hollow-barrel samplers (section 6.1.4) or cased bore holes and proper advancement techniques should be used to limit cross-contamination between sampling depths in the vadose zone. Although a cased bore hole does not guarantee that contamination will not be spread from one sampling depth to another, it lowers the possibility and eliminates the potential for bore hole collapse and side wall slough that can compromise the integrity of the samples removed from uncased bore holes. When there is standing ground water in the bore hole, a sealed sampler system should be used.

5.1.7 Site accessibility.

5.1.8 Time constraints.

5.1.9 Appropriate equipment availability.

6. Sampling Equipment

6.1 The types of core barrel samplers discussed in this practice are the split-barrel, ring-lined barrel, thin-walled tube, and solid-barrel samplers. These samplers are part of equipment that is either manually or mechanically powered, are designed to excavate a bore hole to the sampling depth, and may remain in the bore hole during the sample collection activity (i.e., cased bore hole or dual-walled casing).

6.1.1 *Split-Barrel Sampler*—As described in Methods D 1586 and D 4700, the split-barrel sampler is composed of a core barrel cut in half along the length of the barrel, a hardened metal drive shoe (cutting tip) and a sample head that vents (e.g., a ball check valve) to allow air to be displaced as it is filled (see Fig. 1). The shoe and the head thread onto opposite ends of the split barrel and hold the two halves together. A common barrel size is 5.08 cm (2 in.) outside diameter and 3.81 cm (1.5 in.) inside diameter. The drive shoe used with this particular barrel size has an inside diameter of 3.49 cm (1.375 in.). If fitted with a liner for encasing the sample, the inside diameter of the core barrel liner should not be less than the drive shoe. Several other sizes of split-barrel samplers are available, with inside diameters ranging from 2.5 to 10 cm. A

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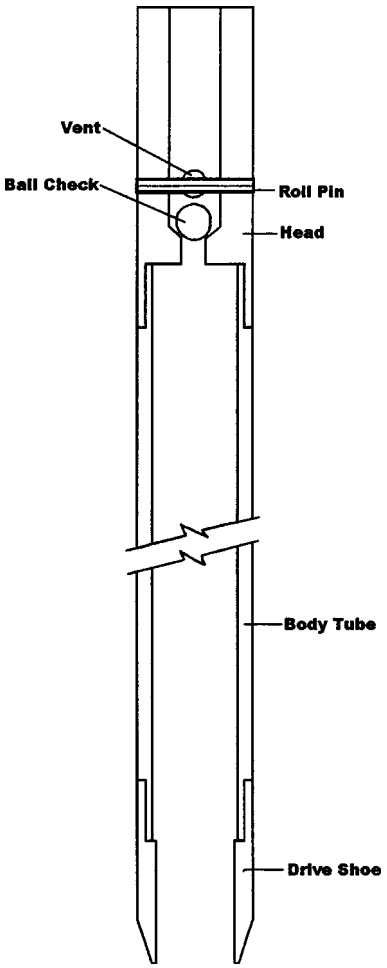

FIG. 1 Split Barrel Sampler

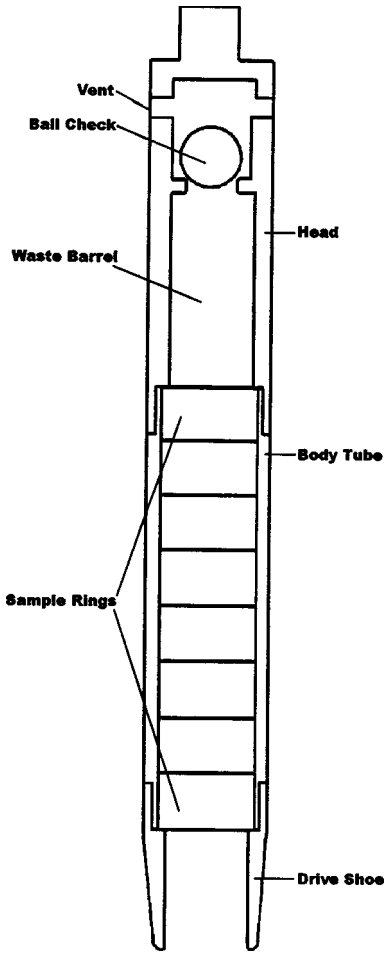

FIG. 2 Ring-Lined Barrel Sampler

core barrel catcher (basket) can be used with this type of sampler to help retain non-cohesive materials. The split-barrel sampler is often used in conjunction with hollow-stem continuous-flight augers or an equivalent drilling or direct-push probe system (D 4700 and D 6282).

6.1.2 *Ring-Lined Barrel Sampler*—As described in Methods D 3550 and D 4700, the ring-lined barrel sampler consists of an intact barrel or two split-barrel halves, a drive shoe, rings, a waste barrel, and a sampler head that vents (e.g., a ball check valve) to allow air to be displaced as it is filled (Fig. 2). The rings, which come in various lengths and are made of several different materials, should fit snugly within the barrel. The inside diameter of the rings should not be less than that of the drive shoe opening. The lengths of the rings will depend on the sampling plan so as to either allow quick access to a cross section of the soil core at a depth of interest or allow the appropriate size sample to be collected (see section 8.1.2). The waste barrel section allows the rings to be filled with undisturbed soil by leaving space to contain the disturbed soil that often is present at the bottom of a hole. A core catcher (basket) can be used with this type of sampler to help retain non-cohesive materials. This sampler is often used in conjunction with hollow-stem continuous flight augers, or an equivalent drilling or direct-push probe system (D 4700 and D 6282).

6.1.3 *Thin-Walled Tube Sampler*—As described in Methods D 1587 and D 4700, the thin-walled tube sampler consists of a core barrel attached to a head (Fig. 3). The head connects to standard drill rods and contains a vent (e.g., a ball check valve) to allow air to be displaced as it is filled. This sampler description is unique to the Shelby tube, which is available with outside diameters of 5.08, 7.62, and 12.70 cm (2, 3, and 5 in.), and a length of approximately 0.91 m (36 in.). In all cases the drive end of the thin-walled tube sampler has a slightly smaller diameter than the inside of the tube. A core barrel catcher (basket) cannot be used with this type of sampler; therefore, non-cohesive materials may be lost during retrieval. These samplers are often used in conjunction with hollow-stem continuous-flight augers or an equivalent drilling or direct-push probe system (D 4700 and D 6282).

6.1.4 *Solid Barrel Sampler*—The solid-barrel sampler is similar in design to the thin-tube sampler, with some important exceptions; the walls are thicker and they often can be equipped with a liner(s) and a core catcher (Method D 6282, see Figs. 4 and 5). Most of the core barrel samplers in D 6282 are designed to be a closed chamber until the depth of interest is reached, then either the entire sampler or an inner barrel is driven to a greater depth, without advancing or after retracting the drive point or piston tip. The open chamber (no drive point or piston tip) sampler design is often used for near-surface sampling equipment (Fig. 5).

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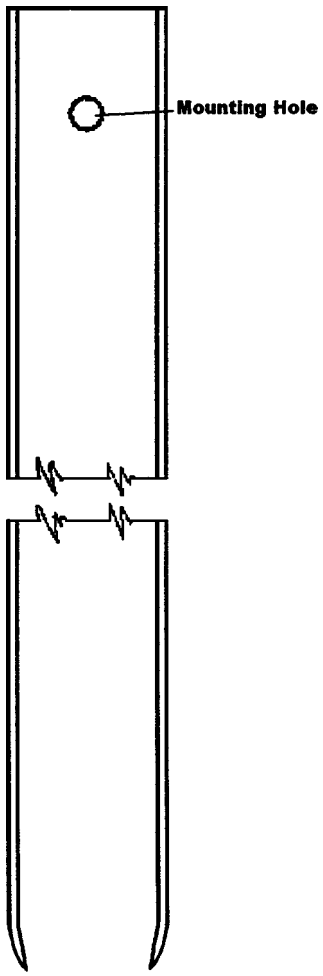

FIG. 3 Thin-Walled Tube Sampler

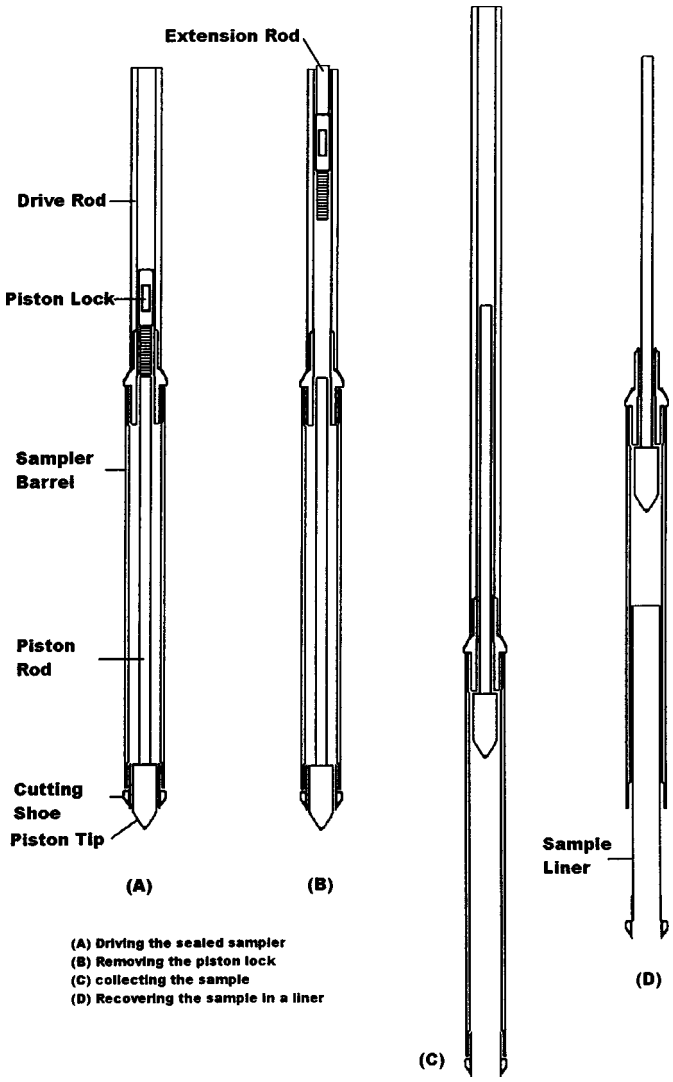

FIG. 4 Direct Push, Single Tube Sampler

7. Pre-Sampling

7.1 The pre-sampling activities are:

7.1.1 Equipment that comes into direct contact with the sample should be steam cleaned, washed with a detergent solution, and rinsed with contaminant-free water, desorbing agents, and deionized water (D 5088). The other pieces of equipment should be either steam-cleaned or washed with a detergent solution and rinsed with contaminant-free water.

7.1.2 The cutting tip or shoe should have a sharp edge. Once dulled, the cutting tip or shoe should be sharpened or replaced.

7.1.3 A work station should be set up for capping the core barrel sampler or when opening to remove subsamples. This work station should consist of a flat clean surface and be set up in a location which provides protection from extreme weather conditions and that is upwind of any local emission sources.

7.1.4 When sampling for volatile organic compounds or when subsampling on-site for constituents that are subject to oxidation or rapid biodegradation, the vessels used for transportation, the on-site sample storage chamber, and the equipment used for obtaining subsamples should be prepared for immediate use. For example, when using an on-site chemical or physical method of sample preservation, it is necessary to perform all of the steps leading up to the transfer of soil subsample from the sampler to the sample container. This may involve adding a solvent or acid solution to a vessel and recording a tared weight or having a chamber available that is capable of maintaining the appropriate refrigeration temperature.

8. Sampling

8.1 *Sampling Method*—A core barrel sampler can be used at the surface or threaded onto extension rods and lowered to the bottom of a cased or uncased bore hole or pushed as a single unit (direct push D 6282) to the depth of interest. The core barrel sampler is then driven into the soil manually or by some mechanical means to a depth that does not exceed the length of the core barrel. The filled sampler is then pulled out as smoothly (minimizing vibration) as possible to retain a maximum amount of soil in the sample chamber. Depending on the chemical and physical characteristics of the contaminants of concern, either the collection of subsamples should be initiated immediately or the sampler or barrel liner(s) should be capped and preserved in preparation for storage and transportation. The core barrel sampler should be handled by personnel wearing a fresh pair of gloves, and if opened on site, this operation should be performed on a clean surface that is positioned upwind of any local emission sources.

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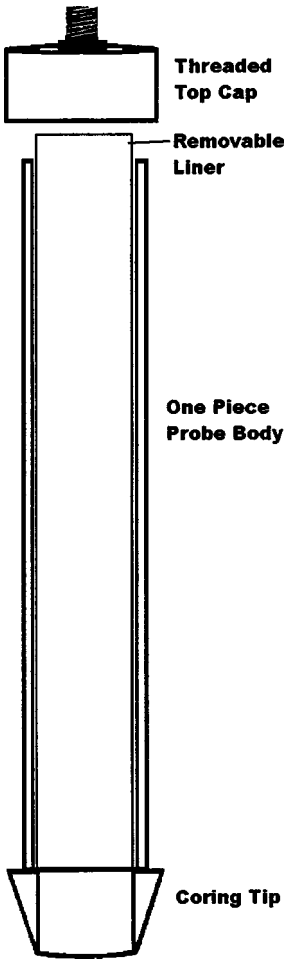

FIG. 5 Open Chamber Sampler

8.1.1 *Sampling for Volatile Organic Compounds*—Volatile organic compounds often simultaneously exist in three physical phases, that is, gas, liquid and solid. In general, the loss of volatile organic compounds from the gas phase presents the greatest challenge to intrusive sampling protocols. To minimize losses of volatile organic compounds, subsurface soils should be retrieved and subsampled as quickly as possible, taking special care to limit exposure and disaggregration of the soil's physical structure. Therefore, the core barrel should not be removed from the borehole until the sampling personnel are prepared, and the collection of subsamples for volatile organic compounds analysis should be the first activity performed (i.e., pre-empting even the logging of core barrel sample recovery and other soil core characteristics) once a core barrel has been opened.

8.1.1.1 When removing the drive shoe or drive head or both, care should be taken not to disaggregate (vibrate) the sample. The ends should be removed using the appropriate wrenches while the sampler is held in a vise. In the case of a split-barrel sampler without a liner, once the two ends (shoe and head, Fig. 1) have been removed, the sample is exposed by removing one half of the barrel. For a ring-lined barrel sampler, after removing the ends the rings should be gently pushed out of the barrel as a single piece, if possible. Once removed, the rings should be separated using a flat-bladed knife to create a flat cross-sectional surface. When a single core barrel liner is used to encase the entire sample and the length sampled is greater than 15 cm (6 in.), a plastic liner should be used. Thin-walled plastic liners can easily be cut open using a hand saw or razor knife to allow access at any location. When a 15-cm or longer metal liner is used, special sampling tools that allow smaller diameter cores of soil to be removed from well within the liner should be used (see D 4547). For all of these samplers, once a fresh soil surface is exposed, the collection of samples for volatile organic compound analysis should be initiated immediately. Subsamples of 5 to 25 g should be obtained with a rigid, thin-walled, small coring tool (D 4547). For example, coring tools for the purpose of transferring a subsample can be made by cutting off the front end of a disposable plastic syringe. These smaller coring tools help to maintain the sample structure during collection and transfer to the sample bottle, as do their larger counterparts, i.e., the core barrel samplers (see sections 6.1.1-6.1.4). A more complete description of the sampling tools, containers, and general procedures that should be used for the collection, handling, and preservation of samples taken for the analysis of volatile organic compounds can be found in D 4547. Lastly, if the surface has been exposed for more than a minute or two because of an unforeseen delay, a fresh surface in the soil core should be created just prior to sampling.

8.1.1.2 For the characterization of volatile organic compounds in soil, the sampling plan should specify the collection of either a discrete subsample (i.e., approximately 5 g of soil, D 4547) or one that is representative of the sampling interval. When a discrete subsample is specified, only a single location in the soil core is sampled for analysis. Typically, the highest reading established by a field-portable instrument capable of continuously measuring the total concentration of detectable volatile organic compounds, in the vapor phase adjacent to the surface of the soil core, is used to select the sampling location. Traditionally, only a single subsample has been taken from a soil core for the analysis of volatile organic compounds because most homogenization techniques fail to maintain representative concentrations for this class of constituents. A sample that is more representative of the concentration of volatile organic compounds over the sampling interval can be obtained by composite sampling (D 6051). For volatile organic compounds this could be performed by placing several (at least 3 per 30 cm [1 ft] of vertical distance, evenly spaced) subsamples into a vessel containing a solvent (D 4547) or by obtaining several subsamples and averaging the concentration for the soil core by either combining extracts when an organic solvent is used for extraction or after performing the analysis of several discrete subsamples.

8.1.1.3 To limit loss of soil gases, small (< 2.5-cm) diameter hollow-barrel samplers (large sample surface area to volume ratio) or ones that require that the sample be extruded from the core barrel (compaction) are not recommended for obtaining soils for volatile organic compound characterization.

8.1.1.4 Core barrel and core barrel liners are not recommended for storage and transportation since sheets of polytetrafluoroethylene or aluminum foil do not serve as a hermetic barrier for volatile organic compounds, sealing waxes readily

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sorb volatile organic compounds, and many adhesives contain volatile organic compounds of interest (D 4547).

8.1.2 *Sampling for Semi-Volatile Organic Compounds and Inorganic Constituents*—When sampling for contaminants that have low vapor pressures and that are not rapidly affected by oxidation or biodegradation, the sample handling does not have to be as careful or as expeditious as for volatile organic compounds. In general the same handling procedures stated above for the different soil core barrel samplers should be used (see section 8.1.1.1). One major difference is that samples can be removed from the core barrel or core barrel liner using a clean stainless steel spatula or similar plastic device, depending on the constituents of concern. However, since many semi-volatile organic compounds are susceptible to biodegradation, they should be preserved if not analyzed immediately. Preservation methods and the preparation of sample containers for many of the compounds that fall under the general classification of organic constituents can be found in D 3694.

8.1.2.1 For the characterization of semi-volatile and inorganic constituents in soil cores, sampling plans often specify that the subsample be representative of the sampling interval. Therefore, sample compositing and mixing schemes should be used prior to removing a representative sample for analysis. D 6051 describes procedures that could be used to homogenize the soil obtained from a core barrel that could either be used in the field or in a laboratory setting prior to removing a subsample for analysis. When oxidation or rapid biodegradation is a concern, practices similar to those cited above (see 8.1.1.2) for handling several discrete or composite samples for the characterization of volatile organic compounds should be used. That is, the entire sampling process should be performed as quickly as possible from the point of filling the core barrel sampler to the point where subsampling is performed. When removing subsamples for chemical analysis, care should be taken to limit exposure to the atmosphere and, if not analyzed immediately, they should be appropriately preserved. If subsampling is performed off-site, the ends of the core barrel or core barrel liner should be sealed with the appropriate materials and the entire soil core preserved by placing it in a refrigerated container.

8.1.2.2 Larger samples are usually collected for the analysis of semi-volatile organic compound than for either volatile organic compounds or inorganic constituents (see section 5.1.3). When sampling plans specify an 240-mL (8-oz; approximately 400-g) bottle be filled to capacity for the collection of a sample for semi-volatile organic compound analysis, a small-diameter (< 2.5-cm) hollow-barrel sampler would not be recommended.

9. Post-Sampling

9.1 The core barrel sampler and metal core barrel liners and the rest of the down-hole equipment should be decontaminated in accordance with D 5088 (see 7.1.1).

9.2 Nonreusable equipment (that is, plastic core barrel liners and baskets) should be disposed of properly.

9.3 The sample handling table should be properly decontaminated between subsampling activities.

10. Keywords

10.1 contaminants; core barrel samplers; split-barrel, ring-lined barrel; subsurface soil sampling; thin-walled tube

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Designation: D 6771 – 02

Standard Practice for Low-Flow Purging and Sampling for Wells and Devices Used for Ground-Water Quality Investigations[1]

This standard is issued under the fixed designation D 6771; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval. A superscript epsilon (ε) indicates an editorial change since the last revision or reapproval.

1. Scope

1.1 This practice covers the method for purging and sampling wells and devices used for ground-water quality investigations and monitoring programs known as low-flow purging and sampling. This method is also known by the terms minimal drawdown purging or low-stress purging. This method could be used for other types of ground-water sampling programs but these uses are not specifically addressed in this practice.

1.2 This practice applies only to wells sampled at the wellhead.

1.3 This practice does not address sampling of wells containing either light or dense non-aqueous-phase liquids (LNAPLs or DNAPLs).

1.4 This practice offers a set of instructions for performing one or more specific operations. This document cannot replace education or experience and should be used in conjunction with professional judgment. Not all aspects of this practice may be applicable in all circumstances. This ASTM standard is not intended to represent or replace the standard of care by which the adequacy of a given professional service must be judged, nor should this document be applied without consideration of a project's many unique aspects. The word "standard" in the title means that the document has been approved through the ASTM consensus process.

1.5 *This standard does not purport to address all of the safety concerns, if any, associated with its use. It is the responsibility of the user of this standard to establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.*

2. Referenced Documents

2.1 *ASTM Standards:*

D 4750 Test Method for Determining Subsurface Liquid Levels in a Borehole or Monitoring Well (Observation Well)[2]

D 5088 Practice for Decontamination of Field Equipment Used at Non-Radioactive Waste Sites[2]

D 5092 Practice for Design and Installation of Ground-Water Monitoring Wells in Aquifers[2]

D 5521 Guide for Development of Ground-Water Monitoring Wells in Granular Aquifers[2]

D 5903 Guide for Planning and Preparing for a Ground-Water Sampling Event[3]

D 6026 Practice for Using Significant Digits in Geotechnical Data[3]

D 6089 Guide for Documenting a Ground-Water Sampling Event[3]

D 6452 Guide for Purging Methods for Wells Used for Ground-Water Quality Investigations[3]

D 6517 Guide for Field Preservation of Ground-Water Samples[3]

D 6564 Guide for Field Filtration of Ground-Water Samples[3]

D 6634 Guide for the Selection of Purging and Sampling Devices for Ground-Water Monitoring Wells[3]

3. Terminology

3.1 *drawdown (low-flow purging and sampling), n*—lowering of the water level in a well caused by pumping the well.

3.2 *entrance velocity, n*—the velocity with which formation pore water passes through a well screen during pumping of the well. This velocity should be controlled (held to less than 0.10 ft/s or 3.0 cm/s) to avoid turbulent flow through the screen and to minimize or eliminate deleterious effects on water chemistry and on well construction materials.

3.3 *low flow, n*—refers to the velocity that is imparted during pumping to the formation pore water adjacent to the well screen. It does not necessarily refer to the flow rate of water discharged by a pump at the surface.

4. Summary of Practice

4.1 Low-flow purging and sampling is a method of collecting samples from a well that, unlike traditional purging methods, does not require the removal of large volumes of water from the well. Low-flow purging differs from traditional methods of purging (as described in Guide D 6452) in that its use is based on the observations of many researchers that water moving through the formation also moves through the well

[1] This practice is under the jurisdiction of ASTM Committee D18 on Soil and Rock and is the direct responsibility of Subcommittee D18.21 on Ground-Water and Vadose Zone Investigations.

Current edition approved Feb. 10, 2002. Published March 2002.

[2] *Annual Book of ASTM Standards*, Vol 04.08.

[3] *Annual Book of ASTM Standards*, Vol 04.09.

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screen. Thus, the water in the screen is representative of the formation water surrounding the screen. This assumes that the well has been properly designed, constructed, and developed as described in Practice D 5092 and Guide D 5521. In wells in which the flow through the screen or intake zone is limited by hydraulic conductivity contrasts (for example, borehole smearing, residual filter cake, filter pack grain size, or well screen open area), the head difference induced by low-flow pumping provides an exchange of water between the formation and the well. Low-flow purging involves removing water directly from the screened interval without disturbing any stagnant water above the screen. This is done by pumping the well at a low enough flow rate to maintain minimal drawdown of the water column within the well as determined through water-level measurement during pumping. The objective is to pump in a manner that minimizes stress to the ground-water system to the extent practical, taking into account site sampling objectives. Pumping at low rates, in effect, hydraulically isolates the column of stagnant water in the well and negates the need for its removal prior to sample collection. Typically, flow rates on the order of 0.1 to 0.5 L/min are used; however, this is dependent on site-specific and well-specific factors **(1)**. Some very coarse textured formations have been successfully purged and sampled in this manner at flow rates up to 1 L/min. Pumping water levels in the well and water-quality indicator parameters (such as pH, temperature, specific conductance, dissolved oxygen and redox potential) should be monitored during pumping, with stabilization indicating that purging is completed and sampling can begin. Because the flow rate used for purging is, in most cases, the same or only slightly higher than the flow rate used for sampling, and because purging and sampling are conducted as one continuous operation in the field, the process is referred to as low-flow purging and sampling.

5. Significance and Use

5.1 The objective of most ground-water sampling programs is to obtain samples that are representative of formation-quality water. Wells used in ground-water quality investigations or monitoring programs are generally purged of some amount of water in an attempt to obtain a representative sample. For traditional methods of purging (for example, well-volume purging), purging is done to minimize bias associated with stagnant water standing in the casing of the well (above the well screen), which generally does not accurately reflect ambient ground-water chemistry. To use low-flow purging and sampling, a pump intake is set within the well screen and the pump is operated at a low flow rate (generally less than or equal to the natural recovery rate of the well), minimizing drawdown in the well and thus hydraulically isolating the water in the screened zone from the water in the casing. Water pumped in this way comes directly from the screened interval of the well. This obviates the need to purge the stagnant water in the well prior to collecting samples. Access to formation-quality water is confirmed by monitoring water quality parameters to the point at which they stabilize as described in Guide D 6452.

5.2 Low-flow purging and sampling may be used in any well that can be pumped at a constant rate of 1.0 L/min or less without continuous drawdown of the water level in the well **(1)**. It is feasible to implement low-flow purging and sampling in wells in which the water level is always above the top of the well screen, and in wells that are constructed so that the water level is always within the well screen.

5.3 Low-flow purging and sampling can be used to collect samples for all categories of aqueous-phase contaminants and naturally occurring analytes, including volatile and semi-volatile organic compounds (VOCs and SVOCs), metals and other inorganics, pesticides, PCBs, other organic compounds, radionuclides and microbiological constituents. It is particularly well suited for use where it is desirable to sample aqueous-phase constituents that may sorb or partition to particulate matter. It is not applicable to sampling either light or dense non-aqueous-phase liquids (LNAPLs or DNAPLs).

6. Benefits and Limitations of Low-Flying Purging and Sampling

6.1 Purging and sampling at a low flow rate offers a number of benefits over traditional methods including:

6.1.1 Improved sample quality and reduced (or eliminated) need for sample filtration, through minimized disturbance of the well and the formation, which results in reduced artifactual sample turbidity and minimization of false positives for analytes associated with particulate matter;

6.1.2 Improved sample accuracy and precision and greatly reduced sample variability as a result of reduced stress on the formation, reduced mixing of the water column in the well and dilution of analytes, and reduced potential for sample agitation, aeration and degassing or volatilization;

6.1.3 Samples represent a smaller section or volume of the formation, representing a significant improvement in the ability to detect and resolve contaminant distributions, which may vary greatly over small distances in three-dimensional space;

6.1.4 Overall, improved sample reproducibility, especially when using dedicated pumps;

6.1.5 Improved ability to directly quantify the total mobile contaminant load (including mobile colloid-sized particulate matter) without the need for sample filtration;

6.1.6 Increased well life through reduced pumping stress on the well and formation, resulting in greatly reduced movement of fine sediment into the filter pack and well screen;

6.1.7 Greatly reduced purge-water volume, (often 90 to 95 %) resulting in significant savings of cost related to purge water handling and disposal or treatment, and reduced exposure of field personnel to potentially contaminated purge water; and

6.1.8 Reduced purging and sampling time (much reduced at sites using dedicated pumps), resulting in savings of labor cost, depending on the time required for water-quality indicator parameters to stabilize.

6.2 Though the application of low-flow purging and sampling will improve sampling results and produce significant technical and cost benefits at most sites, not all sites, and not all individual wells within a site, are well suited to this approach. Limitations of the method include the following:

6.2.1 On a practical basis, low-flow purging and sampling is generally not suitable for use in very low-yield wells (those that will not yield sufficient water without continued drawdown

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with pumping over time). This limitation is largely a function of the limitations of discharge rates of available pumps and the volume of the flow cell (if used) for indicator parameter measurement;

6.2.2 The need to use a variable flow-rate pump capable of pumping within the desired flow-rate range. Low-flow purging cannot be performed using grab sampling devices, such as bailers, or inertial lift devices, which severely agitate the water column in the well, resulting in significant mixing of the water column and release of considerable sediment, which shows up as increased turbidity in samples.

6.2.3 For some applications, the need to use a flow-through cell, which may increase capital costs, lead to slightly greater set-up time in the field, and add one piece of field equipment.

7. Equipment Requirements for Low-Flow Purging and Sampling

7.1 A variety of pumps capable of pumping at low flow rates may be used for low-flow purging and sampling. Continuous discharge and cyclic discharge pumps work equally well as long as the pump has adjustable flow rate controls and is capable of being run at a low enough flow rate to avoid causing continuous drawdown in the well. Because the purging and sampling processes are joined together into one continuous operation, the pump selected (see Guide D 6634) should be appropriate for use both in purging and sampling the analytes of interest. For example, if VOCs or other pressure-sensitive parameters (for example, dissolved oxygen, carbon dioxide, trace metals) are analytes of interest, peristaltic and other suction-lift pumps should be avoided because they may cause loss of VOCs, degassing and redox and pH changes **(2-5)**.

7.2 Dedicated pumps (those that are permanently installed in the well) are preferred over portable pumps because they eliminate disturbance to the water column in the well resulting in lower turbidity values, shorter purge times and lower purge volumes to achieve stabilized indicator parameter measurements. However, portable pumps can be used if care is taken to minimize disturbance to the water column during pump installation and some time is allowed prior to pump operation for any fines agitated in the water column to settle.

7.3 Grab sampling devices, such as bailers and kemmerer samplers, and inertial-lift devices, cannot be used for low-flow purging and sampling because of the disturbance they cause to the water column in the well and the attendant effects of mixing and increased sample turbidity.

7.4 A volume measuring device (for example, graduated cylinder) and a time piece capable of measuring in seconds will be necessary to calculate the flow rate from the discharge tube from the pump.

7.5 Low-flow purging and sampling requires continuous or periodic water-level measurements (see Test Method D 4750). Any water-level measurement equipment that does not disturb the water column in the well may be used, as long as it provides the accuracy required by the sampling program (generally ± 0.01 ft [3 mm]).

7.6 Low-flow purging and sampling requires continuous or periodic measurement of selected water-quality indicator parameters (and, possibly, turbidity) to determine when purging is complete and sampling can commence. Continuous monitoring in a closed flow-through cell of known volume generally provides the most consistent and reliable results, especially for dissolved oxygen and redox potential, and is the preferred method of measuring indicator parameters. However, individual instruments designed to measure the most common water-quality indicator parameters (temperature, pH, and conductivity or specific conductance) may also be used. Dissolved oxygen and redox potential measurements made after the purged water is exposed to atmospheric conditions, however, will not accurately reflect in-situ conditions. All instruments used to measure indicator parameters should be properly calibrated and maintained in accordance with manufacturers' instructions at the well head at the start of each day of sampling and calibration should be checked periodically throughout the sampling event.

7.7 Other equipment and supplies that may be used in low-flow purging and sampling include those items specified by the site-specific sampling and analysis plan (for example, decontamination supplies, sample bottles, filtration media and equipment, preservation supplies, wellhead screening instruments [PID, FID, OVA, combustible gas indicators], sample shipping containers, and field documentation materials [for example, field notebook, field data sheets, chain-of-custody forms, sample bottle labels, shipping documents]).

8. Description of the Procedure

8.1 *General*:

8.1.1 "Low flow" refers to the velocity with which water enters the pump intake and that is imparted during pumping to the formation pore water adjacent to the well screen. This velocity must be minimized to preclude the entrainment of artifactual particulate matter in the water to be collected as a sample. Low-flow does not necessarily refer to the flow rate of water discharged by a pump at the surface, which can be affected by valves, restrictions in the discharge tubing or flow regulators. Some researchers refer to the method as "low-stress" purging, where "low-stress" refers to the impact of pumping the well on the formation. Water-level drawdown provides a measurable indicator of the stress on a given formation imparted by a pumping device operated at a given flow rate. The objective of low-flow purging is to pump in a manner that minimizes stress (drawdown) or disturbance to the ground-water flow system to the extent practical.

8.2 *Preparation for Low-Flow Purging and Sampling*:

8.2.1 Prior to conducting the initial sampling event, the sampling team should prepare themselves and any equipment and materials to be used in the event in accordance with Practice D 5903. Any equipment used in the sampling program that could contact the water in the well, the water collected during field parameter measurement, or the water collected as a sample should be properly cleaned before each use (see Practice D 5088). The clean equipment should not be allowed to contact the ground or other surfaces that could impart contaminants. An effort should be made to closely match the length of the tubing used for portable pumps with the depth at which the pump will be set in the well. Excess tubing can affect the temperature of the water sampled, which could affect sample chemistry (see Guide D 6634). All instrumentation used during low-flow purging and sampling must be properly

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calibrated. Instructions for calibration are specific to the individual instrument and manufacturers' instructions should be followed. The frequency and timing of calibration should be in accordance with the site-specific sampling and analysis plan.

8.3 *Pump Placement*:

8.3.1 In situations where a well is screened or open across a single zone of interest, and that zone is comprised of nearly homogeneous geologic materials, the pump intake should be positioned at or near the mid-point of the well screen. In this type of situation, the water that is withdrawn will likely represent the water quality of the entire screened zone, even at low-flow pumping rates. In situations in which the geology of the screened zone consists of heterogeneous materials with layers of contrasting hydraulic conductivity, the pump intake should be positioned adjacent to the zone of highest hydraulic conductivity (as defined by geologic samples). This provides the preferred flow pathway for ground water, and samples will be drawn primarily from this zone. In situations in which dissolved-phase contaminants of interest are known to concentrate near the top or bottom of the screened zone, it may be desirable to position the pump intake to target this zone.

8.3.2 Care should be taken not to position the pump intake too near the top of the screen in wells in which the water level is above the top of the screen (to avoid drawing in water from storage in the casing), or too near the bottom of the screen (to avoid mobilization and entrainment of settled solids from the bottom of the well). If screen length allows, the pump intake should be at least two feet from the top and two feet from the bottom of the screen.

8.3.3 Portable pumps can be used for low-flow purging and sampling, but the pump must be installed carefully and lowered slowly into the screened zone to minimize disturbance of the water column. Even if done with the utmost care, the installation of a portable pump will result in some mixing of the water column above the well screen with that within the screened interval, and the release of some suspended material. This usually requires pumping for a longer period of time to achieve stabilization of indicator parameters and turbidity. Ideally the pump should remain in place prior to operation until any turbidity resulting from pump installation has settled out and until horizontal flow through the well screen has been reestablished. Carefully lowering the pump intake to the appropriate position in the well screen, then completing preparation of other equipment and materials to be used in the sampling event often allows sufficient time for reduction of initial turbidity to acceptable levels. If, after the pump is started, initial turbidity readings are high (for example, >100 NTU) and reducing the pumping rate does not result in lower readings after a few minutes, it may be necessary to stop the pump and allow turbidity to settle for an hour or more. The time required for turbidity to settle is well-specific and should be determined on a well-by-well basis.

8.4 *Pumping Rate*:

8.4.1 In general, the pumping rate used during low-flow purging and sampling must be low enough to minimize mobilization and entrainment of particulate matter that is not naturally mobile (for example, artifactual particles) under ambient, non-pumping conditions and to minimize hydraulic stress on the well and the formation (for example, to minimize drawdown and to eliminate inclusion of stagnant water from the casing in the sample).

8.4.2 Because each well screen is installed in a hydraulically unique position, and because of differences in the effects that drilling and well development may have had on the borehole and adjacent formation, the hydraulic performance of each well will be different. This means that the pumping rate used for low-flow purging and sampling should be determined on a well-specific basis. It is not appropriate to assess one well in a network of wells and apply the low-flow purging and sampling techniques and rates from that one well to all of the wells in the network. If possible, the optimum pumping rate for each well should be established in advance of the initial sampling event. For newly installed wells, this can be done immediately following well development by running a short-term single well pilot test ideally using the same pump that will be used for low-flow purging and sampling. Once the optimum pumping rate is established for a given well, the same pumping rate can be used for that well for each sampling event, provided well performance does not vary over the life of the well.

8.4.3 To determine the appropriate pumping rate for any given well, the following procedure is recommended. After the pump intake is properly set in the well, the pump should be started at a low pumping rate, generally 100 mL/min or less. For pumps that cannot achieve a flow rate this low, start the pump at the lowest flow rate possible. From the time the pump is started, the water level in the well should be measured (see 8.5) to determine the amount of drawdown caused by pumping. If drawdown is rapid and continuous, the pumping rate should be lowered until drawdown decreases and stabilizes. If drawdown is very slow or imperceptible, the pumping rate may be raised slowly and adjusted to the point at which drawdown stabilizes. The maximum pumping rate used for sampling should not exceed the rate used for purging. Increases in pumping rates may induce increases in turbidity **(6-9)**.

8.5 *Drawdown and Water-Level Measurement*:

8.5.1 Prior to installing a portable pump in the well or prior to the commencement of pumping in wells in which dedicated pumps are installed, an initial water level measurement should be obtained.

8.5.2 Measurement of the water level in the well during purging, on either a continuous or periodic basis, is critical to establishing the optimum flow rate for purging and to determining the stress placed on the well by pumping. The goal is to achieve a stabilized pumping water level as quickly as possible with minimal drawdown. Continuous water-level measurements may be made using devices such as downhole pressure transducers, bubblers or acoustic tools; periodic measurements may be made with electric tapes, poppers or ploppers or other devices as described in Test Method D 4750. Measurement accuracy of the device used should be in accordance with that specified in the sampling and analysis plan (generally ± 0.01 ft [3 mm]). Water-level measurements should be taken every one to two minutes to the point at which the water level in the well has stabilized, or at which drawdown ceases. Pumping rate (see 8.4) may need to be adjusted to allow the water level to stabilize.

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8.5.3 After the water level in the well has stabilized, water-level measurements can be discontinued. Once the optimum pumping rate is established for the well, it may be necessary to periodically monitor the water level during subsequent purging and sampling events, more frequently if a significant difference in well performance (generally signified by an increase in drawdown over time) is noted in subsequent sampling events.

8.5.4 Several researchers have proposed limits on the amount of drawdown that should be allowed before water-level stabilization occurs, but none have provided any scientific rationale for the proposed limits. For example, Puls and Barcelona suggest a limit of less than 0.1 m (0.33 ft or about 4 in.) drawdown for all wells, conceding that this goal may be difficult to achieve under some conditions due to geologic heterogeneities within the screened interval, and may require adjustment based on site-specific conditions and personal experience **(1)**. In practical terms, allowable drawdown should never exceed the distance between the top of the well screen and the pump intake, which is normally positioned near the mid-point of the screen. To provide a safety factor, drawdown should generally not exceed 25 % of this distance to ensure that no water stored in the casing prior to purging is drawn down into the pump intake and collected as part of the sample.

8.6 *Measurement of Water Quality Indicator Parameters and Turbidity*:

8.6.1 Water-quality indicator parameters should be measured to determine when purging is complete and sampling can commence. In wells in which the pump intake is set in the screen and operated at a rate less than the natural recovery rate of the well, stabilized water chemistry indicates that formation-quality water is being pumped and, therefore, that conditions are suitable for sampling **(1)**. The water quality parameters that are most easily measured in the field and that provide evidence that formation-quality water is being provided include: pH, conductivity (or specific conductance), dissolved oxygen and oxidation-reduction potential (redox or ORP, also measured as Eh).

8.6.2 Water-quality indicator parameters can be monitored on either a continuous or periodic basis, though continuous monitoring in a closed flow-through cell provides the most consistent and reliable results, particularly for dissolved oxygen and redox potential. Indicator parameters are considered stable when three consecutive readings made several minutes apart fall within the ranges presented in Table 1.

8.6.3 While the criteria in Table 1 are reasonable criteria for many hydrogeochemical situations, it should be recognized that firm criteria may not be appropriate for other situations because of factors including variability in aquifer properties, monitoring well hydraulics, and natural spatial and temporal variation in ground-water chemistry and contaminant distribution. Therefore, the criteria in Table 1 should be compared to well-specific measurements to determine if the site-specific criteria need to be adjusted. Additionally, these criteria should be evaluated to select those that are most important and relevant to meeting the sampling objectives for the specific site. Not all criteria need to be met for all sites. Stabilization criteria that are too stringent may unnecessarily lead to the generation of large amounts of contaminated purge water without providing the benefit of ensuring that the samples are any more representative.

TABLE 1 Example Criteria for Defining Stabilization of Water-Quality Indicator Parameters

Parameter	Stabilization Criterion
pH	±0.2 pH units[A]
Conductivity	±3 % of reading
Dissolved Oxygen	±10 % of reading or ±0.2 mg/L, whichever is greater[A]
Eh or ORP	±20 mV[A]

[A] Related to the measurement accuracy of commonly available field instruments.

8.6.4 For in-line flow-through cells, the frequency of the measurements should be based on the time required to completely evacuate one volume of the cell, to ensure that independent measurements are made. For example, a 500 mL cell in a system pumped at a rate of 250 mL/min will be evacuated in 2 min so measurements should be made at least 2 min apart. It is important, therefore, that the sampling team establish the following volumes and rates in the field prior to the sampling event: (*1*) Volume of the pump and discharge tubing; (*2*) Optimum pump discharge rate; and (*3*) Volume of the flow-through cell corrected for displacement volume of the field parameter measurement instrumentation installed inside the flow-through cell. It is also important to know the manufacturer's recommendations for the amount of time to allow individual sensors being used to measure field parameters (for example, dissolved oxygen) to stabilize to ensure that representative data are being collected.

8.6.5 For wells in which dedicated pumps are used, chemical indicator parameters tend to stabilize more readily because there is minimal disturbance of the water column in the well. For wells in which portable pumps are used, the effects of pump installation on the water column usually result in the need to remove significantly more water before chemical indicator parameters (and, as noted below, turbidity) reach stabilization.

8.6.6 Though not a chemical parameter, and not indicative of when formation-quality water is being pumped, turbidity may also be a useful parameter to monitor. Turbidity is a physical parameter that provides a measure of the suspended particulate matter in the water being pumped. Turbidity may be most indicative of pumping stress on the formation. Sources of turbidity in monitoring wells can include: (*1*) Naturally occurring colloid-sized or larger solids that may be in transit through the formation; (*2*) Naturally occurring solids or artifactual solids from well drilling and installation (for example, drilling fluids, filter pack, grout) that have not been effectively removed by well development and are mobilized by agitation of the water column (that is, by bailing, by installation of a portable pump, or by overpumping the well); (*3*) Microbial growth that often occurs within monitoring wells in the presence of certain types of contaminants (that is, petroleum hydrocarbons); and (*4*) Precipitation caused by different redox conditions in the well than in the aquifer. Turbidity levels elevated above the natural formation condition can result in biased analytical results for many chemical parameters. Naturally occurring turbidity in some ground water can exceed 10 NTU **(1)** and

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may be unavoidable. Turbidity in a properly designed, constructed and developed well is most often a result of significant disturbance of the water column or excessive stress placed on the formation by overpumping.

8.6.7 To avoid artifacts in sample analysis, turbidity should be as low as possible when samples are collected.[4] Turbidity measurements should be taken at the same time that chemical parameter measurements are made, or, at a minimum, once when pumping is initiated and again just prior to sample collection, after indicator parameters have stabilized. The stabilization criterion for turbidity is ±10 % of the prior reading or ±1.0 NTU, whichever is greater. If turbidity values are persistently high, the pumping rate should be lowered until turbidity decreases. If high turbidity persists even after lowering the pumping rate, the pump may have to be stopped for a period of time until turbidity settles, and the purging process restarted. If this fails to solve the problem, well maintenance or redevelopment may be necessary. Difficulties with high turbidity should be identified during pilot tests prior to implementing low-flow purging or during the initial low-flow sampling event, and contingencies should be established to minimize the problem of elevated turbidity.

8.7 *Sample Collection Following Purging*:

8.7.1 After drawdown and chemical indicator parameters stabilize, sampling can begin per the site's approved sampling and analysis plan. If an in-line flow-through cell is used to continuously monitor chemical indicator parameters, it should be disconnected or bypassed during sample collection. The pumping rate may remain at the established purging rate or it may be adjusted downward to minimize aeration, bubble formation, or turbulent filling of sample bottles. For most parameters, sampling rates of less than 500 mL/min are appropriate **(1)**. Sampling rates for the most sensitive parameters (for example, VOCs) should be lower (generally less than 250 mL/min). Generally, the most sensitive parameters, or those that are of greatest interest at the site, should be sampled first; analyses that require filtration should be sampled last **(1)**. Sample filtration (see Guide D 6564), preservation (see Guide D 6517), handling, shipping and documentation (see Guide D 6089) should be consistent with procedures documented in the approved site-specific sampling and analysis plan.

[4] The primary reason for minimizing turbidity during purging and sampling is that turbidity can affect the aqueous phase concentration of the analytes of interest for both organic and inorganic analytes. The accurate analysis of aqueous-phase inorganic analytes can be affected by stripping of cations, particularly metal species, from the surface of suspended inorganic particulate matter (for example, clays) by the sample preservation process (acidification). The accurate analysis of hydrophobic organic compounds can be affected by the presence of both organic and inorganic particulate matter. In addition, analysis of aqueous-phase organic analytes can be hampered by the physical presence of suspended solids (that is, causing clogging of the nebulizer on the analytical equipment).

9. Reporting

9.1 The procedures and equipment used during low-flow purging and sampling must be documented in the field. Specific guidance on documenting a ground-water sampling event is provided in Guide D 6089. Field data specific to low-flow purging and sampling that should be recorded includes:

9.1.1 Equipment calibration;

9.1.2 Equipment decontamination;

9.1.3 Equipment configuration for purging and sampling;

9.1.4 Pump placement (relative to well screen position and static water level);

9.1.5 Initial static water level;

9.1.6 Initial pumping rate;

9.1.7 Drawdown measurements;

9.1.8 Stabilized pumping water level;

9.1.9 Final pumping rate;

9.1.10 Water quality indicator and turbidity measurements;

9.1.11 Times for all measurements; and

9.1.12 Sampling flow rate.

10. Keywords

10.1 ground water; ground-water monitoring; ground-water quality; ground-water sampling; indicator parameters; low-flow purging; low-stress purging; micropurging; minimal drawdown purging; purging; water quality monitoring

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U.S. ENVIRONMENTAL PROTECTION AGENCY
REGION I

LOW STRESS (low flow) PURGING AND SAMPLING PROCEDURE FOR THE COLLECTION OF GROUND WATER SAMPLES FROM MONITORING WELLS

July 30, 1996
Revision 2

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LOW STRESS (low flow) PURGING AND SAMPLING PROCEDURE FOR THE COLLECTION OF GROUND WATER SAMPLES FROM MONITORING WELLS

I. SCOPE & APPLICATION

This standard operating procedure (SOP) provides a general framework for collecting ground water samples that are indicative of mobile organic and inorganic loads at ambient flow conditions (both the dissolved fraction and the fraction associated with mobile particulates). The SOP emphasizes the need to minimize stress by low water-level drawdowns, and low pumping rates (usually less than 1 liter/min) in order to collect samples with minimal alterations to water chemistry. This SOP is aimed primarily at sampling monitoring wells that can accept a submersible pump and have a screen, or open interval length of 10 feet or less (this is the most common situation). However, this procedure is flexible and can be used in a variety of well construction and ground-water yield situations. Samples thus obtained are suitable for analyses of ground water contaminants (volatile and semi-volatile organic analytes, pesticides, PCBs, metals and other inorganics), or other naturally occurring analytes.

This procedure does not address the collection of samples from wells containing light or dense non-aqueous phase liquids (LNAPLs and DNAPLs). For this the reader may wish to check: Cohen, R.M. and J.W. Mercer, 1993, DNAPL Site Evaluation; C.K. Smoley (CRC Press), Boca Raton, Florida and U.S. Environmental Protection Agency, 1992, RCRA Ground-Water Monitoring: Draft Technical Guidance; Washington, DC (EPA/530-R-93-001).

The screen, or open interval of the monitoring well should be optimally located (both laterally and vertically) to intercept existing contaminant plume(s) or along flowpaths of potential contaminant releases. It is presumed that the analytes of interest move (or potentially move) primarily through the more permeable zones within the screen, or open interval.

Use of trademark names does not imply endorsement by U.S.EPA but is intended only to assist in identification of a specific type of device.

Proper well construction and development cannot be overemphasized, since the use of installation techniques that are appropriate to the hydrogeologic setting often prevents "problem well" situations from occurring. It is also recommended that as part of development or redevelopment the well should be tested to determine the appropriate pumping rate to obtain stabilization of field indicator parameters with minimal drawdown in shortest amount of time. With this information field crews can then conduct purging and sampling in a more expeditious manner.

The mid-point of the saturated screen length (which should not exceed 10 feet) is used by convention as the location of the pump intake. However, significant chemical or permeability contrast(s) within the screen may require additional field work to determine the optimum vertical location(s) for the intake, and appropriate pumping rate(s) for purging and sampling more localized target zone(s). Primary flow zones (high(er) permealability and/or high(er) chemical concentrations) should be identified in wells with screen lengths longer than 10 feet, or in wells with open boreholes in bedrock. Targeting these zones for water sampling will help insure that the low stress procedure will not underestimate contaminant concentrations. The Sampling and Analysis Plan must provide clear instructions on how the pump intake depth(s) will be selected, and reason(s) for the depth(s) selected.

Stabilization of indicator field parameters is used to indicate that conditions are suitable for sampling to begin. Achievement of turbidity levels of less than 5 NTU and stable drawdowns of less than 0.3 feet, while desirable, are not mandatory. Sample collection may still take place provided the remaining criteria in this procedure are met. If after 4 hours of purging indicator field parameters have not stabilized, one of 3 optional courses of action may be taken: a) continue purging until stabilization is achieved, b) discontinue purging, do not collect any samples, and record in log book that stabilization could not be achieved (documentation must describe attempts to achieve stabilization) c) discontinue purging, collect samples and provide full explanation of attempts to achieve stabilization (note: there is a risk that the analytical data obtained, especially metals and strongly hydrophobic organic analytes, may not meet the sampling objectives).

Changes to this SOP should be proposed and discussed when the site Sampling and Analysis Plan is submitted for approval. Subsequent requests for modifications of an approved plan must include adequate technical justification for proposed changes. All changes and modifications must be approved before implementation in field.

II.EQUIPMENT

A. Extraction device

Adjustable rate, submersible pumps are preferred (for example, centrifugal or bladder pump constructed of stainless steel or

Teflon).

Adjustable rate, peristaltic pumps (suction) may be used with caution. Note that EPA guidance states: "Suction pumps are not recommended because they may cause degassing, pH modification, and loss of volatile compounds" (EPA/540/P-87/001, 1987, page 8.5-11).

The use of inertial pumps is discouraged. These devices frequently cause greater disturbance during purging and sampling and are less easily controlled than the pumps listed above. This can lead to sampling results that are adversely affected by purging and sampling operations, and a higher degree of data variability.

B. Tubing

Teflon or Teflon lined polyethylene tubing are preferred when sampling is to include VOCs, SVOCs, pesticides, PCBs and inorganics.

PVC, polypropylene or polyethylene tubing may be used when collecting samples for inorganics analyses. However, these materials should be used with caution when sampling for organics. If these materials are used, the equipment blank (which includes the tubing) data must show that these materials do not add contaminants to the sample.

Stainless steel tubing may be used when sampling for VOCs, SVOCs, pesticides, and PCBs. However, it should be used with caution when sampling for metals.

The use of 1/4 inch or 3/8 inch (inner diameter) tubing is preferred. This will help ensure the tubing remains liquid filled when operating at very low pumping rates.

Pharmaceutical grade (Pharmed) tubing should be used for the section around the rotor head of a peristaltic pump, to minimize gaseous diffusion.

C. Water level measuring device(s), capable of measuring to 0.01 foot accuracy (electronic “tape”, pressure transducer). Recording pressure transducers, mounted above the pump, are especially helpful in tracking water levels during pumping operations, but their use must include check measurements with a water level “tape” at the start and end of each record.

D. Flow measurement supplies (e.g., graduated cylinder and stop watch).

E. Interface probe, if needed.

F. Power source (generator, nitrogen tank, etc.). If a gasoline generator is used, it must be located downwind and at least 30 feet from the well so that the exhaust fumes do not contaminate the samples.

G. Indicator field parameter monitoring instruments - pH, Eh, dissolved oxygen (DO), turbidity, specific conductance, and temperature. Use of a flow-through-cell is required when measuring all listed parameters, except turbidity. Standards to perform field calibration of instruments. Analytical methods are listed in 40 CFR 136, 40 CFR 141, and SW-846. For Eh measurements, follow manufacturer's instructions.

H. Decontamination supplies (for example, non-phosphate detergent, distilled/deionized water, isopropyl alcohol, etc.).

I. Logbook(s), and other forms (for example, well purging forms).

J. Sample Bottles.

K. Sample preservation supplies (as required by the analytical methods).

L. Sample tags or labels.

M. Well construction data, location map, field data from last sampling event.

N. Well keys.

O. Site specific Sample and Analysis Plan/Quality Assurance Project Plan.

P. PID or FID instrument (if appropriate) to detect VOCs for health and safety purposes, and provide qualitative field evaluations.

III.PRELIMINARY SITE ACTIVITIES

Check well for security damage or evidence of tampering, record pertinent observations.

Lay out sheet of clean polyethylene for monitoring and sampling equipment.

Remove well cap and immediately measure VOCs at the rim of the well with a PID or FID instrument and record the reading in the field logbook.

If the well casing does not have a reference point (usually a V-cut or indelible mark in the well casing), make one. Describe its location and record the date of the mark in the logbook.

A synoptic water level measurement round should be performed (in the shortest possible time) before any purging and sampling activities begin. It is recommended that water level depth (to 0.01 ft.) and

total well depth (to 0.1 ft.) be measured the day before, in order to allow for re-settlement of any particulates in the water column. If measurement of total well depth is not made the day before, it should not be measured until after sampling of the well is complete. All measurements must be taken from the established referenced point. Care should be taken to minimize water column disturbance.

Check newly constructed wells for the presence of LNAPLs or DNAPLs before the initial sampling round. If none are encountered, subsequent check measurements with an interface probe are usually not needed unless analytical data or field head space information signal a worsening situation. Note: procedures for collection of LNAPL and DNAPL samples are not addressed in this SOP.

IV. PURGING AND SAMPLING PROCEDURE

Sampling wells in order of increasing chemical concentrations (known or anticipated) is preferred.

1. Install Pump

Lower pump, safety cable, tubing and electrical lines slowly (to minimize disturbance) into the well to the midpoint of the zone to be sampled. The Sampling and Analysis Plan should specify the sampling depth, or provide criteria for selection of intake depth for each well (see Section I). If possible keep the pump intake at least two feet above the bottom of the well, to minimize mobilization of particulates present in the bottom of the well. Collection of turbid free water samples may be especially difficult if there is two feet or less of standing water in the well.

2. Measure Water Level

Before starting pump, measure water level. If recording pressure transducer is used-initialize starting condition.

3. Purge Well

3a. Initial Low Stress Sampling Event

Start the pump at its lowest speed setting and slowly increase the speed until discharge occurs. Check water level. Adjust pump speed until there is little or no water level drawdown (less than 0.3 feet). If the minimal drawdown that can be achieved exceeds 0.3 feet but remains stable, continue purging until indicator field parameters stabilize.

Monitor and record water level and pumping rate every three to five minutes (or as appropriate) during purging. Record any pumping rate adjustments (both time and flow rate). Pumping rates should, as needed, be reduced to the minimum capabilities of the pump (for example, 0.1 - 0.4 l/min) to ensure stabilization of indicator

parameters. Adjustments are best made in the first fifteen minutes of pumping in order to help minimize purging time. During pump start-up, drawdown may exceed the 0.3 feet target and then "recover" as pump flow adjustments are made. Purge volume calculations should utilize stabilized drawdown value, not the initial drawdown. Do not allow the water level to fall to the intake level (if the static water level is above the well screen, avoid lowering the water level into the screen). The final purge volume must be greater than the stabilized drawdown volume plus the extraction tubing volume.

Wells with low recharge rates may require the use of special pumps capable of attaining very low pumping rates (bladder, peristaltic), and/or the use of dedicated equipment. If the recharge rate of the well is lower than extraction rate capabilities of currently manufactured pumps and the well is essentially dewatered during purging, then the well should be sampled as soon as the water level has recovered sufficiently to collect the appropriate volume needed for all anticipated samples (ideally the intake should not be moved during this recovery period). Samples may then be collected even though the indicator field parameters have not stabilized.

3b. Subsequent Low Stress Sampling Events

After synoptic water level measurement round, check intake depth and drawdown information from previous sampling event(s) for each well. Duplicate, to the extent practicable, the intake depth and extraction rate (use final pump dial setting information) from previous event(s). Perform purging operations as above.

4. Monitor Indicator Field Parameters

During well purging, monitor indicator field parameters (turbidity, temperature, specific conductance, pH, Eh, DO) every three to five minutes (or less frequently, if appropriate). Note: during the early phase of purging emphasis should be put on minimizing and stabilizing pumping stress, and recording those adjustments. Purging is considered complete and sampling may begin when all the above indicator field parameters have stabilized. Stabilization is considered to be achieved when three consecutive readings, taken at three (3) to five (5) minute intervals, are within the following limits:

turbidity (10% for values greater than 1 NTU),
DO (10%),
specific conductance (3%),
temperature (3%),
pH (± 0.1 unit),
ORP/Eh (± 10 millivolts).

All measurements, except turbidity, must be obtained using a flow-through-cell. Transparent flow-through-cells are preferred, because they allow field personnel to watch for particulate build-up within the cell. This build-up may affect indicator field parameter values

measured within the cell and may also cause an underestimation of turbidity values measured after the cell. If the cell needs to be cleaned during purging operations, continue pumping and disconnect cell for cleaning, then reconnect after cleaning and continue monitoring activities.

The flow-through-cell must be designed in a way that prevents air bubble entrapment in the cell. When the pump is turned off or cycling on/off (when using a bladder pump), water in the cell must not drain out. Monitoring probes must be submerged in water at all times. If two flow-through-cells are used in series, the one containing the dissolved oxygen probe should come first (this parameter is most susceptible to error if air leaks into the system).

5. Collect Water Samples

Water samples for laboratory analyses must be collected before water has passed through the flow-through-cell (use a by-pass assembly or disconnect cell to obtain sample).

VOC samples should be collected first and directly into pre-preserved sample containers. Fill all sample containers by allowing the pump discharge to flow gently down the inside of the container with minimal turbulence.

During purging and sampling, the tubing should remain filled with water so as to minimize possible changes in water chemistry upon contact with the atmosphere. It is recommended that 1/4 inch or 3/8 inch (inside diameter) tubing be used to help insure that the sample tubing remains water filled. If the pump tubing is not completely filled to the sampling point, use one of the following procedures to collect samples: (1) add clamp, connector (Teflon or stainless steel) or valve to constrict sampling end of tubing; (2) insert small diameter Teflon tubing into water filled portion of pump tubing allowing the end to protrude beyond the end of the pump tubing, collect sample from small diameter tubing; (3) collect non-VOC samples first, then increase flow rate slightly until the water completely fills the tubing, collect sample and record new drawdown, flow rate and new indicator field parameter values.

Add preservative, as required by analytical methods, to samples immediately after they are collected if the sample containers are not pre-preserved. Check analytical methods (e.g. EPA SW-846, water supply, etc.) for additional information on preservation. Check pH for all samples requiring pH adjustment to assure proper pH value. For VOC samples, this will require that a test sample be collected during purging to determine the amount of preservative that needs to be added to the sample containers prior to sampling.

If determination of filtered metal concentrations is a sampling objective, collect filtered water samples using the same low flow procedures. The use of an in-line filter is required, and the filter

size (0.45 um is commonly used) should be based on the sampling objective. Pre-rinse the filter with approximately 25 - 50 ml of ground water prior to sample collection. Preserve filtered water sample immediately. Note: filtered water samples are not an acceptable substitute for unfiltered samples when the monitoring objective is to obtain chemical concentrations of total mobile contaminants in ground water for human health risk calculations.

Label each sample as collected. Samples requiring cooling (volatile organics, cyanide, etc.) will be placed into a cooler with ice or refrigerant for delivery to the laboratory. Metal samples after acidification to a pH less than 2 do not need to be cooled.

6. Post Sampling Activities

If recording pressure transducer is used, remeasure water level with tape.

After collection of the samples, the pump tubing may either be dedicated to the well for resampling (by hanging the tubing inside the well), decontaminated, or properly discarded.

Before securing the well, measure and record the well depth (to 0.1 ft.), if not measured the day before purging began. Note: measurement of total well depth is optional after the initial low stress sampling event. However, it is recommended if the well has a “silting” problem or if confirmation of well identity is needed.

Secure the well.

V. DECONTAMINATION

Decontaminate sampling equipment prior to use in the first well and following sampling of each subsequent well. Pumps will not be removed between purging and sampling operations. The pump and tubing (including support cable and electrical wires which are in contact with the well) will be decontaminated by one of the procedures listed below.

Procedure 1

The decontaminating solutions can be pumped from either buckets or short PVC casing sections through the pump or the pump can be disassembled and flushed with the decontaminating solutions. It is recommended that detergent and isopropyl alcohol be used sparingly in the decontamination process and water flushing steps be extended to ensure that any sediment trapped in the pump is removed. The pump exterior and electrical wires must be rinsed with the decontaminating solutions, as well. The procedure is as follows:

Flush the equipment/pump with potable water.

Flush with non-phosphate detergent solution. If the solution is recycled, the solution must be changed periodically.

Flush with potable or distilled/deionized water to remove all of the detergent solution. If the water is recycled, the water must be changed periodically.

Flush with isopropyl alcohol (pesticide grade). If equipment blank data from the previous sampling event show that the level of contaminants is insignificant, then this step may be skipped.

Flush with distilled/deionized water. The final water rinse must not be recycled.

Procedure 2

Steam clean the outside of the submersible pump.

Pump hot potable water from the steam cleaner through the inside of the pump. This can be accomplished by placing the pump inside a three or four inch diameter PVC pipe with end cap. Hot water from the steam cleaner jet will be directed inside the PVC pipe and the pump exterior will be cleaned. The hot water from the steam cleaner will then be pumped from the PVC pipe through the pump and collected into another container. Note: additives or solutions should not be added to the steam cleaner.

Pump non-phosphate detergent solution through the inside of the pump. If the solution is recycled, the solution must be changed periodically.

Pump potable water through the inside of the pump to remove all of the detergent solution. If the solution is recycled, the solution must be changed periodically.

Pump distilled/deionized water through the pump. The final water rinse must not be recycled.

VI. FIELD QUALITY CONTROL

Quality control samples are required to verify that the sample collection and handling process has not compromised the quality of the ground water samples. All field quality control samples must be prepared the same as regular investigation samples with regard to sample volume, containers, and preservation. The following quality control samples shall be collected for each batch of samples (a batch may not exceed 20 samples). Trip blanks are required for the VOC samples at a frequency of one set per VOC sample cooler.

Field duplicate.

Matrix spike.

Matrix spike duplicate.

Equipment blank.

Trip blank (VOCs).

Temperature blank (one per sample cooler).

Equipment blank shall include the pump and the pump's tubing. If tubing is dedicated to the well, the equipment blank will only include the pump in subsequent sampling rounds.

Collect samples in order from wells with lowest contaminant concentration to highest concentration. Collect equipment blanks after sampling from contaminated wells and not after background wells.

Field duplicates are collected to determine precision of sampling procedure. For this procedure, collect duplicate for each analyte group in consecutive order (VOC original, VOC duplicate, SVOC original, SVOC duplicate, etc.).

If split samples are to be collected, collect split for each analyte group in consecutive order (VOC original, VOC split, etc.). Split sample should be as identical as possible to original sample.

All monitoring instrumentation shall be operated in accordance with EPA analytical methods and manufacturer's operating instructions. EPA analytical methods are listed in 40 CFR 136, 40 CFR 141, and SW-846 with exception of Eh, for which the manufacturer's instructions are to be followed. Instruments shall be calibrated at the beginning of each day. If a measurement falls outside the calibration range, the instrument should be re-calibrated so that all measurements fall within the calibration range. At the end of each day, check calibration to verify that instruments remained in calibration. Temperature measuring equipment, thermometers and thermistors, need not be calibrated to the above frequency. They should be checked for accuracy prior to field use according to EPA Methods and the manufacturer's instructions.

VII.FIELD LOGBOOK

A field log shall be kept to document all ground water field monitoring activities (see attached example matrix), and record all of the following:

Well identification.

Well depth, and measurement technique.

Static water level depth, date, time and measurement technique.

Presence and thickness of immiscible liquid (NAPL) layers and

detection method.

Pumping rate, drawdown, indicator parameters values, and clock time, at the appropriate time intervals; calculated or measured total volume pumped.

Well sampling sequence and time of each sample collection.

Types of sample bottles used and sample identification numbers.

Preservatives used.

Parameters requested for analysis.

Field observations during sampling event.

Name of sample collector(s).

Weather conditions.

QA/QC data for field instruments.

Any problems encountered should be highlighted.

Description of all sampling equipment used, including trade names, model number, diameters, material composition, etc.

VIII. DATA REPORT

Data reports are to include laboratory analytical results, QA/QC information, and whatever field logbook information is needed to allow for a full evaluation of data useability.

EXAMPLE (Minimum Requirements) Page____of____

Well PURGING-FIELD WATER QUALITY MEASUREMENTS FORM

Location (Site/Facility Name)_____ Depth to _____/_____ of screen
Well Number_____Date_____ (below MP) top bottom
Field Personnel_____ Pump Intake at (ft. below MP)_____
Sampling Organization_____ Purging Device; (pump type)_____
Identify MP_____

Clock Time 24 HR	Water Depth below MP ft	Pump Dial[1]	Purge Rate ml/min	Cum. Volume Purged liters	Temp. °C	Spec. Cond.[2] µS/cm	pH	ORP/ Eh[3] mv	DO mg/L	Turb-idity NTU	Comments

1. Pump dial setting (for example: hertz, cycles/min, etc).
2. µSiemens per cm(same as µmhos/cm)at 25 °C.
3. Oxidation reduction potential (stand in for Eh).

STANDARD OPERATING PROCEDURE GW-2

LOW STRESS (LOW FLOW) GROUNDWATER PURGING AND SAMPLING

1. SCOPE AND APPLICATION

This Standard Operating Procedure (SOP) is in accordance with the EPA Region I Low Stress (Low Flow) SOP: SOP No. GW 0001, Revision Number 2, dated July 30, 1996 (99-0167). This SOP provides a general framework for collecting groundwater samples that are indicative of mobile organic and inorganic loads at ambient flow conditions (both the dissolved fraction and the fraction associated with mobile particulates). This SOP emphasizes the need to minimize stress by low water-level drawdowns, and low pumping rates (usually less than 1 liter/min) in order to collect samples with minimal alterations to water chemistry. This SOP is aimed primarily at sampling monitoring wells that can accept a submersible pump and have a screen, or open interval length of 10 feet or less (this is the most common situation); however, this procedure is flexible and can be used in a variety of well construction and groundwater yield situations. Samples thus obtained are suitable for analyses of groundwater contaminants (volatile and semivolatile organic analytes, pesticides, PCBs, metals, and other inorganics), or other naturally occurring analytes.

This procedure does not address the collection of samples from wells containing light or dense non-aqueous phase liquids (LNAPLs and DNAPLs).

The screen, or open interval of the monitoring well, should be optimally located (both laterally and vertically) to intercept existing contaminant plume(s) or along flowpaths of potential contaminant releases. It is presumed that the analytes of interest move (or potentially move) primarily through the more permeable zones within the screen, or open interval.

Proper well construction and development cannot be overemphasized, because the use of installation techniques that are appropriate to the hydrogeologic setting often prevents “problem well” situations from occurring. It is also recommended that, as part of development or redevelopment, the well should be tested to determine the appropriate pumping rate to obtain

stabilization of field indicator parameters with minimal drawdown in the shortest amount of time. With this information, field crews can then conduct purging and sampling in a more expeditious manner.

The mid-point of the saturated screen length (which should not exceed 10 feet) is used by convention as the location of the pump intake; however, significant chemical or permeability contrast(s) within the screen may require additional field work to determine the optimum vertical location(s) for the intake, and appropriate pumping rate(s) for purging and sampling more localized target zone(s). Primary flow zones (high(er) permeability and/or high(er) chemical concentrations) should be identified in wells with screen lengths longer than 10 feet, or in wells with open boreholes in bedrock. Targeting these zones for water sampling will help ensure that the low stress procedure will not underestimate contaminant concentrations. The Work Plan should provide clear instructions on how the pump intake depth(s) will be selected, and reason(s) for the depth(s) selected.

Stabilization of indicator field parameters is used to indicate that conditions are suitable for sampling to begin. Achievement of turbidity levels of less than 5 NTU and stable drawdowns of less than 0.3 feet, while desirable, are not mandatory. Sample collection may still take place provided the remaining criteria in this procedure are met. If after 4 hours of purging indicator field parameters have not stabilized, one of 3 optional courses of action may be taken: (1) continue purging until stabilization is achieved; (2) discontinue purging, do not collect any samples, and record in log book that stabilization could not be achieved (documentation must describe attempts to achieve stabilization); and (3) discontinue purging, collect samples, and provide full explanation of attempts to achieve stabilization (note: there is a risk that the analytical data obtained, especially metals and strongly hydrophobic organic analytes, may not meet the sampling objectives). Option 3 is the normally selected option.

Changes to this SOP should be proposed and discussed when the site Work Plan is submitted for approval. Subsequent requests for modifications of an approved plan must include adequate technical justification for proposed changes. All changes and modifications must be approved before implementation in the field.

2. EQUIPMENT

2.1 EXTRACTION DEVICE

Adjustable rate, submersible pumps are preferred (for example, Redi-flo 2 or bladder pump constructed of stainless steel or Teflon).

Adjustable rate, peristaltic pumps (suction) may be used with caution. Note that EPA guidance states: "Suction pumps are not recommended because they may cause degassing, pH modification, and loss of volatile compounds" (EPA/5-40/P-87/001, 1987, page 8.5-11) (99-0185).

2.2 TUBING

Teflon or Teflon-lined polyethylene tubing is preferred when sampling is to include VOCs, SVOCs, pesticides, PCBs, and inorganics.

PVC, polypropylene, or polyethylene tubing may be used when collecting samples for inorganics analyses; however, these materials should be used with caution when sampling for organics. If these materials are used, the equipment blank (which includes the tubing) data must show that these materials do not add contaminants to the sample.

Stainless steel tubing may be used when sampling for VOCs, SVOCs, pesticides, and PCBs; however, it should be used with caution when sampling for metals.

The use of 1/4 inch or 3/8 inch (inner diameter) tubing is preferred. This will help ensure the tubing remains liquid filled when operating at very low pumping rates.

Pharmaceutical grade (Pharmed) tubing should be used for the section around the rotor head of a peristaltic pump to minimize gaseous diffusion.

2.3 SUPPLIES

- Water level measuring device(s) capable of measuring to 0.01-foot accuracy (electronic "tape," pressure transducer). Recording pressure transducers, mounted

above the pump, are especially helpful in tracking water levels during pumping operations, but their use must include check measurements with a water level "tape" at the start and end of each record.

- Flow measurement supplies (e.g., graduated cylinder and stop watch).
- Interface probe, if needed.
- Power source (generator, nitrogen tank, etc.).
  - If a gasoline generator is used, it must be located downwind and at least 30 feet from the well so that the exhaust fumes do not contaminate the samples.
- Indicator field parameter monitoring instruments such as the YSI model 6820 - pH, Eh, dissolved oxygen (DO), turbidity, specific conductance, and temperature. Use of a flow-through-cell is required when measuring all listed parameters, except turbidity. Standards to perform field calibration of instruments and analytical methods are listed in 40 CFR 136, 40 CFR 141, and SW-846. For Eh measurements, follow manufacturer's instructions.
- Decontamination supplies (for example, non-phosphate detergent, distilled/de-ionized water, isopropanol, etc.) (see SOP G-2).
- Logbook(s) and other forms (for example, well purging forms).
- Sample bottles.
- Sample preservation supplies (as required by the analytical methods).
- Sample tags or labels.
- Well construction data, location map, field data from last sampling event.
- Well keys.
- Site-specific Work Plan.
- PID or FID instrument (if appropriate) to detect VOCs for health and safety purposes, and provide qualitative field evaluations.

3. RELATED PROCEDURES

G-1 Calibration of Field Screening Instruments

G-2 Decontamination

G-3 Field Documentation

G-5 Field Measurements

G-6 Field Sample Numbering

G-7 Management of IDW

G-9 Quality Assurance/Quality Control Sampling

G-10 Sample Documentation

G-11 Sample Packing and Shipping

SS-1 Determination of Presence of Free Product

GW-4 NAPL Sampling

GW-8 Water Level Measurements

4. PROCEDURE

4.1 PRELIMINARY SITE ACTIVITIES

- Check well for security damage or evidence of tampering; record pertinent observations.
- Lay out sheet of clean polyethylene for monitoring and sampling equipment.
- Remove well cap and immediately measure VOCs at the rim of the well with a PID or FID instrument, and record the reading in the field logbook.
- If the well casing does not have a reference point (usually a V-cut or indelible mark in the well casing), make one. Describe its location and record the date of the mark in the logbook.
- A synoptic water level measurement round should be performed (in the shortest possible time) before any purging and sampling activities begin. It is recommended that water level depth (to 0.01 ft) and total well depth (to 0.1 ft) be measured the day before, in order to allow for re-settlement of any particulates in the water column. If measurement of total well depth is not made the day before, it should not be measured until after sampling of the well is complete. All measurements must be taken from the established referenced point. Care should be taken to minimize water column disturbance.
- Check newly constructed wells for the presence of LNAPLs or DNAPLs before the initial sampling round. If none are encountered, subsequent check measurements with an interface probe are usually not needed unless analytical data or field head space

information signal a worsening situation. Note: procedures for collection of LNAPL and DNAPL samples are addressed in SOP GW-4, NAPL Sampling.

4.2 PURGING AND SAMPLING PROCEDURE

Sampling wells in order of increasing chemical concentrations (known or anticipated) is preferred.

4.2.1 Install Pump

Lower pump, safety cable, tubing, and electrical lines slowly (to minimize disturbance) into the well to the midpoint of the zone to be sampled. The Work Plan should specify the sampling depth, or provide criteria for selection of intake depth for each well. If possible, keep the pump intake at least two feet above the bottom of the well to minimize mobilization of particulates present in the bottom of the well. Collection of turbid free water samples may be especially difficult if there are two feet or less of standing water in the well.

4.2.2 Measure Water Level

Before starting pump, measure water level. If recording pressure transducer is used, initialize starting condition.

4.2.3 Purge Well

4.2.3.1 Initial Sampling (Well Not Previously Sampled)

Start the pump at its lowest speed setting and slowly increase the speed until discharge occurs. Check water level. Adjust pump speed until there is little or no water level drawdown (less than 0.3 foot). If the minimal drawdown that can be achieved exceeds 0.3 foot but remains stable, continue purging until indicator field parameters stabilize.

Monitor and record water level and pumping rate every 3 to 5 minutes (or as appropriate) during purging. Record any pumping rate adjustments (both time and flow rate). Pumping rates should, as needed, be reduced to the minimum capabilities of the pump (for example, 0.1 - 0.4 l/min) to ensure stabilization of indicator parameters. Adjustments are best made in the first 15 minutes of

pumping in order to help minimize purging time. During pump startup, drawdown may exceed the 0.3-foot target and then "recover" as pump flow adjustments are made. Purge volume calculations should utilize stabilized drawdown value, not the initial drawdown. Do not allow the water level to fall to the intake level (if the static water level is above the well screen, avoid lowering the water level into the screen). The final purge volume must be greater than the stabilized drawdown volume plus the extraction tubing volume.

Wells with low recharge rates may require the use of special pumps capable of attaining very low pumping rates (bladder, peristaltic), and/or the use of dedicated equipment. If the recharge rate of the well is lower than extraction rate capabilities of currently manufactured pumps and the well is essentially dewatered during purging, then the well should be sampled as soon as the water level has recovered sufficiently to collect the appropriate volume needed for all anticipated samples (ideally, the intake should not be moved during this recovery period). Samples may then be collected even though the indicator field parameters have not stabilized.

4.2.3.2 Subsequent Sampling

After the synoptic water level measurement round, check intake depth and drawdown information from previous sampling event(s) for each well. Duplicate, to the extent practicable, the intake depth and extraction rate (use final pump dial setting information) from previous event(s). Perform purging operations as above.

4.2.4 Monitor Indicator Field Parameters

During well purging, monitor indicator field parameters (turbidity, temperature, specific conductance, pH, Eh, DO) every 3 to 5 minutes (or less frequently, if appropriate). Note: during the early phase of purging, emphasis should be put on minimizing and stabilizing pumping stress, and recording those adjustments. Purging is considered complete and sampling may begin when all the above indicator field parameters have stabilized. Stabilization is considered to be achieved when three consecutive readings, taken at 3- to 5-minute intervals, are within the following limits:

- Turbidity (10% for values greater than 1 NTU).

- DO (10%).
- Specific conductance (3%).
- Temperature (3%).
- pH (± 0.1 unit).
- ORP/Eh (± 10 millivolts).

All measurements, except turbidity, must be obtained using a flow-through cell. Transparent flow-through cells are preferred, because they allow field personnel to watch for particulate buildup within the cell. This buildup may affect indicator field parameter values measured within the cell, and may also cause an underestimation of turbidity values measured after the cell. If the cell needs to be cleaned during purging operations, continue pumping and disconnect cell for cleaning, then reconnect after cleaning and continue monitoring activities.

The flow-through cell must be designed in a way that prevents air bubble entrapment in the cell. When the pump is turned off or cycling on/off (when using a bladder pump), water in the cell must not drain out. Monitoring probes must be submerged in water at all times. If two flow-through cells are used in series, the one containing the dissolved oxygen probe should come first (this parameter is most susceptible to error if air leaks into the system).

4.2.5 Collect Water Samples

Water samples for laboratory analyses must be collected before water has passed through the flow-through cell (use a by-pass assembly or disconnect cell to obtain sample).

VOC samples should be collected first and directly into pre-preserved sample containers. Fill all sample containers by allowing the pump discharge to flow gently down the inside of the container with minimal turbulence.

During purging and sampling, the tubing should remain filled with water so as to minimize possible changes in water chemistry upon contact with the atmosphere. It is recommended that 1/4 inch or 3/8 inch (inside diameter) tubing be used to help ensure that the sample tubing remains water filled. If the pump tubing is not completely filled to the sampling point, use one of the following procedures to collect samples: (1) add clamp, connector (Teflon or stainless steel)

or valve to constrict sampling end of tubing; (2) insert small-diameter Teflon tubing into water-filled portion of pump tubing, allowing the end to protrude beyond the end of the pump tubing, collect sample from small diameter tubing; (3) collect non-VOC samples first, then increase flow rate slightly until the water completely fills the tubing, collect sample, and record new drawdown, flow rate, and new indicator field parameter values.

Add preservative, as required by analytical methods, to samples immediately after they are collected if the sample containers are not pre-preserved. Check QAPP Section 6 (WESTON, 00-0507) for additional information on preservation. Check pH for all samples requiring pH adjustment to ensure proper pH value. For VOC samples, this will require that a test sample be collected during purging to determine the amount of preservative that needs to be added to the sample containers prior to sampling.

If determination of filtered metal concentrations is a sampling objective, collect filtered water samples using the same low flow procedures. The use of an in-line filter is required, and the filter size (0.45 μm is commonly used) should be based on the sampling objective. Pre-rinse the filter with approximately 25 - 50 ml of groundwater prior to sample collection. Preserve filtered water sample immediately. Note: filtered water samples are not an acceptable substitute for unfiltered samples when the monitoring objective is to obtain chemical concentrations of total mobile contaminants in groundwater for human health risk calculations.

Label each sample as collected. Samples requiring cooling (volatile organics, cyanide, etc.) will be placed into a cooler with ice or refrigerant for delivery to the laboratory. Metal samples after acidification to a pH less than 2 do not need to be cooled.

4.2.6 Post Sampling Activities

If recording pressure transducer is used, remeasure water level with tape.

After collection of the samples, the pump tubing may either be dedicated to the well for resampling (by hanging the tubing inside the well), decontaminated, or properly discarded.

Before securing the well, measure and record the well depth (to 0.1 ft), if not measured the day before purging began. Note: measurement of total well depth is optional after the initial low

stress sampling event; however, it is recommended if the well has a “silting” problem or if confirmation of well identity is needed.

Secure the well.

5. DECONTAMINATION

Decontaminate sampling equipment prior to use in the first well and following sampling of each subsequent well. Pumps will not be removed between purging and sampling operations. The pump and tubing (including support cable and electrical wires that are in contact with the well) will be decontaminated by one of the procedures listed below.

5.1 PROCEDURE 1

The decontaminating solutions can be pumped from either buckets or short PVC casing sections through the pump, or the pump can be disassembled and flushed with the decontaminating solutions. It is recommended that detergent and isopropanol be used sparingly in the decontamination process, and water flushing steps be extended to ensure that any sediment trapped in the pump is removed. The pump exterior and electrical wires must be rinsed with the decontaminating solutions, as well. The procedure is as follows:

1. Flush the equipment/pump with potable water.
2. Flush with non-phosphate detergent solution. If the solution is recycled, the solution must be changed periodically.
3. Flush with potable or distilled/deionized water to remove all of the detergent solution. If the water is recycled, the water must be changed periodically.
4. Flush with isopropanol (pesticide grade). If equipment blank data from the previous sampling event show that the level of contaminants is insignificant, then this step may be skipped.
5. Flush with distilled/deionized water. The final water rinse must not be recycled.

5.2 PROCEDURE 2

1. Steam clean the outside of the submersible pump.

2. Pump hot potable water from the steam cleaner through the inside of the pump. This can be accomplished by placing the pump inside a 3- or 4-inch diameter PVC pipe with end cap. Hot water from the steam cleaner jet will be directed inside the PVC pipe, and the pump exterior will be cleaned. The hot water from the steam cleaner will then be pumped from the PVC pipe through the pump and collected into another container. Note: additives or solutions should not be added to the steam cleaner.

3. Pump non-phosphate detergent solution through the inside of the pump. If the solution is recycled, the solution must be changed periodically.

4. Pump potable water through the inside of the pump to remove all of the detergent solution. If the solution is recycled, the solution must be changed periodically.

5. Pump distilled/deionized water through the pump. The final water rinse must not be recycled.

6. FIELD QUALITY CONTROL

Quality control samples are required to verify that the sample collection and handling process has not compromised the quality of the groundwater samples. All field quality control samples must be prepared the same as regular investigation samples with regard to sample volume, containers, and preservation. The following quality control samples shall be collected for each batch of samples (a batch may not exceed 20 samples). Trip blanks are required for the VOC samples at a frequency of one set per VOC sample cooler.

- Field duplicate.
- Matrix spike.
- Matrix spike duplicate.
- Equipment blank.
- Trip blank (VOCs).
- Temperature blank (one per sample cooler).

Equipment blank shall include the pump and the pump's tubing. If tubing is dedicated to the well, the equipment blank will only include the pump in subsequent sampling rounds.

Collect samples in order from wells with lowest contaminant concentration to highest concentration. Collect equipment blanks after sampling from contaminated wells and not after background wells.

Field duplicates are collected to determine the precision of sampling procedure. For this procedure, collect duplicate for each analyte group in consecutive order (VOC original, VOC duplicate, SVOC original, SVOC duplicate, etc.).

If split samples are to be collected, collect split for each analyte group in consecutive order (VOC original, VOC split, etc.). Split sample should be as identical as possible to original sample.

All monitoring instrumentation shall be operated in accordance with EPA analytical methods and manufacturer's operating instructions (see SOP G-1). EPA analytical methods are listed in 40 CFR 136, 40 CFR 141, and SW-846 with the exception of Eh, for which the manufacturer's instructions are to be followed. Instruments shall be calibrated at the beginning of each day. If a measurement falls outside the calibration range, the instrument should be re-calibrated so that all measurements fall within the calibration range. At the end of each day, check calibration to verify that instruments remained in calibration. Temperature measuring equipment, thermometers, and thermistors need not be calibrated to the above frequency. They should be checked for accuracy prior to field use according to EPA Methods and the manufacturer's instructions.

7. FIELD LOGBOOK

A field log shall be kept to document all groundwater field monitoring activities, and record all of the following:

- Well identification.
- Well depth and measurement technique.
- Static water level depth, date, time, and measurement technique.
- Presence and thickness of immiscible liquid (NAPL) layers and detection method.
- Pumping rate, drawdown, indicator parameter values, and clock time, at the appropriate time intervals; calculated or measured total volume pumped.
- Well sampling sequence and time of each sample collection.

- Types of sample bottles used and sample identification numbers.
- Preservatives used.
- Parameters requested for analysis.
- Field observations during sampling event.
- Name of sample collector(s).
- Weather conditions.
- QA/QC data for field instruments.
- Any problems encountered should be highlighted.
- Description of all sampling equipment used, including trade names, model number, diameters, material composition, etc.

8. REFERENCES

00-0507 WESTON (Roy F. Weston, Inc.). March 2001. *Quality Assurance Project Plan.* Environmental Remediation Contract, GE/Housatonic River Project. Volumes I, II, IIA, and IV. DCN GE-021601-AAHM.

99-0167 U.S. Environmental Protection Agency (EPA) Region I. 1996. *Low Stress (Low Flow) Purging and Sampling Procedure for the Collection of Ground Water Samples from Monitoring Wells.* SOP No. GW 0001, Revision Number 2, July 30, 1996.

99-0185 U.S. Environmental Protection Agency (EPA). 1987. *A Compendium of Superfund Field Operations Methods.* Office of Emergency and Remedial Response, Washington, DC, EPA/5-40/P-87/001.

STANDARD OPERATING PROCEDURE GW-8

WATER LEVEL AND WELL DEPTH MEASUREMENTS

1. SCOPE AND APPLICATION

The purpose of this Standard Operating Procedure (SOP) is to delineate protocols for measuring water level and well depth. This procedure is applicable to the sampling of monitoring wells and must be performed prior to any activities that may disturb the water level, such as purging or aquifer testing.

These measurements will be taken at least 24 hours after development or immediately before sampling. Measurement will be made using an electronic water level meter. The depth to groundwater will be measured and reported to the nearest 0.01 ft. Measurement will be made from the highest point on the rim of the well casing or riser (not protective casing). This same point on the well casing will be surveyed for vertical control. Surface water levels will be measured at least to the nearest 0.1 ft using an adjacent temporary or permanent survey marker as a datum for current and future reference.

2. MATERIAL

Electronic water level indicator with cable measured at 0.01-foot increments

Tape for total depth measurement (optional)

Transducer and datalogger (optional for continuous monitoring)

Oil-water interface probe

Plastic sheeting

Photoionization detector (PID) or intrinsically safe flame ionization detector (FID)

3. RELATED PROCEDURES

G-1 Calibration of Field Screen Instruments

G-2 Decontamination

G-3 Field Documentation

G-5 Field Measurements

GW-4 NAPL Sampling

4. PROCEDURE

4.1 PRELIMINARY STEPS

- Locate the well and verify its position on the site map. Record whether positive identification was obtained, including the well number and any identifying marks or codes contained on the well or protective casing. Note any damage or missing locks.

- Open the well.

- Locate the permanent reference mark at the top of the casing. The reference point will be scribed, notched, or otherwise noted on the top of the casing. If no such marks are present, measure from the highest point of the well casing, and note this in the field notebook.

- Record any observations and remarks regarding the completion characteristics and well condition, such as evidence of cracked casing or surface seals, security of the well (locked cap), and evidence of tampering.

- Keep all equipment and supplies protected from gross contamination; use plastic sheeting. Keep the water level indicator probe in its protective compartment when not in use.

4.2 OPERATION

- Sample the air in the well head for gross organic vapors by lifting the well cap only high enough for an organic vapor monitor (PID or FID) probe to be entered into the well casing. This will indicate the level of gross volatile contaminants as well as indicate the potential for sampler exposure. Always perform NAPL checks in wells with suspected NAPL contamination, and in wells where headspace tests reveal the presence of volatiles. Always perform a NAPL check the first time a well is sampled.

- Remove cap. Allow well to vent for at least 90 seconds.

4.2.1 NAPL Present

If non-aqueous phase liquid (NAPL) contamination is suspected, use an interface probe to determine the existence and thickness of NAPLs.

- Open the probe housing, turn the probe on, and test the alarm. Slowly lower the probe into the well until the alarm sounds. A continuous alarm indicates a NAPL, while an intermittent alarm indicates water. If a NAPL is detected, record the initial level (first alarm). Mark the spot by grasping the cable with the thumb and forefinger at the top of the casing. If a mark is present on the casing, use the mark as the reference point. If no mark is present, use the highest point on the casing as the reference point. Record the depth.

- Continue to slowly lower the probe until it passes into the water phase. Record the water level and the thickness of NAPL (NAPL – water depths).

- Continue to slowly lower the probe through the water column to check for the presence of DNAPL.

- Measure depths to DNAPL and the bottom of the well, and record the thickness of any DNAPL layer.

- Fully decontaminate the probe (see SOP G-2).

4.2.2 No NAPL Present

If no NAPL is present, use an electronic water level detector as follows:

- Remove the probe from the retainer, turn on the sounder, and test the battery and sensitivity scale by pressing the red button. Adjust the sensitivity scale (volume) until you hear the buzzer.

- Slowly lower the probe and cable into the well, allowing the cable reel to unwind. Continue lowing until the meter buzzes. Very slowly, raise and lower the probe until the point is reached where the meter just buzzes. Mark the spot by grasping the cable with the thumb and forefinger at the top of the casing. If a mark is present on the casing, use the mark as the reference point. If no mark is present, use the highest point on the casing as the reference point. Record the depth.

- To measure the well depth, lower the water level indicator probe or tape until slack is noted. Raise and lower the tape until the bottom is felt. Record the depth. Note: if the electric water level indicator is used to determine the depth of the well, the offset distance from the tip to the electrode must be added to the depth.

- Withdraw the tape and probe, and wipe with paper towels and water spray. Generally proceed from clean to "dirty" wells to minimize the possibility of cross contamination.

5. CALIBRATION

No field calibration is necessary.

6. PRECAUTIONS

- Check instrument batteries prior to each use.
- Fully decontaminate probe and tape if exposed to NAPL.
- Make sure that the cable is not twisted and that the cable is intact and the lengths are correct (cables are sometimes spliced and may be shortened in the process).

7. REFERENCES

99-0170 U.S. Environmental Protection Agency (EPA), Office of Solid Waste and Emergency Response. 1989. *Accuracy of Depth to Groundwater Measurements.* EPA Superfund Groundwater Issue. EPA/540/4-89/002.

STANDARD OPERATING PROCEDURE GW-9

WELL DEVELOPMENT

1. SCOPE AND APPLICATION

Well development is the process by which foreign materials and solids are removed from the screen filter pack or open hole, allowing water to flow freely into the well. This process is accomplished by moving water through the well screen or borehole into and out of the surrounding material. Well development serves four principal purposes:

- Removes materials that have built up in the openings of the screen or borehole during the well drilling and installation process.
- Removes fine materials from the side of the borehole that result from the drilling procedures (e.g., drilling mud).
- Increases hydraulic conductivity of the filter pack and adjacent geologic materials by removing fine materials.
- Stabilizes the fine materials that remain in the vicinity of the well, thereby retarding their entry into the well.

The benefits are increased yield and reduced suspended solids.

The well will be developed using mechanical surging and overpumping. In this method (surge blocking), a surge block is pushed in and pulled out of the well in a plunger-like fashion. As fines are flushed into the well, they are pumped out or bailed out. This method is the most effective method of development, but is only used to develop screened wells because it may cause collapse in an open borehole.

All materials placed in the wells must be decontaminated prior to their use. All pumps must be equipped with clean wiring (no electrical or duct tape), and have either PVC or polyethylene tubing.

2. EQUIPMENT

Well development forms and pens

De-ionized water and decontamination supplies

Stopwatch/wristwatch

Electronic water level measurement device

Flow rate/volume measurement devices

Turbidity meter

Thermometer

pH meter

Electrical conductivity meter

Organic vapor detector (PID or FID)

Dissolved oxygen meter (optional)

Eh meter (optional)

1,000-ml Imhoff cone (optional)

3. RELATED PROCEDURES

G-1 Calibration of Field Screening Instruments

G-2 Decontamination

G-3 Field Documentation

G-7 Management of IDW

GW-9 Water Level Measurements

4. WELL DEVELOPMENT PROCEDURES

Overburden wells are developed as follows:

- Development should not be performed sooner than 48 hours after installation to ensure that the grout has had ample time to cure, unless grout is above the depth of the water table.

- Overburden well development will be performed using surge block techniques. Depending on well construction design, the surging will either be performed manually using a surge block connected to a tremie pipe (or equivalent) or operated mechanically from the drilling rig. The entire length of the saturated well screen will be surged. Surging will alternate with pumping for a minimum of 1 hour or up to 4 hours, until sediment production nearly ceases.

- The wells will then be pumped (if yields are high enough: >0.5 gpm) using a decontaminated submersible pump (low-yielding wells should be pumped with a 2-inch OD adjustable rate pump or manually bailed). All pumps will be equipped with clean wiring and PVC or polyethylene tubing. The submersible pumps should be capable of operating at a range of pumping rates (generally from 1 to 10 gpm), either by use of different pumps or throttling back on pump flow to meet well yield conditions.

- At regular intervals, such as every 15 minutes during development, purge rate; depth to water; and groundwater pH, temperature, electrical conductivity, PID/FID readings, turbidity, incremental, and total volume purged will be recorded. All purge water will be containerized. Well development will continue until turbidity measurements are 5 NTUs or less, and readings stabilize over 3 successive 5-minute intervals, or for a minimum of 1 hour or a maximum of 4 hours. After 4 hours, if a turbidity of 5 NTU cannot be achieved, well development will discontinue, and the final turbidity will be noted in the log.

- Because one of the objectives during well development is the determination of well yield in gpm, the depth to water will be measured at the same time as the other parameters, and the flow of the submersible pump (if used) will be adjusted so that the water level stabilizes. At that point, flow rate should be approximately equal to well yield. If the well goes dry during development, water levels should be recorded during a 10-minute recovery test that will be run to determine the rate that groundwater is entering the well. Water levels are taken at intervals of 0 seconds, 15 seconds, 30 seconds, 1 minute, 2 minutes, 5 minutes, and 10 minutes. At the end of development, an estimation of yield will be recorded on the GEOLIS Well Development Form.

5. REFERENCES

99-0165 Driscoll, F. 1986. *Groundwater and Wells*. Second Edition. Published by Johnson Filtration Systems, Inc., St. Paul, MN.

APPENDIX C

LABORATORY ANALYTICAL METHOD STANDARD OPERATING PROCEDURE

CONFIDENTIAL
DO NOT DUPLICATE

STL Denver

Controlled Copy No. _____

Implementation Date 2-10-04

STANDARD OPERATING PROCEDURE

TITLE: PERCHLORATE BY LC/MS/MS

(SUPERSEDES: Revision 0)

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Laboratory Director

Received
FEB 09 2004
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1. SCOPE AND APPLICATION

This procedure describes the analysis of perchlorate by electrospray ionization liquid chromatography tandem mass spectrometry (LC/MS/MS). The procedure applies to water, soil, and vegetation samples. The routine reporting limit is 0.2 ug/L in water and 5 ug/kg in soil and vegetation.

2. SUMMARY OF METHOD

2.1 Water Preparation – Samples are filtered as needed to remove solids using a PTFE filter.

2.2 Soil Preparation - Soil samples are mixed with reagent water at a 10:1 ratio (water to soil) for one hour. The mixture is filtered through a glass fiber filter.

2.3 Vegetation Preparation – Freeze dried or macerated vegetation tissue is mixed with reagent water at a 10:1 ratio for one hour. The mixture is filtered through a glass fiber filter. The extract is cleaned up with basic alumina and a C-18 solid phase extraction cartridge.

2.4 Analysis – The liquid chromatograph is equipped with an ion exchange column. The separation is isocratic. The electrospray interface between the liquid chromatograph and the mass spectrometer system is operated in the negative ion mode. Perchlorate is formed from the two naturally occurring isotopes of chorine (Cl^{35} and Cl^{37}), which produces perchlorate with molecular weights of 99 and 101 amu. The two parent ions for perchlorate (m/z = 99 & 101) are selected at the first quadrupole. The parent ions are fragmented in the collision cell second stage, and then the resultant daughter ions (m/z = 83 & 85) are used for quantitation. The presence of all four ions, parent and daughter ions, and the ratio of the detected ions is used as confirmation of the presence of perchlorate.

2.5 Calibration is based on internal standardization using O-18 labeled perchlorate monitoring. The 107 to 89 m/z transition is monitored for the labeled perchlorate. Use of the labeled perchlorate generally improves accuracy, helps control calibration drift, and provides a retention time reference point.

3. DEFINITIONS

3.1 Ionization Suppression – Ionic species co-eluting with perchlorate can cause suppression of the perchlorate signal. Techniques for producing accurate results given ionization suppression are discussed in the Interference section.

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3.2 The quality control terms used in this procedure follow SW-846 conventions, which are defined in the glossary of STL Denver's Laboratory Quality Manual (LQM).

4. INTERFERENCES

4.1 This LC/MS/MS procedure is highly selective for perchlorate. Perchlorate is identified based on:

a) chromatographic separation on the ion exchange column,
b) generation of negative ions,
c) selection of two parent ions,
d) selection of two daughter ions, and
e) the ratio of the selected ions matching the natural abundance of Cl^{35}/ Cl^{37}

However, the procedure is not entirely free of interferences. Interferences can be detected through a variety of symptoms (e.g, poor internal standard recovery, poor matrix spike recovery, retention time shifts, or complex peaks). Techniques for handling the interferences are discussed in the following sections.

4.2 Ionization Suppression

4.2.1 The ion exchange columns provide adequate separation of perchlorate from common anions at levels typically encountered in natural waters. Some coelution is possible with samples containing high concentrations of dissolved solids, which can cause ionization suppression in the ESI interface and a resulting depressed signal for perchlorate.

4.2.2 Ionization suppression is monitored in each sample by including oxygen-18 labeled perchlorate as an internal standard. To ensure accurate quantitation, the internal standardization technique is used. Any samples producing internal standard recoveries below 50% are routinely diluted and reanalyzed.

4.2.3 Rather than diluting samples known to contain elevated concentrations of these anions, another option used on a non-routine basis for specific projects is column cleanup. Sulfate and bicarbonate are species that can cause ionization suppression at high concentrations, approximately 2,000 mg/L or higher taken individually. Barium cartridges can be used to remove sulfate. Hydrogen cartridges can be used to remove bicarbonate.

4.3 Samples containing high concentrations of organic material can also cause interferences with this procedure. Vegetation samples and samples suspected to contain high concentrations of organic compounds are all subject to an organic cleanup, which is described in Section 11.

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4.4 Some samples of laboratory detergents (e.g. some samples of Alconox) have been shown to contain concentrations of perchlorate in the low part-per-million concentrations. Use of disposable labware and simply rinsing volumetric flasks with de-ionized water, rather than washing in detergent, is required to avoid background contamination.

4.5 Contamination by carryover can occur whenever high-level and low-level samples are sequentially analyzed. To reduce carryover, the sample syringe must be rinsed with solvent between samples. Whenever an unusually concentrated sample is encountered, it should be followed by the analysis of solvent to check for cross contamination.

5 SAFETY PRECAUTIONS

5.1 Employees must abide by the policies and procedures in the Corporate Safety Manual, Radiation Safety Manual and this document.

5.2 Specific Safety Concerns

5.2.1 The mass spectrometer chambers past the interface are under high vacuum. The detector system must be brought to atmospheric pressure prior to working on those sections of the instrument.

5.2.2 There are areas of high voltage in both the HPLC and the mass spectrometer. Depending on the type of work involved, either turn the power to the instrument off, or disconnect it from its source of power.

5.3 Primary Materials With Safety Concerns

The following is a list of the materials used in this method, which have a serious or significant hazard rating.

NOTE: This list does not include all materials used in the method. The table contains a summary of the primary hazards listed in the MSDS for each of the materials listed in the table. A complete list of materials used in the method can be found in the reagents and materials section. Employees must review the information in the MSDS for each material before using it for the first time or when there are major changes to the MSDS.

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Material (1)	Hazards	Exposure Limit (2)	Signs and symptoms of exposure
Methanol	Flammable Poison Irritant	200 ppm-TWA	A slight irritant to the mucous membranes. Toxic effects exerted upon nervous system, particularly the optic nerve. Symptoms of overexposure may include headache, drowsiness and dizziness. Methyl alcohol is a defatting agent and may cause skin to become dry and cracked. Skin absorption can occur; symptoms may parallel inhalation exposure. Irritant to the eyes.
1 – Always add acid to water to prevent violent reactions.			
2 – Exposure limit refers to the OSHA regulatory exposure limit.			

6 EQUIPMENT AND SUPPLIES

6.1 Liquid Chromatograph/Mass Spectrometer System

The column heater must be capable of maintaining a temperature of 35° +/- 1°C. The mass spectrometer system must have an ESI interface capable of operation at 0.5 mLs per minute flow and be capable of negative ion analysis.

6.2 Chromatography Column

Dual Alltech GA-1 7.5x4.6 mm All-Guard cartridges in series

6.3 Data System

A computer system must be interfaced to the mass spectrometer. The system must allow the continuous acquisition and storage on machine-readable media of all mass spectra obtained throughout the duration of the chromatographic program. The computer must have software that can search any LC/MS data file for ions of a specific mass and that can plot such ion abundances versus time or scan number. Software must also be available that allows integrating the abundances between specified time.

6.4 Balance, capable of measuring ± 0.01 g

6.5 250 mL HDPE bottles for soil extractions

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6.6 TCLP-style tumbler, 30 rpm rotation rate, for extracting solids

6.7 40 mL glass vials

6.8 PTFE Teflon filter syringe cartridges, with pore sizes ranging from 0.2 to 1.0 um

6.9 Disposable pipettes

6.10 Shaker table for mixing during the organic cleanup process

6.11 Activated alumina, 100 mesh, basic form

6.12 Solid phase extraction cartridge, 500 mg C-18

6.13 Sand, reagent grade

7 REAGENTS AND STANDARDS

7.1 Standards

Standards are stored at 4 ± 2 °C in glass or plastic. Standards are assigned an expiration date of one year from receipt or the vendor's expiration date, whichever occurs sooner. All dilutions are prepared using reagent water. Expiration dates for intermediate and working solutions are the same as for the parent stock standard. Standards are monitored for signs of degradation or evaporation, and replaced as necessary.

7.1.1 Stock Standards

Commercial 1,000 ug/mL standards are purchased for use as stock standards. All stocks are subject to verification of accuracy prior to use (see SOP# DEN-QA-0015 for details).

7.1.2 Intermediate Standard Solutions

A series of intermediate standards are prepared by sequential dilution of the stock standard with reagent water, ending in a 10 ug/L intermediate used to prepare calibration standards.

7.1.3 Calibration Standards

Six calibration levels are prepared from the 10 ug/mL intermediate standard, as shown in Table 1. Standards are prepared in reagent water.

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7.1.4 Second-Source Calibration Initial Calibration Verification (ICV), 1.0 ug/L

The ICV is prepared from a 1,000 ug/mL stock standard obtained from a different vendor than are the calibration standards. A 10 ug/L intermediate solution is prepared from stock, which is then used to prepare a 1.0 ug/L working standard used to verify the initial calibration (see Section 10.4).

7.1.5 Spikes, LCS and Matrix Spikes

7.1.5.1 Spikes in Water Samples, 1.0 ug/L

20 uL of a 50 ug/L intermediate standard is added to 1.0mL of sample.

7.1.5.2 Spikes in Soil Samples, 10. ug/kg

1 mL of a 100 ug/L intermediate standard is added to 10 g of sample.

7.1.6 Internal Standard, O-18 labeled Perchlorate

7.1.6.1 Internal standard $\geq$ 95% purity as $Cl^{8}O_{4}^{-}$, i.e., <5% of the oxygen present as O-16, obtained from commercial sources.

7.1.6.2 Prepared to 1.0 ug/L in water samples and dilutions of extracts.

7.1.6.3 Prepared to 10 ug/kg in soil samples.

7.2 Polyethylene Glycol Mass Calibration Solution - PEG-400, 600, 800 mixture, made from neat standards obtained from a commercial source

7.3 Reagent Water - Either HPLC-grade or de-ionized water $\geq$ 18 Mohm-cm

7.4 Methanol – HPLC grade

7.5 0.01 M Ammonium Acetate - Filter through a 0.45 micron membrane filter

7.6 Nitrogen gas - 99+%

8 SAMPLE PRESERVATION AND STORAGE

8.1 Samples should be collected in 40 mL glass containers. Duplicate vials for each sample are preferred to assure adequate sample is available for analysis.

8.2 No chemical preservative is required. Samples should be refrigerated to 4 $\pm$ 2 ° C. The holding time is 28 days from collection to analysis. These specifications are based on Method 314.0.

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9 QUALITY CONTROL

Quality control (QC) procedures specific to this SOP are described in this section. Further quality control information, such as the process for establishing control limits, are given in QC Policy # QA-003. Any failure to meet the QC requirements listed in this section must be described in a Non-Conformance Memo (NCM), which is detailed in SOP# CORP-QA-0010.

9.1 Method Blank (MB)

A method blank (MB) is prepared and analyzed with each batch of samples. The MB is an aliquot of Reagent water. Results are acceptable if the measured perchlorate concentration is less than or equal to the lowest reported concentration for samples.

Corrective Action: If the MB does not meet the acceptance criteria, the source of contamination must be investigated and measures taken to correct, minimize or eliminate the problem. Samples associated with the contaminated blank shall be reprocessed for reanalysis.

9.2 Laboratory Control Sample (LCS)

A laboratory control sample (LC) is prepared and analyzed with each batch of samples. The LCS is prepared from HPLC-grade or de-ionized water, and for soil batches is prepared using Reagent grade sand. The LCS recovery must be within established control limits. Initial control limits of 80-120% for waters and 70-130% for solids are used prior to collecting a minimum of 20 data points, at which time three standard deviation control limits are used, as described in QC Policy # QA-003.

Corrective Actions: If the perchlorate recovery is not within the acceptance limits, the system is out of control and corrective action must occur. Generally this requires reextraction and reanalysis of all associated samples. If the LCS is biased high and all associated samples are ND, not detected, it may be possible to report results with an NCM (see requirements for individual programs).

9.3 Matrix Spike Samples (MS/MSD)

An MS/MSD pair is prepared for each batch of samples. The initial control limits for the spike recoveries are 50-150% and 30% RPD until sufficient data is available to calculate three standard deviation control limits.

Corrective Actions:

- If any individual recovery or RPD falls outside the acceptable range, corrective action must occur. The initial corrective action will be to check the recovery of that analyte in the Quality Control Check Sample (LCS). Generally, if the recovery of

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the analyte in the LCS is within limits, then the laboratory operation is in control and analysis may proceed.

- If the recovery for any component is outside QC limits for both the Matrix spike / spike duplicate and the LCS, the laboratory is out of control and corrective action must be taken. Corrective action will normally include repreparation and reanalysis of the batch.
- If a MS/MSD is not possible due to limited sample, then a duplicate LCS should be analyzed.
- The matrix spike / duplicate must be analyzed at the same dilution level as the unspiked sample, unless the matrix spike components would then be above the calibration range.

9.4 Internal Standard (IS)

Oxygen-18 labeled perchlorate is added as an IS to every standard, sample, and dilution tested. The IS recovery must be within 50-150%.

Corrective Actions: If recoveries are outside the acceptance limits, then the sample should be diluted and reanalyzed.

9.5 Reporting Limit Verification Standard (RLV)

Each analytical batch will include an RLV standard prepared at or below the reporting limit. The RLV is subject to the complete analytical process. The acceptance limits are 50-150%.

Corrective Actions: If recoveries are outside acceptance limits, instrument settings and the calibration should be checked. Recalibrate and rerun all associated samples.

10 CALIBRATION AND STANDARDIZATION

10.1 Set up the instrument according to the recommended settings shown in Tables 1 - 2.

10.2 Mass Calibration and Mass Calibration Check

10.2.1 The LC/MS/MS settings, such as mass windows and voltage settings, are checked each time the instrument is set up for perchlorate analysis. Perchlorate is used for the check and optimization, as needed.

10.2.2 When troubleshooting instrument problems or after major maintenance (e.g., stripping the instrument down to clean the collision cell or the quadrupoles), a mass calibration is performed using the PEG solution. The PEG is introduced directly at the ESI interface, after the HPLC. The solution is analyzed in the

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positive ion mode. The mass range scanned is 89 to > 1000 amu. The instrument is tuned to the masses shown in Table 5.

10.3 Initial Calibration

10.3.1 The laboratory routinely calibrates using six concentration levels (see Table 4) on each day of operation. The lowest point on the calibration curve is at or below the RL. These concentrations define the working range for analysis.

10.3.2 Calibration Curves

10.3.2.1 The initial calibration data are fitted to a calibration curve using least-squares regression. A 1/X or $1/X^2$ weighting is recommended.

Note about weighting:
In a linear or quadratic calibration fit, the points at the lower end of the calibration curve have less weight in determining the curve generated than points at the high concentration end of the curve. However, in environmental analysis, accuracy at the low end of the curve is very important. For this reason it is preferable to increase the weighting of the lower concentration points. $1/Concentration^2$ weighting (often called $1/X^2$ weighting) will improve accuracy at the low end of the curve and should be used if the data system has this capability.

Note about rejecting calibration points:
Generally, it is NOT acceptable to remove points from a calibration for the purposes of meeting calibration criteria, unless the points are the highest or lowest on the curve AND the reporting limit and/or the linear range is adjusted accordingly. The only exception is that a level may be removed from the calibration if the reason can be clearly documented, for example a broken vial. A minimum of five levels must remain in the calibration (six for second-order curve fits). The documentation must be retained with the initial calibration. Alternatively, if the analyst believes that a point on the curve is inaccurate, the point may be reanalyzed and the reanalysis used for the calibration. All initial calibration points must be analyzed without any changes to instrument conditions, and all points must be analyzed within 24 hours.

10.3.2.2 Linearity

For first order linear regression fits, there must be at least five contiguous levels and the correlation coefficient must be ≥ 0.995.

For second-order regression fits, the coefficient of determination must be ≥ 0.990.

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Second-order regression equations may be used, but there must be at least six contiguous calibration levels, the coefficient of determination must be ≥ 0.990, and the intercept and degree of curvature should be examined to be sure that results will be reliable throughout the working range.

Corrective Action: If these criteria are not met, the accuracy of standards and instrument settings should be examined, fixed as needed, and then recalibrate.

10.4 Second-Source Initial Calibration Verification (ICV)

A 1.0 ug/L standard obtained from a different source than the initial calibration standards is used to verify the initial calibration. The ICV recovery must be within 80-120% recovery.

Corrective Actions: If this is not achieved, the calibration standards and instrument operating conditions should be checked and the instrument recalibrated.

10.5 Continuing Calibration Verification (CCV)

1.0 ug/L and 0.5 ug/L standards from the same source as the initial calibration standards are analyzed alternately after every 10 samples. The CCV results must be within 70-130% recovery.

Corrective Actions: If this is not achieved, the calibration standards and instrument operating conditions should be checked and the instrument recalibrated.

11 PROCEDURE – SAMPLE PREPARATION

11.1 Procedural variations are allowed only if deemed necessary in the professional judgment of the supervisor to accommodate variation in sample matrix, radioactivity, chemistry, sample size, or other parameters. Any variation in procedure shall be completely documented using a Nonconformance Memo (NCM) and approved by a supervisor and QA/QC manager. If contractually required, the client shall be notified. The NCM shall be filed in the project file. The nonconformance is also addressed in the case narrative. Any unauthorized deviations from this procedure must also be documented as a nonconformance, with a cause and corrective action described. For further details on the NCM process see SOP# CORP-QA-0010DEN.

11.2 Filtration of Aqueous Samples - Samples containing visible solids are filtered through a 0.45 um PTFE filter. A 1.0 um prefilter may also be used to prevent overloading of the 0.45 um filter. If turbidity is evident after filtration to 0.45 um, then a 0.2 um filter may be use.

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11.3 Extraction of Soil or Vegetation Samples

11.3.1 Place a 10.0 g of ground solid material into a 250 mL HDPE bottle. Add 100 mL of reagent water.

11.3.2 Seal the bottle and tumble in a TCLP extractor for 1 hour.

11.3.3 Decant and filter a minimum of 10 mL of the extract through a glass fiber filter, with additional filtration per Section 11.2 as needed.

11.3.4 For vegetation samples or solids with high organic content, continue with the organic cleanup in the next section. For other solid extracts, proceed to the Instrumental Analysis Section 12.

11.4 Organic Cleanup

11.4.1 Add 2.5 g of basic alumina to 5 mL of aqueous extract in a glass vial.

11.4.2 Mix on a shaker table for 1 hour.

11.4.3 Remove 1 mL of extract, and dilute to 10 mL with reagent water.

11.4.4 Pass the extract from the previous step through a C-18 cartridge.

11.4.5 Collect the eluent, which is ready for analysis.

12 PROCEDURE – INSTRUMENTAL ANALYSIS

12.1 General instrument settings are shown in Tables 1 - 2. Instrument calibration is described in Section 10.

12.2 All samples must be analyzed using the same instrument conditions as the calibration standards.

12.3 The data system will determine the concentration of the analytes in the extract using calculations equivalent to those in section 13.

12.4 Dilutions

If the response for any compound exceeds the working range of the LC/MS system, a dilution of the extract is prepared and analyzed. Ideally the dilution will produce an instrument response near the center of the calibration range.

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12.5 Troubleshooting Guide

12.5.1 Instrument Maintenance

The column head pressure should be monitored for high pressures and unstable pressure readings. Check the column and the mobile phase being used. The mass spectrometer should be monitored to verify interface and source parameters are properly set.

12.5.2 Major Maintenance

12.5.2.1 If minor maintenance does not result in an acceptable chromatography. Additional maintenance steps may be necessary.

12.5.2.2 Mass calibration is performed if the analyst notices mass assignment errors.

12.5.2.3 Refer to the manufacturer's manual for specific guidance.

13 DATA ANALYSIS AND CALCULATIONS

13.1 Qualitative identification

Perchlorate is identified by retention time, detection of the 99 > 83 and 101 > 85 m/z characteristic ion transitions, and the 83:85 ion ratios. Retention time and the 107 > 89 m/z ion transition is used for identification of the O-18 labeled perchlorate.

13.1.1.1 Retention Time (RT)

The sample perchlorate RT should be within ± 0.5 minutes of the RT for perchlorate in the initial calibration. If retention times are shifted more than 0.5 minutes, as indicated by the labeled perchlorate, and in the technical judgment of the analyst the other identification criteria indicate that perchlorate is present, the analyst shall report that identification and proceed with quantitation.

13.1.1.2 Ion Ratio

The natural abundance of Cl^{35} is 75.5%, with the remaining 24.5% of natural chlorine occurring as Cl^{37}. The expected ratio of Cl^{35} : Cl^{37} is 3.08. Therefore, the expected ratio of the perchlorate daughter ions 83:85 m/z is also 3.08. The measured value should be within ± 50% of the expected value (i.e., 1.5 to 4.6). If this ratio is not achieved, then the result must be qualified as a tentative identification.

13.1.1.3 If the identification is in doubt because of retention time shifts combined with poor chromatography, then additional sample analysis may be required including dilutions and/or spike additions to confirm the identification of perchlorate.

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13.2 Sample Calculations

13.2.1.1 Calculation of concentration using Linear fit:

$$\textbf{Concentration } \mu g / L = A + Bx$$

13.2.1.2 Calculation of concentration using Quadratic fit:

$$\textbf{Concentration } \mu g / L = A + Bx + Cx^2$$

x is defined in the next equation
A is a constant defined by the intercept
B is the slope of the curve
C is the curvature

$$x = \frac{(A_x)(I_S)(D_f)}{(A_{is})(D_{wt})(V_0)}$$

Where:

x = Sample concentration (ug/L or ug/kg)

A_x = Area of the perchlorate quantitation ion

A_{is} = Area of the characteristic ion for the internal standard

I_s = Amount of internal standard (ng)

$D_{wt} = \frac{100 - \%Moisture}{100}$, dry weight correction for solids

D_f = Dilution factor

V_o = Sample aliquot (mL or g)

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13.3 Percent Recovery

$$\text{Recovery} = \frac{SSR}{SA} \times 100$$

Where:

SSR = Spike sample result

SA = Standard added

13.4 MS/MSD Recovery

$$\text{Recovery} = \frac{S_{SR} - S_R}{S_A} \times 100\%$$

S_{SR} = Spike sample result

S_R=Sample result

S_A = Spike added

13.5 Relative % Difference calculation for the MS/MSD

$$RPD = \frac{MS_R - MSD_R}{1/2(MS_R + MSD_R)} \times 100$$

RPD = Relative percent difference

MS_R = Matrix spike result

MSD_R = Matrix spike duplicate result

13.6 All results are subject to two levels of technical review, which is documented on the checklist shown in Figure 1.

14 METHOD PERFORMANCE

Analysts performing this procedure must be skilled in the interpretation of liquid chromatograms and mass spectra. The following studies must be completed initially before samples are analyzed, and must be repeated on an annual basis.

14.1 Initial Demonstration of Capability (IDOC)

Each analyst performing this procedure must successfully analyze four LCS QC samples using current laboratory LCS control limits. The results of the IDOC study

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are summarized in the NELAC format, as described in SOP# DEN-QA-0024. IDOCs are approved by the Quality Assurance Manager and the Technical Director. IDOC records are maintained by the QA staff in the central training files.

14.2 Method Detection Limit (MDL)

Annual MDL studies s are performed following the 40CFR136B protocol. See Policy # QA-005 for details. MDL study results are reviewed and approved by the QA staff, and are stored in QuanTIMS, the laboratory LIMS system.

14.3 MDL Verification (MDLV)

Calculated MDLs from the annual studies are subject to verification by analyzing an MDLV standard prepared at 1-2 times the calculated MDL concentration. An MDLV standard is analyzed immediately after each MDL study and quarterly thereafter. This standard is subject to the entire preparation and analysis process. The calculated MDL is verified if the MDLV standard is detected, nominally signal to noise ratio $\geq$ 3, under routine instrument conditions.

Corrective Actions:

If the first MDLV is not detected, the MDLV standard will be reprepared and analyzed at twice the original concentration. The lowest concentration that produces a detectable signal will then be reported as the MDL.

15 POLLUTION PREVENTION

None.

16 WASTE MANAGEMENT

16.1 Waste generated in this procedure must be collected and segregated according to *the STL Denver Waste Management Plan* (HS-001) and procedure (DEN-HS-0002) *Collection and Accumulation of Hazardous Waste*. Questions regarding waste management for this procedure should be directed to the Waste Coordinator (or his/her designee).

16.2 For this method, the following waste streams have been identified:

- Methanol Waste - Flammable - (C)

Note: Radioactive waste, mixed waste, and potentially radioactive waste must be segregated from non-radioactive waste as appropriate. Contact the Waste Coordinator for proper management of these materials.

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17 REFERENCES

17.1 Method 8321A, SW-846, Test Methods for Evaluating Solid Waste, Third Edition, Update III, December 1996.

17.2 EPA Method 314.0, Revision 1.0, November 1999.

17.3 Ellington & Evans, Journal of Chromatography, 898 (2000), 193-199.

18 MISCELLANEOUS -

18.1 Deviations from Method 8321A

18.1.1 Method 8321A is a general purpose LC/MS or LC/UV environmental method listing a variety of instrument configurations to analyze for a wide variety of classes of compounds. Section 1.2 of the method states that "This method may be applicable to the analysis of other non-volatile or semivolatile compounds." This SOP describes a specific LC/MS configuration (ESI and the negative ion mode). Many of the details in the method for herbicides, pesticides, and dyes do not apply to perchlorate analysis.

18.1.2 Tables 7 and 8 of the method list calibration masses for PEG 400 and PEG 600, which are generally different than the masses listed in Table 5 of this SOP. Table 5 of this SOP includes calibration masses for PEG 800, in addition to the other two.

18.2 Changes from Previous Revision

18.2.1 The scope of the SOP has been expanded to include vegetation. The organic cleanup process is described in Section 11.4.

18.2.2 The use of O-18 labeled perchlorate as an internal standard is now used for all analyses. The previous revision included an external calibration option that has been discontinued. Details concerning the use of the labeled internal standard are added throughout the SOP.

18.2.3 Section 4.2.3 includes an option to perform column cleanups to treat samples containing unusually high concentrations of sulfate or bicarbonate.

18.2.4 A warning about the possibility of perchlorate contamination from lab detergent was added in Section 4.4.

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18.2.5 The Safety Section 5 has been expanded according to STL guidelines.

18.2.6 Sample collection containers in Section 8.1 are changed from 500 mL plastic bottles to 40 mL glass vials.

18.2.7 Control limits for the second source initial calibration verification in Section 10.4 were tightened to 80-120%.

18.2.8 The option to use average response factors for the initial calibration were removed. It is not an option on the current LC/MS/MS data system.

18.2.9 The formulas in Section 13 were updated to reflect calculation by the internal standardization technique.

18.2.10 An ion ratio acceptance criterion for qualitative identification was added to Section 13.1.1.2.

18.2.11 MDL verification requirements were added in Section 14.3.

18.2.12 The Waste Management Section 16 was expanded to describe the flammable waste stream derived from methanol in the eluent.

18.2.13 A reference for the organic cleanup procedure was added in Section 17.3.

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Table 1
HPLC Operating Conditions

Parameter	Setting
Column	Dual sequential Alltech GA-1, 7.5x4.6mm All-Guard cartridge
Column Temperature	35 °C
Eluant Flow Rate	0.5 mL/min
Eluant Identification	A = Water (0.01M NH_4Ac) B = Methanol
Solvent Program	80% A + 20% B Isocratic, 10 min. run time
Injection Volume	50 µL

Table 2
Recommended Mass Spectrometer Operating Conditions

Parameter	Setting
Scan Mode	ESI, Negative Ion
Capillary Current	0.5 Kv
Multiplier Voltage	650 Volts
Desolvation Temperature	450°C
Source Temperature	120°C
Desolvation Gas Flow	800 L/hr
Cone Gas Flow	100 L/hr

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Table 3
Characteristic Ions and Scan Conditions

Analyte	Parent/Daughter Ion (m/z)	Dwell Time (sec)
Perchlorate (Cl^{37})	101 / 85	0.40
Perchlorate (Cl^{35})	99 / 83	0.40

Table 4
Calibration Levels, ug/L

Analytes	Level 1	Level 2	Level 3	Level 4	Level 5	Level 6
Perchlorate	0.1	0.2	0.5	1.0	2.0	5.0

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Table 5 – Calibration Masses for PEG Solution (amu)
89.06
133.09
177.11
221.14
239.15
283.18
327.20
371.23
415.25
459.28
503.31
564.36
608.39
652.41
696.44
740.46
784.49
828.52
872.54
916.57
960.60
1004.62

All ion abundances are 100%.

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Figure 1: Data Review Checklist

STL Denver – LC/MS Data Review Checklist

Analytical SOP #_____ **Lot #** _____

Batch # _____

Review Items	----- Level 1 ----- Yes	No	N/A	Level 2	Comments & Samples Affected
Calibration & Calibration Verification					
1. ICAL date verified?					
2. Sufficient number of calibration points used?					
3. Reasons for removal of points documented?					
4. %RSD or correlation coefficient within acceptable limits?					
5. Isometric pairs checked for correct peak assignment?					
6. Manual integrations documented and checked?					
7. Were ICV criteria met?					
8. Were CCV criteria met?					
9. Were RLV criteria met?					
Client Samples & QC Sample Results					
1. Was the correct analysis performed & project instructions followed?					
2. Was correct SOP and protocol followed?					
3. Was preparation and analysis done within holding times?					
4. Are samples quantitated against correct RF or calibration curve?					
5. Are positive results within calibration range?					
6. Dilutions due to target cpds? ____ Dilutions due to non-targets? ____					
7. Are internal standard (IS) recoveries acceptable?					
8. Are target constitients and surrogates in LCS acceptable?					
9. Are target cpds in method blank < RL? (requires NCM if "no")					
10. Are surrogate recoveries acceptable?					
11. Are fortified sample (MS) recoveries and duplicate precision (RPDs) acceptable?					
12. Manual integrations documented and checked?					
13. Are nonconformances documented on an NCM?					
14. Is the appropriate raw data included?					
15. For soils, is dry-weight flag set correctly in QuantIMS (run query)?					
16. Are all results manually entered into LIMS verified by 2nd person?					

1st Level Reviewer: _____ Date: _____

2nd Level Reviewer: _____ Date: _____

Separatory Funnel Liquid-Liquid Extraction

Reference Method Nos.: **EPA 3510C (EPA 608 and EPA 625)**

Reference: SW-846, Test Methods for Evaluating Solid Waste: Physical/Chemical Methods, EPA SW-846, Update III, 1997.

Test Procedures for the Analysis of Organic Pollutants. Appendix A, Part 136, Code of Federal Regulations. July 1, 1985 edition.

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Copy No. _____

Prepared by:

Name: Kristin Fleming Position: Organic Preparation Supervisor

Signature: Kristin Fleming Date: 7/30/04

Authorized by:

Name: James Todaro Position: Laboratory Director

Signature: James Todaro Date: 7/30/04

ISSUE AMENDMENTS

Changes since last issue:

Section 7.17: Added to include pH paper.

Section 8.1: Eliminated references to Organic-free water.

Section 8.5: Edited baking temperature for Na_2SO_4

Section 8.6: Edited Silica Gel mesh size.

Section 9.2.2: Clarified NOTE.

Section 9.2.6: Split this section into two parts All Extracts and EPH extracts.

Section 9.4.4: Added the Slurry Method of cleanup.

Section 9.5: Added EPH Fractionation procedure.

Section 10.2.3: Modified to account for the analysis of a LCSD.

Table 1: Added column for Final Volume; added Silica Gel cleanup for CT-ETPH analysis; separated out 8081, 8082 and 8082 low level.

Table 2: Modified entire Table. Added Footnote regarding target Aroclors.

Separatory Funnel Liquid-Liquid Extraction

Reference Method Nos.: **EPA 3510C (EPA 608 and EPA 625)**

Reference: SW-846, Test Methods for Evaluating Solid Waste: Physical/Chemical Methods, EPA SW-846, Update III, 1997.

Test Procedures for the Analysis of Organic Pollutants. Appendix A, Part 136, Code of Federal Regulations. July 1, 1985 edition.

1. Scope and Application

Matrices: This method is applicable to aqueous samples.

Definitions: See Alpha Laboratories Quality Manual Appendix A

This method describes the procedure for extracting water-insoluble and lightly water-soluble organic compounds from aqueous samples. The method also describes concentration and extract clean-up techniques suitable for preparing the extract for the various determinative methods listed in Table 1.

The data report packages present the documentation of any method modification related to the samples tested. Depending upon the nature of the modification and the extent of intended use, the laboratory may be required to demonstrate that the modifications will produce equivalent results for the matrix. Approval of all method modifications is by one of the following laboratory personnel before performing the modification: Area Supervisor, Laboratory Services Manager, Laboratory Director, or Quality Assurance Officer.

This method is restricted to use by or under the supervision of trained analysts. Each analyst must demonstrate the ability to generate acceptable results with this method by performing an initial demonstration of capability, analyzing a proficiency test sample and completing the record of training.

After initial demonstration, ongoing demonstration is based on acceptable laboratory performance of at least a quarterly laboratory control sample or acceptable performance from an annual proficiency test sample. A major modification to this procedure requires demonstration of performance. The identification of major method modification requiring performance demonstration is directed by the QA Officer and Laboratory Director on a case-by-case basis.

2. Summary of Method

A measured volume of sample, typically 1 liter, is serially extracted with methylene chloride using a separatory funnel. Depending on the analytes to be detected, it may be necessary to adjust the pH of the aqueous sample prior to extraction (Table 1).

Any water is removed from the sample extract by filtering through a powder funnel containing approximately 20g of anhydrous sodium sulfate. The extract is then concentrated and, as needed, exchanged into a solvent compatible with the cleanup or determinative step being employed. The various cleanup methods used are described in Section 9.4 and summarized in Table 1.

2.1 Method Modifications from Reference

None.

3. Detection Limits

The laboratory follows the procedure found in 40CFR Part 136 to determine the MDLs for the various determinative methods on an annual basis. Details on MDL levels and frequency are in the

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SOPs for the analytical methods. The method detection limits determined by the laboratory are on file for review.

4. Interferences

4.1 The most common cause of contamination is from improperly cleaned glassware and lab supplies. All glassware and re-useable extraction equipment must be scrupulously cleaned, following the cleaning SOP.

4.2 Impurities in solvents and reagents may also yield artifacts and/or interferences that may compromise the results of sample analysis. All of these materials must be demonstrated to free from interferences under the conditions of extract preparation and analysis by preparing method blanks with each extraction batch. The same solvents and reagents are used for the method blank and the associated samples.

4.3 Phthalate esters contaminate many types of products used in the laboratory. Plastic materials must not contact the samples or extracts, as phthalates could be easily leached from the plastic. The exception is in the use of various pre-packed reagent cartridges (Florisil, Silica gel) used in the extract cleanup steps. Each new lot of cartridges is checked for contamination, and is monitored on an on-going basis through the analysis of method blanks.

4.4 Additional specific interference or contamination concerns are addressed in the various analytical SOPs.

5. Safety

The toxicity or carcinogenicity of each reagent and standard used in this method is not fully established; however, each chemical compound should be treated as a potential health hazard. From this viewpoint, exposure to these chemicals must be reduced to the lowest possible level by whatever means available. A reference file of material data handling sheets is available to all personnel involved in the chemical analysis. Additional references to laboratory safety are available in the Chemical Hygiene Plan.

All personnel handling environmental samples known to contain or to have been in contact with municipal waste must follow safety practices for handling known disease causative agents.

5.1 Lab coats, safety glasses, and gloves must be worn when handling samples, extracts, standards or solvents and when washing glassware.

5.2 All extract concentration steps must be performed in the extraction hoods. All solvent and extract transfers must also be handled in the hood.

5.3 All expired stock standards, working standards, and spent sample extracts must be placed into the waste bucket in the lab, for future disposal by the Hazardous Waste Manager. The container must be properly labeled with hazard warning labels indicating the container contents.

5.4 Bottles containing flammable solvents must be stored in the flammables cabinet or in the vented cabinets found under the hoods

5.5 All waste solvents must be transferred to the satellite waste storage containers located in the extraction lab. Separate containers are provided for chlorinated and non-chlorinated solvents and must be used accordingly. Under no circumstances are solvents to be poured down the sink drains.

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5.6 Inspect all glassware prior to use. Do not use any glassware that is chipped, cracked or etched if it could present a safety hazard. Damaged glassware is put aside for repair, otherwise discard the piece. A number is etched onto each KD concentrator tube to keep track of calibration (Refer to SOP/08-04, KD Tube Calibration).

6. Sample Collection, Preservation, and Handling

6.1 Sample Collection and Preservation

Sample collection and preservation requirements are described in the various analytical method SOPs.

6.2 Sample Handling

All aqueous samples are stored, refrigerated, in the Custody Sample Bank. Samples are taken by the analyst immediately prior to sample extraction. The analyst must take custody of the samples by signing them out utilizing the LIMS.

Visually inspect the samples prior to starting the extraction process, as described in Section 9.1. Typically the entire contents of the 1L amber jar is used for extraction. After the sample or sample aliquot is removed, the samples or empty sample containers are returned to the Custody Sample Bank. If there is sample remaining, place in the sample return refrigerator. If the entire sample volume was used, leave the empty sample containers on a cart for disposal by login staff. Custody of the samples is transferred back by signing them back in utilizing the LIMS.

After the extraction is performed, the sample extract is stored in a stoppered KD tube before being transferred to a crimp-top or screw-cap vial for analysis and long term storage.

7. Equipment and Supplies

7.1 Separatory Funnel: 2-Liter, glass or Teflon, with polytetrafluoroethylene (PTFE) stopcock and cap.

7.2 Erlenmeyer Flasks: 250 and 500 mL.

7.3 Centrifuge Tubes.

7.4 Pipets: 1mL.

7.5 Disposable Borosilicate Transfer Pipets.

7.6 Syringes: 100, 250, 500, and 1000µL.

7.7 Powder Funnels.

7.8 Glass wool.

7.9 Water Bath: Heated, with concentric ring cover, with variable temperature control.

7.10 Kuderna-Danish (KD) Apparatus:

7.10.1 Evaporation Flask: 500mL KD flask.

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7.10.2 Concentrator Tube: 25mL, graduated.

7.10.3 3-Ball Macro Snyder Column.

7.10.4 Micro Snyder Column.

7.10.5 Plastic clips.

7.11 Boiling Chips: Solvent extracted, approximately 10/40 mesh (silicon carbide, or equivalent).

7.12 Graduated Cylinders: 25, 50 and 1000 mL.

7.13 Solid Phase Extraction (SPE) Manifold: Visiprep DL SPE vacuum manifold (Supelco Cat # 5-7044), or equivalent.

7.14 Florisil Cartridges: Supelclean LC-Florisil, 1 gram (Supelco Cat #57057), or equivalent.

7.15 Silica Gel (Fractionation) Cartridges: Teflon Inert II, 5 grams/20mL (Burdick & Jackson).

7.16 N-EVAP: Organomation; utilized for micro blowdown.

7.17 pH Paper: Multibanded, wide range.

8. Standards and Reagents

Pesticide or reagent grade chemicals are used in all tests. All reagents conform to the specifications of the Committee on Analytical Reagents of the American Chemical Society, where such specifications are available. Other grades may be used, provided it is first ascertained that the reagent is of sufficiently high purity to permit its use without lessening the accuracy of the determination.

8.1 Reagent Water: All references to water in this method refer to reagent water from Alpha's RO water treatment system.

8.2 Sodium hydroxide solution (25%), NaOH: Dissolve 245g NaOH in reagent water and dilute to 1000mL. Other concentrations of sodium hydroxide may be used to adjust sample pH, provided that the volume added to the aqueous samples does not change the total sample volume by more than 1%.

8.3 Sulfuric Acid: Concentrated.

8.4 Sulfuric acid solution (1:1 v/v), H_2SO_4: Prepare by slowly adding 500mL of concentrated H_2SO_4 to 500mL of reagent water, in a 1-Liter beaker placed in an ice water bath.

8.5 Sodium Sulfate (Na_2SO_4): Granular anhydrous; purified by baking at 400ºC for 4 hours in a shallow tray. Store in closed glass containers. All references to sodium sulfate in this method refer to this prepared reagent.

8.6 Silica Gel: 70 - 230 mesh, chromatography grade.

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8.7 Methylene Chloride: Pesticide quality or equivalent.

8.8 Hexane: Pesticide quality or equivalent.

8.9 Acetone: Pesticide quality or equivalent.

8.10 Spiking Solutions: The various surrogate and LCS/MS spiking solutions used in the extraction steps are listed in Table 2. The preparation of these solutions is described in the analytical SOPs.

9. Procedure

All glassware must be cleaned following the procedure described in the glassware washing SOP. In addition, the glassware must be rinsed with acetone, followed by methylene chloride, just prior to use. The separatory funnels are rinsed with acetone, followed by DCM, prior to use.

9.1 Sample Extraction

9.1.1 Carefully examine the sample prior to beginning the extraction process. The sample should be a single phase, with minimal or no sediment or solid material present. If this is not the case, contact the Prep Supervisor or Organics Manager to determine how to handle the sample. The supervisor may need to contact login or the project manager to determine how the client would like the sample handled. Note all observations and/or deviations from the routine extraction steps in the extraction logbook.

9.1.2 Using a 1-Liter graduated cylinder, measure 1 liter of sample (or reagent water for blanks and LCSs). Alternatively, if the entire contents of the sample bottle are to be extracted, mark the level of sample on the outside of the bottle for volume measurement. If high analyte concentrations are anticipated, a smaller sample volume may be taken and diluted to 1L with reagent water. On occasion, smaller sample volumes may be provided by the client.

9.1.3 Check the pH of the sample with wide-range pH paper and adjust the pH, if necessary, to the pH indicated in Table 1, using the base and acid solutions listed in Sections 8.2 and 8.3. The amount of acid or base required to achieve the desired pH is highly sample dependant, but is typically 5 – 15 mL.

9.1.4 Transfer the sample from the sample container or graduated cylinder into a 2L separatory funnel. Add the appropriate volume(s) of the surrogate spiking solution(s), listed in Table 2, into each sample. Add the appropriate volume(s) of the spiking solutions to the LCS and MS/MSD samples, if required.

9.1.5 If there was no sediment or non-aqueous material present in the sample container, use 60mL of methylene chloride to rinse the sample cylinder (or bottle) and transfer this rinseate into the separatory funnel.

If the sample did contain sediment or solid material that is not considered part of the sample, add 60mL of methylene chloride directly into the separatory funnel. If the sample was transferred directly from the sample bottle, refill the bottle to the mark made in Section 9.1.2 with water and then measure and record the volume of sample that was in the bottle.

9.1.6 Seal and shake the separatory funnel vigorously for 2 minutes with periodic venting to release excess pressure.

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NOTE: *Methylene chloride creates excessive pressure very rapidly, therefore, initial venting should be done immediately after the separatory funnel has been sealed and shaken once. The separatory funnel should be vented into a hood to avoid analyst exposure to solvent vapors.*

9.1.7 Allow the organic layer to separate from the water phase for a minimum of 10 minutes. If the emulsion interface between layers is more than one-third the size of the solvent layer, the analyst must employ mechanical techniques to complete the phase separation. The optimum technique depends upon the sample and may include stirring, filtration of the emulsion through glass wool, centrifugation, addition of sodium chloride, or other physical methods. Filter the extract through a powder funnel packed with glass wool and approximately 20 grams of sodium sulfate, collecting the filtrate in an Erlenmeyer flask labeled with the sample I.D.

9.1.8 Repeat the extraction two more times for 2 minutes each, using fresh portions of solvent (Section 9.1.5 through 9.1.7). Collect all three solvent extract portions in the same labeled Erlenmeyer flask.

9.1.9 If further pH adjustment and extraction is required, adjust the pH of the aqueous phase to the desired pH indicated in Table 1. Serially extract three more times with 60mL of methylene chloride, as outlined in Sections 9.1.5 through 9.1.7. Collect these solvent extract portions in the same labeled Erlenmeyer flask.

9.1.10 The extract is now ready for concentration, cleanup, or analysis, depending on the extent of interferrants and the determinative method to be employed. Refer to Section 9.4 for guidance on selecting appropriate cleanup methods. Excess water present in extracts is removed by filtering the extract through a bed of anhydrous sodium sulfate. Certain cleanup and/or determinative methods may require a solvent exchange prior to cleanup and/or sample analysis.

9.2 Initial Concentration: K-D Technique

9.2.1 Assemble the Kuderna-Danish (KD) apparatus (Section 7.10) by attaching a 25mL KD tube to a 500mL KD flask. Add 1 - 2 boiling chips to the apparatus and label the KD flask with the sample I.D. Add 10mL DCM to the assembled apparatus to check for leaks or cracks prior to transferring the sample (Section 9.2.2).

9.2.2 Pour the extract into a KD flask, labeled with the sample I.D. Rinse the Erlenmeyer flask with approximately 10mL of methylene chloride two times, pouring the rinseate into the funnel.

NOTE: All extracts that are exchanged into Hexane (Table 1) are pretreated with ¼ extract volume of hexane (i.e. if the extract is 40mL, add 10mL Hexane prior to concentration).

9.2.3 Attach a three-ball Snyder column to the top of the flask. Place the KD apparatus on a hot water bath (heated to approximately 80°C) so that the concentrator tube is partially immersed in the hot water, and so that the entire lower rounded surface of the flask is bathed in hot water vapor. Adjust the position of the apparatus as required to complete the concentration in 10 to 20 minutes. At the proper rate of distillation, the balls in the column will actively chatter, but the chambers will not flood with solvent.

9.2.4 If a solvent exchange is required (see Table 1), add 20 to 25mL of the exchange solvent to the top of the Snyder column while the concentrator is still on the water

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bath. Continue with the concentration until the extract volume is reduced to below 10mL.

9.2.5 Remove the KD apparatus from the water bath. Rinse the flask and its lower ground glass joint with 1 to 2 mL of acetone to cool the extract and remove any moisture from the outside of the glassware. Disassemble the KD apparatus. Transcribe sample I.D. onto the KD tube. Rinse the Snyder column and KD flask with methylene chloride and set aside.

9.2.6 **All Extracts** (except for EPH Extracts, proceed to Section 9.2.6.1): Place the KD apparatus on the N-EVAP. The N-EVAP is set at 30 °C with the nitrogen flow at 10. Samples remain on N-EVAP until they are reduced to 1mL. The inside of the KD tube wall is rinsed with 5mL of appropriate solvent, and then reduced back down to 1mL.

9.2.6.1 **EPH Extracts:** Attach a micro-Snyder column. Place the KD apparatus in the hot water bath so that the concentrator tube is partially immersed in the hot water. Closely watch the concentration, adjusting the height of the apparatus as needed to complete the concentration in 5 to 10 minutes.

When the apparent volume reaches 1 mL, remove the KD apparatus from the bath. Rinse the lower half of the KD tube with a small amount of acetone to cool the extract.

9.2.7 The extract is now ready for sample cleanup (if required) or for transfer to the instrument lab(s) for analysis.

9.3 Alternate Concentration Technique

An alternative concentration technique is available, using the Turbovap II, which is a self-contained water bath with nitrogen blow-down. It is equipped with sensors to allow for automatic shutdown when the extract volume goes below 1mL.

This concentration technique may be used if the extract volume is small enough to fit in the Zymark concentration tube. If the extract is dark or viscous, this technique is not recommended, as the extract volume sensor will not function properly.

9.3.1 Quantitatively transfer the extract to the appropriate size Zymark concentration tube. The tube is labeled with the sample I.D. Place the tube into the TurboVap II concentration unit. The water bath is set to 38°C, and the nitrogen pressure is set to 13 psi. Start the nitrogen blow-down by pressing the button on the front panel of the unit.

9.3.2 When the concentration is complete, the nitrogen stream will be automatically shut off. The light on the front panel will flash, and the instrument will beep. Remove the tube from the TurboVap II concentrator, and quantitatively transfer the extract into a labeled screw-cap or crimp-top vial.

9.3.3 The extract is now ready for sample cleanup (if required) or for transfer to instrument lab(s) for analysis.

9.4 Extract Cleanup Procedures

Several different cleanup procedures are used, depending upon the compounds to be determined and the sample matrix. The typical cleanups are described in the sections below, and the applicability to the determinative methods is listed in Table 1. All extract cleanup procedures must be documented in the extraction logbook. If a cleanup procedure

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not described in this SOP is used, describe the cleanup performed in detail on a narrative sheet for inclusion in the client report. Alternative cleanups must be approved by the Section Supervisor or Organics Manager.

9.6.1 Florisil Cleanup

Florisil cleanup is used for all pesticide and pesticide/PCB extracts, and occasionally for PAH only 8270 or 625 extracts. Florisil cartridges are purchased pre-packed from commercial vendors.

9.6.1.1 Place extract collection vials in the SPE vacuum manifold. Screw florisil cartridge onto manifold cover. Start vacuum pump, setting the vacuum to between 15 and 20 psi.

9.6.1.1 Add 4mL of hexane to florisil cartridge to be used to pre-wet the cartridge. Slowly twist cartridge counter-clockwise to open, until hexane begins to drain. Continue to drain the hexane until the level is just above the top of the florisil – do not allow the florisil to go dry. Twist the cartridge clockwise to close and stop the draining. At the correct pressure, the rinse will be complete in approximately 2 minutes.

9.6.1.1 Using a disposable glass pipet or syringe, add the appropriate aliquot of the extract onto the florisil. Twist the cartridge to open, and allow the extract to be drawn onto the head of the cartridge. Stop when the extract level is just at the top of the florisil. Allow the extract to sit on the cartridge for 1 minute.

9.6.1.1 Measure 20mL of the elution solvent (See Table 1 for appropriate solvent) into a 25mL graduated cylinder. Slowly pour, in stages, onto the florisil, under vacuum, to elute the sample extract. Carefully watch the cartridge to ensure that it does not go dry during this step. Collect the entire 20mL extract in the collection vial.

9.6.1.1 The cleaned extract may now be re-concentrated, using the techniques listed in Sections 9.2.6 through 9.2.7, and Section 9.3.

9.6.1 Sulfuric Acid Cleanup

Sulfuric acid cleanup is used to remove organic interfering compounds from PCB extracts. Due to the destructive nature of this cleanup, it is only used for PCB extracts, as PCBs are not destroyed by the acid.

9.6.1.1 Typical PCB extract volumes are 5mL or 1mL of hexane. Transfer 5mL of extract into a labeled 22mL screwcap vial. Set the auto-pipetter on the concentrated sulfuric acid bottle to 5mL or 0.5mL. Slowly add the acid to the sample extract in the vial.

9.6.1.1 Cap the KD tube with the ground glass stopper. Vortex the extract for 5 – 10 seconds, and allow the layers to separate. The top layer is the hexane extract.

9.6.1.1 The extract is now ready for transfer to instrument lab for analysis.

9.6.1 Silica Gel Cleanup

Silica gel cleanup is used to remove interferences from extracts to be analyzed for petroleum hydrocarbons. The silica gel removes many polar compounds such as fatty acids, while allowing the petroleum material to remain in the extract.

9.6.1.1 Dry the extract by passing it through a powder funnel containing approximately 20 grams of sodium sulfate. Collect the filtrate in an Erlenmeyer flask. Add approximately 20 grams of silica gel to the extract. Place the flask on the shaker table, and shake for 20 minutes. The shaking should be vigorous enough to

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ensure good contact of the silica gel with the extract, but not so vigorous that the extract splashes.

9.6.1.1 Rinse a filter funnel with 25mL of appropriate solvent to ensure quantitative transfer of the sample extract. Filter the extract through sodium sulfate to remove the silica gel and any residual water, and collect in the concentration apparatus.

9.4.4 Slurry Method

This cleanup step may be used to remove interferences from sample extracts to be analyzed for ETPH or TPH-8100 SGC.

9.4.4.1 Following Turbovap concentration (Section 9.3), place the Zymark tubes in a fume hood. Using a clean 250µL microdispenser, add approximately 100µL of Silica Gel to each 1mL sample and QC sample, ensuring that the majority of the Silica Gel is placed at the bottom of the Zymark tube. Using a 9-inch disposable glass pipet (Section 7.5), mix the extract and Silica Gel thoroughly, ensuring contact between the sorbent material and the extract.

9.5 Fractionation of EPH Sample Extracts

9.5.1 Sample Preparation

9.5.1.1 Using a transfer pipet and clean Hexane, bring all sample extracts to a volume of 1.0mL.

NOTE: If an extract is to be at a final volume greater than 1.0mL, bring the extract to the appropriate final volume with Hexane. Use a 1mL portion of this final volume for Fractionation. Save the remainder of the extract as in Section 9.6.4.4.

9.5.1.2 Rinse a 1mL syringe with Hexane. Add 1mL FRAC surrogate to the extract and replace the cap.

9.5.2 Glassware Preparation

Label two ZYMARK tubes for each sample: one for ALI (aliphatic / Hexane) and one for ARO (aromatic / DCM). Also, if the sample extract is at a final volume >1mL, write this on the ZYMARK tube.

9.5.3 Manifold and FRAC Cartridge Preparation

9.5.3.1 Place one collection tube into each slot on the manifold unit.

9.5.3.2 Place manifold lid onto the manifold unit.

9.5.3.3 Set up one FRAC cartridge for each sample on the manifold lid, making sure that each one is closed hand tight (do not over tighten).

9.5.3.4 Turn on the vacuum pump and adjust the manifold pressure to 20” Hg.

9.5.3.5 Once the pressure has been adjusted, rinse a graduated cylinder first with Acetone, then DCM.

9.5.3.6 Fill the graduated cyllinder to 15mL with DCM.

9.5.3.7 Open the valve slowly to start the vacuum flow.

9.5.3.8 Add the 15mL DCM to the cartridge. Allow the vacuum to pull the DCM through.

9.5.3.9 Repeat Sections 9.5.3.6 through 9.5.3.8 for each of the 6 cartridges.

9.5.3.10 Turn off the vacuum and release the pressure.

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9.5.3.11 Remove the manifold lid and place it on a beaker.

9.5.3.12 Remove the collection tubes one at a time and place the rinsed DCM into a waste container. Place collection tubes back into the same slots in the manifold unit.

9.5.3.13 Replace the manifold lid with the pre-rinsed cartridges back onto the manifold unit.

9.5.3.14 Rinse a graduated cylinder with Acetone, DCM, then Hexane.

9.5.3.15 Fill the graduated cylinder to 40mL with Hexane.

9.5.3.16 Open the valve slowly to start the vacuum flow.

9.5.3.17 Add the 40mL Hexane to the cartridge. Allow the vacuum to pull the Hexane through.

NOTE: Leave an approximate 1mL layer of Hexane in the cartridge to ensure it will not go dry.

9.5.3.18 Repeat Sections 9.5.3.15 through 9.5.3.17 for each of the 6 cartridges.

9.5.3.19 Turn off the vacuum pump and release the pressure.

9.5.3.20 Remove the manifold lid and place it on a beaker, being careful that the remaining Hexane layer does not spill.

9.5.3.21 Remove the collection tubes one at a time and place the rinsed hexane into a waste container. Place collection tube back into the same slots in the manifold unit.

9.5.3.22 Replace the manifold lid with the pre-rinsed cartridges back onto the manifold unit.

9.5.4 Fractionation Procedure

9.5.4.1 Aliphatic Portion

9.5.4.1.1 Using a transfer pipet, draw sample extract from the KD tube and dispense back into the KD tube a few times to ensure that the extract is thoroughly mixed with the FRAC surrogate added in Section 9.6.1.2.

9.5.4.1.2 Remove a 1mL portion of the mixed extract, and dispense onto a pre-rinsed FRAC cartridge. Leave the remaining 1mL portion in the KD tube.

9.5.4.1.3 After all samples have been dispensed onto pre-rinsed cartridges, turn on the vacuum pump and adjust the manifold pressure to 20" Hg.

9.5.4.1.4 Using the 25mL graduated cylinder (Section 9.6.3.5), fill it with Hexane to the predetermined volume.

9.5.4.1.5 Add a small amount of Hexane into the cartridge with the sample extract, and open the valve to start the vacuum. Add small amounts of Hexane at a time, letting the vacuum draw it through the cartridge.

9.5.4.1.6 Once all of the Hexane has been added from the cylinder, it is important to leave an approximate 1mL layer in the cartridge. ***Do not let the cartridge go dry***.

9.5.4.1.7 Repeat Sections 9.6.4.1.1 – 9.6.4.1.6 for all samples.

9.5.4.1.8 Turn off the vacuum pump and release the pressure.

9.5.4.1.9 Remove the manifold lid and place it on a beaker being careful that the remaining Hexane layer does not spill.

9.5.4.1.10 Remove the collection tubes, one at a time, and pour into the corresponding ZYMARK Tube for Aliphatics. Replace the collection tube into the same slot on the manifold.

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9.5.4.1.11 Replace the manifold lid onto the manifold unit.

9.5.4.1.12 Place the Aliphatic ZYMARK tubes into the TurboVap and allow to concentrate to 1mL at a pressure of 7psi and temperature of 35 °C.

9.5.4.2 Aromatic Portion

9.5.4.2.1 Turn on the vacuum pump and adjust the manifold pressure to 20" Hg.

9.5.4.2.2 Rinse a 25mL graduated cylinder with Acetone, then with DCM. Fill with 20mL of DCM.

9.5.4.2.3 Add a small amount of DCM into the cartridge and open the valve to start the vacuum. Add small amounts of DCM at a time, allowing the vacuum to draw the DCM through the cartridge.

9.5.4.2.4 Once all of the DCM has been added from the cylinder, it is important to leave an approximate 1mL layer in the cartridge. ***Do not let the cartridge go dry***.

9.5.4.2.5 Repeat Sections 9.6.4.2.1 – 9.6.4.2.4 for all samples.

9.5.4.2.6 Turn off the vacuum pump and release the pressure.

9.5.4.2.7 Remove the manifold lid and place it on a beaker being careful that the remaining DCM layer does not spill.

9.5.4.2.8 Remove the collection tubes, one at a time, and pour into the corresponding ZYMARK Tube for Aromatics.

9.5.4.2.9 Place the Aromatic ZYMARK tubes into the TurboVap and allow to concentrate to 1mL at a pressure of 7psi and temperature of 35 °C.

9.5.4.3 Cleanup of Manifold Unit

9.5.4.3.1 Remove the spent cartridges from the manifold unit.

9.5.4.3.2 Open all valves. Rinse the inside of the valves with DCM and then with Hexane.

9.5.4.3.3 Rinse all collection tubes with DCM and then with Hexane.

9.5.4.4 Storage of Remaining Extracts

9.5.4.4.1 Label a 1.5mL screwcap vial with the sample ID. If the sample extract is at a final volume, be sure to also write this on the vial.

9.5.4.4.2 Using a fresh transfer pipet for each sample, transfer the sample extract from the KD tube into the corresponding screwcap vial.

9.5.4.4.3 Place the 1.5mL vial(s) into a Wheaton vial storage box and mapped on the sheet.

9.5.4.4.4 Store sample extracts in the refrigerator at 4±2 °C for a minimum of 40 days..

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9.6 Instrument Maintenance

9.6.1 Turbovap II Concentrators

9.6.1.1 Maintain the level of the water bath by adding water daily to fill. Add 4 – 5 drops of Clear Bath weekly to keep water clear. This will extend the life of the extract level sensors in the bath.

9.6.1.2 Keep unit clean. Avoid solvent spills on or around unit. Clean periodically with a damp cloth.

9.6.1.3 Sensor calibration checks should be performed at least annually, or when sensor failures are suspected.

9.6.2 Water Bath

9.6.2.1 The water bath should be kept full at all times. Add reagent water as necessary.

9.6.2.2 Keep unit clean. Avoid solvent spills on or around unit. Clean periodically with a damp cloth.

10. Quality Control and Data Assessment

The laboratory maintains records to document the quality of data that is generated. Ongoing data quality checks are compared with established performance criteria to determine if the results of analyses meet the performance characteristics of the method.

10.1 Demonstration of Capability

The analyst must make an initial, one-time, demonstration of the ability to generate acceptable accuracy and precision with this method. Each time a method modification is made, the analyst is required to repeat the procedure.

Extraction IDCs are performed in conjunction with the analytical methods. See analytical SOPs for specifics on IDC requirements and acceptance criteria.

10.2 Extraction QC Elements

Each extraction batch contains various QC samples used to ensure the validity of the sample results. The particular QC elements performed for a given extraction batch are determined by the requirements of the determinative method. The purpose and definition of the QC samples performed are listed below. The specific QC requirements of the analytical methods are listed in Table 2.

10.2.1 Surrogates

Surrogates are compounds specified by the analytical method that are added to all samples and QC samples prior to beginning the extraction process. Surrogate recoveries are calculated and serve as a sample specific quantitative check of the extraction. The various spiking solutions are prepared according to the directions found in the analytical SOPs. The required solutions and volumes used are listed in Table 2.

10.2.2 Blank

Blanks, or method blanks, are measured aliquots of reagent water (for aqueous extractions) that are treated identically to the associated samples. Surrogates are added, and the blanks are carried through all stages of the sample extraction, concentration, and cleanup procedures. Blanks serve to ensure that no systematic contamination exists. A blank is extracted with each batch or 20 or less samples.

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10.2.3 Laboratory Control Sample / Laboratory Control Sample Duplicate (LCS/LCSD)

LCS samples are measured aliquots of reagent water (for aqueous extractions) that are spiked with a solution containing known amounts of target compounds, in addition to the surrogate solution. The LCS is carried through all stages of the sample extraction, concentration, and cleanup procedures. LCS samples serve as batch specific quantitative checks of the extraction. An LCS is extracted with each batch of 20 or less samples.

An LCSD is performed in addition to an LCS for all Massachusetts Contingency Plan (MCP) methods, as well as in lieu of the MS/MSD or Duplicate when there is insufficient sample volume available. The required solutions and volumes are listed in Table 2.

10.2.4 Duplicate

Duplicates are laboratory selected replicate samples, prepared by taking an additional sample aliquot of a sample. The duplicate is carried through all stages of the sample extraction, concentration, and cleanup procedures. Duplicates serve as a measure of the extraction precision, by comparing the results of the sample and duplicate.

10.2.5 Matrix Spike/Matrix Spike duplicate (MS/MSD)

MS and MSDs are field samples spiked with a known quantity of the target analyte(s). They are prepared by taking additional sample aliquots, and adding the appropriate amounts of surrogate and spiking solutions. The MS/MSD are carried through all stages of the sample extraction, concentration, and cleanup procedures. MS samples serve as a measure of extraction accuracy, by allowing the comparison of the found amount(s) of target analyte(s) with the spiked amount(s). An MS/MSD set also allows for the calculation of the extraction precision, by comparing the results of the two samples.

11. Method Performance

Method performance data is on file in the laboratory QC department. Comparison of method performance data for the laboratory to the reference method criteria occurs when laboratory in-house acceptance limits are generated. In-house generated data must be within the specifications of the reference method or the analysis is not continued until corrective action is completed.

The performance of this method is evaluated on an on-going basis by the QC criteria listed in the analytical SOPs. Specifically surrogates, blanks, LCSs, MS/MSDs, and duplicates are all used to ensure that the method is producing results of consistently high quality. In addition, Alpha participates in several blind and double blind PE studies annually to demonstrate the ability of this method to produce accurate and reproducible data.

12. Corrective Actions

Holding time exceedence, improper preservation and observed sample headspace are noted on the nonconformance report form.

When analysis of samples indicates possible extraction problems, such as poor surrogate recoveries, poor LCS/MS/MSD recoveries, or suspected contamination in blanks or samples, re-extractions are required. Depending on the particular failure, the re-extraction may be of a specific sample or the entire extraction batch.

The analyst that determines the need for re-extraction must fill out a sample re-extract request form. This form notes the reason for the re-extraction request along with any special requirements, and the date and time that the re-extract is needed. Re-extraction request forms are maintained on

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file to help track the cause for re-extractions, and to be used as a tool in improving systems to minimize the need for re-extractions.

Depending on the results of the re-extraction, the first, second, or both sets of results may be reported to the client, along with a narrative report detailing the problems encountered and the resolution.

13. Pollution Prevention

See Chemical Hygiene Plan for pollution prevention operations.

14. Waste Management

See Chemical Hygiene Plan for waste handling and disposal.

15. Attachments

Table 1 – Specific Extraction Conditions for Various Determinative Methods
Table 2 – Liquid Extraction Guide

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Table 1

Specific Extraction Conditions for Various Determinative Methods

Determinative Method	Initial Extraction pH	Secondary Extraction pH	Extraction Solvent	Exchange Solvent Required	Final Volume	Appropriate Cleanup Technique
8081	5 – 9	None	DCM	Hexane	1 mL	Florisil [b]
8082	5 – 9	None	DCM	Hexane	5 mL	Sulfuric acid
8082 Low Level	5 – 9	None	DCM	Hexane	1mL	Sulfuric acid
608	5 – 9	None	DCM	Hexane	1 mL	Florisil [b]
8270 [a]	< 2	> 11	DCM	n/a	1 mL	n/a
625 [a]	< 2	> 11	DCM	n/a	1 mL	n/a
8100	As received	None	DCM	n/a	1 mL	n/a
8100-SGC	As received	None	DCM	n/a	1 mL	Silica Gel
TPH-DRO	As received	None	DCM	n/a	1 mL	n/a
MA-EPH	< 2	None	DCM	Hexane	1 mL	Silica Gel Fractionation
CT-ETPH	As received	None	DCM	n/a	1 mL	Silica Gel

[a] **8270 and 625 methods are for extraction of both acidic and base/neutral compounds. If only acid compounds (i.e. phenols) are required, the basic extraction is eliminated. If only basic compounds (i.e. PAHs) are required, the acidic extraction is eliminated.**

[b] **The elution solvent for the florisil cleaning step is hexane/acetone (9:1). If this cleaning method is used for PAH only samples, the solvent is hexane/ether (8:2).**

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Table 2

Liquid Extraction Guide

Analytical Method	QC *	Surrogate Solution	LCS/LCSD MS/MSD Solution	Solvent	pH (Acid/Base /Neutral)
625	WB, LCS, MS, Dup	1mL ABN	1mL ABN	DCM	A/B
625-AEXT	WB, LCS, MS, Dup	1mL ABN	1mL ABN	DCM	A
625-BNEXT	WB, LCS, MS, Dup	1mL ABN	1mL ABN	DCM	A
625-PHT	WB, LCS, MS, Dup	1mL ABN	1mL ABN	DCM	A
608 PCB/PEST	WB, LCS, MS, Dup	1mL PEST	1mL PEST	DCM	N
608-PCB	WB, LCS, MS, Dup	1mL PEST	1mL PCB	DCM	N
8270	WB, LCS, MS, MSD	1mL ABN	1mL ABN	DCM	A/B
PAH	WB, LCS, MS, MSD	1mL ABN	1mL ABN	DCM	A
PAH-Low	WB, LCS, MS, MSD	1mL ABN	1mL ABN	DCM	A
MCP 8270	WB, LCS, LCSD	1mL ABN	1mL MCP ABN	DCM	A/B
MCP PAH	WB, LCS, LCSD	1mL ABN	1mL MCP ABN	DCM	A
MCP PAH-L	WB, LCS, LCSD	1mL ABN	1mL MCP PAH-L	DCM	A
PEST	WB, LCS, MS, MSD	1mL PEST	1mL PEST	DCM	N
PEST-LL	WB, LCS, MS, MSD	250µL PEST	250µL PEST	DCM	N
MCP PEST-LL	WB, LCS, LCSD	250µL PEST	250µL PEST	DCM	N
MCP PEST	WB, LCS, LCSD	1mL PEST	1mL PEST	DCM	N
PCB	WB, LCS, MS, MSD	1mL PEST	1mL PCB	DCM	N
PCB-LL	WB, LCS, MS, MSD	250µL PEST	250µL PCB	DCM	N
MCP PCB-LL	WB, LCS, LCSD	250µL PEST	250µL PCB	DCM	N
MCP PCB	WB, LCS, LCSD	1mL PEST	1mL PCB	DCM	N
EPH	WB, LCS, LCSD, Dup	1mL EPH	1mL EPH	DCM	A
EPH/PAH-LOW	WB, LCS, LCSD, Dup	1mL EPH	1mL EPH	DCM	A
EPH/TPH	WB, LCS, LCSD, Dup	1mL EPH	1mL EPH	DCM	A
PETRO	WB, LCS, Dup	1mL DRO	1mL ETPH	DCM	N
TPH-DRO	WB, LCS, Dup	1mL DRO	1mL ETPH	DCM	N
TPH-8100 SGC	WB, LCS, Dup	1mL DRO	1mL ETPH	DCM	N
ETPH	WB, LCS, MS, Dup	1mL DRO	1mL ETPH	DCM	N
HERB RCRA	WB, LCS, MS, MSD	1mL HERB	1mL HERB	ETHER	A/B/A
HERB 8151	WB, LCS, MS, MSD	1mL HERB	1mL HERB	ETHER	A/B/A
HERB TCLP	WB, LCS, MS, MSD	1mL HERB	1mL HERB	ETHER	A/B/A
ABN-TCLP	WB, LCS, MS, MSD	1mL ABN	1mL TCLP ABN	DCM	A/B

*** For Projects where target Aroclors are known to be present, a laboratory Duplicate will be performed in lieu of the MSD.**

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Soxhlet Extraction

Reference Method No.: **EPA Method 3540C**

Reference: SW-846, Test Methods for Evaluating Solid Waste:
Physical/Chemical Methods, EPA SW-846, Update III, 1997.

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Prepared by:

Name: Kristin Fleming Position: Organic Prep Supervisor

Signature: Kristin Fleming Date: 7/30/04

Authorized by:

Name: James Todaro Position: Laboratory Director

Signature: James Todaro Date: 7/30/04

ISSUE AMENDMENTS

Changes since last issue:

Section 2.0: Changed typical amount of sample to be 15 grams.
Section 7.1: Divided into two sections to account for both sizes of soxhlet extractors.
Section 7.6: Edited the size of the extraction thimbles.
Section 7.8: Changed beaker sizes.
Section 7.10.1: Added that the Concentrator Tube is calibrated
Section 7.14: Added Microdispenser.
Section 7.18: Edited the Glass wool specifications.
Section 7.22: Edited the Silica Gel Cartridge specifications.
Section 7.24: Added TurboVap. Deleted reference to the Zymark Concentrator.
Section 7.26: Added Zymark Tubes.
Section 8.1: Eliminated references to Organic-free water
Section 8.2: Edited baking temperature for Na_2SO_4.
Section 8.3: Edited Silica Gel mesh size.
Section 8.4: Added Ottawa Sand.
Section 9.1.2: Clarified the homogenization of samples. Changed typical amount of sample to be 15 grams.
Section 9.2.3: Added turning on of condenser unit.
Section 9.3.2: Modified to state that all samples are filtered through Na_2SO_3. Also clarified NOTE.
Section 9.3.6: Split this section into two parts All Extracts and EPH extracts.
Section 9.5.4: Added the Slurry Method of cleanup.
Section 9.6: Added EPH Fractionation procedure.
Section 10.2.3: Modified to account for the analysis of a LCSD.
Table 1: Added Silica Gel cleanup for CT-ETPH analysis; separated out 8081, 8082 and 8082 low level.

Soxhlet Extraction

Reference Method No.: **EPA Method 3540C**

Reference: SW-846, Test Methods for Evaluating Solid Waste:
Physical/Chemical Methods, EPA SW-846, Update III, 1997.

1. Scope and Application

Matrices: This method is applicable to solids, soils, and sludges.

Definitions: See Alpha Laboratories Quality Manual Appendix A.

This method is applicable to the extraction of semivolatile organic compounds from solids such as soils, sludges, and wastes. The Soxhlet extraction procedure ensures intimate contact of the sample matrix with the extraction solvent.

This method is applicable to the extraction of a variety of semivolatile organic compounds, which are then be analyzed by the appropriate chromatographic procedure(s).

The data report packages present the documentation of any method modification related to the samples tested. Depending upon the nature of the modification and the extent of intended use, the laboratory may be required to demonstrate that the modifications will produce equivalent results for the matrix. Approval of all method modifications is by one of the following laboratory personnel before performing the modification: Area Supervisor, Laboratory Services Manager, Laboratory Director, or Quality Assurance Officer.

This method is restricted to use by or under the supervision of trained analysts. Each analyst must demonstrate the ability to generate acceptable results with this method by performing an initial demonstration of capability, analyzing a proficiency test sample and completing the record of training.

After initial demonstration, ongoing demonstration is based on acceptable laboratory performance of at least a quarterly laboratory control sample or acceptable performance from an annual proficiency test sample. A major modification to this procedure requires demonstration of performance. The identification of major method modification requiring performance demonstration is directed by the QA Officer and Laboratory Director on a case-by-case basis.

2. Summary of Method

Weighed samples, typically 15 grams, are prepared for extraction by mixing the sample with anhydrous sodium sulfate until the sample is free-flowing. The sample is then placed in an extraction thimble and extracted using the appropriate solvent (Table 1) in a Soxhlet extractor. The extract is allowed to cool prior to proceeding with additional extract preparation steps.

Any water is removed from the sample extract by filtering through a powder funnel containing approximately 20g of anhydrous sodium sulfate. The extract is then concentrated and, as needed, exchanged into a solvent compatible with the cleanup or determinative step being employed. The various cleanup methods used are described in Section 9.5 and summarized in Table 1.

2.1 Method Modifications from Reference

None.

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3. Detection Limits

The laboratory follows the procedure found in 40CFR Part 136 to determine the MDLs for the various determinative methods on an annual basis. Details on MDL levels and frequency are in the SOPs for the determinative methods. The method detection limits determined by the laboratory are on file for review.

4. Interferences

4.1 The most common cause of contamination is from improperly cleaned glassware and lab supplies. All glassware and re-useable extraction equipment (i.e. spatulas) must be scrupulously cleaned, following the cleaning SOP.

4.2 Impurities in solvents and reagents may also yield artifacts and/or interferences that may compromise the results of sample analysis. All of these materials must be demonstrated to free from interferences under the conditions of extract preparation and analysis by preparing method blanks with each extraction batch. The same solvents and reagents are used for the method blank and the associated samples.

4.3 Phthalate esters contaminate many types of products used in the laboratory. Plastic materials must not contact the samples or extracts, as phthalates could be easily leached from the plastic. The exception is in the use of various pre-packed reagent cartridges (Florisil, Silica gel) used in the extract cleanup steps. Each new lot of cartridges is checked for contamination, and is monitored on an on-going basis through the analysis of method blanks. The extraction thimbles are especially prone to contain phthalate contaminants, and are therefore extracted for 4 hours prior to use with 1:1 Acetone/DCM to remove excessive phthalate contamination.

4.4 Additional specific interference or contamination concerns are addressed in the various analytical SOPs.

5. Safety

The toxicity or carcinogenicity of each reagent and standard used in this method is not fully established; however, each chemical compound should be treated as a potential health hazard. From this viewpoint, exposure to these chemicals must be reduced to the lowest possible level by whatever means available. A reference file of material data handling sheets is available to all personnel involved in the chemical analysis. Additional references to laboratory safety are available in the Chemical Hygiene Plan.

All personnel handling environmental samples known to contain or to have been in contact with municipal waste must follow safety practices for handling known disease causative agents.

5.1 Lab coats, safety glasses, and gloves must be worn when handling samples, extracts, standards or solvents and when washing glassware.

5.2 All extract concentration steps must be performed in the extraction hoods. All solvent and extract transfers must also be handled in the hood.

5.3 All expired stock standards, working standards, and spent sample extracts must be placed into the waste bucket in the lab, for future disposal by the Hazardous Waste Manager. The container must be properly labeled with hazard warning labels indicating the container contents.

5.4 Bottles containing flammable solvents must be stored in the flammables cabinet or in the vented cabinets found under the hoods

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5.5 All waste solvents must be transferred to the satellite waste storage containers located in the extraction lab. Separate containers are provided for chlorinated and non-chlorinated solvents and must be used accordingly. Under no circumstances are solvents to be poured down the sink drains.

5.6 Inspect all glassware prior to use. Do not use any glassware that is chipped, cracked or etched if it could present a safety hazard. Damaged glassware is put aside for repair, otherwise discard the piece. A number is etched onto each KD concentrator tube to keep track of calibration (Refer to SOP/08-04, KD Tube Calibration).

6. Sample Collection, Preservation, and Handling

6.1 Sample Collection and Preservation

Sample collection and preservation requirements are described in the various analytical method SOPs.

6.2 Sample Handling

All soil samples are stored, refrigerated, in the Custody Sample Bank. Samples are taken by the analyst immediately prior to sample extraction. The analyst must take custody of the samples by signing them out utilizing the LIMS.

All samples must be fully homogenized prior to taking the sample aliquot, as described in Section 9.1. After the sample aliquot is removed, the samples are returned to the Sample Bank and placed in the sample return refrigerator. Custody of the samples is transferred back by signing them back in utilizing the LIMS.

After the extraction is performed, the sample extract is stored in a stoppered KD tube before being transferred to a crimp-top or screw-cap vial for analysis and long term storage.

7. Equipment and Supplies

7.1 Small Soxhlet Extractor: 45/50, with 250mL or 300mL round bottom flask.

7.2 Large Soxhlet Extractor: 55/50, with 500mL round bottom flask.

7.3 Refrigerated Water Recirculator: Neslab CFT-75 or equivalent. Allows solvents to cool in the condenser while extracting.

7.4 Analytical Balance: Capable of weighing to 0.1g.

7.5 Heating Mantle: Rheostat controlled.

7.6 Extraction Thimbles: (33 x 800mm, 43 x 123mm) Whatman 2800-338, 2800-432. Contaminant-free. Extracted prior to use, see Section 4.3.

7.7 Spatulas: Stainless steel.

7.8 Beakers: 250mL, 400mL.

7.9 Mortar and Pestle: Capable of reducing particle size to <1mm.

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7.10 Kuderna-Danish (K-D) apparatus:

7.10.1 Concentrator tube: 25mL, graduated and calibrated. A ground-glass stopper is used to prevent evaporation of extracts.

7.10.2 Evaporation flask: 500mL. Attach to concentrator tube with springs, clamps, or equivalent.

7.10.3 Snyder column: Three-ball macro.

7.10.4 Snyder column: Micro.

7.10.5 Plastic clamps

7.11 Water Bath: Heated, with concentric ring cover, capable of temperature control (± 5°C). The bath should be used in a hood.

7.12 Boiling Chips: Solvent-extracted, approximately 10/40 mesh (silicon carbide or equivalent).

7.13 Vials: Glass, 2mL capacity, with PTFE-lined screw or crimp top.

7.14 Microdispenser: 250µL, Teflon tip with disposable tube.

7.15 Disposable Borosilicate Transfer Pipets.

7.16 Syringes: 100, 250, 500, 1000µL

7.17 Powder Funnel.

7.18 Glass wool: SUPELCO, silane treated.

7.19 Graduated Cylinder: 25 and 50mL.

7.20 Solid Phase Extraction (SPE) Manifold: Visiprep DL SPE vacuum manifold (Supelco Cat # 5-7044), or equivalent.

7.21 Florisil Cartridges: Supelclean LC-Florisil, 1 gram (Supelco Cat #57057), or equivalent.

7.22 Silica Gel (Fractionation) Cartridges: Teflon Inert II, 5 grams/20mL (Burdick & Jackson).

7.23 N-EVAP: Organomation; utilized for micro blowdown.

7.24 Turbo Vap II: Auto-concentrator; Caliper Life Sciences.

7.25 Zymark Tubes: 50mL or 200mL, calibrated

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8. Standards and Reagents

Reagent grade inorganic chemicals are used in all tests. All reagents shall conform to the specifications of the Committee on Analytical Reagents of the American Chemical Society, where such specifications are available. Other grades are used, provided it is first ascertained that the reagent is of sufficiently high purity to permit its use without lessening the accuracy of the determination.

8.1 Reagent Water: All references to water in this method refer to reagent water from Alpha's RO water treatment system.

8.2 Sodium Sulfate (Na_2SO_4): Granular anhydrous; purified by baking at 400ºC for 4 hours in a shallow tray. Store in closed glass containers. All references to sodium sulfate in this method refer to this prepared reagent.

8.3 Silica Gel: 70 - 230 mesh, chromatography grade.

8.4 Ottawa Sand: 20 – 20 mesh, baked at 400 °C for 4 hours.

8.5 Methylene Chloride: Pesticide quality or equivalent.

8.6 Hexane: Pesticide quality or equivalent.

8.7 Acetone: Pesticide quality or equivalent.

8.8 Sulfuric Acid: Concentrated.

8.9 Nitrogen Gas: Reagent grade, used to purge and pressurize the extraction cell and as the blow-down gas in the Turbovap II auto-concentrator units and the N-EVAP.

8.10 Spiking Solutions: The various surrogate and LCS/MS spiking solutions used in the extraction steps are listed in Table 2. The preparation of these solutions is described in the analytical SOPs.

9. Procedure

All extraction information is recorded by the analyst performing the work in the appropriate extraction logbook. This is done at the time that the work is performed. In addition to recording the extraction and concentration information, the analyst must note any observations, deviations from the procedure, or difficulties encountered with the samples in the comment section of the logbook. All notations in the extraction logbooks must be legible, and all corrections must be done using a single-line cross-out, initialed by the analyst performing the correction.

9.1 Sample Preparation

9.1.1 Before starting the extraction process, each soil or sediment sample should be visually inspected. If a sample contains a significant amount of free water, the analyst must contact login or the project manager to determine if the water is to be considered part of the sample. If the water is not to be homogenized with the solid material, decant and discard the water layer. Record this in the extraction logbook.

Any artifacts (rocks, leaves, sticks, or similar materials) are not typically considered part of the soil sample and should not be included. If necessary, transfer these artifacts to another container prior to homogenizing the sample. Note the presence of sample artifacts in the extraction logbook. Gummy, fibrous, or oily materials not

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amenable to grinding should be cut, shredded, or otherwise reduced in size to allow mixing and maximum exposure of the sample surfaces for the extraction. The addition of anhydrous sodium sulfate to the sample (1:1) may make the mixture amenable to grinding. If this needs to be done, weigh the sample prior to addition of the sodium sulfate.

9.1.2 Homogenize the sample well by mixing the entire contents of the sample container. In instances where the sample container is filled to the top and packed in tightly, the entire sample contents are emptied into a larger glass container (400mL glass beaker) and homogenized. If this is difficult due to sample matrix, describe the non-homogeneity in the extraction logbook. Weigh out the appropriate amount of sample, typically 15.0 grams, into a 300mL beaker. Add approximately 15g anhydrous sodium sulfate to the beaker and mix with a spatula until a free flowing powder is obtained. For samples that contain higher amounts of water or organic matter, larger amounts of sodium sulfate may be required. Certain samples may require grinding with a mortar and pestle to achieve the free flowing consistency.

9.2 Sample Extraction

9.2.1 The analyst must demonstrate that all parts of the equipment in contact with the sample and reagents are interference-free. This is accomplished through the analysis of a solid matrix (Na_2SO_4) Method Blank. A Method Blank is extracted with each batch of 20 or less samples. The samples are transferred to the soxhlet extraction thimbles. The sample must be added so that the soxhlet will drain freely for the duration of the extraction period.

9.2.2 Add the appropriate volume(s) of surrogate and spike solution(s) listed in Table 2 to the samples and QC samples.

9.2.3 Pour approximately 200mL of the extraction solvent (Section Table 1) into a 250mL or 300mL round bottom flask containing one or two clean boiling chips. Label the flask with the sample I.D. Attach the flask to the extractor and extract the sample for 16 – 18 hours at 6 cycles/hour. Turn on the condenser for the entire extraction and cooling time.

9.2.4 Allow the extract to cool after the extraction is complete.

9.2.5 After the extract has cooled, drain the solvent into the round bottom flask. Tip the Soxhlet to empty, collecting the thimble and the sample in a drying pan. Rinse the Soxhlet with solvent if any residual sample is present. Place the drying pan and Soxhlets in the hood to allow solvent to evaporate. Once dry, the thimbles and samples are disposed of in the waste barrels. Prior to next use, bake the Soxhlet extractors in a drying kiln for 4-8 hours, or thoroughly rinse with DCM.

9.3 Sample Concentration

9.3.1 Assemble the Kuderna-Danish (KD) apparatus (Section 7.14) by attaching a 25mL KD tube to a 500mL KD flask. Add 1 - 2 boiling chips to the apparatus and label the KD flask with the sample I.D. Add 10mL DCM to the assembled apparatus to check for leaks or cracks prior to transferring the sample (Section 9.3.2).

9.3.2 Dry the extract by passing it through a powder funnel containing 20g of sodium sulfate. Collect the filtrate in the KD flask. Rinse the round bottom flask with approximately 10mL of methylene chloride two times, pouring the rinseate into the funnel. Using a squirt bottle containing methylene chloride, gently spray the sodium sulfate with approximately 20mL of solvent to complete the quantitative transfer.

NOTE: All extracts that are exchanged into Hexane (Table 1) are pretreated with ¼ extract volume of Hexane (i.e. if the soil extract is 40mL, add 10mL Hexane prior to concentration).

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9.3.3 Attach a three-ball Snyder column to the top of the flask. Place the KD apparatus on a hot water bath (heated to approximately 80°C) so that the concentrator tube is partially immersed in the hot water, and so that the entire lower rounded surface of the flask is bathed in hot water vapor. Adjust the position of the apparatus as required to complete the concentration in 10 to 20 minutes. At the proper rate of distillation, the balls in the column will actively chatter, but the chambers will not flood with solvent.

9.3.4 If a solvent exchange is required (see Table1), add 25mL of the exchange solvent to the top of the Snyder column while the concentrator is still on the water bath. Continue with the concentration until the extract volume is reduced to below 10mL.

9.3.5 Remove the KD apparatus from the water bath. Rinse the flask and its lower ground glass joint with 1 to 2 mL of acetone to cool the extract and remove any moisture from the outside of the glassware.

9.3.6 **All Extracts** (except for EPH Extracts, proceed to Section 9.3.6.1): Place the KD apparatus on the N-EVAP. The N-EVAP is set at 30 °C with the nitrogen flow at 10. Samples remain on N-EVAP until they are reduced to 1mL. The inside of the KD tube wall is rinsed with 5mL of appropriate solvent, and then reduced back down to 1mL.

9.3.6.1 **EPH Extracts:** Attach a micro-Snyder column. Place the KD apparatus in the hot water bath so that the concentrator tube is partially immersed in the hot water. Closely watch the concentration, adjusting the height of the apparatus as needed to complete the concentration in 5 to 10 minutes.

When the apparent volume reaches 1mL, remove the KD apparatus from the bath. Rinse the lower half of the KD tube with a small amount of acetone to cool the extract.

9.3.7 The extract is now ready for sample cleanup (if required) or for transfer to the instrument lab(s) for analysis.

9.4 Alternate Concentration Technique

An alternative concentration technique is available, and may be used if the extract volume is sufficiently low and the extract is not overly dark or viscous. The equipment used is the Zymark Turbovap II, which is a self-contained water bath with nitrogen blow-down. It is equipped with sensors to allow for automatic shutdown when the extract volume goes below 1mL. This technique is mainly used for TPH-8100, ETPH and TPH-DRO extracts.

Quantitatively transfer the extract to the appropriate size Zymark concentration tube. The tube is labeled with the sample I.D. Place the tube into the Zymark concentration unit. The water bath is set to 38°C, and the nitrogen pressure is set to 13 psi. Start the nitrogen blow-down by pressing the button on the front panel of the unit.

9.4.1 When the concentration is complete, the nitrogen stream will be automatically shut off. The light on the front panel will flash, and the instrument will beep. Remove the tube from the Zymark concentrator, and quantitatively transfer the extract into a labeled screw-cap or crimp-top vial. The interior walls of the Zymark tube are rinsed with solvent.

9.4.2 The extract is now ready for sample cleanup (if required) or for transfer to instrument lab(s) for analysis.

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9.5 Extract Cleanup Procedures

Several different cleanup procedures are used, depending upon the compounds to be determined and the sample matrix. The typical cleanups are described in the sections below, and the applicability to the determinative methods is listed in Table 1. All extract cleanup procedures must be documented in the extraction logbook. If a cleanup procedure not described in this SOP is used, describe the cleanup performed in detail on a narrative sheet for inclusion in the client report. Alternative cleanups must be approved by the Section Supervisor or Organics Manager.

9.5.1 Florisil Cleanup

Florisil cleanup is used for all pesticide and pesticide/PCB extracts, and occasionally for PAH only 8270 extracts. Florisil cartridges are usually purchased pre-packed from commercial vendors.

9.5.1.1 Place extract collection vials in the SPE vacuum manifold. Screw florisil cartridge onto manifold cover. Fill each cartridge with Hexane. Start the vacuum pump, setting the vacuum to between 15 and 20 psi.

9.5.1.2 Add 4mL of hexane to florisil cartridge to be used to pre-wet the cartridge. Slowly twist cartridge counter-clockwise to open, until hexane begins to drain. Continue to drain the hexane until the level is just above the top of the florisil – do not allow the florisil to go dry. Twist the cartridge clockwise to close and stop the draining. At the correct pressure, the rinse will be complete in approximately 2 minutes.

9.5.1.3 Using a disposable glass pipet or syringe, add the appropriate aliquot of the extract onto the florisil. Twist the cartridge to open, and allow the extract to be drawn onto the head of the cartridge. Stop when the extract level is just at the top of the florisil. Allow the extract to sit on the cartridge for 1.5 minutes.

9.5.1.4 Measure 20mL of the elution solvent (See Table 1 for appropriate solvent) into a 25mL graduated cylinder. Slowly pour, in stages, onto the florisil, under vacuum, to elute the sample extract. Carefully watch the cartridge to ensure that it does not go dry during this step. Collect the entire 20mL extract in the collection vial.

9.5.1.5 The cleaned extract may now be re-concentrated, using the techniques listed in Sections 9.3.3 through 9.3.7, and Section 9.4.

9.5.2 Sulfuric Acid Cleanup

Sulfuric acid cleanup is used to remove organic interfering compounds from PCB extracts. Due to the destructive nature of this cleanup, it is only used for PCB extracts, as PCBs are not destroyed by the acid.

9.5.2.1 Typical PCB extract volumes are 5mL or 1mL of hexane. Transfer 5mL of extract into a labeled 22mL screwcap vial. Set the auto-pipetter on the concentrated sulfuric acid bottle to 5mL or 0.5mL. Slowly add the acid to the sample extract in the vial.

9.5.2.2 Cap the KD tube with the ground glass stopper. Vortex the extract for 5 – 10 seconds, and allow the layers to separate. The top layer is the hexane extract.

9.5.2.3 The extract is now ready for transfer to instrument lab for analysis.

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9.5.3 Silica Gel Cleanup

Silica gel cleanup is used to remove interferences from extracts to be analyzed for petroleum hydrocarbons. The silica gel removes many polar compounds such as fatty acids, while allowing the petroleum material to remain in the extract.

9.5.3.1 Dry the extract by passing it through a powder funnel containing approximately 20 grams of sodium sulfate. Collect the filtrate in an Erlenmeyer flask. Add approximately 20 grams of silica gel to the extract. Place the flask on the shaker table, and shake for 20 minutes. The shaking should be vigorous enough to ensure good contact of the silica gel with the extract, but not so vigorous that the extract splashes.

9.5.3.2 Rinse a filter funnel with 25mL of appropriate solvent to ensure quantitative transfer of the sample extract. Filter the extract through sodium sulfate to remove the silica gel and any residual water, and collect in the concentration apparatus.

9.5.4 Slurry Method

This cleanup step may be used to remove interferences from sample extracts to be analyzed for ETPH or TPH-8100 SGC.

9.5.4.1 Following Turbovap concentration (Section 9.4), place the Zymark tubes in a fume hood. Using a clean 250µL microdispenser, add approximately 100µL of Silica Gel to each 1mL sample and QC sample, ensuring that the majority of the Silica Gel is placed at the bottom of the Zymark tube. Using a 9-inch disposable glass pipet (Section 7.15), mix the extract and Silica Gel thoroughly, ensuring contact between the sorbent material and the extract.

9.6 Fractionation of EPH Sample Extracts

9.6.1 Sample Preparation

9.6.1.1 Using a transfer pipet and clean Hexane, bring all sample extracts to a volume of 1.0mL.

NOTE: If an extract is to be at a final volume greater than 1.0mL, bring the extract to the appropriate final volume with Hexane. Use a 1mL portion of this final volume for Fractionation. Save the remainder of the extract as in Section 9.6.4.4.

9.6.1.2 Rinse a 1mL syringe with Hexane. Add 1mL FRAC surrogate to the extract and replace the cap.

9.6.2 Glassware Preparation

Label two ZYMARK tubes for each sample: one for ALI (aliphatic / Hexane) and one for ARO (aromatic / DCM). Also, if the sample extract is at a final volume >1mL, write this on the ZYMARK tube.

9.6.3 Manifold and FRAC Cartridge Preparation

9.6.3.1 Place one collection tube into each slot on the manifold unit.

9.6.3.2 Place manifold lid onto the manifold unit.

9.6.3.3 Set up one FRAC cartridge for each sample on the manifold lid, making sure that each one is closed hand tight (do not over tighten).

9.6.3.4 Turn on the vacuum pump and adjust the manifold pressure to 20” Hg.

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9.6.3.5 Once the pressure has been adjusted, rinse a graduated cylinder first with Acetone, then DCM.

9.6.3.6 Fill the graduated cyllinder to 15mL with DCM.

9.6.3.7 Open the valve slowly to start the vacuum flow.

9.6.3.8 Add the 15mL DCM to the cartridge. Allow the vacuum to pull the DCM through.

9.6.3.9 Repeat Sections 9.6.3.6 through 9.6.3.8 for each of the 6 cartridges.

9.6.3.10 Turn off the vacuum and release the pressure.

9.6.3.11 Remove the manifold lid and place it on a beaker.

9.6.3.12 Remove the collection tubes one at a time and place the rinsed DCM into a waste container. Place collection tubes back into the same slots in the manifold unit.

9.6.3.13 Replace the manifold lid with the pre-rinsed cartridges back onto the manifold unit.

9.6.3.14 Rinse a graduated cylinder with Acetone, DCM, then Hexane.

9.6.3.15 Fill the graduated cylinder to 40mL with Hexane.

9.6.3.16 Open the valve slowly to start the vacuum flow.

9.6.3.17 Add the 40mL Hexane to the cartridge. Allow the vacuum to pull the Hexane through.

NOTE: Leave an approximate 1mL layer of Hexane in the cartridge to ensure it will not go dry.

9.6.3.18 Repeat Sections 9.6.3.15 through 9.6.3.17 for each of the 6 cartridges.

9.6.3.19 Turn off the vacuum pump and release the pressure.

9.6.3.20 Remove the manifold lid and place it on a beaker, being careful that the remaining Hexane layer does not spill.

9.6.3.21 Remove the collection tubes one at a time and place the rinsed hexane into a waste container. Place collection tube back into the same slots in the manifold unit.

9.6.3.22 Replace the manifold lid with the pre-rinsed cartridges back onto the manifold unit.

9.6.4 Fractionation Procedure

9.6.4.1 Aliphatic Portion

9.6.4.1.1 Using a transfer pipet, draw sample extract from the KD tube and dispense back into the KD tube a few times to ensure that the extract is thoroughly mixed with the FRAC surrogate added in Section 9.6.1.2.

9.6.4.1.2 Remove a 1mL portion of the mixed extract, and dispense onto a pre-rinsed FRAC cartridge. Leave the remaining 1mL portion in the KD tube.

9.6.4.1.3 After all samples have been dispensed onto pre-rinsed cartridges, turn on the vacuum pump and adjust the manifold pressure to 20" Hg.

9.6.4.1.4 Using the 25mL graduated cylinder (Section 9.6.3.5), fill it with Hexane to the predetermined volume.

9.6.4.1.5 Add a small amount of Hexane into the cartridge with the sample extract, and open the valve to start the vacuum. Add small amounts of Hexane at a time, letting the vacuum draw it through the cartridge.

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9.6.4.1.6 Once all of the Hexane has been added from the cylinder, it is important to leave an approximate 1mL layer in the cartridge. ***Do not let the cartridge go dry***.

9.6.4.1.7 Repeat Sections 9.6.4.1.1 – 9.6.4.1.6 for all samples.

9.6.4.1.8 Turn off the vacuum pump and release the pressure.

9.6.4.1.9 Remove the manifold lid and place it on a beaker being careful that the remaining Hexane layer does not spill.

9.6.4.1.10 Remove the collection tubes, one at a time, and pour into the corresponding ZYMARK Tube for Aliphatics. Replace the collection tube into the same slot on the manifold.

9.6.4.1.11 Replace the manifold lid onto the manifold unit.

9.6.4.1.12 Place the Aliphatic ZYMARK tubes into the TurboVap and allow to concentrate to 1mL at a pressure of 7psi and temperature of 35 °C.

9.6.4.2 Aromatic Portion

9.6.4.2.1 Turn on the vacuum pump and adjust the manifold pressure to 20" Hg.

9.6.4.2.2 Rinse a 25mL graduated cylinder with Acetone, then with DCM. Fill with 20mL of DCM.

9.6.4.2.3 Add a small amount of DCM into the cartridge and open the valve to start the vacuum. Add small amounts of DCM at a time, allowing the vacuum to draw the DCM through the cartridge.

9.6.4.2.4 Once all of the DCM has been added from the cylinder, it is important to leave an approximate 1mL layer in the cartridge. ***Do not let the cartridge go dry***.

9.6.4.2.5 Repeat Sections 9.6.4.2.1 – 9.6.4.2.4 for all samples.

9.6.4.2.6 Turn off the vacuum pump and release the pressure.

9.6.4.2.7 Remove the manifold lid and place it on a beaker being careful that the remaining DCM layer does not spill.

9.6.4.2.8 Remove the collection tubes, one at a time, and pour into the corresponding ZYMARK Tube for Aromatics.

9.6.4.2.9 Place the Aromatic ZYMARK tubes into the TurboVap and allow to concentrate to 1mL at a pressure of 7psi and temperature of 35 °C.

9.6.4.3 Cleanup of Manifold Unit

9.6.4.3.1 Remove the spent cartridges from the manifold unit.

9.6.4.3.2 Open all valves. Rinse the inside of the valves with DCM and then with Hexane.

9.6.4.3.3 Rinse all collection tubes with DCM and then with Hexane.

9.6.4.4 Storage of Remaining Extracts

9.6.4.4.1 Label a 1.5mL screwcap vial with the sample ID. If the sample extract is at a final volume, be sure to also write this on the vial.

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9.6.4.4.2 Using a fresh transfer pipet for each sample, transfer the sample extract from the KD tube into the corresponding screwcap vial.

9.6.4.4.3 Place the 1.5mL vial(s) into a Wheaton vial storage box and mapped on the sheet.

9.6.4.4.4 Store sample extracts in the refrigerator at 4±2 °C for a minimum of 40 days.

9.7 Instrument Maintenance

9.7.1 Refrigeration Re-circulator

The Refrigeration Re-circulator should be checked periodically to insure that it is running correctly and that the level of reagent water is constant with manufactures recommendation.

The re-circulator tubing should be inspected for leaks, cracks, and crimps prior to each use.

9.7.2 Zymark Turbovap II Concentrators

9.7.2.1 Maintain the level of the water bath by adding water daily to fill. Add 4 – 5 drops of Clear Bath weekly to keep water clear. This will extend the life of the extract level sensors in the bath.

9.7.2.2 Keep unit clean. Avoid solvent spills on or around unit. Clean periodically with a damp cloth.

9.7.2.3 Sensor calibration checks should be performed at least annually, or when sensor failures are suspected.

9.7.3 Analytical Balance

9.7.3.1 All balances are calibrated and serviced every six months by an instrument service company. All service records are kept on file.

9.7.3.2 Keep balances clean. Brush off any sample spills immediately. Keep the balance doors closed and the balance turned off when not in use.

10. Quality Control and Data Assessment

The laboratory maintains records to document the quality of data that is generated. Ongoing data quality checks are compared with established performance criteria to determine if the results of analyses meet the performance characteristics of the method.

10.1 Demonstration of Capability

The analyst must make an initial, one-time, demonstration of the ability to generate acceptable accuracy and precision with this method. Each time a method modification is made, the analyst is required to repeat the procedure.

Extraction IDCs are performed in conjunction with the analytical methods. See analytical SOPs for specifics on IDC requirements and acceptance criteria.

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10.2 Extraction QC Elements

Each extraction batch contains various QC samples used to ensure the validity of the sample results. The particular QC elements performed for a given extraction batch are determined by the requirements of the determinative method. The purpose and definition of the QC samples performed are listed below. The specific QC requirements of the analytical methods are listed in Table 2.

10.2.1 Surrogates

Surrogates are compounds specified by the analytical method that are added to all samples and QC samples prior to beginning the extraction process. Surrogate recoveries are calculated and serve as a sample specific quantitative check of the extraction. The various spiking solutions are prepared according to the directions found in the analytical SOPs. The required solutions and volumes used are listed in Table 2.

10.2.2 Blank

Blanks, or method blanks, are measured aliquots of clean matrix (typically sodium sulfate for soil extractions) that are treated identically to the associated samples. Surrogates are added, and the blanks are carried through all stages of the sample extraction, concentration, and cleanup procedures. Blanks serve to ensure that no systematic contamination exists. A blank is extracted with each batch or 20 or less samples.

10.2.3 Laboratory Control Sample / Laboratory Control Sample Duplicate (LCS/LCSD)

LCS samples are measured aliquots of clean matrix (typically sodium sulfate for soil extractions) that are spiked with a solution containing known amounts of target compounds, in addition to the surrogate solution. The LCS is carried through all stages of the sample extraction, concentration, and cleanup procedures. LCS samples serve as batch specific quantitative checks of the extraction. An LCS is extracted with each batch of 20 or less samples.

An LCSD is performed in addition to an LCS for all Massachusetts Contingency Plan (MCP) methods, as well as in lieu of the MS/MSD or Duplicate when there is insufficient sample volume available. The required solutions and volumes are listed in Table 2.

10.2.4 Duplicate

Duplicates are laboratory selected replicate samples, prepared by taking an additional sample aliquot of a sample. The duplicate is carried through all stages of the sample extraction, concentration, and cleanup procedures. Duplicates serve as a measure of the extraction precision, by comparing the results of the sample and duplicate.

10.2.5 Matrix Spike/Matrix Spike duplicate (MS/MSD)

MS and MSDs are field samples spiked with a known quantity of the target analyte(s). They are prepared by taking additional sample aliquots, and adding the appropriate amounts of surrogate and spiking solutions. The MS/MSD is carried through all stages of the sample extraction, concentration, and cleanup procedures. MS samples serve as a measure of extraction accuracy, by allowing the comparison of the found amount(s) of target analyte(s) with the spiked amount(s). An MS/MSD set also allows for the calculation of the extraction precision, by comparing the results of the two samples.

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11. Method Performance

Method performance data is on file in the laboratory QC department. Comparison of method performance data for the laboratory to the reference method criteria occurs when laboratory in-house acceptance limits are generated. In-house generated data must be within the specifications of the reference method or the analysis is not continued until corrective action is completed.

The performance of this method is evaluated on an on-going basis by the QC criteria listed in the analytical SOPs. Specifically surrogates, blanks, LCSs, MS/MSDs, and duplicates are all used to ensure that the method is producing results of consistently high quality. In addition, Alpha participates in several blind and double blind PE studies annually to demonstrate the ability of this method to produce accurate and reproducible data.

12. Corrective Actions

Holding time exceedence and improper preservation are noted on the nonconformance report form.

When analysis of samples indicates possible extraction problems, such as poor surrogate recoveries, poor LCS/MS/MSD recoveries, or suspected contamination in blanks or samples, re-extractions are required. Depending on the particular failure, the re-extraction may be of a specific sample or the entire extraction batch.

The analyst that determines the need for re-extraction must fill out a sample re-extract request form. This form notes the reason for the re-extraction request along with any special requirements, and the date and time that the re-extract is needed. Re-extraction request forms are maintained on file to help track the cause for re-extractions, and to be used as a tool in improving systems to minimize the need for re-extractions.

Depending on the results of the re-extraction, the first, second, or both sets of results may be reported to the client, along with a narrative report detailing the problems encountered and the resolution.

13. Pollution Prevention

See Chemical Hygiene Plan for pollution prevention operations.

14. Waste Management

See Chemical Hygiene Plan for waste handling and disposal.

15. Attachments

Table 1 – Specific Extraction Conditions for Various Determinative Methods
Table 2 – Soil Extraction Guide

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Table 1

Specific Extraction Conditions for Various Determinative Methods

Determinative Method	Extraction Solvent	Exchange Solvent Required	Typical Final Volume	Appropriate Cleanup Technique
8081	1:1 DCM/Acetone	hexane	1 mL	florisil
8082	1:1 DCM/Acetone	hexane	5 mL	Sulfuric acid
8082 Low Level	1:1 DCM/Acetone	hexane	1 mL	Sulfuric acid
8270	1:1 DCM/Acetone	---	1 mL	---
8100	DCM	---	1 mL	---
8100-SGC	DCM	---	1 mL	Silica gel
TPH-DRO	DCM	---	1 mL	---
MA EPH	DCM	hexane	1 mL	Silica gel Fractionation
CT ETPH	DCM	---	1 mL	Silica gel

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Table 2

Soil Extraction Guide

Analytical Method	QC *	Solvent	Surrogate Solution	LCS/LCSD MS/MSD Solution	Container
8270	SB, LCS, MS, MSD	DCM/ACE	1mL ABN	1mL ABN	GLASS
MCP 8270	SB, LCS, LCSD	DCM/ACE	1mL ABN	1mL MCP ABN	GLASS
PAH	SB, LCS, MS, MSD	DCM/ACE	1mL ABN	1mL ABN	GLASS
MCP PAH	SB, LCS, LCSD	DCM/ACE	1mL ABN	1mL MCP ABN	GLASS
PAH-Low	SB, LCS, MS, MSD	DCM/ACE	1mL ABN	1mL ABN	GLASS
MCP PAH-Low	SB, LCS, LCSD	DCM/ACE	1mL ABN	1mL MCP PAH-L	GLASS
PEST	SB, LCS, MS, MSD	DCM/ACE	1mL PEST	1mL PEST	Paper
MCP PEST-LL	SB, LCS, LCSD	DCM/ACE	250µL PEST	250µL PEST	Paper
MCP PEST	SB, LCS, LCSD	DCM/ACE	1mL PEST	1mL PEST	Paper
PEST – LL	SB, LCS, MS, MSD	DCM/ACE	250µL PEST	250µL PEST	Paper
PCB	SB, LCS, MS, MSD	DCM/ACE	1mL PEST	1mL PCB	Paper
PCB - LL	SB, LCS, MS, MSD	DCM/ACE	250µL PEST	250µL PCB	Paper
MCP PCB-LL	SB, LCS, LCSD	DCM/ACE	250µL PEST	250µL PCB	Paper
MCP PCB	SB, LCS, LCSD	DCM/ACE	1mL PEST	1mL PCB	Paper
EPH	SB, LCS, LCSD, Dup	DCM	1mL EPH	1mL EPH	Paper
EPH / PAH-L	SB, LCS, LCSD, Dup	DCM	1mL EPH	1mL EPH	Paper
EPH/TPH	SB, LCS, LCSD, Dup	DCM	1mL EPH	1mL EPH	Paper
PETRO	SB, LCS, Dup	DCM	1mL DRO	1mL ETPH	Paper
ETPH	SB, LCS, MS, Dup	DCM	1mL DRO	1mL ETPH	Paper
TPH-DRO	SB, LCS, Dup	DCM	1mL DRO	1mL ETPH	Paper
Herb 8151	SB, LCS, MS, MSD	HEX/ACE	1mL HERB	1mL HERB	Paper

*** For Projects where target Aroclors are known to be present, a laboratory Duplicate will be performed in lieu of the MSD.**

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Volatile Organic Compounds by Gas Chromatography/Mass Spectrometry (GC/MS)

References.: **Method 8260 B**, SW-846, Test Methods for Evaluating Solid Waste: Physical/Chemical Methods, EPA SW-846, Update III, December 1996.

Method 5035, Closed System Purge &Trap and Extraction for Volatile Organics in Soil and Waste Samples. SW-846, Test Methods for Evaluating Solid Waste: Physical/Chemical Methods, EPA SW-846, Update III, December, 1996.

Method 5030B, Purge & Trap for Aqueous Samples. SW-846, Test Methods for Evaluating Solid Waste: Physical/Chemical Methods, EPA SW-846, Update III, December, 1996.

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ISSUE AMENDMENTS

Changes since last issue:

Section 9.4.1.5.1: Edited the volume of methanol.

Table 4: Edited units to µg/L.

Volatile Organic Compounds by Gas Chromatography/Mass Spectrometry (GC/MS)

References.: **Method 8260 B**, SW-846, Test Methods for Evaluating Solid Waste: Physical/Chemical Methods, EPA SW-846, Update III, December 1996.

Method 5035, Closed System Purge &Trap and Extraction for Volatile Organics in Soil and Waste Samples. SW-846, Test Methods for Evaluating Solid Waste: Physical/Chemical Methods, EPA SW-846, Update III, December, 1996.

Method 5030B, Purge & Trap for Aqueous Samples. SW-846, Test Methods for Evaluating Solid Waste: Physical/Chemical Methods, EPA SW-846, Update III, December, 1996.

1. Scope and Application

Matrices:

Method 8260 is used to determine volatile organic compounds in a variety of solid waste matrices. This method is applicable to nearly all types of samples, regardless of water content, including various air sampling trapping media, ground and surface water, aqueous sludges, caustic liquors, acid liquors, waste solvents, oily wastes, mousses, tars, fibrous wastes, polymeric emulsions, filter cakes, spent carbons, spent catalysts, soils, and sediments. The following compounds can be determined by this method:

8260B LIST OF ANALYTES		
dichlorodifluoromethane	carbon tetrachloride	isopropylbenzene
chloromethane	1,2-dichloroethane	1,4-dichloro-2-butane
vinyl chloride	benzene	1,1,2,2-tetrachloroethane
chloroethane	trichloroethene	trans-1,4-dichloro-2-butene
bromomethane	1,2-dichloropropane	1,2,3-trichloropropane
trichlorofluoromethane	bromodichloromethane	n-propylbenzene
ethyl ether	dibromomethane	bromobenzene
acrolein	4-methyl-2-pentanone	2-chlorotoluene
acetone	cis-1,3-dichloropropene	1,3,5-trimethylbenzene
1,1-dichloroethene	toluene	4-chlorotoluene
iodomethane	trans-1,3-dichloropropene	tert-butylbenzene
carbon disulfide	ethyl-methacrylate	1,2,4-trimethylbenzene
methylene chloride	1,1,2-trichloroethane	sec-butylbenzene
acrylonitrile	2-hexanone	p-isopropyltoluene
methyl-tert-butyl ether	1,3-dichloropropane	1,3-dichlorobenzene
trans-1,2-dichloroethene	tetrachloroethene	1,4-dichlorobenzene
1,1-dichloroethane	chlorodibromomethane	n-butylbenzene
vinyl acetate	1,2-dibromoethane	1,2-dichlorobenzene
2-butanone	chlorobenzene	1,2-dibromo-3-chloropropane
2,2-dichloropropane	1,1,1,2-tetrachloroethane	1,2,4-trichlorobenzene
cis-1,2-dichloroethene	ethyl benzene	hexachlorobutadiene
chloroform	p/m xylene	naphthalene
bromochloromethane	o xylene	1,2,3-trichlorobenzene
tetrahydrofuran	styrene	
1,1,1-trichloroethane	bromoform	
1,1-dichloropropene		

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There are various techniques by which these components may be introduced into the GC/MS system. Purge-and-trap, by Methods 5030 (aqueous samples) and 5035 (solid and waste oil samples), is the most commonly used technique for volatile organic analytes. However, other techniques are also appropriate and necessary for some analytes. One technique is direct injection of an aqueous sample (concentration permitting).

The data report packages present the documentation of any method modification related to the samples tested. Depending upon the nature of the modification and the extent of intended use, the laboratory may be required to demonstrate that the modifications will produce equivalent results for the matrix. Approval of all method modifications is by one of the following laboratory personnel before performing the modification: Area Supervisor, Laboratory Services Manager, Laboratory Director, or Quality Assurance Officer. A major modification to this procedure requires demonstration of performance.

This method is restricted to use by or under the supervision of analysts experienced in the operation of the gas chromatograph/mass spectrometers and in the interpretation of mass spectra and their use as a quantitative tool. Each analyst must demonstrate the ability to generate acceptable results with this method by performing an initial demonstration of capability, analyzing a proficiency test sample and completing the record of training.

After initial demonstration, ongoing demonstration is based on acceptable laboratory performance of at least a quarterly laboratory control sample or acceptable performance from an annual proficiency test sample.

2. Summary of Method

The volatile compounds are introduced into the gas chromatograph by the purge-and-trap method or by direct injection. The analytes are introduced to a narrow-bore capillary column for analysis. The column is temperature-programmed to separate the analytes, which are then detected with a mass spectrometer (MS) interfaced to the gas chromatograph (GC).

Analytes eluted from the capillary column are introduced into the mass spectrometer via a direct connection. Identification of target analytes is accomplished by comparing their mass spectra with the electron impact (or electron impact-like) spectra of authentic standards. Quantitation is accomplished by comparing the response of a major (quantitation) ion relative to an internal standard, comparing sample response to the calibration standards.

2.1 Method Modifications from Reference

None.

3. Detection Limits

The laboratory follows the procedure found in 40CFR Part 136 to determine the MDL on an annual basis. The method detection limits determined by the laboratory are on file for review. Table 1 lists our typical reporting limits. Whenever MDL studies are performed, the MDL results are compared with our reporting limits to ensure that our calculated MDLs are equal to or below the reporting limits.

4. Interferences

4.1 Impurities in the purge gas, organic compounds out-gassing from the plumbing ahead of the trap, and solvent vapors in the laboratory account for the majority of contamination problems. The analytical system must be free from contamination under the conditions of the analysis. Running laboratory reagent blanks as described in Section 9.4 and 10.2 demonstrates the system is free of contamination. The use of non-Teflon plastic tubing, non-Teflon thread sealants, or flow controllers with rubber components in the purge and trap system must be avoided.

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4.2 Sample contamination occurs by diffusion of volatile organics (particularly fluorocarbons and methylene chloride) through the septum seal into the sample during shipment and storage. A trip blank or a field reagent blank prepared from reagent water and carried through the sampling and handling protocol serves as a check on such contamination.

4.3 Contamination by carry-over can occur whenever high level and low level samples are sequentially analyzed. To reduce carry-over, the sample syringe must be rinsed with reagent water between sample analyses. Each autosampler position is also monitored for positive hits and subsequent sample analyses are checked for potential carry-over. If carry-over is suspected, the sample is rerun for confirmation. Whenever an unusually concentrated sample is encountered, it should be followed by an analysis of reagent water to check for cross contamination. For samples containing large amounts of water-soluble materials, suspended solids, high boiling compounds or high purgeable levels, it may be necessary to wash the purging device with a detergent solution, rinse it with reagent water, and then dry it in a 105°C oven between analyses. The trap and other parts of the system are subject to contamination; therefore, frequent bakeout and purging of the entire system may be required.

5. Safety

The toxicity or carcinogenicity of each reagent and standard used in this method is not fully established; however, each chemical compound should be treated as a potential health hazard. From this viewpoint, exposure to these chemicals must be reduced to the lowest possible level by whatever means available. A reference file of material data handling sheets is available to all personnel involved in the chemical analysis. Additional references to laboratory safety are available in the Chemical Hygiene Plan.

All personnel handling environmental samples known to contain or to have been in contact with municipal waste must follow safety practices for handling known disease causative agents.

The following method analytes have been tentatively classified as known or suspected human or mammalian carcinogens: benzene, carbon tetrachloride, 1,4-dichlorobenzene, 1,2-dichloroethane, hexachlorobutadiene, 1,1,2,2-tetrachloroethane, 1,1,2-trichloroethane, chloroform, 1,2-dibromoethane, tetrachloroethene, trichloroethene, and vinyl chloride. Pure standard materials and stock standard solutions of these compounds should be handled in a hood. A NIOSH/MESA approved toxic gas respirator should be worn when the analyst handles high concentrations of these toxic compounds.

5.1 Lab coats, safety glasses, and gloves must be worn when handling samples, standards, or solvents.

5.2 All standard preparation must be performed in the volatiles hood.

5.3 All expired standards must be placed into the waste bucket in the lab, for future disposal by the Health and Safety Officer. The container must be labeled properly with hazard warning labels indicating the container contents.

5.4 Bottles containing flammable solvents must be stored in the flammables cabinet.

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6. Sample Collection, Preservation, Shipping, and Handling

6.1 Sample Collection and Preservation

6.1.1 Aqueous Samples

Grab samples are collected in standard 40mL amber glass screw-cap vials with Teflon lined silicon septa (VOA vial). Two VOA vials are filled per sample location. EPA Method 8260 requires that samples be acidified to eliminate the possibility of biological degradation. Unless otherwise directed for project-specific reasons, all VOA vials are delivered to the client with approximately 2 – 4 drops of 1:1 HCl added to the vial, which is sufficient to adjust the pH of the sample to 2. Prepared trip blanks are provided to the client to accompany field samples for QC purposes.

Fill the sample vial just to overflowing. Samples must be introduced into the vials gently to reduce agitation, which might drive off volatile compounds or cause loss of the HCl preservative.

Seal the bottle so that no air bubbles are in the VOA vial. If preservative has been added, shake vigorously for one minute. Invert the bottle and tap to check for air bubbles. Recollect the samples if any air bubbles are present.

Maintain the hermetic seal on the VOA vial until time of analysis.

Ice or refrigerate all samples from the time of collection until analysis, maintaining the sample temperature between 1 and 4 °C. Sample receiving personnel note on the sample delivery group form when samples received at the laboratory are not within the temperature criteria.

6.1.2 Soil Samples

The recommended sampling method for soil samples is EPA 5035. Method 5035 provides for two distinct sampling procedures, depending on the required reporting limits and suspected or known concentration levels of target analytes. These methods are referred to as the High Level and Low Level methods. Both are listed below, but depending on the samples only one of the methods may be required. If concentration levels are unknown, it is recommended that samples be collected using both procedures. The Lab will analyze the high level sample first, followed by the low level sample if the results from the high level analysis show that the sample is clean or contains analytes at low levels. The typical reporting levels of the two methods are listed in Table 1.

6.1.2.1 High Level Soil Samples

Collect sample in a standard 40mL amber glass screw-cap vial with Teflon lined silicon septa (VOA vial). The vial is provided containing 15mL of Purge and Trap Grade methanol, and is labeled and weighed prior to addition of sample. Record the weight of the vial with methanol on the vial label. Prepared trip blanks are provided to the client to accompany field samples for QC purposes.

Approximately 15g of soil is added to the vial in the field, making sure that the sample is completely covered by the methanol.

Maintain the hermetic seal on the VOA vial until the time of analysis.

Ice or refrigerate all samples from the time of collection until analysis, maintaining the sample temperature between 1 and 4 °C. Sample receiving personnel note on the nonconformance report form when samples received at the laboratory are not within the temperature criteria.

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6.1.2.2 Low Level Soil Samples

` Collect sample in a standard 40mL amber glass screw-cap vials with Teflon lined silicon septa (VOA vial). Two samples should be taken per sample location. Vials are provided containing a magnetic stirring bar and 5 mL of 25% sodium bisulfate solution prepared by a certified vendor, and labeled and weighed prior to addition of sample. Record the weight of the vial with the stirring bar and preservative on the vial label.

Approximately 5g of soil is added tot he vial in the field, making sure that the sample is completely covered by the sodium bisulfate solution.

Maintain the hermetic seal on the VOA until the time of analysis.

Ice or refrigerate all samples from the time of collection until analysis, maintaining the sample temperature between 1 and 4 °C. Sample receiving personnel note on the nonconformance report form when samples received at the laboratory are not within the temperature criteria.

6.2 Sample Shipping

Samples requiring shipment to the laboratory are shipped in ice-packed coolers via an overnight delivery service in accordance with applicable Department of Transportation regulations.

6.3 Sample Handling

Upon receipt of samples at the laboratory, sample receiving personnel label the vials with the Alpha sample number, and store the samples in the volatiles refrigerator. If more than one vial is received for a sample the vials are stored in separate refrigerators. Storing the vials apart provides a useful check if laboratory contamination of a sample is suspected. Samples must be analyzed within 14 days of collection. Unpreserved samples requiring aromatic analysis must be analyzed within 7 days of collection.

Document client specific sample handling, preservation and collection criteria in the project file. The laboratory Log-in staff documents sample temperature at the time of receipt.

Record deviations from this SOP or client specific criteria on the chain of custody form.

Record holding time exceedence, improper preservation and observed sample headspace on the nonconformance report form.

7. Equipment and Supplies

7.1 Purge and Trap System (For Aqueous samples and High Level Soils): The purge-and-trap system consists of two separate pieces of equipment: a purging device coupled to the desorber (Tekmar 2016 and Tekmar 2000/3000, or equivalent).

7.1.1 Purge gas = Helium, analytical grade (99.999%).

7.1.2 The purging device is configured with 25 mL sample purge tubes, and the helium purge gas is introduced at the bottom of the water column as finely divided bubbles

7.1.3 The trap used in the desorber is typically a Supelco “K” trap. Different traps may be used if equivalent performance is demonstrated.

7.1.4 The desorber is capable of rapidly heating the trap to 260°C. The trap is not heated above manufacturer’s specifications

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7.2. Purge and Trap System (For Low Level Soil Samples): The purge and trap system consists of two separate pieces of equipment: a purging device coupled to the desorber (Varian Archon or Tekmar Solatek, with Tekmar 2000/3000, or equivalents).

7.2.1. Purge gas = Helium, analytical grade (99.999%).

7.2.2. The Archon or Tekmar Solatek purging device is a closed system, designed to accept the 40mL VOA vials. The VOA vial, containing the soil sample, sodium bisulfate, and stirring bar is placed into the Archon tray. The instrument automatically adds reagent water, internal standards, and surrogates to the unopened VOA vial. The vial is heated to 40 °C, and the helium purge gas is introduced into the aqueous portion to purge the volatile components onto the trap.

7.2.3. The trap used in the desorber is typically a Supelco "K" trap. Different traps may be used if equivalent performance is demonstrated.

7.2.4. The desorber is capable of rapidly heating the trap to 260 °C. The trap is not heated above manufacturer specifications.

7.3 Gas Chromatography/Mass Spectrometer/Data System:

7.3.1 Gas Chromatograph, Hewlett Packard 5890/6890 or equivalent: An analytical system complete with a temperature-programmable gas chromatograph with appropriate interface for sample introduction device. The system includes all required accessories, including syringes, analytical columns, and gases. The capillary column is directly coupled to the source of the GC/MS system.

7.3.2 Gas Chromatographic Columns:

7.3.2.1 Column 1: Restek 502.2, 40 meter, 0.18mm ID, or equivalent.

7.3.2.2 Column 2: Restek 502.2, 60 meter, 0.25mm ID, or equivalent.

7.3.3 Mass Spectrometer, Hewlett Packard 5973 or equivalent: Scanning from 35 to 300 amu every 2 seconds or less, using 70 volts (nominal) electron energy in the electron impact ionization mode. The mass spectrometer must be capable of producing a mass spectrum for 4-Bromofluorobenzene (BFB) which meets all of the criteria in Table 3, when 50ng of the GC/MS tuning standard (BFB) are injected through the GC.

7.3.4 Data System: Hewlett-Packard EnviroQuant software is used for data acquisition, and allows the continuous acquisition and storage on machine-readable media of all mass spectra obtained throughout the duration of the chromatographic program.

Thruput Target 4.12 software is used for data processing, and allows searching of any GC/MS data file for ions of a specified mass, and plotting such ion abundances versus time or scan-number.

The most recent version of the EPA/NIST Mass Spectral Library is loaded onto the Target data system.

7.4 Wiretrol or Microsyringes: 10µL - 1,000µL.

7.5 Syringes: 5mL, 10mL, or 25mL, glass with Luerlock tip.

7.6 Balances: Top-loading, capable of weighing 0.1g.

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7.7 Vials: 2mL, 4mL.

7.8 Disposable Pipets.

7.9 Volumetric Flasks: Class A, appropriate sizes, with ground-glass stoppers.

8. Standards and Reagents

Reagent grade inorganic chemicals shall be used in all tests. Unless otherwise indicated, it is intended that all inorganic reagents shall conform to the specifications of the Committee on Analytical Reagents of the American Chemical Society, where such specifications are available. Other grades may be used, provided it is first ascertained that the reagent is of sufficiently high purity to permit its use without lessening the accuracy of the determination.

Great care must be taken to maintain the integrity of all standard solutions. Standards in methanol are stored at –10ºC or less, in amber vials with PTFE-lined screw-caps.

8.1 Organic-free Reagent Water:

All references to water in this method refer to organic-free reagent water, which is tap water passed through activated carbon.

8.2 Methanol:

Purge and Trap Grade or equivalent, demonstrated to be free of volatile analytes. Store in flammables cabinet.

8.3 Stock Solutions:

All stock standard solutions are purchased from commercial vendors as ampulated certified solutions. When an ampulated stock solution is opened, it is transferred to a labeled amber screw-cap vial with minimal headspace. The expiration date of the stock solution is either the vendor specified expiration date or 6 months from the date the ampule was opened, whichever is sooner. Typical stock standard concentrations are listed in Table 4.

8.4 Intermediate Standards: Intermediate standards are prepared volumetrically by diluting the appropriate stock standard(s) with methanol. Initial Calibration solutions expire 1 month from the date of preparation. If the Intermediate Standards are used as a second source to verify a valid Initial Calibration solution, there is no expiration date.

8.4.1 Internal Standard Solutions:

The internal standards are fluorobenzene, chlorobenzene-d_5, and 1,4-dichlorobenzene-d_4. Two intermediate I.S. solutions are prepared by diluting the stock solution(s) with methanol. One solution, at a concentration of 20 µg/mL, is used for addition to the standards and samples analyzed using the Tekmar 2016 method. The second solution, at a concentration of 100 µg/mL, is used for addition to the standards and samples analyzed using the Archon method. The appropriate amount of I.S. solution is added to the water or soil sample to achieve a final concentration of 100 ng/sample or standard. Internal standard is added at the same concentration to all standards, samples, and QC samples.

8.4.2 Surrogate Standard Solutions:

The surrogate standards are dibromofluoromethane, 1,2-dichloroethane-d_4, Toluene-d_8, and 4-bromofluorobenzene. Two intermediate surrogate solutions are prepared by diluting the stock solution(s) with methanol. One solution, at a concentration of 20 µg/mL, is used

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for addition to the standards and samples analyzed using the Tekmar 2016 method. The second solution, at a concentration of 100 µg/mL, is used for addition to the standards and samples analyzed using the Archon method. The appropriate amount of surrogate solution is added to the water or soil sample to achieve a final concentration of 100 ng/sample.

8.4.3 Target Compound Solutions:

The target analytes routinely reported by this method are listed in Table 4. Two sets of intermediate target compound solutions are prepared by diluting the stock solution(s) with methanol. One set of solutions, at concentrations of 20 µg/mL, is used for preparation of the calibration standards at the concentrations listed in Table 4 for analysis using the Tekmar 2016 method. The second set of solutions, at concentrations of 200 µg/mL, is used for preparation of the calibration standards at the concentrations listed in Table 4 for analysis using the Archon method.

8.4.4 4-Bromofluorobenzene (BFB) Tune solution:

A solution containing BFB at a concentration of 25 µg/mL is prepared by volumetrically diluting the BFB stock solution. 2 µL of this solution is direct-injected or purged into the GC/MS system to verify system performance prior to any standard or sample analysis.

8.5 Calibration Standards:

There are two types of calibration standards used for this method – initial calibration standards and calibration verification standards.

8.5.1 Initial Calibration Standards:

Initial calibration standards are prepared at the levels listed in Table 4. Prepare these solutions in organic-fee reagent water. The standards correspond to the range of concentrations found in typical samples and do not exceed the working range of the GC/MS system. Initial calibration should be mixed from fresh stock standards and dilution standards when generating an initial calibration curve.

8.5.2 Continuing Calibration Verification Standards:

The continuing calibration verification standard, or calibration check standard, is at the same concentrations as the level 3 initial calibration standard. This standard is run daily, following the BFB tune standard, to verify system performance. This standard is made from a second source than the Initial Calibration Standards.

9. Procedure

9.1 Instrument Set-up Conditions: Typical instrument operating conditions are listed below. Alternate conditions are allowed, as long as method performance criteria can be met.

9.1.1 GC Conditions:

Temperature 1:	35°C	Carrier gas:	Helium, 99.999%
Hold Time 1:	4 minutes	Carrier mode:	Constant flow
Ramp 1:	6°C/minute	Carrier flow:	1 mL/minute
Temperature 2:	150°C		
Hold Time 2:	0 minutes		
Ramp 2:	8°C/minute		
Temperature 3:	220°C		
Final Time:	1 minute		

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9.1.2 MS Conditions:

Mass scan range:	35 – 260 amu
Scan time:	0.5 minutes/scan
Source temperature:	230°C

9.1.3 Purge and Trap Conditions:

Purge time:	11 minutes
Dry purge:	4 minutes
Desorb preheat:	245°C
Desorb temp:	250°C
Desorb time:	4 minutes
Bake temp:	260°C
Bake time:	15 minutes

9.2 Initial Calibration

9.2.1 The initial calibration is performed at the 7 concentration levels listed in Table 4. The calibration is performed using instrument conditions listed in Section 9.1. BFB must be analyzed prior to analysis of the initial calibration standards, and must pass the criteria listed in Table 3.

9.2.1.1 Aqueous/High Level Soil Curve on Tekmar 2016: To prepare a calibration standard, add the appropriate volume of the intermediate standard solution (Section 8.4.3) to a 10mL Luerlock syringe filled with organic-free water. Add the appropriate amount of the surrogate standard (Section 8.4.2) and 5µl of the internal standard solution (8.4.1) to the syringe. Load the calibration standard into a sample tube on the purge-and-trap device (LSC 2016).

9.2.1.2 Low Level Soil Curve on Archon/Solatek: To prepare a calibration standard, add the appropriate volume of standard solution(s) to a 100mL volumetric flask using a microsyringe. Remove the needle quickly and mix by inverting the flask 3 times. Pour several mLs of the aqueous standard into the waste vessel, then gently fill a 5mL syringe with standard and transfer to a 40mL VOA vial containing 5 grams of organic-free Ottawa sand and a magnetic stir bar. Load the vial onto Archon/Solatek Autosampler.

9.2.1.3 Aqueous Curve on Archon/Solatek: To prepare a calibration standard, add the appropriate volume of standard solution(s) to a 100mL volumetric flask using a microsyringe. Remove the needle quickly and mix by inverting the flask 3 times. Pour several mLs of the aqueous standard into the waste vessel, then gently fill a 40mL VOA vial to the top. Load the vial onto the Archon/Solatek Autosampler.

9.2.2 Establish the GC operating conditions by loading the appropriate GC method. Typical instrument conditions are listed in Section 9.1. The same operating conditions are used for calibration and sample analyses. Create the analytical sequence using the HP Enviroquant data acquisition software.

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Relative Response Factors: The internal standard calibration technique is used. In each calibration standard, calculate the relative response factor for each analyte and the relative standard deviation (RSD) of the response factors using the Target data processing software. The response factors are calculated using the areas of the characteristic (quantitation) ion for each target analyte and internal standard. The calculations are performed automatically using the Target software, using the formulae listed in Alpha's Quality Manual.

9.2.3 Initial Calibration Criteria: The following sections outline the method acceptance criteria for an initial calibration curve. All criteria must be met for the calibration to be deemed acceptable, and for sample analysis to proceed.

9.2.3.1 System performance check compounds (SPCCs):

Five compounds (the System Performance Check Compounds, or SPCCs) must meet minimum response factor criteria. These compounds are: chloromethane, 1,1-dichloroethane, bromoform, chlorobenzene, and 1,1,2,2-tetrachloroethane. These compounds are monitored to demonstrate system performance. Possible causes of low response for these analytes are listed below.

Chloromethane response may be low if the purge flow is too fast.

Bromoform response may be low if the purge flow is too slow. Cold spots and/or active sites in the transfer lines may adversely affect response as well.

1,1,2,2-Tetrachloroethane and 1,1-dichloroethane response may be low in there are contaminated transfer lines in the purge-and-trap system, or the trap may need to be replaced.

The minimum mean response factors for the volatile SPCCs are as follows:

Chloromethane	0.10
1,1-Dichloroethane	0.10
Bromoform	0.10
Chlorobenzene	0.30
1,1,2,2-Tetrachloroethane	0.30

9.2.3.2 Relative Standard Deviation Criteria: If the RSD for each target analyte is less than or equal to 15%, then the response for this compound is considered linear over the calibration range and the mean calibration factor can be used to quantitate sample results. If the 15% RSD criterion is not met for an analyte, linear regression may be used if $\mathbf{r}^2 \leq 0.995$. The calibration may be repeated for any compounds that fail, or a calibration curve must be generated for this compound and used for sample quantitation.

Six of the target analytes are designated as Calibration Check Compounds (CCCs). For these compounds, listed below, the %RSD must be below 30%. If this criterion is not met for all 6 compounds, the calibration curve is invalid and cannot be used. If the %RSD is less than of equal to 15%, the mean RF is used for sample quantitation. It the %RSD is between 15 and 30%, linear regression may be used for sample quantitation. The CCCs are:

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1,1-Dichloroethene	Toluene
Chloroform	Ethylbenzene
1,2-Dichloropropane	Vinyl chloride

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If an RSD of greater than 30% is measured for any CCC, then corrective action to eliminate a system leak and/or column reactive sites is necessary before reattempting calibration.

9.2.4 Evaluation of Retention Times: The relative retention times used for identification of target analytes are +/- 0.06 RRT (Relative Retention Time) units, based on the most recent standard run. It has been determined that these limits work well, being wide enough to eliminate false-negative results while being tight enough to eliminate false positive results. Due to the selectivity of the mass spectrometer, compound identification is more definitive than when using a less selective detector.

9.3 Continuing Calibration Verification

Calibration verification consists of three steps that are performed at the beginning of each 12-hour analytical shift.

9.3.1 Prior to the analysis of samples or calibration standards, inject or purge 2 µL (50 ng) of the 4-bromofluorobenzene standard (Section 8.4.4) into the GC/MS system. The resultant mass spectra for the BFB must meet the criteria given in Table 3 before sample analysis begins.

9.3.2 The initial calibration curve for each compound of interest must be verified once every 12 hours prior to sample analysis. This is accomplished by analyzing the continuing calibration check standard (Section 8.5.2). The results from the calibration standard analysis must meet the verification acceptance criteria provided in Sections 9.3.4 through 9.3.7.

9.3.3 A method blank must be analyzed prior to any samples, typically immediately following the continuing calibration check standard, to ensure that the analytical system is free of contaminants. The method blank must not contain any target analytes at or above the required compound reporting limits.

9.3.4 System Performance Check Compounds (SPCCs):

9.3.4.1 The relative response factors for the 5 SPCC compounds must meet the minimum response factor criteria listed in Section 9.2.3.1.

9.3.4.2 If the minimum response factors are not met, the system must be evaluated, and corrective action must be taken before sample analysis begins. Possible problems include standard mixture degradation, injection port inlet contamination, contamination at the front end of the analytical column, and active sites in the column or chromatographic system.

9.3.5 Calibration Check Compounds (CCCs):

9.3.5.1 The percent difference or drift for each CCC listed in Section 9.2.3.2 must be less than or equal to 20%. If the criterion is not met for any one CCC, (i.e., greater than 20% difference or drift), then corrective action must be taken prior to the analysis of samples. All other analytes should also meet the 25%D criteria. An allowance is made to fail 10% of the compounds with > 25% D. If any samples have a hit of an analyte with >25% D, these results should be considered and estimate or rerun to verify.

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9.3.5.2 Analytical system problems similar to those that affect the SPCC response can also cause problems with the CCCs. If the problem cannot be corrected by performing system maintenance, a new seven-point initial calibration must be generated.

9.3.6 Internal Standard Retention Time:

The retention times of the internal standards in the calibration verification standard are evaluated after data acquisition. If the retention time for any internal standard changes by more than 30 seconds from that in the mid-point standard level of the most recent initial calibration sequence, then the chromatographic system must be inspected for malfunctions and corrections must be made, as required. When corrections are made, reanalysis of samples analyzed while the system was malfunctioning is required.

9.3.7 Internal Standard Response:

If the EICP area for any of the internal standards in the calibration verification standard changes by a factor of two (-50% to +100%) from that in the mid-point standard level of the most recent initial calibration sequence, the mass spectrometer must be inspected for malfunctions and corrections must be made, as appropriate. When corrections are made, reanalysis of samples analyzed while the system was malfunctioning is required.

9.4 Sample Analysis and Data Processing

The same GC, MS, and Purge and Trap conditions used for the initial calibration must be employed for sample analysis. After verification of system performance by analysis of BFB, the continuing calibration standard, and method blank, samples are analyzed and processed as described below.

9.4.1 Analysis of Samples

Retrieve sample VOA vials from the sample bank refrigerator just prior to loading onto the purge and trap system. High level soil samples must be shaken for 1 – 2 minutes to extract the volatile components into the methanol. Let sample settle prior to taking methanol aliquot. Low level soil sample should be shaken briefly to ensure that the stir bar is loose, and will spin on the Archon unit.

9.4.1.1 Aqueous samples: (LSC 2016)
Rinse a 10 mL Luerlock syringe with reagent water. Open the sample VOA vial, and pour off about 1 – 2 mL of sample into the waste container. Gently fill the syringe to overflowing, and adjust the volume to 10 mL. Add 5 µL of the internal standard (Section 8.4.1) and surrogate (8.4.2) solutions to the syringe using a 10 µL syringe. Load the sample into a sample tube on the purge and trap device.

9.4.1.2 High level soil samples: (LSC 2016)
Rinse a 10 mL Luerlock syringe with reagent water. Fill the syringe to overflowing with reagent water, and adjust the volume to 9.9mL. Using the appropriate microsyringe, measure the required aliquot of the methanol (typically 100 µL). Transfer the methanol into the syringe. Add 5 µL of the internal standard (Section 8.4.1) and surrogate (8.4.2) solutions to the syringe using a 10 µL syringe. Load the sample into the sample into a sample tube on the purge and trap device.

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9.4.1.3 Low level soil samples: (Archon/Solatek)
Take the low level VOA vial and place directly into the rack of the Archon sampling unit. Surrogate and internal standards are added automatically by the Archon prior to sample purging.

9.4.1.4 Aqueous samples: (Archon/Solatek)
Load the VOA vial directly on the sampling rack. Dilutions may be prepared volumetrically and poured into VOA vials ensuring there is no headspace left in the vial. The Archon/Solatek will then sample 10mL from the VOA vial.

9.4.1.5 High level soil samples: (Archon/Solatek)

9.4.1.5.1 Through liquid path
Load 430µL of the methanol into a half-full VOA vial. Fill the VOA vial up to the top with water and cap with no headspace. Allow the autosampler to sample 10mL out of the VOA vial which would be equivalent to injecting 100µL of the methanol extract. Prepare dilutions accordingly.

9.4.1.5.2 Through soil path
Into a VOA vial with a stir bar added, load 4.9mL of water pluse 100 µL of methanol extract from a 5mL luerlock syringe. Cap the vial and load onto the autosampler.

9.4.2 Qualitative Analysis:

9.4.2.1 The qualitative identification of each compound is based on retention time and on comparison of the sample mass spectrum with the reference mass spectrum. The reference mass spectrum must be generated by the laboratory on the same GC/MS system. The characteristic ions from the reference mass spectrum are defined to be the three ions of greatest relative intensity, or any ions over 30% relative intensity if less than three such ions occur in the reference spectrum. Compounds are identified as present when the following criteria are met:

9.4.2.1.1 The intensities of the characteristic ions of a compound maximize in the same scan or within one scan of each other. The Target data system is configured to make this check.

9.4.2.1.2 The relative retention time (RRT) of the sample component is within ±0.06 RRT units of the RRT of the standard component.

9.4.2.1.3 The relative intensities of the characteristic ions agree within 30% of the relative intensities of these ions in the reference spectrum. (Example: For an ion with an abundance of 50% in the reference spectrum, the corresponding abundance in a sample spectrum can range between 20% and 80%.)

9.4.2.1.4 Structural isomers that produce very similar mass spectra should be identified as individual isomers if they have sufficiently different GC retention times. Sufficient GC resolution is achieved if the height of the valley between two isomer peaks is less than 25% of the sum of the two peak heights. Otherwise, structural isomers are identified as isomeric pairs (i.e., m and p-xylene).

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9.4.2.1.5 Identification is hampered when sample components are not resolved chromatographically and produce mass spectra containing ions contributed by more than one analyte. When gas chromatographic peaks obviously represent more than one sample component (i.e., a broadened peak with shoulder(s) or a valley between two or more maxima), appropriate selection of analyte spectra and background spectra is important.

9.4.2.1.6 Examination of extracted ion current profiles of appropriate ions can aid in the selection of spectra, and in qualitative identification of compounds. When analytes coelute (i.e., only one chromatographic peak is apparent), the identification criteria may be met, but each analyte spectrum will contain extraneous ions contributed by the coeluting compound.

9.4.2.2 For samples containing non-target analytes, a library search will be performed at client request. Compound identification will be classified as "tentative", and the concentration will be reported as an estimate as no quantitative standards are run for these compounds.

1) Relative intensities of major ions in the reference spectrum (ions greater than 10% of the most abundant ion) should be present in the sample spectrum.
2) The relative intensities of the major ions should agree within ±20%. (Example: For an ion with an abundance of 50% in the standard spectrum, the corresponding sample ion abundance must be between 30 and 70%.)
3) Molecular ions present in the reference spectrum should be present in the sample spectrum.
4) Ions present in the sample spectrum but not in the reference spectrum should be reviewed for possible background contamination or presence of coeluting compounds.
5) Ions present in the reference spectrum but not in the sample spectrum should be reviewed for possible subtraction from the sample spectrum because of background contamination or coeluting peaks.

9.4.3 Quantitative Analysis:

9.4.3.1 Quantitation of a target compound detected in a sample is performed automatically by the Target data processing software, using the formulae found in Alpha's Quality Manual. Either the average response factor or calibration curve will be used for sample quantitation, depending on how the particular analyte was processed in the initial calibration curve.

9.4.3.2 If non-target compounds are to be reported, the quantitation is performed automatically by the Target software using the total area of the compound and the nearest internal standard, and assuming a relative response factor of 1.0.

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9.5 Maintenance

Routine preventive maintenance should be performed on the analytical system. This includes replacement of GC septa and periodic rinsing or replacement of purge and trap tubes and sparge needles. The trap should be replaced every six months, or sooner if performance criteria cannot be met. Periodic cleaning (typically twice per year) of the mass spectrometer ion source is required. More frequent source cleaning may be needed, especially if dirty samples are analyzed. In addition, semi-annual preventive maintenance is provided by the instrument manufacturer as part of our service agreement.

If system performance deteriorates, additional maintenance may be required. This includes replacement of injector ports and seals, clipping several inches off of the front end of the GC column, or in extreme cases the replacement of the GC column. Flushing or replacement of purge and trap lines may be necessary if they become contaminated or develop active sites.

10. Quality Control and Data Assessment

The laboratory must maintain records to document the quality of data that is generated. Ongoing data quality checks are compared with established performance criteria to determine if the results of analyses meet the performance characteristics of the method.

10.1 Demonstration of Capability

The analyst must make an initial, one-time, demonstration of the ability to generate acceptable accuracy and precision with this method. Each time a method modification is made, the analyst is required to repeat the procedure.

Prepare a Level 3 QC check standard according to the specifications in Section 8.5.

Analyze four 5mL aliquots of the well-mixed QC check standard.

Calculate the result for each aliquot in µg/L, the relative standard deviation of the four results in µg/L, the average result for the four aliquots in µg/L, and the percent recovery for each parameter of interest using the four results.

For each parameter, compare the average percent recovery of the four results. All parameters of interest must meet the acceptance criteria before actual sample analysis begins. If any individual parameter exceeds the precision limit or any individual falls outside the range for accuracy, the system performance is unacceptable for that parameter. Recovery must be 70 – 130% of the true value.

10.2 Method Blank

Analyze a reagent water blank each day prior to sample analysis to demonstrate that interferences from the analytical system are under control. The reagent blank must contain the internal standards and surrogates.

Analyze the reagent water blank from the same lot of water used for preparing the standards, QC samples and making sample dilutions. The method blank must not contain any target analytes at or above the compound reporting limits.

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10.3 Laboratory Control Sample (LCS)

A laboratory control sample is analyzed at the beginning of each analytical sequence. Since the LCS contains the same compounds at the same concentrations as the continuing calibration check standard, the same analysis is used to satisfy both QC elements. The LCS must meet the QC criteria listed in Table 2.

10.4 Matrix Spike/Matrix Spike Duplicates (MS/MSD)

A matrix spike/matrix spike duplicate pair is analyzed with each batch of 20 or less samples. The MS/MSD are sample aliquots spiked with the target compounds at the same concentration as the continuing calibration standard. The MS/MSD must meet the QC criteria listed in Table 2. If the MS/MSD does not meet the criteria, but the LCD does, the failure may be attributed to sample matrix. Report the MS/MSD, including a narrative sheet for inclusion with the client report.

NOTE: A matrix spike/matrix spike duplicate pair is only analyzed upon client request for Low Level Soil samples. A sample duplicate is analyzed instead.

10.5 Internal Standards

Area counts of the internal standard peaks in all samples and QC samples must be between 50-200% of the areas of the internal standards in the QC check standard.

If any individual percent recovery falls outside the range, that parameter has failed the acceptance criteria. For calibration standards, CV or blanks the internal standard must be within the range for data to be reported to the clients. For samples, matrix spikes and duplicates: if the data is not within the range, the sample is rerun to confirm that the failure is due to sample matrix. A nonconformance report form is completed to ensure client notification and reporting if matrix effect is confirmed.

10.6 Surrogates

Surrogates are added to each field sample and QC sample. The laboratory must evaluate surrogate recovery data from individual samples versus the surrogate control limits developed by the laboratory. The surrogate acceptance criteria are listed in Table 2.

10.7 Control Limits

The laboratory maintains performance records to document the quality of data that is generated. Method accuracy for samples is assessed and records maintained.

Control limits for the method parameters are generated by the QC staff and distributed to the analysts. The control limits are calculated based on in-house performance data. The limits are compared to the control limits found in the reference method.

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10.8 Analytical Sequence

In a 12-hour period, the analytical sequence is as follows:

BFB
QC Check Standard/Laboratory Control Sample
Method Blank
Samples
MS (as required)
MSD (as required)

11. Method Performance

The method detection limit (MDL) is defined as the minimum concentration of a substance that can be measured and reported with 99% confidence that the value is above zero. The MDL concentrations were obtained using reagent water. Similar results were achieved using representative wastewaters. The MDL actually achieved in a given analysis will vary depending on instrument sensitivity and matrix effects.

Method performance data is on file in the laboratory QC department. Comparison of method performance data for the laboratory to the reference method criteria occurs when laboratory in-house acceptance limits are generated. In-house generated data must be within the specifications of the reference method or the analysis is not continued until corrective action is completed.

The performance of this method is evaluated on an on-going basis by the QC criteria listed throughout this SOP. Specifically, Initial Calibration criteria, Continuing Calibration Check criteria, surrogates, blanks, LCSs, and MS/MSDs are all used to ensure that the method is producing results of consistently high quality. In addition, Alpha participates in several blind and double blind PE studies annually to demonstrate the ability of this method to produce accurate and reproducible data.

12. Corrective Actions

Holding time exceedence, improper preservation and observed sample headspace are noted on the nonconformance report form.

Perform routine preventative maintenance as described throughout this SOP. Record all maintenance in the instrument logbook.

Review of internal standard, surrogates and QC check standard response for acceptable performance occurs for each batch of samples. Record any trends or unusual performance on a nonconformance action form.

All batch and sample specific QC criteria outlined in section 10 are evaluated by the analyst prior to approval of the data. When any QC criteria fail, the cause for the failure must be identified and corrected. This may include instrument recalibration followed by sample reanalysis, sample cleanup, or sample re-extraction. If it is determined that the failure is due to sample matrix effects, a project narrative report is written by the analyst for inclusion in the data report. If there is insufficient sample volume to perform the re-analysis for confirmation, this is also noted in the narrative and included in the client report.

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13. Pollution Prevention

See Chemical Hygiene Plan for pollution prevention operations.

14. Waste Management

See Chemical Hygiene Plan for waste handling and disposal.

15. Attachments

TABLE 1: 8260 REPORTING LIMITS

TABLE 2: 8260 QC ACCEPTANCE CRITERIA

TABLE 3: BFB TUNING CRITERIA

TABLE 4: STANDARD SOLUTIONS

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Table 1

Standard Reported Detection Limits

US EPA METHOD 8260B and 5035/8260B

Analyte	RDL (µg/L)	RDL(µg/KG)[1]	RDL (µg/KG)[2]
Acetone	5.0	10.0	500
Acrolein	12.5	25.0	1250
Acrylonitrile	5.0	10.0	500
Benzene	0.5	1.0	50
Bromobenzene	2.5	5.0	250
Bromochloromethane	2.5	5.0	250
Bromodichloromethane	0.5	1.0	50
Bromoform	2.0	4.0	200
Bromomethane	1.0	2.0	100
2-Butanone	5.0	10.0	500
n-Butyl benzene	0.5	1.0	50
sec-Butyl benzene	0.5	1.0	50
tert-Butyl benzene	2.5	5.0	250
Carbon disulfide	5.0	10.0	500
Carbon tetrachloride	0.5	1.0	50
Chlorobenzene	0.5	1.0	50
Chloroethane	1.0	2.0	100
Chloroform	0.75	1.5	75
Chloromethane	2.5	5.0	250
o-Chlorotoluene	2.5	5.0	250
p-Chlorotoluene	2.5	5.0	250
Dibromochloromethane	0.5	1.0	50
1,2-Dibromo-3-chloropropane	2.5	5.0	250
1,2-Dibromoethane	2.5	5.0	250
Dibromomethane	5.0	10.0	500
1,2-Dichlorobenzene	2.5	5.0	250
1,3-Dichlorobenzene	2.5	5.0	250
1,4-Dichlorobenzene	2.5	5.0	250
1,4-Dichlorobutane	5.0	10.0	500
trans-1,4-Dichloro-2-butene	2.5	5.0	250
Dichlorodifluoromethane	5.0	10.0	500
1,1-Dichloroethane	0.75	1.5	75
1,2-Dichloroethane	0.75	1.5	75
1,1-Dichloroethene	0.75	1.5	75
cis-1,2-Dichloroethene	0.5	1.0	50
trans-1,2-Dichloroethene	0.75	1.5	75

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Table 1 (continued)

Standard Reported Detection Limits

US EPA METHOD 8260B and 5035/8260B

Analyte	RDL (µg/L)	RDL(µg/KG)(1)	RDL (µg/KG) (2)
1,2-Dichloropropane	1.75	3.5	175
1,3-Dichloropropane	2.5	5.0	250
2,2-Dichloropropane	2.5	5.0	250
1,1-Dichloropropene	12.5	25.0	1250
cis-1,3-Dichloropropene	0.5	1.0	50
trans-1,3-Dichloropropene	0.5	1.0	50
Ethylbenzene	0.5	1.0	50
Ethyl ether	12.5	25.0	1250
Ethyl methacrylate	5.0	10.0	500
Hexachlorobutadiene	2.5	5.0	250
2-Hexanone	5.0	10.0	500
Iodomethane	5.0	10.0	500
Isopropylbenzene	0.5	1.0	50
p-Isopropyltoluene	0.5	1.0	50
Methylene chloride	2.5	5.0	250
4-Methyl-2-pentanone	5.0	10.0	500
Methyl-tert-butyl-ether	1.0	2.0	100
Naphthalene	2.5	5.0	250
n-Propylbenzene	0.5	1.0	50
Styrene	0.5	1.0	50
1,1,1,2-Tetrachloroethane	2.5	5.0	250
1,1,2,2-Tetrachloroethane	0.5	1.0	50
Tetrachloroethene	0.75	1.5	75
Tetrahydrofuran	10.0	20.0	1000
Toluene	0.75	1.5	75
1,2,3-Trichlorobenzene	2.5	5.0	250
1,2,4-Trichlorobenzene	2.5	5.0	250
1,1,1-Trichloroethane	0.5	1.0	50
1,1,2-Trichloroethane	0.75	1.5	75
Trichloroethene	0.5	1.0	50
Trichlorofluoromethane	2.5	5.0	250
1,2,3-Trichloropropane	5.0	10.0	500
1,2,4-Trimethylbenzene	2.5	5.0	250
1,3,5-Trimethylbenzene	2.5	5.0	250
Vinyl acetate	5.0	10.0	500
Vinyl chloride	1.0	2.0	100
m/p-Xylenes	0.5	1.0	50
o-Xylene	0.5	1.0	50

(1) Detection Limits are for Low-level Sodium Bisulfate preserved samples.
(2) Detection Limits are for High-level Methanol preserved samples.

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Table 2

QUALITY CONTROL ACCEPTANCE CRITERIA

Surrogate Spike Percent Recovery	Aqueous Limits		Soil Limits	
	Lower Control Limit	Upper Control Limit	Lower Control Limit	Upper Control Limit
1,2-Dichloroethane-d_4	70%	130%	70%	130%
4-Bromofluorobenzene	70%	130%	70%	130%
Toluene-d_8	70%	130%	70%	130%
Dibromofluoromethane	70%	130%	70%	130%

MS/MSD and LCS Percent Recovery	Aqueous Limits		Soil Limits	
	Lower Control Limit	Upper Control Limit	Lower Control Limit	Upper Control Limit
1,1-Dichloroethene	61%	145%	59%	172%
Trichloroethene	71%	120%	62%	137%
Chlorobenzene	75%	130%	60%	133%
Benzene	76%	127%	66%	142%
Toluene	76%	125%	59%	139%

MS/MSD Relative Percent Difference	Aqueous Limits	Soil Limits
All Target Compounds	20%	30%

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Table 3

BFB (4-BROMOFLUOROBENZENE) MASS INTENSITY CRITERIA

m/z	Required Intensity (relative abundance)
50	15 to 40% of m/z 95
75	30 to 60% of m/z 95
95	Base peak, 100% relative abundance
96	5 to 9% of m/z 95
173	Less than 2% of m/z 174
174	Greater than 50% of m/z 95
175	5 to 9% of m/z 174
176	Greater than 95% but less than 101% of m/z 174
177	5 to 9% of m/z 176

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Table 4

Stock Standard Concentrations and Calibration Concentration Levels

Target Compounds	Stock (µg/mL)	Level 1 (µg/L)	Level 2 (µg/L)	Level 3 (µg/L)	Level 4 (µg/L)	Level 5 (µg/L)	Level 6 (µg/L)	Level 7 (µg/L)
Acetone	2000	0.5	2	10	20	30	50	100
Acrolein	2000	0.5	2	10	20	30	50	100
Acrylonitrile	2000	0.5	2	10	20	30	50	100
Benzene	2000	0.5	2	10	20	30	50	100
Bromobenzene	2000	0.5	2	10	20	30	50	100
Bromochloromethane	2000	0.5	2	10	20	30	50	100
Bromodichloromethane	2000	0.5	2	10	20	30	50	100
Bromoform	2000	0.5	2	10	20	30	50	100
Bromomethane	2000	0.5	2	10	20	30	50	100
2-Butanone	2000	0.5	2	10	20	30	50	100
n-Butyl benzene	2000	0.5	2	10	20	30	50	100
sec-Butyl benzene	2000	0.5	2	10	20	30	50	100
tert-Butyl benzene	2000	0.5	2	10	20	30	50	100
Carbon disulfide	2000	0.5	2	10	20	30	50	100
Carbon tetrachloride	2000	0.5	2	10	20	30	50	100
Chlorobenzene	2000	0.5	2	10	20	30	50	100
Chloroethane	2000	0.5	2	10	20	30	50	100
Chloroform	2000	0.5	2	10	20	30	50	100
Chloromethane	2000	0.5	2	10	20	30	50	100
o-Chlorotoluene	2000	0.5	2	10	20	30	50	100
p-Chlorotoluene	2000	0.5	2	10	20	30	50	100
Dibromochloromethane	2000	0.5	2	10	20	30	50	100
1,2-Dibromo-3-chloropropane	2000	0.5	2	10	20	30	50	100
1,2-Dibromoethane	2000	0.5	2	10	20	30	50	100
Dibromomethane	2000	0.5	2	10	20	30	50	100
1,2-Dichlorobenzene	2000	0.5	2	10	20	30	50	100
1,3-Dichlorobenzene	2000	0.5	2	10	20	30	50	100
1,4-Dichlorobenzene	2000	0.5	2	10	20	30	50	100
1,4-Dichlorobutane	2000	0.5	2	10	20	30	50	100
trans-1,4-Dichloro-2-butene	2000	0.5	2	10	20	30	50	100
Dichlorodifluoromethane	2000	0.5	2	10	20	30	50	100
1,1-Dichloroethane	2000	0.5	2	10	20	30	50	100
1,2-Dichloroethane	2000	0.5	2	10	20	30	50	100
1,1-Dichloroethene	2000	0.5	2	10	20	30	50	100
cis-1,2-Dichloroethene	2000	0.5	2	10	20	30	50	100
trans-1,2-Dichloroethene	2000	0.5	2	10	20	30	50	100
1,2-Dichloropropane	2000	0.5	2	10	20	30	50	100
1,3-Dichloropropane	2000	0.5	2	10	20	30	50	100

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Table 4 (continued)

Stock Standard Concentrations and Calibration Concentration Levels

Target Compounds	Stock (µg/mL)	Level 1 (µg/L)	Level 2 (µg/L)	Level 3 (µg/L)	Level 4 (µg/L)	Level 5 (µg/L)	Level 6 (µg/L)	Level 7 (µg/L)
2,2-Dichloropropane	2000	0.5	2	10	20	30	50	100
1,1-Dichloropropene	2000	0.5	2	10	20	30	50	100
cis-1,3-Dichloropropene	2000	0.5	2	10	20	30	50	100
trans-1,3-Dichloropropene	2000	0.5	2	10	20	30	50	100
Ethylbenzene	2000	0.5	2	10	20	30	50	100
Ethyl ether	2000	0.5	2	10	20	30	50	100
Ethyl methacrylate	2000	0.5	2	10	20	30	50	100
Hexachlorobutadiene	2000	0.5	2	10	20	30	50	100
2-Hexanone	2000	0.5	2	10	20	30	50	100
Iodomethane	2000	0.5	2	10	20	30	50	100
Isopropylbenzene	2000	0.5	2	10	20	30	50	100
p-Isopropyltoluene	2000	0.5	2	10	20	30	50	100
Methylene chloride	2000	0.5	2	10	20	30	50	100
4-Methyl-2-pentanone	2000	0.5	2	10	20	30	50	100
Methyl-tert-butyl-ether	2000	0.5	2	10	20	30	50	100
Naphthalene	2000	0.5	2	10	20	30	50	100
n-Propylbenzene	2000	0.5	2	10	20	30	50	100
Styrene	4000	1	4	20	40	60	100	200
1,1,1,2-Tetrachloroethane	2000	0.5	2	10	20	30	50	100
1,1,2,2-Tetrachloroethane	2000	0.5	2	10	20	30	50	100
Tetrachloroethene	2000	0.5	2	10	20	30	50	100
Tetrahydrofuran	2000	0.5	2	10	20	30	50	100
Toluene	2000	0.5	2	10	20	30	50	100
1,2,3-Trichlorobenzene	2000	0.5	2	10	20	30	50	100
1,2,4-Trichlorobenzene	2000	0.5	2	10	20	30	50	100
1,1,1-Trichloroethane	2000	0.5	2	10	20	30	50	100
1,1,2-Trichloroethane	2000	0.5	2	10	20	30	50	100
Trichloroethene	2000	0.5	2	10	20	30	50	100
Trichlorofluoromethane	2000	0.5	2	10	20	30	50	100
1,2,3-Trichloropropane	2000	0.5	2	10	20	30	50	100
1,2,4-Trimethylbenzene	2000	0.5	2	10	20	30	50	100
1,3,5-Trimethylbenzene	2000	0.5	2	10	20	30	50	100
Vinyl acetate	2000	0.5	2	10	20	30	50	100
Vinyl chloride	2000	0.5	2	10	20	30	50	100
m/p-Xylenes	4000	1	4	20	40	60	100	200
o-Xylene	4000	1	4	20	40	60	100	200

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Table 4 (continued)

Stock Standard Concentrations and Calibration Concentration Levels

Target Compounds	Stock (µg/mL)	Level 1 (µg/L)	Level 2 (µg/L)	Level 3 (µg/L)	Level 4 (µg/L)	Level 5 (µg/L)	Level 6 (µg/L)	Level 7 (µg/L)
Internal Standards								
Fluorobenzene	2500	10	10	10	10	10	10	10
Chlorobenzene-d5	2500	10	10	10	10	10	10	10
1,4-Dichlorobenzene-d4	2500	10	10	10	10	10	10	10
Surrogates								
Dibromofluoromethane	2500	10	10	10	10	10	10	10
1,2-Dichloroethane-d4	2500	10	10	10	10	10	10	10
Toluene-d8	2500	10	10	10	10	10	10	10
4-Bromofluorobenzene	2500	10	10	10	10	10	10	10

- For Low Level Soil analysis, the calibration levels are the same in µg/Kg units.
- For High Level Soil analysis, the calibration levels are at 50X the levels listed due to sample preparation requirements.

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Polynuclear Aromatic Hydrocarbons (PAH)

by Selected Ion Monitoring (SIM)

Reference Method No.: **EPA # 8270C (Modified)**

Reference Method: SW-846, Test Methods for Evaluating Solid Waste: Physical/Chemical Methods, EPA SW-846, Update III, 1997.

Copy No. _____

Alpha Analytical Labs
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Prepared by:

Name: Joseph Clements Position: Laboratory Manager

Signature: _____ Date: 10/26/01

Authorized by:

Name: Scott McLean Position: President / Laboratory Director

Signature: _____ Date: 10/26/01

ISSUE AMENDMENTS

Changes since last issue:

Sections 7.1.1 and 7.1.3: Specific instrumentation has been defined.

Polynuclear Aromatic Hydrocarbons (PAH)

by Selected Ion Monitoring (SIM)

Reference Method No.: **EPA # 8270C (Modified)**

Reference Method: SW-846, Test Methods for Evaluating Solid Waste: Physical/Chemical Methods, EPA SW-846, Update III, 1997.

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1. Scope and Application

Matrices: This method is used to determine the concentration of semivolatile organic compounds in extracts prepared from many types of solid waste matrices, soils, groundwater and wastewater samples.

This method is used to quantitate the neutral, acidic, and basic organic compounds listed in Table 6 that are soluble in methylene chloride and capable of being eluted, without derivatization, from a gas chromatographic fused-silica capillary column coated with a slightly polar silicone.

The following compounds may require special treatment when being determined by this method:

- Hexachlorocyclopentadiene is subject to thermal decomposition in the inlet of the gas chromatograph, chemical reaction in acetone solution, and photochemical decomposition.
- Pentachlorophenol, is subject to erratic chromatographic behavior, especially if the GC system is contaminated with high boiling material.

The data report packages present the documentation of any method modification related to the samples tested. Depending upon the nature of the modification and the extent of intended use, the laboratory may be required to demonstrate that the modifications will produce equivalent results for the matrix. Approval of all method modifications is by one of the following laboratory personnel before performing the modification: Area Supervisor, Laboratory Services Manager, Laboratory Director, or Quality Assurance Officer.

This method is restricted to use by or under the supervision of analysts experienced in the operation of a gas chromatograph/mass spectrometer operating in the selected ion monitoring (SIM) mode. Each analyst must demonstrate the ability to generate acceptable results with this method by performing an initial demonstration of capability (Section 10.1), analyzing a proficiency test sample and completing the record of training. After initial demonstration, ongoing demonstration is based on acceptable laboratory performance of at least a quarterly laboratory control sample or acceptable performance from an annual proficiency test sample.

2. Summary of Method

The samples are introduced into the GC/MS by injecting 1µL of the sample extract into a gas chromatograph (GC) with a narrow-bore fused-silica capillary column. The GC column is temperature-programmed to separate the analytes, which are then detected with a mass spectrometer (MS) connected to the gas chromatograph.

The mass spectrometer is operated in the selected ion monitoring (SIM) mode. In this mode of operation, only the characteristic ions of the compounds listed in Table 6 are detected. For this reason, only the targeted analytes can be detected and reported. It is not possible to identify any other compounds that may be present in the sample.

Analytes eluted from the capillary column are introduced into the mass spectrometer via direct connection. Identification of target analytes is accomplished by comparing the retention times of the characteristic ions with the retention times of these compounds in the daily check standard. Quantitation is accomplished using the internal standard method, using the average response factors from the initial calibration curve.

2.1 Method Modifications from Reference

Operating the mass spectrometer in the SIM mode is a modification from method 8270, which requires operating in the scan mode. This SIM method is used when a project requires lower reporting limits than can be achieved running method 8270 or 625. The sensitivity of the SIM method is approximately 5 – 10 times higher than the full scan method. This method can only be used when the compounds to be reported are those listed in Table 6.

3. Detection Limits

The laboratory follows the procedure found in 40CFR Part 136 to determine the MDL on an annual basis. The method detection limits determined by the laboratory are on file for review.

Table 6 lists our routine reporting limits. Whenever MDL studies are performed, the MDL results are compared with our reporting limits to ensure that the calculated MDLs are equal to or below our reporting limits.

4. Interferences

4.1 Instrumental

4.1.1 Only high purity helium is used in the GC system to eliminate this source of possible contamination. The helium (carrier gas) is certified by the gas supplier.

4.1.2 Preventive instrument maintenance is performed routinely, and whenever highly contaminated extracts are analyzed that could result in chromatographic interferences or result in degradation of system performance. Section 9.7 details the maintenance steps.

4.1.3 Glassware must be scrupulously cleaned. This procedure is detailed in the extraction SOPs. Store dry glassware in a clean environment.

4.2 Parameters

4.2.1 Contaminated solvents or reagents are also possible sources or contamination. All solvents used are pesticide grade or equivalent, and reagents are purchased as certified contaminant free. All of these materials are routinely determined to be free of interferences by analysis of extraction blanks with every extraction batch performed.

4.2.2 Contamination by carry-over can occur whenever high-concentration and low-concentration samples are sequentially analyzed. Whenever an unusually concentrated sample is encountered, it should be followed by the analysis of a solvent blank to check for possible carryover. If this is not done, the sample run immediately after the high concentration sample must be rerun to confirm any positive hits.

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5. Safety

The toxicity or carcinogenicity of each reagent and standard used in this method is not fully established; however, each chemical compound should be treated as a potential health hazard. From this viewpoint, exposure to these chemicals must be reduced to the lowest possible level by whatever means available. A reference file of material data handling sheets is available to all personnel involved in the chemical analysis. Additional references to laboratory safety are available in the Chemical Hygiene Plan.

All personnel handling environmental samples known to contain or to have been in contact with municipal waste must follow safety practices for handling known disease causative agents.

5.1 Lab coats, safety glasses, and gloves should be worn when handling samples, extracts, standards or solvents.

5.2 All solvent and extract transfers should be handled in the vented bench area in the GC/MS laboratory.

5.3 All stock standards, working standards, and vialed sample extracts must be placed into the waste bucket in the lab for future disposal by the Health and Safety Officer. The container must be labeled properly with hazard warning labels indicating the container contents.

5.4 Flammable solvent bottles must be stored in the flammables cabinet.

6. Sample Collection, Preservation, and Handling

6.1 Sample Collection

Aqueous samples are collected in two 1L amber glass jars with teflon-lined lids. Solid samples are collected in 250mL wide-mouth glass jars with teflon-lined lids. All containers are purchased pre-cleaned and certified from commercial vendors.

6.2 Sample Preservation

Both aqueous and solid samples are then preserved by packing in coolers with ice or ice packs, to maintain a temperature of $\leq$ 4ºC. Upon receipt at the laboratory, the samples are transferred into sample storage refrigerators to maintain at a temperature of $\leq$ 4ºC.

6.3 Sample Handling

Aqueous samples must be extracted within 7 days of sample collection, solid samples within 14 days of collection. Once extracted, the samples must be analyzed within 40 days of the extraction date.

7. Equipment and Supplies

7.1 Gas Chromatograph/Mass Spectrometer System:

7.1.1 Gas Chromatograph, Hewlett Packard 6890 or equivalent: An analytical system complete with a temperature-programmable gas chromatograph configured for split/splitless-injection and all required accessories, including syringes, analytical columns, and gases. The capillary column is directly coupled to the source.

7.1.2 Column: 30m x 0.25mm ID, 0.25 µm film thickness silicone-coated, fused-silica capillary column (RTX-5MS, Restek), or equivalent.

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7.1.3 Mass Spectrometer, Hewlett Packard 5973 or equivalent: Scanning in SIM mode (See Table 7 for SIM parameters) using 70 volts (nominal) electron energy in the electron impact ionization mode. The mass spectrometer is capable of producing a mass spectrum for decafluorotriphenylphosphine (DFTPP) which meets the criteria in Table 1 when 1 µL of the GC/MS tuning standard is injected through the GC (50ng of DFTPP).

7.1.4 Data System: A computer system is interfaced to the Mass Spectrometer. The system allows the continuous acquisition and storage on machine-readable media of all mass spectra obtained throughout the duration of the chromatographic program. The computer software allows the analyst to search for any GC/MS data file for ions of specific mass and plot such ion abundances versus time or scan number. *HP ChemServer* software is used for data acquisition and *Thruput Systems Target 3.1* is used for data reduction.

7.2 Syringes: 10, 25, 50, 100, 250, 500, and 1000µL.

7.3 Volumetric Flasks, Class A: Appropriate sizes with ground-glass stoppers.

7.4 Vials: Glass autosampler vials with polytetrafluoroethylene (PTFE)-lined crimp top caps.

8. Standards and Reagents

8.1 Stock Standard Solutions

All stock standard solutions are purchased from commercial vendors as ampulated certified solutions or prepared in house from neat materials. When an ampulated stock solution is opened, or prepared volumetrically from neat materials, it must be transferred into amber vials with PTFE-lined screwcaps. The lot number, catalog number, expiration date, preparation date and analyst initials are recorded in the standard prep logbook.

Store, protected from light, at –10ºC or less. Stock standard solutions are checked for signs of degradation or evaporation, especially just prior to preparing secondary dilution standards.

Stock standard solutions are all replaced after 1 year, or sooner if comparison with quality control check samples indicates degradation of the standard.

8.1.1 Internal Standard Stock Solution

The internal stock internal standard solution is purchased as an ampulated, certified solution containing the compounds listed below. (Supelco, 2000µg/mL in DCM, catalog# 4-8902, or equivalent).

1,4-dichlorobenzene-d_4
naphthalene-d_8
acenaphthene-d_{10}
phenanthrene-d_{10}
chrysene-d_{12}
perylene-d_{12}

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8.1.2 Calibration Stock Solutions

Stock Standard	Catalog Number	Concentration
Ultra Scientific Toxic Substances Mixture #1	US-103	2000 µg/mL
Ultra Scientific Toxic Substances Mixture #2	US-104	2000µg/mL
Ultra Scientific Phenol Mix	US-107	2000µg/mL
Supelco TCL Phenol/Benzidine Mix	47992-U	2000µg/mL
Supelco TCL Hazardous Substances Mix #1	4-8907	2000µg/mL
Supelco TCL Hazardous Substances Mix #2	4-8908	2000µg/mL
Supelco TCL Base-Neutral Mix	47991-U	2000µg/mL
Supelco Polynuclear Aromatic Hydrocarbons Mix	48905-U	2000µg/mL
Ultra Scientific PAH Mixture	US-106N-4	2000µg/mL
Ultra Scientific Base-Neutrals Mixture #1	US-100N-4	2000µg/mL
Ultra Scientific Base-Neutrals Mixture #2	US-101N-4	2000µg/mL

8.2 Intermediate Standard Solutions

8.2.1 Internal Standard Intermediate Solution

The intermediate internal standard solution is prepared by diluting the internal standard stock solution with hexane. 100µL of the internal standard stock solution is combined with 900µL of hexane in a 2 mL amber screw-cap vial, resulting in a final concentration of 200µg/mL.

500µL aliquots of standards, blanks and sample extracts are spiked with 10µL of the intermediate internal standard solution, resulting in a concentration of 4µg/mL.

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8.2.2 Surrogate Spiking Solution

The surrogate spiking solution is prepared from neat compounds, as follows:

To a 1L volumetric flask add: 0.2 g Phenol d_6 (Acid Surrogate)
0.1 g Terphenyl d_{14} (B/N Surrogate)
0.1 g Nitrobenzene d_4 (B/N Surrogate)
0.1 g 2-Fluorobiphenyl (B/N Surrogate)
0.2 g 2-Fluorophenol (Acid Surrogate)
0.2 g 2,4,6-Tribromophenol (Acid Surrogate).

Bring to volume with Acetone. The final concentration is 200µg/mL for the acid surrogates and 100µg/mL for the B/N surrogates.

1mL of this surrogate spiking solution is added to each sample, blank and QC samples prior to extraction. See the extraction SOPs for details.

Record the standard preparation information in the standards prep logbook, including the analyst's initials, preparation date, expiration date and standard identifier.

To prepare the instrument calibration standards, the surrogate spiking solution must be in Hexane. See extraction SOPs for solvent exchange procedure.

8.2.3 Intermediate Calibration Standards

Calibration standards are prepared by diluting the stock standard solutions (Section 8.1.2) with hexane. They are stored in the refrigerator at ≤ 4 °C and expire after 1 year or on the earliest expiration date of any of the stock standards used, whichever is sooner. Two sources of standards are prepared, one is used for the initial calibration curve, and the other is used as the daily calibration check standard. These intermediate solutions are then used to prepare the working initial calibration and calibration check standards as listed in the table in Section 8.2.4.

Record the standard preparation information in the standards prep logbook, including the analyst's initials, preparation date, expiration date and standard identifier.

8.2.3.1 Acid Intermediate Standard (Primary):

1mL of the stock standards listed below are brought to 5mL hexane, resulting in a final concentration of 400µg/mL:

Toxic Substances Mix #1	Ultra Scientific
Toxic Substances Mix #2	Ultra Scientific
Phenol mixture	Ultra Scientific

8.2.3.2 Acid Intermediate Standard (Secondary):

1mL of the stock standards listed below are brought to 5mL hexane, resulting in a final concentration of 400µg/mL:

TCL Hazardous Substances Mix 1, Supelco
TCL Hazardous Substances Mix 2, Supelco
TCL Phenol / Benzidine Mix, Supelco

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8.2.3.3 Base/Neutral Intermediate Standard #1 (Primary):
1mL of the stock standards listed below are brought to 5mL hexane, resulting in a final concentration of 400µg/mL:

TCL Polynuclear Aromatic Hydrocarbon Mix, Supelco
TCL Base – Neutral Mix, Supelco

8.2.3.4 Base/Neutral Intermediate Standard #1 (Secondary):
1mL of the stock standards listed below are brought to 5mL hexane, resulting in a final concentration of 400µg/mL:

Base/Neutral Mixture #1, Ultra Scientific
Base/Neutral Mixture #2, Ultra Scientific
PAH Mixture, Ultra Scientific

8.2.3.5 Base/Neutral Intermediate Standard #2 (Primary and Secondary):
0.05g of the neat standards listed below are brought to 25mL hexane, resulting in a final concentration of 2000µg/mL. 1mL of this solution is brought to 5mL volume with hexane, to prepare the intermediate standard at 400µg/mL.

1-methylnaphthlene
2-methylnaphthlene
pyridine

8.2.4 Working Calibration Standards

The secondary dilution standards are used to prepare the initial calibration standards and the daily continuing calibration check standard. Six calibration levels are prepared and analyzed, as listed in the table below. A five point calibration is used for each target compound. The daily continuing calibration check standard is from the alternate source, at the 8.0 µg/mL level.

Level	Surrogate	Standard A	Standard B	Standard C	Hexane
µg/mL	Section 8.2.2	Section 8.3.1 or Section 8.3.2	Section 8.3.3 or Section 8.3.4	Section 8.3.5	
80	100µL	100µL	100µL	100µL	100µL
40	300µL	50µL	50µL	50µL	50µL
8.0	460µL	10µL	10µL	10µL	10µL

µg/mL	Solution	Volume	Volume Hexane
4.0	40 ppb standard	100µL	900µL
0.8	8 ppb standard	100µL	900µL
0.2	8 ppb standard	25µL	975µL

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8.2.5 LCS/MS/MSD Spiking Solution

The spiking solution is prepared from neat compounds.

To a 250mL volumetric flask add 0.025g of each of the following compounds:

- p-chloro-m-cresol
- 2-chlorophenol
- 4-nitrophenol
- pentachlorophenol *
- phenol
- acenaphthene *
- 1,2,4-trichlorobenzene
- 1,4-dichlorobenzene
- 2,4-dinitrotoluene
- n-nitrosodipropylamine
- pyrene *

The final concentration is 100µg/mL. For the SIM analysis, only the compounds marked with a * are reported.

Record the standard preparation information in the standards prep logbook, including the analyst's initials, preparation date, expiration date and standard identifier.

8.2.6 GC/MS Tuning Standard

The stock standard is purchased as an ampulated, certified solution containing decafluorotriphenylphosphine (DFTPP), 4,4'DDT, pentachlorophenol, and benzidine at 2000 µg/mL (Ultra Scientific, Catalog# GCM-150, or equivalent).

The intermediate standard is prepared by taking 25µL of the stock solution and bringing up to 1 mL in hexane. The resulting concentration is 50µg/mL. The 4,4'DDT, pentachlorophenol, and benzidine are used to verify injection port inertness and GC column performance. Store at –10ºC or less when not in use.

8.3 Reagents

Reagent grade or pesticide grade chemicals and solvents are used in all tests. Unless otherwise indicated, it is intended that all reagents shall conform to specifications of the Committee on Analytical Reagents of the American Chemical Society, where such specifications are available. Other grades may be used, provided it is first ascertained that the reagent is of sufficient high purity to permit its use without lessening the accuracy of the determination.

8.3.1 Methylene chloride: Pesticide grade or equivalent.

8.3.2 Hexane: Pesticide grade or equivalent.

8.3.3 Acetone: Pesticide grade or equivalent.

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9. Procedure

9.1 SET-UP

9.1.1 GC/MS Operating Conditions:

Typical GC/MS operating conditions are listed below, but may be altered as long as method performance criteria are met.

Mass range:	SIM Mode (See Table 7)
Initial temperature:	35°C, hold for 2 minutes
Temperature program:	35°C at 10°C / minute
Final temperature:	310°C, hold for 3 minutes
Injector temperature:	280°C
Transfer line temperature:	280°C
Source temperature:	230ºC
Injector:	Split-injection, ratio 10:1
Injection volume:	1µL
Carrier gas:	Helium at 41 cm / second, constant flow

9.1.2 GC/MS Tune Check:

At the beginning of every 12 hour sequence, analyze the 50µg/L GC/MS tuning standard (Section 8.2.6).

The resultant mass spectrum for DFTPP must meet the criteria given in Table 1 before standard or sample analysis may begin.

The GC/MS tuning standard is also used to assess GC column performance and injection port inertness. Degradation of DDT to DDE and DDD should not exceed 20%. Benzidine and pentachlorophenol should be present at their normal responses and no peak tailing should be visible.

The tailing factor for benzidine and pentachlorophenol should be calculated in every DFTPP run. (See Table 4)

If degradation is excessive and/or poor chromatography is noted, the system needs maintenance (see Section 9.5).

9.2 Initial Calibration

9.2.1 Prepare calibration standards for the target analytes at the six concentration levels specified in Section 8.2.4.

9.2.2 Add 10µL of the intermediate internal standard solution (Section 8.2.1) to 500µL of each calibration standard directly in the autosampler vial. Each vial is capped prior to loading onto the autosampler tray. Analyze each calibration standard according to conditions listed in Section 9.1.1.

9.2.3 Create the analytical sequence using the HP Chemserver data acquisition software. Enter the calibration standard level, concentration, and analyst's initials in the analytical sequence list.

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9.2.4 In each standard, calculate the relative response factor (RRF) for each analyte, the average RRF, and the relative standard deviation (RSD) of the RRFs, using the Target data processing software. The calculations are performed automatically, using the formulae listed in Alpha's Quality Manual.

9.2.5 Initial Calibration Minimum RRF Criteria:
The minimum acceptable average RRF for all analytes is 0.050. If the minimum response factors are not met, the system must be evaluated, and corrective action must be taken before sample analysis begins. Possible problems include standard mixture degradation, injection port inlet contamination, contamination at the front end of the analytical column, and active sites in the column or chromatographic system. This check must be met before sample analysis begins.

9.2.6 Initial Calibration RF Criteria:
The %RSDs for the following compounds must be less than 30%: Acenaphthene, Hexachlorobutadiene, Fluoranthene, Benzo(a)pyrene, and Pentachlorophenol. If any of these compounds do not meet the 30% RSD criteria, the initial calibration curve is not valid and cannot be used. Perform instrument maintenance or prepare fresh calibration standards and recurve the instrument.

For all analytes, including the compounds listed above, if the RSD is $\leq$ 15% the mean response factor is used for sample quantitation. If the RSD is > 15%, then linearity through the origin cannot be assumed. The calibration may be repeated for any compounds that fail, or a calibration curve may be used for any compounds that exceed the criteria.

9.2.7 Evaluation of Retention Times:
The relative retention time (RRT) of each target analyte in each calibration standard should agree within 0.06 RRT units. Late-eluting target analytes usually have much better agreement.

9.3 Continuing Calibration Verification

9.3.1 The initial calibration (Section 9.2) for each target compound must be verified once every 12 hours prior to sample analysis. This is accomplished by analyzing a calibration standard at the 8.0 µg/mL level. An acceptable GC/MS tuning standard must be run prior to analyzing the continuing calibration standard.

9.3.2 Analyze the standard and calculate the % Difference (%D) for each analyte according to the formula in Alpha's Quality Manual.

If the % Difference for each analyte is $\leq$ 20%, then the calibration is assumed to be valid. If this criterion is not met, then corrective action must be taken prior to the analysis of samples.

9.3.3 If this criterion is exceeded, inspect the gas chromatographic system to determine the cause and perform whatever maintenance is necessary before verifying calibration and proceeding with sample analysis.

9.3.4 If routine maintenance does not return the instrument performance to meet the QC requirements (Section 10) based on the last initial calibration, then a new initial calibration must be performed. Due to the large number of analytes present, allowances may be made for a RF that drifts out high, as long as there are no positive hits for that particular analyte in any of the associated samples. Any QC failures must be written up by the analyst on narrative sheets for inclusion with the sample data.

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9.3.5 Internal Standard Retention Time

The retention times of the internal standards in the calibration verification standard are evaluated after data acquisition. If the retention time for any internal standard changes by more than 30 seconds from that in the mid-point standard of the most recent initial calibration, then the chromatographic system must be inspected for malfunctions and corrections must be made, as required. When corrections are made, reanalysis of samples analyzed while the system was malfunctioning is required.

9.3.6 Internal Standard Response

If the area for any of the internal standards in the calibration verification standard changes by a factor of two (-50% to +100%) from that in the mid-point standard level of the most recent initial calibration sequence, the mass spectrometer must be inspected for malfunctions and corrections must be made, as appropriate. When corrections are made, reanalysis of samples analyzed while the system was malfunctioning is required.

9.4 Sample Analysis

9.4.1 Preparation of extracted samples for analysis

All extracted samples in K-D tubes need to be brought up to 1mL volume with Hexane. Transfer exactly 500µL of the extract into 1mL vials with crimp top. Cap the vials with 11mm aluminum crimp caps with red septa. If extract dilutions are needed, perform the dilution and then transfer 500µL to the vial.

Enter the sample number or QC sample identifier, dilution, and analyst's initials in the analytical sequence list. Note any deviations from this procedure or visual observations on a sample narrative sheet.

9.4.2 GC/MS Analysis of Samples

9.4.2.1 Allow the sample extracts to warm to room temperature.

9.4.2.2 Add 10µL of the intermediate internal standard solution (Section 8.2.1) to the 500µL of sample extract.

9.4.2.3 The autosampler is programmed to inject 1µL aliquot of the sample extract into the GC/MS system, using the same instrument conditions that were used for calibration (Section 9.1.1). The injection volume of the sample must be the same as the volume used for the calibration standard.

9.4.2.4 If the response of any quantitation ion exceeds the initial calibration range of the GC/MS system, the sample extract must be diluted and reanalyzed.

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9.5 Qualitative Identification

Perform first level data review. Obtain the primary m/z (Table 5) masses for each parameter of interest. The following criteria must be met to make qualitative identification:

- The retention time must fall within ± 0.1 minutes of the retention time of the compound in the analytical standard. However, analyst experience should be used in making the qualitative identification.

Structural isomers that have the same primary ion are identified only if the resolution between authentic isomers in a standard mix is less than 25% of the sum of the two peak heights. Otherwise, structural isomers are identified as isomeric pairs.

9.6 Calculations

9.6.1 When a parameter is identified, the quantitation of that parameter should be based on the integrated abundance of the quantitation characteristic m/z given in Table 5.

9.6.2 Calculate the concentration in the sample using the average response factor (RF) from the initial calibration curve according to the formulae in Alpha's Quality Manual.

9.6.2.1 Aqueous samples

$$\text{Concentration } (\mu g/L) = \frac{C \times DF \times Vf \times 1000}{Vo}$$

where:

C = Extract concentration (µg/mL)
DF = Dilution factor
Vf = Final extract volume (mL)
Vo = Sample volume (mL)

9.6.2.2 Soil/sediment samples

$$\text{Concentration } (\mu g/Kg, \text{ dry weight}) = \left[\frac{C \times DF \times Vf \times 1000}{W \text{ (gm)}}\right] \div \%S$$

where:

C = Extract concentration (µg/mL)
DF = Dilution factor
Vf = Final extract volume (mL)
W = Weight of the sample extracted (10g for high, 30g for low)
%S = Percent solids, as a decimal value

9.6.4 Results for positive hits in samples are reported in µg/L or µg/Kg units. After performing technical data review, validating that all QC criteria have been met and confirming all positive hits, the data report is sent electronically to the LIMS computer for generation of the client report. There are two levels of review of the data in the LIMS system prior to release of data. These reviews should be done by two separate individuals.

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9.7 Maintenance

Additional maintenance may be required if system performance degrades. GC injector ports are of critical concern. Injectors that are contaminated or chemically active can cause poor sensitivity for the compounds listed in Section 9.2.4

When poor sensitivity is observed, replacement of the injector liner and seal may solve the problem. If not, clip approximately 3 – 6 inches from the injector end of the GC column. If the sensitivity does not improve it may be necessary to replace the split line or the injector weldment assembly. If the problem persists, it may be necessary to replace the GC column.

Periodic cleaning (typically twice per year) of the mass spectrometer ion source is required. More frequent source cleaning may be needed, especially if dirty samples are analyzed. In addition, semi-annual preventive maintenance is provided by the instrument manufacturer as part of our service agreement.

10. Quality Control and Data Assessment

The laboratory must maintain records to document the quality of data that is generated. Ongoing data quality checks are compared with established performance criteria to determine if the results of analyses meet the performance characteristics of the method.

10.1 Demonstration of Capability

The analyst must make an initial, one-time, demonstration of the ability to generate acceptable accuracy and precision with this method. Each time a method modification is made, the analyst is required to repeat the procedure.

Analyze four QC check samples spiked with all analytes at 10 – 50 times the MDL.

Calculate the result for each aliquot in µg/L, the relative standard deviation of the four results, and the average percent recovery for each analyte.

The average percent recovery should be 70 – 130%. However, due to poor extraction efficiencies of several target analytes this may not be achievable for all compounds.

NOTE: The large number of parameters in Table 5 present a substantial probability that one or more will fail at least one of the acceptance criteria when all parameters are analyzed. The majority of compounds must meet the 70 – 130% recovery criteria for the IDC to be acceptable.

10.2 Blank

Extraction blanks are performed with each extraction batch of 20 or less samples, according to the extraction SOPs. The extraction blank must not contain any of the reportable analytes above the reporting limit. If any reportable analytes are detected in the blank, the entire extraction batch is suspect and re-extraction of all associated samples is required. The surrogate recoveries must also be within the acceptance criteria listed in Table 2. If surrogate acceptance criteria are exceeded, the extraction batch must be evaluated to determine if re-extraction or re-analysis is necessary.

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10.3 Laboratory Control Sample (LCS)

A Laboratory Control Sample (LCS) is extracted with each analytical batch. The LCS consists of an aliquot of a clean (control) matrix similar to the sample matrix and of the same weight or volume. The spike compounds and levels are listed in Section 8.2.5. The recovery acceptance criteria are listed in Table 3. If any recovery criteria are not met, the extract should be reanalyzed. If the criteria are still not met, the entire batch should be re-extracted. If this is not possible, due to insufficient sample or holding time exceedence, the analyst must write up the failure on a narrative sheet for inclusion in the client report.

10.4 Duplicate

A duplicate sample is extracted and analyzed for each batch of 20 or less method 625 samples. The duplicate is an additional aliquot of a field sample, extracted and analyzed in the same manner as the samples. The surrogate recovery criteria listed in Table 2 must be met. In addition, the RPD for any target compound detected must be <40% for aqueous samples and <50% for solids.

10.5 Matrix Spike and Matrix Spike Duplicate (MS / MSD)

A matrix spike/matrix spike duplicate pair is extracted and analyzed for each batch of 20 or less method 8270 samples. A matrix spike is performed, along with a sample duplicate, for method 625 samples. The spike compounds and levels are listed in Section 8.2.5. The recovery acceptance criteria are listed in Table 3. If the recovery criteria are not met, but are met in the LCS, this should be noted on a narrative sheet for inclusion in the client report.

10.6 Surrogates

All extracted samples and associated QC are spiked with surrogates as described in Section 8.2.2. The laboratory must evaluate surrogate recovery data from individual samples and QC samples versus the surrogate control limits listed in Table 2. If the surrogate limits are not met, the extract should be reanalyzed to determine if the failure was due to an instrument problem. If the criteria are still not met, the affected samples should be re-extracted to confirm that the failure was due to sample matrix. If matrix effect is confirmed, this must be noted on a narrative sheet for inclusion in the client report.

10.7 Control Limits

The laboratory maintains performance records to document the quality of data that is generated. Method accuracy for samples is assessed and records maintained.

Control charts for the method parameters are generated by the QC staff and distributed to the analysts. The control limits are based on in-house performance data, and are compared to the control limits found in the reference method.

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10.8 Analytical Sequence

In a 12-hour period, the analytical sequence is:

- DFTPP
- Continuing or Daily Standard (Section 8.6.5)
- Method Blank
- Samples
- QC (as required)

11. Method Performance

The method detection limit (MDL) is defined as the minimum concentration of a substance that can be measured and reported with 99% confidence that the value is above zero. The MDL concentrations were obtained using Ottawa Sand. The MDL actually achieved in a given analysis will vary depending on instrument sensitivity and matrix effects.

Method performance data is on file in the laboratory QC department. Comparison of method performance data for the laboratory to the reference method criteria occurs when laboratory in-house acceptance limits are generated. In-house generated data must be within the specifications of the reference method or the analysis is not continued until corrective action is completed.

The performance of this method is evaluated on an on-going basis by the QC criteria listed throughout this SOP. Specifically, Initial Calibration criteria, Continuing Calibration Check criteria, surrogates, blanks, LCSs, MS/MSDs, and duplicates are all used to ensure that the method is producing results of consistently high quality. In addition, Alpha participates in several blind and double blind PE studies annually to demonstrate the ability of this method to produce accurate and reproducible data.

12. Corrective Actions

Holding time exceedence and improper preservation are noted on the nonconformance report form.

Perform instrument maintenance as described throughout this SOP as needed when instrument calibration criteria are not met. Record all maintenance in the instrument logbook.

All batch and sample specific QC criteria outlined in section 10 are evaluated by the analyst prior to approval of the data. When any QC criteria fail, the cause for the failure must be identified and corrected. This may include instrument recalibration followed by sample reanalysis, sample cleanup, or sample re-extraction. If it is determined that the failure is due to sample matrix effects, a project narrative report is written by the analyst for inclusion in the data report. If there is insufficient sample volume to perform the re-analysis for confirmation, this is also noted in the narrative and included in the client report.

13. Pollution Prevention

See Chemical Hygiene Plan for pollution prevention operations.

14. Waste Management

See Chemical Hygiene Plan for waste handling and disposal.

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15. Attachments

Table 1: DFTPP Key Ions and Ion Abundance Criteria

Table 2: Acceptable Surrogate Spike Recovery Limits

Table 3: QC Acceptance Criteria: LCS, MS, MSD

Table 4: Tailing Factor Calculation

Table 5: Characteristic Ions for Semivolatile Compounds

Table 6: Reported Detection Limits

Table 7: SIM Parameters

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TABLE 2

ACCEPTABLE SURROGATE SPIKE RECOVERY LIMITS

Analytical Fraction	Surrogate Compound	Water	Soil/Sediment
BNA	Nitrobenzene-d_5	23-120%	23-120%
BNA	Phenol-d_6	10-120%	10-120%
BNA	2-Fluorophenol	21-120%	25-120%
BNA	2-Fluorobiphenyl	43-120%	30-120%
BNA	p-Terphenyl-d_{14}	33-120%	18-120%
BNA	2,4,6-Tribromophenol	10-120%	19-120%

TABLE 3

QC ACCEPTANCE CRITERIA: LCS, MS, MSD

Analytical Fraction	Spike Compound	LCS/MS % Recovery Water	LCS/MS % Recovery Soil/Sediment	MS/MSD %RPD Water	MS/MSD %RPD Soil/Sediment
BN	Acenaphthene	46-118%	31-137%	40%	50%
BN	Pyrene	26-127%	35-142%	40%	50%
Acid	Pentachlorophenol	9-103%	17-109%	40%	50%

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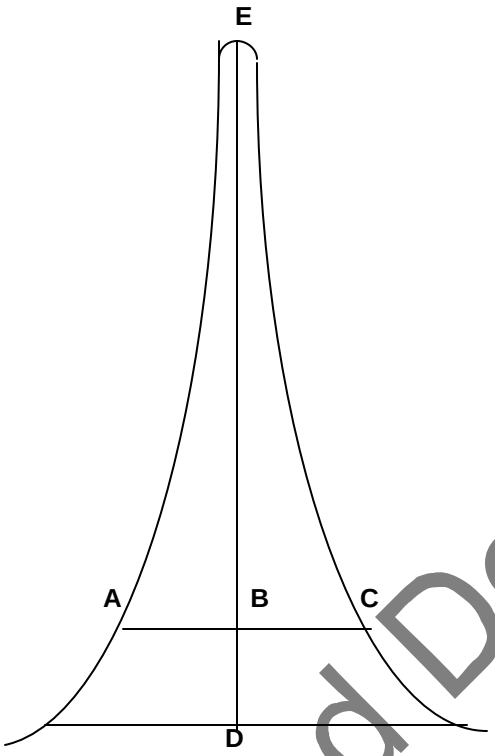
TABLE 4



Tailing Factor = $\frac{BC}{AB}$

Example calculation:

Peak Height = DE = 100mm
10% Peak Height = BD = 10mm
Peak Width at 10% Peak Height = AC = 23mm

AB = 11mm
BC = 12mm

Therefore: Tailing Factor = $\frac{12}{11}$ = 1.1

Tailing factor for benzidine < 3.0

Tailing factor for pentachlorophenol < 5.0

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TABLE 1

DFTPP KEY IONS AND ION ABUNDANCE CRITERIA

Mass	Ion Abundance Criteria
51	30-60% of mass 198
68	< 2% of mass 69
70	< 2% of mass 69
127	40-60% of mass 198
197	< 1% of mass 198
198	Base peak, 100% relative abundance
199	5-9% of mass 198
275	10-30% of mass 198
365	> 1% of mass 198
441	Present but less than mass 443
442	> 40% of mass 198
443	17-23% of mass 442

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TABLE 5

CHARACTERISTIC IONS FOR SEMIVOLATILE COMPOUNDS

Compound	Primary Ion
1,4-Dichlorobenzene-d_4 (IS)	152
Naphthalene-d_8 (IS)	136
Naphthalene	128
Hexachlorobutadiene	225
2-Methylnaphthalene	142
1-Methylnaphthalene	115
2-Chloronaphthalene	162
Acenaphthylene	152
Acenaphthene-d_{10} (IS)	164
Acenaphthene	154
Fluorene	166
Hexachlorobenzene	284
Pentachlorophenol	266
Phenanthrene-d_{10} (IS)	188
Phenanthrene	178
Anthracene	179
Fluoranthene	202
Pyrene	202
Benz(a)anthracene	228
Chrysene-d_{12} (IS)	240
Chrysene	228
Benzo(b)fluoranthene	252
Benzo(k)fluoranthene	252
Benzo(a)pyrene	252
Perylene-d_{12} (IS)	264
Indeno(1,2,3-cd)pyrene	276
Dibenz(a,h)anthracene	278
Benzo(g,h,i)perylene	276
2-Fluorobiphenyl (Surrogate)	172
Nitrobenzene-d_5 (Surrogate)	82
Terphenyl-d_{14} (Surrogate)	244

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TABLE 6

REPORTED DETECTION LIMITS

FOR SEMIVOLATILE ORGANIC COMPOUNDS

Analyte	RDL (µg/L)	RDL (µg/Kg)
Acenaphthene	0.2	20
Acenaphthylene	0.2	20
Anthracene	0.2	20
Benzo(a)anthracene	0.2	20
Benzo(b)fluoranthene	0.2	20
Benzo(k)fluoranthene	0.2	20
Benzo(ghi)perylene	0.2	20
Benzo(a)pyrene	0.2	20
2-Chloronaphthalene	0.2	20
Chrysene	0.2	20
Dibenz o(a,h)anthracene	0.2	20
Fluoranthene	0.2	20
Fluorene	0.2	20
Indeno(1,2,3-cd)pyrene	0.2	20
1-Methylnaphthalene	0.2	20
2-Methylnaphthalene	0.2	20
Naphthalene	0.2	20
Phenanthrene	0.2	20
Pyrene	0.2	20

Additional non-PAH Analytes Available	RDL (µg/L)	RDL (µg/Kg)
Hexachlorobenzene	0.2	20
Hexachlorobutadiene	0.2	20
Pentachlorophenol	0.8	80

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TABLE 7

SIM PARAMETERS

	Group Start Time	MASS (amu)	DWELL Time (milliseconds)
GROUP 1	**5.00**	**45.0**	**42**
		99.0	**42**
		150.0	**42**
		82.0	**42**
		112.0	**42**
		93.0	**42**
		128.0	**42**
GROUP 2	**10.50**	**107.0**	**60**
		136.0	**60**
		127.0	**60**
		223.0	**60**
		128.0	**60**
GROUP 3	**12.50**	**142.0**	**60**
		162.0	**60**
		154.0	**60**
		172.0	**60**
		156.0	**60**
GROUP 4	**14.90**	**152.0**	**50**
		165.0	**50**
		154.0	**50**
		166.0	**50**
		164.0	**50**
		330.0	**50**
GROUP 5	**17.90**	**178.0**	**75**
		284.0	**75**
		188.0	**75**
		266.0	**75**
GROUP 6	**20.00**	**192.0**	**50**
		240.0	**50**
		202.0	**50**
		244.0	**50**
		228.0	**50**
		252.0	**50**
GROUP 7	**26.30**	**252.0**	**75**
		278.0	**75**
		264.0	**75**
		276.0	**75**

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Semivolatile Organic Compounds by Gas Chromatography/ Mass Spectrometry (GC/MS)

Reference Method No.: **EPA # 8270C**

Reference: SW-846, Test Methods for Evaluating Solid Waste: Physical/Chemical Methods, EPA SW-846, Update III, December 1996.

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Prepared by:

Name: Joseph Watkins Position: Semivolatile Organics Supervisor

Signature: Joseph Watkins Date: 7/30/04

Authorized by:

Name: James Todaro Position: Laboratory Director

Signature: James Todaro Date: 7/30/04

ISSUE AMENDMENTS

Changes since last issue:

Section 4.2.2: Defined 'unusually concentrated samples'.

Section 6.2: Edited sample storage temperature range.

Section 8.1: Identified abbreviation for 'dichloromethane'.

Section 8.5: Edited the Spike Solution Standards.

Section 9.2.5: Added an alternate calculation for Initial Calibration response factor.

Section 9.4.1: Clarified what information is noted on a sample narrative sheet during the preparation of sample extracts for analysis.

Semivolatile Organic Compounds by Gas Chromatography/ Mass Spectrometry (GC/MS)

Reference Method No.: **EPA # 8270C**

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1. Scope and Application

Matrices: This method is used to determine the concentration of semivolatile organic compounds in extracts prepared from many types of solid waste matrices, soils, and wastewater samples.

This method is used to quantitate most neutral, acidic, and basic organic compounds that are soluble in methylene chloride and capable of being eluted, without derivatization, as sharp peaks from a gas chromatographic fused-silica capillary column coated with a slightly polar silicone.

The following compounds may require special treatment when being determined by this method:

- Benzidine may be subject to oxidative losses during solvent concentration and its chromatographic behavior is poor.
- Hexachlorocyclopentadiene is subject to thermal decomposition in the inlet of the gas chromatograph, chemical reaction in acetone solution, and photochemical decomposition.
- n-Nitrosodimethylamine is difficult to separate from the solvent under the chromatographic conditions described.
- n-Nitrosodiphenylamine decomposes in the gas chromatographic inlet and cannot be separated from diphenylamine.
- Pentachlorophenol, 2,4-dinitrophenol, nitrophenol, benzoic acid, 4,6-dinitro-2-methylphenol, 4-chloro-3-methylphenol, 2-nitroaniline, 3-nitroaniline, 4-chloroaniline, and benzyl alcohol are subject to erratic chromatographic behavior, especially if the GC system is contaminated with high boiling material.
- Pyridine may perform poorly at the GC injection port temperatures listed in the method. Lowering the injection port temperature may reduce the amount of degradation. The analyst needs to use caution if modifying the injection port temperature as the performance of other analytes may be adversely affected.

The data report packages present the documentation of any method modification related to the samples tested. Depending upon the nature of the modification and the extent of intended use, the laboratory may be required to demonstrate that the modifications will produce equivalent results for the matrix. Approval of all method modifications is by one of the following laboratory personnel before performing the modification: Area Supervisor, Laboratory Services Manager, Laboratory Director, or Quality Assurance Officer

This method is restricted to use by or under the supervision of analysts experienced in the operation of a gas chromatograph/mass spectrometer and in the interpretation of mass spectra. Each analyst must demonstrate the ability to generate acceptable results with this method by performing an initial demonstration of capability (Section 10.1), analyzing a proficiency test sample and completing the record of training. After initial demonstration, ongoing demonstration is based on acceptable laboratory performance of at least a quarterly laboratory control sample or acceptable performance from an annual proficiency test sample.

2. Summary of Method

The samples are introduced into the GC/MS by injecting 1µL of the sample extract into a gas chromatograph (GC) with a narrow-bore fused-silica capillary column. The GC column is temperature-programmed to separate the analytes, which are then detected with a mass spectrometer (MS) connected to the gas chromatograph.

Analytes eluted from the capillary column are introduced into the mass spectrometer via direct connection. Identification of target analytes is accomplished by comparing their mass spectra with the electron impact spectra of standards run on the same GC/MS system. Quantitation is accomplished by comparing the response of quantitation ion relative to an internal standard using a five-point calibration curve.

2.1 Method Modifications from Reference

None.

3. Detection Limits

The laboratory follows the procedure found in 40CFR Part 136 to determine the MDL on an annual basis. The method detection limits determined by the laboratory are on file for review.

Table 6 lists our routine reporting limits. Whenever MDL studies are performed, the MDL results are compared with our reporting limits to ensure that the calculated MDLs are equal to or below our reporting limits.

4. Interferences

4.1 Instrumental

4.1.1 Only high purity helium is used in the GC system to eliminate this source of possible contamination. The helium (carrier gas) is certified by the gas supplier.

4.1.2 Preventive instrument maintenance is performed routinely, and whenever highly contaminated extracts are analyzed that could result in chromatographic interferences or result in degradation of system performance. Section 9.5 details the maintenance steps.

4.1.3 Glassware must be scrupulously cleaned. This procedure is detailed in the extraction SOPs. Store dry glassware in a clean environment.

4.2 Parameters

4.2.1 Contaminated solvents or reagents are also possible sources or contamination. All solvents used are pesticide grade or equivalent, and reagents are purchased as certified contaminant free. All of these materials are routinely determined to be free of interferences by analysis of extraction blanks with every extraction batch performed.

4.2.2 Contamination by carry-over can occur whenever high-concentration and low-concentration samples are sequentially analyzed. Whenever an unusually concentrated sample is encountered, it should be followed by the analysis of a solvent blank to check for possible carryover. Unusually concentrated samples may consist of either target or non-target compounds at concentrations greater than 2x the highest concentration of the calibration curve.

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5. Safety

The toxicity or carcinogenicity of each reagent and standard used in this method is not fully established; however, each chemical compound should be treated as a potential health hazard. From this viewpoint, exposure to these chemicals must be reduced to the lowest possible level by whatever means available. A reference file of material data handling sheets is available to all personnel involved in the chemical analysis. Additional references to laboratory safety are available in the Chemical Hygiene Plan.

All personnel handling environmental samples known to contain or to have been in contact with municipal waste must follow safety practices for handling known disease causative agents.

5.1 Lab coats, safety glasses, and gloves should be worn when handling samples, extracts, standards or solvents.

5.2 All solvent and extract transfers should be handled in the vented bench area in the GC/MS laboratory.

5.3 All stock standards, working standards, and vialed sample extracts must be placed into the waste bucket in the lab for future disposal by the Health and Safety Officer. The container must be labeled properly with hazard warning labels indicating the container contents.

5.4 Flammable solvent bottles must be stored in the flammables cabinet.

6. Sample Collection, Preservation, and Handling

6.1 Sample Collection

Aqueous samples are collected in two 1L amber glass jars with teflon-lined lids. Solid samples are collected in 250mL wide-mouth glass jars with teflon-lined lids. All containers are purchased pre-cleaned and certified from commercial vendors.

6.2 Sample Preservation

Both aqueous and solid samples are then preserved by packing in coolers with ice or ice packs, to maintain a temperature of 4 ± 2ºC. Upon receipt at the laboratory, the samples are transferred into sample storage refrigerators to maintain at a temperature of 4 ± 2ºC.

6.3 Sample Handling

Aqueous samples must be extracted within 7 days of sample collection, solid samples within 14 days of collection. Once extracted, the samples must be analyzed within 40 days of the extraction date.

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7. Equipment and Supplies

7.1 Gas Chromatograph/Mass Spectrometer System:

7.1.1 Gas Chromatograph, Hewlett Packard 6890 or equivalent: An analytical system complete with a temperature-programmable gas chromatograph configured for split/splitless-injection and all required accessories, including syringes, analytical columns, and gases. The capillary column is directly coupled to the source.

7.1.2 Column: 30m x 0.25mm ID, 0.25 µm film thickness silicone-coated, fused-silica capillary column (RTX-5MS, Restek), or equivalent.

7.1.3 Mass Spectrometer, Hewlett Packard 5973 or equivalent: Scanning from 35 to 500 amu every 1 second or less, using 70 volts (nominal) electron energy in the electron impact ionization mode. The mass spectrometer is capable of producing a mass spectrum for decafluorotriphenylphosphine (DFTPP) which meets the criteria in Table 1 when 1 µL of the GC/MS tuning standard is injected through the GC (50ng of DFTPP).

7.1.4 Data System: A computer system is interfaced to the Mass Spectrometer. The system allows the continuous acquisition and storage on machine-readable media of all mass spectra obtained throughout the duration of the chromatographic program. The computer software allows the analyst to search for any GC/MS data file for ions of specific mass and plot such ion abundances versus time or scan number. *HP ChemServer* software is used for data acquisition and *Target / NT Revision 4.12* is used for data reduction.

7.1.5 Syringe: 10 µL.

7.1.6 Volumetric Flasks, Class A: Appropriate sizes with ground-glass stoppers.

7.1.7 Vials: Glass autosampler vials with polytetrafluoroethylene (PTFE)-lined crimp top caps.

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8. Standards and Reagents

8.1 Stock Standard Solutions

Certified stock standard solution in dichloromethane (DCM). Stock standards include calibration standards, calibration verification, and internal standard.

All stock standards, lot number, catalog number, expiration date, preparation date and initials are recorded in a logbook.

All stock standard solutions must be transferred into bottles with PTFE-lined screwcaps. Store, protected from light, at –10ºC or less. Stock standard solutions are checked for signs of degradation or evaporation, especially just prior to preparing secondary dilution standards.

Stock standard solutions are all replaced after 1 year or sooner if comparison with quality control check samples indicates a problem.

Vendor	Standard	Catalog Number	Concentration
Supelco			
	TCL Hazardous Substance Mix 1	4-8907	2000µg/mL
	TCL Hazardous Substance Mix 2	4-8908	2000µg/mL
	TCL Phenols/Benzidine Mix	47992-U	2000µg/Ml
	2,6-Dichlorophenol	4-0302	5000µg/mL
	TCL Polynuclear Hydrocarbons Mix	48905-U	2000µg/mL
	TCL Base-Neutrals Mix	47991-U	2000µg/mL
Accustandard			
	Custom BN Mix	S-8558	2000µg/mL
Crescent Chemical Co., Inc.			
	Custom PAH Mix	CCS-446	200µg/mL
	Semivolatiles Mix 5	8SM-008	2000µg/mL
Chemservice			
	Chlorobenzilate	F986	Neat
	Dimethoate	F989	Neat
	Ethylmethanesulfonate	F919	Neat
	Hexachloropropene	F920	Neat
	Isodrin	F921	Neat
	Methylmethanesulfonate	F925	Neat

8.1.1 Acid Standard Stock Solution, 400µg/mL

Use 1mL of each of the following:

TCL Hazardous Substance Mix 1
TCL Hazardous Substance Mix 2
TCL Phenols/Benzidine Mix

Bring up to a volume of 5mL with Hexance.

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8.1.2 Additional Acid Standard Stock Solution, 400µg/mL

Take 2mL of 2,6-Dichlorophenol Stock Solution (1000µg/mL, Section 8.1.2.1) and bring up to 5mL volume with Hexane.

8.1.2.1 Preparation of 2,6-Dichlorophenol Stock Solution, 1000µg/mL

Use 1mL of 2,6-Dichlorophenol (Section 8.1) and bring up to 5mL volume with Acetone/Hexane.

8.1.3 Base – Neutrals Standard Stock Solution, 400µg/mL

Use 1mL of each of the following:

TCL Base-Neutrals Mix
TCL Polynuclear Aromatic Hydrocarbons Mix

Bring up to a volume of 5mL with Hexane.

8.1.4 Additional Base-Neutrals Standard Stock Solution, 400µg/mL

Use 1mL of each of the following:

Custom BN Mix
Custom PAH Mix

Bring up to a volume of 5mL with Hexane.

8.1.5 AP 9 Standard Stock Solution, 400µg/mL

Use 1mL of Semivolatiles Mix 5 and bring up to 5mL volume with Hexane.

8.1.6 Additional AP 9 Standard Stock Solution, 400µg/mL

Take 1mL of Additional AP 9 Stock Solution (8000µg/mL, Section 8.1.5.1) and bring up to 5mL volume with Hexane.

8.1.6.1 Preparation of Additional AP 9 Standard Stock Solution, 8000µg/mL

In a 25mL volumetric flask, add 0.02g of each of the following:

Chlorobenzilate
Dimethoate
Ethylmethanesulfonate
Hexachloropropene
Isodrin
Methylmethanesulfonate

Bring up to 25mL volume with DCM/Hexane.

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8.1.7 Calibration Standard Preparation

A minimum of 5 calibration standards for each analyte are prepared at 5 different concentrations.

	Concentration (µg/mL)	AH / BN / AP9 (µL)	Additional AH / BN / AP9 (µL)	Calibration Surrogate (µL)
L1	5			
L2	10	12.5	12.5	475
L3	20	25	25	450
L4	40	50	50	400
L5	80	100	100	300
L6	120	150	150	200
L7	160	200	200	100
L8	200	250	250	None

8.1.8 Continuing Calibration Standard Preparation

Usually 3 different standards contain all target analytes: Acid Standard, BN Standard, AP 9 Standard.

8.1.8.1 Acid Standard, 80µg/mL

In a 1mL vial, add 300µL of calibration surrogate, 100µL of Acid Standard Stock Solution (400µg/mL, Section 8.1.1) and 100µL of Additional Acid Standard Stock Solution (400µg/mL, Section 8.1.2).

8.1.8.2 Base Neutrals Standard, 80µg/mL

In a 1mL vial, add 300µL of calibration surrogate, 100µL of Base Neutrals Standard Stock Solution (400µg/mL, Section 8.1.3) and 100µL of Additional Base-Neutrals Standard Stock Solution (400µg/mL, Section 8.1.4)

8.1.8.3 AP 9 Standard, 80µg/mL

In a 1mL vial, add 300µL of calibration surrogate, 100µL of AP 9 Standard Stock Solution (400µg/mL, Section 8.1.5) amd 100µL of Additional AP 9 Standard Stock Solution (400µg/mL, Section 8.1.6).

8.2 Internal Standard Solution

The internal standards are:

1,4-dichlorobenzene-d_4
naphthalene-d_8
acenaphthene-d_{10}
phenanthrene-d_{10}
chrysene-d_{12}
perylene-d_{12}

This is a premixed, certified solution from Supelco, 2000ng/mL in DCM, catalog #4-8902, Each 500µL of standards, blank and sample extracts are spiked with 10µL of Internal Standard Solution, resulting in a concentration of 40ng/ µL.

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8.3 GC/MS Tuning Standard

A methylene chloride solution containing 50ng/µL of decafluorotriphenylphosphine (DFTPP). The standard also contains 50ng/µL each of 4,4'DDT, pentachlorophenol, and benzidine to verify injection port inertness and GC column performance. Store at –10ºC or less when not in use.

This working standard is prepared from a stock solution, purchased from Ultra Scientific, Catalog# GCM-150.

8.4 Surrogate Spiking Solution

During extraction of samples, add 1mL of the surrogate spiking solution to each sample, blank and QC samples. See extraction SOP(s) for details.

Record the preparation, analyst's initials, preparation date, expiration date and identifier in a logbook.

To prepare the instrument calibration standards, the surrogate spiking solution must be in Hexane. See extraction SOP for solvent exchange procedure.

Vendor	Standard	Catalog Number	Concentration
Chemservice			
	Base-Neutrals Surrogate Standard Mix High Concentration 8250, 8270, CLP	CLPH-2M	5000µg/mL
	Acid Surrogate Standard Mix High Concentration 8250, 8270, CLP	CLPH-1M	10000µg/mL
Ultra Scientific			
	Acid Surrogate Standard Spiking Soln.	ISM-290N	2000µg/mL
	B/N Surrogate Standard Spiking Soln.	ISM-280N	1000µg/mL

8.4.1 Extraction Surrogate Preparation

In a 1000mL volumetric flask, add 20mL of CLPH-2M and CLP-1M. Bring up to volume with Acetone. The final concentration is 200µg/mL for the acid surrogates and 100µg/mL for the B/N surrogates.

8.4.2 Calibration Surrogate Preparation

In a 25mL volumetric flask, add 2.5mL of ISM-290N and 2.5mL of ISM-280N. Bring up to volume with Hexane. The final concentration is 200µg/mL for the acid surrogates and 100µg/mL for the B/N surrogates.

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8.5 Spike Solution (LCS, MS, MSD)

Record the preparation, preparation date, analyst's initials, expiration date and identifier in a logbook.

Vendor	Standard	Catalog Number	Concentration
Accustandard			
	Custom BN Mix	S-8558	2000µg/mL
Cresent Chemical Co. Inc.			
	Custom PAH Mix	CCS-446	2000µg/mL
Supelco			
	TCL Hazardous Substances Mix 1	4-8907	2000µg/mL
	TCL Hazardous Substances Mix 2	4-8908	2000µg/mL
	TCL Phenols/Benzidine Mix	47992-U	2000µg/mL
	TCL Base-Neutral Mix	47991-U	2000µg/mL
	TCL Polynuclear Aromatic Hydrocarbons Mix	48905-U	2000µg/mL
	2,6-Dichlorophenol	4-0302	5000µg/mL

8.5.1 Spike Solution Preparation

In a 100mL volumetric flask add 2mL each (S-8558, CCS-446, 4-8907, 4-8908, 47992-U, 47991-U and 48905-U) and 800µL of 4-0302. Bring up to volume with Acetone. The final concentraion is 40µg/mL.

8.6 Secondary Source Standards

Vendor	Standard	Catalog Number	Concentration
Accustandard Inc.			
	Custom Organic Solution	S-10458	2000 µg/mL
	Semivolatile by Capillary Column GC/MS Mix 1	M-8270-01	2000 µg/mL
	Semivolatile by Capillary Column GC/MS Mix 2	M-8270-02	2000 µg/mL
	Semivolatile by Capillary Column GC/MS Mix 3	M-8270-03	2000 µg/mL
	Semivolatile by Capillary Column GC/MS Mix 4A	M-8270-04A	2000 µg/mL
	Method 8270 Semivolatile Mix 4B-R1	M-8270-04B-R1	2000 µg/mL
	Semivolatile by Capillary Column GC/MS Mix 5	M-8270/05	2000 µg/mL
	Semivolatile by Capillary Column GC/MS Mix 6	M-8270-06	2000 µg/mL

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9. Procedure

9.1 SET-UP

9.1.1 GC/MS Operating Conditions:

Typical GC/MS operating conditions are listed below, but may be altered as long as method performance criteria are met.

Mass range:	35 – 500 amu
Scan time:	1 second / scan
Initial temperature:	35°C, hold for 2 minutes
Temperature program:	35°C at 10°C / minute
Final temperature:	310°C, hold for 6 minutes
Injector temperature:	280°C
Transfer line temperature:	280°C
Source temperature:	230ºC
Injector:	Grob-type, split-injection, ratio 10:1
Injection volume:	1µL
Carrier gas:	helium at 41 cm / second, constant flow

After achieving the key ion abundance criteria for DFTPP, calibrate or verify the calibration of the system daily as described in Sections 9.2 and 9.3. If performance criteria are not achieved, take corrective action as defined in Section 12.

9.1.2 GC/MS Tune:

At the beginning of every 12 hour sequence, analyze the 50µg/L DFTPP tuning solution (Section 8.3).

The resultant mass spectrum for DFTPP must meet the criteria given in Table 1 before sample analysis begins.

The GC/MS tuning standard is also used to assess GC column performance and injection port inertness. Degradation of DDT to DDE and DDD should not exceed 20%. Benzidine and pentachlorophenol should be present at their normal responses and no peak tailing should be visible.

The tailing factor for benzidine and pentachlorophenol should be calculated in every DFTPP run. (See Table 4)

If degradation is excessive and/or poor chromatography is noted, the system needs maintenance (see Section 9.5).

9.2 Initial Calibration

9.2.1 Prepare calibration standards for all target analytes at the five concentration levels specified in Section 8.1.7.

9.2.2 Add 10µL of Internal Standard to each calibration standard directly into the autosampler vial containing 500µL of standard. Analyze each calibration standard according to Section 9.1.1.

9.2.3 Record the calibration standard, identifier, concentration, and analyst's initials in the analytical sequence list.

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9.2.4 In each standard, calculate the response factor (RF) for each analyte, the average RF, and the relative standard deviation (RSD) of the RFs, using the Target data processing software. The calculations are performed automatically, using the formulae listed in Alpha's Quality Manual.

The minimum acceptable average RF for all analytes is 0.050.

Some of the target analytes (2,4-dinitrophenol, 4-nitrophenol, 4,6-dinitrocresol and hexachlorocyclopentadiene) have a tendency to decrease in response as the chromatographic system begins to deteriorate or standard materials begin to deteriorate. They are usually the first to show poor performance, therefore they must be monitored as indicators of degrading system performance.

If the minimum response factors are not met, the system must be evaluated, and corrective action must be taken before sample analysis begins. Possible problems include standard mixture degradation, injection port inlet contamination, contamination at the front end of the analytical column, and active sites in the column or chromatographic system. This check must be met before sample analysis begins.

9.2.5 Initial Calibration RF Criteria:
For all analytes, including the compounds listed above, the RSD must be $\leq$ 15% for the mean response factor to be used for sample quantitation. If the RSD is > 15%, then linearity through the origin cannot be assumed. An alternate calculation may be performed by using the linearity, provided that the correlation coefficient is $\geq$ 0.995. If both quantitation methods fail the acceptance criteria for any compound in the initial calibration, then the system must be re-evaluated and a new calibration curve must be analyzed.

9.2.6 Evaluation of Retention Times:
The relative retention time (RRT) of each target analyte in each calibration standard should agree within 0.06 RRT units. Late-eluting target analytes usually have much better agreement.

9.3 Continuing Calibration Verification

9.3.1 Continuing calibration verification is performed at the beginning of each 12 hour analytical sequence.

9.3.2 The criteria given in Table 1 for DFTPP must be met for each 12-hour shift during which samples are analyzed.

9.3.3 The initial calibration (Section 9.2) for each compound of interest should be verified once every 12 hours prior to sample analysis. This is accomplished by analyzing calibration standards at a concentration near the midpoint concentration for the calibrating range of the GC/MS.

9.3.4 Analyze the standards and calculate the % Difference for each analyte according to the formula in Alpha's Quality Manual.

If the % Difference for each CCC analyte is $\leq$ 20%, then the calibration is assumed to be valid. If this criterion is not met, then corrective action must be taken prior to the analysis samples.

Due to the large number of analytes present, allowances may be made for a RF that drifts out high, as long as there are no positive hits for that particular analyte in any of the associated samples. Any QC failures must be written up by the analyst on narrative sheets for inclusion with the sample data.

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9.3.5 If this criterion is exceeded, inspect the gas chromatographic system to determine the cause and perform whatever maintenance is necessary before verifying calibration and proceeding with sample analysis.

9.3.6 If routine maintenance does not return the instrument performance to meet the QC requirements (Section 10) based on the last initial calibration, then a new initial calibration must be performed.

9.3.7 Internal Standard Retention Time

The retention times of the internal standards in the calibration verification standard is evaluated after data acquisition. If the retention time for any internal standard changes by more than 30 seconds from that in the mid-point standard of the most recent initial calibration, then the chromatographic system must be inspected for malfunctions and corrections must be made, as required. When corrections are made, reanalysis of samples analyzed while the system was malfunctioning is required.

9.3.8 Internal Standard Response

If the area for any of the internal standards in the calibration verification standard changes by a factor of two (-50% to +100%) from that in the mid-point standard level of the most recent initial calibration sequence, the mass spectrometer must be inspected for malfunctions and corrections must be made, as appropriate. When corrections are made, reanalysis of samples analyzed while the system was malfunctioning is required.

9.4 Sample Analysis

9.4.1 Preparation of extracted samples for analysis

All extracted samples in K-D tubes need to be brought up to 1mL volume with DCM. Cap the vials with crimper, using 11mm aluminum crimp caps with red septa. If extract dilutions are needed, perform the dilution and then transfer 500µL to the vial.

Record the sample number (standard or QC sample identifier), dilution and analyst's initials in the analytical sequence list. Note any deviations from this procedure and all visual observations on a sample narrative sheet.

9.4.2 GC/MS Analysis of Samples

9.4.2.1 Allow the sample extracts to warm to room temperature.

9.4.2.2 Transfer all of the sample extract to a 1.5mL vial. Remove 500µL of sample extract to another vial, and add 10µL of the internal standard solution(Section 8.2).

9.4.2.3 The autosampler is programmed to inject 1µL aliquot of the sample extract into the GC/MS system, using the same instrument conditions that were used for calibration (Section 9.1.1). The injection volume of the sample must be the same as the volume used for the calibration standard.

9.4.2.4 If the response of any quantitation ion exceeds the initial calibration range of the GC/MS system, the sample extract must be diluted and reanalyzed.

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9.5 Maintenance

Additional maintenance may be required if system performance degrades. GC injector ports are of critical concern. Injectors that are contaminated or chemically active can cause poor sensitivity for the compounds listed in Section 9.2.4

When poor sensitivity is observed, replacement of the injector liner and seal may solve the problem. If not, clip approximately 3 – 6 inches from the injector end of the GC column. If the sensitivity does not improve it may be necessary to replace the split line or the injector weldment assembly. If the problem persists, it may be necessary to replace the GC column.

Periodic cleaning (typically twice per year) of the mass spectrometer ion source is required. More frequent source cleaning may be needed, especially if dirty samples are analyzed.

9.6 Qualitative Identification

Perform first level data review. Obtain the primary m/z (Table 4) masses for each parameter of interest. The following criteria must be met to make qualitative identification:

- Compare the background subtracted mass spectra for the sample to the reference spectra. The characteristic masses of each parameter of interest must maximize in the same or within one scan of each other.
- The retention time must fall within ± 0.1 minutes of the retention time of the compound in the analytical standard. However, analyst experience should be used in making the qualitative identification.
- The relative peak height of the one characteristic mass must fall within 20% of the relative intensity of the mass in a reference mass spectrum. The reference spectrum is obtained from a standard analyzed on the GC/MS system.

Structural isomers that have very similar mass spectra are identified only if the resolution between authentic isomers in a standard mix is less than 25% of the sum of the two peak heights. Otherwise, structural isomers are identified as isomeric pairs.

9.7 Calculations

9.7.1 When a parameter is identified, the quantitation of that parameter should be based on the integrated abundance of the quantitation characteristic m/z given in Table 5. If the sample produces an interference for the primary m/z, use a secondary characteristic m/z to quantitate.

9.7.2 Calculate the concentration in the sample using the average response factor (RF) from the initial calibration curve according to the formulae in Alpha's Quality Manual.

9.7.3 Results for positive hits in samples are reported in µg/L or µg/Kg units. After performing technical data review, validating that all QC criteria have been met and confirming all positive hits, the data report is sent electronically to the LIMS computer for generation of the client report. There are two levels of review of the data in the LIMS system prior to release of data. These reviews should be done by two separate individuals.

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10. Quality Control and Data Assessment

The laboratory must maintain records to document the quality of data that is generated. Ongoing data quality checks are compared with established performance criteria to determine if the results of analyses meet the performance characteristics of the method.

10.1 Demonstration of Capability

The analyst must make an initial, one-time, demonstration of the ability to generate acceptable accuracy and precision with this method. Each time a method modification is made, the analyst is required to repeat the procedure.

Analyze four QC check samples spiked with all analytes at 10 – 50 times the MDL.

Calculate the result for each aliquot in µg/L, the relative standard deviation of the four results, and the average percent recovery for each analyte.

The average percent recovery should be 70 – 130%. However, due to poor extraction efficiencies of several target analytes this may not be achievable for all compounds.

NOTE: The large number of parameters in Table 5 present a substantial probability that one or more will fail at least one of the acceptance criteria when all parameters are analyzed. The majority of compounds must meet the 70 – 130% recovery criteria for the IDC to be acceptable.

10.2 Blank

Extraction blanks are performed with each extraction batch of 20 or less samples, according to the extraction SOPs. The extraction blank must not contain any of the reportable analytes above the reporting limit. If any reportable analytes are detected in the blank, and all associated samples are ND (Non-Detected) for that analyte, the data may be used. If the blank and samples have reportable hits for a target analyte, re-extraction of the batch is required.

The surrogate recoveries must also be within the acceptance criteria listed in section 10.5. If surrogate acceptance criteria are exceeded, the extraction batch must be evaluated to determine if re-extraction or re-analysis is necessary.

10.3 Laboratory Control Sample (LCS)

A Laboratory Control Sample (LCS) is extracted with each analytical batch. The LCS consists of an aliquot of a clean (control) matrix similar to the sample matrix and of the same weight or volume. The spike compounds and levels are listed in Section 8.5.1.

The recovery acceptance criteria are listed in Table 3. If <20% of all analytes or <15% of a particular class of analytes fall outside the acceptance criteria, the LCS is valid. If this is not the case, the entire batch is re-extracted. If this is not possible, due to insufficient sample or holding time exceedence, the analyst must write up the failure on a narrative sheet for inclusion in the client report.

10.4 Matrix Spike and Matrix Spike Duplicate, (MS / MSD)

A matrix spike/matrix spike duplicate pair is extracted and analyzed for each batch of 20 or less samples. The spike compounds and levels are listed in Section 8..5.1. The recovery acceptance criteria are listed in Table 3. If the recovery criteria are not met, but are met in the LCS, this should be noted on a narrative sheet for inclusion in the client report.

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10.5 Surrogates

All extracted samples and associated QC are spiked with surrogates at the levels listed in Section 8.4. The laboratory must evaluate surrogate recovery data from individual samples and QC samples versus the surrogate control limits listed in Table 2.

If two or more surrogates for any one fraction are outside acceptance criteria, or if any surrogate recovery is <10%, the extract should be reanalyzed to determine if the failure was due to an instrument problem. If the criteria are still not met, the affected samples should be re-extracted to confirm that the failure was due to sample matrix. If matrix effect is confirmed, this must be noted on a narrative sheet for inclusion in the client report.

10.6 Control Limits

The laboratory maintains performance records to document the quality of data that is generated. Method accuracy for samples is assessed and records maintained.

Control charts for the method parameters are generated by the QC staff and distributed to the analysts. The control limits are based on in-house performance data, and are compared to the control limits found in the reference method.

10.7 Analytical Sequence

In a 12-hour period, the typical analytical sequence is:

- DFTPP
- Continuing or Daily Standards (1 – 3)
  - (1) Acid: 80ppm
  - (2) Base-Neutral: 80ppm
  - (3) Additional: 80ppm
- Method Blank
- Samples
- QC (as required)

11. Method Performance

The method detection limit (MDL) is defined as the minimum concentration of a substance that can be measured and reported with 99% confidence that the value is above zero. The MDL concentrations were obtained using Ottawa Sand. The MDL actually achieved in a given analysis will vary depending on instrument sensitivity and matrix effects.

Method performance data is on file in the laboratory QC department. Comparison of method performance data for the laboratory to the reference method criteria occurs when laboratory in-house acceptance limits are generated. In-house generated data must be within the specifications of the reference method or the analysis is not continued until corrective action is completed.

The performance of this method is evaluated on an on-going basis by the QC criteria listed throughout this SOP. Specifically, Initial Calibration criteria, Continuing Calibration Check criteria, surrogates, blanks, LCSs, MS/MSDs, and duplicates are all used to ensure that the method is producing results of consistently high quality. In addition, Alpha participates in several blind and double blind PE studies annually to demonstrate the ability of this method to produce accurate and reproducible data.

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12. Corrective Actions

Holding time exceedence and improper preservation are noted on the nonconformance report form.

Perform instrument maintenance as described throughout this SOP as needed when instrument calibration criteria are not met. Record all maintenance in the instrument logbook.

All batch and sample specific QC criteria outlined in section 10 are evaluated by the analyst prior to approval of the data. When any QC criteria fail, the cause for the failure must be identified and corrected. This may include instrument recalibration followed by sample reanalysis, sample cleanup, or sample re-extraction. If it is determined that the failure is due to sample matrix effects, a project narrative report is written by the analyst for inclusion in the data report. If there is insufficient sample volume to perform the re-analysis for confirmation, this is also noted in the narrative and included in the client report.

13. Pollution Prevention

See Chemical Hygiene Plan for pollution prevention operations.

14. Waste Management

See Chemical Hygiene Plan for waste handling and disposal.

15. Attachments

Table 1: DFTPP Key Ions and Ion Abundance Criteria

Table 2: Acceptable Surrogate Spike Recovery Limits

Table 3: Acceptable Matrix Spike Recovery Limits for Organics and Inorganics

Table 4: Tailing Factor Calculation

Table 5: Characteristic Ions for Semivolatile Compounds

Table 6: Reported Detection Limits

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TABLE 1

DFTPP KEY IONS AND ION ABUNDANCE CRITERIA

Mass	Ion Abundance Criteria
51	30-60% of mass 198
68	< 2% of mass 69
70	< 2% of mass 69
127	40-60% of mass 198
197	< 1% of mass 198
198	Base peak, 100% relative abundance
199	5-9% of mass 198
275	10-30% of mass 198
365	> 1% of mass 198
441	Present but less than mass 443
442	> 40% of mass 198
443	17-23% of mass 442

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TABLE 2

ACCEPTABLE SURROGATE SPIKE RECOVERY LIMITS

Analytical Fraction	Surrogate Compound	Water	Soil/Sediment
BNA-8270C	Nitrobenzene-d_5	23-120%	23-120%
BNA-8270C	Phenol-d_6	10-120%	10-120%
BNA-8270C	2-Fluorophenol	21-120%	25-120%
BNA-8270C	2-Fluorobiphenyl	43-120%	30-120%
BNA-8270C	p-Terphenyl-d_{14}	33-120%	18-120%
BNA-8270C	2,4,6-Tribromophenol	10-120%	19-120%

TABLE 3

ACCEPTABLE LCS AND MATRIX SPIKE RECOVERY LIMITS FOR ORGANICS AND INORGANICS

Analytical Fraction	Spike Compound	Water	Soil/Sediment
BN-8270C	1,2,4-Trichlorobenzene	39-98%	38-107%
BN-8270C	Acenaphthene	46-118%	31-137%
BN-8270C	2,4-Dinitrotoluene	24-96%	28-89%
BN-8270C	Pyrene	26-127%	35-142%
BN-8270C	n-Nitroso-di-n-propylamine	41-116%	41-126%
BN-8270C	1,4-Dichlorobenzene	36-97%	28-104%
Acid-8270C	Pentachlorophenol	9-103%	17-109%
Acid-8270C	Phenol	12-110%	26-90%
Acid-8270C	2-Chlorophenol	27-123%	25-102%
Acid-8270C	4-Chloro-3-methylphenol	23-97%	26-103%
Acid-8270C	4-Nitrophenol	10-80%	11-114%

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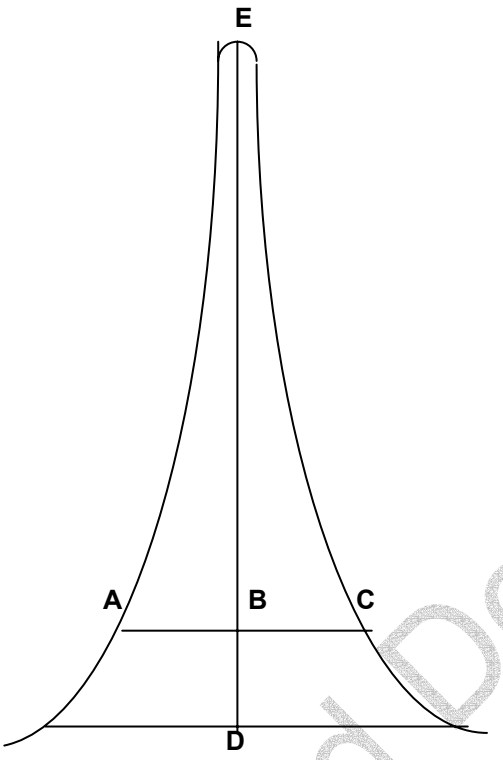
TABLE 4



$$\text{Tailing Factor} = \frac{BC}{AB}$$

Example calculation:

Peak Height = DE = 100mm
10% Peak Height = BD = 10mm
Peak Width at 10% Peak Height = AC = 23mm

AB = 11mm
BC = 12mm

$$\text{Therefore: Tailing Factor} = \frac{12}{11} = 1.1$$

Tailing factor for benzidine < 3.0

Tailing factor for pentachlorophenol < 5.0

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TABLE 5

CHARACTERISTIC IONS FOR SEMIVOLATILE COMPOUNDS

Compound	Primary Ion	Secondary Ion(s)
a,a-Dimethylphenylamine	58	91, 65, 134, 42
Acenaphthene	154	153, 152
Acenaphthylene	152	151, 153
2-Acetamidofluorene	181	223, 152
Acetophenone	105	71, 51, 120
4-Aminobiphenyl	169	168, 170, 115
Aniline	93	66, 65
Anthracene	179	176, 179
Aramite	185	191, 319
Benzidine	184	92, 185
Benzo(a)anthracene	228	229, 226
Benzo(a)pyrene	252	253, 125
Benzo(b)fluoranthene	252	253, 125
Benzo(g,h,i)perylene	276	138, 277
Benzo(k)fluoranthene	252	253, 125
Benzoic acid	122	105, 77
Benzyl alcohol	108	79, 77
Bis (2-chloroethoxy) methane	93	95, 123
Bis (2-chloroethyl) ether	93	63, 95
Bis (2-chloroisopropyl) ether	45	77, 121
Bis (2-ethylhexyl) phthalate	149	167, 279
4-Bromophenyl phenyl ether	248	250, 141
Butyl Benzyl phthalate	149	91, 206
4-Chloro-3-methylphenol	107	144, 142
4-Chloroaniline	127	129, 65, 92
Chlorobenzilate	251	139, 253, 111, 141
1-Chloronaphthalene	162	127, 164
2-Chloronaphthalene	162	127, 164
2-Chlorophenol	128	64, 130
4-Chlorophenyl phenyl ether	204	206, 141
Chrysene	228	226, 229
Diallate (cis or trans)	86	234, 43, 70
Dibenz(a,h)anthracene	278	139, 279
Dibenzofuran	168	139
1,2-Dichlorobenzene	146	148, 111

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TABLE 5

CHARACTERISTIC IONS FOR SEMIVOLATILE COMPOUNDS

Compound	Primary Ion	Secondary Ion(s)
1,3-Dichlorobenzene	146	148, 111
1,4-Dichlorobenzene	146	148, 111
3,3'-Dichlorobenzidine	252	254, 126
2,4-Dichlorophenol	162	164, 98
Diethyl phthalate	149	177, 150
Dimethoate	87	93, 125, 143, 229
Dimethyl phthalate	163	194, 164
3,3'-Dimethylaminoazobenzene	225	120, 77, 105, 148, 42
7,12-Dimethylbenz(a)anthracene	256	241, 239, 120
2,4-Dimethylphenol	122	107, 121
Di-n-butyl phthalate	149	150, 104
Di-n-octyl phthalate	149	167, 43
4,6-Dinitro-2-methylphenol	198	51, 105
1,3-Dinitrobenzene	168	76, 50, 75, 92, 122
2,4-Dinitrophenol	184	63, 154
2,6-Dinitrophenol	162	164, 126, 98, 63
2,4-Dinitrotoluene	165	63, 89
2,6-Dinitrotoluene	165	63, 89
Dinoseb	211	163, 147
Diphenylamine	169	168, 167
Disulfoton	88	97, 89, 142, 186
Ethyl methanesulfonate	79	109, 97, 45, 65
Fampyr	218	125, 93
Fluoranthene	202	101, 203
Fluorene	166	165, 167
Hexachlorobenzene	284	142, 249
Hexachlorobutadiene	225	223, 227
Hexachlorocyclopentadiene	237	235, 272
Hexachloroethane	117	201, 199
Hexachloropropene	213	211, 215, 117, 106, 141
Indeno(1,2,3-cd)pyrene	276	138, 227
Isodrin	193	66, 195, 263, 265, 147
Isophorone	82	95, 138
Isosafrole	162	131, 104, 77, 51
Kepone	272	274, 237, 178, 143, 270

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TABLE 5

CHARACTERISTIC IONS FOR SEMIVOLATILE COMPOUNDS

Compound	Primary Ion	Secondary Ion(s)
Malathion	173	125, 127
Methapyrilene	58	97, 191
3-Methylcholanthrene	268	252, 253, 126, 134, 113
Methyl methanesulfonate	80	79, 65, 95
2-Methylnaphthalene	142	141
Methyl parathion	109	125, 263, 79, 93
2-Methylphenol	107	108, 77, 79, 90
3/4-Methylphenol	107	108, 77, 79, 90
4-Methylphenol	107	108, 77, 79, 90
Naphthalene	128	129, 127
1,4-Naphthoquinone	158	104, 102, 76, 50, 130
1-Naphthylamine	143	115, 89, 63
2-Naphthylamine	143	115, 116
2-Nitroaniline	65	92, 138
3-Nitroaniline	138	108, 92
4-Nitroaniline	138	65, 108, 92, 80, 39
Nitrobenzene	77	123, 65
5-Nitro-o-toluidine	152	77, 79, 106, 94
2-Nitrophenol	139	109, 65
4-Nitrophenol	139	109, 65
4-Nitroquinoline-1-oxide	174	101, 128, 75, 116
n-Nitrosodiethylamine	102	42, 57, 44, 56
n-Nitrosodimethylamine	42	74, 44
n-Nitrosodi-n-butylamine	84	57, 41, 116, 158
n-Nitrosodi-n-propylamine	70	42, 101, 130
n-Nitrosodiphenylamine	169	168, 167
n-Nitrosomethylethylamine	88	42, 43, 56
n-Nitrosomorpholine	56	86
n-Nitrosopiperidine	114	42, 55, 56, 41
n-Nitrosopyrrolidine	100	41, 42, 68, 69
o-Toluidine	106	107, 77, 51, 79
Parathion, ethyl	97	109, 139
Pentachlorobenzene	250	252, 108, 248, 215, 254
Pentachloronitrobenzene	237	142, 214, 249, 295, 265
Pentachlorophenol	266	264, 268

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TABLE 5

CHARACTERISTIC IONS FOR SEMIVOLATILE COMPOUNDS

Compound	Primary Ion	Secondary Ion(s)
Phenacetin	108	180, 179, 109, 137, 80
Phenanthrene	178	179, 176
Phenol	94	65, 66
1,4-Phenylenediamine	108	80, 53, 54, 52
Phorate	75	121, 97
2-Picoline	93	66, 92
Pronamide	173	175, 145, 109, 147
Pyrene	202	200, 203
Safrole	162	104, 77, 103, 135
Sulfotepp	202	65, 322
1,2,4,5-Tetrachlorobenzene	216	214, 179, 108, 143, 218
2,3,4,6-Tetrachlorophenol	232	131, 230, 166, 234, 168
Thionazine	107	96, 97, 143, 79, 68
1,2,4-Trichlorobenzene	180	182, 145
2,4,5-Trichlorophenol	196	198, 97, 132, 99
2,4,6-Trichlorophenol	196	198, 200
1,3,5-Trinitrobenzene	75	74, 213, 120, 91, 63
Acenaphthene-d_{10} (IS)	164	162, 160
Chrysene-d_{12} (IS)	240	120, 236
1,4-Dichlorobenzene-d_4 (IS)	152	150, 115
Naphthalene-d_8 (IS)	136	68
Perylene-d_{12} (IS)	264	260, 265
Phenanthrene-d_{10} (IS)	188	94, 80
2-Fluorobiphenyl (Surrogate)	172	171
2-Fluoroophenol (Surrogate)	112	64
Nitrobenzene-d_5 (Surrogate)	82	128, 54
Phenol-d_6 (Surrogate)	99	42, 71
Terphenyl-d_{14} (Surrogate)	244	122, 212
2,4,6-Tribromophenol (Surrogate)	330	332, 141

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TABLE 6

REPORTED DETECTION LIMITS

FOR SEMIVOLATILE ORGANIC COMPOUNDS

Analyte	RDL (µg/L)	RDL (µg/Kg)
Acenaphthene	5.0	500
Acenaphthylene	5.0	500
Acetophenetidide	10.0	1000
Acetophenone	20.0	2000
4-Aminobiphenyl	10.0	1000
Aniline	10.0	1000
Anthracene	5.0	500
Azobenzene	5.0	500
Benzidine	50.0	5000
Benzo(a)anthracene	5.0	500
Benzo(b)fluoranthene	5.0	500
Benzo(k)fluoranthene	5.0	500
Benzo(ghi)perylene	5.0	500
Benzo(a)pyrene	5.0	500
Benzoic acid	50.0	5000
Benzyl alcohol	10.0	1000
Bis(2-chloroethyl)ether	5.0	500
Bis(2-chloroisopropyl)ether	5.0	500
Bis(2-chloroethoxy)methane	5.0	500
Bis(2-ethylhexyl)phthalate	10.0	1000
4-Bromophenyl phenyl ether	5.0	500
Butyl benzyl phthalate	5.0	500
4-Chloroaniline	5.0	500
Chlorobenzilate	20.0	2000
p-Chloro-m-cresol	5.0	500
1-Chloronaphthalene	5.0	500
2-Chloronaphthalene	5.0	500
2-Chlorophenol	5.0	500
4-Chlorophenyl phenyl ether	5.0	500
Chrysene	5.0	500
m/p-Methylphenol	5.0	500
o-Methylphenol	5.0	500
Dibenzo(a,h)anthracene	5.0	500
Dibenzofuran	5.0	500
Di-n-butylphthalate	5.0	500
1,2-Dichlorobenzene	5.0	500

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TABLE 6 (continued)

REPORTED DETECTION LIMITS

FOR SEMIVOLATILE ORGANIC COMPOUNDS

Analyte	RDL (µg/L)	RDL (µg/Kg)
1,3-Dichlorobenzene	5.0	500
1,4-Dichlorobenzene	5.0	500
3,3-Dichlorobenzidine	50.0	5000
2,4-Dichlorophenol	10.0	1000
2,6-Dichlorophenol	10.0	1000
Diethyl phthalate	5.0	500
Dimethoate	20.0	2000
p-Dimethylaminoazobenzene	10.0	1000
7,12-Dimethylbenzo(a)anthracene	10.0	1000
a,a-Dimethylphenethylamine	50.0	5000
2,4-Dimethylphenol	10.0	1000
Dimethyl phthalate	5.0	500
4,6-Dinitro-o-cresol	20.0	2000
2,4-Dinitrophenol	20.0	2000
2,4-Dinitrotoluene	5.0	500
2,6-Dinitrotoluene	5.0	500
Di-n-octylphthalate	5.0	500
Ethylmethanesulfonate	15.0	1500
Fluoranthene	5.0	500
Fluorene	5.0	500
Hexachlorobenzene	5.0	500
Hexachlorobutadiene	10.0	1000
Hexachlorocyclopentadiene	10.0	1000
Hexachloroethane	5.0	500
Hexachloropropene	50.0	5000
Indeno(1,2,3-cd)pyrene	5.0	500
Isodrin	10.0	1000
Isophorone	5.0	500
3-Methylchlolanthrene	20.0	2000
Methyl methanesulfonate	20.0	2000
1-Methylnaphthalene	5.0	500
2-Methylnaphthalene	5.0	500
a-Naphthalamine	20.0	2000
b-Naphthalamine	20.0	2000
Naphthalene	5.0	500
2-Nitroaniline	5.0	500
3-Nitroaniline	5.0	500
4-Nitroaniline	5.0	500

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TABLE 6 (continued)

REPORTED DETECTION LIMITS

FOR SEMIVOLATILE ORGANIC COMPOUNDS

Analyte	RDL (µg/L)	RDL (µg/Kg)
Nitrobenzene	5.0	500
2-Nitrophenol	10.0	1000
4-Nitrophenol	10.0	1000
Nitrosodi-n-butylamine	10.0	1000
n-Nitrosodimethylamine	50.0	5000
n-Nitrosodiphenylamine	5.0	500
Nitrosodipiperidine	20.0	2000
n-Nitrosodi-n-propylamine	5.0	500
Pentachlorobenzene	20.0	2000
Pentachloronitrobenzene	10.0	1000
Pentachlorophenol	20.0	2000
Phenacetin	10.0	1000
Phenanthrene	5.0	500
Phenol	5.0	500
2-Picoline	20.0	2000
Pronamide	20.0	2000
Pyrene	5.0	500
1,2,4,5-Tetrachlorobenzene	20.0	2000
1,2,4-Trichlorobenzene	5.0	500
2,4,5-Trichlorophenol	5.0	500
2,4,6-Trichlorophenol	5.0	500

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Organochlorine Pesticides

By Capillary Column Gas Chromatography

Reference Method No.: **Method 8081**

Reference: SW-846, Test Methods for Evaluating Solid Waste: Physical/Chemical Methods, EPA SW-846, Update III, 1997

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Copy No. _____

Prepared by:

Name: Joseph Watkins Position: Semivolatile Organics Supervisor

Signature: Joseph Watkins Date: 7/30/04

Authorized by:

Name: James Todaro Position: Laboratory Director

Signature: James Todaro Date: 7-30-04

ISSUE AMENDMENTS

Changes since last issue:

Removed all references to PCB analysis by Method 8082.

Section 6.2: Edited sample storage temperature range.

Section 8. NOTE: Edited standard storage temperature range.

Section 9.4.2: Added %RPD acceptance criteria between columns when tentatively identifying a compound.

Section 9.4.5: Clarified frequency of Calibration Verification Standard analysis.

Section 10.7: Added the Initial Calibration Verification Standard in the Initial Calibraation Sequence.

Table 1: Updated Reporting Limits.

Organochlorine Pesticides

By Capillary Column Gas Chromatography

Reference Method No.: **Method 8081**

Reference: SW-846, Test Methods for Evaluating Solid Waste: Physical/Chemical Methods, EPA SW-846, Update III, 1997.

1. Scope and Application

Method 8081A is used to determine the concentrations of various organochlorine pesticides in extracts from solid and liquid matrices. This SOP details the analysis for these compounds using fused-silica, open-tubular, capillary columns with electron capture detectors (ECD).

Matrices: Extracts from solid and liquid matrices.

Definitions: See Alpha Laboratories Quality Manual Appendix A

Regulatory Parameter List: The compounds listed below are determined by this method:

Parameter	CAS
Aldrin	309-00-2
Alpha-BHC	319-84-6
Beta-BHC	319-85-7
Gamma-BHC	58-89-9
Lindane	58-89-9
Delta-BHC	319-86-8
Alpha-chlordane	5103-71-9
Gamma-chlordane	5103-74-2
4,4'-DDD	72-54-8
4,4'-DDE	72-55-9
4,4'-DDT	50-29-3
Dieldrin	60-57-1
Endosulfan I	959-98-8
Endosulfan II	33213-65-9
Endosulfan Sulfate	1031-07-8
Endrin	72-20-8
Endrin Aldehyde	7421-93-4
Endrin Ketone	53494-70-5
Heptachlor	76-44-8
Heptachlor Epoxide	1024-57-3
Hexachlorobenzene	118-74-1
Methoxychlor	72-43-5
trans-Nonachlor	39765-80-5
Toxaphene	8001-35-2
Technical Chlordane	57-74-9

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The data report packages present the documentation of any method modification related to the samples tested. Depending upon the nature of the modification and the extent of intended use, the laboratory may be required to demonstrate that the modifications will produce equivalent results for the matrix. Approval of all method modifications is by one of the following laboratory personnel before performing the modification: Area Supervisor, Laboratory Services Manager, Laboratory Director, or Quality Assurance Officer

This method is restricted to use by or under the supervision of analysts experienced in the operation of the gas chromatograph (GC) and in the interpretation of gas chromatograms. Each analyst must demonstrate the ability to generate acceptable results with this method by performing an initial demonstration of capability (see section 10.1), analyzing a proficiency test sample and completing the record of training.

After initial demonstration, ongoing demonstration is based on acceptable laboratory performance of at least a quarterly laboratory control sample or acceptable performance from an annual proficiency test sample. A major modification to this procedure requires demonstration of performance. The identification of major method modification requiring performance demonstration is directed by the QA Officer and Laboratory Director on a case-by-case basis.

2. Summary of Method

A measured volume or weight of sample (approximately 1L for liquids, 10g to 30g for solids) is extracted using the appropriate matrix-specific sample extraction technique.

Liquid samples are extracted at neutral pH with methylene chloride using Method 3510C (separatory funnel), or other appropriate technique.

Solid samples are extracted with methylene chloride:acetone (1:1) using Method 3540C (Soxhlet), Method 3545 (accelerated solvent extraction), Method 3550 (ultrasonic extraction), or other appropriate technique.

Wipe samples are extracted with methylene chloride:acetone (1:1) using Method 3540C (Soxhlet) or other appropriate technique.

Oil samples are diluted with hexane following the procedure outlined in the extraction SOP.

A variety of cleanup steps may be applied to the extract, depending on the nature of the matrix interferences and the target analytes to be determined. Routine cleanups used include Florisil (Method 3620), and Method 3660 for the removal of elemental sulfur from sample extracts.

After cleanup, the extract is analyzed by injecting a 1µL sample into a gas chromatograph equipped with narrow- or wide-bore fused silica capillary columns and electron capture (GC/ECD) detectors.

2.1 Method Modifications from Reference

None.

3. Detection Limits

The laboratory follows the procedure found in 40CFR Part 136 to determine the MDL on an annual basis. The method detection limits determined by the laboratory are on file for review.

Table 1 lists our routine reporting limits. Whenever MDL studies are performed, the MDL results are compared with our reporting limits to ensure that the calculated MDLs are equal to or below our reporting limits.

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4. Interferences

4.1 Instrumental

4.1.1 Only high purity gases are used in the GC system to eliminate this source of possible contamination. Both the helium (carrier gas – 99.999%) and argon-methane (detector make-up gas) are certified by the gas supplier.

4.1.2 Preventive instrument maintenance is performed routinely, and whenever highly contaminated extracts are analyzed that could result in chromatographic interferences or result in degradation of system performance. Section 9.5 details the maintenance steps.

4.1.3 Glassware must be scrupulously cleaned. This procedure is detailed in the extraction SOPs. Store dry glassware in a clean environment.

4.2 Parameters

4.2.1 All solvents used are pesticide grade or equivalent, and reagents are purchased as certified contaminant free. All of these materials are routinely determined to be free of interferences by analysis of extraction blanks with every extraction batch performed.

4.2.2 Certain compounds (i.e. phthalates) can be extracted from the sample matrix and be detected by the ECD that could possibly result in false positive results or complicate the data interpretation. The use of the cleanup procedures detailed in the extraction SOPs minimize these possible interferences. Analyst experience is also crucial in making compound determinations.

4.2.3 Interferences co-extracted from the samples will vary considerably from waste to waste. While general cleanup techniques are referenced or provided as part of the method, unique samples may require additional cleanup approaches to achieve desired degrees of discrimination and quantitation.

4.2.4 Interferences by phthalate esters introduced during sample preparation can pose a major problem in pesticide determinations.

4.2.4.1 Common flexible plastics contain varying amounts of phthalate esters which are easily extracted or leached from such materials during laboratory operations.

4.2.4.2 Cross-contamination of clean glassware routinely occurs when plastics are handled during extraction steps, especially when solvent-wetted surfaces are handled.

4.2.4.3 Interferences from phthalate esters are minimized by avoiding contact with any plastic materials and checking all solvents and reagents for phthalate contamination.

4.2.5 The presence of elemental sulfur will result in broad peaks that interfere with the detection of early-eluting organochlorine pesticides. Sulfur contamination is often seen in sediment and some soil samples. Method 3660 is used for removal of sulfur.

4.2.6 Other halogenated pesticides or industrial chemicals may interfere with the analysis of pesticides. Coeluting chlorophenols are eliminated by using Method 3620 (florisil).

4.2.7 The following compounds often coelute using the dual-column analysis scheme.

DB-5: 4,4'-DDD / Endosulfan II

DB-1701: 4,4'-DDE / Dieldrin

If these compounds are detected, the results are reported from the column that does not exhibit the coelution.

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5. Safety

The toxicity or carcinogenicity of each reagent and standard used in this method is not fully established; however, each chemical compound should be treated as a potential health hazard. From this viewpoint, exposure to these chemicals must be reduced to the lowest possible level by whatever means available. A reference file of material data handling sheets is available to all personnel involved in the chemical analysis. The following analytes covered by this method have been tentatively classified as known or suspected human or mammalian carcinogens: 4,4-DDT, 4,4-DDD, and BHC's. Additional references to laboratory safety are available in the Chemical Hygiene Plan.

All personnel handling environmental samples known to contain or to have been in contact with municipal waste must follow safety practices for handling known disease causative agents.

5.1 Lab coats, safety glasses, and gloves must be worn when handling samples, extracts, standards or solvents.

5.2 All solvent and extract transfers must be handled in the vented bench area in the GC laboratory.

5.3 All stock standards, working standards, and vialed sample extracts must be placed into the waste bucket in the lab, for future disposal by the Hazardous Waste Manager. The container must be labeled properly with hazard warning labels indicating the container contents.

5.4 Bottles containing flammable solvents must be stored in the flammables cabinet.

6. Sample Collection, Preservation, and Handling

6.1 Sample Collection

Aqueous samples are collected in two 1L amber glass jars with teflon-lined lids. Solid samples are collected in one 250 mL wide-mouth glass jar with a teflon-lined lid. All containers are purchased pre-cleaned and certified from commercial vendors.

6.2 Sample Preservation

Both aqueous and solid samples are then preserved by packing in coolers with ice or ice packs, to maintain a temperature of 4 ± 2° C. Upon receipt at the laboratory, the samples are transferred into sample storage refrigerators to maintain at a temperature of 4 ± 2° C.

6.3 Sample Handling

Aqueous samples must be extracted within 7 days of sample collection, solid samples within 14 days of collection. Once extracted, the samples must be analyzed within 40 days of the extraction date.

7. Equipment and Supplies

7.1 Gas Chromatograph, Hewlett Packard 6890: An analytical system complete with gas chromatograph configured for split-splitless injection and all required accessories including syringes, analytical columns, gases, electron capture detectors (ECD), and data system.

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7.2 GC Columns: Alpha utilizes dual-column analyses. The dual-column approach involves either a single injection that is split between two columns that are mounted in a single gas chromatograph, or dual injections of the split extract on a single GC equipped with two columns. Typical column pairs used are listed below. Other columns may be used as long as method performance criteria can be met.

7.2.1 Column pair 1

30m x 0.32mm ID fused silica capillary column chemically bonded with SE-54 (DB-5, SPB-5, RTx-5 , or equivalent), 0.25µm film thickness.

30m x 0.32mm ID fused silica capillary column chemically bonded with 50 percent phenyl methylpolysiloxane (DB-1701, or equivalent) 0.25µm film thickness.

7.2.2 Column pair 2

30m x 0.53mm ID fused silica capillary column chemically bonded with SE-54 (DB-5, SPB-5, RTx5, or equivalent), 0.5µm film thickness.

30m x 0.53mm ID fused silica capillary column chemically bonded with 50 percent phenyl methylpolysiloxane (DB-1701, or equivalent), 0.5µm film thickness.

7.3 Volumetric Flasks: 10mL and 25mL, for the preparation of standards.

7.4 Microsyringes/Wiretrol syringes: 10 µL – 1000 µL

7.5 Disposable Borosilicate Pipets

7.6 Vials: 2 mL clear glass, crimp-top and screw-cap.

8. Standards and Reagents

Reagent grade or pesticide grade chemicals are used in all tests. Unless otherwise indicated, it is intended that all reagents shall conform to specifications of the Committee on Analytical Reagents of the American Chemical Society, where such specifications are available. Other grades may be used, provided it is first ascertained that the reagent is of sufficient high purity to permit its use without lessening the accuracy of the determination.

NOTE: Store the standard solutions (stock, composite, calibration, internal, and surrogate) at 4 $\pm$ 2°C in Teflon(R)-sealed containers in the dark. When a lot of standards is prepared, aliquots of that lot are stored in individual small vials. All stock standard solutions must be replaced after one year or sooner if routine QC tests indicate a problem. All other standard solutions must be replaced after six months or sooner if routine QC indicates a problem.

8.1 n-Hexane: Pesticide quality or equivalent.

8.2 Acetone: Pesticide quality or equivalent.

8.3 Methylene chloride: Pesticide quality or equivalent.

8.4 Organic-free Reagent Water: All references to water in this method refer to organic-free reagent water from Alpha's RO water treatment system.

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8.5 Stock Standard Solutions: All stock standard solutions are purchased from commercial vendors as ampulated certified solutions. When an ampulated stock solution is opened, it is transferred to a labeled amber screw-cap vial. The expiration date of the stock solution is either the vendor specified expiration date, or 1 year from the date the ampule was opened, whichever is sooner. Typical stock standard concentrations are listed in Table 2.

8.6 Calibration Standards: Calibration standards are prepared volumetrically by diluting the appropriate stock standard(s) with hexane. Calibration standards expire 6 months from the date of preparation, or on the earliest expiration date of any of the stock solutions used to prepare the calibration standard. Calibrations are performed at the 6 concentration levels listed in Table 2.

8.7 Internal Standard Solution: 1-Bromo-2-nitrobenzene is used as the internal standard, and is added to all single-component calibration standards and sample extracts to achieve a concentration of 0.25 µg/mL.

8.8 Surrogate Standards: Tetrachloro-m-xylene and decachlorobiphenyl are used as surrogates. They are added to the calibration standards at the concentrations listed in Table 2, and are spiked into all samples and QC samples prior to extraction. The spiking solution is prepared in acetone at the concentrations listed in Table 2.

8.9 LCS/MS Spiking Solutions: The LCS/MS spiking solutions are prepared volumetrically by diluting the appropriate stock standards in acetone. The spiking solution concentrations are listed in Table 2.

9. Procedure

9.1 SET-UP

9.1.1 Sample Extraction

Water samples are extracted at a neutral pH with methylene chloride using a separatory funnel (Method 3510C). See extraction SOP for details.

Solid samples are extracted with methylene chloride:acetone (1:1) using Soxhlet extraction (Method 3540C), accelerated solvent extraction (Method 3545) or ultrasonic extraction (Method 3550) procedures. See extraction SOP for details.

9.1.2 Extract Cleanup

Cleanup procedures may not be necessary for a relatively clean sample matrix, but most extracts from environmental and waste samples will require additional preparation before analysis. The specific cleanup procedure used will depend on the nature of the sample to be analyzed and the data quality objectives for the measurements. See extraction SOPs for details.

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9.1.3 GC Conditions:

The dual-column / dual-detector approach involves the use of the columns listed in section 7.2. The columns are connected to an injection tee or dual injection GC, and separate electron capture detectors. Typical GC conditions for the HP 6890 instruments are listed below, but may be altered as long as method performance criteria are met.

Temperature 1:	100 °C
Time 1:	1 minute
Ramp 1:	20 °C/minute
Temperature 2:	160 °C
Time 2:	0 minutes
Ramp 2:	6 ° C/minute
Final temperature:	270 °C
Final time:	2.67 minutes
Injector temperature:	200 °C

Injector mode:	Pulsed Split
	2:1 split, 0.75 min pulse
Injector Flow:	6.0 mL/min split flow
Detector temperature:	350 °C
Carrier gas:	Helium
Carrier flow:	3 mL/min
Carrier mode:	Constant flow
Makeup gas:	Argon/methane (P5)
Total detector flow:	55 mL/min
Injection volume:	1 µL

9.1.4 DDT and Endrin Breakdown
The breakdown of DDT and Endrin must be measured before samples are analyzed and at the beginning of each 12-hour shift. Injector maintenance must be completed if the breakdown in greater than 15% for either compound. (See Section 9.5.2)

9.2 Initial Calibration

9.2.1 Prepare calibration standards using the procedures in Section 8.6 and Table 2. The calibration standards are aliquoted into autosampler vials and capped prior to loading onto the autosampler tray.

9.2.2 Establish the GC operating conditions by loading the appropriate GC method. Typical instrument conditions are listed in section 9.1.3. The same operating conditions are used for calibrations and sample analyses. Create the analytical sequence using the Turbochrom data acquisition software.

9.2.3 A 1µL injection volume of each calibration standard is typically used. Other injection volumes may be employed, provided that the analyst can demonstrate adequate sensitivity for the compounds of interest. The same injection volume must be used for all standards and samples.

9.2.4 Because of the low concentration of pesticide standards injected on a GC/ECD, column adsorption may be a problem when the GC has not been used for a day or more or after system maintenance. The GC column may be primed (or deactivated) by injecting a pesticide standard mixture approximately 20 times more concentrated than the mid-concentration standard. Inject this standard mixture prior to beginning the initial calibration or calibration verification.

Alternaltely, the system may be primed by baking at the final analytical temperature for approximately 30 minutes.

Several analytes may be observed in the injection just following system priming. Always run an instrument blank after system priming.

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9.2.5 Calibration Factors

Internal standard calibration techniques are employed in this method.

9.2.5.1 Internal Standard Procedure. In each standard, calculate the response factor (RF) for each analyte, the average RF, and the relative standard deviation (RSD) of the RFs, using the Target data processing software. The calculations are performed automatically, using the formulae listed in Alpha's Quality Manual.

9.2.6 Initial Calibration Criteria

If the RSD for an analyte is $\leq$ 20%, then the response of the instrument for this compound is considered linear over the range and the mean calibration factor can be used to quantitate sample results.

If the RSD for any analyte is > 20%, then linearity through the origin cannot be assumed. The mean response factor cannot be used for quantitation. An alternative calculation may be done by the use of linearity as long as the correlation coefficient is $\geq$0.995. If both of these quantitation methods fail criteria for any compound in the initial calibration, then the system must be reevaluated and a new calibration curve must be analyzed.

9.2.7 Retention Time Windows

9.2.7.1 The retention time windows used for the identification of target analysts are as follows: for compounds eluting before heptachlor epoxide, the window is ± 0.05 minutes; for all other compounds, the window is ± 0.07 minutes. These criteria have been adopted from the EPA CLP Statement of Work (OLM04.2). It has been found that these limits work well, being wide enough to eliminate false-negatives while being tight enough to eliminate false-positives. Windows that are calculated using the procedure recommended in Method 8000 tend to be very narrow, creating the risk of false negative results.

9.2.7.2 The windows listed above are used as guidance, however the experience of the analyst weighs heavily in the interpretation of the chromatograms. For example, it has been observed that certain oil matrices can cause the retention times to shift more dramatically. Additionally, if any positive results are questionable and at sufficiently high concentration, GC/MS analysis is used for confirmation.

9.3 Continuing Calibration Verification

9.3.1 Verify calibration each 12-hour shift by injecting calibration verification standards prior to conducting any sample analyses. High and low concentration mixtures of single-component analytes and multi-component analytes are alternated for calibration verification. A calibration standard must also be injected at intervals of not less than once every twenty samples (after every 4 - 8 samples is routine practice to minimize the number of samples requiring re-injection when QC limits are exceeded) and at the end of the analysis sequence.

9.3.1.1 The calibration factor (for external standard compounds) and response factor (for internal standard compounds) for each analyte to be quantitated must not exceed a ± 15% difference when compared to the initial calibration curve. The Target data processing software automatically calculates the %D for all analytes according to the formulae in Alpha's Quality Manual.

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9.3.1.2 If this criterion is exceeded, inspect the gas chromatographic system to determine the cause and perform whatever maintenance is necessary before verifying calibration and proceeding with sample analysis.

9.3.1.3 If routine maintenance does not return the instrument performance to meet the QC requirements (Section 10) based on the last initial calibration, then a new initial calibration must be performed. Due to the large number of analytes present, allowances may be made for a CF or RF that drifts out high, as long as there are no positive hits for that particular analyte in any of the associated samples. Any QC failures must be written up by the analyst on narrative sheets for inclusion with the sample data.

9.3.2 Compare the retention time of each analyte in the calibration standard with the absolute retention time windows described in section 9.2.7. The center of the absolute retention time window for each analyte is its retention time in the mid-concentration standard analyzed during the initial calibration. Each analyte in each standard must fall within its respective retention time window. If not, the gas chromatographic system must either be adjusted so that a second analysis of the standard does result in all analytes falling within their retention time windows, or a new initial calibration must be performed and new retention time windows established.

9.4 Sample Analysis

9.4.1 The same GC operating conditions used for the initial calibration must be employed for sample analyses, including sample injection volume (Section 9.1.3).

9.4.2 Tentative identification of an analyte occurs when a peak from a sample extract falls within the retention time window for the compound. Each tentative identification is confirmed using a second GC column of dissimilar stationary phase. Confirmation is positive when the %RPD is $\leq$ 40% from the results of the two columns. In particularly difficult matrices, confirmation by GC/MS may be advisable (see Section 9.4.10).

9.4.3 The concentration reported for an identified target analyte in an extract is calculated using the Target data processing software. The Target methods have been configured to utilize the quantitation formulas found in Alpha's Quality Manual. Proper quantitation requires the appropriate selection of a baseline from which the peak area or height can be determined. See the Manual Integration SOP for integration guidelines.

9.4.3.1 If the responses exceed the calibration range of the system, dilute the extract and reanalyze.

9.4.4 Each sample analysis must be bracketed with an acceptable initial calibration, calibration verification standard(s) (each 12-hour analytical shift), or calibration standards interspersed within the samples. When a calibration verification standard fails to meet the QC criteria, all samples that were injected after the last standard that last met the QC criteria must be re-injected.

9.4.5 Sample injections may continue for as long as the calibration verification standards and standards interspersed with the samples meet instrument QC requirements. Standards are typically analyzed after every 4 – 8 samples to minimize the number of samples that must be re-injected when the standards fail the QC limits. However, calibration verification standards must be analyzed after every 20 samples. The sequence ends when the set of samples has been injected or when qualitative and/or quantitative QC criteria are exceeded.

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9.4.6 Use the calibration standards analyzed during the sequence to evaluate retention time stability. The retention time windows are established using the absolute retention time of each analyte in the mid-concentration standard during the initial calibration as the mid-point of the window. The widths of the windows are defined in Section 9.2.7.

9.4.7 Each subsequent injection of a standard during the 12-hour analytical shift (i.e., those standards injected every 20 samples, or more frequently) must be checked against the retention time windows. If any of these subsequent standards fall outside their absolute retention time windows, the GC system is out of control. Determine the cause of the problem and correct it. If the problem cannot be corrected, a new initial calibration must be performed.

9.4.8 Identification of mixtures (i.e. Chlordane and Toxaphene) is based on the characteristic 'fingerprint' retention time and shape of the indicator peak(s); and quantitation is based on the area under the characteristic peaks as compared to the area under the corresponding calibration peaks(s) of the same retention time and shape generated using internal calibration procedures.

9.4.9 If compound identification or quantitation is precluded due to interference (e.g., broad, rounded peaks or ill-defined baselines are present) cleanup of the extract may be needed. If instrument problems are suspected, rerun the extract on another instrument to determine if the problem results from analytical hardware or the sample matrix. Refer to the extraction SOPs for the procedures to be followed in sample cleanup.

9.4.10 GC/MS Confirmation

GC/MS confirmation may be used in conjunction with either single-column or dual-column analysis if the concentration is sufficient for detection by GC/MS.

9.4.10.1 Full-scan GC/MS will normally require a concentration of approximately 10ng/µL in the final extract for each single-component compound.

9.4.10.2 The GC/MS must be calibrated for the specific target pesticides when it is used for quantitative analysis.

9.4.10.3 GC/MS may not be used for confirmation when concentrations are below the sensitivity of the instrument.

9.4.10.4 GC/MS confirmation should be accomplished by analyzing the same extract that is used for GC/ECD analysis.

9.4.10.5 The base/neutral/acid extract and the associated blank may be used for GC/MS confirmation if the surrogates and internal standards do not interfere and if it is demonstrated that the analyte is stable during acid/base partitioning. However, if the compounds are not detected in the base/neutral/acid extract, then GC/MS analysis of the pesticide extract should be performed.

9.4.10.6 A QC reference sample containing the compound should also be analyzed by GC/MS. The concentration of the QC reference sample must demonstrate that those pesticides identified by GC/ECD can be confirmed by GC/MS.

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9.5 Instrument Maintenance

9.5.1 Preventive Maintenance

Routine preventive maintenance should be performed to maintain GC system performance. This includes periodic replacement of injector septa, replacement of injector liner(s), and replacement of injector seals.

9.5.2 Other Maintenance

Additional maintenance may be required if system performance degrades.

9.5.2.1 GC injector ports are of critical concern, especially in the analysis of DDT and Endrin.

9.5.2.1.1 Injectors that are contaminated or chemically active can cause the degradation ("breakdown") of the analytes. Endrin and DDT breakdown to Endrin aldehyde, Endrin ketone, DDD, or DDE.

Check for degradation problems by injecting a standard containing only 4,4'-DDT and Endrin. Presence of 4,4'-DDE, 4,4'-DDD, Endrin ketone or Endrin indicates breakdown. If degradation of either DDT or Endrin exceeds 15%, take corrective action before proceeding with calibration.

When such breakdown is observed, replacement of the injector liner and seal may solve the problem. If not, clip approximately 3 – 6 inches from the injector end of the GC column. If the degradation does not improve, it may be necessary to replace the column(s).

Calculate percent breakdown as follows:

$$\%\ \text{breakdown of DDT} = \frac{\text{sum of degradation peak areas (DDD+DDE)}}{\text{sum of all peak areas (DDT+DDE+DDD)}} \times 100$$

$$\%\ \text{breakdown of Endrin} = \frac{\text{sum of degradation peak areas (aldehyde+ketone)}}{\text{sum of all peak areas (Endrin+aldehyde+ketone)}} \times 100$$

9.5.2.2 ECD detectors may also become contaminated, requiring bake out at elevated temperatures, or repair by the manufacturer.

9.6 Calculations

9.6.1 Quantitation of Single Component Pesticide and Congeners

The single component pesticide compounds are calculated as described in Section 9.4.3, and reported in µg/L or µg/Kg units. After performing technical data review, validating that all QC criteria have been met and confirming all positive hits, the data report is sent electronically to the LIMS computer for generation of the client report. There are two levels of review of the data in the LIMS system prior to release of data. These reviews should be done by two separate individuals.

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9.6.2 Quantitation of Multiple-Component Analytes

Quantitation is based on use of 5 of the major peaks present in the analyte. Each of these peaks are individually calibrated with a five-point calibration based on average response factors. The %RSD must meet the criteria of ≤15%. The five major peaks are calculated as described in Section 9.4.3. After individual calculation meets criteria, the average of the major five peaks is used to determine the final concentration.

9.6.2.1 Toxaphene

Toxaphene is quantitated by the interal standard method, using the five largest peaks found in the standard and averaging the resulting concentrations.

9.6.2.2 Chlordane

Chlordane is a technical mixture of at least 11 major components and 30 or more minor components. Trans- and cis-Chlordane (alpha and gamma, respectively), are the two major components of technical Chlordane. However, the exact percentage of each in the technical material is not completely defined, and is not consistent from batch to batch.

9.6.2.2.1 The GC pattern of a Chlordane residue may differ considerably from that of the technical standard. Depending on the sample substrate and its history, residues of Chlordane can consist of almost any combination of constituents from the technical Chlordane, plant and/or animal metabolites, and products of degradation caused by exposure to environmental factors such as water and sunlight.

9.6.2.2.2 Whenever possible, when Chlordane residue does not resemble technical Chlordane, the analyst should quantitate the peaks of alpha-Chlordane, gamma-Chlordane, Heptachlor, and trans-Nonachlor separately against the appropriate reference materials, and report the individual residues.

9.6.2.2.3 When the GC pattern of the residue resembles that of technical Chlordane, the analyst may quantitate Chlordane residues by comparing the total area of the Chlordane chromatogram using the five major peaks.

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10. Quality Control and Data Assessment

The laboratory maintains records to document the quality of data that is generated. Ongoing data quality checks are compared with established performance criteria to determine if the results of analyses meet the performance characteristics of the method.

10.1 Demonstration of Capability

The analyst must make an initial, one-time, demonstration of the ability to generate acceptable accuracy and precision with this method. This is done by extraction and analysis of 4 replicate Quality Control Reference Samples. Each time a major method modification is made, the analyst is required to repeat the procedure.

When one or more of the parameters tested fail at least one of the acceptance criteria, the analyst must locate and correct the source of the problem and repeat the test for failed parameters of the method.

Repeated failure confirms a general problem with the measurement system or analytical technique of the analyst. If the failure repeats, locate and correct the source of the problem and repeat the test for all parameters listed in the method.

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The QC reference sample concentrates are used to perform the IDC. At a minimum, the analyst must perform the IDC on the single component pesticide compounds and one of the Aroclors. The concentrations of the IDC concentrates are near the midpoint of the calibration curve.

If the recovery of any compound found in the QC reference sample is less than 70 percent or greater than 130 percent of the certified value, the laboratory performance is judged to be out of control, and the problem must be corrected. A new set of calibration standards should be prepared and analyzed.

10.2 Blank

Extraction blanks are performed with each extraction batch of 20 or less samples, according to the extraction SOPs. The extraction blank must not contain any of the reportable analytes above the reporting limit. If any reportable analytes are detected in the blank, the entire extraction batch is suspect and re-extraction of all associated samples is required.

10.3 Laboratory Control Samples (LCS)

A Laboratory Control Sample (LCS) is extracted with each analytical batch. The LCS consists of an aliquot of a clean (control) matrix similar to the sample matrix and of the same weight or volume. The LCS is spiked with the single component pesticide analytes. The concentration of the spiking solution is listed in Table 2. The recovery acceptance criteria are listed in Table 3. If any recovery criteria are not met, the extract should be reanalyzed. If the criteria are still not met, the entire batch should be re-extracted. If this is not possible, due to insufficient sample or holding time exceedence, the analyst must write up the failure on a narrative sheet for inclusion in the client report.

10.4 Matrix Spikes / Spike Duplicates / Duplicates

A matrix spike/matrix spike duplicate pair is extracted and analyzed for each batch of 20 or less samples. The spike compounds and levels are listed in Table 2. The recovery acceptance criteria are listed in Table 3. If the recovery criteria are not met, but are met in the LCS, the failure may be attributed to sample matrix effects and must be noted on a narrative sheet for inclusion in the client report.

10.5 Surrogates

All extracted samples and associated QC are spiked with surrogates at the levels listed in Table 2. The laboratory must evaluate surrogate recovery data from individual samples and QC samples versus the surrogate control limits listed in Table 3. If the surrogate limits are not met, the extract should be reanalyzed to determine if the failure was due to an instrument problem. If the criteria are still not met, the affected samples should be re-extracted to confirm that the failure was due to sample matrix. If matrix effect is confirmed, this must be noted on a narrative sheet for inclusion in the client report.

10.6 Control Limits

The laboratory maintains performance records to document the quality of data that is generated. Method accuracy for samples is assessed and records maintained.

Control limits for the method parameters are generated by the QC staff and distributed to the analysts. The control limits are calculated based on in-house performance data, and are compared to the control limits found in the reference method.

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10.7 Analytical Sequence

Initial calibration:

1. Instrument Blank
2. Std Level 1
3. Std Level 2
4. Std Level 3
5. Std Level 4
6. Std Level 5
7. Std Level 6
8. Blank
9. Initial Calibration Verification Standard (ICV)

Repeat std Levels 1 – 6 for other mixes until curve is complete.

[**NOTE:** If multiple calibration mixtures are analyzed, it is acceptable to analyze appropriate ICV's after all calibration standards have been injected.]

Daily sequence:

1. Degradation Check Standard
2. Pesticide Continuing Calibration Standard
3. Chlordane/Toxaphene Continuing Calibration Standard
4. Extraction Blank
5. Laboratory Control Sample
6. Matrix Spike
7. Duplicate/Matrix Spike Duplicate
8. Samples (4 – 8)
9. Cal check

Repeat 4 – 9 (as needed)

11. Method Performance

The method detection limit (MDL) is defined as the minimum concentration of a substance that can be measured and reported with 99% confidence that the value is above zero. The MDL concentrations were obtained using reagent water. The MDL actually achieved in a given analysis will vary depending on instrument sensitivity and matrix effects.

Method performance data is on file in the laboratory QC department. Comparison of method performance data for the laboratory to the reference method criteria occurs when laboratory in-house acceptance limits are generated. In-house generated data must be within the specifications of the reference method or the analysis is not continued until corrective action is completed.

The performance of this method is evaluated on an on-going basis by the QC criteria listed throughout this SOP. Specifically, Initial Calibration criteria, Continuing Calibration Check criteria, surrogates, blanks, LCSs, MS/MSDs, duplicates, and pesticide degradation check standards are all used to ensure that the method is producing results of consistently high quality. In addition, Alpha participates in several blind and double blind PE studies annually to demonstrate the ability of this method to produce accurate and reproducible data.

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12. Corrective Actions

Holding time exceedence and/or improper preservation are noted on the nonconformance report form.

Perform instrument maintenance as described throughout this SOP as needed when instrument calibration criteria are not met. Record all maintenance in the instrument logbook.

All batch and sample specific QC criteria outlined in Section 10 are evaluated by the analyst prior to approval of the data. When any QC criteria fail, the cause for the failure must be identified and corrected. This may include instrument recalibration followed by sample reanalysis, sample cleanup, or sample re-extraction. If it is determined that the failure is due to sample matrix effects, a project narrative report is written by the analyst for inclusion in the data report. If there is insufficient sample volume to perform the re-analysis for confirmation, this is also noted in the narrative and included in the client report.

13. Pollution Prevention

See Chemical Hygiene Plan for pollution prevention operations.

14. Waste Management

See Chemical Hygiene Plan for waste handling and disposal.

15. Attachments

Table 1: REPORTING LIMITS

Table 2: STANDARD SOLUTIONS

Table 3: QC ACCEPTANCE CRITERIA

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TABLE 1

REPORTING LIMITS*

	RL (Aqueous)	RL (Soil)
Pesticides		
Alpha-BHC	0.02 µg/L	5µg/Kg
Hexachlorobenzene	0.02 µg/L	5µg/Kg
Lindane	0.02 µg/L	5µg/Kg
Heptachlor	0.02 µg/L	5µg/Kg
Endosulfan I	0.02 µg/L	5µg/Kg
Dieldrin	0.04 µg/L	5µg/Kg
Endrin	0.04 µg/L	5µg/Kg
4, 4'-DDD	0.04 µg/L	5µg/Kg
4, 4'-DDT	0.04 µg/L	5µg/Kg
Methoxychlor	0.2 µg/L	20 µg/Kg
Aldrin	0.02 µg/L	5 µg/Kg
Beta-BHC	0.02 µg/L	5µg/Kg
Delta-BHC	0.02 µg/L	5µg/Kg
Heptachlor Epoxide	0.02 µg/L	5µg/Kg
trans-Chlordane	0.02 µg/L	5µg/Kg
cis-Chlordane	0.02 µg/L	5µg/Kg
trans-Nonachlor	0.02 µg/L	5µg/Kg
4, 4'- DDE	0.04 µg/L	5µg/Kg
Endosulfan II	0.04 µg/L	5µg/Kg
Endrin Aldehyde	0.04 µg/L	5µg/Kg
Endosulfan Sulfate	0.04 µg/L	5µg/Kg
Endrin Ketone	0.04 µg/L	µg/Kg
Technical Chlordane	0.2 µg/L	20 µg/Kg
Toxaphene	0.2 µg/L	20 µg/Kg

*** RL:** Typical laboratory reporting limit. Actual RL's may be higher depending on sample matrix. RLs are not adjusted for % Moisture.

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TABLE 2

STANDARD SOLUTIONS

	Stock solution (µg/mL)	Level 6 (µg/mL)	Level 5 (µg/mL)	Level 4 (µg/mL)	Level 3 (µg/mL)	Level 2 (µg/mL)	Level 1 (µg/mL)	Std. Spike Solution (µg/mL)	Std. LCS Solution (µg/mL)
Alpha-BHC	8	0.32	0.16	0.08	0.04	0.02	0.01	0.625	0.625
Lindane	8	0.32	0.16	0.08	0.04	0.02	0.01	0.625	0.625
Heptachlor	8	0.32	0.16	0.08	0.04	0.02	0.01	0.625	0.625
Endosulfan I	8	0.32	0.16	0.08	0.04	0.02	0.01	0.625	0.625
Hexachlorobenzene	100	0.32	0.16	0.08	0.04	0.02	0.01	0.625	0.625
trans-Nonachlor	100	0.32	0.16	0.08	0.04	0.02	0.01	0.625	0.625
Dieldrin	16	0.64	0.32	0.16	0.08	0.04	0.02	0.625	0.625
Endrin	16	0.64	0.32	0.16	0.08	0.04	0.02	0.625	0.625
4, 4'-DDD	16	0.64	0.32	0.16	0.08	0.04	0.02	0.625	0.625
4, 4'-DDT	16	0.64	0.32	0.16	0.08	0.04	0.02	0.625	0.625
Methoxychlor	80	3.2	1.6	0.8	0.4	0.2	0.1	0.625	0.625
Tetrachloro-m-Xylene	8	0.64	0.32	0.16	0.08	0.04	0.02	2.0	2.0
Decachloro-Biphenyl	16	1.28	0.64	0.32	0.16	0.08	0.04	2.0	2.0
Aldrin	8	0.32	0.16	0.08	0.04	0.02	0.01	0.625	0.625
Beta-BHC	8	0.32	0.16	0.08	0.04	0.02	0.01	0.625	0.625
Delta-BHC	8	0.32	0.16	0.08	0.04	0.02	0.01	0.625	0.625
Heptachlor Epoxide	8	0.32	0.16	0.08	0.04	0.02	0.01	0.625	0.625
Trans-Chlordane	8	0.32	0.16	0.08	0.04	0.02	0.01	0.625	0.625
Cis-Chlordane	8	0.32	0.16	0.08	0.04	0.02	0.01	0.625	0.625
4, 4'- DDE	16	0.64	0.32	0.16	0.08	0.04	0.02	0.625	0.625
Endosulfan II	16	0.64	0.32	0.16	0.08	0.04	0.02	0.625	0.625
Endrin Aldehyde	16	0.64	0.32	0.16	0.08	0.04	0.02	0.625	0.625
Endosulfan Sulfate	16	0.64	0.32	0.16	0.08	0.04	0.02	0.625	0.625
Endrin Ketone	16	0.64	0.32	0.16	0.08	0.04	0.02	0.625	0.625
Technical Chlordane	100	0.1	5.0	2.5	1.0	0.5	0.25		
Toxaphene	100	0.25	10	5	2.5	1.0	0.5		
Internal Standard									
1-Bromo-2-Nitrobenzene	5000	0.25	0.25	0.25	0.25	0.25	0.25		

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TABLE 3

QC ACCEPTANCE CRITERIA

	Aqueous		Soil	
Surrogate % Recovery	**Lower Control Limit**	**Upper Control Limit**	**Lower Control Limit**	**Upper Control Limit**
2,4,5,6-Tetrachloro-m-xylene	30%	150%	30%	150%
Decachlorobiphenyl	30%	150%	30%	150%

	Aqueous % Recovery		Soil % Recovery		Duplicate and/or MSD	
MS/MSD and LCS	**Lower Control Limit**	**Upper Control Limit**	**Lower Control Limit**	**Upper Control Limit**	**Aqueous RPD**	**Soil RPD**
Alpha-BHC	30%	150%	30%	150%	30%	50%
Hexachlorobenzene	30%	150%	30%	150%	30%	50%
Lindane	30%	150%	30%	150%	30%	50%
Heptachlor	30%	150%	30%	150%	30%	50%
Endosulfan I	30%	150%	30%	150%	30%	50%
Dieldrin	30%	150%	30%	150%	30%	50%
Endrin	30%	150%	30%	150%	30%	50%
4, 4'-DDD	30%	150%	30%	150%	30%	50%
4, 4'-DDT	30%	150%	30%	150%	30%	50%
Methoxychlor	30%	150%	30%	150%	30%	50%
Aldrin	30%	150%	30%	150%	30%	50%
Beta-BHC	30%	150%	30%	150%	30%	50%
Delta-BHC	30%	150%	30%	150%	30%	50%
Heptachlor Epoxide	30%	150%	30%	150%	30%	50%
trans-Chlordane	30%	150%	30%	150%	30%	50%
cis-Chlordane	30%	150%	30%	150%	30%	50%
trans-Nonachlor	30%	150%	30%	150%	30%	50%
4, 4'- DDE	30%	150%	30%	150%	30%	50%
Endosulfan II	30%	150%	30%	150%	30%	50%
Endrin Aldehyde	30%	150%	30%	150%	30%	50%
Endosulfan Sulfate	30%	150%	30%	150%	30%	50%
Endrin Ketone	30%	150%	30%	150%	30%	50%

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PCBs

By Capillary Column Gas Chromatography

Reference Methods No.: **Method 8082**

Reference: SW-846, Test Methods for Evaluating Solid Waste: Physical/Chemical Methods, EPA SW-846, Update III, 1997.

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Prepared by:

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Signature: Joseph Watkins Date: 7/30/04

Authorized by:

Name: James Todaro Position: Laboratory Director

Signature: James Todaro Date: 7-30-04

ISSUE AMENDMENTS

Changes since last issue:

None.

PCBs

By Capillary Column Gas Chromatography

Reference Methods No.: **Method 8082**

Reference: SW-846, Test Methods for Evaluating Solid Waste: Physical/Chemical Methods, EPA SW-846, Update III, 1997.

1. Scope and Application

Method 8082 is used to determine the concentrations of Polychlorinated Biphenyls (PCBs) as Aroclors or as individual congeners in extracts from solid and liquid matrices. This SOP details the analysis for PCBs using fused-silica, open-tubular, capillary columns with electron capture detectors (ECD).

Matrices: Extracts from solid and liquid matrices.

Definitions: See Alpha Laboratories Quality Manual Appendix A

Regulatory Parameter List: The compounds listed below are determined by this method:

Parameter	CAS
Arochlor 1016	12674-11-2
Arochlor 1221	11104-28-2
Arochlor 1232	11141-16-5
Arochlor 1242	53469-21-9
Arochlor 1248	12672-29-6
Arochlor 1254	11097-69-1
Arochlor 1260	11096-82-5
Arochlor 1262	37324-23-5
Arochlor 1268	11100-14-4
2-Chlorobiphenyl	2051-60-7
2,3-Dichlorobiphenyl	16605-91-7
2,2',5-Trichlorobiphenyl	37680-65-2
2,4',5-Trichlorobiphenyl	16606-02-3
2,2',3,5'-Tetrachlorobiphenyl	41464-39-5
2,2',5,5'-Tetrachlorobiphenyl	35693-99-3
2,3',4,4'-Tetrachlorobiphenyl	32598-10-0
2,2',3,4,5'-Pentachlorobiphenyl	38380-02-8
2,2',4,5,5'-Pentachlorobiphenyl	37680-73-2
2,3,3',4',6-Pentachlorobiphenyl	38380-03-9
2,2',3,4,4',5'-Hexachlorobiphenyl	35065-28-2
2,2',3,4,5,5'-Hexachlorobiphenyl	52712-04-6
2,2',3,5,5',6-Hexachlorobiphenyl	52663-63-5
2,2',4,4',5,5'-Hexachlorobiphenyl	35065-27-1
2,2',3,3',4,4',5-Heptachlorobiphenyl	35065-30-6
2,2',3,4,4',5,5'-Heptachlorobiphenyl	35065-29-3
2,2',3,4,4',5',6-Heptachlorobiphenyl	52663-69-1
2,2',3,4',5,5',6-Heptachlorobiphenyl	52663-68-0
2,2',3,3',4,4',5,5',6-Nonachlorobiphenyl	40186-72-9

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The data report packages present the documentation of any method modification related to the samples tested. Depending upon the nature of the modification and the extent of intended use, the laboratory may be required to demonstrate that the modifications will produce equivalent results for the matrix. Approval of all method modifications is by one of the following laboratory personnel before performing the modification: Area Supervisor, Laboratory Services Manager, Laboratory Director, or Quality Assurance Officer.

This method is restricted to use by or under the supervision of analysts experienced in the operation of the gas chromatograph (GC) and in the interpretation of gas chromatograms. Each analyst must demonstrate the ability to generate acceptable results with this method by performing an initial demonstration of capability (see section 10.1), analyzing a proficiency test sample and completing the record of training.

After initial demonstration, ongoing demonstration is based on acceptable laboratory performance of at least a quarterly laboratory control sample or acceptable performance from an annual proficiency test sample. A major modification to this procedure requires demonstration of performance. The identification of major method modification requiring performance demonstration is directed by the QA Officer and Laboratory Director on a case-by-case basis.

2. Summary of Method

A measured volume or weight of sample (approximately 1L for liquids, 10g to 30g for solids) is extracted using the appropriate matrix-specific sample extraction technique.

Liquid samples are extracted at neutral pH with methylene chloride using Method 3510C (separatory funnel), or other appropriate technique.

Solid samples are extracted with methylene chloride:acetone (1:1) using Method 3540C (Soxhlet), Method 3545 (accelerated solvent extraction), Method 3550 (ultrasonic extraction), or other appropriate technique.

Wipe samples are extracted with methylene chloride:acetone (1:1) using Method 3540C (Soxhlet) or other appropriate technique.

Oil samples are diluted with hexane following the procedure outlined in the extraction SOP.

Sulfuric acid cleanup (Method 3665) is utilized for PCB extracts.

After cleanup, the extract is analyzed by injecting a 1µL sample into a gas chromatograph equipped with narrow- or wide-bore fused silica capillary columns and electron capture (GC/ECD) detectors.

2.1 Method Modifications from Reference

Internal standard calibration is used for all analytes. The internal standard used is 1-bromo-2-nitrobenzene.

3. Detection Limits

The laboratory follows the procedure found in 40CFR Part 136 to determine the MDL on an annual basis. The method detection limits determined by the laboratory are on file for review.

Table 1 lists our routine reporting limits. Whenever MDL studies are performed, the MDL results are compared with our reporting limits to ensure that the calculated MDLs are equal to or below our reporting limits.

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4. Interferences

4.1 Instrumental

4.1.1 Only high purity gases are used in the GC system to eliminate this source of possible contamination. Both the helium (carrier gas – 99.999%) and argon-methane (detector make-up gas) are certified by the gas supplier.

4.1.2 Preventive instrument maintenance is performed routinely, and whenever highly contaminated extracts are analyzed that could result in chromatographic interferences or result in degradation of system performance. Section 9.5 details the maintenance steps.

4.1.3 Glassware must be scrupulously cleaned. This procedure is detailed in the extraction SOPs. Store dry glassware in a clean environment.

4.2 Parameters

4.2.1 All solvents used are pesticide grade or equivalent, and reagents are purchased as certified contaminant free. All of these materials are routinely determined to be free of interferences by analysis of extraction blanks with every extraction batch performed.

4.2.2 Certain compounds (i.e. phthalates) can be extracted from the sample matrix and be detected by the ECD that could possibly result in false positive results or complicate the data interpretation. The use of the cleanup procedure mentioned in Section 2.1 and detailed in the extraction SOP minimizes these possible interferences. Analyst experience is also crucial in making compound determinations.

4.2.3 Interferences co-extracted from the samples will vary considerably from waste to waste. While a general cleanup technique is referenced or provided as part of the method, unique samples may require additional cleanup approaches to achieve desired degrees of discrimination and quantitation.

5. Safety

The toxicity or carcinogenicity of each reagent and standard used in this method is not fully established; however, each chemical compound should be treated as a potential health hazard. From this viewpoint, exposure to these chemicals must be reduced to the lowest possible level by whatever means available. A reference file of material data handling sheets is available to all personnel involved in the chemical analysis. PCBs have been tentatively classified as known or suspected human or mammalian carcinogens. Additional references to laboratory safety are available in the Chemical Hygiene Plan.

All personnel handling environmental samples known to contain or to have been in contact with municipal waste must follow safety practices for handling known disease causative agents.

5.1 Lab coats, safety glasses, and gloves must be worn when handling samples, extracts, standards or solvents.

5.2 All solvent and extract transfers must be handled in the vented bench area in the GC laboratory.

5.3 All stock standards, working standards, and vialed sample extracts must be placed into the waste bucket in the lab, for future disposal by the Hazardous Waste Manager. The container must be labeled properly with hazard warning labels indicating the container contents.

5.4 Bottles containing flammable solvents must be stored in the flammables cabinet.

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6. Sample Collection, Preservation, and Handling

6.1 Sample Collection

Aqueous samples are collected in two 1L amber glass jars with teflon-lined lids. Solid samples are collected in one 250 mL wide-mouth glass jar with a teflon-lined lid. All containers are purchased pre-cleaned and certified from commercial vendors.

6.2 Sample Preservation

Both aqueous and solid samples are then preserved by packing in coolers with ice or ice packs, to maintain a temperature of 4 ± 2° C. Upon receipt at the laboratory, the samples are transferred into sample storage refrigerators to maintain at a temperature of 4 ± 2° C.

6.3 Sample Handling

Aqueous samples must be extracted within 7 days of sample collection, solid samples within 14 days of collection. Once extracted, the samples must be analyzed within 40 days of the extraction date.

7. Equipment and Supplies

7.1 Gas Chromatograph, Hewlett Packard 6890: An analytical system complete with gas chromatograph configured for split-splitless injection and all required accessories including syringes, analytical columns, gases, electron capture detectors (ECD), and data system.

7.2 GC Columns: Alpha utilizes dual-column analyses. The dual-column approach involves either a single injection that is split between two columns that are mounted in a single gas chromatograph, or dual injections of the split extract on a single GC equipped with two columns. Typical column pairs used are listed below. Other columns may be used as long as method performance criteria can be met.

7.2.1 Column pair 1

30m x 0.32mm ID fused silica capillary column chemically bonded with SE-54 (DB-5, SPB-5, RTx-5 , or equivalent), 0.25µm film thickness.

30m x 0.32mm ID fused silica capillary column chemically bonded with 50 percent phenyl methylpolysiloxane (DB-1701, or equivalent) 0.25µm film thickness.

7.2.2 Column pair 2

30m x 0.53mm ID fused silica capillary column chemically bonded with SE-54 (DB-5, SPB-5, RTx5, or equivalent), 0.5µm film thickness.

30m x 0.53mm ID fused silica capillary column chemically bonded with 50 percent phenyl methylpolysiloxane (DB-1701, or equivalent), 0.5µm film thickness.

7.3 Volumetric Flasks: 10mL and 25mL, for the preparation of standards.

7.4 Microsyringes/Wiretrol syringes: 10 µL – 1000 µL

7.5 Disposable Borosilicate Pipets

7.6 Vials: 2 mL clear glass, crimp-top and screw-cap.

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8. Standards and Reagents

Reagent grade or pesticide grade chemicals are used in all tests. Unless otherwise indicated, it is intended that all reagents shall conform to specifications of the Committee on Analytical Reagents of the American Chemical Society, where such specifications are available. Other grades may be used, provided it is first ascertained that the reagent is of sufficient high purity to permit its use without lessening the accuracy of the determination.

NOTE: Store the standard solutions (stock, composite, calibration, internal, and surrogate) at 4 ± 2° C in Teflon(R)-sealed containers in the dark. When a lot of standards is prepared, aliquots of that lot are stored in individual small vials. All stock standard solutions must be replaced after one year or sooner if routine QC tests indicate a problem. All other standard solutions must be replaced after six months or sooner if routine QC indicates a problem.

8.1 n-Hexane: Pesticide quality or equivalent.

8.2 Acetone: Pesticide quality or equivalent.

8.3 Methylene chloride: Pesticide quality or equivalent.

8.4 Organic-free Reagent Water: All references to water in this method refer to organic-free reagent water from Alpha's RO water treatment system.

8.5 Stock Standard Solutions: All stock standard solutions are purchased from commercial vendors as ampulated certified solutions. When an ampulated stock solution is opened, it is transferred to a labeled amber screw-cap vial. The expiration date of the stock solution is either the vendor specified expiration date, or 1 year from the date the ampule was opened, whichever is sooner. Typical stock standard concentrations are listed in Table 2.

8.6 Calibration Standards: Calibration standards are prepared volumetrically by diluting the appropriate stock standard(s) with hexane. Calibration standards expire 6 months from the date of preparation, or on the earliest expiration date of any of the stock solutions used to prepare the calibration standard. Calibrations are performed at the 6 concentration levels listed in Table 2.

8.7 Internal Standard Solution: 1-Bromo-2-nitrobenzene is used as the internal standard, and is added to all single-component calibration standards and sample extracts to achieve a concentration of 0.25 µg/mL.

8.8 Surrogate Standards: Tetrachloro-m-xylene and decachlorobiphenyl are used as surrogates. They are added to the calibration standards at the concentrations listed in Table 2, and are spiked into all samples and QC samples prior to extraction. The spiking solution is prepared in acetone at the concentrations listed in Table 2.

8.9 LCS/MS Spiking Solutions: The LCS/MS spiking solutions are prepared volumetrically by diluting the appropriate stock standards in acetone. The spiking solution concentrations are listed in Table 2.

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9. Procedure

9.1 SET-UP

9.1.1 Sample Extraction

Water samples are extracted at a neutral pH with methylene chloride using a separatory funnel (Method 3510). See extraction SOP for details.

Solid samples are extracted with methylene chloride:acetone (1:1) using Soxhlet extraction (Method 3540C), accelerated solvent extraction (Method 3545) or ultrasonic extraction (Method 3550) procedures. See extraction SOP for details.

9.1.2 Extract Cleanup

Cleanup procedures may not be necessary for a relatively clean sample matrix, but most extracts from environmental and waste samples will require additional preparation before analysis. The sulfuric acid cleanup method (Method 3665) is utilized. See extraction SOPs for details.

9.1.3 GC Conditions:

The dual-column / dual-detector approach involves the use of the columns listed in section 7.2. The columns are connected to an injection tee or dual injection GC, and separate electron capture detectors. Typical GC conditions for the HP 6890 instruments are listed below, but may be altered as long as method performance criteria are met.

Temperature 1:	100 °C
Time 1:	1 minute
Ramp 1:	20 °C/minute
Temperature 2:	160 °C
Time 2:	0 minutes
Ramp 2:	6 ° C/minute
Final temperature:	270 °C
Final time:	2.67 minutes
Injector temperature:	200 °C

Injector mode:	Pulsed Split
	2:1 split, 0.75 min pulse
Injector Flow:	6.0 mL/min split flow
Detector temperature:	350 °C
Carrier gas:	Helium
Carrier flow:	3 mL/min
Carrier mode:	Constant flow
Makeup gas:	Argon/methane (P5)
Total detector flow:	55 mL/min
Injection volume:	1 µL

9.2 Initial Calibration

9.2.1 Prepare calibration standards using the procedures in Section 8.6 and Table 2. The calibration standards are aliquoted into autosampler vials and capped prior to loading onto the autosampler tray.

9.2.2 Establish the GC operating conditions by loading the appropriate GC method. Typical instrument conditions are listed in section 9.1.3. The same operating conditions are used for calibrations and sample analyses. Create the analytical sequence using the Turbochrom data acquisition software.

9.2.3 A 1µL injection volume of each calibration standard is typically used. Other injection volumes may be employed, provided that the analyst can demonstrate adequate sensitivity for the compounds of interest. The same injection volume must be used for all standards and samples.

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9.2.4 Column adsorption may be a problem when the GC has not been used for a day or more or after system maintenance. The GC column may be primed (or deactivated) by injecting a PCB standard mixture approximately 20 times more concentrated than the mid-concentration standard. Inject this standard mixture prior to beginning the initial calibration or calibration verification.

Alternaltely, the system may be primed by baking at the final analytical temperature for approximately 30 minutes.

Several analytes may be observed in the injection just following system priming. Always run an instrument blank after system priming.

9.2.5 Calibration Factors

Internal standard calibration techniques are employed in this method.

9.2.5.1 Internal Standard Procedure. In each standard, calculate the response factor (RF) for each analyte, the average RF, and the relative standard deviation (RSD) of the RFs, using the Target data processing software. The calculations are performed automatically, using the formulae listed in Alpha's Quality Manual.

9.2.6 Initial Calibration Criteria

If the RSD for an analyte is $\leq$ 20%, then the response of the instrument for this compound is considered linear over the range and the mean calibration factor can be used to quantitate sample results.

If the RSD for any analyte is > 20%, then linearity through the origin cannot be assumed. The mean response factor cannot be used for quantitation. An alternative calculation may be done by the use of linearity as long as the correlation coefficient is $\geq$0.995. If both of these quantitation methods fail criteria for any compound in the initial calibration, then the system must be reevaluated and a new calibration curve must be analyzed.

9.2.7 Retention Time Window

9.2.7.1 The retention time window used for the identification of target analytes is ± 0.07 minutes. These criteria have been adopted from the EPA CLP Statement of Work (OLM04.2). It has been found that these limits work well, being wide enough to eliminate false-negatives while being tight enough to eliminate false-positives. Windows that are calculated using the procedure recommended in Method 8000 tend to be very narrow, creating the risk of false negative results.

9.2.7.2 The window listed above are used as guidance, however the experience of the analyst weighs heavily in the interpretation of the chromatograms. For example, it has been observed that certain oil matrices can cause the retention times to shift more dramatically. Additionally, if any positive results are questionable and at sufficiently high concentration, GC/MS analysis is used for confirmation.

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9.3 Continuing Calibration Verification

9.3.1 Verify calibration each 12-hour shift by injecting calibration verification standards prior to conducting any sample analyses. High and low concentration mixtures of single-component analytes and multi-component analytes are alternated for calibration verification. A calibration standard must also be injected at intervals of not less than once every twenty samples (after every 4 - 8 samples is routine practice to minimize the number of samples requiring re-injection when QC limits are exceeded) and at the end of the analysis sequence.

9.3.1.1 The calibration factor (for external standard compounds) and response factor (for internal standard compounds) for each analyte to be quantitated must not exceed a ± 15% difference when compared to the initial calibration curve. The Target data processing software automatically calculates the %D for all analytes according to the formulae in Alpha's Quality Manual.

9.3.1.2 If this criterion is exceeded, inspect the gas chromatographic system to determine the cause and perform whatever maintenance is necessary before verifying calibration and proceeding with sample analysis.

9.3.1.3 If routine maintenance does not return the instrument performance to meet the QC requirements (Section 10) based on the last initial calibration, then a new initial calibration must be performed. Due to the large number of analytes present, allowances may be made for a CF or RF that drifts out high, as long as there are no positive hits for that particular analyte in any of the associated samples. Any QC failures must be written up by the analyst on narrative sheets for inclusion with the sample data.

9.3.2 Compare the retention time of each analyte in the calibration standard with the absolute retention time windows described in section 9.2.7. The center of the absolute retention time window for each analyte is its retention time in the mid-concentration standard analyzed during the initial calibration. Each analyte in each standard must fall within its respective retention time window. If not, the gas chromatographic system must either be adjusted so that a second analysis of the standard does result in all analytes falling within their retention time windows, or a new initial calibration must be performed and new retention time windows established.

9.4 Sample Analysis

9.4.1 The same GC operating conditions used for the initial calibration must be employed for sample analyses, including sample injection volume (Section 9.1.3).

9.4.2 Tentative identification of an analyte occurs when a peak from a sample extract falls within the retention time window for the compound. Each tentative identification is confirmed using a second GC column of dissimilar stationary phase. Confirmation is positive when the %RPD is $\leq$ 40% from the results of the two columns. In particularly difficult matrices, confirmation by GC/MS may be advisable (see Section 9.4.10).

9.4.2.1 In addition to utilizing retention time windows, the pattern of peaks in the sample extract is compared to the known Aroclor patterns.

9.4.3 The concentration reported for an identified target analyte in an extract is calculated using the Target data processing software. The Target methods have been configured to utilize the quantitation formulas found in Alpha's Quality Manual. Proper quantitation requires the appropriate selection of a baseline from which the peak area or height can be determined. See the Manual Integration SOP for integration guidelines.

9.4.3.1 If the responses exceed the calibration range of the system, dilute the extract and reanalyze.

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9.4.4 Each sample analysis must be bracketed with an acceptable initial calibration, calibration verification standard(s) (each 12-hour analytical shift), or calibration standards interspersed within the samples. When a calibration verification standard fails to meet the QC criteria, all samples that were injected after the last standard that last met the QC criteria must be re-injected.

Calibration verification standards that are interspersed throughout the analytical sequence are varied to verify performance of all analytes.

9.4.5 Sample injections may continue for as long as the calibration verification standards and standards interspersed with the samples meet instrument QC requirements. Standards are typically analyzed after every 4 – 8 samples to minimize the number of samples that must be re-injected when the standards fail the QC limits. However, a calibration verification standard must be analyzed after every 20 samples. The sequence ends when the set of samples has been injected or when qualitative and/or quantitative QC criteria are exceeded.

9.4.6 Use the calibration standards analyzed during the sequence to evaluate retention time stability. The retention time windows are established using the absolute retention time of each analyte in the mid-concentration standard during the initial calibration as the mid-point of the window. The widths of the windows are defined in Section 9.2.7.

9.4.7 Each subsequent injection of a standard during the 12-hour analytical shift (i.e., those standards injected every 20 samples, or more frequently) must be checked against the retention time windows. If any of these subsequent standards fall outside their absolute retention time windows, the GC system is out of control. Determine the cause of the problem and correct it. If the problem cannot be corrected, a new initial calibration must be performed.

9.4.8 Identification of mixtures (i.e. Aroclor 1248) is based on the characteristic 'fingerprint' retention time and shape of the indicator peak(s); and quantitation is based on the area under the characteristic peaks as compared to the area under the corresponding calibration peaks(s) of the same retention time and shape generated using internal calibration procedures.

9.4.9 If compound identification or quantitation is precluded due to interference (e.g., broad, rounded peaks or ill-defined baselines are present) cleanup of the extract may be needed. If instrument problems are suspected, rerun the extract on another instrument to determine if the problem results from analytical hardware or the sample matrix. Refer to the extraction SOPs for the procedures to be followed in sample cleanup.

9.4.10 GC/MS Confirmation

GC/MS confirmation may be used in conjunction with either single-column or dual-column analysis if the concentration is sufficient for detection by GC/MS.

9.4.10.1 Full-scan GC/MS will normally require a concentration of approximately 10ng/µL in the final extract for each single-component compound.

9.4.10.2 The GC/MS must be calibrated for the specific target analytes when it is used for quantitative analysis.

9.4.10.3 GC/MS may not be used for confirmation when concentrations are below the sensitivity of the instrument.

9.4.10.4 GC/MS confirmation should be accomplished by analyzing the same extract that is used for GC/ECD analysis.

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9.4.10.5 The base/neutral/acid extract and the associated blank may be used for GC/MS confirmation if the surrogates and internal standards do not interfere and if it is demonstrated that the analyte is stable during acid/base partitioning. However, if the compounds are not detected in the base/neutral/acid extract, then GC/MS analysis of the pesticide extract should be performed.

9.4.10.6 A QC reference sample containing the compound should also be analyzed by GC/MS. The concentration of the QC reference sample must demonstrate that those pesticides identified by GC/ECD can be confirmed by GC/MS.

9.5 Instrument Maintenance

9.5.1 Preventive Maintenance

Routine preventive maintenance should be performed to maintain GC system performance. This includes periodic replacement of injector septa, replacement of injector liner(s), and replacement of injector seals.

9.5.2 Other Maintenance

ECD detectors may become contaminated, requiring bake out at elevated temperatures, or repair by the manufacturer.

9.6 Calculations

9.6.1 Quantitation of Individual Congeners

The individual congers are calculated as described in Section 9.4.3, and reported in µg/L or µg/Kg units. After performing technical data review, validating that all QC criteria have been met and confirming all positive hits, the data report is sent electronically to the LIMS computer for generation of the client report. There are two levels of review of the data in the LIMS system prior to release of data. These reviews should be done by two separate individuals.

9.6.2 Quantitation of Multiple-Component Analytes (Aroclor Mixtures)

Quantitation is based on use of 5 of the major peaks present in the analyte. Each of these peaks are individually calibrated with a five-point calibration based on average response factors. The %RSD must meet the criteria of $\leq$15%. The five major peaks are calculated as described in Section 9.4.3. After individual calculation meets criteria, the average of the major five peaks is used to determine the final concentration.

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10. Quality Control and Data Assessment

The laboratory maintains records to document the quality of data that is generated. Ongoing data quality checks are compared with established performance criteria to determine if the results of analyses meet the performance characteristics of the method.

10.1 Demonstration of Capability

The analyst must make an initial, one-time, demonstration of the ability to generate acceptable accuracy and precision with this method. This is done by extraction and analysis of 4 replicate Quality Control Reference Samples. Each time a major method modification is made, the analyst is required to repeat the procedure.

When one or more of the parameters tested fail at least one of the acceptance criteria, the analyst must locate and correct the source of the problem and repeat the test for failed parameters of the method.

Repeated failure confirms a general problem with the measurement system or analytical technique of the analyst. If the failure repeats, locate and correct the source of the problem and repeat the test for all parameters listed in the method.

The QC reference sample concentrates are used to perform the IDC. The concentrations of the IDC concentrates are near the midpoint of the calibration curve.

If the recovery of any compound found in the QC reference sample is less than 70 percent or greater than 130 percent of the certified value, the laboratory performance is judged to be out of control, and the problem must be corrected. A new set of calibration standards should be prepared and analyzed.

10.2 Blank

Extraction blanks are performed with each extraction batch of 20 or less samples, according to the extraction SOPs. The extraction blank must not contain any of the reportable analytes above the reporting limit. If any reportable analytes are detected in the blank, the entire extraction batch is suspect and re-extraction of all associated samples is required.

10.3 Laboratory Control Samples (LCS)

A Laboratory Control Sample (LCS) is extracted with each analytical batch. The LCS consists of an aliquot of a clean (control) matrix similar to the sample matrix and of the same weight or volume. The LCS is spiked with a mixture of Arochlor 1016 and 1260. The concentrations of the spiking solutions are listed in Table 2. The recovery acceptance criteria are listed in Table 3. If any recovery criteria are not met, the extract should be reanalyzed. If the criteria are still not met, the entire batch should be re-extracted. If this is not possible, due to insufficient sample or holding time exceedence, the analyst must write up the failure on a narrative sheet for inclusion in the client report.

10.4 Matrix Spikes / Spike Duplicates / Duplicates

A matrix spike and sample duplicate are extracted and analyzed with each batch of 20 or less samples. The matrix spike and matrix spike duplicate are extracted and analyzed only per client request. The PCB spike compounds and concentrations are listed in Table 2. The recovery acceptance criteria are listed in Table 3. If the recovery criteria are not met, but are met in the LCS, the failure may be attributed to sample matrix effects and must be noted on a narrative sheet for inclusion in the client report.

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10.5 Surrogates

All extracted samples and associated QC are spiked with surrogates at the levels listed in Table 2. The laboratory must evaluate surrogate recovery data from individual samples and QC samples versus the surrogate control limits listed in Table 3. If the surrogate limits are not met, the extract should be reanalyzed to determine if the failure was due to an instrument problem. If the criteria are still not met, the affected samples should be re-extracted to confirm that the failure was due to sample matrix. If matrix effect is confirmed, this must be noted on a narrative sheet for inclusion in the client report.

10.6 Control Limits

The laboratory maintains performance records to document the quality of data that is generated. Method accuracy for samples is assessed and records maintained.

Control limits for the method parameters are generated by the QC staff. The control limits are calculated based on in-house performance data, and are compared to the control limits found in the reference method.

10.7 Analytical Sequence

Initial calibration:

1. Instrument Blank
2. Std Level 1
3. Std Level 2
4. Std Level 3
5. Std Level 4
6. Std Level 5
7. Std Level 6
8. Blank
9. Initial Calibration Verification Standard (ICV)

Repeat std Levels 1 – 6 for other mixes until curve is complete

[**NOTE:** If multiple calibration mixtures are analyzed, it is acceptable to analyze appropriate ICV's after all calibration standards have been injected.]

Daily sequence:

1. 1016/1260 Continuing Calibration Standard (or Congener Mix, if appropriate)
2. Extraction Blank
3. Laboratory Control Sample
4. Matrix Spike / Matrix Spike Duplicate (if requested by Client)
5. Duplicate
6. Samples (4 – 8)
7. Cal check (Alternating the Aroclors or congener mix)

Repeat 2 – 8 (as needed)

[**NOTE:** Individual congeners and Aroclor mixtures are typically analyzed in separate sequences.]

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11. Method Performance

The method detection limit (MDL) is defined as the minimum concentration of a substance that can be measured and reported with 99% confidence that the value is above zero. The MDL concentrations were obtained using reagent water. The MDL actually achieved in a given analysis will vary depending on instrument sensitivity and matrix effects.

Method performance data is on file in the laboratory QC department. Comparison of method performance data for the laboratory to the reference method criteria occurs when laboratory in-house acceptance limits are generated. In-house generated data must be within the specifications of the reference method or the analysis is not continued until corrective action is completed.

The performance of this method is evaluated on an on-going basis by the QC criteria listed throughout this SOP. Specifically, Initial Calibration criteria, Continuing Calibration Check criteria, surrogates, blanks, LCSs, MS/MSDs and duplicates are all used to ensure that the method is producing results of consistently high quality. In addition, Alpha participates in several blind PE studies annually to demonstrate the ability of this method to produce accurate and reproducible data.

12. Corrective Actions

Holding time exceedence and/or improper preservation are noted on the nonconformance report form.

Perform instrument maintenance as described throughout this SOP as needed when instrument calibration criteria are not met. Record all maintenance in the instrument logbook.

All batch and sample specific QC criteria outlined in Section 10 are evaluated by the analyst prior to approval of the data. When any QC criteria fail, the cause for the failure must be identified and corrected. This may include instrument recalibration followed by sample reanalysis, sample cleanup, or sample re-extraction. If it is determined that the failure is due to sample matrix effects, a project narrative report is written by the analyst for inclusion in the data report. If there is insufficient sample volume to perform the re-analysis for confirmation, this is also noted in the narrative and included in the client report.

13. Pollution Prevention

See Chemical Hygiene Plan for pollution prevention operations.

14. Waste Management

See Chemical Hygiene Plan for waste handling and disposal.

15. Attachments

Table 1: REPORTING LIMITS

Table 2: STANDARD SOLUTIONS

Table 3: QC ACCEPTANCE CRITERIA

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TABLE 1

REPORTING LIMITS*

	RL (Aqueous)	RL (Soil)
Aroclors		
Arochlor 1016	0.5 µg/L	50 µg/Kg
Arochlor 1221	0.5 µg/L	50 µg/Kg
Arochlor 1232	0.5 µg/L	50 µg/Kg
Arochlor 1248	0.5 µg/L	50 µg/Kg
Arochlor 1254	0.5 µg/L	50 µg/Kg
Arochlor 1260	0.5 µg/L	50 µg/Kg
Arochlor 1262	0.5 µg/L	50 µg/Kg
Arochlor 1268	0.5 µg/L	50 µg/Kg
Individual Congeners		
2-Chlorobiphenyl	4.0 µg/L	400 µg/Kg
2,3-Dichlorobiphenyl	0.04 µg/L	4 µg/Kg
2,2',5-Trichlorobiphenyl	0.04 µg/L	4 µg/Kg
2,4',5-Trichlorobiphenyl	0.04 µg/L	4 µg/Kg
2,2',3,5'-Tetrachlorobiphenyl	0.04 µg/L	4 µg/Kg
2,2',5,5'-Tetrachlorobiphenyl	0.04 µg/L	4 µg/Kg
2,3',4,4'-Tetrachlorobiphenyl	0.04 µg/L	4 µg/Kg
2,2',3,4,5'-Pentachlorobiphenyl	0.04 µg/L	4 µg/Kg
2,2',4,5,5'-Pentachlorobiphenyl	0.04 µg/L	4 µg/Kg
2,3,3',4',6-Pentachlorobiphenyl	0.04 µg/L	4 µg/Kg
2,2',3,4,4',5'-Hexachlorobiphenyl	0.04 µg/L	4 µg/Kg
2,2',3,4,5,5'-Hexachlorobiphenyl	0.04 µg/L	4 µg/Kg
2,2',3,5,5',6-Hexachlorobiphenyl	0.04 µg/L	4 µg/Kg
2,2',4,4',5,5'-Hexachlorobiphenyl	0.04 µg/L	4 µg/Kg
2,2',3,3',4,4',5-Heptachlorobiphenyl	0.04 µg/L	4 µg/Kg
2,2',3,4,4',5,5'-Heptachlorobiphenyl	0.04 µg/L	4 µg/Kg
2,2',3,4,4',5',6-Heptachlorobiphenyl	0.04 µg/L	4 µg/Kg
2,2',3,4',5,5',6-Heptachlorobiphenyl	0.04 µg/L	4 µg/Kg
2,2',3,3',4,4',5,5',6-Nonachlorobiphenyl	0.04 µg/L	4 µg/Kg

*** RL:** Typical laboratory reporting limit. Actual RL's may be higher depending on sample matrix. RLs are not adjusted for % Moisture.

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TABLE 2

STANDARD SOLUTIONS

	Stock solution (ug/mL)	Level 6 (ug/mL)	Level 5 (ug/mL)	Level 4 (ug/mL)	Level 3 (ug/mL)	Level 2 (ug/mL)	Level 1 (ug/mL)	Spike Solution (ug/mL)	LCS Solution (ug/mL)
PCB 1016/1260 Mix									
Arochlor 1016	100	0.1	10	5	2.5	1.0	0.5	12.5	12.5
Arochlor 1260	100	0.1	10	5	2.5	1.0	0.5	12.5	12.5
PCB 1221/1254 MIX									
Arochlor 1221	100	0.1	10	5	2.5	1.0	0.5		
Arochlor 1254	100	0.1	10	5	2.5	1.0	0.5		
Arochlor 1248	100	0.1	10	5	2.5	1.0	0.5		
Arochlor 1232	100	0.1	10	5	2.5	1.0	0.5		
Arochlor 1262	100	0.1	10	5	2.5	1.0	0.5		
Arochlor 1268	100	0.1	10	5	2.5	1.0	0.5		
Internal Standard									
1-Bromo-2-Nitrobenzene	5000	0.25	0.25	0.25	0.25	0.25	0.25		

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TABLE 3

QC ACCEPTANCE CRITERIA

	Aqueous		Soil	
Surrogate % Recovery	**Lower Control Limit**	**Upper Control Limit**	**Lower Control Limit**	**Upper Control Limit**
2,4,5,6-Tetrachloro-m-xylene	30%	150%	30%	150%
Decachlorobiphenyl	30%	150%	30%	150%

	Aqueous % Recovery		Soil % Recovery		Duplicate and/or MSD	
MS/MSD and LCS	**Lower Control Limit**	**Upper Control Limit**	**Lower Control Limit**	**Upper Control Limit**	**Aqueous RPD**	**Soil RPD**
Arochlor 1242/1016	40%	140%	40%	140%	30%	50%
Arochlor 1260	40%	140%	40%	140%	30%	50%

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Microwave Assisted Acid Digestion of Sediments, Sludges, Soil, and Oils

Reference Method No.: **EPA # 3051**

Reference: SW-846, Test Methods for Evaluating Solid Waste: Physical/Chemical Methods, EPA SW-846, Update III, 1997.

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Prepared by:

Name: Joseph Clements Position: Inorganics Supervisor

Signature: _____ Date: 4/16/03

Authorized by:

Name: Ellen Collins Position: Quality Assurance Officer

Signature: _____ Date: 4-15-03

ISSUE AMENDMENTS

Changes since last issue:

Section 7.1.1: Microwave output was clarified.

Section 8.1: The concentration of NH_4OH was clarified to be 1:1.

Section 8.2: The concentration of HCl was clarified to be 1:1.

Sections 8.11.3 and 8.11.4: Acronymns were clarified.

Section 9.2.2: Beaker type was clarified.

Section 9.3.4.5: Aqua Regia is added to each sample.

Section 9.3.7: Modified to include filling the carousel completely.

Section 9.3.8.1: TAP and FAN were defined.

Section 10.6: Preparation Sequence was modified per the above changes.

Microwave Assisted Acid Digestion of Sediments, Sludges, Soil, and Oils

Reference Method No.: **EPA # 3051**

Reference: SW-846, Test Methods for Evaluating Solid Waste: Physical/Chemical Methods, EPA SW-846, Update III, 1997.

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1. Scope and Application

Matrices: This method is applicable to microwave assisted acid digestion of sludges, sediments, soils, and oils for the following elements:

Aluminum	Cadmium	Iron	Molybdenum	Sodium
Antimony	Calcium	Lead	Nickel	Strontium
Arsenic	Chromium	Magnesium	Potassium	Thallium
Boron	Cobalt	Manganese	Selenium	Vanadium
Barium	Copper	Mercury	Silver	Zinc
Beryllium				

Definitions: See Alpha Laboratories Quality Manual Appendix A.

This method is provided as an alternative to method 3050. It is intended to provide a rapid multi-element acid leach digestion prior to analysis so that decisions can be made about site cleanup levels, the need for TCLP testing of a waste, and whether a BDAT process is providing acceptable performance. Digests produced by the method are suitable for analysis by:

- Graphite furnace atomic absorption (GFAA)
- Inductively coupled plasma emission spectroscopy (ICP-ES).

Due to the rapid advances in microwave technology, consult your manufacturer's recommended instructions for guidance on their microwave digestion system.

The data report packages present the documentation of any method modification related to the samples tested. Depending upon the nature of the modification and the extent of intended use, the laboratory may be required to demonstrate that the modifications will produce equivalent results for the matrix. Approval of all method modifications is by one of the following laboratory personnel before performing the modification: Area Supervisor, Metals Manager, Laboratory Services Manager, Laboratory Director, or Quality Assurance Officer.

Each analyst must demonstrate the ability to generate acceptable results with this method by performing an initial demonstration of capability, analyzing a proficiency test sample and completing the record of training.

After initial demonstration, ongoing demonstration is based on acceptable laboratory performance of at least a quarterly laboratory control sample or acceptable performance from an annual proficiency test sample. A major modification to this procedure requires demonstration of performance. The identification of major method modification requiring performance demonstration is directed by the QA Officer and Laboratory Director on a case-by-case basis.

2. Summary of Method

A representative sample from 1g to 5g is digested, either in 20mL of concentrated nitric acid ($cHNO_3$) or 20mL of Aqua Regia (75% HCl and 25% HNO_3), and heated for 15 minutes using a suitable laboratory microwave unit. The sample and acid are placed in a fluorocarbon (PFA or TFM) microwave vessel. The vessel is capped and heated in the microwave unit. After cooling, if the sample is in $cHNO_3$, uncap and add 2mL of 30% H_2O_2. Reheat for 3 minutes, then filter and bring up to volume. If the sample is in Aqua Regia, uncap, filter, and bring up to volume.

2.1 Method Modifications from Reference

None.

3. Detection Limits

Refer to Table 2 for Reporting Limit information. The Reporting Limit is determined by the amount of sample used for preparation. Therefore a review of Client requirements for Reporting Limits is necessary prior to sample preparation.

4. Interferences

If the sample is not homogeneous, it may be difficult to obtain a representative sample for digestion.

Very reactive or volatile materials in the sample may create high pressures when heated. Therefore, venting of the vessel, with potential loss of sample and analytes may occur.

5. Safety

Caution must be used when handling the following:

- 30% H_2O_2
- $cHNO_3$
- 50% NH_4OH
- 50% HCl
- 10% HNO_3
- Aqua Regia

These chemicals are corrosives and can cause harm to skin and eyes. When using these corrosives, the analyst must wear a lab coat, gloves, and protective eyewear.

The toxicity or carcinogenicity of each reagent and standard used in this method is not fully established; however, each chemical compound should be treated as a potential health hazard. From this viewpoint, exposure to these chemicals is reduced to the lowest possible level by whatever means available. A reference file of material data handling sheets is available to all personnel involved in the chemical analysis. Additional references to laboratory safety are available in the Chemical Hygiene Plan.

All personnel handling environmental samples known to contain or to have been in contact with municipal waste must follow safety practices for handling known disease causative agents.

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6. Sample Collection, Preservation, and Handling

6.1 Sample Collection

Samples are collected in glass jars.

6.2 Sample Preservation

None.

6.3 Sample Handling

Samples are refrigerated upon receipt and are digested and analyzed as soon as possible.

7. Equipment and Supplies

7.1 Microwave:

7.1.1 The microwave unit provides a minimum of 574W, which can be programmed to within ±10W of the required power. Typical units provide a nominal 600W to 1200W power. Microwave pressure and temperature are monitored and controlled. The microwave output is > 900 W of power.

7.1.2 The microwave unit cavity is corrosion resistant and well ventilated.

7.1.3 All electronics are protected against corrosion to ensure safe operation.

7.1.4 Fluorocarbon (PFA or TFM) Digestion Vessels: 120mL capacity, (with tops and caps), capable of withstanding pressure up to 7.5 ± 0.7atm (110 ± 10psi). Capable of controlled pressure relief at pressures exceeding 7.5 ± 0.7atm (110 ± 10psi).

7.1.5 A rotating turntable is employed to ensure homogeneous distribution of microwave radiation within the unit. The speed of the turntable should be a minimum of 3rpm.

7.2 Volumetric Flasks: 200mL, 100mL, or 50mL.

7.3 Teflon Funnel.

7.4 Whatman 41 Filter Paper.

7.5 Polypropylene Bottles: 250mL or 125mL

7.6 Centrifuge Tubes: 50mL

7.7 Weighing Tray.

7.8 Microwave Carousel.

7.9 Spatula.

7.10 Balance: Capable of weighing to 0.001g.

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7.11 Teflon or Glass Beaker: 1000mL.

8. Standards and Reagents

8.1 1:1 Ammonium Hydroxide (NH_4OH)

8.2 1:1 Hydrochloric Acid (HCl)

8.3 10% Nitric Acid (HNO_3)

8.4 Aqua Regia: 75% concentrated HCl + 25% concentrated HNO_3

8.5 Nitric Acid, concentrated (HNO_3)

8.6 30% Hydrogen Peroxide (H_2O_2)

8.7 DI water

8.8 Standards of metals being tested, Stock E in-house standards.

8.9 Ottawa sand.

8.10 1000ppm Single Element Stock Standards: These are commercially prepared standards for various elements.

8.11 Spiking Solutions:

8.11.1 CLP ICP Spike Standard #1: This is a commericially prepared standard. Refer to Table 1 for specific analyte concentrations.

8.11.2 CLP ICP Spike Standard #3: This is a commericially prepared standard. Refer to Table 1 for specific analyte concentrations.

8.11.3 ICP Performance Standard (IPS) Standard: 20mL of CLP ICP Spike Standard #1 + 10mL of 1000ppm Sb Standard + 1mL of 1000ppm Cd Standard. Bring to a volume of 200mL with 5% HNO_3.

8.11.4 Furnace Performance Standard (FPS) Standard: 1.0mL of CLP ICP Spike Standard #3 + 25mL of 1000ppm Pb Standard. Bring to a volume of 500mL with 5% HNO_3.

8.11.5 Mixed Standard: 10mL each of the following standards: 1000ppm B Standard, 10,000ppm Ca Standard, 10,000ppm Mg Standard, 1000ppm Mo Standard, 10,000ppm K Standard, 1000ppm Sr Standard, 10,000ppm Na Standard, 1000ppm Ti Standard. Bring to a volume of 100ml with 5% HNO_3.

8.11.6 TCLP Spike: 10mL each of the following standards: 10,000ppm Ba Standard, 1000ppm As Standard, 1000ppm Cd Standard, 1000ppm Cr Standard, 1000ppm Pb Standard, 1000ppm Ag Standard. Add 20mL of 1000ppm Se Standard, and bring to a volume of 200mL with 5% HNO_3.

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9. Procedure

9.1 SET-UP

9.1.1 Turn on microwave.

9.1.2 Set up the laboratory notebook with the following information:

- Date, Chemist's initials
- Job number, Metals analysis requested
- Vessel #, Sample #, Sample weight
- Lot # $cHNO_3$ or Lot # Aqua Regia, Lot # H_2O_2, Final Volume
- Color of sample, Texture of sample
- MS / LCSS used

9.2 Microwave Calibration

Microwave calibration is done on a quarterly basis.

9.2.1 Warm up microwave at 100% power, 0 psi, for 5 minutes.

9.2.2 Place 1000mL of room temperature DI water in a 1000mL Teflon or glass beaker.

9.2.3 Record the initial DI water temperature (T_i) to the nearest 0.1ºC.

9.2.4 Place the 1000mL beaker of DI in the microwave at 100% power, 0 psi, for 2 minutes.

9.2.5 Remove beaker from the microwave. Stir DI water thoroughly for 30 seconds and record the final temperature (T_f).

9.2.6 The microwave power output is calculated as follows:

$$P \text{ (microwave power in W)} = (35W/ºC)\ (T_f\ ºC - T_i\ ºC)$$

9.2.7 Acceptable power is ≥ 900W. If the power is less 900W, repeat the calibration. If it remains less than 900W, refer to "Instrument Trouble-Shooting Guide" page 97 of CEM Microwave Operation Manual.

9.3 Sample Digestion

9.3.1 Acid Rinse Fluorocarbon Digestion Vessel, as follows:

9.3.1.1 Rinse 1 time with 50% NH_4OH.

9.3.1.2 Rinse 1 time with DI water.

9.3.1.3 Rinse 1 time with 50% HCl.

9.3.1.4 Rinse 1 time with DI water.

9.3.1.5 Rinse 1 time with 10% HNO_3.

9.3.1.6 Rinse 3 times with DI water.

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9.3.2 Acid rinse tops and caps following Sections 9.3.1.3 through 9.3.1.6.

9.3.3 Mix up the sample in a weighing tray to get a good representative sample.

9.3.4 Soil, Sediment and Sludge Samples:

9.3.4.1 Weigh 5.000-5.099g of sample into a numbered vessel. If the sample is limited, use 1 gram. Include a sample duplicate.

9.3.4.2 PBS: Use the acid quantity of the mentioned matrix.

9.3.4.3 LCSS: Use Ottawa Sand weighing the same as the sample. Use 2mL of premade standard. If the desired metal is not included in the LCSS solution, add to the sample the appropriate amount of desired metal standard stock 1000ppm solution.

9.3.4.4 Matrix Spike (MS): Use 2mL of premade standard. If the desired metal is not included in the spiking solution, add to the sample the appropriate amount of the desired metal standard stock 1000ppm solution.

9.3.4.5 To each sample add 20mL of Aqua Regia, when the final volume is 200mL. If the sample is limited, add a proportionately less amount. Perform this step while under a laboratory hood. Cover the vessels with tops and caps.

9.3.4.6 Proceed to Section 9.3.7.

9.3.5 Total Oil Samples:

9.3.5.1 Weigh 0.500-0.509g of sample.

9.3.5.2 PBS: Use the acid quantity of the mentioned matrix.

9.3.5.3 LCSS: Use Ottawa Sand weighing the same as the sample. Use 1mL of premade standard. If the desired metal is not included in the LCSS solution, add to the sample the appropriate amount of the desired metal standard stock 1000ppm solution.

9.3.5.4 Matrix Spike (MS): Use 1mL of premade standard and appropriate amount of the desired metal standard solution. If the desired metal is not included in the spiking solution, add to the sample the appropriate amount of the desired metal standard stock 1000ppm solution.

9.3.5.5 To each sample add 10mL of concentrated HNO_3, when the final volume is 100mL. If the sample is limited, add a proportionately less amount. Perform this step while under a laboratory hood. Cover the vessels with tops and caps.

9.3.5.6 Proceed to Section 9.3.7.

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9.3.6 TCLP Oil Samples:

9.3.6.1 Measure 0.5mL of sample.

9.3.6.2 LCSWP: Use 0.5mL of the filtered PBC or 0.5mL of DI water. Use 2mL of premade standard. If the desired metal is not included in the spiking solution, add to the sample the appropriate amount of the desired metal standard stock 1000ppm solution.

9.3.6.3 Matrix Spike (MS): Use 1mL of the premade TCLP spike solution, 0.5mL of IPS, FPSS, MIX, and the appropriate amount of the desired metal standard. If the desired metal is not included in the spiking solution, add to the sample the appropriate amount of the desired metal standard stock 1000ppm solution.

9.3.6.4 To each sample add 10mL of concentrated HNO_3, when the final volume is 50mL. If the sample is limited, add a proportionately less amount. Perform this step while under a laboratory hood. Cover the vessels with tops and caps.

9.3.7 Place the vessels in a microwave carousel tray. If the carousel is not full, add extra vessels containing DI water. Fill empty spots in the carousel with 25mL DI water in the vessels.

9.3.8 Place the full carousel in the microwave and run the appropriate program.

9.3.8.1 Soil, sediment and sludge samples:
Use the soil program: 50% power, 120psi, 15 minutes time, 2000 TAP, 100 FAN.

NOTE: TAP = Time and Pressure, FAN = Fan Speed (%)

9.3.8.2 Total oil and TCLP oil samples:
Use the oil program: 50% power, 20psi, 10 minutes time, 2000 TAP, 100 FAN.

9.3.9 When the microwave program ends, allow the samples to cool for 60 minutes. Place the carousel under a laboratory hood and slowly add 2mL of 30% H_2O_2 to each vessel.

NOTE: If the sample is to be analyzed for Antimony, omit this step.

9.3.10 Place the carousel back into the microwave and run the "heat-up" program:
50% power, 20psi, 3 minutes time, 500 TAP, 100 FAN.

9.3.11 Allow the samples to cool.

9.3.12 Acid rinse a volumetric flask and Teflon funnel for each sample. Follow the acid rinse procedure as outlined in Section 9.3.1.

9.3.13 Place a Whatman 41 filter into the funnel and filter the sample into the volumetric flask. Rinse each vessel 3 times with DI water, and filter each rinseate into the volumetric flask.

9.3.14 Bring samples up to the appropriate volume with DI water: 100mL for oils, 200mL for soils.

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9.3.15 Soil, sediment and sludge samples:
Transfer the filtrate into a labeled 250mL polypropylene bottle.

9.3.16 Total oil samples:
Transfer the filtrate into a labeled 125mL polypropylene bottle.

9.3.17 TCLP oil samples:
Transfer the filtrate into a labeled 50mL centrifuge tube.

10. Quality Control and Data Assessment

The laboratory must maintain records to document the quality of data that is generated. Ongoing data quality checks are compared with established performance criteria to determine if the results of analyses meet the performance characteristics of the method. When results of sample spikes indicate atypical method performance, a calibration verification standard is used to confirm the measurements were performed in an in-control mode of operation.

10.1 Demonstration of Capability

The analyst must make an initial, one-time, demonstration of the ability to generate acceptable accuracy and precision with this method. Each time a method modification is made, the analyst is required to repeat the procedure.

When one or more of the parameters tested fail at least one of the acceptance criteria, the analyst must locate and correct the source of the problem and repeat the test for failed parameters of the method.

Repeated failure confirms a general problem with the measurement system or analytical technique of the analyst. If the failure repeats, locate and correct the source of the problem and repeat the test for all parameters listed in the method.

10.2 Blank

10.2.1 PBS: Prep blank for soil = acid quantity for the matrix.

10.3 Laboratory Control Samples (LCS)

10.3.1 LCSS: Laboratory Control Sample for soil, total oils and sludges = use the same amount of Ottawa Sand as the sample volume.

10.3.1.1 Soil, sediment, sludge: 2mL of premade standard added to the sample.

10.3.1.2 Total oil: 1mL of premade standard added to the sample.

10.3.1.3 TCLP oil: 1mL of TCLP spike added to the sample.

10.3.2 LCSWP: Laboratory Control Sample for water TCLP = use 0.5mL of filtered PBC or 0.5mL of DI water.

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10.4 Matrix Spike

10.4.1 Soil, sediment, sludge: 2mL of premade standard added to the sample.

10.4.2 Total oil: 1mL of premade standard added to the sample.

10.4.3 TCLP oil: 1mL of TCLP spike added to the sample.

10.5 Duplicates

10.5.1 One duplicate sample is digested per matrix batch.

10.6 Preparation Sequence:

- Acid rinse microwave vessels, tops and caps.
- Mix sample in a weighing tray.
- Weigh appropriate amount of sample, and QC samples.
- Add appropriate volume of Aqua Regia.
- Cap vessels.
- Run the appropriate microwave program.
- Cool for 60 minutes.
- If sample was digested in cHNO_3, then add 2mL 30% H_2O_2.
- Microwave using Heat-up program.
- Cool
- Acid rinse volumetric flasks, funnels.
- Filter sample and bring to the appropriate volume.
- Transfer samples to polypropylene bottles.

11. Method Performance

The method detection limit (MDL) is defined as the minimum concentration of a substance that can be measured and reported with 99% confidence that the value is above zero. The MDL concentrations were obtained using reagent water. The MDL actually achieved in a given analysis will vary depending on instrument sensitivity and matrix effects.

Method performance data is on file in the laboratory QC department. Comparison of method performance data for the laboratory to the reference method criteria occurs when laboratory in-house acceptance limits are generated. In-house generated data must be within the specifications of the reference method or the analysis is not continued until corrective action is completed.

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12. Corrective Actions

Holding time exceedence and improper preservation are noted on the nonconformance report form.

Perform routine preventative maintenance following manufacturer's specification. Record all maintenance in the instrument logbook.

Review of standards, blanks and standard response for acceptable performance occurs for each batch of samples. Record any trends or unusual performance on a nonconformance action form.

If the LCS recovery of any parameter falls outside the designated acceptance range, the laboratory performance for that parameter is judged to be out of control, and the problem must be immediately identified and corrected. The analytical result for that parameter in the unspiked samples is suspect and is only reported for regulatory compliance purposes with the appropriate nonconformance action form. Immediate corrective action includes reanalyzing all affected samples by using any retained sample before the expiration of the holding time.

13. Pollution Prevention

See Chemical Hygiene Plan for pollution prevention operations.

14. Waste Management

See Chemical Hygiene Plan for waste handling and disposal.

15. Attachments

TABLE 1: CLP ICP Spike Standard Analyte Concentrations

TABLE 2: Reporting Limits

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TABLE 1

CLP ICP Spike Standard

Analyte Concentrations

Standard	Analyte	Concentration
CLP ICP Spike Standard # 1	Al, Ba	2000µg/mL
	Fe	1000µg/mL
	Co, Mn, Ni, V, Zn	500µg/mL
	Cu	250µg/mL
	Cr	200µg/mL
	Be, Ag	50µg/mL
CLP ICP Spike Standard # 3	As,Se, Tl	2000µg/mL
	Pb	500µg/mL
	Cd	50µg/mL

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TABLE 2

Reporting Limits

Analyte	1g sample / 200mL final volume	5g sample / 200mL final volume
Aluminum	20 mg/Kg	4 mg/Kg
Antimony	100 mg/Kg	20 mg/Kg
Arsenic	1.0 mg/Kg	0.2 mg/Kg
Barium	2.0 mg/Kg	0.4 mg/Kg
Beryllium	1.0 mg/Kg	0.2 mg/Kg
Boron	6.0 mg/Kg	1.2 mg/Kg
Cadmium	1.0 mg/Kg	0.2 mg/Kg
Calcium	100 mg/Kg	20 mg/Kg
Chromium	2.0 mg/Kg	0.4 mg/Kg
Cobalt	4.0 mg/Kg	0.8 mg/Kg
Copper	2.0 mg/Kg	0.4 mg/Kg
Iron	10 mg/Kg	2.0 mg/Kg
Lead	10 mg/Kg	2.0 mg/Kg
Magnesium	100 mg/Kg	20 mg/Kg
Manganese	2.0 mg/Kg	0.4 mg/Kg
Molybdenum	10 mg/Kg	2.0 mg/Kg
Nickel	10 mg/Kg	2.0 mg/Kg
Potassium	500 mg/Kg	100 mg/Kg
Selenium	1.0 mg/Kg	0.2 mg/Kg
Silver	2.0 mg/Kg	0.4 mg/Kg
Sodium	100 mg/Kg	20 mg/Kg
Strontium	2.0 mg/Kg	0.4 mg/Kg
Thallium	1.0 mg/Kg	0.2 mg/Kg
Vanadium	2.0 mg/Kg	0.4 mg/Kg
Zinc	10 mg/Kg	2.0 mg/Kg

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Hot Block Digestion
for Aqueous Samples

Reference Methods: **EPA 200.7,** Code of Federal Regulations 40, Part 136, Appendix C, July 1, 1999 edition; **EPA 200.8,** Environmental Monitoring Systems Laboratory Office of Research and Development U.S. EPA Cincinnati, OH Rev 5.4; **EPA 200.9,** Code of Federal Regulations 40, Part 136, Appendix C, July 1, 1999 edition; **Method 3005A,** SW-846, Test Methods for Evaluating Solid Waste: Physical/Chemical Methods, EPA SW-846, Update I, 1992.

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ISSUE AMENDMENTS

Changes since last issue:

Added Reference to EPA Method 200.8.

Section 7.4: Changed to threaded caps.

Section 8.3.1: Added Trace-grade HNO_3.

Section 9.3.1.1: Added NOTE regarding DW samples to be analyzed by EPA 200.8.

Section 10.15: Added bullet point to not add HCl to DW samples to be analyzed by EPA 200.8.

Hot Block Digestion
for Aqueous Samples

Reference Methods: **EPA 200.7,** Code of Federal Regulations 40, Part 136, Appendix C, July 1, 1999 edition; **EPA 200.8,** Environmental Monitoring Systems Laboratory Office of Research and Development U.S. EPA Cincinnati, OH Rev 5.4; **EPA 200.9,** Code of Federal Regulations 40, Part 136, Appendix C, July 1, 1999 edition; **Method 3005A,** SW-846, Test Methods for Evaluating Solid Waste: Physical/Chemical Methods, EPA SW-846, Update I, 1992.

1. Scope and Application

Matrices: This method is appropriate for the digestion of all influents, effluents, surface waters, monitoring wells, liquids, drinking waters, furnace metals and soluble metals.

Definitions: See Alpha Laboratories Quality Manual Appendix A.

The data report packages present the documentation of any method modification related to the samples tested. Depending upon the nature of the modification and the extent of intended use, the laboratory may be required to demonstrate that the modifications will produce equivalent results for the matrix. Approval of all method modifications is by one of the following laboratory personnel before performing the modification: Area Supervisor, Metals Manager, Laboratory Services Manager, Laboratory Director, or Quality Assurance Officer.

This method is restricted to use by or under the supervision of trained analysts. Each analyst must demonstrate the ability to generate acceptable results with this method by performing an initial demonstration of capability, analyzing a proficiency test sample and completing the record of training.

After initial demonstration, ongoing demonstration is based on acceptable laboratory performance of at least a quarterly laboratory control sample or acceptable performance from an annual proficiency test sample. A major modification to this procedure requires demonstration of performance. The identification of major method modification requiring performance demonstration is directed by the QA Officer and Laboratory Director on a case-by-case basis.

2. Summary of Method

Aqueous samples and appropriate QC samples are poured into 50mL digestion cups. Acid is added to the cup and the samples are reduced at 96.5 °C for 5 hours. The samples are then brought up to a final volume of 50mL, and are ready for analysis by ICP **or ICP-MS.**

2.1 Method Modifications from Reference

None.

3. Detection Limits

The laboratory follows the procedure found in 40CFR Part 136 to determine the MDL on an annual basis. The method detection limits determined by the laboratory are on file for review.

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4. Interferences

Potential interferences that may be encountered during analysis are discussed in the individual analytical methods.

5. Safety

The toxicity or carcinogenicity of each reagent and standard used in this method is not fully established; however, each chemical compound should be treated as a potential health hazard. From this viewpoint, exposure to these chemicals must be reduced to the lowest possible level by whatever means available. A reference file of material data handling sheets is available to all personnel involved in the chemical analysis. Additional references to laboratory safety are available in the Chemical Hygiene Plan.

All personnel handling environmental samples known to contain or to have been in contact with municipal waste must follow safety practices for handling known disease causative agents. This includes wearing personal protective equipment such as a labcoat, safety glasses, gloves and respirator (as necessary).

6. Sample Collection, Preservation, and Handling

6.1 Sample Collection

Samples are collected in plastic bottles.

6.2 Sample Preservation

If samples are for soluble metals analysis, filtration must take place prior to preservation with 1:1 HNO_3 to a pH < 2.

Samples for total metals analysis are preserved with 1:1 HNO_3 to a pH <2.

6.3 Sample Handling

Samples are stored under refrigeration at 4°C. Samples for soluble metals analysis should be filtered and preserved within 24 hours of collection.

7. Equipment and Supplies

7.1 Hot Block Apparatus: Set to 96.5 °C, with sample cup rack

7.2 Digestion cups: 50mL volume, polypropylene

7.3 Watch Glass: Ribbed, polypropylene to cover the digestion cups during digestion

7.4 Threaded Caps: To cover digestate following digestion

7.5 Volumetric Glassware: Various sizes of volumetric flasks and pipets, as needed

7.6 Filter Mate Push Plunger Filter

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8. Standards and Reagents

8.1 Analytical Standards: All standards shall be prepared according to the appropriate method of analysis.

8.2 1:1 Hydrochloric Acid

8.3 Concentrated Nitric Acid ($cHNO_3$)

8.3.1 Trace-grade $cHNO_3$: For all samples to be analylzed by EPA Method 200.8, Trace-grade cHNO3 is utilized for the digestion.

8.4 Deionized Water (DI)

8.5 Standard Spiking Solutions

8.5.1 IPS: Containing Sb, Ba, Be, Cd, Cr, Cu, Ni, Ag, Zn, Fe, Mn, Al, Co, V.

8.5.2 FPS: Containing As, Pb, Se, Tl.

8.5.3 MIX: Containing B, Ca, Mg, Mo, K, Na, Ti.

8.5.4 1000ppm Standards of individual metals

9. Procedure

9.1 Set-Up

9.1.1 Inspect all samples and determine QC duplicate (dp) and spike (ms). This decision is normally based upon client sample content history and analytes requested. The ideal sample for QC is one that has both ample volume and the most requested analytes of all the samples in the batch.

9.1.2 Samples of an overly cloudy nature or those with pH and preservation issues should be avoided. Do not prep samples requesting Na and K with samples requesting B, Si, Ca, Ti, Sn, unless the analyst approves the digestion.

9.1.3 One spike and one duplicate must be performed per batch of 20 samples or less.

9.1.4 Each batch must have a Prep Blank Water (PBW) and a Laboratory Control Sample Water (LCSW).

9.2 Sample Preparation for Digestion

9.2.1 Obtain on 50mL polypropylene digestion cup for each sample and QC sample to be digested. Label the cups with the sample number across the top 1/3 of the cup and at the bottom write “TOT” for total metals, “SOL” for soluble metals, and/or “DW” for a drinking water. Additionally, if the sample is being re-prepped, note this with a “II” on the cup.

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9.2.2 Using the Hot Block lab notebook, begin writing up the batch as follows:

9.2.2.1 The heading includes the date, prep chemist's initials, the digestion being performed, and the time of prep.

9.2.2.2 Evenly spaced columns are created with the following headings, left to right: Sample Number, Amount (mLs), cHNO_3 (conc. Nitric acid), V_f (final volume), Color, Clarity.

9.2.3 Place all samples on the lab bench in a chosen order from left to right. Place the appropriately labeled cup in front of each sample, and another cup for the QC samples (dp and ms).

9.2.4 Shake and pour 50mL of each sample into the appropriate cup. 50mL of DI water is used for the Blank (PBW) and LCSW.

9.2.5 Note the Color and Clarity of each sample in the appropriate columns in the laboratory notebook. Clarity is used to describe any sediment the sample may contain.

9.2.6 Hardness

If samples require Hardness analysis then perform the following:

9.2.6.1 Determine if there is any sediment in the sample. If there is none, then simply decant the sample into the cup without shaking.

9.2.6.2 If the sample does contain sediment and the only requested analyte is Hardness, then let the sample settle and decant only the top layer, avoiding the sedimentary layer.

9.2.6.3 If other analytes are requested on the sample, first decant 50mL off the top layer into a tube marked with the sample number and "Ha" below. Then shake the sample and pour it into a second tube labeled with the sample number. The first tube will be used for the Hardness analysis, and the second tube will be used for the analysis of the other analytes requested.

9.2.7 Any sample dilutions must be performed based upon initial knowledge of sample concentration or if the sample is either soapy or foamy. Dilutions up to 10x are prepared directly in the digestion cup, utilizing the graduated markings as a guide. Otherwise, for dilutions > 10x, volumetric glassware is used.

9.2.8 Spike the samples based upon the analytes requested and the final volume desired. All Hot Block samples are brought up to a 50mL final volume. The metals analysis commonly uses 0.5mL each of any or all of the 3 stock spiking solutions (Section 8.5).

50µL of the individual 1000ppm metal standard is used, if the requested metal is not included in the other spike mixes.

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9.2.9 Once spiked, the sample cups can be placed in a clear hot block rack and then 2.5mL of $cHNO_3$ is added to each sample cup. If either furnace metals or EPA Method 200.8 are requested, then Trace-grade nitric acid must be used.

9.2.9.1 Drinking Water Samples

Only 2mL of $cHNO_3$ is added to each sample cup.

9.3 Sample Digestion

9.3.1 The sample cups are placed on the hot block set to a temperature of 96.5 °C. Each cup is covered with a ribbed polypropylene watch glass and remains on the hot block until it reduces 50% or 5 hours, whichever occurs first.

9.3.1.1 Drinking Water Samples

After the samples have reduced by about 20 – 25mL, add another 2mL of $cHNO_3$.

After the samples have reduced another 12mL, add 5mL of 1:1 HCl. Keep samples on the hot block for an additional 20 minutes.

NOTE: Omit the addition of 1:1 HCl for all drinking water samples to be analyzed by EPA Method 200.8.

9.3.2 Upon completion of the digestion, the samples are removed from the hot block and brought up to a final volume of 50mL using DI water. All digestates that are sediment-free are capped with a snap cap. If any samples contain sediment, they are filtered using a filter mate push plunger filter. The filter is clipped onto the plunger and then pushed into the tube gently but with enough force to move it downward throught the column. The sample is then capped and ready for instrumental analysis.

9.4 Preventative Maintenance

The Hot Block temperature is calibrated on an annual basis by an instrument service company. Certificates are kept on file.

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10. Quality Control and Data Assessment

The laboratory must maintain records to document the quality of data that is generated. Ongoing data quality checks are compared with established performance criteria to determine if the results of analyses meet the performance characteristics of the method.

10.1 Demonstration of Capability

The analyst must make an initial, one-time, demonstration of the ability to generate acceptable accuracy and precision with this method. Each time a method modification is made, the analyst is required to repeat the procedure.

When one or more of the parameters tested fail at least one of the acceptance criteria, the analyst must locate and correct the source of the problem and repeat the test for failed parameters of the method.

Repeated failure confirms a general problem with the measurement system or analytical technique of the analyst. If the failure repeats, locate and correct the source of the problem and repeat the test for all parameters listed in the method.

10.2 Blank

A minimum of one blank must be analyzed for every batch or 20 samples, whichever comes first.

10.3 Matrix Spike

A matrix spike is performed for each sample matrix. A minimum of one matrix spike must be analyzed for each batch.

10.4 Duplicates

Each batch of 20 or less samples will include a duplicate sample.

10.5 Digestion Sequence

- Determine which samples will be used for batch QC.
- Pour 50mL sample into a digestion cup
- Add spike solution to samples, as appropriate
- Place digestion cups into a hot block rack
- Add 2.5mL cHNO3 (2mL for DW samples)
- Heat on hot block until reduced by half, or 5 hours
    - If DW sample: After reduced by half, add another 20mL cHNO3. After reduced another ¼, add 5mL of 1:1 HCl. Heat on Hot Block for additional 20 mins.
        - Do not add 1:1 HCl to DW samples to be analyzed by EPA Method 200.8.
- Bring samples to 50mL volume with DI water. Filter any digestates containing sediment.

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11. Method Performance

The method detection limit (MDL) is defined as the minimum concentration of a substance that can be measured and reported with 99% confidence that the value is above zero. The MDL concentrations were obtained using reagent water. Similar results were achieved using representative wastewaters. The MDL actually achieved in a given analysis will vary depending on instrument sensitivity and matrix effects.

Method performance data is on file in the laboratory QC department. Comparison of method performance data for the laboratory to the reference method criteria occurs when laboratory in-house acceptance limits are generated. In-house generated data must be within the specifications of the reference method or the analysis is not continued until corrective action is completed.

12. Corrective Actions

Holding time exceedence and improper preservation are noted on the nonconformance report form.

Perform routine preventative maintenance following manufacturer's specification. Record all maintenance in the instrument logbook.

Review of standards, blanks and standard response for acceptable performance occurs for each batch of samples. Record any trends or unusual performance on a nonconformance action form.

If the CV or LCS recovery of any parameter falls outside the designated acceptance range, the laboratory performance for that parameter is judged to be out of control, and the problem must be immediately identified and corrected. The analytical result for that parameter in the unspiked samples is suspect and is only reported for regulatory compliance purposes with the appropriate nonconformance action form. Immediate corrective action includes reanalyzing all affected samples by using any retained sample before the expiration of the holding time.

13. Pollution Prevention

See Chemical Hygiene Plan for pollution prevention operations.

14. Waste Management

See Chemical Hygiene Plan for waste handling and disposal.

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Inductively Coupled Plasma - Atomic Emission Spectrometry

Reference Method No.: **Method 6010B**

Reference: SW-846, Test Methods for Evaluating Solid Waste: Physical/Chemical Methods, EPA SW-846, Update III, 1997.

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ISSUE AMENDMENTS

Changes since last issue:

Section 9.1.2.4.2: Removed reference to MDLs performed in a clean sand matrix.

Section 9.1.2.4.3: Removed reference to the use of the method of standard additions.

Section 9.6.2: Removed reference to the use of the method of standard additions.

Section 9.6.3: Removed reference to the use of the method of standard additions.

Section 12: Removed reference to the use of the method of standard additions.

Inductively Coupled Plasma - Atomic Emission Spectrometry

Reference Method No.: **Method 6010B**

Reference: SW-846, Test Methods for Evaluating Solid Waste: Physical/Chemical Methods, EPA SW-846, Update III, 1997.

1. Scope and Application

Matrices: Digestate from all matrices.

Definitions: See Alpha Laboratories Quality Manual Appendix A

Inductively coupled plasma-atomic emission spectrometry (ICP-AES) determines trace elements, including metals, in solution. The method is applicable to all of the elements listed in Table 1. All matrices, excluding filtered groundwater samples but including ground water, aqueous samples, TCLP and EP extracts, industrial and organic wastes, soils, sludges, sediments, and other solid wastes, require digestion prior to analysis. Groundwater samples that have been prefiltered and acidified will not need acid digestion. Samples which are not digested must either use an internal standard or be matrix matched with the standards. Refer to Metals Preparation SOPs for the appropriate digestion procedures.

Table 1 lists the elements for which this method is applicable. Detection limits, sensitivity, and the optimum and linear concentration ranges of the elements can vary with the wavelength, spectrometer, matrix and operating conditions. Table 1 lists the recommended analytical wavelengths for the elements in clean aqueous matrices. Table 3 lists the Reported Detection Limits. The reported detection limit data may be used to estimate instrument and method performance for other sample matrices. Elements other than those listed in Table 1 may be analyzed by this method if performance at the concentration levels of interest (see Section 10) is demonstrated.

Users of the method should state the data quality objectives prior to analysis and must document and have on file the required initial demonstration performance data described in the following sections prior to using the method for analysis.

The data report packages present the documentation of any method modification related to the samples tested. Depending upon the nature of the modification and the extent of intended use, the laboratory may be required to demonstrate that the modifications will produce equivalent results for the matrix. Approval of all method modifications is made by one of the following laboratory personnel before performing the modification: Area Supervisor, Metals Manager, Laboratory Services Manager, Laboratory Director, or Quality Assurance Officer.

Use of this method is restricted to spectroscopists who are knowledgeable in the correction of spectral, chemical, and physical interferences described in this method. Each analyst must demonstrate the ability to generate acceptable results with this method by performing an initial demonstration of capability, analyzing a proficiency test sample and completing the record of training.

After initial demonstration, ongoing demonstration is based on acceptable laboratory performance of at least a quarterly laboratory control sample or acceptable performance from an annual proficiency test sample. A major modification to this procedure requires demonstration of performance. The identification of major method modification requiring performance demonstration is directed by the QA Officer and Laboratory Director on a case-by-case basis.

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2. Summary of Method

Prior to analysis, samples must be solubilized or digested using appropriate Sample Preparation Methods. When analyzing groundwater samples for dissolved constituents, acid digestion is not necessary if the samples are filtered and acid preserved prior to analysis.

This method describes multielemental determinations by ICP-AES using sequential or simultaneous optical systems and axial or radial viewing of the plasma. The instrument measures characteristic emission spectra by optical spectrometry. Samples are nebulized and the resulting aerosol is transported to the plasma torch. Element-specific emission spectra are produced by a radio-frequency inductively coupled plasma. The spectra are dispersed by a grating spectrometer, and the intensities of the emission lines are monitored by photosensitive devices. Background correction is required for trace element determination. Background must be measured adjacent to analyte lines on samples during analysis. The position selected for the background-intensity measurement, on either or both sides of the analytical line, will be determined by the complexity of the spectrum adjacent to the analyte line. In one mode of analysis the position used should be as free as possible from spectral interference and should reflect the same change in background intensity as occurs at the analyte wavelength measured. Background correction is not required in cases of line broadening where a background correction measurement would actually degrade the analytical result. The possibility of additional interferences named in Section 4.0 should also be recognized and appropriate corrections made; tests for their presence are described in Section 9.4.4. Alternatively, users may choose multivariate calibration methods. In this case, point selections for background correction are superfluous since whole spectral regions are processed.

2.1 Method Modifications from Reference

None.

3. Detection Limits

The laboratory follows the procedure found in 40CFR Part 136 to determine the MDL on an annual basis. The method detection limits determined by the laboratory are on file for review.

4. Interferences

4.1 Spectral

Spectral interferences are caused by background emission from continuous or recombination phenomena, stray light from the line emission of high concentration elements, overlap of a spectral line from another element, or unresolved overlap of molecular band spectra.

4.1.1 Background emission and stray light can usually be compensated for by subtracting the background emission determined by measurements adjacent to the analyte wavelength peak. Spectral scans of samples or single element solutions in the analyte regions may indicate when alternate wavelengths are desirable because of severe spectral interference. These scans will also show whether the most appropriate estimate of the background emission is provided by an interpolation from measurements on both sides of the wavelength peak or by measured emission on only one side. The locations selected for the measurement of background intensity will be determined by the complexity of the spectrum adjacent to the wavelength peak. The locations used for routine measurement must be free of off-line spectral interference (interelement or molecular) or adequately corrected to reflect the same change in background intensity

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as occurs at the wavelength peak. For multivariate methods using whole spectral regions, background scans should be included in the correction algorithm. Off-line spectral interferences are handled by including spectra on interfering species in the algorithm.

4.1.2 To determine the appropriate location for off-line background correction, the user must scan the area on either side adjacent to the wavelength and record the apparent emission intensity from all other method analytes. This spectral information must be documented and kept on file. The location selected for background correction must be either free of off-line interelement spectral interference or a computer routine must be used for automatic correction on all determinations. If a wavelength other than the recommended wavelength is used, the analyst must determine and document both the overlapping and nearby spectral interference effects from all method analytes and common elements and provide for their automatic correction on all analyses. Tests to determine spectral interference must be done using analyte concentrations that will adequately describe the interference. Normally, 100 mg/L single element solutions are sufficient; however, for analytes such as iron that may be found at high concentration, a more appropriate test would be to use a concentration near the upper analytical range limit.

4.1.3 Spectral overlaps may be avoided by using an alternate wavelength or can be compensated by equations that correct for interelement contributions. Instruments that use equations for interelement correction require the interfering elements be analyzed at the same time as the element of interest. When operative and uncorrected, interferences will produce false positive determinations and be reported as analyte concentrations. More extensive information on interferant effects at various wavelengths and resolutions is available in reference wavelength tables and books. Users may apply interelement correction equations determined on their instruments with tested concentration ranges to compensate (off line or on line) for the effects of interfering elements. For multivariate methods using whole spectral regions, spectral interferences are handled by including spectra of the interfering elements in the algorithm. The interferences listed are only those that occur between method analytes. Only interferences of a direct overlap nature are listed. These overlaps were observed with a single instrument having a working resolution of 0.035 nm.

4.1.4 When using interelement correction equations, the interference may be expressed as analyte concentration equivalents (i.e. false analyte concentrations) arising from 100 mg/L of the interference element. For example, assume that As is to be determined (at 193.696 nm) in a sample containing approximately 10 mg/L of Al. 100 mg/L of Al would yield a false signal for As equivalent to approximately 1.3 mg/L. Therefore, the presence of 10 mg/L of Al would result in a false signal for As equivalent to approximately 0.13 mg/L. The user is cautioned that each instrument may exhibit somewhat different levels of interference. The interference effects must be evaluated for each individual instrument since the intensities will vary.

Major known interferences are Fe, Al, Ca, Mg, V, Ni, Cu, and Cr. To minimize any of these interferences, every analyte is analyzed on each instrument at or near its linear range and corrected for these interferences. This is done on an annual basis, and data is kept on file.

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4.1.5 Interelement corrections will vary for the same emission line among instruments because of differences in resolution, as determined by the grating, the entrance and exit slit widths, and by the order of dispersion. Interelement corrections will also vary depending upon the choice of background correction points. Selecting a background correction point where an interfering emission line may appear should be avoided when practical. Interelement corrections that constitute a major portion of an emission signal may not yield accurate data. Users should not forget that some samples may contain uncommon elements that could contribute spectral interferences.

4.1.6 The interference effects must be evaluated for each individual instrument whether configured as a sequential or simultaneous instrument. For each instrument, intensities will vary not only with optical resolution but also with operating conditions (such as power, viewing height and argon flow rate). When using the recommended wavelengths, the analyst is required to determine and document for each wavelength the effect from referenced interferences as well as any other suspected interferences that may be specific to the instrument or matrix. The analyst is encouraged to utilize a computer routine for automatic correction on all analyses.

4.1.7 The primary wavelength for each anaylte is based upon the instrument manufacturer's recommendations. An alternate wavelength is chosen if there is an indication of elevated background or overlap of another spectral wavelength. The wavelength for each analyte must be as free from interferences as possible.

4.1.8 If the correction routine is operating properly, the determined apparent analyte(s) concentration from analysis of each interference solution should fall within a specific concentration range around the calibration blank. The concentration range is calculated by multiplying the concentration of the interfering element by the value of the correction factor being tested and divided by 10. If after the subtraction of the calibration blank the apparent analyte concentration falls outside of this range in either a positive or negative direction, a change in the correction factor of more than 10% should be suspected. The cause of the change should be determined and corrected and the correction factor updated. The interference check solutions should be analyzed more than once to confirm a change has occurred. Adequate rinse time between solutions and before analysis of the calibration blank will assist in the confirmation.

4.1.9 When interelement corrections are applied, their accuracy should be verified, daily, by analyzing spectral interference check solutions. If the correction factor or multivariate correction matrices tested on a daily basis (by running a check solution on each analytical run) are found to be within 20% criteria for 5 consecutive days, analysis may be extended to a weekly basis. Also, if the nature of the samples analyzed is such that they do not contain concentrations of the interfering elements greatee than the reported detection limit, daily verification is not required. All interelement spectral correction factors or multivariate correction matrices are verified and updated on an annual basis or when an instrumentation change, such as in the torch, nebulizer, injector, or plasma conditions occurs. The standard solution should be inspected to ensure that there is no contamination that may be perceived as a spectral interference.

4.1.10 When interelement corrections are <u>not</u> used, verification of absence of interferences is required.

4.1.10.1 One method is to use a computer software routine for comparing the determinative data to limits, files for notifying the analyst when an interfering element is detected in the sample at a concentration that will produce either an apparent false positive concentration, (i.e., greater than) the analyte

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instrument detection limit, or false negative analyte concentration, (i.e., less than the lower control limit of the calibration blank defined for a 99% confidence interval).

4.1.10.2 Another method is to analyze an Interference Check Solution(s) which contains similar concentrations of the major components of the samples (>10 mg/L) on a continuing basis to verify the absence of effects at the wavelengths selected. These data must be kept on file with the sample analysis data. If the check solution confirms an operative interference that is >20% of the analyte concentration, the analyte must be determined using (1) analytical and background correction wavelengths (or spectral regions) free of the interference, (2) by an alternative wavelength, or (3) by another documented test procedure.

4.2 Physical

Physical interferences are effects associated with the sample nebulization and transport processes. Changes in viscosity and surface tension can cause significant inaccuracies, especially in samples containing high dissolved solids or high acid concentrations. If physical interferences are present, they must be reduced by diluting the sample, using a peristaltic pump, use of an internal standard or by using a high solids nebulizer. Another problem that can occur with high dissolved solids is salt buildup at the tip of the nebulizer, affecting aerosol flow rate and causing instrumental drift. The problem can be controlled by wetting the argon prior to nebulization, using a tip washer, using a high solids nebulizer or diluting the sample. Also, it has been reported that better control of the argon flow rate, especially to the nebulizer, improves instrument performance: this may be accomplished with the use of mass flow controllers. The test described in Section 9.4.4.1 will help determine if a physical interference is present.

4.3 Chemical

Chemical interferences include molecular compound formation, ionization effects, and solute vaporization effects. Normally, these effects are not significant with the ICP technique, but if observed, can be minimized by careful selection of operating conditions (incident power, observation position, and so forth), by buffering of the sample, by matrix matching, and by standard addition procedures. Chemical interferences are highly dependent on matrix type and the specific analyte element.

4.4 Memory

Memory interferences result when analytes in a previous sample contribute to the signals measured in a new sample. Memory effects can result from sample deposition on the uptake tubing to the nebulizer and from the build up of sample material in the plasma torch and spray chamber. The site where these effects occur is dependent on the element and can be minimized by flushing the system with a rinse blank between samples. The possibility of memory interferences should be recognized within an analytical run and suitable rinse times should be used to reduce them. The rinse times necessary for a particular element must be estimated prior to analysis. This may be achieved by aspirating a standard containing elements at a concentration ten times the usual amount or at the top of the linear dynamic range. The aspiration time for this sample should be the same as a normal sample analysis period, followed by analysis of the rinse blank at designated intervals. The length of time required to reduce analyte signals to within a factor of two of the method detection limit should be noted. Until the required rinse time is established, this method suggests a rinse period of at least 60 seconds between samples and standards. If a memory interference is suspected, the sample must be reanalyzed after a rinse period of sufficient length. Alternate rinse times may be established by the analyst based upon their DQOs.

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4.5 Other Interferences

4.5.1 Users are advised that high salt concentrations can cause analyte signal suppressions and confuse interference tests. If the instrument does not display negative values, fortify the interference check solution with the elements of interest at 0.5 to 1 mg/L and measure the added standard concentration accordingly. Concentrations should be within 20% of the true spiked concentration or dilution of the samples will be necessary. In the absence of measurable analyte, overcorrection could go undetected if a negative value is reported as zero.

5. Safety

The toxicity or carcinogenicity of each reagent and standard used in this method is not fully established; however, each chemical compound should be treated as a potential health hazard. From this viewpoint, exposure to these chemicals must be reduced to the lowest possible level by whatever means available. A reference file of material data handling sheets is available to all personnel involved in the chemical analysis. Additional references to laboratory safety are available in the Chemical Hygiene Plan.

All personnel handling environmental samples known to contain or to have been in contact with municipal waste must follow safety practices for handling known disease causative agents.

6. Sample Collection, Preservation, and Handling

6.1 Sample Collection

Samples are collected in plastic bottles.

6.2 Sample Preservation

Samples for Total Metals are preserved with 1:1 Nitric acid.

If samples are for Soluble Metals, they should not be preserved prior to filtration. They are preserved with 1:1 Nitric acid post-filter.

6.3 Sample Handling

Samples to be analyzed for soluble metals, that have not been filtered, must be filtered and preserved within 24 hours of sample collection.

Preserved samples have a hold time of 6 months, and are stored under refrigeration at 4°C.

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7. Equipment and Supplies

7.1 Inductively coupled argon plasma emission spectrometer:

- **Perkin Elmer Optima 3000 DV**
- **Thermo Jarrell Ash 61E Trace Analyzer (Vacuum)**
- **Thermo Jarrell Ash 61E Trace Analyzer (Purge)**

7.1.1 Computer-controlled emission spectrometer with background correction.

7.1.2 Radio-frequency generator compliant with FCC regulations.

7.1.3 Optional mass flow controller for argon nebulizer gas supply.

7.1.4 Optional peristaltic pump.

7.1.5 Optional Autosampler.

7.1.6 Argon gas supply - high purity.

7.2 Volumetric flasks of suitable precision and accuracy.

7.3 Volumetric pipets of suitable precision and accuracy.

8. Standards and Reagents

Reagent semiconductor and/or trace grade chemicals shall be used in all tests. Unless otherwise indicated, it is intended that all reagents shall conform to the specifications of the Committee on Analytical Reagents of the American Chemical Society, where such specifications are available. Other grades may be used, provided it is first ascertained that the reagent is of sufficiently high purity to permit its use without lessening the accuracy of the determination. If the purity of a reagent is in question, analyze for contamination. If the concentration of the contamination is less than the MDL then the reagent is acceptable.

8.1 Hydrochloric acid (conc), HCl.

8.2 Hydrochloric acid (1:1), HCl. Add 500 mL concentrated HCl to 400 mL DI water and dilute to 1 liter in an appropriately sized beaker.

8.3 Nitric acid (conc), HNO_3.

8.4 Nitric acid (1:1), HNO_3. Add 500 mL concentrated HNO_3 to 400 mL DI water and dilute to 1 liter in an appropriately sized beaker.

8.5 Reagent Water. All references to water in the method refer to reagent water unless otherwise specified. Reagent water will be interference free. Refer to Chapter One for a definition of reagent water.

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8.6 Standard stock solutions may be purchased or prepared from ultra- high purity grade chemicals or metals (99.99% pure or greater). All stock standards are ordered through ISO and American Association for Lab Accreditation vendors. All standards are in aqueous solutions and are at concentrations of 1000ppm and 10,000ppm.

NOTE: This section does not apply when analyzing samples that have been prepared by Method 3040.

Typical stock solution preparation procedures follow. Concentrations are calculated based upon the weight of pure metal added, or with the use of the element fraction.

For metals:

$$\text{Concentration (ppm)} = \frac{\text{weight (mg)}}{\text{Volume (L)}}$$

8.6.1 Aluminum solution, stock, 1 mL =1000 ug Al: Dissolve 1.000 g of aluminum metal, weighed accurately to at least four significant figures, in an acid mixture of 4.0 mL of (1:1) HCl and 1.0 mL of concentrated HNO_3 in a beaker. Warm beaker slowly to effect solution. When dissolution is complete, transfer solution quantitatively to a 1-liter flask, add an additional 10.0 mL of (1:1) HCl and dilute to volume with reagent water.

NOTE: Weight of analyte is expressed to four significant figures for consistency with the weights below because rounding to two decimal places can contribute up to 4 % error for some of the compounds.

8.6.2 Antimony solution, stock, 1 mL = 1000 ug Sb: Dissolve 2.6673 g $K(SbO)C_4H_4O_6$ (element fraction Sb = 0.3749), weighed accurately to at least four significant figures, in water, add 10 mL (1:1) HCl, and dilute to volume in a 1,000 mL volumetric flask with water.

8.6.3 Arsenic solution, stock, 1 mL = 1000 ug As: Dissolve 1.3203 g of As_2O_3 (element fraction As = 0.7574), weighed accurately to at least four significant figures, in 100 mL of water containing 0.4 g NaOH. Acidify the solution with 2 mL concentrated HNO_3 and dilute to volume in a 1,000 mL volumetric flask with water.

8.6.4 Barium solution, stock, 1 mL = 1000 ug Ba: Dissolve 1.5163 g $BaCl_2$ (element fraction Ba = 0.6595), dried at 250°C for 2 hours, weighed accurately to at least four significant figures, in 10 mL water with 1 mL (1:1) HCl. Add 10.0 mL (1:1) HCl and dilute to volume in a 1,000 mL volumetric flask with water.

8.6.5 Beryllium solution, stock, 1 mL = 1000 ug Be: Do not dry. Dissolve 19.6463 g $BeSO_4 \cdot 4H_2O$ (element fraction Be = 0.0509), weighed accurately to at least four significant figures, in water, add 10.0 mL concentrated HNO_3, and dilute to volume in a 1,000 mL volumetric flask with water.

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8.6.6 Boron solution, stock, 1 mL = 1000 ug B: Do not dry. Dissolve 5.716 g anhydrous H_3BO_3 (B fraction = 0.1749), weighed accurately to at least four significant figures, in reagent water and dilute, in a 1L volumetric flask with reagent water. Transfer immediately after mixing in a clean polytetrafluoroethylene (PTFE) bottle to minimize any leaching of boron from the glass volumetric container. Use of a non-glass volumetric flask is recommended to avoid boron contamination from glassware.

8.6.7 Cadmium solution, stock, 1 mL = 1000 ug Cd: Dissolve 1.1423 g CdO (element fraction Cd = 0.8754), weighed accurately to at least four significant figures, in a minimum amount of (1:1) HNO_3. Heat to increase rate of dissolution. Add 10.0 mL concentrated HNO_3 and dilute to volume in a 1,000 mL volumetric flask with water.

8.6.8 Calcium solution, stock, 1 mL = 1000 ug Ca: Suspend 2.4969 g $CaCO_3$ (element Ca fraction = 0.4005), dried at 180°C for 1 hour before weighing, weighed accurately to at least four significant figures, in water and dissolve cautiously with a minimum amount of (1:1) HNO_3. Add 10.0 mL concentrated HNO_3 and dilute to volume in a 1,000 mL volumetric flask with water.

8.6.9 Chromium solution, stock, 1 mL = 1000 ug Cr: Dissolve 1.9231 g CrO_3 (element fraction Cr = 0.5200), weighed accurately to at least four significant figures, in water. When solution is complete, acidify with 10 mL concentrated HNO_3 and dilute to volume in a 1,000 mL volumetric flask with water.

8.6.10 Cobalt solution, stock, 1 mL = 1000 ug Co: Dissolve 1.00 g of cobalt metal, weighed accurately to at least four significant figures, in a minimum amount of (1:1) HNO_3. Add 10.0 mL (1:1) HCl and dilute to volume in a 1,000 mL volumetric flask with water.

8.6.11 Copper solution, stock, 1 mL = 1000 ug Cu: Dissolve 1.2564 g Cu (element fraction Cu = 0.7989), weighed accurately to at least four significant figures), in a minimum amount of (1:1) HNO_3. Add 10.0 mL concentrated HNO_3 and dilute to volume in a 1,000 mL volumetric flask with water.

8.6.12 Iron solution, stock, 1 mL = 1000 ug Fe: Dissolve 1.4298 g Fe_2O_3 (element fraction Fe = 0.6994), weighed accurately to at least four significant figures, in a warm mixture of 20 mL (1:1) HCl and 2 mL of concentrated HNO_3. Cool, add an additional 5.0 mL of concentrated HNO_3, and dilute to volume in a 1,000 mL volumetric flask with water.

8.6.13 Lead solution, stock, 1 mL = 1000 ug Pb: Dissolve 1.5985 g $Pb(NO_3)_2$ (element fraction Pb = 0.6256), weighed accurately to at least four significant figures, in a minimum amount of (1:1) HNO_3. Add 10 mL (1:1) HNO_3 and dilute to volume in a 1,000 mL volumetric flask with water.

8.6.14 Lithium solution, stock, 1 mL = 1000 ug Li: Dissolve 5.3248 g lithium carbonate (element fraction Li = 0.1878), weighed accurately to at least four significant figures, in a minimum amount of (1:1) HCl and dilute to volume in a 1,000 mL volumetric flask with water.

8.6.15 Magnesium solution, stock, 1 mL = 1000 ug Mg: Dissolve 1.6584 g MgO (element fraction Mg = 0.6030), weighed accurately to at least four significant figures, in a minimum amount of (1:1) HNO_3. Add 10.0 mL (1:1) concentrated HNO_3 and dilute to volume in a 1,000 mL volumetric flask with water.

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8.6.16 Manganese solution, stock, 1 mL = 1000 ug Mn: Dissolve 1.00 g of manganese metal, weighed accurately to at least four significant figures, in acid mixture (10 mL concentrated HCl and 1 mL concentrated HNO_3) and dilute to volume in a 1,000 mL volumetric flask with water.

8.6.17 Molybdenum solution, stock, 1 mL = 1000 ug Mo: Dissolve 1.7325 g $(NH_4)_6Mo_7O_{24}{\cdot}4H_2O$ (element fraction Mo = 0.5772), weighed accurately to at least four significant figures; in water and dilute to volume in a 1,000 mL volumetric flask with water.

8.6.18 Nickel solution, stock, 1 mL = 1000 ug Ni: Dissolve 1.00 g of nickel metal, weighed accurately to at least four significant figures, in 10.0 mL hot concentrated HNO_3, cool, and dilute to volume in a 1,000 mL volumetric flask with water.

8.6.19 Phosphate solution, stock, 1 mL = 1000 ug P: Dissolve 4:3937 g anhydrous KH_2PO_4 (element fraction P = 0.2276), weighed accurately to at least four significant figures, in water. Dilute to volume in a 1,000 mL volumetric flask with water.

8.6.20 Potassium solution, stock, 1 mL = 1000 ug K: Dissolve 1.9069 g KCl (element fraction K = 0.5244) dried at 110°C, weighed accurately to at least four significant figures, in water, and dilute to volume in a 1,000 mL volumetric flask with water.

8.6.21 Selenium solution, stock, 1 mL = 1000 ug Se: Do not dry. Dissolve 1.6332 g H_2SeO_3 (element fraction Se = 0.6123), weighed accurately to at least four significant figures, in water and dilute to volume in a 1,000 mL volumetric flask with water.

8.6.22 Silica solution, stock, 1 mL = 1000 ug SiO_2: Do not dry. Dissolve 2.964 g NH_4SiF_6, weighed accurately to at least four significant figures, in 200 mL (1:20) HCl with heating at 85°C to effect dissolution. Let solution cool and dilute to volume in a 1L volumetric flask with reagent water.

8.6.23 Silver solution, stock, 1 mL = 1000 ug Ag: Dissolve 1.5748 g $AgNO_3$ (element fraction Ag = 0.6350), weighed accurately to at least four significant figures, in water and 10 mL concentrated HNO_3. Dilute to volume in a 1,000 mL volumetric flask with water.

8.6.24 Sodium solution, stock, 1 mL = 1000 ug Na: Dissolve 2.5419 g NaCl (element fraction Na = 0.3934), weighed accurately to at least four significant figures, in water. Add 10.0 mL concentrated HNO_3 and dilute to volume in a 1,000 mL volumetric flask with water.

8.6.25 Strontium solution, stock, 1 mL = 1000 ug Sr: Dissolve 2.4154 g of strontium nitrate $(Sr(N0_3)_2)$ (element fraction Sr = 0.4140), weighed accurately to at least four significant figures, in a 1-liter flask containing 10 mL of concentrated HCl and 700 mL of water. Dilute to volume in a 1,000 mL volumetric flask with water.

8.6.26 Thallium solution, stock, 1 mL = 1000 ug Tl: Dissolve 1.3034 g $TlNO_3$ (element fraction Tl = 0.7672), weighed accurately to at least four significant figures, in water. Add 10.0 mL concentrated HNO_3 and dilute to volume in a 1,000 mL volumetric flask with water.

8.6.27 Tin solution, stock, 1 mL = 1000 ug Sn: Dissolve 1.000 g Sn shot, weighed accurately to at least 4 significant figures, in 200 mL (1:1) HCl with heating to effect dissolution. Let solution cool and dilute with (1:1) HCl in a 1L volumetric flask.

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8.6.28 Vanadium solution, stock, 1 mL = 1000 ug V: Dissolve 2.2957 g NH_4VO_3 (element fraction V = 0.4356), weighed accurately to at least four significant figures, in a minimum amount of concentrated HN03. Heat to increase rate of dissolution. Add 10.0 mL concentrated HNO_3 and dilute to volume in a 1,000 mL volumetric flask with water.

8.6.29 Zinc solution, stock, 1 mL = 1000 ug Zn: Dissolve 1.2447 g ZnO (element fraction Zn = 0.8034), weighed accurately to at least four significant figures, in a minimum amount of dilute HNO_3. Add 10.0 mL concentrated HNO_3 and dilute to volume in a 1,000 mL volumetric flask with water.

8.7 Mixed calibration standard solutions

Prepare mixed calibration standard solutions by combining appropriate volumes of the stock solutions in volumetric flasks. Add the appropriate types and volumes of acids so that the standards are matrix matched with the sample digestates. Care should be taken when preparing the mixed standards to ensure that the elements are compatible and stable together. Transfer the mixed standard solutions to FEP fluorocarbon or previously unused polyethylene or polypropylene bottles for storage. Fresh mixed standards should be prepared, as needed, with the realization that concentration can change on aging.

NOTE: If the addition of silver to the recommended acid combination results in an initial precipitation, add 15 mL of water and warm the flask until the solution clears. Cool and dilute to 100 mL with water. For this acid combination, the silver concentration should be limited to 2 mg/L. Silver under these conditions is stable in a tap-water matrix for 30 days. Higher concentrations of silver require additional HCl.

8.8 Blanks

Two types of blanks are required for the analysis for samples prepared by any method other than 3040. The calibration blank is used in establishing the analytical curve, and the method blank is used to identify possible contamination resulting from varying amounts of the acids used in the sample processing.

8.8.1 The calibration blank is prepared by acidifying reagent water to the same concentrations of the acids found in the standards and samples. Prepare a sufficient quantity to flush the system between standards and samples. The calibration blank will also be used for all initial and continuing calibration blank determinations (see Sections 9.2 and 9.3). Refer to Section 9.3.1.2 for acceptance criteria and/or corrective actions.

8.8.2 The method blank must contain all of the reagents in the same volumes as used in the processing of the samples. The method blank must be carried through the complete procedure and contain the same acid concentration in the final solution as the sample solution used for analysis. Refer to Section 10.2 for acceptance criteria and/or corrective actions.

8.9 The Initial Calibration Verification Standard (ICV) and the Continuing Calibration Verification Standard (CCV)

These Standards are prepared by the analyst by combining compatible elements from a standard source different than that of the calibration standard and within the mid-point of the calibration curve.

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8.10 Interference Check Solution

These solutions are prepared to contain known concentrations of interfering elements that will provide an adequate test of the correction factors. Spike the sample with the elements of interest. In the absence of measurable analyte, overcorrection could go undetected because a negative value could be reported as zero. If the particular instrument will display overcorrection as a negative number, this spiking procedure will not be necessary.

8.11 CRI

The CRI is an ICP standard that is analyzed at a concentration of 2 - 5 times each element's RDL. The CRI should be recovered within 80-120% of its true value. If the CRI does not meet these criteria, it is remade and reanalyzed. If the CRI fails a second time, the analysis is terminated, the problem determined and corrected. The instrument is then recalibrated.

CRI solutions are made for each type of instrument.

8.11.1 CRI Stock Standard Solution, for the TJA Trace instruments

To a 500mL volumetric flask, add 200mL DI water and 50mL of 1:1 HNO_3. Add the following volumes of each certified 1000ppm stock standard:

Pb	0.9 mL	Ni	1.6 mL
Se	0.2 mL	Ag	0.4 mL
Sb	2.0 mL	Tl	0.4 mL
As	0.4 mL	V	2.0 mL
Ba	0.8 mL	Zn	0.8 mL
Be	0.2 mL	Al	4.0 mL
Cd	0.2 mL	Ca	4.0 mL
Co	2.0 mL	Mg	4.0 mL
Cr	0.4 mL	B	2.0 mL
Cu	1.0 mL	Sr	0.4 mL
Fe	4.0 mL	Ti	0.4 mL
Mn	0.6 mL	Sn	0.4 mL
Mo	2.0 mL		

And the following volumes of each certified 10000ppm stock standard:

K	4.0 mL
Na	4.0 mL
Si	2.0 mL

Bring to volume of 500mL with DI water. This solution expires one month after the date of preparation.

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8.11.1.1 CRI Working Standard Solution

To a 1L volumetric flask, add 25mL of CRI Stock Standard Solution (Section 8.11.1). Bring to volume with DI water. This solution will contain elements in the following concentrations:

Pb	0.045 ppm	Ag	0.02 ppm
Se	0.01 ppm	Tl	0.02 ppm
Sb	0.10 ppm	V	0.10 ppm
As	0.02 ppm	Zn	0.04 ppm
Ba	0.04 ppm	Al	0.20 ppm
Be	0.01 ppm	Ca	0.20 ppm
Cd	0.01 ppm	Mg	0.20 ppm
Co	0.10 ppm	B	0.10 ppm
Cr	0.02 ppm	Sr	0.02 ppm
Cu	0.05 ppm	Ti	0.02 ppm
Fe	0.20 ppm	Sn	0.02 ppm
Mn	0.03 ppm	K	2.0 ppm
Mo	0.10 ppm	Na	2.0 ppm
Ni	0.08 ppm	Si	1.0 ppm

8.11.2 ICP Multi-element Laboratory Performance Check Standard (LPCS)

Commercially prepared by Accustandard Corp. This standard is used to prepare the CRI Working Standard Solution for the PE Optima 3000DV.

8.11.2.1 CRI Working Standard Solution for the PE Optima 3000DV

To a 500mL volumetric flask, add 200mL DI water and 50mL of 1:1 HNO_3. Add 0.5mL of ICP Multi-element Laboratory Performance Check Standard, and the following volumes of each certified 1000ppm stock standard:

Se	0.05mL	Ca	0.2mL
Sb	0.05mL	Mg	0.2mL
Fe	0.1mL	Na	0.5mL
Al	0.2mL		

Also add 0.05mL of 10000ppm K Stock Standard. Bring to volme with DI water. This solution expires two weeks after the date of preparation.

NOTE: This solution will contain elements in the following concentrations:

Pb	0.02 ppm	Ni	0.02 ppm
Se	0.125 ppm	Ag	0.005 ppm
Sb	0.125 ppm	Tl	0.02 ppm
As	0.02 ppm	V	0.02 ppm
Ba	0.02 ppm	Zn	0.02 ppm

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Be	0.02 ppm	Al	0.42 ppm
Cd	0.02 ppm	Ca	0.42 ppm
Co	0.02 ppm	Mg	0.42 ppm
Cr	0.02 ppm	B	0.02 ppm
Cu	0.02 ppm	Sn	0.02 ppm
Fe	0.22 ppm	K	1.1 ppm
Mn	0.02 ppm	Na	1.0 ppm
Mo	0.02 ppm	Li	0.02 ppm

9. Procedure

9.1 SET-UP

9.1.1 Sample Preparation

Preliminary treatment of most matrices is necessary because of the complexity and variability of sample matrices. Groundwater samples which have been prefiltered and acidified will not need acid digestion. Samples which are not digested must either use an internal standard or be matrix matched with the standards. Solubilization and digestion procedures are presented in Sample Preparation Methods (Chapter Three, Inorganic Analytes).

9.1.2 Instrument Set-Up

Set up the instrument with proper operating parameters established as detailed below. The instrument must be allowed to become thermally stable before beginning (usually requiring at least 30 minutes of operation prior to calibration).

Startup Procedures

For the PE Optima 3000 DV

- Perform weekly/monthly maintenance.
  - Weekly maintenance- change pump tubing
  - Monthly maintenance- Remove torch, nebulizer, and spray chamber and clean each with 10% nitric acid solution and rinse with D.I. water.
- Switch on Instrument main power.
- Switch on RF generator main power.
- Open Nitrogen Tank valve. Flow pressure set at 40 psi.
- Turn on computer.
- Enter Winlab32 software.
- Click Plasma Icon.
- Click Plasma On switch. Instrument performs a 75 second initial and 10-second final Nitrogen purge before ignition.
- After Plasma Ignition, activate Internal Standard pump. Pump set at 16.5 rpm.
- Allow 30 minutes for instrument thermal stabilization.
- To perform profile, place probe in 10 mg/L Mn solution and open Spectrometer Control under Tools window. In Spectrometer Control, under manual settings click Radial to specify plasma profile. Click Align view and click O.K. to begin profile. If radial profile intensity counts do not exceed 10000, do not save profile

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and perform necessary maintenance- i.e. change torch, nebulizer, injector parts or adjust positioning, or clean radial purge window. If this does not work, consult Perkin Elmer service technician.

- To repeak/realign elemental spectra, analyze blank and cal-standard and click on Examine Spectra Icon. Select appropriate data set and select blank and calibration standard for all method elements. Use left/right directional keys to move cursor along baseline directly under highest point in peak, which is the area with highest intensity counts. Right click mouse to select Adjust Wavelength option. Instrument will repeak/realign spectra

For the TJA Trace 61E Vacuum and Purge ICP's

- Turn on the main power switch
- Turn on the power to the chillers
- Push the re-set switch on the front of the spectrometers
- Turn on the computer
- Click on the "Thermo-Spec" software icon
- Click on "Set-Up"
- Choose "Plasma Control Panel"
- Click on F1. This is the automated start-up sequence.
- Escape back to the Main Menu and move the cursor over to "Operations" and type in (ALL02) in the method box. This will automatically set up the instrument with the correct method Parameters.
- Wait 30 minutes for the instrument to come to equilibrium
- Enter F5 then F3 (Profile)
- Profile instrument with 1.0 mg/L As standard. When acceptable profile has been performed, enter profile intensity in instrument logbook, and press F9. This will bring you back to the Main Menu.
- Select " Auto Sampler Set-up"
- Input batch #s and sample ID's
- Select "Analyze"

9.1.2.1 Specific wavelengths are listed in Table 1. Other wavelengths may be substituted if they can provide the needed sensitivity and are corrected for spectral interference. The instrument and operating conditions utilized for determination must be capable of providing data of acceptable quality to the program and data user.

Operating conditions for aqueous solutions using the Optima 3000 DV plasma are set for 1450 watts forward power, 0.3 L/min auxillary argon coolant flow, 15 L/min plasma argon coolant flow, 0.59 L/min argon nebulizer flow and a pump rate of 1.5 mL/min. A second pre-flush time and 35 second measurement time is recommended.

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Operating conditions for axial plasma will vary from 1100 – 1500 wats forward power, 15-19 Liters/min argon coolant flow, 0.5 – 0.7 L/min argon nebulizer flow, 140 – 200 rpm pump rate and a 1 minute preflush time and 10 second measurement time is recommended for all simultaneous instruments.

9.1.2.2 The plasma operating conditions need to be optimized prior to use of the instrument. This routine is not required on a daily basis, but only when first setting up a new instrument or following a change in operating conditions. The following procedure is recommended or follow manufacturer's recommendations. The purpose of plasma optimization is to provide a maximum signal to background ratio for some of the least sensitive elements in the analytical array. The use of a mass flow controller to regulate the nebulizer gas flow or source optimization software greatly facilitates the procedure.

9.1.2.2.1 Ignite the radial plasma and select an appropriate incident RF power. Allow the instrument to become thermally stable before beginning, about 30 to 60 minutes of operation. While aspirating a 1000 ug/L solution of yttrium, follow the instrument manufacturer's instructions and adjust the aerosol carrier gas flow rate through the nebulizer so a definitive blue emission region of the plasma extends approximately from 5 to 20 mm above the top of the load coil. Record the nebulizer gas flow rate or pressure setting for future reference. The yttrium solution can also be used for coarse optical alignment of the torch by observing the overlay of the blue light over the entrance slit to the optical system.

9.1.2.2.2 The TJA ICP's use a Meinhard Nebulizer; the 3000DV uses a high solids nebulizer. The nebulizer flow for each instrument is listed below:

- TJA Trace (Vacuum): 0.52 L/min
- TJA Trace (Purge): 0.65 L/min
- PE Optima 3000DV: 0.59 L/min

9.1.2.2.3 Profiles on the TJA Trace ICP's use a 1.0mg/L solution of Arsenic. The Optima 3000DV uses a 1.0mg/L and 10.0 mg/L solution of Manganese. Peak position on the TJA instruments have a tolerance of 0.1. If the tolerance is not met, the computer program automatically corrects and re-profiles. Profile intensity is recorded in the instrument notebook. Dramatic loss of intensity should be a signal that there is a problem with the instrument. Usually this entails checking and cleaning the nebulizer, and making sure that the nebulizer flows are correct.

9.1.2.2.4 The instrument operating condition finally selected as being optimum should provide the lowest reliable instrument detection limits and method detection limits.

9.1.2.2.5 If either the instrument operating conditions, such as incident power or nebulizer gas flow rate are changed, or a new torch injector tube with a different orifice internal diameter is installed, the plasma and viewing height should be reoptimized.

9.1.2.2.6 After completing the initial optimization of operating conditions, but before analyzing samples, the laboratory must establish and initially verify an interelement spectral interference correction routine to be used during

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sample analysis. A general description concerning spectral interference and the analytical requirements for background correction in particular are discussed in the section on interferences. Criteria for determining an interelement spectral interference is an apparent positive or negative concentration for the analyte that falls within ± the RDL. The upper control limit is the analyte instrument detection limit. Once established, the entire routine is periodically verified annually. In between that time, IEC's are done on a need be basis per analyte. Only a portion of the correction routine must be verified more frequently or on a daily basis. Initial and periodic verification of the routine should be kept on file. Special cases where continual verification is required are described elsewhere.

9.1.2.2.7 Before daily calibration and after the instrument warmup period, the nebulizer gas flow rate must be reset to the determined optimized flow. If a mass flow controller is being used, it should be set to the recorded optimized flow rate. In order to maintain valid spectral interelement correction routines the nebulizer gas flow rate should be the same (< 2% change) from day to day.

9.1.2.3 For operation with organic solvents, use of the auxiliary argon inlet is recommended, as are solvent-resistant tubing, increased plasma (coolant) argon flow, decreased nebulizer flow, and increased RF power to obtain stable operation and precise measurements.

9.1.2.4 Sensitivity, instrumental detection limit, precision, linear dynamic range, and interference effects must be established for each individual analyte line on each particular instrument. All measurements must be within the instrument linear range where the correction equations are valid.

9.1.2.4.1 Method detection limits must be established for all wavelengths utilized for each type of matrix commonly analyzed. The matrix used for the MDL calculation must contain analytes of known concentrations within 3-5 times the anticipated detection limit.

9.1.2.4.2 Determination of limits using reagent water MDLs represent a best case situation and do not represent possible matrix effects of real world samples.

9.1.2.4.3 If additional confirmation is desired, reanalyze the seven replicate aliquots on two more non-consecutive days and again calculate the method detection limit values for each day. An average of the three values for each analyte may provide for a more appropriate estimate.

9.1.2.4.4 The upper limit of the linear dynamic range must be established for each wavelength utilized by determining the signal responses from a minimum for three, preferably five, different concentration standards across the range. One of these should be near the upper limit of the range. The ranges which may be used for the analysis of samples should be judged by the analyst from the resulting data. The data, calculations and rationale for the choice of range made should be documented and kept on file. The upper range limit should be an observed signal no more than 10% below the level extrapolated from lower standards. Determined analyte concentrations that are above the upper range limit must be diluted and reanalyzed. The analyst should also be aware that if an interelement correction from an analyte above

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the linear range exists, a second analyte where the interelement correction has been applied may be inaccurately reported. New dynamic ranges should be determined whenever there is a significant change in instrument response. The linear dynamic range is checked on an annual basis. For those analytes that are known interferences, and are present at above the linear range, the analyst should ensure that the interelement correction has not been inaccurately applied.

NOTE: Many of the alkali and alkaline earth metals have non-linear response curves due to ionization and self-absorption effects. These curves may be used if the instrument allows; however the effective range must be checked and the second order curve fit should have a correlation coefficient of 0.995 or better. Third order fits are not acceptable. These non-linear response curves should be revalidated and recalculated every six months. These curves are much more sensitive to changes in operating conditions than the linear lines and should be checked whenever there have been moderate equipment changes.

9.1.2.5 The analyst must (1) verify that the instrument configuration and operating conditions satisfy the analytical requirements and (2) maintain quality control data confirming instrument performance and analytical results.

9.2 Initial Calibration

Profile and calibrate the instrument according to the instrument manufacturer's recommended procedures, using the typical mixed calibration standard solutions described in Section 8.7. Flush the system with the calibration blank (Section 8.8.1) between each standard or as the manufacturer recommends. (Use the average intensity of multiple exposures for both standardization and sample analysis to reduce random error.) The calibration curve must consist of a minimum of a blank and a standard.

9.3 Calibration Verification

9.3.1 Verify calibration with the Continuing Calibration Verification (CCV) Standard (Section 8.9) immediately following daily calibration, after every ten samples, and at the end of an analytical run. Check calibration with an ICV following the initial calibration (Section 8.9). At the laboratory's discretion, an ICV may be used in lieu of the continuing calibration verifications. If used in this manner, the ICV should be at a concentration near the mid-point of the calibration curve. Use a calibration blank (Section 8.8.1) immediately following daily calibration, after every 10 samples and at the end of the analytical run.

A CRI (Section 8.11) should be analyzed after the ICB. The concentration of the CRI is 2 – 5 times that of each element's RDL. The linearity of the instrument is determined on an annual basis by linear ranges, therefore a high standard is not usually analyzed.

9.3.1.1 The results of the ICV are to agree within 5% of the expected value, and CCVs are to agree within 10% of the expected value; if not, terminate the analysis, correct the problem, and recalibrate the instrument.

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9.3.1.2 The results of the calibration blank are to agree within three times the IDL. If not, repeat the analysis two more times and average the results. If the average is not within three standard deviations of the background mean, terminate the analysis, correct the problem, recalibrate, and reanalyze the previous 10 samples. If the blank is less than 1/10 the concentration of the action level of interest, and no sample is within ten percent of the action limit, analyses need not be rerun and recalibration need not be performed before continuation of the run.

9.3.1.3 The results of the CRI must be within 20% of the true value. If they are not, correct the problem and recalibrate the instrument. (Any element may be analyzed on a different ICP that has passsed the CRI.)

9.3.2 Verify the interelement and background correction factors at the beginning of each analytical run. Do this by analyzing the interference check sample (Section 8.10). Results should be within ± 20% of the true value.

9.3.3 When low-level sensitivity is required, a check standard at the requested limit of quantitation is analyzed to confirm the reported detection limit (RDL). This is performed on a project-by-project basis. *(Please note that the check standard must be prepared from a second source standard separate from that used for calibration.)*

9.4 Equipment Operation and Sample Analysis

9.4.1 For all analytes and determinations, the laboratory must analyze an ICV (Section 8.9), and a calibration blank (Section 8.8.1), immediately following daily calibration. A calibration blank and either a calibration verification (CCV) or an ICV must be analyzed after every tenth sample and at the end of the sample run. Analysis of the check standard and calibration verification must verify that the instrument is within 10% of calibration with relative standard deviation < 5% from replicate (minimum of two) integrations. If the calibration cannot be verified within the specified limits, the sample analysis must be discontinued, the cause determined and the instrument recalibrated. All samples following the last acceptable ICV, CCV or check standard must be reanalyzed. The analysis data of the calibration blank, check standard, and ICV or CCV must be kept on file with the sample analysis data.

9.4.2 Rinse the system with the calibration blank solution (Section 8.8.1) before the analysis of each sample. The rinse time will be one minute. Each laboratory may establish a reduction in this rinse time through a suitable demonstration.

9.4.3 Dilute and reanalyze samples that exceed the linear calibration range or use an alternate, less sensitive line for which quality control data is already established.

9.4.4 It is recommended that whenever a new or unusual sample matrix is encountered, a series of tests be performed prior to reporting concentration data for analyte elements. These tests, as outlined in Sections 9.4.4.1 and 9.4.4.2, will ensure that neither positive nor negative interferences are operating on any of the analyte elements to distort the accuracy of the reported values.

9.4.4.1 Dilution Test: If the analyte concentration is sufficiently high (minimally, a factor of 10 above the instrumental detection limit after dilution), an analysis of a 1:5 dilution should agree within ± 10% of the original determination. If not, a chemical or physical interference effect should be suspected.

9.4.4.2 Post Digestion Spike Addition: An analyte spike added to a portion of a prepared sample, or its dilution, should be recovered to within 75% to 125% of the known value. The spike addition should produce a minimum level of 10 times and a maximum of 100

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times the instrumental detection limit. If the spike is not recovered within the specified limits, a matrix effect should be suspected.

9.4.5 **CAUTION:** If spectral overlap is suspected, use of computerized compensation, an alternate wavelength, or comparison with an alternate method is recommended.

9.5 Preventative Maintenance

The TJA Trace ICP's and the PE Optima 3000 DV have similar maintenance procedures. Whenever maintenance is performed, it is noted in the instrument's Maintenance Logbook.

9.5.1 Daily

Change the nebulizer pump tubing from the Autosampler to the Nebulizer.

9.5.2 Monthly or as needed

Remove the torch, nebulizer and spray chamber. Clean each with 10% Nitric Acid and 5% Hydrochloric Acid. Soak the torch and spray chamber for one hour, then rinse well with DI water. Soak the nebulizer in an ultrasonic bath for 30 minutes, then rinse with DI water.

9.5.3 Every 6 months

Preventive Maintenance is performed by the Vendor as follows:

- clean the lenses
- check/replace the power tube
- check the cooling system
- refill the chiller with distilled water
- clean the instrument to regain intensity
- clean/replace air filters on the rear of the instruments.

9.6 Calculations

9.6.1 If dilutions were performed, the appropriate factors must be applied to sample values. All results should be reported with up to three significant figures.

9.6.2 Soil samples

Soil samples are calculated as follows:

$$\mathbf{A} = \frac{\text{Sample weight (grams)}}{\text{Final Volume (mL)}}$$

$$\mathbf{B}\ (\text{concentration in mg/Kg}) = \frac{\text{Concentration of analyte (mg/L)}}{\mathbf{A}}$$

9.6.2.1 Dry weight correction

The LIMS calculates the dry weight correction, however it is calculated as follows:

$$\text{Final concentration in mg/Kg dry weight} = \frac{\mathbf{B}}{\%\ \text{Solids}}$$

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9.6.3 Liquid samples

Liquid samples are calculated as follows:

$$\text{Dilution Factor} = \frac{\text{Final Volume (mL)}}{\text{Sample Volume (mL)}}$$

Final concentration in mg/L = Concentration of analyte (mg/L) x Dilution Factor

10. Quality Control and Data Assessment

The laboratory must maintain records to document the quality of data that is generated. Ongoing data quality checks are compared with established performance criteria to determine if the results of analyses meet the performance characteristics of the method. When results of sample spikes indicate atypical method performance, a calibration verification standard is used to confirm the measurements were performed in an in-control mode of operation.

10.1 Demonstration of Capability

The analyst must make an initial, one-time, demonstration of the ability to generate acceptable accuracy and precision with this method. Each time a method modification is made, the analyst is required to repeat the procedure.

When one or more of the parameters tested fail at least one of the acceptance criteria, the analyst must locate and correct the source of the problem and repeat the test for failed parameters of the method.

Repeated failure confirms a general problem with the measurement system or analytical technique of the analyst. If the failure repeats, locate and correct the source of the problem and repeat the test for all parameters listed in the method.

Before using this procedure to analyze samples, there must be data available documenting initial demonstration of performance. The required data documents the selection criteria of background correction points; analytical dynamic ranges, the applicable equations, and the upper limits of those ranges; the method and instrument detection limits; and the determination and verification of interelement correction equations or other routines for correcting spectral interferences. This data must be generated using the same instrument, operating conditions and calibration routine to be used for sample analysis. These documented data must be kept on file and be available for review by the data user or auditor.

10.2 Method Blank

Employ a minimum of one method blank per sample batch to determine if contamination or any memory effects are occurring. A method blank is a volume of reagent water carried through the same preparation process as a sample.

The method blank results must be less than the reported detection limit (RDL) for all analytes of concern. If the results of the method blank exceed the RDL for any analyte, perform re-analysis of a new aliquot of the method blank.

If the results continue to exceed the RDL, proceed as follows:

If all of the samples for the analyte are non-detected, and the method blank is at or above the RDL, no action is required.

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If one or more associated samples for that analyte have positive results at or above the RDL, those samples must be considered to be out of control, and are re-digested and reanalyzed.

10.3 Laboratory Control Samples (LCS)

Analyze one LCSW/LCSS per sample batch. A LCS/LCSW sample is a spiked volume of reagent water that is brought through the entire preparation and analytical process. The LCSW must have a % Recovery of ± 25% within the actual value or within the documented historical limits for each matrix.

If the LCSW % Recovery is outside the acceptable limits as stated in Table 2, or outside any historical documentation, the failed analytes are re-prepped and re-analyzed. Otherwise, a nonconformance report form is raised to document the exact problem and this form is then authorized by the QA/QC Director and/or the Laboratory Manager(s).

10.4 Interference Check Standards

A check solution is analyzed twice per each calibration curve. One solution has only elevated concentrations of Fe, Al, Ca, Mg to ensure no interferences occur. The other check solution is the same solution spiked with a known amount of each analyte. These solutions are analyzed at the beginning and at the end of each analytical run.

If the Interference Check Solution falls outside the acceptable limits of ± 20%, the failed analytes are re-analyzed. Otherwise, a nonconformance Report form is raised to document the exact problem and this form is then authorized by the QA/QC Director and/or the Laboratory Manager(s).

10.5 Matrix Spike

Analyze matrix spike samples at a frequency of one per matrix batch. A matrix spike sample is a sample brought through the entire sample preparation and analytical process.

10.5.1 The percent recovery is to be calculated as follows:

$$\% \text{ Recovery} = \frac{MS - S}{C} \times 100$$

where:

MS = Matix Spike value
S = Sample value.
C = Concentration of the Spiking solution.

10.5.2 If the Matrix Spike falls outside of the limits as stated in Table 2, or outside any historical documentation, the failed analytes are either re-prepped and re-analyzed, or a post analytical spike is performed. The acceptable % Recovery of the post analytical spike is 75 – 125%. A nonconformance report form is raised and is attached to the data package. This form is then authorized by the QA/QC Director and/or the Laboratory Manager.

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10.6 Duplicates

A duplicate sample is analyzed once per matrix batch. This sample is brought through the entire sample preparation and analytical process.

10.6.1 The relative percent difference between duplicate determinations is to be calculated as follows:

$$RPD = \frac{| D_1 - D_2 |}{(| D_1 + D_2 |) / 2} \times 100$$

where:

RPD = relative percent difference.
D_1 = first sample value.
D_2 = second sample value (replicate).

10.6.2 If the Duplicate falls outside of the limits as stated in Table 2, or outside any historical documentation, the failed analytes are re-prepped and re-analyzed. A nonconformance report form is raised and is attached to the data package. This form is then authorized by the QA/QC Director and/or the Laboratory Manager.

If re-digestion is not available or applicable, a nonconformance report form is raised and is attached to the data package. This form is then authorized by the QA/QC Director and/or the Laboratory Manager.

10.7 Control Limits

The laboratory maintains performance records to document the quality of data that is generated. Method accuracy for samples is assessed and records maintained. After the analysis of 20 spiked samples, and 20 laboratory control samples, calculate the average percent recovery (R) and the standard deviation of the percent recovery (S).

Control limits for the method parameters are generated by the QC staff and distributed to the analysts. The control limits are calculated based on in-house performance data. The limits are compared to the control limits found in the reference method.

10.8 Analytical Sequence

- Calibration of instrument
- Initial Calibration Verification Standard
- Initial Calibration Blank
- CRI
- Blank (to check for carry-over)
- Interference Check Solution A
- Interference Check Solution AB
- Continuing Calibration Verification Standard
- Continuing Calibration Blank
- 10 samples
- Continuing Calibration Verification Standard
- Continuing Calibration Blank

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11. Method Performance

The method detection limit (MDL) is defined as the minimum concentration of a substance that can be measured and reported with 99% confidence that the value is above zero. The MDL concentrations were obtained using reagent water. The MDL actually achieved in a given analysis will vary depending on instrument sensitivity and matrix effects.

Method performance data is on file in the laboratory QC department. Comparison of method performance data for the laboratory to the reference method criteria occurs when laboratory in-house acceptance limits are generated. In-house generated data must be within the specifications of the reference method or the analysis is not continued until corrective action is completed.

12. Corrective Actions

Holding time exceedence, improper preservation and observed sample headspace are noted on the nonconformance report form.

Perform routine preventative maintenance on both of the TJA Trace ICP's and the PE Optima 3000 DV according to Section 9.5. Record all maintenance in the instrument logbooks. Evaluate the notes in the maintenance logbook to determine whether further maintenance is necessary on the instrument, e.g. dropping or low intensities when profiling. Notify the Department Manager when these types of trends occur.

Review of standards, blanks and LCS for acceptable performance occurs for each batch of samples. If any part of batch quality control does not meet acceptance criteria, the Department Manager is notified. If enough sample remains and holding time has not expired, then the batch is redigested and reanalyzed. If there is not sufficient sample remaining to allow redigestion, then the analysis is repeated and both sets of data are reported, with the nonconformance narrated on the final report.

If either the CVV/CCB, LCS or Method Blank recovery falls outside the designated acceptance range, the laboratory performance for that parameter is judged to be out of control, and the problem must be immediately identified and corrected. The analytical result in the unspiked samples is suspect and is only reported for regulatory compliance purposes with the appropriate nonconformance action form.

Immediate corrective action for a failing CCV/CCB includes reanalyzing the failing standard. If the standard passes the second time then the analysis may be continued. The raw data is noted. If the standard fails again, the problem must be found and corrected. The CCV/CCB standard is remade and reanalyzed. If the standard passes, then the data that had failed up to the previous passing standard is reanalyzed. The raw data is noted and all data associated with the failing standard should have one line drawn through the data, indicating its unusability.

If the standard fails after instrument maintenance, the instrument is recalibrated. A new ICV/ICB is performed, and all previous data that had failed up to the previous passing CCV/CCB is reanalyzed.

The procedure outline above is also conducted for a failing LCS or Method Blank.

If the Matrix Spike does not meet acceptance criteria, an analytical spike is performed. The recovery should be within 85 – 115% of the true value. If this criteria is met, then the Matrix Spike data is reported, with the post spike narrated on the final report. If the post spike fails the acceptance criteria, the Department Manager is notified to determine what type of matrix interferent is present, and whether a serial dilution should be perfomed.

If sample Duplicates are outside of the acceptance criteria, the analyst examines the sample for homogeneity. If the sample is not homogenous, this is narrated on the final report. Clean, homogenous samples are redistilled and reanalyzed within holding time.

Sample nonconformance regarding a Matrix Spike recovery or a duplicate %RSD is narrated on the final report along with the corrective action(s) taken.

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13. Pollution Prevention

See Chemical Hygiene Plan for pollution prevention operations.

14. Waste Management

See Chemical Hygiene Plan for waste handling and disposal.

15. Attachments

TABLE 1: Element Wavelengths

TABLE 2: Precision and Accuracy Acceptance Criteria

TABLE 3: Reporting Limits

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TABLE 1
ELEMENT WAVELENGTHS

Element	Wavelength (nm)
Aluminum	308.215
Antimony	206.833
Arsenic	189.042 [a]
Barium	493.409
Beryllium	313.042
Boron	249.678 x 2
Cadmium	228.802 [a]
Calcium	317.933
Chromium	267.716
Cobalt	228.616
Copper	324.754
Iron	259.940 [b]
Lead	220.353
Lithium	460.286
Magnesium	279.079
Manganese	257.610
Molybdenum	202.030
Nickel	231.604 x 2
Phosphorus	214.914
Potassium	766.491
Selenium	196.026
Silica (SiO_2)	251.611
Silver	328.068
Sodium	588.995
Strontium	421.552
Thallium	190.864
Tin	189.980 x 2
Titanium	337.280
Vanadium	292.402
Zinc	213.856 x 2 [c]

a The wavelengths indicated for Arsenic and Cadmium are those from the TJ61E analyzer.

b The TJA Trace analyzer has two lines for Iron: λ 259.940 and 271.441.

c The TJA Trace analyzer has λ 213.838 for Zinc.

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TABLE 2
PRECISION AND ACCURACY ACCEPTANCE CRITERIA

	Aqueous % Recovery LCS / MS		Soil % Recovery LCS / MS		Duplicate	
Element	**Lower Control Limit**	**Upper Control Limit**	**Lower Control Limit**	**Upper Control Limit**	**Aqueous %RPD**	**Soil %RPD**
Aluminum	75	125	70	140	20	35
Antimony	75	125	70	140	20	35
Arsenic	75	125	70	140	20	35
Barium	75	125	70	140	20	35
Berylium	75	125	70	140	20	35
Boron	75	125	70	140	20	35
Cadmium	75	125	70	140	20	35
Calcium	75	125	70	140	20	35
Chromium	75	125	70	140	20	35
Cobalt	75	125	70	140	20	35
Copper	75	125	70	140	20	35
Iron	75	125	70	140	20	35
Lead	75	125	70	140	20	35
Lithium	75	125	70	140	20	35
Magnesium	75	125	70	140	20	35
Manganese	75	125	70	140	20	35
Molybdenum	75	125	70	140	20	35
Nickel	75	125	70	140	20	35
Phosphorus	75	125	70	140	20	35
Potassium	75	125	70	140	20	35
Selenium	75	125	70	140	20	35
Silica (SiO_2)	75	125	70	140	20	35
Silver	75	125	70	140	20	35
Sodium	75	125	70	140	20	35
Strontium	75	125	70	140	20	35
Thallium	75	125	70	140	20	35
Tin	75	125	70	140	20	35
Titanium	75	125	70	140	20	35
Vanadium	75	125	70	140	20	35
Zlnc	75	125	70	140	20	35

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TABLE 3
REPORTING LIMITS

	PE Optima 3000 DV and TJA Trace ICP Analyzers (mg/L)
ALUMINUM	0.10 or 0.02
ANTIMONY	0.05 or 0.005
ARSENIC	0.005
BARIUM	0.01 or 0.005
BERYLLIUM	0.005 or 0.001
BORON	0.03
CADMIUM	0.005 or 0.001
CALCIUM	0.10
CHROMIUM	0.01 or 0.005
COBALT	0.01
COPPER	0.01 or 0.0025
IRON	0.01
LEAD	0.05 or 0.0025
MAGNESIUM	0.10
MANGANESE	0.01
MOLYBDENUM	0.05 or 0.005
NICKEL	0.025 OR 0.004
POTASSIUM	2.5 or 1.0
SELENIUM	0.005
SILVER	0.01 or 0.005
SODIUM	2.0 or 1.0
STRONTIUM	0.01
THALLIUM	0.005
TIN	0.05
TITANIUM	0.01
VANADIUM	0.01
ZINC	0.01 or 0.0025

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Mercury in Liquid Waste

(Automated Cold-Vapor Technique)

Reference Method No.: **EPA 7470A**

Reference: SW-846, Test Methods for Evaluating Solid Waste: Physical/Chemical Methods, EPA SW-846, Update II, September 1994.

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Alpha Analytical Labs
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Prepared by:

Name: Joseph Clements Position: Inorganics Supervisor

Signature: _____ Date: 7/30/04

Authorized by:

Name: James Todaro Position: Laboratory Director

Signature: _____ Date: 7/30/04

ISSUE AMENDMENTS

Changes since last issue:

Section 9.6: Clarified calculations.

Section 10.4: Deleted reference regarding utilization of method of standard additions. Added preparation, calculation equation and acceptance criteria for a post-analytical spike.

Mercury in Liquid Waste

(Automated Cold-Vapor Technique)

Reference Method No.: **EPA 7470A**

Reference: SW-846, Test Methods for Evaluating Solid Waste: Physical/Chemical Methods, EPA SW-846, Update II, September 1994.

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1. Scope and Application

Matrices: Method 7470 is a cold-vapor atomic absorption procedure approved for determining the concentration of mercury in mobility-procedure extracts, aqueous wastes, and ground waters. (Method 7470 can also be used for analyzing certain solid and sludge-type wastes; however, Method 7471 is usually the method of choice for these waste types.) All samples must be subjected to an appropriate dissolution step prior to analysis.

Definitions: See Alpha Laboratories Quality Manual Appendix A.

The data report packages present the documentation of any method modification related to the samples tested. Depending upon the nature of the modification and the extent of intended use, the laboratory may be required to demonstrate that the modifications will produce equivalent results for the matrix. Approval of all method modifications is by one of the following laboratory personnel before performing the modification: Area Supervisor, Metals Manager, Laboratory Services Manager, Laboratory Director, or Quality Assurance Officer.

This method is restricted to use by or under the supervision of analysts experienced in the operation of the Mercury Analyzer and in the interpretation of Mercury data. Each analyst must demonstrate the ability to generate acceptable results with this method by performing an initial demonstration of capability, analyzing a proficiency test sample and completing the record of training.

After initial demonstration, ongoing demonstration is based on acceptable laboratory performance of at least a quarterly laboratory control sample or acceptable performance from an annual proficiency test sample. A major modification to this procedure requires demonstration of performance. The identification of major method modification requiring performance demonstration is directed by the QA Officer and Laboratory Director on a case-by-case basis.

2. Summary of Method

Prior to analysis, the liquid samples must be prepared according to the procedure discussed in this method.

Method 7470, a cold-vapor atomic absorption technique, is based on the absorption of radiation at 253.7-nm by mercury vapor. The mercury is reduced to the elemental state and aerated from solution in a closed system. The mercury vapor passes through a cell positioned in the light path of an atomic absorption spectrophotometer. Absorbance (peak height) is measured as a function of mercury concentration.

2.1 Method Modifications from Reference

2.1.1 A smaller sample sized is prepared, and therefore proportionately less reagent volumes are used.

2.1.2 The original method does not address the automated instrument procedure.

3. Detection Limits

The laboratory follows the procedure found in 40CFR Part 136 to determine the MDL on an annual basis. The method detection limits determined by the laboratory are on file for review.

The typical reporting limit for Mercury is 0.001mg/L. This satisfies Massachusetts, GW1 and GW 2 criteria. Connecticut mobility criteria for SPLP is 0.0004mg/L, Rhode Island is 0.002mg/L, and the Drinking Water reporting limit is 0.0002mg/L.

4. Interferences

Potassium permanganate is added to eliminate possible interference from sulfide. Concentrations as high as 20 mg/L of sulfide as sodium sulfide do not interfere with the recovery of added inorganic mercury from reagent water.

Copper has also been reported to interfere; however, copper concentrations as high as 10 mg/L had no effect on recovery of mercury from spiked samples.

Seawaters, brines, and industrial effluents high in chlorides require additional permanganate (as much as 25 mL) because, during the oxidation step, chlorides are converted to free chlorine, which also absorbs radiation of 253.7 nm. Care must therefore be taken to ensure that free chlorine is absent before the mercury is reduced and swept into the cell. This may be accomplished by using an excess of hydroxylamine sulfate reagent (25 mL). In addition, the dead air space in the BOD bottle must be purged before adding stannous sulfate. Both inorganic and organic mercury spikes have been quantitatively recovered from seawater by using this technique.

Certain volatile organic materials that absorb at this wavelength may also cause interference. A preliminary run without reagents should determine if this type of interference is present.

5. Safety

The toxicity or carcinogenicity of each reagent and standard used in this method is not fully established; however, each chemical compound should be treated as a potential health hazard. From this viewpoint, exposure to these chemicals must be reduced to the lowest possible level by whatever means available. A reference file of material data handling sheets is available to all personnel involved in the chemical analysis. Additional references to laboratory safety are available in the Chemical Hygiene Plan.

All personnel handling environmental samples known to contain or to have been in contact with municipal waste must follow safety practices for handling known disease causative agents.

Mercury compounds are highly toxic if swallowed, inhaled, or absorbed through the skin. Analysis is conducted under a laboratory exhaust hood. The analyst must wear chemical resistant gloves when handling concentrated mercury standards.

The acidification of samples containing reactive materials may result in the release of toxic gases, such as cyanides or sulfides. Therefore, the acidification of samples is to be conducted under a laboratory exhaust hood.

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6. Sample Collection, Preservation, and Handling

6.1 Sample Collection

Samples are collected in either glass or plastic containers.

6.2 Sample Preservation

Samples are preserved with HNO_3 to a pH of <2.

6.3 Sample Handling

Samples are stored under refrigeration at 4°C and analyzed as soon as possible after collection. The samples have a 28-day holding time from the time of collection.

7. Equipment and Supplies

7.1 Perkin Elmer FIMS 100 Atomic absorption spectrophotometer: Use instrument settings recommended by the manufacturer. The PE FIMS is designed specifically for the measurement of mercury using the cold-vapor technique.

7.1.1 The FIMS has a PC that serves as a data station, collects and compiles the data, and the PC also contains the required software and hardware to operate the FIMS.

7.1.2 The FIMS employs a Plexiglass tube; it has an i.d. of 4mm, and an optical path length of 260mm. It has removable quartz windows on both ends of the tube. The cell is pre-aligned, so there is no need to align the cell for maximum throughput of energy.

7.1.3 The FIMS uses peristaltic pumps to transport the various reagents and sample through the system. The speed of the pumps is under software control: 20 – 120rpm or off.

7.1.3.1 Each pump accepts up to four magazines, which hold the pump tubing in place. There are different size magazines for different pump tubing sizes. Refer to the FIMS manual for replacement sizes. The pump tubing is available in different diameters depending on the reagent used. The different sizes have different colored collars. These can be ordered from Perkin Elmer.

7.1.4 The FIMS employs a 5-port Flow Injection Valve. The valve has two positions: fill and inject. The valve uses a sample loop to switch between fill and inject. The sample loops are made from PTFE. Alpha utilizes a 500µL loop. Sizes can range from 50 – 1000µL.

7.1.5 Sample and reagent are mixed in the manifold. The manifold has two purposes: to either initiate the reaction or to dilute one of the two mixing streams. The manifold blocks have three channels that are interconnected. The inlets of the channels have a ¼ -inch 28UNF internal screw thread. The blocks are made from inert, translucent plastic.

7.1.6 The gas/liquid separator is used in the mercury cold-vapor technique to separate the gas and liquid in the mixture as it leaves the manifold. It is connected to the manifold block by way of connector pegs.

7.1.7 An inert carrier gas is required for mercury determinations with FIMS. The FIMS is hard plumbed to accept Argon. The Argon is plumbed into the rear of the spectrometer, at the GAS IN connection. The gas outlet, flow regulator and flow gauge are on the front panel of the FIMS. Usable flows are between 40mL/minute and 250mL/minute at a recommended gas inlet pressure between 320kPa and 400kPa. The gas flow is off when the control knob is turned fully clockwise.

7.1.8 The radiation source is a low-pressure mercury lamp that is specific for the FIMS. This may be purchased from Perkin Elmer. The detector is a photocell with maximum sensitivity at 254nm.

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7.1.9 Waste is pumped directly into a waste bottle. When the waste is full, it is emptied into the Metals/Wet Chem waste drum in the transfer room.

7.2 Hot plate or equivalent: Adjustable and capable of maintaining a temperature of 90-95°C.

7.3 Graduated cylinder or equivalent: Rinse once with 50% HNO_3 and then rinse with reagent water prior to use.

7.4 Volumetric Flasks, Class A, various volumes: Rinse once with 50% HNO_3 and then rinse with reagent water prior to use.

7.5 Water Bath: Fisher Isotemp Water Bath, 28L capacity.

8. Standards and Reagents

8.1 Reagent Water: Reagent water is DI water shown to be interference free. All references to water in this method will refer to reagent water unless otherwise specified.

8.2 Sulfuric acid (H_2SO_4), concentrated: Reagent grade.

8.3 Hydrochloric acid, concentrated: Trace Metal grade.

8.4 Carrier, Hydrochloric Acid, 3%: This is the ***carrier*** for the PE FIMS Instrument. In a 1L volumetric flask, add 30mL concentrated trace grade HCl (Section 8.3). Bring to volume with reagent water.

8.5 Reductant, Stannous Chloride in 3% HCl: This is the ***reductant*** for the PE FIMS Instrument. In a 1L volumetric flask, add 30mL concentrated trace grade HCl and 11g $SnCl_2 \cdot 2H_20$. Mix to dissolve the solid and bring to volume with reagent water.

8.6 Nitric acid (HNO_3), concentrated: Reagent grade of low mercury content. If a high reagent blank is obtained, it may be necessary to distill the nitric acid.

8.7 Sodium chloride-hydroxylamine hydrochloride solution: Dissolve 12 g of sodium chloride and 12 g of hydroxylamine hydrochloride in reagent water and dilute to 100mL.

8.8 Potassium permanganate, mercury-free, 5% solution (w/v): Dissolve 5 g of potassium permanganate in 100 mL of reagent water.

8.9 Potassium persulfate, 5% solution (w/v): Dissolve 5 g of potassium persulfate in 100 mL of reagent water.

8.10 Mercury Stock Standard, 1000ppm: Purchased from a commercial source with a certificate of analysis. Purchase three different sources.

8.11 Mercury Stock Calibration Standard, 10ppm: To a 100mL volumetric flask, add 5mL of concentrated HNO_3 and 1mL of 1000ppm Mercury Stock Standard (Section 8.10, use one source). Bring to volume with reagent water. Prepare weekly.

8.12 Mercury Working Calibration Standard / Matrix Spike Solution, 0.1ppm: To a 500mL volumetric flask, add 25mL of concentrated HNO_3 and 5mL of 10ppm Mercury Stock Standard (Section 8.11). Bring to volume with reagent water. Prepare weekly.

8.13 Mercury Calibration Standards

8.13.1 0 ppm Calibration Standard: To a 200mL volumetric flask, add 10mL of concentrated HNO_3 (Section 8.6). Bring to volume with reagent water.

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8.13.2 **0.0002ppm Calibration Standard:** To a 250mL volumetric flask, add 0.5mL of 0.1ppm Working Standard (Section 8.12) and 12.5mL of concentrated HNO_3 (Section 8.6). Bring to volume with reagent water.

8.13.3 **0.0005ppm Calibration Standard:** To a 100mL volumetric flask, add 0.5mL of 0.1ppm Working Standard (Section 8.12) and 5.0mL of concentrated HNO_3 (Section 8.6). Bring to volume with reagent water.

8.13.4 **0.001ppm Calibration Standard:** To a 100mL volumetric flask, add 1.0mL of 0.1ppm Working Standard (Section 8.12) and 5.0mL of concentrated HNO_3 (Section 8.6). Bring to volume with reagent water.

8.13.5 **0.002ppm Calibration Standard:** To a 100mL volumetric flask, add 2.0mL of 0.1ppm Working Standard (Section 8.12) and 5.0mL of concentrated HNO_3 (Section 8.6). Bring to volume with reagent water.

8.13.6 **0.005ppm Calibration Standard:** To a 100mL volumetric flask, add 5.0mL of 0.1ppm Working Standard (Section 8.12) and 5.0mL of concentrated HNO_3 (Section 8.6). Bring to volume with reagent water.

8.13.7 **0.010ppm Calibration Standard / Post Analytical Spike Solution:** To a 100mL volumetric flask, add 10mL of 0.1ppm Working Standard (Section 8.12) and 5.0mL of concentrated HNO_3 (Section 8.6). Bring to volume with reagent water.

8.14 Mercury Stock LCS Standard, 10ppm: Prepare monthly. To a 100mL volumetric flask add 25mL of reagent water and 5mL of concentrated HNO_3 (Section 8.6). Add 1mL of 1000ppm Mercury Stock Standard (Section 8.10, use alternate source than that used for the calibration standards). Bring to volume with reagent water.

8.15 Mercury Working LCS Standard, 0.1ppm: Prepare monthly. To a 100mL volumetric flask add 25mL of reagent water and 5mL concentrated HNO_3 (Section 8.6). Add 1mL of 10ppm Stock LCS Standard (Section 8.14). Bring to volume with reagent water.

8.16 Mercury LCS Standard, 0.001ppm: Prepare with each batch of samples. To a 100mL volumetric flask add 25mL of reagent water and 5mL concentrated HNO_3 (Section 8.6). Add 1mL of 0.1ppm Working LCS Standard (Section 8.15). Bring to volume with reagent water. A 25mL aliquot of this standard is treated for the LCS as in Section 9.1.2.

8.17 Mercury Stock ICV Standard, 10ppm: Prepare monthly. To a 100mL volumetric flask add 25mL of reagent water and 5mL of concentrated HNO_3 (Section 8.6). Add 1mL of 1000ppm Mercury Stock Standard (Section 8.10, use alternate source than that used for both the calibration standards and the LCS Stock Standard). Bring to volume with reagent water.

8.18 Mercury Working ICV Standard, 0.3ppm: Prepare monthly. To a 100mL volumetric flask add 25mL of REAGENT water and 5mL of concentrated HNO_3 (Section 8.6). Add 3mL of 10ppm Stock ICV Standard (Section 8.17). Bring to volume with reagent water.

8.19 Mercury ICV Standard, 0.003ppm: Prepare with each batch of samples. To a 100mL volumetric flask add 25mL of reagent water and 5mL of concentrated HNO_3 (Section 8.6). Add 1mL of 0.3ppm Working ICV Standard (Section 8.18). Bring to volume with reagent water. A 25mL aliquot of this standard is treated for the ICV as in Section 9.1.2.

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9. Procedure

9.1 Preparation and Digestion

9.1.1 Samples

9.1.1.1 Transfer 25mL of the sample (or an aliquot of the sample diluted to 25mL with reagent water) to a 50mL centrifuge tube.

9.1.1.2 Add 1.25mL of concentrated H_2SO_4 (Section 8.2), 0.625mL of concentrated HNO_3 (Section 8.6), 2mL of Potassium Persulfate Solution (Section 8.9), and 3.75mL of Potassium Permanganate Solution (Section 8.8)

9.1.1.3 Heat samples for 2 hours in a 95°C waterbath. Cool, and add 1.5mL of Sodium Chloride-Hydroxylamine hydrochloride solution (Section 8.7).

9.1.1.4 Filter the sample if needed to remove any sediment or particulate.

9.1.1.5 Analyze samples using the PE FIMS 100 as outlined in Section 9.4.

9.1.2 Standards

Standards are prepared each time samples are digested.

9.1.2.1 Transfer 25mL of each of the standards (Sections 8.13.1 through 8.13.7, 8.16, and 8.19) into 50mL centrifuge tubes.

9.1.2.2 Add 1.25mL of concentrated H_2SO_4 (Section 8.2), 0.625mL of concentrated HNO_3 (Section 8.6), 2mL of Potassium Persulfate Solution (Section 8.9), and 3.75mL of Potassium Permanganate Solution (Section 8.8)

9.1.2.3 Heat samples for 2 hours in a 95°C waterbath. Cool, and add 1.5mL of Sodium Chloride-Hydroxylamine hydrochloride solution (Section 8.7).

9.1.2.4 The digested calibration standards (Sections 8.13.1 through 8.13.7) are used in Section 9.2 to generate a calibration curve on the PE FIMS instrument.

9.2 Initial Calibration

Construct a calibration curve by plotting the absorbances of standards versus micrograms of mercury. Determine the peak height of the unknown from the absorbance maxima on the spectrometer, and read the mercury value from the standard curve.

The curve correlation coefficient (cc) must be greater than or equal to 0.995 in order for the curve to be linear. If the correlation coefficient is less than 0.995, find and correct the problem. When the problem has been corrected, re-analyze either the previous standards or new standards. When the curve has generated an acceptable cc then the analysis can continue with the ICV.

9.3 Standardization (Continuing Calibration Verification)

Continuing calibration verification samples are analyzed after every 10 samples in the sample run, as outlined in Section 9.4.5.

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9.4 Equipment Operation and Sample Analysis

Sample and standard analysis using the Perkin Elmer FIMS 100:

9.4.1 Instrument Setup

9.4.1.1 Turn the instrument on by flipping the power switch on the face of the instrument. The autosampler will initialize itself.

9.4.1.2 Choose AA Winlab Analyst from the START menu. The autosampler will initialize again.

NOTE: The instrument must be turned on before the application is started. Otherwise, an error message will result.

9.4.1.3 Click the button next to "open a custom workspace".

9.4.1.4 Select "startup.fms" from the list and click OPEN. This will open the "FIAS Control" and "Automated Analysis" windows.

9.4.1.5 Click on the "Analyze" tab in the Automated Analysis window, then click on the "Select Location" button. Click OK and the probe will go to the autosampler rinse.

9.4.1.6 Fill the carrier and reductant bottles.

9.4.1.6.1 The Carrier is 3% HCl (Section 8.4).

9.4.1.6.2 The Reductant is 1.1% $SnCl_2$ in 3% HCl (Section 8.5).

9.4.1.7 Allow the instrument to warm up while clearing samples. Samples that are cloudy or with particulate present after clearing must be filtered through Whatman 41 filter paper before analysis.

9.4.1.8 Place carrier takeup line (blue/yellow tubing) and reductant takeup line (red/red tubing) into graduated cylinders containing reagent water.

9.4.1.9 Load carrier and reductant lines into pump magazines above the roller so that the long ends come out on the right side. The carrier line goes into the inner magazine, and the reductant line goes into the outer magazine.

9.4.1.10 Load the two waste lines into the pump magazines below the roller.

9.4.1.10.1 The blue/yellow line goes into the inner two-channel magazine so that the long end comes out on the left side.

9.4.1.10.2 The black line goes into the outer magazine so that the long end comes out on the right side

9.4.1.11 Lock both the top and bottom magazines into place.

9.4.1.12 Unscrew the fitting from the sample absorption cell leading to the liquid vapor separator and place it into an empty dilu-vial.

9.4.1.13 Click the "Pump1" button in the "FIAS Control" window to start the roller.

9.4.1.14 Adjust the tension on the lower pump magazine using the thumbscrews until a steady (but not too fast) stream of bubbles comes out of the liquid vapor separator and through the black tubing.

9.4.1.15 Adjust the tension on the upper pump magazines to obtain the following flow rates:

9.4.1.15.1 Carrier = 9 – 11 mL/minute

9.4.1.15.2 Reductant = 5 – 7 mL/minute

9.4.1.16 When the flow rates are set, click on the "Pump1" button to stop the roller.

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9.4.1.17 Place carrier takeup line in the carrier bottle and reductant line in the reductant bottle.

9.4.1.18 Click the "Pump1" button to restart the roller. Allow to run for a couple of minutes to flush the reagent water from the lines. Click on the "Fill/Inject" button several times to flush the sample loop.

9.4.1.19 With the "Fill/Inject" button in the "Fill" position, (button not depressed), click the "Pump1" button to stop the roller.

9.4.1.20 Remove the cap from the liquid/vapor separator and wipe dry with a KimWipe. Blow canned air through the vapor transfer line to dry it out.

9.4.1.21 Place a PTFE membrane, rough side up, in the liquid/vapor separator; replace the cap and reattach the vapor transfer line to the sample absorption cell.

9.4.1.22 Click on the "Pump1" button to start the roller.

9.4.1.23 Adjust the gas flow by turning the black knob below the air flow meter to obtain a reading of just over 50.

9.4.1.24 Click on the "Pump1" button to stop the roller.

9.4.2 Creating a Sample Information File and Loading the Sample Tray

9.4.2.1 Click the "SamInfo" button on the toolbar.

9.4.2.2 In the description line, type "prep date MM/DD/YY".

9.4.2.3 In the analyst line, type the analyst's initials.

9.4.2.4 Drag the scroll bar so that the autosampler location 12 is showing.

9.4.2.5 Double-click the "Sample Units" cell in line 12.

9.4.2.6 Select "µg/L" from the list and enter the range of locations (12 up to 44) and click OK.

9.4.2.7 Starting with position 12, type in the sample ID

9.4.2.8 When finished, choose "Save As" from the "File" menu, then choose the "Sample Information" file.

9.4.2.9 Save the file as MMDDYYA

9.4.2.10 Load the samples into the tray as follows:

Position 1	Calibration Blank
Position 2	0.2ppb Standard
Position 3	0.5ppb Standard
Position 4	1.0ppb Standard
Position 5	2.0ppb Standard
Position 6	5.0ppb Standard
Position 7	10.0ppb Standard
Position 8	ICV
Position 9	ICB
Position 10	CCV
Position 11	CCB

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Position 12 PBW listed in the sample information file.

Position 13 LCSW listed in the sample information file.

Positions 14 – 44 Samples as listed in the sample information file.

9.4.2.11 Click the "Load Tray" button.

9.4.2.12 Replace the empty tray with the tray containing the standards and samples.

9.4.2.13 Click the "Load Tray" button.

9.4.2.14 Click the "Select Location" button and click OK to lower the probe into the autosampler rinse.

9.4.3 Instrument Calibration

9.4.3.1 Click the "Workspace" button in the toolbar.

9.4.3.2 Select daves.fms and click OK.

9.4.3.3 Click on the Setup tab in the automated analysis window.

9.4.3.4 Click the "Browse" button under "Sample Information File"

9.4.3.4.1 Select the sample information file that you want to open and click OK.

9.4.3.5 Click the "Browse" button under "Results Data Set Name".

9.4.3.5.1 Type in the data set name in the format MMDDYYA and click OK.

9.4.3.6 Click the "X" under the "Use Entire Sample Info File" so that it disappears.

9.4.3.7 Under the "Use Autosampler Locations Listed Below", enter the order of samples to be run. NOTE: Do not include standards and QC checks.

9.4.3.8 Click the "Analyze" tab.

9.4.3.9 Click the "Calibrate' button

9.4.3.9.1 The instrument will run the calibration curve.

9.4.3.9.2 Watch the calibration blank run; if the readings vary widely, stop the run by clicking the "Calibrate" button.

9.4.4 Initial Calibration Verification

9.4.4.1 When the calibration is complete (6 – 7 minutes), click the "Analyze Samples" button.

9.4.4.1.1 The instrument will run the ICV and ICB. If the recoveries of these are within the proper ranges (Sections 10.2.1 and 10.3.1), the instrument will continue with analysis of samples as outlined in Section 9.4.5.

9.4.4.1.2 If the recoveries of the ICV and/or ICB are not within the proper ranges (Sections 10.2.1 and 10.3.1), the problem must be found and corrected, and the instrument recalibrated per Section 9.4.3.

9.4.5 Sample Analysis

9.4.5.1 The instrument will now run ten analytical samples, a CCV and CCB, ten analytical samples, CCV, CCB, etc. The CCBs and CCVs must be recovered within the proper ranges (Sections10.2.2 and 10.3.2) for analysis to continue.

9.4.5.2 If the recoveries of the CCB and/or CCV are not within the proper ranges (Sections 10.2.1 and 10.3.1), the instrument must be recalibrated per Section 9.4.3. The samples that were analyzed after the last valid CCV/CCB must be re-analyzed.

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9.4.6 Instrument Shut Down

9.4.6.1 When analysis is complete, click the "Workspace" button in the toolbar.

9.4.6.2 Place reagent takeup lines in a beaker of reagent water.

9.4.6.3 Click on the "Analyze" tab.

9.4.6.4 Click on the "Pump1" button to start the roller

9.4.6.4.1 Allow to run for several minutes to flush reagents out of the lines.

9.4.6.4.2 Click on the "Fill/Inject" button several times to rinse the sample loop.

9.4.6.5 Click the "Move Probe Up/Down" button to raise the probe out of the autosampler rinse.

9.4.6.6 Pull the reagent takeup lines out of the reagent water beaker to allow the pump to draw air through the lines.

9.4.6.7 Click "Fill/Inject" button several times to pull air through the sample loop.

9.4.6.8 With the "Fill/Inject' button in the "Fill" position, click "Pump1" button to stop roller.

9.4.6.9 Unlock the top and bottom pump magazines and remove tubing from the magazines.

9.4.6.10 Return the reagent takeup lines to the reagent water beaker.

9.4.6.11 Click the "Move Probe Up/Down" button to lower the probe into the rinse beaker.

9.4.6.12 Select "EXIT" from the File menu to exit the WinLab application.

9.4.6.12.1 A "Shutting Down System" message will display.

9.4.6.13 When the desktop appears, turn off the power switch on the instrument.

9.4.6.14 Dump the samples and instrument waste in the Metals/Wet Chem waste drum located in the transfer room.

9.5 Preventative Maintenance

Preventative maintenance is conducted per the manufacturer's instructions. All preventative maintenance is recorded in the Instrument Maintenance Logbook.

9.6 Calculations

Calculate Mercury concentration from the daily calibration curve. The curve is generated utilizing a straight-line equation defined as:

$$A = k_1 + k_2C$$

Where:

A = Average peak height of the sample/standard integrations
C = Sample/Standard Concentration, µg/L
k_1 = y-intercept
k2 = slope

The instrument will plot peak height against concentration (µg/L). The result is generated in µg/L . This value is divided by 1000 to convert the units to mg/L. If the sample is diluted (DF), the result is multiplied by the DF to generate the final result.

$$\text{Result, mg/L} = (\text{concentration, µg/L}) \times (1\text{mg}/1000\mu\text{g}) \times (\text{DF})$$

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10. Quality Control and Data Assessment

The laboratory must maintain records to document the quality of data that is generated. Ongoing data quality checks are compared with established performance criteria to determine if the results of analyses meet the performance characteristics of the method. When results of sample spikes indicate atypical method performance, a calibration verification standard is used to confirm the measurements were performed in an in-control mode of operation.

10.1 Demonstration of Capability

The analyst must make an initial, one-time, demonstration of the ability to generate acceptable accuracy and precision with this method. Each time a method modification is made, the analyst is required to repeat the procedure.

When one or more of the parameters tested fail at least one of the acceptance criteria, the analyst must locate and correct the source of the problem and repeat the test for failed parameters of the method.

Repeated failure confirms a general problem with the measurement system or analytical technique of the analyst. If the failure repeats, locate and correct the source of the problem and repeat the test for all parameters listed in the method.

10.2 Blank

10.2.1 ICB: This is a 25mL aliquot of 0ppm calibration standard brought through the preparation procedure as outlined in Section 9.1.2. The ICB must be within ± 0.2µg/L.

10.2.2 CCB: This is a 25mL aliquot of 0ppm calibration standard brought through the preparation procedure as outlined in Section 9.1.2. The CCB must be recovered within ± 0.2µg/L.

10.3 Calibration Verification and Laboratory Control Samples (LCS)

10.3.1 ICV Standard: The ICV Standard consists of a 25mL aliquot of 0.003ppm Mercury ICV Standard (Section 8.19). This standard is brought through the preparation procedure as outlined in Section 9.1.2. The ICV must be recovered within 5% of the true value.

10.3.2 CCV Standard: The CCV Standard consists of a 25mL aliquot of 0.005ppm calibration standard (Section 8.13.6). This standard is brought through the preparation procedure as outlined in Section 9.1.2. The CCV must be recovered within 10% of the true value.

10.3.3 LCS Standard: The LCS Standard consists of a 25mL aliquot of 0.001ppm Mercury LCS Standard (Section 8.16). This standard is brought through the preparation procedure as outlined in Section 9.1.2. The LCS Standard must be recovered within ± 30% of the true value.

10.4 Matrix Spike

The matrix spike sample consists of 0.25mL of the 0.1ppm Working Calibration/Matrix Spike Standard (Section 8.12) and 1.25mL concentrated NHO_3 (Section 8.6) added to a 50mL centrifuge tube. Bring to a final volume of 25mL with the sample. The final concentration of the matrix spike is 0.001mg/L.

The matrix spike sample is brought through the preparation procedure as outlined in Section 9.1.2. A matrix spike is analyzed once per batch of samples. A batch consists of 10 samples for DW samples, influents and effluents; 20 samples for monitoring wells and surface waters. The recovery of the matrix spike must be between 70 – 130%.

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If the recovery of the matrix spike is out of range, a post-analytical spike is analyzed. Prepare the post analytical spike by adding 5mL of 0.010ppm Calibration Standard / Post Analytical Spike Solution (Section 8.13.7) and 5mL of the sample digestate to a 50mL centrifuge tube for a final concentration of 0.005mg/L. Analyze the post spike as outlined in Section 9.4.

Calculate the post spike concentration as follows:

Post Analytical Spike Sample Concentration (mg/L) =

[Sample Concentration (mg/L) x (0.5)] + 0.005mg/L

The percent recovery of the post-analytical spike must be between 75 – 125%.

If the recovery of the post analytical spike continues to be out of range, the sample and its spike are redigested as per Section 9.1.1.

10.5 Duplicates

A sample is analyzed in duplicate once per batch of samples. A batch consists of 10 samples for DW samples, influents and effluents; 20 samples for monitoring wells and surface waters.

10.6 Control Limits

The laboratory maintains performance records to document the quality of data that is generated. Method accuracy for samples is assessed and records maintained. After the analysis of 20 spiked samples, and 20 laboratory control samples, calculate the average percent recovery (R) and the standard deviation of the percent recovery (S).

Control limits for the method parameters are generated by the QC staff and distributed to the analysts. The control limits are calculated based on in-house performance data. The limits are compared to the control limits found in the reference method.

10.7 Analytical Sequence

- Calibration Blank
- 0.0002 ppm Calibration Standard
- 0.0005 ppm Calibration Standard
- 0.001 ppm Calibration Standard
- 0.002 ppm Calibration Standard
- 0.005 ppm Calibration Standard
- 0.010 ppm Calibration Standard
- ICV
- ICB
- Ten analytical samples
- CCV
- CCB
- Ten analytical samples
- CCV
- CCB
- Etc.

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11. Method Performance

The method detection limit (MDL) is defined as the minimum concentration of a substance that can be measured and reported with 99% confidence that the value is above zero. The MDL concentrations were obtained using reagent water. Similar results were achieved using representative wastewaters. The MDL actually achieved in a given analysis will vary depending on instrument sensitivity and matrix effects.

Method performance data is on file in the laboratory QC department. Comparison of method performance data for the laboratory to the reference method criteria occurs when laboratory in-house acceptance limits are generated. In-house generated data must be within the specifications of the reference method or the analysis is not continued until corrective action is completed.

12. Corrective Actions

Holding time exceedence and improper preservation are noted on the nonconformance report form.

Perform routine preventative maintenance following manufacturer's specification. Record all maintenance in the instrument logbook.

Review of standards, blanks and standard response for acceptable performance occurs for each batch of samples. Record any trends or unusual performance on a nonconformance action form.

If the CV or LCS recovery of any parameter falls outside the designated acceptance range, the laboratory performance for that parameter is judged to be out of control, and the problem must be immediately identified and corrected. The analytical result for that parameter in the unspiked samples is suspect and is only reported for regulatory compliance purposes with the appropriate nonconformance action form. Immediate corrective action includes reanalyzing all affected samples by using any retained sample before the expiration of the holding time.

13. Pollution Prevention

See Chemical Hygiene Plan for pollution prevention operations.

14. Waste Management

See Chemical Hygiene Plan for waste handling and disposal.

15. Attachments

Figure 1: Method 7470A Flow Chart

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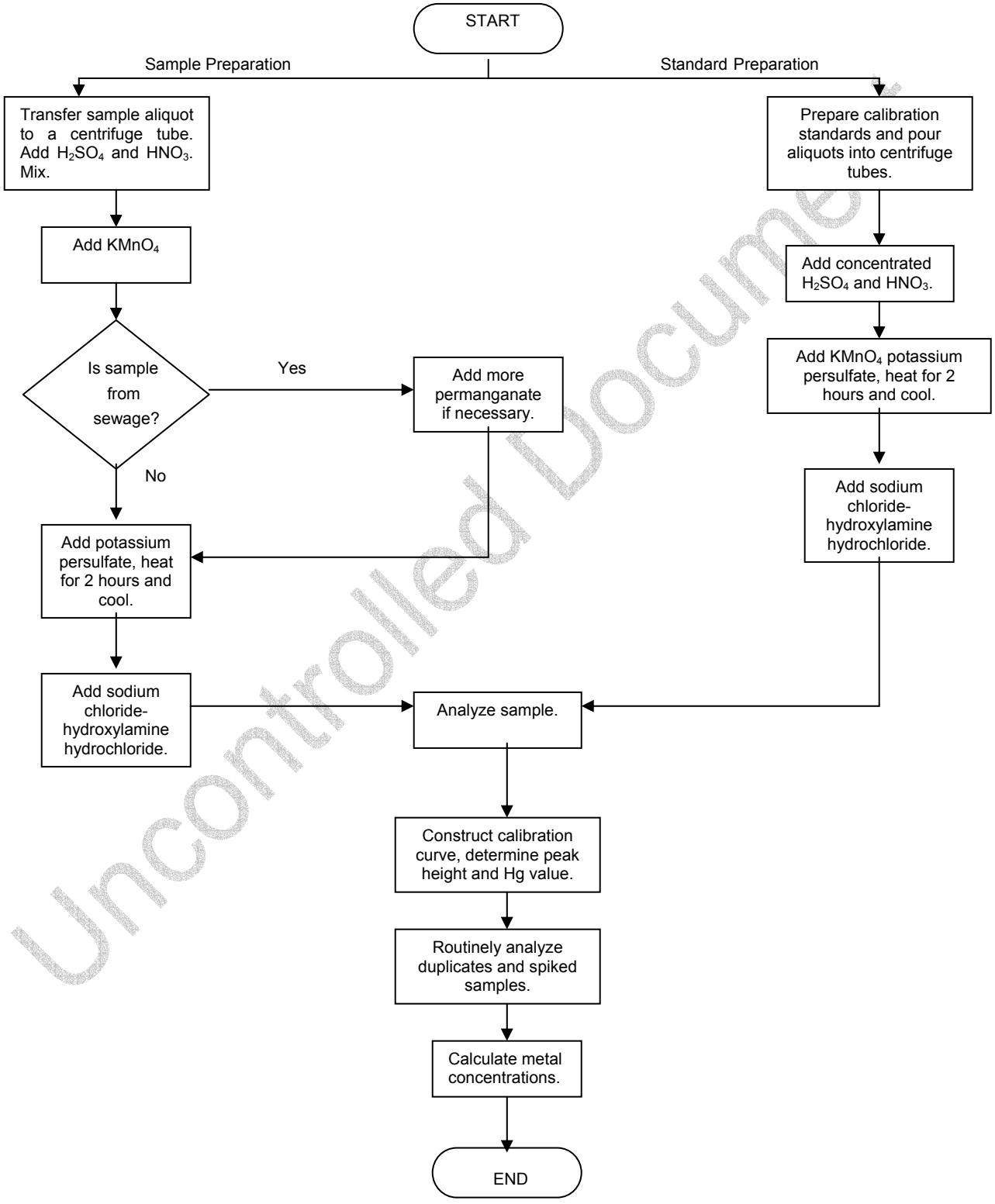
Figure 1

Method 7470A Flow Chart



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Mercury in Solid or Semisolid Waste

(Manual Cold-Vapor Technique)

Reference Method No.: **EPA 7471A**

Reference: SW-846, Test Methods for Evaluating Solid Waste: Physical/Chemical Methods, EPA SW-846, Update II, September 1994.

Copy No. _____

Alpha Analytical Labs
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Prepared by:

Name: Joseph Clements Position: Inorganics Supervisor

Signature: _____ Date: 7/30/04

Authorized by:

Name: James Todaro Position: Laboratory Director

Signature: _____ Date: 7/30/04

ISSUE AMENDMENTS

Changes since last issue:

Section 9.6: Clarified calculations.

Section 10.2: Added Blank acceptance criteria.

Section 10.5: Added preparation, calculation equation and acceptance criteria for a post-analytical spike.

Mercury in Solid or Semisolid Waste

(Manual Cold-Vapor Technique)

Reference Method No.: **EPA 7471A**

Reference: SW-846, Test Methods for Evaluating Solid Waste: Physical/Chemical Methods, EPA SW-846, Update II, September 1994.

1. Scope and Application

Matrices: Method 7471 is approved for measuring total mercury (organic and inorganic) in soils, sediments, bottom deposits, and sludge-type materials. All samples must be subjected to an appropriate dissolution step prior to analysis. If this dissolution procedure is not sufficient to dissolve a specific matrix type or sample, then this method is not applicable for that matrix.

Definitions: See Alpha Laboratories Quality Manual Appendix A

The data report packages present the documentation of any method modification related to the samples tested. Depending upon the nature of the modification and the extent of intended use, the laboratory may be required to demonstrate that the modifications will produce equivalent results for the matrix. Approval of all method modifications is by one of the following laboratory personnel before performing the modification: Area Supervisor, Metals Manager, Laboratory Services Manager, Laboratory Director, or Quality Assurance Officer.

This method is restricted to use by or under the supervision of analysts experienced in the operation of the Mercury Analyzer and in the interpretation of Mercury data. Each analyst must demonstrate the ability to generate acceptable results with this method by performing an initial demonstration of capability, analyzing a proficiency test sample and completing the record of training.

After initial demonstration, ongoing demonstration is based on acceptable laboratory performance of at least a quarterly laboratory control sample or acceptable performance from an annual proficiency test sample. A major modification to this procedure requires demonstration of performance. The identification of major method modification requiring performance demonstration is directed by the QA Officer and Laboratory Director on a case-by-case basis.

2. Summary of Method

Prior to analysis, the solid or semi-solid samples must be prepared according to the procedures discussed in this method.

Method 7471, a cold-vapor atomic absorption method, is based on the absorption of radiation at the 253.7-nm wavelength by mercury vapor. The mercury is reduced to the elemental state and aerated from solution in a closed system. The mercury vapor passes through a cell positioned in the light path of an atomic absorption spectrophotometer. Absorbance (peak height) is measured as a function of mercury concentration.

2.1 Method Modifications from Reference

Alpha analyzes only one 0.6g aliquot of sample.

3. Detection Limits

The laboratory follows the procedure found in 40CFR Part 136 to determine the MDL on an annual basis. The method detection limits determined by the laboratory are on file for review.

The reporting limit for this method is 0.25mg/Kg.

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4. Interferences

Potassium permanganate is added to eliminate possible interference from sulfide. Concentrations as high as 20 mg/Kg of sulfide, as sodium sulfide, do not interfere with the recovery of added inorganic mercury in reagent water.

Copper has also been reported to interfere; however, copper concentrations as high as 10 mg/Kg had no effect on recovery of mercury from spiked samples.

Samples high in chlorides require additional permanganate (as much as 25 mL) because, during the oxidation step, chlorides are converted to free chlorine, which also absorbs radiation of 253 nm. Care must therefore be taken to ensure that free chlorine is absent before the mercury is reduced and swept into the cell. This may be accomplished by using an excess of hydroxylamine sulfate reagent (25 mL). In addition, the dead air space in the BOD bottle must be purged before adding stannous chloride.

Certain volatile organic materials that absorb at this wavelength may also cause interference. A preliminary run without reagents should determine if this type of interference is present.

5. Safety

The toxicity or carcinogenicity of each reagent and standard used in this method is not fully established; however, each chemical compound should be treated as a potential health hazard. From this viewpoint, exposure to these chemicals must be reduced to the lowest possible level by whatever means available. A reference file of material data handling sheets is available to all personnel involved in the chemical analysis. Additional references to laboratory safety are available in the Chemical Hygiene Plan.

All personnel handling environmental samples known to contain or to have been in contact with municipal waste must follow safety practices for handling known disease causative agents.

Because mercury vapor is toxic, precaution must be taken to avoid its inhalation.

6. Sample Collection, Preservation, and Handling

6.1 Sample Collection

Samples may be collected in plastic or glass containers.

6.2 Sample Preservation

None.

6.3 Sample Handling

Samples are stored under refrigeration at 4°C and analyzed as soon as possible after collection. The samples have a 28-day holding time from the time of collection.

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7. Equipment and Supplies

7.1 Perkin Elmer FIMS 100 Atomic absorption spectrophotometer: Use instrument settings recommended by the manufacturer. The PE FIMS is designed specifically for the measurement of mercury using the cold-vapor technique.

7.1.1 The FIMS has a PC that serves as a data station, collects and compiles the data, and the PC also contains the required software and hardware to operate the FIMS.

7.1.2 The FIMS employs a Plexiglass tube; it has an i.d. of 4mm, and an optical path length of 260mm. It has removable quartz windows on both ends of the tube. The cell is pre-aligned, so there is no need to align the cell for maximum throughput of energy.

7.1.3 The FIMS uses peristaltic pumps to transport the various reagents and sample through the system. The speed of the pumps is under software control: 20 – 120rpm or off.

7.1.3.1 Each pump accepts up to four magazines, which hold the pump tubing in place. There are different size magazines for different pump tubing sizes. Refer to the FIMS manual for replacement sizes. The pump tubing is available in different diameters depending on the reagent used. The different sizes have different colored collars. These can be ordered from Perkin Elmer.

7.1.4 The FIMS employs a 5-port Flow Injection Valve. The valve has two positions: fill and inject. The valve uses a sample loop to switch between fill and inject. The sample loops are made from PTFE. Alpha utilizes a 500µL loop. Sizes can range from 50 – 1000µL.

7.1.5 Sample and reagent are mixed in the manifold. The manifold has two purposes: to either initiate the reaction or to dilute one of the two mixing streams. The manifold blocks have three channels that are interconnected. The inlets of the channels have a ¼ -inch 28UNF internal screw thread. The blocks are made from inert, translucent plastic.

7.1.6 The gas/liquid separator is used in the mercury cold-vapor technique to separate the gas and liquid in the mixture as it leaves the manifold. It is connected to the manifold block by way of connector pegs.

7.1.7 An inert carrier gas is required for mercury determinations with FIMS. The FIMS is hard plumbed to accept Argon. The Argon is plumbed into the rear of the spectrometer, at the GAS IN connection. The gas outlet, flow regulator and flow gauge are on the front panel of the FIMS. Usable flows are between 40mL/minute and 250mL/minute at a recommended gas inlet pressure between 320kPa and 400kPa. The gas flow is off when the control knob is turned fully clockwise.

7.1.8 The radiation source is a low-pressure mercury lamp that is specific for the FIMS. This may be purchased from Perkin Elmer. The detector is a photocell with maximum sensitivity at 254nm.

7.1.9 Waste is pumped directly into a waste bottle. When the waste is full, it is emptied into the Metals/Wet Chem waste drum in the transfer room.

7.2 Hot plate or equivalent: Adjustable and capable of maintaining a temperature of 90-95°C.

7.3 Graduated cylinder or equivalent.

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8. Standards and Reagents

8.1 Reagent Water: Reagent water is DI water shown to be interference free. All references to water in this method refer to reagent water unless otherwise specified.

8.2 Aqua regia: Prepare immediately before use by carefully adding three volumes of concentrated HCl to one volume of concentrated HNO_3.

8.3 Concentrated Sulfuric Acid, (H_2SO_4)

8.4 Concentrated Hydrochloric Acid, (HCl): Trace grade.

8.5 Reductant, Stannous Chloride in 3% HCl: This is the ***reductant*** for the PE FIMS Instrument. In a 1L volumetric flask, add 30mL concentrated trace grade HCl and 11g $SnCl_2 \cdot 2H_20$. Mix to dissolve the solid and bring to volume with reagent water.

8.6 Carrier, Hydrochloric Acid, 3%: This is the ***carrier*** for the PE FIMS Instrument. In a 1L volumetric flask, add 30mL concentrated trace grade HCl (Section 8.4). Bring to volume with reagent water.

8.7 Potassium permanganate, mercury-free, 5% solution (w/v): Dissolve 5 g of potassium permanganate in 100 mL of reagent water.

8.8 Sodium chloride-hydroxylamine hydrochloride solution: Dissolve 12 g of sodium chloride and 12 g of hydroxylamine hydrochloride in reagent water and dilute to 100 mL.

8.9 Mercury stock solution, 1000ppm: This solution is purchased commercially prepared with a certificate of analysis. Three solutions are purchased, each from a different source.

8.9.1 10ppm Mercury Stock Standard: To a 100mL volumetric flask, add 5mL of concentrated HNO_3 and 1.0mL of 1000ppm Mercury Stock Solution (Section 8.9). Bring to volume with reagent water. This solution is prepared on a weekly basis.

8.9.1.1 0.1ppm Mercury Working Stock / Matrix Spike Solution: To a 500mL volumetric flask, add 5mL of concentrated HNO_3 and 5 mL of 10ppm Mercury Stock Standard (Section 8.9.1). Bring to volume with reagent water. This solution is prepared on a weekly basis.

8.9.2 10ppm Mercury ICV Stock Standard: To a 100mL volumetric flask, add 5mL of concentrated HNO_3 and 1.0mL of Mercury Stock Solution (Section 8.9, from an alternate source than that used in Section 8.9.1). Bring to volume with reagent water.

8.9.2.1 0.3ppm Mercury ICV Working Stock: To a 100mL volumetric flask, add 5mL of concentrated HNO_3 and 3.0mL of 10ppm Hg ICV Stock Standard (Section 8.9.2). Bring to volume with reagent water.

8.9.3 10ppm Mercury LCS Stock Standard: To a 100mL volumetric flask, add 5mL of concentrated HNO_3 and 1.0mL of 1000ppm Mercury Stock Solution (Section 8.9, from an alternate source than that used in Sections 8.9.1 and 8.9.2). Bring to volume with reagent water.

8.9.3.1 0.1ppm Mercury LCS Working Stock: To a 100mL volumetric flask, add 5mL of concentrated HNO_3 and 1.0mL of 10ppm Mercury LCS Stock Standard (Section 8.9.3). Bring to volume with reagent water.

8.10 Ottawa Sand: Purchased from a commercial source.

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9. Procedure

9.1 SET-UP

9.1.1 Sample preparation: Weigh a 0.6-g portion of untreated sample and place in the bottom of a BOD bottle. Add 5 mL of reagent water and 5 mL of aqua regia (Section 8.2). Heat 2 min in a water bath at 95°C. Cool; then add 50 mL reagent water and 15 mL potassium permanganate solution (Section 8.7) to the sample bottle. Mix thoroughly and place in the water bath for 30 min at 95°C. Cool and add 6 mL of sodium chloride-hydroxylamine hydrochloride (Section 8.8) to reduce the excess permanganate.

CAUTION: Perform this addition under a hood, as Cl_2 could be evolved.

Add 55 mL of reagent water. Continue as described under Section 9.4.1.2.1.

9.1.2 Standard preparation: Standard preparation is performed each time samples are digested.

9.1.2.1 Calibration Standards

9.1.2.1.1 0 ppb: Using a graduated pipet, add 10mL of reagent water to a BOD bottle.

9.1.2.1.2 0.5ppb: Using a graduated pipet, add 9.5mL of reagent water. Using a volumetric pipet, add 0.5mL of 0.1ppm Mercury Working Stock (Section 8.9.1.1) to the BOD bottle.

9.1.2.1.3 1.0ppb: Using a graduated pipet, add 9.0mL of reagent water. Using a volumetric pipet, add 1.0mL of 0.1ppm Mercury Working Stock (Section 8.9.1.1) to the BOD bottle.

9.1.2.1.4 2.0ppb: Using a graduated pipet, add 8.0mL of reagent water. Using a volumetric pipet, add 2.0mL of 0.1ppm Mercury Working Stock (Section 8.9.1.1) to the BOD bottle.

9.1.2.1.5 5.0ppb: Using a graduated pipet, add 5.0mL of reagent water. Using a volumetric pipet, add 5.0mL of 0.1ppm Mercury Working Stock (Section 8.9.1.1) to the BOD bottle.

9.1.2.1.6 10ppb: Using a volumetric pipet, add 10mL of 0.1ppm Mercury Working Stock (Section 8.9.1.1) to the BOD bottle.

9.1.2.2 ICV Standard, 3.0ppb: This standard is used for calibration verification.

9.1.2.2.1 Using a graduated pipet, add 9.0mL of reagent water. Using a volumetric pipet, add 1.0mL of 0.3ppm Mercury Working Stock (Section 8.9.2.1) to the BOD bottle. Digest the ICV Standard as in Section 9.1.3.

9.1.2.3 LCS Standard, 1.0ppb: This standard is prepared and analyzed with each analytical batch.

9.1.2.3.1 Prepare the LCS Standard by adding a 1mL aliquot of 0.1ppm Mercury LCS Working Stock (Section 8.9.3.1) to 0.6g of clean Ottawa Sand (Section 8.10). Digest the LCS Standard as in Section 9.1.3.

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9.1.3 Standard Digestion:

To each standard (Sections 9.1.2.1 through 9.1.2.3), add 5 mL of aqua regia (Section 8.2) and heat 2 min in a water bath at 95°C. Allow the standard to cool; add 50 mL reagent water and 15 mL of $KMnO_4$ solution (Section 8.7) to each bottle and return to the water bath for 30 min. Cool and add 6 mL of sodium chloride-hydroxylamine hydrochloride solution (Section 8.8) to reduce the excess permanganate. Add 50 mL of reagent water. Treating each bottle individually, after instrument setup, continue as described in Section 9.4.1.2.1.

9.2 Initial Calibration

Construct a calibration curve by plotting the absorbances of standards versus micrograms of mercury. Determine the peak height of the unknown from the absorbance maxima on the spectrometer, and read the mercury value from the standard curve.

The curve correlation coefficient (cc) must be greater than or equal to 0.995 in order for the curve to be linear. If the correlation coefficient is less than 0.995, find and correct the problem. When the problem has been corrected, re-analyze either the previous standards or new standards. When the curve has generated an acceptable cc, then the analysis can continue with the ICV.

9.3 Standardization (Continuing Calibration Verification)

Analyze an Initial Calibration Verification Standard (ICV), an Initial Calibration Blank sample (ICB) at the start of the analytical run. After every 10 samples, analyze a Continuing Calibration Verification Standard (CCV), and a Continuing Calibration Blank sample (CCB). Determine the concentrations from the calibration curve. The results for the ICV must be within 10% of the true value. The results for the CCV must be within 20% of the true value.

9.4 Equipment Operation and Sample Analysis

The prepared sample is allowed to stand quietly without manual agitation. The circulating pump, which has previously been adjusted to a rate of 1 L/min, is allowed to run continuously. The absorbance, as exhibited on the spectrophotometer meter, will increase and reach maximum within 30 seconds, which is the reading recorded. Continue the aeration until the absorbance returns to its minimum value. Remove the fritted tubing from the BOD bottle, and continue the aeration.

Sample Analysis using the PE FIMS 100

9.4.1 Instrument Setup

9.4.1.1 Turn the instrument on by flipping the power switch on the face of the instrument. The autosampler will initialize itself.

9.4.1.2 Choose AA Winlab Analyst from the START menu. The autosampler will initialize again.

NOTE: The instrument must be turned on before the application is started. Otherwise, an error message will result.

9.4.1.3 Click the button next to “open a custom workspace”.

9.4.1.4 Select “startup.fms” from the list and click OPEN. This will open the “FIAS Control” and “Automated Analysis” windows.

9.4.1.5 Click on the “Analyze” tab in the Automated Analysis window, then click on the “Select Location” button. Click OK and the probe will go to the autosampler rinse.

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9.4.1.6 Fill the carrier and reductant bottles.

9.4.1.6.1 The Carrier is 3% HCl (Section 8.6).

9.4.1.6.2 The Reductant is 1.1% $SnCl_2$ in 3% HCl (Section 8.5).

9.4.1.7 Allow the instrument to warm up while clearing samples. Samples that are cloudy or with particulate present after clearing must be filtered through Whatman 41 filter paper before analysis.

9.4.1.8 Place carrier takeup line (blue/yellow tubing) and reductant takeup line (red/red tubing) into graduated cylinders containing reagent water.

9.4.1.9 Load carrier and reductant lines into pump magazines above the roller so that the long ends come out on the right side. The carrier line goes into the inner magazine, and the reductant line goes into the outer magazine.

9.4.1.10 Load the two waste lines into the pump magazines below the roller.

9.4.1.10.1 The blue/yellow line goes into the inner two-channel magazine so that the long end comes out on the left side.

9.4.1.10.2 The black line goes into the outer magazine so that the long end comes out on the right side

9.4.1.11 Lock both the top and bottom magazines into place.

9.4.1.12 Unscrew the fitting from the sample absorption cell leading to the liquid vapor separator and place it into an empty dilu-vial.

9.4.1.13 Click the “Pump1” button in the “FIAS Control” window to start the roller.

9.4.1.14 Adjust the tension on the lower pump magazine using the thumbscrews until a steady (but not too fast) stream of bubbles comes out of the liquid vapor separator and through the black tubing.

9.4.1.15 Adjust the tension on the upper pump magazines to obtain the following flow rates:

9.4.1.15.1 Carrier = 9 – 11 mL/minute

9.4.1.15.2 Reductant = 5 – 7 mL/minute

9.4.1.16 When the flow rates are set, click on the “Pump1” button to stop the roller.

9.4.1.17 Place carrier takeup line in the carrier bottle and reductant line in the reductant bottle.

9.4.1.18 Click the “Pump1” button to restart the roller. Allow to run for a couple of minutes to flush the reagent water from the lines. Click on the “Fill/Inject” button several times to flush the sample loop.

9.4.1.19 With the “Fill/Inject” button in the “Fill” position, (button not depressed), click the “Pump1” button to stop the roller.

9.4.1.20 Remove the cap from the liquid/vapor separator and wipe dry with a KimWipe. Blow canned air through the vapor transfer line to dry it out.

9.4.1.21 Place a PTFE membrane, rough side up, in the liquid/vapor separator; replace the cap and reattach the vapor transfer line to the sample absorption cell.

9.4.1.22 Click on the “Pump1” button to start the roller.

9.4.1.23 Adjust the gas flow by turning the black knob below the air flow meter to obtain a reading of just over 50.

9.4.1.24 Click on the “Pump1” button to stop the roller.

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9.4.2 Creating a Sample Information File and Loading the Sample Tray

9.4.2.1 Select "Method 0.5 – 10ppb B". Click the "SamInfo" button on the toolbar.

9.4.2.2 In the description line, type "prep date MM/DD/YY".

9.4.2.3 In the analyst line, type the analyst's initials.

9.4.2.4 Drag the scroll bar so that the autosampler location 12 is showing.

9.4.2.5 Double-click the "Sample Units" cell in line 11.

9.4.2.6 Select "µg/L" from the list and enter the range of locations (12 up to 91) and click OK.

9.4.2.7 Starting with position 11, type in the sample ID

9.4.2.8 When finished, choose "Save As" from the "File" menu, then choose the "Sample Information" file.

9.4.2.9 Save the file as MMDDYYA

9.4.2.10 Load the samples into the tray as follows:

Position 92	Calibration Blank
Position 93	0.5ppb Standard
Position 94	1.0ppb Standard
Position 95	2.0ppb Standard
Position 96	5.0ppb Standard
Position 97	10.0ppb Standard
Position 98	ICV
Position 99	ICB
Position 1	CCV
Position 2	CCB
Position 11	PBS listed in the sample information file.
Position 12	LCSS listed in the sample information file.
Positions 13 – 91	Samples as listed in the sample information file.

9.4.2.11 Click the "Load Tray" button.

9.4.2.12 Replace the empty tray with the tray containing the standards and samples.

9.4.2.13 Click the "Load Tray" button.

9.4.2.14 Click the "Select Location" button and click OK to lower the probe into the autosampler rinse.

9.4.3 Instrument Calibration

9.4.3.1 Click the "Workspace" button in the toolbar.

9.4.3.2 Select daves.fms and click OK. Select "Method 0.5 – 10 ppb B".

9.4.3.3 Click on the Setup tab in the automated analysis window.

9.4.3.4 Click the "Browse" button under "Sample Information File"

9.4.3.4.1 Select the sample information file that you want to open and click OK.

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9.4.3.5 Click the "Browse" button under "Results Data Set Name".

9.4.3.5.1 Type in the data set name in the format MMDDYYA and click OK.

9.4.3.6 Click the "X" under the "Use Entire Sample Info File" so that it disappears.

9.4.3.7 Under the "Use Autosampler Locations Listed Below", enter the order of samples to be run. NOTE: Do not include standards and QC checks.

9.4.3.8 Click the "Analyze" tab.

9.4.3.9 Click the "Calibrate' button

9.4.3.9.1 The instrument will run the calibration curve.

9.4.3.9.2 Watch the calibration blank run; if the readings vary widely, stop the run by clicking the "Calibrate" button.

9.4.4 Initial Calibration Verification

9.4.4.1 When the calibration is complete (6 – 7 minutes), click the "Analyze Samples" button.

9.4.4.1.1 The instrument will run the ICV and ICB. If the recoveries of these are within the proper ranges (Sections 10.3.1 and 10.3.2), the instrument will continue with analysis of samples as outlined in Section 9.4.5.

9.4.4.1.2 If the recoveries of the ICV and/or ICB are not within the proper ranges (Sections 10.3.1 and 10.3.2), the problem must be found and corrected, and the instrument recalibrated per Section 9.4.3.

9.4.5 Sample Analysis

9.4.5.1 The instrument will now run ten analytical samples, a CCV and CCB, ten analytical samples, CCV, CCB, etc. The CCBs and CCVs must be recovered within the proper ranges (Sections10.3.3 and 10.3.4) for analysis to continue.

9.4.5.2 If the recoveries of the CCB and/or CCV are not within the proper ranges (Sections 10.3.3 and 10.3.4), the instrument must be recalibrated per Section 9.4.3. The samples that were analyzed after the last valid CCV/CCB must be re-analyzed.

9.4.6 Instrument Shut Down

9.4.6.1 When analysis is complete, click the "Workspace" button in the toolbar.

9.4.6.2 Place reagent takeup lines in a beaker of reagent water.

9.4.6.3 Click on the "Analyze" tab.

9.4.6.4 Click on the "Pump1" button to start the roller

9.4.6.4.1 Allow to run for several minutes to flush reagents out of the lines.

9.4.6.4.2 Click on the "Fill/Inject" button several times to rinse the sample loop.

9.4.6.5 Click the "Move Probe Up/Down" button to raise the probe out of the autosampler rinse.

9.4.6.6 Pull the reagent takeup lines out of the reagent water beaker to allow the pump to draw air through the lines.

9.4.6.7 Click "Fill/Inject" button several times to pull air through the sample loop.

9.4.6.8 With the "Fill/Inject' button in the "Fill" position, click "Pump1" button to stop roller.

9.4.6.9 Unlock the top and bottom pump magazines and remove tubing from the magazines.

9.4.6.10 Return the reagent takeup lines to the reagent water beaker.

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9.4.6.11 Click the "Move Probe Up/Down" button to lower the probe into the rinse beaker.

9.4.6.12 Select "EXIT" from the File menu to exit the WinLab application.

9.4.6.12.1 A "Shutting Down System" message will display.

9.4.6.13 When the desktop appears, turn off the power switch on the instrument.

9.4.1.3.1 Dump the samples and instrument waste in the Metals/Wet Chem waste drum located in the transfer room.

9.5 Preventative Maintenance

Preventative maintenance is conducted per the manufacturer's instuctions. All preventative maintenance is recorded in the Instrument Maintenance Logbook.

9.6 Calculations

Calculate Mercury concentration from the daily calibration curve. The curve is generated utilizing a straight-line equation defined as:

$$A = k_1 + k_2C$$

Where:

A = Average peak height of the sample/standard integrations
C = Sample/Standard Concentration, µg/L
k_1 = y-intercept
k2 = slope

The instrument will plot peak height against concentration (µg/L). The result is generated in µg/L . This value is divided by 1000 to convert the units to mg/L. The mg/L units are converted to mg/Kg by multiplying by L/Kg. A dilution factor (DF) is applied if necessary. The Result is then divided by the % Total Solids prior to release to the client.

Result, mg/Kg = (concentration, µg/L) x (1mg/1000µg) x (DF) x (L/Kg)

Where:

$$L/Kg = \frac{\text{Final volume of digestate, in L}}{\text{Weight of original sample, in Kg}}$$

10. Quality Control and Data Assessment

The laboratory must maintain records to document the quality of data that is generated. Ongoing data quality checks are compared with established performance criteria to determine if the results of analyses meet the performance characteristics of the method. When results of sample spikes indicate atypical method performance, a calibration verification standard is used to confirm the measurements were performed in an in-control mode of operation.

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10.1 Demonstration of Capability

The analyst must make an initial, one-time, demonstration of the ability to generate acceptable accuracy and precision with this method. Each time a method modification is made, the analyst is required to repeat the procedure.

When one or more of the parameters tested fail at least one of the acceptance criteria, the analyst must locate and correct the source of the problem and repeat the test for failed parameters of the method.

Repeated failure confirms a general problem with the measurement system or analytical technique of the analyst. If the failure repeats, locate and correct the source of the problem and repeat the test for all parameters listed in the method.

10.2 Method Blank

The Method Blank consists of the 0ppm standard as prepared in Section 9.1.2.1.1. Analyze one Method Blank per analytical batch of twenty samples or less. The Method Blank must be less than the Reporting Limit (RL).

10.3 Calibration Verification and Laboratory Control Samples (LCS)

10.3.1 ICV
The ICV is analyzed after the calibration curve. It is prepared in the manner specified in Section 9.1.2.2.1. The ICV must be recovered within ± 10% of the true value.

10.3.2 ICB
The ICB is analyzed after the ICV, and is prepared in the same manner as the 0ppm standard (Section 9.1.2.1.1). The ICB must be recovered within ± 0.2 µg/L.

10.3.3 CCV
The CCV is analyzed after every ten analytical samples. It is prepared in the same manner as the 5.0ppb calibration standard (Section 9.1.2.1.5). The CCV must be recovered within 20% of the true value.

10.3.4 CCB
The CCB is analyzed after the CCV. It is prepared in the same manner as the 0ppm standard (Section 9.1.2.1.1). The CCB must be recovered within ± 0.2 µg/L.

10.3.5 LCS
The LCS is analyzed once per each analytical batch of twenty samples or less. It is prepared in the same manner as in Section 9.1.2.3.1. The LCS must be recovered within 85 – 115% of the true value.

10.3.6 PBS
A preparation blank is analyzed once per batch of twenty samples or less. It is prepared in the same manner as the 0ppm standard (Section 9.1.2.1.1). The PBS must be recovered within ± 0.2 µg/L.

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10.5 Matrix Spike

To a 300mL BOD bottle add 0.6g of untreated sample. Add 1mL of 0.1ppm Mercury Spike Solution (Section 8.9.1.1), 5mL reagent water (Section 8.1) and 5mL aqua regia (Section 8.2). The matrix spike is brought through the preparation procedure as outlined in Section 9.1.1. The final concentration of the Matrix Spike is 0.001mg/L.

Analyze one matrix spike per twenty or less analytical samples. The recovery of the matrix spike must be between 70 – 130%.

If the recovery of the matrix spike is out of range, a post-analytical spike is analyzed. Prepare the post analytical spike by adding 5mL of 0.010ppm Calibration Standard (Section 9.1.2.1.6) and 5mL of the sample digestate to a 50mL centrifuge tube for a final concentration of 0.005mg/L. Analyze the post spike as outlined in Section 9.4.

Calculate the post spike concentration as follows:

Post Analytical Spike Sample Concentration (mg/L) =

[Sample Concentration (mg/L) x (0.5)] + 0.005mg/L

The percent recovery of the post-analytical spike must be between 75 – 125%.

If the recovery of the post analytical spike continues to be out of range, the sample and its spike are redigested as per Section 9.1.1.

10.6 Duplicates

Analyze one sample in duplicate per twenty or less analytical samples.

10.7 Control Limits

The laboratory maintains performance records to document the quality of data that is generated. Method accuracy for samples is assessed and records maintained. After the analysis of 20 spiked samples, and 20 laboratory control samples, calculate the average percent recovery (R) and the standard deviation of the percent recovery (S).

Control limits for the method parameters are generated by the QC staff and distributed to the analysts. The control limits are calculated based on in-house performance data. The limits are compared to the control limits found in the reference method.

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10.8 Analytical Sequence

- Sample preparation
- Sample digestion
- Standards preparation:
  - Calibration standards
  - ICV standard
  - LCS standard
- Standards digestion
- Analysis of calibration standards
- Generation of calibration curve
- Analysis of samples and standards:
  - ICV
  - ICB
  - analytical samples
  - CCV
  - CCB
  - analytical samples
  - CCV
  - CCB
  - etc.
- Calculation of sample results

11. Method Performance

Precision and accuracy data are available in Method 245.5 of Methods for Chemical Analysis of Water and Wastes.

The data shown in Table 1 were obtained from records of state and contractor laboratories. The data are intended to show the precision of the combined sample preparation and analysis method.

The method detection limit (MDL) is defined as the minimum concentration of a substance that can be measured and reported with 99% confidence that the value is above zero. The MDL concentrations were obtained using reagent water. Similar results were achieved using representative wastewaters. The MDL actually achieved in a given analysis will vary depending on instrument sensitivity and matrix effects.

Method performance data is on file in the laboratory QC department. Comparison of method performance data for the laboratory to the reference method criteria occurs when laboratory in-house acceptance limits are generated. In-house generated data must be within the specifications of the reference method or the analysis is not continued until corrective action is completed.

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12. Corrective Actions

Holding time exceedence and improper preservation are noted on the nonconformance report form.

Perform routine preventative maintenance following manufacturer's specification. Record all maintenance in the instrument logbook.

Review of standards, blanks and standard response for acceptable performance occurs for each batch of samples. Record any trends or unusual performance on a nonconformance action form.

If the CV or LCS recovery of any parameter falls outside the designated acceptance range, the laboratory performance for that parameter is judged to be out of control, and the problem must be immediately identified and corrected. The analytical result for that parameter in the unspiked samples is suspect and is only reported for regulatory compliance purposes with the appropriate nonconformance action form. Immediate corrective action includes reanalyzing all affected samples by using any retained sample before the expiration of the holding time.

13. Pollution Prevention

See Chemical Hygiene Plan for pollution prevention operations.

14. Waste Management

See Chemical Hygiene Plan for waste handling and disposal.

15. Attachments

TABLE 1: Method Performance Data
FIGURE 1: Flow Chart for Method 7471A

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Table 1

METHOD PERFORMANCE DATA

Sample Matrix	Preparation Method	Laboratory Replicates
Emission control dust	Not known	12, 12 µg/g
Wastewater treatment sludge	Not known	0.4, 0.28 µg/g

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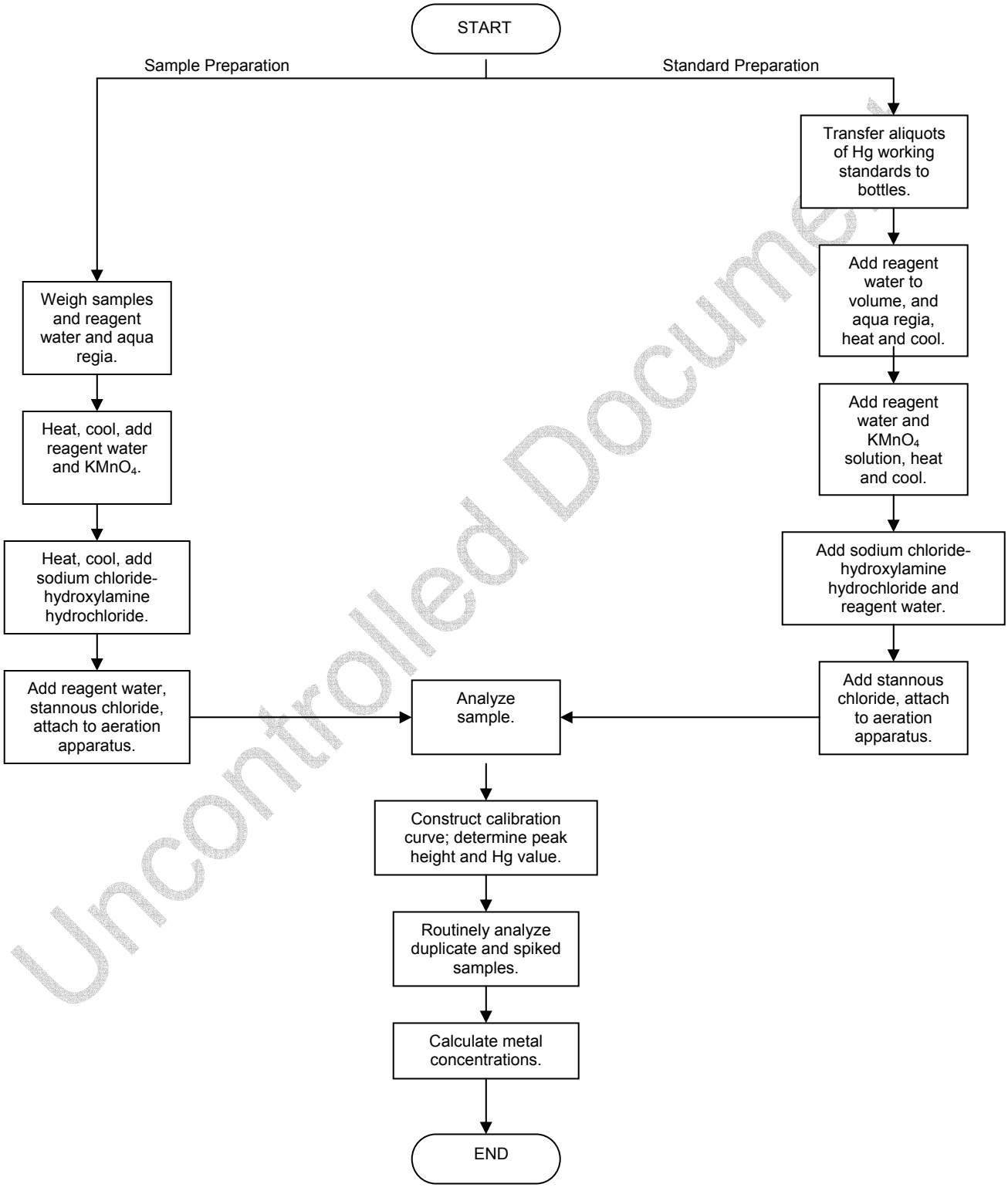
Figure 1

Method 7471A Flow Chart



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Inductively Coupled Plasma - Mass Spectrometry

Reference Methods: **Method 6020,** Test Methods for Evaluating Solid Waste: Physical/Chemical Methods, EPA SW-846, Update II, September 1994.

Method 6020A, Test Methods for Evaluating Solid Waste: Physical/Chemical Methods, EPA SW-846, Draft Update IVA, May 1998.

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ISSUE AMENDMENTS

Changes since last issue:

Section 9.3: Clarified calibration standard criteria

Section 10.4.2: Added acceptance criteria for the preparation blank.

Section 12: Omitted references to a one-point calibration.

Table 6: Added footnote.

Inductively Coupled Plasma - Mass Spectrometry

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1. Scope and Application

Matrices: Groundwaters, aqueous samples, industrial waste, soils, sludges, sediments, and other solid wastes.

Definitions: See Alpha Laboratories Quality Manual Appendix A

Inductively coupled plasma-mass spectrometry (ICP-MS) is applicable to the determination of sub µg/L concentrations of a large number of elements in water samples, waste extracts or digestates.

ICP-MS has been applied to the determination of over 60 elements in various matrices. Elements for which EPA has determined the acceptability of Method 6020 in a mulit-laboratory study on solid wastes are listed below and in Table 1.

If method 6020 is used to determine any analyte not listed in Table 1 below, it is the responsibility of the analyst to demonstrate the accuracy and precision of the method in the waste to be analyzed. The analyst is always required to monitor potential sources of interferences and take appropriate action to ensure data of known quality.

Use of this method is restricted to spectroscopists who are knowledgeable in the recognition and in the correction of spectral, chemical, and physical interferences in ICP-MS.

An appropriate internal standard is required for each analyte determined by ICP-MS. Recommended Internal standards are ^{6}Li, ^{45}Sc,^{89}Y,^{103}Rh,^{115}In,^{159}Tb,^{165}Ho, and ^{209}Bi. The Lithium internal standard should have an enriched abundance of 6Li, so that interference from Lithium native to the sample is minimized. Other elements may need to be used as internal standards when samples contain significant amounts of the recommended internal standards. The internal standard used in this method is as follows: ^{6}Li,^{45}Sc, ^{74}Ge, ^{89}Y, ^{115}In, ^{209}Bi

TABLE 1

Parameter	CAS
Aluminum	7429-90-5
Antimony	7440-36-0
Arsenic	7440-38-2
Barium	7440-39-3
Beryllium	7440-41-7
Cadmium	7440-43-9
Calcium	7440-70-2
Chromium	7440-47-3
Cobalt	7440-48-4
Copper	7440-50-8
Iron	7439-89-6
Lead	7439-92-1

Parameter	CAS
Magnesium	7439-95-4
Manganese	7439-96-5
Mercury	7439-97-6
Molybdenum	7439-98-7
Nickel	7440-02-0
Potassium	7440-09-7
Selenium	7782-49-2
Silver	7440-22-4
Sodium	7440-23-5
Thallium	7440-28-0
Vanadium	7440-62-2
Zinc	7440-66-6

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The data report packages present the documentation of any method modification related to the samples tested. Depending upon the nature of the modification and the extent of intended use, the laboratory may be required to demonstrate that the modifications will produce equivalent results for the matrix. Approval of all method modifications is by one of the following laboratory personnel before performing the modification: Area Supervisor, Metals Manager, Laboratory Services Manager, Laboratory Director, or Quality Assurance Officer.

This method is restricted to use by or under the supervision of analysts experienced in the operation of the ICP-MS and in the interpretation of ICP-MS data. Each analyst must demonstrate the ability to generate acceptable results with this method by performing an initial demonstration of capability, analyzing a proficiency test sample and completing the record of training.

After initial demonstration, ongoing demonstration is based on acceptable laboratory performance of at least a quarterly laboratory control sample or acceptable performance from an annual proficiency test sample. A major modification to this procedure requires demonstration of performance. The identification of major method modification requiring performance demonstration is directed by the QA Officer and Laboratory Director on a case-by-case basis.

2. Summary of Method

When dissolved constituents are required, samples must be filtered and acid-preserved prior to analysis. No digestion is required prior to analysis for dissolved elements in water samples. Acid digestion prior to filtration and analysis is required for groundwater, aqueous samples, industrial waste, soils, sludge's, sediments, and other solid wastes for which total (acid-leachable) elements are required.

Method 6020 describes the multi-elemental determination of analytes by ICP-MS. The method measures ions produced by a radio-frequency inductively coupled plasma. Analyte species originating in a liquid are nebulized and the resulting aerosol transported by argon gas into the plasma torch. The ions produced are entrained in the plasma gas and introduced, by means of an interface, into the mass spectrometer. The ions produced in the plasma are sorted according to their mass-to-charge ratio and quantified with a channel electron multiplier. Interferences must be assessed and valid corrections applied or the data flagged to indicate a problem. Interference correction must include compensation for background ions contributed by the plasma gas, reagents, and constituents of the sample matrix.

2.1 Method Modifications from Reference

This method is performed in a 5% Nitric Acid matrix.

3. Detection Limits

The laboratory follows the procedure found in 40CFR Part 136 to determine the MDL on an annual basis. The method detection limits determined by the laboratory are on file for review.

Instrument detection limits, sensitivities, and linear ranges will vary with the matrices, instrumentation and operating conditions. In relatively simple matrices, detection limits will generally be below 0.02 µg/L.

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4. Interferences

4.1 Isobaric Elemental Interference

Isobaric elemental interferences in ICP-MS are caused by isotopes of different elements forming atomic ions with the same nominal mass-to-charge ratio (m/z). A data system must be used to correct for these interferences. This involves determining the signal for another isotope of the interfering element and subtracting the appropriate signal from the analyte isotope signal. Since commercial ICP-MS instruments nominally provide unit resolution at 10% of the peak height, very high ion currents at adjacent masses can also contribute to ion signals at the mass of interest. Although this type of interference is uncommon, it is not easily corrected, and samples exhibiting a significant problem of this type could require resolution improvement, matrix separation, or analysis using another verified and documented isotope, or use of another method.

4.2 Isobaric Molecular and Doubly Charged Ion Interference

Isobaric molecular and doubly-charged ion interferences in ICP-MS are caused by ions consisting of more than one atom or charge, respectively. Most isobaric interferences that could affect ICP-MS determinations have been identified in the literature. Examples include $ArCl^+$ ions on the ^{75}As signal and MoO^+ ions on the Cadmium isotopes. While the approach used to correct for molecular isobaric interferences is demonstrated below using the natural isotope abundances form the literature, the most precise coefficients for an instrument can be determined form the ratio of the net isotope signals observed for a standing solution at a concentration providing suitable (<1 percent) counting statistics. Because the ^{35}Cl natural abundance of 75.77 percent is 3.13 times the ^{37}Cl abundance of 24.23 percent, the chloride correction for arsenic can be calculated (approximately) as follows (where the $^{38}Ar^{37}Cl^+$ contribution at m/z 75 is a negligible 0.06 percent of the $^{40}Ar^{35}Cl^+$ signal):

Corrected arsenic signal (using natural isotopes abundances for coefficient approximations) = (m/z 75 signal) – (3.13) (m/z 77 signal) + (2.73) (m/z) (82 signal), (where the final term adjust for any selenium contribution at 77 m/z)

Note: Arsenic values can be biased high by this type of equation when the net signal at m/z 82 is caused by ions other than $^{82}Se^+$, (e.g. $^{81}BrH^+$ from bromine waste)

Similarly, corrected cadmium signal (using natural isotopes abundances for coefficient approximations) = (m/z 114 signal) – (0.027) (m/z 118 signal) – (1.63) (m/z 108 signal), (where the last two terms adjust for any tin or MoO^+ contributions at m/z 114).

> **Note:** Cadmium values will be biased low by this type of equation when $^{92}ZrO^+$ ions contribute at m/z 108, but use of the m/z 111 for Cd is even subject to direct ($^{94}ZrOH^+$) and indirect ($^{90}ZrO^+$) additive interferences when Zr is present.
>
> **Note**: As for the arsenic equation above, the coefficients in the Cd equation are for only illustrative purposes. The most appropriate coefficients for an instrument can be determined from the ratio of the net isotope signals observed for a standard solution at a concentration providing suitable (<1 percent) counting precision.

The accuracy of these types of equations is based upon the constancy of the OBSERVED isotopic ratios for the interfering species. Corrections that presume a constant fraction of a molecular ion relative to the "parent" ion have not been found to be reliable, e.g. oxide levels can vary. If a correction for an oxide ion is based upon the ratio of parent –to-oxide ion intensities, the correction must be adjusted for the degree of outside formation by the use of an appropriate oxide internal standard previously demonstrated to form a similar level of oxide as the interferant. This type of correction has been reported for oxide-ion corrections using

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ThO^+/Th for the determination of rare earth elements. The use of aerosol desolvation and/or mixed plasmas has been shown to greatly reduce molecular interferences. These techniques can be used provided that method detection limits, accuracy, and precision requirements for analysis of the samples can be met.

4.3 Physical Interference

Physical interferences are associated with the sample nebulization and transport processes as well as with ion-transmission efficiencies. Nebulization and transport processes can be affected if a matrix component causes a change in surface tension or viscosity. Changes in matrix composition can cause significant signal suppression or enhancement. Dissolved solids can deposit on the nebulizer tip of a pneumatic nebulizer and on the interface skimmers (reducing the orifice size and the instrument performance). Total solid levels below 0.2% (2,000mg/L) have been currently recommended to minimize solid deposition. An internal standard can be used to correct for the physical interferences, if it is carefully matched to the analyte so that the two elements are similarly affected by the matrix change. When the intensity level of an internal standard is less than 30 percent or greater than 120 percent of the intensity of the first standard used during calibration, the sample must be reanalyzed after a fivefold (1+4) or greater dilution has been performed.

4.4 Memory Interference

Memory interferences can occur when there are large concentration differences between samples or standards which are analyzed sequentially. Sample deposition on the sampler and skimmer cones, spray chamber design, and the type of nebulizer affect the extent of the memory interferences which are observed. The rinse period between samples must be long enough to eliminate significant memory interferences.

5. Safety

The toxicity or carcinogenicity of each reagent and standard used in this method is not fully established; however, each chemical compound should be treated as a potential health hazard. From this viewpoint, exposure to these chemicals must be reduced to the lowest possible level by whatever means available. A reference file of material data handling sheets is available to all personnel involved in the chemical analysis. Additional references to laboratory safety are available in the Chemical Hygiene Plan.

All personnel handling environmental samples known to contain or to have been in contact with municipal waste must follow safety practices for handling known disease causative agents.

6. Sample Collection, Preservation, and Handling

6.1 Sample Collection

Only Polyethylene or fluorocarbon (PFA or TFE) containers are recommended. Alpha uses polyethylene bottles. 0.5L is the recommended size.

6.2 Sample Preservation

Samples for total metals are preserved with (1:1) Nitric Acid to a pH<2.

Samples for soluble metals should be preserved with (1:1) Nitric Acid to a pH of <2 **after** filtration through a 0.45 um filter.

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6.3 Sample Handling

Samples that are to be analyzed for soluble metals, and have not been field filtered, should be filtered through a 0.45um filter as soon as possible. Samples are then preserved with 1:1 Nitric Acid to a pH<2, and then held for 18 hours. After the 18 hours the pH should be re-checked. If after 18 hours the pH is still >2, then the sample should be re-acidified and held again for 18 hours. If the pH is till >2 after this 18 hour period , then the Inorganics Manager should be told.

Samples preserved with Nitric Acid to a pH<2, and are not being analyzed for Mercury, have a hold time of 6 months.

Samples and digestates are stored in the refrigerator at 4 °C.

7. Equipment and Supplies

7.1 Agilent 7500a ICP-MS:

The ICP features a wide-diameter ICP torch injector for improved resistance to clogging with samples containing high dissolved solids levels. A high energy 27.12 MHz plasma, a solid state RF generator. Torch alignment is performed by auto-tuning software. The sample is introduced using an Agilent High Solids Nebulizer.

The MS features dual extraction lenses and a compound ion lens system that ensures a mass range from Li-U (masses 6-240). It also features the enhanced Omega II off-axis ion lens which gives mean random background of typically <2cps. The quadrapole rods produce an ideal true hyperbolic field, with digitally synthesized drive circuits to ensure faster scan speeds and greater stability to operate at high frequency –3MHz. The detector is a new electron multiplier operating simultaneously in pulse counting mode and analog mode. The log amplifier circuit extends dynamic range to 9 orders of magnitude with a high speed analog mode (minimum dwell time 100µsec) designed specifically for transient signal analysis. The software is ChemStation, it controls all instrument operations including tuning, data question, data analysis and reporting. The software provides the capability for qualitative, semiquantitive and quantitive analysis, as well as time-resolved, isotope ratio and isotope dilution analysis. A comprehensive array of autotune functions provide hands-free optimization of torch alignment, ion lenses, mass calibration and resolution, and detector calibration.

7.2 CETAC ASX-510 Autosampler: Delivers sample and internal standard to the torch

7.3 Edwards E2M18 Rotary Pump: Creates the necessary vacuum to operate the MS

7.4 Neslab M-75 Chiller: Cools the torch and the MS

7.5 Eppendorf pipets: Accurate means to make trace standards

8. Standards and Reagents

8.1 Nitric Acid (HNO_3), Trace metals grade: 18M Concentrated

8.2 5% Nitric Acid (v/v): 50mL of 18M HNO_3 diluted to 1L using Type I water

8.3 Type I De-Ionized Water

8.4 Calibration Standard: Agilent #5183-4682 stock (Table 4)

8.5 Internal Standard: Agilent #5183-4681. 5.0 mL of internal standard diluted to 50mL in 5% HNO_3 (Table 8)

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8.6 Tune Stock: Agilent #8500-6943 10 µg/mL each of ^{7}Li,^{89}Y,^{140}Ce,^{205}Tl. Dilute 0.2mL to 200mL (Table 9)

8.7 ICV/CCV: Agilent #5183-4682 stock (Table 10)

8.8 ICSA: Agilent #8500-6998 stock. Dilute 10 mL to 100 mL (Table 11)

8.9 ICSB: Agilent #8500-7001. Dilute 1 mL to 100mL (Table 11)

8.10 ICSAB: Dilute 10 mL of ICSA and 1.0 mL of ICSB to a final volume of 100 mL (Table 11)

8.11 Argon Gas: 0.9995 or better grade. Plumbed into the lab.

9. Procedure

9.1 Set-Up

9.1.1 Sample Preparation

Prior to analysis, samples which require total (acid-leachable) values must be digested using appropriate sample preparation methods, such as Methods 3005A, 3015, 3051 and 3050B.

9.1.2 Turning the instrument on from Stand By

- Tighten the peristaltic pump windings for the sample, Internal standard and spray chamber drain.
- Turn on the Argon gas supply and Neslab M-75 chiller under the bench.
- Turn on the computer, monitor and printer. Make sure that the printer is loaded with paper. Once the computer has booted, the Agilent ICP-MS top page will be shown. At this page select "**Instrument control"** (Note: Standby mode is indicated here and also by a yellow light on the front of the instrument.) From the "**Instrument control"** select "**Plasma"**. From "**Plasma**" select "**Plasma On"**.
- The instrument will start automatically and go into **"Analysis Mode"** which will be indicated on the instrument control page and on the instrument when the yellow light turns green. The autosampler probe should be in the autosampler rinse at position #1, and the internal standard should be blank. The autosampler can be positioned by selecting **"ALS"** from the **"Instrument control"**.
- Allow the instrument to warm up for **30 minutes.**

9.2 Tuning

9.2.1 After the 30 minute warm up period has passed, a daily tune must be performed and a report generated. This tuning solution (Section 8.6) must be analyzed **four** times with relative standard deviations of **less than or equal to 5%** for the analytes contained in the tuning solution (^{7}Li, ^{89}Y, ^{205}Tl). The tuning solution also acts as a **Daily Performance Check Solution**, and serves as a **check on oxide interferences and double charged ion interferences; the criteria is <3% Note**: Precautions must be taken to protect the channel electron multiplier from high ion currents. The channel electron multiplier suffers from fatigue after being exposed to high ion currents. This fatigue can last form several seconds to hours depending on the extent of exposure. During this time period, response factors are constantly changing, which invalidates the calibration curve, causes instability, and invalidates sample analysis.

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9.2.2 The mass calibration and resolution check is also performed during the tuning. The mass calibration and resolution parameters are required criteria which must be met prior to any samples being analyzed. If the mass calibration differs more than 0.1 amu from the true value, then the mass calibration must be adjusted to the correct value. The resolution must also be verified to be less than 0.9 amu full width at 10 percent peak height.

9.2.3 The stock tune solution (Section 8.6) is a 10 µg/L solution of **Li, Y, Ce** and **Tl** and is located at position #3 on the **"ALS"** which is accessed from the **"Instrument control"**

9.2.3.1 When the solution has been introduced to the plasma, select **"Instrument Control"** and then **"Tune".**

9.2.4 The **Sensitivity Tuning Page** will come up on the screen showing masses **7, 89** and **205**. Click **"START"** to begin the tuning. ***Caution:*** Typical tune parameters and a sample tune report are shown below to be an example. However, a detailed explanation of the tuning is found in the Agilent Users Manual pages 4.2 through 4.19. This chapter introduces the theory and mechanics of the tune. The physics involved in the tune and the effects of the tune on the calibration. This chapter should be read and understood by any operator before going any further. This manual will be found next to the computer near the spectrophotometer. When the analyst is satisfied that the tune has passed all of the quality control measures, then a tune report is generated and kept on file. To generate the report do the following from the **"Instrument Control"** page: go to **"Tune"** and then to **"Autotune"** and then **"Run"**. Make sure that these items are selected for the report: EM, ADJUST DISCRIMINATOR, RESOLUTION / AXIS, TUNING REPORT. The remaining autotune parameters such as TORCH VERTICAL / HORIZONTAL and LENS / PLASMA are easier to perform manually prior to running autotune and should not be selected.

9.2.5 The Analytical Sequence can now be started. In most instances, an analytical sequence will be set up and run automatically from an autosampler table and will consist of the following blocks: **CALIBRATION**: for the calibration standards. **SAMPLES:** Unknown samples with periodic QC checks (ICV, ICB, ICSA, ICSB, CCV, CCB). **TERM:** Termination block which instructs the instrument to perform certain functions when the analysis is complete. Usually this will consist of a final CCV/CCB and either shutdown or wait for further instruction.

9.2.6 When an acceptable tune has been achieved, a **pulse/analog** tune must be performed. This helps prevent damage to the detector by establishing the switching point between pulse mode and the analog mode. This tune is also necessary to achieve accurate quantification of result. From the **ALS** page move the autosampler to the 100 µg/L Calibration Standard. The internal standards should be present. From **"Instrument Tune"** select **"P/A Factor"** then select **"Run".** A new list of factors will be shown on the monitor. Close this screen and it will ask if you would like to save these new factors. Select **"Yes"**.

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Typical values of tuning parameters

Parameter	Typical Conditions	Adjustment
RF Power (W)	1300	1200 to 1600
Sampling Depth (mm)	6	4 to 8
Carrier gas (L/min)	1.2	0.8 to 1.3
Makeup gas (L/min)	0	0 to 0.4
Peri-pump 1 (rps)	0.1	0.06 TO 0.15
S/C Temp (°C)	2	Normally used at 2 °C
Extraction	-150	-200 to -100
Extraction	-70	-150 to -10
Einzel 1.3 (V)	-100	-130 to -40
Einzel 2(V)	7	-20 to +70
Omega Bias (V)	-35	-40 to 0
Omega (+)(V)	5	0 to +30

Typical value of Sensitivity and RSD (Using the normal torch)

Mass	Counts / 10ppb Integ. Time = 0.1 sec	RSD
^{7}Li	>6400	<15%
^{89}Y	>16000	<15%
^{205}Tl	>9600	<15%

9.3 Initial Calibration (ICV / ICB)

Mixed calibration standard solutions are prepared by diluting the stock-standard solutions to levels within the linear range for the instrument in a solvent consisting of 5% HNO_3 (v/v) in reagent water. The calibration standard solutions must contain a suitable concentration of an appropriate internal standard for each analyte. Internal standards are added at the time of analysis using a second channel of the peristaltic pump and an appropriate mixing manifold. The **CETAC ASX-510 Autosampler** handles this task of the operation. Generally, an internal standard should be no more than 50amu removed from the analyte. Alpha employs the following internal standards: ^{6}Li, ^{45}Sc, ^{74}Ge, ^{89}Y, ^{115}In and ^{209}Bi.

Prior to preparing the mixed standards, each stock solution must be analyzed separately to determine possible spectral interferences or the presence of impurities. Care must be taken when preparing the mixed standards that the elements are compatible and stable. Transfer the mixed standard solutions to freshly acid-cleaned FEP fluorocarbon bottles for storage. Fresh mixed standards must be prepared as needed with the realization that concentrations can change upon aging. Calibration standards must be initially verified using a quality control standard (ICV), and monitored weekly for stability.

Calibrate the instrument for the analytes of interest (recommended isotopes for the analytes in Table 1 are provided in Table 3), using the calibration blank (Section 10.4.1) and the set of 5 standards (see Table 4.). The analytical range brackets an RDL of 0.1 µg/L to 200 µg/L with the exceptions of Fe, K, Na, Ca and Mg which bracket the range of 10µg/L to 20,000µg/L. All solutions and standards are prepared in a 5% Nitric Acid matrix. The calibration is defined as the calibration blank and five standards. The only standards that may be discarded in the calibration are the first standard (the low standard) and the fifth standard (the high standard). The only instance when the standard may be discarded is if the linearity of the element in question does not meet the correlation coefficient acceptance criteria of 0.995 or greater. No

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mid-level standards are ever discarded. All standards, QC samples and samples are to be integrated three times and then averaged. The calibration block is part of the analytical sequence and includes an ICV and an ICB immediately following the analysis of the calibration standards. The calibration block can also contain a pause so that the analyst can evaluate the calibration prior to sample analysis. The calibration sequence is as follows:

Blank #1
Cal blank #2
0.1 µg/L std (10 µg/L Fe, K, Na, Ca, Mg)
1.0 µg/L std (100 µg/L Fe, K, Na, Ca, Mg)
10.0 µg/L std (1000 µg/L Fe, K, Na, Ca, Mg)
100.0 µg/L std (10,000 µg/L Fe, K, Na, Ca, Mg)
200.0 µg/L std (200,000 µg/L Fe, K, Na, Ca, Mg) this standard is optional in the calibration, it extends the linear range.

When the calibration standards have finished running then the analyst may choose to delete certain standards entirely or certain elements from a given standard in order to produce an acceptable correlation coefficient. To view the calibration data sheet go to **"Off Line Data Analysis"** then **"Calibrate"** then **"Cal Graph". "Cal Graph"** will produce a graph of each element in the calibration. Data points can be rejected or restored from this screen. If a standard is found to be made incorrectly it can be deleted entirely by accessing **"Calibrate"** then **"Std Data Files".**

The quality control standard is the Initial Calibration Verification solution (ICV), which must be prepared in the same acid matrix as the calibration standards. This solution must be an independent standard near the midpoint of the linear range at a concentration other than that used for instrument calibration. An independent standard is defined as a standard composed of analytes from a source other than that used for the standards for instrument calibration.

Immediately after the calibration has been established, the calibration must be verified and documented for every analyte by the analysis of the Initial Calibration Verification solution (ICV) (Section 8.7). The calibration is verified if the solution is within the 10% of the true value (Table 5.) for each element. See Section 12 for corrective action if the ICV fails. The ICB/CCB (10.4.1) are analyzed immediately following the ICV/CCV. The ICB/CCB should be no greater than ± |RL| for any analyte.

9.4 Interference Check Solution (ICSA and ICSAB)

The interference check solution (ICS) is prepared to contain known concentrations of interfering elements that will demonstrate the magnitude of interference and provide an adequate test of any corrections.

Chloride in the ICS provides a means to evaluate software corrections for chloride-related interferences such as $^{35}Cl^{16}O^{+}$ on $^{51}V^{+}$ and $^{40}Ar^{35}Cl^{+}$ on $^{75}As^{+}$.

Iron is used to demonstrate adequate resolution of the spectrometer for the determination of manganese.

Molybdenum serves to indicate oxide effects on cadmium isotopes.

The other components are present to evaluate the ability of the measurement system to correct for various molecular-ion isobaric interferences. The ICS is used to verify that the interference levels are corrected by the data system within quality control limits. The ICSA solution (Section 8.8) contains 1000mg/L of Cl^{-} , 200 mg/L of C, 100 mg/L of Al, Ca, Fe, K , Mg, Na, P, S and 2 mg/L of Mo and Ti. The ICSAB (Section 8.9) solution contains ICSA plus the addition of 0.1 mg/L of As, Cd, Cr, Cu, Mn, Ni Ag and Zn.

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9.5 Sample Analysis and Continuing Calibration Verification (CCV)

Sample analysis takes place from the **"Samples"** block. When filling out the autosampler table in the tuning section (Section 9.2.6), fill in the block for "Samples". This will run the ICV, ICB, ICSA, ICSAB, samples and CCV and CCB. After the initial Instrument QC has been analyzed and passed, then 10 samples will be analyzed. After the tenth sample has been analyzed, a CCV and a CCB will be analyzed. Analysis of standards and samples should only take place when the instrument has come to equilibrium. All masses which could affect data quality should be monitored to determine potential effects from matrix components on the analyte peaks. The recommended isotopes to be monitored are listed in Table 3. When the analysis is ready to start, flush the system with the rinse blank solution (Section 10.4.3) until the signal levels return to the method's level of quantitation (usually about 30 seconds) before the analysis of each sample. Nebulize each sample until a steady-state signal is achieved (usually in about 30 seconds) prior to collecting the data. Analyze the Continuing Calibration Verification solution (CCV) (Section 8.7) and the continuing Calibration blank (Section 10.4.1) at a frequency of at least once per ten analytical samples, and at the end of the analytical run. Flow injection systems may be used as long as they meet the performance criteria of this method. Dilute and reanalyze samples that are more concentrated than the linear range (or species needed for a correction) or measure an alternate less-abundant isotope. The linearity at the alternate mass must be confirmed by appropriate calibration.

9.6 Scheduled Maintenance

The scheduled maintenance is automatically tracked by the run time log for the following parameters. A message will appear on the computer screen reminding the analyst that a piece of maintance must be performed. An electronic log, along with a maintance notebook is kept. Below is a list what needs to be performed:

1. Check rough pump oil
2. Replace rough pump oil
3. Replace mist filter
4. Clean the Einzel lenses
5. Clean the extraction lenses
6. Clean the skimmer cone
7. Clean the sampling cone
8. Clean the nebulizer
9. Clean the spray chamber
10. Change pump tubing for the samples and the internal standards daily
11. The cones are soaked in Citrinox for 15-20 minutes when carryover becomes a problem

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9.7 Calculations

The quantitative values are reported in appropriate units, such as micrograms per liter (µg/L) for aqueous samples and milligrams per kilograms (mg/Kg) for solid samples. If dilutions were performed, the appropriate corrections must be applied to the sample values.

It is required that results for solids be reported on a dry weight basis as follows:

1. A separate determination of percent solids is performed by the Wet Chemistry Department and the result is loaded in the **LIMS**. To retrieve the result in the LIMS, go to **"Status"** and type in the sample ID. Click the sample number that is part of that sample ID, and click the product that says **TS-S**. The percent solids for the sample is there. LIMS will automatically correct the sample for percent solids after the metals analysis has been **Final Metals Reviewed.** This is the calculation:

   $$\text{Concentration (dry weight) (mg/Kg)} = \frac{C \times V}{W \times S}$$

   Where:
   C= Digest Concentration (mg/L)
   V= Final volume in Liters after sample preparation
   W= Weight in Kg of wet sample
   $S = \frac{\%\text{Solids}}{100}$

2. Calculations should include appropriate interference corrections (see Section 4.1 for examples), internal-standard normalization, and the summation of signals at 206, 207, and 208 m/z for Lead (to compensate for any differences in the abundances of these isotopes between samples and standards).

10. Quality Control and Data Assessment

The laboratory must maintain records to document the quality of data that is generated. Ongoing data quality checks are compared with established performance criteria to determine if the results of analyses meet the performance characteristics of the method. When results of sample spikes indicate atypical method performance, a calibration verification standard is used to confirm the measurements were performed in an in-control mode of operation.

10.1 Demonstration of Capability

The analyst must make an initial, one-time, demonstration of the ability to generate acceptable accuracy and precision with this method. Each time a method modification is made, the analyst is required to repeat the procedure.

When one or more of the parameters tested fail at least one of the acceptance criteria, the analyst must locate and correct the source of the problem and repeat the test for failed parameters of the method.

Repeated failure confirms a general problem with the measurement system or analytical technique of the analyst. If the failure repeats, locate and correct the source of the problem and repeat the test for all parameters listed in the method.

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10.2 Instrument Detection Limits (IDLs)

Instrument Detection limits (in µg/L) can be estimated by calculating the average of the standard deviations of the three runs on three non-consecutive days from the analysis of a reagent blank solution with seven consecutive measurements per day. Each measurement must be performed as though it were a separate analytical sample (i.e. each measurement must be followed by a rinse and/or any other procedure normally performed between the analysis of separate samples). IDLs must be determined at least every three months and kept in the instrument log book.

10.3 Internal Standards

The intensities of all internal standards must be monitored for every analysis. When the intensity of any internal standard fails to fall between 30 and 120% of the intensity of that internal standard in the initial calibration, the following procedure is followed:

The sample must be diluted fivefold (1+4) and reanalyzed with the addition of appropriate amounts of internal standards. This procedure must be repeated until the internal-standard intensities fall within the prescribed window.

The intensity levels of the internal standards for the calibration blank (Section 10.4.1) and the Continuing Calibration Verification standard (CCV) (Section 8.7) must agree within +/- of 20 percent of the intensity level of the internal standard of the original calibration solution. If they do not agree, terminate the analysis, correct the problem, recalibrate, verify the new calibration, and reanalyze the affected samples.

10.4 Blank

Three types of blanks are required for the analysis. The calibration blank, which is also the ICB/CCB, is used in establishing the calibration curve. The ICB/CCB is used to monitor carryover, signal noise, and drift. The preparation blank is used to monitor for possible contamination resulting from the sample preparation procedure. The rinse blank is used to flush the system between all samples and standards.

10.4.1 The Calibration blank, Initial Calibration Blank and the Continuing Calibration Blank consists of the same concentration of the same acid used to prepare the final dilution of the calibrating solutions of the analytes. This is a 5% HNO_3 solution (v/v) in Type I de-ionized water along with the selected concentrations of internal standard element for each of the analytes. The Calibration Blank is analyzed before the standards are analyzed. The Initial Calibration Blank should follow the Initial Calibration Verification standard (ICV) and the Continuing Calibration Blank should follow the Continuing Calibration Verification standard (CCV). These should be analyzed at a frequency of every 10 or less samples and at the end of the analytical run. The ICB/CCB should be no greater than ± |RL| for any analyte.

10.4.2 The preparation (or reagent) blank must be carried through the complete preparation procedure and contain the same volumes of reagents as the sample solutions. Results for the preparation blank must be less than the RL for any analyte.

10.4.3 The rinse blank consists of HNO_3 (1% or 2%) (v/v) in reagent water. Prepare a sufficient quantity to flush the system between standards and samples.

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10.5 Calibration Verification (ICV/CCV) and Laboratory Control Samples (LCS)

The ICV and CCV must have a recovery that is within ±10% of the true value. The ICV and the CCV are from the same solution, and must contain all of the elements that are calibrated. The ICV/CCV is an independent source other than those standards used for the calibration of the instrument. The ICV should be analyzed following the calibration. The CCV should be analyzed at a frequency of 10 samples or less and at the end of the analytical run. The Laboratory Control Sample (LCS) should be analyzed for each analyzed for each analyte using the same sample preparations, analytical methods and QA/QC procedures employed for the test samples. One LCS should be prepared and analyzed for each sample batch at a frequency of one LCS for each 20 samples or less. Aqueous LCS recoveries should be 80-120%, and soil LCS recoveries should be 70-130%.

10.6 Interference Check Standards

Verify the magnitude of elemental and molecular-ion isobaric interferences and the adequacy of any corrections at the beginning of an analytical run or once every 12 hours, whichever is more frequent. Do this by analyzing the interference check solutions A and AB (9.4). The analyst should be aware that precipitation from solution AB may occur with some with some elements, specifically silver. Refer to Section 4.0 for a discussion on interferences and potential solutions to those interferences if additional guidance is needed. ICSAB should have a recovery of 80-120%.

10.7 Dilution Test

If the analyte concentration is within the linear dynamic range of the instrument and sufficiently high (minimally, a factor of at least 100 times greater than the concentration of the reagent blank (10.4.2), an analysis of a fivefold (1+4) dilution must agree within ± 10% of the original determination. If not, interference must be suspected. One dilution test must be included for every twenty samples (or less) of each matrix.

10.8 Post Digestion Spike Addition

An analyte spike added to a portion of a prepared sample, or its dilution, should be recovered to within 75 to 125 percent of the known value or within the laboratory derived acceptance criteria. The spike addition should be based on the indigenous concentration of each element of interest in the sample.

10.9 Duplicates

Analyze one duplicate sample for every matrix in a batch at a frequency of one matrix duplicate for every 20 samples.

The relative percent difference (RPD) must be calculated as follows:

$$RPD = \frac{|D_1 - D_2|}{(D_1 + D_2)/2} \times 100$$

Where:
RPD = relative percent difference
D_1 = first sample value
D_2 = second sample value (duplicate)

A control limit of 20% RPD should not be exceeded for analyte values greater than 100 times the instrument detection limit (Section 10.2).

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10.10 Control Limits

The laboratory maintains performance records to document the quality of data that is generated. Method accuracy for samples is assessed and records maintained. After the analysis of 20 spiked samples, and 20 laboratory control samples, calculate the average percent recovery (R) and the standard deviation of the percent recovery (S).

Control limits for the method parameters are generated by the QC staff and distributed to the analysts. The control limits are calculated based on in-house performance data. The limits are compared to the control limits found in the reference method.

10.11 Analytical Sequence

Performance Check Solution / Tuning Solution

PA Tune Solution

Calibration of instrument

Initial Calibration Verification Standard

Initial Calibration Blank

Interference Check Solution A

Interference Check Solution AB

Continuing Calibration Verification Standard

Continuing Calibration Blank

Samples (10)

Continuing Calibration Verification Standard

Continuing Calibration Blank

11. Method Performance

The method detection limit (MDL) is defined as the minimum concentration of a substance that can be measured and reported with 99% confidence that the value is above zero. The MDL concentrations were obtained using reagent water in 5% HNO_3. The MDL actually achieved in a given analysis will vary depending on instrument sensitivity and matrix effects.

Method performance data is on file in the laboratory QC department. Comparison of method performance data for the laboratory to the reference method criteria occurs when laboratory in-house acceptance limits are generated. In-house generated data must be within the specifications of the reference method or the analysis is not continued until corrective action is completed.

12. Corrective Actions

Holding time exceedence, improper preservation and observed sample headspace are noted on the nonconformance report form.

Perform routine preventative maintenance following manufacturer's specification. Record all maintenance in the instrument logbook.

Review of standards, blanks and standard response for acceptable performance occurs for each batch of samples. Record any trends or unusual performance on a nonconformance action form.

If the CV or LCS recovery of any parameter falls outside the designated acceptance range, the laboratory performance for that parameter is judged to be out of control, and the problem must be

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immediately identified and corrected. The analytical result for that parameter in the unspiked samples is suspect and is only reported for regulatory compliance purposes with the appropriate nonconformance action form. Immediate corrective action includes reanalyzing all affected samples by using any retained sample before the expiration of the holding time.

The performance check standard is included in the tuning solution. Ce is included with the tuning solution and monitors the formation of oxides and the effect of doubly-charged ions. If the solution fails >3% (Section 9.2.1) then instrument maintenance should be performed and the solution re-run.

For the Tune to pass, the mass calibration for the three tune elements (Section 9.2.1) must not differ by more than 0.1 amu from the true value and the resolution must be <0.9 amu full width at 10% peak height. Furthermore the RSD for the three tune elements must be <5% If any of these criteria fail then the mass calibration must be adjusted to the correct value. This is done by re-optimizing the instrument conditions and re-tuning.

The results of the calibration blank (Section 10.4.1) must be less than 3 times the current IDL for each element. If this is not the case, the reason for the out-of-control condition must be found and corrected, and affected samples must be reanalyzed. If the laboratory consistently has concentrations greater than 3 times the IDL, the IDL may be indicative of an estimated IDL and should be re-evaluated.

Calibration is performed after the tune passes. A five point calibration is performed (Section 9.3). If more than three points are to be used for the calibration, then the resultant curve must have a correlation coefficient (cc) of 0.995 or greater. If the cc is <0.995, then the instrument should be re-optimized and re-calibrated. The calibration should define the working linear range of the curve. The reporting RL should be the low standard, and the upper linear range should be defined by the high standard.

The ICV (Section 9.3) is performed immediately after an acceptable calibration has been produced. The acceptable range for this standard is 90-110%. If this standard fails then the analysis should be stopped and the instrument re-calibrated, and the ICV re-analyzed. Analysis cannot continue until this standard passes.

The ICB (Section 10.4.1) must be performed immediately after the ICV. The ICB must be < Reporting Limit. If the ICB fails then the analysis is terminated, sources of contamination are checked for, and the instrument is re-calibrated and the ICV and ICB are re-analyzed.

The Interference Check Solutions (Section 10.6), ICSA and ICSAB monitor how well the system is correcting for interference. The target elements in ICSA should be below the RL for those elements in question. Solution ICSAB should have a % recovery of 80-120% for the target elements. If the recovery of these solutions is outside of the control limits, the non-compliance should be narrated. There is no corrective action required because instrument corrections are based on natural isotope abundances that cannot be changed. If the IS is in compliance then the data is acceptable.

The Method (Preparation) Blank (Section 10.4.2) must be less than the RL for all of the elements that are being analyzed. If the element in question is non-detect, and the method blank is positive then the corrective action is a narration on the final report. If the samples associated with the method blank have “hits”, and they are 10x greater then the method blank, then the corrective action is a narration on the final report. If the method blank is not less than the RL, and the associated samples have results that are greater then the RL but less than 10x the method blank, then the samples must be re-digested and re-analyzed.

If the LCS (Section 10.5) fails, then all samples associated with that batch must be re-digested and re-analyzed. (Massachusetts recognizes that if the MS passes and the LCS fails then the data can be accepted. Narrate then non-compliance. This is only for MCP projects)

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Failure of the CCV (Section 10.5) terminates the analysis immediately. Correct the problem, and re-calibrate and re-analyze all samples since the last compliant CCV.

Failure of the CCB (10.4.1) terminates the analysis immediately. Evaluate the data; if associated sample results are greater than 10x CCB level then the results are acceptable. Otherwise, re-calibrate and re-analyze all samples since last compliant CCB.

If the dilution test (Section 10.7) fails, then an interference must be suspected. There is no corrective action to be applied. Narrate the non-compliance on the final report.

If the Post–Digestion Spike (Section 10.8) fails, then the sample must be diluted and re-analyzed to compensate for the matrix effect. Narrate the non-compliance on the final report.

Failure of the duplicate sample (Section 10.9) should be investigated. If the sample is found to be non-homogeneous then the non-compliance should be narrated on the final report. If the sample is aqueous in nature or a homogenous soil, then the duplicates should be re-digested and re-analyzed and the non-compliance narrated on the final report.

If the Internal Standards (Section 10.3) fail the acceptance criteria, then dilute the samples until the IS passes. If the criteria are still not met, then terminate the analysis, re-calibrate, verify the new calibration, and reanalyze all of the affected samples.

13. Pollution Prevention

See Chemical Hygiene Plan for pollution prevention operations.

14. Waste Management

See Chemical Hygiene Plan for waste handling and disposal.

15. Attachments

Table 2: Detection Limits
Table 3: Interference Check Solution Concentrations
Table 4: Calibration Standards
Table 5: Recommended Isotopes for Selected Elements
Table 6: Precision and Accuracy Acceptance Criteria
Table 7: Metals LCS Concentrations
Table 8: Internal Standard
Table 9: Tune Solution
Table 10: ICV / CCV Solution
Table 11: Interference Check Solutions

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Table 2
Detection Limits

Element	Atomic Symbol	Mass (m/z)	Aqueous (µg/L)	Soil / Solid (mg/Kg)
Beryllium	Be	9	0.10	0.004
Sodium	Na	23	10	0.40
Magnesium	Mg	24	10	0.40
Aluminum	Al	27	0.10	0.004
Potassium	K	39	10	0.40
Calcium	Ca	42	10	0.40
Vanadium	V	51	0.10	0.004
Chromium	Cr	52	0.10	0.004
Manganese	Mn	55	0.10	0.004
Iron	Fe	57	10	0.40
Cobalt	Co	59	0.10	0.004
Nickel	Ni	60	0.10	0.004
Copper	Cu	65	0.10	0.004
Zinc	Zn	66	0.10	0.004
Arsenic	As	75	0.10	0.004
Selenium	Se	82	0.10	0.004
Molybdenum	Mo	98	0.10	0.004
Silver	Ag	107	0.10	0.004
Cadmium	Cd	111	0.10	0.004
Antimony	Sb	121	0.10	0.004
Barium	Ba	137	0.10	0.004
Thallium	Tl	205	0.10	0.004
Lead	Pb	208	0.10	0.004
Internal Standards				
Lithium	Li	6		
Scandium	Sc	45		
Germanium	Ge	74		
Yttrium	Y	89		
Indium	In	115		
Bismuth	Bi	209		

ND = Not determined or listed in the reference method.
NL = Compound not listed in the reference method.
Calculated Method Detection Limits are on file in the QC Department.

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Table 3
Interference Check Solution

Solution Component	Solution A Concentration (mg/L)	Solution AB Concentration (mg/L)
Al	100.0	100.0
Ca	100.0	100.0
Fe	100.0	100.0
Mg	100.0	100.0
Na	100.0	100.0
P	100.0	100.0
K	100.0	100.0
S	100.0	100.0
C	200.0	200.0
Cl	1000.0	1000.0
Mo	2.0	2.0
Ti	2.0	2.0
As	0.0	0.1000
Cd	0.0	0.1000
Cr	0.0	0.1000
Co	0.0	0.1000
Cu	0.0	0.1000
Mn	0.0	0.1000
Ni	0.0	0.1000
Ag	0.0	0.1000
Zn	0.0	0.1000

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Table 4
Calibration Standards

Agilent Stock# 5183-4682 (Section 8.4)

Stock Standard B = 1000 mg/L of the following: Fe, K, Ca, Na, Mg, Sr

Stock Standard A = 10 mg/L of the following: Ag, Al, As, Ba, Be, Cd, Co, Cr, Cu, Mn, Mo, Ni, Pb, Sb, Se, Tl, V, Zn, Th, U

All Calibration Standards are prepared in 5% HNO3 (v/v) diluted to 50mL.

Standard #1 (0.1 µg/L of **B** and 10 µg/L of **A**): Dilute 5 mL of Standard #2 below, with 5% HNO_3 (v/v) to 50mL final volume.

Standard #2 (1.0 µg/L of **B** and 100 µg/L of **A**): Dilute 5 mL of Standard #3 below, with 5% HNO_3 (v/v) to 50mL final volume.

Standard #3 (10.0 µg/L of **B** and 1000 µg/L of **A**): Dilute 0.05 mL of Agilent Stock# 5183-4682, with 5% HNO_3 (v/v) to 50mL final volume.

Standard #4 (100 µg/L of **B** and 10000 µg/L of **A**): Dilute 0.5 mL of Agilent Stock# 5183-4682, with 5% HNO_3 (v/v) to 50mL final volume.

Standard #5 (200 µg/L of **B** and 20000 µg/L of **A**): Dilute 1.0 mL of Agilent Stock# 5183-4682, with 5% HNO_3 (v/v) to 50mL final volume.

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Table 5
Recommended Isotopes for Selected Elements

Mass	Element of Interest
27	Aluminum
121, **123**	Antimony
75	Arsenic
138, 137, 136, **135**, 134	Barium
9	Beryllium
209	Bismuth (IS)
114, 112, **111**, 110, 113, 116, 106	Cadmium
42, 43, **44**, 46, 48	Calcium (I)
35, 37, (77, 82)[a]	Chlorine (I)
52, 53, **50**, 54	Chromium
59	Cobalt
63, **65**	Copper
165	Holmium (IS)
115, 113	Indium (IS)
56, 54, **57**, 58	Iron (I)
139	Lanthanum (I)
208, 207, **206**, 204	Lead
6[b], 7	Lithium (IS)
24**, 25**, **26**	Magnesium (I)
55	Manganese
98, 96, 92, **97**, 94 (108)[a]	Molybdenum (I)
58, **60**, 62, **61**, 64	Nickel
39	Potassium (I)
103	Rhodium (IS)
45	Scandium (IS)
80,**78**,**82**,**76**,**77**,74	Selenium
107, **109**	Silver
23	Sodium (I)
159	Terbium (IS)
205, 203	Thallium
51 ,50	Vanadium
120, **118**	Tin (I)
89	Yttrium (IS)
64, **66, 68**, **67**, 70	Zinc

NOTE: Method 6020 is recommended for only those analytes listed in Table 1. Other elements are included in this Table because they are potential interferents (I) in the determination of recommended analytes, or because they are commonly used internal standards (IS). Isotopes are listed in descending order of natural abundance. The most useful isotopes are underlined and in boldface, although certain matrices may require the use of alternative isotopes.

[a] These masses are also useful for interference correction (Section 4.2)
[b] Internal standard must be enriched in the 6Li isotope. This minimizes interference from indigenous Li.

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Table 6
Precision and Accuracy Acceptance Criteria *

	Aqueous % Recovery LCS		Soil % Recovery LCS		Duplicate	
Element	**Lower Control Limit**	**Upper Control Limit**	**Lower Control Limit**	**Upper Control Limit**	**Aqueous %RPD**	**Soil %RPD**
Aluminum	80	120	70	140	20	35
Antimony	80	120	70	140	20	35
Arsenic	80	120	70	140	20	35
Barium	80	120	70	140	20	35
Berylium	80	120	70	140	20	35
Cadmium	80	120	70	140	20	35
Calcium	80	120	70	140	20	35
Chromium	80	120	70	140	20	35
Cobalt	80	120	70	140	20	35
Copper	80	120	70	140	20	35
Iron	80	120	70	140	20	35
Lead	80	120	70	140	20	35
Magnesium	80	120	70	140	20	35
Manganese	80	120	70	140	20	35
Molybdenum	80	120	70	140	20	35
Nickel	80	120	70	140	20	35
Potassium	80	120	70	140	20	35
Selenium	80	120	70	140	20	35
Silver	80	120	70	140	20	35
Sodium	80	120	70	140	20	35
Thallium	80	120	70	140	20	35
Vanadium	80	120	70	140	20	35
Zlnc	80	120	70	140	20	35

* These are default limits. The limits are re-evaluated and updated as necessary pending compilation of the minimum number of data points.

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Table 7
Metals LCS Concentrations

Analyte	Liquid Concentration (mg/L)	Soil Concentration (mg/Kg)
Antimony	0.5	20
Arsenic	0.12	4.8
Barium	2.00	80
Beryllium	0.05	2.0
Cadmium	0.051	2.04
Chromium	0.20	8.0
Copper	0.25	10
Lead	0.51	20.4
Nickel	0.50	20
Selenium	0.12	4.8
Silver	0.05	2.0
Thallium	0.12	4.8
Zinc	0.50	20
Iron	1.00	40
Manganese	0.50	20
Calcium	10.0	400
Magnesium	10.0	400
Potassium	10.0	400
Sodium	10.0	400
Aluminum	2.00	80
Cobalt	0.50	20
Vanadium	0.50	20

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Table 8
Internal Standard

Agilent Stock# 5183-4681 (Section 8.5), 10mg/L of ^{6}Li,^{45}Sc, ^{74}Ge, ^{89}Y, ^{115}In, ^{209}Bi

Working Internal Standard (IS) Solution (1 mg/L of ^{6}Li,^{45}Sc, ^{74}Ge, ^{89}Y, ^{115}In, ^{209}Bi): Dilute 5.0 mL of Agilent Stock# 5183-4681, with 5% HNO_3 (v/v) to 50mL final volume.

Table 9
Tune Solution

Agilent Stock# 8500-6943 (Section 8.6), 10mg/L of ^{7}Li, ^{140}Ge, ^{89}Y, ^{204}Tl

Working Tune Solution (0.01 mg/L of ^{7}Li, ^{140}Ge, ^{89}Y, ^{204}Tl): Dilute 0.2 mL of Agilent Stock# 8500-6943, with 5% HNO_3 (v/v) to 200mL final volume.

Table 10
ICV / CCV Solution

Agilent Stock# 5183-4682 (Section 8.7): **1000mg/L** of K, Na, Ca, Mg, Fe, Sr
10mg/L of Ag, Al, As, Ba, Be, Cd, Co, Cr, Cu, Mn, Mo, Ni, Pb, Sb, Se, Tl, V, An, Th, U

Working ICV/CCV Solution: Dilute 0.25 mL of Agilent Stock# 5183-4682, with 5% HNO_3 (v/v) to 50mL final volume. This will give the following concentrations:

5000µg/L of K, Na, Ca, Mg, Fe, Sr
50µg/L of Ag, Al, As, Ba, Be, Cd, Co, Cr, Cu, Mn, Mo, Ni, Pb, Sb, Se, Tl, V, An, Th, U

Table 11
Interference Check Solutions

ICSA, Agilent Stock Solution # 8500-6998 (Section 8.8):
10000 mg/L of Cl^-
2000 mg/L of C
1000 mg/L of Al, Ca, Fe, K, Mg, Na, P, S
20 mg/L of Mo, Ti

Working ICSA Solution: Dilute 10 mL of Agilent Stock# 8500-6998, with 5% HNO_3 (v/v) to 100mL final volume. This will give the following concentrations:
1000 mg/L of Cl^-
200 mg/L of C
100 mg/L of Al, Ca, Fe, K, Mg, Na, P, S
2 mg/L of Mo, Ti

ICSB, Agilent Stock Solution # 8500-7001 (Section 8.9): **10 mg/L** of Ag, As, Cd, Co, Cr, Cu, Mn, Ni, Zn

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Working ICSAB Solution (Section 8.10): Dilute 10 mL of ICSA Agilent Stock Solution # 8500-6998, and 1mL of ICSB Agilent Stock Solution # 8500-7001 with 5% HNO_3 (v/v) to 100mL final volume. This will give the following concentrations:
1000 mg/L of Cl^-
200 mg/L of C
100 mg/L of Al, Ca, Fe, K, Mg, Na, P, S
2 mg/L of Mo, Ti
0.1 mg/L of Ag, As, Cd, Co, Cr, Cu, Mn, Ni, Zn

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Extractable Petroleum Hydrocarbons (EPH)

Reference Method No.: Method for the Determination of Extractable Petroleum Hydrocarbons (EPH), Massachusetts DEP, ORS, BWSC. January, 1998.

Copy No. _____

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Prepared by:

Name: Joseph Watkins Position: Semivolatile Organics Manager

Signature: Joseph Watkins Date: 8/15/03

Authorized by:

Name: Ellen Collins Position: Quality Assurance Officer

Signature: Ellen Collins Date: 8/15/03

ISSUE AMENDMENTS

Changes since last issue:

Section 1: The Reporting Limits of this method for TPH were updated.

Section 4.1.1: The detector make-up gasses were changed.

Section 8.2: Ampulated stock solutions are transferred to clear crimp-top vials upon opening.

Table 2: Calibration levels were updated.

Extractable Petroleum Hydrocarbons (EPH)

Reference Method No.: Method for the Determination of Extractable Petroleum Hydrocarbons (EPH), Massachusetts DEP, ORS, BWSC. January, 1998.

1. Scope and Application

This method is used to measure the collective concentrations of extractable aliphatic and aromatic petroleum hydrocarbons in water and soil. Extractable aliphatic hydrocarbons are collectively quantitated within two ranges: C_9 through C_{18}, and C_{19} through C_{36}. Extractable aromatic and aromatic hydrocarbon ranges correspond to a boiling point range between approximately 150 °C and 500 °C.

This method is based on a solvent extraction, silica gel solid-phase extraction/fractionation process (SPE), and gas chromatography (GC) analysis using a flame ionization detector (FID). This procedure is used by, or under the supervision of, analysts experienced in extractable organics analysis. Analysts must be skilled in the interpretation of gas chromatograms and their use as a quantitative tool. Each analyst must demonstrate the ability to generate acceptable results with this method by performing an initial demonstration of capability, analyzing a proficiency test sample and completing the record of training.

This method is also able to measure the individual concentrations of Target Polynuclear Aromatic Hydrocarbons (PAH) Analytes, including Diesel PAH Analytes, in water and soil. Results for these individual analytes are reported at client request. The Method Detection Limits for some of these PAH compounds in water are greater than the notification and/or cleanup standards specified in the Massachusetts Contingency Plan for sites located in drinking water resource areas. In cases where it is necessary to demonstrate compliance with these standards, the use of a GC/MS method in the SIM mode may be necessary.

The fractionation step described in this method may be eliminated to allow for the determination of a Total Petroleum Hydrocarbon (TPH) value, and/or obtain qualitative "fingerprinting" information. While TPH provides little information on the chemistry, toxicity, or environmental fate of petroleum mixtures, it may be a cost-effective screening tool in cases where relatively low concentrations of contamination are suspected.

Petroleum products suitable for evaluation by this method include kerosene, fuel oil #2, fuel oil #4, fuel oil #6, diesel fuel, jet fuel, and certain lubricating oils. This method, in and of itself, is not suitable for the evaluation of gasoline, mineral spirits, petroleum naphthas, or other petroleum products that contain a significant percentage of hydrocarbons lighter than C_9. This method, in and of itself, is also not suitable for the evaluation of petroleum products that contain a significant percentage of hydrocarbons heavier than C_{36}.

The Reporting Limits (RLs) of this method for each of the collective aliphatic and aromatic fractional ranges are typically 10 mg/kg in soil and 100 µg/L in water. The RLs of this method for TPH is typically 30 mg/kg in soil and 200 µg/L in water. The RLs of this method for the Target PAH Analytes are typically 0.5 mg/kg in soil and 20 µg/L in water.

This method includes a data adjustment step to subtract the concentration of Target Analytes from the concentration of C_{11} through C_{22} Aromatic Hydrocarbons. This step is taken by the laboratory, and both adjusted and unadjusted values are reported to the client.

Data generated using this method is reported using the required format.

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Like all GC procedures, this method is subject to a "false positive" bias in the reporting of Target PAH Analytes, in that non-targeted hydrocarbon compounds eluting or co-eluting within a specified retention time window may be falsely identified and/or quantitated as a Target or Diesel PAH Analyte. While cleanup procedures specified in this method to segregate aliphatic and aromatic fractions will serve to mitigate this concern, confirmatory analysis by gas chromatography/mass spectrometry (GC/MS) analysis may be performed in cases where a target PAH analyte identification is suspect.

Matrices: This method is suitable for the analysis of waters, soils, and sediments.

Definitions: See Alpha Laboratories Quality Manual Appendix A

Regulatory Parameter List:

Parameter	CAS
C9-C18 Aliphatic Hydrocarbons	-
C19-C36 Aliphatic Hydrocarbons	-
C11-C22 Aromatic Hydrocarbons	-
Naphthalene	91-20-3
2-Methylnaphthalene	91-57-6
Acenaphthylene	208-96-8
Acenaphthene	83-32-9
Fluorene	86-73-7
Phenanthrene	85-01-8
Anthracene	120-12-7
Fluoranthene	206-44-0
Pyrene	129-00-0
Benzo(a)anthracene	56-55-3
Chrysene	218-01-9
Benzo(b)fluoranthene	205-99-2
Benzo(k)fluoranthene	207-08-9
Benzo(a)pyrene	50-32-8
Indeno(1,2,3-cd)pyrene	193-39-5
Dibenzo(a,h)Anthracene	53-70-3
Benzo(g,h,i)perylene	191-24-2

The data report packages present the documentation of any method modification related to the samples tested. Depending upon the nature of the modification and the extent of intended use, the laboratory may be required to demonstrate that the modifications will produce equivalent results for the matrix. Approval of all method modifications is by one of the following laboratory personnel before performing the modification: Area Supervisor, Laboratory Services Manager, Laboratory Director, or Quality Assurance Officer.

After initial demonstration, ongoing demonstration is based on acceptable laboratory performance of at least a quarterly laboratory control sample or acceptable performance from an annual proficiency test sample. A major modification to this procedure requires demonstration of performance. The identification of major method modification requiring performance demonstration is directed by the QA Officer and Laboratory Director on a case-by-case basis.

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2. Summary of Method

Samples submitted for EPH analysis are extracted with methylene chloride, dried over sodium sulfate, solvent exchanged into hexane, and concentrated in a Kuderna-Danish apparatus. Sample cleanup and separation into aliphatic and aromatic fractions is conducted using commercially available silica gel cartridges. The two extracts produced are then re-concentrated to final volumes of 1mL each (i.e., an aliphatic extract and an aromatic extract). The extracts are then separately analyzed by a capillary column gas chromatograph equipped with a flame ionization detector.

Average calibration factors are determined using an aliphatic hydrocarbon standard mixture and are used to calculate the collective concentrations of C_9 through C_{18} and C_{19} through C_{36} aliphatic hydrocarbons. An average calibration factor is determined using a PAH standard mixture and is used to calculate the collective C_{11} through C_{22} aromatic hydrocarbon concentration. Calibration factors determined for individual components of the PAH standard mixture are also used to calculate individual concentrations of Target PAH Analytes.

2.1 Method Modifications from Reference

In addition to the soil extraction techniques listed in the method, an accelerated solvent extraction technique is used. The procedure is detailed in the extraction SOP, and IDCs and MDL studies have been performed using this method to demonstrate equivalent performance.

Any significant modifications to the method are disclosed and described on the data report form, as detailed in Section 9.8.

3. Detection Limits

The laboratory follows the procedure found in the MADEP "Method for the Determination of Extractable Petroleum Hydrocarbons (EPH)" to determine the MDL on an annual basis. The method detection limits determined by the laboratory are on file for review.

Table 1 lists our routine reporting limits. Whenever MDL studies are performed, the MDL results are compared with our reporting limits to ensure that the calculated MDLs are equal to or below our reporting limits.

3.1 Method Detection Limits for Individual Analytes

Analyze a minimum of seven replicate reagent water and/or clean sand blanks that have been fortified with all analytes or interest. Spiking concentrations are 20 µg/L for water, and 1.0 mg/kg for soil. Extract and analyze each replicate according to the procedures described in Section 9.

3.1.1 Water MDLs are determined by extracting 7 replicates of 1L reagent water blanks spiked with OTP, COD and each analyte of interest.

3.1.2 Soil/sediment MDLs are determined by extracting 7 replicates of 10g sand blanks spiked with OTP, COD, and each analyte of interest.

3.1.3 For each analyte, excluding C36, the mean accuracy, expressed as a percentage of the true value, must be between 40% and 140%. For each analyte, the %RSD must be less than or equal to 25.

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3.2 Method Detection Limits for Collective Hydrocarbon Ranges / TPH

Analyze a minimum of seven replicate reagent water and/or clean sand blanks that have been fortified with diesel fuel. Spiking concentrations are 0.5 mg/L for water, and 50 mg/kg for soil. Extract and analyze each replicate according to the procedures described in Section 9.

3.2.1 Water MDLs are determined by extracting 7 replicates of 1L reagent water blanks spiked with OTP, COD and the petroleum reference standard.

3.2.2 Soil/sediment MDLs are determined by extracting 7 replicates of 10g sand blanks spiked with OTP, COD, and the petroleum reference standard.

3.2.3 The mean recovery of the summation of all (unadjusted) hydrocarbon ranges (including Target Analytes), expressed as a percentage of the true value of the petroleum reference standard, must be between 40% and 140%. For the total hydrocarbon values, the %RSD must be less than or equal to 25%

4. Interferences

4.1 Instrumental

4.1.1 Only high purity gases are used in the GC system to eliminate this source of possible contamination. The helium (carrier gas – 99.999%), air, and hydrogen (detector make-up gases) are certified by the gas supplier.

4.1.2 Preventive instrument maintenance is performed routinely, and whenever highly contaminated extracts are analyzed that could result in chromatographic interferences or result in degradation of system performance. Section 9.7 details the maintenance steps.

4.1.3 Glassware must be scrupulously cleaned. This procedure is detailed in the extraction SOPs. Store dry glassware in a clean environment.

4.1.4 The leaching of plasticizers and other compounds have been observed from commercially available silica gel cartridges used to fractionate EPH sample extracts. This possible source of contamination is continuously monitored and documented by analysis of Laboratory Method Blanks.

4.1.5 Contamination by carry-over can occur whenever high-concentration and low-concentration samples are sequentially analyzed. Whenever an unusually concentrated sample is encountered, it should be followed by the analysis of a solvent blank to check for possible carry-over. If this is not done, the sample analyzed immediately following the high-concentration sample must be rerun to confirm any positive hits.

4.2 Parameters

4.2.1 Matrix interferences may be caused by contaminants that are co-extracted from the sample. The extent of matrix interference will vary considerably from one source to another depending upon the nature and diversity of the site being sampled. The silica gel SPE cleanup procedure is used to overcome many of these interferences, but some samples may require additional cleanup approaches that are beyond the scope of this method.

4.2.2 Certain organic compounds not associated with releases of petroleum products, including chlorinated hydrocarbons, phenols, and phthalate esters, will be quantitated as Extractable and Total Petroleum Hydrocarbons. If necessary and/or desirable, additional

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sample cleanup and/or analytical procedures may be employed to minimize or document the presence of such compounds.

4.2.3 Because of their weakly polar nature, naphthalene and substituted naphthalenes are readily fractionated into the aliphatic extract if excessive amounts of hexane are used to elute the silica gel cartridge/column. Because these compounds constitute a significant percentage of the water-soluble fraction of fuel oils, this occurrence is especially problematic in the analysis of water samples. For this reason, the method requires the use of 2-Bromonaphthalene as one of the fractionation surrogate standards, which behaves similarly to naphthalene, to monitor and document fractionation accuracy.

5. Safety

The toxicity or carcinogenicity of each reagent and standard used in this method is not fully established; however, each chemical compound should be treated as a potential health hazard. From this viewpoint, exposure to these chemicals must be reduced to the lowest possible level by whatever means available. A reference file of material data handling sheets is available to all personnel involved in the chemical analysis. Additional references to laboratory safety are available in the Chemical Hygiene Plan.

All personnel handling environmental samples known to contain or to have been in contact with municipal waste must follow safety practices for handling known disease causative agents.

5.1 Lab coats, safety glasses, and gloves must be worn when handling samples, extracts, standards or solvents.

5.2 All solvent and extract transfers must be handled in the vented bench area in the GC laboratory.

5.3 All stock standards, working standards, and vialed sample extracts must be placed into the waste bucket in the lab, for future disposal by the Hazardous Waste Manager. The container must be labeled properly with hazard warning labels indicating the container contents.

5.4 Bottles containing flammable solvents must be stored in the flammables cabinet.

6. Sample Collection, Preservation, and Handling

6.1 Sample Collection

Aqueous samples are collected in two 1L amber glass jars with teflon-lined lids. Solid samples are collected in 250mL wide-mouth glass jars with teflon-lined lids. All containers are purchased pre-cleaned and certified from commercial vendors.

6.2 Sample Preservation

Both aqueous and solid samples are then preserved by packing in coolers with ice or ice packs, to maintain a temperature of $\leq 4^{o}$ C. Additionally, aqueous samples are preserved at the time of sampling by the addition of approximately 5mLs of 1:1 HCl. The sample pH must be less than 2.0 after addition of the acid. Upon receipt at the laboratory, the samples are transferred into sample storage refrigerators to maintain at a temperature of $\leq 4^{o}$ C.

6.3 Sample Handling

Aqueous samples must be extracted within 14 days of sample collection, solid samples within 7 days of collection. Once extracted, the samples must be analyzed within 40 days of the extraction date.

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7. Equipment and Supplies

7.1 Gas Chromatograph, Hewlett Packard 5890 or equivalent: An analytical system complete with gas chromatograph configured for split-splitless injection and all required accessories including autosampler syringes, analytical columns, gases, and flame ionization detectors (FID). The systems used for this analysis are configured with dual injectors/dual columns for simultaneous injection and analysis of both the aliphatic and aromatic extracts.

7.2 Data System: A computer system is interfaced to the GC for collection of data. Perkin Elmer Turbochrom software is used for data acquisition, and Thruput Target software is used for data reduction and processing.

7.3 GC Columns: RTx-5, 30 m x 0.32 mm ID fused silica capillary column, 0.25 µm film thickness. Alternative columns may be used as long as the method performance criteria can be met.

7.4 Microsyringes: 10µL, 100µL, 250µL, 500µL and 1000µL

7.5 Volumetric Flasks: 10mL and 25mL, used for standard preparation.

7.6 Disposable Borosilicate Pipets

7.7 Vials: 2 mL clear glass, crimp-top and screw-cap.

8. Standards and Reagents

Reagent grade or pesticide grade chemicals are used in all tests. Unless otherwise indicated, it is intended that all reagents shall conform to specifications of the Committee on Analytical Reagents of the American Chemical Society, where such specifications are available. Other grades may be used, provided it is first ascertained that the reagent is of sufficient high purity to permit its use without lessening the accuracy of the determination.

NOTE: Store the standard solutions (stock, composite, calibration, internal, and surrogate) at 4 °C in Teflon(R)-sealed containers in the dark. When a lot of standards is prepared, aliquots of that lot are stored in individual small vials. All stock standard solutions must be replaced after one year or sooner if routine QC tests indicate a problem. All other standard solutions must be replaced after six months or sooner if routine QC indicates a problem.

8.1 Reagents

8.1.1 Reagent Water: All reagent water is from Alpha's RO treatment system, and is demonstrated to be free of interferences or contaminants

8.1.2 Solvents: Hexane, methylene chloride, and acetone; pesticide grade or better. Store away from other solvents.

8.2 Stock Standard Solutions: All stock standard solutions are purchased from commercial vendors as ampulated certified solutions. When an ampulated stock solution is opened, it is transferred to a labeled clear crimp-top vial. The expiration date of the stock solution is either the vendor specified expiration date, or 1 year from the date the ampule was opened, whichever is sooner. Stock solutions are stored at <0°C. Typical stock standard concentrations are listed in Table 2.

8.2.1 Aromatic Hydrocarbon Standard: The Aromatic Hydrocarbon Standard consists of the 17 PAH compounds listed in Table 2. Typical stock concentrations are 1000µg/mL.

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8.2.2 Aliphatic Hydrocarbon Standard: The Aliphatic Hydrocarbon Standard consists of the 14 normal alkanes listed in Table 2. Typical stock concentrations are 1000µg/mL.

8.2.3 Extraction Surrogate Standards: The extraction surrogates are chloro-octadecane (COD) and ortho-terphenyl (OTP). Typical stock concentrations are 2000µg/mL.

8.2.4 Fractionation Surrogate Standards: The fractionation surrogates are 2-Fluorobiphenyl and 2-Bromonaphthalene. Typical stock concentrations are 2000µg/mL.

8.3 Calibration Standards

Calibration standards are prepared volumetrically by diluting the appropriate stock standard(s) with methylene chloride. Calibration standards expire 6 months from the date of preparation, or on the earliest expiration date of any of the stock solutions used to prepare the calibration standard. Calibrations are performed at the 5 concentration levels listed in Table 2. All working standards are stored refrigerated at between 1°-4°C.

8.4 Surrogate Spiking Solution

The surrogate spiking solution is prepared from the extraction surrogate stock standard, by volumetric dilution with acetone. The final concentration of the spiking solution is 20µg/mL.

8.5 LFB/MS Spiking Solution

This solution is used for preparing Laboratory Fortified Blanks (LFB) and Matrix Spikes (MS), if required. The solution is prepared from the aromatic and aliphatic stock standards, by volumetric dilution with acetone. The final concentration of the spiking solution is 50µg/mL.

Note: Although the solution contains all of the aliphatic and aromatic compounds, only C_9, C_{14}, C_{19}, C_{20}, and C_{28} normal alkanes and naphthalene, acenaphthene, anthracene, pyrene and chrysene are quantitated and reported.

8.6 Fractionation Surrogate Solution

This solution is added to all extracted samples and QC samples prior to sample cleanup and fractionation using the silica gel cartridges. This serves as an important check on the ability of the fractionation to accurately separate the aliphatic from the aromatic compounds. The solution is prepared from the fractionation surrogate stock standard, by volumetric dilution with hexane. The final concentration of the surrogate solution is 40µg/mL.

8.7 Fractionation Check Solution

This solution is used to monitor the fractionation efficiency of the silica gel cartridge, and to establish the optimum volume of hexane needed to sufficiently elute aliphatic hydrocarbons from the cartridge without eluting the aromatic hydrocarbons prior to the methylene chloride elution. Fractionation checks are performed whenever a new lot of silica gel cartridges is received, prior to using them for actual samples.

The solution is prepared from the aromatic and aliphatic stock standards, by volumetric dilution with hexane. The final concentration of the solution is 20µg/mL.

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9. Procedure

9.1 Set-up

9.1.1 Sample Extraction

Water samples are extracted at acid pH (less than pH 2) with methylene chloride using a separatory funnel (Method 3510). See extraction SOP for details.

Solid samples are extracted with methylene chloride using Soxhlet extraction (Method 3540), accelerated solvent extraction (Method 3545) or ultrasonic extraction (Method 3550) procedures. See extraction SOP for details.

9.1.2 Extract Fractionation

Silica gel fractionation is used for sample cleanup and separation into aliphatic and aromatic extracts. Silica gel cartridges are purchased from commercial vendors, and tested prior to use. See fractionation SOP for details.

9.1.3 GC Conditions:

A dual-injector/dual-column/dual-detector approach involves the use of the columns listed in section 7.2. This allows for the simultaneous analysis of both fractions. Typical GC conditions are listed below, but may be altered as long as method performance criteria are met.

Temperature 1:	60 °C
Time 1:	1 minute
Ramp 1:	8 °C/minute
Temperature 2:	300 °C
Time 2:	6.75 minutes
Injector temperature:	290 °C
FID temperature:	350 °C
Carrier gas:	Helium
Carrier pressure program:	15 psi initial
	10 minute hold
	1 °C/minute
	36 psi final
	9 minutes hold
Detector Air:	400 mL/minute
Detector Hydrogen:	40 mL/minute
Injection volume:	1 µL

9.2 Initial Calibration

9.2.1 Prepare calibration standards using the procedures in Section 8.3 at the concentrations listed in Table 2. The calibration standards are aliquoted into autosampler vials and capped prior to loading onto the autosampler tray.

9.2.2 Establish the GC operating conditions by loading the appropriate GC method. Typical instrument conditions are listed in section 9.1.3. The same operating conditions are used for calibrations and sample analyses. Create the analytical sequence using the Turbochrom data acquisition software.

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9.2.3 A 1µL injection volume of each calibration standard is typically used. Other injection volumes may be employed, provided that the analyst can demonstrate adequate sensitivity for the compounds of interest. The same injection volume must be used for all standards and samples.

9.2.4 Calibration Factors

The external standard calibration technique is employed in this method. Calibration factors are determined for the individual PAH target compounds, the aromatic hydrocarbon range, and the two aliphatic hydrocarbon ranges as described below.

9.2.4.1 Individual PAH Target Compounds: In each standard, calculate the calibration factor for each analyte, the mean calibration factor, and the relative standard deviation (RSD) of the calibration factors, using the Target data processing software. The calculations are performed automatically, using the formulae listed in Alpha's Quality Manual.

9.2.4.2 Hydrocarbon Ranges: In each standard, calculate the calibration factor for each range, the mean calibration factor, and the relative standard deviation (RSD) of the calibration factors, using the Target data processing software. The calculations are performed automatically, using the formulae listed in Alpha's Quality Manual.

9.2.5 Initial Calibration Criteria

If the RSD for an analyte or range is $\leq$ 25%, then the response of the instrument for this compound is considered linear over the range and the mean calibration factor can be used to quantitate sample results. If the RSD for any analyte is > 25%, then linearity through the origin cannot be assumed. The calibration must be repeated for any compounds that fail, or a calibration curve may be generated for this compound and used for sample quantitation instead of the mean calibration factor. If a linear regression curve is used, the correlation coefficient (r) must be at least 0.99.

9.2.6 Retention Time Windows

9.2.6.1 The retention time windows used for the identification of each aliphatic individual compound, aromatic individual compound, and surrogate is ± 0.07 minutes. It has been determined that these limits work well, being wide enough to eliminate false-negatives while being tight enough to eliminate false-positives. Windows that are calculated using the procedure described in the method tend to be very narrow, creating the risk of false negative results. The experience of the analyst also weighs heavily in the interpretation of chromatograms.

9.2.6.2 EPH retention time (Rt) windows are defined as beginning 0.1 minutes before the Rt of the beginning marker compound and ending 0.1 minutes after the Rt of the ending marker compound, except for n-C_{19}, which is both a beginning and ending marker compound for two different ranges.

The C_9 – C_{18} Aliphatic Hydrocarbon range ends immediately (0.01minutes) before the elution of the n-C_{19} peak. The C_{19} – C_{36} Aliphatic Hydrocarbon range begins 0.01 before the elution of the n-C_{19} peak; therefore there is no overlap of the two ranges and the n-C_{19} peak is only included in the C_{19} – C_{36} Aliphatic Hydrocarbon range.

EPH marker compounds and windows are summarized in Table 4.

9.2.6.3 If a TPH analysis is done, without fractionation, TPH retention time (Rt) windows are defined as beginning 0.1 minutes before the Rt of n-Nonane and ending 0.1 minutes after the Rt of n-Hexatricontane.

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9.3 Continuing Calibration Verification

9.3.1 The initial calibration curve is verified on each working day prior to the analysis of samples by the injection of a mid-level calibration standard. The percent difference (%D) for all aliphatic and aromatic analytes must be less than or equal to 25%. Continuing calibrations are also run throughout the analytical sequence, typically after every 10 samples but at a minimum frequency of every 20 samples. The %D criteria must also be met in the calibration checks.

9.3.2 If the %D criteria cannot be met, inspect the gas chromatographic system to determine the cause and perform whatever maintenance is necessary before verifying calibration and proceeding with sample analysis.

9.3.3 If after maintenance the system still fails the calibration verification criteria, a new initial calibration curve must be analyzed.

9.4 Additional Instrument QC

9.4.1 All four surrogate compounds must be adequately resolved from any individual analytes in the aliphatic and aromatic standards.

9.4.2 The n-nonane peak must be adequately resolved from the solvent peak.

9.4.3 All individual compound peaks in the aliphatic standard must be adequately resolve to baseline. In the aromatic standard, baseline separation should be seen for Phenanthrene and Anthracene. Benzo(a)anthracene, Chrysene, Benzo(b)fluoranthene, Benzo(k)fluoranthene, Dibenzo(a,h)anthracene, and Indeno(1,2,3-cd)pyrene will not demonstrate baseline separation; however, the peaks should be 50% resolved.

9.4.4 The response ratio of C_{28} to C_{20} should be at least 0.85, to demonstrate that the system is not exhibiting mass discrimination.

9.5 Sample Analysis

9.5.1 The same GC operating conditions used for the initial calibration must be employed for sample analyses, including sample injection volume (Section 9.1.3).

9.5.2 Samples are analyzed in a set referred to as an analysis sequence. The sequence begins with instrument calibration followed by sample extracts interspersed with blanks and QC samples. The sequence ends when the set of sample extracts has been injected or when qualitative and/or quantitative QC criteria are exceeded.

9.5.3 Establish daily retention time windows for each analyte of interest. Use the absolute retention time for each analyte as the midpoint of the window for that day. The daily retention time window equals the midpoint ± 0.07 minutes.

9.5.3.1 Tentative identification of an analyte occurs when a peak from a sample extract falls within the daily retention time window. Confirmation by GC/MS analysis may be necessary.

9.5.3.2 Validation of GC system qualitative performance must be accomplished by the analysis of midlevel standards within the analysis sequence. If any of the standards fall outside their daily retention time window, the system is out of control. In such cases, the cause of the problem must be determined and corrected.

9.5.4 Aliphatic and aromatic ranges of interest are determined by the collective integration of all peaks eluting between specified range “marker” compounds.

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9.5.5 When quantifying the aliphatic and aromatic ranges the integration must be from baseline (i.e., must include the unresolved complex mixture, or "hump", areas). For the integration of individual Target Analytes and surrogate compounds, a valley-to-valley approach should typically be used, though this approach may be modified on a case-by-case basis by an experienced analyst.

9.5.6 Baseline correction using a system solvent blank is permissible by the method, but is not routinely performed by Alpha.

9.5.7 If the Target PAH Analytes are to be quantitated using this method, and the response for an individual analyte exceeds the linear range of the system, dilute the extract and reanalyze. Extracts should be diluted so that all peaks are on scale. Overlapping peaks are not always evident when peaks are off scale. Computer reproduction of chromatograms, manipulated to ensure that all peaks are on scale over a 100-fold range, is acceptable if linearity is demonstrated prior to the analysis of samples.

9.5.8 For non-target analytes eluting in the aliphatic, aromatic or TPH fractions, the upper linear range of the system should be defined by peak height measurement, based upon the maximum peak height documented for an aliphatic or aromatic standard within the fraction that is shown to be within the linear range of the detector.

In addition, sample extracts may require re-fractionation at a dilution and re-analysis if it is determined that the silica gel cartridge was overloaded during the initial fractionation. The cartridge is considered overloaded if the amount of total hydrocarbons exceeds 25,000µg/mL.

9.6 Calculations

The concentration reported for a particular hydrocarbon range or individual target analyte in an extract is calculated using the Target data processing software. The Target methods have been configured to utilize the quantitation formulas found in Alpha's Quality Manual. Proper quantitation requires the appropriate selection of a baseline from which the peak area or height can be determined. See the Manual Integration SOP for integration guidelines.

9.6.1 Hydrocarbon Ranges

9.6.1.1 Aliphatic Fraction

9.6.1.1.1 Determine the total area count for all peaks eluting 0.1 minutes before the retention time (Rt) for n-C_9 and 0.01 minutes before the Rt for n-C_{19}. It is not necessary to identify or quantitate individual aliphatic compounds within this range. The area due to the aliphatic extraction surrogate (COD) must not be included in this area.

9.6.1.1.2 Using the average calibration factor from the initial calibration, or linear regression analysis (if used), calculate the collective concentrations of C_9 through C_{18} Aliphatic Hydrocarbons, C_{19} through C_{36} Aliphatic Hydrocarbons, and individual concentrations of the sample surrogate.

9.6.1.2 Aromatic Fraction

9.6.1.2.1 Determine the total area count for all peaks eluting 0.1 minutes before the retention time (Rt) for naphthalene and 0.1 minutes after the Rt for benzo(g,h,i)perylene. The area due to the aromatic extraction surrogate (OTP) and the fractionation surrogates (2-Fluorobiphenyl and 2-Bromonaphthalene) must not be included in this area.

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9.6.1.2.2 Using the average calibration factor from the initial calibration, or linear regression analysis (if used), calculate the concentrations of Unadjusted C_{11} through C_{22} Aromatic Hydrocarbons, the sample surrogate standard (COD), and the fractionation surrogates.

9.6.2 Individual Aromatic Target Analytes

Determine the area for each of the individual PAH analytes found in the aromatic fraction. Using the average calibration factor from the initial calibration, or linear regression analysis (if used), calculate the concentrations of the individual analytes.

9.6.3 Data Manipulations

9.6.3.1 By definition, the collective concentration of the aromatic fraction (and/or TPH) **excludes** the individual concentrations of the Target PAH Analytes. Accordingly, a data manipulation step is necessary to adjust the collective range concentration calculated in Sections 9.6.1.1 and 9.6.1.2, to eliminate 'double counting' of analytes.

This necessary data manipulation step is taken by Alpha for inclusion on the client report. Subtract the individual concentrations of the Target or Diesel PAH Analytes from the collective concentration of Unadjusted C_{11} through C_{22} Aromatic Hydrocarbons and/or Unadjusted TPH. This calculation is performed automatically by Alpha's LIMS system.
The extent of data manipulations taken by the laboratory must be noted on the data reporting form.

9.6.3.2 Baseline Correction for Instrument Noise Level

Range integration areas may be corrected by the manual or automatic subtraction of the baseline established by the injection of a system solvent blank. Correction in this manner is not routinely performed by Alpha, but is permissible according to the method in cases where all reasonable steps have been taken to eliminate or minimize baseline noise and rise. This is not performed without written approval of the Organics Laboratory Manager.

9.6.3.2.1 Instrument baseline shall be established by the direct injection of a system solvent blank. Alternatively, this level may be established by the injection of an air blank, or by activation of a programmed run without the injection of any material. All system and run elements and parameters must be identical to those of the sample run.

9.6.3.2.2 If baseline correction is used, instrument baseline must be established for every batch of samples, and after the analysis of samples that are suspected to be highly contaminated. Baseline correction can not be used on any sample is which the instrument baseline level is 25% above mean response levels, as established by a system of control charts that must be established to monitor instrument baseline as a function of time.

9.7 Instrument Maintenance

9.7.1 Preventive Maintenance

Routine preventive maintenance should be performed to maintain GC system performance. This includes periodic replacement of injector septa, replacement of injector liner(s), and clipping several inches off of the injector end of the capillary column.

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9.7.2 Additional Maintenance

Additional maintenance may be required if system performance degrades. Autosampler syringes and syringe needles should be periodically inspected, especially if erratic response or peak discrimination is seen. If the maintenance steps listed above do not improve system performance, it may be necessary to replace the GC column(s).

9.8 Data Reporting Format

9.8.1 The purpose of this format is to provide data users with a succinct and complete summary of pertinent information and data, a clear indication of whether significant modifications were made to the EPH Method, and a clear affirmation on whether the QA/QC procedures and standards specified in this method were followed and achieved. While it is permissible to alter the form and presentation of data, all of the information must be provided in a clear, concise, and succinct manner.

9.8.1.1 "Significant Modifications" to this method shall include, without limitation, all of the following:

9.8.1.1.1 The use of other than a silica-gel fractionation technique;

9.8.1.1.2 The use of a soil extraction procedure other than Soxhlet, Soxtec, or sonication;

9.8.1.1.3 The use of solvents other than those recommended in this method;

9.8.1.1.4 The use of a detector other than a Flame ionization Detector (FID) to quantitate range/TPH concentrations;

9.8.1.1.5 The use of surrogate compounds with relative retention times less than the recommended compounds;

9.8.1.1.6 The use of a fractionation surrogate compound with a relative retention time greater than the recommended compounds.

Positive affirmation that all required QA/QC procedures and performance standards were followed and achieved means that all of the required steps and procedures detailed in Section 10 have been followed, and that all data obtained from these steps and procedures were within the acceptance limits specified for these steps and procedures.

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10. Quality Control and Data Assessment

The laboratory must maintain records to document the quality of data that is generated. Ongoing data quality checks are compared with method performance criteria to determine if the results of analyses meet the performance characteristics of the method.

10.1 Demonstration of Capability

The analyst must make an initial, one-time, demonstration of the ability to generate acceptable accuracy and precision with this method. Each time a method modification is made, the analyst is required to repeat the procedure.

10.1.1 Accuracy and Precision

To demonstrate initial laboratory capability, analyze a minimum of four replicate reagent water and/or clean sand blanks spiked with each analyte of interest at approximately 50 µg/L and /or 5 mg/kg, respectively.

10.1.1.1 Extract each replicate according to the extraction SOP, and analyze each replicate according to the procedures described in Section 9.5.

10.1.1.2 Calculate the measured concentrations of each analyte in all replicates, the mean accuracy (as percentage of true value) for each analyte, and the precision (as %RSD) of the measurements for each analyte.

10.1.1.3 For each analyte, excluding n-C_{36}, the mean accuracy, expressed as a percentage of the true value, must be between 40% and 140%. Poorer recoveries may be experienced for the n-C_{36} standard. For each analyte, the %RSD must be less than or equal to 25%.

10.1.1.4 If desired, the Accuracy and Precision evaluation may be combined with the MDL evaluation specified in Section 3, at the MDL concentrations listed.

10.1.2 Fractionation

10.1.2.1 To demonstrate the capability of properly fractionating aliphatic and aromatic hydrocarbons in a sample, the analyst must first prepare and analyze the Fractionation Check Solution specified in Section 8.6.

10.1.2.2 For each analyte within the Fractionation Check Solution, excluding n-C_{36}, the mean accuracy, expressed as a percentage of the true value, must be between 40% and 140%.

10.1.2.3 Subsequent to the initial demonstration of laboratory capability, a Fractionation Check Solution is analyzed for each new lot of silica gel cartridges, as described in Section 8.6.

10.2 Blank

Extraction blanks are performed with each extraction batch of 20 or less samples, according to the extraction SOPs. The extraction blank must not contain any of the individual target analytes or hydrocarbon ranges above the reporting limits. If any reportable analytes are detected in the blank, the entire extraction batch is suspect and re-extraction of all associated samples is required. The surrogate recoveries must also be within the acceptance criteria listed in Section 10.6. If surrogate acceptance criteria are exceeded, the extraction batch must be evaluated to determine if re-extraction or re-analysis is necessary.

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10.3 Laboratory Fortified Blank (LFB)

An LFB is extracted with each analytical batch. The LFB consists of an aliquot of a clean (control) matrix similar to the sample matrix and of the same weight or volume. The LFB is spiked with the aliphatic and aromatic compounds, as described in Section 8.5. The recovery of C_9, C_{14}, C_{19}, C_{20}, and C_{28} normal alkanes and naphthalene, acenaphthene, anthracene, pyrene and chrysene must be between 40% and 140%. If any recovery criteria are not met, the extract may be re-fractionated to see if the recoveries improve. If the criteria are still not met, the entire batch should be re-extracted. If this is not possible, due to insufficient sample or holding time exceedence, the analyst must write up the failure on a narrative sheet for inclusion in the client report.

10.4 Duplicate

A laboratory duplicate is extracted with each analytical batch. The duplicate is a sample aliquot split from the same container as the sample, and is extracted and analyzed separately following the same procedures. The RPDs for any hits in the samples, for hydrocarbon ranges or individual analytes (if reported) must be less than 50%. If the RPD criteria is not met, and all other QC criteria are met for the sample and it's duplicate, inspect the sample for possible non-homogeneity. If this is the suspected cause of the high RPD result(s) note this on a narrative sheet for inclusion in the client report. Otherwise, re-extraction of the sample and duplicate, and possibly the entire extraction batch, may be required.

10.5 Matrix Spike/ Matrix Spike Duplicate

A Matrix Spike and/or a Matrix Spike/Matrix Spike Duplicate pair are performed at client's request. The MS(/MSD) is an aliquot of actual sample spiked with the aliphatic and aromatic compounds, as described in Section 8.5. The recoveries in the MS(/MSD), corrected for the concentrations found in the neat sample, should be between 40% and 140%. If the recovery criteria are not met, but are met in the LFB, the failure may be attributed to sample matrix effects and must be noted on a narrative sheet for inclusion in the client report. If an MS/MSD is performed, the %RPD should be less than 50% for C_9, C_{14}, C_{19}, C_{20}, and C_{28} normal alkanes and naphthalene, acenaphthene, anthracene, pyrene and chrysene.

10.6 Surrogates

All extracted samples and associated QC are spiked with the extraction surrogates listed in Section 8.4. Sample extracts are also spiked with the fractionation surrogates listed in Section 8.6 prior to cleanup and fractionation using the silica gel cartridges. All surrogate recoveries must be between 40% and 140%. If any surrogates fail the recovery criteria, samples may be re-fractionated and re-analyzed. If the surrogate limits are still not met, the affected samples should be re-extracted to confirm that the failure was due to sample matrix. If matrix effect is confirmed, this must be noted on a narrative sheet for inclusion in the client report.

The only exception to this is when large amounts of extracted material co-elute with any of the surrogate compounds, resulting in false high recoveries. When this is evident by examination of the sample chromatogram, re-extraction or re-fractionation is not required. Note the cause for the high recovery on a narrative sheet for inclusion in the client report.

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10.7 Control Limits

The laboratory maintains performance records to document the quality of data that is generated. Method accuracy for samples is assessed and records maintained.

Control limits for this method are listed specifically in the referenced method, and are described throughout this SOP. Limits are not derived from laboratory data.

10.8 Analytical Sequence

The daily analytical sequence is:

- Calibration Standards (initial) or mid-range Calibration Check Standard (daily check of initial calibration)
- Laboratory Method Blank
- Laboratory Fortified Blank
- Samples
- Duplicate sample
- Laboratory Fortified Matrix/duplicate [as requested]
- Mid-range Calibration Check Standard [typically after 10 samples, as appropriate]

11. Method Performance

Method performance data is on file in the laboratory QC department. Comparison of method performance data for the laboratory to the reference method criteria occurs when laboratory in-house acceptance limits are generated. In-house generated data must be within the specifications of the reference method or the analysis is not continued until corrective action is completed.

The performance of this method is evaluated on an on-going basis by the QC criteria listed throughout this SOP. Specifically, Initial Calibration criteria, Continuing Calibration Check criteria, surrogates, blanks, LFBs, MS/MSDs, and duplicates are all used to ensure that the method is producing results of consistently high quality. In addition, Alpha participates in several blind and double blind PE studies annually to demonstrate the ability of this method to produce accurate and reproducible data.

12. Corrective Actions

Holding time exceedence, improper preservation and observed sample headspace are noted on the nonconformance report form.

Perform instrument maintenance as described throughout this SOP as needed when instrument calibration criteria are not met. Record all maintenance in the instrument maintenance logbook.

All batch and sample specific QC criteria outlined in Section 10 are evaluated by the analyst prior to approval of the data. When any QC criteria fail, the cause for the failure must be identified and corrected. This may include instrument recalibration followed by sample reanalysis or sample re-extraction. If it is determined that the failure is due to sample matrix effects, a project narrative report is written by the analyst for inclusion in the data report. If there is insufficient sample volume to perform the re-analysis for confirmation, this is also noted in the narrative and included in the client report.

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13. Pollution Prevention

See Chemical Hygiene Plan for pollution prevention operations.

14. Waste Management

See Chemical Hygiene Plan for waste handling and disposal.

15. Attachments

Table 1 – REPORTING LIMITS

Table 2 – LIST OF COMPOUNDS AND CALIBRATION LEVELS

Table 3 – HOLDING TIMES AND PRESERVATION REQUIREMENTS

Table 4 – EPH MARKER COMPOUNDS

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Table 1
Reporting Limits

Parameter	Aqueous	Soil
C9-C18 Aliphatic Hydrocarbons	100 µg/L	10 mg/Kg
C19-C36 Aliphatic Hydrocarbons	100 µg/L	10 mg/Kg
C11-C22 Aromatic Hydrocarbons	100 µg/L	10 mg/Kg
Naphthalene	20 µg/L	0.5 mg/Kg
2-Methylnaphthalene	20 µg/L	0.5 mg/Kg
Acenaphthylene	20 µg/L	0.5 mg/Kg
Acenaphthene	20 µg/L	0.5 mg/Kg
Fluorene	20 µg/L	0.5 mg/Kg
Phenanthrene	20 µg/L	0.5 mg/Kg
Anthracene	20 µg/L	0.5 mg/Kg
Fluoranthene	20 µg/L	0.5 mg/Kg
Pyrene	20 µg/L	0.5 mg/Kg
Benzo(a)anthracene	20 µg/L	0.5 mg/Kg
Chrysene	20 µg/L	0.5 mg/Kg
Benzo(b)fluoranthene	20 µg/L	0.5 mg/Kg
Benzo(k)fluoranthene	20 µg/L	0.5 mg/Kg
Benzo(a)pyrene	20 µg/L	0.5 mg/Kg
Indeno(1,2,3-cd)pyrene	20 µg/L	0.5 mg/Kg
Dibenzo(a,h)Anthracene	20 µg/L	0.5 mg/Kg
Benzo(g,h,i)perylene	20 µg/L	0.5 mg/Kg

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Table 2
List of Compounds and Calibration Levels

Component	**Concentration of standard analytes (µg/mL)**					
	Level 1	**Level 2**	**Level 3**	**Level 4**	**Level 5**	**Level 6**
Individual Aliphatic, Aromatic and Surrogate Compounds	2.5	5	20	50	100	200
Total Mass $C_9 - C_{18}$ Aliphatic Hydrocarbons, ng (6 components)	15	30	120	300	600	1200
Total Mass $C_{19} - C_{36}$ Aliphatic Hydrocarbons, ng (8 components)	20	40	160	400	800	1600
Total Mass $C_{11} - C_{22}$ Aromatic Hydrocarbons/PAHs, ng (17 components)	42.5	85	340	850	1700	3400

Table 3
Holding Times and Preservatives for EPH Samples

Matrix	Container	Preservation	Holding Time
Aqueous Samples	1 Liter amber glass bottle with Teflon-lined screw cap	Add 5mL of 1:1 HCl; cool to 4 °C	Samples must be extracted within 14 days and extracts analyzed within 40 days
Soil/Sediments Samples	4 oz. (120mL) widemouth amber glass jar with Teflon-lined screw cap	Cool to 4 °C	Samples must be extracted within 7 days and extracts analyzed within 40 days

Table 4
EPH Marker Compounds

Range/Hydrocarbon Standard	Beginning Marker Compound	Ending Marker Compound
C_9 – C_{18} Aliphatic Hydrocarbons	n-Nonane	Just before n-Nonadecane
C_{19} – C_{36} Aliphatic Hydrocarbons	n-Nonadecane	n-Hexatriacontane
C_{11} – C_{22} Aromatic Hydrocarbons	Naphthalene	Benzo (g,h,i) Perylene

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PCDDs AND PCDFs BY HRGC/HRMS - METHOD 8290 & TO-9	
TLI SOP: DHR182 Version: 12	Date Revised: December 12, 2003

Revised by: Dan Hudson Effective Date: 12/12/2003

Authorization: Phil Albro Date Authorized: 12/12/2003
Management

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I. **PURPOSE:** This SOP is intended to describe the procedures to implement Method 8290.

II. **SCOPE:** This method provides procedures for the analysis of polychlorinated dibenzo-p-dioxins (tetra- through octachlorinated homologues; PCDDs), and polychlorinated dibenzofurans (tetra- through octachlorinated homologues; PCDFs) from extracts of samples prepared according to SW 846 Method 8290 and TO-9.

III. **SAFETY CONSIDERATIONS:** The 2,3,7,8-TCDD isomer has been found to be acnegenic, carcinogenic, and teratogenic in laboratory animal studies. Other PCDDs and PCDFs containing chlorine atoms in the 2,3,7,8 positions are known to have toxicities comparable to that of 2,3,7,8-TCDD. Extreme care must be exercised in all handling of extracts and standards in the application of this SOP. For additional safety information, see the Triangle Laboratories, Inc. Safety and Health Manual and the appropriate MSDSs.

IV. **SAMPLE COLLECTION, PRESERVATION, AND HANDLING:** See SOP No. 5.01 for sample collection, preservation, and handling information.

V. **EQUIPMENT:** The High-Resolution Gas Chromatograph/High-Resolution Mass Spectrometer/Data System (GC/MS/DS) equipment utilized for this analysis includes the following:

A. Gas Chromatographs: Hewlett Packard 5890 or 5890 Series II (equipped for temperature programming and capillary columns)

B. High Resolution Mass Spectrometers: VG 70-S Series, VG 70-SE Series, VG 70-VS Series, VG 70-SQ Series

C. Data Systems: VG Analytical PDP11 with 11-250 software or VAX Alpha with Opus 3.2 or Opus 3.6 software.

D. GC Injection Port - The GC injection port is designed for capillary columns. Typically, 2 µL injection volumes are used unless otherwise noted.

E. Gas Chromatograph/Mass Spectrometer(GC/MS) Interface - The GC/MS interface components can withstand 350°C. The interface has been designed so

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that the separation of 2,3,7,8-TCDD from the other TCDD isomers achieved in the gas chromatographic column is not appreciably degraded. The GC column is fitted directly into the mass spectrometer ion source without being exposed to the ionizing electron beam. Graphite ferrules should be avoided in the injection port because they may adsorb the PCDDs and PCDFs. Vespel™, or equivalent, ferrules are recommended.

F. Mass Spectrometer - The static resolving power of the instrument must be maintained at a minimum of 10,000 (10 percent valley).

G. Data System - A dedicated data system is employed to control the rapid selected-ion monitoring (SIM) process and to acquire the data. Quantitation data (peak areas or peak heights) and SIM traces (displays of intensities of each ion signal being monitored including the lock-mass ion as a function of time) must be acquired during the analyses and stored. Quantitation may be reported based upon computer generated peak areas or upon measured peak heights. The data system is set to acquire data as low as 10 ions in a single scan. Table 1 presents a listing of the ions which are typically monitored. The data system is set to switch to different sets of ions (descriptors) at specified times during an HRGC/HRMS acquisition. The data system provides hard copies of individual ion chromatograms for selected gas chromatographic time intervals. It also acquires mass spectral peak profiles and provides hard copies of peak profiles to demonstrate the required resolving power. Measurements of noise on the base line are performed using the hard copies of individual ion chromatograms provided by the data system.

NOTE: The detector ADC zero setting must be set to allow peak-to-peak measurement of the noise on the base line of every monitored channel and allow for good estimation of the instrument resolving power.

H. GC Columns

1. In order to have an isomer specific determination for 2,3,7,8-TCDD and to allow the detection of OCDD/OCDF within a reasonable time interval in one HRGC/HRMS analysis, the 60 m DB-5 fused silica capillary column is used.

2. The 2,3,7,8-TCDF isomer must be confirmed on a 30 m DB-225 fused silica capillary column, when 2,3,7,8-TCDF is detected on the DB-5 column at a level greater than or equal to the target detection limit.

VI. STANDARDS:

A. Calibration Solutions - Six nonane solutions containing 17 unlabeled PCDDs and PCDFs, 17 $^{13}C_{12}$ -labeled PCDDs and PCDFs, and $^{37}Cl_4$-2,3,7,8-TCDD at known concentrations are used to calibrate the instrument. The analyte concentration ranges are homologue dependent, with the lowest values for the tetrachlorinated

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dioxin and furan (0.5 ng/mL) and the highest values for the octachlorinated congeners (2000 ng/mL) (Table 2).

B. Recovery Standard Solution - This nonane solution contains two recovery standards, $^{13}C_{12}$-1,2,3,4-TCDD and $^{13}C_{12}$-1,2,3,7,8,9-HxCDD, at a nominal concentration of 100 ng/mL per compound.

C. GC Column Performance/Retention Window Check Solution (RTCHK)- This solution contains the first and last eluting isomers for each homologous series from tetra- through heptachlorinated congeners. The solution also contains a series of closely eluting TCDD and TCDF isomers for the purpose of documenting the chromatographic resolution (Table 3).

D. Acceptance Criteria for Newly Prepared Standards - All components and concentrations of each calibration standard, recovery standard, internal standard, and matrix spike solutions are verified prior to use for the analysis of samples. Testing of standards is detailed in Triangle Labs SOP STD002.

E. Standards are stored in amber glass vials at room temperature.

VII. SYSTEM PERFORMANCE CRITERIA

System performance criteria are presented below. It must be documented that all applicable system performance criteria specified in this Section are met before analysis for any sample is performed. Table 4 provides recommended GC conditions that can be used to satisfy the required criteria. During a typical 12-hour analysis sequence, the GC column performance and mass spectrometer resolving power checks must be performed at the beginning of the 12-hour period of operation. A routine calibration verification is required at the beginning and end of each 12-hour period during which samples are analyzed. A method blank or solvent blank is required between a calibration run and the first sample run.

A. GC Column Performance

1. Inject the column performance check solution described in the standards section of this SOP. Acquire selected-ion monitoring (SIM) data using the equipment and settings described in the equipment section of this SOP.

2. The chromatographic separation between 2,3,7,8-TCDD and the peaks representing any other TCDD isomers or between 2,3,7,8-TCDF and the peaks representing other TCDF isomers must be resolved with a valley of $\leq$ 25% (Fig. 1), where:

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Valley Percent	=	(x/y) x 100
x	=	height of valley measured between 2,3,7,8-TCDD or 2,3,7,8-TCDF and the closest TCDD or TCDF eluting isomers, and
y	=	the peak height of 2,3,7,8-TCDD or 2,3,7,8-TCDF.

3. The acquisition time windows must be set to allow observation of the first and last eluting isomer of each congener. All first and last eluters of a homologous series should be labeled and identified on chromatograms.

B. Mass Spectrometer Performance

1. The mass spectrometer must be operated in the electron ionization mode. It is recommended that the ionization potential be set to optimize sensitivity for the given column flow and source design. A static resolving power of at least 10,000 (10% valley definition) must be demonstrated at appropriate masses before any analyses are performed. Static resolving power checks must be performed at the beginning and at the end of each 12-hour period of operation. It is recommended, however, that a check of the static resolution be made and documented by using the peak matching unit before and after each analysis. Corrective actions must be implemented whenever the resolving power does not meet the requirement.

2. Chromatography time for PCDDs and PCDFs exceeds the long-term mass stability of the mass spectrometer. Because the instrument is operated in the high-resolution mode, mass drifts of a few ppm can have serious adverse effects on instrument performance. Therefore, a mass-drift correction is mandatory. To that effect, use a lock-mass ion from the reference compound Perfluorokerosene (PFK) used for tuning the mass spectrometer and monitor and record the lock-mass ion channel during SIM acquisitions. The level of the reference compound (PFK) metered inside the ion chamber during HRGC/HRMS analyses should be adjusted so that the amplitude of the selected lock-mass ion signal, regardless of the description number, does not exceed 10% of the full scale deflection for a given set of detector parameters. Under those conditions, sensitivity changes that might occur during the analysis can be more effectively monitored.

3. Using PFK molecular leak and an appropriate ion within the scan window, tune the instrument to meet the minimum required resolving power of 10,000 (10% valley).

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a) Documentation of the mass spectrometer resolving power is accomplished by recording the peak profile of the high-mass reference signal (m/z 416.9760) obtained during a peak matching experiment by using the low-mass PFK ion at m/z 330.9792 (or lower in mass) as a reference.

b) The format of the peak profile representative allows manual determination of the peak resolution. The peak width (at 5% peak height) of the high-mass reference ion must not exceed 100 ppm (resolving power: 10,000). Peak width is determined by triangulation with no more than 10% allowance for sampling error. Instrumental ion transmission and resolution will be checked, adjusted and documented in case the resolution is below the minimum required 10,000 resolving power.

VIII. CALIBRATION PROCEDURES:

A. Initial Calibration (ICAL)- Initial calibration of the instrument is required before any samples are analyzed for PCDDs and PCDFs. Initial calibration or other corrective action is also required if any continuing calibration does not meet the required criteria listed in the acceptance criteria for continuing calibration section of this SOP.

1. All six calibration solutions listed in Table 2 must be used for the initial calibration.

2. Tune the instrument with PFK to achieve a static resolving power of at least 10,000 (10% valley) as described in the section on mass spectrometer performance.

3. Inject 2 µL of the GC column performance check solution and acquire SIM mass spectral data –using the equipment and settings described in the equipment section of this SOP. Further analysis must not be performed until the column performance criteria listed in the GC column performance section has been met and documented.

4. Using the same GC and MS conditions that produced acceptable results for the column performance check solution, analyze a 2 µL portion of each of the six calibration solutions with the following requirements.

   a) The ratio of integrated ion current for the ions appearing in Table 5 (homologous series quantitation ions) must be within the indicated control limits (set for each homologous series).

   b) The ratio of integrated ion current for the ions belonging to the carbon-labeled internal, surrogate, alternate, and recovery standards must be within the control limits stipulated in Table 5.

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NOTE: Ion ratios for all 17 native analytes and 19 carbon-labeled (internal and recovery) standards must be within the specified control limits simultaneously in one run for each of the six (6) calibration standard solutions. If the ion abundance ratios are outside the limits, corrective action must be taken and acceptable abundance ratios achieved before any samples may be analyzed.

NOTE: Additional Tetras (1368-TCDD, 1379-TCDD, 1368-TCDF, 1278-TCDF are not required to meet the ion ratios in the lowest two points of the ICAL. Ion ratios are required to meet for the additional tetras for all other points of the ICAL. This exception is made because these additional tetra compounds have lower response than the 2378 substituted tetras.

c) For each SICP and for each GC signal representing the elution of a target analyte the signal-to-noise ratio (S/N) must be greater than or equal to 10:1.

NOTE: Signal-to-noise ratio for the additional tetras must be greater than or equal to 3:1. This exception is made because these additional tetra compounds have lower response than the 2378 substituted tetras.

d) Referring to Table 6, calculate the 17 relative response factors (RRF) for unlabeled target analytes relative to their appropriate internal standards, according to the following formula:

$$RRF(n) = \frac{A_x \times Q_{is}}{Q_x \times A_{is}}$$

Where:

RRF(n)=		Analyte RRF
A	=	sum of the integrated ion abundances of the quantitation ions (Table 1) for unlabeled PCDDs/PCDFs
A_{is}	=	sum of the integrated ion abundances of the quantitation ions (Table 1) for the labeled internal standards
Q_{is}	=	quantity of the internal standard injected (pg)

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Q_x = quantity of the unlabeled PCDD/PCDF analyte injected (pg)

The RRF(n) is a dimensionless quantity; the units used to express Q_{is} and Q_x must be the same.

e) Calculate the average analyte RRF and their respective percent relative standard deviations (%RSD) for the six calibration solutions.

$$\overline{RRF}_{(n)} = \frac{1}{6}\sum_{j=1}^{6} RRF_{(n)j}$$

Where n represents a particular PCDD/PCDF (2,3,7,8 substituted congener), and j is the injection number (or calibration solution number).

f) The relative response factors to be used for the determination of the concentration of total isomers in a homologous series are calculated as follows:

(1) For congeners that belong to a homologous series containing only one isomer (e.g., OCDD and OCDF) or only one 2,3,7,8-substituted isomer (TCDD, PeCDD, HpCDD, and TCDF), the mean RRF used will be the same as the mean RRF calculated for the associated unlabeled target analyte.

NOTE: The calibration solutions do not contain $^{13}C_{12}$-OCDF as an internal standard. This is because a minimum resolving power of 12,000 is required to resolve the $[M+6]^+$ ion of $^{13}C_{12}$-OCDF from the $[M+2]^+$ ion of OCDD (and $[M+4]^+$ from $^{13}C_{12}$-OCDF with $[M]^+$ of OCDD). Therefore, the RRF for OCDF is calculated relative to $^{13}C_{12}$-OCDD.

(2) For congeners that belong to a homologous series containing more than one 2,3,7,8-substituted isomer (PeCDF - two, HxCDF - four, HxCDD - three, HpCDF - two) the mean RRF used for those homologous series will be the average of the mean RRFs calculated for all individual 2,3,7,8-substituted congeners.

NOTE: HRGC/HRMS responses of all isomers in a homologous series that do not have the 2,3,7,8-substitution pattern are assumed to be the same as the

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responses of one or more of the 2,3,7,8-substituted isomer(s) in that homologous series.

g) Referring to Table 7 and 8. calculate relative response factors (RRF) and average relative response factors (RRF) for internal, surrogate, and alternate standards relative to their appropriate recovery standards, according to the following formula:

$$RRF_{(m)} = \frac{A_s \times Q_{rs}}{Q_s \times A_{rs}}$$

$$\overline{RRF}_{(m)} = \frac{1}{6}\sum_{j=1}^{6} RRF_{(m)j}$$

Where:

m = congener type

j = injection number

A_s = sum of the integrated ion abundances of the quantitation ions for a given standard

A_{rs} = sum of the integrated ion abundances of the quantitation ions for the appropriate recovery standard

Q_{rs}, Q_s = quantities of, respectively, the recovery standard (rs) and a particular standard injected (pg)

$RRF_{(m)}$ = relative response factor of a particular standard relative to an appropriate recovery standard, as determined from one injection, and

$\overline{RRF}_{(m)}$ = calculated mean relative response factor of a particular labeled standard relative to an appropriate recovery standard, as determined from the six initial calibration injections.

5. Acceptance Criteria for Initial Calibration - The criteria listed below for acceptable calibration must be met before any analysis is performed.

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a) The percent relative standard deviations for the mean response factors from the 17 unlabeled standards and the additional tetras (1368-TCDD, 1379-TCDD, 1368-TCDF, 1278-TCDF) must not exceed ± 20 percent, and those for the labeled reference compounds must not exceed ± 30%.

b) The S/N ratio for the GC signals present in every SICP (including the ones for the labeled standards) must be ≥ 10.

NOTE: Signal-to-noise ratio for the additional tetras must be greater than or equal to 3:1. This exception is made because these additional tetra compounds have lower response than the 2378 substituted tetras.

c) The isotopic ratios (Table 5) must be within the specified control limits.

NOTE: Additional Tetras (1368-TCDD, 1379-TCDD, 1368-TCDF, 1278-TCDF are not required to meet the ion ratios in the lowest two points of the ICAL. Ion ratios are required to meet for the additional tetras for all other points of the ICAL. This exception is made because these additional tetra compounds have lower response than the 2378 substituted tetras.

NOTE: If the criterion for acceptable calibration is met, the analyte specific RRF can then be considered independent of the analyte quantity for the calibration concentration range. The mean RRFs will be used for all calculations until the continuing calibration criteria are no longer met. At such time, new mean RRFs will be calculated from a new set of injections of the initial calibration solutions.

B. Continuing Calibration Check (CONCAL) - Continuing calibrations must be performed at the beginning of a 12 hour period after successful mass resolution and GC resolution performance checks. A continuing calibration is also required at the end of a 12 hour shift.

1. Inject 2 µL of the CONCAL solution, third point of the ICAL, (Table 2) using the same HRGC/HRMS conditions described in the system performance criteria section and used to acquire the initial calibration data.

2. Acceptance Criteria for Continuing Calibration - The following criteria must be met before further analyses are performed.

a) The measured RRFs for the unlabeled standards (including the additional tetras) obtained during the continuing calibration runs

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must be within ± 20 percent of the mean values established during the initial calibration.

b) The measured RRFs for the labeled standards obtained during the routine calibration must be within ± 30 percent of the mean values established during the initial.

c) The ion-abundance ratios (Table 5) must be within the allowed control limits.

d) If either one of the RRF criteria listed above is not satisfied, repeat one more time. If these criteria are still not satisfied, the entire continuing calibration process must be reviewed.

e) If the continuing calibration at the end of a 12-hour period fails no more than 25% RPD for the unlabeled compounds and 35% RPD for the labeled reference compounds, use the mean RRFs from the two daily calibration runs to compute analyte concentrations, instead of the RRFs obtained from the initial calibration.

NOTE: If RRFs for up to two labeled standards fail by more than 35%, the calibration is considered acceptable, as long as corresponding unlabeled analytes meet criteria.

NOTE: If the first ending CONCAL fails these criteria, a second ending CONCAL may be analyzed. If the second ending CONCAL meets these criteria, use the mean RRFs from the beginning CONCAL and the second ending CONCAL to compute analyte concentrations, instead of the RRFs obtained from the initial calibration.

f) Two continuing calibrations analyzed at the end of the 12 hour period which fail by more than 25% RPD for the unlabeled compounds and 35% RPD for the labeled reference compounds are not acceptable. Samples analyzed during this 12 hour period should be reanalyzed.

IX. ANALYSIS

A. A valid analysis of column performance check (RTCHK), calibration (CONCAL), and method or instrument blank must have been obtained prior to the analysis of any sample.

B. Remove the sample extract (blown to dryness) or blank from storage. Add recovery standard, mix, and dissolve thoroughly.

C. Inject a 2 µL aliquot of the extract into the GC, operated under the GC conditions that have produced acceptable CONCAL and RTCHK results.

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D. Acquire SIM data using the same acquisition and mass spectrometer operating conditions previously used to determine the relative response factors.

NOTE: The acquisition period must at least encompass the PCDD/PCDF overall retention time window previously determined. Selected ion current profiles (SICP) for the lock-mass ions (one per mass descriptor) must also be recorded and included in the data package. These SICPs must be true representations of the evolution of the lock-mass ions amplitudes during the HRGC/HRMS run. The analyst may be required to monitor a PFK ion, not as a lock mass, but as a QC ion, in order to meet this requirement. It is recommended to examine the QC ion or lock-mass ion SICP for obvious basic sensitivity and stability changes of the instrument during the GC/MS run that could affect the measurements. Report any discrepancies in the case narrative.

E. Identification Criteria - For a gas chromatographic peak to be identified as a PCDD or PCDF, it must meet all of the following criteria:

1. Retention Times

a) For 2,3,7,8-substituted congeners, which have an isotopically labeled internal or recovery standard present in the sample extract (this represents a total of 9 congeners as listed in Table 1.), the retention time (RRT at maximum peak height) of the sample components (i.e., the two ions used for quantitation purposes listed in Table 1), must be within -1 to +3 seconds of the isotopically labeled standard.

b) For 2,3,7,8-substituted compounds that do not have an isotopically labeled internal standard present in the sample extract (this represents a total of eight congeners listed inTable 1), the retention time must fall within 0.005 retention time units of the relative retention times measured in the continuing calibration. Identification of OCDF is based on its retention time relative to $^{13}C_{12}$-OCDD as determined from the 12 hour continuing calibration results.

c) For non-2,3,7,8-substituted compounds (tetra through octa totaling 119 congeners), the retention time must be within the corresponding homologous retention time windows established by analyzing the RTCHK solution.

d) The ion current responses for both ions used in quantitation (e.g., for TCDDs: m/z 319.8965 and 321.8936) must reach maximum simultaneously (± 2 seconds).

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e) The ion current responses for both ions used for the labeled standards (e.g., for $^{13}C_{12}$-TCDD: m/z 331.9368 and m/z 333.9339) must reach maximum simultaneously (± 2 seconds).

2. Ion Abundance Ratios

The integrated ion current for the two ions used for quantitation purposes must have a ratio between the lower and upper limits established for the homologous series to which the peak is assigned (Table 5).

3. Signal-to-Noise (S/N) Ratio

All ion current intensities must be ≥ 2.5 times noise level for positive identification of a PCDD/PCDF compound or a group of coeluting isomers.

4. Polychlorinated Diphenyl Ether Interferences

In addition to the above criteria, the identification of a GC peak as a PCDF can only be made if and only if the following criteria are met:

a) Polychlorinated diphenyl ethers (PCDPE) S/N ≥ 2.5 is detected.

b) PCDPE is detected at the same retention time (± 2 seconds) as PCDF.

c) PCDPE signal is > 10% of the PCDF signal.

F. Quantitation

1. For gas chromatographic peaks that have met specified criteria calculate the concentration of the PCDD or PCDF compounds using the formula:

$$C_x = \frac{A_x \times Q_{is}}{A_{is} \times W \times \overline{RRF}_{(n)}}$$

Where:

C_x = concentration of unlabeled PCDD/PCDF congeners (or group of coeluting isomers within an homologous series),

A_x = sum of the integrated ion abundances of the quantitation ions (Table 1) for unlabeled PCDDs/PCDFs,

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A_{is} = sum of the integrated ion abundances of the quantitation ions (Table 1) for the labeled internal standards,

Q_{is} = quantity of the internal standard added to the sample before extraction,

W = weight or volume of the sample, and

$RRF_{(n)}$ = calculated mean relative response factor for the analyte.

2. Calculate the percent recovery of the nine internal standards measured in the sample extract, using the formula:

$$\text{Internal Standard Recovery} = \frac{A_{is} \times Q_{rs}}{Q_{is} \times A_{rs} \times \overline{RRF}_{(m)}} \times 100$$

Where:

A_{is} = sum of the integrated ion abundances of the quantitation ions (Table 1) for the labeled internal standard,

A_{rs} = sum of the integrated ion abundances of the quantitation ions (Table 1) for the labeled recovery standard; the selection of the recovery standard depends on the type of congeners (Table 7),

Q_{is} = quantity of the internal standard added to the sample before extraction,

Q_{rs} = quantity of the recovery standard added to the cleaned-up sample residue before HRGC/HRMS analysis, and

$\overline{RRF}_{(m)}$ = calculated mean relative response factor for the labeled internal standard relative to the appropriate (see Table 7) recovery standard.

3. Calculate the percent recovery of seven surrogate and alternate standards using the same equation used to calculate percent recovery of the internal standards.

4. If the concentration in the final extract of any of the seventeen 2,3,7,8-substituted PCDD/PCDF compound exceeds the dynamic range of the instrument (i.e., saturation in a mass channel) then a dilution will be performed. Any dilutions must be pre-approved by the client.

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5. The total concentration for each homologous series of PCDD and PCDF is calculated by summing up the concentrations of all positively identified isomers of each homologous series. Therefore, the total should also include the 2,3,7,8-substituted congeners. The total number of GC signals included in the homologous total concentration value must be specified in the report.

6. Sample Specific Estimated Detection Limit - The sample specific estimated detection limit (EDL) is the concentration of a given analyte required to produce a signal with a peak height of at least 2.5 times the background signal level. An EDL is calculated for each 2,3,7,8-substituted congener that is not identified, regardless of whether or not other non-2,3,7,8-substituted isomers are present. Two methods of calculation can be used, depending on the type of response produced during the analysis of a particular sample.

   a) Samples giving a response for at least one quantitation ion that is less than 2.5 times the background level.

      The area of the analyte is replaced by the noise level measured in a region of the chromatogram clear of genuine GC signals. The detection limits represent the maximum possible concentration of a target analyte that could be present without being detected.

$$DL = \frac{2.5 \times H \times Q_{is}}{H_{is} \times RRF_{(n)} \times W}$$

Where:

DL	=	estimated detection limit for a target analyte,
2.5	=	minimum signal/ noise required for a GC signal to be accepted,
H	=	height of the noise,
H_{is}	=	integrated current of the characteristic ions of the corresponding internal standard,
Q_{is}	=	amount of internal standard added to sample before extraction,
$\overline{RRF_{(n)}}$	=	mean analyte relative response factor from the initial calibration, and

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W = sample weight or volume.

b) Samples characterized by a response above the background level with a S/N of at least 2.5 for both quantitation ions.

When the signal has the same retention time as a 2,3,7,8-substituted congener, S/N in excess of 2.5, and does not meet ion ratio requirements (Table 5), calculate the Estimated Maximum Possible Concentration (EMPC) using the following equation:

$$C_x = \frac{A_x \times Q_{is}}{A_{is} \times W \times \overline{RRF}_{(n)}}$$

Where:

C_x = concentration of unlabeled PCDD/PCDF congeners (or group of coeluting isomers within an homologous series),

A_x = sum of the area under the smaller peak and of the other peak area calculated using the theoretical chlorine isotope ratio,

A_{is} = sum of the integrated ion abundances of the quantitation ions (Table 1) for the labeled internal standards,

Q_{is} = quantity of the internal standard added to the sample before extraction,

W = weight or volume of the sample, and

$RRF_{(n)}$ = calculated mean relative response factor for the analyte.

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X. QUALITY CONTROL REQUIREMENTS

NOTE: For allowed exceptions to the quality control requirements, refer to the Non-Conformance SOP.

A. GC column performance must be demonstrated initially and verified prior to analyzing any sample in a 12-hour period. The GC column performance check solution must be analyzed under the same chromatographic and mass spectrometric conditions used for other samples and standards.

B. Routine calibrations must be performed at the beginning of a 12-hour period after successful mass resolution and GC resolution performance checks and at the end of a 12-hour period following the analysis of samples.

C. The quantitation limits (or target detection limits) will be the following:

1. Quantitation limits for waters (sample size - 1L):

≤ 10 ppq	TCDD & TCDF
≤ 50 ppq	PentaCDD & CDF - HeptaCDD & CDF
≤ 100 ppq	OCDD & OCDF

2. Quantitation limits for solids (sample size - 10g):

≤ 1 ppt	TCDD & TCDF
≤ 5 ppt	PentaCDD & CDF - HeptaCDD & CDF
≤ 10 ppt	OCDD & OCDF

3. Quantitation limits for air or Wipes (sample size - 1):

≤ 50 pg	TCDD & TCDF
≤ 250 pg	PentaCDD & CDF - HeptaCDD & CDF
≤ 500 pg	OCDD & OCDF

D. Method Blank

1. Percent recoveries of all labeled standards should be between 40 - 135%.

2. Qunatitation limites (target detection limits) must be met for each analyte.

3. No reportable analytes or interferences should be present in the Method Blank.

E. LCS/ LCSD

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1. Percent recoveries of all labeled standards should be between 40 - 135%.
2. Percent recoveries of all analytes should be between 70 - 130%.
3. Relative percent difference between LCS and LCSD should be $\leq$ 20% for all analytes.

F. MS/MSD

1. Percent Recoveries of all labelled standards should be between 40 - 135%.
2. Percent recoveries of all analytes should be between 70 - 130%.
3. Relative percent difference between MS and MSD should be $\leq$ 25% for all analytes.

G. Samples

1. Percent recoveries of all labeled standards should be between 40 - 135%.
2. Specific detection limits must not exceed the target detection limits unless prohibited by a limited sample size or the need for dilution.
3. Samples which fail acceptance criteria listed above or are associated with failing method blank or LCS/ LCSD must be addressed in accordance with the Non-Conformance SOP.

XI. **REFERENCES:** EPA SW-846 Method 8290 and EPA Method TO-9.

XII. SOP Links: 5.04, DSP104, DSP105, DSP112, DSP130, DSP131, DSP133, DSP139, DSP161, DSP192, DSP254, DSP261, DSP278, DSP284, DSP290, DSP296, DSP298, DSP299, DSP124, DSP170, DSP198, DSP253, DSP260, DSP272, DSP280, DSP286.

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XIII. INTERFERENCES

A. Phthalate interferences are characterized by major quantitative interference in the PeCDF and PeCDD regions.

B. Interferences caused by the presence of sulfur in a sample are characterized by quantitative interference in the TCDF and TCDD regions.

C. Interferences caused by the presence of three-ring PAHs are characterized by quantitative interference in the Tetra through HexaCDD/CDF regions.

NOTE: Triangle Laboratories, Inc. has additonal cleanup procedures to remove these interferences.

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TABLE 1: ELEMENTAL COMPOSITIONS AND EXACT MASSES OF THE IONS MONITORED BY HRGC/HRMS FOR PCDDs AND PCDFs

Descriptor Number[b]	Accurate Mass[a]	Ion Type	Elemental Composition	Analyte
2	292.9825	LOCK	C_7F_{11}	PFK
	303.9016	M	$C_{12}H_4{}^{35}Cl_4O$	TCDF
	305.8987	M+2	$C_{12}H_4{}^{35}Cl_3{}^{37}ClO$	TCDF
	315.9419	M	$^{13}C_{12}H_4{}^{35}Cl_4O$	TCDF (S)
	317.9389	M+2	$^{13}C_{12}H_4{}^{35}Cl_3{}^{37}ClO$	TCDF (S)
	319.8965	M	$C_{12}H_4{}^{35}Cl_4O_2$	TCDD
	321.8936	M+2	$C_{12}H_4{}^{35}Cl_3{}^{37}ClO_2$	TCDD
	327.8847	M	$C_{12}H_4{}^{37}Cl_4O_2$	TCDD (S)
	330.9792	QC	C_7F_{13}	PFK
	331.9368	M	$13C_{12}H_4{}^{35}Cl_4O_2$	TCDD (S)
	333.9339	M+2	$^{13}C_{12}H_4{}^{35}Cl_3{}^{37}ClO_2$	TCDD (S)
	375.8364	M+2	$C_{12}H_4{}^{35}Cl_5{}^{37}ClO$	HxCDPE
	339.8597	M+2	$C_{12}H_3{}^{35}Cl_4{}^{37}ClO$	PeCDF
	341.8567	M+4	$C_{12}H_3{}^{35}Cl_3{}^{37}Cl_2O$	PeCDF
	351.9000	M+2	$^{13}C_{12}H_3{}^{35}Cl_4{}^{37}ClO$	PeCDF (S)
	353.8970	M+4	$^{13}C_{12}H_3{}^{35}Cl_3{}^{37}Cl_2O$	PeCDF (S)
	355.8546	M+2	$C_{12}H_3{}^{35}Cl_4{}^{37}ClO_2$	PeCDD
	357.8516	M+4	$C_{12}H_3{}^{35}Cl_3{}^{37}Cl_2O_2$	PeCDD
	367.8949	M+2	$^{13}C_{12}H_3{}^{35}Cl_4{}^{37}ClO_2$	PeCDD (S)
	369.8919	M+4	$^{13}C_{12}H_3{}^{35}Cl_3{}^{37}Cl_2O_2$	PeCDD (S)
	409.7974	M+2	$C_{12}H_3{}^{35}Cl_6{}^{37}ClO$	HpCDPE
3	373.8208	M+2	$C_{12}H_2{}^{35}Cl_5{}^{37}ClO$	HxCDF
	375.8178	M+4	$C_{12}H_2{}^{35}Cl_4{}^{37}Cl_2O$	HxCDF
	383.8639	M	$^{13}C_{12}H_2{}^{35}Cl_6O$	HxCDF (S)

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TABLE 1 CONTINUED

Descriptor Number[b]	Accurate Mass[a]	Ion Type	Elemental Composition	Analyte
3 Continued	385.8610	M+2	$^{13}C_{12}H_2{}^{35}Cl_5{}^{37}ClO$	HxCDF (S)
	389.8157	M+2	$C_{12}H_2{}^{35}Cl_5{}^{37}ClO_2$	HxCDD
	391.8127	M+4	$C_{12}H_2{}^{35}Cl_4{}^{37}Cl_2O_2$	HxCDD
	392.9760	LOCK	C_9F_{15}	PFK
	401.8559	M+2	$^{13}C_{12}H_2{}^{35}Cl_5{}^{37}ClO_2$	HxCDD (S)
	403.8529	M+4	$13C_{12}H_2{}^{35}Cl_4{}^{37}Cl_2O_2$	HxCDD (S)
	445.7555	M+4	$C_{12}H_2{}^{35}Cl_6{}^{37}Cl_2O$	OCDPE
	430.9729	QC	C_9F_{17}	PFK
4	407.7818	M+2	$C_{12}H^{35}Cl_6{}^{37}ClO$	HpCDF
	409.7789	M+4	$C_{12}H^{35}Cl_5{}^{37}Cl_2O$	HpCDF
	417.8253	M	$^{13}C_{12}H^{35}Cl_7O$	HpCDF (S)
	419.8220	M+2	$^{13}C_{12}H^{35}Cl_6{}^{37}ClO$	HpCDF (S)
	423.7766	M+2	$C_{12}H^{35}Cl_6{}^{37}ClO_2$	HpCDD
	425.7737	M+4	$C_{12}H^{35}Cl_5{}^{37}Cl_2O_2$	HpCDD
	435.8169	M+2	$^{13}C_{12}H^{35}Cl_6{}^{37}ClO_2$	HpCDD (S)
	437.8140	M+4	$^{13}C_{12}H^{35}Cl_5{}^{37}Cl_2O_2$	HpCDD (S)
	479.7165	M+4	$C_{12}H^{35}Cl_7{}^{37}Cl_2O$	NCDPE
	430.9729	LOCK	C_9F_{17}	PFK
	441.7428	M+2	$C_{12}{}^{35}Cl_7{}^{37}ClO$	OCDF
	443.7399	M+4	$C_{12}{}^{35}Cl_6{}^{37}Cl_2O$	OCDF
	457.7377	M+2	$C_{12}{}^{35}Cl_7{}^{37}ClO_2$	OCDD
	459.7348	M+4	$C_{12}{}^{35}Cl_6{}^{37}Cl_2O_2$	OCDD
	469.7779	M+2	$^{13}C_{12}{}^{35}Cl_7{}^{37}ClO_2$	OCDD (S)
	471.7750	M+4	$^{13}C_{12}{}^{35}Cl_6{}^{37}Cl_2O_2$	OCDD (S)

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TABLE 1 CONTINUED

Descriptor Number[b]	Accurate Mass[a]	Ion Type	Elemental Composition	Analyte
4 Continued	513.6775	M+4	$C_{12}{}^{35}Cl_8{}^{37}Cl_2O$	DCDPE
	442.9728	QC	$C_{10}F_{17}$	PFK

a) The following nuclidic masses were used:

H = 1.007825
C = 12.000000
^{13}C = 13.003355
F = 18.9984
O = 15.994915
^{35}Cl = 34.968853
^{37}Cl = 36.965903

S = Labeled Standard
QC = Ion Selected for Monitoring the Instrument Stability During the GC/MS Analysis

b) Descriptor 1 contains mono-, di- and trichlorinated dibenzodioxins and dibenzofurans that are not quantitated by Method 8290.

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TABLE 2: COMPOSITION OF THE INITIAL CALIBRATION SOLUTIONS

Compound	Concentrations (ng/mL) Sol. Number: 1	2	3	4	5	6
Unlabeled Analytes						
2,3,7,8-TCDD	0.5	1	10	50	100	200
2,3,7,8-TCDF	0.5	1	10	50	100	200
1,2,3,7,8-PeCDD	2.5	5	50	250	500	1000
1,2,3,7,8-PeCDF	2.5	5	50	250	500	1000
2,3,4,7,8-PeCDF	2.5	5	50	250	500	1000
1,2,3,4,7,8-HxCDD	2.5	5	50	250	500	1000
1,2,3,6,7,8-HxCDD	2.5	5	50	250	500	1000
1,2,3,7,8,9-HxCDD	2.5	5	50	250	500	1000
1,2,3,4,7,8-HxCDF	2.5	5	50	250	500	1000
1,2,3,6,7,8-HxCDF	2.5	5	50	250	500	1000
1,2,3,7,8,9-HxCDF	2.5	5	50	250	500	1000
2,3,4,6,7,8-HxCDF	2.5	5	50	250	500	1000
1,2,3,4,6,7,8-HpCDD	2.5	5	50	250	500	1000
1,2,3,4,6,7,8-HpCDF	2.5	5	50	250	500	1000
1,2,3,4,7,8,9-HpCDF	2.5	5	50	250	500	1000
OCDD	5	10	100	500	1000	2000
OCDF	5	10	100	500	1000	2000
Internal Standards						
$^{13}C_{12}$-2,3,7,8-TCDD	100	100	100	100	100	100
$^{13}C_{12}$-1,2,3,7,8-PeCDD	100	100	100	100	100	100
$^{13}C_{12}$-1,2,3,6,7,8-HxCDD	100	100	100	100	100	100
$^{13}C_{12}$-1,2,3,4,6,7,8-HpCDD	100	100	100	100	100	100

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TABLE 2 CONTINUED

Compound	Concentrations (ng/mL) Sol. Number: 1	2	3	4	5	6
Internal Standards Continued						
$^{13}C_{12}$-OCDD	200	200	200	200	200	200
$^{13}C_{12}$-2,3,7,8-TCDF	100	100	100	100	100	100
$^{13}C_{12}$-1,2,3,7,8-PeCDF	100	100	100	100	100	100
$^{13}C_{12}$-1,2,3,6,7,8-HxCDF	100	100	100	100	100	100
$^{13}C_{12}$-1,2,3,4,6,7,8-HpCDF	100	100	100	100	100	100
Surrogate Standards						
$^{37}Cl_4$-2,3,7,8-TCDD	0.5	1	10	50	100	200
$^{13}C_{12}$-2,3,4,7,8-PeCDF	100	100	100	100	100	100
$^{13}C_{12}$-1,2,3,4,7,8-HxCDD	100	100	100	100	100	100
$^{13}C_{12}$-1,2,3,4,7,8-HxCDF	100	100	100	100	100	100
$^{13}C_{12}$-1,2,3,4,7,8,9-HpCDF	100	100	100	100	100	100
Alternate Standard						
$^{13}C_{12}$-1,2,3,7,8,9-HxCDF	100	100	100	100	100	100
$^{13}C_{12}$-2,3,4,6,7,8-HxCDF	100	100	100	100	100	100
Recovery Standards						
$^{13}C_{12}$-1,2,3,4-TCDD	100	100	100	100	100	100
$^{13}C_{12}$-1,2,3,7,8,9-HxCDD	100	100	100	100	100	100

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TABLE 3: GC RETENTION TIME WINDOW DEFINING SOLUTION AND ISOMER SPECIFICITY TEST STANDARD (SECTION IV. C.)

DB-5 COLUMN GC RETENTION TIME WINDOW DEFINING SOLUTION

CDD/ CDF	FIRST ELUTED	LAST ELUTED
TCDF	1,3,6,8	1,2,8,9
TCDD	1,3,6,8	1,2,8,9
PeCDF	1,3,4,6,8	1,2,3,8,9
PeCDD	1,2,4,7,9	1,2,3,8,9
HxCDF	1,2,3,4,6,8	1,2,3,4,8,9
HxCDD	1,2,4,6,7,9	1,2,3,4,6,7
HpCDF	1,2,3,4,6,7,8	1,2,3,4,7,8,9
HpCDD	1,2,3,4,6,7,9	1,2,3,4,6,7,8

DB-5 COLUMN TCDD SPECIFICITY TEST STANDARD

1,2,3,7 + 1,2,3,8 - TCDD
2,3,7,8 - TCDD
1,2,3,9 - TCDD

DB-225 COLUMN TCDF ISOMER SPECIFICTY TEST STANDARD

2,3,4,7 - TCDF
2,3,7,8 - TCDF
1,2,3,9 - TCDF

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TABLE 4: GAS CHROMATOGRAPHY CONDITIONS

Column type	DB-5	DB-225
Length (m)	60	30
i.d. (mm)	0.25	0.25
Film Thickness (um)	0.25	0.25
Carrier Gas	Helium	Helium
Carrier Gas Flow (mL/min)	1-2	1-2
Injection Mode	⇐ splitless ⇒	
Valve Time (s)	60	60
Initial Temperature (°C)	150	130
Injection Port Temperature (°C)	250	250
Program Temperature	⇐ See Note ⇒	

Note: The GC temperature program is subject to change. Refer to work area guidelines for exact definitions of the current run conditions and descriptor name.

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TABLE 5. ION-ABUNDANCE RATIO ACCEPTABLE RANGES FOR PCDDs AND PCDFs

Number of Chlorine Atoms	Ion Type	Theoretical Ratio	Control Limits	
			Lower	Upper
4	M/M+2	0.77	0.65	0.89
5	M+2/M+4	1.55	1.32	1.78
6	M+2/M+4	1.24	1.05	1.43
6a	M/M+2	0.51	0.43	0.59
7b	M/M+2	0.44	0.37	0.51
7	M+2/M+4	1.04	0.88	1.20
8	M+2/M+4	0.89	0.76	1.02

a) Used only for ^{13}C-HxCDF
b) Used only for ^{13}C-HpCDF

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TABLE 6. UNLABELED ANALYTES QUANTITATION RELATIONSHIPS

Analyte	Standard Used During Quantitation
2,3,7,8-TCDD	$^{13}C_{12}$-2,3,7,8-TCDD
Other TCDDs	$^{13}C_{12}$-2,3,7,8-TCDD
1,2,3,7,8-PeCDD	$^{13}C_{12}$-1,2,3,7,8-PeCDD
Other PeCDDs	$^{13}C_{12}$-1,2,3,7,8-PeCDD
1,2,3,4,7,8-HxCDD	$^{13}C_{12}$-1,2,3,6,7,8-HxCDD
1,2,3,6,7,8-HxCDD	$^{13}C_{12}$-1,2,3,6,7,8-HxCDD
1,2,3,7,8,9-HxCDD	$^{13}C_{12}$-1,2,3,6,7,8-HxCDD
Other HxCDDs	$^{13}C_{12}$-1,2,3,6,7,8-HxCDD
1,2,3,4,6,7,8-HpCDD	$^{13}C_{12}$-1,2,3,4,6,7,8-HpCDD
Other HpCDD	$^{13}C_{12}$-1,2,3,4,6,7,8-HpCDD
OCDD	$^{13}C_{12}$-OCDD
2,3,7,8-TCDF	$^{13}C_{12}$-2,3,7,8-TCDF
Other TCDFs	$^{13}C_{12}$-2,3,7,8-TCDF
1,2,3,7,8-PeCDF	$^{13}C_{12}$-1,2,3,7,8-PeCDF
2,3,4,7,8-PeCDF	$^{13}C_{12}$-1,2,3,7,8-PeCDF
Other PeCDFs	$^{13}C_{12}$-1,2,3,7,8-PeCDF
1,2,3,4,7,8-HxCDF	$^{13}C_{12}$-1,2,3,6,7,8-HxCDF
1,2,3,6,7,8-HxCDF	$^{13}C_{12}$-1,2,3,6,7,8-HxCDF
1,2,3,7,8,9-HxCDF	$^{13}C_{12}$-1,2,3,6,7,8-HxCDF

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TABLE 6 CONTINUED

Analyte	Standard Used During Quantitation
2,3,4,6,7,8-HxCDF	$^{13}C_{12}$-1,2,3,6,7,8-HxCDF
Other HxCDFs	$^{13}C_{12}$-1,2,3,6,7,8-HxCDF
1,2,3,4,6,7,8-HpCDF	$^{13}C_{12}$-1,2,3,4,6,7,8-HpCDF
1,2,3,4,7,8,9-HpCDF	$^{13}C_{12}$-1,2,3,4,6,7,8-HpCDF
Other HpCDFs	$^{13}C_{12}$-1,2,3,4,6,7,8-HpCDF
OCDF	$^{13}C_{12}$-OCDD

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TABLE 7: INTERNAL STANDARDS QUANTITATION RELATIONSHIPS

Internal Standard	Standard Used During Percent Recovery Determination
$^{13}C_{12}$-2,3,7,8-TCDD	$^{13}C_{12}$-1,2,3,4-TCDD
$^{13}C_{12}$-1,2,3,7,8-PeCDD	$^{13}C_{12}$-1,2,3,4-TCDD
$^{13}C_{12}$-1,2,3,6,7,8-HxCDD	$^{13}C_{12}$-1,2,3,7,8,9-HxCDD
$^{13}C_{12}$-1,2,3,4,6,7,8-HpCDD	$^{13}C_{12}$-1,2,3,7,8,9-HxCDD
$^{13}C_{12}$-OCDD	$^{13}C_{12}$-1,2,3,7,8,9-HxCDD
$^{13}C_{12}$-2,3,7,8-TCDF	$^{13}C_{12}$-1,2,3,4-TCDD
$^{13}C_{12}$-1,2,3,7,8-PeCDF	$^{13}C_{12}$-1,2,3,4-TCDD
$^{13}C_{12}$-1,2,3,6,7,8-HxCDF	$^{13}C_{12}$-1,2,3,7,8,9-HxCDD
$^{13}C_{12}$-1,2,3,4,6,7,8-HpCDF	$^{13}C_{12}$-1,2,3,7,8,9-HxCDD

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TABLE 8: SURROGATE/ALTERNATE STANDARDS QUANTITATION RELATIONSHIPS

Surrogate/Alternate/Cleanup Standard	Standard Used During Percent Recovery Determination
$^{37}Cl_4$-2,3,7,8-TCDD	$^{13}C_{12}$-1,2,3,4-TCDD
$^{13}C_{12}$-2,3,4,7,8-PeCDF	$^{13}C_{12}$-1,2,3,4-TCDD
$^{13}C_{12}$-1,2,3,4,7,8-HxCDD	$^{13}C_{12}$-1,2,3,7,8,9-HxCDD
$^{13}C_{12}$-1,2,3,4,7,8-HxCDF	$^{13}C_{12}$-1,2,3,7,8,9-HxCDD
$^{13}C_{12}$-1,2,3,4,7,8,9-HpCDF	$^{13}C_{12}$-1,2,3,7,8,9-HxCDD
$^{13}C_{12}$-1,2,3,7,8,9-HxCDF	13C_{12}-1,2,3,7,8,9-HxCDD
$^{13}C_{12}$-2,3,4,6,7,8-HxCDF	$^{13}C_{12}$-1,2,3,7,8,9-HxCDD

NOTE : For air samples (PUF and M-0023A) recoveries of surrogate standards are quantitated relative to their appropriate internal standards.

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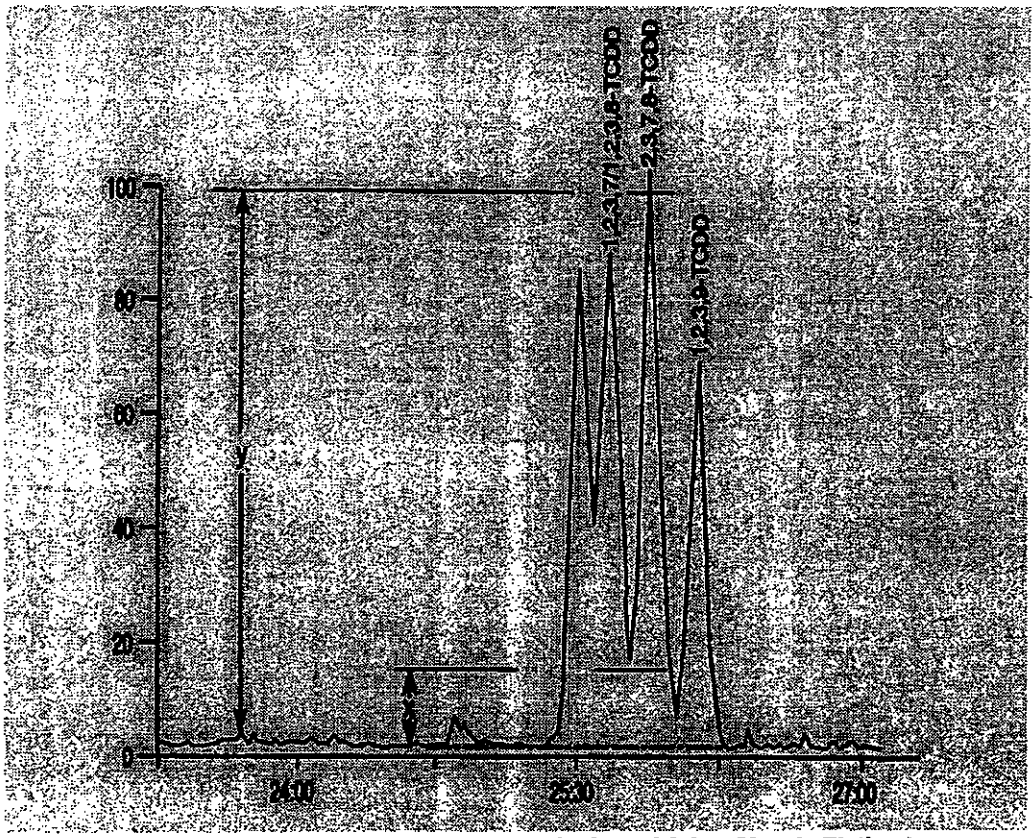

FIGURE 1. Valley between 2,3,7,8 - Tetrachlorodibenzo-p-dioxin and Other Closely Eluting Isomers.

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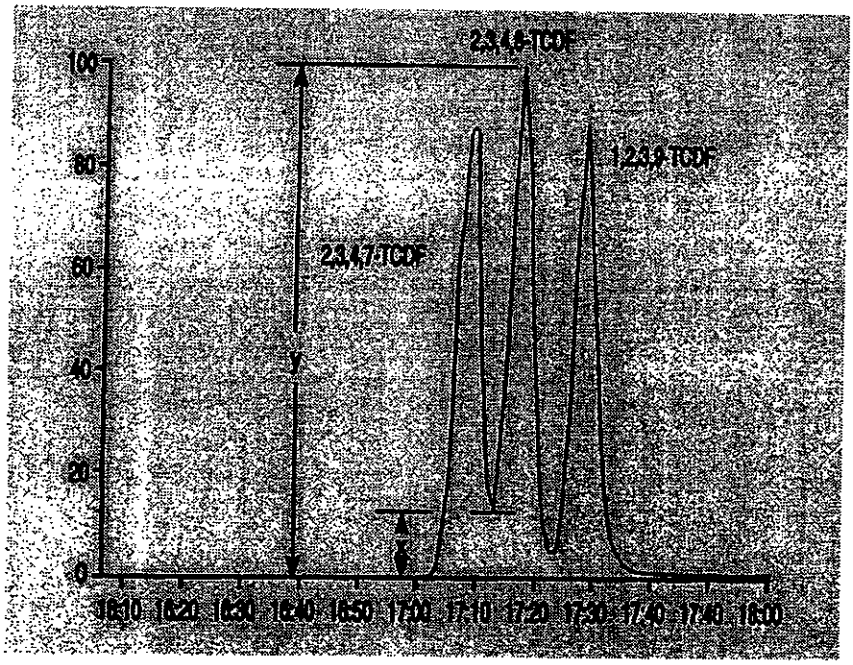

FIGURE 2. Valley between 2,3,7,8 - Tetrachlorodibenzofuran and Other Closely Eluting Isomers.

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APPENDIX 1

Deviations from and improvements to US EPA Method 8290
POLYCHLORINATED DIBENZODIOXINS (PCDDs) AND POLYCHLORINATED DIBENZOFURANS (PCDFs) BY HIGH-RESOLUTION GAS CHROMATOGRAPHY/ HIGH-RESOLUTION MASS SPECTROMETRY (HRGC/ HRMS)
as performed at Triangle Laboratories, Inc.

See Section	
• VI. A. and Table 2.	Triangle Laboratories uses 6 calibration points ranging from 0.5 pg/µL to 200 pg/µL for tetrachlorinated dioxin and furan. Concentrations of penta- through heptachlorinated analytes are 5 times higher than tetra congeners and octachlorinated analytes are 10 times higher (Compare with Table 5., Method 8290).
• VI. A.	Seven more labeled PCDDs/ PCDFs are used as surrogate and alternate standards to provide additional quality control information.
• VI. A.	The 1,2,3,6,7,8 - hexachlorodibenzofuran (HxCDF) is used as an internal standard instead of 1,2,3,4,7,8 - HxCDF. Triangle Laboratories uses 1,2;3,4,7,8 - HxCDF as a surrogate standard.
• VI. A.	Each carbon-labeled standard in the initial calibration solution has a concentration of 100 pg/µL except $^{13}C_{12}$ - OCDD, which is at 200 pg/µL. Concentrations of $^{13}C_{12}$ - labeled standards in sample fortification solutions are the same as in the initial calibration solution (See section 5.9., Method 8290).
• VII.	The method blank does not need to be analyzed on each analysis clock that samples are analyzed. Once a valid analysis is provided for the method blank it may be replaced with HRGC/ HRMS solvent blank (See section 8.2., Method 8290).
• VII. B. 3. a)	Documentation of the mass spectrometer resolving power is accomplished by recording the peak profile of m/z 416.9760 and 330.9792 (See section 8.2.2.3., Method 8290).
• XI. D. - F. 1.	The Internal Standard recoveries in all QC samples and field samples are considered valid as long as the signal to noise ratio is greater than 10:1, the recovery is $\geq$ 25% and target detection limits for the analytes are met (See section 8.4., Method 8290).

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1.0 PURPOSE

This method is intended for the analysis of explosives residues in soil, water, sediments, or wipes. This method is limited to use by analysts experienced in handling and analyzing explosives. Specific compounds that can be analyzed by this method are summarized in the following table.

Abbreviation	Compound	CAS No.*
HMX	Octahydro-1,3,5,7-tetranitro-1,3,5,7-tetrazocine	2691-41-0
RDX	Hexahydro-1,3,5-trinitro-1,3,5-triazine	121-82-4
1,3,5-TNB	1,3,5-Trinitrobenzene	99-35-4
1,3-DNB	1,3-Dinitrobenzene	99-65-0
Tetryl	Methyl-2,4,6-trinitrophenylnitramine	479-45-8
NB	Nitrobenzene	98-95-3
2,4,6-TNT	2,4,6-Trinitrotoluene	118-96-7
2,6-DNT	2,6-Dinitrotoluene	606-20-2
2,4-DNT	2,4-Dinitrotoluene	121-14-2
2-Am-4,6-DNT	2-Amino-4,6-dinitrotoluene	355-72-78-2
4-Am-2,6-DNT	4-Amino-2,6-dinitrotoluene	1946-51-0
2-NT	2-Nitrotoluene	88-72-2
4-NT	4-Nitrotoluene	99-99-0
3-NT	3-Nitrotoluene	99-08-1

* Chemical Abstracts Service Registry Number

2.0 REFERENCES

2.1 "Draft Method 8330, Nitroaromatics and Nitramines by High Performance Liquid Chromatography (HPLC)", Revision 0, November 1992. This method was obtained from the US Army Corps of Engineers (COE), as a draft document developed by the COE for submittal and eventual approval for publication in EPA SW-846, Test Methods for Evaluating Solid Waste, 3rd Edition.

2.2 "Method 8330, Nitroaromatics and Nitramines by High Performance Liquid Chromatography (HPLC)", Revision 0, September 1994.

2.3 Supplemental bibliography is given in Section 11.

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Nitroaromatics and Nitramines by HPLC

3.0 SCOPE AND APPLICATION

3.1 This method is used to determine the concentration of the compounds listed in Section 1.0 in water, soil, sediment or wipes.

3.2 This method provides a salting-out extraction procedure for low concentration (i.e., parts per billion) explosives residues in surface or ground water. Direct injection of diluted and filtered water samples can be used for water samples of higher concentration. An ultrasonic extraction technique is described for soil and sediment samples.

3.3 All of the compounds listed in Section 1 either are used in the manufacture of explosives or are the degradation products of compounds used for that purpose. When making stock solutions for calibration, treat each compound as if it were extremely explosive.

3.4 This method is restricted to use by, or under the supervision of, analysts experienced in the use of HPLC, skilled in the interpretation of chromatograms, and experienced in handling explosive materials.

4.0 SUMMARY OF METHOD

This method provides instrument operating parameters for the detection of ppb levels of certain explosives and explosives residues in extracts of soil, sediment or water samples by high performance liquid chromatography (HPLC).

The sample extracts must be generated by the appropriate sample preparation techniques.

4.1 Reverse Salting-out Extraction Method (RSOE)

This procedure has replaced the Low-Level Salting-out Method, as it offers technical advantages. The principles remain the same, as aqueous samples are treated to near saturation with sodium chloride and extracted with acetonitrile. This procedure is performed in mixing flasks. An acetonitrile/salt water partition is established with vigorous stirring whereby the analytes are extracted into the organic phase, and the salt water becomes saturated with acetonitrile. The resultant extract is concentrated by reestablishing the acetonitrile/salt water partition using reagent salt water, allowing approximately 14 mL of the 20 mL acetonitrile extract from the initial extraction to dissolve, obtaining a nominal extract final volume of 6.0 mL. On the day of analysis, 500 µL of the extract is diluted with 500 µL of the water dilution solution.

4.2 High-Level Direct Injection Method

Aqueous samples of higher concentration can be diluted 1/1 (v/v) with methanol or acetonitrile, filtered, and analyzed.

4.3 Soil, Sediment and Wipe Samples

These are extracted using acetonitrile in an ultrasonic bath. On the day of analysis, 500 µL of the extract is diluted with 500 µL reagent water (as described in Section 7.4.1).

5.0 INTERFERENCES

5.1 Solvents, glassware and other sample processing hardware may yield discrete artifacts and/or elevated baselines, causing misinterpretation of the chromatograms. All of these materials must be demonstrated to be free from interferences under the conditions of the analysis by running method blanks. Specific selection of reagents and purification of solvents by distillation in all-glass systems may be required.

5.2 2,4-DNT and 2,6-DNT elute at similar retention times on the ODS (C-18) column. A large concentration of one isomer may mask the response of the other isomer. If it is not apparent that both isomers are present, an isomeric mixture may be reported.

5.3 2-Am-4,6-DNT and 4-Am-2,6-DNT completely coelute on the ODS column while 4-Am-2,6-DNT and 2,4,6-TNT will elute at similar times on the CN column. If it is not apparent which amino-DNT isomer is present, an isomeric mixture should be reported. This is typically done under the conditions specified in this OP.

5.4 Tetryl decomposes rapidly in methanol/water solutions, as well as with heat or prolonged exposure to light. When performing analysis by direct injection, all aqueous samples expected to contain Tetryl should be diluted with acetonitrile prior to filtration. All samples expected to contain Tetryl should not be exposed to temperatures above room temperature.

5.5 Degradation products of Tetryl appear as a shoulder on the TNT peak when using the ODS column. Peak heights rather than peak areas should be used when Tetryl is present in concentrations that are significant relative to the concentration of TNT. It is imperative that the automatic liquid samplers employed have the capability of being chilled to 5°C to minimize Tetryl degradation while standards and samples are awaiting analysis.

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Otherwise, it has been shown that Tetryl remains stable in extracts diluted into pH3 (HCl) water instead of neutral water at room temperature. Amber vials are employed to reduce the effects of light sensitivity.

5.6 All standards containing Tetryl are to be stored in a freezer (-10° to -20°C) to reduce Tetryl degradation whenever possible.

5.7 The recommended surrogate, 1,2-Dinitrobenzene, interferes with the confirmation of low levels of 2,4-DNT using the CN column.

5.8 The Nitrotoluene series coelute when analyzed on the CN column.

6.0 APPARATUS AND MATERIALS

6.1 HPLC System

6.1.1 HPLC equipped with: pump capable of achieving 4000 psi,
automatic liquid sampler and
254-nm UV detector
column oven (recommended)
on-line degasser (optional)

(Hewlett Packard 1050 or equivalent)

6.1.2 HPLC Columns:

- ODS reverse phase, 25 cm x 4.6 mm (5 µm particle size):
  Burdick and Jackson 9575 or equivalent
- CN reverse phase, 25 cm x 4.6 mm (5 µm particle size):
  Dupont Zorbax CN or equivalent
- C-8 reverse phase, 25 cm x 4.6 mm (5 µm particle size):
  Dupont Zorbax or equivalent

6.1.3 Chromatography Data System

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6.2 Other Equipment

6.2.1 Temperature Controlled Ultrasonic Bath

6.2.2 Magnetic Stir Plate (Lab-Line 1278 or equivalent) capable of stirring to 1200 r.p.m.

6.2.3 Balance, ± 0.1 mg

6.2.4 Oven: forced air, without heating

6.3 Materials

6.3.2 Disposable Cartridge Filters: 0.20 µm Teflon® filter
0.45 µm Teflon® filter (optional)

6.3.3 Pipettes: 10 mL, 5mL volumetric Class A, glass

6.3.4 Pasteur Pipettes

6.3.5 10 mL Disposable Graduated Glass Pipettes

6.3.6 Vials: 12 mL glass, Teflon®-lined cap
16 mL amber glass, Teflon®-lined cap
40 mL glass, Teflon®-lined cap
4 mL amber glass, Teflon®-lined cap
2 mL amber autosampler

6.3.7 Syringes: 10 µL, 50 µL, 100 µL, 250 µL glass with metal plunger

6.3.8 Pipettors: 10-100 uL size, 100 µL-1000 µL size

6.3.9 Disposable Syringes: Glaspak, 5 mL or equivalent

6.3.10 Volumetric Flask: 10.0 mL

6.3.11 Etching pen or scribe

6.3.12 Magnetic Stir Bars: 1" and 1½"

6.3.13 1 Liter mixing flasks (Baxter F4651-1L, or equivalent)

6.3.14 100 mL custom flat bottom flasks (A.A. Pesce, Kennett Square, PA)

6.3.15 10 mL Class A volumetric cylinders

6.3.16 Polypropylene Powder Funnel, 60°, 145mm or equivalent

6.3.17 Bottle Top Dispenser (2), 100 mL capacity (optional)

7.0 REAGENTS AND STANDARDS

7.1 Reagents

Use HPLC grade chemicals in all tests. It is intended that all reagents shall conform to the specifications of the Committee on Analytical Reagents of the American Chemical Society, where such specifications are available. Other grades may be used, provided it is first ascertained that the reagent is of sufficiently high purity to permit its use without lowering the accuracy of the determination.

7.2 Analytical Standards

Analytes listed in Section 1.0. Allow ample lead time (up to six months) for obtaining these compounds. RDX and Tetryl are stored wet for stability during shipment. The primary source for these explosives is military contracts. Some commercial vendors such as EM Science, Restek, Accu-Standard and Radian now have explosives available in solution. Other nitro-compounds are metabolites of the explosives and should be commercially available.

7.3 Surrogate Standard

1,2-Dinitrobenzene, purchased from Accu-Standard or Restek in solution at 1000 µg/mL. 800 uL diluted to 10 mL with ACN yields a working solution at 80 µg/mL.

7.4 Other Reagents

7.4.1 Reagent Water: All references to water in this method refer to water in which an interference is not observed at the detection limit of the compounds of interest. Reagent water can be generated by passing tap water through a carbon filter feed containing about

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1 pound of activated carbon. A water purification system may be used to generate organic-free deionized water.

7.4.2 Acetonitrile (ACN), HPLC grade

7.4.3 Methanol (MeOH), HPLC grade, distilled in glass

7.4.4 Sodium Chloride, NaCl, Reagent grade. Kiln dried at 400°C for two hours. Stored in glass bottles.

7.4.5 Mobile Phase I: 54% water/33% MeOH/13% ACN
Mobile Phase II: 50% water/50% MeOH
Mobile Phase III: 60% water/40% ACN

Mobile phases may be varied to optimize separation.

7.4.6 Salt Water: 325 grams NaCl / liter DI H_2O

7.5 Diluents

7.5.1 Instrument Calibration Solution: 55% water/45%acetonitrile.

7.5.2 Sample extracts requiring dilution: 1:1 water/acetonitrile.

8.0 SAMPLE COLLECTION, PRESERVATION, AND HANDLING

8.1 Grab samples must be collected and stored in glass containers. Follow conventional sampling procedures.

8.2 Samples and sample extracts must be kept below 4°C and in the dark, except soil/solid samples during drying.

8.3 Soil and sediment samples should be air dried to constant weight at room temperature or colder after collection.

8.4 All water samples must be extracted within 7 days of collection and analyzed within 40 days after extraction.

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All soil and sediment samples must be extracted within 14 days of collection and analyzed within 40 days after extraction.

9.0 PROCEDURE

9.1 Sample Preparation: Aqueous Samples

Option 1: The low-level method may be used for all samples, provided they are diluted into the calibration range when necessary.

Option 2: If both low-level and high level methods are to be used, it is highly recommended that all samples of this type be screened with the high-level method (>50 µg/L) to determine if the low-level method (1-50 µg/L) is required.

9.1.1 Low-Level Method: Reverse Salting Out Extraction (RSOE)

9.1.1.1 Weigh out the appropriate number of 251.3 gram (to nearest 0.1 gram) aliquots of NaCl.

9.1.1.2 Add a 770 mL sample aliquot to a 1 L mixing flask containing a 1½" magnetic stir bar. Add surrogate to all samples and the appropriate amount of matrix spike solution to the designated QC samples at this time. Begin stirring by slowly increasing the speed control to a setting of 6 (Lab-Line). Adjust the position of the mixing flasks on the stir plate as to reduce the knocking sound, which will improve mixing efficiency and reduce the possibility of flask breakage.

9.1.1.3 Add 251.3 grams of NaCl weighed in Section 9.1.1.1 to the sample at a rate slow enough as not to interrupt the stirring action. Some of the NaCl will get caught in the neck of the mixing flask and must be dissolved into the sample by attaching a stopper and inverting the flask.

9.1.1.4 Once all of the NaCl is dissolved (about 15 minutes), add 162 mL acetonitrile to each sample and increase stir rate to a setting of greater than 8 (Lab-Line). Initially, the vigorous stirring will cause a noticeable vortex between the phases along with degassing which will decrease as the acetonitrile dissolves into the aqueous phase. The aqueous phase should appear cloudy. Stir for 15 minutes. Turn off the stirrer and allow the phases to separate for 10 minutes.

9.1.1.5 Remove the acetonitrile (upper) layer with a 10 mL disposable pipet and transfer to a 100 mL stirring flask (Section 6.3.14). If the volume recovered is less than 8 mL, make up the difference to 10 mL with acetonitrile.

9.1.1.6 Add 10 mL fresh acetonitrile to the water sample in the 1 L mixing flask and repeat the stirring procedure of Section 9.1.2.4 and Section 9.1.2.5. Since the aqueous phase is already saturated with acetonitrile, further dissolution should be minimal.

9.1.1.7 Add a 1" magnetic stir bar and 92 mL salt water (Section 7.4.6) to the flask containing the acetonitrile extract. If the top of the liquid is not mid-way up the neck of the flask, add additional salt water to raise the liquid level. Stir at a fast enough setting to allow complete or near complete mixing of the acetonitrile and aqueous phases for 1 minute. A sufficient stirring rate is obtained when the liquid appears cloudy.

During this step of the procedure, it is not uncommon for the entire acetonitrile phase to become dissolved into the aqueous phase. If this should occur, add a sufficient volume of acetonitrile (one mL at a time) and stir in order to reestablish the partition of the two phases.

Allow the two phases to separate for 10 minutes and transfer the acetonitrile extract to a 10 mL volumetric cylinder. An optimum volume for the acetonitrile recovered in this step is 3-4 mL.

9.1.1.8 Add 1 mL fresh acetonitrile to the flask and repeat the vigorous stirring for 1 minute. Allow the two phases to separate for 10 minutes and transfer the acetonitrile phase to the 10 mL volumetric cylinder. Adjust the volume to 6 mL, homogenize and transfer a 4 mL aliquot to a 4 mL amber screw cap vial.

If the final volume is greater than 6 mL, record the actual final volume in the preparation logbook.

9.1.1.9 On the day of analysis, dilute 500 µL of extract with 500 µL of DI H_2O. If the diluted extract is turbid, filter through a 0.2µm Teflon® filter.

9.1.2 High-Level Method

9.1.2.1 Sample Filtration

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Place a 5-mL aliquot of each water sample in a 12 mL screw cap vial, add 5 mL of acetonitrile, shake thoroughly, and filter through a 0.2 µm Teflon® filter. Discard the first 3 mL of filtrate, and retain the remainder in a Teflon®-capped vial for RP-HPLC analysis as in Section 9.5. HMX quantitation can be improved with the use of methanol rather than acetonitrile for dilution before filtration. However, as stated in Section 5.4, the use of methanol may affect tetryl stability.

9.2 Sample Preparation: Soil, Sediment and Wipe Samples

9.2.1 Sample Homogenization

Dry soil and sediment samples in air at room temperature or colder, being careful not to expose the sample to direct sunlight. Pulverize the sample with a spatula and remove any sticks, rocks or other extraneous material. Particle size should resemble soil passed through a 30 mesh sieve.

See safety section regarding extraction of wet soils for high level samples.

9.2.2 Sample Extraction

9.2.2.1 Place a 2.0 g aliquot of each soil/sediment sample or an entire wipe sample into a 16 mL amber glass vial. Add surrogate to all samples and the appropriate amount of matrix spike solution to the designated QC samples at this time. Add 10 mL acetonitrile, cap with a Teflon lined screw cap.

NOTE: It may be necessary to use a larger sample extraction container if the wipe is too large to fit into the 16 mL vial. If this is the case, larger volumes of acetonitrile will be required to fully submerge the wipe during extraction. A proportional increase of surrogate/matrix spike solution is used to maintain the same concentration in the extract.

9.2.2.2 On the screw cap for each sample, etch a unique ID which can be cross-referenced to the sample ID.

9.2.2.3 Place the 16-mL sample vials into the vial rack and fill ultrasonic bath with sufficient water to a level such that the vials will almost become buoyant. Turn ultrasonic bath power on and extraction will proceed for 18 hours.

9.2.2.4 After sonication, allow the sample to settle for a minimum of 30 minutes.

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9.2.2.5 Transfer the supernatant to a disposable syringe and filter through a 0.2 µm Teflon® filter.

9.2.2.6 On day of analysis, dilute 500 µL of the prepared sample with 500 µL water.

9.3 Chromatographic Conditions

Primary Column:	B & J ODS (Cat. 9575), or equivalent (C-18 Reverse Phase HPLC Column, 250 mm X 4.6 mm ID, 5 micron particle size)
Mobile Phase:	54% water/33% MeOH/13% ACN
Flow Rate:	1.4 mL/min
Injection volume:	65 µL DAD; 50 µL VWD
UV Detector:	254 nm
Column Temperature:	Stable; minimum 7°C above ambient room temperature. Nominally 38°C.
Confirmation Column I:	Dupont Zorbax CN, or equivalent (CN Reverse Phase HPLC Column, 250 mm x 4.6 mm ID, 5 micron particle size)
Mobile Phase:	50% Water/50% MeOH
Flow Rate:	1.5 mL/min
Injection Volume:	65 µL DAD; 50 µL VWD
UV Detector:	254 nm
Column Temperature:	Stable; minimum 7°C above ambient room temperature Nominally 35°C.
Confirmation Column II:	Dupont Zorbax C8, or equivalent (C8 Reverse Phase HPLC Column, 250 mm x 4.6 mm ID, 5 micron particle size)
Mobile Phase:	60% Water/40% ACN
Flow Rate:	1.5 mL/min
Injection Volume:	65 µL DAD; 50 µL VWD
UV Detector:	254 nm
Column Temperature:	Stable; minimum 7°C above ambient room temperature Nominally 38°C.

DAD-Diode Array Detector; VWD- Variable Wavelength Detector

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9.4 Calibration of HPLC

9.4.1 All electronic equipment is allowed to warm up for thirty minutes. During this period, at least 15 void volumes of mobile phase are passed through the column (approximately 20 min at 1.5 mL/min) and continued until the baseline is level at the UV detector's greatest sensitivity range.

9.4.2 Instrument Initial Calibration Standards

When instrument calibration is required, prepare a set of a minimum of five concentration levels into 2:1 water/acetonitrile. The calibration curve is based on peak heights or peak areas, as appropriate. Details regarding the preparation of the calibration standards are found in Figure D..

Certain projects may require the use of triplicate injections for all calibration standards as described in Method 8330 in SW-846, with the average response obtained from the triplicate injections utilized for each level of the calibration curve. Projects with this requirement will be identified in the Technical Profile.

9.4.3 Initial calibration data are entered into the chromatography data system, which calculates a least squares regression using the responses as Y values and target concentrations as X values. The program will calculate an equation to describe the data. The general form of the equation is:

$Y = aX + b$,

X = instrument detector response
Y = true concentration
a = slope of the regression line
b = Y intercept (X = 0)

Values of a and b are obtained from the computer regression calculations. Evaluate the correlation coefficient (r) of the least squares regression. A correlation coefficient of at least 0.996 is required for the quantitation of target compound concentrations.

Alternatively, the response factors for the initial calibration standards may be averaged and used to determine the extract concentration using the equation:

$$Y=(X)(\text{average response factor})$$

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9.4.4 Instrument Continuing Calibration Verification

Prepare and analyze a continuing calibration verification standard (CCV) after every ten samples and at the end of a run sequence. The deviation is obtained using either absolute detector response or calculated concentration from the calibration (Y from Section 9.4.3). Therefore, a CCV standard is compared to the detector response of the corresponding initial calibration standard or the true concentration of the analytes in the CCV. The deviation should agree within ±15% of expected, whether it be detector response or true concentration, respectively. If the deviation from the CCV exceeds 15%, reanalyze the CCV. If the deviation for the second CCV is still greater than 15%, perform corrective action, such as re-preparing the CCV or, if necessary, recalibrate the instrument. All samples analyzed after an unacceptable CCV must be reanalyzed. CCV are at the D level.

9.4.5 Instrument Daily Calibration Verification

Analyze a CCV in triplicate at the beginning of each daily analytical sequence. The deviation of this standard must be within ±15%, as detailed in Section 9.4.4. Subsequent continuing calibration standards for that day require only a single injection.

9.5 HPLC Analysis

9.5.1 Analyze the samples using the chromatographic conditions given in Section 9.3. Evaluate the sample chromatograms for the presence of peaks which fall within the retention time windows established for target compounds (see Section 9.5.3). Retention time windows are used as a guide for the analyst. Final interpretation of the chromatographic data is dependent upon an evaluation by an experienced analyst.

9.5.1.1 Dilute samples as necessary to obtain results within the calibration range for each analyte.

9.5.2 Confirmation of positive identifications.

9.5.2.1 Analyze using CN column. The acceptance criteria for confirmation will be an RPD of 40% or less. If the RPD exceeds 40%, technical evaluation will be performed and the results from the primary column will be reported and a note will be made in the case narrative to advise the client of the disparity between the results.

Limitation: The CN column will not allow confirmation of 2,4-DNT and 2,6-DNT when using 1,2-DNB as a surrogate. C-8 Recommended if confirming these compounds.

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9.5.2.2 Analyze using C8 column.

Limitation: HMX and RDX coelute on the C-8 column. CN recommended when confirming these compounds.

9.5.2.3 Qualitative evaluation of positively identified analytes may be determined using the capabilities of a Diode Array Detector. UV spectral data for peaks falling within a specific retention time window of an analyte in a sample extract are compared against a UV spectrum of that respective analyte. The estimated reliability of this option is at a concentration from the mid-point of the calibration range upward. Details of this procedure are not covered here.

9.5.3 Absolute Retention Time Windows- A retention time window of 1% (absolute) is established using the third daily CCV (Section 9.4.5) as the center of the window.

9.5.4 Relative Retention Time Window (when RT shifts >1%)

If the retention times should drift outside the 1% window, the surrogate may be used to generate relative retention time windows. Calculate the relative retention time for each analyte, using the following equation:

$$\text{Relative RT of Analyte} = \frac{\text{RT of Analyte}}{\text{RT of 1,2-Dinitrobenzene}}$$

Calculate the mean and the standard deviation of relative RT for each analyte using the initial calibration. Apply plus or minus three times the standard deviation to the mean relative RT. This range of retention times defines the relative retention time window of the analyte.

9.5.5 Table 3 presents the approximate retention times on the ODS, CN and C-8 columns for the analytes determined by this method, using the operating conditions in Section 9.3.

9.5.6 Record the resulting peak sizes in peak heights or area units. The use of peak heights is recommended to improve reproducibility of low level samples.

9.5.7 Concentrations of target compounds in sample extracts are derived from the least squares regression calculation or average response factor using initial calibration data

(Section 9.4.3). The peak area or height for the target compound is the Y variable. The concentration in the extract (Y variable in µg/mL) is calculated from the calibration data.

9.5.8 Calculate results in the original matrix, using the following information:

µg/mL = concentration of the sample from the calibration curve.
DF = Instrument dilution required.
2 = All preparation schemes in this method have a two-fold procedural dilution prior to instrument analysis (Sections 9.1.1.9 and 9.2.2.6).
L or g = liters or grams, i.e., sample size.
FV = Extract final volume (mL). Nominally 6 mL for RSOE and 10 mL for soil extracts.

Calculate the final result using the following equations:

- Direct Injection Water: µg/mL X DF X 2 X 1,000 = µg/L
- Soil: µg/mL X FV X DF X 2 ÷ g = µg/g
- RSOE Water: µg/mL X FV X DF X 2 ÷ L = µg/L
- Wipe: µg/mL X FV X DF X 2 = total µg

10.0 QUALITY CONTROL

10.1 Prior to preparation of stock solutions, acetonitrile, methanol, and water blanks should be run to determine possible interferences with analyte peaks. If the acetonitrile, methanol, or water blanks show contamination, a different batch should be used.

10.2 Each analytical batch comprises up to 20 samples. For each batch, the following minimum QC should be performed:

Method Blank
Blank Spike
Blank Spike Duplicate
(prepare when an MSD or sample duplicate is not prepared)
Matrix Spike*
Matrix Spike Duplicate or Sample Duplicate*
*Not required for Wipe samples.

Spike samples at approximately ten times the lowest initial calibration level. Perform spikes with standards prepared independently from the calibration mix. Recoveries must be within laboratory quality control limits. Reanalyze any samples with results outside control limits.

10.3 Method Blanks, Blank Spikes and Blank Spike Duplicates

10.3.1 Method blanks for the analysis of aqueous samples should be reagent water carried through all sample storage, preparation and handling procedures.

10.3.2 Method blanks for the analysis of soil samples should be uncontaminated USAEC standard soil or Ottawa sand carried through all sample storage, extraction and handling procedures.

10.3.3 Blank spikes and blank spike duplicates are prepared with the same standard for matrix spikes at a level approximately ten times the lowest initial calibration level. Samples batched with the BS/BSD must be re-extracted if the blank spike recoveries are outside the laboratory quality control limits.

11.0 SUPPLEMENTAL REFERENCES

11.1 Bauer, C.F., T.F. Jenkins, S.M. Koza, P.W. Schumacher, P.H. Miyares and M.E. Walsh (1989). "Development of an Analytical Method for the Determination of Explosive Residues in Soil, Part 3. Collaborative Test Results and Final Performance Evaluation". USA Cold Regions Research and Engineering Laboratory, CRREL Report 89-9.

11.2 Grant, C.L. A.D. Hewitt and T.F. Jenkins (1989) "Comparison of Low Concentration Measurement Capability Estimates in Trace Analysis: Method Detection Limits and Certified Reporting Limits". USA Cold Regions Research and Engineering Laboratory, Special Report 89-20.

11.3 Jenkins, T.F., C.F. Bauer, D.C. Leggett and C.L. Grant (1984). "Reversed-phase HPLC Method for Analysis of TNT, RDX, HMX and 2,4-DNT in munitions wastewater. USA Cold Regions Research and Engineering Laboratory, CRREL Report 84-29.

11.4 Jenkins, T.F. and M.E. Walsh (1987). "Development of an Analytical Method for Explosive Residues in soil." USA Cold Regions Research and Engineering Laboratory. CRREL Report 87-7.

11.5 Jenkins. T.F., P.H. Miyares and M.E. Walsh (1988a). "An improved RP-HPLC Method for Determining Nitroaromatics and Nitramines in Water." USA Cold Regions Research and Engineering Laboratory, Special Report 88-23.

11.6 Jenkins, T.F., P.W. Schumacher, M.E. Walsh and C.F. Bauer (1988b). "Development of an Analytical Method for the Determination of Explosive Residues in Soil. Part II#: Further Development and Ruggedness Testing." USA Cold Regions Research and Engineering Laboratory. CRREL Report 88-8.

11.7 Leggett, D.C., T.F. Jenkins and P.H. Miyares (1990). "Salting-out Solvent Extraction for Pre-concentration of Neutral Polar Organic Solutes from Water." *Analytical Chemistry*, 62: 1355-1356.

11.8 Miyares, P.H. and T.F. Jenkins (1990). "Salting-out Solvent Extraction for Determining Low Levels of Nitroaromatics and Nitramines in Water." USA Cold Regions Research and Engineering Laboratory, Special Report 90-30.

12.0 SAFETY

12.1 Standard precautionary measures used for handling other organic compounds should be sufficient for safe handling of the analytes targeted by this method.

12.2 If samples are suspected of containing 10% or greater explosives, the samples should be extracted without drying and reported on a wet weight basis. The laboratory may institute a screening program for wet soils, at its option.

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FIGURE A
Explosives Reporting Limits

Compound	Low-Level Water[1] (µg/L)	High Level Water (µg/L)	Soil/Sediment (mg/kg)	Wipe[2] (Total µg)
HMX	1.72	220	2.2	4.4
RDX	0.78	100	1.0	2.0
1,3,5-TNB	0.20	25	0.25	0.5
1,3-DNB	0.20	25	0.25	0.5
Nitrobenzene	0.20	25	0.25	0.5
Tetryl	0.71	75	0.75	1.5
2,4,6-TNT	0.20	25	0.25	0.5
2,6-DNT	0.20	25	0.25	0.5
2,4-DNT	0.20	25	0.25	0.5
2-Am-4,6-DNT	0.20	25	0.25	0.5
4-Am-2,6-DNT	0.20	25	0.25	0.5
2-NT	0.78	100	1.0	2.0
4-NT	2.34	300	3.0	6.0
3-NT	0.78	100	1.0	2.0

[1]-Subject to small variations due to changes in MDL results
[2] Assuming a 10mL extract volume

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FIGURE B

Retention Time of Analytes by HPLC[1]

Compound	ODS Column RT (min)	CN Column RT (min)	C8 Column RT (min)
HMX	2.99	10.93	7.28*
RDX	4.05	7.36	7.28*
1,3,5-TNB	5.56	5.30	11.23
1,2-DNB (surr)	6.23	6.10*	11.00
1,3-DNB	6.73	5.05	10.48
Nitrobenzene	7.81	4.76	10.98
Tetryl	8.16	10.13	19.74
2,4,6-TNT	9.23	6.46	18.60
2,6-DNT	10.42	5.89	16.18
2,4-DNT	10.76	6.18	15.70
2-Am-4,6-DNT	8.87*	6.76	12.08
4-Am-2,6-DNT	8.87*	6.30	13.00
2-Nitrotoluene	12.79	5.20	
4-Nitrotoluene	13.88	5.20	
3-Nitrotoluene	14.83	5.20	

* Coelute

[1] Approximate, as analyzed according to instrument conditions specified in section 9.3

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FIGURE C
Example HPLC Analysis Log

Lionville Laboratory Inc.

HPLC ANALYSIS LOG

METHOD: LC-8330 REV 00

INSTRUMENT #: _____ MOBILE PHASE: _____ ANALYST: _____

DETECTOR: _____ FLOW RATE: _____

WAVELENGTH: _____ COLUME TYPE: _____ COLUMN #: _____

CALIBRATION _____ SPIKING _____ LOG BOOK #: _____

#	CLAS ID # & RUN #	INSTRUMENT FILE ID	ANALYSIS DATE/TIME	LvLI SAMPLE # /DESCRIPTION	DF	COMMENTS

REVIEWED BY/DATE _____

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FIGURE D
Explosives Calibration Standards Preparation Summary

		Volume (uL) of Calibration Working Standard to Prepare 1 mL					
		80	40	20	8	4	2
Analyte	Calibration Working (µg/mL)	Level F (µg/mL)	Level E (µg/mL)	Level D (µg/mL)	Level C (µg/mL)	Level B (µg/mL)	Level A (µg/mL)
HMX	55	4.40	2.20	1.100	0.440	0.220	0.1100
RDX	25	2.00	1.00	0.500	0.200	0.100	0.0500
1,3,5-TNB	6.3	0.50	0.25	0.126	0.050	0.025	0.0126
1,2-DNB	10	0.80	0.40	0.200	0.080	0.040	0.0200
1,3-DNB	6.3	0.50	0.25	0.126	0.050	0.025	0.0126
Nitrobenzene	6.5	0.52	0.26	0.130	0.052	0.026	0.0130
Tetryl	18.4	1.47	0.74	0.368	0.147	0.074	0.0368
2-Amino-4,6-DNT	6.3	0.50	0.25	0.126	0.050	0.025	0.0126
4-Amino-2,6-DNT	6.25	0.50	0.25	0.125	0.050	0.025	0.0125
2,4,6-TNT	6.3	0.50	0.25	0.126	0.050	0.025	0.0126
2,6-DNT	6.5	0.52	0.26	0.130	0.052	0.026	0.0130
2,4-DNT	6.35	0.51	0.25	0.127	0.051	0.025	0.0127
2-Nitrotoluene	25	2.00	1.00	0.500	0.200	0.100	0.0500
4-Nitrotoluene	75	6.00	3.00	1.500	0.600	0.300	0.1500
3-Nitrotoluene	25	2.00	1.00	0.500	0.200	0.100	0.0500

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This record serves to document training for this OP revision. The employee was given the opportunity to ask any questions on the presented material. Completion of this training constitutes qualification to perform this procedure. Backup documentation, such as performance test result scores, data, or ancillary checklists *IS / IS NOT (trainer circle)* required for the training file.

Trainer* Signature and Title/Date
(*authorized agent of Unit Leader/Section Mgr)

I have read and understand this in-house OP, and received the training summarized above. All questions concerning the procedure have been adequately addressed. I agree to follow the procedure as written, unless superseded by written, project-specific modification.

Date	Printed Name	Signature	Employee No.	Dept. No.

LC-8330.1-0701

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Approvals, Lionville Laboratory Incorporated:

QA Manager — Carol Schenkel 8/24/01
Signature/Printed /Date

Technical Manager — Joseph M. Mecum 8/24/01
Signature/Printed /Date

Technical Director/Corporate Officer — J. Michael Taylor 8/24/01
Signature/Printed /Date

Historical File:

Reasons for Change:

No revisions have occurred other than a name change to Lionville Laboratory Incorporated (LvLI), headers and footers to reflect the name change, and inclusion of updated references to Operating Procedures.

Accelerated Solvent Extraction (ASE)

Reference Method No.: **EPA # 3545 (Pressurized Fluid Extraction)**

Reference: SW-846, Test Methods for Evaluating Solid Waste: Physical/Chemical Methods, EPA SW-846, Update III, 1997.

Alpha Analytical Labs
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Copy No. _____

Prepared by:

Name: Kristin Fleming Position: Organic Prep Supervisor

Signature: Kristin Fleming Date: 7/30/04

Authorized by:

Name: James Todaro Position: Laboratory Director

Signature: James Todaro Date: 7/30/04

ISSUE AMENDMENTS

Changes since last issue:

Section 2.0: Changed typical amount of sample to be 15 grams.
Section 7.1: Section was divided to account for 2 types of Extraction units.
Section 7.2: Section was divided to account for 2 types of Filter Disks.
Section 7.7: Added Teflon Spatulas.
Section 7.8: Changed beaker sizes.
Section 7.12: Edited the Glass wool specifications.
Section 7.13: Added Microdispenser.
Section 7.15.2: Added that the Concentrator Tube is calibrated.
Section 7.20: Edited the Silica Gel Cartridge specifications.
Section 7.22: Added TurboVap.
Section 7.23: Added Zymark Tubes.
Section 8.1: Eliminated references to Organic-free water.
Section 8.2: Edited baking temperature for Na_2SO_4
Section 8.3: Edited Silica Gel mesh size.
Section 8.4: Added Ottawa Sand.
Section 9.1.2: Clarified the homogenization of samples. Changed typical amount of sample to be 15 grams.
Section 9.2.2 and 9.2.3: Edited the sequence of adding the sodium sulfate to top off the extraction cell.
Section 9.3.2: Modified to state that all samples are filtered through Na_2SO_3. Also clarified NOTE.
Section 9.3.6: Split this section into two parts All Extracts and EPH extracts.
Section 9.5.4: Added the Slurry Method of cleanup.
Section 9.6: Added EPH Fractionation procedure.
Section 10.2.3: Modified to account for the analysis of a LCSD.
Table 1: Added Silica Gel cleanup for CT-ETPH analysis; separated out 8081, 8082 and 8082 low level.
Table 2: Modified entire Table. Added Footnote regarding target Aroclors.

Accelerated Solvent Extraction (ASE)

Reference Method No.: **EPA # 3545 (Pressurized Fluid Extraction)**

Reference: SW-846, Test Methods for Evaluating Solid Waste: Physical/Chemical Methods, EPA SW-846, Update III, 1997.

1. Scope and Application

Matrices: This method is applicable to solid and soil samples.

Definitions: See Alpha Laboratories Quality Manual Appendix A

Method 3545 is a procedure for extracting water insoluble or slightly water soluble semivolatile organic compounds from soils, clays, sediments, sludges, and waste solids. The method uses elevated temperature (100ºC) and pressure (1500-2000psi) to extract analytes from the solid sample matrix.

This method is applicable to the extraction of semivolatile organic compounds, organophosphorus pesticides, organochlorine pesticides, and PCBs, which may then be analyzed by a variety of chromatographic procedures.

If necessary, soil/sediment samples may be air-dried and ground to a fine powder prior to extraction. Soil/sediment samples are mixed with anhydrous sodium sulfate to form a free-flowing solid. The amount of sample typically prepared is 10g.

The data report packages present the documentation of any method modification related to the samples tested. Depending upon the nature of the modification and the extent of intended use, the laboratory may be required to demonstrate that the modifications will produce equivalent results for the matrix. Approval of all method modifications is by one of the following laboratory personnel before performing the modification: Area Supervisor, Laboratory Services Manager, Laboratory Director, or Quality Assurance Officer.

This method is restricted to use by or under the supervision of trained analysts. Each analyst must demonstrate the ability to generate acceptable results with this method by performing an initial demonstration of capability, analyzing a proficiency test sample and completing the record of training.

After initial demonstration, ongoing demonstration is based on acceptable laboratory performance of at least a quarterly laboratory control sample or acceptable performance from an annual proficiency test sample. A major modification to this procedure requires demonstration of performance. The identification of major method modification requiring performance demonstration is directed by the QA Officer and Laboratory Director on a case-by-case basis.

2. Summary of Method

Weighed samples, typically 15 grams, are prepared for extraction by mixing the sample with anhydrous sodium sulfate until the sample is free-flowing. The sample is then loaded into the extraction cell for extraction on the Accelerated Solvent Extraction (ASE) equipment.

The ASE unit is programmed to load each extraction cell containing the sample into the heated oven area. The cell is heated to the extraction temperature, pressurized with the extraction solvent (typically methylene chloride), and extracted for 5 minutes. The solvent is flushed into the extract collection vial, and all lines are rinsed with solvent. The extract is allowed to cool prior to proceeding with additional extract preparation steps.

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Any water is removed from the sample extract by filtering through a powder funnel containing approximately 20g of anhydrous sodium sulfate. The extract is then concentrated and, as needed, exchanged into a solvent compatible with the cleanup or determinative step being employed. The various cleanup methods used are described in Section 9.5 and summarized in Table 1.

2.1 Method Modifications from Reference

None.

3. Detection Limits

The laboratory follows the procedure found in 40CFR Part 136 to determine the MDLs for the various determinative methods on an annual basis. Details on MDL levels and frequency are in the SOPs for the determinative methods. The method detection limits determined by the laboratory are on file for review.

4. Interferences

4.1 The most common cause of contamination is from improperly cleaned glassware and lab supplies. All glassware and re-useable extraction equipment (i.e. ASE cell, spatulas) must be scrupulously cleaned, following the cleaning SOP.

4.2 Impurities in solvents and reagents may also yield artifacts and/or interferences that may compromise the results of sample analysis. All of these materials must be demonstrated to free from interferences under the conditions of extract preparation and analysis by preparing method blanks with each extraction batch. The same solvents and reagents are used for the method blank and the associated samples.

4.3 Phthalate esters contaminate many types of products used in the laboratory. Plastic materials must not contact the samples or extracts, as phthalates could be easily leached from the plastic. The exception is in the use of various pre-packed reagent cartridges (Florisil, Silica gel) used in the extract cleanup steps. Each new lot of cartridges is checked for contamination, and is monitored on an on-going basis through the analysis of method blanks.

4.4 Additional specific interference or contamination concerns are addressed in the various analytical SOPs.

5. Safety

The toxicity or carcinogenicity of each reagent and standard used in this method is not fully established; however, each chemical compound should be treated as a potential health hazard. From this viewpoint, exposure to these chemicals must be reduced to the lowest possible level by whatever means available. A reference file of material data handling sheets is available to all personnel involved in the chemical analysis. Additional references to laboratory safety are available in the Chemical Hygiene Plan.

All personnel handling environmental samples known to contain or to have been in contact with municipal waste must follow safety practices for handling known disease causative agents.

5.1 Lab coats, safety glasses, and gloves must be worn when handling samples, extracts, standards or solvents and when washing glassware.

5.2 All extract concentration steps must be performed in the extraction hoods. All solvent and extract transfers must also be handled in the hood.

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5.3 All expired stock standards, working standards, and spent sample extracts must be placed into the waste bucket in the lab, for future disposal by the Hazardous Waste Manager. The container must be properly labeled with hazard warning labels indicating the container contents.

5.4 Bottles containing flammable solvents must be stored in the flammables cabinet or in the vented cabinets found under the hoods

5.5 All waste solvents must be transferred to the satellite waste storage containers located in the extraction lab. Separate containers are provided for chlorinated and non-chlorinated solvents and must be used accordingly. Under no circumstances are solvents to be poured down the sink drains.

5.6 Inspect all glassware prior to use. Do not use any glassware that is chipped, cracked or etched if it could present a safety hazard. Damaged glassware is put aside for repair, otherwise discard the piece. A number is etched onto each KD concentrator tube to keep track of calibration (Refer to SOP/08-04, KD Tube Calibration).

5.7 The use of organic solvents, elevated temperatures, and high pressure in this method present additional potential safety concerns in the laboratory. Common sense laboratory practices can be employed to minimize these concerns. However, the following sections describe additional steps that should be taken.

5.7.1 Extraction cells in the oven are hot enough to burn unprotected skin. Allow the cells to cool before removing them from the oven or use appropriate protective equipment such as insulated gloves or tongs.

5.7.2 The instrument may contain flammable vapor sensors and should be operated with all covers in place and doors closed to ensure proper operation of the sensors.

6. Sample Collection, Preservation, and Handling

6.1 Sample Collection and Preservation

Sample collection and preservation requirements are described in the various analytical method SOPs.

6.2 Sample Handling

All soil samples are stored, refrigerated, in the Custody Sample Bank. Samples are taken by the analyst immediately prior to sample extraction. The analyst must take custody of the samples by signing them out utilizing the LIMS.

All samples must be fully homogenized prior to taking the sample aliquot, as described in Section 9.1. After the sample aliquot is removed, the samples are returned to the Sample Bank and placed in the sample return refrigerator. Custody of the samples is transferred back by signing them back in utilizing the LIMS.

After the extraction is performed, the sample extract is stored in a stoppered KD tube before being transferred to a crimp-top or screw-cap vial for analysis and long term storage.

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7. Equipment and Supplies

7.1 Dionex Accelerated Solvent Extractors

7.1.1 Dionex Accelerated Solvent Extractor 200: Pressurized fluid extraction device with 33mL extraction cells. Cells are made of stainless steel, capable of withstanding the pressure requirements (2000+ psi) necessary for this procedure.

7.1.2 Dionex Accelerated Solvent Extractor 300: Pressurized fluid extraction device with 100mL extraction cells. Cells are made of stainless steel, capable of withstanding the pressure requirements (2000+ psi) necessary for this procedure.

7.2 Vials for Collection of Extracts: 60mL, pre-cleaned, open-top screw-cap with PTFE-lined silicone septum. Purchased certified from commercial vendor.

7.3 Filter Disks

7.3.1 Filter Disks for ASE 200: 1.98cm, Type D28 (Dionex 049458)

7.3.2 Filter Disks for ASE 300: 30mm Type D28 (Dionex 056780)

7.4 Cell Cap Sealing Disk: Dionex 49454, or equivalent.

7.5 Mortar and Pestle: Capable of reducing particle size to < 1mm.

7.6 Analytical Balance: Capable of weighing to 0.1g.

7.7 Spatulas: Stainless steel and Teflon

7.8 Beakers: 250mL, 400mL

7.9 Disposable Borosilicate Glass Transfer Pipets.

7.10 Syringes: 100, 250, 500, and 1000µL.

7.11 Powder Funnels.

7.12 Glass wool: SUPELCO, silane-treated

7.13 Microdispenser: 250µL, Teflon tip with disposable tube

7.14 Water Bath: Heated, with concentric ring cover, with variable temperature control.

7.15 Kuderna-Danish (KD) Apparatus:

7.15.1 Evaporation Flask: 500mL KD flask.

7.15.2 Concentrator Tube: 25mL, graduated and calibrated

7.15.3 3-Ball Macro Snyder Column.

7.15.4 Micro Snyder Column.

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7.15.5 Plastic clips.

7.16 Boiling Chips: Solvent extracted, approximately 10/40 mesh (silicon carbide, or equivalent).

7.17 Graduated Cylinder: 25 and 50mL.

7.18 Solid Phase Extraction (SPE) Manifold: Visiprep DL SPE vacuum manifold (Supelco Cat # 5-7044), or equivalent.

7.19 Florisil Cartridges: Supelclean LC-Florisil, 1 gram (Supelco Cat #57057), or equivalent.

7.20 Silica Gel (Fractionation) Cartridges: Teflon Inert II, 5 grams/20mL (Burdick & Jackson).

7.21 N-EVAP: Organomation; utilized for micro blowdown.

7.22 Turbo Vap II: Auto-concentrator, Caliper Life Sciences.

7.23 Zymark Tubes: 50mL or 200mL, calibrated

8. Standards and Reagents

Pesticide or reagent grade chemicals are used in all tests. All reagents conform to the specifications of the Committee on Analytical Reagents of the American Chemical Society, where such specifications are available. Other grades may be used, provided it is first ascertained that the reagent is of sufficiently high purity to permit its use without lessening the accuracy of the determination.

8.1 Reagent Water: All references to water in this method refer to reagent water from Alpha's RO water treatment system.

8.2 Sodium Sulfate (Na_2SO_4): Granular anhydrous; purified by baking at 400ºC for 4 hours in a shallow tray. Store in closed glass containers. All references to sodium sulfate in this method refer to this prepared reagent.

8.3 Silica Gel: 70 - 230 mesh, chromatography grade.

8.4 Ottawa Sand: 20 – 30 mesh, baked at 400°C for 4 hours.

8.5 Methylene Chloride: Pesticide quality or equivalent.

8.6 Hexane: Pesticide quality or equivalent.

8.7 Acetone: Pesticide quality or equivalent.

8.8 Sulfuric Acid: Concentrated.

8.9 Nitrogen Gas: Reagent grade, used to purge and pressurize the extraction cell and as the blow-down gas in the Turbovap II auto-concentrator units and the N-EVAP.

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8.10 Spiking Solutions: The various surrogate and LCS/MS spiking solutions used in the extraction steps are listed in Table 2. The preparation of these solutions is described in the analytical SOPs.

9. Procedure

All extraction information is recorded by the analyst performing the work in the appropriate extraction logbook. This is done at the time that the work is performed. In addition to recording the extraction and concentration information, the analyst must note any observations, deviations from the procedure, or difficulties encountered with the samples in the comment section of the logbook. All notations in the extraction logbooks must be legible, and all corrections must be done using a single-line cross-out, initialed by the analyst performing the correction.

9.1 Sample Preparation

9.1.1 Before starting the extraction process, each soil or sediment sample should be visually inspected. If a sample contains a significant amount of free water, the analyst must contact login or the project manager to determine if the water is to be considered part of the sample. If the water is not to be homogenized with the solid material, decant and discard the water layer. Record this in the extraction logbook.

Any artifacts (rocks, leaves, sticks, or similar materials) are not typically considered part of the soil sample and should not be included. If necessary, transfer these artifacts to another container prior to homogenizing the sample. Note the presence of sample artifacts in the extraction logbook.

9.1.2 Homogenize the sample well by mixing the entire contents of the sample container. In instances where the sample container is filled to the top and packed in tightly, the entire sample contents are emptied into a larger glass container (400mL beaker) and homogenized. If this is difficult due to sample matrix, describe the non-homogeneity in the extraction logbook. Weigh out the appropriate amount of sample, typically 15.0 grams, into a 300mL beaker. Add approximately 15g of anhydrous sodium sulfate to the beaker and mix with a spatula until a free flowing powder is obtained. For samples that contain higher amounts of water or organic matter, larger amounts of sodium sulfate may be required. Certain samples may require grinding with a mortar and pestle to achieve the free flowing consistency.

9.1.3 Gummy, fibrous, or oily materials, soils with unusually high moisture content, or unusual solid materials such as concrete should not be extracted using this method. Soxhlet or sonication should be used instead.

9.2 Sample Extraction

9.2.1 The analyst must demonstrate that all parts of the equipment in contact with the sample and reagents are interference-free. This is accomplished through the analysis of a solid matrix (Na_2SO_4) method blank. A method blank is extracted with each batch of 20 or less samples.

9.2.2 The samples are transferred to the ASE extraction cells as follows. Screw an endcap onto an extraction cell body. Label the cell with the sample I.D. Insert a cellulose filter using the filter insertion tool. Pour the sample into the tube, taking care that no sample is spilled and that the threads do not become clogged with sample or sodium sulfate.

9.2.3 Add the appropriate volume of surrogate and spike solution(s) listed in Table 2 to the samples and QC samples. Top off the extraction cell with sodium sulfate, filling to within 5 – 10 mm of the top. Screw an endcap onto the extraction cell body. Grasp

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both endcaps, and twist firmly to seal the extraction cell. Gently wiggle the caps to make sure that they have sealed well. Do not over-tighten.

9.2.4 Place the extraction cell into the upper tray of the ASE unit. Place an extract collection vial (Section 7.2), labeled with the sample I.D., in the corresponding position on the lower tray of the ASE.

9.2.5 Typical ASE operating conditions:

Oven temperature:	100ºC
Pressure:	1700psi
Static time:	5 minutes (after 5 min. pre-heat equilibration)
Flush volume:	60% of the cell volume
Nitrogen purge:	75sec at 150psi
Static cycles:	1

The same program is used for the entire extraction batch.

9.2.6 Start the ASE by pressing the "Start" button on the front panel. The ASE will now proceed to automatically extract the samples, performing a rinse cycle between each sample. Allow the extracts to cool after the extractions are complete. The analyst should examine the solvent volume of in each collection vial. If the volumes are low or inconsistent a problem with the ASE or samples may be indicated.

9.2.7 The extract is now ready for concentration, cleanup, or analysis, depending on the extent of interferrants and the determinative method to be employed. Refer to Section 9.5 for guidance on selecting appropriate cleanup methods. Excess water present in extracts is removed by filtering the extract through a bed of anhydrous sodium sulfate. Certain cleanup and/or determinative methods may require a solvent exchange prior to cleanup and/or sample analysis.

9.3 Sample Concentration

9.3.1 Assemble the Kuderna-Danish (KD) apparatus (Section 7.14) by attaching a 25mL KD tube to a 500mL KD flask. Add 1 - 2 boiling chips to the apparatus and label the KD flask with the sample I.D. Add 10mL DCM to the assembled apparatus to check for leaks or cracks prior to transferring the sample (Section 9.3.2).

9.3.2 Dry the extract by passing it through a powder funnel containing approximately 20 grams of sodium sulfate. Collect the filtrate in the KD flask. Rinse the ASE collection vial with approximately 10mL of methylene chloride two times, pouring the rinseate into the funnel. Using a squirt bottle containing methylene chloride, gently spray the sodium sulfate with approximately 20mL of solvent to complete the quantitative transfer.

NOTE: All extracts that are exchanged into Hexane (Table 1) are pretreated with ¼ mL extract volume of Hexane (i.e. if the soil extract is 40mL, add 10mL Hexane prior to concentration).

9.3.3 Attach a three-ball Snyder column to the top of the flask. Place the KD apparatus on a hot water bath (heated to approximately 80°C) so that the concentrator tube is partially immersed in the hot water, and so that the entire lower rounded surface of the flask is bathed in hot water vapor. Adjust the position of the apparatus as required to complete the concentration in 10 to 20 minutes. At the proper rate of distillation, the balls in the column will actively chatter, but the chambers will not flood with solvent.

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9.3.4 If a solvent exchange is required (see Table1), add 20 to 25mL of the exchange solvent to the top of the Snyder column while the concentrator is still on the water bath. Continue with the concentration until the extract volume is reduced to below 10mL.

9.3.5 Remove the KD apparatus from the water bath. Rinse the flask and its lower ground glass joint with 1 to 2 mL of acetone to cool the extract and remove any moisture from the outside of the glassware.

9.3.6 All Extracts (except for EPH Extracts, proceed to Section 9.3.6.1): Place the KD apparatus on the N-EVAP. The N-EVAP is set at 30 °C with the nitrogen flow at 10. Samples remain on N-EVAP until they are reduced to 1mL. The inside of the KD tube wall is rinsed with 5mL of appropriate solvent, and then reduced back down to 1mL.

9.3.6.1 EPH Extracts: Attach a micro-Snyder column. Place the KD apparatus in the hot water bath so that the concentrator tube is partially immersed in the hot water. Closely watch the concentration, adjusting the height of the apparatus as needed to complete the concentration in 5 to 10 minutes.

When the apparent volume reaches 1mL, remove the KD apparatus from the bath. Rinse the lower half of the KD tube with a small amount of acetone to cool the extract.

9.3.7 The extract is now ready for sample cleanup (if required) or for transfer to the instrument lab(s) for analysis.

9.4 Alternate Concentration Technique

An alternative concentration technique is available, and may be used if the extract volume is sufficiently low and the extract is not overly dark or viscous. The equipment used is the Turbovap II, which is a self-contained water bath with nitrogen blow-down. It is equipped with sensors to allow for automatic shutdown when the extract volume goes below 1mL.

9.4.1 Quantitatively transfer the extract to the appropriate size Zymark concentration tube. The tube is labeled with the sample I.D. Place the tube into the TurboVap II concentration unit. The water bath is set to 38°C, and the nitrogen pressure is set to 13 psi. Start the nitrogen blow-down by pressing the button on the front panel of the unit.

9.4.2 When the concentration is complete, the nitrogen stream will be automatically shut off. The light on the front panel will flash, and the instrument will beep. Remove the tube from the TurboVap II concentrator, and quantitatively transfer the extract into a labeled screw-cap or crimp-top vial.

9.4.3 The extract is now ready for sample cleanup (if required) or for transfer to instrument lab(s) for analysis.

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9.5 Extract Cleanup Procedures

Several different cleanup procedures are used, depending upon the compounds to be determined and the sample matrix. The typical cleanups are described in the sections below, and the applicability to the determinative methods is listed in Table 1. All extract cleanup procedures must be documented in the extraction logbook. If a cleanup procedure not described in this SOP is used, describe the cleanup performed in detail on a narrative sheet for inclusion in the client report. Alternative cleanups must be approved by the Section Supervisor or Organics Manager.

9.5.1 Florisil

Florisil cleanup is used for all pesticide and pesticide/PCB extracts, and occasionally for PAH only 8270 extracts. Florisil cartridges are purchased pre-packed from commercial vendors.

9.5.1.1 Place extract collection vials in the SPE vacuum manifold. Screw florisil cartridge onto manifold cover. Start vacuum pump, setting the vacuum to between 15 and 20 psi.

9.5.1.2 Add 4mL of hexane to florisil cartridge to be used to pre-wet the cartridge. Slowly twist cartridge counter-clockwise to open, until hexane begins to drain. Continue to drain the hexane until the level is just above the top of the florisil – do not allow the florisil to go dry. Twist the cartridge clockwise to close and stop the draining. At the correct pressure, the rinse will be complete in approximately 2 minutes.

9.5.1.3 Using a disposable glass pipet or syringe, add the appropriate aliquot of the extract onto the florisil. Twist the cartridge to open, and allow the extract to be drawn onto the head of the cartridge. Stop when the extract level is just at the top of the florisil. Allow the extract to sit on the cartridge for 1 minute.

9.5.1.4 Measure 20mL of the elution solvent (See Table 1 for appropriate solvent) into a 25mL graduated cylinder. Slowly pour, in stages, onto the florisil, under vacuum, to elute the sample extract. Carefully watch the cartridge to ensure that it does not go dry during this step. Collect the entire 20mL extract in the collection vial.

9.5.1.5 The cleaned extract may now be re-concentrated, using the techniques listed in Sections 9.3.3 through 9.3.7, and Section 9.4.

9.5.2 Sulfuric Acid Cleanup

Sulfuric acid cleanup is used to remove organic interfering compounds from PCB extracts. Due to the destructive nature of this cleanup, it is only used for PCB extracts, as PCBs are not destroyed by the acid.

9.5.2.1 Typical PCB extract volumes are 5mL or 1mL of hexane. Transfer 5mL of extract into a labeled 22mL screwcap vial. Set the auto-pipetter on the concentrated sulfuric acid bottle to 5mL or 0.5mL. Slowly add the acid to the sample extract in the vial.

9.5.2.2 Cap the KD tube with the ground glass stopper. Vortex the extract for 5 – 10 seconds, and allow the layers to separate. The top layer is the hexane extract.

9.5.2.3 The extract is now ready for transfer to instrument lab for analysis.

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9.5.3 Silica Gel Cleanup

Silica gel cleanup is used to remove interferences from extracts to be analyzed for petroleum hydrocarbons. The silica gel removes many polar compounds such as fatty acids, while allowing the petroleum material to remain in the extract.

9.5.3.1 Dry the extract by passing it through a powder funnel containing approximately 20 grams of sodium sulfate. Collect the filtrate in an Erlenmeyer flask. Add approximately 20 grams of silica gel to the extract. Place the flask on the shaker table, and shake for 20 minutes. The shaking should be vigorous enough to ensure good contact of the silica gel with the extract, but not so vigorous that the extract splashes.

9.5.3.2 Rinse a filter funnel with 25mL of appropriate solvent to ensure quantitative transfer of the sample extract. Filter the extract through sodium sulfate to remove the silica gel and any residual water, and collect in the concentration apparatus.

9.5.4 Slurry Method

This cleanup step may be used to remove interferences from sample extracts to be analyzed for ETPH or TPH-8100 SGC.

9.5.4.1 Following Turbovap concentration (Section 9.4), place the Zymark tubes in a fume hood. Using a clean 250µL microdispenser, add approximately 100µL of Silica Gel to each 1mL sample and QC sample, ensuring that the majority of the Silica Gel is placed at the bottom of the Zymark tube. Using a 9-inch disposable glass pipet (Section 7.9), mix the extract and Silica Gel thoroughly, ensuring contact between the sorbent material and the extract.

9.6 Fractionation of EPH Sample Extracts

9.6.1 Sample Preparation

9.6.1.1 Using a transfer pipet and clean Hexane, bring all sample extracts to a volume of 1.0mL.

NOTE: If an extract is to be at a final volume greater than 1.0mL, bring the extract to the appropriate final volume with Hexane. Use a 1mL portion of this final volume for Fractionation. Save the remainder of the extract as in Section 9.6.4.4.

9.6.1.2 Rinse a 1mL syringe with Hexane. Add 1mL FRAC surrogate to the extract and replace the cap.

9.6.2 Glassware Preparation

Label two ZYMARK tubes for each sample: one for ALI (aliphatic / Hexane) and one for ARO (aromatic / DCM). Also, if the sample extract is at a final volume >1mL, write this on the ZYMARK tube.

9.6.3 Manifold and FRAC Cartridge Preparation

9.6.3.1 Place one collection tube into each slot on the manifold unit.

9.6.3.2 Place manifold lid onto the manifold unit.

9.6.3.3 Set up one FRAC cartridge for each sample on the manifold lid, making sure that each one is closed hand tight (do not over tighten).

9.6.3.4 Turn on the vacuum pump and adjust the manifold pressure to 20” Hg.

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9.6.3.5 Once the pressure has been adjusted, rinse a graduated cylinder first with Acetone, then DCM.

9.6.3.6 Fill the graduated cyllinder to 15mL with DCM.

9.6.3.7 Open the valve slowly to start the vacuum flow.

9.6.3.8 Add the 15mL DCM to the cartridge. Allow the vacuum to pull the DCM through.

9.6.3.9 Repeat Sections 9.6.3.6 through 9.6.3.8 for each of the 6 cartridges.

9.6.3.10 Turn off the vacuum and release the pressure.

9.6.3.11 Remove the manifold lid and place it on a beaker.

9.6.3.12 Remove the collection tubes one at a time and place the rinsed DCM into a waste container. Place collection tubes back into the same slots in the manifold unit.

9.6.3.13 Replace the manifold lid with the pre-rinsed cartridges back onto the manifold unit.

9.6.3.14 Rinse a graduated cylinder with Acetone, DCM, then Hexane.

9.6.3.15 Fill the graduated cylinder to 40mL with Hexane.

9.6.3.16 Open the valve slowly to start the vacuum flow.

9.6.3.17 Add the 40mL Hexane to the cartridge. Allow the vacuum to pull the Hexane through.

NOTE: Leave an approximate 1mL layer of Hexane in the cartridge to ensure it will not go dry.

9.6.3.18 Repeat Sections 9.6.3.15 through 9.6.3.17 for each of the 6 cartridges.

9.6.3.19 Turn off the vacuum pump and release the pressure.

9.6.3.20 Remove the manifold lid and place it on a beaker, being careful that the remaining Hexane layer does not spill.

9.6.3.21 Remove the collection tubes one at a time and place the rinsed hexane into a waste container. Place collection tube back into the same slots in the manifold unit.

9.6.3.22 Replace the manifold lid with the pre-rinsed cartridges back onto the manifold unit.

9.6.4 Fractionation Procedure

9.6.4.1 Aliphatic Portion

9.6.4.1.1 Using a transfer pipet, draw sample extract from the KD tube and dispense back into the KD tube a few times to ensure that the extract is thoroughly mixed with the FRAC surrogate added in Section 9.6.1.2.

9.6.4.1.2 Remove a 1mL portion of the mixed extract, and dispense onto a pre-rinsed FRAC cartridge. Leave the remaining 1mL portion in the KD tube.

9.6.4.1.3 After all samples have been dispensed onto pre-rinsed cartridges, turn on the vacuum pump and adjust the manifold pressure to 20” Hg.

9.6.4.1.4 Using the 25mL graduated cylinder (Section 9.6.3.5), fill it with Hexane to the predetermined volume.

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9.6.4.1.5 Add a small amount of Hexane into the cartridge with the sample extract, and open the valve to start the vacuum. Add small amounts of Hexane at a time, letting the vacuum draw it through the cartridge.

9.6.4.1.6 Once all of the Hexane has been added from the cylinder, it is important to leave an approximate 1mL layer in the cartridge. ***Do not let the cartridge go dry***.

9.6.4.1.7 Repeat Sections 9.6.4.1.1 – 9.6.4.1.6 for all samples.

9.6.4.1.8 Turn off the vacuum pump and release the pressure.

9.6.4.1.9 Remove the manifold lid and place it on a beaker being careful that the remaining Hexane layer does not spill.

9.6.4.1.10 Remove the collection tubes, one at a time, and pour into the corresponding ZYMARK Tube for Aliphatics. Replace the collection tube into the same slot on the manifold.

9.6.4.1.11 Replace the manifold lid onto the manifold unit.

9.6.4.1.12 Place the Aliphatic ZYMARK tubes into the TurboVap and allow to concentrate to 1mL at a pressure of 7psi and temperature of 35 °C.

9.6.4.2 Aromatic Portion

9.6.4.2.1 Turn on the vacuum pump and adjust the manifold pressure to 20" Hg.

9.6.4.2.2 Rinse a 25mL graduated cylinder with Acetone, then with DCM. Fill with 20mL of DCM.

9.6.4.2.3 Add a small amount of DCM into the cartridge and open the valve to start the vacuum. Add small amounts of DCM at a time, allowing the vacuum to draw the DCM through the cartridge.

9.6.4.2.4 Once all of the DCM has been added from the cylinder, it is important to leave an approximate 1mL layer in the cartridge. ***Do not let the cartridge go dry***.

9.6.4.2.5 Repeat Sections 9.6.4.2.1 – 9.6.4.2.4 for all samples.

9.6.4.2.6 Turn off the vacuum pump and release the pressure.

9.6.4.2.7 Remove the manifold lid and place it on a beaker being careful that the remaining DCM layer does not spill.

9.6.4.2.8 Remove the collection tubes, one at a time, and pour into the corresponding ZYMARK Tube for Aromatics.

9.6.4.2.9 Place the Aromatic ZYMARK tubes into the TurboVap and allow to concentrate to 1mL at a pressure of 7psi and temperature of 35 °C.

9.6.4.3 Cleanup of Manifold Unit

9.6.4.3.1 Remove the spent cartridges from the manifold unit.

9.6.4.3.2 Open all valves. Rinse the inside of the valves with DCM and then with Hexane.

9.6.4.3.3 Rinse all collection tubes with DCM and then with Hexane.

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9.6.4.4 Storage of Remaining Extracts

9.6.4.4.1 Label a 1.5mL screwcap vial with the sample ID. If the sample extract is at a final volume, be sure to also write this on the vial.

9.6.4.4.2 Using a fresh transfer pipet for each sample, transfer the sample extract from the KD tube into the corresponding screwcap vial.

9.6.4.4.3 Place the 1.5mL vial(s) into a Wheaton vial storage box and mapped on the sheet.

9.6.4.4.4 Store sample extracts in the refrigerator at 4±2 °C for a minimum of 40 days.

9.7 Instrument Maintenance

9.7.1 Accelerated Solvent Extractors (ASE)

9.7.1.1 The instrument must be kept clean. The upper and lower tray areas should be wiped clean as needed, to ensure that no sample or sodium sulfate gets into the tray mechanisms. Any spilled solvent should be cleaned up immediately.

9.7.1.2 Check the solvent reservoir daily and fill as needed. Check the waste and rinse vials daily, and empty to solvent waste containers as needed.

9.7.1.3 The extraction cells (and caps) must be cleaned after each use. After the extraction is complete, remove the end-caps. Use the ASE cleaning brush to empty the contents of the extraction cell to waste. Place the cell bodies and caps in beakers containing clean methylene chloride. Place the beakers in a sonicator, and sonicate for 10 minutes, turning the extraction bodies after 5 minutes. Remove extraction cells parts from the beakers and allow to dry under a hood.

9.7.1.4 The extraction cell caps will become worn with use. Visually inspect the external o-rings prior to use – if they appear worn do not use until they are repaired. The internal seals and frits must also be periodically replaced, usually at the same time as the o-rings.

9.7.2 Turbovap II Concentrators

9.7.2.1 Maintain the level of the water bath by adding water daily to fill. Add 4 – 5 drops of Clear Bath weekly to keep water clear. This will extend the life of the extract level sensors in the bath.

9.7.2.2 Keep unit clean. Avoid solvent spills on or around unit. Clean periodically with a damp cloth.

9.7.2.3 Sensor calibration checks should be performed at least annually, or when sensor failures are suspected.

9.7.3 Analytical Balance

9.7.3.1 All balances are calibrated and serviced every six months by an instrument service company. All service records are kept on file.

9.7.3.2 Keep balances clean. Brush of any sample spills immediately. Keep the balance doors closed and the balance turned off when not in use.

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10. Quality Control and Data Assessment

The laboratory maintains records to document the quality of data that is generated. Ongoing data quality checks are compared with established performance criteria to determine if the results of analyses meet the performance characteristics of the method.

10.1 Demonstration of Capability

The analyst must make an initial, one-time, demonstration of the ability to generate acceptable accuracy and precision with this method. Each time a method modification is made, the analyst is required to repeat the procedure.

Extraction IDCs are performed in conjunction with the analytical methods. See analytical SOPs for specifics on IDC requirements and acceptance criteria.

10.2 Extraction QC Elements

Each extraction batch contains various QC samples used to ensure the validity of the sample results. The particular QC elements performed for a given extraction batch are determined by the requirements of the determinative method. The purpose and definition of the QC samples performed are listed below. The specific QC requirements of the analytical methods are listed in Table 2.

10.2.1 Surrogates

Surrogates are compounds specified by the analytical method that are added to all samples and QC samples prior to beginning the extraction process. Surrogate recoveries are calculated and serve as a sample specific quantitative check of the extraction. The various spiking solutions are prepared according to the directions found in the analytical SOPs. The required solutions and volumes used are listed in Table 2.

10.2.2 Blank

Blanks, or method blanks, are measured aliquots of clean matrix (typically sodium sulfate for soil extractions) that are treated identically to the associated samples. Surrogates are added, and the blanks are carried through all stages of the sample extraction, concentration, and cleanup procedures. Blanks serve to ensure that no systematic contamination exists. A blank is extracted with each batch or 20 or less samples.

10.2.3 Laboratory Control Sample / Laboratory Control Sample Duplicate (LCS/LCSD)

LCS samples are measured aliquots of clean matrix (typically sodium sulfate for soil extractions) that are spiked with a solution containing known amounts of target compounds, in addition to the surrogate solution. The LCS is carried through all stages of the sample extraction, concentration, and cleanup procedures. LCS samples serve as batch specific quantitative checks of the extraction. An LCS is extracted with each batch of 20 or less samples.

An LCSD is performed in addition to an LCS for all Massachusetts Contingency Plan (MCP) methods, as well as in lieu of the MS/MSD or Duplicate when there is insufficient sample volume available. The required solutions are listed in Table 2.

10.2.4 Duplicate

Duplicates are laboratory selected replicate samples, prepared by taking an additional sample aliquot of a sample. The duplicate is carried through all stages of the sample extraction, concentration, and cleanup procedures. Duplicates serve as a measure of the extraction precision, by comparing the results of the sample and duplicate.

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10.2.5 Matrix Spike/Matrix Spike duplicate (MS/MSD)

MS and MSDs are field samples spiked with a known quantity of the target analyte(s). They are prepared by taking additional sample aliquots, and adding the appropriate amounts of surrogate and spiking solutions. The MS/MSD are carried through all stages of the sample extraction, concentration, and cleanup procedures. MS samples serve as a measure of extraction accuracy, by allowing the comparison of the found amount(s) of target analyte(s) with the spiked amount(s). An MS/MSD set also allows for the calculation of the extraction precision, by comparing the results of the two samples.

11. Method Performance

Method performance data is on file in the laboratory QC department. Comparison of method performance data for the laboratory to the reference method criteria occurs when laboratory in-house acceptance limits are generated. In-house generated data must be within the specifications of the reference method or the analysis is not continued until corrective action is completed.

The performance of this method is evaluated on an on-going basis by the QC criteria listed in the analytical SOPs. Specifically surrogates, blanks, LCSs, MS/MSDs, and duplicates are all used to ensure that the method is producing results of consistently high quality. In addition, Alpha participates in several blind and double blind PE studies annually to demonstrate the ability of this method to produce accurate and reproducible data.

12. Corrective Actions

Holding time exceedence, improper preservation and observed sample headspace are noted on the nonconformance report form.

When analysis of samples indicates possible extraction problems, such as poor surrogate recoveries, poor LCS/MS/MSD recoveries, or suspected contamination in blanks or samples, re-extractions are required. Depending on the particular failure, the re-extraction may be of a specific sample or the entire extraction batch.

The analyst that determines the need for re-extraction must fill out a sample re-extract request form. This form notes the reason for the re-extraction request along with any special requirements, and the date and time that the re-extract is needed. Re-extraction request forms are maintained on file to help track the cause for re-extractions, and to be used as a tool in improving systems to minimize the need for re-extractions.

Depending on the results of the re-extraction, the first, second, or both sets of results may be reported to the client, along with a narrative report detailing the problems encountered and the resolution.

13. Pollution Prevention

See Chemical Hygiene Plan for pollution prevention operations.

14. Waste Management

See Chemical Hygiene Plan for waste handling and disposal.

15. Attachments

Table 1 – Specific Extraction Conditions for Various Determinative Methods

Table 2 – Soil Extraction Guide

Table 3 – ASE Operation Flowchart

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Table 1

Specific Extraction Conditions for Various Determinative Methods

Determinative Method	Extraction Solvent	Exchange Solvent Required	Typical Final Volume	Appropriate Cleanup Technique
8081	1:1 DCM/Acetone	hexane	1 mL	florisil
8082	1:1 DCM/Acetone	hexane	5 mL	Sulfuric acid
8082 Low Level	1:1 DCM/Acetone	hexane	1 mL	Sulfuric acid
8270	1:1 DCM/Acetone	---	1 mL	---
8100	DCM	---	1 mL	---
8100-SGC	DCM	---	1 mL	Silica gel
TPH-DRO	DCM	---	1 mL	---
MA EPH	DCM	hexane	1 mL	Silica gel Fractionation
CT ETPH	DCM	---	1 mL	Silica gel

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Table 2

Soil Extraction Guide

Analytical Method	QC *	Solvent	Surrogate Solution	LCS/LCSD MS/MSD Solution	Container
8270	SB, LCS, MS, MSD	DCM/ACE	1mL ABN	1mL ABN	GLASS
MCP 8270	SB, LCS, LCSD	DCM/ACE	1mL ABN	1mL MCP ABN	GLASS
PAH	SB, LCS, MS, MSD	DCM/ACE	1mL ABN	1mL ABN	GLASS
MCP PAH	SB, LCS, LCSD	DCM/ACE	1mL ABN	1mL MCP ABN	GLASS
PAH-Low	SB, LCS, MS, MSD	DCM/ACE	1mL ABN	1mL ABN	GLASS
MCP PAH-Low	SB, LCS, LCSD	DCM/ACE	1mL ABN	1mL MCP PAH-L	GLASS
PEST	SB, LCS, MS, MSD	DCM/ACE	1mL PEST	1mL PEST	Paper
MCP PEST-LL	SB, LCS, LCSD	DCM/ACE	250µL PEST	250µL PEST	Paper
MCP PEST	SB, LCS, LCSD	DCM/ACE	1mL PEST	1mL PEST	Paper
PEST – LL	SB, LCS, MS, MSD	DCM/ACE	250µL PEST	250µL PEST	Paper
PCB	SB, LCS, MS, MSD	DCM/ACE	1mL PEST	1mL PCB	Paper
PCB - LL	SB, LCS, MS, MSD	DCM/ACE	250µL PEST	250µL PCB	Paper
MCP PCB-LL	SB, LCS, LCSD	DCM/ACE	250µL PEST	250µL PCB	Paper
MCP PCB	SB, LCS, LCSD	DCM/ACE	1mL PEST	1mL PCB	Paper
EPH	SB, LCS, LCSD, Dup	DCM	1mL EPH	1mL EPH	Paper
EPH / PAH-L	SB, LCS, LCSD, Dup	DCM	1mL EPH	1mL EPH	Paper
EPH/TPH	SB, LCS, LCSD, Dup	DCM	1mL EPH	1mL EPH	Paper
PETRO	SB, LCS, Dup	DCM	1mL DRO	1mL ETPH	Paper
ETPH	SB, LCS, MS, Dup	DCM	1mL DRO	1mL ETPH	Paper
TPH-DRO	SB, LCS, Dup	DCM	1mL DRO	1mL ETPH	Paper
Herb 8151	SB, LCS, MS, MSD	HEX/ACE	1mL HERB	1mL HERB	Paper

*** For Projects where target Aroclors are known to be present, a laboratory Duplicate will be performed in lieu of the MSD.**

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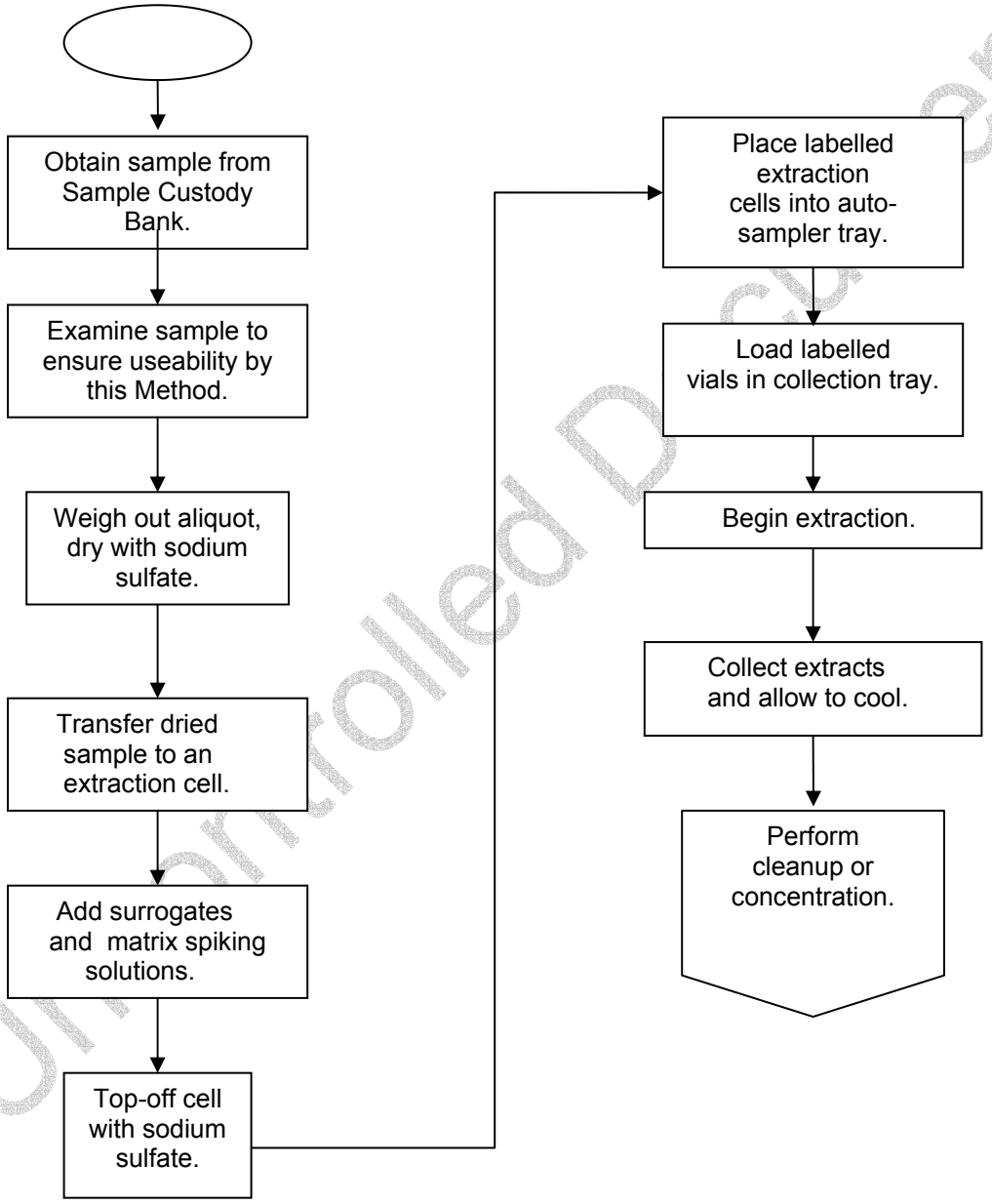
Table 3

ASE Operation Flowchart



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APPENDIX J

PROUCL STATISTICAL ANALYSIS TABLES

IA-1 ProUCL Output

Data File \\Fsmnh01\User1\PROJECTS\03886110\02\ Variable: Aluminum

Raw Statistics	
Number of Valid Samples	12
Number of Unique Samples	10
Minimum	4700
Maximum	10500
Mean	7413.333
Median	6900
Standard Deviation	1680.878
Variance	2825352
Coefficient of Variation	0.226737
Skewness	0.45854

Gamma Statistics	
k hat	21.48796
k star (bias corrected)	16.17153
Theta hat	344.9994
Theta star	458.4189
nu hat	515.7111
nu star	388.1167
Approx.Chi Square Value (.05)	343.4451
Adjusted Level of Significance	0.02896
Adjusted Chi Square Value	337.0289

Log-transformed Statistics	
Minimum of log data	8.455318
Maximum of log data	9.259131
Mean of log data	8.887586
Standard Deviation of log data	0.226668
Variance of log data	0.051378

RECOMMENDATION

Data are normal (0.05)

Use Student's-t UCL

Normal Distribution Test	
Shapiro-Wilk Test Statisitic	0.944991
Shapiro-Wilk 5% Critical Value	0.859
Data are normal at 5% significance level	

95% UCL (Assuming Normal Distribution)	
Student's-t UCL	8284.746

Gamma Distribution Test	
A-D Test Statistic	0.347021
A-D 5% Critical Value	0.731749
K-S Test Statistic	0.199739
K-S 5% Critical Value	0.245188
Data follow gamma distribution	
at 5% significance level	

95% UCLs (Assuming Gamma Distribution)	
Approximate Gamma UCL	8377.577
Adjusted Gamma UCL	8537.067

Lognormal Distribution Test	
Shapiro-Wilk Test Statisitic	0.955328
Shapiro-Wilk 5% Critical Value	0.859
Data are lognormal at 5% significance level	

95% UCLs (Assuming Lognormal Distribution)	
95% H-UCL	8439.306
95% Chebyshev (MVUE) UCL	9539.515
97.5% Chebyshev (MVUE) UCL	10459.33
99% Chebyshev (MVUE) UCL	12266.14

95% Non-parametric UCLs	
CLT UCL	8211.462
Adj-CLT UCL (Adjusted for skewness)	8280.092
Mod-t UCL (Adjusted for skewness)	8295.451
Jackknife UCL	8284.746
Standard Bootstrap UCL	8149.475
Bootstrap-t UCL	8397.695
Hall's Bootstrap UCL	8449.681
Percentile Bootstrap UCL	8213.333
BCA Bootstrap UCL	8280
95% Chebyshev (Mean, Sd) UCL	9528.392
97.5% Chebyshev (Mean, Sd) UCL	10443.58
99% Chebyshev (Mean, Sd) UCL	12241.29

IA-1 ProUCL Output

Data File \\Fsmnh01\User1\PROJECTS\03886110\020 Variable: Arsenic

Raw Statistics	
Number of Valid Samples	12
Number of Unique Samples	12
Minimum	9.1
Maximum	46
Mean	27.15
Median	27.65
Standard Deviation	9.892008
Variance	97.85182
Coefficient of Variation	0.364347
Skewness	0.069033

Gamma Statistics	
k hat	6.979153
k star (bias corrected)	5.28992
Theta hat	3.890157
Theta star	5.132402
nu hat	167.4997
nu star	126.9581
Approx.Chi Square Value (.05)	101.9281
Adjusted Level of Significance	0.02896
Adjusted Chi Square Value	98.50899

Log-transformed Statistics	
Minimum of log data	2.208274
Maximum of log data	3.828641
Mean of log data	3.228028
Standard Deviation of log data	0.426913
Variance of log data	0.182255

RECOMMENDATION

Data are normal (0.05)

Use Student's-t UCL

Normal Distribution Test	
Shapiro-Wilk Test Statisitic	0.980413
Shapiro-Wilk 5% Critical Value	0.859
Data are normal at 5% significance level	

95% UCL (Assuming Normal Distribution)	
Student's-t UCL	32.27829

Gamma Distribution Test	
A-D Test Statistic	0.29163
A-D 5% Critical Value	0.731321
K-S Test Statistic	0.143951
K-S 5% Critical Value	0.245712
Data follow gamma distribution	
at 5% significance level	

95% UCLs (Assuming Gamma Distribution)	
Approximate Gamma UCL	33.81709
Adjusted Gamma UCL	34.99084

Lognormal Distribution Test	
Shapiro-Wilk Test Statisitic	0.919582
Shapiro-Wilk 5% Critical Value	0.859
Data are lognormal at 5% significance level	

95% UCLs (Assuming Lognormal Distribution)	
95% H-UCL	36.00729
95% Chebyshev (MVUE) UCL	42.40149
97.5% Chebyshev (MVUE) UCL	48.88685
99% Chebyshev (MVUE) UCL	61.62608

95% Non-parametric UCLs	
CLT UCL	31.84701
Adj-CLT UCL (Adjusted for skewness)	31.90781
Mod-t UCL (Adjusted for skewness)	32.28777
Jackknife UCL	32.27829
Standard Bootstrap UCL	31.67527
Bootstrap-t UCL	32.59982
Hall's Bootstrap UCL	32.54491
Percentile Bootstrap UCL	31.675
BCA Bootstrap UCL	31.5
95% Chebyshev (Mean, Sd) UCL	39.59717
97.5% Chebyshev (Mean, Sd) UCL	44.98307
99% Chebyshev (Mean, Sd) UCL	55.56263

IA-1 ProUCL Output

Data File \\Fsmnh01\User1\PROJECTS\03886110\02\ Variable: Iron

Raw Statistics	
Number of Valid Samples	12
Number of Unique Samples	10
Minimum	6300
Maximum	14500
Mean	10700
Median	11250
Standard Deviation	2165.011
Variance	4687273
Coefficient of Variation	0.202337
Skewness	-0.48704

Gamma Statistics	
k hat	23.90377
k star (bias corrected)	17.98339
Theta hat	447.6281
Theta star	594.9936
nu hat	573.6906
nu star	431.6013
Approx.Chi Square Value (.05)	384.4287
Adjusted Level of Significance	0.02896
Adjusted Chi Square Value	377.6304

Log-transformed Statistics	
Minimum of log data	8.748305
Maximum of log data	9.581904
Mean of log data	9.256936
Standard Deviation of log data	0.22161
Variance of log data	0.049111

RECOMMENDATION

Data are normal (0.05)

Use Student's-t UCL

Normal Distribution Test	
Shapiro-Wilk Test Statisitic	0.944699
Shapiro-Wilk 5% Critical Value	0.859
Data are normal at 5% significance level	

95% UCL (Assuming Normal Distribution)	
Student's-t UCL	11822.4

Gamma Distribution Test	
A-D Test Statistic	0.511464
A-D 5% Critical Value	0.73157
K-S Test Statistic	0.178043
K-S 5% Critical Value	0.245167
Data follow gamma distribution	
at 5% significance level	

95% UCLs (Assuming Gamma Distribution)	
Approximate Gamma UCL	12012.98
Adjusted Gamma UCL	12229.24

Lognormal Distribution Test	
Shapiro-Wilk Test Statisitic	0.90462
Shapiro-Wilk 5% Critical Value	0.859
Data are lognormal at 5% significance level	

95% UCLs (Assuming Lognormal Distribution)	
95% H-UCL	12158.21
95% Chebyshev (MVUE) UCL	13718.19
97.5% Chebyshev (MVUE) UCL	15017.64
99% Chebyshev (MVUE) UCL	17570.17

95% Non-parametric UCLs	
CLT UCL	11728.01
Adj-CLT UCL (Adjusted for skewness)	11634.12
Mod-t UCL (Adjusted for skewness)	11807.76
Jackknife UCL	11822.4
Standard Bootstrap UCL	11702.47
Bootstrap-t UCL	11685.64
Hall's Bootstrap UCL	11637.55
Percentile Bootstrap UCL	11675
BCA Bootstrap UCL	11591.67
95% Chebyshev (Mean, Sd) UCL	13424.25
97.5% Chebyshev (Mean, Sd) UCL	14603.03
99% Chebyshev (Mean, Sd) UCL	16918.52

IA-1 ProUCL Output

Data File \\Fsmnh01\User1\PROJECTS\03886110\02\ Variable: Manganese

Raw Statistics	
Number of Valid Samples	12
Number of Unique Samples	12
Minimum	120
Maximum	330
Mean	219.5
Median	212.5
Standard Deviation	61.16074
Variance	3740.636
Coefficient of Variation	0.278637
Skewness	0.186124

Gamma Statistics	
k hat	13.41832
k star (bias corrected)	10.1193
Theta hat	16.35823
Theta star	21.69123
nu hat	322.0398
nu star	242.8632
Approx.Chi Square Value (.05)	207.7769
Adjusted Level of Significance	0.02896
Adjusted Chi Square Value	202.8241

Log-transformed Statistics	
Minimum of log data	4.787492
Maximum of log data	5.799093
Mean of log data	5.353627
Standard Deviation of log data	0.2928
Variance of log data	0.085732

RECOMMENDATION

Data are normal (0.05)

Use Student's-t UCL

Normal Distribution Test	
Shapiro-Wilk Test Statisitic	0.971617
Shapiro-Wilk 5% Critical Value	0.859
Data are normal at 5% significance level	

95% UCL (Assuming Normal Distribution)	
Student's-t UCL	251.2074

Gamma Distribution Test	
A-D Test Statistic	0.231865
A-D 5% Critical Value	0.730833
K-S Test Statistic	0.136042
K-S 5% Critical Value	0.245318
Data follow gamma distribution	
at 5% significance level	

95% UCLs (Assuming Gamma Distribution)	
Approximate Gamma UCL	256.5659
Adjusted Gamma UCL	262.831

Lognormal Distribution Test	
Shapiro-Wilk Test Statisitic	0.961169
Shapiro-Wilk 5% Critical Value	0.859
Data are lognormal at 5% significance level	

95% UCLs (Assuming Lognormal Distribution)	
95% H-UCL	261.3949
95% Chebyshev (MVUE) UCL	301.5139
97.5% Chebyshev (MVUE) UCL	336.8635
99% Chebyshev (MVUE) UCL	406.3009

95% Non-parametric UCLs	
CLT UCL	248.5409
Adj-CLT UCL (Adjusted for skewness)	249.5545
Mod-t UCL (Adjusted for skewness)	251.3655
Jackknife UCL	251.2074
Standard Bootstrap UCL	247.6834
Bootstrap-t UCL	253.8857
Hall's Bootstrap UCL	252.778
Percentile Bootstrap UCL	247.0833
BCA Bootstrap UCL	248.0833
95% Chebyshev (Mean, Sd) UCL	296.4589
97.5% Chebyshev (Mean, Sd) UCL	329.7591
99% Chebyshev (Mean, Sd) UCL	395.1709

IA-1 ProUCL Output

Data File \\Fsmnh01\User1\PROJECTS\03886110\02\ Variable: Nickel

Raw Statistics	
Number of Valid Samples	12
Number of Unique Samples	11
Minimum	6.9
Maximum	27
Mean	19.76667
Median	21.75
Standard Deviation	6.327621
Variance	40.03879
Coefficient of Variation	0.320116
Skewness	-0.70222

Gamma Statistics	
k hat	8.188322
k star (bias corrected)	6.196797
Theta hat	2.414007
Theta star	3.18982
nu hat	196.5197
nu star	148.7231
Approx.Chi Square Value (.05)	121.5312
Adjusted Level of Significance	0.02896
Adjusted Chi Square Value	117.7826

Log-transformed Statistics	
Minimum of log data	1.931521
Maximum of log data	3.295837
Mean of log data	2.921693
Standard Deviation of log data	0.399834
Variance of log data	0.159867

RECOMMENDATION

Data are normal (0.05)

Use Student's-t UCL

Normal Distribution Test	
Shapiro-Wilk Test Statisitic	0.914496
Shapiro-Wilk 5% Critical Value	0.859
Data are normal at 5% significance level	

95% UCL (Assuming Normal Distribution)	
Student's-t UCL	23.04708

Gamma Distribution Test	
A-D Test Statistic	0.598295
A-D 5% Critical Value	0.730912
K-S Test Statistic	0.223887
K-S 5% Critical Value	0.245579
Data follow gamma distribution	
at 5% significance level	

95% UCLs (Assuming Gamma Distribution)	
Approximate Gamma UCL	24.18934
Adjusted Gamma UCL	24.95921

Lognormal Distribution Test	
Shapiro-Wilk Test Statisitic	0.841851
Shapiro-Wilk 5% Critical Value	0.859
Data not lognormal at 5% significance level	

95% UCLs (Assuming Lognormal Distribution)	
95% H-UCL	25.68349
95% Chebyshev (MVUE) UCL	30.18533
97.5% Chebyshev (MVUE) UCL	34.60269
99% Chebyshev (MVUE) UCL	43.27974

95% Non-parametric UCLs	
CLT UCL	22.7712
Adj-CLT UCL (Adjusted for skewness)	22.37555
Mod-t UCL (Adjusted for skewness)	22.98536
Jackknife UCL	23.04708
Standard Bootstrap UCL	22.66114
Bootstrap-t UCL	22.51531
Hall's Bootstrap UCL	22.36648
Percentile Bootstrap UCL	22.51667
BCA Bootstrap UCL	22.275
95% Chebyshev (Mean, Sd) UCL	27.72875
97.5% Chebyshev (Mean, Sd) UCL	31.17395
99% Chebyshev (Mean, Sd) UCL	37.94137

IA-1 ProUCL Output

Data File \\Fsmnh01\User1\PROJECTS\03886110\02 Variable: Benzo(a)pyrene

Raw Statistics	
Number of Valid Samples	6
Number of Unique Samples	3
Minimum	0
Maximum	660
Mean	140
Median	0
Standard Deviation	264.7263
Variance	70080
Coefficient of Variation	1.890902
Skewness	2.097281

Normal Distribution Test	
Shapiro-Wilk Test Statisitic	0.643782
Shapiro-Wilk 5% Critical Value	0.788
Data not normal at 5% significance level	
95% UCL (Assuming Normal Distribution)	
Student's-t UCL	357.7744

Gamma Statistics Not Available

Lognormal Statistics Not Available

RECOMMENDATION	95% Non-parametric UCLs	
Data are Non-parametric (0.05)	CLT UCL	317.766
	Adj-CLT UCL (Adjusted for skewness)	416.6402
	Mod-t UCL (Adjusted for skewness)	373.1968
	Jackknife UCL	357.7744
	Standard Bootstrap UCL	N/R
	Bootstrap-t UCL	N/R
	Hall's Bootstrap UCL	N/R
	Percentile Bootstrap UCL	N/R
	BCA Bootstrap UCL	N/R
Use 95% Chebyshev (Mean, Sd) UCL	95% Chebyshev (Mean, Sd) UCL	611.0839
	97.5% Chebyshev (Mean, Sd) UCL	814.9222
	99% Chebyshev (Mean, Sd) UCL	1215.323

IA-1 ProUCL Output

Data File \\Fsmnh01\User1\PROJECTS\03886110\02\ Variable: Dibenz(a,h)Anthracene

Raw Statistics	
Number of Valid Samples	6
Number of Unique Samples	3
Minimum	0
Maximum	70
Mean	14
Median	0
Standard Deviation	28
Variance	784
Coefficient of Variation	2
Skewness	2.25

Normal Distribution Test	
Shapiro-Wilk Test Statisitic	0.611136
Shapiro-Wilk 5% Critical Value	0.788
Data not normal at 5% significance level	
95% UCL (Assuming Normal Distribution)	
Student's-t UCL	37.03392

Gamma Statistics Not Available

Lognormal Statistics Not Available

RECOMMENDATION	95% Non-parametric UCLs	
Data are Non-parametric (0.05)	CLT UCL	32.80224
	Adj-CLT UCL (Adjusted for skewness)	44.02165
	Mod-t UCL (Adjusted for skewness)	38.78392
	Jackknife UCL	37.03392
	Standard Bootstrap UCL	N/R
	Bootstrap-t UCL	N/R
	Hall's Bootstrap UCL	N/R
	Percentile Bootstrap UCL	N/R
	BCA Bootstrap UCL	N/R
Use 95% Chebyshev (Mean, Sd) UCL	95% Chebyshev (Mean, Sd) UCL	63.82637
	97.5% Chebyshev (Mean, Sd) UCL	85.38627
	99% Chebyshev (Mean, Sd) UCL	127.7365

IA-2 ProUCL Output

Data File \\Fsmnh01\User1\PROJECTS\03886110\02\ Variable: Aluminum

Raw Statistics	
Number of Valid Samples	84
Number of Unique Samples	53
Minimum	2000
Maximum	16000
Mean	7609.524
Median	7400
Standard Deviation	3287.661
Variance	10808718
Coefficient of Variation	0.432046
Skewness	0.083043

Gamma Statistics	
k hat	4.430605
k star (bias corrected)	4.280305
Theta hat	1717.491
Theta star	1777.799
nu hat	744.3416
nu star	719.0913
Approx.Chi Square Value (.05)	657.8577
Adjusted Level of Significance	0.047143
Adjusted Chi Square Value	656.8445

Log-transformed Statistics	
Minimum of log data	7.600902
Maximum of log data	9.680344
Mean of log data	8.82008
Standard Deviation of log data	0.525458
Variance of log data	0.276106

RECOMMENDATION

Data are normal (0.05)

Use Student's-t UCL

Normal Distribution Test	
Lilliefors Test Statisitic	0.074314
Lilliefors 5% Critical Value	0.096671
Data are normal at 5% significance level	

95% UCL (Assuming Normal Distribution)	
Student's-t UCL	8206.215

Gamma Distribution Test	
A-D Test Statistic	1.742274
A-D 5% Critical Value	0.75536
K-S Test Statistic	0.137813
K-S 5% Critical Value	0.097852
Data do not follow gamma distribution	
at 5% significance level	

95% UCLs (Assuming Gamma Distribution)	
Approximate Gamma UCL	8317.821
Adjusted Gamma UCL	8330.651

Lognormal Distribution Test	
Lilliefors Test Statisitic	0.171829
Lilliefors 5% Critical Value	0.096671
Data not lognormal at 5% significance level	

95% UCLs (Assuming Lognormal Distribution)	
95% H-UCL	8648.615
95% Chebyshev (MVUE) UCL	9810.657
97.5% Chebyshev (MVUE) UCL	10699.54
99% Chebyshev (MVUE) UCL	12445.58

95% Non-parametric UCLs	
CLT UCL	8199.555
Adj-CLT UCL (Adjusted for skewness)	8203.028
Mod-t UCL (Adjusted for skewness)	8206.756
Jackknife UCL	8206.215
Standard Bootstrap UCL	8203.223
Bootstrap-t UCL	8203.602
Hall's Bootstrap UCL	8187.198
Percentile Bootstrap UCL	8225.714
BCA Bootstrap UCL	8239.286
95% Chebyshev (Mean, Sd) UCL	9173.119
97.5% Chebyshev (Mean, Sd) UCL	9849.687
99% Chebyshev (Mean, Sd) UCL	11178.68

IA-2 ProUCL Output

Data File \\Fsmnh01\User1\PROJECTS\03886110\02\ Variable: Arsenic

Raw Statistics	
Number of Valid Samples	84
Number of Unique Samples	51
Minimum	4.9
Maximum	58
Mean	19.49405
Median	18
Standard Deviation	11.26744
Variance	126.9553
Coefficient of Variation	0.577994
Skewness	0.874586

Gamma Statistics	
k hat	3.091782
k star (bias corrected)	2.989298
Theta hat	6.305116
Theta star	6.521279
nu hat	519.4194
nu star	502.2021
Approx.Chi Square Value (.05)	451.2238
Adjusted Level of Significance	0.047143
Adjusted Chi Square Value	450.3874

Log-transformed Statistics	
Minimum of log data	1.589235
Maximum of log data	4.060443
Mean of log data	2.79976
Standard Deviation of log data	0.601047
Variance of log data	0.361258

RECOMMENDATION

Data are lognormal (0.05)

Use H-UCL

Normal Distribution Test	
Lilliefors Test Statisitic	0.139466
Lilliefors 5% Critical Value	0.096671
Data not normal at 5% significance level	

95% UCL (Assuming Normal Distribution)	
Student's-t UCL	21.53902

Gamma Distribution Test	
A-D Test Statistic	0.939462
A-D 5% Critical Value	0.758705
K-S Test Statistic	0.104018
K-S 5% Critical Value	0.098223
Data do not follow gamma distribution	
at 5% significance level	

95% UCLs (Assuming Gamma Distribution)	
Approximate Gamma UCL	21.69644
Adjusted Gamma UCL	21.73673

Lognormal Distribution Test	
Lilliefors Test Statisitic	0.085751
Lilliefors 5% Critical Value	0.096671
Data are lognormal at 5% significance level	

95% UCLs (Assuming Lognormal Distribution)	
95% H-UCL	22.33226
95% Chebyshev (MVUE) UCL	25.69522
97.5% Chebyshev (MVUE) UCL	28.31279
99% Chebyshev (MVUE) UCL	33.4545

95% Non-parametric UCLs	
CLT UCL	21.5162
Adj-CLT UCL (Adjusted for skewness)	21.64155
Mod-t UCL (Adjusted for skewness)	21.55857
Jackknife UCL	21.53902
Standard Bootstrap UCL	21.53734
Bootstrap-t UCL	21.77385
Hall's Bootstrap UCL	21.66964
Percentile Bootstrap UCL	21.4881
BCA Bootstrap UCL	21.54048
95% Chebyshev (Mean, Sd) UCL	24.85279
97.5% Chebyshev (Mean, Sd) UCL	27.17152
99% Chebyshev (Mean, Sd) UCL	31.72621

IA-2 ProUCL Output

Data File \\Fsmnh01\User1\PROJECTS\03886110\02 Variable: Chromium

Raw Statistics	
Number of Valid Samples	51
Number of Unique Samples	34
Minimum	2.9
Maximum	32
Mean	13.27059
Median	12
Standard Deviation	8.155275
Variance	66.50852
Coefficient of Variation	0.614538
Skewness	0.580714

Gamma Statistics	
k hat	2.544617
k star (bias corrected)	2.408006
Theta hat	5.215161
Theta star	5.511029
nu hat	259.5509
nu star	245.6166
Approx.Chi Square Value (.05)	210.3252
Adjusted Level of Significance	0.045294
Adjusted Chi Square Value	209.3784

Log-transformed Statistics	
Minimum of log data	1.064711
Maximum of log data	3.465736
Mean of log data	2.376373
Standard Deviation of log data	0.682229
Variance of log data	0.465436

RECOMMENDATION

Data follow gamma distribution (0.05)

Use Approximate Gamma UCL

Normal Distribution Test	
Lilliefors Test Statisitic	0.140685
Lilliefors 5% Critical Value	0.124065
Data not normal at 5% significance level	

95% UCL (Assuming Normal Distribution)	
Student's-t UCL	15.18442

Gamma Distribution Test	
A-D Test Statistic	0.651439
A-D 5% Critical Value	0.759703
K-S Test Statistic	0.116391
K-S 5% Critical Value	0.125441
Data follow gamma distribution	
at 5% significance level	

95% UCLs (Assuming Gamma Distribution)	
Approximate Gamma UCL	15.49732
Adjusted Gamma UCL	15.5674

Lognormal Distribution Test	
Lilliefors Test Statisitic	0.12734
Lilliefors 5% Critical Value	0.124065
Data not lognormal at 5% significance level	

95% UCLs (Assuming Lognormal Distribution)	
95% H-UCL	16.49486
95% Chebyshev (MVUE) UCL	19.64623
97.5% Chebyshev (MVUE) UCL	22.30074
99% Chebyshev (MVUE) UCL	27.51503

95% Non-parametric UCLs	
CLT UCL	15.14896
Adj-CLT UCL (Adjusted for skewness)	15.24818
Mod-t UCL (Adjusted for skewness)	15.19989
Jackknife UCL	15.18442
Standard Bootstrap UCL	15.11956
Bootstrap-t UCL	15.39477
Hall's Bootstrap UCL	15.12911
Percentile Bootstrap UCL	15.10588
BCA Bootstrap UCL	15.14314
95% Chebyshev (Mean, Sd) UCL	18.24831
97.5% Chebyshev (Mean, Sd) UCL	20.40217
99% Chebyshev (Mean, Sd) UCL	24.63302

IA-2 ProUCL Output

Data File \\Fsmnh01\User1\PROJECTS\03886110\02\ Variable: Iron

Raw Statistics	
Number of Valid Samples	84
Number of Unique Samples	51
Minimum	17.2
Maximum	28000
Mean	10274.46
Median	9555
Standard Deviation	5371.271
Variance	28850551
Coefficient of Variation	0.522779
Skewness	0.548153

Gamma Statistics	
k hat	2.090106
k star (bias corrected)	2.023396
Theta hat	4915.759
Theta star	5077.828
nu hat	351.1378
nu star	339.9305
Approx.Chi Square Value (.05)	298.2006
Adjusted Level of Significance	0.047143
Adjusted Chi Square Value	297.5235

Log-transformed Statistics	
Minimum of log data	2.844909
Maximum of log data	10.23996
Mean of log data	8.979516
Standard Deviation of log data	1.102458
Variance of log data	1.215414

RECOMMENDATION

Data are Non-parametric (0.05)

Use 97.5% Chebyshev (Mean, Sd) UCL

Normal Distribution Test	
Lilliefors Test Statisitic	0.097934
Lilliefors 5% Critical Value	0.096671
Data not normal at 5% significance level	

95% UCL (Assuming Normal Distribution)	
Student's-t UCL	11249.31

Gamma Distribution Test	
A-D Test Statistic	2.195917
A-D 5% Critical Value	0.763488
K-S Test Statistic	0.131857
K-S 5% Critical Value	0.098767
Data do not follow gamma distribution	
at 5% significance level	

95% UCLs (Assuming Gamma Distribution)	
Approximate Gamma UCL	11712.26
Adjusted Gamma UCL	11738.91

Lognormal Distribution Test	
Lilliefors Test Statisitic	0.205119
Lilliefors 5% Critical Value	0.096671
Data not lognormal at 5% significance level	

95% UCLs (Assuming Lognormal Distribution)	
95% H-UCL	19316.65
95% Chebyshev (MVUE) UCL	23704.97
97.5% Chebyshev (MVUE) UCL	27726.01
99% Chebyshev (MVUE) UCL	35624.57

95% Non-parametric UCLs	
CLT UCL	11238.43
Adj-CLT UCL (Adjusted for skewness)	11275.88
Mod-t UCL (Adjusted for skewness)	11255.15
Jackknife UCL	11249.31
Standard Bootstrap UCL	11245.08
Bootstrap-t UCL	11286.32
Hall's Bootstrap UCL	11299.91
Percentile Bootstrap UCL	11249.64
BCA Bootstrap UCL	11241.75
95% Chebyshev (Mean, Sd) UCL	12829.01
97.5% Chebyshev (Mean, Sd) UCL	13934.36
99% Chebyshev (Mean, Sd) UCL	16105.62

IA-2 ProUCL Output

Data File \\Fsmnh01\User1\PROJECTS\03886110\02\ Variable: Lead

Raw Statistics	
Number of Valid Samples	51
Number of Unique Samples	38
Minimum	2.5
Maximum	50
Mean	7.960784
Median	6.9
Standard Deviation	6.845526
Variance	46.86123
Coefficient of Variation	0.859906
Skewness	4.769785

Gamma Statistics	
k hat	2.795055
k star (bias corrected)	2.643712
Theta hat	2.848167
Theta star	3.011215
nu hat	285.0956
nu star	269.6586
Approx.Chi Square Value (.05)	232.6227
Adjusted Level of Significance	0.045294
Adjusted Chi Square Value	231.6256

Log-transformed Statistics	
Minimum of log data	0.916291
Maximum of log data	3.912023
Mean of log data	1.885102
Standard Deviation of log data	0.580367
Variance of log data	0.336826

RECOMMENDATION

Assuming gamma distribution (0.05)

Use Approximate Gamma UCL

Normal Distribution Test	
Lilliefors Test Statisitic	0.212518
Lilliefors 5% Critical Value	0.124065
Data not normal at 5% significance level	

95% UCL (Assuming Normal Distribution)	
Student's-t UCL	9.567249

Gamma Distribution Test	
A-D Test Statistic	0.882399
A-D 5% Critical Value	0.758233
K-S Test Statistic	0.099745
K-S 5% Critical Value	0.12527
Data follow approximate gamma distibution	
at 5% significance level	

95% UCLs (Assuming Gamma Distribution)	
Approximate Gamma UCL	9.228224
Adjusted Gamma UCL	9.267947

Lognormal Distribution Test	
Lilliefors Test Statisitic	0.086359
Lilliefors 5% Critical Value	0.124065
Data are lognormal at 5% significance level	

95% UCLs (Assuming Lognormal Distribution)	
95% H-UCL	9.134537
95% Chebyshev (MVUE) UCL	10.70054
97.5% Chebyshev (MVUE) UCL	11.97053
99% Chebyshev (MVUE) UCL	14.46517

95% Non-parametric UCLs	
CLT UCL	9.537484
Adj-CLT UCL (Adjusted for skewness)	10.22158
Mod-t UCL (Adjusted for skewness)	9.673954
Jackknife UCL	9.567249
Standard Bootstrap UCL	9.534099
Bootstrap-t UCL	10.96367
Hall's Bootstrap UCL	16.56665
Percentile Bootstrap UCL	9.696078
BCA Bootstrap UCL	10.68235
95% Chebyshev (Mean, Sd) UCL	12.13907
97.5% Chebyshev (Mean, Sd) UCL	13.94702
99% Chebyshev (Mean, Sd) UCL	17.49839

IA-2 ProUCL Output

Data File \\Fsmnh01\User1\PROJECTS\03886110\02\ Variable: Manganese

Raw Statistics	
Number of Valid Samples	84
Number of Unique Samples	54
Minimum	38
Maximum	640
Mean	195.3262
Median	183
Standard Deviation	119.6982
Variance	14327.66
Coefficient of Variation	0.612812
Skewness	1.023983

Gamma Statistics	
k hat	2.669847
k star (bias corrected)	2.582432
Theta hat	73.16007
Theta star	75.63654
nu hat	448.5343
nu star	433.8485
Approx.Chi Square Value (.05)	386.5502
Adjusted Level of Significance	0.047143
Adjusted Chi Square Value	385.7772

Log-transformed Statistics	
Minimum of log data	3.637586
Maximum of log data	6.461468
Mean of log data	5.075858
Standard Deviation of log data	0.662625
Variance of log data	0.439072

RECOMMENDATION

Assuming gamma distribution (0.05)

Use Approximate Gamma UCL

Normal Distribution Test	
Lilliefors Test Statisitic	0.12043
Lilliefors 5% Critical Value	0.096671
Data not normal at 5% significance level	

95% UCL (Assuming Normal Distribution)	
Student's-t UCL	217.0507

Gamma Distribution Test	
A-D Test Statistic	0.72855
A-D 5% Critical Value	0.760618
K-S Test Statistic	0.112548
K-S 5% Critical Value	0.098439
Data follow approximate gamma distibution	
at 5% significance level	

95% UCLs (Assuming Gamma Distribution)	
Approximate Gamma UCL	219.2263
Adjusted Gamma UCL	219.6656

Lognormal Distribution Test	
Lilliefors Test Statisitic	0.119556
Lilliefors 5% Critical Value	0.096671
Data not lognormal at 5% significance level	

95% UCLs (Assuming Lognormal Distribution)	
95% H-UCL	229.756
95% Chebyshev (MVUE) UCL	267.2392
97.5% Chebyshev (MVUE) UCL	296.8588
99% Chebyshev (MVUE) UCL	355.0408

95% Non-parametric UCLs	
CLT UCL	216.8082
Adj-CLT UCL (Adjusted for skewness)	218.3673
Mod-t UCL (Adjusted for skewness)	217.2939
Jackknife UCL	217.0507
Standard Bootstrap UCL	215.9887
Bootstrap-t UCL	219.0422
Hall's Bootstrap UCL	218.8862
Percentile Bootstrap UCL	216.369
BCA Bootstrap UCL	217.6214
95% Chebyshev (Mean, Sd) UCL	252.2541
97.5% Chebyshev (Mean, Sd) UCL	276.8868
99% Chebyshev (Mean, Sd) UCL	325.273

IA-2 ProUCL Output

Data File \\Fsmnh01\User1\PROJECTS\03886110\02\ Variable: Thallium

Raw Statistics	
Number of Valid Samples	51
Number of Unique Samples	9
Minimum	0.42
Maximum	2.2
Mean	1.084118
Median	1.1
Standard Deviation	0.207096
Variance	0.042889
Coefficient of Variation	0.191027
Skewness	2.564969

Gamma Statistics	
k hat	29.65304
k star (bias corrected)	27.92181
Theta hat	0.03656
Theta star	0.038827
nu hat	3024.61
nu star	2848.025
Approx.Chi Square Value (.05)	2725.006
Adjusted Level of Significance	0.045294
Adjusted Chi Square Value	2721.529

Log-transformed Statistics	
Minimum of log data	-0.8675
Maximum of log data	0.788457
Mean of log data	0.06381
Standard Deviation of log data	0.190895
Variance of log data	0.036441

RECOMMENDATION

Data are Non-parametric (0.05)

Use Student's-t UCL
or Modified-t UCL

Normal Distribution Test	
Lilliefors Test Statisitic	0.33218
Lilliefors 5% Critical Value	0.124065
Data not normal at 5% significance level	

95% UCL (Assuming Normal Distribution)	
Student's-t UCL	1.132718

Gamma Distribution Test	
A-D Test Statistic	7.862281
A-D 5% Critical Value	0.748043
K-S Test Statistic	0.315618
K-S 5% Critical Value	0.123857
Data do not follow gamma distribution at 5% significance level	

95% UCLs (Assuming Gamma Distribution)	
Approximate Gamma UCL	1.13306
Adjusted Gamma UCL	1.134507

Lognormal Distribution Test	
Lilliefors Test Statisitic	0.329874
Lilliefors 5% Critical Value	0.124065
Data not lognormal at 5% significance level	

95% UCLs (Assuming Lognormal Distribution)	
95% H-UCL	1.136914
95% Chebyshev (MVUE) UCL	1.212496
97.5% Chebyshev (MVUE) UCL	1.267623
99% Chebyshev (MVUE) UCL	1.375909

95% Non-parametric UCLs	
CLT UCL	1.131817
Adj-CLT UCL (Adjusted for skewness)	1.142946
Mod-t UCL (Adjusted for skewness)	1.134454
Jackknife UCL	1.132718
Standard Bootstrap UCL	1.132827
Bootstrap-t UCL	1.146134
Hall's Bootstrap UCL	1.436202
Percentile Bootstrap UCL	1.134706
BCA Bootstrap UCL	1.139608
95% Chebyshev (Mean, Sd) UCL	1.210522
97.5% Chebyshev (Mean, Sd) UCL	1.265218
99% Chebyshev (Mean, Sd) UCL	1.372656

IA-2 ProUCL Output

Data File \\Fsmnh01\User1\PROJECTS\03886110\02 Variable: Benzo(a)pyrene

Raw Statistics	
Number of Valid Samples	39
Number of Unique Samples	7
Minimum	0
Maximum	81
Mean	5.679487
Median	0
Standard Deviation	13.97671
Variance	195.3485
Coefficient of Variation	2.460911
Skewness	4.470704

Normal Distribution Test	
Shapiro-Wilk Test Statisitic	0.449765
Shapiro-Wilk 5% Critical Value	0.939
Data not normal at 5% significance level	
95% UCL (Assuming Normal Distribution)	
Student's-t UCL	9.452763

Gamma Statistics Not Available

Lognormal Statistics Not Available

	95% Non-parametric UCLs	
	CLT UCL	9.360777
	Adj-CLT UCL (Adjusted for skewness)	11.07275
	Mod-t UCL (Adjusted for skewness)	9.719796
	Jackknife UCL	9.452763
	Standard Bootstrap UCL	9.317561
	Bootstrap-t UCL	13.855
RECOMMENDATION	Hall's Bootstrap UCL	22.8828
Data are Non-parametric (0.05)	Percentile Bootstrap UCL	9.794872
	BCA Bootstrap UCL	11.83333
Use 95% Chebyshev (Mean, Sd) UCL	95% Chebyshev (Mean, Sd) UCL	15.43499
	97.5% Chebyshev (Mean, Sd) UCL	19.6562
	99% Chebyshev (Mean, Sd) UCL	27.94796

IA-2 ProUCL Output

Data File \\Fsmnh01\User1\PROJECTS\03886110\02\ Variable: 4,4-DDE

Raw Statistics	
Number of Valid Samples	39
Number of Unique Samples	13
Minimum	0
Maximum	247
Mean	8.122308
Median	0
Standard Deviation	39.41708
Variance	1553.706
Coefficient of Variation	4.852941
Skewness	6.167104

Normal Distribution Test	
Shapiro-Wilk Test Statisitic	0.213013
Shapiro-Wilk 5% Critical Value	0.939
Data not normal at 5% significance level	
95% UCL (Assuming Normal Distribution)	
Student's-t UCL	18.76369

Gamma Statistics Not Available

Lognormal Statistics Not Available

	95% Non-parametric UCLs	
	CLT UCL	18.50427
	Adj-CLT UCL (Adjusted for skewness)	25.16438
	Mod-t UCL (Adjusted for skewness)	19.80253
	Jackknife UCL	18.76369
	Standard Bootstrap UCL	18.11263
	Bootstrap-t UCL	107.435
RECOMMENDATION	Hall's Bootstrap UCL	67.02767
Data are Non-parametric (0.05)	Percentile Bootstrap UCL	20.78141
	BCA Bootstrap UCL	27.39615
Use 95% Chebyshev (Mean, Sd) UCL	95% Chebyshev (Mean, Sd) UCL	35.63474
	97.5% Chebyshev (Mean, Sd) UCL	47.53939
	99% Chebyshev (Mean, Sd) UCL	70.92377

IA-2 ProUCL Output

Data File \\Fsmnh01\User1\PROJECTS\03886110\02 Variable: 4,4-DDT

Raw Statistics	
Number of Valid Samples	39
Number of Unique Samples	13
Minimum	0
Maximum	751
Mean	21.36923
Median	0
Standard Deviation	119.9954
Variance	14398.9
Coefficient of Variation	5.615337
Skewness	6.230957

Normal Distribution Test	
Shapiro-Wilk Test Statisitic	0.182701
Shapiro-Wilk 5% Critical Value	0.939
Data not normal at 5% significance level	
95% UCL (Assuming Normal Distribution)	
Student's-t UCL	53.76425

Gamma Statistics Not Available

Lognormal Statistics Not Available

	95% Non-parametric UCLs	
	CLT UCL	52.97451
	Adj-CLT UCL (Adjusted for skewness)	73.45948
	Mod-t UCL (Adjusted for skewness)	56.95949
	Jackknife UCL	53.76425
	Standard Bootstrap UCL	52.36892
	Bootstrap-t UCL	816.7309
RECOMMENDATION	Hall's Bootstrap UCL	475.8136
Data are Non-parametric (0.05)	Percentile Bootstrap UCL	59.845
	BCA Bootstrap UCL	97.48397
Use 95% Chebyshev (Mean, Sd) UCL	95% Chebyshev (Mean, Sd) UCL	105.1239
	97.5% Chebyshev (Mean, Sd) UCL	141.3647
	99% Chebyshev (Mean, Sd) UCL	212.5526

IA-2 ProUCL Output

Data File \\Fsmnh01\User1\PROJECTS\03886110\02\ Variable: Alt 4,4-DDE

Raw Statistics	
Number of Valid Samples	39
Number of Unique Samples	11
Minimum	0
Maximum	13
Mean	1.450513
Median	0
Standard Deviation	3.028146
Variance	9.169668
Coefficient of Variation	2.087638
Skewness	2.563797

Normal Distribution Test	
Shapiro-Wilk Test Statisitic	0.558202
Shapiro-Wilk 5% Critical Value	0.939
Data not normal at 5% significance level	

95% UCL (Assuming Normal Distribution)	
Student's-t UCL	2.268018

Gamma Statistics Not Available

Lognormal Statistics Not Available

RECOMMENDATION	95% Non-parametric UCLs	
	CLT UCL	2.248088
	Adj-CLT UCL (Adjusted for skewness)	2.460793
	Mod-t UCL (Adjusted for skewness)	2.301195
	Jackknife UCL	2.268018
	Standard Bootstrap UCL	2.23603
	Bootstrap-t UCL	2.584456
	Hall's Bootstrap UCL	2.394499
Data are Non-parametric (0.05)	Percentile Bootstrap UCL	2.3
	BCA Bootstrap UCL	2.494359
Use 95% Chebyshev (Mean, Sd) UCL	95% Chebyshev (Mean, Sd) UCL	3.564106
	97.5% Chebyshev (Mean, Sd) UCL	4.478659
	99% Chebyshev (Mean, Sd) UCL	6.275122

IA-3 ProUCL Output

Data File \\Fsmnh01\User1\PROJECTS\03886110\02 Variable: Aluminum

Raw Statistics	
Number of Valid Samples	30
Number of Unique Samples	24
Minimum	4200
Maximum	11000
Mean	7553.333
Median	7400
Standard Deviation	1756.904
Variance	3086713
Coefficient of Variation	0.2326
Skewness	0.363262

Gamma Statistics	
k hat	19.14717
k star (bias corrected)	17.25467
Theta hat	394.4883
Theta star	437.7558
nu hat	1148.83
nu star	1035.28
Approx.Chi Square Value (.05)	961.5727
Adjusted Level of Significance	0.041
Adjusted Chi Square Value	957.4909

Log-transformed Statistics	
Minimum of log data	8.34284
Maximum of log data	9.305651
Mean of log data	8.903403
Standard Deviation of log data	0.234797
Variance of log data	0.05513

RECOMMENDATION

Data are normal (0.05)

Use Student's-t UCL

Normal Distribution Test	
Shapiro-Wilk Test Statisitic	0.959604
Shapiro-Wilk 5% Critical Value	0.927
Data are normal at 5% significance level	

95% UCL (Assuming Normal Distribution)	
Student's-t UCL	8098.354

Gamma Distribution Test	
A-D Test Statistic	0.300685
A-D 5% Critical Value	0.74442
K-S Test Statistic	0.092231
K-S 5% Critical Value	0.159704
Data follow gamma distribution	
at 5% significance level	

95% UCLs (Assuming Gamma Distribution)	
Approximate Gamma UCL	8132.322
Adjusted Gamma UCL	8166.99

Lognormal Distribution Test	
Shapiro-Wilk Test Statisitic	0.97328
Shapiro-Wilk 5% Critical Value	0.927
Data are lognormal at 5% significance level	

95% UCLs (Assuming Lognormal Distribution)	
95% H-UCL	8166.427
95% Chebyshev (MVUE) UCL	8981.621
97.5% Chebyshev (MVUE) UCL	9598.719
99% Chebyshev (MVUE) UCL	10810.89

95% Non-parametric UCLs	
CLT UCL	8080.945
Adj-CLT UCL (Adjusted for skewness)	8103.677
Mod-t UCL (Adjusted for skewness)	8101.9
Jackknife UCL	8098.354
Standard Bootstrap UCL	8057.455
Bootstrap-t UCL	8136.594
Hall's Bootstrap UCL	8133.073
Percentile Bootstrap UCL	8073.333
BCA Bootstrap UCL	8116.667
95% Chebyshev (Mean, Sd) UCL	8951.517
97.5% Chebyshev (Mean, Sd) UCL	9556.512
99% Chebyshev (Mean, Sd) UCL	10744.91

IA-3 ProUCL Output

Data File \\Fsmnh01\User1\PROJECTS\03886110\02\ Variable: Arsenic

Raw Statistics	
Number of Valid Samples	30
Number of Unique Samples	16
Minimum	10
Maximum	31
Mean	19.76667
Median	19.5
Standard Deviation	6.061087
Variance	36.73678
Coefficient of Variation	0.306632
Skewness	0.043993

Gamma Statistics	
k hat	10.31794
k star (bias corrected)	9.308368
Theta hat	1.915757
Theta star	2.123537
nu hat	619.0764
nu star	558.5021
Approx.Chi Square Value (.05)	504.6776
Adjusted Level of Significance	0.041
Adjusted Chi Square Value	501.7358

Log-transformed Statistics	
Minimum of log data	2.302585
Maximum of log data	3.433987
Mean of log data	2.934756
Standard Deviation of log data	0.326613
Variance of log data	0.106676

RECOMMENDATION

Data are normal (0.05)

Use Student's-t UCL

Normal Distribution Test	
Shapiro-Wilk Test Statisitic	0.944204
Shapiro-Wilk 5% Critical Value	0.927
Data are normal at 5% significance level	

95% UCL (Assuming Normal Distribution)	
Student's-t UCL	21.64692

Gamma Distribution Test	
A-D Test Statistic	0.599985
A-D 5% Critical Value	0.745453
K-S Test Statistic	0.138969
K-S 5% Critical Value	0.159951
Data follow gamma distribution	
at 5% significance level	

95% UCLs (Assuming Gamma Distribution)	
Approximate Gamma UCL	21.87481
Adjusted Gamma UCL	22.00306

Lognormal Distribution Test	
Shapiro-Wilk Test Statisitic	0.934956
Shapiro-Wilk 5% Critical Value	0.927
Data are lognormal at 5% significance level	

95% UCLs (Assuming Lognormal Distribution)	
95% H-UCL	22.15459
95% Chebyshev (MVUE) UCL	25.06032
97.5% Chebyshev (MVUE) UCL	27.33177
99% Chebyshev (MVUE) UCL	31.79358

95% Non-parametric UCLs	
CLT UCL	21.58686
Adj-CLT UCL (Adjusted for skewness)	21.59636
Mod-t UCL (Adjusted for skewness)	21.6484
Jackknife UCL	21.64692
Standard Bootstrap UCL	21.60095
Bootstrap-t UCL	21.66986
Hall's Bootstrap UCL	21.59659
Percentile Bootstrap UCL	21.53333
BCA Bootstrap UCL	21.53333
95% Chebyshev (Mean, Sd) UCL	24.59022
97.5% Chebyshev (Mean, Sd) UCL	26.67737
99% Chebyshev (Mean, Sd) UCL	30.77718

IA-3 ProUCL Output

Data File \\Fsmnh01\User1\PROJECTS\03886110\02\ Variable: Iron

Raw Statistics	
Number of Valid Samples	30
Number of Unique Samples	21
Minimum	6300
Maximum	15000
Mean	9753.333
Median	9000
Standard Deviation	2511.18
Variance	6306023
Coefficient of Variation	0.257469
Skewness	0.827276

Gamma Statistics	
k hat	16.9027
k star (bias corrected)	15.23465
Theta hat	577.0281
Theta star	640.2071
nu hat	1014.162
nu star	914.0792
Approx.Chi Square Value (.05)	844.891
Adjusted Level of Significance	0.041
Adjusted Chi Square Value	841.0684

Log-transformed Statistics	
Minimum of log data	8.748305
Maximum of log data	9.615805
Mean of log data	9.155492
Standard Deviation of log data	0.244782
Variance of log data	0.059918

RECOMMENDATION

Data are lognormal (0.05)

Use Student's-t UCL

Use Modified-t UCL

Use H-UCL

Normal Distribution Test	
Shapiro-Wilk Test Statisitic	0.89747
Shapiro-Wilk 5% Critical Value	0.927
Data not normal at 5% significance level	

95% UCL (Assuming Normal Distribution)	
Student's-t UCL	10532.34

Gamma Distribution Test	
A-D Test Statistic	0.792786
A-D 5% Critical Value	0.744682
K-S Test Statistic	0.160974
K-S 5% Critical Value	0.159767
Data do not follow gamma distribution	
at 5% significance level	

95% UCLs (Assuming Gamma Distribution)	
Approximate Gamma UCL	10552.03
Adjusted Gamma UCL	10599.99

Lognormal Distribution Test	
Shapiro-Wilk Test Statisitic	0.939703
Shapiro-Wilk 5% Critical Value	0.927
Data are lognormal at 5% significance level	

95% UCLs (Assuming Lognormal Distribution)	
95% H-UCL	10569.92
95% Chebyshev (MVUE) UCL	11663.34
97.5% Chebyshev (MVUE) UCL	12493.76
99% Chebyshev (MVUE) UCL	14124.96

95% Non-parametric UCLs	
CLT UCL	10507.46
Adj-CLT UCL (Adjusted for skewness)	10581.45
Mod-t UCL (Adjusted for skewness)	10543.88
Jackknife UCL	10532.34
Standard Bootstrap UCL	10507.78
Bootstrap-t UCL	10679.85
Hall's Bootstrap UCL	10570.13
Percentile Bootstrap UCL	10460
BCA Bootstrap UCL	10563.33
95% Chebyshev (Mean, Sd) UCL	11751.79
97.5% Chebyshev (Mean, Sd) UCL	12616.52
99% Chebyshev (Mean, Sd) UCL	14315.12

IA-3 ProUCL Output

Data File C:\Documents and Settings\schmidlj\Deskto Variable: Lead

Raw Statistics	
Number of Valid Samples	61
Number of Unique Samples	50
Minimum	5.9
Maximum	59.4
Mean	17.09677
Median	13
Standard Deviation	12.50107
Variance	156.2768
Coefficient of Variation	0.731195
Skewness	1.984412

Gamma Statistics	
k hat	2.813292
k star (bias corrected)	2.685862
Theta hat	6.077138
Theta star	6.365466
nu hat	343.2216
nu star	327.6752
Approx.Chi Square Value (.05)	286.7262
Adjusted Level of Significance	0.046066
Adjusted Chi Square Value	285.8043

Log-transformed Statistics	
Minimum of log data	1.774952
Maximum of log data	4.084294
Mean of log data	2.650758
Standard Deviation of log data	0.579921
Variance of log data	0.336309

RECOMMENDATION

Data are lognormal (0.05)

Use H-UCL

Normal Distribution Test	
Lilliefors Test Statisitic	0.229538
Lilliefors 5% Critical Value	0.113441
Data not normal at 5% significance level	

95% UCL (Assuming Normal Distribution)	
Student's-t UCL	19.7708

Gamma Distribution Test	
A-D Test Statistic	2.191173
A-D 5% Critical Value	0.7589
K-S Test Statistic	0.142741
K-S 5% Critical Value	0.114844
Data do not follow gamma distribution	
at 5% significance level	

95% UCLs (Assuming Gamma Distribution)	
Approximate Gamma UCL	19.53845
Adjusted Gamma UCL	19.60148

Lognormal Distribution Test	
Lilliefors Test Statisitic	0.09936
Lilliefors 5% Critical Value	0.113441
Data are lognormal at 5% significance level	

95% UCLs (Assuming Lognormal Distribution)	
95% H-UCL	19.34156
95% Chebyshev (MVUE) UCL	22.48512
97.5% Chebyshev (MVUE) UCL	24.98611
99% Chebyshev (MVUE) UCL	29.89882

95% Non-parametric UCLs	
CLT UCL	19.72952
Adj-CLT UCL (Adjusted for skewness)	20.16406
Mod-t UCL (Adjusted for skewness)	19.83858
Jackknife UCL	19.7708
Standard Bootstrap UCL	19.70427
Bootstrap-t UCL	20.30781
Hall's Bootstrap UCL	20.19898
Percentile Bootstrap UCL	19.78374
BCA Bootstrap UCL	20.18533
95% Chebyshev (Mean, Sd) UCL	24.07361
97.5% Chebyshev (Mean, Sd) UCL	27.0925
99% Chebyshev (Mean, Sd) UCL	33.02252

IA-3 ProUCL Output

Data File \\Fsmnh01\User1\PROJECTS\03886110\02\ Variable: Manganese

Raw Statistics	
Number of Valid Samples	30
Number of Unique Samples	23
Minimum	64
Maximum	240
Mean	138.3667
Median	125
Standard Deviation	54.29008
Variance	2947.413
Coefficient of Variation	0.392364
Skewness	0.366744

Gamma Statistics	
k hat	6.675023
k star (bias corrected)	6.029743
Theta hat	20.72902
Theta star	22.94736
nu hat	400.5014
nu star	361.7846
Approx.Chi Square Value (.05)	318.6963
Adjusted Level of Significance	0.041
Adjusted Chi Square Value	316.3699

Log-transformed Statistics	
Minimum of log data	4.158883
Maximum of log data	5.480639
Mean of log data	4.853135
Standard Deviation of log data	0.402238
Variance of log data	0.161796

RECOMMENDATION

Data are Non-parametric (0.05)

Use Student's-t UCL
or Modified-t UCL

Normal Distribution Test	
Shapiro-Wilk Test Statisitic	0.906704
Shapiro-Wilk 5% Critical Value	0.927
Data not normal at 5% significance level	

95% UCL (Assuming Normal Distribution)	
Student's-t UCL	155.2084

Gamma Distribution Test	
A-D Test Statistic	0.920114
A-D 5% Critical Value	0.746155
K-S Test Statistic	0.165453
K-S 5% Critical Value	0.160193
Data do not follow gamma distribution	
at 5% significance level	

95% UCLs (Assuming Gamma Distribution)	
Approximate Gamma UCL	157.0741
Adjusted Gamma UCL	158.2291

Lognormal Distribution Test	
Shapiro-Wilk Test Statisitic	0.924108
Shapiro-Wilk 5% Critical Value	0.927
Data not lognormal at 5% significance level	

95% UCLs (Assuming Lognormal Distribution)	
95% H-UCL	159.6758
95% Chebyshev (MVUE) UCL	184.1746
97.5% Chebyshev (MVUE) UCL	203.9219
99% Chebyshev (MVUE) UCL	242.7116

95% Non-parametric UCLs	
CLT UCL	154.6704
Adj-CLT UCL (Adjusted for skewness)	155.3796
Mod-t UCL (Adjusted for skewness)	155.319
Jackknife UCL	155.2084
Standard Bootstrap UCL	154.7445
Bootstrap-t UCL	156.0757
Hall's Bootstrap UCL	155.0186
Percentile Bootstrap UCL	154.5333
BCA Bootstrap UCL	155.1667
95% Chebyshev (Mean, Sd) UCL	181.5719
97.5% Chebyshev (Mean, Sd) UCL	200.2669
99% Chebyshev (Mean, Sd) UCL	236.9895

IA-3 ProUCL Output

Data File \\Fsmnh01\User1\PROJECTS\03886110\02 Variable: Nickel

Raw Statistics	
Number of Valid Samples	30
Number of Unique Samples	21
Minimum	5.8
Maximum	25
Mean	14.41333
Median	14
Standard Deviation	5.618426
Variance	31.56671
Coefficient of Variation	0.389808
Skewness	0.245775

Gamma Statistics	
k hat	6.328794
k star (bias corrected)	5.718137
Theta hat	2.277422
Theta star	2.520634
nu hat	379.7277
nu star	343.0882
Approx.Chi Square Value (.05)	301.1594
Adjusted Level of Significance	0.041
Adjusted Chi Square Value	298.8995

Log-transformed Statistics	
Minimum of log data	1.757858
Maximum of log data	3.218876
Mean of log data	2.587074
Standard Deviation of log data	0.423059
Variance of log data	0.178979

RECOMMENDATION

Data are normal (0.05)

Use Student's-t UCL

Normal Distribution Test	
Shapiro-Wilk Test Statisitic	0.954091
Shapiro-Wilk 5% Critical Value	0.927
Data are normal at 5% significance level	

95% UCL (Assuming Normal Distribution)	
Student's-t UCL	16.15626

Gamma Distribution Test	
A-D Test Statistic	0.311244
A-D 5% Critical Value	0.746224
K-S Test Statistic	0.078281
K-S 5% Critical Value	0.160217
Data follow gamma distribution	
at 5% significance level	

95% UCLs (Assuming Gamma Distribution)	
Approximate Gamma UCL	16.42003
Adjusted Gamma UCL	16.54418

Lognormal Distribution Test	
Shapiro-Wilk Test Statisitic	0.948223
Shapiro-Wilk 5% Critical Value	0.927
Data are lognormal at 5% significance level	

95% UCLs (Assuming Lognormal Distribution)	
95% H-UCL	16.84439
95% Chebyshev (MVUE) UCL	19.52253
97.5% Chebyshev (MVUE) UCL	21.70085
99% Chebyshev (MVUE) UCL	25.97973

95% Non-parametric UCLs	
CLT UCL	16.10059
Adj-CLT UCL (Adjusted for skewness)	16.14977
Mod-t UCL (Adjusted for skewness)	16.16393
Jackknife UCL	16.15626
Standard Bootstrap UCL	16.12528
Bootstrap-t UCL	16.14836
Hall's Bootstrap UCL	16.15307
Percentile Bootstrap UCL	16.10667
BCA Bootstrap UCL	16.11
95% Chebyshev (Mean, Sd) UCL	18.8846
97.5% Chebyshev (Mean, Sd) UCL	20.81932
99% Chebyshev (Mean, Sd) UCL	24.61971

IA-3 ProUCL Output

Data File \\Fsmnh01\User1\PROJECTS\03886110\02\ Variable: Benzo(a)pyrene

Raw Statistics	
Number of Valid Samples	6
Number of Unique Samples	5
Minimum	0
Maximum	620
Mean	115
Median	15.5
Standard Deviation	247.8693
Variance	61439.2
Coefficient of Variation	2.155385
Skewness	2.42881

Normal Distribution Test	
Shapiro-Wilk Test Statisitic	0.550289
Shapiro-Wilk 5% Critical Value	0.788
Data not normal at 5% significance level	
95% UCL (Assuming Normal Distribution)	
Student's-t UCL	318.9072

Gamma Statistics Not Available

Lognormal Statistics Not Available

RECOMMENDATION	95% Non-parametric UCLs	
	CLT UCL	281.4464
	Adj-CLT UCL (Adjusted for skewness)	388.6589
	Mod-t UCL (Adjusted for skewness)	335.6302
	Jackknife UCL	318.9072
	Standard Bootstrap UCL	266.5731
	Bootstrap-t UCL	2938.536
	Hall's Bootstrap UCL	2306.781
Data are Non-parametric (0.05)	Percentile Bootstrap UCL	314
	BCA Bootstrap UCL	323
Use 95% Chebyshev (Mean, Sd) UCL	95% Chebyshev (Mean, Sd) UCL	556.0867
	97.5% Chebyshev (Mean, Sd) UCL	746.9453
	99% Chebyshev (Mean, Sd) UCL	1121.85

IA-3 ProUCL Output

Data File \\Fsmnh01\User1\PROJECTS\03886110\02\ Variable: Dibenz(a,h)Anthracene

Raw Statistics	
Number of Valid Samples	6
Number of Unique Samples	4
Minimum	0
Maximum	82
Mean	17.25
Median	7
Standard Deviation	31.91512
Variance	1018.575
Coefficient of Variation	1.850152
Skewness	2.382081

Normal Distribution Test	
Shapiro-Wilk Test Statisitic	0.590488
Shapiro-Wilk 5% Critical Value	0.788
Data not normal at 5% significance level	
95% UCL (Assuming Normal Distribution)	
Student's-t UCL	43.50466

Gamma Statistics Not Available

Lognormal Statistics Not Available

RECOMMENDATION	95% Non-parametric UCLs	
	CLT UCL	38.68128
	Adj-CLT UCL (Adjusted for skewness)	52.22015
	Mod-t UCL (Adjusted for skewness)	45.61644
	Jackknife UCL	43.50466
	Standard Bootstrap UCL	N/R
	Bootstrap-t UCL	N/R
	Hall's Bootstrap UCL	N/R
Data are Non-parametric (0.05)	Percentile Bootstrap UCL	N/R
	BCA Bootstrap UCL	N/R
Use 95% Chebyshev (Mean, Sd) UCL	95% Chebyshev (Mean, Sd) UCL	74.04338
	97.5% Chebyshev (Mean, Sd) UCL	98.61791
	99% Chebyshev (Mean, Sd) UCL	146.8898

IA-3 ProUCL Output

Data File \\Fsmnh01\User1\PROJECTS\03886110\02\ Variable: Phenanthrene

Raw Statistics	
Number of Valid Samples	6
Number of Unique Samples	5
Minimum	0
Maximum	540
Mean	179.8333
Median	177
Standard Deviation	197.2059
Variance	38890.17
Coefficient of Variation	1.096604
Skewness	1.372573

Normal Distribution Test	
Shapiro-Wilk Test Statisitic	0.820918
Shapiro-Wilk 5% Critical Value	0.788
Data are normal at 5% significance level	

95% UCL (Assuming Normal Distribution)	
Student's-t UCL	342.0628

Gamma Statistics Not Available

Lognormal Statistics Not Available

95% Non-parametric UCLs	
CLT UCL	312.2588
Adj-CLT UCL (Adjusted for skewness)	360.463
Mod-t UCL (Adjusted for skewness)	349.5817
Jackknife UCL	342.0628
Standard Bootstrap UCL	299.46
Bootstrap-t UCL	429.8278
Hall's Bootstrap UCL	901.055
Percentile Bootstrap UCL	300.6667
BCA Bootstrap UCL	330.6667
95% Chebyshev (Mean, Sd) UCL	530.7638
97.5% Chebyshev (Mean, Sd) UCL	682.6117
99% Chebyshev (Mean, Sd) UCL	980.8875

RECOMMENDATION

Data are normal (0.05)

Use Student's-t UCL

IA-3 ProUCL Output

Data File \\Fsmnh01\User1\PROJECTS\03886110\02\ Variable: Pyrene

Raw Statistics	
Number of Valid Samples	6
Number of Unique Samples	5
Minimum	0
Maximum	850
Mean	231.5
Median	177
Standard Deviation	315.5432
Variance	99567.5
Coefficient of Variation	1.363038
Skewness	2.01825

Normal Distribution Test	
Shapiro-Wilk Test Statisitic	0.720469
Shapiro-Wilk 5% Critical Value	0.788
Data not normal at 5% significance level	
95% UCL (Assuming Normal Distribution)	
Student's-t UCL	491.0784

Gamma Statistics Not Available

Lognormal Statistics Not Available

RECOMMENDATION	95% Non-parametric UCLs	
	CLT UCL	443.39
	Adj-CLT UCL (Adjusted for skewness)	556.803
	Mod-t UCL (Adjusted for skewness)	508.7686
	Jackknife UCL	491.0784
	Standard Bootstrap UCL	436.3204
	Bootstrap-t UCL	826.9546
	Hall's Bootstrap UCL	1451.826
Data are Non-parametric (0.05)	Percentile Bootstrap UCL	454.1667
	BCA Bootstrap UCL	514.1667
Use 95% Chebyshev (Mean, Sd) UCL	95% Chebyshev (Mean, Sd) UCL	793.0132
	97.5% Chebyshev (Mean, Sd) UCL	1035.98
	99% Chebyshev (Mean, Sd) UCL	1513.242

IA-5 ProUCL Output

Data File \\Fsmnh01\User1\PROJECTS\03886110\02\ Variable: Aluminum

Raw Statistics	
Number of Valid Samples	24
Number of Unique Samples	19
Minimum	5100
Maximum	12000
Mean	7875
Median	7700
Standard Deviation	1567.676
Variance	2457609
Coefficient of Variation	0.19907
Skewness	0.708788

Gamma Statistics	
k hat	27.38272
k star (bias corrected)	23.98766
Theta hat	287.5901
Theta star	328.2938
nu hat	1314.371
nu star	1151.408
Approx.Chi Square Value (.05)	1073.612
Adjusted Level of Significance	0.0392
Adjusted Chi Square Value	1068.344

Log-transformed Statistics	
Minimum of log data	8.536996
Maximum of log data	9.392662
Mean of log data	8.953078
Standard Deviation of log data	0.194947
Variance of log data	0.038004

RECOMMENDATION

Data are normal (0.05)

Use Student's-t UCL

Normal Distribution Test	
Shapiro-Wilk Test Statisitic	0.961731
Shapiro-Wilk 5% Critical Value	0.916
Data are normal at 5% significance level	

95% UCL (Assuming Normal Distribution)	
Student's-t UCL	8423.44

Gamma Distribution Test	
A-D Test Statistic	0.212116
A-D 5% Critical Value	0.742236
K-S Test Statistic	0.086719
K-S 5% Critical Value	0.17749
Data follow gamma distribution	
at 5% significance level	

95% UCLs (Assuming Gamma Distribution)	
Approximate Gamma UCL	8445.636
Adjusted Gamma UCL	8487.285

Lognormal Distribution Test	
Shapiro-Wilk Test Statisitic	0.985881
Shapiro-Wilk 5% Critical Value	0.916
Data are lognormal at 5% significance level	

95% UCLs (Assuming Lognormal Distribution)	
95% H-UCL	8464.263
95% Chebyshev (MVUE) UCL	9248.212
97.5% Chebyshev (MVUE) UCL	9842.994
99% Chebyshev (MVUE) UCL	11011.33

95% Non-parametric UCLs	
CLT UCL	8401.354
Adj-CLT UCL (Adjusted for skewness)	8450.824
Mod-t UCL (Adjusted for skewness)	8431.156
Jackknife UCL	8423.44
Standard Bootstrap UCL	8396.865
Bootstrap-t UCL	8480.694
Hall's Bootstrap UCL	8530.139
Percentile Bootstrap UCL	8375
BCA Bootstrap UCL	8466.667
95% Chebyshev (Mean, Sd) UCL	9269.85
97.5% Chebyshev (Mean, Sd) UCL	9873.403
99% Chebyshev (Mean, Sd) UCL	11058.97

IA-5 ProUCL Output

Data File \\Fsmnh01\User1\PROJECTS\03886110\02\ Variable: Arsenic

Raw Statistics	
Number of Valid Samples	24
Number of Unique Samples	12
Minimum	20
Maximum	38
Mean	25.95833
Median	24
Standard Deviation	5.237649
Variance	27.43297
Coefficient of Variation	0.201771
Skewness	0.915007

Gamma Statistics	
k hat	27.87056
k star (bias corrected)	24.41452
Theta hat	0.931389
Theta star	1.063234
nu hat	1337.787
nu star	1171.897
Approx.Chi Square Value (.05)	1093.402
Adjusted Level of Significance	0.0392
Adjusted Chi Square Value	1088.084

Log-transformed Statistics	
Minimum of log data	2.995732
Maximum of log data	3.637586
Mean of log data	3.238445
Standard Deviation of log data	0.190386
Variance of log data	0.036247

RECOMMENDATION

Data are Non-parametric (0.05)

Use Student's-t UCL
or Modified-t UCL

Normal Distribution Test	
Shapiro-Wilk Test Statisitic	0.858155
Shapiro-Wilk 5% Critical Value	0.916
Data not normal at 5% significance level	

95% UCL (Assuming Normal Distribution)	
Student's-t UCL	27.79069

Gamma Distribution Test	
A-D Test Statistic	1.317169
A-D 5% Critical Value	0.742233
K-S Test Statistic	0.21995
K-S 5% Critical Value	0.177489
Data do not follow gamma distribution	
at 5% significance level	

95% UCLs (Assuming Gamma Distribution)	
Approximate Gamma UCL	27.82188
Adjusted Gamma UCL	27.95784

Lognormal Distribution Test	
Shapiro-Wilk Test Statisitic	0.883602
Shapiro-Wilk 5% Critical Value	0.916
Data not lognormal at 5% significance level	

95% UCLs (Assuming Lognormal Distribution)	
95% H-UCL	27.836
95% Chebyshev (MVUE) UCL	30.36183
97.5% Chebyshev (MVUE) UCL	32.27498
99% Chebyshev (MVUE) UCL	36.033

95% Non-parametric UCLs	
CLT UCL	27.7169
Adj-CLT UCL (Adjusted for skewness)	27.93027
Mod-t UCL (Adjusted for skewness)	27.82397
Jackknife UCL	27.79069
Standard Bootstrap UCL	27.6777
Bootstrap-t UCL	28.26429
Hall's Bootstrap UCL	27.81005
Percentile Bootstrap UCL	27.83333
BCA Bootstrap UCL	27.83333
95% Chebyshev (Mean, Sd) UCL	30.61857
97.5% Chebyshev (Mean, Sd) UCL	32.63505
99% Chebyshev (Mean, Sd) UCL	36.59605

IA-5 ProUCL Output

Data File \\Fsmnh01\User1\PROJECTS\03886110\02 Variable: Chromium

Raw Statistics	
Number of Valid Samples	24
Number of Unique Samples	14
Minimum	10
Maximum	33
Mean	18
Median	17
Standard Deviation	5.34871
Variance	28.6087
Coefficient of Variation	0.297151
Skewness	1.313015

Gamma Statistics	
k hat	13.40596
k star (bias corrected)	11.75799
Theta hat	1.342686
Theta star	1.530873
nu hat	643.4861
nu star	564.3837
Approx.Chi Square Value (.05)	510.2702
Adjusted Level of Significance	0.0392
Adjusted Chi Square Value	506.6598

Log-transformed Statistics	
Minimum of log data	2.302585
Maximum of log data	3.496508
Mean of log data	2.852611
Standard Deviation of log data	0.275305
Variance of log data	0.075793

RECOMMENDATION

Data are lognormal (0.05)

Use Student's-t UCL

Use Modified-t UCL

Use H-UCL

Normal Distribution Test	
Shapiro-Wilk Test Statisitic	0.879017
Shapiro-Wilk 5% Critical Value	0.916
Data not normal at 5% significance level	

95% UCL (Assuming Normal Distribution)	
Student's-t UCL	19.87121

Gamma Distribution Test	
A-D Test Statistic	0.786651
A-D 5% Critical Value	0.743632
K-S Test Statistic	0.213668
K-S 5% Critical Value	0.177672
Data do not follow gamma distribution at 5% significance level	

95% UCLs (Assuming Gamma Distribution)	
Approximate Gamma UCL	19.90887
Adjusted Gamma UCL	20.05074

Lognormal Distribution Test	
Shapiro-Wilk Test Statisitic	0.948778
Shapiro-Wilk 5% Critical Value	0.916
Data are lognormal at 5% significance level	

95% UCLs (Assuming Lognormal Distribution)	
95% H-UCL	19.96829
95% Chebyshev (MVUE) UCL	22.43204
97.5% Chebyshev (MVUE) UCL	24.36143
99% Chebyshev (MVUE) UCL	28.15134

95% Non-parametric UCLs	
CLT UCL	19.79585
Adj-CLT UCL (Adjusted for skewness)	20.10852
Mod-t UCL (Adjusted for skewness)	19.91998
Jackknife UCL	19.87121
Standard Bootstrap UCL	19.76728
Bootstrap-t UCL	20.53012
Hall's Bootstrap UCL	20.63845
Percentile Bootstrap UCL	19.875
BCA Bootstrap UCL	19.91667
95% Chebyshev (Mean, Sd) UCL	22.75905
97.5% Chebyshev (Mean, Sd) UCL	24.81829
99% Chebyshev (Mean, Sd) UCL	28.86328

IA-5 ProUCL Output

Data File \\Fsmnh01\User1\PROJECTS\03886110\02\ Variable: Iron

Raw Statistics	
Number of Valid Samples	24
Number of Unique Samples	13
Minimum	7400
Maximum	15000
Mean	10737.5
Median	11000
Standard Deviation	1870.32
Variance	3498098
Coefficient of Variation	0.174186
Skewness	0.503776

Gamma Statistics	
k hat	35.15545
k star (bias corrected)	30.7888
Theta hat	305.4292
Theta star	348.747
nu hat	1687.462
nu star	1477.862
Approx.Chi Square Value (.05)	1389.57
Adjusted Level of Significance	0.0392
Adjusted Chi Square Value	1383.567

Log-transformed Statistics	
Minimum of log data	8.909235
Maximum of log data	9.615805
Mean of log data	9.267208
Standard Deviation of log data	0.172371
Variance of log data	0.029712

RECOMMENDATION

Data are normal (0.05)

Use Student's-t UCL

Normal Distribution Test	
Shapiro-Wilk Test Statisitic	0.956461
Shapiro-Wilk 5% Critical Value	0.916
Data are normal at 5% significance level	

95% UCL (Assuming Normal Distribution)	
Student's-t UCL	11391.82

Gamma Distribution Test	
A-D Test Statistic	0.410901
A-D 5% Critical Value	0.742189
K-S Test Statistic	0.170768
K-S 5% Critical Value	0.177459
Data follow gamma distribution	
at 5% significance level	

95% UCLs (Assuming Gamma Distribution)	
Approximate Gamma UCL	11419.75
Adjusted Gamma UCL	11469.3

Lognormal Distribution Test	
Shapiro-Wilk Test Statisitic	0.972157
Shapiro-Wilk 5% Critical Value	0.916
Data are lognormal at 5% significance level	

95% UCLs (Assuming Lognormal Distribution)	
95% H-UCL	11440.3
95% Chebyshev (MVUE) UCL	12391.91
97.5% Chebyshev (MVUE) UCL	13108.06
99% Chebyshev (MVUE) UCL	14514.79

95% Non-parametric UCLs	
CLT UCL	11365.47
Adj-CLT UCL (Adjusted for skewness)	11407.42
Mod-t UCL (Adjusted for skewness)	11398.36
Jackknife UCL	11391.82
Standard Bootstrap UCL	11352.16
Bootstrap-t UCL	11476.39
Hall's Bootstrap UCL	11441.5
Percentile Bootstrap UCL	11362.5
BCA Bootstrap UCL	11400
95% Chebyshev (Mean, Sd) UCL	12401.63
97.5% Chebyshev (Mean, Sd) UCL	13121.7
99% Chebyshev (Mean, Sd) UCL	14536.14

IA-5 ProUCL Output

Data File C:\Documents and Settings\schmidlj\Desktop Variable: Lead

Raw Statistics	
Number of Valid Samples	49
Number of Unique Samples	44
Minimum	6.60E+00
Maximum	2.03E+02
Mean	3.57E+01
Median	1.90E+01
Standard Deviation	4.61E+01
Variance	2124.8279
Coefficient of Variation	1.2927524
Skewness	2.7462393

Gamma Statistics	
k hat	1.1539988
k star (bias corrected)	1.0969513
Theta hat	3.09E+01
Theta star	3.25E+01
nu hat	113.09188
nu star	107.50122
Approx.Chi Square Value (.05)	84.567675
Adjusted Level of Significance	0.045102
Adjusted Chi Square Value	83.951557

Log-transformed Statistics	
Minimum of log data	1.8870696
Maximum of log data	5.313206
Mean of log data	3.0817571
Standard Deviation of log data	0.9249243
Variance of log data	0.855485

RECOMMENDATION

Data are Non-parametric (0.05)

Use 95% Chebyshev (Mean, Sd) UCL

Normal Distribution Test	
Shapiro-Wilk Test Statisitic	0.6097508
Shapiro-Wilk 5% Critical Value	0.947
Data not normal at 5% significance level	

95% UCL (Assuming Normal Distribution)	
Student's-t UCL	4.67E+01

Gamma Distribution Test	
A-D Test Statistic	2.1401895
A-D 5% Critical Value	0.7756503
K-S Test Statistic	0.1569219
K-S 5% Critical Value	0.1298246
Data do not follow gamma distribution	
at 5% significance level	

95% UCLs (Assuming Gamma Distribution)	
Approximate Gamma UCL	4.53E+01
Adjusted Gamma UCL	4.57E+01

Lognormal Distribution Test	
Shapiro-Wilk Test Statisitic	0.9196793
Shapiro-Wilk 5% Critical Value	0.947
Data not lognormal at 5% significance level	

95% UCLs (Assuming Lognormal Distribution)	
95% H-UCL	4.51E+01
95% Chebyshev (MVUE) UCL	5.50E+01
97.5% Chebyshev (MVUE) UCL	6.45E+01
99% Chebyshev (MVUE) UCL	8.31E+01

95% Non-parametric UCLs	
CLT UCL	4.65E+01
Adj-CLT UCL (Adjusted for skewness)	49.249185
Mod-t UCL (Adjusted for skewness)	47.132447
Jackknife UCL	4.67E+01
Standard Bootstrap UCL	4.65E+01
Bootstrap-t UCL	52.505189
Hall's Bootstrap UCL	48.644162
Percentile Bootstrap UCL	4.75E+01
BCA Bootstrap UCL	4.89E+01
95% Chebyshev (Mean, Sd) UCL	6.44E+01
97.5% Chebyshev (Mean, Sd) UCL	7.68E+01
99% Chebyshev (Mean, Sd) UCL	1.01E+02

IA-5 ProUCL Output

Data File \\Fsmnh01\User1\PROJECTS\03886110\02 Variable: Aluminum

Raw Statistics	
Number of Valid Samples	24
Number of Unique Samples	19
Minimum	5100
Maximum	12000
Mean	7875
Median	7700
Standard Deviation	1567.676
Variance	2457609
Coefficient of Variation	0.19907
Skewness	0.708788

Gamma Statistics	
k hat	27.38272
k star (bias corrected)	23.98766
Theta hat	287.5901
Theta star	328.2938
nu hat	1314.371
nu star	1151.408
Approx.Chi Square Value (.05)	1073.612
Adjusted Level of Significance	0.0392
Adjusted Chi Square Value	1068.344

Log-transformed Statistics	
Minimum of log data	8.536996
Maximum of log data	9.392662
Mean of log data	8.953078
Standard Deviation of log data	0.194947
Variance of log data	0.038004

RECOMMENDATION

Data are normal (0.05)

Use Student's-t UCL

Normal Distribution Test	
Shapiro-Wilk Test Statisitic	0.961731
Shapiro-Wilk 5% Critical Value	0.916
Data are normal at 5% significance level	

95% UCL (Assuming Normal Distribution)	
Student's-t UCL	8423.44

Gamma Distribution Test	
A-D Test Statistic	0.212116
A-D 5% Critical Value	0.742236
K-S Test Statistic	0.086719
K-S 5% Critical Value	0.17749
Data follow gamma distribution	
at 5% significance level	

95% UCLs (Assuming Gamma Distribution)	
Approximate Gamma UCL	8445.636
Adjusted Gamma UCL	8487.285

Lognormal Distribution Test	
Shapiro-Wilk Test Statisitic	0.985881
Shapiro-Wilk 5% Critical Value	0.916
Data are lognormal at 5% significance level	

95% UCLs (Assuming Lognormal Distribution)	
95% H-UCL	8464.263
95% Chebyshev (MVUE) UCL	9248.212
97.5% Chebyshev (MVUE) UCL	9842.994
99% Chebyshev (MVUE) UCL	11011.33

95% Non-parametric UCLs	
CLT UCL	8401.354
Adj-CLT UCL (Adjusted for skewness)	8450.824
Mod-t UCL (Adjusted for skewness)	8431.156
Jackknife UCL	8423.44
Standard Bootstrap UCL	8402.748
Bootstrap-t UCL	8490.135
Hall's Bootstrap UCL	8504.178
Percentile Bootstrap UCL	8408.333
BCA Bootstrap UCL	8450
95% Chebyshev (Mean, Sd) UCL	9269.85
97.5% Chebyshev (Mean, Sd) UCL	9873.403
99% Chebyshev (Mean, Sd) UCL	11058.97

IA-5 ProUCL Output

Data File \\Fsmnh01\User1\PROJECTS\03886110\02\ Variable: Nickel

Raw Statistics	
Number of Valid Samples	24
Number of Unique Samples	15
Minimum	12
Maximum	52
Mean	21.16667
Median	20
Standard Deviation	7.976415
Variance	63.62319
Coefficient of Variation	0.376838
Skewness	2.60856

Gamma Statistics	
k hat	10.01772
k star (bias corrected)	8.793283
Theta hat	2.112922
Theta star	2.40714
nu hat	480.8506
nu star	422.0776
Approx.Chi Square Value (.05)	375.4416
Adjusted Level of Significance	0.0392
Adjusted Chi Square Value	372.3545

Log-transformed Statistics	
Minimum of log data	2.484907
Maximum of log data	3.951244
Mean of log data	3.001686
Standard Deviation of log data	0.308217
Variance of log data	0.094997

RECOMMENDATION

Data follow gamma distribution (0.05)

Use Approximate Gamma UCL

Normal Distribution Test	
Shapiro-Wilk Test Statisitic	0.757806
Shapiro-Wilk 5% Critical Value	0.916
Data not normal at 5% significance level	

95% UCL (Assuming Normal Distribution)	
Student's-t UCL	23.95716

Gamma Distribution Test	
A-D Test Statistic	0.647132
A-D 5% Critical Value	0.744326
K-S Test Statistic	0.138163
K-S 5% Critical Value	0.17775
Data follow gamma distribution	
at 5% significance level	

95% UCLs (Assuming Gamma Distribution)	
Approximate Gamma UCL	23.79592
Adjusted Gamma UCL	23.9932

Lognormal Distribution Test	
Shapiro-Wilk Test Statisitic	0.929705
Shapiro-Wilk 5% Critical Value	0.916
Data are lognormal at 5% significance level	

95% UCLs (Assuming Lognormal Distribution)	
95% H-UCL	23.72565
95% Chebyshev (MVUE) UCL	26.92084
97.5% Chebyshev (MVUE) UCL	29.45912
99% Chebyshev (MVUE) UCL	34.44509

95% Non-parametric UCLs	
CLT UCL	23.84478
Adj-CLT UCL (Adjusted for skewness)	24.77114
Mod-t UCL (Adjusted for skewness)	24.10165
Jackknife UCL	23.95716
Standard Bootstrap UCL	23.85191
Bootstrap-t UCL	25.64392
Hall's Bootstrap UCL	36.80749
Percentile Bootstrap UCL	23.91667
BCA Bootstrap UCL	24.79167
95% Chebyshev (Mean, Sd) UCL	28.26373
97.5% Chebyshev (Mean, Sd) UCL	31.33464
99% Chebyshev (Mean, Sd) UCL	37.36684

IA-5 ProUCL Output

Data File \\Fsmnh01\User1\PROJECTS\03886110\02\ Variable: Total PCBs

Raw Statistics	
Number of Valid Samples	32
Number of Unique Samples	21
Minimum	2.1222224
Maximum	288.0005
Mean	54.09379
Median	0.00E+00
Standard Deviation	103.6255
Variance	10738.24
Coefficient of Variation	1.915663
Skewness	1.541081

Gamma Statistics	
k hat	0.001849
k star (bias corrected)	0.022509
Theta hat	29260.3
Theta star	2403.236
nu hat	0.118317
nu star	1.440558
Approx.Chi Square Value (.05)	0.117622
Adjusted Level of Significance	0.0416
Adjusted Chi Square Value	0.117121

Log-transformed Statistics	
Minimum of log data	-722.259
Maximum of log data	5.662962
Mean of log data	-531.36
Standard Deviation of log data	314.7612
Variance of log data	99074.61

RECOMMENDATION

Data are Non-parametric (0.05)

Use Hall's Bootstrap UCL

In case Hall's Bootstrap method yields an erratic, unreasonably large UCL value, use 99% Chebyshev (Mean, Sd) UCL

Normal Distribution Test	
Shapiro-Wilk Test Statisitic	0.553726
Shapiro-Wilk 5% Critical Value	0.93
Data not normal at 5% significance level	

95% UCL (Assuming Normal Distribution)	
Student's-t UCL	85.153259

Gamma Distribution Test	
A-D Test Statistic	10.707809
A-D 5% Critical Value	2.51E-302
K-S Test Statistic	0.4848784
K-S 5% Critical Value	2.970816057E-312
Data do not follow gamma distribution at 5% significance level	

95% UCLs (Assuming Gamma Distribution)	
Approximate Gamma UCL	662.50323
Adjusted Gamma UCL	665.34257

Lognormal Distribution Test	
Shapiro-Wilk Test Statisitic	0.5433102
Shapiro-Wilk 5% Critical Value	0.93
Data not lognormal at 5% significance level	

95% UCLs (Assuming Lognormal Distribution)	
95% H-UCL	N/A
95% Chebyshev (MVUE) UCL	4.80E-128
97.5% Chebyshev (MVUE) UCL	6.48E-128
99% Chebyshev (MVUE) UCL	9.80E-128

95% Non-parametric UCLs	
CLT UCL	84.225152
Adj-CLT UCL (Adjusted for skewness)	89.557547
Mod-t UCL (Adjusted for skewness)	85.985005
Jackknife UCL	85.153259
Standard Bootstrap UCL	83.471248
Bootstrap-t UCL	95.300965
Hall's Bootstrap UCL	83.441671
Percentile Bootstrap UCL	82.593823
BCA Bootstrap UCL	89.093831
95% Chebyshev (Mean, Sd) UCL	133.94257
97.5% Chebyshev (Mean, Sd) UCL	168.4932
99% Chebyshev (Mean, Sd) UCL	236.36122

IA-6 ProUCL Output

Data File C:\Documents and Settings\schmidlj\Deskto Variable: Aluminum

Raw Statistics	
Number of Valid Samples	63
Number of Unique Samples	48
Minimum	3930
Maximum	14600
Mean	9691.429
Median	10100
Standard Deviation	2324.057
Variance	5401241
Coefficient of Variation	0.239805
Skewness	-0.45381

Gamma Statistics	
k hat	14.97277
k star (bias corrected)	14.27036
Theta hat	647.2704
Theta star	679.13
nu hat	1886.569
nu star	1798.065
Approx.Chi Square Value (.05)	1700.556
Adjusted Level of Significance	0.04619
Adjusted Chi Square Value	1698.354

Log-transformed Statistics	
Minimum of log data	8.276395
Maximum of log data	9.588777
Mean of log data	9.145232
Standard Deviation of log data	0.276251
Variance of log data	0.076314

RECOMMENDATION

Data are normal (0.05)

Use Student's-t UCL

Normal Distribution Test	
Lilliefors Test Statisitic	0.09985
Lilliefors 5% Critical Value	0.111626
Data are normal at 5% significance level	

95% UCL (Assuming Normal Distribution)	
Student's-t UCL	10180.35

Gamma Distribution Test	
A-D Test Statistic	1.436639
A-D 5% Critical Value	0.750016
K-S Test Statistic	0.130284
K-S 5% Critical Value	0.112059
Data do not follow gamma distribution	
at 5% significance level	

95% UCLs (Assuming Gamma Distribution)	
Approximate Gamma UCL	10247.13
Adjusted Gamma UCL	10260.41

Lognormal Distribution Test	
Lilliefors Test Statisitic	0.141663
Lilliefors 5% Critical Value	0.111626
Data not lognormal at 5% significance level	

95% UCLs (Assuming Lognormal Distribution)	
95% H-UCL	10346.87
95% Chebyshev (MVUE) UCL	11228.13
97.5% Chebyshev (MVUE) UCL	11877.24
99% Chebyshev (MVUE) UCL	13152.3

95% Non-parametric UCLs	
CLT UCL	10173.05
Adj-CLT UCL (Adjusted for skewness)	10155.16
Mod-t UCL (Adjusted for skewness)	10177.56
Jackknife UCL	10180.35
Standard Bootstrap UCL	10182.4
Bootstrap-t UCL	10162.34
Hall's Bootstrap UCL	10153.97
Percentile Bootstrap UCL	10157.62
BCA Bootstrap UCL	10133.33
95% Chebyshev (Mean, Sd) UCL	10967.73
97.5% Chebyshev (Mean, Sd) UCL	11519.99
99% Chebyshev (Mean, Sd) UCL	12604.79

IA-6 ProUCL Output

Data File C:\Documents and Settings\schmidlj\Deskto Variable: Antimony

Raw Statistics	
Number of Valid Samples	63
Number of Unique Samples	41
Minimum	0.12
Maximum	10
Mean	1.120159
Median	0.86
Standard Deviation	1.302265
Variance	1.695895
Coefficient of Variation	1.162572
Skewness	5.276856

Gamma Statistics	
k hat	1.567374
k star (bias corrected)	1.503319
Theta hat	0.714672
Theta star	0.745124
nu hat	197.4891
nu star	189.4182
Approx.Chi Square Value (.05)	158.5737
Adjusted Level of Significance	0.04619
Adjusted Chi Square Value	157.9159

Log-transformed Statistics	
Minimum of log data	-2.12026
Maximum of log data	2.302585
Mean of log data	-0.23827
Standard Deviation of log data	0.837943
Variance of log data	0.702149

RECOMMENDATION

Data follow gamma distribution (0.05)

Use Approximate Gamma UCL

Normal Distribution Test	
Lilliefors Test Statisitic	0.221239
Lilliefors 5% Critical Value	0.111626
Data not normal at 5% significance level	

95% UCL (Assuming Normal Distribution)	
Student's-t UCL	1.394123

Gamma Distribution Test	
A-D Test Statistic	0.556714
A-D 5% Critical Value	0.768104
K-S Test Statistic	0.066457
K-S 5% Critical Value	0.114211
Data follow gamma distribution	
at 5% significance level	

95% UCLs (Assuming Gamma Distribution)	
Approximate Gamma UCL	1.338043
Adjusted Gamma UCL	1.343617

Lognormal Distribution Test	
Lilliefors Test Statisitic	0.085206
Lilliefors 5% Critical Value	0.111626
Data are lognormal at 5% significance level	

95% UCLs (Assuming Lognormal Distribution)	
95% H-UCL	1.402346
95% Chebyshev (MVUE) UCL	1.69219
97.5% Chebyshev (MVUE) UCL	1.943609
99% Chebyshev (MVUE) UCL	2.437473

95% Non-parametric UCLs	
CLT UCL	1.39003
Adj-CLT UCL (Adjusted for skewness)	1.506581
Mod-t UCL (Adjusted for skewness)	1.412303
Jackknife UCL	1.394123
Standard Bootstrap UCL	1.384675
Bootstrap-t UCL	1.638201
Hall's Bootstrap UCL	2.575142
Percentile Bootstrap UCL	1.402778
BCA Bootstrap UCL	1.570794
95% Chebyshev (Mean, Sd) UCL	1.835323
97.5% Chebyshev (Mean, Sd) UCL	2.144776
99% Chebyshev (Mean, Sd) UCL	2.752635

IA-6 ProUCL Output

Data File C:\Documents and Settings\schmidlj\Deskto Variable: Arsenic

Raw Statistics	
Number of Valid Samples	63
Number of Unique Samples	56
Minimum	8.3
Maximum	46.1
Mean	21.34762
Median	17.5
Standard Deviation	9.876852
Variance	97.55221
Coefficient of Variation	0.462668
Skewness	0.772959

Gamma Statistics	
k hat	5.098986
k star (bias corrected)	4.866759
Theta hat	4.18664
Theta star	4.386414
nu hat	642.4723
nu star	613.2117
Approx.Chi Square Value (.05)	556.7559
Adjusted Level of Significance	0.04619
Adjusted Chi Square Value	555.505

Log-transformed Statistics	
Minimum of log data	2.116256
Maximum of log data	3.830813
Mean of log data	2.959688
Standard Deviation of log data	0.451796
Variance of log data	0.204119

RECOMMENDATION

Data are lognormal (0.05)

Use Student's-t UCL

Use Modified-t UCL

Use H-UCL

Normal Distribution Test	
Lilliefors Test Statisitic	0.168533
Lilliefors 5% Critical Value	0.111626
Data not normal at 5% significance level	

95% UCL (Assuming Normal Distribution)	
Student's-t UCL	23.42547

Gamma Distribution Test	
A-D Test Statistic	1.115717
A-D 5% Critical Value	0.753544
K-S Test Statistic	0.126334
K-S 5% Critical Value	0.112512
Data do not follow gamma distribution at 5% significance level	

95% UCLs (Assuming Gamma Distribution)	
Approximate Gamma UCL	23.5123
Adjusted Gamma UCL	23.56524

Lognormal Distribution Test	
Lilliefors Test Statisitic	0.0994
Lilliefors 5% Critical Value	0.111626
Data are lognormal at 5% significance level	

95% UCLs (Assuming Lognormal Distribution)	
95% H-UCL	23.72977
95% Chebyshev (MVUE) UCL	26.84648
97.5% Chebyshev (MVUE) UCL	29.23479
99% Chebyshev (MVUE) UCL	33.92616

95% Non-parametric UCLs	
CLT UCL	23.39442
Adj-CLT UCL (Adjusted for skewness)	23.5239
Mod-t UCL (Adjusted for skewness)	23.44566
Jackknife UCL	23.42547
Standard Bootstrap UCL	23.37862
Bootstrap-t UCL	23.65939
Hall's Bootstrap UCL	23.4752
Percentile Bootstrap UCL	23.4619
BCA Bootstrap UCL	23.45397
95% Chebyshev (Mean, Sd) UCL	26.77169
97.5% Chebyshev (Mean, Sd) UCL	29.11868
99% Chebyshev (Mean, Sd) UCL	33.72891

IA-6 ProUCL Output

Data File C:\Documents and Settings\schmidlj\Deskto Variable: Beryllium

Raw Statistics	
Number of Valid Samples	63
Number of Unique Samples	33
Minimum	0.18
Maximum	1.1
Mean	0.40619
Median	0.37
Standard Deviation	0.163751
Variance	0.026814
Coefficient of Variation	0.403138
Skewness	2.412699

Gamma Statistics	
k hat	8.598648
k star (bias corrected)	8.19977
Theta hat	0.047239
Theta star	0.049537
nu hat	1083.43
nu star	1033.171
Approx.Chi Square Value (.05)	959.5396
Adjusted Level of Significance	0.04619
Adjusted Chi Square Value	957.8908

Log-transformed Statistics	
Minimum of log data	-1.7148
Maximum of log data	0.09531
Mean of log data	-0.96021
Standard Deviation of log data	0.328887
Variance of log data	0.108167

RECOMMENDATION

Data are Non-parametric (0.05)

Use Student's-t UCL
or Modified-t UCL

Normal Distribution Test	
Lilliefors Test Statisitic	0.235848
Lilliefors 5% Critical Value	0.111626
Data not normal at 5% significance level	

95% UCL (Assuming Normal Distribution)	
Student's-t UCL	0.44064

Gamma Distribution Test	
A-D Test Statistic	2.462601
A-D 5% Critical Value	0.751749
K-S Test Statistic	0.182595
K-S 5% Critical Value	0.112283
Data do not follow gamma distribution	
at 5% significance level	

95% UCLs (Assuming Gamma Distribution)	
Approximate Gamma UCL	0.43736
Adjusted Gamma UCL	0.438113

Lognormal Distribution Test	
Lilliefors Test Statisitic	0.155535
Lilliefors 5% Critical Value	0.111626
Data not lognormal at 5% significance level	

95% UCLs (Assuming Lognormal Distribution)	
95% H-UCL	0.434986
95% Chebyshev (MVUE) UCL	0.478335
97.5% Chebyshev (MVUE) UCL	0.51062
99% Chebyshev (MVUE) UCL	0.574038

95% Non-parametric UCLs	
CLT UCL	0.440125
Adj-CLT UCL (Adjusted for skewness)	0.446826
Mod-t UCL (Adjusted for skewness)	0.441685
Jackknife UCL	0.44064
Standard Bootstrap UCL	0.439882
Bootstrap-t UCL	0.450272
Hall's Bootstrap UCL	0.45529
Percentile Bootstrap UCL	0.439365
BCA Bootstrap UCL	0.447143
95% Chebyshev (Mean, Sd) UCL	0.496117
97.5% Chebyshev (Mean, Sd) UCL	0.535029
99% Chebyshev (Mean, Sd) UCL	0.611463

IA-6 ProUCL Output

Data File C:\Documents and Settings\schmidlj\Deskto Variable: Chromium

Raw Statistics	
Number of Valid Samples	63
Number of Unique Samples	59
Minimum	9.8
Maximum	60.7
Mean	24.02381
Median	22.2
Standard Deviation	11.33301
Variance	128.437
Coefficient of Variation	0.471741
Skewness	0.911835

Gamma Statistics	
k hat	4.902729
k star (bias corrected)	4.679847
Theta hat	4.90009
Theta star	5.13346
nu hat	617.7438
nu star	589.6608
Approx.Chi Square Value (.05)	534.3226
Adjusted Level of Significance	0.04619
Adjusted Chi Square Value	533.0976

Log-transformed Statistics	
Minimum of log data	2.282382
Maximum of log data	4.105944
Mean of log data	3.073609
Standard Deviation of log data	0.462591
Variance of log data	0.213991

RECOMMENDATION

Data are Non-parametric (0.05)

Use Student's-t UCL
or Modified-t UCL

Normal Distribution Test	
Lilliefors Test Statisitic	0.163763
Lilliefors 5% Critical Value	0.111626
Data not normal at 5% significance level	

95% UCL (Assuming Normal Distribution)	
Student's-t UCL	26.408

Gamma Distribution Test	
A-D Test Statistic	1.177274
A-D 5% Critical Value	0.753652
K-S Test Statistic	0.147783
K-S 5% Critical Value	0.112529
Data do not follow gamma distribution	
at 5% significance level	

95% UCLs (Assuming Gamma Distribution)	
Approximate Gamma UCL	26.51188
Adjusted Gamma UCL	26.5728

Lognormal Distribution Test	
Lilliefors Test Statisitic	0.131356
Lilliefors 5% Critical Value	0.111626
Data not lognormal at 5% significance level	

95% UCLs (Assuming Lognormal Distribution)	
95% H-UCL	26.80183
95% Chebyshev (MVUE) UCL	30.39262
97.5% Chebyshev (MVUE) UCL	33.15166
99% Chebyshev (MVUE) UCL	38.57126

95% Non-parametric UCLs	
CLT UCL	26.37237
Adj-CLT UCL (Adjusted for skewness)	26.54764
Mod-t UCL (Adjusted for skewness)	26.43533
Jackknife UCL	26.408
Standard Bootstrap UCL	26.34263
Bootstrap-t UCL	26.55769
Hall's Bootstrap UCL	26.71426
Percentile Bootstrap UCL	26.41111
BCA Bootstrap UCL	26.64444
95% Chebyshev (Mean, Sd) UCL	30.24755
97.5% Chebyshev (Mean, Sd) UCL	32.94057
99% Chebyshev (Mean, Sd) UCL	38.23048

IA-6 ProUCL Output

Data File C:\Documents and Settings\schmidlj\Deskto Variable: Iron

Raw Statistics	
Number of Valid Samples	63
Number of Unique Samples	57
Minimum	6930
Maximum	24800
Mean	13896.51
Median	13100
Standard Deviation	4380.574
Variance	19189426
Coefficient of Variation	0.315228
Skewness	0.387511

Gamma Statistics	
k hat	10.21615
k star (bias corrected)	9.74025
Theta hat	1360.249
Theta star	1426.71
nu hat	1287.235
nu star	1227.271
Approx.Chi Square Value (.05)	1146.916
Adjusted Level of Significance	0.04619
Adjusted Chi Square Value	1145.111

Log-transformed Statistics	
Minimum of log data	8.843615
Maximum of log data	10.1186
Mean of log data	9.489653
Standard Deviation of log data	0.32054
Variance of log data	0.102746

RECOMMENDATION

Data are normal (0.05)

Use Student's-t UCL

Normal Distribution Test	
Lilliefors Test Statisitic	0.096584
Lilliefors 5% Critical Value	0.111626
Data are normal at 5% significance level	

95% UCL (Assuming Normal Distribution)	
Student's-t UCL	14818.07

Gamma Distribution Test	
A-D Test Statistic	0.658898
A-D 5% Critical Value	0.750986
K-S Test Statistic	0.090619
K-S 5% Critical Value	0.112185
Data follow gamma distribution	
at 5% significance level	

95% UCLs (Assuming Gamma Distribution)	
Approximate Gamma UCL	14870.13
Adjusted Gamma UCL	14893.56

Lognormal Distribution Test	
Lilliefors Test Statisitic	0.095513
Lilliefors 5% Critical Value	0.111626
Data are lognormal at 5% significance level	

95% UCLs (Assuming Lognormal Distribution)	
95% H-UCL	14953.14
95% Chebyshev (MVUE) UCL	16409.53
97.5% Chebyshev (MVUE) UCL	17492.23
99% Chebyshev (MVUE) UCL	19619

95% Non-parametric UCLs	
CLT UCL	14804.3
Adj-CLT UCL (Adjusted for skewness)	14833.09
Mod-t UCL (Adjusted for skewness)	14822.56
Jackknife UCL	14818.07
Standard Bootstrap UCL	14792.05
Bootstrap-t UCL	14829.53
Hall's Bootstrap UCL	14806.39
Percentile Bootstrap UCL	14839.05
BCA Bootstrap UCL	14838.89
95% Chebyshev (Mean, Sd) UCL	16302.19
97.5% Chebyshev (Mean, Sd) UCL	17343.12
99% Chebyshev (Mean, Sd) UCL	19387.85

IA-6 ProUCL Output

Data File C:\Documents and Settings\schmidlj\Deskto Variable: Lead

Raw Statistics	
Number of Valid Samples	63
Number of Unique Samples	62
Minimum	3
Maximum	643
Mean	75.31111
Median	41.5
Standard Deviation	104.9228
Variance	11008.8
Coefficient of Variation	1.393192
Skewness	3.471995

Gamma Statistics	
k hat	0.942549
k star (bias corrected)	0.908248
Theta hat	79.90153
Theta star	82.91913
nu hat	118.7612
nu star	114.4392
Approx.Chi Square Value (.05)	90.73781
Adjusted Level of Significance	0.04619
Adjusted Chi Square Value	90.24507

Log-transformed Statistics	
Minimum of log data	1.098612
Maximum of log data	6.466145
Mean of log data	3.704892
Standard Deviation of log data	1.125219
Variance of log data	1.266117

RECOMMENDATION

Data are lognormal (0.05)

Use H-UCL

Normal Distribution Test	
Lilliefors Test Statisitic	0.268807
Lilliefors 5% Critical Value	0.111626
Data not normal at 5% significance level	

95% UCL (Assuming Normal Distribution)	
Student's-t UCL	97.3843

Gamma Distribution Test	
A-D Test Statistic	1.269828
A-D 5% Critical Value	0.782455
K-S Test Statistic	0.162194
K-S 5% Critical Value	0.115738
Data do not follow gamma distribution	
at 5% significance level	

95% UCLs (Assuming Gamma Distribution)	
Approximate Gamma UCL	94.98295
Adjusted Gamma UCL	95.50155

Lognormal Distribution Test	
Lilliefors Test Statisitic	0.08209
Lilliefors 5% Critical Value	0.111626
Data are lognormal at 5% significance level	

95% UCLs (Assuming Lognormal Distribution)	
95% H-UCL	107.8312
95% Chebyshev (MVUE) UCL	132.3973
97.5% Chebyshev (MVUE) UCL	157.0869
99% Chebyshev (MVUE) UCL	205.5848

95% Non-parametric UCLs	
CLT UCL	97.05448
Adj-CLT UCL (Adjusted for skewness)	103.2331
Mod-t UCL (Adjusted for skewness)	98.34804
Jackknife UCL	97.3843
Standard Bootstrap UCL	96.51881
Bootstrap-t UCL	110.9348
Hall's Bootstrap UCL	134.5618
Percentile Bootstrap UCL	99.41905
BCA Bootstrap UCL	104.6254
95% Chebyshev (Mean, Sd) UCL	132.9315
97.5% Chebyshev (Mean, Sd) UCL	157.8639
99% Chebyshev (Mean, Sd) UCL	206.8388

IA-6 ProUCL Output

Data File C:\Documents and Settings\schmidlj\Deskto Variable: Manganese

Raw Statistics	
Number of Valid Samples	63
Number of Unique Samples	57
Minimum	54.4
Maximum	808
Mean	230.3381
Median	195
Standard Deviation	138.6698
Variance	19229.31
Coefficient of Variation	0.602027
Skewness	1.461091

Gamma Statistics	
k hat	3.099962
k star (bias corrected)	2.962927
Theta hat	74.30352
Theta star	77.74006
nu hat	390.5952
nu star	373.3288
Approx.Chi Square Value (.05)	329.5395
Adjusted Level of Significance	0.04619
Adjusted Chi Square Value	328.582

Log-transformed Statistics	
Minimum of log data	3.996364
Maximum of log data	6.694562
Mean of log data	5.26967
Standard Deviation of log data	0.598086
Variance of log data	0.357707

RECOMMENDATION

Data follow gamma distribution (0.05)

Use Approximate Gamma UCL

Normal Distribution Test	
Lilliefors Test Statisitic	0.135893
Lilliefors 5% Critical Value	0.111626
Data not normal at 5% significance level	

95% UCL (Assuming Normal Distribution)	
Student's-t UCL	259.5108

Gamma Distribution Test	
A-D Test Statistic	0.505344
A-D 5% Critical Value	0.757494
K-S Test Statistic	0.083586
K-S 5% Critical Value	0.113004
Data follow gamma distribution	
at 5% significance level	

95% UCLs (Assuming Gamma Distribution)	
Approximate Gamma UCL	260.9455
Adjusted Gamma UCL	261.7059

Lognormal Distribution Test	
Lilliefors Test Statisitic	0.092141
Lilliefors 5% Critical Value	0.111626
Data are lognormal at 5% significance level	

95% UCLs (Assuming Lognormal Distribution)	
95% H-UCL	269.0086
95% Chebyshev (MVUE) UCL	313.3234
97.5% Chebyshev (MVUE) UCL	348.666
99% Chebyshev (MVUE) UCL	418.0895

95% Non-parametric UCLs	
CLT UCL	259.0749
Adj-CLT UCL (Adjusted for skewness)	262.5113
Mod-t UCL (Adjusted for skewness)	260.0468
Jackknife UCL	259.5108
Standard Bootstrap UCL	259.4822
Bootstrap-t UCL	264.2662
Hall's Bootstrap UCL	266.0592
Percentile Bootstrap UCL	259.0794
BCA Bootstrap UCL	262.754
95% Chebyshev (Mean, Sd) UCL	306.4913
97.5% Chebyshev (Mean, Sd) UCL	339.4429
99% Chebyshev (Mean, Sd) UCL	404.1699

IA-6 ProUCL Output

Data File C:\Documents and Settings\schmidlj\Deskto Variable: Nickel

Raw Statistics	
Number of Valid Samples	63
Number of Unique Samples	59
Minimum	7.9
Maximum	50.6
Mean	21.79048
Median	18.3
Standard Deviation	10.49456
Variance	110.1357
Coefficient of Variation	0.481612
Skewness	0.691676

Gamma Statistics	
k hat	4.576994
k star (bias corrected)	4.369623
Theta hat	4.760871
Theta star	4.986809
nu hat	576.7012
nu star	550.5726
Approx.Chi Square Value (.05)	497.1399
Adjusted Level of Significance	0.04619
Adjusted Chi Square Value	495.9591

Log-transformed Statistics	
Minimum of log data	2.066863
Maximum of log data	3.923952
Mean of log data	2.968272
Standard Deviation of log data	0.481879
Variance of log data	0.232208

RECOMMENDATION

Data are Non-parametric (0.05)

Use Student's-t UCL
or Modified-t UCL

Normal Distribution Test	
Lilliefors Test Statisitic	0.178621
Lilliefors 5% Critical Value	0.111626
Data not normal at 5% significance level	

95% UCL (Assuming Normal Distribution)	
Student's-t UCL	23.99827

Gamma Distribution Test	
A-D Test Statistic	1.522464
A-D 5% Critical Value	0.753842
K-S Test Statistic	0.128035
K-S 5% Critical Value	0.112565
Data do not follow gamma distribution	
at 5% significance level	

95% UCLs (Assuming Gamma Distribution)	
Approximate Gamma UCL	24.13252
Adjusted Gamma UCL	24.18998

Lognormal Distribution Test	
Lilliefors Test Statisitic	0.129584
Lilliefors 5% Critical Value	0.111626
Data not lognormal at 5% significance level	

95% UCLs (Assuming Lognormal Distribution)	
95% H-UCL	24.47015
95% Chebyshev (MVUE) UCL	27.86215
97.5% Chebyshev (MVUE) UCL	30.48129
99% Chebyshev (MVUE) UCL	35.62608

95% Non-parametric UCLs	
CLT UCL	23.96528
Adj-CLT UCL (Adjusted for skewness)	24.0884
Mod-t UCL (Adjusted for skewness)	24.01748
Jackknife UCL	23.99827
Standard Bootstrap UCL	23.98442
Bootstrap-t UCL	24.17504
Hall's Bootstrap UCL	24.05163
Percentile Bootstrap UCL	23.91905
BCA Bootstrap UCL	24.16508
95% Chebyshev (Mean, Sd) UCL	27.55377
97.5% Chebyshev (Mean, Sd) UCL	30.04755
99% Chebyshev (Mean, Sd) UCL	34.9461

IA-6 ProUCL Output

Data File C:\Documents and Settings\schmidlj\Deskto Variable: Thallium

Raw Statistics	
Number of Valid Samples	63
Number of Unique Samples	37
Minimum	0.21
Maximum	1.6
Mean	0.453016
Median	0.42
Standard Deviation	0.204195
Variance	0.041696
Coefficient of Variation	0.450746
Skewness	3.661608

Gamma Statistics	
k hat	8.441032
k star (bias corrected)	8.04966
Theta hat	0.053668
Theta star	0.056278
nu hat	1063.57
nu star	1014.257
Approx.Chi Square Value (.05)	941.3136
Adjusted Level of Significance	0.04619
Adjusted Chi Square Value	939.6808

Log-transformed Statistics	
Minimum of log data	-1.56065
Maximum of log data	0.470004
Mean of log data	-0.85223
Standard Deviation of log data	0.316662
Variance of log data	0.100275

RECOMMENDATION

Data are Non-parametric (0.05)

Use Student's-t UCL
or Modified-t UCL

Normal Distribution Test	
Lilliefors Test Statisitic	0.297898
Lilliefors 5% Critical Value	0.111626
Data not normal at 5% significance level	

95% UCL (Assuming Normal Distribution)	
Student's-t UCL	0.495974

Gamma Distribution Test	
A-D Test Statistic	4.020691
A-D 5% Critical Value	0.75183
K-S Test Statistic	0.233571
K-S 5% Critical Value	0.112293
Data do not follow gamma distribution	
at 5% significance level	

95% UCLs (Assuming Gamma Distribution)	
Approximate Gamma UCL	0.488121
Adjusted Gamma UCL	0.488969

Lognormal Distribution Test	
Lilliefors Test Statisitic	0.199445
Lilliefors 5% Critical Value	0.111626
Data not lognormal at 5% significance level	

95% UCLs (Assuming Lognormal Distribution)	
95% H-UCL	0.481243
95% Chebyshev (MVUE) UCL	0.527607
97.5% Chebyshev (MVUE) UCL	0.562046
99% Chebyshev (MVUE) UCL	0.629695

95% Non-parametric UCLs	
CLT UCL	0.495332
Adj-CLT UCL (Adjusted for skewness)	0.508013
Mod-t UCL (Adjusted for skewness)	0.497951
Jackknife UCL	0.495974
Standard Bootstrap UCL	0.494617
Bootstrap-t UCL	0.521878
Hall's Bootstrap UCL	0.546294
Percentile Bootstrap UCL	0.499524
BCA Bootstrap UCL	0.508016
95% Chebyshev (Mean, Sd) UCL	0.565154
97.5% Chebyshev (Mean, Sd) UCL	0.613676
99% Chebyshev (Mean, Sd) UCL	0.708988

IA-6 ProUCL Output

Data File C:\Documents and Settings\schmidlj\Deskto Variable: Benzo(a)pyrene

Raw Statistics	
Number of Valid Samples	11
Number of Unique Samples	6
Minimum	0.55
Maximum	190
Mean	50.90455
Median	0.65
Standard Deviation	86.21145
Variance	7432.414
Coefficient of Variation	1.69359
Skewness	1.197138

Gamma Statistics	
k hat	0.248299
k star (bias corrected)	0.241187
Theta hat	205.0127
Theta star	211.058
nu hat	5.462588
nu star	5.306125
Approx.Chi Square Value (.05)	1.29576
Adjusted Level of Significance	0.02783
Adjusted Chi Square Value	1.003601

Log-transformed Statistics	
Minimum of log data	-0.59784
Maximum of log data	5.247024
Mean of log data	1.066186
Standard Deviation of log data	2.670926
Variance of log data	7.133844

RECOMMENDATION

Data are Non-parametric (0.05)

Use 99% Chebyshev (Mean, Sd) UCL

Normal Distribution Test	
Shapiro-Wilk Test Statisitic	0.584278
Shapiro-Wilk 5% Critical Value	0.85
Data not normal at 5% significance level	

95% UCL (Assuming Normal Distribution)	
Student's-t UCL	98.01717

Gamma Distribution Test	
A-D Test Statistic	2.247896
A-D 5% Critical Value	0.84078
K-S Test Statistic	0.44924
K-S 5% Critical Value	0.279008
Data do not follow gamma distribution	
at 5% significance level	

95% UCLs (Assuming Gamma Distribution)	
Approximate Gamma UCL	208.4536
Adjusted Gamma UCL	269.1366

Lognormal Distribution Test	
Shapiro-Wilk Test Statisitic	0.608527
Shapiro-Wilk 5% Critical Value	0.85
Data not lognormal at 5% significance level	

95% UCLs (Assuming Lognormal Distribution)	
95% H-UCL	30679.27
95% Chebyshev (MVUE) UCL	187.9682
97.5% Chebyshev (MVUE) UCL	251.0218
99% Chebyshev (MVUE) UCL	374.8784

95% Non-parametric UCLs	
CLT UCL	93.66043
Adj-CLT UCL (Adjusted for skewness)	103.6857
Mod-t UCL (Adjusted for skewness)	99.58091
Jackknife UCL	98.01717
Standard Bootstrap UCL	91.88727
Bootstrap-t UCL	107.3565
Hall's Bootstrap UCL	76.49645
Percentile Bootstrap UCL	86.70455
BCA Bootstrap UCL	101.1773
95% Chebyshev (Mean, Sd) UCL	164.2086
97.5% Chebyshev (Mean, Sd) UCL	213.2353
99% Chebyshev (Mean, Sd) UCL	309.5389

Recommended UCL exceeds the maximum observation

IA-6 ProUCL Output

Data File C:\Documents and Settings\schmidlj\Deskto Variable: Benzo(b)fluoranthene

Raw Statistics	
Number of Valid Samples	11
Number of Unique Samples	7
Minimum	175
Maximum	880
Mean	258.6364
Median	190
Standard Deviation	207.8833
Variance	43215.45
Coefficient of Variation	0.803767
Skewness	3.217514

Gamma Statistics	
k hat	3.581272
k star (bias corrected)	2.665167
Theta hat	72.21914
Theta star	97.04321
nu hat	78.78797
nu star	58.63368
Approx.Chi Square Value (.05)	42.02569
Adjusted Level of Significance	0.02783
Adjusted Chi Square Value	39.74255

Log-transformed Statistics	
Minimum of log data	5.164786
Maximum of log data	6.779922
Mean of log data	5.409359
Standard Deviation of log data	0.471384
Variance of log data	0.222203

RECOMMENDATION

Data are Non-parametric (0.05)

Use Student's-t UCL
or Modified-t UCL

Normal Distribution Test	
Shapiro-Wilk Test Statisitic	0.440117
Shapiro-Wilk 5% Critical Value	0.85
Data not normal at 5% significance level	

95% UCL (Assuming Normal Distribution)	
Student's-t UCL	372.2399

Gamma Distribution Test	
A-D Test Statistic	2.486052
A-D 5% Critical Value	0.732991
K-S Test Statistic	0.373014
K-S 5% Critical Value	0.256694
Data do not follow gamma distribution	
at 5% significance level	

95% UCLs (Assuming Gamma Distribution)	
Approximate Gamma UCL	360.846
Adjusted Gamma UCL	381.5759

Lognormal Distribution Test	
Shapiro-Wilk Test Statisitic	0.542125
Shapiro-Wilk 5% Critical Value	0.85
Data not lognormal at 5% significance level	

95% UCLs (Assuming Lognormal Distribution)	
95% H-UCL	343.7736
95% Chebyshev (MVUE) UCL	402.9724
97.5% Chebyshev (MVUE) UCL	470.4471
99% Chebyshev (MVUE) UCL	602.9879

95% Non-parametric UCLs	
CLT UCL	361.7344
Adj-CLT UCL (Adjusted for skewness)	426.7066
Mod-t UCL (Adjusted for skewness)	382.3743
Jackknife UCL	372.2399
Standard Bootstrap UCL	357.4063
Bootstrap-t UCL	1454.99
Hall's Bootstrap UCL	1013.29
Percentile Bootstrap UCL	379.0909
BCA Bootstrap UCL	448.1818
95% Chebyshev (Mean, Sd) UCL	531.8485
97.5% Chebyshev (Mean, Sd) UCL	650.0676
99% Chebyshev (Mean, Sd) UCL	882.2862

IA-6 ProUCL Output

Data File C:\Documents and Settings\schmidlj\Deskto Variable: Dibenz(a,h)Anthracene

Raw Statistics	
Number of Valid Samples	11
Number of Unique Samples	6
Minimum	0.55
Maximum	190
Mean	50.96727
Median	0.65
Standard Deviation	86.17152
Variance	7425.531
Coefficient of Variation	1.690723
Skewness	1.197116

Gamma Statistics	
k hat	0.252864
k star (bias corrected)	0.244507
Theta hat	201.56
Theta star	208.449
nu hat	5.563008
nu star	5.379157
Approx.Chi Square Value (.05)	1.330838
Adjusted Level of Significance	0.02783
Adjusted Chi Square Value	1.033305

Log-transformed Statistics	
Minimum of log data	-0.59784
Maximum of log data	5.247024
Mean of log data	1.127362
Standard Deviation of log data	2.643357
Variance of log data	6.987337

RECOMMENDATION

Data are Non-parametric (0.05)

Use 99% Chebyshev (Mean, Sd) UCL

Normal Distribution Test	
Shapiro-Wilk Test Statisitic	0.585336
Shapiro-Wilk 5% Critical Value	0.85
Data not normal at 5% significance level	

95% UCL (Assuming Normal Distribution)	
Student's-t UCL	98.05808

Gamma Distribution Test	
A-D Test Statistic	2.115644
A-D 5% Critical Value	0.838955
K-S Test Statistic	0.41351
K-S 5% Critical Value	0.278731
Data do not follow gamma distribution	
at 5% significance level	

95% UCLs (Assuming Gamma Distribution)	
Approximate Gamma UCL	206.0062
Adjusted Gamma UCL	265.3244

Lognormal Distribution Test	
Shapiro-Wilk Test Statisitic	0.637964
Shapiro-Wilk 5% Critical Value	0.85
Data not lognormal at 5% significance level	

95% UCLs (Assuming Lognormal Distribution)	
95% H-UCL	27066.74
95% Chebyshev (MVUE) UCL	189.6334
97.5% Chebyshev (MVUE) UCL	253.1516
99% Chebyshev (MVUE) UCL	377.9206

95% Non-parametric UCLs	
CLT UCL	93.70335
Adj-CLT UCL (Adjusted for skewness)	103.7238
Mod-t UCL (Adjusted for skewness)	99.62107
Jackknife UCL	98.05808
Standard Bootstrap UCL	91.6679
Bootstrap-t UCL	107.4265
Hall's Bootstrap UCL	76.54522
Percentile Bootstrap UCL	86.82727
BCA Bootstrap UCL	101.2718
95% Chebyshev (Mean, Sd) UCL	164.2188
97.5% Chebyshev (Mean, Sd) UCL	213.2229
99% Chebyshev (Mean, Sd) UCL	309.4818

Recommended UCL exceeds the maximum observation

IA-7 ProUCL Output

Data File C:\Documents and Settings\schmidlj\Deskto Variable: Aluminum

Raw Statistics	
Number of Valid Samples	12
Number of Unique Samples	12
Minimum	0
Maximum	10000
Mean	4908.333
Median	5050
Standard Deviation	2867.517
Variance	8222652
Coefficient of Variation	0.584214
Skewness	0.276388

Normal Distribution Test	
Shapiro-Wilk Test Statisitic	0.966287
Shapiro-Wilk 5% Critical Value	0.859
Data are normal at 5% significance level	
95% UCL (Assuming Normal Distribution)	
Student's-t UCL	6394.932

Gamma Statistics Not Available

Lognormal Statistics Not Available

95% Non-parametric UCLs	
CLT UCL	6269.911
Adj-CLT UCL (Adjusted for skewness)	6340.482
Mod-t UCL (Adjusted for skewness)	6405.94
Jackknife UCL	6394.932
Standard Bootstrap UCL	6204.497
Bootstrap-t UCL	6532.651
Hall's Bootstrap UCL	6643.204
Percentile Bootstrap UCL	6233.333
BCA Bootstrap UCL	6300
95% Chebyshev (Mean, Sd) UCL	8516.546
97.5% Chebyshev (Mean, Sd) UCL	10077.82
99% Chebyshev (Mean, Sd) UCL	13144.65

RECOMMENDATION
Data are normal (0.05)
Use Student's-t UCL

IA-7 ProUCL Output

Data File C:\Documents and Settings\schmidlj\Deskto Variable: Antimony

Raw Statistics	
Number of Valid Samples	12
Number of Unique Samples	6
Minimum	0
Maximum	2.4
Mean	1.2
Median	1.05
Standard Deviation	0.622312
Variance	0.387273
Coefficient of Variation	0.518594
Skewness	0.591388

Normal Distribution Test	
Shapiro-Wilk Test Statisitic	0.747517
Shapiro-Wilk 5% Critical Value	0.859
Data not normal at 5% significance level	
95% UCL (Assuming Normal Distribution)	
Student's-t UCL	1.522624

Gamma Statistics Not Available

Lognormal Statistics Not Available

RECOMMENDATION	95% Non-parametric UCLs	
	CLT UCL	1.495492
	Adj-CLT UCL (Adjusted for skewness)	1.528262
	Mod-t UCL (Adjusted for skewness)	1.527735
	Jackknife UCL	1.522624
	Standard Bootstrap UCL	1.481291
	Bootstrap-t UCL	1.687611
Data are Non-parametric (0.05)	Hall's Bootstrap UCL	2.195461
	Percentile Bootstrap UCL	1.495833
	BCA Bootstrap UCL	1.508333
Use 95% Chebyshev (Mean, Sd) UCL	95% Chebyshev (Mean, Sd) UCL	1.983059
	97.5% Chebyshev (Mean, Sd) UCL	2.32189
	99% Chebyshev (Mean, Sd) UCL	2.987456

IA-7 ProUCL Output

Data File C:\Documents and Settings\schmidlj\Deskto Variable: Arsenic

Raw Statistics	
Number of Valid Samples	12
Number of Unique Samples	8
Minimum	0
Maximum	52
Mean	24.5
Median	25
Standard Deviation	11.40574
Variance	130.0909
Coefficient of Variation	0.46554
Skewness	0.438486

Normal Distribution Test	
Shapiro-Wilk Test Statisitic	0.796005
Shapiro-Wilk 5% Critical Value	0.859
Data not normal at 5% significance level	
95% UCL (Assuming Normal Distribution)	
Student's-t UCL	30.41305

Gamma Statistics Not Available

Lognormal Statistics Not Available

RECOMMENDATION	95% Non-parametric UCLs	
Data are Non-parametric (0.05)	CLT UCL	29.91577
	Adj-CLT UCL (Adjusted for skewness)	30.3611
	Mod-t UCL (Adjusted for skewness)	30.48251
	Jackknife UCL	30.41305
	Standard Bootstrap UCL	29.69216
	Bootstrap-t UCL	30.45756
	Hall's Bootstrap UCL	33.72974
	Percentile Bootstrap UCL	29.66667
	BCA Bootstrap UCL	30.16667
Use 95% Chebyshev (Mean, Sd) UCL	95% Chebyshev (Mean, Sd) UCL	38.85191
	97.5% Chebyshev (Mean, Sd) UCL	45.06199
	99% Chebyshev (Mean, Sd) UCL	57.26049

IA-7 ProUCL Output

Data File C:\Documents and Settings\schmidlj\Deskto Variable: Iron

Raw Statistics	
Number of Valid Samples	12
Number of Unique Samples	11
Minimum	0
Maximum	14000
Mean	8841.667
Median	9600
Standard Deviation	3353.006
Variance	11242652
Coefficient of Variation	0.379228
Skewness	-1.56141

Normal Distribution Test	
Shapiro-Wilk Test Statisitic	0.850657
Shapiro-Wilk 5% Critical Value	0.859
Data not normal at 5% significance level	

95% UCL (Assuming Normal Distribution)	
Student's-t UCL	10579.96

Gamma Statistics Not Available

Lognormal Statistics Not Available

RECOMMENDATION

Data are Non-parametric (0.05)

Use 95% Chebyshev (Mean, Sd) UCL

95% Non-parametric UCLs	
CLT UCL	10433.77
Adj-CLT UCL (Adjusted for skewness)	9967.594
Mod-t UCL (Adjusted for skewness)	10507.24
Jackknife UCL	10579.96
Standard Bootstrap UCL	10349.8
Bootstrap-t UCL	10135.48
Hall's Bootstrap UCL	10170.34
Percentile Bootstrap UCL	10225
BCA Bootstrap UCL	9983.333
95% Chebyshev (Mean, Sd) UCL	13060.77
97.5% Chebyshev (Mean, Sd) UCL	14886.38
99% Chebyshev (Mean, Sd) UCL	18472.44

IA-7 ProUCL Output

Data File C:\Documents and Settings\schmidlj\Deskto Variable: Lead

Raw Statistics	
Number of Valid Samples	12
Number of Unique Samples	10
Minimum	0
Maximum	220
Mean	64.29167
Median	28.5
Standard Deviation	68.91182
Variance	4748.839
Coefficient of Variation	1.071862
Skewness	1.249988

Normal Distribution Test	
Shapiro-Wilk Test Statisitic	0.817042
Shapiro-Wilk 5% Critical Value	0.859
Data not normal at 5% significance level	
95% UCL (Assuming Normal Distribution)	
Student's-t UCL	100.0174

Gamma Statistics Not Available

Lognormal Statistics Not Available

RECOMMENDATION	95% Non-parametric UCLs	
Data are Non-parametric (0.05)	CLT UCL	97.01295
	Adj-CLT UCL (Adjusted for skewness)	104.683
	Mod-t UCL (Adjusted for skewness)	101.2138
	Jackknife UCL	100.0174
	Standard Bootstrap UCL	95.69622
	Bootstrap-t UCL	116.2583
	Hall's Bootstrap UCL	99.43671
	Percentile Bootstrap UCL	97.45833
	BCA Bootstrap UCL	100.25
Use 95% Chebyshev (Mean, Sd) UCL	95% Chebyshev (Mean, Sd) UCL	151.0038
	97.5% Chebyshev (Mean, Sd) UCL	188.5242
	99% Chebyshev (Mean, Sd) UCL	262.2258

IA-7 ProUCL Output

Data File C:\Documents and Settings\schmidlj\Deskto Variable: Manganese

Raw Statistics	
Number of Valid Samples	12
Number of Unique Samples	11
Minimum	0
Maximum	340
Mean	213.3333
Median	235
Standard Deviation	86.68997
Variance	7515.152
Coefficient of Variation	0.406359
Skewness	-1.27012

Normal Distribution Test	
Shapiro-Wilk Test Statisitic	0.905965
Shapiro-Wilk 5% Critical Value	0.859
Data are normal at 5% significance level	
95% UCL (Assuming Normal Distribution)	
Student's-t UCL	258.2758

Gamma Statistics Not Available

Lognormal Statistics Not Available

RECOMMENDATION
Data are normal (0.05)
Use Student's-t UCL

95% Non-parametric UCLs	
CLT UCL	254.4962
Adj-CLT UCL (Adjusted for skewness)	244.692
Mod-t UCL (Adjusted for skewness)	256.7465
Jackknife UCL	258.2758
Standard Bootstrap UCL	252.3582
Bootstrap-t UCL	250.5671
Hall's Bootstrap UCL	247.7989
Percentile Bootstrap UCL	250
BCA Bootstrap UCL	246.6667
95% Chebyshev (Mean, Sd) UCL	322.4158
97.5% Chebyshev (Mean, Sd) UCL	369.6159
99% Chebyshev (Mean, Sd) UCL	462.3313

IA-7 ProUCL Output

Data File C:\Documents and Settings\schmidlj\Deskto Variable: Nickel

Raw Statistics	
Number of Valid Samples	12
Number of Unique Samples	9
Minimum	0
Maximum	25
Mean	18.41667
Median	20.5
Standard Deviation	7.025387
Variance	49.35606
Coefficient of Variation	0.381469
Skewness	-1.75445

Normal Distribution Test	
Shapiro-Wilk Test Statisitic	0.827911
Shapiro-Wilk 5% Critical Value	0.859
Data not normal at 5% significance level	
95% UCL (Assuming Normal Distribution)	
Student's-t UCL	22.05882

Gamma Statistics Not Available

Lognormal Statistics Not Available

	95% Non-parametric UCLs	
	CLT UCL	21.75252
	Adj-CLT UCL (Adjusted for skewness)	20.65501
	Mod-t UCL (Adjusted for skewness)	21.88763
	Jackknife UCL	22.05882
	Standard Bootstrap UCL	21.62162
	Bootstrap-t UCL	21.2917
RECOMMENDATION	Hall's Bootstrap UCL	20.99705
Data are Non-parametric (0.05)	Percentile Bootstrap UCL	21.25
	BCA Bootstrap UCL	20.83333
Use 95% Chebyshev (Mean, Sd) UCL	95% Chebyshev (Mean, Sd) UCL	27.25675
	97.5% Chebyshev (Mean, Sd) UCL	31.08186
	99% Chebyshev (Mean, Sd) UCL	38.59555

Recommended UCL exceeds the maximum observation

IA-7 ProUCL Output

Data File \\Fsmnh01\User1\PROJECTS\03886110\02\ Variable: Nickel

Raw Statistics	
Number of Valid Samples	14
Number of Unique Samples	11
Minimum	13
Maximum	43
Mean	22.71429
Median	22
Standard Deviation	7.81939
Variance	61.14286
Coefficient of Variation	0.34425
Skewness	1.493343

Gamma Statistics	
k hat	10.62276
k star (bias corrected)	8.394076
Theta hat	2.138265
Theta star	2.70599
nu hat	297.4374
nu star	235.0341
Approx.Chi Square Value (.05)	200.5377
Adjusted Level of Significance	0.03122
Adjusted Chi Square Value	196.3112

Log-transformed Statistics	
Minimum of log data	2.564949
Maximum of log data	3.7612
Mean of log data	3.075187
Standard Deviation of log data	0.312688
Variance of log data	0.097774

RECOMMENDATION

Data follow gamma distribution (0.05)

Use Approximate Gamma UCL

Normal Distribution Test	
Shapiro-Wilk Test Statisitic	0.870074
Shapiro-Wilk 5% Critical Value	0.874
Data not normal at 5% significance level	

95% UCL (Assuming Normal Distribution)	
Student's-t UCL	26.41522

Gamma Distribution Test	
A-D Test Statistic	0.39255
A-D 5% Critical Value	0.734496
K-S Test Statistic	0.19466
K-S 5% Critical Value	0.228636
Data follow gamma distribution	
at 5% significance level	

95% UCLs (Assuming Gamma Distribution)	
Approximate Gamma UCL	26.62159
Adjusted Gamma UCL	27.19474

Lognormal Distribution Test	
Shapiro-Wilk Test Statisitic	0.959846
Shapiro-Wilk 5% Critical Value	0.874
Data are lognormal at 5% significance level	

95% UCLs (Assuming Lognormal Distribution)	
95% H-UCL	26.82995
95% Chebyshev (MVUE) UCL	31.00575
97.5% Chebyshev (MVUE) UCL	34.61848
99% Chebyshev (MVUE) UCL	41.71499

95% Non-parametric UCLs	
CLT UCL	26.15173
Adj-CLT UCL (Adjusted for skewness)	27.04295
Mod-t UCL (Adjusted for skewness)	26.55423
Jackknife UCL	26.41522
Standard Bootstrap UCL	26.04059
Bootstrap-t UCL	28.23239
Hall's Bootstrap UCL	47.3266
Percentile Bootstrap UCL	26.28571
BCA Bootstrap UCL	26.42857
95% Chebyshev (Mean, Sd) UCL	31.8236
97.5% Chebyshev (Mean, Sd) UCL	35.76521
99% Chebyshev (Mean, Sd) UCL	43.50773

IA-8 ProUCL Output

Data File \\Fsmnh01\User1\PROJECTS\03886110\02(Variable: Aluminum

Raw Statistics	
Number of Valid Samples	6
Number of Unique Samples	4
Minimum	4700
Maximum	7800
Mean	5733.333
Median	5700
Standard Deviation	1134.313
Variance	1286667
Coefficient of Variation	0.197845
Skewness	1.360436

Gamma Statistics	
k hat	33.48014
k star (bias corrected)	16.85118
Theta hat	171.2458
Theta star	340.2333
nu hat	401.7617
nu star	202.2142
Approx.Chi Square Value (.05)	170.3045
Adjusted Level of Significance	0.01222
Adjusted Chi Square Value	159.6857

Log-transformed Statistics	
Minimum of log data	8.455318
Maximum of log data	8.961879
Mean of log data	8.639044
Standard Deviation of log data	0.186128
Variance of log data	0.034644

Normal Distribution Test	
Shapiro-Wilk Test Statisitic	0.836477
Shapiro-Wilk 5% Critical Value	0.788
Data are normal at 5% significance level	

95% UCL (Assuming Normal Distribution)	
Student's-t UCL	6666.465

Gamma Distribution Test	
A-D Test Statistic	0.492049
A-D 5% Critical Value	0.696996
K-S Test Statistic	0.283747
K-S 5% Critical Value	0.331766
Data follow gamma distribution	
at 5% significance level	

95% UCLs (Assuming Gamma Distribution)	
Approximate Gamma UCL	6807.578
Adjusted Gamma UCL	7260.269

Lognormal Distribution Test	
Shapiro-Wilk Test Statisitic	0.868427
Shapiro-Wilk 5% Critical Value	0.788
Data are lognormal at 5% significance level	

95% UCLs (Assuming Lognormal Distribution)	
95% H-UCL	6829.65
95% Chebyshev (MVUE) UCL	7627.651
97.5% Chebyshev (MVUE) UCL	8448.82
99% Chebyshev (MVUE) UCL	10061.85

95% Non-parametric UCLs	
CLT UCL	6495.035
Adj-CLT UCL (Adjusted for skewness)	6769.849
Mod-t UCL (Adjusted for skewness)	6709.33
Jackknife UCL	6666.465
Standard Bootstrap UCL	N/R
Bootstrap-t UCL	N/R
Hall's Bootstrap UCL	N/R
Percentile Bootstrap UCL	N/R
BCA Bootstrap UCL	N/R
95% Chebyshev (Mean, Sd) UCL	7751.859
97.5% Chebyshev (Mean, Sd) UCL	8625.276
99% Chebyshev (Mean, Sd) UCL	10340.94

RECOMMENDATION

Data are normal (0.05)

Use Student's-t UCL

IA-8 ProUCL Output

Data File \\Fsmnh01\User1\PROJECTS\03886110\020\0110-PA Variable: Arsenic

Raw Statistics	
Number of Valid Samples	6
Number of Unique Samples	6
Minimum	19
Maximum	36
Mean	27.83333
Median	27.5
Standard Deviation	5.913262
Variance	34.96667
Coefficient of Variation	0.212453
Skewness	-0.14445

Gamma Statistics	
k hat	25.28191
k star (bias corrected)	12.75207
Theta hat	1.100919
Theta star	2.182653
nu hat	303.3829
nu star	153.0248
Approx.Chi Square Value (.05)	125.4249
Adjusted Level of Significance	0.01222
Adjusted Chi Square Value	116.3869

Log-transformed Statistics	
Minimum of log data	2.944439
Maximum of log data	3.583519
Mean of log data	3.306327
Standard Deviation of log data	0.222216
Variance of log data	0.04938

RECOMMENDATION

Data are normal (0.05)

Use Student's-t UCL

Normal Distribution Test	
Shapiro-Wilk Test Statisitic	0.990485
Shapiro-Wilk 5% Critical Value	0.788
Data are normal at 5% significance level	

95% UCL (Assuming Normal Distribution)	
Student's-t UCL	32.69782

Gamma Distribution Test	
A-D Test Statistic	0.184548
A-D 5% Critical Value	0.697053
K-S Test Statistic	0.154876
K-S 5% Critical Value	0.331744
Data follow gamma distribution	
at 5% significance level	

95% UCLs (Assuming Gamma Distribution)	
Approximate Gamma UCL	33.9581
Adjusted Gamma UCL	36.59509

Lognormal Distribution Test	
Shapiro-Wilk Test Statisitic	0.971727
Shapiro-Wilk 5% Critical Value	0.788
Data are lognormal at 5% significance level	

95% UCLs (Assuming Lognormal Distribution)	
95% H-UCL	34.55812
95% Chebyshev (MVUE) UCL	38.86264
97.5% Chebyshev (MVUE) UCL	43.62771
99% Chebyshev (MVUE) UCL	52.98776

95% Non-parametric UCLs	
CLT UCL	31.80414
Adj-CLT UCL (Adjusted for skewness)	31.65203
Mod-t UCL (Adjusted for skewness)	32.67409
Jackknife UCL	32.69782
Standard Bootstrap UCL	31.46677
Bootstrap-t UCL	32.74968
Hall's Bootstrap UCL	32.54971
Percentile Bootstrap UCL	31.5
BCA Bootstrap UCL	31.16667
95% Chebyshev (Mean, Sd) UCL	38.35606
97.5% Chebyshev (Mean, Sd) UCL	42.90925
99% Chebyshev (Mean, Sd) UCL	51.85312

IA-8 ProUCL Output

Data File \\Fsmnh01\User1\PROJECTS\03886110\02(Variable: Iron

Raw Statistics	
Number of Valid Samples	6
Number of Unique Samples	3
Minimum	11000
Maximum	13000
Mean	11833.33
Median	11500
Standard Deviation	983.1921
Variance	966666.7
Coefficient of Variation	0.083087
Skewness	0.455939

Gamma Statistics	
k hat	176.3132
k star (bias corrected)	88.26769
Theta hat	67.11543
Theta star	134.0619
nu hat	2115.758
nu star	1059.212
Approx.Chi Square Value (.05)	984.6439
Adjusted Level of Significance	0.01222
Adjusted Chi Square Value	958.3463

Log-transformed Statistics	
Minimum of log data	9.305651
Maximum of log data	9.472705
Mean of log data	9.375837
Standard Deviation of log data	0.082253
Variance of log data	0.006766

RECOMMENDATION

Assuming gamma distribution (0.05)

Use Approximate Gamma UCL

Normal Distribution Test	
Shapiro-Wilk Test Statisitic	0.774587
Shapiro-Wilk 5% Critical Value	0.788
Data not normal at 5% significance level	

95% UCL (Assuming Normal Distribution)	
Student's-t UCL	12642.15

Gamma Distribution Test	
A-D Test Statistic	0.729515
A-D 5% Critical Value	0.69621
K-S Test Statistic	0.324521
K-S 5% Critical Value	0.33154
Data follow approximate gamma distibution	
at 5% significance level	

95% UCLs (Assuming Gamma Distribution)	
Approximate Gamma UCL	12729.49
Adjusted Gamma UCL	13078.79

Lognormal Distribution Test	
Shapiro-Wilk Test Statisitic	0.77505
Shapiro-Wilk 5% Critical Value	0.788
Data not lognormal at 5% significance level	

95% UCLs (Assuming Lognormal Distribution)	
95% H-UCL	N/A
95% Chebyshev (MVUE) UCL	13565.11
97.5% Chebyshev (MVUE) UCL	14314.56
99% Chebyshev (MVUE) UCL	15786.7

95% Non-parametric UCLs	
CLT UCL	12493.56
Adj-CLT UCL (Adjusted for skewness)	12573.39
Mod-t UCL (Adjusted for skewness)	12654.6
Jackknife UCL	12642.15
Standard Bootstrap UCL	N/R
Bootstrap-t UCL	N/R
Hall's Bootstrap UCL	N/R
Percentile Bootstrap UCL	N/R
BCA Bootstrap UCL	N/R
95% Chebyshev (Mean, Sd) UCL	13582.94
97.5% Chebyshev (Mean, Sd) UCL	14339.99
99% Chebyshev (Mean, Sd) UCL	15827.08

IA-8 ProUCL Output

IA-8 ProUCL Output

Data File \\Fsmnh01\User1\PROJECTS\03886110\02(Variable: Manganese

Raw Statistics	
Number of Valid Samples	6
Number of Unique Samples	5
Minimum	230
Maximum	290
Mean	266.6667
Median	275
Standard Deviation	25.81989
Variance	666.6667
Coefficient of Variation	0.096825
Skewness	-0.70488

Gamma Statistics	
k hat	123.5979
k star (bias corrected)	61.91004
Theta hat	2.157535
Theta star	4.307325
nu hat	1483.174
nu star	742.9205
Approx.Chi Square Value (.05)	680.6612
Adjusted Level of Significance	0.01222
Adjusted Chi Square Value	658.8902

Log-transformed Statistics	
Minimum of log data	5.438079
Maximum of log data	5.669881
Mean of log data	5.581949
Standard Deviation of log data	0.099488
Variance of log data	0.009898

RECOMMENDATION

Data are normal (0.05)

Use Student's-t UCL

Normal Distribution Test	
Shapiro-Wilk Test Statisitic	0.858386
Shapiro-Wilk 5% Critical Value	0.788
Data are normal at 5% significance level	

95% UCL (Assuming Normal Distribution)	
Student's-t UCL	287.9071

Gamma Distribution Test	
A-D Test Statistic	0.503703
A-D 5% Critical Value	0.69621
K-S Test Statistic	0.233513
K-S 5% Critical Value	0.33154
Data follow gamma distribution	
at 5% significance level	

95% UCLs (Assuming Gamma Distribution)	
Approximate Gamma UCL	291.0584
Adjusted Gamma UCL	300.6755

Lognormal Distribution Test	
Shapiro-Wilk Test Statisitic	0.85211
Shapiro-Wilk 5% Critical Value	0.788
Data are lognormal at 5% significance level	

95% UCLs (Assuming Lognormal Distribution)	
95% H-UCL	N/A
95% Chebyshev (MVUE) UCL	313.8997
97.5% Chebyshev (MVUE) UCL	334.3293
99% Chebyshev (MVUE) UCL	374.4594

95% Non-parametric UCLs	
CLT UCL	284.0049
Adj-CLT UCL (Adjusted for skewness)	280.7638
Mod-t UCL (Adjusted for skewness)	287.4016
Jackknife UCL	287.9071
Standard Bootstrap UCL	282.3026
Bootstrap-t UCL	285.1391
Hall's Bootstrap UCL	278.0645
Percentile Bootstrap UCL	281.6667
BCA Bootstrap UCL	280
95% Chebyshev (Mean, Sd) UCL	312.6135
97.5% Chebyshev (Mean, Sd) UCL	332.4947
99% Chebyshev (Mean, Sd) UCL	371.5476

IA-8 ProUCL Output

Data File \\Fsmnh01\User1\PROJECTS\03886110\02(Variable: Nickel

Raw Statistics	
Number of Valid Samples	6
Number of Unique Samples	4
Minimum	19
Maximum	31
Mean	26.83333
Median	28.5
Standard Deviation	5.076088
Variance	25.76667
Coefficient of Variation	0.189171
Skewness	-0.73525

Gamma Statistics	
k hat	30.81615
k star (bias corrected)	15.51918
Theta hat	0.870756
Theta star	1.729043
nu hat	369.7937
nu star	186.2302
Approx.Chi Square Value (.05)	155.6567
Adjusted Level of Significance	0.01222
Adjusted Chi Square Value	145.5281

Log-transformed Statistics	
Minimum of log data	2.944439
Maximum of log data	3.433987
Mean of log data	3.273332
Standard Deviation of log data	0.202402
Variance of log data	0.040966

RECOMMENDATION

Data are normal (0.05)

Use Student's-t UCL

Normal Distribution Test	
Shapiro-Wilk Test Statisitic	0.839454
Shapiro-Wilk 5% Critical Value	0.788
Data are normal at 5% significance level	

95% UCL (Assuming Normal Distribution)	
Student's-t UCL	31.00913

Gamma Distribution Test	
A-D Test Statistic	0.546316
A-D 5% Critical Value	0.697014
K-S Test Statistic	0.310673
K-S 5% Critical Value	0.331759
Data follow gamma distribution	
at 5% significance level	

95% UCLs (Assuming Gamma Distribution)	
Approximate Gamma UCL	32.10384
Adjusted Gamma UCL	34.33822

Lognormal Distribution Test	
Shapiro-Wilk Test Statisitic	0.836666
Shapiro-Wilk 5% Critical Value	0.788
Data are lognormal at 5% significance level	

95% UCLs (Assuming Lognormal Distribution)	
95% H-UCL	32.58259
95% Chebyshev (MVUE) UCL	36.52379
97.5% Chebyshev (MVUE) UCL	40.70856
99% Chebyshev (MVUE) UCL	48.92872

95% Non-parametric UCLs	
CLT UCL	30.24197
Adj-CLT UCL (Adjusted for skewness)	29.57732
Mod-t UCL (Adjusted for skewness)	30.90545
Jackknife UCL	31.00913
Standard Bootstrap UCL	N/R
Bootstrap-t UCL	N/R
Hall's Bootstrap UCL	N/R
Percentile Bootstrap UCL	N/R
BCA Bootstrap UCL	N/R
95% Chebyshev (Mean, Sd) UCL	35.8663
97.5% Chebyshev (Mean, Sd) UCL	39.77487
99% Chebyshev (Mean, Sd) UCL	47.4525

Recommended UCL exceeds the maximum observation

IA-8 ProUCL Output

Data File \\Fsmnh01\User1\PROJECTS\03886110\02(Variable: Vanadium

Raw Statistics	
Number of Valid Samples	6
Number of Unique Samples	4
Minimum	9.8
Maximum	15
Mean	11.63333
Median	11
Standard Deviation	1.790717
Variance	3.206667
Coefficient of Variation	0.15393
Skewness	1.63444

Gamma Statistics	
k hat	55.49407
k star (bias corrected)	27.85814
Theta hat	0.209632
Theta star	0.417592
nu hat	665.9288
nu star	334.2977
Approx.Chi Square Value (.05)	292.9249
Adjusted Level of Significance	0.01222
Adjusted Chi Square Value	278.8312

Log-transformed Statistics	
Minimum of log data	2.282382
Maximum of log data	2.70805
Mean of log data	2.444838
Standard Deviation of log data	0.144145
Variance of log data	0.020778

RECOMMENDATION

Data are normal (0.05)

Use Student's-t UCL

Normal Distribution Test	
Shapiro-Wilk Test Statisitic	0.819455
Shapiro-Wilk 5% Critical Value	0.788
Data are normal at 5% significance level	

95% UCL (Assuming Normal Distribution)	
Student's-t UCL	13.10645

Gamma Distribution Test	
A-D Test Statistic	0.598835
A-D 5% Critical Value	0.696806
K-S Test Statistic	0.3103
K-S 5% Critical Value	0.33178
Data follow gamma distribution	
at 5% significance level	

95% UCLs (Assuming Gamma Distribution)	
Approximate Gamma UCL	13.27643
Adjusted Gamma UCL	13.94749

Lognormal Distribution Test	
Shapiro-Wilk Test Statisitic	0.85573
Shapiro-Wilk 5% Critical Value	0.788
Data are lognormal at 5% significance level	

95% UCLs (Assuming Lognormal Distribution)	
95% H-UCL	13.26547
95% Chebyshev (MVUE) UCL	14.61164
97.5% Chebyshev (MVUE) UCL	15.90232
99% Chebyshev (MVUE) UCL	18.43761

95% Non-parametric UCLs	
CLT UCL	12.83582
Adj-CLT UCL (Adjusted for skewness)	13.35704
Mod-t UCL (Adjusted for skewness)	13.18775
Jackknife UCL	13.10645
Standard Bootstrap UCL	N/R
Bootstrap-t UCL	N/R
Hall's Bootstrap UCL	N/R
Percentile Bootstrap UCL	N/R
BCA Bootstrap UCL	N/R
95% Chebyshev (Mean, Sd) UCL	14.81994
97.5% Chebyshev (Mean, Sd) UCL	16.19878
99% Chebyshev (Mean, Sd) UCL	18.90726

IA-8 ProUCL Output

Data File \\Fsmnh01\User1\PROJECTS\03886110\02(Variable: Benzo(a)anthracene

Raw Statistics	
Number of Valid Samples	6
Number of Unique Samples	6
Minimum	175
Maximum	6100
Mean	1440.917
Median	547.5
Standard Deviation	2319.207
Variance	5378721
Coefficient of Variation	1.609536
Skewness	2.282044

Gamma Statistics	
k hat	0.65638
k star (bias corrected)	0.439301
Theta hat	2195.247
Theta star	3280.02
nu hat	7.876563
nu star	5.271615
Approx.Chi Square Value (.05)	1.27928
Adjusted Level of Significance	0.01222
Adjusted Chi Square Value	0.703052

Log-transformed Statistics	
Minimum of log data	5.164786
Maximum of log data	8.716044
Mean of log data	6.343903
Standard Deviation of log data	1.441234
Variance of log data	2.077157

RECOMMENDATION

Data follow gamma distribution (0.05)

Use Approximate Gamma UCL

Normal Distribution Test	
Shapiro-Wilk Test Statisitic	0.635495
Shapiro-Wilk 5% Critical Value	0.788
Data not normal at 5% significance level	

95% UCL (Assuming Normal Distribution)	
Student's-t UCL	3348.789

Gamma Distribution Test	
A-D Test Statistic	0.657627
A-D 5% Critical Value	0.726555
K-S Test Statistic	0.291896
K-S 5% Critical Value	0.345382
Data follow gamma distribution	
at 5% significance level	

95% UCLs (Assuming Gamma Distribution)	
Approximate Gamma UCL	5937.684
Adjusted Gamma UCL	10804.26

Lognormal Distribution Test	
Shapiro-Wilk Test Statisitic	0.83288
Shapiro-Wilk 5% Critical Value	0.788
Data are lognormal at 5% significance level	

95% UCLs (Assuming Lognormal Distribution)	
95% H-UCL	73420.92
95% Chebyshev (MVUE) UCL	4256.047
97.5% Chebyshev (MVUE) UCL	5560.803
99% Chebyshev (MVUE) UCL	8123.743

95% Non-parametric UCLs	
CLT UCL	2998.284
Adj-CLT UCL (Adjusted for skewness)	3940.809
Mod-t UCL (Adjusted for skewness)	3495.804
Jackknife UCL	3348.789
Standard Bootstrap UCL	2874.705
Bootstrap-t UCL	10217.64
Hall's Bootstrap UCL	10693.61
Percentile Bootstrap UCL	3137.667
BCA Bootstrap UCL	3445.917
95% Chebyshev (Mean, Sd) UCL	5567.976
97.5% Chebyshev (Mean, Sd) UCL	7353.758
99% Chebyshev (Mean, Sd) UCL	10861.58

IA-8 ProUCL Output

Data File \\Fsmnh01\User1\PROJECTS\03886110\02(Variable: Benzo(a)pyrene

Raw Statistics	
Number of Valid Samples	6
Number of Unique Samples	6
Minimum	100
Maximum	5500
Mean	1519.25
Median	637.75
Standard Deviation	2101.508
Variance	4416335
Coefficient of Variation	1.383254
Skewness	1.787327

Gamma Statistics	
k hat	0.617702
k star (bias corrected)	0.419962
Theta hat	2459.518
Theta star	3617.587
nu hat	7.412427
nu star	5.039547
Approx.Chi Square Value (.05)	1.170096
Adjusted Level of Significance	0.01222
Adjusted Chi Square Value	0.630809

Log-transformed Statistics	
Minimum of log data	4.60517
Maximum of log data	8.612503
Mean of log data	6.329952
Standard Deviation of log data	1.65276
Variance of log data	2.731617

RECOMMENDATION

Data follow gamma distribution (0.05)

Use Approximate Gamma UCL

Normal Distribution Test	
Shapiro-Wilk Test Statisitic	0.762606
Shapiro-Wilk 5% Critical Value	0.788
Data not normal at 5% significance level	

95% UCL (Assuming Normal Distribution)	
Student's-t UCL	3248.034

Gamma Distribution Test	
A-D Test Statistic	0.414327
A-D 5% Critical Value	0.728854
K-S Test Statistic	0.287237
K-S 5% Critical Value	0.346181
Data follow gamma distribution	
at 5% significance level	

95% UCLs (Assuming Gamma Distribution)	
Approximate Gamma UCL	6543.334
Adjusted Gamma UCL	12137.32

Lognormal Distribution Test	
Shapiro-Wilk Test Statisitic	0.895672
Shapiro-Wilk 5% Critical Value	0.788
Data are lognormal at 5% significance level	

95% UCLs (Assuming Lognormal Distribution)	
95% H-UCL	318721.7
95% Chebyshev (MVUE) UCL	5654.849
97.5% Chebyshev (MVUE) UCL	7443.197
99% Chebyshev (MVUE) UCL	10956.06

95% Non-parametric UCLs	
CLT UCL	2930.431
Adj-CLT UCL (Adjusted for skewness)	3599.335
Mod-t UCL (Adjusted for skewness)	3352.37
Jackknife UCL	3248.034
Standard Bootstrap UCL	2798.534
Bootstrap-t UCL	6040.608
Hall's Bootstrap UCL	9620.318
Percentile Bootstrap UCL	2973.333
BCA Bootstrap UCL	3466.667
95% Chebyshev (Mean, Sd) UCL	5258.911
97.5% Chebyshev (Mean, Sd) UCL	6877.065
99% Chebyshev (Mean, Sd) UCL	10055.62

Recommended UCL exceeds the maximum observation

IA-8 ProUCL Output

Data File \\Fsmnh01\User1\PROJECTS\03886110\02(Variable: Benzo(b)fluoranthene

Raw Statistics	
Number of Valid Samples	6
Number of Unique Samples	6
Minimum	175
Maximum	4230
Mean	1092.583
Median	530
Standard Deviation	1577.081
Variance	2487184
Coefficient of Variation	1.443442
Skewness	2.18461

Gamma Statistics	
k hat	0.791768
k star (bias corrected)	0.506995
Theta hat	1379.929
Theta star	2155.018
nu hat	9.501214
nu star	6.08394
Approx.Chi Square Value (.05)	1.682406
Adjusted Level of Significance	0.01222
Adjusted Chi Square Value	0.979987

Log-transformed Statistics	
Minimum of log data	5.164786
Maximum of log data	8.349957
Mean of log data	6.245698
Standard Deviation of log data	1.302362
Variance of log data	1.696147

RECOMMENDATION

Data follow gamma distribution (0.05)

Use Approximate Gamma UCL

Normal Distribution Test	
Shapiro-Wilk Test Statisitic	0.665362
Shapiro-Wilk 5% Critical Value	0.788
Data not normal at 5% significance level	

95% UCL (Assuming Normal Distribution)	
Student's-t UCL	2389.953

Gamma Distribution Test	
A-D Test Statistic	0.64478
A-D 5% Critical Value	0.720006
K-S Test Statistic	0.297331
K-S 5% Critical Value	0.343016
Data follow gamma distribution	
at 5% significance level	

95% UCLs (Assuming Gamma Distribution)	
Approximate Gamma UCL	3951.016
Adjusted Gamma UCL	6782.958

Lognormal Distribution Test	
Shapiro-Wilk Test Statisitic	0.828424
Shapiro-Wilk 5% Critical Value	0.788
Data are lognormal at 5% significance level	

95% UCLs (Assuming Lognormal Distribution)	
95% H-UCL	28099.33
95% Chebyshev (MVUE) UCL	3180.519
97.5% Chebyshev (MVUE) UCL	4130.358
99% Chebyshev (MVUE) UCL	5996.131

95% Non-parametric UCLs	
CLT UCL	2151.607
Adj-CLT UCL (Adjusted for skewness)	2765.167
Mod-t UCL (Adjusted for skewness)	2485.656
Jackknife UCL	2389.953
Standard Bootstrap UCL	2050.828
Bootstrap-t UCL	5242.466
Hall's Bootstrap UCL	6318.211
Percentile Bootstrap UCL	2320.083
BCA Bootstrap UCL	2566.667
95% Chebyshev (Mean, Sd) UCL	3899.019
97.5% Chebyshev (Mean, Sd) UCL	5113.366
99% Chebyshev (Mean, Sd) UCL	7498.716

IA-8 ProUCL Output

Data File \\Fsmnh01\User1\PROJECTS\03886110\02(Variable: Dibenz(a,h)Anthracene

Raw Statistics	
Number of Valid Samples	6
Number of Unique Samples	6
Minimum	175
Maximum	2300
Mean	702.5833
Median	325
Standard Deviation	834.2913
Variance	696042
Coefficient of Variation	1.187462
Skewness	1.879036

Gamma Statistics	
k hat	1.10753
k star (bias corrected)	0.664876
Theta hat	634.3694
Theta star	1056.713
nu hat	13.29036
nu star	7.978515
Approx.Chi Square Value (.05)	2.721905
Adjusted Level of Significance	0.01222
Adjusted Chi Square Value	1.743902

Log-transformed Statistics	
Minimum of log data	5.164786
Maximum of log data	7.740664
Mean of log data	6.039617
Standard Deviation of log data	1.072957
Variance of log data	1.151237

RECOMMENDATION

Data follow gamma distribution (0.05)

Use Approximate Gamma UCL

Normal Distribution Test	
Shapiro-Wilk Test Statisitic	0.735097
Shapiro-Wilk 5% Critical Value	0.788
Data not normal at 5% significance level	

95% UCL (Assuming Normal Distribution)	
Student's-t UCL	1388.905

Gamma Distribution Test	
A-D Test Statistic	0.570657
A-D 5% Critical Value	0.713528
K-S Test Statistic	0.296098
K-S 5% Critical Value	0.340119
Data follow gamma distribution	
at 5% significance level	

95% UCLs (Assuming Gamma Distribution)	
Approximate Gamma UCL	2059.43
Adjusted Gamma UCL	3214.384

Lognormal Distribution Test	
Shapiro-Wilk Test Statisitic	0.843802
Shapiro-Wilk 5% Critical Value	0.788
Data are lognormal at 5% significance level	

95% UCLs (Assuming Lognormal Distribution)	
95% H-UCL	6666.18
95% Chebyshev (MVUE) UCL	1890.229
97.5% Chebyshev (MVUE) UCL	2423.069
99% Chebyshev (MVUE) UCL	3469.73

95% Non-parametric UCLs	
CLT UCL	1262.817
Adj-CLT UCL (Adjusted for skewness)	1541.996
Mod-t UCL (Adjusted for skewness)	1432.451
Jackknife UCL	1388.905
Standard Bootstrap UCL	1213.853
Bootstrap-t UCL	3064.617
Hall's Bootstrap UCL	4554.127
Percentile Bootstrap UCL	1253.333
BCA Bootstrap UCL	1410.083
95% Chebyshev (Mean, Sd) UCL	2187.216
97.5% Chebyshev (Mean, Sd) UCL	2829.617
99% Chebyshev (Mean, Sd) UCL	4091.491

IA-8 ProUCL Output

Data File \\Fsmnh01\User1\PROJECTS\03886110\02(Variable: Indeno(1,2,3-c,d)Pyrene

Raw Statistics	
Number of Valid Samples	6
Number of Unique Samples	6
Minimum	175
Maximum	3700
Mean	992.5833
Median	495
Standard Deviation	1368.636
Variance	1873164
Coefficient of Variation	1.378862
Skewness	2.130985

Gamma Statistics	
k hat	0.852195
k star (bias corrected)	0.537209
Theta hat	1164.737
Theta star	1847.668
nu hat	10.22634
nu star	6.446503
Approx.Chi Square Value (.05)	1.871594
Adjusted Level of Significance	0.01222
Adjusted Chi Square Value	1.114444

Log-transformed Statistics	
Minimum of log data	5.164786
Maximum of log data	8.216088
Mean of log data	6.209571
Standard Deviation of log data	1.252657
Variance of log data	1.569149

RECOMMENDATION

Data follow gamma distribution (0.05)

Use Approximate Gamma UCL

Normal Distribution Test	
Shapiro-Wilk Test Statisitic	0.683192
Shapiro-Wilk 5% Critical Value	0.788
Data not normal at 5% significance level	

95% UCL (Assuming Normal Distribution)	
Student's-t UCL	2118.478

Gamma Distribution Test	
A-D Test Statistic	0.616242
A-D 5% Critical Value	0.718582
K-S Test Statistic	0.299341
K-S 5% Critical Value	0.342387
Data follow gamma distribution	
at 5% significance level	

95% UCLs (Assuming Gamma Distribution)	
Approximate Gamma UCL	3418.846
Adjusted Gamma UCL	5741.599

Lognormal Distribution Test	
Shapiro-Wilk Test Statisitic	0.833512
Shapiro-Wilk 5% Critical Value	0.788
Data are lognormal at 5% significance level	

95% UCLs (Assuming Lognormal Distribution)	
95% H-UCL	20338.78
95% Chebyshev (MVUE) UCL	2864.312
97.5% Chebyshev (MVUE) UCL	3710.543
99% Chebyshev (MVUE) UCL	5372.799

95% Non-parametric UCLs	
CLT UCL	1911.634
Adj-CLT UCL (Adjusted for skewness)	2431.029
Mod-t UCL (Adjusted for skewness)	2199.493
Jackknife UCL	2118.478
Standard Bootstrap UCL	1837.631
Bootstrap-t UCL	4139.163
Hall's Bootstrap UCL	5421.757
Percentile Bootstrap UCL	2043.417
BCA Bootstrap UCL	2255
95% Chebyshev (Mean, Sd) UCL	3428.089
97.5% Chebyshev (Mean, Sd) UCL	4481.934
99% Chebyshev (Mean, Sd) UCL	6552.008

IA-8 ProUCL Output

Data File \\Fsmnh01\User1\PROJECTS\03886110\02(Variable: Total PCBs

Raw Statistics	
Number of Valid Samples	58
Number of Unique Samples	33
Minimum	0
Maximum	6100
Mean	243.2362
Median	5.5
Standard Deviation	879.4671
Variance	773462.4
Coefficient of Variation	3.615692
Skewness	5.728985

Normal Distribution Test	
Lilliefors Test Statisitic	0.391054
Lilliefors 5% Critical Value	0.116337
Data not normal at 5% significance level	

95% UCL (Assuming Normal Distribution)	
Student's-t UCL	436.3215

Gamma Statistics Not Available

Lognormal Statistics Not Available

RECOMMENDATION

Data are Non-parametric (0.05)

Use 95% Chebyshev (Mean, Sd) UCL

95% Non-parametric UCLs	
CLT UCL	433.1834
Adj-CLT UCL (Adjusted for skewness)	526.0051
Mod-t UCL (Adjusted for skewness)	450.7999
Jackknife UCL	436.3215
Standard Bootstrap UCL	431.5025
Bootstrap-t UCL	920.5297
Hall's Bootstrap UCL	1146.64
Percentile Bootstrap UCL	451.5707
BCA Bootstrap UCL	559.7302
95% Chebyshev (Mean, Sd) UCL	746.6005
97.5% Chebyshev (Mean, Sd) UCL	964.4066
99% Chebyshev (Mean, Sd) UCL	1392.245

IA-9 ProUCL Output

Data File \\Fsmnh01\User1\PROJECTS\03886110\02(Variable: Aluminum

Raw Statistics	
Number of Valid Samples	24
Number of Unique Samples	19
Minimum	3500
Maximum	8500
Mean	5670.833
Median	5650
Standard Deviation	1410.359
Variance	1989112
Coefficient of Variation	0.248704
Skewness	0.275227

Gamma Statistics	
k hat	16.79658
k star (bias corrected)	14.72479
Theta hat	337.6183
Theta star	385.1216
nu hat	806.236
nu star	706.7898
Approx.Chi Square Value (.05)	646.0923
Adjusted Level of Significance	0.0392
Adjusted Chi Square Value	642.021

Log-transformed Statistics	
Minimum of log data	8.160518
Maximum of log data	9.047821
Mean of log data	8.613028
Standard Deviation of log data	0.251849
Variance of log data	0.063428

RECOMMENDATION

Data are normal (0.05)

Use Student's-t UCL

Normal Distribution Test	
Shapiro-Wilk Test Statisitic	0.956953
Shapiro-Wilk 5% Critical Value	0.916
Data are normal at 5% significance level	

95% UCL (Assuming Normal Distribution)	
Student's-t UCL	6164.237

Gamma Distribution Test	
A-D Test Statistic	0.343295
A-D 5% Critical Value	0.742937
K-S Test Statistic	0.09481
K-S 5% Critical Value	0.177594
Data follow gamma distribution	
at 5% significance level	

95% UCLs (Assuming Gamma Distribution)	
Approximate Gamma UCL	6203.583
Adjusted Gamma UCL	6242.922

Lognormal Distribution Test	
Shapiro-Wilk Test Statisitic	0.961993
Shapiro-Wilk 5% Critical Value	0.916
Data are lognormal at 5% significance level	

95% UCLs (Assuming Lognormal Distribution)	
95% H-UCL	6240.445
95% Chebyshev (MVUE) UCL	6957.273
97.5% Chebyshev (MVUE) UCL	7513.199
99% Chebyshev (MVUE) UCL	8605.207

95% Non-parametric UCLs	
CLT UCL	6144.367
Adj-CLT UCL (Adjusted for skewness)	6161.649
Mod-t UCL (Adjusted for skewness)	6166.932
Jackknife UCL	6164.237
Standard Bootstrap UCL	6142.143
Bootstrap-t UCL	6175.433
Hall's Bootstrap UCL	6158.383
Percentile Bootstrap UCL	6141.667
BCA Bootstrap UCL	6133.333
95% Chebyshev (Mean, Sd) UCL	6925.709
97.5% Chebyshev (Mean, Sd) UCL	7468.695
99% Chebyshev (Mean, Sd) UCL	8535.286

IA-9 ProUCL Output

Data File \\Fsmnh01\User1\PROJECTS\03886110\02(Variable: Arsenic

Raw Statistics	
Number of Valid Samples	24
Number of Unique Samples	17
Minimum	4.3
Maximum	130
Mean	25.9625
Median	20
Standard Deviation	26.0655
Variance	679.4103
Coefficient of Variation	1.003967
Skewness	3.147464

Gamma Statistics	
k hat	1.850947
k star (bias corrected)	1.647356
Theta hat	14.02661
Theta star	15.7601
nu hat	88.84545
nu star	79.0731
Approx.Chi Square Value (.05)	59.5821
Adjusted Level of Significance	0.0392
Adjusted Chi Square Value	58.39228

Log-transformed Statistics	
Minimum of log data	1.458615
Maximum of log data	4.867534
Mean of log data	2.962829
Standard Deviation of log data	0.746937
Variance of log data	0.557915

RECOMMENDATION

Data are lognormal (0.05)

Use H-UCL

Normal Distribution Test	
Shapiro-Wilk Test Statisitic	0.631458
Shapiro-Wilk 5% Critical Value	0.916
Data not normal at 5% significance level	

95% UCL (Assuming Normal Distribution)	
Student's-t UCL	35.08132

Gamma Distribution Test	
A-D Test Statistic	0.937465
A-D 5% Critical Value	0.756992
K-S Test Statistic	0.193241
K-S 5% Critical Value	0.180492
Data do not follow gamma distribution	
at 5% significance level	

95% UCLs (Assuming Gamma Distribution)	
Approximate Gamma UCL	34.45557
Adjusted Gamma UCL	35.15765

Lognormal Distribution Test	
Shapiro-Wilk Test Statisitic	0.953017
Shapiro-Wilk 5% Critical Value	0.916
Data are lognormal at 5% significance level	

95% UCLs (Assuming Lognormal Distribution)	
95% H-UCL	36.11895
95% Chebyshev (MVUE) UCL	43.36012
97.5% Chebyshev (MVUE) UCL	51.21219
99% Chebyshev (MVUE) UCL	66.63606

95% Non-parametric UCLs	
CLT UCL	34.7141
Adj-CLT UCL (Adjusted for skewness)	38.36665
Mod-t UCL (Adjusted for skewness)	35.65104
Jackknife UCL	35.08132
Standard Bootstrap UCL	34.56898
Bootstrap-t UCL	46.82162
Hall's Bootstrap UCL	77.93409
Percentile Bootstrap UCL	34.70417
BCA Bootstrap UCL	38.275
95% Chebyshev (Mean, Sd) UCL	49.15445
97.5% Chebyshev (Mean, Sd) UCL	59.18962
99% Chebyshev (Mean, Sd) UCL	78.90178

IA-9 ProUCL Output

Data File \\Fsmnh01\User1\PROJECTS\03886110\02(Variable: Iron

Raw Statistics	
Number of Valid Samples	24
Number of Unique Samples	20
Minimum	4500
Maximum	16000
Mean	8354.167
Median	8050
Standard Deviation	2905.015
Variance	8439112
Coefficient of Variation	0.347732
Skewness	0.992223

Gamma Statistics	
k hat	9.35981
k star (bias corrected)	8.217611
Theta hat	892.5573
Theta star	1016.617
nu hat	449.2709
nu star	394.4453
Approx.Chi Square Value (.05)	349.4014
Adjusted Level of Significance	0.0392
Adjusted Chi Square Value	346.4257

Log-transformed Statistics	
Minimum of log data	8.411833
Maximum of log data	9.680344
Mean of log data	8.976146
Standard Deviation of log data	0.334546
Variance of log data	0.111921

RECOMMENDATION

Data are normal (0.05)

Use Student's-t UCL

Normal Distribution Test	
Shapiro-Wilk Test Statisitic	0.925457
Shapiro-Wilk 5% Critical Value	0.916
Data are normal at 5% significance level	

95% UCL (Assuming Normal Distribution)	
Student's-t UCL	9370.464

Gamma Distribution Test	
A-D Test Statistic	0.263351
A-D 5% Critical Value	0.744566
K-S Test Statistic	0.102256
K-S 5% Critical Value	0.177822
Data follow gamma distribution	
at 5% significance level	

95% UCLs (Assuming Gamma Distribution)	
Approximate Gamma UCL	9431.165
Adjusted Gamma UCL	9512.176

Lognormal Distribution Test	
Shapiro-Wilk Test Statisitic	0.973831
Shapiro-Wilk 5% Critical Value	0.916
Data are lognormal at 5% significance level	

95% UCLs (Assuming Lognormal Distribution)	
95% H-UCL	9515.922
95% Chebyshev (MVUE) UCL	10878.14
97.5% Chebyshev (MVUE) UCL	11973.36
99% Chebyshev (MVUE) UCL	14124.7

95% Non-parametric UCLs	
CLT UCL	9329.538
Adj-CLT UCL (Adjusted for skewness)	9457.868
Mod-t UCL (Adjusted for skewness)	9390.481
Jackknife UCL	9370.464
Standard Bootstrap UCL	9306.478
Bootstrap-t UCL	9564.813
Hall's Bootstrap UCL	9653.902
Percentile Bootstrap UCL	9316.667
BCA Bootstrap UCL	9404.167
95% Chebyshev (Mean, Sd) UCL	10938.92
97.5% Chebyshev (Mean, Sd) UCL	12057.35
99% Chebyshev (Mean, Sd) UCL	14254.28

IA-9 ProUCL Output

Data File \\Fsmnh01\User1\PROJECTS\03886110\02(Variable: Manganese

Raw Statistics	
Number of Valid Samples	24
Number of Unique Samples	15
Minimum	42
Maximum	350
Mean	163.875
Median	145
Standard Deviation	76.11337
Variance	5793.245
Coefficient of Variation	0.46446
Skewness	0.801756

Gamma Statistics	
k hat	4.7258
k star (bias corrected)	4.162853
Theta hat	34.67667
Theta star	39.36603
nu hat	226.8384
nu star	199.8169
Approx.Chi Square Value (.05)	168.1042
Adjusted Level of Significance	0.0392
Adjusted Chi Square Value	166.061

Log-transformed Statistics	
Minimum of log data	3.73767
Maximum of log data	5.857933
Mean of log data	4.989587
Standard Deviation of log data	0.499228
Variance of log data	0.249228

RECOMMENDATION

Data are normal (0.05)

Use Student's-t UCL

Normal Distribution Test	
Shapiro-Wilk Test Statisitic	0.918335
Shapiro-Wilk 5% Critical Value	0.916
Data are normal at 5% significance level	

95% UCL (Assuming Normal Distribution)	
Student's-t UCL	190.5027

Gamma Distribution Test	
A-D Test Statistic	0.61275
A-D 5% Critical Value	0.746866
K-S Test Statistic	0.180391
K-S 5% Critical Value	0.17842
Data follow approximate gamma distibution at 5% significance level	

95% UCLs (Assuming Gamma Distribution)	
Approximate Gamma UCL	194.7899
Adjusted Gamma UCL	197.1866

Lognormal Distribution Test	
Shapiro-Wilk Test Statisitic	0.930401
Shapiro-Wilk 5% Critical Value	0.916
Data are lognormal at 5% significance level	

95% UCLs (Assuming Lognormal Distribution)	
95% H-UCL	204.2356
95% Chebyshev (MVUE) UCL	241.8383
97.5% Chebyshev (MVUE) UCL	274.9076
99% Chebyshev (MVUE) UCL	339.8659

95% Non-parametric UCLs	
CLT UCL	189.4304
Adj-CLT UCL (Adjusted for skewness)	192.1473
Mod-t UCL (Adjusted for skewness)	190.9265
Jackknife UCL	190.5027
Standard Bootstrap UCL	189.2402
Bootstrap-t UCL	194.7284
Hall's Bootstrap UCL	193.8625
Percentile Bootstrap UCL	189.625
BCA Bootstrap UCL	192.0833
95% Chebyshev (Mean, Sd) UCL	231.5974
97.5% Chebyshev (Mean, Sd) UCL	260.9009
99% Chebyshev (Mean, Sd) UCL	318.462

IA-9 ProUCL Output

Data File C:\Documents and Settings\schmidlj\Deskto| Variable: Nickel

Raw Statistics	
Number of Valid Samples	24
Number of Unique Samples	18
Minimum	4.3
Maximum	24
Mean	11.35833
Median	11
Standard Deviation	5.395966
Variance	29.11645
Coefficient of Variation	0.475067
Skewness	0.921402

Gamma Statistics	
k hat	4.94174
k star (bias corrected)	4.351801
Theta hat	2.298448
Theta star	2.610031
nu hat	237.2035
nu star	208.8864
Approx.Chi Square Value (.05)	176.4347
Adjusted Level of Significance	0.0392
Adjusted Chi Square Value	174.3399

Log-transformed Statistics	
Minimum of log data	1.458615
Maximum of log data	3.178054
Mean of log data	2.325374
Standard Deviation of log data	0.469232
Variance of log data	0.220179

RECOMMENDATION

Data follow gamma distribution (0.05)

Use Approximate Gamma UCL

Normal Distribution Test	
Shapiro-Wilk Test Statisitic	0.913576
Shapiro-Wilk 5% Critical Value	0.916
Data not normal at 5% significance level	

95% UCL (Assuming Normal Distribution)	
Student's-t UCL	13.24607

Gamma Distribution Test	
A-D Test Statistic	0.301114
A-D 5% Critical Value	0.746318
K-S Test Statistic	0.11589
K-S 5% Critical Value	0.178333
Data follow gamma distribution	
at 5% significance level	

95% UCLs (Assuming Gamma Distribution)	
Approximate Gamma UCL	13.44747
Adjusted Gamma UCL	13.60906

Lognormal Distribution Test	
Shapiro-Wilk Test Statisitic	0.974466
Shapiro-Wilk 5% Critical Value	0.916
Data are lognormal at 5% significance level	

95% UCLs (Assuming Lognormal Distribution)	
95% H-UCL	13.81485
95% Chebyshev (MVUE) UCL	16.27788
97.5% Chebyshev (MVUE) UCL	18.4042
99% Chebyshev (MVUE) UCL	22.58093

95% Non-parametric UCLs	
CLT UCL	13.17005
Adj-CLT UCL (Adjusted for skewness)	13.39141
Mod-t UCL (Adjusted for skewness)	13.2806
Jackknife UCL	13.24607
Standard Bootstrap UCL	13.12845
Bootstrap-t UCL	13.48699
Hall's Bootstrap UCL	13.38318
Percentile Bootstrap UCL	13.19583
BCA Bootstrap UCL	13.40417
95% Chebyshev (Mean, Sd) UCL	16.15943
97.5% Chebyshev (Mean, Sd) UCL	18.23687
99% Chebyshev (Mean, Sd) UCL	22.31759

IA-9 ProUCL Output

Data File \\Fsmnh01\User1\PROJECTS\03886110\02(Variable: Vanadium

Raw Statistics	
Number of Valid Samples	14
Number of Unique Samples	14
Minimum	4.4
Maximum	13
Mean	8.157143
Median	7.9
Standard Deviation	2.447515
Variance	5.99033
Coefficient of Variation	0.300046
Skewness	0.459481

Gamma Statistics	
k hat	11.82532
k star (bias corrected)	9.338944
Theta hat	0.689803
Theta star	0.873455
nu hat	331.109
nu star	261.4904
Approx.Chi Square Value (.05)	225.0381
Adjusted Level of Significance	0.03122
Adjusted Chi Square Value	220.5524

Log-transformed Statistics	
Minimum of log data	1.481605
Maximum of log data	2.564949
Mean of log data	2.056016
Standard Deviation of log data	0.308038
Variance of log data	0.094888

RECOMMENDATION

Data are normal (0.05)

Use Student's-t UCL

Normal Distribution Test	
Shapiro-Wilk Test Statisitic	0.969426
Shapiro-Wilk 5% Critical Value	0.874
Data are normal at 5% significance level	

95% UCL (Assuming Normal Distribution)	
Student's-t UCL	9.315556

Gamma Distribution Test	
A-D Test Statistic	0.145142
A-D 5% Critical Value	0.734431
K-S Test Statistic	0.085196
K-S 5% Critical Value	0.228589
Data follow gamma distribution	
at 5% significance level	

95% UCLs (Assuming Gamma Distribution)	
Approximate Gamma UCL	9.478461
Adjusted Gamma UCL	9.671237

Lognormal Distribution Test	
Shapiro-Wilk Test Statisitic	0.976206
Shapiro-Wilk 5% Critical Value	0.874
Data are lognormal at 5% significance level	

95% UCLs (Assuming Lognormal Distribution)	
95% H-UCL	9.641787
95% Chebyshev (MVUE) UCL	11.12917
97.5% Chebyshev (MVUE) UCL	12.41146
99% Chebyshev (MVUE) UCL	14.93028

95% Non-parametric UCLs	
CLT UCL	9.233084
Adj-CLT UCL (Adjusted for skewness)	9.318915
Mod-t UCL (Adjusted for skewness)	9.328944
Jackknife UCL	9.315556
Standard Bootstrap UCL	9.190746
Bootstrap-t UCL	9.429716
Hall's Bootstrap UCL	9.471717
Percentile Bootstrap UCL	9.2
BCA Bootstrap UCL	9.307143
95% Chebyshev (Mean, Sd) UCL	11.00841
97.5% Chebyshev (Mean, Sd) UCL	12.24216
99% Chebyshev (Mean, Sd) UCL	14.66561

Data File \\Fsmnh01\User1\PROJECTS\03886110\02(Variable: Arsenic

Raw Statistics	
Number of Valid Samples	23
Number of Unique Samples	16
Minimum	4.3
Maximum	70
Mean	21.43913
Median	20
Standard Deviation	14.03249
Variance	196.9107
Coefficient of Variation	0.654527
Skewness	1.981813

Gamma Statistics	
k hat	2.855506
k star (bias corrected)	2.512034
Theta hat	7.507998
Theta star	8.534571
nu hat	131.3533
nu star	115.5536
Approx.Chi Square Value (.05)	91.73102
Adjusted Level of Significance	0.0389
Adjusted Chi Square Value	90.19334

Log-transformed Statistics	
Minimum of log data	1.458615
Maximum of log data	4.248495
Mean of log data	2.880016
Standard Deviation of log data	0.641249
Variance of log data	0.411201

RECOMMENDATION

Data follow gamma distribution (0.05)

Use Approximate Gamma UCL

Normal Distribution Test	
Shapiro-Wilk Test Statisitic	0.826141
Shapiro-Wilk 5% Critical Value	0.914
Data not normal at 5% significance level	

95% UCL (Assuming Normal Distribution)	
Student's-t UCL	26.46345

Gamma Distribution Test	
A-D Test Statistic	0.462199
A-D 5% Critical Value	0.750981
K-S Test Statistic	0.139852
K-S 5% Critical Value	0.18287
Data follow gamma distribution	
at 5% significance level	

95% UCLs (Assuming Gamma Distribution)	
Approximate Gamma UCL	27.00687
Adjusted Gamma UCL	27.4673

Lognormal Distribution Test	
Shapiro-Wilk Test Statisitic	0.956258
Shapiro-Wilk 5% Critical Value	0.914
Data are lognormal at 5% significance level	

95% UCLs (Assuming Lognormal Distribution)	
95% H-UCL	29.20298
95% Chebyshev (MVUE) UCL	35.05595
97.5% Chebyshev (MVUE) UCL	40.85585
99% Chebyshev (MVUE) UCL	52.24863

95% Non-parametric UCLs	
CLT UCL	26.25193
Adj-CLT UCL (Adjusted for skewness)	27.54389
Mod-t UCL (Adjusted for skewness)	26.66497
Jackknife UCL	26.46345
Standard Bootstrap UCL	26.06153
Bootstrap-t UCL	28.18396
Hall's Bootstrap UCL	33.82532
Percentile Bootstrap UCL	26.36522
BCA Bootstrap UCL	27.77826
95% Chebyshev (Mean, Sd) UCL	34.19316
97.5% Chebyshev (Mean, Sd) UCL	39.71184
99% Chebyshev (Mean, Sd) UCL	50.55222

IA-10 ProUCL Output

Data File \\Fsmnh01\User1\PROJECTS\03886110\02(Variable: Aluminum

Raw Statistics	
Number of Valid Samples	147
Number of Unique Samples	78
Minimum	2000
Maximum	16000
Mean	7839.388
Median	7600
Standard Deviation	2675.46
Variance	7158085
Coefficient of Variation	0.341284
Skewness	0.336294

Gamma Statistics	
k hat	7.796231
k star (bias corrected)	7.641659
Theta hat	1005.536
Theta star	1025.875
nu hat	2292.092
nu star	2246.648
Approx.Chi Square Value (.05)	2137.515
Adjusted Level of Significance	0.048367
Adjusted Chi Square Value	2136.475

Log-transformed Statistics	
Minimum of log data	7.600902
Maximum of log data	9.680344
Mean of log data	8.901414
Standard Deviation of log data	0.382698
Variance of log data	0.146457

RECOMMENDATION

Data are normal (0.05)

Use Student's-t UCL

Normal Distribution Test	
Lilliefors Test Statisitic	0.070499
Lilliefors 5% Critical Value	0.073076
Data are normal at 5% significance level	

95% UCL (Assuming Normal Distribution)	
Student's-t UCL	8204.672

Gamma Distribution Test	
A-D Test Statistic	0.916719
A-D 5% Critical Value	0.753215
K-S Test Statistic	0.08786
K-S 5% Critical Value	0.077348
Data do not follow gamma distribution	
at 5% significance level	

95% UCLs (Assuming Gamma Distribution)	
Approximate Gamma UCL	8239.633
Adjusted Gamma UCL	8243.645

Lognormal Distribution Test	
Lilliefors Test Statisitic	0.111598
Lilliefors 5% Critical Value	0.073076
Data not lognormal at 5% significance level	

95% UCLs (Assuming Lognormal Distribution)	
95% H-UCL	8352.098
95% Chebyshev (MVUE) UCL	9019.179
97.5% Chebyshev (MVUE) UCL	9505.19
99% Chebyshev (MVUE) UCL	10459.86

95% Non-parametric UCLs	
CLT UCL	8202.355
Adj-CLT UCL (Adjusted for skewness)	8208.895
Mod-t UCL (Adjusted for skewness)	8205.693
Jackknife UCL	8204.672
Standard Bootstrap UCL	8207.397
Bootstrap-t UCL	8199.166
Hall's Bootstrap UCL	8217.511
Percentile Bootstrap UCL	8200.34
BCA Bootstrap UCL	8199.32
95% Chebyshev (Mean, Sd) UCL	8801.258
97.5% Chebyshev (Mean, Sd) UCL	9217.46
99% Chebyshev (Mean, Sd) UCL	10035.01

IA-10 ProUCL Output

Data File \\Fsmnh01\User1\PROJECTS\03886110\02(Variable: Antimony

Raw Statistics	
Number of Valid Samples	122
Number of Unique Samples	16
Minimum	0
Maximum	24
Mean	1.410656
Median	1.1
Standard Deviation	2.477712
Variance	6.139059
Coefficient of Variation	1.756426
Skewness	7.496818

Normal Distribution Test	
Lilliefors Test Statisitic	0.460434
Lilliefors 5% Critical Value	0.080215
Data not normal at 5% significance level	

95% UCL (Assuming Normal Distribution)	
Student's-t UCL	1.782479

Gamma Statistics Not Available

Lognormal Statistics Not Available

RECOMMENDATION

Data are Non-parametric (0.05)

Use 95% Chebyshev (Mean, Sd) UCL

95% Non-parametric UCLs	
CLT UCL	1.779632
Adj-CLT UCL (Adjusted for skewness)	1.942317
Mod-t UCL (Adjusted for skewness)	1.807854
Jackknife UCL	1.782479
Standard Bootstrap UCL	1.772218
Bootstrap-t UCL	2.234423
Hall's Bootstrap UCL	4.202699
Percentile Bootstrap UCL	1.801639
BCA Bootstrap UCL	2.053279
95% Chebyshev (Mean, Sd) UCL	2.388451
97.5% Chebyshev (Mean, Sd) UCL	2.811543
99% Chebyshev (Mean, Sd) UCL	3.642627

IA-10 ProUCL Output

Data File \\Fsmnh01\User1\PROJECTS\03886110\02(Variable: Arsenic

Raw Statistics	
Number of Valid Samples	147
Number of Unique Samples	63
Minimum	6.3
Maximum	68
Mean	24.66395
Median	24
Standard Deviation	11.19157
Variance	125.2512
Coefficient of Variation	0.453762
Skewness	0.998131

Gamma Statistics	
k hat	4.94256
k star (bias corrected)	4.846227
Theta hat	4.990116
Theta star	5.089309
nu hat	1453.113
nu star	1424.791
Approx.Chi Square Value (.05)	1338.119
Adjusted Level of Significance	0.048367
Adjusted Chi Square Value	1337.298

Log-transformed Statistics	
Minimum of log data	1.84055
Maximum of log data	4.219508
Mean of log data	3.100783
Standard Deviation of log data	0.472252
Variance of log data	0.223022

RECOMMENDATION

Data are normal (0.05)

Use Student's-t UCL

Normal Distribution Test	
Lilliefors Test Statisitic	0.07007
Lilliefors 5% Critical Value	0.073076
Data are normal at 5% significance level	

95% UCL (Assuming Normal Distribution)	
Student's-t UCL	26.19195

Gamma Distribution Test	
A-D Test Statistic	0.75059
A-D 5% Critical Value	0.75521
K-S Test Statistic	0.061874
K-S 5% Critical Value	0.077473
Data follow gamma distribution	
at 5% significance level	

95% UCLs (Assuming Gamma Distribution)	
Approximate Gamma UCL	26.26146
Adjusted Gamma UCL	26.27758

Lognormal Distribution Test	
Lilliefors Test Statisitic	0.092041
Lilliefors 5% Critical Value	0.073076
Data not lognormal at 5% significance level	

95% UCLs (Assuming Lognormal Distribution)	
95% H-UCL	26.6456
95% Chebyshev (MVUE) UCL	29.24338
97.5% Chebyshev (MVUE) UCL	31.15949
99% Chebyshev (MVUE) UCL	34.92334

95% Non-parametric UCLs	
CLT UCL	26.18225
Adj-CLT UCL (Adjusted for skewness)	26.26345
Mod-t UCL (Adjusted for skewness)	26.20461
Jackknife UCL	26.19195
Standard Bootstrap UCL	26.23113
Bootstrap-t UCL	26.20815
Hall's Bootstrap UCL	26.23723
Percentile Bootstrap UCL	26.19048
BCA Bootstrap UCL	26.23401
95% Chebyshev (Mean, Sd) UCL	28.68749
97.5% Chebyshev (Mean, Sd) UCL	30.42849
99% Chebyshev (Mean, Sd) UCL	33.84833

IA-10 ProUCL Output

Data File \\Fsmnh01\User1\PROJECTS\03886110\02(Variable: Chromium

Raw Statistics	
Number of Valid Samples	100
Number of Unique Samples	39
Minimum	4.8
Maximum	40
Mean	16.928
Median	16
Standard Deviation	7.063465
Variance	49.89254
Coefficient of Variation	0.417265
Skewness	0.548493

Gamma Statistics	
k hat	5.426217
k star (bias corrected)	5.270097
Theta hat	3.119669
Theta star	3.212085
nu hat	1085.243
nu star	1054.019
Approx.Chi Square Value (.05)	979.6369
Adjusted Level of Significance	0.0476
Adjusted Chi Square Value	978.5994

Log-transformed Statistics	
Minimum of log data	1.568616
Maximum of log data	3.688879
Mean of log data	2.734003
Standard Deviation of log data	0.457631
Variance of log data	0.209426

RECOMMENDATION

Assuming gamma distribution (0.05)

Use Approximate Gamma UCL

Normal Distribution Test	
Lilliefors Test Statisitic	0.099685
Lilliefors 5% Critical Value	0.0886
Data not normal at 5% significance level	

95% UCL (Assuming Normal Distribution)	
Student's-t UCL	18.10081

Gamma Distribution Test	
A-D Test Statistic	0.4563
A-D 5% Critical Value	0.754146
K-S Test Statistic	0.10567
K-S 5% Critical Value	0.089575
Data follow approximate gamma distibution	
at 5% significance level	

95% UCLs (Assuming Gamma Distribution)	
Approximate Gamma UCL	18.21332
Adjusted Gamma UCL	18.23263

Lognormal Distribution Test	
Lilliefors Test Statisitic	0.133598
Lilliefors 5% Critical Value	0.0886
Data not lognormal at 5% significance level	

95% UCLs (Assuming Lognormal Distribution)	
95% H-UCL	18.57519
95% Chebyshev (MVUE) UCL	20.63889
97.5% Chebyshev (MVUE) UCL	22.18138
99% Chebyshev (MVUE) UCL	25.2113

95% Non-parametric UCLs	
CLT UCL	18.08984
Adj-CLT UCL (Adjusted for skewness)	18.13123
Mod-t UCL (Adjusted for skewness)	18.10727
Jackknife UCL	18.10081
Standard Bootstrap UCL	18.06995
Bootstrap-t UCL	18.13496
Hall's Bootstrap UCL	18.07251
Percentile Bootstrap UCL	18.093
BCA Bootstrap UCL	18.082
95% Chebyshev (Mean, Sd) UCL	20.00689
97.5% Chebyshev (Mean, Sd) UCL	21.33913
99% Chebyshev (Mean, Sd) UCL	23.95606

IA-10 ProUCL Output

Data File \\Fsmnh01\User1\PROJECTS\03886110\02(Variable: Iron

Raw Statistics	
Number of Valid Samples	147
Number of Unique Samples	68
Minimum	17.2
Maximum	28000
Mean	11559.37
Median	11000
Standard Deviation	4330.603
Variance	18754122
Coefficient of Variation	0.37464
Skewness	0.742057

Gamma Statistics	
k hat	5.042334
k star (bias corrected)	4.943964
Theta hat	2292.464
Theta star	2338.077
nu hat	1482.446
nu star	1453.525
Approx.Chi Square Value (.05)	1365.973
Adjusted Level of Significance	0.048367
Adjusted Chi Square Value	1365.143

Log-transformed Statistics	
Minimum of log data	2.844909
Maximum of log data	10.23996
Mean of log data	9.252826
Standard Deviation of log data	0.646543
Variance of log data	0.418018

RECOMMENDATION

Data are Non-parametric (0.05)

Use 95% Chebyshev (Mean, Sd) UCL

Normal Distribution Test	
Lilliefors Test Statisitic	0.105737
Lilliefors 5% Critical Value	0.073076
Data not normal at 5% significance level	

95% UCL (Assuming Normal Distribution)	
Student's-t UCL	12150.63

Gamma Distribution Test	
A-D Test Statistic	2.198275
A-D 5% Critical Value	0.755109
K-S Test Statistic	0.0873
K-S 5% Critical Value	0.077462
Data do not follow gamma distribution	
at 5% significance level	

95% UCLs (Assuming Gamma Distribution)	
Approximate Gamma UCL	12300.27
Adjusted Gamma UCL	12307.75

Lognormal Distribution Test	
Lilliefors Test Statisitic	0.167403
Lilliefors 5% Critical Value	0.073076
Data not lognormal at 5% significance level	

95% UCLs (Assuming Lognormal Distribution)	
95% H-UCL	14235.91
95% Chebyshev (MVUE) UCL	16099.39
97.5% Chebyshev (MVUE) UCL	17510.83
99% Chebyshev (MVUE) UCL	20283.33

95% Non-parametric UCLs	
CLT UCL	12146.88
Adj-CLT UCL (Adjusted for skewness)	12170.24
Mod-t UCL (Adjusted for skewness)	12154.28
Jackknife UCL	12150.63
Standard Bootstrap UCL	12133.45
Bootstrap-t UCL	12186.39
Hall's Bootstrap UCL	12168.46
Percentile Bootstrap UCL	12139.32
BCA Bootstrap UCL	12165.65
95% Chebyshev (Mean, Sd) UCL	13116.29
97.5% Chebyshev (Mean, Sd) UCL	13789.97
99% Chebyshev (Mean, Sd) UCL	15113.29

IA-10 ProUCL Output

Data File \\Fsmnh01\User1\PROJECTS\03886110\02(Variable: Manganese

Raw Statistics	
Number of Valid Samples	147
Number of Unique Samples	65
Minimum	55.2
Maximum	640
Mean	230.9605
Median	230
Standard Deviation	103.1845
Variance	10647.04
Coefficient of Variation	0.446762
Skewness	0.905302

Gamma Statistics	
k hat	4.995704
k star (bias corrected)	4.898286
Theta hat	46.23183
Theta star	47.1513
nu hat	1468.737
nu star	1440.096
Approx.Chi Square Value (.05)	1352.954
Adjusted Level of Significance	0.048367
Adjusted Chi Square Value	1352.128

Log-transformed Statistics	
Minimum of log data	4.010963
Maximum of log data	6.461468
Mean of log data	5.338835
Standard Deviation of log data	0.472017
Variance of log data	0.2228

RECOMMENDATION

Assuming gamma distribution (0.05)

Use Approximate Gamma UCL

Normal Distribution Test	
Lilliefors Test Statisitic	0.07952
Lilliefors 5% Critical Value	0.073076
Data not normal at 5% significance level	

95% UCL (Assuming Normal Distribution)	
Student's-t UCL	245.0485

Gamma Distribution Test	
A-D Test Statistic	0.860056
A-D 5% Critical Value	0.755144
K-S Test Statistic	0.068037
K-S 5% Critical Value	0.077465
Data follow approximate gamma distibution	
at 5% significance level	

95% UCLs (Assuming Gamma Distribution)	
Approximate Gamma UCL	245.8364
Adjusted Gamma UCL	245.9865

Lognormal Distribution Test	
Lilliefors Test Statisitic	0.09845
Lilliefors 5% Critical Value	0.073076
Data not lognormal at 5% significance level	

95% UCLs (Assuming Lognormal Distribution)	
95% H-UCL	249.7662
95% Chebyshev (MVUE) UCL	274.1053
97.5% Chebyshev (MVUE) UCL	292.0573
99% Chebyshev (MVUE) UCL	327.3203

95% Non-parametric UCLs	
CLT UCL	244.9591
Adj-CLT UCL (Adjusted for skewness)	245.6381
Mod-t UCL (Adjusted for skewness)	245.1544
Jackknife UCL	245.0485
Standard Bootstrap UCL	244.7864
Bootstrap-t UCL	245.7612
Hall's Bootstrap UCL	246.3904
Percentile Bootstrap UCL	244.7891
BCA Bootstrap UCL	245.3687
95% Chebyshev (Mean, Sd) UCL	268.057
97.5% Chebyshev (Mean, Sd) UCL	284.1087
99% Chebyshev (Mean, Sd) UCL	315.6391

IA-10 ProUCL Output

Data File \\Fsmnh01\User1\PROJECTS\03886110\02(Variable: Nickel

Raw Statistics	
Number of Valid Samples	147
Number of Unique Samples	67
Minimum	4.9
Maximum	73
Mean	21.7381
Median	22
Standard Deviation	10.83991
Variance	117.5036
Coefficient of Variation	0.49866
Skewness	1.154365

Gamma Statistics	
k hat	4.004748
k star (bias corrected)	3.927554
Theta hat	5.42808
Theta star	5.534767
nu hat	1177.396
nu star	1154.701
Approx.Chi Square Value (.05)	1076.792
Adjusted Level of Significance	0.048367
Adjusted Chi Square Value	1076.056

Log-transformed Statistics	
Minimum of log data	1.589235
Maximum of log data	4.290459
Mean of log data	2.94905
Standard Deviation of log data	0.534512
Variance of log data	0.285703

RECOMMENDATION

Data are Non-parametric (0.05)

Use 95% Chebyshev (Mean, Sd) UCL

Normal Distribution Test	
Lilliefors Test Statisitic	0.083466
Lilliefors 5% Critical Value	0.073076
Data not normal at 5% significance level	

95% UCL (Assuming Normal Distribution)	
Student's-t UCL	23.21808

Gamma Distribution Test	
A-D Test Statistic	1.651383
A-D 5% Critical Value	0.756379
K-S Test Statistic	0.106467
K-S 5% Critical Value	0.077624
Data do not follow gamma distribution	
at 5% significance level	

95% UCLs (Assuming Gamma Distribution)	
Approximate Gamma UCL	23.3109
Adjusted Gamma UCL	23.32684

Lognormal Distribution Test	
Lilliefors Test Statisitic	0.135357
Lilliefors 5% Critical Value	0.073076
Data not lognormal at 5% significance level	

95% UCLs (Assuming Lognormal Distribution)	
95% H-UCL	23.8788
95% Chebyshev (MVUE) UCL	26.49514
97.5% Chebyshev (MVUE) UCL	28.44256
99% Chebyshev (MVUE) UCL	32.26788

95% Non-parametric UCLs	
CLT UCL	23.20869
Adj-CLT UCL (Adjusted for skewness)	23.29965
Mod-t UCL (Adjusted for skewness)	23.23227
Jackknife UCL	23.21808
Standard Bootstrap UCL	23.20305
Bootstrap-t UCL	23.2848
Hall's Bootstrap UCL	23.38036
Percentile Bootstrap UCL	23.17211
BCA Bootstrap UCL	23.20272
95% Chebyshev (Mean, Sd) UCL	25.63521
97.5% Chebyshev (Mean, Sd) UCL	27.3215
99% Chebyshev (Mean, Sd) UCL	30.63389

IA-10 ProUCL Output

Data File \\Fsmnh01\User1\PROJECTS\03886110\02(Variable: Thallium

Raw Statistics	
Number of Valid Samples	114
Number of Unique Samples	14
Minimum	0
Maximum	1.1
Mean	0.531711
Median	0.55
Standard Deviation	0.251501
Variance	0.063253
Coefficient of Variation	0.473003
Skewness	-0.24234

Normal Distribution Test	
Lilliefors Test Statisitic	0.349006
Lilliefors 5% Critical Value	0.082982
Data not normal at 5% significance level	

95% UCL (Assuming Normal Distribution)	
Student's-t UCL	0.570776

Gamma Statistics Not Available

Lognormal Statistics Not Available

RECOMMENDATION

Data are Non-parametric (0.05)

Use 95% Chebyshev (Mean, Sd) UCL

95% Non-parametric UCLs	
CLT UCL	0.570455
Adj-CLT UCL (Adjusted for skewness)	0.569884
Mod-t UCL (Adjusted for skewness)	0.570687
Jackknife UCL	0.570776
Standard Bootstrap UCL	0.570123
Bootstrap-t UCL	0.571018
Hall's Bootstrap UCL	0.567321
Percentile Bootstrap UCL	0.571623
BCA Bootstrap UCL	0.568947
95% Chebyshev (Mean, Sd) UCL	0.634385
97.5% Chebyshev (Mean, Sd) UCL	0.678813
99% Chebyshev (Mean, Sd) UCL	0.766082

IA-10 ProUCL Output

Data File \\Fsmnh01\User1\PROJECTS\03886110\02(Variable: Anthracene

Raw Statistics	
Number of Valid Samples	113
Number of Unique Samples	14
Minimum	0
Maximum	3200
Mean	75.47788
Median	0
Standard Deviation	316.9889
Variance	100481.9
Coefficient of Variation	4.199759
Skewness	8.870851

Normal Distribution Test	
Lilliefors Test Statisitic	0.405898
Lilliefors 5% Critical Value	0.083348
Data not normal at 5% significance level	

95% UCL (Assuming Normal Distribution)	
Student's-t UCL	124.9362

Gamma Statistics Not Available

Lognormal Statistics Not Available

RECOMMENDATION

Data are Non-parametric (0.05)

Use 95% Chebyshev (Mean, Sd) UCL

95% Non-parametric UCLs	
CLT UCL	124.5271
Adj-CLT UCL (Adjusted for skewness)	151.1167
Mod-t UCL (Adjusted for skewness)	129.0836
Jackknife UCL	124.9362
Standard Bootstrap UCL	125.826
Bootstrap-t UCL	239.4732
Hall's Bootstrap UCL	321.2927
Percentile Bootstrap UCL	133.6726
BCA Bootstrap UCL	164.6681
95% Chebyshev (Mean, Sd) UCL	205.4594
97.5% Chebyshev (Mean, Sd) UCL	261.7025
99% Chebyshev (Mean, Sd) UCL	372.1812

IA-10 ProUCL Output

Data File \\Fsmnh01\User1\PROJECTS\03886110\02(Variable: Benzo(a)anthracene

Raw Statistics	
Number of Valid Samples	100
Number of Unique Samples	11
Minimum	0
Maximum	6100
Mean	129.9
Median	0
Standard Deviation	624.3425
Variance	389803.5
Coefficient of Variation	4.806332
Skewness	9.065334

Normal Distribution Test	
Lilliefors Test Statisitic	0.417592
Lilliefors 5% Critical Value	0.0886
Data not normal at 5% significance level	

95% UCL (Assuming Normal Distribution)	
Student's-t UCL	233.5652

Gamma Statistics Not Available

Lognormal Statistics Not Available

RECOMMENDATION

Data are Non-parametric (0.05)

Use 95% Chebyshev (Mean, Sd) UCL

95% Non-parametric UCLs	
CLT UCL	232.5952
Adj-CLT UCL (Adjusted for skewness)	293.0718
Mod-t UCL (Adjusted for skewness)	242.9984
Jackknife UCL	233.5652
Standard Bootstrap UCL	233.6513
Bootstrap-t UCL	590.713
Hall's Bootstrap UCL	572.9785
Percentile Bootstrap UCL	251
BCA Bootstrap UCL	326.4
95% Chebyshev (Mean, Sd) UCL	402.0446
97.5% Chebyshev (Mean, Sd) UCL	519.8018
99% Chebyshev (Mean, Sd) UCL	751.1129

IA-10 ProUCL Output

Data File \\Fsmnh01\User1\PROJECTS\03886110\02(Variable: Benzo(a)pyrene

Raw Statistics	
Number of Valid Samples	100
Number of Unique Samples	18
Minimum	0
Maximum	5500
Mean	99.255
Median	0
Standard Deviation	568.3716
Variance	323046.3
Coefficient of Variation	5.726377
Skewness	8.933782

Normal Distribution Test	
Lilliefors Test Statisitic	0.430685
Lilliefors 5% Critical Value	0.0886
Data not normal at 5% significance level	

95% UCL (Assuming Normal Distribution)	
Student's-t UCL	193.6269

Gamma Statistics Not Available

Lognormal Statistics Not Available

RECOMMENDATION

Data are Non-parametric (0.05)

Use 95% Chebyshev (Mean, Sd) UCL

95% Non-parametric UCLs	
CLT UCL	192.7438
Adj-CLT UCL (Adjusted for skewness)	246.9998
Mod-t UCL (Adjusted for skewness)	202.0897
Jackknife UCL	193.6269
Standard Bootstrap UCL	191.0089
Bootstrap-t UCL	483.2993
Hall's Bootstrap UCL	475.9331
Percentile Bootstrap UCL	203.205
BCA Bootstrap UCL	272.625
95% Chebyshev (Mean, Sd) UCL	347.0024
97.5% Chebyshev (Mean, Sd) UCL	454.2029
99% Chebyshev (Mean, Sd) UCL	664.7776

IA-10 ProUCL Output

Data File \\Fsmnh01\User1\PROJECTS\03886110\02(Variable: Benzo(b)fluoranthene

Raw Statistics	
Number of Valid Samples	100
Number of Unique Samples	11
Minimum	0
Maximum	3800
Mean	104.2
Median	0
Standard Deviation	401.2617
Variance	161011
Coefficient of Variation	3.85088
Skewness	8.203312

Normal Distribution Test	
Lilliefors Test Statisitic	0.397555
Lilliefors 5% Critical Value	0.0886
Data not normal at 5% significance level	

95% UCL (Assuming Normal Distribution)	
Student's-t UCL	170.8251

Gamma Statistics Not Available

Lognormal Statistics Not Available

RECOMMENDATION

Data are Non-parametric (0.05)

Use 95% Chebyshev (Mean, Sd) UCL

95% Non-parametric UCLs	
CLT UCL	170.2017
Adj-CLT UCL (Adjusted for skewness)	205.3737
Mod-t UCL (Adjusted for skewness)	176.3113
Jackknife UCL	170.8251
Standard Bootstrap UCL	168.2972
Bootstrap-t UCL	301.4416
Hall's Bootstrap UCL	396.4167
Percentile Bootstrap UCL	181.05
BCA Bootstrap UCL	231.05
95% Chebyshev (Mean, Sd) UCL	279.1059
97.5% Chebyshev (Mean, Sd) UCL	354.7879
99% Chebyshev (Mean, Sd) UCL	503.4504

IA-10 ProUCL Output

Data File \\Fsmnh01\User1\PROJECTS\03886110\02(Variable: Benzo(g,h,i)perylene

Raw Statistics	
Number of Valid Samples	100
Number of Unique Samples	15
Minimum	0
Maximum	2800
Mean	76.85
Median	0
Standard Deviation	302.6058
Variance	91570.28
Coefficient of Variation	3.937616
Skewness	7.802141

Normal Distribution Test	
Lilliefors Test Statisitic	0.399763
Lilliefors 5% Critical Value	0.0886
Data not normal at 5% significance level	

95% UCL (Assuming Normal Distribution)	
Student's-t UCL	127.0944

Gamma Statistics Not Available

Lognormal Statistics Not Available

RECOMMENDATION

Data are Non-parametric (0.05)

Use 95% Chebyshev (Mean, Sd) UCL

95% Non-parametric UCLs	
CLT UCL	126.6242
Adj-CLT UCL (Adjusted for skewness)	151.8516
Mod-t UCL (Adjusted for skewness)	131.0293
Jackknife UCL	127.0944
Standard Bootstrap UCL	126.9523
Bootstrap-t UCL	220.5683
Hall's Bootstrap UCL	298.1285
Percentile Bootstrap UCL	133.95
BCA Bootstrap UCL	169.975
95% Chebyshev (Mean, Sd) UCL	208.7528
97.5% Chebyshev (Mean, Sd) UCL	265.8273
99% Chebyshev (Mean, Sd) UCL	377.939

IA-10 ProUCL Output

Data File \\Fsmnh01\User1\PROJECTS\03886110\02(Variable: Dibenz(a,h)Anthracene

Raw Statistics	
Number of Valid Samples	100
Number of Unique Samples	13
Minimum	0
Maximum	2300
Mean	49.955
Median	0
Standard Deviation	251.8238
Variance	63415.2
Coefficient of Variation	5.041012
Skewness	7.799001

Normal Distribution Test	
Lilliefors Test Statisitic	0.446159
Lilliefors 5% Critical Value	0.0886
Data not normal at 5% significance level	

95% UCL (Assuming Normal Distribution)	
Student's-t UCL	91.76758

Gamma Statistics Not Available

Lognormal Statistics Not Available

RECOMMENDATION

Data are Non-parametric (0.05)

Use 95% Chebyshev (Mean, Sd) UCL

95% Non-parametric UCLs	
CLT UCL	91.37632
Adj-CLT UCL (Adjusted for skewness)	112.3617
Mod-t UCL (Adjusted for skewness)	95.04087
Jackknife UCL	91.76758
Standard Bootstrap UCL	91.7745
Bootstrap-t UCL	200.0892
Hall's Bootstrap UCL	245.011
Percentile Bootstrap UCL	95.37
BCA Bootstrap UCL	125.965
95% Chebyshev (Mean, Sd) UCL	159.7224
97.5% Chebyshev (Mean, Sd) UCL	207.2189
99% Chebyshev (Mean, Sd) UCL	300.5165

IA-10 ProUCL Output

Data File \\Fsmnh01\User1\PROJECTS\03886110\02(Variable: Fluoranthene

Raw Statistics	
Number of Valid Samples	100
Number of Unique Samples	15
Minimum	0
Maximum	13000
Mean	209.65
Median	0
Standard Deviation	1309.721
Variance	1715369
Coefficient of Variation	6.247179
Skewness	9.611624

Normal Distribution Test	
Lilliefors Test Statisitic	0.462939
Lilliefors 5% Critical Value	0.0886
Data not normal at 5% significance level	
95% UCL (Assuming Normal Distribution)	
Student's-t UCL	427.1149

Gamma Statistics Not Available

Lognormal Statistics Not Available

RECOMMENDATION

Data are Non-parametric (0.05)

Use 95% Chebyshev (Mean, Sd) UCL

95% Non-parametric UCLs	
CLT UCL	425.08
Adj-CLT UCL (Adjusted for skewness)	559.5904
Mod-t UCL (Adjusted for skewness)	448.0958
Jackknife UCL	427.1149
Standard Bootstrap UCL	430.3342
Bootstrap-t UCL	1633.036
Hall's Bootstrap UCL	1144.012
Percentile Bootstrap UCL	460.425
BCA Bootstrap UCL	646.805
95% Chebyshev (Mean, Sd) UCL	780.5442
97.5% Chebyshev (Mean, Sd) UCL	1027.571
99% Chebyshev (Mean, Sd) UCL	1512.806

IA-10 ProUCL Output

Data File \\Fsmnh01\User1\PROJECTS\03886110\02(Variable: Indeno(1,2,3-c,d)Pyrene

Raw Statistics	
Number of Valid Samples	100
Number of Unique Samples	11
Minimum	0
Maximum	3700
Mean	103.9
Median	0
Standard Deviation	392.1043
Variance	153745.7
Coefficient of Variation	3.773862
Skewness	8.104345

Normal Distribution Test	
Lilliefors Test Statisitic	0.395512
Lilliefors 5% Critical Value	0.0886
Data not normal at 5% significance level	

95% UCL (Assuming Normal Distribution)	
Student's-t UCL	169.0046

Gamma Statistics Not Available

Lognormal Statistics Not Available

RECOMMENDATION

Data are Non-parametric (0.05)

Use 95% Chebyshev (Mean, Sd) UCL

95% Non-parametric UCLs	
CLT UCL	168.3954
Adj-CLT UCL (Adjusted for skewness)	202.3501
Mod-t UCL (Adjusted for skewness)	174.3009
Jackknife UCL	169.0046
Standard Bootstrap UCL	167.4495
Bootstrap-t UCL	289.219
Hall's Bootstrap UCL	394.5843
Percentile Bootstrap UCL	174.65
BCA Bootstrap UCL	230.9
95% Chebyshev (Mean, Sd) UCL	274.8143
97.5% Chebyshev (Mean, Sd) UCL	348.769
99% Chebyshev (Mean, Sd) UCL	494.0388

IA-10 ProUCL Output

Data File

Variable: Total PCBs

Raw Statistics	
Number of Valid Samples	213
Number of Unique Samples	64
Minimum	4.4
Maximum	13000
Mean	170.0596
Median	14
Standard Deviation	983.155
Variance	966593.8
Coefficient of Variation	5.781237
Skewness	11.17239

Gamma Statistics	
k hat	0.295551
k star (bias corrected)	0.294518
Theta hat	575.3988
Theta star	577.4165
nu hat	125.9047
nu star	125.4647
Approx.Chi Square Value (.05)	100.5896
Adjusted Level of Significance	0.048873
Adjusted Chi Square Value	100.4391

Log-transformed Statistics	
Minimum of log data	1.481605
Maximum of log data	9.472705
Mean of log data	2.797302
Standard Deviation of log data	1.50985
Variance of log data	2.279647

Normal Distribution Test	
Lilliefors Test Statisitic	0.433096
Lilliefors 5% Critical Value	0.060708
Data not normal at 5% significance level	

95% UCL (Assuming Normal Distribution)	
Student's-t UCL	281.351

Gamma Distribution Test	
A-D Test Statistic	44.16086
A-D 5% Critical Value	0.871375
K-S Test Statistic	0.449275
K-S 5% Critical Value	0.067558
Data do not follow gamma distribution	
at 5% significance level	

95% UCLs (Assuming Gamma Distribution)	
Approximate Gamma UCL	212.1141
Adjusted Gamma UCL	212.432

Lognormal Distribution Test	
Lilliefors Test Statisitic	0.307477
Lilliefors 5% Critical Value	0.060708
Data not lognormal at 5% significance level	

95% UCLs (Assuming Lognormal Distribution)	
95% H-UCL	67.22753
95% Chebyshev (MVUE) UCL	83.31464
97.5% Chebyshev (MVUE) UCL	97.42885
99% Chebyshev (MVUE) UCL	125.1535

95% Non-parametric UCLs	
CLT UCL	280.8647
Adj-CLT UCL (Adjusted for skewness)	335.9668
Mod-t UCL (Adjusted for skewness)	289.9458
Jackknife UCL	281.351
Standard Bootstrap UCL	283.052
Bootstrap-t UCL	496.7116
Hall's Bootstrap UCL	683.539
Percentile Bootstrap UCL	305.696
BCA Bootstrap UCL	369.8254
95% Chebyshev (Mean, Sd) UCL	463.6954
97.5% Chebyshev (Mean, Sd) UCL	590.7519
99% Chebyshev (Mean, Sd) UCL	840.3297

RECOMMENDATION

Data are Non-parametric (0.05)

Use 97.5% Chebyshev (Mean, Sd) UCL

IA-11 ProUCL Output

Data File \\Fsmnh01\User1\PROJECTS\03886110\02(Variable: Aluminum

Raw Statistics	
Number of Valid Samples	28
Number of Unique Samples	25
Minimum	0
Maximum	13000
Mean	7328.571
Median	7750
Standard Deviation	3067.253
Variance	9408042
Coefficient of Variation	0.418534
Skewness	-0.53812

Normal Distribution Test	
Shapiro-Wilk Test Statisitic	0.968522
Shapiro-Wilk 5% Critical Value	0.924
Data are normal at 5% significance level	

95% UCL (Assuming Normal Distribution)	
Student's-t UCL	8315.893

Gamma Statistics Not Available

Lognormal Statistics Not Available

RECOMMENDATION
Data are normal (0.05)

Use Student's-t UCL

95% Non-parametric UCLs	
CLT UCL	8282.021
Adj-CLT UCL (Adjusted for skewness)	8219.034
Mod-t UCL (Adjusted for skewness)	8306.069
Jackknife UCL	8315.893
Standard Bootstrap UCL	8240.328
Bootstrap-t UCL	8248.589
Hall's Bootstrap UCL	8265.86
Percentile Bootstrap UCL	8253.571
BCA Bootstrap UCL	8207.143
95% Chebyshev (Mean, Sd) UCL	9855.235
97.5% Chebyshev (Mean, Sd) UCL	10948.52
99% Chebyshev (Mean, Sd) UCL	13096.08

IA-11 ProUCL Output

Data File \\Fsmnh01\User1\PROJECTS\03886110\02(Variable: Arsenic

Raw Statistics	
Number of Valid Samples	28
Number of Unique Samples	16
Minimum	0
Maximum	52
Mean	20.07143
Median	20
Standard Deviation	8.554525
Variance	73.17989
Coefficient of Variation	0.426204
Skewness	1.513367

Normal Distribution Test	
Shapiro-Wilk Test Statisitic	0.843477
Shapiro-Wilk 5% Critical Value	0.924
Data not normal at 5% significance level	

95% UCL (Assuming Normal Distribution)	
Student's-t UCL	22.82505

Gamma Statistics Not Available

Lognormal Statistics Not Available

RECOMMENDATION
Data are Non-parametric (0.05)

Use 95% Chebyshev (Mean, Sd) UCL

95% Non-parametric UCLs	
CLT UCL	22.73059
Adj-CLT UCL (Adjusted for skewness)	23.22463
Mod-t UCL (Adjusted for skewness)	22.90212
Jackknife UCL	22.82505
Standard Bootstrap UCL	22.64429
Bootstrap-t UCL	23.39072
Hall's Bootstrap UCL	25.37403
Percentile Bootstrap UCL	22.82143
BCA Bootstrap UCL	22.85714
95% Chebyshev (Mean, Sd) UCL	27.11826
97.5% Chebyshev (Mean, Sd) UCL	30.16742
99% Chebyshev (Mean, Sd) UCL	36.15693

IA-11 ProUCL Output

Data File \\Fsmnh01\User1\PROJECTS\03886110\02(Variable: Barium

Raw Statistics	
Number of Valid Samples	17
Number of Unique Samples	12
Minimum	0
Maximum	23
Mean	12.41765
Median	12
Standard Deviation	5.275206
Variance	27.82779
Coefficient of Variation	0.424815
Skewness	-0.19756

Normal Distribution Test	
Shapiro-Wilk Test Statisitic	0.957773
Shapiro-Wilk 5% Critical Value	0.892
Data are normal at 5% significance level	

95% UCL (Assuming Normal Distribution)	
Student's-t UCL	14.65137

Gamma Statistics Not Available

Lognormal Statistics Not Available

RECOMMENDATION
Data are normal (0.05)

Use Student's-t UCL

95% Non-parametric UCLs	
CLT UCL	14.52211
Adj-CLT UCL (Adjusted for skewness)	14.45661
Mod-t UCL (Adjusted for skewness)	14.64116
Jackknife UCL	14.65137
Standard Bootstrap UCL	14.42205
Bootstrap-t UCL	14.66756
Hall's Bootstrap UCL	14.58736
Percentile Bootstrap UCL	14.3
BCA Bootstrap UCL	14.35294
95% Chebyshev (Mean, Sd) UCL	17.99453
97.5% Chebyshev (Mean, Sd) UCL	20.40766
99% Chebyshev (Mean, Sd) UCL	25.14777

IA-11 ProUCL Output

Data File \\Fsmnh01\User1\PROJECTS\03886110\02(Variable: Iron

Raw Statistics	
Number of Valid Samples	28
Number of Unique Samples	19
Minimum	0
Maximum	29000
Mean	11039.29
Median	9950
Standard Deviation	5581.473
Variance	31152844
Coefficient of Variation	0.505601
Skewness	1.325588

Normal Distribution Test	
Shapiro-Wilk Test Statisitic	0.898325
Shapiro-Wilk 5% Critical Value	0.924
Data not normal at 5% significance level	

95% UCL (Assuming Normal Distribution)	
Student's-t UCL	12835.91

Gamma Statistics Not Available

Lognormal Statistics Not Available

RECOMMENDATION	95% Non-parametric UCLs	
	CLT UCL	12774.28
	Adj-CLT UCL (Adjusted for skewness)	13056.62
	Mod-t UCL (Adjusted for skewness)	12879.95
	Jackknife UCL	12835.91
	Standard Bootstrap UCL	12766.22
	Bootstrap-t UCL	13380.37
	Hall's Bootstrap UCL	13652.94
Data are Non-parametric (0.05)	Percentile Bootstrap UCL	12828.57
	BCA Bootstrap UCL	12950
Use 95% Chebyshev (Mean, Sd) UCL	95% Chebyshev (Mean, Sd) UCL	15637.05
	97.5% Chebyshev (Mean, Sd) UCL	17626.51
	99% Chebyshev (Mean, Sd) UCL	21534.41

IA-11 ProUCL Output

Data File \\Fsmnh01\User1\PROJECTS\03886110\02(Variable: Manganese

Raw Statistics	
Number of Valid Samples	28
Number of Unique Samples	22
Minimum	0
Maximum	690
Mean	187.8929
Median	135
Standard Deviation	141.2259
Variance	19944.77
Coefficient of Variation	0.75163
Skewness	1.924363

Normal Distribution Test	
Shapiro-Wilk Test Statisitic	0.824461
Shapiro-Wilk 5% Critical Value	0.924
Data not normal at 5% significance level	

95% UCL (Assuming Normal Distribution)	
Student's-t UCL	233.3522

Gamma Statistics Not Available

Lognormal Statistics Not Available

RECOMMENDATION

Data are Non-parametric (0.05)

Use 95% Chebyshev (Mean, Sd) UCL

95% Non-parametric UCLs	
CLT UCL	231.7927
Adj-CLT UCL (Adjusted for skewness)	242.1638
Mod-t UCL (Adjusted for skewness)	234.9699
Jackknife UCL	233.3522
Standard Bootstrap UCL	231.5438
Bootstrap-t UCL	250.307
Hall's Bootstrap UCL	271.1824
Percentile Bootstrap UCL	230.5714
BCA Bootstrap UCL	244.75
95% Chebyshev (Mean, Sd) UCL	304.2284
97.5% Chebyshev (Mean, Sd) UCL	354.5668
99% Chebyshev (Mean, Sd) UCL	453.447

IA-11 ProUCL Output

Data File \\Fsmnh01\User1\PROJECTS\03886110\02(Variable: Nickel

Raw Statistics	
Number of Valid Samples	28
Number of Unique Samples	22
Minimum	0
Maximum	48
Mean	17.50357
Median	15.5
Standard Deviation	9.95019
Variance	99.00628
Coefficient of Variation	0.568466
Skewness	1.147307

Normal Distribution Test	
Shapiro-Wilk Test Statisitic	0.926901
Shapiro-Wilk 5% Critical Value	0.924
Data are normal at 5% significance level	

95% UCL (Assuming Normal Distribution)	
Student's-t UCL	20.70645

Gamma Statistics Not Available

Lognormal Statistics Not Available

95% Non-parametric UCLs	
CLT UCL	20.59657
Adj-CLT UCL (Adjusted for skewness)	21.03221
Mod-t UCL (Adjusted for skewness)	20.7744
Jackknife UCL	20.70645
Standard Bootstrap UCL	20.58887
Bootstrap-t UCL	21.04751
Hall's Bootstrap UCL	21.90073
Percentile Bootstrap UCL	20.72143
BCA Bootstrap UCL	21.03929
95% Chebyshev (Mean, Sd) UCL	25.70009
97.5% Chebyshev (Mean, Sd) UCL	29.24672
99% Chebyshev (Mean, Sd) UCL	36.21341

RECOMMENDATION
Data are normal (0.05)

Use Student's-t UCL

IA-11 ProUCL Output

Data File \\Fsmnh01\User1\PROJECTS\03886110\02(Variable: Benzo(a)anthracene

Raw Statistics	
Number of Valid Samples	7
Number of Unique Samples	5
Minimum	0
Maximum	2000
Mean	390
Median	175
Standard Deviation	715.169
Variance	511466.7
Coefficient of Variation	1.833767
Skewness	2.563541

Normal Distribution Test	
Shapiro-Wilk Test Statisitic	0.55674
Shapiro-Wilk 5% Critical Value	0.803
Data not normal at 5% significance level	

95% UCL (Assuming Normal Distribution)	
Student's-t UCL	915.2579

Gamma Statistics Not Available

Lognormal Statistics Not Available

RECOMMENDATION

Data are Non-parametric (0.05)

Use 95% Chebyshev (Mean, Sd) UCL

95% Non-parametric UCLs	
CLT UCL	834.6179
Adj-CLT UCL (Adjusted for skewness)	1114.472
Mod-t UCL (Adjusted for skewness)	958.9094
Jackknife UCL	915.2579
Standard Bootstrap UCL	802.9862
Bootstrap-t UCL	2861.163
Hall's Bootstrap UCL	4437.848
Percentile Bootstrap UCL	908.5714
BCA Bootstrap UCL	962.8571
95% Chebyshev (Mean, Sd) UCL	1568.247
97.5% Chebyshev (Mean, Sd) UCL	2078.076
99% Chebyshev (Mean, Sd) UCL	3079.535

IA-11 ProUCL Output

Data File \\Fsmnh01\User1\PROJECTS\03886110\02(Variable: Benzo(a)pyrene

Raw Statistics	
Number of Valid Samples	7
Number of Unique Samples	5
Minimum	0
Maximum	1800
Mean	267.4286
Median	7
Standard Deviation	675.9381
Variance	456892.3
Coefficient of Variation	2.527546
Skewness	2.643502

Normal Distribution Test	
Shapiro-Wilk Test Statisitic	0.470289
Shapiro-Wilk 5% Critical Value	0.803
Data not normal at 5% significance level	

95% UCL (Assuming Normal Distribution)	
Student's-t UCL	763.8732

Gamma Statistics Not Available

Lognormal Statistics Not Available

RECOMMENDATION

Data are Non-parametric (0.05)

Use 95% Chebyshev (Mean, Sd) UCL

95% Non-parametric UCLs	
CLT UCL	687.6567
Adj-CLT UCL (Adjusted for skewness)	960.4094
Mod-t UCL (Adjusted for skewness)	806.4171
Jackknife UCL	763.8732
Standard Bootstrap UCL	657.3328
Bootstrap-t UCL	24930.49
Hall's Bootstrap UCL	15425.68
Percentile Bootstrap UCL	775.1429
BCA Bootstrap UCL	1029.571
95% Chebyshev (Mean, Sd) UCL	1381.043
97.5% Chebyshev (Mean, Sd) UCL	1862.904
99% Chebyshev (Mean, Sd) UCL	2809.428

IA-11 ProUCL Output

Data File \\Fsmnh01\User1\PROJECTS\03886110\02(Variable: Benzo(b)fluoranthene

Raw Statistics	
Number of Valid Samples	7
Number of Unique Samples	5
Minimum	0
Maximum	1200
Mean	275.7143
Median	175
Standard Deviation	416.6076
Variance	173561.9
Coefficient of Variation	1.511012
Skewness	2.402115

Normal Distribution Test	
Shapiro-Wilk Test Statisitic	0.62765
Shapiro-Wilk 5% Critical Value	0.803
Data not normal at 5% significance level	

95% UCL (Assuming Normal Distribution)	
Student's-t UCL	581.6929

Gamma Statistics Not Available

Lognormal Statistics Not Available

RECOMMENDATION

Data are Non-parametric (0.05)

Use 95% Chebyshev (Mean, Sd) UCL

95% Non-parametric UCLs	
CLT UCL	534.7177
Adj-CLT UCL (Adjusted for skewness)	687.4755
Mod-t UCL (Adjusted for skewness)	605.5201
Jackknife UCL	581.6929
Standard Bootstrap UCL	515.0876
Bootstrap-t UCL	1146.156
Hall's Bootstrap UCL	2013.159
Percentile Bootstrap UCL	565.7143
BCA Bootstrap UCL	620
95% Chebyshev (Mean, Sd) UCL	962.0791
97.5% Chebyshev (Mean, Sd) UCL	1259.07
99% Chebyshev (Mean, Sd) UCL	1842.45

IA-11 ProUCL Output

Data File \\Fsmnh01\User1\PROJECTS\03886110\02(Variable: Dibenz(a,h)Anthracene

Raw Statistics	
Number of Valid Samples	7
Number of Unique Samples	5
Minimum	0
Maximum	560
Mean	84.21429
Median	7
Standard Deviation	209.8309
Variance	44028.99
Coefficient of Variation	2.49163
Skewness	2.644207

Normal Distribution Test	
Shapiro-Wilk Test Statisitic	0.467807
Shapiro-Wilk 5% Critical Value	0.803
Data not normal at 5% significance level	

95% UCL (Assuming Normal Distribution)	
Student's-t UCL	238.3252

Gamma Statistics Not Available

Lognormal Statistics Not Available

RECOMMENDATION
Data are Non-parametric (0.05)

Use 95% Chebyshev (Mean, Sd) UCL

95% Non-parametric UCLs	
CLT UCL	214.6653
Adj-CLT UCL (Adjusted for skewness)	299.3583
Mod-t UCL (Adjusted for skewness)	251.5355
Jackknife UCL	238.3252
Standard Bootstrap UCL	206.2663
Bootstrap-t UCL	5900.178
Hall's Bootstrap UCL	6263.718
Percentile Bootstrap UCL	242.0714
BCA Bootstrap UCL	244.2143
95% Chebyshev (Mean, Sd) UCL	429.9125
97.5% Chebyshev (Mean, Sd) UCL	579.4964
99% Chebyshev (Mean, Sd) UCL	873.325

IA-11 ProUCL Output

Data File \\Fsmnh01\User1\PROJECTS\03886110\02(Variable: Indeno(1,2,3-c,d)Pyrene

Raw Statistics	
Number of Valid Samples	7
Number of Unique Samples	5
Minimum	0
Maximum	1100
Mean	261.4286
Median	175
Standard Deviation	379.7117
Variance	144181
Coefficient of Variation	1.452449
Skewness	2.35229

Normal Distribution Test	
Shapiro-Wilk Test Statisitic	0.643541
Shapiro-Wilk 5% Critical Value	0.803
Data not normal at 5% significance level	

95% UCL (Assuming Normal Distribution)	
Student's-t UCL	540.3089

Gamma Statistics Not Available

Lognormal Statistics Not Available

RECOMMENDATION
Data are Non-parametric (0.05)

Use 95% Chebyshev (Mean, Sd) UCL

95% Non-parametric UCLs	
CLT UCL	497.4939
Adj-CLT UCL (Adjusted for skewness)	633.8351
Mod-t UCL (Adjusted for skewness)	561.5754
Jackknife UCL	540.3089
Standard Bootstrap UCL	479.4273
Bootstrap-t UCL	997.91
Hall's Bootstrap UCL	1764.911
Percentile Bootstrap UCL	522.8571
BCA Bootstrap UCL	574.2857
95% Chebyshev (Mean, Sd) UCL	887.0069
97.5% Chebyshev (Mean, Sd) UCL	1157.695
99% Chebyshev (Mean, Sd) UCL	1689.41

IA-11 ProUCL Output

Data File \\Fsmnh01\User1\PROJECTS\03886110\02(Variable: Aldrin

Raw Statistics	
Number of Valid Samples	10
Number of Unique Samples	9
Minimum	0
Maximum	1060
Mean	139.4935
Median	6.635
Standard Deviation	330.3541
Variance	109133.9
Coefficient of Variation	2.36824
Skewness	2.940184

Normal Distribution Test	
Shapiro-Wilk Test Statisitic	0.497011
Shapiro-Wilk 5% Critical Value	0.842
Data not normal at 5% significance level	
95% UCL (Assuming Normal Distribution)	
Student's-t UCL	330.9936

Gamma Statistics Not Available

Lognormal Statistics Not Available

RECOMMENDATION
Data are Non-parametric (0.05)

Use 95% Chebyshev (Mean, Sd) UCL

95% Non-parametric UCLs	
CLT UCL	311.3267
Adj-CLT UCL (Adjusted for skewness)	415.1117
Mod-t UCL (Adjusted for skewness)	347.1819
Jackknife UCL	330.9936
Standard Bootstrap UCL	299.6585
Bootstrap-t UCL	1774.686
Hall's Bootstrap UCL	1738.693
Percentile Bootstrap UCL	331.8415
BCA Bootstrap UCL	454.826
95% Chebyshev (Mean, Sd) UCL	594.8553
97.5% Chebyshev (Mean, Sd) UCL	791.8907
99% Chebyshev (Mean, Sd) UCL	1178.929