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FINAL
REMEDIAL INVESTIGATION REPORT
AREA OF CONTAMINATION (AOC) 69W
DEVENS, MASSACHUSETTS

VOLUME I OF II
TEXT SECTIONS 1 THROUGH 10
AND FIGURES AND TABLES

CONTRACT DAAA-31-94-D-0061
DELIVERY ORDER NUMBER 0001

U.S. ARMY CORPS OF ENGINEERS
NEW ENGLAND DISTRICT
CONCORD, MASSACHUSETTS

August 1998

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Prepared for:

U.S. Army Corps of Engineers
New England District
Concord, Massachusetts

Prepared by:

Harding Lawson Associates
Portland, ME
Project No. 09144-03

August 1998

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Harding Lawson Associates (HLA), formerly ABB Environmental Services, Inc. (ABB-ES) prepared this Remedial Investigation (RI) Report on Area of Contamination (AOC) 69W to support Task Order 001 and Modification No. 001 of Contract DAAA-31-94-D-0061 under the oversight of the U.S. Army Corps of Engineers - New England District (CENAE). This RI Report details the results of the RI and previous investigations at AOC 69W, which were completed in accordance with relevant U.S. Environmental Protection Agency (USEPA), U.S. Army Environmental Center (USAEC), and CENAE guidance.

Fort Devens was identified for cessation of operations and closure under Public Law 101-510, the Defense Base Realignment and Closure Act of 1990, and was officially closed in September 1996. Portions of the property formerly occupied by Fort Devens were retained by the Army 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. AOC 69W is located in an area designated for transfer to the Massachusetts Government Land Bank for reuse as a recreation area and open space. An existing school building within AOC 69W may be re-opened in the future.

AOC 69W is located on the northern portion of the former Main Post near the northeast corner of the intersection of MacArthur Avenue and Antietam Street. AOC 69W is comprised of the former Fort Devens Elementary School (Building 215) and the associated parking lot and adjacent lawn extending approximately 300 feet northwest to Willow Brook (Figure ES-1).

AOC 69W was identified for investigation based upon reports of fuel oil releases which occurred in 1972 and 1978. Each release was reported to have been between 7,000 and 8,000 gallons. In response to the 1972 fuel oil release an oil recovery system was installed consisting of a subsurface pipe leading from the school foundation to a 250 gallon UST located adjacent to Willow Brook (Figure ES-1).

RI ACTIVITIES

In general, the efforts associated with this RI have defined two areas of soil contamination at AOC 69W. The larger of the two areas was attributed to the 1972 fuel oil release and extended from the new boiler room to approximately 300 feet northwest. Detected contaminants included primarily TPHC and PAHs at approximately 6 to 10 feet below ground surface (bgs) adjacent to the school and 0 to 4 feet bgs downgradient near the wooded area. Contaminant distributions indicated that the underground recovery system piping had acted as a conduit for contaminant migration. Based on a review of the soil and groundwater contaminant data, a removal action was undertaken in the winter of 1997 and 1998 to remove contaminated subsurface soil in the vicinity of the 1972 fuel oil spill and the associated recovery system. Confirmatory sample results indicate that concentrations of PAHs, VPH, and EPH still exceed MCP S-1/GW-1 standards immediately adjacent to the school, but that concentrations of fuel-related contaminants in other portions of the site are generally low. The soil removal action has removed the majority of the source area contamination.

The other identified area of soil contamination is attributed to the 1978 fuel oil release and is located adjacent to the school building outside the old boiler room and beneath the paved parking lot. Contaminants are primarily TPHC at depths of 4 to 7 feet bgs. The observed contamination does not appear to be migrating downgradient based upon analytical sample results from numerous downgradient TerraProbe^{SM} explorations and monitoring wells. In addition, the area of the release is covered by the school building and the paved parking lot which inhibit groundwater recharge. No further migration is expected based upon the age of the spill.

Fuel related VOCs, SVOCs, TPHC, and inorganics comprise the majority of the observed groundwater contaminants at AOC 69W. Groundwater contamination identified by field and off-site analytical data was coincident with the observed soil contamination and fuel recovery system. Soil and groundwater contaminants appear to be predominantly located in the vicinity of the water table.

Review of contaminant distribution in sediment samples from Willow Brook suggests that the petroleum contamination may have contributed SVOCs to Willow Brook sediments as deep as 2 feet bgs. However, the stream bed is lined with chunks of asphalt which may be acting as an alternative source of SVOCs. Pesticides, PCBs, and TPHCs were detected primarily in upgradient samples suggesting that their source is not site related.

Human Health Risk Assessment

Possible health risks were evaluated for the current and anticipated future land uses at AOC 69W. Since the former elementary school at AOC 69W is presently closed, exposures and risks for current site use were evaluated for a site maintenance worker (possible exposure to surface soil), and a trespasser ages 6 through 18 (possible exposure to sediment and groundwater discharge to surface water). The possible health risks associated with future site use were evaluated assuming that the school will be re-opened, and included evaluation of a pupil ages 6 through 18 (possible exposure to surface soil, sediment, groundwater discharge to surface water, and indoor air), and an excavation worker (possible exposure to surface soil and subsurface soil). In addition, future use of the groundwater as a potable water source was evaluated. Since groundwater at and beneath AOC 69W is not presently used as a source of drinking or industrial water, evaluation of potable use represents a *hypothetical worst-case* evaluation of potential exposures and risks.

The risk assessment evaluated post-removal action conditions for surface soil and subsurface soil, and pre-removal action conditions for groundwater, sediment, and indoor air. Chemicals of potential concern (CPCs) were identified in surface soil, subsurface soil, sediment, groundwater, and indoor air, and included metals, semi-volatile organic compounds (SVOCs), volatile organic compounds (VOCs), and petroleum-related compounds including total petroleum hydrocarbons (TPHC), extractable petroleum hydrocarbons (EPH), volatile petroleum hydrocarbons (VPH), and polynuclear aromatic hydrocarbons (PAH). Among these chemicals of potential concern, only the petroleum-related compounds are directly associated with the release of fuel oil at AOC 69W. The presence of the constituents detected in the building air is likely due to the presence of numerous ambient sources within and outside the building, and not due to fuel-related constituents that may be present in soil and groundwater beneath the building. Nevertheless, circumstantial evidence indicated that a possible association between low level detections of xylenes, ethylbenzene, and methylheptane detected in air samples and soil samples collected in the vicinity of the northwestern portion of the building could not be ruled out. However, potential exposures to the maximum detected concentrations of these three analytes, as well as all others detected in indoor air samples collected from the building rooms, were not associated with risks above USEPA threshold risk levels. This indicates that pupils and school staff members who may hypothetically be exposed to these constituents in building air would not incur health risks considered to be of concern by the USEPA.

Possible health risks were quantified for carcinogenic and non-carcinogenic effects, for both reasonable maximum and central tendency exposure assumptions. Estimated cancer and non-cancer risks associated with possible current and future land use exposures to surface soil, subsurface soil, sediment, groundwater discharge to surface water and indoor air were within acceptable levels established the USEPA (Table ES-1). Estimated cancer and non-cancer risks associated with hypothetical exposures to AOC 69W groundwater used as a residential drinking water source exceeded levels generally considered acceptable by USEPA. However, these risks are primarily due to the presence of arsenic in the groundwater, which is not interpreted to be directly related to the release of fuel-oil at AOC 69W.

Based on the conclusions of the risk assessment, there are no unacceptable human health risks associated with surface soil, subsurface soil, groundwater discharge, sediment, or indoor air at AOC 69W. Future use of the site as a school is not associated with any unacceptable risks. Moreover, the soil removal action at AOC 69W significantly reduced fuel oil contamination in soil thereby mitigating possible exposures to fuel-related CPCs in soil, reducing the CPC concentrations in groundwater, and eliminating a possible source of fuel-related vapors. Therefore, the risk estimates presented in this risk assessment are worst-case estimates that are unlikely to be exceeded under conceivable future land use conditions.

Ecological Risk Assessment

Potential risks for ecological receptors were evaluated for chemicals detected in surface soil, sediment, and groundwater at AOC 69W. CPCs that were identified in these media included metals, pesticides, PCBs, SVOCs, VOCs, and petroleum-related compounds including TPHC, EPH/VPH, and PAHs.

Exposure point concentrations (i.e., the concentration in environmental media to which ecological receptors may be exposed) in soil reflect conditions after the soil removal action occurred, whereas exposure point concentrations in groundwater and sediment reflect conditions before the soil removal action occurred. However, the soil removal action has mitigated the reducing conditions that has likely mobilized certain metals in groundwater. Risks to ecological receptors were determined based on a conservative comparison of exposure point concentrations or exposure doses with appropriate toxicological benchmarks. If an exposure dose or concentration in site media exceeded a toxicological benchmark, then risks to ecological receptors might occur, and the uncertainties associated with those risks are discussed.

The following exposure pathways were evaluated in the ERA:

- small mammal and bird, predatory mammal, terrestrial plant, and soil invertebrate exposures to surface soil,
- small mammal and bird, predatory mammal, and aquatic receptor exposures to sediment in Willow Brook, and
- aquatic receptors exposures to groundwater that seasonally discharges to Willow Brook.

The ERA for aquatic receptors is highly conservative as Willow Brook is only seasonally inundated and is generally characterized as a degraded ditch habitat (i.e., the ditch is bordered by maintained grass, and is lined with asphalt in the upper portions).

The risk results of the AOC 69W ERA are summarized in Table ES-2. In general, there are no risks to ecological receptors except in few cases where negligible risks were estimated (i.e., exposure point concentrations or doses only slightly exceeded the toxicity benchmark). Risks to terrestrial plants may occur at one surface soil sample location (ZWS-95-42X) due to the presence of lead. However, the presence of lead at this location may be associated more with road run-off or lawn mower maintenance than from the fuel oil release, which occurred approximately 300 feet to the southeast. Risks to plants would be localized, and are not likely to result in population-level effects.

Risks to aquatic organisms were also identified for certain metals; however, the soil removal action has likely mitigated the reducing conditions in the subsurface soils that may have mobilized the metals in groundwater. Adverse effects were observed for aquatic organisms exposed to sediment in toxicity tests; however, these adverse effects are likely related to the poor habitat and substrate quality, rather than the presence of site-related chemicals. This is supported by the fact that exposure point concentrations for chemicals detected in sediment only slightly exceeded sediment benchmarks.

Based on the conclusions of the ERA, there are no unacceptable risks associated with site-related fuel oil contamination at AOC 69W.

RECOMMENDATIONS

Based upon the results and interpretation of the RI, supplemental sampling, and the soil removal action it is recommended that AOC 69W be proposed for limited action consisting of long term monitoring of downgradient groundwater quality with no additional investigation or remedial action. This course of action is supported by the following:

- The soil removal significantly reduced surficial and subsurface contaminants that were acting as a source for groundwater contamination
- There are no unacceptable risks posed to human health or the environment from site related fuel contamination
- Estimated risks associated with hypothetical exposure to groundwater used as a residential drinking water source exceeded levels generally considered acceptable by the USEPA. However, groundwater at AOC 69W is not used as a source of drinking or industrial water. Estimated risks for groundwater as a drinking water source are primarily due to the presence of arsenic. The presence of the arsenic is attributed to the mobilization of naturally occurring arsenic by reducing conditions in the aquifer brought on by the aerobic degradation of fuel related contaminants. The soil removal will act to lessen reducing conditions in the aquifer and therefore decrease arsenic concentrations in the groundwater.
- Because the soil removal eliminated the majority of source area contaminants, estimated risks and interpretations represent worst-case estimates that are unlikely to be exceeded under future land use conditions.

1.0 INTRODUCTION

This Remedial Investigation (RI) Report (Data Item A009) for Area of Contamination (AOC) 69W at Devens in north central Massachusetts was prepared by Harding Lawson Associates (HLA) formerly ABB Environmental Services, Inc. (ABB-ES), as a component of Task Order 001 of Contract DAAA31-94-D-001 (ABB-ES, 1996a) with the U.S. Army Corps of Engineers, New England District (CENAE), (ABB-ES, 1996b). This report details the results of the RI program at AOC 69W, which was completed in accordance with relevant USACE, U.S. Army Environmental Center (USAEC), and U.S. Environmental Protection Agency (USEPA) guidance.

1.1 PURPOSE AND SCOPE

The scope of work for the RI at AOC 69W was specified by the Army based on previous studies and investigations, and by the USEPA and Massachusetts Department of Environmental Protection (MADEP) comments on prior investigations at this AOC.

Prior investigations included a supplemental site investigation (SSI) activities completed in 1994 under the Areas Requiring Environmental Evaluation (AREE) program. The investigation phase was undertaken to establish the nature and distribution of site-related contaminants in groundwater and subsurface soil at then AREE 69W. Based on the findings of the SSI it was recommended that further investigation of groundwater and subsurface soil contamination should be conducted. In compliance with the Interagency Agreement (IAG) AREE 69W was administratively transferred to the RI/FS process and redesignated AOC 69W. The following activities were included in the RI investigation:

- Background research of historical records, personnel interviews, areal photographic interpretation, and literature search.
- A geophysical survey to determine if any additional site-related contaminant source areas were present, and to clear intrusive investigation activities.

- Sediment and toxicity test sampling in nearby Willow Brook.
- Sampling and field analysis from TerraProbe^{SM} points and soil borings to further define the horizontal and vertical distribution of soil and groundwater contamination.
- Installation of groundwater monitoring wells, and groundwater sampling from new and existing monitoring wells for off-site laboratory analyses.
- Installation of piezometers and a surface water measurement station in nearby Willow Brook.
- Aquifer testing.
- Ecological survey and wetland investigations.
- Vertical and horizontal location surveys.

Based upon the RI data, supplemental sampling was conducted in 1996 to address identified data gaps. The supplemental sampling consisted of:

- Air quality sampling within Building 215 (the Elementary School) to assess impacts to indoor air from subsurface soil contamination;
- Installation of soil borings and collection of soil samples within both of the boiler rooms and courtyard to identify potential contaminant source areas;
- Installation of monitoring wells;
- Two rounds of groundwater sampling for off-site analysis;
- Aquifer testing;
- Vertical and horizontal location surveys; and

- Additional air sampling and groundwater sampling in 1997.

1.2 REPORT ORGANIZATION

Preparation of this RI Report consisted of characterizing the geologic and hydrogeologic conditions at the site, and assessing the distribution, migration, and potential effects of identified chemicals on human and ecological receptors. The content and presentation of this report relies heavily upon figures and tables which present the data in the context of exploration locations on site maps. The text within the report supports the figures, and provides detail, interpretation, and analysis that cannot be presented in figures.

After acquiring and evaluating the field and off-site laboratory data and identifying chemical-specific Applicable or Relevant and Appropriate Requirements (ARARs), HLA prepared this RI Report for AOC 69W in accordance with USEPA and USAEC guidance. The report describes the field methods employed, and presents, summarizes, and evaluates the relevant background information, field and laboratory data, results and conclusions from previous investigations, and assesses the potential human health and ecological risks.

Section 2.0 of this report describes the history and physical setting of the Devens area. Section 3.0 summarizes the RI analytical program, including the field procedures, QA and QC, and data management. Section 4.0 presents potential ARARs and background concentrations of inorganic analytes in soil and groundwater. Section 5.0 of this report summarizes the AOC 69W background and physical conditions, previous investigations, technical objectives of the RI, and RI sampling and investigatory techniques. Section 6.0 presents the interpretation of geologic and hydrogeologic conditions at AOC 69W. Section 7.0 presents the nature and distribution of detected site contaminants, Section 8.0 outlines the fate and transport of the detected site contaminants, Section 9.0 presents the human health and ecological baseline risk assessment, and Section 10.0 presents the conclusions and recommendations for AOC 69W.

In accordance with the Federal Facilities Agreement (FFA), this RI report will be presented in a Draft version, and after regulatory review, a Final version.

1.3 PROJECT OBJECTIVES

The objective of the project at AOC 69W was to perform an RI in accordance with all relevant MADEP and USEPA guidance and in compliance with applicable Army approved field methods and procedures. The purpose of the RI conducted at AOC 69W was to further define the site contaminants detected in the soil and groundwater during the AREE 69W SSI, and to determine whether remediation is warranted.

1.4 PROJECT APPROACH

To meet the project objectives, a significant amount of effort was focused on the production of several RI planning documents. The planning documents were developed in compliance with the appropriate regulatory guidance for remedial investigations, regulatory and Army comments, and results of previous investigations.

The project plans were designed to answer data gaps identified from the previous investigation and gather additional data on the physical conditions of the AOC, the nature and distribution of site-related contaminants, and assess the risks to human and ecological receptors.

1.4.1 Project Operations Plan

The principal planning document was the Fort Devens Project Operations Plan (POP) (ABB-ES, 1995a), which provides detailed descriptions and discussions of the elements essential to conducting field investigation activities. The purpose of this plan was to define responsibilities and authorities for data quality, and to define requirements such that the field investigation activities undertaken by HLA at Devens would be planned and executed in a manner consistent with Army quality assurance (QA) program objectives. The Fort Devens POP (ABB-ES, 1995a) includes the specified elements of a Sampling and Analysis Plan (SAP) and Health and Safety Plan (HASP). The Fort Devens POP (ABB-ES, 1995a) also includes the essential elements of the Quality Assurance Project Plan (QAPP) and the Field Sampling Plan. USEPA has prepared guidance on the preparation of a Fort Devens POP (ABB-ES, 1995a) in "Guidance for Preparation of Combined Work/Quality Assurance Project Plans for Environmental Monitoring"; (USEPA, 1984). The guidance was designed to eliminate the necessity for preparation of multiple, redundant documents.

The requirements of the Fort Devens POP (ABB-ES, 1995a) were applied to HLA and subcontractor activities related to the collection of environmental data at Devens. The Fort Devens POP (ABB-ES, 1995a) adheres to the requirements and guidelines contained in the "USAEC QA Program, January 1990" for collection and analysis of samples and the USAEC "Geotechnical Requirements for Drilling, Monitoring Wells, Data Acquisition, and Reports, March 1987" for the installation of test pits, soil borings and monitoring wells, collection of soil, surface water, sediment, and groundwater samples, and for land survey location. In addition, the Fort Devens POP (ABB-ES, 1995a) meets guidelines of USAEC chain-of-custody (COC) procedures.

The Fort Devens POP (ABB-ES, 1995a) provides guidance and specifications to ensure that samples are obtained under controlled conditions using appropriate, documented procedures; and that samples are identified uniquely and controlled through sample tracking systems and COC protocols. The Fort Devens POP (ABB-ES, 1995a) also includes specifications to ensure that field determinations and laboratory analytical results are of known quality and are valid, consistent, and compatible with the USAEC chemical data base through the use of certified methods, preventive maintenance, calibration, and analytical protocols, quality control (QC) measurements, review, correction of out-of-control situations, and audits. The Fort Devens POP (ABB-ES, 1995a) also specifies the methods and procedures to be used to ensure that calculations and evaluations are accurate, appropriate, and consistent throughout the projects; generated data are validated and their use in calculations is documented; and records are retained as documentary evidence of the quality of samples, applied processes, equipment, and results.

The HASP was prepared as an integral element of the Fort Devens POP (ABB-ES, 1995a) in accordance with the same schedule and review requirements (ABB-ES, 1995b, Appendix A). The HASP complies with USAEC's EM 385-1-1, AMC-R-385-100, and Devens RFTA safety requirements, as well as Occupational Safety and Health Administration (OSHA) Regulations 29 CFR 1910.120. The HASP development was based on appropriate information contained in previous investigation documents from Devens. The HASP portion of the Fort Devens POP (ABB-ES, 1995a) ensures that health and safety procedures are maintained by requiring inclusion of the health and safety staff function in the project organization.

1.4.2 Task Order Work Plan

The background, rationale, and specific scope for the RI are set forth in companion planning documents, the Task Order Work Plan, Task Order Work Plan Addendum, and specific sampling approach documents. The Revised Final Task Order Work Plan for AOC 69W was prepared under Contract DAAA31-94-D-0061 Task Order No. 001 (ABB-ES, 1996a) and the Work Plan Addendum was prepared under Modification No. 1 of the aforementioned contract (ABB-ES, 1996b). The Task Order Work Plans were developed to comply with the Massachusetts Contingency Plan (MCP) (310 Code of Massachusetts Regulations [CMR] 40.000); the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA), as amended by the Superfund Amendments and Reauthorization Act (SARA) of 1986; the corrective action provisions of the Hazardous and Solid Waste Amendments; and the Toxic Substances Control Act. Work conducted under the Task Order Work Plans was performed in accordance with the provisions of the Federal Facility Agreement (FFA) (USEPA and U.S. Army, 1991) and Army guidelines.

The background information provided in the Revised Final Task Order Work Plan for AOC 69W was based largely on information in the Master Environmental Plan (MEP), review of installation documents, observations made during site visits conducted by HLA, interviews with installation personnel, and the AREE 69W SSI. Summaries of each of these activities and discussions of specific field activities to be conducted under Task Order 001 were included in the Revised Final Task Order Work Plans. The discussions focused specifically on the objectives and scope of proposed RI activities.

2.0 INSTALLATION DESCRIPTION

Devens is located in the towns of Ayer and Shirley (Middlesex County) and Harvard and Lancaster (Worcester County), approximately 35 miles northwest of Boston, Massachusetts. It lies within the Ayer, Shirley, and Clinton map quadrangles (7½-minute series). Devens and the RFTA occupy approximately 9,260 acres and are divided into the Former North Post, the Main Post, and South Post (Figure 2-1).

Fort Devens was identified for cessation of operations and closure under Public Law 101-510, the Defense Base Realignment and Closure Act of 1990, and was 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 (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. AOC 69W is located in an area planned for transfer to the Massachusetts Government Land Bank for recreation/open space reuse.

Over 6,000 acres at Fort Devens were used for training and military maneuvers, and over 3,000 acres were developed for housing, buildings, and other facilities; the installation has been reported as the largest undeveloped land holding under a single owner in north-central Massachusetts (United States Fish and Wildlife Service [USFWS], 1992).

The South Post is located south of Massachusetts Route 2 and is largely undeveloped. The Main Post and North Post primarily contain developed lands, including recreational areas (e.g., a golf course and Mirror Lake), training areas, and an airfield. AOC 69W is located on the Main Post (Figure 2-2).

The following subsections describe the history and physical setting of Devens.

2.1 HISTORY

Camp Devens was created as a temporary cantonment in 1917 for training soldiers from the New England area. It was named after Charles Devens -- a Massachusetts Brevet Major General in the Union Army during the Civil War who later became

Attorney General under President Rutherford Hayes. Camp Devens served as a reception center for selectees, as a training facility, and, at the end of World War I, as a demobilization center (Marcoa Publishing Inc., 1990). At Camp Devens the 1918 outbreak of Spanish influenza infected 14,000 people, killed 800, and caused the installation to be quarantined (McMaster et al., 1982). Peak military strength during World War I was 38,000. After World War II, Camp Devens became an installation of the U.S. Army Field Forces, CONARC in 1962, and the U.S. Army Forces Command in 1973 (Biang et al., 1992).

In 1921, Camp Devens was placed in caretaker status. During summers from 1922 to 1931, it was used as a training camp for National Guard troops, Reserve units, Reserve Officer Training Corps cadets, and the Civilian Military Training Corps. In 1929, Dr. Robert Goddard used Fort Devens to test his early liquid-fuel rockets, and there is a monument to him on Sheridan Road near Jackson Gate (Fort Devens Dispatch, 1992).

In 1931, troops were again garrisoned at Camp Devens. It was declared a permanent installation, and in 1932 was formally dedicated as Fort Devens. During the 1930s, there was a limited building program, and beautification projects were conducted by the Works Progress Administration (WPA) and Civilian Conservation Corps.

In 1940, Fort Devens became a reception center for New England draftees. It expanded to more than 10,000 acres. Approximately 1,200 wooden buildings were constructed, and two 1,200-bed hospitals were built. In 1941, the Army Airfield was constructed by the WPA in a period of 113 days (Fort Devens Dispatch, 1992). In 1942, the Whittemore Service Command Base Shop for motor vehicle repair (Building 3713) was built, and at the time it was known as the largest garage in the world (U.S. Army, 1979). The installation's current wastewater treatment plant was also constructed in 1942 (Biang et al., 1992).

During World War II, more than 614,000 inductees were processed. Fort Devens' population reached a peak of 65,000. Three Army divisions and the Fourth Women's Army Corps trained at Fort Devens, and it was the location of the Army's Chaplain School, the Cook & Baker School, and a basic training center for Army nurses. A prisoner of war camp for 5,000 German and Italian soldiers was operated from 1944 to 1946. At the end of the war, Fort Devens again became a demobilization center, and in 1946 it reverted to caretaker status.

Fort Devens was reactivated in July 1948 and again became a reception center during the Korean Conflict. It has been an active Army facility since that time.

Most recently, the mission at Fort Devens was to command and train its assigned duty units, operate the South Boston Support Activity in Boston, Massachusetts, the Sudbury Training Annex, and the Hingham U.S. Army Reserve (USAR) Annex, and support the 10th Special Forces Group (A), the U.S. Army Intelligence School, Fort Devens, the U.S. Army Reserves, Massachusetts Army National Guard, and Reserve Officer Training Programs. No major industrial operations occur at Fort Devens, although several small-scale industrial operations were performed under the Directorate of Plans, Training, and Security; the Directorate of Logistics; and the Directorate of Engineering and Housing. The major waste-producing operations performed by these groups was photographic processing and maintenance of vehicles, aircraft, and small engines. Past artillery fire, mortar fire, and waste explosive disposal at Fort Devens are potential sources for explosives contamination (USAEC, 1993).

2.2 PHYSICAL SETTING

The climate, vegetation, ecology, physiography, soils, surficial and bedrock geology, and regional hydrogeology of Devens are described in the subsections that follow.

2.2.1 Climate

The climate of Devens is typical of the northeastern United States, with long cold winters and short hot summers. Climatological data were reported for Fort Devens by U.S. Department of the Army (1979), based in part on a 16-year record from Moore Army Airfield (MAAF).

The mean daily minimum temperature in the coldest months (January and February) is 17 degrees Fahrenheit (°F), and the mean daily maximum temperature in the hottest month (July) is 83°F. The average annual temperature is 58°F. There are normally 12 days per year when the temperature reaches or exceeds 90°F and 134 days when it falls to or below freezing.

The average annual rainfall is 39 inches. Mean monthly precipitation varies from a low of 2.3 inches (in June) to a high of 5.5 inches (in September). The average annual snowfall is 65 inches, and snowfall has been recorded in the months of September through May (falling most heavily from December through March).

Wind speed averages 5 miles per hour (mph), ranging from the highest monthly average of 7 mph (March-April) to the lowest monthly average of 4 mph (September).

Average daytime relative humidities range from 71 percent (January) to 91 percent (August), and average nighttime relative humidities range from 46 percent (April) to 60 percent (January).

2.2.2 Vegetation

The Main and North Posts at Devens are primarily characterized by urban and developed cover types. Approximately 56 percent of these areas are covered by developed lands, the golf course, the airfield, and the wastewater infiltration beds. Early successional forest cover types (primarily black cherry-aspen hardwoods) cover approximately 2 percent of the area, mixed oak-red maple hardwoods approximately 20 percent, and white pine-hardwood mixes approximately 11 percent. The rest of the North and Main Posts are characterized by various coniferous species, shrub habitat, and herbaceous cover types.

Much of the South Post is undeveloped forested land. The area includes approximately 8 percent early successional forest (black cherry, red birch, grey birch, quaking aspen, red maple); 26 percent mixed oak hardwoods; and 9 percent coniferous forest (white pine, pitch pine, red pine). Four percent of the area comprises a mixed shrub community. The 200-acre Turner Drop Zone is maintained as a grassland that represents a "prairie" habitat. Vegetative cover in the large "impact area" of the central South Post has not been mapped in detail. It is dominated by fire-tolerant species such as pitch pine and scrub oak.

Extensive sandy glaciofluvial soils are found in the Nashua River Valley, particularly in the South and North Post areas of Devens. Extensive accumulations of these soils are unusual in Massachusetts outside of Cape Cod and adjacent areas of southeastern

Massachusetts, and they account for some of the floral and faunal diversity at the installation.

2.2.3 Ecology

The former Fort Devens encompasses numerous terrestrial, wetland, and aquatic habitats in various successional stages. Floral and faunal diversity is strengthened by the installation's close proximity to the Nashua River; the amount, distribution, and nature of wetlands; and the undeveloped state and size of the South Post (USFWS, 1992). Much of Fort Devens was formerly agricultural land and included pastures, woodlots, orchards, and cropped fields. Existing habitat types reflect this agrarian history, ranging from abandoned agricultural land to secondary growth forested regions. Devens is generally reverting back to a forested state.

There are 1,313 acres of wetlands at Devens. The wetlands are primarily palustrine, although riverine and lacustrine types are also found. Forested palustrine floodplain wetlands associated with the Nashua River and its tributary Nonacoicus Brook are located on Devens' Main and North Posts. These include 191 acres of flooded areas, emergent marsh, and shrub wetlands. Also present are 245 acres of isolated regions of palustrine wetlands and lacustrine systems. On the South Post, there are 877 acres of wetlands, consisting of deciduous forested wetlands, deciduous shrub swamps, emergent marsh, open lacustrine waters in ponds, and open riverine waters.

Approximately half of Devens' land area abuts the northern boundary of the Oxbow National Wildlife Refuge (NWR), a federal resource administered as part of the Great Meadows NWR (USFWS, 1992).

Devens supports an abundance and diversity of wildlife. Identified taxa include 771 vascular plant species, 538 species of butterflies and moths, eight tiger beetle species, 30 vernal pool invertebrates, 15 amphibian species (six salamanders, two toads, seven frogs), 19 reptile species (seven turtles, 12 snakes), 152 bird species, and 42 mammal species. The status of fish populations in Devens aquatic systems has not been fully defined.

Rare and endangered species at Devens include the federally listed (threatened) bald eagle and peregrine falcon (both occasional transients); the state-listed (endangered) upland sandpiper, ovoid spike rush, and Houghton's flatsedge; the state-listed (threatened) Blanding's turtle, cattail sedge, pied-billed grebe, and northern harrier; and the state-listed (special concern) blue-spotted salamander, grasshopper sparrow, spotted turtle, wood turtle, water shrew, blackpoll warbler, American bittern, Cooper's hawk, sharp-shinned hawk, and Mystic Valley amphipod. Also state-listed as rare or endangered are three Lepidoptera (butterfly and moth) species identified at Devens.

The Massachusetts Natural Heritage Program has developed Watch Lists of unprotected species that are uncommon or rare in Massachusetts. From the Watch Lists, 14 plant species, two amphibian species, and 15 bird species have been observed at Devens.

2.2.4 Physiography

Devens is in a transitional area between the coastal lowland and central upland regions of Massachusetts. All of the landforms are products of glacial erosion and deposition on a crystalline bedrock terrain. Glacial erosion was superimposed on ancient bedrock landforms that were developed by the erosional action of preglacial streams. Generally, what were bedrock hills and ridges before the onset of Pleistocene glaciation were only moderately modified by glacial action, and they remain bedrock hills and ridges today. Similarly, preglacial bedrock valleys are still bedrock valleys. In post-glacial time, streams have locally modified the surficial glacial landforms but generally have not affected bedrock.

The predominant physiographic (and hydrologic) feature in the Devens area is the Nashua River (see Figure 2-1). It forms the eastern installation boundary on the South Post, where its valley varies from a relatively narrow channel (at Still River Gate), to an extensive floodplain with a meandering river course and numerous cutoff meanders (at Oxbow National Wildlife Sanctuary). The Nashua River forms the western boundary of much of the Main Post, and there its valley is deep and comparatively steep-sided with extensive bedrock outcroppings on the eastern bank. The river flows through the North Post in a well-defined channel within a broad forested floodplain.

Terrain at Devens falls generally into three types. The least common is bedrock terrain, where rocks that have been resistant to both glacial and fluvial erosion remain as topographic highs, sometimes thinly veneered by glacial deposits.

Shepley's Hill on the Main Post is the most prominent example.

A similar but more common terrain at Devens consists of materials (tills) deposited directly by glaciers as they advanced through the area or as the ice masses wasted (melted). These landforms often conform to the shape of the underlying bedrock surface. They range from areas of comparatively low topographic relief (such as near Lake George Street on the Main Post) to elongated hills (drumlins) whose orientations reflect the direction of glacier movement (such as Whittemore Hill on the South Post).

The third type of terrain was formed by sediment accumulations in glacial-meltwater streams and lakes (glaciofluvial and glaciolacustrine deposits). This is the most common terrain, comprising most of the North and South Posts and much of the Main Post. Its form bears little or no relationship to the shape of the underlying bedrock surface. Landforms include extensive flat uplands such as the hills on which MAAF and the wastewater infiltration beds are located on the North Post. Those are large remnants of what was once a continuous surface that was later incised and divided by downcutting of the Nashua River. Another prominent glacial meltwater feature is the area around Cranberry Pond and H-Range on the South Post. This is classic kame-and-kettle topography formed by sand and gravel deposition against and over large isolated ice blocks, followed by melting of the ice and collapse of the sediments. The consistent elevations of the tops of these ice-contact deposits are an indication of the glacial-lake stage with which they are associated. Mirror Lake and Little Mirror Lake on the Main Post occupy another conspicuous kettle.

2.2.5 Soils

Devens and the RFTA lies within Worcester County and Middlesex County in Massachusetts (see Figure 2-1). The soils of Worcester County have been mapped by the Soil Conservation Service (SCS) of the U.S. Department of Agriculture (USDA) (SCS, 1985). Mapping of the soils of Middlesex County has not been completed. However, an interim report (SCS, 1991), field sheet #19 (SCS, 1989), and an unpublished general soil map (SCS, undated) are available.

Soil mapping units ("soil series") that occur together in intricate characteristic patterns in given geographic areas are grouped into soil "associations." Soils in the Worcester County portions of Devens consist generally of three associations. Three associations also have been mapped in the Middlesex County portions of Devens. Although the mapped associations are not entirely the same on both sides of the county line, the differences reflect differences in definition and the interim status of Middlesex County mapping. The general distributions of the soil associations are shown in Figure 2-3, and descriptions of the soil series in those associations are provided below.

WORCESTER COUNTY (SCS, 1985)

Winooski-Limerick-Saco Association:

Winooski Series. Very deep; moderately well-drained; slopes 0 to 3 percent; occurs on floodplains; forms in silty alluvium.

Limerick Series. Very deep; poorly drained; slopes 0 to 3 percent; occurs on floodplains; forms in silty alluvium.

Saco Series. Very deep; very poorly drained; slopes 0 to 3 percent; occurs on floodplains; derived mainly from schist and gneiss.

Hinckley-Merrimac-Windsor Association:

Hinckley Series. Very deep; excessively drained; slopes 0 to 35 percent; occurs on stream terraces, eskers, kames, and outwash plains.

Merrimac Series. Very deep; excessively drained; slopes 0 to 25 percent; occurs on stream terraces, eskers, kames, and outwash plains.

Windsor Series. Very deep; moderately well-drained; slopes 0 to 3 percent; occurs on floodplains.

Paxton-Woodbridge-Canton Association:

Paxton Series. Very deep; well-drained; slopes 3 to 35 percent; occurs on glacial till uplands; formed in friable till overlying firm till.

Woodbridge Series. Very deep; moderately well-drained; slopes 0 to

15 percent; occurs on glacial till uplands; formed in firm till.

Canton Series. Very deep; well-drained; slopes 3 to 35 percent; occurs on glaciated uplands; formed in friable till derived mainly from gneiss and schist.

MIDDLESEX COUNTY (SCS, 1991)

Hinckley-Freetown-Windsor Association: The soils at AOC 69W are comprised of this soil type (See Figure 2-3). (This is a continuation of the Hinckley-Merrimac-Windsor Association mapped in Worcester County):

Hinckley Series. Deep; excessively drained; nearly level to very steep; occurs on glacial outwash terraces, kames, and eskers; formed in gravelly and cobbley coarse textured glacial outwash.

Freetown Series. Deep; very poorly drained; nearly level, organic; occurs in depressions and on flat areas of uplands and glacial outwash plains.

Windsor Series. Deep; excessively drained; nearly level to very steep; occurs on glacial outwash plains, terraces, deltas, and escarpments; formed in sandy glacial outwash.

Quonset-Carver Association:

Quonset Series. Deep; excessively drained; nearly level to very steep; occurs on glacial outwash plains, terraces, eskers, and kames; formed in water-sorted sands derived principally from dark phyllite, shale, or slate.

Carver Series. Deep; excessively drained; nearly level to steep; occurs on glacial outwash plains, terraces, and deltas; formed in coarse, sandy, water-sorted material.

Winooski-Limerick-Saco Association: (This is a continuation of the same association mapped along the Nashua River floodplain in Worcester County).

2.2.6 Surficial Geology

Devens and the RFTA lie in three topographic quadrangles: Ayer, Clinton, and Shirley. The surficial geology of Devens has been mapped only in the Ayer quadrangle (Jahns, 1953) and Clinton quadrangle (Koteff, 1966); the Shirley quadrangle is unmapped.

Unconsolidated surficial deposits of glacial and postglacial origin comprise nearly all of the exposed geologic materials at Devens. The glacial units consist of till, deltaic deposits of glacial Lake Nashua, and deposits of glacial meltwater streams.

The superficial geology at AOC 69W can be placed in the following geologic setting. The till ranges from unstratified gravel to silt, and it is characteristically bouldery. Jahns (1953) and Koteff (1966) recognize a deeper unit of dense, subglacial till, and an upper, looser material that is probably a slightly younger till of englacial or superglacial origin. Till is exposed in ground-moraine areas of the Main Post (such as in the area of Lake George Street) and on the South Post at and south of Whittemore Hill. It also underlies some of the water-laid deposits (Jahns, 1953). Till averages approximately 10 feet in thickness but reaches 60 feet in drumlin areas (Koteff, 1966).

Most of the surficial glacial units in the Nashua Valley are associated with deposition in glacial Lake Nashua, which formed against the terminus of the Wisconsinan ice sheet as it retreated northward along the valley. Successively lower outlets were uncovered by the retreating glacier, and the lake level was correspondingly lowered. Koteff (1966) and Jahns (1953) recognize six lake levels (stages) in the Devens area, distinguished generally by the elevations and distribution of their associated deposits. The stages are, in order of development: Clinton Stage; Pin Hill Stage; Old Mill Stage; Harvard Stage; Ayer Stage; and Groton Stage.

The glacial lake deposits consist chiefly of sand and gravelly sand. Coarser materials are found in topset beds of deltas built out into the lakes and in glacial stream beds graded to the lakes. Delta foreset beds are typically composed of medium to fine sand, silt, and clay. Lake-bottom deposits, which consist of fine sand, silt, and clay, are mostly covered by delta deposits and are seldom observed in glacial Lake Nashua deposits. One of the few known exposures of glacial lake-bottom sediments in the region is on the South Post near A- and C-Ranges. There, a section of more than

14 feet of laminated clay was mined for brick-making in the early part of this century (Alden, 1925, pp. 70-71). The general physical characteristics of glacial lake deposits are the same regardless of the particular lake stage in which the deposits accumulated (Koteff, 1966; Jahns, 1953). Although glaciofluvial and glaciolacustrine sediments are typically well stratified, correlations between borings are difficult because of laterally abrupt changes characteristic of these generally high-energy depositional environments.

Postglacial deposits consist mostly of river-terrace sands and gravels; fine alluvial sands and silts beneath modern floodplains; and muck, peat, silt, and sand in swampy areas.

Jahns (1953) also observed a widespread veneer of windblown sand and ventifacts above the glacial materials (and probably derived from them in the brief interval between lake drainage and the establishment of vegetative cover).

2.2.7 Bedrock Geology

Devens and the RFTA is underlain by low-grade metasedimentary rocks, gneisses, and granites. The rocks range in age from Late Ordovician to Early Devonian (approximately 450 million to 370 million years old). Devens is situated approximately 2 miles west of the Clinton-Newbury-Bloody Bluff fault zone, that developed when the ancestral European continental plate collided with and underthrust the ancestral North American plate. The continents reseparated in the Mesozoic to form the modern Atlantic Ocean. Devens is located on the very eastern edge of the ancestral North American continental plate. A piece of the ancestral European continent (areas now east of the Bloody Bluff fault) broke off and remained attached to North America.

Preliminary bedrock maps (at scale 2,000 feet/inch) are available for the Clinton quadrangle (Peck, 1975 and 1976) and Shirley quadrangle (Russell and Allmendinger, 1975; Robinson, 1978). Bedrock information for the Ayer quadrangle is from the Massachusetts state bedrock map (at a regional scale of 4 miles/inch) (Zen, 1983) and in associated references (Robinson and Goldsmith, 1991; Wones and Goldsmith, 1991). Among these sources, there is some disagreement about unit names and stratigraphic sequence; however, there is general agreement about the distribution of rock types.

In contrast to the high metamorphic grade and highly sheared rocks of the Clinton-Newbury zone, the rocks in the Devens area are low grade metamorphics (generally below the biotite isograd) and typically exhibit less brittle deformation. Major faults have been mapped, however, including the Wekepeke fault exposed west of Devens (in an outcrop 0.25 mile west of the old Howard Johnson rest stop on Route 2).

Figure 2-4 is a generalized summary of the bedrock geology of Devens. It is compiled from Peck (1975), Robinson (1978), Russell and Allmendinger (1975), and Zen (1983), and it adopts the nomenclature of Zen (1983). Because of limited bedrock exposures, the locations of mapped contacts are considered approximate, and the mapped faults are inferred. Rock units strike generally northward to northeastward but vary locally. The bedrock units underlying Devens and the RFTA are as follows:

DSw **WORCESTER FORMATION** (Lower Devonian and Silurian) Carbonaceous slate and phyllite, with minor metagraywacke to the west (Zen, 1983; Peck, 1975). Bedding is typically obscure due to a lack of compositional differences. It is relatively resistant to erosion and forms locally prominent outcrops. The abandoned Shaker slate quarry on the South Post is in rocks of the Worcester Formation. The unit corresponds to the "DSgs" and "DSs" units of Peck (1975) and the "e3" unit of Russell and Allmendinger (1975).

So **OAKDALE FORMATION** (Silurian) Metasiltstone and phyllite. It is fine-grained and consists of quartz and minor feldspar and ankerite, and it is commonly deformed by kink banding (Zen, 1983; Peck, 1975; Russell and Allmendinger, 1975). In outcrop it has alternating layers of brown siltstone and greenish phyllite. The Oakdale Formation crops out most visibly on Route 2 just east of the Jackson Gate exit. It corresponds to the "DSsp" unit of Peck (1975), the "e2" unit of Russell and Allmendinger (1975), and "ms" unit of Robinson (1978). The bedrock at AOC 69W has been identified as part of this formation.

Sb **BERWICK FORMATION** (Silurian) Thin- to thick-bedded metamorphosed calcareous metasiltstone, biotitic metasiltstone, and fine-grained metasandstone, interbedded with quartz-muscovite-garnet schist and feldspathic quartzite (Zen, 1983; Robinson and Goldsmith, 1991). In areas northwest of Fort Devens, cataclastic zones have been observed (Robinson, 1978).

Dcgr **CHELMSFORD GRANITE** (Lower Devonian) Light-colored and gneissic, even and medium-grained, quartz-microcline-plagioclase-muscovite-biotite, pervasive ductile deformation visible in elongate quartz grains aligned parallel to mica. It intrudes the Berwick Formation and Ayer granite (Wones and Goldsmith, 1991).

AYER GRANITE

Sacgr **Clinton facies** (Lower Silurian) Coarse-grained, porphyritic, foliated biotite granite with a nonporphyritic border phase; it intrudes the Oakdale and Berwick Formations and possibly the Devens-Long Pond Facies (Zen, 1983; Wones and Goldsmith, 1991).

SOad **Devens-Long Pond facies** (Upper Ordovician and Lower Silurian) Gneissic, equigranular to porphyoblastic biotite granite and granodiorite. Its contact relationship with the Clinton facies is unknown (Wones and Goldsmith, 1991). Observations of mapped exposures of this unit on Fort Devens indicate that it may not be intrusive.

Bedrock is typically unweathered to only slightly weathered at Devens. Glaciers stripped away virtually all of the preglacially weathered materials, and there has been insufficient time for chemical weathering of rocks in the comparatively brief geologic interval since glacial retreat.

2.2.8 Regional Hydrogeology

Devens is in the Nashua River drainage basin, and the Nashua River is the eventual discharge locus for all surface water and groundwater flow at the installation.

The water of the Nashua River has been assigned to Class B under Commonwealth of Massachusetts regulations. Class B surface water is "designated for the uses of protection and propagation of fish, other aquatic life and wildlife, and for primary and secondary contact recreation" (314 CMR 4.03).

The principal tributaries of the north-flowing Nashua River at Devens are Nonacoicus Brook and Walker Brook on the North Post; Cold Spring Brook (which is a tributary of Nonacoicus Brook) on the Main Post; and Spectacle Brook and Ponakin Brook (tributaries of the North Nashua River), Slate Rock Brook, and New Cranberry Pond Brook on the South Post (see Figure 2-5).

There are two ponds on Devens' South Post that are called Cranberry Pond. For the purpose of the SIs, the isolated kettle pond located east of H-Range is referred to as Cranberry Pond, and the pond impounded in the 1970s 0.5-mile west of the Still River gate is referred to as New Cranberry Pond.

Glacial meltwater deposits constitute the primary aquifer at Devens. Measured hydraulic conductivities in meltwater deposits were comparatively high - typically 10^{-3} to 10^{-2} centimeters per second (cm/sec) or 2.8 to 28 feet per day (ft/day). In till and in clayey lake-bottom sediments, measured hydraulic conductivities were lower and ranged generally from 10^{-6} to 10^{-4} cm/sec or 2.8×10^{-3} to 0.28 ft/day. Groundwater also occurs in the underlying bedrock; however, flow is limited because the rocks have no primary porosity and water moves only in fractures and dissolution voids.

Groundwater in the surficial aquifer at Devens has been assigned to Class I under Commonwealth of Massachusetts regulations. Class I consists of groundwaters that are "found in the saturated zone of unconsolidated deposits or consolidated rock and bedrock and are designated as a source of potable water supply" (314 CMR 6.03).

The transmissivity of an aquifer is the product of its hydraulic conductivity and saturated thickness, and as such it is a good measure of groundwater availability. Figure 2-5 shows aquifer transmissivities at Devens, based on the regional work of Brackley and Hansen (1977). Transmissivities in the meltwater deposits range from 10 square feet per day (ft^2/day) to more than 4,000 ft^2/day. Aquifer transmissivities between 10 and 1,350 ft^2/day correspond to potential well yields generally between 10 and 100 gallons per minute (gpm); transmissivities from 1,350 to 4,000 ft^2/day typically yield from 100 to 300 gpm; and where transmissivities exceed 4,000 ft^2/day, well yields greater than 300 gpm can be expected. (Most domestic wells in the area are drilled 100 to 200 feet into bedrock and yield less than 10 gpm. Higher yields are associated with deeper bedrock wells.)

In Figure 2-5, the zones of highest transmissivity are found in areas of thick glacial meltwater deposits on the North and Main Posts, and these encompass the Sheboken, Patton, and McPherson production wells and the largely inactive Grove Pond wellfield. AOC 69W is located in the area of the installation with a moderate transmissivity (1,350 to 4,000 ft^2/day) (see Figure 2-5). The zones of lowest transmissivity are associated with exposed till and bedrock and are located on the Main Post surrounding Shepley's Hill and between Jackson Gate and the parade ground and on the South Post at Whittemore Hill and isolated areas to the north and west.

A regional study of water resources in the Nashua River basin was reported by Brackley and Hansen (1977). A digital model of groundwater flow at Devens is available in a draft final report by Engineering Technologies Associates, Inc. (ETA) (1992).

According to ETA (1992), in the absence of pumping or other disturbances, groundwater recharge occurs in upland areas (e.g., the high ground on the Main Post between Queenstown, Givry, and Lake George Streets, and on the South Post the area around Whittemore Hill). The groundwater flows generally from the topographic highs to topographic lows. It discharges in wetlands, ponds, streams, and directly into the Nashua River. Groundwater discharge maintains the dry-weather flow of the rivers and streams. Figures 2-6 and 2-7, respectively, present ETA's regional overburden and bedrock groundwater flow maps (ETA, 1992).

3.0 ANALYTICAL PROGRAM

Based on data obtained from previous investigations summarized in the Final Task Order Work Plan for AOC 57, 63AX, and 69W (ABB-ES, 1996a) and Task Work Plan Addendum for AOC 69W (ABB-ES, 1996b), an analytical program for the RI was established to identify contaminants that were potentially present at AOC 69W due to historical activities. Fuel hydrocarbons and chlorinated solvent contaminants were discovered in past investigations at AOC 69W. The purpose of the following subsection is to outline only those analytical procedures used during the RI program. Analytical results generated during the previous AREE 69W SSE will be included in the RI; however, the analytical program is not described in this document. Information on the AREE 69W SSE is referenced in Section 5.0 and Section 7.0.

The AOC 69W RI analytical program included field analysis as well as off-site laboratory analyses for a predetermined set of organic and inorganic analytes. The specific analyses implemented for these investigations are outlined in Subsection 3.1 for the on-site methods and Subsection 3.2 for the off-site analytical program. The following subsections describe the field and off-site analytical programs implemented for both the RI and Supplemental RI completed by ABB-ES at AOC 69W.

3.1 FIELD ANALYTICAL METHODS

Samples were analyzed in the field during the RI investigation conducted in 1995 and 1996 to provide real-time chemical data. Soil and groundwater samples were analyzed for selected volatile organic compounds (VOCs) and total petroleum hydrocarbons (TPHC), gasoline range organics (GRO), and diesel range organics (DRO) during the 1995 field program. During the 1996 program, samples were analyzed for VOCs and TPHC. Data were primarily used to evaluate the distribution of benzene, toluene, ethylbenzene, and xylene (BTEX), chlorinated solvents, and petroleum related contamination in groundwater and soil at AOC 69W. A discussion of field analytical procedures, data quality objectives, field documentation procedures, and quality control steps are outlined in Subsection 4.6 of the Fort Devens POP (ABB-ES, 1995a) and Appendix D. Target compounds and detection limits for on-site field analysis compounds are outlined in Table 3-1.

TPHC analyses using a Miran Fixed Filter Infrared Spectrophotometer (IR) was the primary field method for evaluating semivolatile petroleum hydrocarbons in soil samples. This method is similar to USEPA Method 418.1. A soil microextraction sample preparation technique was developed for use in a field laboratory. This method provides qualitative data on the presence and absence, and relative concentration, of hydrocarbons. During the 1995 program DRO gas chromatography (GC)/Flame Ionization Detector (FID) analysis was also conducted on a subset of soils to provide semiquantitative data on medium molecular weight range petroleum hydrocarbons. DRO analysis was conducted for a subset of samples that exhibited hydrocarbon characteristics on the VOC analysis.

A Hewlett Packard 5890 Series II GC, in series with a Tekmar 3000 purge and trap concentrator, was used to measure concentrations of VOCs. Target analytes included BTEX, chlorinated solvents, and GRO to measure the volatile petroleum hydrocarbons. Several detectors were used in conjunction with the GC during the 1995 and 1996 field programs. Detectors included a FID, photoionization detector (PID), electron capture detector (ECD) and/or Electrolytic Conductivity Detector (ELCD).

During the 1995 program, detectors included ECD/PID/FID in series. During the 1996 program, detectors included PID/ELCD as specified in USEPA Method 8021 for VOCs.

3.1.1 Instrument Calibration

For analysis of samples for target compounds using a GC, an initial calibration was established. The initial calibration was accomplished through the analysis of three to five different concentrations of working standards. The response of the instrument to each standard was plotted versus the concentrations of standards to establish a calibration curve. The range of standards used to create the calibration curve was determined by the anticipated range of VOC contamination. Once all points were established on the calibration curve, the linearity was measured using linear regression analysis. The r^2 value, which provided a measure of this linearity, was required to be a minimum of 0.95 for all target analytes.

Prior to analysis of samples, a continuing calibration check standard was analyzed each day to ensure that the response of the instrument had not changed from the initial calibration. The concentration of the check standard was at mid-level in the calibration curve. The initial calibration remained valid if concentrations obtained for the target analytes were no greater than 30 percent different from values obtained from the initial calibration. If greater than two target compounds for multianalyte analysis for BTEX and chlorinated compounds were outside the 30 percent difference, a new initial calibration was created.

3.1.2 Sample Preparation and Analysis

Sample preparation for the total petroleum hydrocarbon procedure (IR analysis) is detailed in Subsection 4.6.2 of the Fort Devens POP (ABB-ES, 1995a). The IR analysis was used for gross hydrocarbon measurements and to indicate the presence or absence of contamination. A freon-113 extraction was used to prepare samples. Samples were analyzed by USEPA Method 418.1 (USEPA, 1983).

Sample preparation techniques for GC VOCs and GRO were adapted from protocols outlined in USEPA Method 5030 (USEPA, 1986). Soil samples were prepared for field analysis by the measurement of 5 grams into a soil sparger. For water samples, the amount used was 5 milliliters (mL). Both soil and groundwater samples were analyzed by the purge and trap concentration and GC separation. A DB-624 capillary column was installed in the gas chromatograph for the purpose of separating out the various compounds. A retention time window of +/- 3 percent was used for the identification of target compounds.

For DRO analysis sample preparation, techniques were adapted from USEPA Method 3550 and Method 8015 (USEPA, 1986). The extraction procedure required the measurement of 2 grams of soil into a test tube with the addition of 2 grams of sodium sulfate and 2 mL of methylene chloride (solvent). The supernatant was then transferred to an injection vial labeled with the sample identification. The GC, equipped with an autosampler for a 2 microliters (μL) sample volume injection, then analyzed the sample for identification and quantitation of DRO concentration. Additional solvent may have been added if a sufficient volume of supernatant was not initially achieved. If additional solvent was added, a dilution factor was incorporated during sample quantitation.

3.1.3 Target Compound Concentrations Calculations

Target VOC concentrations were determined from comparisons of responses of compounds in samples versus responses from standards in the initial calibration curves described in Subsection 3.1.1. Soil compound concentrations were reported on a dry weight basis. Solid fraction data was used to calculate final VOC, GRO, DRO, and IR concentrations. Dilutions performed on both water and soil samples also were used to calculate final VOC, GRO, DRO, and IR concentrations. Dilution factors were calculated for any analyses where sample amounts were modified due to high concentrations of chemicals present in samples. Final sample results were calculated by dividing original unadjusted sample results by fraction of solid and multiplying results by any dilution factors.

Based on secondary data reviews conducted by HLA's Quality Assurance Officer and project chemist, possible data bias was identified in the GRO and DRO data set. The possible data bias is discussed below for GRO and DRO.

The results of the GRO analyses contain a possible positive bias which overestimated the measured concentration by approximately 20 percent of the true value. The bias was introduced during the preparation of the stock standard for the GRO analysis. The density of GRO was approximated as the density of benzene (0.88 grams per milliliter [g/mL]), however, according to information in the Installation Restoration Program Toxicology Guide (U.S. Air Force) gasoline has a density of approximately 0.73 g/mL.

The results of the DRO analyses should be considered estimated. Possible impacts on quantitation of hydrocarbons was introduced during the set-up of the GC analytical run program. The instrument conditions used for DRO analyses caused the loss of approximately 25 percent of the light end hydrocarbons within the diesel hydrocarbon range. The primary purpose of the DRO analysis was to estimate concentrations of fuel oils or waste oils at the site. The analytical run would effectively detect the medium to heavy molecular weight fraction of oil products; however, concentrations should be considered estimated within approximately 0.5 to 2 times the reported concentration.

3.1.4 Field Documentation Procedures

Instrument logbooks were completed for each instrument used during each of the field analytical programs. A log of all chromatography runs was recorded in these logbooks. The logbooks recorded the concentrations for all calibration standards used, sample run number, sample identification, date, standard preparation records, instrument maintenance records, percent solid determination data, sample volume or weight, and any additional comments or observations of the field chemist. In addition, the results from each GC run were saved into a computerized database.

At the conclusion of the RI field effort, raw data from the GC analyses and instrument logbooks were transferred for storage at HLA's Portland, Maine office. Raw data includes chromatograms, quantitation reports, and instrument and notebook records to document analyses.

3.1.5 Field Analytical Quality Control

A QC program for the field analytical results was established prior to commencement of the RI on-site laboratory analysis. This program was developed to ensure that the data generated at the field laboratory was of sufficient quality to be considered satisfactory for its intended use. QC parameters for the RI field analytical program included initial and daily calibration check standard runs, mid-level calibration check standards after every ten samples, low-level and mid-level method blanks, cleaning blanks, and field or laboratory duplicates. QC objectives for the on-site laboratory analyses are outlined in the Fort Devens POP (ABB-ES, 1995a) and Appendix D of this report. QC sample results for the on-site laboratory are assessed in Appendix D.

Method blanks were analyzed daily to document that the analytical system was free of contamination. Samples were not run if the there were any target compounds detected above the Practical Quantitation Limit (PQL) in the method blank. In addition to the low-level method blank, a mid-level method blank was run in instances where methanol extractions were necessary. One hundred μL of methanol were added to deionized water and analyzed to ensure that it was free of contamination.

During VOC GC analyses, cleaning blanks were run at the beginning of each day to show that the analytical system was clean. They were also run after particularly heavily contaminated samples were run through the GC.

For VOC analyses, a surrogate was added to every sample to determine if the matrix was having an effect on the recovery of the target compounds. The surrogate used for all field investigations was 4-Bromofluorobenzene. This surrogate was used because it is chemically similar to the target compounds and responds well on the detectors selected for the field programs. Surrogate recovery goals of 30 percent to 170 percent were established for the screening program. Data usability goals for the screening samples in the field program allowed for a wider range of accuracy because providing real time Level II quality data was the goal. The surrogate recovery limits were based on the need to analyze a large number of screening samples with a 24-hour turnaround to provide Level II data quality. Samples for which the surrogate did not meet this criteria were reanalyzed and/or qualified.

Field duplicate samples were also analyzed to determine the precision of sampling and analytical techniques. Reported concentrations of target compounds for each sample and associated duplicate pair were compared by calculating the relative percent difference (RPD) of the results. RPDs were compared to criteria from USEPA (hazardous site evaluation division) Region I laboratory data validation functional guidelines for evaluating organics analyses to evaluate the precision of measurements. Duplicate results for the RI are presented in Appendix D.

In some instances, data qualifiers were used to address data quality issues associated with a particular sample. The following qualifiers were used during the RI at AOC 69W:

J - Denotes target compound concentrations that are estimated.

E - Denotes target compound concentrations that exceed the highest standard of the calibration curve.

U - Denotes sample concentrations that are less than PQLs.

N - Denotes a value that is a possible false positive due to method blank contamination.

Results of the on-site sample analyses are presented in discussions of the nature and distribution of site contaminants, in Subsection 7.0 and Appendix L of this report.

3.1.6 Method Detection Limits and Data Qualifiers

Method Detection Limits (MDLs) were established during the RI for the ELCD, PID, and the FID detector target compounds. The MDL study was completed for all VOC target compounds to provide data to verify the reporting limit (RL) concentrations used for the various field programs. RL goals of 1-2 µg/L were established based on project needs and regulatory considerations prior to each field program. MDLs were calculated based on procedures published in CFR Appendix B, Part 136, vol. 49, no. 209. The MDL study provides an estimation of the lower concentration limit of what the detectors were able to measure. The MDLs obtained during the RI field analytical program are presented in Appendix D. With the exception of 1,1-dichloroethene (1,1-DCE), MDLs calculated for all target analytes were less three times the reporting limits indicating RL goals specified for the project were achievable. During the 1995 program, 1,1-Dichloroethane was not observed at the 1 µg/L reporting limit concentration with reliability, therefore its RL was set at 5 µg/L. The lower standard concentration used for initial calibrations was equivalent to the RL for all target compounds.

3.2 OFF-SITE LABORATORY ANALYTICAL PARAMETERS

Soil and groundwater samples collected during the 1995 and 1996 RIs from AOC 69W were analyzed at an off-site laboratory for chemical parameters on the Devens Project Analyte List (PAL). Off-site laboratory analyses for PAL organics and inorganics were considered equivalent to USEPA definitive data (USEPA, 1993). The Devens PAL and off-site laboratory methods are presented in the Fort Devens POP (ABB-ES, 1995a) and Appendix D of this report. A summary of analytical methods requested for each sample collected at AOC 69W is contained in Section 5.0, Table 5-2. Supplemental analyses were conducted in 1997 on groundwater and air samples as discussed in Subsection 3.4.

During the 1995 and 1996 investigations, off-site laboratories performing the analytical work for all Devens investigations were required to implement the 1990 U.S. Army Toxic and Hazardous Materials Agency (USATHAMA, now USAEC) QA

Program (USATHAMA, 1990). All method performance demonstrations, data management, and oversight for previous USATHAMA analytical procedures were performed by the USAEC.

The off-site laboratory contracted to implement the analytical program for the RI at AOCs 69W was Environmental Science and Engineering, Inc. (ESE) of Gainesville, Florida. This laboratory was approved to complete analyses using USATHAMA and USEPA methods. Analyses were completed while implementing the 1990 USATHAMA QA Program. Specific performance demonstration and QC components of the 1990 USATHAMA QA Plan are detailed in Subsection 3.2.3 of this report.

The following subsection describes the procedures implemented to achieve the objectives of the QA program and any additional quality control processes implemented during the RI.

3.2.1 Off-Site Laboratory Certification

In accordance with the 1990 USATHAMA QA Program, laboratories were required to demonstrate competency by performance demonstration of the PAL analytical methods conducted in association with field investigations. The USAEC requires that a laboratory demonstrate proficiency in performing USAEC methods for specific analytes. Analytical methods are based on USEPA procedures (USEPA 1983; 1986). Laboratories demonstrate proficiency by submitting data from runs of pre-certification calibration standards. Performance samples are then sent for analysis to the laboratory by the USAEC. The true concentrations of the analytes in the performance samples are unknown by the laboratory. The data obtained from the analyses of these samples are then sent to the USAEC to determine the laboratory's precision and accuracy. Qualifications to perform USAEC methods are awarded to laboratories based on this performance. Certified Reporting Limits (CRLs) are also determined through this process based on calculations and certification standard analyses outlined in the USATHAMA QA Program (USATHAMA, 1990). A method code associated with each USAEC analysis and laboratory is then assigned and reported with the results. Listings of USAEC certified analytical methods used during the RI, target analytes, and CRLs are presented in Appendix D-1, Table D-1 for the 1995 Field Investigation and in Appendix D-3, Table D-1 for the 1996 Field Investigation.

Some standard USEPA methods such as hardness, total organic carbon (TOC), TPHC, and total suspended solids (TSS) have no associated USAEC certification. The USAEC recognizes standard USEPA protocols or internal laboratory methods for these analyses. Listings of USEPA analytical methods used during the RI and project reporting limits are presented in Appendix D-1, Table D-1 for the 1995 Field Investigation and in Appendix D-3, Table D-1 for the 1996 Field Investigation.

3.2.2 Off-Site Laboratory Methods Quality Control

All field samples sent to the laboratory were organized into lots which were assigned a three digit code using letters of the alphabet. Each lot consisted of the maximum number of samples, including QC samples, that can be processed through the rate limiting step of the method during a single time period (not exceeding 24 hours). Associated with each lot were laboratory control samples. Control samples were spikes of high and low concentrations of specific analytes that help monitor ESE's precision and accuracy. The recoveries of these spikes were plotted on control charts generated by ESE and submitted to the USAEC. Data generated during the performance demonstration process were used to calculate a mean of the recoveries. Control and warning limits were statistically generated by the USAEC Chemistry Branch to help measure laboratory data quality. Control charts are generated with each lot providing a continuous benchmark for trend evaluation of laboratory performance.

Method blanks were also analyzed at ESE to evaluate the potential for target analytes to be introduced during the processing and analysis of samples. One method blank was included with each analytical lot. Because analytical lots included samples from several areas, method blank results are presented and discussed for all AOCs investigated during the RI.

3.2.3 Data Reduction, Validation, and Reporting

Initial responsibility for accuracy and completeness of Devens analytical data packages rested with ESE. Secondary data quality reviews were completed by the USAEC Chemistry Branch and HLA. The USAEC Chemistry Branch conducts reviews on control chart data from low and high concentration blank spikes provided with each data lots submitted by the ESE. The processes for reporting control chart data and determining data accuracy is outlined in the USATHAMA QA Program

(USATHAMA, 1990). Complete evaluations of QC results including blank data, surrogate and spike recovery data, field duplicate data, and tentatively identified compounds is completed by HLA, and data quality interpretations are provided in Section 7.0 and Appendix D.

All laboratory submissions to the USAEC first underwent a review process, including checks on the data quality, which evaluated completeness of the ESE data, accuracy of reporting limits, compliance with QC limits and holding times, and correlation of ESE data to associated laboratory tests.

The following items were validated by ESE before submission to the USAEC:

- COC records;
- instrument printouts for agreement with handwritten results;
- calibration records to ensure a particular lot is associated with only one calibration;
- chromatograms and explanations for operator corrective actions (such as manual integration);
- standard preparation and documentation of source;
- calculations on selected samples;
- notebooks and sheets of paper to ensure all pages were dated and initialed, and explanations of procedure changes;
- GC/mass spectrometer (MS) library search of unknown compounds; and
- transfer files and records to ensure agreement with analysis results.

3.2.4 Data Reporting

After review and validation by ESE, the data were encoded for transmission into the USAEC's Installation Restoration Data Management Information System (IRDMIS) as Level 1 Data. IRDMIS, a computerized data management system used by the USAEC, is described in detail in Subsection 3.3. Once the data were entered into the system, a group and records check was completed. Data were then transferred to USAEC's data management contractor. During this phase, the data were elevated to Level 2. Another group and records check was performed and the data were reviewed by the USAEC Chemistry Branch. When errors were identified, the data were returned to ESE for correction. Control charts were produced by ESE that plotted recoveries of high and low concentrations of laboratory control spikes of the target analytes. The control charts provided the USAEC with information about the accuracy of the analytical methods performed by ESE. Once data were reviewed by the USAEC Chemistry Branch, the determination was made on a lot-by-lot basis whether the data were acceptable. Qualifiers may be added to results to identify quality issues related to data quality. Two types of qualifiers are used for data entered into the IRDMIS data base. Qualifiers include flagging codes which are entered by the subcontract laboratory and data qualifiers which are entered by USAEC Chemistry Branch during the secondary review process described in Subsection 3.2.2. Flagging codes and data qualifiers codes used on the IRDMIS are described in Table 3-2. The data that were accepted were then elevated to Level 3 and made available to USAEC personnel and ABB-ES by modem to a main frame computer. Off-site results are presented in Subsection 7.0 and Appendix L-2.

3.2.5 Field Quality Control Samples

Field QC samples which were collected routinely during the RI included MS/matrix spike duplicates (MSDs), field duplicate samples, rinse blanks, and trip blanks.

Before field investigations were initiated, a sample of water, collected from the source, was used for sampling equipment decontamination. The water source for the RI at AOC 69W was the South Post Water Point (Well D-1). For the purpose of off-site laboratory QC, this was identified as the field blank (source water sample). The field blank data were sent to the USAEC Chemistry Branch where approval was granted for the use of this water in decontamination procedures.

As specified in the Fort Devens POP (ABB-ES, 1995a), MS/MSDs were spiked and analyzed for PAL inorganics, and pesticides/polychlorinated biphenyl (PCBs), as well as several USEPA Methods for hardness, total petroleum hydrocarbons, (TPH) by USEPA Methods 9071 and 8105, TOC, total phosphate, nitrate and nitrite-nitrogen, and kjeldahl-nitrogen. HLA personnel made the determination of which samples were to be designated as MS/MSDs. This was noted on the COC forms submitted to ESE.

Samples designated as MS/MSDs were spiked at the off-site laboratory with specified concentrations of analytes to determine matrix effects based on USAEC and USEPA method guidelines. MS/MSD data were also used to assess the accuracy of the analyses used. MS/MSD samples were collected at a rate of one set per 20 samples. During the RI field investigation, samples were collected from AOCs 69W, 57 and 63AX simultaneously. Therefore, assessments of MS/MSD data, contained in Appendix D, were made for these AOCs collectively.

Field duplicate samples were collected at a rate of one per 20 field samples. The purpose of duplicate sample analysis was to assess the sampling and off-site laboratory precision for particular methods. AOCs were investigated simultaneously during the RI field effort, and field duplicates were collected for each media sampled. Duplicate data were assessed collectively for the RIs. Duplicate sample results are presented in Appendix D.

Rinse blanks were collected and analyzed for PAL analytes and TPH by USEPA Methods 418.1 and 8015. Rinse blanks consisted of previously analyzed deionized water which was poured over sampling equipment. Analysis of this water provided information used to evaluate the potential for sample contamination during sample collection. The results were also used to assess decontamination procedures for the sampling equipment. As specified in the Fort Devens POP (ABB-ES, 1995a), rinse blanks were collected at a rate of one per 20 samples. Rinse blank results from the RIs are included in the data quality reports in Appendix D. Discussions regarding rinse blank contamination are relevant to both AOCs investigated during the RIs.

For every shipment of VOC samples to ESE, trip blanks accompanied the samples. The purpose of analyzing trip blanks was to determine if there was any VOC cross contamination during the shipment and handling of samples. The trip blanks consisted of previously analyzed deionized water that was bottled at ESE. Trip blanks were shipped in sealed containers to the job site. As needed, trip blanks were then included with shipments of VOC field samples. Trip blank data are associated with AOCs 69W, 57, and 63AX simultaneously. Data were included for trip blanks sent with samples from all AOCs investigated during the RI. Trip blank data are presented in Appendix D.

3.2.6 Off-Site Analytical Data Quality Evaluation

Off-site data quality reviews were conducted by the project chemist for results generated during the RI. In addition to USAEC laboratory data reviews described in Subsection 3.2.2, precision and accuracy of results were assessed by reviewing MS/MSD results, field duplicate results, and surrogate recovery. QC sample results were compared to goals outlined in the Fort Devens POP (ABB-ES, 1995a) and USEPA Region I validation guidelines (USEPA, 1988; USEPA, 1989). Detailed discussions of these reviews are contained in Appendix D. Conclusions on the precision and accuracy of analytical measurements and possible sample contaminants are summarized in Subsection 7.1.2.

Off-site laboratory data collected during the AOCs 69W, 57 and 63AX RIs at Devens were evaluated for possible off-site laboratory or sampling-related contamination. QC blank results were evaluated to assess the potential for sample contamination during sample collection or at the off-site laboratory. This evaluation did not include validation according to USEPA guidelines. Sample results reported and discussed in this report were not adjusted for reported analytes that were also detected at similar concentrations in blanks associated with that sample; action levels were not established, and the 10X rule was not applied to compounds considered by the USEPA to be common laboratory contaminants. Examples of these contaminants include the VOCs acetone, methylene chloride, and the phthalate semivolatile organic compounds (SVOCs). Likewise, action levels for other analytes using the 5X rule application were not established. Analytes that would have been below these action levels were not removed from the data as they would have been in the USEPA validation process.

General trends relating to blank and sample contamination were examined. Comparison of blank data with results from the entire data set are discussed as a data assessment. Assessments are made based on analyte detection in blanks, the frequency of the detection and the concentrations of these analytes. A summary of blank contamination is presented in Subsection 7.1.2 of this report. Some analytes are interpreted to represent non-site related contamination in the contamination assessments presented in Section 7.0

3.3 CHEMICAL DATA MANAGEMENT

Chemical data were managed by HLA's Sample Tracking System and the USAEC's IRDMIS. These systems are described in the following sections.

3.3.1 Sample Tracking System

HLA employed its computerized Sample Management System to track environmental samples from field collection to shipment to the off-site laboratory. HLA also tracked the status of analyses and reporting by the off-site laboratory.

Each day the field sampling teams carried computer-generated sample labels into the field that stated the sample control number, sample identification, size and type of container, sample preservation summary, analysis method code, and sample medium. The labels also provided space for sampling date, time, depth (if applicable), and the collector's initials to be added at the time of collection.

After collection in the field, the samples were stored on ice for transport back to the HLA field office. Samples were temporarily stored in the HLA field office refrigerator. They were checked-in on the field office computer, and the collector's initials and the sampling date and time were entered. The system would then indicate the sample status as "COLLECTION IN PROGRESS."

When the samples were prepared for shipment, they were "RELEASED" by the sample management system. Upon request, the system printed an Analysis Request Form (ARF) and a COC, which were signed and included with the samples in the shipment. The system would then indicate the sample status as "SENT TO LAB."

This system substantially reduced the time required for preparation of sample tracking documentation, and it provided an automated record of sample status.

After shipment of samples to the off-site laboratory, ABB-ES continued to use the sample tracking system to track and record the status of the samples, including the date analyzed (to determine actual holding time), the date a transfer file was established by ESE, and the date the data were sent to IRDMIS (see Subsection 3.3.2).

3.3.2 Installation Restoration Data Management Information System

IRDMIS is an integrated system for collection, validation, storage, retrieval, and presentation of data of the USAEC's Installation Restoration and Base Closure Program. It uses personal computers (PCs), a UNIX-based minicomputer, printers, plotters, and communications networks to link these devices.

For each sample lot, HLA developed a "provisional" map file for the sample locations, which was entered into IRDMIS by Potomac Research, Inc. (PRI), USAEC's data management contractor.

Following analysis of the sample lot, ESE created chemical files using data codes provided by HLA and entered the analytical results (Level 1) on a PC in accordance with the User's Manual (PRI, 1993). For each sample lot, a hard copy was printed, reviewed, and checked by ESE's Laboratory Program Manager. ESE created a transfer file from accepted records which was sent to HLA (Level 2). HLA performed a group and record check and sent approved records in a chemical transfer file to PRI. PRI checked the data and, if accepted, entered it in to the IRDMIS minicomputer (Level 3). Level 3 chemical data are the data used for evaluating site conditions, and are the data used in this AOC 69W report.

3.4 1997 SUPPLEMENTAL ANALYSES

Additional samples were collected in the Fall 1997 for off-site laboratory analyses to supplement existing data sets. Groundwater samples were analyzed for volatile petroleum hydrocarbons (VPH) and extractable petroleum hydrocarbons (EPH) using Massachusetts methodologies (MADEP, 1995a; MADEP, 1995b), and USEPA Methods 8260B and 8270B (USEPA, 1996). Air samples were also collected and analyzed for VOCs using USEPA Method TO14. Laboratory data packages were reviewed by the HLA project chemists, and data were validated in accordance with

USEPA Region I guidelines. Data validation reports are presented in Appendix D-4.

4.0 APPLICABLE OR RELEVANT AND APPROPRIATE REQUIREMENTS IDENTIFICATION

CERCLA was enacted by Congress in 1980, establishing the Superfund program. The regulations implementing this program are found in 40 CFR Part 300, also known as the National Contingency Plan (NCP). CERCLA was amended in 1986 by SARA, which mandated that the level or standard of control specified in a remedial action be "at least that of any ARAR standard, requirement, criteria, or limitation under any federal environmental law, or any more stringent standard, requirement, criteria or limitation promulgated pursuant to a state environmental statute." SARA also established that the requirements of the NCP apply to federal facilities.

The purpose of the RI was to determine the nature and distribution of site-related soil and groundwater contamination at AOC 69W. In order to evaluate whether there is a potential threat to human health and the environment, preliminary ARARs are identified in this section and will then be compared to site-specific data. ARARs are federal and state human health and environmental requirements used to (1) evaluate the distribution of site impacts and the appropriate extent of site cleanup; (2) define and formulate remedial action alternatives; and (3) govern implementation and operation of the final remedy.

Identification and evaluation of ARARs is an iterative task, necessary throughout the remedial response process. Therefore, the preliminary lists of requirements identified for AOC 69W and their relevance may change as more information is obtained, as the preferred alternative is chosen, and as the design and approach to remediation becomes more refined.

Applicable Requirements - Applicable requirements are those cleanup standards, standards of control, and other substantive environmental protection requirements, criteria, or limitations promulgated under federal or state law that specifically address a hazardous substance, pollutant, contaminant, remedial action, location, or other circumstance that have jurisdiction at a site. An example of an applicable requirement is the use of the Safe Drinking Water Act (SDWA) MCLs drinking water standards for a site where hazardous substances have caused water in a public water supply distribution system to become contaminated.

Relevant and Appropriate Requirements - Relevant and appropriate requirements are cleanup standards, standards of control, and other substantive environmental protection requirements, criteria, or limitations that, while not "applicable" to a hazardous substance, pollutant, contaminant, remedial action, location or other circumstance at a site, address problems or situations sufficiently similar to those encountered at the site that their use is well-suited to the particular site. For example, MCLs for drinking water would be relevant and appropriate requirements at a site where hazardous substances are found in or could enter drinking water classified as a current or future drinking water source. When a requirement is found to be relevant and appropriate, it is complied with to the same degree as if it were applicable.

To be Considered (TBC) Material. Non-promulgated advisories or guidance issued by the federal and state government are not legally binding and do not have the status of potential ARARs. However, in many circumstances, TBCs will be considered along with ARARs as part of the site risk assessment, and may be used in determining the level of cleanup for protection of human health or the environment.

ARARs that pertain to the remedial response can be classified into three categories: chemical-, location-, and action-specific. The following subsections provide an overview of these ARARs.

4.1 CHEMICAL-SPECIFIC ARARS

Because of their site-specific nature, the identification of ARARs requires an evaluation of the federal, state, and local environmental regulations with respect to chemicals of concern and site characteristics. Chemical-specific ARARs generally involve health- or risk-based numerical values or methodologies that establish site-specific acceptable chemical concentrations or amounts. These values are used to develop action levels or cleanup concentrations.

4.1.1 Groundwater

Table 4-1 sets forth the federal chemical-specific ARARs and TBC information for groundwater. USEPA SDWA MCLs are legally applicable to contaminants found in public water systems that have at least 15 service connections or serve an average of at least 25 people daily at least 60 days per year. Even when not legally applicable, MCLs may be relevant and appropriate to groundwater remediation. Non-zero maximum contaminant level goals (MCLGs) are health-based goals at which no known or anticipated adverse effects on health will occur and could be relevant and appropriate standards if considered as cleanup levels. Table 4-1 also includes the current version of USEPA Region III risk-based concentrations (RBCs) which are commonly used as TBC information at CERCLA sites. The surface water criteria set forth in Table 4-1 are TBC information and will only be applicable if a discharge to surface water will be part of the groundwater remedial action.

Table 4-2 sets forth the state chemical-specific ARARs and TBC information for groundwater. The Commonwealth of Massachusetts has developed drinking water standard and guidelines, expressed in terms of maximum levels of contaminants allowed in drinking water. Groundwater data from AOC 69W will be applied to Massachusetts Maximum Contaminant Levels (MMCLs), Massachusetts Class I groundwater quality standards, and/or USEPA Region III RBCs for tap water.

4.1.2 Soil

Table 4-3 sets forth the soil screening levels (TBCs) from the current USEPA Region III RBC documents.

4.1.3 Massachusetts Contingency Plan

The NCP provides that CERCLA response actions must comply with environmental and public health laws and regulations to the extent they are substantive (i.e., pertain directly to actions or conditions in the environment), but do not need to comply with those that are administrative (i.e., mechanisms that facilitate the implementation of the substantive requirements).

The provisions of the MCP, 310 CMR 40.0000 (January 13, 1995) are mostly administrative in nature and, therefore do not have to be complied with in connection with the response action selected for AOC 69W. Further, the MCP contains a specific provision (310 CMR 40.0111) for deferring application of the MCP at CERCLA sites. As stated in the MCP, response actions at CERCLA sites are deemed adequately regulated for purposes of compliance with the MCP, provided the MADEP concurs in the CERCLA Record of Decision (ROD).

However, some provisions of the MCP contain substantive requirements that may be ARARs. Section 310 CMR 40.0940 sets forth three methods of risk characterization. Section 310 CMR 40.0942 provides that any of the three methods may be used, subject to certain specified limitations. MCP Method 1 establishes specific numerical standards for certain listed contaminants (see 310 CMR 40.0974.-0975). Since MCP Method 1 contains promulgated numerical standards, it may be an ARAR if this method is selected.

MCP Method 3 does not contain substantive numerical standards; rather it provides a risk characterization methodology to determine the appropriate cleanup level (see 310 CMR 40.0991.-0996). Because MCP Method 3 is a methodology and does not contain substantive standards, and because it defines protectiveness in a way which is inconsistent with the CERCLA NCP, Method 3 is not an ARAR which has to be met. Therefore, these standards of the MCP do not apply to the remedial response at AOC 69W.

4.2 LOCATION-SPECIFIC ARARS

Location-specific ARARs represent restrictions placed on the concentration of hazardous substances or the conduct of activities because of the location or characteristics of a site. These ARARs set restrictions relative to special locations such as wetlands, floodplains, sensitive ecosystems, as well as historic or archeological sites, and provide a basis for assessing existing site conditions. Table 4-4 lists location-specific federal and state requirements.

Some of the location-specific ARARs for areas such as wetlands and floodplains may or may not be applicable, or relevant and appropriate, depending on the remedial action selected because the regulations do not apply unless some activity is conducted in a certain defined area.

4.3 ACTION-SPECIFIC ARARS

Action-specific ARARs involve design, implementation, and performance requirements that are generally technology- or activity-based. Action-specific ARARs, unlike location- and chemical-specific ARARs, are usually technology- or activity-based limitations that direct how remedial actions are conducted. After remedial alternatives are developed, the evaluation of action-specific ARARs is one criterion for assessing the feasibility and effectiveness of compliance with proposed remedial alternatives. The applicability of this set of requirements is directly related to the particular remedial activities selected for the site. Table 4-5 represents an overview of potential action-specific ARARs that may or may not ultimately be applicable to AOC 69W.

4.4 BACKGROUND CONCENTRATIONS

As a means to evaluate concentrations of inorganic analytes detected in samples collected as part of each phase of investigation, background concentrations were calculated for the Fort Devens installation. Background concentration calculations were based on analytical data results gathered from soil and groundwater samples collected throughout the Fort Devens installation, selected as representative of background (non-contaminated) conditions. Although most of the calculations include assumptions on both the distribution of chemical concentrations and on the selection of representative samples that are not statistically rigorous, the results are considered representative of actual background concentrations at Fort Devens.

For soil, chemical data gathered from 20 soil samples collected by Ecology & Environment, Inc. (E&E) as part of their Group 1A and 1B investigation activities were used. The samples were collected from the major soil associations throughout Fort Devens specifically to establish background concentrations of inorganic analytes in soil. The background soil samples were collected from locations that were visually undisturbed, at least 50 feet from any road, and 300 feet from any known SA.

The calculations were performed on 22 of the 23 PAL inorganic analytes (no data was available for thallium). For analytes that were not detected in the majority of soil samples, the detection limit for that analyte was selected as the background concentration. Sample location, data ranges, mean values, details of calculations, and calculated background concentrations are summarized in Appendix K.

For groundwater, HLA selected 10 representative groundwater samples collected from the Round I groundwater sampling events, completed in 1992, for Groups 2, 3, 5, 6 and 7 for the purpose of calculating background inorganic analyte concentrations in groundwater. Representative groundwater samples were selected from specific monitoring wells located upgradient of a SA, exhibiting low TSS and/or low aluminum concentrations. Aware that elevated TSS concentrations artificially elevate inorganic analyte concentrations, HLA selected samples that exhibited TSS concentrations on the same order of magnitude as the South Post Water Point (Well D-1). Because a close correlation between TSS concentrations and aluminum concentrations was observed in all the groundwater samples analyzed, the aluminum concentration was used as an alternate selection criterion in the absence of TSS data. The concentration values detected in the ten samples were calculated using the same assumptions on outliers and detection limits applied to the soils background concentration calculations. The statistical analysis calculations for groundwater inorganics, and the resulting background concentrations, data ranges, mean values, and details of the calculations are also provided in Appendix K.

5.0 AOC 69W REMEDIAL INVESTIGATION

5.1 SITE BACKGROUND AND CONDITIONS

AOC 69W is located on the northern portion of the Main Post near the northeast corner of the intersection of MacArthur Avenue and Antietam Street (Figure 5-1). AOC 69W is comprised of the former Fort Devens Elementary School (Building 215), the associated parking lot, and adjacent lawn extending approximately 300 feet northwest to Willow Brook (Figure 5-2).

A reference in the 1971 Ayer Annual Town Report indicated that the Fort Devens Elementary School was constructed in 1951. Various historical site plans indicated that heating oil for the Elementary School was provided by a 10,000 gallon underground storage tank (UST) located in what is now the school courtyard. In 1972, an addition was added to the school resulting in the current building. As part of the addition a new boiler room was added to complement the existing boiler. The 10,000 gallon UST, located in what is now the courtyard, and associated piping were removed and a new 10,000 gallon UST was installed under the parking lot on the north side of the school. This UST serviced the school until the school's closure in 1993. A review of historical records and a series of personal interviews indicated that there have been two separate releases of fuel oil at AOC 69W, the first in 1972 and the second in 1978.

The 1972 fuel oil release was due to a crimp in the piping which ran from the new 10,000 gallon UST to the new boiler room. It has been estimated that approximately 7,000 to 8,000 gallons of fuel oil were released into soil and groundwater prior to repair of the piping. The exact location of the release is unknown; however, some visual evidence and contaminant distributions suggest that the release was in the vicinity of the boiler room.

As a result of the fuel oil release a "skimmer system" was installed next to the UST in either late 1972 or early 1973. The nature and exact location of the system was unclear; however, some evidence suggested that the system is little more than a french drain. It is known that the system was connected to, or possibly comprised of, a pipe buried approximately three feet below ground surface extending from the vicinity of the 10,000 gallon UST to a buried 250 gallon UST located approximately

250 feet to the northwest. The 250 gallon UST collected oily water and was pumped out approximately every three months. Sometime after 1986 the UST was filled with crushed rock. The "skimmer system" was excavated and removed during the 1997-1998 soil removal action. Details and descriptions of the removal action, piping, and value are provided in Subsection 5.5.

The 1978 fuel oil release resulted from a failed piping joint from fuel oil pipes leading to the old boiler. Approximately 7,000 to 8,000 gallons of fuel oil were released into soil and groundwater during the 1978 incident. A large hole was excavated on the north side of the school adjacent to the loading dock in an attempt to locate the source of the release. Reports indicate that the excavation collected residual oil for one month before the damaged piping was found and replaced. Shortly after the release an oily sheen was reported in Willow Brook and the associated wetlands to the north of the school. Following the spill, 2,600 gallons of residual oil were pumped from the 250 gallon UST.

5.2 SUMMARY OF PREVIOUS INVESTIGATIONS

The following subsections discuss results of the AREE 69W site evaluation and investigation performed at AOC 69W by ADL. A brief summary of analytical data is presented to demonstrate the need for subsequent investigations at the site. A complete assessment of the analytical data is presented in Section 7.0 of this RI report. The scope of investigation activities performed at AOC 69W is summarized chronologically in Table 5-1.

5.2.1 ADL AREE 69 Evaluation (AREE 69W)

In July of 1993 ADL investigated the Fort Devens Elementary School, designated AREE 69W, as part of the basewide AREE 69 (Past Spill Sites) evaluation. The investigation focused on the 1978 fuel oil release and was comprised of a document review and site visit. The study concluded that there was a potential for fuel oil contamination in the soil and groundwater (ADL, 1995).

Further investigation was performed at AREE 69W from March through June of 1994. The investigation involved sampling, field screening, and laboratory analysis of surface soil, subsurface soil, groundwater, surface water, and sediment, and a geophysical survey to locate subsurface utilities.

5.2.1.1 Surface Soil. Six surface soil samples were collected from a depth of 0 to 1 foot below ground surface (bgs), from the grassy area north and northwest of the parking lot (Figure 5-2). The samples were analyzed by portable field instruments for BTEX and TPHC, using GC and NDIR techniques, respectively. The sample with the highest observed TPHC concentration was submitted for laboratory analysis of PAL VOCs, PAL SVOCs, TPHC, PAL inorganics, and TOC. AREE 69W field analytical soils data are presented in Table 5-2. AREE 69W off-site analytical soils data are presented in Table 5-3.

TPHC field screening concentrations obtained from the surface soil samples ranged from 9.5 parts per million (ppm) to a high of 131 ppm (observed at location HA-5, located just off the northwest corner of the paved area). No BTEX were detected in the screening results. Laboratory results from the single surface soil sample submitted for laboratory analysis revealed no compounds at concentrations exceeding Massachusetts Contingency Plan (MCP) Method 1, S-1/GW-1 Standards. Carcinogenic polycyclic aromatic hydrocarbons (cPAHs) detected in the surface soils at the site consisted of benzo(a)anthracene and chrysene at a combined concentration of 0.29 μg/g.

5.2.1.2 Subsurface Soil. Subsurface soil samples were collected during the installation of groundwater monitoring wells and during the Geoprobe investigations. During the first round of Geoprobe sampling, subsurface samples were collected from 0 to 2 and 3 to 5 feet bgs at 16 locations (Figure 5-2) for field analysis of TPHC and BTEX. Of the 32 samples analyzed in the field, three samples exhibiting the highest TPHC concentrations and one sample with the lowest TPHC concentration were submitted for laboratory analysis of PAL VOC, PAL SVOCs, TPHC, PAL inorganics and TOC analysis. During the second Geoprobe sampling round, nine additional locations were investigated (Figure 5-2). Subsurface soil samples were collected from a depth of 3 to 5 feet bgs and field screened for TPHC. AREE 69W field analytical data are provided in Table 5-2. Off-site analytical soils data are provided in Table 5-3.

Subsurface soil samples were collected at depth intervals of 0 to 2 feet, 2 to 4 feet, and 11 to 13 feet bgs during the monitoring well installation effort. These samples were screened in the field for TPHC and BTEX. The samples from the 2 to 4 and

4 to 6 foot depth intervals were submitted for laboratory analysis of TPHC, PAL VOCs, PAL SVOCs, PAL inorganics, and TOC analysis.

TPHC concentrations in soils collected with the Geoprobe and from monitoring well soil borings ranged from 7.5 ppm to 15,500 ppm (GP-2 at 3 to 5 feet bgs). Concentrations of benzo(b)fluoranthene, benzo(a)anthracene, and chrysene detected in Geoprobe soils were above MCP Method 1, S-1/GW-1 standards.

Based on the field screening and laboratory analysis results, TPHC and cPAH soil contamination appears to be concentrated in the area of the existing UST (the presumed source area), and may have migrated downgradient towards Willow Brook.

5.2.1.3 Groundwater. Groundwater samples were collected from each Geoprobe location and from the six newly installed groundwater monitoring wells. Sixteen groundwater samples were collected during the first Geoprobe sampling round and field screened for TPHC and BTEX (GP-01 through GP-16). Filtered and non-filtered groundwater samples collected during the second Geoprobe sampling round were field screened for TPHC (GP-17 through GP-25).

Field screening results from the 25 Geoprobe groundwater samples indicated that TPHC was present in groundwater. BTEX was not detected. Five sample locations from the first Geoprobe sampling round exhibiting the highest field screening TPHC concentrations were resampled and submitted to the laboratory for analysis of PAL VOCs, PAL SVOCs, TPHC and water quality parameters. No samples from the second geoprobe sampling round were sent for laboratory analysis. Results indicated that TPHC, inorganic analytes (arsenic, lead, antimony, beryllium, chromium, and nickel), and organic compounds (1,1-dichloroethene, benzene, carbon tetrachloride, chloroform, tetrachloroethene, trichloroethene, 2-methyl naphthalene, and naphthalene) were detected at concentrations exceeding MCP Method 1 GW-1 Standards. Most of these exceedances occurred at locations GP-1, GP-2, GP-6 and GP-15, located in the area of the UST and downgradient of this location. No cPAHs were detected in the Geoprobe groundwater samples. AREE 69W field analytical results are provided in Table 5-2. Results of off-site analysis of groundwater samples are provided in Table 5-4.

Six monitoring wells installed at the site confirmed the results of the Geoprobe investigation. Groundwater samples were submitted for analysis of TPHC, PAL

VOCs, PAL SVOCs, unfiltered inorganics and water quality parameters. Results indicated that TPHC, arsenic, beryllium, cadmium, chromium, lead, nickel, 2-methyl naphthalene, acenaphthene, and naphthalene were detected at concentrations exceeding MCP Method 1 GW-1 Standards. These exceedances occurred at monitoring wells 69W-94-10, 69W-94-11, 69W-94-13 and 69W-94-14 (Figure 5-2). No cPAHs were detected in the groundwater samples.

Groundwater sample results indicate that the area around the UST has the greatest number of compounds exceeding MCP Standards. Groundwater northwest of the UST was also found to have elevated concentrations of inorganics and TPHC, suggesting that contaminants have potentially migrated downgradient of the UST location.

5.2.1.4 Surface Water and Sediment. Surface water and sediment samples were collected from two locations in Willow Brook (Figure 5-2). One sample location (69W-94-16) was placed in line with the inferred plume migration pathway indicated by the Geoprobe survey, and the other (69W-94-15) was placed upstream of this area. Samples were analyzed for TPHC, PAL VOCs, PAL SVOCs, unfiltered inorganics, and water quality parameters. Surface water and sediment off-site analytical results are presented in Tables 5-5 and 5-6, respectively.

The results indicated the presence of cPAHs in both sediment samples, and TPHC in sample 69W-94-16. Specifically, the cPAHs benzo(a)anthracene, chrysene, benzo(b)fluoranthene, and benzo(k)fluoranthene were detected in the 69W-94-15 (upstream) sediment sample. In sediment sample 69W-94-16, TPHC, benzo(a)anthracene and chrysene were detected. Total cPAHs in the upstream sample barely exceeded 7.0 ppm. Total cPAHs in the downstream sample (69W-94-16) were an order of magnitude less than the clean-up values. Other PAHs and metals were detected in both samples.

TPHC and cPAHs were not detected in surface water samples.

5.3 REMEDIAL INVESTIGATION PROGRAM

5.3.1 Technical Objectives

The following subsections present the technical objectives of the AOC 69W RI field investigations.

5.3.1.1 Geophysical Survey. The technical objective of the geophysical survey is to gather AOC-wide, non-intrusive data on subsurface features. Specific objectives included: confirming that the fuel oil UST and ancillary piping were removed from the school courtyard, clearing exploration locations for subsurface utilities, and providing information on subsurface geology.

5.3.1.2 TerraProbe^{SM} and Soil Borings. The technical objective of the TerraProbe^{SM} and soil boring program was to obtain representative soil and groundwater samples for conducting field screening analyses, off-site laboratory analyses, and grain size distribution. In addition, borings were intended to yield data to further define horizontal and vertical VOC and TPHC contaminant distribution and characterize the geologic setting at AOC 69W. This includes location of the site within the regional stratigraphic setting and identification of heterogeneous soil layers.

5.3.1.3 Monitoring Wells. The technical objective of the monitoring well installation program was to characterize local groundwater flow, and groundwater quality, and define contaminant distribution and source areas. This included collecting water level data to establish flow directions, vertical and horizontal gradients, and estimate the hydraulic conductivity of the geologic strata.

5.3.1.4 Piezometer Installation. Piezometers were installed to determine vertical hydraulic gradients in the vicinity of Willow Brook. Hydrogeologic data obtained from the piezometers helped to define Willow Brooks relationship to the local and regional hydrogeology.

5.3.1.5 Test Pitting. The technical objective of the test pitting was to investigate subsurface geophysical anomalies identified during the geophysical survey. The test pitting was also intended to help define subsurface stratigraphy.

5.3.1.6 Field Laboratory Analysis. The technical objective of the field analytical program was to quickly generate USEPA Level II analytical data for previously identified site-related compounds (specifically TPHC and BTEX) allowing for preliminary identification of contaminant distribution. This information enabled more accurate placement of groundwater monitoring wells. In addition, field analytical data were used to support the results and findings of the contaminant assessment. Field analytical techniques employed as part of this RI are discussed in detail in Subsection 3.1 of this report. Results of the field analyses are discussed in detail in Section 7.0 of this report.

5.3.1.7 Off-Site Laboratory Analytical Sampling. The technical objective of the analytical sampling program was to supplement the existing field analytical data for subsurface soil and groundwater at AOC 69W, and to better characterize site conditions in surface soil, subsurface soil, groundwater, and sediment. This database was used as the foundation for the contamination assessment, fate and transport discussion, and risk assessment. Off-site laboratory analytical methods employed as part of this RI are discussed in detail in Subsection 3.2 of this report. Results of the analytical data are discussed in detail in Section 7.0 of this report.

5.3.1.8 Air Sampling. The objective of the air sampling was to determine if fuel-related contaminants present in soil and groundwater beneath the school are impacting air quality within the school. Analytical data from the 1997 air sampling event are discussed in the contamination assessment, fate and transport discussion, and risk assessment. Analytical protocol are discussed in Subsection 3.3 of this report. Due to sample collection issues with the first air sampling event completed in 1996, air sample analytical data for 1996 are not discussed in this report.

5.3.2 Data Quality Objectives

Data Quality Objectives (DQOs) are qualitative or quantitative statements developed by the data user to specify the quality of data needed from a particular activity to support specific decisions. DQOs are the starting point in the design of the RI. The DQO development process matches sampling and analytical capabilities to the data targeted for specific uses and ensures that the quality of the data does not underestimate project requirements. The procedures of the QA objectives presented in Section 3.0 of Volume I of the Fort Devens POP (ABB-ES, 1995a) were followed during the RI field programs at AOC 69W. This subsection includes a general scope of work, DQOs, and the QA/QC approach.

Analyses were conducted on samples collected from AOC 69W to evaluate the nature and distribution of the contaminants detected in the previous AREE 69W investigation. On-site field analysis conformed with the guidelines presented in Subsection 4.6 of Volume I of the Fort Devens POP (ABB-ES, 1995a). Off-site laboratory analytical procedures are presented in Section 7.0 of Volume I of the Fort Devens POP (ABB-ES 1995a), and the Laboratory QA Plan and the USAEC Certified Analytical Methods procedures are presented in Appendices B and C, respectively, in Volume II of the Fort Devens POP (ABB-ES, 1995a).

USEPA has identified five general levels of analytical data quality as being potentially applicable to field investigations conducted at potential hazardous waste sites under CERCLA (USEPA, 1987). The five levels were replaced by two levels including definitive data, and screening data with confirmation by the USEPA after the AOC 69W investigation was initiated (USEPA, 1993). For consistency with the Fort Devens POP (ABB-ES, 1995a) and historic planning documents, the five data quality levels are referenced in this RI. These levels are summarized as follows:

- Level I - Field Screening. This level is characterized by the use of portable instruments that can provide real time data to assist in optimization of sampling point locations and for health and safety support. Data can be generated regarding the presence or absence of certain contaminants (especially volatiles) at sampling locations.
- Level II - Field Analysis. This level is characterized by the on-site use of portable analytical instruments and mobile laboratories which can

render qualitative and quantitative data.

- Level III - Laboratory analysis using methods other than Contract Laboratory Program (CLP) Routine Analytical Services (RAS). This level is used primarily to support engineering studies using standard USEPA-approved procedures. Some procedures may be equivalent to the USEPA RAS, without the CLP requirements for documentation.
- Level IV - CLP RAS. This level is characterized by rigorous QA/QC protocols and documentation, providing qualitative and quantitative analytical data.
- Level V - Non-standard methods. This level includes analyses that may require modification and/or development. CLP Special Analytical Services are considered Level V.

For AOC 69W RI efforts, field measurements such as pH, temperature, conductivity, and readings from a PID and O_2/Explosimeter constituted Level I field analytical data. Field GC analysis constituted Level II field analytical data. Off-site analyses of soil and groundwater for organics, inorganics, TOC, TPHC, water quality parameters, and pesticides and PCBs were considered approximately equivalent to USEPA analytical support Level III. The sampling approaches and analytical procedures described in the Fort Devens POP (ABB-ES, 1995a) have been selected to meet Level III data quality.

DQOs were established to support the level of detail required for RI activities. Data generated during field and off-site laboratory tasks were used to characterize AOC 69W conditions and to perform baseline risk assessments.

DQOs and QC for field measurements and laboratory analyses conform to USAEC and USEPA requirements (as specified in the USACE Quality Assurance Manual, 1990, and Guidance for Conducting Remedial Investigations and Feasibility Studies Under CERCLA, 1988).

USAEC requirements and analytical processes are discussed in Section 3.0 of this report. They focus on the use of laboratory control spikes in associated data lots to measure the performance of the laboratory in the use of USAEC methods. Many of the USAEC methods are identical to standard USEPA methods. The performance demonstration process, required by laboratories performing USAEC work, is discussed in Subsection 3.2.1. The data review and evaluation process are described in Subsection 3.2.3.

Off-site laboratory data were evaluated for precision, accuracy, representativeness, completeness and comparability (PARCC) to meet USEPA Level III requirements. This was accomplished through the collection of field quality control blanks such as field blanks, trip blanks, and equipment rinsate blanks, and through the evaluation of laboratory blanks such as method blanks. The specific purpose of collecting each of these is discussed in Section 3.0 of this report. Laboratory control spikes are run in the certification process to generate control charts that help to establish control limits that are used to ensure accuracy of the results. This process is also described in the text of the report in Section 3.0. Matrix spike and duplicate samples were also analyzed to meet PARCC data quality objectives. These are presented in Appendix D-1.

The precision of the data is a measurement of the ability to reproduce a value under certain conditions. It is a quantitative measurement based on the differences of two values. Precision was evaluated using the RPD of MS/MSD sample pairs and field duplicate sample pairs. Evaluations of the precision of the data are found in Appendix D.

Accuracy measurements identify the performance of a measurement system based on tests with known values. The off-site laboratory, sampling, and media effects on accuracy were assessed by reviewing the percent recoveries of spiked analytes for MS/MSDs, off-site laboratory control samples, and surrogate compounds.

Representativeness refers to the extent to which a measurement accurately and precisely represents a given population within the accepted variation of laboratory and sampling measurements. Collection techniques that obtained samples characteristic of the matrix and location being evaluated were chosen. Historical information was used to identify sample locations. Representativeness was also evaluated using method blanks and field QC sample data. By evaluating method blank and field QC samples, false positive results should be identified. Representativeness was also measured by evaluating field duplicate pair precision.

Completeness refers to the percentage of usable, valid values obtained through data evaluation. Completeness was determined by the success rate in meeting holding time criteria and acceptance of sample lots by USAEC.

Comparability is a qualitative assessment describing the confidence with which one data set may be compared with another. Comparability was assured using standard operating procedures for sampling, and by reporting analytical results in standard units.

5.4 SUMMARY OF REMEDIAL INVESTIGATION FIELD PROGRAMS

Several field efforts comprised the RI field program. The initial RI field effort was performed in the fall of 1995. As a result of the findings of this field effort it was determined that additional work was necessary to characterize contaminant distribution at AOC 69W. Additional phases of work were performed as Modification 001 conducted in the falls of 1996 and 1997.

The RI techniques were conducted in conformance with the Revised Final Task Order Work Plan for AOC 57, AOC 63AX, and AOC 69W (ABB-ES, 1996a), the Final RI/FS Task Order Work Plan Addendum for AOC 69W (ABB-ES, 1996b), the Final RI/FS Work Plan Addendum for Supplemental Air Sampling for AOC 69W (ABB-ES, 1997a), the Analytical Approach for AOC 69W Groundwater Sampling (ABB-ES, 1997), and the Fort Devens POP (ABB-ES, 1995a).

The RI field program for AOC 69W included:

- a geophysical survey consisting of EM-31, EM-61, magnetometer, and ground penetrating radar;
- twenty-nine TerraProbe^{SM} points (ZWR-95-26X through ZWR-95-28X, and ZWR-95-30X through ZWR-95-55X);
- three soil borings (ZWB-95-01X, ZWB-95-02X, and ZWB-96-03X);
- eight surface soil samples (ZWS-95-35X, ZWS-95-37X, ZWS-95-38X, ZWS-95-39X, ZWS-95-42X, ZWS-95-45X, ZWS-95-46X, and ZWS-95-

47X);

- nine sediment and three toxicity test samples collected in Willow Brook (ZWD-95-01X through ZWD-95-06X);
- installation and development of seven monitoring wells (ZWM-95-15X through ZWM-95-18X and ZWM-96-19X through ZWM-96-21X) and two piezometers (ZWP-95-01X and ZWP-95-02X);
- two rounds of groundwater samples collected from the newly installed and the existing monitoring wells, and two supplemental rounds of groundwater sampling using low-flow techniques;
- one test pit (ZWE-95-01X);
- indoor air sampling at 12 locations and in one monitoring well headspace (ZWA-97-01X through ZWA-97-13X) inside the elementary school;
- field analysis of soil samples from soil borings, TerraProbe^{SM} points, and test pits by GC and IR, and groundwater by GC;
- aquifer testing on the new and existing monitoring wells; and
- horizontal and vertical survey of all RI explorations.

HLA established a project field office in Building 2012 on the former Main Post. The field office was used for equipment storage and maintenance, sample management, shipping and receiving, staff meetings, and communications. A telephone and facsimile machine were maintained in the field office, and each field crew was issued a hand-held cellular phone. A central equipment decontamination pad was constructed near Building 202. HLA and subcontractor staff were briefed about the nature of AOC 69W, health and safety information, Devens traffic regulations, and key technical requirements. HLA began implementation of the AOC 69W field program in September 1995 with equipment mobilization and a geophysical survey.

The subcontractors used by HLA in conducting the RI program were as follows:

- D.L. Maher, North Reading, MA - Drilling and monitoring well installation (1995);
- New Hampshire Boring, Londonderry, NH - Drilling and monitoring well installation (1996);
- ENPRO Services, Inc., Newburyport, MA - Test pit excavation;
- ESE, Gainesville, FL - Chemical analysis of environmental samples;
- Tundra Air Consultants, Woburn, MA - 1996 Indoor air quality sampling and assessment, Devens Elementary School;
- Cashins & Associates, Reading, MA - 1997 Indoor air quality sampling and assessment, Devens Elementary School;
- ENSR Consulting and Engineering, Acton, MA - Chemical analysis of air samples;
- Springborn Laboratories, Inc., Wareham, MA - Sediment toxicity testing and evaluation; and
- Martinage Engineering Associates, Inc., Reading, MA - Surveying of site explorations.

All field activities were conducted in accordance with the Fort Devens POP (ABB-ES, 1995a) and USAEC's Geotechnical Guidelines (USAEC, 1987). The following subsections describe the field activities for the RI at AOC 69W.

5.4.1 Surficial Geophysical Survey

EM-31 and EM-61 surveys were conducted on a 20 foot grid in the parking lot and grassy area to the north of the elementary school at AOC 69W in an attempt to locate the "skimmer system" and associated 250 gallon UST as well as to gather data on subsurface geology and identify subsurface utilities prior to intrusive explorations.

Anomalies identified during the EM-31 and EM-61 surveys were further investigated with GPR. A GPR survey was also performed within the school courtyard to confirm that the 10,000 gallon fuel oil UST and the ancillary piping had actually been removed. Geophysical data and interpretation are provided in Appendix C. Surficial geophysical survey procedures are outlined in Subsection 4.4.3 of Volume I of the Fort Devens POP (ABB-ES, 1995a).

5.4.2 TerraProbe^{SM} Investigation and Surface Soil Sampling

HLA's van-mounted TerraProbe^{SM} System was used to collect soil and groundwater samples for chemical field analysis and soil samples for off-site confirmatory analysis. The TerraProbe^{SM} pushed (hydraulically) and hammered (with vibratory hammer) a 1-inch-diameter steel probe into the ground, which allowed collection of subsurface soil samples from discrete depths. Ninety-two soil samples were collected from the 29 TerraProbe^{SM} points at depths ranging between 0 and 18 feet bgs and analyzed in the field for TPHC using IR (USEPA Method 418.1), and for BTEX, select chlorinated solvents, and TPHC by GC (USEPA Method 8015, GRO only) (Figure 5-3). Select samples were also analyzed for TPHC by GC (USEPA Method 8015, DRO).

Eight TerraProbe^{SM} subsurface soil samples were selected for off-site analysis based upon field analytical results, sampling depth, and exploration location relative to future re-use designation (e.g., gateway or open space/recreation) in order to provide adequate data for the human health risk assessment and characterize contaminant distribution. Eight TerraProbe^{SM} locations were also selected for additional surface soil sampling in order to further characterize the surface contaminant distribution, and to provide adequate data for the risk assessment. Surface and subsurface soil samples selected for off-site analysis were analyzed for PAL VOCs, SVOCs, inorganics, and TPHC.

Groundwater was sampled from each TerraProbe^{SM} point with a peristaltic pump from inside the probe rods. Prior to sampling, the boring was purged using a peristaltic pump to evacuate the hollow sampling rods. Upon recharge or the removal of two boring volumes a groundwater sample was collected. Groundwater samples were analyzed in the field for BTEX and select chlorinated solvents by GC and TPHC using IR (USEPA Method 8015, GRO only).

TerraProbe^{SM} and surface soil sampling procedures are presented in Subsections 4.5.1.3 and 4.5.1.1, respectively, of Volume I of the Fort Devens POP (ABB-ES, 1995a). Sample results are discussed in detail in Section 7.0 of this report.

5.4.3 Test Pitting

One test pit (ZWE-95-01X) was excavated in the grassy area north of the elementary school in an attempt to identify a geophysical anomaly identified by the geophysical survey (see Figure 5-3). A track mounted backhoe was used to excavate the pit to a depth of 5.5 feet bgs where groundwater was encountered. Three soil samples were collected from the test pit for field screening. Test pitting procedures are outlined in Subsection 4.4.4 of Volume I of the Fort Devens POP (ABB-ES, 1995a). During the test pitting, an HLA geologist described activities and observations in test pit logs that are presented in Appendix A.

5.4.4 Soil Borings and Sampling

Based on the results of previous investigations and TerraProbe^{SM} sampling, six soil borings, ZWB-95-01X, ZWB-95-02X, and ZXM-95-15X through ZWM-95-18X, were completed during the 1995 field investigation (see Figure 5-3 and Table 5-7). ZWB-95-01X and ZWB-95-02X were drilled using 4.25-inch inside diameter (ID) hollow-stem augers (HSAs) for the collection of soil samples to augment the TerraProbe^{SM} investigation, while ZWM-95-15X through ZWM-95-18X were drilled using 6.25-inch ID HSAs for the purpose of monitoring well installation. Four additional soil borings were installed as part of the 1996 supplemental field investigation (Figure 5-3). ZWB-96-03B was drilled using 4-inch inside diameter (ID) casing for the collection of soil samples within the courtyard. ZWM-96-19X through ZWM-96-21X were advanced with 4-inch casing for the collection of soil samples and monitoring well installation in each boiler room and within the courtyard. Boring logs are presented in Appendix A.

ZWM-95-15X, ZWB-96-03X, and ZWM-96-19X through ZWM-96-21X were sampled continuously with 2-inch and 3-inch outside diameter (OD) split spoons using the standard penetration test technique to characterize subsurface stratigraphy and vertical distribution of contamination near the suspected source areas. The remaining borings were sampled at approximately 5-foot intervals with an additional sample collected from the water table interval. Two soil samples, one at ground surface and one from the water table, were collected from soil borings ZWB-95-01X and ZWB-95-02X. Soil samples were analyzed for PAL VOCs, PAL SVOCs, PAL inorganics, and TPHC. Two soil samples were collected from each of the borings installed during the 1996 supplemental investigation, one from the water table and another based upon PID measurements and field observations. These samples were analyzed at an off-site laboratory for EPH/VPH and TPHC. A soil sample was collected from the screened interval of all monitoring well borings and analyzed for TOC and grain size distribution.

Soil sample analysis results are discussed in Section 7.0 of this report. Soil borings were completed in accordance with procedures presented in Subsection 4.4.6.1 of Volume I of the Fort Devens POP (ABB-ES, 1995a).

5.4.5 Monitoring Well Installation

Based on the field analytical results of the TerraProbe^{SM} and soil boring sampling four new monitoring wells (ZXM-95-15X through ZWM-95-18X) were installed during the 1995 phase of the RI (see Figure 5-3 and Table 5-8). Three additional monitoring wells were installed in 1996 (ZWM-96-19X through ZWM-96-21X) to better characterize upgradient and potential source area conditions. All of the monitoring wells are water table wells. Monitoring wells installed in 1995 are constructed of 4-inch ID PVC while monitoring wells installed in 1996 are constructed of 2-inch ID PVC.

Monitoring well construction was completed in accordance with USAEC requirements and Subsection 4.4.6.4 of Volume I of the Fort Devens POP (ABB-ES, 1995a). Monitoring well construction diagrams are provided in Appendix B and a summary of each monitoring well installation is presented in Table 5-8.

5.4.6 Monitoring Well Development

Each of the newly installed RI monitoring wells was developed using the pump and surge method to remove any water added to the boring during drilling and/or well installation, and to remove sediment from the monitoring well screen prior to groundwater sampling. Dedicated equipment was used to minimize the possibility of cross-contamination occurring between wells. The procedures for well development are presented in Subsection 4.4.6.5 of Volume I of the Fort Devens

POP (ABB-ES, 1995a). Well development records are provided in Appendix F.

5.4.7 Groundwater Sampling

Four rounds of groundwater samples were collected at AOC 69W. The first two rounds were collected as part of the 1995 field investigation from the four new (ZWM-95-15X through ZWM-95-18X) and six existing monitoring wells (69W--94-09X through 69W-94-14X) (Table 5-1 and Figure 5-3). Round 1 samples were collected in October and November of 1995, and Round 2 samples were collected in February of 1996. Two additional rounds of groundwater sampling were conducted to focus on EPH/VPH parameters, and included the three wells installed in the school (ZWM-96-19X, ZWM-96-20X, and ZWM-96-21X). Round 3 samples were collected in September and October of 1996, and Round 4 samples were collected in December of 1997.

Groundwater samples for the first and second rounds were submitted for laboratory analysis consisting of PAL VOCs, SVOCs, inorganics (both filtered and unfiltered), pesticides/PCBs, water quality parameters, TPHC, and TDS. Groundwater sampling procedures followed the methodology presented in Subsection 4.5.2.2 of Volume I of the Fort Devens POP (ABB-ES, 1995a).

The third round of groundwater sampling was performed in conjunction with the 1996 supplemental investigation from monitoring wells 69W-94-10, 69W-94-11, ZWM-95-16X, and ZWM-96-19X through ZWM-96-21X. The fourth round of groundwater sampling was performed in December of 1997 prior to the soil removal action at AOC 69W (discussed in Subsection 5.5), consistent with the Analytical Approach for AOC 69W Groundwater Sampling (ABB-ES, 1997b). Both these Round 3 and 4 groundwater sampling events were conducted following USEPA Region I low-flow sampling protocols as described in "Low Flow (minimum stress) Purging and Sampling Procedure for the Collection of Ground Water Samples from Monitoring Wells: SOP # GW 0001" (USEPA, 1996). Groundwater samples from both rounds were analyzed for EPH/VPH aliphatic and aromatic ranges, and target PAHs and VOCs (ABB-ES, 1997b). In addition, Round 3 samples were analyzed for wet chemistry, TOC, and TPHC, and Round 4 samples were analyzed for target PAHs by Method 8270 and target VOCs by Method 8260.

Field data records are presented in Appendix G, and off-site laboratory analytical results are discussed in detail in Section 7.0 of this report.

5.4.8 In-Situ Hydraulic Conductivity Testing and Water Level Measurement

Hydraulic conductivity tests were performed in November of 1995 and January of 1997 on both the newly installed and existing monitoring wells to further define the hydraulic conductivity of the geologic units at AOC 69W. Appendix E presents data and analysis of the hydraulic conductivity testing. Rising head tests were performed on all monitoring wells. The rate of water level recovery to static conditions was monitored with a pressure transducer and electronic data logger. Groundwater head displacement was accomplished with a solid cylindrical PVC slug using the techniques described in Subsection 4.8.2 of Volume I of the Fort Devens POP (ABB-ES, 1995a).

The data from all in-situ hydraulic conductivity tests were analyzed using the methods of Bouwer and Rice (1976) and Hvorslev (1951). Discussion of the in situ hydraulic conductivity testing is presented in Section 6.0 of this RI report. Test data and analyses are provided in Appendix E.

5.4.9 Sediment and Toxicity Test Sampling

Nine sediment samples were collected from six locations in Willow Brook to characterize the distribution of contamination in this downgradient area and for evaluating potential ecological risks (Figure 5-3). One sample was collected at the surface (i.e., from 0 to 6 inches bgs) at all six locations, whereas the other three samples were collected from 2 to 2.5 feet bgs at locations ZWD-95-01X, ZWD-95-02X, and ZWD-95-03X.

Three sediment locations (ZWD-95-04X, ZWD-95-05X, and ZWD-95-01X) were located upgradient of the discharge area for AOC 69W groundwater (closest to the intersection of Antietam Street and MacArthur Avenue) while the other three locations (ZWD-95-02X, ZWD-95-03X, and ZWD-95-06X) were located downgradient of the discharge area for AOC 69W groundwater (closest to Verbeck Gate). All sediment samples were submitted for laboratory analysis consisting of PAL VOCs, SVOCs, metals, pesticides/PCBs, DRO, GRO, TOC, and TPHC (by Method 418.1).

In addition, three toxicity test samples were collected concurrently with surface sediment samples ZWD-95-02X, ZWD-95-03X, and ZWD-95-06X, and were sent to Springborn Laboratories, Inc. for subchronic toxicity testing using the midge (*Chironomus tentans*) and amphipod (*Hyalella azteca*). Sediment collected for toxicity testing and chemical analysis were homogenized in the field.

Sediment sampling procedures are presented in Subsection 4.5.3 of Volume I of the Fort Devens POP (ABB-ES, 1995a). The results of the chemical analyses are discussed in detail in Section 7.0, and the results of the toxicity testing are discussed in detail in Subsection 9.2.

5.4.10 Indoor Air Sampling

Indoor air sampling was completed in October of 1997 at the Devens Elementary School to determine if fuel-related contaminants in soil and groundwater beneath the school contribute to ambient contaminant levels that present an unacceptable health risk. Air sampling was conducted in general accordance with procedures set forth in the "Final Remedial Investigation/Feasibility Study Workplan Addendum for Supplemental Air Sampling, Devens Elementary School" (ABB-ES, 1997c).

Ambient conditions in the school were prepared to simulate worst-case exposures likely to be encountered during inactive periods (i.e., weekends). A total of 12 air samples were collected in and around the school in pre-cleaned and leak-tested canisters at the locations illustrated in Figure 5-4. The air flow into each canister was pre-set to allow each canister to fill over an eight hour time period. The weather conditions on the day of the survey were sunny with 5-10 mph winds from the north and temperatures between 50°- 60°F.

Air samples were analyzed following EPA TO-14 Gas Chromatography/Mass Spectrometry (GC/MS) guidelines. Complete laboratory analytical results are discussed in Section 7.0, and a detailed summary of the air sampling effort is provided in Appendix M.

5.4.11 Equipment Decontamination

Several different sampling and analytical procedures were used during the AOC 69W field program, which led to a variety of decontamination procedures. To document the effectiveness of decontamination procedures, periodic equipment rinsate blanks were collected and submitted for chemical analyses. Analytical results for the rinsate blanks are presented in Appendix D. Decontamination procedures followed during the RI are presented in Subsection 4.3 of Volume I of the Fort Devens POP (ABB-ES, 1995a).

One central decontamination pad was constructed and maintained at Building 202 for the decontamination (via steam cleaning) of the drill rig and other equipment, including but not limited to drill rods, well materials, split spoons, augers, drill bits and vehicles. This decontamination pad was approximately 20 feet long and 20 feet wide and was built with three low sides and a sloped floor to collect liquid residuals. The bottom was lined with high density plastic sheeting and plywood sheeting.

5.4.12 Investigation-Derived Waste

During the field program at AOC 69W a variety of investigation-derived waste (IDW) was produced including: purge water, soil cuttings, well development water, decontamination fluids from the decontamination pad, grout, and personnel protective equipment. As the IDW was produced, it was screened in the field with a PID. As soil cuttings were generated from the drilling process they were segregated into piles (5 feet of drilling depth per pile) on plastic sheeting as the cuttings came off the auger fights. The IDW collection, handling, and disposal procedures followed during the RI are presented in Subsection 4.10 of Volume I of the Fort Devens POP (ABB-ES, 1995a).

5.4.13 Location and Elevation Survey

Upon completion of the field program at AOC 69W, a location and elevation survey was conducted to accurately locate the new explorations including: new and existing monitoring wells, soil borings, TerraProbe^{SM} points, test pit, and geophysical grids, and sediment sample locations.

The survey was conducted by Martinage Engineering, Inc. of Reading, Massachusetts. Horizontal control was established with a Leitz Sokkia II Total Station Vernier reading to one second accuracy. Vertical control was established using a Topcon Auto Level accurate to 0.001 foot.

Monitoring wells were surveyed for horizontal control, and vertical control of the ground surface, top of the protective casing, and the top of the PVC well riser. Test pits soil borings, TerraProbe^{SM} points, and sediment sample locations were surveyed for horizontal control and vertical control. Survey procedures and accuracy followed during the RI are presented in Subsection 4.9 of Volume I of the Fort Devens POP (ABB-ES, 1995a). Appendix H presents a summary of the survey data for AOC 69W.

5.5 SUMMARY OF REMOVAL ACTION AT AOC 69W

In the winter of 1997 and 1998 (December through March), a removal action was undertaken by Roy F. Weston, Inc. (Weston) to remove approximately 3,500 cubic yards (yd ^{3}) of petroleum-contaminated subsurface soil associated with the 1972 fuel oil leak, and to remove the 10,000 gallon UST, the 250 gallon UST, and the associated piping that may serve as a potential conduit to downgradient areas. The removal action encompassed an area approximately 120 by 180 feet immediately north of the elementary school. A narrow "extension" of the removal action reached as far as Willow Brook to the northwest, past the 250 gallon UST. Visual inspection of the 10,000 gallon UST confirmed that it was intact (i.e., no holes or leaks were observed).

Reaching a maximum depth of 13 feet near the school and 8 feet near Willow Brook (in the vicinity of the 250 gallon UST), the excavation intercepted groundwater which ranged from approximately 6.5 to 8 feet bgs at the school, and 3.5 to 5 feet bgs at the 250 gallon UST. No free product was observed in soil or groundwater during the excavation; however, an oily sheen was observed on groundwater emanating from the south sidewall of the excavation (adjacent to the school).

The removal action at AOC 69W removed surface and subsurface soil from several areas that had been investigated as part of the RI. The footprint of the excavation and the soil locations that were removed as part of the soil removal are shown in Figure 5-3 and 5-5. RI soil sample locations that were removed include: ZWB-95-01X, ZWB-95-02X, ZWR-95-27X, ZWR-95-28X, ZWR-95-30X, ZWR-95-31X, ZWR-95-36X, ZWR/ZWS-95-37X, and ZWR/ZWS-95-38X. In addition, the following monitoring wells were also removed: 69W--94-10, 69W--94-11, and 69W--94-13. Physical and chemical data generated for the RI soil samples are discussed in Section

7.0 (Nature and Distribution of Detected Site Contaminants); however, these samples were not included in the risk assessment as they no longer represent an exposure to human or ecological receptors.

Excavated soil was field screened using a target goal of 1,000 ppm TPHC by NDIR. All soil removed from AOC 69W was stockpiled at what is now referred to as "Stockpile D" at the Central Soil Storage Facility (Building 202). The stockpile was constructed in a manner so as to direct all groundwater that was removed with soil during the remedial action into an adjacent manhole.

Thirty-one confirmatory soil samples were collected along the walls and floor of the excavation to confirm the NDIR field screening results, and to ensure that remaining soil concentrations were below the MCP Method 1 S-1/GW-1 standards for EPH/VPH. Chemical data generated from these subsurface soil samples are discussed in Section 7.0 and are used in the human health risk assessment. All confirmatory soil samples collected as part of the removal action are shown in Figure 5-5. A complete report of the AOC 69W removal action is presented in Appendix N.

6.0 SITE HYDROLOGY, GEOLOGY AND GROUNDWATER CHARACTERIZATION

6.1 SITE HYDROLOGY

AOC 69W is located in the northern portion of the Main Post near Verbeck Gate. The site is comprised of the former Fort Devens Elementary School (Building 215) a parking lot, and adjacent lawn located on the northern side of the school. The site extends from the school to Willow Brook which is located approximately 300 feet to the northwest (Figure 5-1 and 5-2).

Willow Brook originates from Robbins Pond located in the central portion of the Main Post. From Robbins Pond the brook flows north through what was formerly a primarily residential area of the Main Post. Willow Brook continues a northerly route along the eastern side of MacArthur Avenue, past the western side of AOC 69W eventually flowing off the Main Post east of Verbeck Gate. Willow Brook then joins Nonacoicus Brook on the North Post and ultimately discharges to the Nashua River. In addition to Robbins Pond, the brook is fed by surface water runoff and discharge from storm sewer systems 19, 20A, 21, 22, and 23 (ADL, 1994).

In the vicinity of AOC 69W Willow Brook consists of a two- to three-foot deep channel approximately five to six feet wide. The channel is lined with asphalt and concrete rubble. The portion of Willow Brook near AOC 69W was dry during both phases of the AOC 69W RI field efforts (August and September of 1995 and August 1996). Water levels in Willow Brook and the streamside piezometer WBP-93-01 were continuously monitored from November 2 to December 8 of 1993 and April 18 to July 8, 1994 by ETA in support of the North and Main Post detailed flow model. The piezometer and a weir for estimating stream flow were located approximately 1,000 feet downstream (north) of AOC 69W at the culvert crossing under Goodblood Drive adjacent to MacArthur Avenue near the Verbeck Gate. Precipitation, surface water, groundwater, and stream flow data collected by ETA are provided in Appendix E. The base flow for this portion of Willow Brook was estimated at 0.01 cubic feet per second (cfs) for November of 1993 and 0.09 cfs for the first week of December 1993. Estimates for April, May and June of 1994 were 0.33, 0.39, and 0.15 cfs, respectively. Data from the streamside piezometer and the surface water station indicates that groundwater discharges to Willow Brook. Following precipitation events the water level in Willow Brook would rise above surrounding groundwater levels and then equilibrate to levels below groundwater.

Other hydrologic features in the vicinity of AOC 69W include a wetland environment with standing water located on the eastern side of Willow Brook approximately 500 feet north of the school. The wetland continues north along the eastern side of Willow Brook for approximately 300 feet.

6.2 SITE GEOLOGY

This subsection presents descriptions of the geologic formations encountered at AOC 69W. Figure 6-1 shows the orientation of the geologic cross-section and Figure 6-2 presents geologic cross-section A-A'.

6.2.1 Overburden Soils

Surficial and subsurface soils at AOC 69W are classified by the SCS as the Hinckley-Merrimac (Freetown)-Windsor Association (Figure 2-3). The soil is described as being deep; excessively to moderately well drained; nearly level to very steep (see Subsection 2.2.5). Boring logs are presented in Appendix A and results of grain size analysis are provided in Appendix I.

Near surface soils beneath the school and parking lot consist of reworked native soils consisting of dark yellowish-brown fine to coarse sands, gravely sands and silty sands. The soil borings and test pit located in the grassy area to the north of the school show that the surficial soils in this area are comprised of reworked silty sand with gravel and cobbles intermixed with pockets of black organic material. The organic material was found at a maximum depth of 4 feet bgs (69W--94-10, 69W--94-12, and 69W--94-14). These deeper organic layers are believed to be undisturbed native deposits. Excavation of the test pit ZWE-95-01X, located approximately 175 feet north of the parking lot, revealed fill material and debris to a depth of 3 feet bgs.

The predominant soil type at AOC 69W consists of dark yellowish-brown fine to coarse sands, gravely sands and silty sands. Explorations in the vicinity of Willow Brook and its associated wetlands (ZWM-95-15X, ZWP-95-02X, and ZWM-95-18X) revealed a four-to five-foot layer of dark grayish-brown, sandy silt overlying the sands and silty sands. In addition, olive-brown to olive gray fine to coarse sands were observed starting at 9 to 10 feet bgs beneath the school and parking lot (explorations 69W--94-10, ZWB-95-01X, and ZWM-95-16X).

6.2.2 Bedrock Geology

Bedrock was not encountered in any of the borings at AOC 69W; however, bedrock mapping performed in the Devens area indicates that AOC 69W is located near an inferred contact between the Devens Long Pond facies of the Ayer granite and the Oakdale Formation.

The Devens-Long Pond facies is described as being a gneissic, equigranular to porphyroblastic biotite granite and granodiorite (Wones and Goldsmith, 1991). The most prominent example of the Devens-Long Pond facies is the outcrop which forms Shepley's Hill located to the west of AOC 69W.

The Oakdale Formation is classified as fine-grained metasiltstone and phyllite, comprised of quartz and minor feldspar and ankerite. The Oakdale Formation is commonly deformed by kink banding (Zen, 1983; Peck, 1975; Russell and Allmendinger, 1975).

Depth to bedrock at AOC 69W is unknown. Bedrock borings in the vicinity of Shepley's Hill Landfill, located approximately 2,500 feet to the northeast of AOC 69W, indicate that depth to bedrock in this area can be highly variant.

6.2.3 Site Geology Interpretation Summary

The geologic conceptual model developed for AOC 69W suggests that the existing wetlands to the east of Willow Brook were historically more widespread. Organic layers observed in soil borings indicates that the wetlands at one point extended to the southeast as far as the current UST location. Soil boring data further suggests that the presumed historic wetlands in the vicinity of the parking lot were filled in by natural processes and more recently the wetlands which existed in the grassy area to the north of the parking lot were filled during some phase of Fort Devens construction. Soils surrounding and underlying Willow Brook consist of dark grayish-brown sandy silt 4 to 5 feet in thickness. The most predominant soil type at AOC 69W consists of dark yellowish-brown fine to coarse sands, gravely sands and silty sands. These soils underlie the wetland deposits and appear to be reworked in the near surface beneath the parking lot and school. In addition, these native sands appear to have been the fill material used to create the grassy area north of the parking lot.

6.3 HYDROGEOLOGY

This subsection presents data and interpretations of hydrogeologic conditions at AOC 69W. Groundwater levels used in this subsection are provided in Table 6-1 and interpretive water table elevation contours are presented in Figure 6-3. Water level elevations at AOC 69W were measured on December 7, 1995, March 26, 1996, July 23, 1996, and January 15, 1997. In addition, water level information obtained during the low-flow groundwater sampling event in December of 1997 are also included. In-situ hydraulic conductivity results are provided in Table 6-2 and Appendix E.

As a result of the type of contaminants (primarily fuel related compounds) identified at AOC 69W all of the monitoring wells have been installed as water table wells (i.e., their screened interval and sandpack span the water table) (see Figure 6-2 and Table 5-8). A total of 13 monitoring wells, 69W--94-09, 69W--94-10, 69W--94-11, 69W--94-12, 69W--94-13, 69W--94-14, ZWM-95-15X, ZWM-95-16X, ZWM-95-17X, ZWM-95-18X, ZWM-96-19X, ZWM-96-20X, and ZWM-96-21X were installed in overburden soils. In addition, two piezometers ZWP-95-01X and ZWP-95-02X were installed adjacent to Willow Brook.

The water table occurs in the overburden across AOC 69W (Figure 6-2). Figure 6-3 presents interpreted water table elevation contours for AOC 69W based on the January 15, 1997 data set. Groundwater flow is predominately south-southeast to north-northwest toward Willow Brook. Depth to groundwater at AOC 69W ranges from approximately 4 to 5 feet bgs on the north side of the school building to approximately 1 foot bgs adjacent to Willow Brook. The January 15, 1997 data set indicates that groundwater was discharging to Willow Brook. It was not possible to verify this at the time as the brook was frozen and snow covered. Groundwater discharge to Willow Brook would be consistent with the fact that the January 1997 water levels were the highest recorded for AOC 69W.

It was not possible to calculate vertical hydraulic gradients at AOC 69W as there are no deep overburden wells; however, data collected from the streamside piezometer and gaging station show groundwater discharges to Willow Brook indicating upward vertical gradients (see Subsection 6.1, Hydrology).

Horizontal hydraulic gradients were calculated from each set of water level measurements. Gradients were calculated using multiple wells that, as much as possible, share a common flow path. In general, horizontal hydraulic gradients are relatively consistent across AOC 69W. Calculations are provided in Appendix E. The geometric mean of horizontal hydraulic gradients calculated for all data sets range between 0.006 ft/ft (December 7, 1995) and 0.008 ft/ft (January 15, 1997).

In-situ Hydraulic Conductivity Results. In-situ hydraulic conductivity test results presented in Table 6-2 indicate that estimates of hydraulic conductivity as calculated by the Bouwer and Rice method range between 1.3 x 10^{-3} cm/sec (3.7 ft/day) at 69W--94-09 and 3 x 10^{-2} cm/sec (85 ft/day) at 69W--94-14 and ZWM-95-15. The geometric mean of the monitoring wells hydraulic conductivities was calculated as 1.6 x 10^{-2} cm/sec (45 ft/day). All of the hydraulic conductivity test data and results are presented in Appendix E.

Groundwater Velocity Analyses. Flow velocities were estimated for AOC 69W using maximum, minimum, and mean horizontal hydraulic gradients and hydraulic conductivities as determined by the Bouwer and Rice method (calculations are provided in Appendix E). An overburden effective porosity of 30 percent was assumed for the predominately sandy soils. The maximum groundwater flow velocity was estimated at 2 feet per day (ft/day). A minimum flow velocity of 0.07 ft/day was calculated for the water table. The geometric means of observed hydraulic conductivities and hydraulic gradients yielded a flow velocity of 0.7 ft/day.

6.3.1 Site Hydrogeology Interpretation Summary

Groundwater at AOC 69W occurs in the overburden and bedrock aquifers. Bedrock aquifer characteristics were not monitored at AOC 69W. Flow directions are predominately south-southeast to north-northwest. Groundwater discharges to Willow Brook in the vicinity of AOC 69W at times of high groundwater levels. Due to surface water runoff and the storm sewer system, water levels in Willow Brook may be higher than groundwater levels following precipitation events. AOC 69W is located within the draft delineated Zone 2 for MacPherson Production well located approximately 3,000 feet to the north (ETA, 1996).

7.0 NATURE AND DISTRIBUTION OF DETECTED SITE CONTAMINANTS

The following subsections address the nature and distribution of analytes detected in soil, groundwater, sediment, and air collected from AOC 69W during the RI. Supplemental groundwater and air sample data collected in 1997 are also presented. Data obtained from the off-site laboratory and from the on-site field analytical laboratory are presented in this section.

During implementation of the RI field program, field analytical results were used to direct placement of soil borings and monitoring wells, and were used to define the vertical and/or horizontal distribution of contaminants. Field analytical results were also used to select samples for off-site laboratory analysis. Samples were collected from hot zones to gather information on the nature and concentrations of contaminants, and samples were collected from clean areas for off-site confirmation. Field analytical data were used to supplement the off-site laboratory analytical data in the assessment of the nature and distribution of detected analytes.

This assessment of site-related contaminants relies upon tables to present the field and off-site laboratory analytical data. The tables contain only detected analytes and concentrations for samples within a given media. The text within the assessment provides detail, interpretation, and analysis of the tabulated data. A complete summary of the field and off-site analytical data is presented in Appendix L.

7.1 APPROACH TO CONTAMINATION ASSESSMENT

Off-site laboratory analytical results and field analytical data are the primary data used to assess impacts at the site from suspected past disposal and storage practices. A complete data set of field and off-site analytical data, including non-detect results, is presented in Appendix L. Tentatively identified compounds (TICs) reported for off-site laboratory data are discussed in Subsection 7.1.1 and are presented in Table 7-1.

Analytes detected in QC blanks analyzed at the off-site laboratory are presented in Subsection 7.1.2. A blank contamination evaluation was performed with this data to identify probable sampling and off-site laboratory-related contaminants. The contamination assessment included determining uncertainty regarding potential false positive results due to sampling and off-site laboratory contaminants. With the exception of the 1997 Supplemental Air and EPH/VPH sample data, data presented in the tables were not qualified or corrected for blank contamination. However, based on the blank contamination assessment performed, a "*" flag has been added to the data when applicable, to indicate probable blank contamination. A detailed review of laboratory method blank and field quality control blank analyses from the RI program is presented in Section 3.0 and in the DQR for the 1995, 1996, and 1997 investigations are located in Appendix D. The DQR include evaluations for data collected from AOCs 57, 63AX and 69W because the investigations were conducted simultaneously.

An evaluation of analytical data precision and accuracy was conducted using results of field duplicate and MS/MSD analyses. Accuracy of VOC and SVOC results were also evaluated using surrogate recovery data from each sample analysis. The results for some analytes have been identified as estimated based on the field duplicate, surrogate, and/or MS/MSD data. In some cases, possible data biases have been identified. A summary of data usability interpretations is contained in Subsection 7.1.2. Detailed discussions of surrogate, field duplicate, and MS/MSD results are presented in the DQRs in Appendix D.

7.1.1 Tentatively Identified Compounds/Non-Project Analyte List Compounds

During off-site laboratory analysis, non-project analyte list compounds present in VOC and SVOC samples were tentatively identified by comparing the GC/MS spectra to those contained in the National Bureau of Standards mass spectral library. Once the tentative identification was made based on matching spectra, the appropriate USAEC code name was assigned for that compound.

Reported concentrations of TICs are considered estimated and are not based on calibration standards. If no compound identification was possible, the compound became listed as an unknown with an assigned number. The assigned number which accompanies the prefix "UNK" is determined by the relative retention time to the internal standard. For example, if the relative retention time of the compound compared to 1,4-difluorobenzene is 1.42, the compound would be assigned the number "UNK142" in IRDMIS.

The requirements for making tentative identification of compounds are listed in the Fort Devens POP (ABB-ES, 1995a) as follows:

1. Relative intensities of major ions in the reference spectrum (ions > 10 percent of the most abundant ion) should be present in the sample spectrum.
2. The relative intensities of the major ions must agree within 20 percent.
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 co-eluting 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 co-eluting compounds. Data system library reduction programs can sometimes create these discrepancies.
6. If in the technical judgment of the mass spectral interpretation specialist, no valid tentative identification can be made, the compound should be reported as unknown.

7.1.1.1 TICs Detected in Samples from AOC 69W. VOC and SVOC TICs and unknown compounds were detected in several soil and groundwater samples collected from AOC 69W. These compounds are differentiated from target analytes in the USAEC's IRDMIS with an "S" flag in the flagging code field. All TICs associated with samples from AOC 69W collected during the 1995 RI investigations and from the Round 2 Groundwater Sampling Event are summarized below and presented in Tables 7-1. TICs were not reported in any of the samples collected during the 1996 investigation.

It is important to note that in addition to the GC/MS method used to identify and report the alkanes and aromatics identified as TICs, USEPA Methods 418.1, 9071 and 8015 were used during the off-site analysis of soil and water samples to quantify and classify hydrocarbons within these chemical classes. Supplemental data was also collected using Massachusetts EPH and VPH methods to further characterize the non-target hydrocarbons. Field analysis was conducted on many samples during the RI using a modified version of USEPA Method 418.1. The field analysis method was designed to provide data on the distribution of these fuel hydrocarbons. Field analytical results were used to direct field exploration programs and provide supporting data for the off-site sample results. The off-site laboratory USEPA Method 418.1 results are the primary data used to make quantitative evaluations of these chemicals as TPHC.

1995 RI TICs. TICs detected in groundwater, soil and sediment samples collected during the 1996 RI consisted primarily of alkenes, alkanes, alkyl-substituted-alkanes, and alkyl-substituted benzenes, toluenes and naphthalenes.

The field samples with the highest concentrations and the most frequent detection of these TICs include soil samples BXZW0107, RXZW2607, RXZW3006, RXZW3607, RXZW3704, groundwater samples MXZW10X4, MXZW13X3, MXZW13X4, MXZW16X1. The concentration of TICs detected in these samples ranged from 4 µg/L to 5,000 µg/L in groundwater samples, and from approximately 0.0052 µg/g to 300 µg/g in soil samples. The presence of alkanes and alkyl-substituted compounds in these samples may be indicative of gasoline, fuel oil, or other fuel related contamination.

Other compounds detected in samples collected from AOC 69W include alpha-pinene, beta-pinene, and gamma-sitosterol. These are interpreted to be related to natural organics and not indicative of waste contamination.

Samples also contained unknown VOCs and SVOCs ranging from 0.03 µg/g to 50 µg/g in sediment samples, 0.006 µg/g to and 10,000 µg/L to 300,000 µg/L in groundwater samples.

7.1.2 Potential Laboratory and Sampling Contaminants

An evaluation of results from rinse, trip, and laboratory method blank analyses was conducted to determine possible contaminant contributions originating from non-site-related sources. Potential sources of contamination include materials used during borehole advancement and monitoring well installation, field sampling procedures, field equipment decontamination, sample shipment, laboratory storage, and laboratory analysis.

Because the majority of off-site analytical data was generated using USAEC methods, USEPA data validation guidelines related to the evaluation of blank contamination were not implemented. The following blank contamination assessment approach for organics was used regarding laboratory method blank and field QC sample blank contamination:

1.) Non-target VOCs and SVOCs TICs that are common organic laboratory contaminants (USEPA, 1988) are not considered chemicals of concern. These common organic laboratory contaminants include:

    - Siloxanes; diethyl ether; 1,1,2-trichloro-1,2,2-trifluoroethane; fluorotrichloromethane; and phthalates at levels less than 100 μg/L or 4 μg/g in samples collected during the 1995 Field Investigation and the Round 2 Groundwater sampling event.

    - trifluorochloromethane at levels less than 0.1 μg/g in samples collected during the 1996 Field Investigation.

    - Solvent preservatives such as cyclohexane, and related by-products including cyclohexene, cyclohexanone, cyclohexenone, cyclohexanol, cyclohexenol, chlorocyclohexene, and chlorohexanol.

    - Aldol condensation products of acetone including 4-hydroxy-4-methyl-2-pentanone, 4-methyl-2-penten-2-one, and5-dimethyl-2(5H)-furanone.

2.) The additional TICs detected in SVOC blanks include heptacosane, nonacosane and dioctyladipate. The VOC TICS detected hexane and ethanol.

The investigations during which these TICs were detected are shown in Table 7-1.

4) For organic target compounds, trends in method and field blanks were evaluated. Several target compounds routinely detected have been identified by USEPA as common laboratory contaminants including:

   - phthalates
   - methylene chloride, acetone, toluene, and methyl ethyl ketone (2-butanone) at concentrations comparable to concentrations observed in blanks.

5) The pesticides malathion detected in method blanks at 0.188 μg/L and alpha- and gamma-chlordane in method blanks at concentrations up to 0.01 μg/g.

Organic target analytes detected in method blanks and rinse blanks during the 1995 and 1996 Field investigations and the 1995 Round 2 Groundwater Sampling Event are presented in Table 7-2 and 7-3. VOCs detected in trip blank samples collected during the 1995 Field Investigations and the Round 2 Groundwater Sampling Event are presented in Table 7-4. Trip blanks analyzed during the 1996 investigation did not have any detections of VOCs reported. Organic compounds detected in samples at similar concentration ranges as those in blanks are discussed qualitatively in the contamination assessment, and carried through the risk assessment calculations. In addition, the spatial distribution and relative concentration of common organic laboratory contaminants, and rationale for elimination of data from consideration as site-related contaminants, are presented in the contamination assessment in Subsection 7.2.

Inorganic elements were not reported in rinse blanks and water method blanks. Inorganic detections in the soil method blanks are not presented because the source of elements is believed to be the blank soil matrix rather than laboratory contamination (see Appendix D-1 and D-3, Section D-2.0). Inorganic sample data presented in the data tables and risk assessment tables were not revised based on blank contamination results. All inorganic detections were used for risk assessment calculations.

During the RI, samples were analyzed for a variety of water quality parameters to generate data to support the development of alternatives during the FS process. No rinse blank or method blank contamination was reported for the water quality parameters analyzed.

A detailed discussion of laboratory QC sample results is presented in Appendix D for each field program.

1997 Supplemental Groundwater and Air Sampling

Groundwater and air sample data were collected on fuel hydrocarbons (EPH/VPH), volatiles, and semivolatiles. Results were validated for blank contamination as outlined in USEPA guidelines (USEPA, 1988; USEPA, 1996), and results were qualified prior to use in the RI. Validation reports are presented in Appendix D. Blank results indicate no contamination was observed for groundwater sample analyses. Acetone, toluene, and xylene contamination was observed at low concentrations in blanks associated with the air analyses. The majority of the reported acetone results were qualified as non-detect U during validation, and it is possible that positive detections of acetone are related to sampling or laboratory contamination.

7.1.3 Analytical Data Accuracy and Precision

Analytical data accuracy and precision was evaluated using MS and field duplicate analyses for the majority of off-site analytical methods. Surrogate recoveries were also reviewed to evaluate the accuracy of VOC and SVOC measurements. This evaluation was conducted to support the AOC 69W 1995 and 1996 RI field programs and the AOC 69W 1996 Round 2 Groundwater Sampling Event. Detailed discussions and presentation of these results are included for the 1995 and 1996 investigations in Appendix D.

Matrix spike, field duplicate, and surrogate results for the majority of the and target analytes evaluated during the RI indicate the accuracy and precision of results were within project goals outlined in the Fort Devens POP (ABB-ES, 1995a) and USEPA control limits (USEPA, 1988; USEPA, 1989). Trends were reviewed for each set of QC sample data from each field event to determine if qualification of the accuracy of results was needed. The results for some analytes in AOC 69W samples have been identified as invalid or as estimated values with potential biases noted. The following items summarize the qualification of results:

AOC 69W 1995 RI

1. Based on spike recovery data discussed in Appendix D-1, Subsection D.3.1.1, positive detections of selenium in soil are considered estimated with no particular low or high bias.

2. Results for MS and MSDs discussed in Appendix D-1, Subsection D.3.1.1 indicate lead results for soil analyzed by GFAA are estimated, and results may be biased low.

3. High frequency of MS/MSD recoveries above the upper control limits indicate that there may be some matrix interference (Appendix D-1, Subsection D.3.1.1). Positive results reported for arsenic in soil samples should be considered estimated and potentially biased high.

4. Due to the low MS recovery in sample DXZW0200 (Appendix D-1, Subsection D.3.1.1), positive results for arsenic in sediment samples from AOC 69W should be considered biased low, and non-detect results are unusable.

5. Due to the low MS recovery in sample DXZW0200 (Appendix D-1, Subsection D.3.1.1), positive results for manganese in sediment samples from AOC 69W should be considered biased low, and non-detect results should be considered unusable.

6. Based on spike recoveries for hardness (Appendix D-1, Subsection 3.3.3), all hardness results for groundwater samples should be considered invalid.

7. VOC surrogate recovery evaluations are presented in Appendix D-1, Subsection D.3.2.1:

   - Groundwater sample MXZW12X3 from AOC 67W had high surrogate recoveries for 1,2-dichlorobenzene-D4. Positive results for ethylbenzene, tetrachloroethene, toluene, xylenes, and chloromethane results are considered estimated and potentially biased high.

- The recoveries of surrogate standards toluene-D8 and 4-bromofluorobenzene in soil sample BXZW0107 from AOC 69W were high. Positive concentrations of ethylbenzene and xylenes in this sample are estimated and possibly biased high.
- The surrogate recovery for toluene-D8 in one sediment sample from AOC 69W (RXZW3006) also exceeded the upper control limit. Positive results for toluene, xylene, and styrene should be considered estimated, and potentially biased high.

8. TPH results reported for all AOC 69W sediment samples should be considered estimated values based on duplicate RPD results presented in Subsection D.4.1.4 in Appendix D-1.
9. As discussed in Subsection D.4.2.1 in Appendix D-1, iron results reported in groundwater samples from AOC 69W are considered estimated based on outlier RPDs between spike sample results.
10. Positive detections of heptachlor epoxide and gamma-chlordane in AOC 69W groundwater sample MXZW10X4 are considered estimated based on RPD exceedances between spiked sample results (Subsection D.4.2.2 in Appendix D-1).

Groundwater, Round 2

1. Phosphate results from AOC 69W groundwater samples are considered estimated values based on outlier RPDs between field duplicate results.
2. VOC surrogate recovery evaluations are presented in Appendix D-1, Subsection D.3.2.1:

- Based on high surrogate recoveries of 1,2-dichlorobenzene-D4 for AOC 69W groundwater samples MXZW14X4, MXZW15X2, and MXZW18X2 positive results for VOCs in these samples should be considered estimated, and biased high. However, only low concentrations of toluene (< 1.2 μg/L) were reported in all samples and high surrogate recoveries are not interpreted to impact data usability.

- Ethyl benzene results reported in AOC 69W groundwater sample MXZW10X4 is estimated and potentially biased high based on high surrogate recoveries of 1,2-dichlorobenzene-D4.

AOC 69W Fall 1996 RI

1. Based on MS recoveries discussed in Appendix D-3, Subsection D.3.1.1, positive detections, and CRLs for non-detect results for mercury, arsenic, and manganese in soil are considered estimated values and potentially biased low.

2. Based on MS recoveries discussed in Appendix D-3, Subsection D.3.1.2, lindane CRL results in AOC 69W groundwater samples may be biased low and should be considered estimated. Lindane was not detected in groundwater samples.

1997 Supplemental Groundwater and Air Samples

A summary of data validation and data qualification actions is contained in Appendix D-4. Based on data validation reviews all groundwater results are usable as reported. The following should be considered when using the air sample results:

- Results for sample ZWA-97-04X have been rejected and are considered unusable due to loss of canister negative pressure during sample collection.

7.2 INVESTIGATIONS AT AOC 69W

7.2.1 1994 ADL AREE 69W Investigation

The following subsection details the analytical findings of the AREE 69W investigation conducted in 1994 by ADL.

In July of 1993 ADL investigated the Fort Devens Elementary School, designated AREE 69W, as part of the basewide AREE 69 (Past Spill Sites) investigation. The investigation focused on the 1978 fuel oil release and was comprised of a document review and site visit. The study concluded that there was a potential for fuel oil contamination in the soil and groundwater (ADL, 1995).

Further investigation was performed at AREE 69W from March through June of 1994. The investigation involved sampling, field screening, and laboratory analysis of surface soil, subsurface soil, groundwater, surface water, sediment, and a geophysical survey to locate subsurface utilities.

7.2.1.1 Surface Soil. Six surface soil samples were collected from a depth of 0 to 1 foot bgs, from the grassy area north and northwest of the parking lot (Figure 5-2). The samples were analyzed by portable field instruments for BTEX and TPHC, using GC and NDIR techniques, respectively. The sample with the highest observed TPHC concentration was submitted for laboratory analysis of PAL VOCs, PAL SVOCs, TPHC, PAL inorganics, and TOC. Field and off-site soil analytical data are provided in Tables 7-5 and 7-6, respectively.

TPHC field screening concentrations ranged from 9.5 ppm to a high of 131 ppm (observed at location HA-5, located just off the northwest corner of the paved area). No BTEX were detected in the screening results. Laboratory results from the single surface soil sample submitted for laboratory analysis revealed no compounds at concentrations exceeding MCP Method 1, S-1/GW-1 Standards. cPAHs detected in the surface soils at the site consisted of benzo(a)anthracene and chrysene at a combined concentration of 0.29 $\mu g/g$.

7.2.1.2 Subsurface Soil. Subsurface soil samples were collected during the installation of groundwater monitoring wells and during the Geoprobe investigations. During the first round of Geoprobe sampling, subsurface samples were collected from 3 to 5 feet bgs at 16 locations (Figure 5-2) for field analysis of TPHC and BTEX. Of the 32 samples analyzed in the field, three samples exhibiting the highest TPHC concentrations and one sample with the lowest TPHC concentration were submitted for laboratory analysis of PAL VOC, PAL SVOCs, TPHC, PAL inorganics and TOC analysis. During the second Geoprobe sampling round, nine additional locations were investigated (Figure 5-2). Subsurface soil samples were collected from a depth of 3 to 5 feet bgs and field screened for TPHC. Field and off-site analytical soils data are provided in Tables 7-5 and 7-6, respectively.

Soil samples were collected at depth intervals of 2 to 4 feet, and 11 to 13 feet bgs during the monitoring well installation effort. These samples were screened in the field for TPHC and BTEX. The samples from the 2 to 4 and 4 to 6 foot depth intervals were submitted for laboratory analysis of TPHC, PAL VOCs, PAL SVOCs, PAL inorganics, and TOC analysis.

TPHC concentrations in soils collected with the Geoprobe and from monitoring well soil borings ranged from 7.5 ppm to 15,500 ppm (GP-2 at 3 to 5 feet bgs). Concentrations of benzo(b)fluoranthene, benzo(a)anthracene, and chrysene detected in Geoprobe soils were above MCP Method 1, S-1/GW-1 standards.

Based on the field screening and laboratory analysis results, TPHC and cPAH soil contamination appears to have been concentrated in the area of the existing UST (the presumed source area), and may have migrated downgradient towards Willow Brook.

7.2.1.3 Groundwater. Groundwater samples were collected from each Geoprobe location and from the six newly installed groundwater monitoring wells. Sixteen groundwater samples were collected during the first Geoprobe sampling round and field screened for TPHC and BTEX (GP-01 through GP-16). Filtered and non-filtered groundwater samples collected during the second Geoprobe sampling round were field screened for TPHC (GP-17 through GP-25). Sample locations are shown in Figure 5-2. Field and off-site analytical results from groundwater samples are provided in Tables 7-5 and 7-7, respectively.

Field screening results from the 25 Geoprobe groundwater samples indicated that TPHC was present in groundwater. BTEX was not detected. Five sample locations from the first Geoprobe sampling round exhibiting the highest field screening TPHC concentrations were resampled and submitted to the laboratory for analysis of PAL VOCs, PAL SVOCs, TPHC and water quality parameters. No samples from the second geoprobe sampling round were sent for laboratory analysis. Results indicated that TPHC, inorganic analytes (arsenic, lead, antimony, beryllium, chromium, and nickel), and organic compounds (1,1-dichloroethene, benzene, carbon tetrachloride, chloroform, tetrachloroethene, trichloroethene, 2-methyl naphthalene, and naphthalene) were detected at concentrations exceeding MCP Method 1, GW-1 Standards. Most of these exceedances occurred at locations GP-1, GP-2, GP-6 and GP-15, in the area of the UST and downgradient of this location. No cPAHs were detected in the Geoprobe groundwater samples.

Six monitoring wells installed at the site confirmed the results of the Geoprobe investigation. Groundwater samples were submitted for analysis of TPHC, PAL VOCs, PAL SVOCs, unfiltered inorganics and water quality parameters. Results indicated that TPHC, arsenic, beryllium, cadmium, chromium, lead, nickel, 2-methyl naphthalene, acenaphthene, and naphthalene were detected at concentrations exceeding MCP Method 1, GW-1 Standards. These exceedances occurred at monitoring wells 69W-94-10, 69W-94-11, 69W-94-13 and 69W-94-14. No cPAHs were detected in the groundwater samples.

Groundwater sample results indicate that the area around the UST has the greatest number of compounds exceeding MCP Standards. Groundwater northwest of the UST was also found to have elevated concentrations of inorganics and TPHC, suggesting that contaminants have potentially migrated downgradient of the UST location.

7.2.1.4 Surface Water and Sediment. Surface water and sediment samples were collected from two locations in Willow Brook (Figure 5-2). One sample location (69W-94-16) was placed in line with the inferred plume migration pathway indicated by the Geoprobe survey, and the other (69W-94-15) was placed upstream of this area. Samples were analyzed for TPHC, PAL VOCs, PAL SVOCs, unfiltered inorganics, and water quality parameters. Surface water and sediment off-site analytical results are provided in Tables 7-8 and 7-9.

The results indicated the presence of cPAHs in both sediment samples, and TPHC in sample 69W-94-16. Specifically, the cPAHs benzo(a)anthracene, chrysene, benzo(b)fluoranthene, and benzo(k)fluoranthene were detected in the 69W-94-15 (upstream) sediment sample. In sediment sample 69W-94-16, TPHC, benzo(a)anthracene and chrysene were detected. Total cPAHs in the upstream sample barely exceeded 7.0 ppm. Total cPAHs in the downstream sample were an order of magnitude less than the clean-up values. Other PAHs and metals were detected in both samples.

TPHC and cPAHs were not detected in surface water samples.

7.2.2 AOC 69W RI and Removal Action Soils Results

The following subsections present field and off-site laboratory analytical soil results for samples collected at AOC 69W during the RI and during the soil removal action. Field analytical soil data from the RI are presented in Table 7-10. Off-site laboratory analytical soil data from the RI are presented in a hits-only format in Tables 7-11 and 7-12. Off-site laboratory analytical soil data from the remedial action are presented in Table 7-13. Complete field analytical and off-site laboratory analytical soil data including non-detects are presented in Appendix L.

7.2.2.1 RI Field Analytical Soil Results. Soil samples were collected for field analysis from TerraProbe^{SM} points, soil borings, and test pits. The field analytical samples were collected in an attempt to define the nature and distribution of the site-related contaminants as well as to delineate potential contaminant source areas. A discussion of the results is presented below.

1995 RI TerraProbe^{SM} and Test Pit Soil Sampling Field Analytical Results. In September of 1995, a total of 92 soil samples were collected from 29 TerraProbe^{SM} points (ZWR-95-26X through ZWR-95-28X, and ZWR-95-30X through ZWR-95-55X) for on-site analysis of BTEX, select VOCs, GRO, and TPHC. Select samples were also analyzed for DRO. Soil samples were generally collected from near ground surface, a midpoint, and the water table as exploration conditions allowed. On-site analytical results for the TerraProbe^{SM} soils are provided in Table 7-10.

VOCs were detected in twelve of the TerraProbe^{SM} soil samples. The majority of the detections were the petroleum related compounds toluene, chlorobenzene, ethylbenzene and xylenes. These detections can be divided into two groups, samples from 6 to 10 feet from within the parking lot adjacent to the school (ZWR-95-26X at 7 feet, ZWR-95-28X at 10 feet, ZWR-95-30X at 6 feet, and ZWR-95-31X at 7 feet) and surficial samples located in the grassy area north of the parking lot (ZWR-95-44X at 0 feet, ZWR-95-45X at 1 foot bgs, and ZWR-95-46X at 0 feet). The highest detected total and individual concentrations of these analytes were found immediately adjacent to the school in the samples from ZWR-95-28X (6,600 μg/kg at 10 feet bgs) and ZWR-95-30X (6,817 μg/kg at 6 feet bgs).

Figures 7-1 and 7-2 provide field analytical results for soils from 0 to 5 feet bgs and 6 to 10 feet bgs, respectively. Other detected VOCs include chloroform at 3.8 μg/kg and 2.5 μg/kg in the 4 feet bgs samples from ZWR-95-33X and ZWR-95-47X, respectively. Carbon tetrachloride was found at 2.4 μg/kg in the 10 feet bgs sample from ZWR-95-30X and TCE was detected at 2.5 μg/kg in the 10 feet bgs sample from ZWR-95-38X.

TPHCs were detected in 42 of the TerraProbe^{SM} soil samples with a maximum detected concentration of 7,700 μg/g at 6 feet bgs in ZWR-95-30X. The most significant detections (i.e., in excess of 500 μg/g) were located in the area of the underground "skimmer system" which leads from the school to the 250 gallon underground holding tank located approximately 300 feet to the northwest. The "skimmer system" that was installed in 1972 appears to have acted as a conduit for migration of TPHC soil contamination. Figures 7-1 and 7-2 provide field analytical TPHC data. As is shown in Figure 7-3 (including 1996 field analytical data), there appear to be two distinct areas of TPHC contamination in AOC 69W subsurface soils. The highest concentrations were observed in the area stretching from the new boiler room located inside the school building to the 250 gallon UST in the wooded area to the northwest. TPHCs were also detected in subsurface soils at 4 to 7 feet bgs in the TerraProbe^{SM} borings ZWR-95-26X and ZWR-95-33X located adjacent to the school building outside of the old boiler room. TPHCs in this area are attributed to the 1978 fuel oil release and appear to be localized to this area and distinct from the TPHC concentrations to the west.

1996 Monitoring Well Boring and Soil Boring Sample Field Analytical Results. In 1996, three monitoring wells (ZWM-96-19X, ZWM-96-20X, and ZWM-96-21X) and one soil boring (ZWB-96-03X) were installed within the Elementary School boiler rooms and courtyard to define the upgradient extent of the petroleum related contamination observed during the 1995 RI investigation. All of the borings were sampled continuously to characterize the vertical distribution of contaminants near the suspected source area. A total of twenty-eight soil samples, including duplicates, were collected from the four explorations and analyzed in the field for select VOCs, SVOCs, and TPHC (Table 7-10). Figure 7-4 provides results of the field analysis in a hits only format. The majority of detected contaminants were observed in the 9 to 13 feet bgs samples from the monitoring well boring ZWM-96-19X. Only one VOC was detected, 580 μg/kg of m/p xylene at 9 feet bgs in ZWM-96-19X. Naphthalene, the only SVOC compound detected, was found in four of the samples from ZWM-96-19X: 680 μg/kg at 3 feet bgs, 3,800 μg/kg at 9 feet bgs, 4,500 μg/kg at 11 feet bgs, and 1,400 μg/kg at 13 feet bgs. TPHC was the only compound detected in the other explorations. The maximum observed concentrations were found in the 9 and 11 feet bgs samples from ZWM-96-19X at 840 μg/g and 790 μg/g, respectively. The only TPHC detections in the other explorations were 62 μg/g at 2 feet bgs in ZWM-96-20X and 57 μg/g at 8 feet bgs in ZWM-96-21X.

7.2.2.2 RI Off-Site Analytical Soils Results. Subsequent to reviewing field analytical results for soil, samples were submitted for laboratory analysis from TerraProbe^{SM} points, soil borings, and surface soil locations. Samples were collected to further define the lateral and vertical extent of contamination and to provide off-site confirmation of the on-site analysis. A discussion of all the results is presented below. As discussed in Subsection 5.5, a removal action was implemented to eliminate the source area and the associated piping which may have acted as a potential conduit to downgradient areas. Therefore, some of the chemical concentrations discussed in the following paragraphs are no longer present at the site (they are noted accordingly).

1995 Soil Boring, TerraProbe^{SM}, and Surface Soil Sample Analytical Results. In the fall of 1995 a total of 28 soil samples were collected from the following locations:

- 2 soil and 3 monitoring well borings (ZWB-95-01X, ZWB-95-02X, ZWM-95-15X, ZWM-95-16X, and ZWM-95-18X),
- 8 TerraProbe^{SM} points (ZWR-95-26X, ZWR-95-30X, ZWR-95-35X, ZWR-95-36X, ZWR-95-37X, ZWR-95-38X, ZWR-95-39X, and ZWR-95-45X,
- 8 surface soil locations (ZWS-95-35X, ZWS-95-37X, ZWS-95-38X, ZWS-95-39X, ZWS-95-42X, ZWS-95-45X, ZWS-95-46X, and ZWS-95-

47X (coincident with TerraProbe^{SM} locations).

Soil analyses included PAL VOCs, SVOCs, inorganics, TPHC, and TOC. RI exploration locations are shown in Figure 5-3. Off-site analytical results are provided in Table 7-11.

Arsenic, beryllium, calcium, cobalt, copper, iron, lead, magnesium, manganese, mercury, nickel, selenium, sodium, and zinc were detected at levels in excess of established Devens background concentrations. The greatest number of exceedances were observed in the 7 feet bgs sample from ZWB-95-01X, the 4 feet bgs sample from ZWR-95-37X, the 4 feet bgs sample from ZWR-95-39X, and the surface soil sample ZWS-95-42X. Two of these locations (ZWB-95-01X and ZWR-95-37X) were removed as part of the remedial action in 1997 and 1998. ZWS-95-42X was found to contain 0.85 μg/g of beryllium and 238 μg/g of lead.

Detected VOCs were comprised primarily of the fuel related compounds toluene, ethylbenzene, and xylene (TEX). The maximum observed concentration of total TEX was 0.48 μg/g (ethylbenzene and xylenes only) in the 7 feet bgs sample from ZWB-95-01X. Other detected analytes include 1,1,2,2-tetrachloroethane in the 5 feet bgs sample from ZWB-95-02X and 0.0034 μg/g of styrene in the 6 feet bgs sample from ZWR-95-30X. All of these locations were removed as part of the soil removal action in 1997 and 1998. The VOCs acetone, dichloromethane (methylene chloride), and trichlorofluoromethane (freon) were identified in a number of samples at concentrations consistent with sampling or analysis contamination. Figures 7-5 and 7-6 illustrate VOC, SVOC, and TPHC concentrations in surface and subsurface soils at AOC 69W.

A number of SVOCs were identified in both surface and subsurface soils at AOC 69W. The highest observed concentrations of the PAHs were observed in subsurface soils immediately adjacent to the school building near the new boiler room and in surface soils in the grassy area north of the school. The 7 feet bgs sample from the soil boring ZWB-95-01X contained 149 μg/g of total SVOCs including 80 μg/g of 2-methylnaphthalene and 40 μg/g of naphthalene; this location was removed as part of the remedial action. The highest observed total SVOC concentration in surface soil, 31 μg/g, was found in ZWS-95-39X. SVOC concentrations appear to be coincident with the pipe leading from the school to the 250 gallon UST.

TPHC were detected in seventeen of the samples collected for off-site analysis. As with the other compounds the highest observed concentrations were found adjacent to the school. The soil boring ZWB-95-01X was shown to contain 14,400 μg/g of TPHC at 7 feet bgs and the TerraProbe^{SM} point ZWR-95-30X contained 3,240 μg/g at 6 feet bgs. Other notable concentrations (e.g., in excess of 500 μg/g) include 661 μg/g in the surface sample from ZWB-95-01X, 1,390 μg/g in the 5 feet bgs sample from ZWB-95-02X, 902 μg/g in the 7 feet bgs sample from ZWR-95-26X, 566 μg/g in the 7 feet bgs sample from ZWR-95-36X, 1,400 μg/g in the 4 feet bgs sample from ZWR-95-37X, 936 μg/g in surface soil sample ZWS-95-35X, and 652 μg/g in surface soil sample ZWS-95-46X. Most of these locations (excluding ZWR-95-26X, ZWS-95-35X, and ZWS-95-46X) were removed during the soil removal action in 1998. In general, the highest observed TPHC concentrations in soil were located at the water table.

1996 Monitoring Well Boring and Soil Boring Soil Sample Analytical Results. Data from the 1995 RI field investigation suggested that contamination existed underneath the school building. As a result, additional investigation was performed in August of 1996. One soil boring (ZWB-96-03X) and one monitoring well (ZWM-96-21X) were installed in the school courtyard, and a monitoring well was installed in each of the school's two boiler rooms (ZWM-96-19X and ZWM-96-20X). A total of nine soil samples were collected from these explorations and analyzed at off-site laboratories for EPH/VPH parameters, TPHC, and TOC. Analytical data for the 1996 samples are provided in Tables 7-11 and 7-12.

EPH/VPH analysis of the samples yielded one detection. The 9 feet bgs sample from ZWM-96-19X contained an equivalent concentration of 150 μg/g of total EPH compounds. Identification of the aliphatic concentrations showed 560 μg/g of the n-C 9 to n-C 18 range and 110 μg/g of the n-C 19 to n-C 36 range. Aromatics in the n-C 10 to n-C 22 range were identified at 120 μg/g. None of the targeted PAHs were detected above the reporting limits. VPH analysis showed the same sample to contain 4,100 μg/kg of VPH compounds, including 270 μg/kg of the n-C 5 to n-C 8 aliphatic range, 8,300 μg/kg of the n-C 9 to n-C 12 aliphatics, and 3,500 μg/kg of the n-C 9 to n-C 10 aromatics. Likewise, none of the targeted VOCs were detected above RLs.

Two of the four soil samples contained detectable levels of TPHC. The 9 feet bgs sample from the new boiler room exploration ZWM-96-19X contained 1,740 μg/g of

TPHC and the 6 feet bgs sample from ZWB-96-03X, located in the courtyard, contained 57.5 μg/g.

7.2.2.3 Remedial Action Off-Site Soil Analytical Results. Based on a review of the analytical data from the RI, a remedial action was implemented at AOC 69W in the winter of 1997 and 1998 to remove the contaminated soil associated with the 1972 fuel leak and downgradient piping. A total of 31 soil samples were collected from the walls and floor of the excavation, and were analyzed at an off-site laboratory for EPH/VPH parameters to confirm that the remaining soil concentrations were generally consistent with or lower than the MCP S-1/GW-1 soil standards. Analytical data for the remedial action subsurface soil samples are provided in Table 7-13, and are shown in Figures 7-7 (east and west) and 7-8.

EPH/VPH analysis of the samples yielded the highest contaminant concentrations in the southernmost portion of the excavation, adjacent to the elementary school. Concentrations of n-C 9 to n-C 18 aliphatic EPH range, n-C 11 to n-C 22 aromatic EPH range, n-C 9 to n-C 10 aromatic VPH range, and of the individual PAHs 2-methylnaphthalene and napthalene exceed their MCP S-1/GW-1 standards in the sample locations along the southern wall of the excavation (69W-HS-SSW-1, 69W-HS-SSW-2, 69W-HS-OB-15, and 69W-HS-FL-2). MCP S-1/GW-1 standards were also slightly exceeded for the n-C 11 to n-C 22 aromatic EPH range at 69W-HS-WSW-3 (in the northern portion of the excavation), and for the n-C 9 to n-C 18 aliphatic VPH range at 69W-V-WSW-1 and 69W-V-ESW-1 (in the northwestern portion of the excavation, near the 250 gallon UST).

The 11 feet bgs sample from 69W-HS-FL-2 contained the highest EPH/VPH results, with the n-C 9 to n-C 18 aliphatic EPH range at 10,000 μg/g, the n-C 19 to n-C 36 aliphatic EPH range at 1,200 μg/g, the n-C 10 to n-C 22 aliphatic EPH range at 2,300 μg/g, the n-C 9 to n-C 12 aliphatic VPH range at 1,300 μg/kg, and the n-C 9 to n-C 10 aromatic VPH range at 960 μg/kg. Target PAHs at 69W-HS-FL-2 were detected at 177 μg/g, and target VOCs were not detected at all.

Target PAHs at 69W-HS-SSW-2, 69W-HS-OB-15, and 69W-HS-SSW-1 were detected at 93, 50, and 98 μg/g, respectively. Target PAHs were also detected between 1 and 10 μg/g at 69W-HS-FL-1, 69W-HS-WSW-3, 69W-PL-FL-6, and 69W-HS-NWS-1; however, none of the individual PAH concentrations exceeded MCP S-1/GW-1 standards at these locations. Target PAHs were less than detection limits at all other locations, and target VOCs were less than detection limits at all sample locations.

EPH/VPH concentrations in the 9 foot bgs sample for ZWM-96-19X, located in the new boiler room upgradient of the excavation, were lower than the EPH/VPH concentrations in the samples from the south wall of the excavation.

7.2.2.4 Summary of Soil Impacts. A review of the field and off-site analytical data from the 1995 and 1996 RI field investigations indicated that there were two areas of fuel related soil contamination at AOC 69W. The larger area extended from the new boiler room to the 250 gallon UST in the wooded area approximately 300 feet northwest of the school. The contamination was attributed to the 1972 release of fuel oil from piping between the 10,000 gallon UST and the new boiler room. Analytical data and visual evidence suggested that the release may have been inside or near the new boiler room. As a result of the release a "skimmer system" was installed in 1972 to remove oil from the source area and presumably from near surface soils in the grassy area north of the school. Contaminant distributions indicated that the underground piping associated with this system may have acted as a conduit for contaminant migration. Detected contaminants were primarily TPHC, PAHs, and EPH/VPH at approximately 6 to 10 feet bgs adjacent to the school and 0 to 4 feet bgs downgradient in the grassy area and vicinity of the 250 gallon UST. Observed subsurface contaminants were identified primarily at or near the water table. Surficial contamination downgradient of the school (in the vicinity of Willow Brook) is attributed to sorption during times of high water levels.

Based on the nature and distribution of contaminants, a remedial action was undertaken in the winter of 1997 and 1998 to remove contaminated soil associated with the 1972 release; soil was excavated and removed to a maximum depth of 13 feet bgs near the school, and 8 feet bgs near the 250 gallon UST. Confirmatory subsurface soil sample results from the remedial action suggest that concentrations of fuel-related contaminants still exceed MCP S-1/GW-1 standards immediately adjacent to the elementary school, but are generally low in downgradient areas (only a few concentrations in soil slightly exceeded MCP S-1/GW-1 standards).

The other identified area of soil contamination is located adjacent to the school building outside of the old boiler room. This contamination is attributed to the 1978 release of fuel oil due to ruptured piping. An excavation at the time of the release showed visible fuel oil contamination emanating from underneath the school.

Analytical data indicate that the contaminants are primarily TPHC at depths of 4 to 7 feet bgs beneath the paved parking lot. Contaminants appear to be localized in the area immediately adjacent to the school. Based upon the absence of site-related contaminants in downgradient soils (e.g., ZWR-95-27X, ZWR-95-54X, and ZWR-95-55X), future migration is not likely as the area is paved, thereby, inhibiting leaching of soils via precipitation.

7.2.3 AOC 69W RI Groundwater Results

The following discussion of groundwater sampling includes field analytical results of water samples collected from TerraProbe^{SM} borings in 1995 as well as the off-site laboratory analytical results for the four rounds of RI groundwater sampling (two rounds in conjunction with the 1995 field effort, and two rounds of low-flow sampling as part of the 1996 and 1997 field efforts).

7.2.3.1 RI Field Analytical Groundwater Results. A total of 29 groundwater samples were collected from the TerraProbe^{SM} points and analyzed in the field for BTEX, select VOCs, and GRO for select samples. Data were used to delineate horizontal contaminant distribution and confirm placement of monitoring well locations. Field analytical results are provided in Table 7-14 and Figure 7-9.

Seven samples contained one or more of the fuel-related contaminants chlorobenzene, ethylbenzene, and xylenes. The majority of detections were from TerraProbe^{SM} points adjacent to the north side of the school building, including the highest observed concentrations of ethylbenzene (73 μg/L) and xylene (120 μg/L) in ZWR-95-28X. Xylenes were also found in two samples from TerraProbe^{SM} points ZWR-95-37X and ZWR-95-45X at concentrations of 7 μg/L and 7.3 μg/L, respectively. These explorations were located in the vicinity of the 250 gallon underground storage tank. The only other VOCs detected in groundwater samples were 1,1,1-TCA at 7 μg/L in ZWR-95-27X, and 5.1 μg/L of 1,1,1-TCA and 12 μg/L of TCE in ZWR-95-33X. Both of these explorations are located adjacent to the school building near the TPHC contamination attributed to the 1978 fuel oil release from the old boiler room.

7.2.3.2 RI Groundwater Off-Site Laboratory Analytical Sample Results.

Round 1 (November 1995) and Round 2 (February 1996) Groundwater Sampling. As part of the RI field investigation HLA installed four monitoring wells at Area 2 in 1995 (ZWM-95-15X, ZWM-95-16X, ZWM-95-17X, and ZWM-95-18X) to supplement the six existing AREE 69W monitoring wells (69W--94-09, 69W--94-10, 69W--94-11, 69W--94-12, 69W--94-13, and 69W--94-14) (Figure 5-3). Two rounds of groundwater sampling were conducted on all of the monitoring wells (except for 69W--94-09) between Rounds 1 and 2. Groundwater samples were analyzed for PAL VOCs, SVOCs, total and filtered PAL inorganics, pesticides/PCBs, TPHC, TDS, and water quality parameters. Analytical results for the Round 1 and Round 2 sampling events are provided in Table 7-15 and Figure 7-10 (TPHC results only).

Several inorganic analytes were detected above the calculated Devens background concentrations in groundwater. Arsenic, calcium, iron, manganese, potassium, and sodium were detected above background in the filtered samples. All of the above inorganic analytes as well as copper were detected above background in one or more of the unfiltered samples. The greatest numbers of background exceedances in both Rounds 1 and 2 were observed in samples from monitoring wells 69W--94-10 and 69W--94-13; soil from around these monitoring wells were removed as part of the soil removal action. These were also the only wells to have inorganics concentrations in excess of MCLs. The arsenic concentrations in 69W--94-10 in both the filtered and unfiltered samples ranged between 150 μg/L and 180 μg/L while the arsenic concentrations in the Round 1 and Round 2 samples from 69W--94-13X ranged between 260 μg/L (Round 1 unfiltered) and 110 μg/L (Round 2 filtered). The arsenic is believed to be due to reducing conditions in the aquifer and the reducing conditions are attributed to the aerobic degradation of the fuel oil contamination.

The most commonly detected VOCs were the fuel related compounds toluene, ethylbenzene, and xylenes. One or more of these compounds were found in eight of the monitoring wells (69W--94-10, 69W--94-12, 69W--94-13, 69W--94-14, ZWM-95-15X, ZWM-95-16X, ZWM-95-17X, and ZWM-95-18X). Monitoring wells 69W--94-10, 69W--94-12, and 69W--94-14 were the only wells to have detections of the above compounds in both Rounds 1 and 2. The maximum concentrations of these compounds were observed in 69W--94-10, 18.4 μg/L in the Round 1 sample comprised of toluene, ethylbenzene, and xylenes, and 20 μg/L in the Round 2 sample comprised entirely of ethylbenzene. As previously mentioned, the soils from around

69W--94-10 were removed during the removal action.

The chlorinated VOCs 1,1,1-TCA and TCE were detected in the Round 1 sample from 69W--94-11 at 1.5 μg/L and 3.3 μg/L respectively. TCE was also observed at 1.2 μg/L in the Round 1 sample from ZWM-95-16X. TCE and 1,1,1-TCA were not detected in any of the Round 2 samples. Chloroform was detected in the Round 1 samples from 69W--94-12 and 69W--94-13 at 0.55 μg/L and 1.1 μg/L, respectively. Acetone, the only other VOC detected, was present in three of the samples at concentrations consistent with laboratory or sampling contamination.

The majority of Round 1 and Round 2 SVOC compounds were detected in the monitoring wells 69W--94-10 and 69W--94-13, which were both removed as part of the soil remedial action. 69W--94-10 was shown to contain 1,380 μg/L of SVOCs in Round 1 and 1,500 μg/L of SVOCs in Round 2. Comprising the total concentrations were 2-methylnaphthalene at 500 μg/L (Round 1) and 600 μg/L (Round 2), fluorene at 80 μg/L (Round 1 only), naphthalene at 200 μg/L (Rounds 1 and 2), phenanthrene at 100 μg/L (Round 1) and 200 μg/L (Round 2), and bis(2-ethylhexyl) phthalate at 500 μg/l (Rounds 1 and 2). 69W--94-13 contained considerably less total SVOCs at 32 μg/L and 29 μg/L for Rounds 1 and 2.

The Round 2 sample from 69W--94-10 was shown to contain 0.115 μg/L of gamma chlordane and 0.059 μg/L of heptachlor epoxide. This was the only sample shown to contain pesticides. None of the Rounds 1 or 2 groundwater samples contained detectable levels of PCBs.

69W--94-10 was the only monitoring well to contain TPHCs in both the Round 1 and Round 2 samples, 159,000 μg/L and 228,000 μg/L respectively. Analysis of the Round 1 sample from 69W--94-11 indicated that TPHC concentrations were below the detection limit. A duplicate sample was collected from this well during the Round 2 sampling event. The original sample was shown to contain 2,420 μg/L of TPHC, but the TPHC concentration in the duplicate was below the detection limit. Similar results were seen in samples from other wells. The Round 1 samples from 69W--94-13 (523 μg/L), 69W--94-14 (1,960 μg/L), ZWM-95-15X (281 μg/L), and ZWM-95-16X (1,340 μg/L) all contained TPHC while all of the Round 2 samples were below detection levels.

It should be noted that for all the samples the total suspended solids decreased dramatically, over an order of magnitude for most samples, from Round 1 to Round 2.

Round 3 (September and October 1996) Low-Flow Groundwater Sampling. Groundwater samples were collected from six monitoring wells as part of the 1996 field effort to delineate potential source areas. The monitoring wells were sampled following USEPA low-flow (minimum stress) purging and sampling protocols (USEPA, 1996). Sampled wells included the three newly installed courtyard and boiler room monitoring wells (ZWM-96-19X, ZWM-96-20X, and ZWM-96-21X) as well as the existing monitoring wells 69W--94-10, 69W--94-11, and ZWM-95-16X. Existing wells were chosen based upon their proximity to suspected source areas and results from Rounds 1 and 2 sampling. Groundwater samples were analyzed for EPH/VPH, TPHC (Method 418.1), water quality parameters, TDS, and TOC. Total concentrations for EPH/VPH compounds are reported as equivalent concentrations while aliphatic ranges, aromatic ranges, and targeted analytes are reported as actual measured concentrations. Analytical results for the Round 3 groundwater sampling are provided in Tables 7-15 and 7-16. Figure 7-10 provides a comparison of all TPHC (Rounds 1, 2, and 3) and EPH/VPH data.

Three of the monitoring wells contained measurable levels of VPH. 69W--94-10, which was removed as part of the soil remedial action, exhibited the highest concentration of total VPH at 830 μg/L. The total concentration consisted of 17 μg/L of the n-C 5 to n-C 8 aliphatics, 550 μg/L of the n-C 9 to n-C 12 aliphatics, and 790 μg/L of the n-C 9 to n-C 10 aromatic range. This sample also contained the only detections of targeted VOCs: 35 μg/L of ethylbenzene and 94 μg/L of naphthalene. EPH compounds were only detected in 69W--94-10. Total EPH compound concentrations were 740 μg/L comprised of 590 μg/L of the n-C 9 to n-C 18 range aliphatics and 710 μg/L of the n-C 10 to n-C 22 range aromatics. Targeted PAH (SVOC) analytes consisted of 89 μg/L of 2-methylnaphthalene, 45 μg/L of naphthalene, and 15 μg/L of acenaphthene. These concentrations in groundwater, which likely reflect soil contamination, have been mitigated by the soil removal around 69W--94-10.

The monitoring well installed in the new boiler room, ZWM-96-19X contained 47 μg/L of VPH compounds. Components of the total VPH concentration consisted of 34 μg/L of the n-C 9 to n-C12 aliphatic range and 45 μg/L of the n-C 9 to n-C10 aromatic range. A duplicate sample from ZWM-96-19X substantiated these results. VPH compounds were also detected in ZWM-95-16X located adjacent to the school outside of the old boiler room. Total VPH compounds were 7 μg/L consisting entirely of the n-C 9 to n-C 10 aromatic range.

TPHCs were below detection limits in all of the Round 3 samples. Total suspended solids in the Round 3 samples were comparable to the Round 2 levels with a maximum concentration of 37,000 μg/L in 69W--94-10.

Round 4 (December 1997) Low-Flow Groundwater Sampling. Groundwater samples were collected from thirteen monitoring wells as part of the 1997 field effort to further characterize potential contamination in groundwater. The monitoring wells were sampled following USEPA low-flow (minimum stress) purging and sampling protocols (USEPA, 1996). Sampled wells included the three courtyard and boiler room monitoring wells (ZWM-96-19X, ZWM-96-20X, and ZWM-96-21X) and the monitoring wells located upgradient and downgradient of the elementary school (69W--94-09 through 69W--94-14, and ZWM-95-15X through ZWM-95-18X). Subsequent to the fourth round of groundwater sampling, soil from around four monitoring wells (ZWM-95-15X, 69W--94-10, 69W--94-11, and 69W--94-13) was removed as part of the soil removal action. Two monitoring wells (69W--94-10 and 69W--94-11) were also removed.

Groundwater samples were analyzed for EPH/VPH (with target PAHs and VOCs), target VOCs by Method 8260, and target PAHs by Method 8270. Aliphatic ranges, aromatic ranges, and targeted analytes measured by EPH/VPH are reported as actual measured concentrations. Analytical results for the Round 4 groundwater sampling are provided in Tables 7-15 and 7-16. Figure 7-11 presents the results of the 1997 EPH/VPH, VOC, and PAH groundwater results.

Three of the monitoring wells contained measurable levels of VPH. 69W--94-10 and 69W--94-13 exhibited the highest n-C 9 to n-C 12 aliphatic ranges (120 and 140 μg/L, respectively), and the highest n-C 9 to n-C 10 aromatic ranges (430 and 330 μg/L, respectively). These samples also contained the only targeted VOCs by VPH (ethylbenzene and naphthalene), and VOCs by Method 8260 (ethylbenzene). The concentrations of n-C 9 to n-C 10 aromatic VPHs and naphthalene (targeted VOC) exceed the MCP GW-1 standard in both wells. As previously mentioned, soil from around these two monitoring wells was removed as part of the soil removal action in 1997 and 1998. ZWM-95-16X, located adjacent to the school outside of the old boiler room, contained 75 μg/L of the n-C 9 to n-C 10 aromatic VPH range; however, no target VOCs by VPH, or VOCs by Method 8260 were detected.

EPH compounds were detected in several of the monitoring wells, including 69W--94-10, 69W--94-11, 69W--94-13, 69W--94-14, and ZWM-95-15X (all located within or near the area of the soil remedial action). The n-C 9 to n-C 18 aliphatic EPHs ranged from 32 to 84 μg/L, and the n-C 11 to n-C 22 aromatic EPHs ranged from 84 to 480 μg/L in these well. The MCP GW-1 standard for n-C 11 to n-C 22 aromatic EPHs was exceeded by concentrations detected in 69W--94-10 and 69W--94-13. Targeted PAH (SVOC) analytes detected in monitoring wells include 2-methylnaphthalene, acenaphthene, acenaphthylene, fluoranthene, and naphthalene. SVOCs (by Method 8270) were also detected in two of the wells (69W--94-10 and 69W--94-13), including 2-methylnaphthalene, naphthalene, fluorene, and phenanthrene. The concentrations of 2-methylnaphthylene in both wells, and the concentration of naphthalene in 69W--94-10 exceed the MCP GW-1 standards for target PAHs by EPH and for PAHs by 8270.

7.2.3.3 Summary of Groundwater Impacts. Fuel-related VOCs, SVOCs, TPHC, and inorganics comprise the observed groundwater contaminants at AOC 69W. Varying degrees of groundwater contamination, as identified by field and off-site analysis, were observed to extend from the new boiler room towards the 250 gallon UST located approximately 300 feet to the northwest. The area of groundwater contamination was coincident with the underground pipe associated with the "skimmer system" installed in response to the 1972 fuel oil release. Contaminant concentrations were highest between the new boiler room and monitoring well 69W--94-13, which was also the area of highest observed soil concentrations. The soil around several monitoring wells that exhibited the highest chemical concentrations was removed during the soil removal action (including 69W--94-10 and 69W--94-13).

Arsenic, calcium, iron, manganese, potassium, and sodium were detected in filtered samples at levels in excess of calculated Devens background levels. The greatest number of background exceedances in Rounds 1 and 2 were observed in monitoring wells 69W--94-10 and 69W--94-13. Contaminated soils surrounding these wells were removed during the soil removal effort.

There does not appear to be any significant groundwater contamination associated with the 1978 fuel oil release in the vicinity of the old boiler room. Low levels of chlorinated VOCs were detected during the 1995 field analysis and Round 1 groundwater sampling; however, there were no chlorinated VOCs detected during the Round 2 groundwater sampling effort.

TPHC data (by Method 418.1) from groundwater samples is highly variant from round to round and even between samples and duplicates. The most reasonable explanation is a methodology problem during IR analysis, as the EPH/VPH analyses do not show the same variations. A data quality review could not substantiate this hypothesis.

7.2.4 AOC 69W RI Sediment Results

Sediment samples were collected from six locations within Willow Brook in the vicinity of AOC 69W (Figure 5-3): ZWD-95-01X, ZWD-95-02X, ZWD-95-03X, ZWD-95-04X, ZWD-95-05X, and ZWD-95-06X. Surface sediment samples (0 to 6 inches bgs) were collected at every location, and deep sediment samples were collected from 2 to 2.5 feet bgs at ZWD-95-01X, ZWD-95-02X, and ZWD-95-03X. All of the sediment samples were analyzed for PAL VOCs, SVOCs, inorganics, pesticides, PCBs, TPHC (Method 418.1), petroleum fingerprinting, and TOC. Analytical data are provided in Table 7-17 and Figure 7-12. Willow Brook was dry at the time of RI sediment sampling.

There is no established set of background concentrations for sediments at Devens; therefore, inorganics concentrations in sediments were compared to background concentrations in soils. The inorganic analytes arsenic, calcium, chromium, cobalt, and manganese were all detected at levels in excess of established Devens background concentrations for soil. The greatest number of background exceedances were observed in the surface and 2 feet bgs samples from the upgradient sampling point ZWD-95-01X.

The only observed VOCs were the common laboratory and sampling contaminants dichloromethane (methylene chloride) and trichlorofluoromethane (freon). Observed concentrations of these analytes in the sediment samples were consistent with laboratory and/or sampling contamination.

SVOC compounds were observed in all but one of the RI sediment samples. The maximum observed concentration of total SVOCs (27.7 μg/g) was observed in the 2 feet bgs sample from ZWD-95-02X. This sample also contained the maximum observed concentrations of all but one (benzo[k]fluoranthene) of the individual SVOCs. This sample is located in Willow Brook adjacent to the 250 gallon UST. The surface sample from this location was the only sample without detectable levels of SVOCs. The second highest concentration of total SVOCs (11 μg/g) was observed in the 2 feet bgs sample from the downgradient sampling point ZWD-95-03X. Both upgradient and downgradient surface sediment samples were shown to contain similar levels of SVOCs. Of the eight SVOCs observed in AOC 69W groundwater, only one (phenanthrene) was detected in sediment samples.

Pesticides were also detected in all but one of the RI sediment samples. The highest levels of total pesticides, as well as the highest individual concentrations, were found in the upgradient surface sediment sample ZWD-95-05X. This sample was found to contain 2.1 μg/g of 4,4'-DDD, 0.081 μg/g of 4,4'-DDE, 0.4 μg/g of 4,4'-DDT, 0.013 μg/g of alpha chlordane, 0.024 μg/g of gamma chlordane, 0.06 μg/g of Dieldrin, and 0.05 μg/g of Endosulfan II. This was also the only sample to contain these last four pesticides. The only sample in which pesticides were not detected was the 2 feet bgs sample from ZWD-95-02X. The lack of detections at depth, and the preponderance of high pesticides concentrations bordering the maintained lawn suggests that the pesticides are not site related.

The surface sample from ZWD-95-05X was the only sample to contain PCBs. Aroclor-1260 was detected at 0.51 μg/g.

The three highest concentrations of TPHC were observed in the upgradient surface samples: ZWD-95-05X (1,230 μg/g), ZWD-95-01X (896 μg/g), and ZWD-95-04X (386 μg/g). The highest concentration of TPHC in the downgradient samples, 287 μg/g, was observed in ZWD-95-06X. Petroleum fingerprinting indicated that the TPHC detections were comprised primarily of gasoline and diesel patterns. For much of its course, Willow brook is bordered by a maintained lawn adjacent to MacArthur Avenue. The elevated TPHC concentrations at the upgradient locations are likely attributable to refueling and operation of lawn care equipment. In addition, the stream bed is lined with chunks of asphalt.

7.2.5 AOC 69W RI Air Sampling Results

As discussed in Subsection 5.4.10, indoor air sampling was completed in October of 1997 at the Devens Elementary School to determine if fuel-related contaminants in soil and groundwater beneath the school contribute to ambient contaminant levels in the school. The off-site analytical results are summarized in Table 7-18, and a complete report of activities and sample data are included in Appendix M. Air sample locations and results are shown in Figure 7-13.

Acetone, toluene, and xylene were detected in one or more of the quality control blank samples associated with the data set indicating potential for false positive contamination. For some samples, results were qualified non-detect "U" in accordance with USEPA Region I guidelines. The analytical results for ZWA-92-04X have been rejected because the sample vacuum was lost during the sampling period.

A well headspace sample (ZWA-97-09X) was collected from ZWM-95-19X on October 14, 1997, to confirm the fingerprint of soil vapor contamination, and to refine the analyte list for the air sampling program. Chemical results for this sample indicate the presence of tetrachloroethylene (360 micrograms per cubic meter [$\mu g/m^3$]) in soil gas from beneath the new boiler room. Tetrachloroethylene was included in the air sampling program, but was not detected in any other air samples, including samples collected from the dirt-floored crawlspace beneath the kitchen and cafeteria (i.e., the areas most likely to be affected by subsurface contamination).

Samples collected from the crawlspace beneath the kitchen (ZWA-97-06X) and the cafeteria (ZWA-97-05X) contained toluene (150 and 13 $\mu g/m^3$, respectively). The sample from beneath the kitchen also contained xylene (18.3 $\mu g/m^3$), octane 5.5 ($\mu g/m^3$), and ethylbenzene (5.2 $\mu g/m^3$).

The three outdoor background samples, ZWA-97-11X, ZWA-97-12X, and ZWA-97-13X, also contained toluene; the results for ZWA-97-12X and SWA-97-13X are "U" qualified because they were also detected in the blank. The indoor background sample, ZWA-97-07X, had detectable levels of six compounds, including xylene (24.8 $\mu g/m^3$), 2-methylheptane (7.2 $\mu g/m^3$), 3-methylheptane (8.9 $\mu g/m^3$), ethylbenzene (9.9 $\mu g/m^3$), nonane (5 $\mu g/m^3$), and octane (9.1 $\mu g/m^3$). Toluene was qualified "U" non-detected during validation. This indoor background sample contained all compounds detected in air samples from the site.

Samples from within the school contained anywhere from three compounds (ZWA-97-08X, from the room adjacent to the new boiler room) to eight compounds (ZWA-97-03X, from a room near the old boiler room in the northeast corner of the school). In general, compound concentrations were consistent throughout the school, and were of the same magnitude as those in the indoor background sample. The only notable detection was toluene (1,000 $\mu g/m^3$) in sample ZWA-97-03X, which exceeds available inhalation toxicity values. All other detections are less than the inhalation toxicity values.

The results of the air sampling program suggest that there are low levels of alkanes and aromatic hydrocarbons in the elementary school air samples that are generally consistent with background levels of these chemicals in air.

8.0 CONTAMINANT FATE AND TRANSPORT

This subsection discusses the migration potential and probable environmental fate of general contaminant groups identified at AOC 69W. Compounds and analytes detected include VOCs, SVOCs, inorganics, and TPHC. The observed distribution of these contaminants in different environmental media (soil, groundwater, and sediment) is the result both of the release pattern and of their physical and chemical properties. For organic chemicals, these properties include specific gravity, solubility, volatility, and organic carbon partition coefficient (K_{oc}). For inorganic constituents, the physical and chemical properties include oxidation state of the analyte, pH, and specific solute species. Site-specific conditions governing fate and transport (e.g., persistence and migration) of analytes include contaminant concentration, topography, meteorological conditions, and in the case of groundwater, hydrogeology.

8.1 COMPOUND PROPERTIES AND TRANSPORT PROCESSES

The primary contaminants detected in soil at AOC 69W are fuel-related VOCs, SVOCs, and TPHC. In addition, some VOCs and SVOCs may have been introduced in samples as laboratory contamination.

The persistence of compounds in soil is determined by chemical properties, source configurations and releases, geochemical and biochemical reactions, and soil and meteorological conditions. Factors and processes that control the persistence of chemicals in water-bearing units, in addition to the aforementioned factors, are water-bearing unit characteristics, advection, and hydrodynamic dispersion. Compounds may exist in the surface and subsurface in gaseous, aqueous, or solid phases. The fate of these compounds is controlled by a combination of all of these factors.

The following subsections discuss general physical and chemical properties, and how these properties affect transport and general attenuation processes.

8.1.1 Physical and Chemical Properties Significant to Fate and Transport

This subsection discusses the physical and chemical properties that affect the fate and transport of contaminants in the environment. Physical and chemical properties of organic contaminants of concern detected at AOC 69W are presented in Table 8-1. Table 8-2 summarizes the relative mobilities of selected inorganic elements in different chemical environments.

Most physical and chemical properties of PAL analytes, including specific gravities, K_{oc}, relative solubility, and relative volatility, are described in "Basics of Pump-and-Treat Groundwater Remediation Technology" (USEPA, 1990b). This reference document does not include inorganics, because analyses conducted measure the total amount of a particular constituent in the sample rather than the actual chemical form or metal oxidation state. The distribution of specific solute species, pH, and oxidation are important factors in establishing the total solubility or mobility of a given inorganic element.

Specific gravity is the ratio of the mass of a given volume of a liquid substance to the mass of an equal volume of water. Liquids with specific gravities greater than 1 are termed "heavier" than water.

Solubility measures the partitioning between the aqueous phase and solid form of a chemical, and the tendency of a material to dissolve in water. Substances with lower solubilities are more likely to remain in a separate phase when in contact with water; substances with higher solubilities will dissolve into, and move with, water.

Volatility measures the tendency of a chemical to partition into the gaseous phase. Volatility can be predicted by an analyte's vapor pressure and Henry's Law Constant value (H_c). Volatility of a compound increases with increasing vapor pressure. Compounds with H_c values less than $1.0\text{x}10^{-5}$ (e.g., pyrene) have a low degree of volatility, and those with H_c values below $3.0\text{x}10^{-7}$ are considered non-volatile. H_c values between $1.0\text{x}10^{-5}$ and $1.0\text{x}10^{-3}$ (e.g., naphthalene and phenanthrene) are moderately volatile, while those with values exceeding $1.0\text{x}10^{-3}$ (e.g., VOCs) are considered highly volatile.

K_{oc} measures the extent that an organic chemical partitions between a solid phase and a liquid phase, and is used to predict to what extent a chemical could be adsorbed to soil organic carbon. Chemicals with a K_{oc} greater than 10,000 will adsorb strongly to soil organic carbon (e.g., fluoranthene, phenanthrene, and pyrene) Chemicals with a K_{oc} ranging from 1,000 to 10,000 will moderately adsorb, and move slowly in the soil profile (e.g., naphthalene). Chemicals with a K_{oc} of less than 1,000 weakly adsorb to soil organic carbon and tend to be more mobile. Examples of weakly adsorbed compounds include many VOCs such as benzene and xylene.

8.1.2 General Transport and Attenuation Processes

Migration and persistence are controlled by various transport and attenuation processes. Processes that tend to disperse contaminants include surface water and groundwater movement (which includes the movement of dissolved and suspended contaminants), facilitated transport, leaching by dissolution or desorption, and surface erosion.

The solubility of a compound in water is considered to be the most important transport factor, because it determines the maximum concentration dissolved in water. Knowledge of the solubility of a chemical provides considerable insight into the fate and transport of that chemical. In general, highly soluble compounds are less likely to partition into soil or sediment, or to volatilize from water, and are more likely to biodegrade (Montgomery, 1991).

Dissolved phase transport can occur via two processes: advection or dispersion. Advection involves transport with flowing groundwater and migrating with the mean velocity of the solvent (groundwater plus dissolved compounds). When compounds move through the ground by advection, they are subject to spreading within the ground, which allows compounds with little or no affinity for soils to migrate faster than the mean groundwater velocity. This spreading is the result of a process known as dispersion. Hydrodynamic dispersion has two components: molecular diffusion and mechanical dispersion (USEPA, 1989a). Diffusion is the process by which ionic or molecular constituents move under the influence of concentration gradients. Mechanical dispersion occurs as the groundwater flows through the media, and compounds spread out through the tortuous pathways of the soil matrix, and mix with clean water. The result is a dilution of the compound by a process known as dispersion (Fetter, 1988). At very low groundwater velocities, diffusion is the dominant process; at higher velocities, mechanical dispersion is the dominant process. Dispersivity is dependent on vertical and horizontal permeability variations, increasing with the degree of heterogeneity and anisotropy, and is dependent on whether flow is principally through porous media or nonporous media (e.g., fractured bedrock) (Walton, 1988).

The rate a compound migrates can be influenced by facilitated transport, which is the combined effects of physical, chemical, and/or biological phenomena that act to increase mobility. Examples of facilitated transport include particle transport, cosolvation, and phase shifting (Keely, 1989).

Particle transport involves the movement of small, solid-phase particles (such as inorganic and organic colloids), macromolecules, or emulsions to which compounds have adhered by sorption, ion exchange, or other means. High molecular weight organic compounds such as PAHs, pesticides, and heavy metals, have a high affinity for mobile subsurface particles, and this affinity increases their mobility (Huling, 1989). Small particles, especially mobile organic carbon phase particles such as biocolloids and macromolecules (e.g., humic substances) are transported in the aqueous phase and may act as mobile sorbents. PAHs and pesticides were detected at AOC 69W.

Cosolvation is the process by which the solubility and mobility of one compound is increased by the presence of another (Keely, 1989). Naturally occurring organic compounds (e.g., humic acids) can undergo complexation reactions with metals and pesticides. Complexation reactions can increase the solubility of metals (including iron, aluminum, copper, nickel, and lead) and pesticides (e.g., DDT). In a cosolvent system, as the fraction of a water-miscible cosolvent increases, the solubilities of the metals or pesticides increase. However, the cosolvent concentration normally needs to be high to ensure a substantial increase in solute velocity. Therefore, cosolvation is important primarily near sources of groundwater impact (USEPA, 1989a). High concentrations of water-miscible phases (e.g., ketones) were not detected at AOC 69W.

Chemical phase shifts involve changes in pH and/or the redox potential of the groundwater. These shifts can increase solubilities and mobilities by ionizing neutral organics, solubilizing precipitated metals, forming complexes, or limiting biological activity (Keely, 1989). These processes are particularly important in determining the mobility of heavy metals.

Processes that tend to attenuate migration of impacted groundwater include retardation resulting from sorption, volatilization, degradation, and precipitation. The sorption properties of individual solutes are dependent on soil and groundwater characteristics. In general, the relative amount of sorption by soil or sediment materials that do not contain organic matter is as follows: clay > silt > sand > gravel (Walton, 1988). The soil beneath AOC 69W is a silty sand to sand. Sorption would be expected to exert a moderate to minimal influence in retarding the migration of fuel-related VOCs and SVOCs in the soil.

The tendency of organic chemicals to be sorbed is also dependent on the organic content of the soil and the degree of hydrophobicity (lack of affinity for water) of the solute (contaminant). The rate of travel for each chemical depends on the groundwater seepage velocity and the degree of sorption. If an organic chemical is extensively adsorbed by particles, it will be rendered relatively immobile. The rates and degree of volatilization, photolysis, hydrolysis, and biodegradation are directly dependent on the extent of adsorption (Montgomery, 1991). The vadose zone typically contains greater amounts of organic material and metal oxides (which may also act as sorbents) than the saturated zone, which may make the rate of movement in the vadose zone substantially less than that in the saturated zone (USEPA, 1989a).

The soil partition or sorption coefficient (K_{oc}) is defined as the ratio of adsorbed chemical per unit weight of organic carbon to the aqueous solute concentration. The coefficient indicates the tendency of a compound to adsorb to organic carbon (degree of retardation) and, therefore, provides a means for estimation of the relative mobility of solutes (Montgomery, 1991). Mobility is a function of the relative rate of transport of a chemical versus the rate of groundwater flow. Chemicals that have relatively low mobilities (i.e., high retardation or sorption) move slowly compared to the velocity of the groundwater. Chemicals that have relatively high mobilities (i.e., low retardation or sorption) move at a rate closer to groundwater velocity. VOCs detected at AOC 69W have relatively high mobility potential, while SVOCs have moderate to high mobility potential (Table 8-1).

Volatilization is the transport of a compound from the liquid to the vapor phase and, ultimately, into the atmosphere. Volatilization rates are affected by soil properties, vapor pressure, temperature, and sorption. VOCs partition between the aqueous and gaseous phase in unsaturated soils. This process will occur most readily for compounds with a high vapor pressure and a high H_c. These compounds tend to partition off into the gas phase and occupy the available soil pore space. In addition, VOCs in the saturated zone or in surface water will partition to the gaseous phase, particularly those with lower solubility (e.g., xylenes). VOCs with greater aqueous solubility (e.g., benzene) tend to remain in solution.

Volatilization is an important process in shallow soils and surface water. In recharge areas composed of sandy or gravelly soil, volatilization may be an important process, especially for compounds with moderate to high volatility (Montgomery, 1991). The effectiveness of volatilization normally decreases with depth in the soil column.

Chemicals released to the environment are susceptible to several degradation pathways, including chemical degradation (e.g., oxidation and reduction); photolysis or photochemical degradation; and biodegradation. Compounds formed by these processes may be more or less toxic and/or more or less mobile than the parent compound.

Oxidation typically involves the loss of electrons during a chemical reaction. In general, substituted aromatic compounds such as ethylbenzene and naphthalene can be oxidized. Oxidation rates for aromatic compounds are typically an order of magnitude faster than for chlorinated aliphatic compounds (e.g., 1,2-dichloroethane [1,2-DCA]). Overall, abiotic (without biological life) oxidation of organic compounds in groundwater systems is limited.

Photochemical breakdown processes involve structural changes in a molecule induced by radiation in the ultraviolet-visible light range. This process may occur in surficial soils at AOC 69W but would not affect contamination in the subsurface soils.

Biodegradation may be defined as the breakdown of organic compounds by microorganisms through metabolic processes. Variables affecting the rate of biodegradation include:

- number of microorganisms
- chemical properties, concentrations, and distribution
- presence of food and nutrients
- temperature
- pH
- moisture and oxygen content

The rate of biodegradation tends to be higher for low molecular weight compounds. Naturally occurring soil and aquatic microorganisms capable of degrading aromatic hydrocarbons (e.g., BTEX) have been studied, and a relationship between dissolved oxygen and biodegradation has been documented (Jamison, et al., 1975; and Bailey, et al., 1973). As the aromatic hydrocarbons are mobilized by dissolution from soil or sediment, they are likely to be rapidly degraded as long as microorganisms and dissolved oxygen are available. Degradation rates for fuel-related contaminants are much slower under anaerobic conditions.

8.2 FATE AND TRANSPORT OF CONTAMINANTS DETECTED AT AOC 69W

This subsection discusses the potential fate and transport of contaminants, by chemical class, detected at AOC 69W.

VOCs. Soil samples collected at or below the water table at AOC 69W contained the fuel-related VOCs TEX as well as the chlorinated aliphatics 1,1,2,2-PCA, acetone, dichloromethane, styrene, and Freon (see Table 7-12). TEX are the primary VOCs detected in groundwater samples from AOC 69W (see Table 7-15 and 7-16). Limited chlorinated aliphatics were detected in one of the Round 1 groundwater samples.

The majority of site-related VOCs detected at AOC 69W can be classified as aromatic hydrocarbons (e.g., TEX). Processes and forces that will control the fate of these VOCs include volatilization, advection/dispersion, and biodegradation.

Factors affecting VOC percolation to groundwater are density and volatility. Compounds with higher density and low volatility are most likely to be transported to groundwater.

Dissolution of VOCs from unsaturated zone soil via infiltrating precipitation may be a transport mechanism for unpaved areas at AOC 69W due to the sandy nature of the soils and the relatively shallow water table.

Volatilization is believed to be the most significant transport mechanism for VOCs in the unsaturated soils at AOC 69W. The fuel-related VOCs at AOC 69W are likely partitioning between the aqueous and gaseous phases in the source area unsaturated soils. This process occurs most readily for compounds with a high vapor pressure and a high H_c (e.g., toluene). In addition, VOCs in the saturated zone will partition to the gaseous phase, particularly those with lower solubility (e.g., TEX). As groundwater transports the fuel-related VOCs away from the source areas, the VOCs with lower solubility will partition to some extent into the gas phase and occupy the available soil pore space above the water table in the unsaturated zone. VOCs with greater aqueous solubility (e.g., benzene which was not detected at AOC 69W) tend to partition more strongly to the aqueous phase.

Dissolved phase transport of VOCs in groundwater is a significant transport mechanism at AOC 69W. Factors affecting partitioning of VOCs from soil to groundwater include solubility and K_{oc}. VOCs with high solubilities and low K_{oc}s, such as benzene, will partition to groundwater from the saturated zone soils. TEX were detected in saturated zone soils and groundwater, which is probably a result of the moderate K_{oc}s and solubilities (see Table 8-1). Processes that tend to attenuate migration of impacted groundwater at AOC 69W include retardation resulting from sorption, volatilization, and degradation.

Biodegradation reactions act to reduce the total mass of VOCs. Naturally occurring soil microorganisms capable of degrading aromatic hydrocarbons have been studied, and a relationship between dissolved oxygen and biodegradation has been documented (Jamison, et al., 1975; and Bailey, et al., 1973). As the aromatic hydrocarbons are mobilized by dissolution from the soil or sediment, they are likely to be rapidly degraded as long as dissolved oxygen and sufficient microorganisms are available.

Fuel-related VOC contaminants at AOC 69W are expected to be reduced through volatilization, biodegradation, and/or dilution and dispersion.

SVOCs. Soil samples collected at or below the water table at AOC 69W contained fuel-related SVOCs (see Table 7-12). Acenaphthene, fluorene, naphthalene, 2-methylnaphthalene, phenanthrene, and phthalates are the primary SVOCs detected in groundwater samples from AOC 69W (Table 7-15 and 7-16).

Dissolution of SVOCs from unsaturated zone soil via infiltrating precipitation may be a probable transport mechanism for unpaved areas at AOC 69W due to the sandy nature of the overburden soils.

Volatilization is a minor transport mechanism for SVOCs in the soils and groundwater at AOC 69W. The fuel-related SVOCs at AOC 69W, such as naphthalene and phenanthrene, are considered moderately volatile, and therefore volatilization is not as significant a transport mechanism as it is for VOCs.

Dissolved phase transport of SVOCs in groundwater is considered a significant transport mechanism at AOC 69W. Factors affecting partitioning of SVOCs from soil to groundwater include solubility and K_{oc}. SVOCs are generally regarded as immobile because of strong adsorption to the organic carbon fraction of soil predicted through higher K_{oc}s and low solubilities (Tinsley, 1979; Kenaga and Goring, 1978). SVOCs with moderate solubilities and moderate to high K_{oc}s, such as pyrene and phenanthrene, will partition slightly to groundwater from the saturated zone soils (see Table 8-1). Results of saturated zone soil samples and groundwater samples indicate that pyrene was not detected in groundwater; however, phenanthrene with a higher solubility than pyrene was detected in groundwater. Processes that tend to attenuate migration of impacted groundwater at AOC 69W include retardation resulting from sorption, volatilization, and degradation.

Biodegradation reactions act to reduce the total mass of lower molecular weight PAHs (e.g., naphthalene). Naturally occurring soil microorganisms capable of degrading aromatic hydrocarbons have been studied, and a relationship between dissolved oxygen and biodegradation has been documented (Jamison, et al., 1975; and Bailey, et al., 1973). As the aromatic hydrocarbons are mobilized from the soil by groundwater movement, they are likely to be degraded as long as dissolved oxygen and sufficient microorganisms are available.

The fate of fuel-related SVOC contaminants at AOC 69W is expected to be reduced through volatilization, biodegradation, and/or dilution and dispersion. The slow rate of migration (due to partitioning to soil) for the PAHs allows for significant degradation, even if degradation rates are small, before they can travel significant distances. The fuel-related PAHs also tend to be more persistent with increasing molecular weight.

Chlorinated pesticides (e.g., DDD, DDE, DDT, and dieldrin) form a small and diverse group of synthetic chemicals characterized by cyclic structures with variable numbers of chlorine atoms. Pesticides generally have low solubilities and high partition coefficients and, therefore, are usually immobile within the soil or sediment

(See Table 7-1). Most pesticides are resistant to degradation in the environment (Moore and Ramamoorthy, 1984); however, the breakdown process is relatively rapid after the halogen bond is broken. DDT converts rapidly to DDD under anaerobic conditions. DDE is the major degradation product of DDT under aerobic conditions and is believed to be produced primarily by chemical processes (Moore and Ramamoorthy, 1984). The distribution of pesticides within Willow Brook sediments suggests that they are not site related contaminants.

Inorganics. Inorganics detected at AOC 69W include metals (aluminum and lead), transition metals (iron, manganese, vanadium, chromium, cobalt, nickel, zinc, and copper), alkaline earth metals (calcium, magnesium, and barium), alkali metals (sodium and potassium), and nonmetallic elements (arsenic).

The mobility of inorganics in soil-water systems is strongly affected by compound solubility, pH, soil cation exchange capacity, soil type, oxidation-reduction potential, adsorption processes, major ion concentrations, and salinity. The distribution of inorganics would most likely be controlled by adsorption processes. Once adsorbed to soil, the inorganics may migrate with the soil by mechanical transport of particles. The migration of dissolved inorganics is dependent upon their individual adsorption characteristics (Oak Ridge National Laboratories, 1989). Mobilities of inorganic elements relative to the redox state of the environment are presented in Table 8-2. Elevated levels of iron and manganese in 69W--94-10 and 69W--94-13 is attributed to the reductive dissolution of iron and manganese oxides. The reducing conditions are attributed to the consumption of dissolved oxygen by the aerobic declaration of fuel related contaminants. This is supported by observed in-situ measurements of the oxidation reduction potential (Appendix G).

8.3 SITE CONCEPTUAL MODEL

Figure 8-1 presents a simplified site conceptual model flow chart encompassing the essential features of AOC 69W showing the potential source and transport mechanisms for the contaminants detected at AOC 69W. The model reflects the current understanding of the site with respect to sources of contamination, the distribution of contamination, and the potential migration pathways.

Based on the results of the RI, the primary site-related contaminants at AOC 69W are fuel-related contaminants in soil and groundwater. VOCs, SVOCs, pesticides, PCBs, and TPHC were detected during the investigation.

Based on the results of the field investigation, it appears that the primary contaminant source was contaminated surface and near surface soils located in the vicinity of the new boiler room. The soil contamination is due to the 1972 fuel oil release from ruptured piping. The 1978 fuel oil release from piping in the vicinity of the old boiler room does not appear to have been a significant source of soil or groundwater contamination.

The primary release mechanism appears to be infiltration into groundwater from source area contaminants above the water table. Potential secondary release mechanism is the contaminated soil downgradient of the source areas. The contaminated soil downgradient of the source areas is believed to be due to sorption of dissolved phase contaminants as well as transport via the underground pipe associated with the "skimmer system".

9.0 BASELINE HUMAN HEALTH RISK ASSESSMENT

9.1 OVERVIEW

Human health and ecological risk assessments have been conducted to evaluate potential risks to humans and the environment under current or foreseeable future site conditions at AOC 69W. The methods used to perform the risk assessments are consistent with relevant national and regional USEPA risk assessment guidance (e.g., Risk Assessment Guidance for Superfund (USEPA, 1989a); EPA New England Risk Updates (USEPA, 1992a; 1994a; 1995; 1996) and incorporate data from the various remedial investigation and removal action sampling activities at AOC 69W. The results of the baseline human health risk assessment are presented in Subsection 9.1, and the results of the ecological risk assessment are presented in Subsection 9.2.

Summary of Site History

AOC 69W is composed of the Former Fort Devens Elementary School (Building 215), which is not currently in use, and a parking lot and adjacent lawn located on the northern side of the school. The site is less than 2 acres, and extends from the school to Willow Brook, which is located approximately 250 feet to the northwest (Figure 9-1).

The Fort Devens Elementary School was originally built in 1951, and comprised the east/southeast half of the existing school. The original school was heated by an oil-fired boiler, and the heating oil was stored in a 10,000-gallon UST located in what is currently the courtyard. In 1972 an addition to the school was built, which approximately doubled the school's size and created the existing courtyard.

During construction of the addition, the original 10,000-gallon UST was removed, and a new 10,000-gallon UST was installed north of the school in the middle of the current parking lot. Underground piping was installed to connect the new tank to a new boiler room in the addition. At the same time, oil lines were installed from the new boiler room to the original boiler room, so that the original boiler room could stay in use. An oil return line was also installed between the old boiler room and the new tank.

According to a former school employee, the company that installed the new underground storage tank crimped the pipe leading to the new boiler room, causing the pipe to split and leak a reported 7,000 to 8,000 gallons of fuel to the ground over a period of a few weeks in Spring 1972. When the problem was discovered, the pipe was unearthed and repaired. The exact location of the pipe split has not been determined. A subsurface oil recovery system was installed shortly after the piping was repaired. It is believed to have consisted of a pipe buried about three feet below grade, running from near the existing UST to a 250-gallon concrete vault located approximately 300 feet northwest of the school (Figure 9-1). Oil apparently flowed through the pipe to the vault, where it was periodically removed. Details of the collection system have not been found, although the presence of the pipe and vault have been confirmed by geophysical and visual means.

In 1978, another leak reportedly occurred from a failed subsurface piping joint near the old boiler room. While investigating the leak, a large hole was dug adjacent to the school between the old boiler room and the UST (near monitoring well ZWM-95-16X, Figure 9-1). Fuel oil was reportedly periodically removed from this hole for a period of a month while the leak was located and repaired.

Based upon documentation of the fuel oil releases, the site was designated AREE 69W and investigations were performed in 1994. The results of the AREE 69W investigation (A.D. Little, 1994) indicated the presence of fuel-related contaminants in both soil and groundwater between the school and the existing UST, and in the area extending from the existing UST northwest to near Willow Brook. Based on the results from the AREE 69W investigation, the Site was redesignated AOC 69W and was recommended for the RI/FS Process as per the IAG.

Site Conceptual Model

The RI identified fuel oil-related contamination adjacent to the school foundation near the loading dock and New Boiler Room, extending to the vault located approximately 300 feet northwest of the school near Willow Brook (Figure 9-1). Figure 9-2 graphically presents the site conceptual model, which relates sources of fuel-related contamination to migration pathways and the environmental media which human and ecological receptors may potentially be exposed to. The model is based on the findings of the RI.

As indicated in Figure 9-2, fuel oil was released to the surface and subsurface soils. The fuel oil contamination, which was quantified in this RI by measuring EPH and VPH fractions along with their associated target analytes (i.e., BTEX and PAHs), contained EPH and VPH as well as low levels of VOCs and PAHs, a finding that is consistent with weathering fuel oil. Inorganic analytes and several other semivolatile organic analytes were detected in site media. These analytes are evaluated in the risk assessments, but do not appear to be associated with any releases from the Site. The lighter EPH and VPH hydrocarbon chains, as well as VOCs and soluble inorganics, can leach from the soil and migrate to groundwater.

The RI identified petroleum-related contamination in groundwater at AOC 69W. Groundwater at AOC 69W is approximately five to nine feet bgs, and flows toward Willow Brook. When the groundwater level is high, such as in the spring, the groundwater is believed to discharge to Willow Brook. This suggests that there is the potential for petroleum-related contamination in the groundwater to discharge to the brook. Once in the brook, the petroleum-related compounds may adsorb to sediment. Petroleum-related compounds were detected in Willow Brook sediment. However, there are several possible upgradient sources of these compounds that are unrelated to AOC 69W, so the presence of these compounds in the stretch of Willow Brook near AOC 69W is not necessarily related to conditions at AOC 69W. Although the groundwater beneath AOC 69W is not used as a source of drinking water, and is not expected to be in the future, it flows in the general direction of the MacPherson groundwater supply well, which is located approximately 3,000 feet downgradient of AOC 69W. However, the contamination in the groundwater at AOC 69W does not effect the same aquifer that the MacPherson well is screened in, and with the completion of the recent soil removal action, is not expected to migrate substantially further (see Section 8.0).

The lighter EPH and VPH fractions, as well as VOCs, can volatilize from the soil or groundwater to ambient air. In addition, these compounds, if present beneath the Former Devens Elementary School, can theoretically volatilize and migrate to the indoor air at the school. Indoor air sampling performed at the school building identified target compounds in the indoor air. However, with the possible exception of ethylbenzene, xylene, and 2-methylheptane in samples collected in the northwestern portion of the building, there was no evidence to suggest that constituents detected in indoor air were associated with the possible presence of fuel oil-contaminated soil and/or groundwater beneath the building (Appendix O-1). In general, indoor air sample concentrations were within the ranges of aliphatic and aromatic hydrocarbon background concentrations published in the literature. This information, combined with the presence of several possible sources of these compounds inside the building, suggested that detections in indoor air samples are merely representative of the ambient conditions in public buildings such as the Former Elementary School. The presence of ethylbenzene, xylene, and 2-methylheptane in air samples collected from rooms in the northwestern portion of the school is likely also related to sources within the building (e.g., carpeting, paint, adhesives, and fuel oil leaks in the new boiler room), as detected concentrations are consistent with the ranges of typical background concentrations. However, because these constituents were detected in indoor air, crawl space air, and subsurface soil or groundwater beneath the that portion of the building, the possible presence of a complete migration pathway could not be ruled out (Appendix O-1).

According to the Devens Reuse Plan (Vanasse Hangen Brustlin, Inc., 1994), the site is designated for reuse as "Open Space" in the vicinity of Willow Brook and the delineated wetlands and "Gateway" for the remainder of AOC 69W. The Reuse Plan also includes reopening the school. Under the present and anticipated future land use conditions, people (e.g., trespassers, maintenance workers, pupils, and faculty) could be exposed to fuel-related contamination in soil, groundwater discharge to surface water in Willow Brook, sediment in Willow Brook, and indoor air. Ecological receptors could be exposed to fuel-related contamination in groundwater discharge to surface water Willow Brook and sediment in Willow Brook.

To mitigate possible exposures and possible continued migration of fuel-related compounds from the soil source areas, the Army conducted a soil removal action in winter 1997-1998. The removal action involved excavation and off-site disposal of cubic yards of contaminated soil between the school foundation and the vault near Willow Brook were removed in the winter of 1997 and 1998. The human health and ecological risk assessments are based on post-removal action soil conditions.

9.2 HUMAN HEALTH RISK ASSESSMENT

The human health risk assessment for AOC 69W was performed using methods consistent with USEPA Region I risk assessment guidance, including USEPA New England Risk Updates (USEPA, 1992a; 1994a; 1995; 1996), Risk Assessment

Guidance for Superfund (USEPA, 1989a), Standard Default Exposure Factors (USEPA, 1991), and Dermal Exposure Assessment: Principles and Applications (USEPA, 1992d). In addition, although USEPA Region I does not require quantitative evaluation petroleum-related constituents (i.e., as measured by the total petroleum hydrocarbon parameter), this risk assessment provides a quantitative evaluation of petroleum-related constituents using the methods described in the MADEP Petroleum Policy (MADEP, 1997). Quantitative evaluation of petroleum-related constituents has been performed in this risk assessment because the primary source of contamination at the site is associated with historic fuel oil releases.

The human health risk assessment for AOC 69W consists of the following components:

- Selection of Chemicals of Potential Concern (CPCs)
- Exposure Assessment
- Toxicity Assessment
- Risk Characterization
- Uncertainty Evaluation
- Summary and Conclusions

Each of these components is discussed in the following subsections.

9.2.1 Selection of Chemicals of Potential Concern

The first step in the risk assessment involves compiling and evaluating the analytical site data to identify those chemicals present in environmental media as a result of potential sources at AOC 69W. Site-related chemicals that were selected for risk evaluation are referred to as CPCs.

9.2.1.1 Identification and Selection of Analytical Data. Samples were collected at AOC 69W from surface and subsurface soil, sediment, groundwater, and indoor air. The sampling and analytical programs are discussed in Section 5.0

Soil

Surface and subsurface soil samples were collected throughout the source area during the RI (Figure 9-1). For the human health risk assessment, surface soil was defined as extending from 0 to 1 foot bgs, and subsurface soil was defined as extending from 1 to 10 feet bgs (USEPA, 1995). Deeper soil is considered isolated and not accessible. Soil samples from many of the Terraprobe locations were submitted for screening-level analysis of VOCs and TPH using on-site field analysis. Samples from select locations and depths were submitted for off-site laboratory analysis of VOCs, SVOCs, pesticides/PCBs, inorganics, and TPH. Only the off-site analytical data were used in this risk assessment because the off-site analyses were performed in accordance with more rigorous QA/QC protocols, and were associated with lower analytical detection limits.

However, the soil associated with off-site analytical samples from several locations in the source area were removed during the soil excavation performed in the fall of 1997. Those soil locations include: ZWR-95-30X (0 ft bgs), ZWR-95-38X (3 ft bgs), ZWB-95-02X (0 and 5 ft bgs), ZWR-95-36X (0 ft bgs), and ZWB-95-01X (7 ft bgs and shallower). These samples, therefore, were not included in the risk assessment data sets. However, 31 confirmatory samples were collected during the removal action from the floor and walls of the soil excavation and analyzed for EPH/VPH. These samples were incorporated in the risk assessment data set. Although confirmatory samples collected from an excavation could be combined and reported as a single analytical result, the excavation area represents a large portion of the site. Therefore, each confirmatory sample collected from the excavation was evaluated as a unique and separate sample.

Table 9-1 lists the sample locations included in the surface soil and subsurface soil data sets. The data sets include RI and removal action confirmatory samples collected in and around the source areas, and from the boiler room and courtyard borings at the school. Sample ZWR-95-26X (0 ft bgs), which was collected from beneath the pavement adjacent to the school, was included in the subsurface soil data set because the soil associated with this sample would have accessibility similar to that assumed for subsurface soil.

Groundwater

At AOC 69W, several rounds of groundwater data have been collected:

- ADL AREE 69W Rounds 1 and 2, April 1994 and June 1994

- HLA AOC 69W RI Round 1, October 1995
- HLA AOC 69W RI Round 2, February 1996
- HLA AOC 69W RI Round 3, October 1996
- HLA AOC 69W RI Round 4, December 1997

The groundwater monitoring well locations are shown in Figure 9-1. Since all historical AREE groundwater wells at and downgradient of the Site were re-sampled by HLA at least once, the AREE groundwater data were not used in this risk assessment. Groundwater samples from HLA Rounds 1 and 2 were analyzed for VOCs, SVOCs, pesticides/PCBs, unfiltered and filtered inorganics, and TPH. In addition, groundwater samples from Round 2 were analyzed for EPH/VPH and associated target analytes. Groundwater samples from Rounds 3 and 4 were analyzed for EPH/VPH and associated target analytes. With the exception of well 69W-95-17X, which is an upgradient location, all groundwater locations at AOC 69W were included in the risk assessment data set. This includes groundwater monitoring wells 69W-94-10, 69W-94-11, and 69W-94-13, which were removed during the soil remediation. Table 9-1 lists the samples included in the groundwater data set.

Although there are slight temporal variations in the magnitude of groundwater concentrations associated with data for HLA rounds 1 through 4, there are no substantial differences in the identity of detected analytes or trends in the direction of groundwater concentrations. To provide a conservative assessment that considers the slight temporal variations in groundwater concentrations, unfiltered groundwater data from all four HLA sampling rounds were used for the risk assessment. Because the Round 4 groundwater sampling was performed just prior to the soil removal action, the groundwater data do not reflect the beneficial effects that the soil source removal action will have on the groundwater concentrations. Groundwater concentrations in the future are expected to show a downward trend as a result of the soil source area removal action. Therefore, the groundwater data used in this risk assessment reflect the highest groundwater concentrations that are anticipated under current and future land use conditions.

Since EPH/VPH was analyzed in at least one sample from each groundwater monitoring well location, EPH/VPH data were used in the risk assessment in lieu of the TPH data collected during Rounds 1 and 2. This is a preferable approach because it allows for a site-specific assessment of the petroleum-related constituents, and is consistent with the MADEP petroleum policy (MADEP, 1997). In addition, because select VOCs and PAHs were analyzed and reported under both SVOC and EPH/VPH methods, multiple results were available for these compounds. To maintain a conservative assessment, the data associated with the analytical method that reported the highest detected concentration of each target PAH or VOC analyte were used in the risk assessment. The analytical methods upon which the data for VOCs and SVOCs are based are indicated in Table 9-2.

Surface Water

No surface water data were collected in Willow Brook. The portion of the brook that could potentially be affected by releases from AOC 69W is normally dry, and appears to only contain surface water during storm events or when the groundwater level is at its most shallow depth during late winter and early spring. During this time, groundwater located upgradient of Willow Brook, including the groundwater from beneath AOC 69W, discharges to Willow Brook. Therefore, to provide a conservative assessment of surface water in Willow Brook, data for the groundwater beneath AOC 69W was used to represent theoretical surface water concentrations. To provide an added degree of conservatism, no modeling or dilution of the groundwater discharged was assumed, as described in detail in Subsection 9.1.2.2.

Sediment

Sediment samples were collected at six locations in Willow Brook (Figure 9-1). The samples were analyzed for VOCs, SVOCs, pesticides/PCBs, inorganics, and TPH. The sediment samples ZWD-95-01X, ZWD-95-04X, and ZWD-95-05X were collected upgradient of AOC 69W. These samples represent media that have not been affected by potential releases from AOC 69W, and were used in the RI to evaluate the significance of constituents detected in downgradient samples. The upgradient samples are therefore not included in the risk assessment data sets. The samples included in the risk assessment data set are provided in Table 9-1.

Indoor Air

Air sampling data were collected from sampling locations inside the school, and

background locations outside the school in October, 1997. The indoor air samples were analyzed for target aliphatic and aromatic hydrocarbon VOCs (Appendix M). As described in Appendix O-1, because 2-methylheptane, ethylbenzene, and xylenes were detected in air and soil samples collected from the northwestern portion of the building, a potentially complete migration pathway could not be ruled out.
The procedures used to evaluate and summarize data and to screen data for the selection of CPCs are discussed below.

9.2.1.2 Data Summary Procedures. Prior to selecting CPCs, the analytical data were grouped into the data sets listed on Table 9-1. The following steps, which are in accordance with USEPA (1989a; 1992c) guidance, were used to summarize the analytical data for this risk assessment:

Data quality was evaluated by validating the data in accordance with USEPA data quality assessment procedures (USEPA, 1992c). Data suitable for use in risk assessment (i.e., those not rejected) were used in the risk assessment. Although data assessment procedures specified in RAGs (USEPA, 1989) were followed, data qualified as estimated and blank-contaminated were used in the risk assessment; uncertainties that may affect the risk assessment results are discussed in Subsection 9.1.5. Several TICs were detected in surface and subsurface soil, groundwater, and sediment, but they are not included in this evaluation because they were few in number and low in concentration compared to identified analytes. A summary of TICs is provided in Table 7-1. The data quality assessment is provided in Appendix D.

Data were summarized by environmental medium (for example, surface soil, groundwater). All chemicals detected in at least one sample in each data set were identified.

For groundwater, analytical results for the multiple HLA RI sampling rounds at a single location were averaged together and evaluated as a single point.

The arithmetic mean concentration was calculated for each chemical using the detected concentration(s), and one-half the sample quantitation limit (SQL) for nondetect(s). Duplicate samples for a given sampling point were also averaged in this manner if a chemical was detected in only one sample of a duplicate pair. Groundwater data were also treated in this manner if a chemical was not detected in all sampling rounds at a given well.

Frequency of detection was calculated as the number of samples in which the chemical was detected over the total number of samples analyzed. Duplicate pairs and data for multiple rounds at a single well were counted as a single result for calculation of the frequency of detection.

The minimum and maximum sample quantitation limits were identified for each analyte in each data set.

95 percent upper confidence levels on the arithmetic mean concentration were calculated in accordance with "Supplemental Guidance to RAGS: Calculating the Concentration Term" (USEPA, 1992b), assuming a log-normal distribution. This guidance states that data sets with fewer than ten samples provide poor estimates of the true mean, with the upper confidence limit (UCL) frequently being greater than the highest measured concentration. Therefore, the 95 percent UCLs on the arithmetic means were not calculated for data sets with fewer than 10 samples; 95 percent UCLs were calculated only for SVOCs, EPH, and VPH in subsurface soil.

Summary sampling data for the surface soil, subsurface soil, groundwater, sediment, and indoor air data sets for AOC 69W are presented in Table 9-2. The table lists frequency of detection, range of SQLs, minimum and maximum detected concentrations, arithmetic mean concentration, and 95 percent UCL for each chemical detected (when applicable).

9.2.1.3 Data Screening Procedures. The procedures used for selection of CPCs, based on USEPA (1989a; 1995) guidance, are described below. The results, including reasons for selection or exclusion of CPCs, are presented in Table 9-2.

- The summary data for soil and groundwater were compared to concentrations of site-specific naturally occurring inorganic analytes. The development of the background data sets for soil and groundwater are described in Appendix K; no background data were available for sediment. In accordance with USEPA Region I guidance, the comparison was not used to eliminate any analytes; however, maximum concentrations of an analyte that were below background levels was noted on Table 9-2. Risks attributable to background concentrations will be discussed in the uncertainty section if inorganic analytes are determined to be risk drivers.

- A screening process was conducted as described by USEPA Region I (USEPA, 1995) to focus the quantitative assessment on the most likely risk drivers. As specified by the guidance, maximum concentrations of chemicals detected in a medium were compared to RBCs derived from USEPA Region III's RBC Table (USEPA, 1997b). Soil concentrations were compared to residential soil RBCs, groundwater concentrations were compared to tap water RBCs, and indoor air concentrations were compared to ambient air RBCs. The RBCs published by USEPA Region III are derived for a $1x10^{-6}$ cancer risk level or a non-cancer hazard quotient (HQ) of 1. Per USEPA Region I guidance (USEPA, 1995), the RBCs based on noncarcinogenic effects have been adjusted for a HQ of 0.1 for the purposes of CPC selection. If the maximum concentration of an analyte exceeded the appropriate RBC, the analyte was retained as a CPC.

- Analytes were also compared to ARARs. No contaminant was eliminated as a CPC if it exceeded an ARAR. In this case, the ARARs used included the USEPA screening level for lead in soil (USEPA, 1994b), and USEPA MCLs, secondary MCLs, and action limits for groundwater (USEPA, 1997a).

- Essential nutrients were eliminated from the risk assessment because they are unlikely to result in adverse effects at low concentrations. Chemicals considered to be essential human nutrients are calcium, magnesium, potassium, and sodium. Iron is also considered a human essential nutrient, but a USEPA Region III screening value is available for it.

- RBCs and ARARs were not available for TPHC, EPH, or VPH. These contaminants were therefore considered CPCs.

CPCs were selected in surface soil, subsurface soil, groundwater, sediment, and indoor air (Table 9-2). The CPCs selected for each medium are discussed below.

Surface Soil. CPCs selected in surface soil included arsenic, beryllium, iron, manganese, and total petroleum hydrocarbons. Among these CPCs, the maximum detected concentrations of arsenic, iron, and manganese did not exceed the background concentrations, suggesting that their presence in AOC 69W surface soil is not attributable to releases at the Site.

Subsurface Soil. CPCs selected in subsurface soil included arsenic, iron, total petroleum hydrocarbons, EPH fractions C11-C22 aromatics, C19-C36 aliphatics, C9-C18 aliphatics, and VPH fractions C9-C12 aliphatics, and C9-C10 aromatics. The maximum detected concentrations of arsenic and iron did not exceed the background concentrations, suggesting that their presence in AOC 69W subsurface soil is not attributable to releases at the Site.

Groundwater. CPCs selected in unfiltered groundwater included aluminum, arsenic, iron, manganese 2-methylnaphthalene, naphthalene, bis(2-ethylhexyl)phthalate, chloroform, trichloroethylene, EPH fractions C9-C18 aliphatics, C11-C22 aromatics, and VPH fractions C9-C12 aliphatics, and C9-C10 aromatics, and C5-C8 aliphatics. Among these CPCs, only petroleum-related constituents (2-methylnaphthalene, naphthalene, EPH fractions, and VPH fractions) are interpreted to be related to the releases of fuel oil at AOC 69W.

Sediment. CPCs selected in downgradient sediment include arsenic, iron, manganese, and total petroleum hydrocarbons.

Indoor Air. No CPCs were selected in indoor air. As indicated in Table 9-2, the maximum detected concentrations of xylene, ethylbenzene, and 2-methylheptane were below the RBCs.

9.2.2 Exposure Assessment

The purpose of the exposure assessment is to identify the potential pathways by which human populations may be exposed to CPCs at AOC 69W, and to make quantitative estimations of those exposures. The following subsections describe the exposure assessment for the human health risk assessment at AOC 69W.

9.2.2.1 Exposure Pathways. An exposure pathway generally consists of four elements:

(1) A source and mechanism of chemical release to the environment;

(2) A retention or transport medium for the released chemical;

(3) A point of potential human contact with the impacted medium (i.e., the exposure point); and

(4) A route of exposure (ingestion or dermal contact, for example) for a potential receptor.

When all four of these elements are present, an exposure pathway is considered "complete." In the risk assessment, only exposure pathways that are complete under present land use, or potentially complete under the anticipated future land use are evaluated. The exposure pathway assessment for AOC 69W draws on information regarding the source of CPCs, fate and transport of CPCs, and information on human populations potentially exposed to CPCs in environmental media. The conceptual site model presented in Section 9.0 provides an overview of the potentially complete migration pathways at AOC 69W. These migration pathways are evaluated in the context of current and anticipated future land use to identify potentially exposed populations, exposure media, and exposure routes to those exposure media.

Current and Anticipated Future Site Use

In evaluating potential human exposure pathways, exposures under both current and potential future site uses and surrounding land use conditions were evaluated. Current land use conditions were evaluated to consider actual or possible exposures. Future land use conditions were considered to address exposures that may occur as a result of possible reuse of the site.

The site consists of the Former Fort Devens Elementary School (Building 215), a paved parking lot, and an adjacent lawn located on the northern side of the school; Willow Brook is located in a wooded wetland area approximately 200 feet northwest of the school (Figure 9-1). Since the school is closed, the site is not used. The only activity at the site is associated with maintaining the grounds (e.g., lawn mowing) during the summer months. Groundwater beneath AOC 69W is not used as a source of potable or industrial water; the school obtains its water supply from the Devens municipal groundwater supply. Willow Brook does not contain standing water most of the year. This feature, accompanied by the wooded nature of the area, indicate that it does not offer a good place for swimming or wading. Although Willow Brook is not ideal for swimming or wading, evaluation of pathways involving Willow Brook are considered in the exposure pathway and scenarios discussions.

The future site and surrounding land use conditions at AOC 69W are anticipated to change. The school will likely be re-opened in the near future as a Charter school which will include elementary, junior high, and high school grade levels. Under these land use conditions, pupils, faculty, and school maintenance workers will occupy the school. In addition, excavation workers associated with construction and/or utility installation and repair may access the Site. Groundwater beneath AOC 69W is not anticipated to be used as a source of potable or industrial water. However, the MacPherson groundwater supply well located approximately 3,000 feet downgradient of AOC 69W is used as a source of potable water.

Exposure Pathways and Scenarios

Possible exposure pathways encompassing both current and future conditions are summarized in Table 9-3 and discussed below.

Soil Pathway. Under both current and future land use, contact with surface soil could occur if a site maintenance worker mows the grassy area, or a child trespasser (under current use) or pupil (under future use) plays in the grassy, unpaved area. Contact with subsurface soil could occur if excavation activities such as utility line repair or building construction were to take place. If pavement currently in place was removed in the future, what is now subsurface soil would be exposed to potential receptors. However, it is likely that any paving removed would be replaced by buildings, new paving, or topsoil for landscaping. Therefore, child trespassers, pupils, and site maintenance workers were selected as the most reasonable receptors to surface soil. A excavation worker performing utility or construction was selected as the most reasonable receptor to subsurface soil.

The two principal routes by which the site maintenance worker, child trespasser, pupil, and utility/construction worker could be exposed to CPCs in surface soil are ingestion and dermal contact. An additional exposure route, the inhalation of compounds volatilizing from the soil or of soil particles entrained in air (dust), is discussed under the Air Pathway below.

Groundwater Pathway. There is no current use of groundwater at AOC 69W. There are existing supplies of water in this area of Devens and it is unlikely that the aquifer at the site would be developed for future use. Groundwater flow is towards Willow Brook and the wetland area. Willow Brook is shallow in the area of AOC 69W, and a child (trespasser or pupil) who plays in the stream could be exposed to CPCs in surface water. The two principal routes by which the child could be exposed to the groundwater discharge to surface water are incidental ingestion and dermal contact. Inhalation of VOCs that may volatilize from surface water is considered insignificant since VOCs were detected at very low frequency and concentration in groundwater.

Although excavation workers could theoretically contact groundwater if they dig excavations to the depth of the groundwater table (5 to 9 ft bgs), excavation workers would wear protective clothing (e.g., boots and gloves) in anticipation of this. Therefore, direct contact with groundwater is not evaluated for construction workers.

Residential use of the shallow groundwater beneath AOC 69W is highly unlikely. However, because this groundwater flows in the general direction of the MacPherson water supply well that is located 3,000 feet downgradient and the site is located within the Defined Zone II, residential use of the groundwater as potable water is evaluated. Groundwater under the site is within a Zone II groundwater protection area and a potentially productive aquifer, as defined by the MADEP.

Sediment Pathway. Under both current and future land use, contact with sediment could occur if a child was to wade in Willow Brook or the wetland area. Therefore, a child trespasser and pupil were selected as the most reasonable receptors to CPCs in sediment. The two principal routes by which these receptors could be exposed to CPCs in sediment are incidental ingestion and dermal contact. An additional potential exposure route, the inhalation of compounds volatilizing or particulates eroding from the sediment, is not considered to be a significant route of exposure because VOCs were detected at very low frequency and concentration, and dust is unlikely to be generated from sediment.

Air Pathway. Air could be a contact medium if VOCs present in the soil or groundwater volatilize into indoor or ambient air, or if airborne particulates containing CPCs are generated from the soil. With the exception of VPH in subsurface soil and groundwater, VOCs were detected at low frequency and concentration in soil and groundwater. Volatile inhalation exposures to a site worker mowing the grass are unlikely to be substantial given the considerable dilution of VOCs that would occur in the ambient air. However, excavation workers who are in closer contact with subsurface soil and groundwater and potentially working in a semi-closed "trench-type" excavation, may incur more substantial exposures. Therefore, volatile inhalation exposures are evaluated for the excavation worker.

Inhalation of soil contaminants entrained on dust generated during site maintenance activities such as mowing the grassy area or a large-scale construction project is of concern for the site maintenance worker and the excavation worker. It is unlikely that a child trespasser or pupil who plays in the grassy area would generate substantial amounts of dust because the grassy area near the school is small and there are recreational ball fields located on the other side of the school for active recreational activities. However, to provide a conservation evaluation, dust inhalation exposures are evaluated for the trespasser and pupil.

There is a potential for the release of VOCs from soil or groundwater to indoor air. Adults (teachers or staff members) and pupils who may occupy the building in the future could be exposed via inhalation of the indoor air. This exposure pathway was evaluated in Appendix O-1 to identify areas of the building where the presence of constituents detected in indoor air could be attributable to migration from subsurface soil and/or groundwater beneath the school. In summary, the analysis presented in Appendix O-1 provided evidence that the presence of the constituents detected in air throughout the building is likely attributable to ambient and anthropogenic sources inside and outside the building, and is not attributable to subsurface fuel oil contamination beneath the building. Although detections of 2-methylheptane, xylenes, and ethylbenzene in air samples collected from the library and an adjacent classroom are likely attributable to sources within the building (e.g., carpeting, paint, adhesives, and fuel oil leaks in the new boiler room), a possible association between the presence of these constituents in air samples from these rooms and the soil in the vicinity of that area of the building could not be ruled out. Although these three analytes may be the only indoor air contaminants potentially associated with subsurface fuel oil contamination, all analytes detected in indoor air samples were evaluated in the risk assessment in order to provide a conservative assessment of potential exposures.

9.2.2.2 Estimation of Exposure. To quantitatively estimate the magnitude of exposures and the risks that may be experienced by an individual, the representative concentration of the CPC in the contact medium at each exposure point must be known or estimated. This concentration is referred to as an exposure point concentration (EPC). The EPC is then combined with receptor-specific variables which describe the magnitude with which the receptor comes into contact with the exposure medium to develop quantitative estimates of exposure.

Exposure Points

There is one exposure point for surface soil, subsurface soil, sediment, surface water (represented by groundwater discharge), and groundwater. The boundaries of each exposure point are defined by the locations of the samples included in each of the media, as listed on Table 9-1 and shown in Figure 9-2. For indoor air, each room sampled represents a seperate exposure point. The crawl space beneath the cafeteria (kitchen and the boiler room wall head) were not considered exposure points, since people would not be expected to occur in these areas.

Exposure Point Concentrations

The EPCs for surface soil, subsurface soil, and sediment are the lesser of the 95 percent UCL on the arithmetic mean concentration or the maximum detected concentration (USEPA, 1992b; 1994a). Because there were less than ten samples included in the data sets for the surface soil and sediment exposure points, 95 percent UCLs were not calculated; the EPCs for these two media are the maximum detected concentrations. The same EPC was used for the reasonable maximum exposure (RME) and CT (CT) exposure scenarios (USEPA, 1995). The 95 percent UCL concentrations and maximum detected concentrations are provided on Table 9-2.

For groundwater potable use, USEPA Region I guidance states that the groundwater EPC for RME conditions is the maximum concentration, whereas the EPC for CT exposures is the arithmetic mean concentration (USEPA, 1995).

As discussed previously, no surface water was present during the RI sampling program and, therefore, no surface water samples were collected from Willow Brook. The arithmatic mean groundwater concentrations are used as EPCs to provide conservative estimates of possible surface water concentrations. Using the arithmetic mean groundwater concentrations to estimate exposure to surface water (as groundwater discharge) overestimates the potential exposure for two reasons: 1) the groundwater contamination is primarily associated with areas near the school, and it is unlikely that these concentrations will ever reach the brook; and 2) groundwater becomes substantially diluted when it enters the brook.

For indoor air, each room sampled represents an individual exposure point. However, to streamline the risk assessment and provide a more conservative estimate of risks, the maximum concentration among all samples collected (i.e., all potential exposure points) was used as the EPC.

Exposure Estimates

Quantitative exposure estimates were derived by combining the EPCs with information describing the extent, frequency, and duration of exposure for the specific receptor (Table 9-4). An overview of the approaches used to quantify exposures is given below, along with specific details for potential exposure pathways. The approaches described in the following paragraphs to quantify exposures are consistent with guidance provided by USEPA (1989a; 1989b; 1991; 1992d; 1994a; 1995).

The term RME is defined as the maximum exposure that is reasonably expected to occur at a site (USEPA, 1989). The RME is intended to place a conservative upper-bound on the potential risks, meaning that the risk estimate is unlikely to be underestimated but it may very well be overestimated. The likelihood that this RME scenario may actually occur is small, due to the combination of conservative assumptions incorporated into the scenario. The RME estimate for a given pathway is derived by combining the EPC of each chemical with reasonable maximum values describing the extent, frequency, and duration of exposure (USEPA, 1994a). The CT (CT) estimate combines the EPC with CT exposure parameters. Many of the exposure parameter values used in this assessment have been defined by USEPA (1989a; 1989b; 1991; 1994a). Both CT and RME exposures were estimated for each receptor exposure scenario evaluated.

The general equation for calculating chemical intake is as follows:

$$\text{Intake} = \frac{C \times CR \times RAF \times EF \times ED}{BW \times AT \times CF}$$

where:

Intake = daily intake averaged over the exposure period (mg/k/day)
C = concentration of the chemical in the exposure medium (mass/volume)
CR = contact rate for the medium of concern (mass/day)
RAF = relative absorption factor (unitless)
EF = exposure frequency (days/year)
ED = exposure duration (years)
BW = body weight of the hypothetically exposed individual (kg)
AT = averaging time (for carcinogens, AT = 70 years; for noncarcinogens, AT = ED)
CF = units conversion factor (365 days/yr)

Specific equations for each exposure scenario are provided in the risk calculation spreadsheets in Appendix O-2. For dermal uptake of soil, sediment, and surface water CPCs, USEPA Region I has developed the following guidance (USEPA, 1995):

Soil/Sediment. USEPA Region I uses the USEPA dermal exposure guidance (USEPA, 1992d), which provides quantitative dermal absorption factors for PCBs, dioxins, and cadmium. None of these chemicals are CPCs at AOC 69W. MADEP risk assessment guidance (MADEP, 1995) requires quantitative evaluation of all CPCs using dermal relative absorption factors published by the MADEP. To satisfy MADEP concerns, dermal exposures to soil/sediment CPCs were evaluated using MADEP (1995) guidance.

Surface Water. Using the approach identified in the USEPA dermal exposure guidance (USEPA, 1992d), the dermal route was evaluated quantitatively using dermal permeability coefficients. For inorganics, a steady-state approach was used, whereas for organic CPCs, a nonsteady-state approach was used. The nonsteady-state approach is applicable to organics that exhibit octanol/water partitioning and is not appropriate for inorganics. The equations and factors used to develop permeability coefficients for each identified CPC in groundwater are listed in Table 9-5.

Standard exposure parameters from USEPA guidance were used, where appropriate, to estimate CPC intake. Table 9-4 presents the parameters used in each exposure scenario. The parameters are discussed briefly below.

Contact Rate. The contact rate reflects the amount of the medium contacted per unit of time or event. For incidental ingestion of soil, the high-end contact rate is 100 mg soil per day for the site maintenance worker and child trespasser and pupil (USEPA, 1994a). The CT value for these receptors is 50 mg/day (USEPA, 1994a). For incidental ingestion of soil, the high-end contact rate is 480 mg soil per day for the excavation worker (USEPA, 1994a). A fraction-ingested variable can be used to account for the amount of soil ingested daily that is assumed to come from the area of concern. It is conservatively assumed that all soil ingested daily would originate at AOC 69W. The contact rate variables used for soil were also used for sediment.

For incidental ingestion of surface water, it was conservatively assumed that the high-end contact rate for the child would be the same contact rate presented for residential exposure via ingestion of chemicals in surface water while swimming, 0.05 liter per hour (USEPA, 1989b). A contact rate of half the high-end contact rate, 0.025 liter per hour, was assumed for the CT exposure.

For ingestion of groundwater used as residential drinking water, the ingestion rate for the RME is 2 liters per day, and 1.4 liters per day for the CT (USEPA, 1994a).

The contact rate for inhalation exposure is 2.5 cubic meters (m^3) of air per hour for the site maintenance worker (USEPA, 1991, USEPA, 1989b). The inhalation rate is 4.8 m^3 of air per hour or 38.4 m^3 per workday for the utility/construction worker, based on a heavy activity rate (USEPA, 1989b).

Relative Absorption Factor. The relative absorption factor represents the ratio of a chemical's bioavailability (i.e., ability to be absorbed and potentially exert an effect) in an environmental matrix to its bioavailability when administered in the experimental dose-response study from which the toxicity criterion for that chemical was derived. The relative bioavailability factor is applied to account for the potentially reduced bioavailability of a chemical when ingested or dermally absorbed in a soil matrix, compared to when experimentally administered in a food mash, water, or a solvent medium. In keeping with the conservative nature of this assessment, a relative oral bioavailability of 100 percent (or 1.0) is assumed for all CPCs. Dermal relative absorption factors were obtained from MADEP sources (MADEP, 1994; 1995), and are presented in the risk calculation tables in Appendix

O-2.

Exposure Frequency and Duration. An exposure rate of two times per week for 32 weeks (April-November), equal to 64 days per year for 25 years, is assumed for the site maintenance worker. It is assumed that the maintenance worker spends 8 hours per day on the days working at the Site. Contact with the soil is negligible when the ground is frozen or snow-covered. An exposure rate of less than five days per week accounts for work performed in other areas of the facility; it is unlikely that the small grassy area adjacent to the building would require activities even two-days per week.

An exposure rate of three days per week for 32 weeks (April-November), equal to 96 days per year, is assumed for the child trespasser exposure to surface soil. Pupil exposure to surface soil is estimated to be five days per week from September to November, and April to mid-June, and three days per week, mid-June to late August (when school is not in session), to result in 140 days/year total exposure. Contact with the soil is negligible during winter months when the ground is frozen or snow-covered. For the trespasser and pupil, exposure to surface water and sediment is assumed to occur two-days per week during the summer (June-August, or 24 days/year). This represents a conservative estimate of exposure since surface water is generally only present in the stretch of Willow Brook near AOC 69W after storm events or when the groundwater level is high during the early spring months. For both the pupil and the trespasser, it is assumed that exposure to surface water and sediment occurs 2.6 hours per day on the days-exposed. This value is based on the average time for swimming (USEPA, 1989a).

A trespasser ages 6 through 18 is assumed to occur at the site for 13 years (equivalent to the duration of age 6 through 18) for the RME scenario, and 9 years for the CT scenario. The CT exposure duration is based on the average length of residence at a single location. Since the Charter school will include grades kindergarten through high school, the ages of the pupils will span 6 through 18. Therefore, the RME scenario is based on a 13 year exposure duration. The central tendency exposure duration is 9 years, and is based on the average length of residence at a single location. The pupil is assumed to occur in the school building six hours per day, for 180 school days per year.

The excavation worker is assumed to work five days a week for 18 weeks, or 90 days over the course of a year.

Body Weight. The body weight used for the excavation worker and the site maintenance worker is 70 kilograms (kg), which represents the standard default value for adult body weight (USEPA, 1994a). The age-adjusted body weight for the child trespasser and pupil, each assumed to be 6 through 18 years of age, is 45 kg (USEPA, 1989b).

Surface Area. The body surface area potentially exposed to surface water while wading in Willow Brook is 5,053 cm^3, based on the age-adjusted surface area of arms, hands, feet, and lower legs of children ages 6 through 18 (USEPA, 1989b). This value is used as a conservative estimate for exposures to surface soil. The body surface area of maintenance and excavation works is 5,200 cm^3, based on the surface area of arms, hands, head, and neck of adult males.

Averaging Time. The averaging time for lifetime exposure, used for developing intake to evaluate carcinogenic risk, is 70 years. Averaging time for noncarcinogenic risk is equal to the exposure duration (USEPA, 1991).

9.2.3 Toxicity Assessment

The objective of the toxicity assessment is to define the relationship between the dose of a substance and the likelihood that a toxic effect, either carcinogenic or noncarcinogenic, will result from exposure to that substance. This is performed by identifying the potential adverse health effects associated with exposure to a substance, and then quantifying those dose-response relationships. Potential adverse health effects associated with each CPC evaluated in this risk assessment are summarized in short toxicity profiles provided in Appendix O-3. Dose-response information for the CPCs, which is used in the risk assessment to estimate the likelihood of adverse effects as a function of human exposure to the CPCs, is presented in Tables 9-6 through 9-10.

There are two types of dose-response values used in this risk assessment: cancer slope factors (CSFs) and reference doses (RfDs). USEPA has derived CSFs and RfDs to evaluate carcinogenic risks and noncarcinogenic (systemic) effects, respectively. The definitions of CSFs and RfDs, as stated in USEPA guidance are:

- Cancer Slope Factor - a plausible upper bound estimate of the probability of a response per unit intake of a chemical over a lifetime.

The CSF is used to estimate an upper-bound probability of an individual developing cancer as a result of a lifetime exposure to a particular concentration of a potential carcinogen (USEPA Class A or B carcinogens) (USEPA, 1989a).

- Chronic Reference Dose - an estimate of a daily exposure level for the human population, including sensitive subpopulations, that is likely to be without an appreciable risk of deleterious effects during a lifetime (e.g., as a Superfund program guideline, seven years to a lifetime) (USEPA, 1989a). The chronic RfD is used to estimate toxicity to all receptors occurring at a site for more than seven years.
- Subchronic Reference Dose - an estimate of a daily exposure level for the human population, including sensitive subpopulations, that is likely to be without an appreciable risk of deleterious effects during a portion of a lifetime (e.g., as a Superfund program guideline, two weeks to seven years) (USEPA, 1989a). The subchronic RfD is used to estimate toxicity to all receptors occurring at a site for between two-weeks and seven years (e.g., excavation worker).

In addition, because the toxicity and/or carcinogenicity of a compound can depend on the route of exposure (e.g., oral or inhalation), unique dose-response values (e.g., CSFs and RfDs) have been developed for the oral and inhalation exposure routes.

The primary source for dose-response values is the USEPA Integrated Risk Information System (IRIS) (USEPA, 1998). If no information is found in IRIS, the USEPA Health Effects Assessment Summary Tables (HEAST) (USEPA, 1997c) are used. If appropriate dose-response values are not available from either of these two sources, other USEPA sources are consulted (e.g., the USEPA National Center for Environmental Assessment).

Inhalation RfDs are not available for CPCs. HEAST and IRIS do, however, list reference concentrations for a number of the CPCs. Risks for these CPCs were evaluated by developing an average daily air concentration and calculating a hazard index (HI) instead of using an inhalation dose to calculate a dose-based HI. The equation for the average daily air concentration, shown on the spreadsheets in Appendix O, is the air concentration multiplied by the exposure time and the duration, divided by the averaging time.

The methodology used to develop dermal toxicity values is obtained from Risk Assessment Guidance for Superfund, Appendix A (USEPA, 1989a). The oral toxicity value is adjusted from administered dose to absorbed dose, if necessary. The gastric absorption efficiency of a particular compound is used to calculate an RfD based on absorbed dose. For example, if the RfD based on administered dose was 20 mg/kg/day, and the gastric absorption efficiency in the study that is the basis of the RfD was 10 percent, then: 20 mg/kg/day x 0.10 = 2 mg/kg/day. Therefore, the adjusted RfD is 2 mg/kg/day. This adjusted value is the dermal reference dose (RfDderm). Similarly, the dermal cancer slope factor (CSFderm) is obtained by adjusting the oral CSF. For example: if the CSF based on administered dose was 1.6 (mg/kg/day)-1, and the gastric absorption efficiency in the study that is the basis of the CSF is 20 percent, then: 1.6 (mg/kg/day)-1/0.20 = 8 (mg/kg/day)-1. This adjusted value is the CSFderm.

The oral (or in some cases, inhalation) absorption efficiency for individual compounds is obtained from IRIS, HEAST, Agency for Toxic Substances and Disease Registry (ATSDR) toxicity profiles, or independent studies. If the gastric absorption efficiency is not available from these sources, the efficiency is assumed to be similar to structurally similar compounds. If a similar compound is not identified, an assumed value for the class of compound (VOCs, SVOCs or inorganic analytes) is used. Based on best professional judgment, the default gastric absorption efficiency values for VOCs, are assumed to be 80 percent; for SVOCs, 20 percent; and for inorganics, 5 percent. If the RfD or the CSF is based on absorbed dose rather than administered dose, no adjustment for gastric absorption efficiency is necessary. Dermal dose-response data are presented in Table 9-10.

No USEPA-approved toxicity values are available for TPHC, EPH, or VPH. However, the "Characterizing Risks posed by Petroleum Contaminated Sites: Implementation of MADEP VPH/EPH Approach" (MADEP, 1997) recommends the application of Reference Doses for indicator compounds to various fractions of petroleum products analyzed for by the EPH and VPH methods as a means of assessing risks associated with media that contain petroleum. These RfDs were used to estimate the risks associated with each EPH/VPH fraction. When there is no information available concerning the concentrations of the various fractions comprising the petroleum, but there are data for TPHC, a quantitative evaluation was completed using the RfD for pyrene as a surrogate.

9.2.4 Risk Characterization

In this final step of the risk assessment process, the exposure and toxicity information are integrated to develop both quantitative and qualitative evaluations of risk. To quantitatively assess risks associated with CPCs in an environmental medium, the average daily intakes calculated in the Exposure Assessment are combined with the dose-response criteria presented in the Toxicity Assessment. The methodology used to quantitatively assess risks is described below.

9.2.4.1 Risk Characterization Methods. USEPA (1989a) has developed guidance for assessing the potential risks to individuals from exposure to carcinogenic and noncarcinogenic chemicals.

Cancer Risks

For exposures to a chemical exhibiting carcinogenic effects, an individual upper bound excess lifetime cancer risk (ELCR) is calculated by multiplying the estimated daily CPC intake by the relevant CSF:

ELCR = Intake (mg/kg/day) x CSF (mg/kg/day)-1

The resulting risk estimate is an upper-bound estimate of the probability of developing cancer as a result of exposure to the potential carcinogen over a 70-year lifetime under the specified exposure conditions. A risk level of 1x10-6, for example, represents an upper bound probability of one in one million that an individual will develop cancer. The upper bound cancer risk estimates provide estimates of the upper limits of risk, and the risk estimates produced are likely to be greater than the 99th percentile of risks faced by actual receptors (USEPA 1989a). This incremental lifetime risk is over and above what is considered an individual's background chances of developing cancer. In the U.S., approximately one in three people develop cancer during their lifetime (American Cancer Society, 1997). To assess the upper bound individual ELCRs associated with simultaneous exposure to all carcinogenic chemicals of concern, the risks derived from the individual chemicals are summed within each exposure pathway. This approach is consistent with the USEPA's guidelines for evaluating the toxic effects of chemical mixtures (USEPA 1989b). It will overestimate risk if maximum concentrations occur in different locations and they are used as EPCs.

The relative significance of carcinogenic risk estimates is evaluated by comparison to a target risk range of 1x10-4 to 1x10-6 established in the National Contingency Plan (USEPA, 1989). USEPA's guidelines state that when the total incremental carcinogenic risk for an individual resulting from exposure at a hazardous waste site is within the range of 1x10-4 to 1x10-6, the decision about whether to take action or not is based on site-specific factors.

Non-Cancer Risks

Unlike carcinogenic effects, noncarcinogenic effects are not expressed as incidence probabilities. Rather, potential noncarcinogenic impacts were evaluated by means of calculating HQs and HIs. To assess effects associated with noncarcinogenic exposures, the ratio of the daily intake to the RfD is calculated by dividing the intake for each noncarcinogenic CPC by the RfD for that CPC to derive an HQ:

$$HQ = \text{Intake (mg/kg/day)} / \text{RfD (mg/kg/day)}$$

In general, HQs that are less than 1 indicate that the associated exposure is not likely to result in any adverse health effects, whereas HQs greater than 1 indicate a greater likelihood of adverse health effects. The effects from simultaneous exposures to all CPCs were computed by summing the individual HQs within each exposure pathway. This sum, the HI, serves the same function for exposures to multiple CPCs as the HQ does for exposure to an individual compound.

HIs for both RME and CT exposures are compared to a target level of 1 established by USEPA. HIs greater than 1 indicate the potential for the occurrence of adverse health effects. However, a conclusion should not be categorically drawn that all HIs greater than 1 are unacceptable. If the individual CPCs effect different target organs or work through different mechanisms of action, then an HI of greater than 1 does not indicate that threshold effect levels have been reached. In cases where an HI is greater than 1, the CPCs may be segregated by target organ/critical effect (e.g., liver, skin, etc.) and the HQs for each group of CPCs may be summed to determine if the target organ-specific HI is greater than 1 (USEPA, 1989a).

9.2.4.2 Risk Characterization Results. The risk calculations for soil and groundwater are presented in Appendix O-2. The risk estimates are summarized in Table 9-11, and are discussed below.

Current Land Use

Surface Soil. Health risks associated with possible current exposures to surface soil were quantified for the site maintenance worker and the child trespasser (ages 6 through 18). Cancer risks for CT and RME scenarios were below or within the USEPA acceptable cancer risk range, with ELCRs ranging between $1x10^{-6}$ (maintenance worker CT) to $6x10^{-6}$ (trespasser RME). Non-cancer risks were below the USEPA threshold HI of 1.

Because the RME and CT cancer and noncancer risks are within or below the USEPA acceptable limits, surface soil does not pose an unacceptable health risk under current land use conditions.

Sediment. Health risks associated with possible exposure to sediment were quantified for the child trespasser (ages 6 through 18). Cancer risks for CT and RME scenarios were each at or below $1x10^{-6}$, indicating that they are below the USEPA cancer risk range and are therefore acceptable. The HIs for the CT and RME scenarios were each 0.1, which are below the USEPA threshold HI of 1. This indicates that non-cancer risks are acceptable for current land use conditions.

Groundwater Discharge. Health risks associated with possible exposure to groundwater discharge to surface water were quantified for the child trespasser (ages 6 through 18). Cancer risks for CT and RME scenarios were $1x10^{-6}$ and $2x10^{-6}$, respectively. These values are within the USEPA acceptable cancer risk range. The HIs for the CT and RME scenarios were each 0.2. These values do not exceed the USEPA threshold HI of 1. This evaluation, therefore, indicates that cancer and non-cancer risks for possible exposures to groundwater discharge to surface water are acceptable for current land use conditions.

Cumulative Risks. The cumulative risks to the trespasser for combined exposures to surface soil, sediment, and groundwater discharge to surface water are within the USEPA acceptable cancer risk range, and do not exceed a HI of 1 (Table 9-2). This indicates that multi-media exposures to CPCs at AOC 69W do not pose unacceptable risk for current land use.

Future Land Use

Surface Soil. Health risks associated with possible future exposures to surface soil were quantified for the pupil (ages 6 through 18) and the excavation worker. Cancer risks for the pupil CT and RME scenarios were within the USEPA acceptable cancer risk range, with ELCRs ranging between $5x10^{-6}$ (CT) and $9x10^{-6}$ (RME). Non-cancer risks were below the USEPA threshold HI of 1.

The cancer and non-cancer risks for the excavation worker were below the USEPA acceptable cancer risk range and below an HI of 1.

Because the RME and CT cancer and noncancer risks are within or below the USEPA acceptable limits, surface soil does not pose an unacceptable health risk under the anticipated future land use conditions.

Subsurface Soil. The total cancer risk to the excavation worker, assuming exposure to RME conditions for subsurface soil (one to ten feet bgs) is $1x10^{-7}$, which is below the USEPA acceptable cancer risk range. The hazard index is 0.9, which is below the USEPA threshold HI of 1. This indicates that subsurface soil does not pose an unacceptable cancer or non-cancer risk under possible future land use conditions.

Because an excavation worker would be potentially exposed to both surface soil and subsurface soil when digging, the cancer and non-cancer risks for surface soil and subsurface soil were added together. The total cancer risk is 4x10-7, and the total non-cancer risk is an HI of 1. These values do not exceed USEPA threshold risk levels, and therefore indicate no unacceptable risk.

Sediment. Health risks associated with possible exposure to sediment were quantified for the pupil (ages 6 through 18). Cancer risks for CT and RME scenarios were each at or below $1x10^{-6}$, indicating that they are below the USEPA cancer risk range, and are therefore acceptable. The HIs for the CT and RME scenarios were below 0.1, which are below the USEPA threshold HI of 1. This indicates that non-cancer risks are acceptable for future land use conditions.

Groundwater Discharge. Health risks associated with possible exposure to groundwater discharge to surface water were quantified for the pupil (ages 6 through 18). Cancer risks for CT and RME scenarios were $1x10^{-6}$ and $2x10^{-6}$, respectively. These values are within the USEPA acceptable cancer risk range. The HIs for the CT and RME scenarios were 0.2. These values are below the USEPA threshold HI of 1. This evaluation, therefore, indicates that cancer and non-cancer risks for possible exposures to groundwater discharge to surface water are acceptable for future land use conditions.

Groundwater. Health risks associated with possible future use of on-site groundwater as residential drinking water were evaluated. This evaluation differs from the evaluation of the future use of the school because the school re-opening is an anticipated future land use, whereas the use of groundwater as drinking water is not an anticipated, but rather a theoretical future land use. Since it is unlikely that the groundwater at AOC 69W will be used as a source of drinking water in the future, these risks represent a hypothetical scenario.

For unfiltered groundwater, the estimated RME cancer risk is $5x10^{-3}$, which is above the USEPA acceptable cancer risk range. The estimated CT cancer risk is 1x10-4, which is at the upper bound of the USEPA acceptable cancer risk range. The RME non-cancer risk for the child and adults are an HI of 25 and 57, respectively. The CT non-cancer risks are an HI of 4 and 8, respectively. These HIs exceed the USEPA threshold HI of 1. This indicates that theoretical future of groundwater as drinking water at AOC 69W is associated with unacceptable risks.

However, greater than 99 percent of the cancer risk, and approximately 70 percent of non-cancer risk, is associated with possible exposures to arsenic in groundwater (Appendix O-2, Tables 27 through 30). The child resident RME HI for petroleum CPCs interpreted to be potentially related to the fuel oil release (i.e., EPH, VPH, and non-carcinogenic PAHs) is 5. The child CT HI for these CPCs is less than 1, which does not exceed the USEPA threshold HI of 1.

Based on the results of this risk assessment, it appears that theoretical use of groundwater as potable water is associated with unacceptable cancer and non-cancer risks. However, the unacceptable risks are primarily due to CPCs that are not directly related to the fuel oil release at AOC 69W.

Cumulative Risks. The cumulative risks to the pupil for combined exposures to surface soil, sediment, groundwater discharge to surface water, and indoor air are within the USEPA acceptable cancer risk range, and do not exceed a HI of 1 (Table 9-2). This indicates that multi-media exposures to CPCs at AOC 69W do not pose unacceptable risk for future pupils who may attend the Charter School. Cumulative risks for the excavation worker (exposure to surface soil and subsurface soil) are also within acceptable limits, as discussed previously.

9.2.5 Evaluation of Uncertainty

The interpretation of risk estimates is subject to a number of uncertainties as a result of conservative assumptions inherent in risk assessment. All quantitative estimates of risk are based on numerous assumptions, most intended to be protective of human health (i.e., conservative). As such, risk estimates are not truly probabilistic estimates of risk, but rather conditional estimates given a series of conservative assumptions about exposure and toxicity.

In general, sources of uncertainty are categorized into site-specific factors (e.g., variability in analytical data, modeling results, and exposure parameter assumptions) and general factors that affect most risk assessments equally, such as toxicity information. Toxicity information for many chemicals is very limited, leading to varying degrees of uncertainty associated with calculated toxicity values. Sources of uncertainty for calculating toxicity factors include extrapolation from short-term to long-term exposures, amount of data (e.g., number of studies) supporting the toxicity factors, consistency of different studies for the same chemical, and responses of various species to equivalent doses. The general uncertainties that affect most risk assessments, and the direction of their potential effects on the risk assessment results (e.g., to over- or under-estimate risks) for AOC 69W are summarized in Table 9-12. Site-specific uncertainties that have the greatest potential effect on the results of this risk assessment are discussed below.

Data Evaluation and Selection of CPCs

Several analytes, most notably arsenic, iron, and manganese, in all media except groundwater were selected as CPCs even though their maximum concentrations did not exceed background concentrations. This suggests that the presence of these analytes are not directly associated with fuel oil releases at AOC 69W; including these analytes as CPCs results in an overestimation of risk for potential exposures to CPCs that are directly related to the fuel oil release at AOC 69W. In addition, the background concentration of arsenic in groundwater is associated with a potable use RME risk ($2x10^{-4}$) that exceeds the USEPA acceptable cancer risk range, and is greater than the AOC 69W central tendency risks for groundwater potable use ($1x10^{-4}$).

Use of the groundwater data for the analytical methods that reported the highest maximum detected concentrations represents a conservative approach that is likely to overestimate risk. Since SVOC data were collected in historical, and not recent sampling rounds, the groundwater concentrations may have decreased, and would be better represented by the more current EPH/VPH data. In addition, removal of the soil source area between the school and the vault is expected to result in a decrease in groundwater concentrations; the groundwater data used in the risk represent pre-remediation groundwater concentrations. Therefore, the groundwater data used in the risk assessment represent pre-remediation groundwater concentrations; the groundwater risk estimates represent the worst-case risks for potential current and future exposures to groundwater.

Use of the Region III RBCs in the CPC selection for indoor air represents a conservative approach. As described in Subsection 9.1.1.3, Region III RBCs for ambient air, adjusted for an HQ of 0.1, were used for CPC selection of constituents detected in indoor air (because RBCs were not available for 2-methylheptane, 3-methylheptane, nonane, and octane, a value equal to 10 percent of the RfC published by MADEP was used in place of the RBCs). The RBCs were developed using inhalation RfCs and exposure assumptions that are appropriate for chronic inhalation exposures to an adult (e.g., 24 hours per day, 365 days per year). However, staff members would only occupy the school for eight hours per day, and 250 days per year at the most. Therefore, the air concentrations which the staff members would potentially be exposed to would be: 250 days/365 days x 8 hours/24 hours, or 23 percent of the RBCs. For a child who would potentially occupy either the library for no more than two or three hours per day, and the classroom for no more than six hours per day 180 days per year, the actual exposure concentrations would be 6 percent to 12 percent of the RBCs.

Exposure Assessment

In general, the exposure scenarios selected for evaluation in this risk assessment overestimate the frequency and magnitude of potential exposures. For example, it is unlikely that a child trespasser will wade in the wetland area two days per week June through August, particularly since surface water is at it's lowest depth during those months. Similarly, it is unlikely that a pupil will be exposed to the grassy area in front of the school five times per week, particularly since the school play grounds and athletic fields are elsewhere at the school. Therefore, the exposure scenarios chosen to represent possible exposures to Site media are unlikely to result in underestimation of risks.

There is some uncertainty associated with the EPCs for inorganics and non-fuel related VOCs in subsurface soil because only two subsurface soil samples were analyzed for these parameters. Additional samples might have shown higher (or lower) concentrations. However, non-fuel related VOCs and inorganics were not the primary chemicals of concern at AOC 69W (i.e., there presence in subsurface soil was not directly related to the fuel oil release at AOC 69W), and were not substantial risk drivers in subsurface soil.

The intended future use of the school is a Charter School which will include grades kindergarten through high school. The risk assessment is protective for pupils in these grades (i.e., ages 6 through 18). However, if the school was used only for younger pupils - grade-school aged children for example - risks would be underestimated because the body weight for younger children would be lower (e.g., 35 kg for children 6 through 13) than the body weight for children ages 6 through 18 (45 kg). Risks for grade-school aged children exposed to surface soil, groundwater discharge, and sediment would be higher than those estimated in this risk assessment by a factor of 1.3 (45 kg / 35 kg = 1.3). However, the combined risks for exposure to surface soil, groundwater discharge, sediment, and indoor air would still not exceed a HI of 1 or an ELCR of 1E-05. Therefore, although this risk assessment evaluated risks for children over a wide age range, risks for younger children would still not exceed threshold risk levels.

As discussed previously, groundwater beneath AOC 69W is not used as a source of drinking water. Although the groundwater flows toward a the MacPherson water supply well located 3,000 feet downgradient of the site, the groundwater contamination at AOC 69W does not affect that aquifer, and it does not appear that site-related fuel oil contamination will ever reach the well. Groundwater monitoring data have indicated that fuel-related compounds are contained in groundwater associated with soil source area, which was recently removed. However, monitoring data from downgradient wells at the site (e.g., ZWM-95-18) indicate that no fuel oil contamination has reached the wells since their installation in 1995. Since the soil source area has recently been removed, groundwater concentrations of fuel related constituents in the former source area are expected to decrease. This, in conjunction with the limited groundwater migration identified to date, suggest that it is extremely unlikely that groundwater containing fuel-related compounds from AOC 69W would migrate to the downgradient water supply well. Moreover, any compounds that did migrate downgradient would be substantially diluted, and would not likely pose a risk of concern.

All analytes detected in indoor air samples collected from rooms within the school building were evaluated in this risk assessment. This represents a conservative assessment of potential exposures to constituents interpreted to be site-related. As discussed in Appendix O-1, based on the exposure pathway analysis, it appears that the presence of only three analytes in indoor air (ethylbenzene, 2-methylheptane, and xylene) is potentially attributable to subsurface contamination beneath the school. Of these, none were detected in the vicinity of the northwestern portion of the school at concentrations that would include them as a CPC in the risk assessment, and only ethylbenzene was detected at a concentration within the school building at a concentration that included it as a CPC in the risk assessment.

The USEPA performed indoor air sampling in April, 1998; the USEPA report is included as Appendix R to this report. In general, the USEPA sampling identified a similar profile of chemicals in indoor air. However, analytes were generally detected at concentrations considerably lower than those detected in the RI sampling effort. Most notably, toluene was detected at only 2 $\mu g/m^3$ in the USEPA samples compared to 1000 $\mu g/m^3$ in the RI samples, ethylbenzene at only 0.5 $\mu g/m^3$ in the USEPA samples compared to 470 $\mu g/m^3$ in the RI samples; nonane and octane were not detected in the USEPA samples, whereas other fuel-related constituents (e.g., decane, dodecane, and trimethylbenzene) were detected at concentrations below 1 $\mu g/m^3$. Methylpentane was detected at 170 $\mu g/m^3$ in the USEPA samples, but was not detected in the RI samples. Methylnaphthalene and naphthalene, which were associated with rejected data in the RI samples, were detected at concentration up to 1.4 $\mu g/m^3$ in the USEPA samples.

Given this information, it appears that the RI sampling effort provided a conservative assessment of the potential concentrations of indoor air constituents. Evaluation of the maximum detected concentrations in indoor air samples collected during the RI sampling effort as the EPCs in the risk assessment provided a conservative assessment that is unlikely to underestimate potential risks to future pupils that may use the school.

Toxicity Assessment

Arsenic was selected as a CPC detected in all media at AOC 69W. Use of the CSF for arsenic to estimate ELCRs is thought to overestimate the true risk by perhaps an order of magnitude or more (USEPA, 1998). The oral CSF for inorganic arsenic is based on dose/response data for skin cancer incidence obtained by Tseng et al. (1968). Individuals in this study were exposed to high levels of inorganic arsenic in drinking water (170 micrograms per milliliter [μg/mL]). Arsenic exposure was approximated based on estimates of water intake. Other exposure pathways contributing to total exposure, such as ingestion of fish, livestock, and plants, were not assessed, potentially resulting in an underestimate of arsenic exposure. The oral slope factor was calculated using a model that assumes the dose/response curve is linear at low doses. Recent evidence suggests that arsenic, at low doses, may be largely detoxified by methylation, producing a non-linear dose/response curve. In the study of Tseng et al. (1968), the overwhelming of the normal detoxification pathways, coupled with an underestimate of exposure, may have resulted in an overestimate of cancer risk. These uncertainties have caused the USEPA to report that, "the uncertainties associated with ingested inorganic arsenic are such that estimates could be modified downwards as much as an order of magnitude, relative to risk estimates associated with most other carcinogens" (USEPA, 1998).

Use of the USEPA provisional oral RfD for iron to estimate noncancer risk may result in an overestimate of risk. The oral RfD for iron is based on average daily intake data for humans from the NHANES II data base. The provisional RfD represents an average dietary intake of iron that is protective against iron deficiency anemia, but is insufficient to cause toxic effects. Therefore, the data do not represent a threshold for adverse effects due to over-exposure. Toxic effects would occur following chronic oral exposures to higher iron levels than those represented by the provisional oral RfD. In addition, the forms of iron administered to individuals reported in the NHANES II data base were bioavailable forms (ferrous form) contained in iron supplements. Iron in environmental media is typically present in the elemental or ferric form, which have substantially lower bioavailability than the ferrous form. These two uncertainties relative to the provisional iron RfD likely result in an overestimate of noncancer risk.

No inhalation dose-response values for acetone and arsenic were published in sources recognized by USEPA Region I (i.e., IRIS, HEAST, NCEA). Therefore, non-cancer inhalation risks were not quantified for these CPCs. However, MADEP has published RfCs or RfC surrogate values for these CPCs. The RME HQ associated with particulate inhalation exposure to arsenic for the excavation worker (the most-exposed receptor to particulate emissions) is 0.001, which does not add measurable risk to the excavation worker RME inhalation HI of 0.8. The RME HQ associated with inhalation exposure to acetone in indoor air for the pupil is 0.07, which increases the pupil RME inhalation HI from 0.4 to 0.5; the HI for combined media exposures remains 1.

Risk Characterization

Given the uncertainties discussed in this section, it appears that the risk estimates reported in this risk assessment overestimate risks rather than underestimate risks. The primary sources of uncertainty the lend to a general overestimation of risks include:

I. Including in the risk assessment inorganic analytes that are detected in Site media at concentrations consistent with background
II. Frequency and contact rate assumed for exposures to soil, surface water, and sediment
III. Likelihood of groundwater use as drinking water
IV. Conservativeness of the arsenic and iron dose-response values
V. Evaluation of inhalation exposures to constituants that are unlikely to be present in indoor as a result of subsurface fuel-oil contamination.
VI. In addition, the quantitative evaluation of total petroleum hydrocarbon data is not required by USEPA Region I, but has been performed in this risk assessment to estimate possible risks associated with fuel oil-related constituents in environmental media. Therefore, non-cancer risks associated with CPCs which are quantitatively evaluated under USEPA Region I guidance are less than those reported in this risk assessment.

9.2.6 Summary and Conclusions

Possible health risks were evaluated for the current and anticipated future land uses at AOC 69W. Since the former elementary school at AOC 69W is presently closed, exposures and risks for current site use were evaluated for a site maintenance worker (possible exposure to surface soil), and a trespasser ages 6 through 18 (possible exposure to sediment and groundwater discharge to surface water). The possible health risks associated with future site use were evaluated assuming that the school will be re-opened, and included evaluation of a pupil ages 6 through 18 (possible exposure to surface soil, sediment, groundwater discharge to surface water, and indoor air), and an excavation worker (possible exposure to surface soil and subsurface soil). In addition, future use of the groundwater as a potable water source was evaluated. Since groundwater at and beneath AOC 69W is not used as a source of drinking or industrial water, evaluation of potable use represents a hypothetical worst-case evaluation of potential exposures and risks.

The risk assessment evaluated post-removal action conditions for surface soil and subsurface soil, and pre-removal action conditions for groundwater, sediment, and indoor air. CPCs were identified in surface soil, subsurface soil, sediment, groundwater, and indoor air and included metals, SVOCs, VOCs, and petroleum-related compounds including TPHCs, EPHs, VPHs, and PAHs. Among these CPCs, only the petroleum-related compounds are directly associated with the release of fuel-oil at AOC 69W.

Possible health risks were quantified for carcinogenic and non-carcinogenic effects, for both reasonable maximum and central tendency exposure assumptions. Estimated cancer and non-cancer risks associated with possible current and future land use exposures to surface soil, subsurface soil, sediment, groundwater discharge to surface water, and indoor air were within acceptable levels established by the USEPA. Risks for multi-media exposures for the site maintenance worker, child, trespasser, future pupil, and future excavation worker were within acceptable levels. Estimated cancer and non-cancer risks associated with hypothetical exposures to AOC 69W groundwater used as a residential drinking water source exceeded levels generally considered acceptable by USEPA. However, these risks are primarily due to the presence of arsenic in the groundwater, which is not interpreted to be directly related to the release of fuel oil at AOC 69W.

Based on the conclusions of the risk assessment, there are no unacceptable human health risks associated with soils, sediment, groundwater discharge, or indoor air. Moreover, the soil removal action at AOC 69W significantly reduced fuel oil contamination in soil thereby mitigating possible exposures to fuel-related CPCs in soil, reducing the CPC concentrations in groundwater, and eliminating a possible source of fuel-related vapors. Therefore, the risk estimates presented in this risk assessment worst-case estimates that are unlikely to be exceeded under conceivable future land use conditions. The only risks that exceed USEPA thresholds are associated with hypothetical future use of the groundwater as a source of residential drinking water.

9.3 ECOLOGICAL RISK ASSESSMENT

This Baseline Ecological Risk Assessment (BERA) evaluates actual and potential adverse effects to ecological receptors associated with exposure to contamination from Area of Contamination (AOC) 69W at Devens, Massachusetts. Fuel spills originating from an underground storage tank and associated piping at AOC 69W (the former Fort Devens Elementary School) in the 1970's have resulted in the presence of petroleum-related contaminants in site media. This BERA utilizes surface soil, sediment, groundwater, and toxicity test data to evaluate potential risks to ecological receptors.

The BERA for AOC 69W was completed in accordance with current guidance materials for BERAs at Superfund sites including the following:

- Risk Assessment Guidance for Superfund, Environmental Evaluation Manual (USEPA, 1989a);
- Ecological Assessment of Hazardous Waste Sites, A Field and Laboratory Reference (USEPA, 1989b);
- Ecological Assessment of Superfund Sites, An Overview (USEPA, 1991a);
- Framework for Ecological Risk Assessment (USEPA, 1992a);
- USEPA Region I, New England "Risk Updates" (issued since 1992);
- Tri-Service Procedural Guidelines for Ecological Risk Assessments, Volumes I and II (Wentsel et. al., 1996); and
- Proposed Guidelines for Ecological Risk Assessment (USEPA, 1996);

and

- Ecological Risk Assessment Guidance for Superfund: Process for Designing and Conducting Ecological Risk Assessments (USEPA, 1997).

Recent risk assessment guidance including the USEPA "Eco Update" bulletins (issued since 1991) and publications (e.g., Maughan, 1993; Suter, 1993) were also consulted.

Discussions of the general site history and layout are provided in Section 2.0, and are briefly summarized at the beginning of Section 9.0. A discussion of historical and current analytical data is provided in the contaminant assessment (Section 5.0). The AOC 69W BERA includes a Site Characterization (Subsection 9.2.1), Problem Formulation (Subsection 9.2.2), Hazard Assessment and Selection of CPCs (Subsection 9.2.3), Exposure Assessment (Subsection 9.2.4), Ecological Effects Assessment (Subsection 9.2.5), Risk Characterization (Subsection 9.2.6), Uncertainty Analysis (Subsection 9.2.7), and Summary (Subsection 9.2.8).

9.3.1 Site Characterization

AOC 69W is located at the intersection of Antietam Street and MacArthur Boulevard (Figure 5-3). The area south and west of AOC 69W is primarily suburban/residential. The Wherring Housing area is located directly north of the site and Shepley's Hill sits immediately behind the site to the east and northeast.

AOC 69W is comprised of the former Fort Devens Elementary School (Building #215), a parking lot and an adjacent lawn located on the northern side of the school, a man-made drainage ditch, and a persistent emergent wetland bordering Willow Brook (Figure 5-3). The site extends from the school, west to a man-made drainage ditch that transitions into Willow Brook, and northwest to a persistent emergent wetland approximately 250 feet away. The original school was built in 1951 and an addition was constructed in 1972. During construction of the addition, the old UST was removed and a new 10,000-gallon UST was installed north of the school in the middle of the current parking lot. In addition, a 250-gallon UST was located about 300 feet to the northeast of the school and about 30 feet in from the edge of the delineated bordering vegetated wetland. Both the 10,000-gallon and 250-gallon USTs have been removed from the site. The 250-gallon UST was part of the recovery system installed after 7,000 to 8,000 gallons of oil leaked from faulty pipes in 1972.

A site investigation completed by ADL (1994) identified contamination in surface soil, subsurface soil and groundwater form the school out towards Willow Brook. The contamination consist of oil leaked from piping associated with the 10,000-gallon underground storage tank. Most of the contamination appears to be beneath the paved area located north of the school. Ecological receptors would not be exposed to contaminants beneath the paved area; however, potential risks to ecological receptors do exist from contaminated surface soil and sediment in the vicinity of Willow Brook and groundwater discharging to the drainage ditch and Willow Brook.

In October of 1995, HLA ecologists visited AOC 69W to characterize habitats associated with the drainage ditch and Willow Brook. In addition, ecological receptors that would likely use the site were identified for evaluation in the BERA. Habitat types in the ditch and brook were characterized based on plant species present, topography, and hydrology. Ecologists divided brook habitats into two portions - upper and lower. The upper portion begins at the outfall of the drainage ditch that goes under Antietam Street. The lower portion begins 300 to 350 yards downgradient of the culvert where the drainage ditch transitions into a small persistent emergent wetland. The following paragraphs summarize the results of the qualitative survey. More information regarding the ecological survey is provided in Appendix P.

9.3.1.1 Vegetative Cover. The area between the upper portion of the ditch and MacArthur Boulevard consists of mowed grass. The dominant tree species along the northwest side of the drainage ditch is Norway spruce (*Picea abies*). The southwest side of the ditch is dominated by red maple (*Acer rubrum*). Other tree and shrub species prevalent along the western side of the ditch include: slippery elm (*Ulmus rubra*), pin oak (*Quercus palustris*), shagbark hickory (*Carya ovata*), American chesnut (*Castanea dentata*), white mulberry (*Morus alba*), red-osier dogwood (*Cornus stolonifera*), arrow-wood (*Viburnum recognitum*), and swamp azalea (*Rhododendron viscosum*). Herbaceous species present along this portion of the site include: sedges (*Cyperus sp.*), rice-cutgrass (*Leersia oryzoides*), nightshade (*Solanum dulcamara*), boneset (*Eupatorium perfoliatum*), cow vetch (*Vicia cracca*), jewelweed (*Impatiens capensis*), common dodder (*Cuscuta gronovii*), buttercup (*Ranunculus sp.*), and cocklebur (*Xanthium strumarium*).

9.3.1.2 Wetland and Drainage Ditch Habitat. The man-made ditch, which leads into Willow Brook, is primarily a stormwater and meltwater conveyance feature and is not likely to support aquatic life for most of the year, because it typically does not contain standing water. However, it is possible that groundwater seasonally discharges to the lower portion of the ditch and may provide habitat for juvenile amphibians and some macroinvertebrates. The ditch is approximately 3 to 5 feet wide with an average depth of 3 feet, and has steep abrupt banks. The bottom of the ditch contains remnants of asphalt underlain by a medium to coarse sand with little to no organic matter.

Approximately 300 to 350 yards below the culvert at Antietam Road, the drainage ditch turns slightly to the northwest. The area immediately adjacent to the northeast side of the drainage ditch transitions into a small triangular-shaped persistent emergent wetland, which is about 0.25 acres in size. The wetland does not contain standing water; however, it is likely that water is at or near the surface throughout much of the year. The wetland area is dominated by herbaceous species, and has an open canopy. Tree and shrub species in this wetland include red maple, white pine (*Pinus strobus*), gray birch (*Betula populifolia*), arrow-wood, highbush blueberry (*Vaccinium corymbosum*), and buckthorn (*Rhamnus frangula*). Herbaceous species reported include tussock sedge (*Carex stricta*), wooly sedge (*Scirpus cyperinus*), blue-joint (*Calamagrostis canadensis*), broad-leaved cattail (*Typha latifolia*), Joe-pye weed (*Eupatorium maculatum*), arrow-leaved tearthumb (*Polygonum sagittatum*), and hardhack (*Spiraea tomentosa*).

9.3.1.3 Wildlife Habitat Characterization. The wetland area and open mowed areas may provide habitat to various small mammals and birds, predatory mammals, and soil invertebrates. Small mammal receptors may include the meadow vole (*Microtus pennsylvanicus*), short-tailed shrew (*Blarina brevicauda*), and the white-footed mouse (*Peromyscus leucopus*). Small birds found at AOC 69W may include the American robin (*Turdus migratorius*), a habitat generalist typically found in forested areas, and the red-winged blackbird (*Agelaius phoeniceus*), found in riparian and field habitats. The fragmented habitat at AOC 69W may not be suitable for many predatory mammals and birds. However, the raccoon (*Procyon lotor*) may exist along the wooded and wetland areas of the site where water may be present.

9.3.1.4 Rare, Threatened, and Endangered Species. The presence or absence of rare and endangered flora and fauna at the site is reviewed in this subsection. Under contract to the U.S. Army Corps of Engineers, HLA developed a database of all flora and fauna known to seasonally or permanently occur at Fort Devens (ABB-ES, 1993a), with particular emphasis on rare and endangered biota. The Fort Devens biological and endangered species baseline study (BESBS) contains information from the Massachusetts Natural Heritage Program (MNHP) and the United States Fish and Wildlife Service (USFWS) regarding all rare and endangered species known to occur at Fort Devens; in addition, more information has been requested for recently documented occurrences. The BESBS has been checked for known occurrences of rare and endangered biota in the vicinity of AOC 69W; no state or federally listed rare and endangered species occur at AOC 69W. AOC 69W may provide suitable habitat for species that are listed by the state as species of special concern or are on the state watch list, including the spotted salamander (*Ambystoma maculata*), northern leopard frog (*Rana pipiens*), olive-sided flycatcher (*Contopus borealis*), eastern bluebird (*Sialia sialis*), and Vesper sparrow (*Pooecetes gramineus*).

According to the MNHP (MNHP, 1997), several species protected by the Massachusetts Endangered Species Act and other implementing regulations have been documented as occurring within 1 mile of AOC 69W. The actual occurrence of these species at the site is unknown. The eastern box turtle (*Terrapene carolina*) (special concern) may be found in the wooded portions of AOC 69W. The following species listed by the MNHP may be found in the upland sandy soils or disturbed portions of AOC 69W: Houghton's flatsedge (*Cyperus houghtonii*) (endangered), New England blazing star (*Liatris scariosa* var. *novae-angliae*) (special concern), and wild senna (*Senna hebecarpa*) (endangered).

9.3.2 Problem Formulation

Problem formulation is the initial step of the BERA process whereby receptors, exposure pathways, and the assessment and measurement endpoints are selected for evaluation.

9.3.2.1 Identification of Receptors. Mammals, birds, reptiles, amphibians, terrestrial plants, and terrestrial invertebrates are expected to be found in the terrestrial habitats of AOC 69W. Semi-terrestrial wildlife (including some mammals and birds) and aquatic receptors (including some macroinvertebrates and amphibians) are expected to inhabit areas around Willow Brook and in the wetland.

9.3.2.2 Identification of Exposure Pathways. Exposure pathways are identified for four groups of ecological receptors (wildlife, terrestrial plants, terrestrial invertebrates, and aquatic receptors). The exposure pathway includes a source of contamination, potentially contaminated media, and an exposure route. The exposure pathways from the AOC 69W contaminant source to ecological receptors are depicted in the contaminant pathway model in Figure 9-3. All of the potential exposure pathways are shown in Figure 9-3; those pathways that are quantitatively evaluated in the AOC 69W BERA are indicated by shading. This limitation is necessary to focus the BERA on the pathways for which: (1) contaminant exposures are the highest and most likely to occur, and (2) there are adequate data pertaining to the receptors, contaminant exposures, and toxicity for completion of risk analyses. Exposure pathways evaluated include portions of food chains (e.g., surface soil → primary consumer → secondary consumer → tertiary consumer), as well as other direct and indirect exposures.

The general classes of contaminants include petroleum related compounds associated with the fuel oil release. Potentially affected media include surface soil, subsurface soil, sediment, and groundwater. The likely ecological effects associated with this type of contamination are identified for terrestrial wildlife, terrestrial plants, terrestrial invertebrates, and aquatic receptors. Given the relatively low concentrations of contaminants detected in site media, it is unlikely that there would be any acute toxicological effects in ecological receptors at AOC 69W. The effects on terrestrial wildlife from exposure to fuel oil contamination may include reduced fecundity, reduced growth, reduced activity, and mortality. The effects on terrestrial plants may include decrease in growth and propagation. The effects on terrestrial invertebrates may include reduced cocoon production, decreased growth, and mortality. The effects on aquatic receptors may include reduced growth and reproduction, and behavioral and developmental effects.

Terrestrial Wildlife. The wildlife exposure routes that are believed to contribute the highest potential contaminant exposures include incidental ingestion of site media and ingestion of food items that have bioaccumulated contaminants from site media. Dermal exposures to wildlife are not evaluated in the AOC 69W BERA because there are few data relating dermal exposures to toxic responses in wildlife. Dermal exposure may be an ecologically significant exposure pathway for amphibians and for young, hairless mammals in subterranean dens; however, in general, an assumption is made that fur, feathers, or chitinous exoskeleton limit the transfer of contamination across the dermis. The reported spills occurred a number of years ago; consequently, in the sandy soils of this region, most deposited VOCs would have already volatized or leached. Therefore, the inhalation exposure pathway was not quantitatively evaluated for ecological receptors. Potential food chain exposures for amphibians and reptiles exist at AOC 69W, but are not evaluated due to a lack of data relating contaminant exposures to adverse responses for these taxa. This data gap is furthered discussed in the uncertainty section.

Wildlife and semi-terrestrial wildlife ingestion exposures from surface soil contaminants in the upland and wetland portions of AOC 69W are evaluated in the BERA.

Terrestrial Plants and Invertebrates. Terrestrial plants and soil invertebrates may be exposed to contamination in surface soil by direct contact, root uptake (plants), or ingestion (invertebrates) of soil.

Aquatic Receptors. Exposure pathways for aquatic receptors at AOC 69W include direct contact with and ingestion of sediment in the downstream portions of the ditch and Willow Brook. Although conservative, this exposure pathway was evaluated because the ditch and Willow Brook may support aquatic life at some time during the year (i.e., when water is present). However, it is more likely that sensitive aquatic receptors would not even be present in the ditch due to the sporadic presence of water in the ditch, and limited availability of habitat (i.e., organic matter and decomposing leaf litter) required by sensitive aquatic receptors to survive during periods of no water. In addition, aquatic receptors may be indirectly exposed to contaminants in groundwater as it discharges to the surface; consequently, potential risks to aquatic receptors from exposure to contaminants in groundwater are evaluated. Exposures to aquatic receptors from sediment in the upstream portions of the ditch were not evaluated because this area is upgradient of the contaminant source, and because the ditch does not provide habitat suitable for supporting aquatic life.

9.3.2.3 Identification of Endpoints. The assessment and measurement endpoints selected for the AOC 69W BERA are listed in Table 9-13. Assessment endpoints represent the ecological component to be protected, whereas the measurement endpoints provide an operational definition of the assessment endpoint. The assessment endpoint selected for this BERA is the survival and propagation of receptor populations at AOC 69W. The specific objectives of the AOC 69W BERA are to determine whether the chemical concentrations detected in surface soil, sediment and groundwater are likely to result in population decline of ecological species.

Measurements of actual toxicity and adverse effects to survival and growth were completed for two benthic invertebrates, the midge (*Chironomus tentans*) and amphipod (*Hyalella azteca*). Assays with these invertebrates were intended to provide more realistic, site-related measures of adverse impact than generic screening values. Site-specific toxicological data are not available for surface soil or groundwater; therefore, the measurement endpoints used to gauge the likelihood of population-level effects are toxicological benchmark values based on laboratory-measured survival, growth, and reproductive effects.

9.3.3 Hazard Assessment and Selection of Contaminants of Potential Concern (CPCs)

The Hazard Assessment includes a review of analytical data and selection of CPCs. CPCs are the analytes detected in environmental media that are considered in the AOC 69W BERA and could present a potential risk to ecological receptors. The process for selecting CPCs is depicted in Figure 9-4.

Historical (i.e., data collected before 1995) surface soil, sediment, and groundwater data were not included in the AOC 69W BERA as they do not represent current conditions at the site. Only current analytical data (i.e., those data collected in 1995, 1996 or 1997) were utilized in the AOC 69W BERA. All of the analytical data are provided in Section 7.0 of the Remedial Investigation (RI) and in electronic format in Appendix L. All samples were analyzed for PAL metals, pesticides/PCBs, PAL SVOCs, PAL VOCs, TPHC, EPH, and VPH. Off-site laboratory analyses for PAL organics and inorganics were considered approximately equivalent to USEPA Level III quality data. TPHC data are not evaluated in this BERA because methods to relate wildlife exposures to TPHC with adverse responses are not available. In addition, wet chemistry data (e.g., alkalinity, chloride, nitrite, nitrogen, phosphate, sulfate, TDS, TSS, and hardness) are available for groundwater. As discussed in Subsection 3.2.6, analytical data for AOC 69W were evaluated to determine their validity for use in the BERA.

The following data sets are evaluated in the AOC 69W BERA:

- Surface soil (a combined data set of upland and wetland soils),
- Downgradient sediment (collected from the bottom of the ditch), and
- Groundwater.

Analytes were not retained as CPCs if the maximum detected concentration is less than the background concentration. The background surface soil and groundwater data sets consist of chemical data gathered from locations designed to establish background concentrations of inorganic analytes for Group 1A sites. The values approximately represent the 68th percentile upper bound limits (the mean values plus one standard deviation) of these chemicals (ABB-ES, 1993b). Sediment data were screened against soil background concentrations since no background database exists for sediment and the upgradient sediment may be contaminated from road run-off. The upgradient sediment data set consists of data collected in 1995 at sampling stations ZWD-95-01X, ZWD-95-04X, and ZWD-95-05X and will be qualitatively compared to downgradient concentrations.

The essential nutrients (e.g., calcium, magnesium, potassium, and sodium) were excluded as CPCs for all media, and iron was excluded as a wildlife CPC for food-chain exposures of surface soils and sediment. These analytes are considered to be essential nutrients; evidence suggests that there is little potential for toxic effects resulting from over-exposure to these essential nutrients. The highly controlled physiological regulatory mechanisms of these inorganics suggest that there is little, if any, potential for bioaccumulation, and available toxicity data demonstrate that high dietary intakes of these nutrients are well-tolerated (NAS, 1977; National Research Council [NRC], 1982; 1984).

All analytes detected in surface soil, sediment, and groundwater are presented in tables that include the following summary statistics: frequency of detection, range of detection limits, range of detected concentrations, and background values. For those analytes that were retained as CPCs in the BERA, the following information is also provided: average of all concentrations, and RME and average exposure point concentrations. Ninety-fifth percent UCLs were not calculated for any data sets as there are fewer than 10 samples in all the data sets. For groundwater, there were 13 samples analyzed for nitrogen, phosphate, hardness, total dissolved solids, total suspended solids, and TPHC. However, these analytes were not quantitatively evaluated, and 95 percent UCLs are not presented. A discussion of how EPCs were calculated is provided in Subsection 9.2.4.1.

9.3.3.1 Surface Soil. Summary statistics for six surface soil samples (ZWS-95-35X, ZWS-95-39X, ZWS-95-42X, and ZWS-95-45X through ZWS-95-47X) collected at AOC 69W (shown in Figure 5-3 and 5-5) are presented in Table 9-14. All organic analytes including acetone, toluene, trichlorofluoromethane, xylenes, eight PAHs, and TPHC were retained as CPCs in the BERA. Eight of the 19 inorganic analytes detected in soil (beryllium, cobalt, copper, lead, mercury, nickel, selenium, and zinc) were retained as CPCs because their maximum detected concentrations exceed background and none are essential nutrients as discussed above.

9.3.3.2 Upgradient Sediment. Summary statistics for three upgradient sediment samples (ZWD-95-01X, ZWD-95-04X, and ZWD-95-05X) (shown in Figure 5-3) are presented in Table 9-15. Information from this table was used for a qualitative comparison with the downgradient sediment samples.

9.3.3.3 Downgradient Sediment. Summary statistics for three sediment samples (ZWD-95-02X, ZWD-95-03X, and ZWD-95-06X) (shown in Figure 5-3) are presented in Table 9-16. All organic analytes including trichlorofluoromethane, 4 PAHs, the DDT_R family (i.e., DDD, DDE, and DDT), TPHC (gas fraction), diesel fuel, and TPHC (total) were retained as CPCs in the BERA. Three of 16 inorganic analytes (cobalt, copper, and nickel) detected in downgradient sediment were retained as CPCs because their maximum detected concentrations exceed background concentrations and they are not essential nutrients. TOC concentrations were low (ranging from 2,400 to 5,400 $\mu g/g$).

9.3.3.4 Groundwater. Summary statistics for ten groundwater samples (69W-94-10 through 69W-94-14, ZWM-95-15X, ZWM-95-16X, and ZWM-95-18X through ZWM-95-20X) collected at AOC 69W (shown in Figure 5-3) are presented in Table 9-17. All organic analytes including three VOCs, seven SVOCs, two pesticides, and TPHC were retained as CPCs. Three inorganic analytes (arsenic, iron, and manganese) detected in filtered and unfiltered groundwater samples were retained as CPCs because their maximum detected concentrations exceeded background concentrations.

9.3.4 Exposure Assessment

Exposure assessment is the process of estimating or measuring the amount of a CPC to which an ecological receptor may be exposed. The following sections briefly describe how contaminant exposures were estimated or measured for wildlife, terrestrial plants, terrestrial soil invertebrates, and aquatic receptors at AOC 69W. The contaminant pathway model (Figure 9-3) provides a summary of the potential exposure pathways that exist at AOC 69W for each group of receptors.

9.3.4.1 Calculation of Exposure Point Concentrations. RME and average EPCs were chosen for all CPCs in surface soil, sediment, and groundwater to evaluate exposures to receptors. An RME concentration represents the highest concentration of an analyte that ecological receptors would likely encounter at the site, whereas average EPCs represent typical site concentrations. For each data set, the RME concentration is equal to the maximum detected concentration because the 95th percent UCL was not calculated when there are fewer than 10 samples in the data set. The average of all samples was used to represent the average EPC unless it exceeds the maximum EPC, in which case the maximum EPC is used for both scenarios. The average of all concentrations assigns a value of one-half of the sample quantitation limit (SQL) to all samples in which the analyte is not detected.

RME and average EPCs are presented in Tables 9-14 through 9-17 for surface soil, sediment, and groundwater. A tiered approach was used to efficiently evaluate exposure and risk at AOC 69W; if no risk was calculated from exposure to the RME concentrations, then average exposure scenarios were not evaluated.

9.3.4.2 Terrestrial Wildlife. Exposure routes for wildlife receptors include direct or indirect ingestion of AOC 69W soil, sediment, and ingestion of contaminated food. To evaluate exposures at AOC 69W, representative wildlife species were selected for evaluation in food chain models which estimate contaminant exposures to wildlife species respective to their position in the food chain. Ecological exposures for the AOC 69W BERA are assumed to occur within the top two feet of soil and the top 6 inches of sediment. Contaminant exposures for terrestrial wildlife are related to the foraging characteristics of the species; therefore, terrestrial and semi-terrestrial receptors were chosen to represent the trophic levels typically found in upland suburban settings, ephemeral ditches, and forested wetland habitats. The following representative wildlife species (summarized in Table 9-18) were selected for evaluating food-chain exposures in the AOC 69W BERA:

- **White footed mouse** (*Peromyscus leucopus*). The white-footed mouse is a small granivorous mammal (i.e., feeding primarily on seeds and young grass shoots) that inhabits wooded or scrub/shrub habitats. Invertebrates also make up a small portion of this receptor's diet. The white-footed mouse represents granivorous mammals found in terrestrial areas at AOC 69W.

- **Short-tailed shrew** (*Blarina brevicauda*). The short-tailed shrew finds suitable habitat in forests, fields, marshes, and brush. It primarily feeds on earthworms, snails, centipedes, insects, small vertebrates, and slugs (DeGraaf and Rudis, 1986). Relative to other small mammals, insectivorous species may receive high doses of contamination through bioaccumulation in prey. The shrew represents small mammal omnivores that may be found in the ditch/Willow Brook and wetland area at AOC 69W.

- **American robin** (*Turdus migratorius*). The robin is often seen perched in open woodlands and foraging in developed areas such as maintained grassy lawns. The robin represents avian receptors that consume earthworms, insects, and plants, and was selected to represent avian omnivores in terrestrial areas at AOC 69W.

- **Red-winged blackbird** (*Agelaius phoeniceus*). The red-winged blackbird is often seen in riparian habitats and fields. The red-winged blackbird represents avian receptors that consume insects, spiders, and seeds, and nests in shrubs, within sedges or grass, or in other emergent vegetation (Ehrlich et al., 1988). The blackbird represents avian omnivores that may be found in the ditch/Willow Brook or wetland areas at AOC 69W.

- **Raccoon** (*Procyon lotor*). The raccoon represents an opportunistic species that is commonly found in virtually every aquatic habitat and in developed areas. Raccoons are primarily active from sunset to sunrise (USEPA, 1993a). Raccoons consume a variety of food items including fleshy fruits, nuts, acorns, grains, insects, frogs, crayfish, and eggs (USEPA, 1993). The raccoon represents higher trophic level omnivorous mammals found in the ditch/Willow Brook and the wetland at AOC 69W.

Exposure assumptions (e.g., body weights, food ingestion rates, relative consumption of food items) for each of the representative wildlife species for AOC 69W are provided in Appendix P, Table P-1.

The Site Foraging Frequency (SFF) approximates the frequency a receptor feeds within a potentially contaminated site area and is calculated by the ratio of the site area to the receptor's home range. By definition, the SFF cannot exceed 1. For instance, the potentially contaminated surface soil area (calculated to be approximately 1 acre) is larger than the home ranges of the white-footed mouse, short-tailed shrew, American robin, and the red-winged blackbird. Therefore, it is assumed that the SFF for these receptors in these areas is 1.

To estimate receptor exposures to contaminants in site media and contaminated food items, a Potential Dietary Exposure (PDE) (or body dose) was estimated for all representative wildlife species for each CPC in all media according to the equations in Table 9-19. The PDEs calculated from exposure to AOC 69W surface soil and sediment CPCs for each receptor are presented in Appendix P, Tables P-8 through P-10.

Tissue concentrations of CPCs in prey items were estimated using bioaccumulation factors (BAFs) for surface soil and sediment. BAFs for most receptors were extrapolated from literature values or estimated using regression equations from scientific literature. Based on the lack of scientific data for VOC bioaccumulation and evidence provided in several reference materials (Suter, 1993; Maughan, 1993), an assumption was made that VOCs do not bioaccumulate in biological tissue. The general approach used to select BAFs for AOC 69W is summarized in Table 9-20. BAFs reported in the scientific literature for avian and mammalian receptors are defined as the reported ratios of CPC concentrations in the tissues of these receptors (mg contaminant/kg tissue wet weight) to the concentrations of CPCs in their food items (mg contaminant/kg tissue wet weight).

BAFs for invertebrate and plant prey items are defined as the ratio of the CPC concentration in plant or invertebrate tissue (mg contaminant/kg tissue wet weight) to the CPC concentration in solid media (mg contaminant/kg dry weight). BAFs for each of the CPCs evaluated at AOC 69W are included in Appendix P, Table P-2.

Although indirect exposures to wildlife from groundwater CPCs exist, this exposure pathway is not a significant route of exposure and is unlikely to result in risk. Groundwater discharges to the surface (i.e., the ditch) for a only a short period during the year, limiting the amount of time an ecological receptor may be exposed to groundwater. The analytes detected in groundwater would likely attenuate to sediments prior to discharge, decreasing the concentration of a contaminant to which an ecological receptor may be exposed. In addition, groundwater would be diluted at the point of discharge, as it is likely that groundwater would be discharging to the ditch when the local water table was high and surface water would most likely be present. Consequently, risks to wildlife from exposure to groundwater CPCs were not quantitatively evaluated at AOC 69W.

9.3.4.3 Terrestrial Plants and Invertebrates. Terrestrial plants and soil invertebrates may be exposed to CPCs via direct contact with, root uptake (plants), or ingestion (invertebrates) of CPCs measured in AOC 69W surface soil. For the purposes of the AOC 69W BERA, exposures to terrestrial plants and invertebrates are assumed to occur within the top 2 feet of surface soil.

9.3.4.4 Aquatic Receptors. Aquatic organisms may be exposed to CPCs via direct contact with sediment and groundwater as it discharges to the surface. Surface water EPCs were estimated based on the detected analyte concentrations in groundwater; however, this exposure assumption may be overly conservative because analytes may attenuate before reaching a discharge area, or may become diluted at the discharge area.

Subchronic toxicity tests were performed using the midge (*Chironomus tentans*) and the amphipod (*Hyalella azteca*). These benthic and epibenthic (respectively) invertebrates were exposed to sediment samples collected from three downgradient locations at AOC 69W (ZWD-95-02X, ZWD-95-03X, and ZWD-95-06X), shown in Figure 5-3. Sediment samples for toxicity testing were collected concurrently at AOC 69W and AOC 57, and it was determined that sample location 57D-95-08X (collected from Cold Spring Brook, a perennial stream at AOC 57) would be used as a reference sample for AOC 69W and AOC 57. However, sediment at AOC 69W contains trace organic matter (< 1 percent) and is described as sandy and gravelly with some cobbles, whereas sediment from the AOC 57 reference sample has sandy texture and finer grain sizes with about 26 percent organic matter. Consequently, the AOC 57 sample location was not an ideal reference for AOC 69W, however it was the only reference location available at the time of the testing. Amphipod survival may be attributable to characteristics of the substrate and percent organic matter rather than site contamination. The uncertainties associated with using 57D-95-08X as a reference station are also discussed in Subsection 9.2.7.

Sediment toxicity studies were conducted in accordance with the guidelines *Methods for Measuring the Toxicity and Bioaccumulation of Sediment-Associated Contaminants with Freshwater Invertebrates* (USEPA, 1994). Eight replicates of laboratory-raised midges and vendor-supplied amphipods were maintained for each sediment sample and the control. Replicates were exposed to whole sediment in 10-day static renewal toxicity tests. After exposure, surviving organisms were counted and weighed. The results of these tests were used to evaluate potential toxicity from exposure to downgradient sediment contamination. A summary of results are presented in Subsection 9.3.5.3. Detailed results of the AOC 69W sediment toxicity testing are presented in Appendix P.

9.3.5 Ecological Effects Assessment

As stated in the problem formulation, the assessment endpoints of the BERA are the survival and propagation of ecological receptor populations at AOC 69W. The ecological effects assessment discusses what measurement endpoints were used to represent the assessment endpoints evaluated in this BERA. Terrestrial and semi-terrestrial wildlife receptors, terrestrial plants, terrestrial invertebrates, and aquatic organisms are potentially exposed to CPCs detected in AOC 69W site media; the measures of adverse ecological effects for these receptor groups are discussed separately.

9.3.5.1 Terrestrial and Semi-terrestrial Wildlife. Because no long-term wildlife population data are available at Devens, a direct measurement of the survival and propagation of wildlife populations at AOC 69W is not possible. The literature-derived results of laboratory toxicity studies that relate the dose of a contaminant in an oral exposure with an adverse response to growth, reproduction, or survival of a test population (avian or mammalian species) were used in food-web models as a measure of the assessment endpoint. Lethal and sublethal wildlife ingestion toxicity data (which are used to derive reference toxicity values (RTVs) for evaluating risk) are presented in Appendix P, Table P-3. Wildlife effects from exposure to CPCs in surface soil and downgradient sediment were evaluated in the AOC 69W BERA.

For each CPC identified and each representative wildlife species selected, two RTVs were identified. A lethal RTV represents the threshold for lethal effects and is based on oral LD_{50} data (oral dose [in mg/kg body weight-day] lethal to 50 percent of a test population). The lethal RTV is equal to one-fifth of the lowest reported LD_{50} for the most closely related test species; this is considered to be protective against lethal effects for 99.9 percent of individuals in a test population (USEPA, 1986). When LD_{50} data were not available, a LOAEL for lethal effects was selected. A sublethal RTV is selected to represent a threshold body weight-normalized dose for adverse effects related to reproduction or growth. A summary of RTVs selected from the ingestion toxicity data are provided in Appendix P, Table P-4.

In some instances, one-fifth of the LD^{50} (the lethal RTV) is less than the sublethal LOAEL or NOAEL. Therefore, the RTV used for evaluating adverse effects to wildlife is conservatively selected as the lessor of the lethal or sublethal RTVs derived from the literature. If neither lethal nor sublethal toxicity information were available for a taxonomic group, RTVs from another taxonomic group were used as surrogates. The uncertainties associated with using inter-taxonomic surrogates are discussed in Subsection 9.3.7.

9.3.5.2 Terrestrial Plants and Invertebrates. Site-specific toxicity data for plants and invertebrates are not available for AOC 69W; therefore, the results of toxicity studies from the literature that relate the soil concentrations of a contaminant to adverse growth, reproduction, or survival effects of a test population were used as a measure of the assessment endpoint. These study results are summarized in Appendix P, Tables P-5 (plants) and P-6 (invertebrates). Terrestrial plant and invertebrate effects from exposure to upland and wetland surface soils are evaluated in the AOC 69W BERA.

For plants, the effects primarily considered were measures of growth or yield as these response parameters are most common in phytotoxicity studies. For invertebrates, the effects primarily considered were measures of reproduction or mortality; when LC_{50} data were used, one-fifth of the LC_{50} was used to be protective of 99.9 percent of the population (USEPA, 1986).

9.3.5.3 Aquatic Receptors. Aquatic organism effects from exposure to sediment are evaluated in the AOC 69W BERA. Potential adverse ecological effects associated with CPCs in sediment were evaluated by comparing the CPC concentrations with literature-derived benchmarks. In addition, adverse effects to aquatic receptors from direct contact with CPCs in sediment were evaluated based on the results of the sediment toxicity study using the midge and amphipod. The results of the sediment toxicity test for the amphipod and midge are presented in Table 9-21 and Appendix P, and are summarized below.

Literature values that relate the concentration of a contaminant with an effect level (derived from data for adverse growth, reproduction, or survival effects of test populations) are used as a measure of the assessment endpoint. Sediment benchmarks selected for comparison to detected sediment concentrations included National Oceanic and Atmospheric Administration (NOAA) Effects Range-Low (ER-L) and Effects Range-Median (ER-M) sediment guidelines (Long et al., 1994) based on the National Status and Trends Program approach; USEPA Sediment Quality Guidelines (SQG) based on equilibrium partitioning (USEPA, 1988a; USEPA, 1993b); Ontario Ministry of the Environment (OME) Lowest Effect Level (LEL) provincial sediment quality guidelines (Persaud et al., 1996) based on the Apparent Effects Threshold (AET) approach; and New York State Department of Environmental Conservation (NYSDEC) sediment quality criteria (NYSDEC, 1994).

Midge survival and growth results for AOC 69W sediments were not significantly different from either the control or the reference samples. Growth results for amphipods exposed to AOC 69W sediment samples were also not significantly different from the control or reference samples. Amphipod survival in sample ZWD-95-06X (36 ± 23 percent) was significantly less than the control (64 ± 18 percent). Amphipod survival was also significantly less in samples ZWD-95-02X (55 ± 24 percent) and ZWD-95-06X compared to the reference sample (80±21 percent).

Results appear to indicate that midge survival and growth, as well as amphipod growth, are not adversely affected from exposure to downgradient sediment at AOC 69W. Amphipod survival may be adversely affected from exposure to sediment at sample locations ZWD-95-02X and ZWD-95-06X. However, there is uncertainty associated with the amphipod control results because the control sample did not meet the 80 percent acceptance criteria for survival, as defined in the *Methods for Measuring the Toxicity and Bioaccumulation of Sediment-Associated Contaminants with Freshwater Invertebrates* (USEPA, 1994). This deviation alters the reliability of the data analysis; however, inferences about this toxicity test can still be discussed. The control sample for the midge did meet its 70 percent acceptance criteria.

The effects of groundwater CPCs on aquatic organisms were evaluated by comparing groundwater EPCs to surface water RTVs. Surface water RTVs selected for comparison to groundwater exposure concentrations include Federal chronic Ambient Water Quality Criteria (AWQC) (USEPA, 1991b; USEPA, 1988b) and aquatic toxicity information from the USEPA AQUIRE database (AQUIRE, 1996). Effects concentration data obtained from AQUIRE are included in Appendix P, Table P-7. Chronic AWQC are concentrations that, if not exceeded by the four-day average chemical concentration more than once every three years, are considered protective of most species of aquatic life and its uses (USEPA, 1983). When criteria were lacking, lowest observed effects concentrations measuring survival, growth, reproduction, and biodiversity endpoints were derived from the AQUIRE database (AQUIRE, 1996).

9.3.6 Risk Characterization

This subsection discusses how risks were characterized for ecological receptors exposed to contaminated media at AOC 69W. A comparison of exposure information with the appropriate concentration-response toxicity data is the basis for risk characterization.

9.3.6.1 Terrestrial and Semi-terrestrial Wildlife. Risks for the representative wildlife species associated with ingestion and bioaccumulation of CPCs in surface soil, sediment, and prey items are quantitatively evaluated using HQs, which are calculated for each CPC by dividing the PDE based on RME concentrations by the selected lethal or sublethal RTV. HIs are determined for each receptor by summing the HQs for all CPCs. When the estimated PDE is less than the RTV (i.e., the HQ < 1), it is assumed that chemical exposures are not associated with adverse effects on survival, growth, or reproduction, and that no risks to wildlife populations exist. When an HI is greater than 1, a discussion of the ecological significance of the HQs comprising the HI is provided, and risks from exposure to average concentrations of CPCs are evaluated.

This hazard ranking scheme evaluates potential ecological effects to individual organisms and does not evaluate potential population-wide effects. Contaminants may cause population reductions by affecting birth and mortality rates, immigration, and emigration (USEPA, 1989a). In many circumstances, lethal or sublethal effects may occur to individual organisms with little population- or community-level impacts; however, as the number of individual organisms experiencing toxic effects increases, the probability that population effects will occur also increases. The number of affected individuals in a population presumably increases with increasing HQ or HI values; therefore, the likelihood of population-level effects occurring is generally expected to increase with higher HQ or HI values.

The HQs and HIs calculated based on RME and average EPCs for each representative wildlife species are provided in Appendix P, Tables P-8 through P-10. A summary of risks to representative wildlife receptors is provided in Table 9-22 and in the following paragraphs. There are no toxicity data available relating wildlife exposures to TPHC with adverse responses; therefore, TPHC exposures were not included in the food-web model, and potential adverse effects from TPHC exposure remain an uncertainty.

Surface Soil. The HQs and HIs calculated for each representative wildlife species are provided in Appendix P, Tables P-8 and P-9; a summary of risks is provided in Table 9-22. The summary HI for the short-tailed shrew exposed to RME concentrations in soil is 2.8. The primary risk contributor to the shrew is lead, which was detected at a maximum concentration (238 μg/g) that exceeds the background concentration for lead (48 μg/g) by nearly five times. The summary HI for the shrew based on average EPCs in soil (which are more representative of site conditions) is 0.88, suggesting that small mammals are generally not at risk from exposure to lead in surface soil. Summary HIs for all other wildlife receptors exposed to RME and average EPCs in soil are less than 1. These results suggest that adverse effects to the small mammal population are negligible. Several site-related factors suggest that the estimated risk to RME lead concentrations may be overstated. These factors include the unlikelihood that receptors would consistently be exposed to these RME concentrations and the (generally) greater availability of inorganics in laboratory dietary studies. Furthermore, the low magnitude of estimated risk from RME concentrations of lead indicates a low probability that small mammals would experience adverse effects. Risks are not expected for small mammals based an HI of 2.8

Sediment. HQs and HIs calculated for each representative wildlife are provided in Appendix P, Table P-10, and a summary of risks is provided in Table 9-22. Summary HIs for all wildlife receptors exposed to RME EPCs in sediment are less than 1. Therefore, it is unlikely that adverse effects to wildlife receptors would occur from exposure to RME concentrations of analytes in AOC 69W sediment.

9.3.6.2 Terrestrial Plants. Risks for terrestrial plants were evaluated by comparing the selected phytotoxicity benchmarks (Appendix P, Table P-5) to RME and average EPCs of analytes detected in soil. The results of the surface soil evaluation for AOC 69W are presented in Table 9-23 and are discussed below. There are no data available relating plant exposures to acetone, trichlorofluoromethane, or TPHC with adverse responses; therefore, risks to plants from exposure to these chemical could not be evaluated. However, the concentrations of acetone and trichlorofluoromethane were extremely low. Furthermore, acetone is a common laboratory contaminant, and the chlorofluorocarbons are highly non-toxic to animal receptors. Consequently, risks attributable to these analytes are considered negligible. Risks resulting from TPHC exposure could not be estimated due to the limited availability of toxicity data relating TPHC concentrations in soil and phytotoxicity.

RME EPCs for lead and zinc in AOC 69W surface soil exceed phytotoxicity benchmarks (Table 9-23). All other CPC exposure concentrations are less than phytotoxicity benchmarks, suggesting that plants are not at risk from exposure to VOCs, SVOCs, pesticides, beryllium, cobalt, copper, mercury, nickel, or selenium in AOC 69W surface soil. The RME and average concentration of lead (238 and 61.2 μg/g, respectively) exceed the background concentration and the phytotoxicity benchmark values (48 and 50 μg/g, respectively) by less than a factor of five and two, respectively. The RME concentration of zinc (71.7 μg/g) slightly exceeds the background (44 μg/g) and benchmark value (50 μg/g) by less than a factor of two. The average concentration of zinc (32.5μg/g) is less than background and the benchmark value. Based on the slight exceedances of the RME concentration, it is likely that risks to plants from exposure to zinc would be negligible.

Maximum lead and zinc concentrations occurred in a single sample location (ZWS-95-42X). It is possible that plants in the vicinity of sample location ZWS-95-42X may exhibit phytotoxic effects from exposures to lead. However, concentrations of lead and zinc in the other six samples were below background concentrations and benchmarks. Given this isolated area of contamination, it is unlikely that population-level effects to plants from these analytes would occur. Risks to plants based on average concentrations of lead and zinc, which are more representative of actual exposures to plant populations at AOC 57 are negligible. In addition, no signs of phytotoxicity were noted during the site survey.

9.3.6.3 Terrestrial Invertebrates. Risks for terrestrial invertebrates were evaluated by comparing the selected invertebrate benchmarks (Appendix P, Table P-6) to RME and average EPCs. The results of the surface soil evaluations for AOC 69W are presented in Table 9-23 and are discussed below. There are no toxicity data available relating invertebrate exposures to acetone, trichlorofluoromethane, beryllium, cobalt, selenium, or TPHC with adverse responses; therefore, invertebrate exposures to these analytes were not evaluated and potential adverse effects remain an uncertainty. Because of low concentrations, low toxicity, and/or presence as a laboratory contaminant, as discussed above, neither trichlorofluoromethane nor acetone are significant risk issues. RME and average EPCs of all other analytes detected in AOC 69W surface soil are less than available invertebrate benchmarks. The available data suggest that, among organics, TPHC may present a significant risk to certain invertebrate communities. Risks related to inorganics exposure are negligible, based on the comparison of EPCs with RTVs (Table 9-23).

9.3.6.4 Aquatic Organisms. Risks to aquatic receptors from exposure to sediment at AOC 69W were characterized based on the toxicity test evaluation performed for the midge and amphipod and on a comparison of sediment EPCs with the toxicity benchmarks discussed in subsection 9.2.5.3. In addition, a qualitative evaluation of upgradient and downgradient sediments is performed.

Sediment - Toxicity Test Results. Risks for aquatic macroinvertebrates were characterized based on the results of sediment toxicity tests. The sediment analytical and toxicity test samples were collected concurrently; therefore, the analytical results for the sediment samples were used to interpret the contaminant exposures and responses of the test species (midges and amphipods) in the toxicity tests.

As previously discussed in Subsection 9.2.5.3, amphipod survival was significantly lower in sediment sample ZWD-95-06X than in the control sample and the reference sample (57D-95-08X), and amphipod survival was significantly lower in sediment sample ZWD-95-02X than in the reference sample. No other statistically significant differences in midge or amphipod survival and growth were observed between the reference or control samples and the sediment collected at AOC 69W.

Since the survival of amphipods exposed to the control sediment was below the 80 percent acceptance criteria, comparisons to the control may not be appropriate. Furthermore, 57D-95-08X may not be a suitable reference station for the ditch sediments at AOC 69W. However, sediment samples for toxicity testing were collected concurrently for AOC 57 and AOC 69W, and it was assumed that the reference location identified at AOC 57 would be suitable for a reference at AOC 69W. The unacceptable control survival, and the physical differences between the reference sediment and site sediment, limit the inferences that can made regarding the data.

Sediment - Benchmark Comparison. The comparison of sediment concentrations with toxicity benchmarks values is provided in Table 9-24. Sediment concentrations of two metals, three pesticides, and four semivolatiles exceeded sediment benchmark values.

RME concentrations of copper (23.4 $\mu g/g$) and nickel (18.1$\mu g/g$) slightly exceed OME LEL and NYSDEC LEL values of 16 $\mu g/g$. These sediment benchmarks are representative of concentrations that can be tolerated by the majority of benthic organisms (Persaud, et al, 1996). Average concentrations of these analytes, which are more representative of site conditions, are below benchmark values. This evidence suggests that copper and nickel may not cause adverse effects to the majority of aquatic organisms. RME and average concentrations of pesticides (DDD, DDE, and DDT) exceeded toxicity benchmarks; however, these analytes are not likely related to the fuel oil spill at AOC 69W. As with metals, RME and average concentrations of semivolatiles slightly exceed the NOAA ER-Ls and the OME LELs; these slight exceedances suggest that in sediment, PAHs may not cause adverse population level effects for aquatic organisms.

Relating the results of the benchmark comparison for chemicals detected in downgradient sediment to the adverse responses observed in the toxicity tests may be difficult. Of the analytes that only slightly exceeded sediment benchmarks, the four PAHs and copper were detected at their highest concentrations at ZWD-95-06X (where *H. azteca* survival was significantly lower than in the control and reference samples), and nickel was detected at its highest concentration at ZWD-95-02X (where *H. azteca* survival was significantly lower than in the reference sample). These results suggest adverse effects to populations of these test organisms. However, *H. azteca* are a highly sensitive macroinvertebrate species, and effects on the more diverse and tolerant community structure occurring in the natural environment are unclear. In addition, sandy nature (i.e., low organic carbon content) of the ditch substrate may have contributed to the reduced survival observed in the amphipod toxicity tests as compared to the reference sample collected from Cold Spring Brook. In addition, the highest concentration of any DDT_R compound was detected at ZWD-95-03X, where no adverse effects were observed in test organisms.

Comparison to Upgradient Sediment. Eight pesticides, five semivolatiles, two volatiles, five metals, and TPHC were selected as CPCs for upgradient sediment. In general, concentrations of contaminants (that were found in both upgradient and downgradient samples) were higher in -upgradient samples. Alpha- and gamma-chlordane, Aroclor-1260, dieldrin, Endosulfan II, and chrysene were detected in upgradient samples, but not in downgradient samples. Lead and zinc were selected as CPCs for upgradient sediment, but not for downgradient sediment. Contamination in upgradient sediments does not appear to be site-related. Upgradient sediment samples were collected in high automotive traffic areas, which may account for higher levels of contamination (particularly TPHC, PAHs, and possibly lead). Pesticides are most likely not associated with site activities. It is likely that concentrations detected in upgradient sediment would influence concentrations observed in downgradient sediment.

Groundwater - Benchmark Comparison. Risks to aquatic organisms from exposures to AOC 69W groundwater are evaluated by comparing exposure concentrations to surface water toxicity benchmarks. This comparison is presented in Table 9-25. Maximum and average concentrations of iron and manganese (filtered and unfiltered) exceeded aquatic benchmarks. However, the benchmarks for these analytes are protective of species (i.e., fish) that would not likely inhabit the ditch at AOC69W. These maximum values were associated with one sample location (69W-94-10) located near the school (i.e., furthest from the discharge point). In addition a soil removal action at the site has mitigated the reducing conditions that may have mobilized these metals in groundwater.

Two pesticides (gamma-chlordane and heptachlor epoxide) were detected in only one of eight samples (at sample location 69W-94-10). Concentrations of both of these analytes exceed toxicity benchmarks. However, these analytes are not associated with past fuel oil spill activities. Bis(2-ethylhexyl)phthalate and phenanthrene were detected in two of eight samples at maximum concentrations well above benchmark values. These maximum concentrations were also associated with 69W-94-10. Given the low frequency of detection and that contamination is associated with a single sampling location, exposure to these analytes at AOC 69W may not result in adverse population-level effects.

9.3.7 Uncertainty Analysis

The objective of the uncertainty analysis is to discuss the assumptions of the BERA process that may influence the risk assessment results and conclusions. General uncertainties inherent in the risk assessment process and in the AOC 69W BERA are included in Table 9-26.

Specific uncertainties associated with the assessment of risks associated with contamination at AOC 69W include the following.

- Risks to terrestrial receptors associated with exposure to TPHC in surface soil, sediment, and groundwater may be underestimated. Although selected as a CPC for these media, TPHC was not evaluated in the BERA because of the lack of toxicological benchmarks.

- Risks to avian species may be over- or underestimated because bioaccumulation and toxicity data for this taxonomic group are generally lacking in the literature. To conservatively estimate risks to avian species at AOC 69W, mammalian data were used as surrogate values when avian data were lacking. Significant metabolic, life stage, and physiological differences between these two taxa provide considerable extrapolation uncertainty. Furthermore, there is considerable uncertainty extrapolating between laboratory text organisms and wildlife.

- Risks to terrestrial wildlife receptors from food chain exposures to lead may have been underestimated because a BAF of zero was used for uptake into plants. This FAB of zero was obtained from the literature; however, the literature varies on the subject. The risk conclusions are not likely to be changed substantially by using other lead FAVs that will only slightly raise the estimated risks from lead exposure.

- Risks to plants and invertebrates may be under- or overestimated because phytotoxicity and invertebrate benchmarks for most analytes are either lacking or are based on a limited number of studies. Specifically, potential risks to plants from exposure to acetone, trichlorofluoromethane, and TPHC, and potential risks to invertebrates from exposure to beryllium, cobalt, selenium, acetone, trichlorofluoromethane, and TPHC, could not be evaluated.

- There is uncertainty associated with using unfiltered groundwater data for evaluating risk to aquatic organisms from exposure to inorganic analytes. Risks to aquatic organisms may be overestimated because unfiltered data represent the total fraction of analytes that occur in groundwater, including those that are sorbed to particulates. The bioavailable (i.e., filtered) fraction provides a better measure of toxicity; however, particulate matter can also be hazardous because of mechanical obstruction with physiological processes.
- No sediment benchmarks exist for cobalt, trichlorofluoromethane, diesel fuel, or TPHC gas fraction; therefore, risks to aquatic organisms from exposure to these analytes remain an uncertainty.
- Risks to aquatic organisms from exposure to several metals (e.g., aluminum, arsenic, barium, cobalt, iron, magnesium, manganese, potassium, and vanadium) in sediment may have been underestimated because these analytes were screened out of the ERA using background values for surface soil. However, none of these metals have sediment toxicity benchmarks (except for arsenic); therefore, it is possible that these analytes do not contribute significantly to adverse effects for aquatic organisms. The maximum detected concentration of arsenic (10 $\mu g/g$) only slightly exceeds the most conservative sediment guideline (OME LEL=6 $\mu g/g$); therefore, potential risks from exposure to arsenic in sediment are unlikely.
- Risks to amphibians may be underestimated, as this exposure pathway was not evaluated due to the paucity of toxicological data relating dermal exposure and toxicological effects to amphibians.
- There is uncertainty associated with the control results in the amphipod toxicity test. Only 64 percent survival was observed in the control samples, as opposed to the recommended minimum of 80 percent. These low survival rates may be attributable to shipment stress or contaminated control sediments. The poor control results may have impacted the results of the evaluation. There are also uncertainties associated with the sample to sample variation as indicated by large standard deviations. In addition, there is

uncertainty associated with using a sample from AOC 57 as a reference sample for AOC 69W, as the habitats for these areas are different. Sediment at AOC 69W contains trace organics (< 1 percent) and is described as sandy and gravely with some cobbles, whereas sediment from the AOC 57 reference sample has sandy texture and finer grain sizes, with about 26 percent organic matter.

- Risks for analytes detected in the method blanks, trip blanks, or rinsate blanks, and in the field samples, may have been overestimated. In particular, phthalates, acetone, and chlorinated solvents were detected in method blanks associated with water samples, and phthalates, TPHC, and various VOCs were detected in method blanks associated with solid media. In addition, several chlorinated solvents, bis(2-ethylhexyl)phthalate, mercury, lead, iron, potassium, and manganese were detected in rinsate blanks, and several chlorinated solvents were detected in trip blanks. Although analytes were detected in blanks, none of the blanks were grossly contaminated. In addition, all of the analytes detected were common laboratory contaminants, most were not analytes of concern, and all were detected at very low levels.

9.3.8 Summary of BERA for AOC 69W

Potential risks for ecological receptors were evaluated for CPCs in surface soil, sediment, and groundwater at AOC 69W. The following items summarize the results of the AOC 69W BERA:

- Small birds, small mammals, and predatory mammals exposed to maximum concentrations of analytes in surface soil would not likely be at risk. HIs for these taxa were all less than one (except for the shrew which had a low HI of 2.8). Uncertainty is greater for avian populations because of a generally inadequate toxicological reference base.

- It is unlikely that wildlife receptors exposed to maximum concentrations of analytes in sediment would be at risk. HIs for all receptors were less than one.

- Terrestrial plants may be at risk from exposure to lead in surface soil; however, elevated lead concentrations were localized. In addition, no stressed vegetation was observed during site walkovers conducted by HLA ecologists.

- It is unlikely that terrestrial invertebrates exposed to maximum detected concentrations of analytes in soil would be at risk. All of the analytes detected in soil were below invertebrate benchmark values or were detected at very low concentrations.

- Given the results of the toxicity tests, benthic macroinvertebrates (e.g., amphipods) may be at risk from exposure to sediment at AOC 69W. However, there are many uncertainties associated with the reliability of the statistical evaluation for amphipods, and the suitability of the ditch to provide adequate aquatic habitat.

- Based on the benchmark comparisons for aquatic receptors, risks from exposure to copper, nickel, and PAHs in sediment and in groundwater that discharges to the surface at AOC 69W are negligible. The monitoring well where maximum concentrations of all groundwater contaminants were detected is located close to the school. Concentrations would likely be lower due to attenuation before discharging to the surface. In addition, the seasonal groundwater discharge to the ditch or the wetland (at least 300 feet away) may be subject to dilution from precipitation, overland flow, and mixing with surface water.

10.0 CONCLUSIONS AND RECOMMENDATIONS

RI activities have been conducted by HLA at AOC 69W to evaluate the nature and distribution of the groundwater and soil contamination detected during previous investigations. Based on a review of RI data, a soil removal action was implemented to eliminate the source of contamination at AOC 69W. Conclusions developed from the RI findings are presented in the following subsections.

10.1 CONCLUSIONS

The following conclusions are based on interpretation of data collected from previous investigations, the RI, and the removal action completed at AOC 69W. Tables 10-1 and 10-2 summarize the results of the Human Health and Ecological Risk Assessments.

- The geologic setting at AOC 69W is comprised of dark yellowish-brown, fine to coarse sands, gravely sands, and silty sands which underlie and are interbedded with organic wetland deposits. The near surface organic deposits are more predominant near Willow Brook and within the grassy area north of the paved parking lot. Soils surrounding and underlying Willow Brook consist of dark grayish-brown sandy silt 4 to 5 feet in thickness.
- For the purpose of this RI the hydrogeologic condition at AOC 69W is dominated by the overburden aquifer. The water table is found in the overburden sands, gravely sands, and silty sands at depths ranging from 7 to 1 foot bgs. Local groundwater flow is primarily to the north-northwest. Groundwater discharges to Willow Brook in the vicinity of AOC 69W at times of high water levels.
- Estimates of hydraulic conductivity range between 1.3×10^{-3} cm/sec (3.7 ft/day) and 3.0×10^{-2} cm-sec (85 ft/day) with a geometric mean 1.6×10^{-2} cm/sec (45 ft/day). A groundwater flow velocity of 0.7 ft/day was calculated using the geometric mean of estimated hydraulic conductivities and horizontal hydraulic gradients.

- The primary contaminant source was identified as contaminated subsurface soil in the vicinity of the new boiler room. The contaminated subsurface soils were attributed to a 1972 fuel oil release from ruptured piping. A 1978 fuel oil release due to poorly joined piping in the vicinity of the old boiler room does not appear to have resulted in a significant contaminant source.

- The largest area of soil contamination extended from the new boiler room to a 250-gallon UST in the wooded area approximately 300 feet northwest of the school. The oil recovery system installed in response to the 1972 fuel oil release consisted of an underground pipe leading from the school to the 250-gallon UST and appeared to have acted as a conduit for contaminant migration. Detected contaminants were primarily TPHC, PAHs, and inorganics at approximately 6 to 10 feet bgs adjacent to the school building and 0 to 4 feet bgs downgradient in the grassy area and vicinity of the 250 gallon UST.

- Based on a review of the RI chemical data, a soil remedial action was completed in the winter of 1997 and 1998 to remove contaminated subsurface soil associated with the 1972 fuel oil spill and downgradient piping leading to the 250-gallon UST, thus, removing the majority of the source of soil and groundwater contamination.

- Confirmatory subsurface sample results indicate that EPH/VPH concentrations immediately adjacent to the school still exceed MCP S-1/GW-1 soil standards, but that subsurface soil concentrations in other portions of the area of the soil remedial action are generally low.

- A second area of soil contamination was identified adjacent to the school building outside of the old boiler room. Analytical data indicates that the contaminants are primarily TPHC at depths of 4 to 7 feet bgs. The observed contamination does not appear to be migrating downgradient based upon the results of numerous TerraProbe^{SM} and monitoring well analytical samples. Further contaminant migration is unlikely based upon the age of the release and the paved parking lot inhibiting recharge.

- Fuel related VOCs, SVOCs, and TPHC comprise the observed groundwater contaminants at AOC 69W. Varying degrees of groundwater contamination, as identified by field and off-site analysis, were observed to extend from the new boiler room towards the 250-gallon UST located approximately 300 feet to the northwest. The area of groundwater contamination was coincident with the underground piping for the oil recovery system. Contaminant concentrations were highest between the new boiler room and monitoring well 69W--94-13, which was also the location of the most contaminated soils. The soils around 69W--94-10 and 69W--94-13 were removed as part of the soil removal action.

- The soil removal action has removed the majority of the source of fuel oil contamination to groundwater, and has likely mitigated the reducing conditions that have caused metals to be mobilized in groundwater. Chemical concentrations in groundwater are expected to improve.
- Soil and groundwater contaminant distributions were vertically located in the vicinity of the water table and above.
- There is not any significant groundwater contamination associated with the 1978 fuel oil release. A soil removal conducted following the release likely mitigated the potential for groundwater contamination.
- TPHC data from groundwater samples collected prior to the soil removal action are highly variant from round to round and even between samples and duplicates.
- Contaminant distribution in sediment samples suggests that the petroleum contamination may have contributed SVOCs to deep (2 feet bgs) Willow Brook sediments. Sediment VOCs may have also come from asphalt-lining in Willow Brook. Pesticides, PCBs, and TPHCs were detected primarily in upgradient samples suggesting that their source is not site related.

Human Health

- Chemicals of potential concern for the human health risk assessment were identified in surface soil and subsurface soil representative of post-removal action conditions, sediment, groundwater and indoor air. They included metals, semi-volatile organic compounds, volatile organic compounds, and petroleum-related compounds including total petroleum hydrocarbons, extractable petroleum hydrocarbons, volatile petroleum hydrocarbons, and polynuclear aromatic hydrocarbons. Among these CPCs, only the petroleum-related compounds are directly associated with the release of fuel oil at AOC 69W.

- The presence of the constituents detected in the building air is likely due to the presence of numerous ambient sources within and outside the building, and not due to fuel-related constituents that may be present in soil and groundwater beneath the building. Nevertheless, circumstantial evidence indicated that a possible association between low level detections of xylenes, ethylbenzene, and methylheptane detected in air samples and soil samples collected in the vicinity of the northwestern portion of the building could not be ruled out. However, even the maximum detected concentrations of these three constituents were below levels that would include them as CPCs in the risk assessment. This indicates that pupils and school staff members who may hypothetically be exposed to these constituents in building air would not incur health risks even close to those considered to be of concern by the USEPA.

- Estimated cancer and non-cancer risks associated with possible current and future land use exposures to surface soil, subsurface soil, sediment, groundwater discharge to surface water and indoor air are within acceptable levels established the USEPA.

- Estimated cancer and non-cancer risks associated with hypothetical exposures to AOC 69W groundwater used as a residential drinking water source exceed levels generally considered acceptable by USEPA. However, these risks represent a *hypothetical worst-case* evaluation of potential exposures and risks because groundwater at and beneath AOC 69W is not used as a source of drinking or industrial water. Moreover, the risks are primarily due to the presence of arsenic in groundwater, which is not interpreted to be directly related to the release of fuel-oil at AOC 69W.

- Based on the conclusions of the risk assessment, there are no unacceptable human health risks associated with non-groundwater media. Future use of the site as a school is not associated with any unacceptable risks. Moreover, the soil removal action at AOC 69W significantly reduced fuel oil contamination in soil thereby mitigating possible exposures to fuel-related CPCs in soil, reducing the CPC concentrations in groundwater, and eliminating a possible source of fuel-related vapors. Therefore, the risk estimates presented in this risk assessment worst-case estimates that are unlikely to be exceeded under conceivable future land use conditions.

Potential risks for ecological receptors were evaluated for CPCs in surface soil, sediment, and groundwater at AOC 69W. The following items summarize the results of the AOC 69W BERA:

Ecological

- There are no anticipated risks to terrestrial wildlife receptors or soil invertebrates exposed to chemicals in surface soil. Likewise, there are no risks to semi-terrestrial wildlife receptors exposed to chemicals in Willow Brook sediment.
- Risks to terrestrial plants may occur at one surface soil sample location (ZWS-95-42X) due to the presence of lead. However, lead at this location may be associated with road run-off or lawn mower maintenance due to the proximity of this sample with MacArthur Avenue. Risks to plants would be localized, and are not likely to result in population-level effects since the average concentration of lead in soil only slightly exceeded toxicity benchmarks.
- Risks to aquatic organisms were identified for certain metals; however, the soil removal action has likely mitigated the reducing conditions in the subsurface soils that may have mobilized the metals in groundwater. Adverse effects were observed for aquatic organisms exposed to sediment in toxicity tests; however, these adverse effects are likely related to the marginal aquatic habitat and substrate quality, rather than the presence of site-related chemicals. Furthermore, although significantly reduced amphipod survival was observed in toxicity tests, the reliability of these tests are questionable (because of the poor control results). The midge toxicity test results indicate a minimal likelihood of risk to aquatic receptors. Exposure point concentrations for chemicals detected in sediment only slightly exceeded sediment benchmarks, suggesting that risks are unlikely.
- Based on the conclusions of the ERA, there are no unacceptable risks associated with site-related fuel oil contamination at AOC 69W.

10.2 RECOMMENDATIONS

Based upon the results and interpretation of the RI, supplemental sampling, and the soil removal action it is recommended that AOC 69W be proposed for limited action consisting of long term monitoring of downgradient groundwater quality with no additional investigation or remedial action. This course of action is supported by the following:

- The soil removal significantly reduced surficial and subsurface contaminants that were acting as a source for groundwater contamination
- No unacceptable risks posed to human health or the environment from site related fuel contamination
- Estimated risks associated with hypothetical exposure to groundwater used as a residential drinking water source exceeded levels generally considered acceptable by the USEPA. However, groundwater at AOC 69W is not used as a source of drinking or industrial water. Estimated risks for groundwater as a drinking water source are primarily due to the presence of arsenic. The presence of the arsenic is attributed to the mobilization of naturally occurring arsenic by reducing conditions in the aquifer brought on by the aerobic degradation of fuel related contaminants. The soil removal will act to lessen reducing conditions in the aquifer and therefore decrease arsenic concentrations in the groundwater.
- No chemicals of potential concern related to historical fuel releases were identified for air samples collected from inside the school
- Because the soil removal eliminated the majority of source area contaminants, estimated risks and interpretations represent worst-case estimates that are unlikely to be exceeded under future land use conditions.

ABB-ES	ABB Environmental Services, Inc.
ADL	Arthur D. Little, Inc.
AOC	area of contamination
AREE	area requiring environmental evaluation
ARF	analysis request form
ARAR	applicable or relevant and appropriate requirements
AST	aboveground storage tank
ATEC	ATEC Environmental Consultants, Inc.
bgs	below ground surface
BNA	base neutralized acids
BRAC	Base Realignment and Closure
BRAC	Base Realignment and Closure Environmental Evaluation
BTEX	benzene, toluene, ethylbenzene, and xylene
°C	degrees Celsius
cm/sec	centimeters per second
CENAE	U.S. Army Corps of Engineers, New England District
CERCLA	Comprehensive Environmental Response, Compensation and Liability Act
CFR	Code of Federal Regulations
CFS	cubic feet per second
CLP	Contract Laboratory Program
CMR	Code of Massachusetts Regulations
COC	chain-of-custody
COR	Contracting Officer's Representative
CPC	chemical of potential concern
CRL	certified reporting limits
CSF	cancer slope factor
1,2-DCA	1,2-dichloroethane
DCE	1,1-dichloroethene
DDD	dichlorodiphenyl dichloroethane
DDE	dichlorodiphenyl dichloroethylene
DDT	dichlorodiphenyl trichloroethane
DOT	Department of Transportation
DQO	data quality objective
DRO	diesel range organics

GLOSSARY OF ACRONYMS AND ABBREVIATIONS

DWEL	Drinking Water Equivalency Level
ECD	electron capture detector
E&E	Ecology & Environment, Inc.
EE	environmental evaluation
EE&G	Environmental Engineering and Geotechnics
ELCD	electronic conductivity detector
ELCR	excess lifetime cancer risk
EMO	Environmental Management Office
EPC	exposure point concentration
EPH	extractable petroleum hydrocarbons
ERA	Ecological Risk Assessment
ESE	Environmental Science and Engineering, Inc.
ETA	Engineering Technologies Associates
ft/ft	feet per foot
ft/min	feet per minute
ft/day	feet per day
ft^2/day	square feet per day
°F	degrees fahrenheit
FFA	Federal Facilities Agreement
FID	flame ionization detector
FS	Feasibility Study
FSP	Field Sampling Plan
GC/MS	gas chromatograph/mass spectrometer
g/mL	grams per milliliter
gpm	gallons per minute
GPR	ground-penetrating radar
GRO	gasoline range organics
H_c	Henry's Law Constant
HASP	Health and Safety Plan
HEAST	Health Effects Assessment Summary Table
HI	hazard index
HQ	hazard quotient
HLA	Harding Lawson Associates
HSA	hollow-stem augers

IAG	Inter Agency Agreement
ID	inside diameter
IDW	investigation-derived waste
IR	infrared spectrophotometer
IRDMIS	Installation Restoration Data Management Information System
IRIS	Integrated Risk Information System
kg	kilograms
K_{oc}	organic carbon partition coefficient
m^3	cubic meters
MAAF	Moore Army Air Field
MADEP	Massachusetts Department of Environmental Protection
MCL	maximum contaminant level
MCLG	maximum contaminant level goals
MCP	Massachusetts Contingency Plan
MDL	method detection limits
MEP	Master Environmental Plan
mg/kg	milligrams per kilogram
mg/L	milligrams per liter
mL	milliliter
MMCL	Massachusetts Maximum Contaminant Level
mph	miles per hour
MS	matrix spike
MSD	matrix spike duplicate
NCEA	National Center for Environmental Assessment
NCP	National Contingency Plan
ND	non-detect
NDIR	non-dispersed infrared
NFA	no further action
NWR	National Wildlife Refuge
OSHA	Occupational Safety and Health Administration
OD	outside diameter
PAH	polynuclear aromatic hydrocarbon
PAL	project analyte list

GLOSSARY OF ACRONYMS AND ABBREVIATIONS

PARCC	precision, accuracy, representativeness, completeness, and comparability
PC	personal computer
PCB	polychlorinated biphenyl
PCE	tetrachloroethene
PID	photoionization detector
POP	Project Operations Plan
ppb	parts per billion
ppm	parts per million
PQL	practical quantitation limit
PRE	preliminary risk evaluation
PRI	Potomoc Research, Inc.
PVC	polyvinyl chloride
QA	quality assurance
QAPP	Quality Assurance Project Plan
QC	quality control
RBC	risk-based concentration
RCRA	Resource Conservation and Recovery Act
RfD	reference dose
RFTA	Reserve Forces Training Area
RI	Remedial Investigation
RME	reasonable maximum exposure
ROD	Record of Decision
RPD	relative percent difference
SA	study area
SAP	Sampling and Analysis Plan
SARA	Superfund Amendments and Reauthorization Act
SCS	Soil Conservation Service
SDWA	Safe Drinking Water Act
SI	Site Investigation
SMCL	secondary maximum contaminant level
SQL	sample quantitation limit
SVOA	semivolatile organic analysis
SVOC	semivolatile organic compound
TBC	to be considered

1,1,1-TCA	1,1,1,-trichloroethane
1,1,2,2-TCA	1,1,2,2-trichloroethane
TCE	trichloroethene
TCL	target compound list
TDS	total dissolved solids
TEX	toluene, ethylbenzene and xylenes
TIC	tentatively identified compounds
TPHC	total petroleum hydrocarbons
TOC	total organic carbon
TSCA	Toxic Substance Control Act
TSS	total suspended solids
μg/g	micrograms per gram
μg/kg	micrograms per kilogram
μg/L	micrograms per liter
μg/m^3	micrograms per cubic meter
μg/ml	micrograms per milliliter
μL	microliter
UCL	upper confidence limit
USACE	U.S. Army Corps of Engineers
USAEC	U.S. Army Environmental Center
USATHAMA	U.S. Army Toxic and Hazardous Materials Agency
USDA	U.S. Department of Agriculture
USEPA	U.S. Environmental Protection Agency
USFWS	U.S. Fish and Wildlife Service
UST	underground storage tank
VC	vinyl chloride
VPH	volatile petroleum hydrocarbons
VOA	volatile organic analysis
VOC	volatile organic compound
WPA	Works Progress Administration
yd^3	cubic yards

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TABLE ES-1
SUMMARY OF HUMAN HEALTH RISK ASSESSMENT
AOC 69W

REMEDIAL INVESTIGATION REPORT
DEVENS, MASSACHUSETTS

EXPOSURE MEDIUM	RECEPTOR	CENTRAL TENDENCY		RME		ARE SITE RISKS UNACCEPTABLE?	
		Total Cancer Risk	Total Hazard Index	Total Cancer Risk	Total Hazard Index	Cancer Risk (greater than 1×10^{-6} - 1×10^{-4}) [1]	Non-Cancer Risk (greater than HI = 1) [2]
CHILD TRESPASSER: Current Land Use							
	SURFACE SOIL:	3×10^{-6}	0.1	6×10^{-6}	0.2	NO	NO
	SEDIMENT:	5×10^{-7}	0.05	1×10^{-6}	0.07	NO	NO
	GROUNDWATER (Discharge to Surface Water) :	1×10^{-6}	0.2	2×10^{-6}	0.2	NO	NO
	TOTAL CHILD TRESPASSER RISK:	6×10^{-6}	0.4	1×10^{-5}	0.6	NO	NO
SITE MAINTENANCE WORKER: Current Land USe							
	SURFACE SOIL:	1×10^{-6}	0.07	5×10^{-6}	0.1	NO	NO
PUPIL: Future Land Use							
	SURFACE SOIL:	5×10^{-6}	0.3	9×10^{-6}	0.3	NO	NO
	SEDIMENT:	5×10^{-7}	0.05	1×10^{-6}	0.07	NO	NO
	GROUNDWATER (Discharge to Surface Water) :	1×10^{-6}	0.2	2×10^{-6}	0.2	NO	NO
	INDOOR AIR:	NC	0.4	NC	0.4	NO	NO
	TOTAL PUPIL RISK:	6×10^{-6}	1	1×10^{-5}	1	NO	NO
EXCAVATION WORKER: Future Land Use							
	SURFACE SOIL:	1×10^{-7}	0.1	3×10^{-7}	0.2	NO	NO
	SUBSURFACE SOIL:	6×10^{-8}	0.9	1×10^{-7}	0.9	NO	NO
	TOTAL EXCAVATION WORKER RISK:	2×10^{-7}	1	4×10^{-7}	1	NO	NO
ADULT RESIDENT: Future Land Use							
	GROUNDWATER HYPOTHETICAL POTABLE USE [3]	1×10^{-4}	4	3×10^{-3}	25	YES	YES
CHILD RESIDENT: Future Land Use							
	GROUNDWATER HYPOTHETICAL POTABLE USE [3]	8×10^{-5}	8	2×10^{-3}	57	YES	YES
	TOTAL RESIDENT RISK:	2×10^{-4}	--	3×10^{-3}	--	YES	YES

NOTES:

1 According to the National Contigency Plan for Superfund Sites, the acceptable cancer risk range is within or below 1 in 10,000 (1×10^{-4}) to 1 in 1 million (1×10^{-6}).

2 According to the National Contigency Plan for Superfund Sites, the acceptable non-cancer risk is a chemical dose that will not result in adverse health effects to sensitive subpopulations; this is often interpreted by the USEPA to be a HI of not greater than 1.

3 Groundwater is not presently, nor will be in the future, used as a source of residential or industrial supply water. Therefore, this evaluation represents a theortical exposure which does not and will not occur.

4 Includes 2-methylheptane, napththalene, extractable petroleum hydrocarbons, volatile petroleum hydrocarbons

5 Includes bis(2-ethylhexyl)phthalate, aluminum, iron, manganese, chloroform, trichloroethene

RME = Reasonable Maximum Exposure
bgs = below ground surface
HI = Hazard Index

Table ES-2
Ecological Risk Assessment Summary
AOC 69W

Remedial Investigation
Devens, Massachusetts

Receptor	Medium		
	Surface Soil	Groundwater	Sediment
Small Mammals	Negligible	NA	None
Small Birds	None	NA	None
Predatory Mammals	None	NA	None
Terrestrial Plants	Pb at ZWS-95-42X? No signs of stressed vegetation	NA	NA
Soil Invertebrates	None	NA	NA
Aquatic Organisms	NA	Fe and Mn [1]. Negligible risk from other analytes	Negligible. Adverse effects observed in toxicity tests may be associated with low habitat quality

[1] Iron and manganese were detected in groundwater at concentrations that exceed AWQC; however, the soil removal action has mitigated the reducing conditions that may have contributed to the mobilization of these analytes in groundwater.

TABLE 3-1
TARGET COMPOUNDS AND REPORTING LIMITS
1995 AND 1996 FIELD SCREENING PROGRAM
AOC 69W

REMEDIAL INVESTIGATION REPORT
DEVENS, MASSACHUSETTS

Year	Target Analyte	Soil µg/g	Water µg/L
1995	Benzene	0.002	2
	Toluene	0.002	2
	Ethylbenzene	0.002	2
	m/p-xylene	0.002	4
	o-xylene	0.002	2
	Tetrachloroethene	0.002	2
	Trichloroethene	0.002	2
	cis-1,2-dichloroethene	0.002	2
	trans-1,2-dicholorethene	0.002	2
	1,1-dichloroethene	0.002	5
	Chloroform	0.002	2
	1,1,1-trichloroethane	0.002	2
	Carbontetrachloride	0.002	2
	Chlorobenzene	0.002	2
	TPH-GRO	0.1	100
	TPH-DRO	100	NA
	TPHC-IR	50	NA
1996	Benzene	0.25	2
	Toluene	0.25	2
	Ethylbenzene	0.25	2
	m/p-xylene	0.5	4
	o-xylene	0.25	2
	Tetrachloroethene	0.25	2
	Trichloroethene	0.25	2
	cis-1,2-dichloroethene	0.25	2
	trans-1,2-dicholorethene	0.25	2
	Vinyl chloride	0.25	2
	1,1-dichloroethene	0.25	2
	Chloroform	0.25	2
	1,1,1-trichloroethane	0.25	2
	Carbontetrachloride	0.25	2
	Chlorobenzene	0.25	2
	Naphthalene*	0.25	2
	1,2-dichlorobenzene*	0.25	2
	1,3-dichlorobenzene*	0.25	2
	1,4-dichlorobenzene*	0.25	2
	TPHC-IR	50	NA

Notes:
NA = soil not analyzed
µg/g = microgram per gram
µg/L = microgram per liter
* = added to list during 1996 field program

TABLE 3-2
USAEC DATA FLAGS AND QUALIFIERS
AOC 69W

REMEDIAL INVESTIGATION REPORT
DEVENS, MASSACHUSETTS

Measurement Boolean	Concentration	Data Qualifier (Upper case letters)	Flagging Codes (Lower case letters or #)
ND	300	J	adf

Measurement Boolean

< = Concentration was less than the certified reporting limit
ND = Not detectable above the indicated value
GT = Greater than the maximum certified concentration
EQ = Equal to the certified reporting limit

Data Qualifiers

? = Control chart for corresponding lot not yet reviewed by AEC Chemist. This qualifier is automatically set when a lot file has been uploaded to the database, but a corresponding control chart has not been approved.
I = The low spike recovery for this lot was high
M = The high spike recovery for this lot was high
J = The low spike recovery for this lot was low
K = Missed holding time for extraction or preparation
L = Missed analysis holding time
N = The high spike recovery for this lot was low
O = Low spike recoveries excessively different
R = Data is rejected and is not useable

Flagging Codes

1 = Result was less than the certified reporting limit but greater than the criteria of detection (COD) for 1990 QA Plan methods
2 = Ending calibration not within acceptable limits
3 = Internal standard not within acceptable limits
7 = Low spike recovery not within control limits
8 = Analyte recovery outside certified range but within acceptable limits. This code is used when analyte concentrations exceeded the certified range by <15 % and the laboratory felt a dilution was not warranted
a = Analyte found in trip blank as well as the sample
b = Analyte found in method blank or QC sample as well as the sample.
c = Analysis was confirmed by a different column or technique.
d = Duplicate analysis
f = Sample was filtered prior to analysis
g = Analyte found in that day's rinsate blank as well as the sample
h = Lot out of control but data accepted due to high recoveries
i = Interences in the sample caused the quantitation and/or identification to be suspect
j = Value is estimated
k = Reported results affected by interferences or high background. An elevated quantitation limit is reported
l = Out of control. Data rejected due to low recoveries
m= High duplicate spike not within control limits
n = Tentatively-identified compound (TIC) by GC/MC with a match greater than 70 %
p = Value is less than the method reporting limit but greater than the instrument detection limit
q = Confirmatory analysis was performed, however sample interferences prevented confirmation
r = Non-target analyte analyzed for but not detected by GC/MS. Laboratory is not certified for this analyte by the given method Analyte was not performance demonstrated or validated
s = Non-target compound analyzed for and detected by GC/MS. Laboratory is not certified for this analyte by the given method. Analyte was not performance demonstrated or validated
t = Non-target compound analyzed for and not detected (non-GC/MS method).
u = Analysis is unconfirmed. Confirmatory analysis was run but did not verify original result
v = Sample was not correctly preserved (i.e. > 4 degrees C or improperly preserved)
z = Non-target analyte analyzed for and detected by non-GC/MS method

TABLE 4-1
FEDERAL ARARS AND TBC GUIDANCE - GROUNDWATER AND SURFACE WATER
AOC 69W

REMEDIAL INVESTIGATION REPORT
DEVENS, MASSACHUSETTS

Analyte	Federal Standards and Guidance					
	Safe Drinking Water Act (SDWA)(a)		Clean Water Act (CWA) Ambient Water Quality Criteria (AWQC)(b)			TBC Region III Tap Water (µg/L)
			For Protection of Human Health		For Protection of Aquatic Life	
	ARAR Drinking Water MCL (µg/L)	TBC Drinking Water MCLG (µg/L)	ARAR Water and Fish Consumption (µg/L)	ARAR Fish Consumption Only (µg/L)	ARAR Fresh Water Acute/Chronic (µg/L)	
Volatile Organics						
acetone	-	-	-	-	-/-	3,700N
benzene	5	zero	0.66	40	5,300/-[2]	0.36C
carbon tetrachloride	5	zero	0.4	6.94	35,200/-[2]	0.16C
chloroform (THM)	100/80[3]	zero	0.19	15.7	28,900/1,240[2]	0.15C
ethylbenzene	700	700	1,400	3,280	32,000/-[2]	1,300N
styrene	100	100	-	-	-/-	1,600N
1,1,2,2-tetrachloroethane	-	-	0.17	10.7	-/2,400[2]	0.052C
tetrachloroethylene	5	zero	0.8	8.85	5,280/840[2]	1.10C
toluene	1,000	1,000	14,300	424,000	17,500/-[2]	750N
1,1,1-trichloroethane	200	200	18,400	1,030,000	-/-	1,300N
trichloroethylene	5	zero	2.7	80.7	45,000/21.900[2]	1.6C
trichlorofluoromethane	-	-	-	-	-/-	1,300N
xylenes (total)	10,000	10,000	-	-	-/-	12,000N

TABLE 4-1
FEDERAL ARARS AND TBC GUIDANCE - GROUNDWATER AND SURFACE WATER
AOC 69W

REMEDIAL INVESTIGATION REPORT
DEVENS, MASSACHUSETTS

Analyte	Federal Standards and Guidance					
	Safe Drinking Water Act (SDWA)[a]		Clean Water Act (CWA) Ambient Water Quality Criteria (AWQC)[b]			TBC Region III Tap Water (µg/L)
			For Protection of Human Health		For Protection of Aquatic Life	
	ARAR Drinking Water MCL (µg/L)	TBC Drinking Water MCLG (µg/L)	ARAR Water and Fish Consumption (µg/L)	ARAR Fish Consumption Only (µg/L)	ARAR Fresh Water Acute/Chronic (µg/L)	
Semivolatile Organics						
acenaphthene	-	-	-	-	-/-	-
anthracene	-	-	-	-	-/-	11,000N
bis(2-ethylhexyl)phthalate	6	zero	-	-	-/-	4.80C
benzo(a)anthracene	-	-	-	-	-/-	0.092C
benzo(a)pyrene	2	zero	-	-	-/-	0.092C
benzo(b)fluoranthene	-	-	-	-	-/-	0.092C
benzo(g,h,i)perylene	-	-	-	-	-/-	-
benzo(k)fluoranthene	-	-	-	-	-/-	0.092C
benzyl alcohol	-	-	-	-	-	11,000N
carbazole	-	-	-	-	-/-	3.4C
chrysene	-	-	-	-	-/-	9.2C
dibenzofuran	-	-	-	-	-/-	150N
di-n-butyl phthalate	-	-	-	-	-	3,700N

continued

TABLE 4-1
FEDERAL ARARS AND TBC GUIDANCE - GROUNDWATER AND SURFACE WATER
AOC 69W

REMEDIAL INVESTIGATION REPORT
DEVENS, MASSACHUSETTS

Analyte	Federal Standards and Guidance					
	Safe Drinking Water Act (SDWA)(a)		Clean Water Act (CWA) Ambient Water Quality Criteria (AWQC)(b)			TBC Region III Tap Water (µg/L)
			For Protection of Human Health		For Protection of Aquatic Life	
	ARAR Drinking Water MCL (µg/L)	TBC Drinking Water MCLG (µg/L)	ARAR Water and Fish Consumption (µg/L)	ARAR Fish Consumption Only (µg/L)	ARAR Fresh Water Acute/Chronic (µg/L)	
fluoranthene	-	-	-	-	-/-	1,500N
fluorene	-	-	-	-	-/-	1,500N
indeno(1,2,3-c,d)pyrene	-	-	-	-	-/-	0.092C
2-methylnaphthalene	-	-	-	-	-/-	-
naphthalene	-	-	-	-	2,300/620[2]	1,500N
n-nitrosodiphenylamine	-	-	4.9	16.1	-/-	14C
phenanthrene	-	-	-	-	30/6.3[5]	-
pyrene	-	-	-	-	-/-	1,100N
Inorganics						
aluminum	-	50 to 200[8]			-/-	37,000N
antimony	6	6[5]	146	45,000	88/30[5]	15N
arsenic	50[1]	-	0.0022	0.0175	360/190[2,7]	11N/0.038C
barium	2,000	2,000	1,000		-/-	2,600
beryllium	4[4]	4	0.0037	0.0641	130/5.3[2]	0.016C

continued

TABLE 4-1
FEDERAL ARARS AND TBC GUIDANCE - GROUNDWATER AND SURFACE WATER
AOC 69W

REMEDIAL INVESTIGATION REPORT
DEVENS, MASSACHUSETTS

Analyte	Federal Standards and Guidance					
	Safe Drinking Water Act (SDWA)[a]		Clean Water Act (CWA) Ambient Water Quality Criteria (AWQC)[b]			TBC Region III Tap Water (µg/L)
			For Protection of Human Health		For Protection of Aquatic Life	
	ARAR Drinking Water MCL (µg/L)	TBC Drinking Water MCLG (µg/L)	ARAR Water and Fish Consumption (µg/L)	ARAR Fish Consumption Only (µg/L)	ARAR Fresh Water Acute/Chronic (µg/L)	
cadmium	5	5	10	-	3.9/1.1[4]	18N
calcium	-	-			-/-	-
chromium (total)	100	100	-	-	1,700/210[4,9]	180
cobalt	-		-	-	-/-	220
copper	TT[10]	1,300	-	-	18/12[4]	1,400N
iron	-	300[8]	300	-	-/1,000	-
lead	TT[11]	zero	50	-	83/3.2[4]	-
magnesium	-	-	-	-	-/-	-
manganese	-	50[8]	50	100	-/-	1,800N
mercury	2	2	0.144	0.146	2.4/0.012	11N
nickel	100[5]	100[5]	13.4	100	1,400/160[4]	730N
potassium	-		-	-	-/-	-
selenium	50	50	10	-	20/5	180N
silver	-	100[8]	50	-	4.1/0.12[4,6]	180N

TABLE 4-1
FEDERAL ARARS AND TBC GUIDANCE - GROUNDWATER AND SURFACE WATER
AOC 69W

REMEDIAL INVESTIGATION REPORT
DEVENS, MASSACHUSETTS

Analyte	Federal Standards and Guidance					
	Safe Drinking Water Act (SDWA)(a)		Clean Water Act (CWA) Ambient Water Quality Criteria (AWQC)(b)			TBC Region III Tap Water (µg/L)
			For Protection of Human Health		For Protection of Aquatic Life	
	ARAR Drinking Water MCL (µg/L)	TBC Drinking Water MCLG (µg/L)	ARAR Water and Fish Consumption (µg/L)	ARAR Fish Consumption Only (µg/L)	ARAR Fresh Water Acute/Chronic (µg/L)	
sodium	-		-	-	-/-	-
vanadium	-					260N
zinc	-	5,000[8]	-	-	12/110[4]	11,000N
Pesticide/PCBs						
DDT	-	-	0.000024	0.000024	1.1/0.001	0.2C
DDD	-	-	-	-	-/-	0.28C
DDE	-	-	-	-	1,050/-[2]	0.2C
endrin	2	2	1.0	-	0.18/.0023	11N
alpha chlordane	2[13]	zero[13]	0.00046[13]	0.00048[13]	2.4/0.0043[13]	0.052[13]
gamma chlordane	2[13]	zero[13]	0.00046[13]	0.00048[13]	2.4/0.0043[13]	0.052C[13]
heptachlor	0.4	zero	0.00028	0.00029	0.52/.0038	0.0023C
PCB 1248	0.5[14]	zero[14]	0.000079[14]	0.000079[14]	2.0/0.014[14]	0.0087C
PCB 1254	0.5[14]	zero[14]	0.000079[14]	0.000079[14]	2.0/0.014[14]	0.73C[14]
PCB 1260	0.5[14]	zero[14]	0.000079[14]	0.000079[14]	2.0/0.014[14]	0.0087C[14]

continued

TABLE 4-1
FEDERAL ARARS AND TBC GUIDANCE - GROUNDWATER AND SURFACE WATER
AOC 69W

REMEDIAL INVESTIGATION REPORT
DEVENS, MASSACHUSETTS

Analyte	Federal Standards and Guidance					
	Safe Drinking Water Act (SDWA)$^{(a)}$		Clean Water Act (CWA) Ambient Water Quality Criteria (AWQC)$^{(b)}$			TBC Region III Tap Water (µg/L)
			For Protection of Human Health		For Protection of Aquatic Life	
	ARAR Drinking Water MCL (µg/L)	TBC Drinking Water MCLG (µg/L)	ARAR Water and Fish Consumption (µg/L)	ARAR Fish Consumption Only (µg/L)	ARAR Fresh Water Acute/Chronic (µg/L)	
Explosives						
cycloetramethylenetetranitramine (HMX)	-	-	-	-	-	-
cyclonite (RDX)	-	-	-	-	-	-
2,4-dinitrotoluene	-	-	-	-	-	73N
2,6-dinitrotoluene	-	-	-	-	-	37N
nitroglycerine	-	-	-	-	-	-
2,4,6-trinitrotoluene	-	-	-	-	-	2.2C
Cations/Anions						
chloride		250,000^{8}	-	-	860K/230K	-
phosphate	-	-	-	-	-/-	-
sulfate	-	500,000^{15}/250,000^{8}	-	-	-/-	-
alkalinity	-	-	-	-	-/20,000	-

continued

TABLE 4-1
FEDERAL ARARS AND TBC GUIDANCE - GROUNDWATER AND SURFACE WATER
AOC 69W

REMEDIAL INVESTIGATION REPORT
DEVENS, MASSACHUSETTS

Analyte	Federal Standards and Guidance					
	Safe Drinking Water Act (SDWA)[a]		Clean Water Act (CWA) Ambient Water Quality Criteria (AWQC)[b]			TBC Region III Tap Water (µg/L)
			For Protection of Human Health		For Protection of Aquatic Life	
	ARAR Drinking Water MCL (µg/L)	TBC Drinking Water MCLG (µg/L)	ARAR Water and Fish Consumption (µg/L)	ARAR Fish Consumption Only (µg/L)	ARAR Fresh Water Acute/Chronic (µg/L)	
Other						
nitrate/nitrite as N	10,000/1,000[12]	-	10,000/-			58,000N/3,100N
TPH	-	-				-

Notes:

(a) USEPA, "Drinking Water Standards and Health Advisories", Office of Water, Washington, D.C.; May 1995.

(b) USEPA, "Water Quality Criteria Summary", Office of Science and Technology, Health and Ecological Criteria Division, Washington, D.C.; May 1, 1991; criteria shown for carcinogens present a one-in-a-million incremental risk.

CWA = Clean Water Act
µg/L = micrograms per liter
MCL = Maximum Contaminant Level
MCLG = Maximum Contaminant Level Goal

TT = Treatment technique required.
\- = No federal or state guidance criteria or standards exist.
N = Noncarcinogenic effects
C = Carcinogenic effects

1 MCL for arsenic currently under review.
2 Insufficient data to develop criteria. Value presented is the Lowest Observed Effect Level (LOEL).
3 1994 Proposed rule for Disinfectants and Disinfection By-Products: Total for all THMs combined would not exceed the 80 ug/L level.
4 Hardness dependent criterion (100 mg/L $CaCO_3$ used).
5 Standard is being remanded.
6 Proposed level, freshwater acute - 0.92 µg/L.
7 Values presented are for trivalent species.
8 Non-enforceable secondary regulation based on aesthetics (e.g., color, odor, taste).
9 Values presented are for hexavalent chromium species.
10 Treatment technique action level 1,300 µg/L.
11 Treatment technique action level 15 µg/L; concentration measured at top.
12 Nitrate or nitrite as nitrogen; standard total nitrate and nitrite is 10,000 µg/L.
13 Values reported for chlordane (CAS #57-74-9).
14 Values reported for total PCBs (CAS #1336-36-3).
15 Proposed criterion.

TABLE 4-2
STATE ARARS AND TBC GUIDANCE - GROUNDWATER
AOC 69W

REMEDIAL INVESTIGATION REPORT
DEVENS, MASSACHUSETTS

ANALYTE	MASSACHUSETTS STANDARDS AND GUIDANCE	
	MMCL/ORSG DRINKING WATER(A) (μg/L)	CLASS I GROUNDWATER(B) (μg/L)
Volatile Organics		
acetone	3000[2]	-
benzene	5	-
carbon tetrachloride	5	-
chloroform	5[2]	100[3]
ethylbenzene	700	-
styrene	100	-
1,1,2,2-tetrachloroethane	-	-
tetrachloroethylene	5	-
toluene	1000	-
1,1,1-trichloroethane	200	-
trichloroethylene	5	-
trichlorofluoromethane	-	-
xylenes (total)	10,000	-
Semivolatile Organics		
acenaphthylene	-	-
anthracene	-	-
bis(2-ethylhexyl)phthalate	6	-
benzo(a)anthracene	-	-
benzo(a)pyrene	0.2	-
benzo(b)fluoranthene	-	-
benzo(g,h,i)perylene	-	-
benzo(k)fluoranthene	-	-
benzyl alcohol	-	-
carbazole	-	-
chrysene	-	-
dibenzofuran	-	-
di-n-butyl phthalate		
fluoranthene	-	-
fluorene	-	-
indeno(1,2,3-c,d)pyrene	-	-
2-methylnaphthalene	-	-
naphthalene	-	-
n-nitrosodiphenylamine	-	-
phenanthrene	-	-

TABLE 4-2
STATE ARARS AND TBC GUIDANCE - GROUNDWATER
AOC 69W

REMEDIAL INVESTIGATION REPORT
DEVENS, MASSACHUSETTS

ANALYTE	MASSACHUSETTS STANDARDS AND GUIDANCE	
	MMCL/ORSG DRINKING WATER(A) (µg/L)	CLASS I GROUNDWATER(B) (µg/L)
pyrene	-	-
Inorganics		
aluminum	50 to 200(10)	-
antimony	6	-
arsenic	50	50
barium	2,000	1,000
beryllium	4	-
cadmium	5	10
calcium	-	-
chromium (total)	100	50
cobalt	-	-
copper	1,300	1,000
iron	300[10]	300
lead	15	50
magnesium	-	-
manganese	50(10)	50
mercury	2	2
nickel	100	-
potassium	-	-
selenium	50	10
silver	100[10]	50
sodium	20.000[2]	-
vanadium	-	-
zinc	5,000[10]	5,000
Pesticides/PCBs		
DDT	-	-
DDD	-	-
DDE	-	-
endrin	2[8]	0.2
alpha chlordane	2	-
gamma chlordane	2	-
heptachlor	0.4	-
PCB 1248	0.5[9]	-
PCB 1254	0.5[9]	-
PCB 1260	0.5[9]	-

TABLE 4-2
STATE ARARs AND TBC GUIDANCE - GROUNDWATER
AOC 69W

REMEDIAL INVESTIGATION REPORT
DEVENS, MASSACHUSETTS

ANALYTE	MASSACHUSETTS STANDARDS AND GUIDANCE	
	MMCL/ORSG DRINKING WATER(A) (μg/L)	CLASS I GROUNDWATER(B) (μg/L)
Explosives		
cyclotetramethylenetetranitramine (HMX)	-	-
cyclonite (RDX)	-	-
2,4-dinitrotoluene	-	-
2,6-dinitrotoluene	-	-
nitroglycerine	-	-
2,4,6-trinitrotoluene	-	-
Cations/Anions		
chloride	250,000[10]	-
phosphate	-	-
sulfate	250,000[10]	250,000
alkalinity	-	-
Other		
nitrate/nitrite (total)	10,000	10,000[8]
TPH	-	-

Notes:

(A) MADEP - Office of Research and Standards; Massachusetts Drinking Water Standards and Guidelines, (310 CMR 22.00) Massachusetts MCLs; Autumn 1994.

(B) MADEP - Division of Water Pollution Control; Massachusetts Surface Water Quality Standards, (314 CMR 6.06) Minimum GW Quality Criteria - Class I; promulgated December 31, 1986.

DWS = Drinking Water Standards
MCLG = Maximum Contaminant Level Goal
MMCL = Massachusetts Maximum Contaminant Level
ORSG = Office of Research and Standards Guideline (Massachusetts)
μg/L = micrograms per liter
\- = Standard not established

(1) MMCL established for 1,4-dichlorobenzene isomer (more stringent than for 1,2- isomer). Reported values are totals (isomers not distinguished).
(2) Value is an Office of Research and Standards guideline.
(3) Standard indicated is concentration of total trihalomethanes (i.e., the sum of concentrations of chloroform, bromodichloromethane, dibromochloromethane, and bromoform).
(4) Defers to USEPA DWS; see federal MCLs/MCLGs.
(5) Mean value per any set of samples.
(6) Numerical standard does not exist. MMCL is based on presence or absence of coliform.
(7) Nitrate as nitrogen.
(8) Value reported for endrin; CAS No. 72208.
(9) Value reported for PCBs; CAS No. 1336363.
(10) SMCLs = Secondary Maximum Contaminant Levels.

TABLE 4-3
ARARs AND TBC GUIDANCE - SOIL AND SEDIMENT
AOC 69W

REMEDIAL INVESTIGATION REPORT
DEVENS, MASSACHUSETTS

ANALYTE	SOIL INGESTION		TBC NOAA SEDIMENT[B] EFFECTS RANGE - LOW (mg/kg)	TBC USEPA SQC[C] (mg/kg ORGANIC CARBON)
	TBC REGION III/RESIDENTIAL[A] (mg/kg)	TBC REGION III/COMMERCIAL /INDUSTRIAL[A] (mg/kg)		
Volatile Organics				
acetone	7,800N	200,000N	-	-
benzene	22C	200C	-	-
carbon tetrachloride	4.9C	44C	-	-
chloroform	100C	940C	-	-
ethylbenzene	7,800N	200,000N	-	-
styrene	16,000N	410,000N	-	-
tetrachloroethylene	12C	110C	-	-
toluene	16,000N	410,000N	-	-
1,1,1-trichloroethane	7,000N	180,000N	-	-
1,1,2,2-tetrachloroethane	3.2C	29C	-	-
trichloroethylene	58C	520C	-	-
trichlorofluoromethane	23,000N	610,000N	-	-
xylenes (total)	160,000N	1E+06N	-	-
Semivolatile Organics				
acenaphthene	-	-	-	-
anthracene	23,000N	610,000N	-	-
bis(2-ethylhexyl)phthalate	46C	410C	-	-
benzo(a)anthracene	0.88C	7.8C	-	1,317

TABLE 4-3
ARARS AND TBC GUIDANCE - SOIL AND SEDIMENT
AOC 69W

REMEDIAL INVESTIGATION REPORT
DEVENS, MASSACHUSETTS

ANALYTE	SOIL INGESTION		TBC NOAA SEDIMENT[B] EFFECTS RANGE - LOW (mg/kg)	TBC USEPA SQC[C] (mg/kg ORGANIC CARBON)
	TBC REGION III/RESIDENTIAL[A] (mg/kg)	TBC REGION III/COMMERCIAL /INDUSTRIAL[A] (mg/kg)		
benzo(a)pyrene	0.088C	0.78C	0.4	1,063
benzo(b)fluoranthene	0.88C	7.8C	-	-
benzo(g,h,i)perylene	-	-	-	-
benzo(k)fluoranthene	8.8C	78C	-	-
benzyl alcohol	23,000N	610,000N	-	-
carbazole	32C	290C	-	-
chrysene	88C	780C	0.4	-
dibenzofuran	310N	8200N	-	-
di-n-butyl phthalate	7,800N	200,000N	-	-
fluoranthene	3,100N	82,000N	0.6	1,883
fluorene	3,100N	82,000N	0.035	-
indeno(1,2,3-c,d)pyrene	0.88C	7.8C	-	-
2-methylnaphthalene	-	-	-	0.065
naphthalene	3,100N	82,000N	0.34	-
n-nitrosodiphenylamine	130C	1200C	-	-
phenanthrene	-	-	0.225	139
pyrene	2,300N	61,000N	0.35	1,311
total PAHs	-	-	4.0	-

TABLE 4-3
ARARS AND TBC GUIDANCE - SOIL AND SEDIMENT
AOC 69W

REMEDIAL INVESTIGATION REPORT
DEVENS, MASSACHUSETTS

ANALYTE	SOIL INGESTION		TBC NOAA SEDIMENT[B] EFFECTS RANGE - LOW (mg/kg)	TBC USEPA SQC[C] (mg/kg ORGANIC CARBON)
	TBC REGION III/RESIDENTIAL[A] (mg/kg)	TBC REGION III/COMMERCIAL /INDUSTRIAL[A] (mg/kg)		
Inorganics				
aluminum	78,000N	1E+06N	-	-
antimony	31N	820N	0.002	-
arsenic	0.37C/23N	3.3C/610N	0.033	-
barium	5,500N	140,000N	-	-
beryllium	0.15C	1.3C	-	-
cadmium	39N	1,000N	0.005	-
calcium	-	-	-	-
chromium	390N[1]	10,000N[1]	0.080	-
cobalt	4,700N	120,000N	-	-
copper	2,900N	76,000N	0.070	-
iron	-	-	-	-
lead	-	-	0.035	-
magnesium	-	-	-	-
manganese	390N	10,000N	-	-
mercury	23N	610N	0.00015	-
nickel	1,600N	41,000N	0.030	-
potassium	-	-	-	-
selenium	390N	10,000N	-	-

TABLE 4-3
ARARS AND TBC GUIDANCE - SOIL AND SEDIMENT
AOC 69W

REMEDIAL INVESTIGATION REPORT
DEVENS, MASSACHUSETTS

ANALYTE	SOIL INGESTION		TBC NOAA SEDIMENT[B] EFFECTS RANGE - LOW (mg/kg)	TBC USEPA SQC[C] (mg/kg ORGANIC CARBON)
	TBC REGION III/RESIDENTIAL[A] (mg/kg)	TBC REGION III/COMMERCIAL /INDUSTRIAL[A] (mg/kg)		
silver	390N	10,000N	0.001	-
sodium	-	-	-	-
vanadium	550N	14,000N	-	-
zinc	23,000N	610,000N	0.120	-
Pesticides/PCBs				
DDT	1.9C	17C	0.001	0.828
DDD	2.7C	24C	0.002	-
DDE	1.9C	17C	0.002	-
endrin	23N	610N	0.00002	.0332
alpha chlordane	0.49C[3]	4.4C[3]	0.0005[3]	-
gamma chlordane	0.49C[3]	4.4C[3]	0.0005[3]	-
heptachlor	0.14C	1.3C	-	0.110
PCB 1248	0.083C[4]	0.74C[4]	0.05[4]	-
PCB 1254	1.6N	41N	0.05[4]	19.5
PCB 1260	0.083C[4]	0.74C[4]	0.05[4]	-
Explosives				
cycloetramethylenetetranitramine (HMX)	-	-	-	-
cyclonite (RDX)	-	-	-	-
2,6-dinitrotoluene	78N	2000N	-	-

TABLE 4-3
ARARs AND TBC GUIDANCE - SOIL AND SEDIMENT
AOC 69W

REMEDIAL INVESTIGATION REPORT
DEVENS, MASSACHUSETTS

ANALYTE	SOIL INGESTION		TBC NOAA SEDIMENT[B] EFFECTS RANGE - LOW (mg/kg)	TBC USEPA SQC[C] (mg/kg ORGANIC CARBON)
	TBC REGION III/RESIDENTIAL[A] (mg/kg)	TBC REGION III/COMMERCIAL /INDUSTRIAL[A] (mg/kg)		
2,4,6-trinitrotoluene	21C	190C	-	-
nitroglycerine	-	-	-	-
Other				
nitrate/nitrite	130,000N/7,800N	1E+06N/200,000N	-	-
TPH	-	-	-	-

Notes:

(1) Chromium IV values.
(2) Dry weight.
(3) Values reported for chlordane (CAS # 57-74-9).
(4) Values reported for total polychlorinated biphenyls (CAS # 1336-36-3).
(a) US Environmental Protection Agency (USEPA) Region III, January 1995 Memorandum from Roy L Smith to RBC (Risk-Based Concentration) Table Mailing List, Subject: Risk-Based Concentration Table.
(b) National Oceanic and Atmospheric Administration (NOAA), March 1990 "The Potential for Biological Effects of Sediment-sorbed Contaminants Tested in the National States and Trends Program"; NOAA Technical Memorandum NOS OMA52 (Edward R Long and Lee G Morgan, authors).
(c) USEPA, May 1988 "Interim Sediment Quality Criteria Values for Nonpolar Hydrophobic Organic Contaminants".
(d) USEPA OSWER Directive 193554-02.

mg/kg = milligrams per kilogram
NOAA = National Oceanic and Atmospheric Administration
N = Non-carcinogenic effects representing an HQ of 10
1E+06 = 1,000,000
SQC = Sediment Quality Criteria
\- = No federal or state guidance criteria or standards exist
C = Carcinogenic effects representing an incremental lifetime cancer risk of 1 in a million

TABLE 4-4
POTENTIAL LOCATION-SPECIFIC ARARS AT DEVENS
AOC 69W

REMEDIAL INVESTIGATION REPORT
DEVENS, MASSACHUSETTS

STATUTORY, REGULATORY BASIS	CITATION	DESCRIPTION
Resource Conservation and Recovery Act	40 CFR Sec. 264.18	Prohibits or restricts siting of hazardous waste management units in certain sensitive areas (100-year floodplain, active seismic area, wetlands).
Migratory Bird Treaty Act of 1972	16 USC Sec. 703-712 50 CFR Parts 10, 20, 21	If migratory birds are present, provides protection of almost all species of native birds in the U.S. from unregulated activities. Unregulated activities can include poisoning at hazardous waste sites.
Endangered Species Act	16 USC 1531 50 CFR Parts 81, 225, 402	Provides for protection and conservation of various species of fish, wildlife, and plants.
Massachusetts Endangered Wildlife and Wild Plants	321 CMR 8.00	The Commonwealth of Massachusetts has authority to research, list, and protect any species deemed endangered, threatened, or of special concern. These species are listed as either endangered, threatened, or species of special concern in the regulations. The Massachusetts lists may differ from the federal lists of endangered species.
Clean Water Act, Section 404	33 USC 1251, Sec. 404; 40 CFR Part 230 33 CFR 320-330	Prohibits discharge of dredged or fill material into wetlands without a permit. Provides for management of dredged material; establishes requirements for structures affecting navigable waterways; and provides for certain permitting requirements.
Fish and Wildlife Coordination Act	16 USC 661	All agencies regulating activities that may have an effect on either fish or wildlife must notify and allow input by agencies overseeing fish and wildlife habitats in the area of the proposed activities.

TABLE 4-4
POTENTIAL LOCATION-SPECIFIC ARARS AT DEVENS
AOC 69W

REMEDIAL INVESTIGATION REPORT
DEVENS, MASSACHUSETTS

STATUTORY, REGULATORY BASIS	CITATION	DESCRIPTION
Protection of Wetlands-Executive Order (EO) 11990	40 CFR Part 6, Appendix A	Appendix A of 40 CFR 6 sets forth policy for carrying out provisions of the Protection of Wetlands Executive Order. Under this order, federal agencies are required to minimize the degradation, loss, or destruction of wetlands, and to preserve the natural and beneficial values of wetlands. Appendix A requires that no remedial alternatives adversely affect a wetland if another practicable alternative is available. If no alternative is available, effects from implementing the chosen alternative must be mitigated.
Wetlands Protection	310 CMR 10.00	Establishes State of Massachusetts regulations for protection of coastal and inland wetlands, including compliance with the Massachusetts Environmental Policy Act.

TABLE 4-5
POTENTIAL ACTION-SPECIFIC FEDERAL ARARS AT DEVENS
AOC 69W

REMEDIAL INVESTIGATION REPORT
DEVENS, MASSACHUSETTS

Standard, Requirement, Criteria, or Limitation	Citation	Description	Comments/ Applicability
Solid Waste Disposal Act	42 USC 6901	Resource Conservation and Recovery Act.	
Criteria for Classification of Solid Waste Disposal Facilities and Practices	40 CFR Part 257	Establishes criteria for use in determining which solid waste disposal facilities and practices pose a reasonable probability of adverse effects on health or the environment and thereby prohibit open dumps.	Not Applicable.
Criteria for Municipal Solid Waste Disposal Facilities	40 CFR Part 258	Establishes minimum federal criteria for design, construction, operation, and permitting of municipal solid waste landfills.	Not Applicable.
Identification and Listing of Hazardous Waste	40 CFR Part 261	Defines those solid wastes which are subject to regulation as hazardous waste.	Applicable for defining whether or not hazardous waste is generated or disposed.
Standards Applicable to Generators of Hazardous Waste	40 CFR Part 262	Establishes standards for generators of hazardous waste.	Relevant and appropriate. If remedial action causes hazardous waste to be generated, then these standards will be applicable.
Standards Applicable to Transporters of Hazardous Waste	40 CFR Part 263	Establishes standards which apply to persons transporting hazardous waste within the U.S..	Applicable. If hazardous waste is transported off-site, these standards will apply.

TABLE 4-5
POTENTIAL ACTION-SPECIFIC FEDERAL ARARS AT DEVENS
AOC 69W

REMEDIAL INVESTIGATION REPORT
DEVENS, MASSACHUSETTS

Standard, Requirement, Criteria, or Limitation	Citation	Description	Comments/ Applicability
Standards for Owners and Operators of Hazardous Waste Treatment, Storage, and Disposal Facilities	40 CFR Part 264	Establishes minimum national standards which define the acceptable management of hazardous waste for owners and operators of facilities which treat, store, or dispose of hazardous waste.	Relevant and appropriate for hazardous waste management activities during remediation.
Standards for Management of Specific Hazardous Wastes and Specific Types of Hazardous Waste Management Facilities	40 CFR Part 266	Establishes requirements which apply to recyclable materials used in a manner constituting disposal or hazardous waste burned for energy recovery.	If hazardous wastes are recycled on- or off-site, these standards are applicable.
Interim Standards for Owners and Operators of New Hazardous Waste Land Disposal Facilities	40 CFR Part 267	Establishes minimum national standards that define acceptable management of hazardous waste land disposal facilities.	Applicable if hazardous waste is present.
Land Disposal Restrictions (LDR) Program	40 CFR Part 268	Sets treatment standards for hazardous wastes based on the levels achievable by current technology; sets two-year national variances from the statutory effective dates due to insufficient treatment capacity.	Applicable for hazardous wastes destined for land disposal.
Technical Standards and Corrective Action Requirements for Owners and Operators of Underground Storage Tanks (USTs)	40 CFR Part 280	Provides regulations pertaining to underground storage tanks.	Applicable if there is operation or removal of an UST.

TABLE 4-5
POTENTIAL ACTION-SPECIFIC FEDERAL ARARS AT DEVENS
AOC 69W

REMEDIAL INVESTIGATION REPORT
DEVENS, MASSACHUSETTS

Standard, Requirement, Criteria, or Limitation	Citation	Description	Comments/ Applicability
Clean Water Act	33 USC 1251		
EPA-Administered Permit Programs: The National Pollutant Discharge Elimination System	40 CFR Part 122	Requirements for the discharge of pollutants from any point source into waters of the U.S.	Applicable if remedial action requires outfall discharge.
Criteria and Standards for the National Pollutant Discharge Elimination System	40 CFR Part 125	Provides discharge criteria, chemical standards, and permit forms for existing industrial operations.	Relevant and appropriate to remedial actions which cause discharge to waters of the U.S..

TABLE 4-5
POTENTIAL ACTION-SPECIFIC FEDERAL ARARS AT DEVENS
AOC 69W

REMEDIAL INVESTIGATION REPORT
DEVENS, MASSACHUSETTS

Standard, Requirement, Criteria, or Limitation	Citation	Description	Comments/ Applicability
Clean Air Act	42 USC 7401		
Massachusetts Air Pollution Control Regulations	310 CMR 7.00	These regulations set emission limits necessary to attain ambient air quality standards.	Remedial activities will be conducted to meet the standards for visible emissions (310 CMR 7.06); dust, odor, construction, and demolition (310 CMR 7.09); noise (310 CMR 7.10); and volatile organic compounds (310 CMR 7.18).

TABLE 4-5
POTENTIAL ACTION-SPECIFIC FEDERAL ARARS AT DEVENS
AOC 69W

REMEDIAL INVESTIGATION REPORT
DEVENS, MASSACHUSETTS

Standard, Requirement, Criteria, or Limitation	Citation	Description	Comments/ Applicability
Department of Transportation - Hazardous Materials Regulations			
Rules for the Transportation of Hazardous Materials	49 CFR Parts 107, 171, 172	Provides requirements for packaging, manifesting, and transportation of hazardous waste.	Applicable if off-site shipment of hazardous wastes occurs.

TABLE 5-1
SUMMARY OF INVESTIGATION ACTIVITIES
AOC 69W

REMEDIAL INVESTIGATION REPORT
DEVENS, MASSACHUSETTS

MONTH/ YEAR	ACTIVITY	CONTRACTOR	NUMBER COMPLETED	EXPLORATION/SAMPLE IDENTIFICATION	PURPOSE OF ACTIVITY
AREE 69 PAST SPILL SITE INVESTIGATION PHASE I					
JULY 1993	DOCUMENT REVIEW AND SITE VISIT	ADL	NA	AREE 69W	DETERMINE STATUS OF 48 PAST SPILL SITES AND RECOMMEND RELEVANT ACTION OR NFA
AREE 69 PAST SPILL SITE INVESTIGATION PHASE II (AREE 69W)					
MARCH 1994	GEOPHYSICAL SURVEY	ADL	1 SURVEY	AREE 69W	IDENTIFY POSSOBLE LOCATIONS OF UNDERGROUND STRUCTURES AND CLEAR BORING LOCATIONS FOR SUBSURFACE UTILITIES
MARCH 1994	SURFACE SOIL SAMPLING	ADL	6 SAMPLES	HA-1 THRU HA-6	COLLECT SURFICIAL SOIL SAMPLES FOR FIELD SCREENING. ONE SAMPLE COLLECTED FOR OFF-SITE CONFIRMATION
APRIL 1994	GEOPROBE™ SOIL AND GROUNDWATER SAMPLING (PHASE I)	ADL	16 BORINGS	GP-01 THRU GP-16	COLLECT SUBSURFACE SOIL AND GROUNDWATER SAMPLES FOR FIELD SCREENING. FOUR SOIL AND FIVE GROUNDWATER SAMPLES COLLECTED FOR OFF-SITE ANALYSIS
MAY 1994	GEOPROBE™ SOIL AND GROUNDWATER SAMPLING (PHASE II)	ADL	9 BORINGS	GP-16 THRU GP-25	COLLECT SUBSURFACE SOIL AND GROUNDWATER SAMPLES FOR FIELD SCREENING.
JUNE 1994	MONITORING WELL BORING AND INSTALLATION	ADL	6 WELLS	69W–94-09X THRU 69W–94-14X	EVALUATE SUBSURFACE SOIL AND GROUNDWATER QUALITY AND CONFIRM TPHC SCREENING RESULTS
JUNE AND SEPT 1994	GROUNDWATER SAMPLING	ADL	6 WELLS	69W–94-09X THRU 69W–94-14X	MONITOR GROUNDWATER QUALITY (OFF-SITE ANALYSIS)
JUNE 1994	SURFACE WATER AND SEDIMENT SAMPLING (WILLOW BROOK)	ADL	2 SW/SED PAIRS	69W–94-15 AND 69W–94-16	EVALUATE IMPACT OF GROUNDWATER CONTAMINATION ON WILLOW BROOK (OFF-SITE ANALYSIS)
AOC 69W REMEDIAL INVESTIGATION					
SEPT. 1995	GEOPHYSICAL SURVEY	ABB-ES	1 SURVEY	PARKING LOT AND GRASSY AREA NORTH OF SCHOOL AND COURTYARD	PERFORM TERRAIN CONDUCTIVITY (EM-31), EM-61, AND GROUND PENETRATING RADAR SURVEYS TO IDENTIFY AND LOCATE POTENTIAL SUBSURFACE CONTAMINANT SOURCES AND UTILITIES.
	SEDIMENT SAMPLING AND TOXICITY TESTING	ABB-ES	9 SED AND 3 TOX TEST SAMPLES	ZWD-95-01X THRU ZWD-95-06X	COLLECT SAMPLES FOR OFF-SITE ANALYSIS AND TOXICITY TESTING TO ASSESS IMPACT TO ECOLOGICAL RECEPTORS IN WILLOW BROOK
	QUALITATIVE ECOLOGICAL SURVEY AND WETLANDS INVESTIGATION	ABB-ES	1 SURVEY	WILLOW BROOK AND ASSOCIATED WETLANDS	IDENTIFY POTENTIAL ECOLOGICAL RECEPTORS AND EXPOSURE PATHWAYS AT AOC 69W

TABLE 5-1
SUMMARY OF INVESTIGATION ACTIVITIES
AOC 69W

REMEDIAL INVESTIGATION REPORT
DEVENS, MASSACHUSETTS

MONTH/ YEAR	ACTIVITY	CONTRACTOR	NUMBER COMPLETED	EXPLORATION/SAMPLE IDENTIFICATION	PURPOSE OF ACTIVITY
	TEST PITTING	ABB-ES	1 TEST PIT	ZWE-96-01X	INVESTIGATE IDENTIFIED GEOPHYSICAL ANAMOLIES
	TERRAPROBE℠ BORINGS	ABB-ES	29 BORINGS	ZWR-95-26X THRU ZWR-95-28X, AND ZWR-95-30X THRU ZWR-95-55X	COLLECT FIELD AND OFF-SITE ANALYTICAL SOIL AND GROUNDWATER SAMPLES TO FURTHER DEFINE THE LATERAL AND VERTICAL CONTAMINANT DISTRIBUTION
	SOIL BORINGS	ABB-ES	2 SOIL BORINGS	ZWB-95-01X AND ZWB-95-02X	COLLECT OFF-SITE SOIL SAMPLES TO CONFIRM FIELD SCREENING RESULTS
	MONITORING WELL INSTALLATION	ABB-ES	4 WELLS	ZWM-95-15X THRU ZWM-95-18X	EVALUATE AND MONITOR GROUNDWATER QUALITY IN THE VICINTY OF AOC 69W
	PIEZOMETER INSTALLATION	ABB-ES	2 PIEZOS	ZWP-95-01X AND ZWP-95-02X	EVALUATE HYDROLOGIC AND HYDROGEOLOGIC CONDITIONS IN THE AREA OF WILLOW BROOK
OCT. AND NOV. 1995	GROUNDWATER SAMPLING ROUND 1	ABB-ES	11 WELLS	69W–94-09X THRU 69W–94-14X AND ZWM-95-14X THRU ZWM-95-18X	MONITOR GROUNDWATER QUALITY AT AOC 69W
NOV. 1995	IN-SITU HYDRAULIC CONDUCTIVITY TESTING	ABB-ES	11 WELLS	69W–94-09X THRU 69W–94-14X AND ZWM-95-14X THRU ZWM-95-18X	ESTIMATE HYDRAULIC CONDUCTIVITIES OF THE OVERBURDEN AQUIFER
FEB. 1996	GROUNDWATER SAMPLING ROUND 2	ABB-ES	11 WELLS	69W–94-09X THRU 69W–94-14X AND ZWM-95-14X THRU ZWM-95-18X	MONITOR GROUNDWATER QUALITY AT AOC 69W
AOC 57 REMEDIAL INVESTIGATION MOD 1					
AUG. 1996	SOIL BORING	ABB-ES	1 BORING	ZWB-96-03X	COLLECT SUBSURFACE SOIL SAMPLES TO CONFIRM THE LIMITS OF CONTAMINATION
	MONITORING WELL INSTALLATION	ABB-ES	3 WELLS	ZWM-96-19X THRU ZWM-96-21X	EVALUATE SOIL AND GROUND WATER QUALITY WITHIN THE BOILER ROOMS AND COURTYARD
SEPT. AND OCT. 1996	GROUNDWATER SAMPLING	ABB-ES	6 WELLS	69W–94-10, 69W–94-11, ZWM-95-16X, AND ZWM-96-19X THRU ZWM-96-21X	MONITOR GROUNDWATER QUALITY AT AOC 69W SOURCE AREA
JAN. 1997	IN-SITU HYDRAULIC CONDUCTIVITY TESTING	ABB-ES	3 WELLS	ZWM-96-19X THRU ZWM-96-21X	ESTIMATE HYDRAULIC CONDUCTIVITIES OF THE OVERBURDEN AQUIFER
OCT. 1997	INDOOR AIR SAMPLING IN THE DEVENS ELEMENTARY SCHOOL	ABB-ES	12 AIR SAMPLES AND 1 WELL HEAD SAMPLE	ZWA-97-01X THRU ZWA-97-13X	AIR SAMPLING TO MEASURE THE LEVELS OF FUEL-RELATED CONTAMINANTS IN INDOOR AIR ASSOCIATED WITH SUBSURFACE AND GROUNDWATER CONTAMINATION

TABLE 5-1
SUMMARY OF INVESTIGATION ACTIVITIES
AOC 69W

REMEDIAL INVESTIGATION REPORT
DEVENS, MASSACHUSETTS

MONTH/ YEAR	ACTIVITY	CONTRACTOR	NUMBER COMPLETED	EXPLORATION/SAMPLE IDENTIFICATION	PURPOSE OF ACTIVITY
DEC. 1997	GROUNDWATER SAMPLING	ABB-ES	13 WELLS	69W–94-09 THRU 69W–94-14, ZWM-95-15X THRU ZWM-95-18X, AND ZWM-96-19X THRU ZWM-96-21X	MONITOR GROUNDWATER QUALITY AT AOC 69W

GeoProbe™ and TerraProbe℠ are proprietary direct push soil and groundwater sampling techniques.

TABLE 5-2
ADL AREE 69W FIELD ANALYTICAL RESULTS
AOC 69W

REMEDIAL INVESTIGATION REPORT
DEVENS, MASSACHUSETTS

SAMPLE POINT	FIELD SCREENING SAMPLE ID	MEDIUM	DEPTH (feet below ground surface)	TPH (mg/kg)
GP-01	69W-94-01-2W	Groundwater	5-7	663
GP-02	69W-94-02-2W	Groundwater	4-6	354
GP-02(Dup)	69W-94-01-2WD	Groundwater	5-7	208
GP-03	69W-94-03-2W	Groundwater	5-7	110
GP-04	69W-94-04-2W	Groundwater	5-7	12
GP-05	69W-94-05-2W	Groundwater	5-7	126
GP-06	69W-94-06-2W	Groundwater	5-7	188
GP-07	69W-94-07-2W	Groundwater	4-6	3
GP-08	69W-94-08-2W	Groundwater	4-6	95
GP-08(Dup)	69W-94-08-2WD	Groundwater	4-6	75
GP-09	69W-94-09-2W	Groundwater	4-6	2
GP-10	69W-94-10-2W	Groundwater	4-6	25
GP-11	69W-94-11-2W	Groundwater	4-6	37
GP-11(Dup)	69W-94-11-2WD	Groundwater	4-7	2
GP-12	69W-94-12-2W	Groundwater	3-5	20
GP-13	69W-94-13-2W	Groundwater	3-5	460
GP-14	69W-94-14-2W	Groundwater	3-5	2
GP-15	69W-94-15-2W	Groundwater	3-5	438
GP-15(Dup)	69W-94-15-2WD	Groundwater	3-5	110
GP-16	69W-94-16-2W	Groundwater	2-5	7
GP-16(Dup)	69W-94-16-2WD	Groundwater	2-5	4
GP-17	69W-94-17-2W	Groundwater	5-7	1,015
GP-17(Filtered)	69W-94-17F	Groundwater	5-7	22
GP-18	69W-94-18-2W	Groundwater	5-7	19
GP-18(Filtered)	69W-94-18F	Groundwater	5-7	12
GP-19	69W-94-19-2W	Groundwater	5-7	15
GP-19(Filtered)	69W-94-19F	Groundwater	5-7	12
GP-20	69W-94-20-2W	Groundwater	5-7	650
GP-20(Filtered)	69W-94-20F	Groundwater	5-7	15
GP-21	69W-94-21-2W	Groundwater	5-7	119
GP-21(Filtered)	69W-94-21F	Groundwater	5-7	11
GP-22	69W-94-22-2W	Groundwater	5-7	1,087
GP-22(Filtered)	69W-94-22F	Groundwater	5-7	17
GP-23	69W-94-23-2W	Groundwater	5-7	45
GP-23(Filtered)	69W-94-23F	Groundwater	5-7	4
GP-24	69W-94-24-2W	Groundwater	5-7	10
GP-24(Filtered)	69W-94-24F	Groundwater	5-7	4
GP-25	69W-94-25-2W	Groundwater	5-7	15
GP-25(Filtered)	69W-94-25F	Groundwater	5-7	5
GP-1	69W-94-01-1	Soil	0-2	123
GP-1(Dup)	69W-94-01-1D	Soil	0-2	120
GP-1	69W-94-01-2	Soil	3-5	226
GP-2	69W-94-02-1	Soil	0-2	1,050
GP-2	69W-94-02-2	Soil	3-5	15,500
GP-3	69W-94-03-1	Soil	0-2	1,150
GP-3	69W-94-03-2	Soil	3-5	387

TABLE 5-2
ADL AREE 69W FIELD ANALYTICAL RESULTS
AOC 69W

REMEDIAL INVESTIGATION REPORT
DEVENS, MASSACHUSETTS

SAMPLE POINT	FIELD SCREENING SAMPLE ID	MEDIUM	DEPTH (feet below ground surface)	TPH (mg/kg)
GP-4	69W-94-04-1	Soil	0-2	1,230
GP-4	69W-94-04-2	Soil	3-5	1,010
GP-5	69W-94-05-1	Soil	0-2	201
GP-5	69W-94-05-2	Soil	3-5	102
GP-6	69W-94-06-1	Soil	0-2	806
GP-6	69W-94-06-2	Soil	3-5	53
GP-7	69W-94-07-1	Soil	0-2	38
GP-7(Dup)	69W-94-07-1D	Soil	0-2	38
GP-7	69W-94-07-2	Soil	3-5	11
GP-8	69W-94-08-1	Soil	0-2	291
GP-8(Dup)	69W-94-08-1D	Soil	0-2	272
GP-8	69W-94-08-2	Soil	3-5	48
GP-9	69W-94-09-1	Soil	0-2	219
GP-9	69W-94-09-2	Soil	3-5	11
GP-10	69W-94-10-1	Soil	0-2	19
GP-10	69W-94-10-2	Soil	3-5	51
GP-11	69W-94-11-1	Soil	0-2	20
GP-11	69W-94-11-2	Soil	3-5	74
GP-12	69W-94-12-1	Soil	0-2	40
GP-12	69W-94-12-2	Soil	3-5	8
GP-13	69W-94-13-1	Soil	0-2	25
GP-13	69W-94-13-2	Soil	3-5	157
GP-14	69W-94-14-1	Soil	0-2	51
GP-14	69W-94-14-2	Soil	3-5	8
GP-15	69W-94-15-1	Soil	0-2	95
GP-15	69W-94-15-2	Soil	3-5	13
GP-16	69W-94-16-1	Soil	0-2	607
GP-16	69W-94-16-2	Soil	3-5	18
GP-17	69W-94-17-1	Soil	3-5	51
GP-17(Dup)	69W-94-17-2D	Soil	3-5	53
GP-18	69W-94-18-2	Soil	3-5	22
GP-19	69W-94-19-2	Soil	3-5	12
GP-20	69W-94-20-2	Soil	3-5	420
GP-21	69W-94-21-2	Soil	3-5	1,497
GP-22	69W-94-22-2	Soil	3-5	14,484
GP-23	69W-94-23-2	Soil	3-5	12
GP-24	69W-94-24-2	Soil	3-5	1,520
GP-25	69W-94-25-2	Soil	3-5	21
69W-94-09	69W-94-09-1	Soil (Boring)	0-2	70
69W-94-09(Dup)	69W-94-09-1D	Soil (Boring)	0-2	71
69W-94-09	69W-94-09-2	Soil (Boring)	2-4	14
69W-94-09	69W-94-09-3	Soil (Boring)	4-6	11
69W-94-09	69W-94-09-4	Soil (Boring)	11-13	12
69W-94-10	69W-94-10-1	Soil (Boring)	0-2	664
69W-94-10	69W-94-10-2	Soil (Boring)	2-4	631
69W-94-10	69W-94-10-3	Soil (Boring)	4-6	7,675

TABLE 5-2
ADL AREE 69W FIELD ANALYTICAL RESULTS
AOC 69W

REMEDIAL INVESTIGATION REPORT
DEVENS, MASSACHUSETTS

SAMPLE POINT	FIELD SCREENING SAMPLE ID	MEDIUM	DEPTH (feet below ground surface)	TPH (mg/kg)
69W-94-10	69W-94-10-4	Soil (Boring)	11-13	164
69W-94-11	69W-94-11-1	Soil (Boring)	0-2	1,735
69W-94-11	69W-94-11-2	Soil (Boring)	2-4	386
69W-94-11	69W-94-11-3	Soil (Boring)	4-6	125
69W-94-11	69W-94-11-4	Soil (Boring)	11-13	55
69W-94-12	69W-94-12-1	Soil (Boring)	0-2	11
69W-94-12	69W-94-12-2	Soil (Boring)	2-4	30
69W-94-12	69W-94-12-3	Soil (Boring)	4-6	667
69W-94-12	69W-94-12-4	Soil (Boring)	11-13	40
69W-94-13	69W-94-13-1	Soil (Boring)	0-2	1,140
69W-94-13	69W-94-13-2	Soil (Boring)	2-4	19
69W-94-13	69W-94-13-3	Soil (Boring)	4-6	2,900
69W-94-13	69W-94-13-4	Soil (Boring)	11-13	71
69W-94-14	69W-94-14-1	Soil (Boring)	0-2	25
69W-94-14	69W-94-14-2	Soil (Boring)	2-4	83
69W-94-14	69W-94-14-3	Soil (Boring)	4-6	1,990
69W-94-14	69W-94-14-4	Soil (Boring)	11-13	49
HA-1	69W-94-01	Soil	0-1	14
HA-1(Dup)	69W-94-01D	Soil	0-1	53
HA-2	69W-94-02	Soil	0-1	16
HA-3	69W-94-03	Soil	0-1	10
HA-4	69W-94-04	Soil	0-1	56
HA-5	69W-94-05	Soil	0-1	131
HA-6	69W-94-06	Soil	0-1	36

Notes:
TPH = Total petroleum hydrocarbons
mg/kg = milligrams per kilogram
Dup = Duplicate sample

TABLE 5-3
ADL, AREE 69W SOIL OFF-SITE ANALYTICAL RESULTS
AOC 69W

REMEDIAL INVESTIGATION REPORT
DEVENS, MASSACHUSETTS

Site ID:	69W-94-01	69W-94-02	69W-94-02	69W-94-03	69W-94-04	69W-94-05	69W-94-09	69W-94-09	69W-94-10	69W-94-10
Field Sample Number:	BXC9W-1U	BDC9W-2L	BXC9W-2L	BXC9W-3U	BXC9W-4U	BXC9W-5U	BXD9W-9U	BXD9W-AL	BXD9W-BU	BXD9W-CL
Field ID:	HA-5	GP-2	GP-2	GP-3	GP-4	GP-13	69W-94-09	69W-94-09	69W-94-10	69W-94-10
Sample Date:	03/30/94	05/02/94	05/02/94	05/02/94	05/02/94	05/02/94	06/06/94	06/06/94	06/06/94	06/06/94
Depth:	0	4	4	0	0	0	2	4	2	4
Units:	µg/g	µg/g	µg/g	µg/g	µg/g	µg/g	µg/g	µg/g	µg/g	µg/g
PAL METALS										
Aluminum	9690	7310 D	10600	7590	7710	10400	7260	5870	8120	8440
Arsenic	12.4	11.5 D	13.7	12.6	11.6	13.8	9.08	11.4	10.2	25.9
Barium	17.4	19.6 D	21.1	19.8	19.7	15.1	20.9	13.2	21.5	13.1
Boron	10	< 6.64 D	< 6.64	< 6.64	< 6.64	< 6.64	< 6.64	< 6.64	13.6	11.8
Calcium	880	1060 D	1060	1510	974	638	894	792	894	1570
Chromium	25.2	15.2 D	22.7	14.5	15.6	16.1	16.1	10.6	13.7	24.6
Cobalt	5.49	5.24 D	5.98	4.73	4.23	< 2.5	5.47 I	3.04 I	3.8 I	4.16 I
Copper	13.2	9.1 D	9.07	7.8	7.81	8.94	10.8	7.78	7.86	6.28
Iron	15300	13200 D	23300	14100	12700	15700	11300	8400	11300	14200
Lead	56	12 D	13.4	9.41	8.78	12.1	2.95	2.86	7.5	6.08
Magnesium	3940	2400 D	4040	2860	2420	2850	2940	1530	1910	3150
Manganese	194	169 D	248	186	173	143	160	109	197	181
Nickel	15.1	15.3 D I	20.2 I	15.8 I	12.6 I	15.6 I	11.9	8.41	10.4	14.5
Potassium	948	903 D	868	950	803	838	1600	581	719	745
Sodium	98.2	154 D	170	183	214	106	285	255	139	252
Thallium	< 34.3	< 34.3 D	< 34.3	< 34.3	< 34.3	< 34.3	< 34.3	< 34.3	< 34.3	45.9
Tin	< 7.43 7	< 7.43 D	< 7.43	11	< 7.43	< 7.43	< 7.43	< 7.43	< 7.43	15.2
Vanadium	20.7	12.2 D	18.9	12.6	11.7	16.4	12.9	6.35	11.6	13.4
Zinc	32.9	26.1 D	30.4	23.8	22.6	25.6	28.9	14.7	27.3	20.3
SEMIVOLATILE ORGANICS										
2-methylnaphthalene	< 0.032	0.1 D	< 0.032	< 0.032	< 0.032	< 0.032	< 0.032	< 0.032	8.4	70
Acenaphthene	< 0.041	< 0.041 D	< 0.041	< 0.041	< 0.041	< 0.041	< 0.041	< 0.041	0.56	5
Acenaphthylene	< 0.033	< 0.033 D	< 0.033	< 0.033	0.13	< 0.033	< 0.033	< 0.033	< 0.033	< 0.3
Benzo[a]anthracene	0.13	0.12 D	0.38	< 0.041	0.81	< 0.041	< 0.041	< 0.041	0.47	< 0.4
Benzo[b]fluoranthene	< 0.31	< 0.31 D	0.75	< 0.31	1.1	< 0.31	< 0.31	< 0.31	1	< 3
Benzo[ghi]perylene	< 0.18	< 0.18 D	0.51	< 0.18	0.69	< 0.18	< 0.18	< 0.18	0.44	< 2
Benzo[k]fluoranthene	< 0.13	< 0.13 D	0.34	< 0.13	0.43	< 0.13	< 0.13	< 0.13	0.36	< 1
Benzyl Alcohol	< 0.032	0.042 D	< 0.032	< 0.032	< 0.032	< 0.032	0.07	0.077	< 0.032	< 0.3
Chrysene	0.16	0.14 D	0.53	< 0.032	0.72	< 0.032	< 0.032	< 0.032	0.76	< 0.3
Diethyl Phthalate	< 0.24	< 0.24 D	< 0.24	< 0.24	< 0.24	< 0.24	< 0.24	< 0.24	< 0.24	< 2
Fluoranthene	0.2	0.12 D	0.9	< 0.032	0.7	< 0.032	< 0.032	< 0.032	0.61	< 0.3
Fluorene	< 0.065	< 0.065 D	< 0.065	< 0.065	< 0.065	< 0.065	< 0.065	< 0.065	1	9
Naphthalene	< 0.74	< 0.74 D	< 0.74	< 0.74	< 0.74	< 0.74	< 0.74	< 0.74	3.2	30
Phenanthrene	0.42	0.15 D	0.95	< 0.032	0.15	< 0.032	< 0.032	< 0.032	2	20
Phenol	< 0.052	< 0.052 D	< 0.052	< 0.052	< 0.052	< 0.052	< 0.052	< 0.052	< 0.052	< 0.5
Pyrene	0.28	0.25 D	1.1	< 0.083	1	< 0.083	< 0.083	< 0.083	0.91	< 0.8
Di-n-butyl Phthalate	< 1.3	< 1.3 D	< 1.3	< 1.3	< 1.3	< 1.3	3.5	1.8	2.6	< 10
VOLATILE ORGANICS										
Chlorobenzene	< 0.1	< 0.1 D	< .1	< .1	< .1	< .1	< .1	< .1	< .1	< .1
Chloroform	< 0.24	< 0.24 D	< .24	< .24	< .24	< .24	< .24	< .24	< .24	< .24
Ethylbenzene	< 0.19	< 0.19 D	< .19	< .19	< .19	< .19	< .19	< .19	< .19	1.1
Toluene	< 0.1	< 0.1 D	< .1	< .1	< .1	< .1	< .1	< .1	< .1	< .1
OTHER										
Total Organic Carbon	18600	7600 D	10800	2930	4310	15100	1360	< 1000	7800	9750
Total Petroleum Hydrocarbons	176	2760 D	2780	1530	1070	325	103	18.6	425	4350

TABLE 5-3
ADL, AREE 69W SOIL OFF-SITE ANALYTICAL RESULTS
AOC 69W

REMEDIAL INVESTIGATION REPORT
DEVENS, MASSACHUSETTS

Site ID:	69W-94-11	69W-94-11	69W-94-11	69W-94-12	69W-94-12	69W-94-13	69W-94-13	69W-94-14	69W-94-14
Field Sample Number:	BXD9W-DU	BXD9W-EL	BXD9W-EL	BXD9W-FU	BXD9W-GL	BXD9W-HU	BXD9W-IL	BXD9W-JU	BXD9W-KL
Field ID:	69W-94-11	69W-94-11	69W-94-11	69W-94-12	69W-94-12	69W-94-13	69W-94-13	69W-94-14	69W-94-14
Sample Date:	06/06/94	06/06/94	06/06/94	06/02/94	06/02/94	06/01/94	06/01/94	06/02/94	06/02/94
Depth:	2	4	4	2	4	2	4	2	4
Units:	µg/g	µg/g	µg/g	µg/g	µg/g	µg/g	µg/g	µg/g	µg/g
PAL METALS									
Aluminum	8200	8220 D	7550	8770	7390	8790	8810	11500	9820
Arsenic	14.4	11.1 D	15.8	9.19	28.6	8.21	22.1	14.2	16.1
Barium	16	17.2 D	15.2	14.8	19	19.6	16.5	18.8	17.2
Boron	9.78	9.65 D	< 6.64	9.44	11	< 6.64	9.03	9.86	15.7
Calcium	1030	876 D	971	430	981	1370	1030	518	981
Chromium	16.1	15.5 D	11.7	13.5	19.6	14.4	32.6	23.8	21.9
Cobalt	4.85 I	3.85 D I	4.79 I	3.08 I	4.8 I	< 2.5 I	4.03 I	10.2 I	5.31 I
Copper	22.4	6.95 D	8.81	6.74	4.9	6.01	10.4	16.8	10.1
Iron	17500	14600 D	13500	11200	13100	11200	14500	28500	18200
Lead	7.37	4.03 D	5.92	8.35	6.1	9.7	2.75	4.97	4.35
Magnesium	3400	3070 D	2510	2250	3370	2160	4140	4530	4480
Manganese	166	143 D	147	158	174	127	127	640	187
Nickel	15	13.7 D	14.2	10.3	13.4	10.6	16.4	44.4	17.9
Potassium	605	690 D	603	402	1280	414	856	427	991
Sodium	234	224 D	218	125	194	196	246	137	223
Thallium	< 34.3	46.8 D	44.7	< 34.3	40.8	< 34.3	58.6	52.7	< 34.3
Tin	< 7.43	< 7.43 D	< 7.43	< 7.43	< 7.43	< 7.43	10.7	< 7.43	< 7.43
Vanadium	13.1	11.1 D	9.13	12.4	13.8	11.5	15	14.6	15.9
Zinc	32.6	23.7 D	21.6	22.9	26.7	21.1	20.9	44	28.2
SEMIVOLATILE ORGANICS									
2-methylnaphthalene	< 0.032	0.67 D	0.32	< 0.032	< 0.032	< 0.032	7.2	< 0.032	< 0.032
Acenaphthene	< 0.041	< 0.041 D	< 0.041	< 0.041	< 0.041	< 0.041	< 0.041	< 0.041	< 0.041
Acenaphthylene	< 0.033	< 0.033 D	< 0.033	< 0.033	< 0.033	0.17	< 0.033	< 0.033	< 0.033
Benzo[a]anthracene	< 0.041	< 0.041 D	< 0.041	0.12	< 0.041	0.64	0.13	0.092	< 0.041
Benzo[b]fluoranthene	< 0.31	< 0.31 D	< 0.31	< 0.31	< 0.31	0.98	< 0.31	< 0.31	< 0.31
Benzo[ghi]perylene	< 0.18	< 0.18 D	< 0.18	< 0.18	< 0.18	0.58	< 0.18	< 0.18	< 0.18
Benzo[k]fluoranthene	< 0.13	< 0.13 D	< 0.13	< 0.13	< 0.13	0.37	< 0.13	< 0.13	< 0.13
Benzyl Alcohol	< 0.032	0.06 D	0.08	< 0.032	< 0.032	< 0.032	< 0.032	< 0.032	< 0.032
Chrysene	0.071	< 0.032 D	0.067	0.11	< 0.032	0.63	0.15	0.13	< 0.032
Diethyl Phthalate	< 0.24	< 0.24 D	< 0.24	< 0.24	< 0.24	< 0.24	3.3	< 0.24	< 0.24
Fluoranthene	0.048	< 0.032 D	< 0.032	0.13	< 0.032	0.26	< 0.032	0.11	< 0.032
Fluorene	< 0.065	0.15 D	< 0.065	< 0.065	< 0.065	< 0.065	0.74	< 0.065	< 0.065
Naphthalene	< 0.74	< 0.74 D	< 0.74	< 0.74	< 0.74	< 0.74	2.4	< 0.74	< 0.74
Phenanthrene	0.078	0.3 D	0.23	0.12	< 0.032	0.45	1.4	0.28	< 0.032
Phenol	< 0.052	< 0.052 D	< 0.052	< 0.052	0.17	< 0.052	< 0.052	< 0.052	< 0.052
Pyrene	< 0.083	< 0.083 D	< 0.083	0.19	< 0.083	0.4	< 0.083	0.22	0.16
Di-n-butyl Phthalate	20	2.1 D	2.7	< 1.3	< 1.3	< 1.3	< 1.3	< 1.3	< 1.3
VOLATILE ORGANICS									
Chlorobenzene	< .1	< .1 D	< .1	< .1	< .1	< .1	.18	.33	< .1
Chloroform	< .24	< .24 D	< .24	< .24	.4	< .24	< .24	< .24	.44
Ethylbenzene	< .19	< .19 D	< .19	< .19	< .19	< .19	.23	< .19	< .19
Toluene	< .1	< .1 D	< .1	< .1	< .1	< .1	< .1	< .1	.11
OTHER									
Total Organic Carbon	6850	2020 D	2450	11600	3040	19000	4110	5430	< 1000
Total Petroleum Hydrocarbons	865	176 D	101	23.4	1390	34.1	2270	123	2430

Notes:
< = The concentration was less than the certified reported limit.
µg/g = micrograms per gram.
D = Duplicate analysis.
I = The low spike recovery for this lot was high.

TABLE 5-4
ADL, AREE 69W GROUNDWATER OFF-SITE ANALYTICAL RESULTS
AOC 69W

REMEDIAL INVESTIGATION REPORT
DEVENS, MASSACHUSETTS

Site ID:	69W-94-02	69W-94-05	69W-94-06	69W-94-07	69W-94-08	69W-94-09	69W-94-09	69W-94-09	69W-94-10	69W-94-10
Field Sample Number:	MXC9W-2X	MXC9W-5X	MXC9W-6X	MXC9W-7X	MXC9W-8X	MDE9W-9X	MXD9W-9X	MXE9W-9X	MXD9W-AX	MXE9W-AX
Field ID:	GP-2	GP-13	GP-1	GP-15	GP-6	69W-94-09	69W-94-09	69W-94-09	69W-94-10	69W-94-10
Sample Date:	05/02/94	05/02/94	05/02/94	05/02/94	05/02/94	09/19/94	08/24/94	09/19/94	08/24/94	09/20/94
Units:	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L
PAL METALS										
Aluminum	140000	45700	27600	150000	105000	1740 D	13400	7590	85200	4200
Antimony	116	< 60	< 60	132	< 60	< 60 D	< 60	< 60	< 60	< 60
Arsenic	< 2.35	< 2.35	320	37.8	170	14.5 D	19.5	20.6	470	350
Barium	605	122	143	374	268	40.5 D	76.2	57.7	347	53.3
Beryllium	7.22	1.6	< 1.12	5.34	5.09	< 1.12 D	< 1.12	1.39	4.41	< 1.12
Cadmium	< 6.78	< 6.78	< 6.78	< 6.78	< 6.78	< 6.78 D	< 6.78	< 6.78	11.4	< 6.78
Calcium	99700	24200	63700	41000	21100	19400 D	20000	19900	34700	21100
Chromium	347	131	83.8	513	312	< 16.8 D	17	< 16.8	192	17.6
Cobalt	114	28.3	28.7	86.5	82.3	< 25 D	< 25	< 25	83.3	< 25
Copper	207	63.8	47.1	230	211	< 18.8 D	< 18.8	< 18.8	165	< 18.8
Iron	225000	58400	137000	177000	172000	868 D	11700	7630	148000	35100
Lead	201	12.8	52.1	71.5	152	< 4.47 D	7.18	5.59	102	6.06
Magnesium	38900	12800	11000	48500	35500	1920 D	3990	3120	24900	3410
Manganese	6460	2850	9880	3630	3550	158 D	265	248	13000	3950
Mercury	.219	< .1	< .1	0.295	< 0.1	< 0.1 D	< 0.1	< 0.1	0.112	< .1
Nickel	318	93.6	67.7	333	278	< 32.1 DH	< 32.1	< 32.1 H	234	< 32.1 H
Potassium	24700	5260	9710	20300	14800	1750 D	5460	3540	14700	5240
Selenium	< 2.53	< 2.53	< 2.53	< 2.53	< 2.53	< 2.53 D	< 2.53	< 2.53	4.05	< 2.53
Sodium	280000	31800	40700	46600	45400	26900 D	28500	27600	32700	23700
Vanadium	195	43.9	44.1	191	137	< 27.6 D	< 27.6	< 27.6	129	< 27.6
Zinc	483 I	132 I	129 I	432 I	344 I	< 18 D	34	22.6	245	20
SEMIVOLATILE ORGANICS										
2-methylnaphthalene	1000	< 1.3	600	< 1.3	400	< 1.3 D	< 1.3	< 1.3	700	400
Acenaphthene	< 60	< 5.8	< 60	< 5.8	< 60	< 5.8 D	< 5.8	< 5.8	34	< 30
Fluorene	< 90	< 9.2	< 90	< 9.2	< 90	< 9.2 D	< 9.2	< 9.2	35	< 50
Naphthalene	600	1.1	300	< .5	500	< .5 D	< .5	< .5	500	300
Phenanthrene	< 100	< 9.9	< 100	< 9.9	< 100	< 9.9 D	< 9.9	< 9.9	64	< 50
VOLATILE ORGANICS										
1,1,1-trichloroethane	< 1	30	20	< 1	< 1	< 1 D	2.6 B	< 1	< 1	< 1
1,1-dichloroethane	< 1	< 1	10	< 1	< 1	< 1 D	< 1	< 1	< 1	< 1
1,1-dichloroethene	< 1	< 1	20	< 1	< 1	< 1 D	< 1	< 1	< 1	< 1
Acetone	< 8	< 8	< 80	37	< 8	< 8 D	< 8	< 8	< 8	< 8
Benzene	< 1	< 1	9	< 1	< 1	< 1 D	< 1	< 1	< 1	< 1
Carbon Tetrachloride	< 1	< 1	10	< 1	< 1	< 1 D	< 1	< 1	< 1	< 1
Chlorobenzene	< 1	< 1	10	< 1	< 1	< 1 D	< 1	< 1	< 1	< 1
Chloroform	< 1	< 1	10	< 1	< 1	< 1 D	< 1	< 1	< 1	< 1
Chloromethane	< 1.2	< 1.2	20	< 1.2	< 1.2	< 1.2 D	< 1.2	< 1.2	< 1.2	< 1.2
Ethylbenzene	80	< 1	40	< 1	< 1	< 1 D	< 1	< 1	52	57
Tetrachloroethene	< 1	< 1	10	< 1	< 1	< 1 D	< 1	< 1	< 1	< 1
Toluene	< 1	< 1	10	< 1	< 1	< 1 D	< 1	< 1	< 1	< 1
Trichloroethylene	< 1	< 1	10	< 1	< 1	< 1 D	3.2	< 1	< 1	< 1
Trichlorofluoromethane	< 1	< 1	20	< 1	< 1	< 1 D	< 1	< 1	< 1	< 1
Xylenes	< 20	< 2	< 20	< 2	< 2	< 2 D	< 2	< 2	8	2.4
WET CHEMISTRY										
Alkalinity							21000		97400	
Chloride						34000	36000	34000	30000	22000
Nitrite, Nitrate-non Specific	14.6	22.9	20	3100	22.3	2100 D	3800	1800	210	310
Nitrogen By Kjeldahl Method	3200	764	5000	1260	2200	< 64 D N	88	< 64 N	810	1180 N
Phosphorus	1800	1900	457	5200	1400	51.2 D		174	1300	330
Sulfate						19000	23000	20000	4000	3660
Total Hardness						55400 D	64900	61200	183000	65300
Total Suspended Solids						344000 D	290000	348000	1620000	174000
OTHER										
Total Petroleum Hydrocarbons	23600 V	522 V	66000 V	< 100 V	21500 V	< 100 D	333	< 100	18500	15700

TABLE 5-4
ADL, AREE 69W GROUNDWATER OFF-SITE ANALYTICAL RESULTS
AOC 69W

REMEDIAL INVESTIGATION REPORT
DEVENS, MASSACHUSETTS

Site ID:	69W-94-11	69W-94-11	69W-94-11	69W-94-12	69W-94-12	69W-94-13	69W-94-13	69W-94-14	69W-94-14
Field Sample Number:	MDD9W-BX	MXD9W-BX	MXE9W-BX	MXD9W-CX	MXE9W-CX	MXD9W-DX	MXE9W-DX	MXD9W-EX	MXE9W-EX
Field ID:	69W-94-11	69W-94-11	69W-94-11	69W-94-12	69W-94-12	69W-94-13	69W-94-13	69W-94-14	69W-94-14
Sample Date:	08/23/94	08/23/94	09/20/94	08/23/94	09/19/94	08/23/94	09/19/94	08/23/94	09/19/94
Units:	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L
PAL METALS									
Aluminum	2790 D	2610	447	11300	7290	337	4610	18100	8330
Antimony	< 60 D	< 60	< 60	< 60	< 60	< 60	< 60	< 60	< 60
Arsenic	38 D	37.8	62.1	25.6	36	60.4	400	70.4	270
Barium	34.4 D	32	22.1	56.5	54.4	25.6	42.9	76	65.3
Beryllium	< 1.12 D	< 1.12	< 1.12	< 1.12	1.96	< 1.12	1.4	< 1.12	< 1.12
Cadmium	< 6.78 D	< 6.78	< 6.78	< 6.78	< 6.78	< 6.78	< 6.78	< 6.78	< 6.78
Calcium	27900 D	26200	26000	24400	18700	19200	20200	18900	18500
Chromium	< 16.8 D	< 16.8	< 16.8	22.2	20.5	< 16.8	< 16.8	39.5	< 16.8
Cobalt	< 25 D	< 25	< 25	< 25	< 25	< 25	< 25	28.8	< 25
Copper	< 18.8 D	< 18.8	< 18.8	< 18.8	< 18.8	< 18.8	< 18.8	27.8	< 18.8
Iron	5430 D	5150	2470	12100	9160	4730	28400	25200	23600
Lead	< 4.47 D	< 4.47	< 4.47	8.92	9.65	< 4.47	11	23.3	15.2
Magnesium	3630 D	3440	2920	4680	3740	2040	3770	5280	2850
Manganese	3340 D	3140	2330	395	409	3910	2920	1850	994
Mercury	< .1 D	< .1	< .1	< .1	< .1	< .1	< .1	.108	< .1
Nickel	< 32.1 D	< 32.1	< 32.1 H	< 32.1	< 32.1 H	< 32.1	< 32.1 H	49.8	< 32.1
Potassium	3270 D	3110	< 1240	4250	4360	2430	2780	3460	2230
Selenium	< 2.53 D	< 2.53	< 2.53	< 2.53	< 2.53	< 2.53	< 2.53	< 2.53	< 2.53
Sodium	37500 D	35500	34900	47300	34300	16700	28900	28000	38300
Vanadium	< 27.6 D	< 27.6	< 27.6	< 27.6	< 27.6	< 27.6	< 27.6	< 27.6	< 27.6
Zinc	32.5 D	45.5	29.1	38.5	29.1	19	22.6	50.8	20
SEMIVOLATILE ORGANICS									
2-methylnaphthalene	37 D	42	7.2	< 1.3	< 1.3	69	29	< 6	< 1.3
Acenaphthene	< 5.8 D	< 5.8	< 5.8	< 5.8	< 5.8	< 5.8	< 5.8	< 30	< 5.8
Fluorene	< 9.2 D	< 9.2	< 9.2	< 9.2	< 9.2	< 9.2	< 9.2	< 50	< 9.2
Naphthalene	8.8 D	11	2.7	< .5	< .5	64	47	< 2	< .5
Phenanthrene	< 9.9 D	< 9.9	< 9.9	< 9.9	< 9.9	< 9.9	< 9.9	< 50	< 9.9
VOLATILE ORGANICS									
1,1,1-trichloroethane	1.5 DB	< 1	< 1	3.1 B	1.7	4.1 B	< 1	< 1	< 1
1,1-dichloroethane	< 1 D	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
1,1-dichloroethene	< 1 D	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
Acetone	< 8 D	< 8	< 8	< 8	< 8	< 8	< 8	< 8	< 8
Benzene	< 1 D	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
Carbon Tetrachloride	< 1 D	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
Chlorobenzene	< 1 D	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
Chloroform	< 1 D	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
Chloromethane	< 1.2 D	< 1.2	< 1.2	< 1.2	< 1.2	< 1.2	< 1.2	< 1.2	< 1.2
Ethylbenzene	< 1 D	< 1	< 1	< 1	< 1	19	9.1	< 1	< 1
Tetrachloroethene	< 1 D	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
Toluene	< 1 D	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
Trichloroethylene	< 1 D	< 1	< 1	5.9	< 1	< 1	< 1	< 1	< 1
Trichlorofluoromethane	< 1 D	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
Xylenes	< 2 D	< 2	< 2	< 2	< 2	< 2	< 2	< 2	< 2
WET CHEMISTRY									
Alkalinity	52600 D	56000		21200		43300		31500	
Chloride	58000 D	58000	48000	81000	41000	35000	40000	40000	52000
Nitrite, Nitrate-non Specific	500 D	350	1100	3100	2000	20.7	162	182	1600
Nitrogen By Kjeldahl Method	627 D	681	145 N	330	203 N	635	1100 N	423	456
Phosphorus	77 D	73.9	45.2	225	400	30.9	560	620	740
Sulfate	17000 D	17000	13000	18000	19000	2520	1850	17000	15000
Total Hardness	83000 D	78000	75400	78600	60600	55300	64600	67200	56700
Total Suspended Solids	47000 D	36000	61000	397000	815000	10000	2190000	640000	545000
OTHER									
Total Petroleum Hydrocarbons	543 D	750	784	815	314	925	2140	11800	50000

Notes:
< = The concentration was less than the certified reported limit.
µg/L = micrograms per liter.
D = Duplicate analysis.
I = The low spike recovery for this lot was high.
H = Lot out of control but data accepted due to high recoveries.
V = Sample was not correctly preserved.
N = The high spike recovery for this lot was low.
B = Analyte found in method blank or QC sample.

TABLE 5-5
ADL, AREE 69W SURFACE WATER OFF-SITE ANALYTICAL RESULTS
AOC 69W

REMEDIAL INVESTIGATION REPORT
DEVENS, MASSACHUSETTS

Site ID:		69W--94-15			69W--94-16	
Field Sample Number:		WXD9W-FX			WXD9W-GX	
Sample Number:		06/24/94			06/24/94	
Units:		μg/L			μg/L	
PAL METALS						
Aluminum		658		<	112	
Arsenic		2.92		<	2.35	
Barium		17.5			13.1	
Calcium		26600			23900	
Iron		1470			276	
Lead		7.65		<	4.47	
Magnesium		4480			3750	
Manganese		164			38.8	
Potassium		1920			1920	
Sodium		42700			40000	
Zinc		24.6		<	18	
VOLATILE ORGANICS						
1,1,1-trichloroethane		3.7	B		2.2	B
WET CHEMISTRY						
Alkalinity	<	10000			42300	
Chloride		77000			75000	
Nitrite, Nitrate-non Specific		930			1100	
Nitrogen By Kjeldahl Method		353			214	
Phosphorus		91.2			24.1	
Sulfate		14000			15000	
Total Hardness		83000			73700	

Notes:
μg/L = micrograms per liter
< + Concentration is less than the certified reporting limit.
B = Analyte found in method blank or QC sample.

TABLE 5-6
ADL, AREE 69W SEDIMENT OFF-SITE ANALYTICAL RESULTS
AOC 69W

REMEDIAL INVESTIGATION REPORT
DEVENS, MASSACHUSETTS

Site ID:		69W--94-15		69W--94-16			69W--94-16
Field Sample Number:		DXD9W-FO		DDD9W-GO			DXD9W-GO
Sample Date:		06/24/94		06/24/94			06/24/94
Depth:		0		0			0
Units:		µg/g		µg/g			µg/g
PAL METALS							
Aluminum		6280		6130	D		7920
Arsenic		6.46		13.2	D		20.3
Barium		15.4		11.2	D		19.8
Boron	<	6.64		12.9	D	<	6.64
Calcium		1200		2660	D		1650
Chromium		18.2		14.6	D		23.6
Cobalt		5.5	<	2.5	D		5.79
Copper		13.1		43.2	D		14.2
Iron		15100		14400	D		16200
Lead		20.7		20.7	D		23.6
Magnesium		3080		3990	D		4470
Manganese		195		259	D		203
Nickel		13.4		12.8	D		18.1
Potassium		842		581	D		979
Sodium		104		79	D		132
Vanadium		12.2		11.5	D		15.3
Zinc		49.5		41.6	D		48.1
SEMIVOLATILE ORGANICS							
Acenaphthylene		0.34		.098	D	<	0.033
Benzo[a]anthracene		1.9		0.3	D		0.16
Benzo[b]fluoranthene		2.2	<	0.31	D	<	0.31
Benzo[ghi]perylene		0.95	<	0.18	D	<	0.18
Benzo[k]fluoranthene		0.99	<	0.13	D	<	0.13
Benzyl Alcohol	<	0.032		0.073	D	<	0.032
Chrysene		2		0.36	D		0.19
Fluoranthene		2.5		0.44	D		0.21
Fluorene		0.55	<	0.065	D	<	0.065
Phenanthrene		3.8		0.59	D		0.13
Pyrene		3.8		0.5	D		0.27
Bis(2-ethylhexyl) Phthalate	<	0.48	<	0.48	D		1.4
OTHER							
Total Organic Carbon		2580		1320	D		1670
Total Petroleum Hydrocarbons		188		123	D		131

Notes:
µg/g = micrograms per gram.
< = Concentration is less than the certified reporting limit.
D = Duplicate analysis.

TABLE 5-7
SUMMARY OF SOIL BORINGS
AOC 69W

REMEDIAL INVESTIGATION REPORT
DEVENS, MASSACHUSETTS

EXPLORATION ID	COMPLETION DEPTH (Feet bgs)	REFERENCE SAMPLE INTERVALS (Feet bgs)	OFF-SITE LABORATORY ANALYTICAL SAMPLES COLLECTED	SOIL TYPE (USCS)	TOTAL VOCS BY PID (ppmv)	COMMENTS
PREVIOUS INVESTIGATIONS						
69W-94-09	15	0-2		SW	0.7	
		2-4	2-4	SW	0.5	
		4-6	4-6	SW	1	
		11-13		SM	0.5	
69W-94-10	15	0-2		SW	15.7	Asphalt to 0.25 feet bgs
		2-4	2-4	OL	279	
		4-6	4-6	SW	541	
		11-13		SW/SP	265	Alternating med and fine sands
69W-94-11	15	0-2		SW	0.5	
		2-4	2-4	SW	0.5	
		4-6	4-6	SW	237	
		11-13		SW	42	
69W-94-12	15.3	0-2		OL	0.9	
		2-4	2-4	OL	1.4	
		4-6	4-6	SW	124	
		11-13		SW	48.4	
69W-94-13	14	0-2		OL	1	
		2-4	2-4	PT/GM	33	0-3" fine to med. black sand
		4-6	4-6	SW	520	
		11-13		SW	234	
69W-94-14	13.5	0-2		OL	0.8	
		2-4	2-4	OL/SW	4.1	
		4-6	4-6	SW	154	
		11-13		SW	107.6	
REMEDIAL INVESTIGATIONS						
ZWM-95-15X	13	0-2		ML	0	
		2-4		SM-ML	0.8	
		4-6	4-6	ML/SW	4.1	
		6-8		SP	0	
		8-9.5		SW-GW	NR	
		9.5-11		SW-GW	NR	
		11-13		SW-GW	NR	
ZWM-95-16X	17	0-2		SM	NR	
		5-7		SP	NR	
		7-9	7-9	SP/SW	NR	
		10-12		SW/SP	NR	
		14-16		SP	NR	
ZWM-95-17X	22	0-2		ML-SM	NR	
		5-7		SP	NR	
		10-12		SP-SW	NR	
		12-14		SW	NR	
		14-16	14-16	SW-SP	NR	
		20-22		SP	NR	
ZWM-95-18X	14	0-2		SM	NR	
		2-4		SW	NR	
		4-6	4-6	ML/SM	NR	
		6-8		SW-SM	NR	Strong petroleum-like odor from augers
		11-13		SW	NR	

TABLE 5-7
SUMMARY OF SOIL BORINGS
AOC 69W

REMEDIAL INVESTIGATION REPORT
DEVENS, MASSACHUSETTS

EXPLORATION ID	COMPLETION DEPTH (Feet bgs)	REFERENCE SAMPLE INTERVALS (Feet bgs)	OFF-SITE LABORATORY ANALYTICAL SAMPLES COLLECTED	SOIL TYPE (USCS)	TOTAL VOCS BY PID (ppmv)	COMMENTS
ZWM-96-19X	16	1-3		SP	0	Concrete floor
		3-5		SP	0	
		5-7	5-7	SP	0	
		7-9		SP-SW	0	Fuel odor
		9-11	9-11	SW	48.2	
		11-13		SM	50	50 ppm at top, 4 ppm at bottom
		13-15		SP	0	
ZWM-96-20X	13	2-4	2-4	SW	0	Concrete floor
		4-6	4-6	SP	0	
		6-8		SP	0	
		8-10		SP	0	
ZWM-96-21X	15	0-2		SW	0	
		2-4		SW	0	
		4-6	4-6	SW	0	
		6-8		SP	0	
		8-10	8-10	SP	0	
		10-12		SW-SM	0	
		12-14		SW	0	Refusal at 15 ft on probable boulder
ZWP-95-01X	12	0-2		ML-SW	NR	
		5-7		SW	NR	
		10-12		SW	NR	
ZWP-95-02X	12	0-2		SM-ML	NR	
		5-7		SW	NR	
		10-12		SP/GW	NR	
ZWB-95-01X	12	0-2	0-2	ML	0	
		5-7		SM	7.6	
		7-9	7-9	SM	3.3	
		10-12		SM	7.5	
ZWB-95-02X	12	0-2	0-2	SM-ML	0	
		5-7	5-7	SW-GW	5.2	
ZWB-96-03X	15	0-2		NR	0	
		2-4		SP-SM	0	
		4-6		SP	0	
		6-8	6-8	SP	0	
		8-10		SP	0	
		10-12	10-12	SP	0	
		12-14		SW-SM	0	

Notes:
bgs = Below ground surface
USCS = Unified Soil Classification System
ppmv = Parts Per Million by Volume
SW = Well graded sand
SM = Silty sand/sandy silt
OL = Organic silts/clays
SP = Poorly graded sand
PT = Peat
GM = Silty gravel/gravel-sand-silt mixtures
ML = Inorganic silts
GW = Well graded gravel

TABLE 5-8
MONITORING WELL COMPLETION DETAILS
AOC 69W

REMEDIAL INVESTIGATION REPORT
DEVENS, MASSACHUSETTS

WELL IDENTIFICATION	SOIL DRILLING METHOD	BEDROCK DRILLING MEHTOD	MEDIUM SCREENED	WELL SCREEN DEPTH (Feet bgs)	WELL SCREEN ELEVATION (Feet NGVD)	COMPLETION DEPTH (Feet bgs)	CONSTRUCTION MATERIAL
AREE 69W							
69W-94-09	HSA^{1}	NA	SOIL	3.5-13.5	220.0-210.0	15	2" ID PVC
69W-94-10	HSA^{1}	NA	SOIL	4.5-14.5	224.2-214.2	15	2" ID PVC
69W-94-11	HSA^{1}	NA	SOIL	4.5-14.5	223.2-213.2	15	2" ID PVC
69W-94-12	HSA^{1}	NA	SOIL	3-13	223.5-213.5	15.3	2" ID PVC
69W-94-13	HSA^{1}	NA	SOIL	3-13	222.3-212.3	13.5	2" ID PVC
69W-94-14	HSA^{1}	NA	SOIL	3-13	222.5-212.5	13.5	2" ID PVC
REMEDIAL INVESTIGATION							
ZWM-95-15X	HSA^{2}	NA	SOIL	3-13	219.9-209.9	13.5	4" ID PVC
ZWM-95-16X	HSA^{2}	NA	SOIL	6.3-16.3	222.7-212.7	17	4" ID PVC
ZWM-95-17X	HSA^{2}	NA	SOIL	12.2-22.2	223.9-213.9	22.5	4" ID PVC
ZWM-95-18X	HSA^{2}	NA	SOIL	3-13	217.7-207.7	14	4" ID PVC
ZWM-96-19X	CHOP & WASH	NA	SOIL	5.8-15.8	225.7-215.7	16	2" ID PVC
ZWM-96-20X	CHOP & WASH	NA	SOIL	2.8-12.8	223.7-213.7	13	2" ID PVC
ZWM-96-21X	CHOP & WASH	NA	SOIL	4.8-14.8	226.4-216.4	15	2" ID PVC
ZWP-95-01X	HSA^{2}	NA	SOIL	10-12	214.4-212.4	12.5	4" ID PVC
ZWP-95-02X	HSA^{2}	NA	SOIL	9.5-11.5	211.2-209.2	12	4" ID PVC

Notes: NA= Not Applicable
HSA^{1} = 4-1/4-inch ID hollow stem augers
HSA^{2} = 6-1/4-inch ID hollow stem augers
Chop & Wash = 4-inch ID casing
ID = Inner diameter
PVC = Polyvinyl chloride
NGVD = National Geodetic Vertical Datum

TABLE 6-1
SUMMARY OF WATER LEVEL ELEVATION DATA
AOC 69W

REMEDIAL INVESTIGATION REPORT
DEVENS, MASSACHUSETTS

WELL ID[1]	ELEV. OF REF POINT (FEET MSL)	DECEMBER 7, 1995		MARCH 26, 1996		JULY 23, 1996		JANUARY 15, 1997		DECEMBER, 1997[2]	
		DEPTH TO WATER (FEET)	ELEV. OF WATER (FEET MSL)	DEPTH TO WATER (FEET)	ELEV. OF WATER (FEET MSL)	DEPTH TO WATER (FEET)	ELEV. OF WATER (FEET MSL)	DEPTH TO WATER (FEET)	ELEV. OF WATER (FEET MSL)	DEPTH TO WATER (FEET)	ELEV. OF WATER (FEET MSL)
69W-94-09	228.40	5.85	222.55	4.08	224.32	4.61	223.79	-	-	7.76	220.64
69W-94-10	227.99	5.81	222.18	4.40	223.59	4.93	223.06	4.39	223.60	7.79	220.20
69W-94-11	227.33	5.22	222.11	3.82	223.51	4.36	222.97	3.82	223.51	7.13	220.20
69W-94-12	228.94	7.33	221.61	5.95	222.99	6.48	222.46	6.00	222.94	7.27	221.67
69W-94-13	227.79	6.22	221.57	3.93	223.86	5.42	222.37	4.95	222.84	8.10	219.69
69W-94-14	228.02	7.24	220.78	6.17	221.85	6.53	221.49	6.16	221.86	9.02	219.00
ZWM-95-15X	225.81	5.23	220.58	4.23	221.58	4.57	221.24	4.24	221.57	6.95	218.86
ZWM-95-16X	228.38	5.73	222.65	3.93	224.45	4.47	223.91	3.88	224.5	7.58	220.80
ZWM-95-17X	238.63	14.98	223.65	12.88	225.75	13.49	225.14	12.68	225.95	16.85	221.78
ZWM-95-18X	222.95	3.48	219.47	2.59	220.36	2.88	220.07	2.61	220.34	5.05	217.90
ZWM-96-19X	231.11	-	-	-	-	-	-	6.78	224.33	10.42	220.69
ZWM-96-20X	225.99	-	-	-	-	-	-	1.09	224.90	4.90	221.09
ZWM-96-21X	230.93	-	-	-	-	-	-	6.52	224.41	10.15	220.78
ZWP-95-01X	226.84	5.45	221.39	4.69	222.15	4.94	221.90	4.61	222.23	-	-
ZWP-95-02X	223.63	4.06	219.57	3.33	220.30	3.51	220.12	3.21	220.42	-	-

NOTES:

[1] The reference point for all the monitoring wells was PVC.

[2] Water levels were obtained during the period of December 11 through December 19 (during the low-flow groundwater sampling event).

MSL = Mean Sea Level

PVC = Top of polyvinyl chloride well riser

TABLE 6-2
SUMMARY OF IN-SITU HYDRAULIC CONDUCTIVITY TESTING
AOC 69W

REMEDIAL INVESTIGATION REPORT
DEVENS, MASSACHUSETTS

									Bouwer and Rice		Hvorslev		
Well ID	Well Diam. (in)	Screen Int. (feet, bgs)	Filter Pack Int (feet, bgs)	Saturated Height (feet)	Rc (feet)	Rw (feet)	Le (feet)	Hw (feet)	Hydraulic Cond. (ft/min)	Hydraulic Cond. (cm/s)	Hydraulic Cond. (ft/min)	Hydraulic Cond. (cm/s)	Screened Geology (USCS)
69W-94-09	2	3.5 to 13.5	2.5 to 15	6.85	0.17	0.29	8.35	8.35	2.60E-03	1.32E-03	1.78E-04	9.02E-05	SP-SM
69W-94-10	2	4.5 to 14.5	3.5 to 15	8.08	0.17	0.29	8.58	8.58	4.10E-02	2.08E-02	2.96E-03	1.50E-03	SW
69W-94-11	4	4.5 to 14.5	3.5 to 15	7.41	0.29	0.46	7.91	7.91	3.10E-02	1.57E-02	3.50E-03	1.78E-03	SP-SM
69W-94-12	2	3 to 13	2.5 to 15	8.26	0.17	0.29	10.26	10.26	1.10E-02	5.59E-03	3.14E-03	1.59E-03	SW
69W-94-13	4	3 to 13	2.5 to 14	9.27	0.29	0.46	10.27	10.27	5.10E-02	2.59E-02	7.40E-03	3.76E-03	SW
69W-94-14	2	3 to 13	2.5 to 13.5	7.62	0.17	0.29	8.12	8.12	5.80E-02	2.95E-02	2.72E-03	1.38E-03	SW
ZWM-95-15X	4	3 to 13	2 to 13.5	9.14	0.29	0.46	9.64	9.64	5.80E-02	2.95E-02	6.07E-03	3.08E-03	SW-GW
ZWM-95-16X	4	6.3 to 16.3	4 to 17	9.06	0.29	0.46	9.76	9.76	1.90E-02	9.65E-03	1.95E-03	9.92E-04	SW-SP
ZWM-95-17X	4	12.2 to 22.2	7 to 22.5	8.75	0.29	0.46	9.05	9.05	3.80E-02	1.93E-02	4.08E-03	2.07E-03	SW-SP
ZWM-95-18X	4	3 to 13	2 to 14	11.65	0.17	0.46	12.65	12.65	5.40E-02	2.74E-02	4.78E-03	2.43E-03	SW-SM
ZWM-96-19X	2	5.8 to 15.8	3.9 to 16	8.6	0.11	0.17	8.8	8.8	8.44E-03	2.74E-02	1.46E-03	7.39E-04	SP-SW-SM
ZWM-96-20X	2	2.8 to 12.8	2.5 to 13	11.21	0.11	0.17	11.41	11.41	8.67E-03	2.74E-02	1.44E-03	7.31E-04	SP
ZWM-96-21X	2	4.8 to 14.8	3.0 to 15.0	8.04	0.11	0.17	8.24	8.24	8.84E-03	2.74E-02	1.42E-03	7.24E-04	SP-SW

Notes:

Data analyzed using AQTESOLV (Bouwer & Rice Solution).

All tests are rising head tests.

Rc = Well casing radius for fully saturated filterpacks and equivalent casing radius which accounts for filterpack resaturation at n=30% for partially saturated filterpacks.

Rw = Radius of borehole.

Le = Saturated length of filterpack.

Hw = Height of Water Column above filterpack bottom.

Saturated Height is height of water column measured in well.

All measurements in feet unless otherwise noted.

TABLE 7-1
UNKNOWN COMPOUNDS DETECTED IN SUBSURFACE SOIL
AOC 69W

REMEDIAL INVESTIGATION REPORT
DEVENS, MASSACHUSETTS

Site ID:	ZWB-95-01X		ZWB-95-01X		ZWB-95-01X		ZWB-95-02X		ZWB-95-02X		ZWR-95-26X		ZWR-95-30X		ZWR-95-35X	
Field Sample Number:	BDZW0100		BXZW0100		BXZW0107		BXZW0200		BXZW0205		RXZW2607		RXZW3006		RXZW3504	
Sample Date:	09/19/95		09/19/95		09/19/95		09/19/95		09/19/95		09/11/95		09/11/95		09/12/95	
Depth:	0		0		7		0		5		0		0		0	
Units:	µg/g		µg/g		µg/g		µg/g		µg/g		µg/g		µg/g		µg/g	
SEMIVOLATILE ORGANICS																
1,2,3-trimethylbenzene					30	S										
1,3-dimethylnaphthalene																
1,4,6-trimethyl-naphthalene									2.1	S	2.2	S	2.3	S		
1,4-dimethylnaphthalene					80	S										
1,6,7-trimethylnaphthalene					50	S										
1,7-dimethylnaphthalene					100	S										
1,8-dimethylnaphthalene											1.1	S				
1-ethyl-2-methylbenzene					20	S										
1-methyl-3-(1-methylethyl)benzene / M-cymene													0.56	S		
1-methylnaphthalene					80	S							3.4	S		
2,3,6-trimethylnaphthalene									4.1	S						
2,3-dihydro-5-methylindene					20	S										
2,3-dimethylnaphthalene					30	S										
2,5-dimethylphenanthrene													2.3	S		
2,6,10,14-tetramethylpentadecane	3	S	5	S	300	S			21	S	8.8	S	23	S		
2,6,10,15-tetramethylheptadecane																
2,7-dimethylnaphthalene					100	S										
2,8-dimethyldibenzo[b,d]thiophene													1.1	S		
3-propyltoluene					50	S										
4mpanr													1.1	S		
Docosane											2.2	S	0.68	S		
Dodecane											1.1	S				
Eicosane			2	S							5.5	S				
Gamma-sitosterol																
Heneicosane			2	S							3.3	S				
Heptacosane																
Heptadecane	2	S	3	S							11	S				
Hexadecane	2	S	2	S							11	S				
Hexadecanoic Acid / Palmitic Acid															0.43	S
Isopropyltoluene					30	S										
Nonacosane																
Nonadecane											7.7	S	5.6	S		
Octadecane	2	S	3	S							11	S				
Pentadecane			2	S							11	S				
Sulfur, Molecular									7.2	S	3.3	S	1.1	S		
Tetradecane											11	S				
Tricosane											.99	S				
Tridecane											5.5	S				
Unk514					80	S										
Unk515							10	S							0.7	S
Unk524																
Unk537					20	S										
Unk544									2	S						
Unk545					60	S							0.7	S		
Unk546					20	S										
Unk548									2	S			0.9	S		
Unk549					30	S			2	S			0.8	S		
Unk550					30	S			1	S			0.6	S		

TABLE 7-1
UNKNOWN COMPOUNDS DETECTED IN SUBSURFACE SOIL
AOC 69W

REMEDIAL INVESTIGATION REPORT
DEVENS, MASSACHUSETTS

Site ID:	ZWB-95-01X		ZWB-95-01X		ZWB-95-01X		ZWB-95-02X		ZWB-95-02X		ZWR-95-26X		ZWR-95-30X		ZWR-95-35X	
Field Sample Number:	BDZW0100		BXZW0100		BXZW0107		BXZW0200		BXZW0205		RXZW2607		RXZW3006		RXZW3504	
Sample Date:	09/19/95		09/19/95		09/19/95		09/19/95		09/19/95		09/11/95		09/11/95		09/12/95	
Depth:	0		0		7		0		5		8		8		0	
Units:	µg/g		µg/g		µg/g		µg/g		µg/g		µg/g		µg/g		µg/g	
Unk551													1	S		
Unk552													1	S		
Unk553					20	S										
Unk554					30	S			2	S			0.5	S		
Unk555					20	S			3	S			0.7	S		
Unk556					30	S			2	S			0.9	S		
Unk557					30	S							3	S		
Unk558					20	S							1	S		
Unk559					20	S			1	S			2	S		
Unk560					20	S							2	S		
Unk561													1	S		
Unk562					30	S							2	S		
Unk563					100	S			5	S	0.9	S	0.3	S		
Unk564					20	S			2	S			5	S		
Unk565					20	S							2	S		
Unk566					30	S							2	S		
Unk567					20	S			2	S	0.4	S	2	S		
Unk568					30	S			6	S	0.7	S	10	S		
Unk569					30	S					0.4	S	1	S		
Unk570					80	S					1	S	2	S		
Unk571					20	S					0.4	S	20	S		
Unk572					20	S			2	S						
Unk573					20	S					0.6	S				
Unk574					20	S					0.3	S				
Unk575					50	S					0.7	S				
Unk576					30	S					0.8	S				
Unk577											0.8	S				
Unk578					20	S			2	S	2	S				
Unk579					80	S			9	S	3	S				
Unk580					30	S										
Unk581					20	S					2	S				
Unk582									3	S	3	S				
Unk583									10	S	0.7	S				
Unk584			2	S	30	S					7	S				
Unk585					100	S			10	S	1	S	3	S		
Unk586					10000	S										
Unk587					30	S					1	S				
Unk588					50	S			2000	S						
Unk589					20	S					2	S				
Unk590					30	S			4	S	3	S				
Unk591											2	S				
Unk592					30	S					0.7	S				
Unk593					50	S										
Unk594					30	S										
Unk595											2	S	9	S		
Unk596					50	S					1	S				
Unk597													3	S		
Unk598					30	S			3	S	2	S	5	S		
Unk599					30	S					1	S				

TABLE 7-1
UNKNOWN COMPOUNDS DETECTED IN SUBSURFACE SOIL
AOC 69W

REMEDIAL INVESTIGATION REPORT
DEVENS, MASSACHUSETTS

Site ID:	ZWB-95-01X		ZWB-95-01X		ZWB-95-01X		ZWB-95-02X		ZWB-95-02X		ZWR-95-26X		ZWR-95-30X		ZWR-95-35X	
Field Sample Number:	BDZW0100		BXZW0100		BXZW0107		BXZW0200		BXZW0205		RXZW2607		RXZW3006		RXZW3504	
Sample Date:	09/19/95		09/19/95		09/19/95		09/19/95		09/19/95		09/11/95		09/11/95		09/12/95	
Depth:	0		0		7		0		5		0		0		0	
Units:	µg/g		µg/g		µg/g		µg/g		µg/g		µg/g		µg/g		µg/g	
Unk600											2	S				
Unk601	2	S	4	S					10	S	6	S				
Unk602											0.9	S				
Unk603	300	S	500	S												
Unk604			3	S	30	S			5	S			1	S		
Unk605													3	S		
Unk607																
Unk608													1	S		
Unk609																
Unk610													1	S		
Unk611													0.7	S		
Unk612													1	S		
Unk613																
Unk614																
Unk615																
Unk616																
Unk617																
Unk618																
Unk619											1	S	2	S		
Unk620																
Unk621																
Unk622																
Unk623																
Unk624																
Unk625																
Unk626																
Unk627																
Unk628																
Unk629																
Unk630																
Unk631																
Unk632																
Unk633																
Unk635																
Unk636																
Unk637																
Unk638																
Unk641																
Unk642																
Unk643																
Unk644																
Unk645																
Unk650																
Unk651																
Unk654																

TABLE 7-1
UNKNOWN COMPOUNDS DETECTED IN SUBSURFACE SOIL
AOC 69W

REMEDIAL INVESTIGATION REPORT
DEVENS, MASSACHUSETTS

Site ID:	ZWB-95-01X	ZWB-95-01X	ZWB-95-01X	ZWB-95-02X	ZWB-95-02X	ZWR-95-26X	ZWR-95-30X	ZWR-95-35X
Field Sample Number:	BDZW0100	BXZW0100	BXZW0107	BXZW0200	BXZW0205	RXZW2607	RXZW3006	RXZW3504
Sample Date:	09/19/95	09/19/95	09/19/95	09/19/95	09/19/95	09/11/95	09/11/95	09/12/95
Depth:	0	0	7	0	5	0	0	0
Units:	µg/g	µg/g	µg/g	µg/g	µg/g	µg/g	µg/g	µg/g
VOLATILE ORGANICS								
1,1,3-trimethylcyclohexane			0.19 S					
1,2,3-trimethylbenzene								
1,2,4-trimethylbenzene								
1,3,5-trimethylcyclohexane								
1,4,6-trimethyl-naphthalene								
1,4-dihydro-1,4-methanonaphthalene								
1,7-dimethylnaphthalene								
1-ethylidene-1h-indene								
1-methyl-3-(1-methylethyl)benzene / M-cymene						0.33 S		
1-methylethylcyclohexane								0.053 S
1-methylnaphthalene								0.21 S
2,3,5-trimethyldecane					0.41 S			
2,3-dimethylnaphthalene								
2,3-dimethyloctane								
2,6-dimethylundecane					0.52 S			0.11 S
2,7-dimethylnaphthalene								
2-ethyl-1-hexanol								
2-methyldecane					0.31 S			0.21 S
2-methylheptane / Isooctane			0.23 S					
2-methylnaphthalene								
26dmo			0.13 S					
3,7-dimethylnonane					0.21 S	0.22 S		
3-methyl-5-propylnonane								
3-methyldecane								0.075 S
3-methyloctane			0.097 S					
3-methylundecane								
3-propyltoluene						0.11 S		
4-(1-methylethyl)toluene / P-cymene						0.33 S		
4-methyldecane					0.31 S	0.33 S		0.11 S
6-methyldodecane								
Cumene / Isopropylbenzene								
Decahydro-2-methylnapthalene						0.22 S		
Decane								
Dodecane								
Hendecane / Undecane						0.11 S		
Heptacosane					0.21 S			
Nonane			0.097 S					
Omctsx								
Octane			0.097 S					
Pentadecane								
Trans-1-ethyl-4-methylcyclohexane								
Unk011								
Unk130			0.06 S					
Unk135								
Unk136			0.3 S					
Unk143								
Unk147			0.2 S					
Unk151		0.02 S						

TABLE 7-1
UNKNOWN COMPOUNDS DETECTED IN SUBSURFACE SOIL
AOC 69W

REMEDIAL INVESTIGATION REPORT
DEVENS, MASSACHUSETTS

Site ID: Field Sample Number: Sample Date: Depth: Units:	ZWB-95-01X BDZW0100 09/19/95 0 µg/g	ZWB-95-01X BXZW0100 09/19/95 0 µg/g	ZWB-95-01X BXZW0107 09/19/95 7 µg/g	ZWB-95-02X BXZW0200 09/19/95 0 µg/g	ZWB-95-02X BXZW0205 09/19/95 5 µg/g	ZWR-95-26X RXZW2607 09/11/95 0 µg/g	ZWR-95-30X RXZW3006 09/11/95 0 µg/g	ZWR-95-35X RXZW3504 09/12/95 0 µg/g
Unk152								
Unk158			0.1 S					
Unk162								0.07 S
Unk166								
Unk172								
Unk173								
Unk175								
Unk178								0.07 S
Unk179					0.2 S			
Unk182					0.1 S			
Unk183						0.6 S		
Unk186			0.1 S					0.07 S
Unk187						0.3 S		
Unk188		0.01 S		0.005 S				
Unk189								0.06 S
Unk190			0.06 S		0.2 S			
Unk191					0.4 S	0.2 S		0.1 S
Unk193								
Unk194					0.1 S	0.3 S		
Unk196								
Unk200								
Unk202					0.2 S			0.1 S
Unk205						0.2 S		
Unk206								
Unk215								

TABLE 7-1
UNKNOWN COMPOUNDS DETECTED IN SUBSURFACE SOIL
AOC 69W

REMEDIAL INVESTIGATION REPORT
DEVENS, MASSACHUSETTS

Site ID:	ZWR-95-36X				ZWR-95-38X		ZWR-95-39X		ZWR-95-45X		ZWS-95-35X		ZWS-95-37X		ZWS-95-37X	
Field Sample Number:	RXZW3607		RXZW3704		RXZW3803		RXZW3904		RXZW4504		SXZW3500		SXZW3700		SXZW3700	
Sample Date:	09/13/95		09/13/95		09/14/95		09/13/95		09/15/95		09/18/95		09/18/95		09/28/95	
Depth:	0		0		3		0		4		0		0		0	
Units:	µg/g		µg/g		µg/g		µg/g		µg/g		µg/g		µg/g		µg/g	
SEMIVOLATILE ORGANICS																
1,2,3-trimethylbenzene																
1,3-dimethylnaphthalene			3.5	S												
1,4,6-trimethyl-naphthalene			2.3	S												
1,4-dimethylnaphthalene																
1,6,7-trimethylnaphthalene																
1,7-dimethylnaphthalene																
1,8-dimethylnaphthalene																
1-ethyl-2-methylbenzene																
1-methyl-3-(1-methylethyl)benzene / M-cymene																
1-methylnaphthalene																
2,3,6-trimethylnaphthalene			2.3	S												
2,3-dihydro-5-methylindene																
2,3-dimethylnaphthalene			.81	S												
2,5-dimethylphenanthrene			.58	S												
2,6,10,14-tetramethylpentadecane	4.3	S													1.1	S
2,6,10,15-tetramethylheptadecane	1.1	S														
2,7-dimethylnaphthalene																
2,8-dimethyldibenzo[b,d]thiophene																
3-propyltoluene																
4mpanr																
Docosane	1.1	S														
Dodecane																
Eicosane	3.2	S														
Gamma-sitosterol															.77	S
Heneicosane	2.2	S														
Heptacosane															1.1	S
Heptadecane	7.6	S														
Hexadecane	5.4	S														
Hexadecanoic Acid / Palmitic Acid															.55	S
Isopropyltoluene																
Nonacosane															5.5	S
Nonadecane	4.3	S														
Octadecane	5.4	S														
Pentadecane	6.5	S													.66	S
Sulfur, Molecular	.32	S	6.9	S	.79	S										
Tetradecane	5.4	S														
Tricosane	.76	S														
Tridecane	2.2	S														
Unk514																
Unk515																
Unk524															.5	S
Unk537																
Unk544																
Unk545																
Unk546																
Unk548																
Unk549																
Unk550																

TABLE 7-1
UNKNOWN COMPOUNDS DETECTED IN SUBSURFACE SOIL
AOC 69W

REMEDIAL INVESTIGATION REPORT
DEVENS, MASSACHUSETTS

Site ID:	ZWR-95-36X			ZWR-95-38X	ZWR-95-39X	ZWR-95-45X	ZWS-95-35X	ZWS-95-37X	ZWS-95-37X
Field Sample Number:	RXZW3607		RXZW3704	RXZW3803	RXZW3904	RXZW4504	SXZW3500	SXZW3700	SXZW3700
Sample Date:	09/13/95		09/13/95	09/14/95	09/13/95	09/15/95	09/18/95	09/18/95	09/28/95
Depth:	0		0	3	0	4	0	0	0
Units:	µg/g		µg/g	µg/g	µg/g	µg/g	µg/g	µg/g	µg/g
Unk551									
Unk552									
Unk553									
Unk554			0.3 S						
Unk555			0.3 S						
Unk556									
Unk557	0.5 S		0.9 S						
Unk558	0.3 S		0.5 S						
Unk559			0.6 S						
Unk560			0.6 S						
Unk561			0.5 S						
Unk562			0.3 S						
Unk563	1 S		2 S						
Unk564	0.5 S		0.7 S						
Unk565			0.3 S						
Unk566	0.4 S		0.6 S						
Unk567	0.5 S		0.7 S						
Unk568	0.6 S		0.7 S						
Unk569	2 S		1 S						
Unk570	0.8 S		1 S						
Unk571			0.6 S						
Unk572	1 S		0.6 S						
Unk573			3 S						
Unk574			0.8 S						
Unk575	0.6 S		1 S						
Unk576	0.8 S		1 S						
Unk577	1 S		1 S						
Unk578	3 S		2 S						
Unk579			3 S						
Unk580	0.8 S		1 S						
Unk581	0.5 S		0.7 S						
Unk582	2 S		1 S						
Unk583	2 S		0.6 S						
Unk584	1 S		1 S						
Unk585	5 S		1 S						
Unk586	0.6 S		0.7 S						
Unk587	0.9 S		6 S						
Unk588			0.5 S						
Unk589	2 S		1 S						
Unk590	1 S		1 S						
Unk591	0.8 S		1 S						
Unk592			0.8 S						
Unk593			3 S						
Unk594	1 S		1 S						
Unk595	1 S		0.5 S						
Unk596	0.9 S		0.6 S						
Unk597			8 S						
Unk598	1 S		0.6 S						
Unk599	1 S		0.6 S						

TABLE 7-1
UNKNOWN COMPOUNDS DETECTED IN SUBSURFACE SOIL
AOC 69W

REMEDIAL INVESTIGATION REPORT
DEVENS, MASSACHUSETTS

Site ID:	ZWR-95-36X				ZWR-95-38X		ZWR-95-39X		ZWR-95-45X		ZWS-95-35X		ZWS-95-37X		ZWS-95-37X	
Field Sample Number:	RXZW3607		RXZW3704		RXZW3803		RXZW3904		RXZW4504		SXZW3500		SXZW3700		SXZW3700	
Sample Date:	09/13/95		09/13/95		09/14/95		09/13/95		09/15/95		09/18/95		09/18/95		09/28/95	
Depth:	0		0		3		0		4		0		0		0	
Units:	µg/g		µg/g		µg/g		µg/g		µg/g		µg/g		µg/g		µg/g	
Unk600			2	S												
Unk601	3	S	0.5	S											0.9	S
Unk602			0.6	S												
Unk603			2	S												
Unk604			3	S												
Unk605			0.5	S												
Unk607			1	S												
Unk608			0.7	S												
Unk609			0.9	S												
Unk610			1	S												
Unk611			1	S												
Unk612			2	S												
Unk613			0.9	S												
Unk614			1	S												
Unk615			1	S												
Unk616			20	S												
Unk617			2	S												
Unk618			1	S												
Unk619	1	S	3	S			0.7	S	0.6	S						
Unk620			3	S												
Unk621			1	S												
Unk622			2	S												
Unk623			3	S												
Unk624			0.7	S												
Unk625			2	S												
Unk626			1	S												
Unk627																
Unk628			0.6	S												
Unk629			1	S												
Unk630			1	S											3	S
Unk631			0.3	S												
Unk632			0.7	S												
Unk633			1	S												
Unk635															4	S
Unk636															3	S
Unk637															1	S
Unk638															0.9	S
Unk641															2	S
Unk642																
Unk643																
Unk644															1	S
Unk645																
Unk650															1	S
Unk651																
Unk654															0.7	S

TABLE 7-1
UNKNOWN COMPOUNDS DETECTED IN SUBSURFACE SOIL
AOC 69W

REMEDIAL INVESTIGATION REPORT
DEVENS, MASSACHUSETTS

Site ID: Field Sample Number: Sample Date: Depth: Units:	ZWR-95-36X RXZW3607 09/13/95 0 µg/g	RXZW3704 09/13/95 0 µg/g	ZWR-95-38X RXZW3803 09/14/95 3 µg/g	ZWR-95-39X RXZW3904 09/13/95 0 µg/g	ZWR-95-45X RXZW4504 09/15/95 4 µg/g	ZWS-95-35X SXZW3500 09/18/95 0 µg/g	ZWS-95-37X SXZW3700 09/18/95 0 µg/g	ZWS-95-37X SXZW3700 09/18/95 0 µg/g
VOLATILE ORGANICS								
1,1,3-trimethylcyclohexane		0.12 S						
1,2,3-trimethylbenzene						0.032 S		
1,2,4-trimethylbenzene						0.043 S		
1,3,5-trimethylcyclohexane		0.23 S						
1,4,6-trimethyl-naphthalene					0.0087 S		0.0052 S	
1,4-dihydro-1,4-methanonaphthalene								
1,7-dimethylnaphthalene	0.054 S		0.0079 S					
1-ethylidene-1h-indene							0.01 S	
1-methyl-3-(1-methylethyl)benzene / M-cymene								
1-methylethylcyclohexane						0.022 S		
1-methylnaphthalene			0.068 S				0.01 S	
2,3,5-trimethyldecane								
2,3-dimethylnaphthalene			0.0056 S					
2,3-dimethyloctane				0.022 S				
2,6-dimethylundecane				0.066 S				
2,7-dimethylnaphthalene			0.0056 S					
2-ethyl-1-hexanol					0.0099 S			
2-methyldecane								
2-methylheptane / Isooctane								
2-methylnaphthalene			0.023 S					
26dmo		0.23 S						
3,7-dimethylnonane								
3-methyl-5-propylnonane	0.076 S							
3-methyldecane								
3-methyloctane								
3-methylundecane	0.11 S							
3-propyltoluene								
4-(1-methylethyl)toluene / P-cymene								
4-methyldecane	0.054 S			0.011 S				
6-methyldodecane	0.22 S							
Cumene / Isopropylbenzene						0.022 S		
Decahydro-2-methylnapthalene								
Decane		0.23 S				0.097 S		
Dodecane	0.11 S					0.054 S		
Hendecane / Undecane						0.086 S		
Heptacosane								
Nonane								
Omctsx							0.21 S	
Octane								
Pentadecane				0.088 S				
Trans-1-ethyl-4-methylcyclohexane		0.12 S						
Unk011						0.1 S		
Unk130								
Unk135				0.02 S				
Unk136							0.008 S	
Unk143		0.3 S						
Unk147								
Unk151								

TABLE 7-1
UNKNOWN COMPOUNDS DETECTED IN SUBSURFACE SOIL
AOC 69W

REMEDIAL INVESTIGATION REPORT
DEVENS, MASSACHUSETTS

Site ID:	ZWR-95-36X				ZWR-95-38X		ZWR-95-39X		ZWR-95-45X		ZWS-95-35X		ZWS-95-37X		ZWS-95-37X	
Field Sample Number:	RXZW3607		RXZW3704		RXZW3803		RXZW3904		RXZW4504		SXZW3500		SXZW3700		SXZW3700	
Sample Date:	09/13/95		09/13/95		09/14/95		09/13/95		09/15/95		09/18/95		09/18/95		09/28/95	
Depth:	0		0		3		0		4		0		0		0	
Units:	µg/g		µg/g		µg/g		µg/g		µg/g		µg/g		µg/g		µg/g	
Unk152			0.3	S												
Unk158																
Unk162							0.02	S								
Unk166					0.009	S										
Unk172											0.05	S				
Unk173							0.01	S								
Unk175																
Unk178			0.1	S			0.03	S								
Unk179											0.04	S				
Unk182	0.08	S														
Unk183			0.2	S												
Unk186																
Unk187													0.2	S		
Unk188	0.1	S									0.1	S				
Unk189			0.1	S												
Unk190			0.2	S												
Unk191							0.03	S								
Unk193			0.2	S												
Unk194	0.05	S														
Unk196													0.005	S		
Unk200	0.06	S														
Unk202							0.02	S								
Unk205																
Unk206																
Unk215	0.06	S			0.01	S										

TABLE 7-1
UNKNOWN COMPOUNDS DETECTED IN SUBSURFACE SOIL
AOC 69W

REMEDIAL INVESTIGATION REPORT
DEVENS, MASSACHUSETTS

Site ID:	ZWS-95-39X		ZWS-95-38X		ZWS-95-45X		ZWS-95-46X		ZWS-95-47X	
Field Sample Number:	SXZW3900		SXZW3800		SXZW4500		SXZW4600		SXZW4700	
Sample Date:	09/18/95		09/18/95		09/18/95		09/18/95		09/18/95	
Depth:	0		0		0		0		0	
Units:	µg/g		µg/g		µg/g		µg/g		µg/g	
SEMIVOLATILE ORGANICS										
1,2,3-trimethylbenzene										
1,3-dimethylnaphthalene										
1,4,6-trimethyl-naphthalene										
1,4-dimethylnaphthalene										
1,6,7-trimethylnaphthalene										
1,7-dimethylnaphthalene										
1,8-dimethylnaphthalene										
1-ethyl-2-methylbenzene										
1-methyl-3-(1-methylethyl)benzene / M-cymene										
1-methylnaphthalene										
2,3,6-trimethylnaphthalene										
2,3-dihydro-5-methylindene										
2,3-dimethylnaphthalene										
2,5-dimethylphenanthrene										
2,6,10,14-tetramethylpentadecane										
2,6,10,15-tetramethylheptadecane										
2,7-dimethylnaphthalene										
2,8-dimethyldibenzo[b,d]thiophene										
3-propyltoluene										
4mpanr										
Docosane										
Dodecane										
Eicosane										
Gamma-sitosterol			3	S	.76	S				
Heneicosane										
Heptacosane									.52	S
Heptadecane										
Hexadecane										
Hexadecanoic Acid / Palmitic Acid										
Isopropyltoluene										
Nonacosane			6	S	.76	S				
Nonadecane										
Octadecane										
Pentadecane										
Sulfur, Molecular					5	S				
Tetradecane										
Tricosane										
Tridecane										
Unk514										
Unk515										
Unk524										
Unk537										
Unk544										
Unk545										
Unk546										
Unk548										
Unk549										
Unk550										

TABLE 7-1
UNKNOWN COMPOUNDS DETECTED IN SUBSURFACE SOIL
AOC 69W

REMEDIAL INVESTIGATION REPORT
DEVENS, MASSACHUSETTS

Site ID:	ZWS-95-39X	ZWS-95-38X	ZWS-95-45X	ZWS-95-46X	ZWS-95-47X
Field Sample Number:	SXZW3900	SXZW3800	SXZW4500	SXZW4600	SXZW4700
Sample Date:	09/18/95	09/18/95	09/18/95	09/18/95	09/18/95
Depth:	0	0	0	0	0
Units:	µg/g	µg/g	µg/g	µg/g	µg/g
Unk551					
Unk552					
Unk553					
Unk554					
Unk555					
Unk556					
Unk557					
Unk558					
Unk559					
Unk560					
Unk561					
Unk562					
Unk563					
Unk564					
Unk565					
Unk566					
Unk567					
Unk568					
Unk569					
Unk570					
Unk571					
Unk572					
Unk573					
Unk574					
Unk575					
Unk576					
Unk577					
Unk578					
Unk579					
Unk580					
Unk581					
Unk582					
Unk583					
Unk584					
Unk585					
Unk586					
Unk587					
Unk588					
Unk589					
Unk590					
Unk591					
Unk592					
Unk593					
Unk594					
Unk595					
Unk596					
Unk597					
Unk598					
Unk599					

TABLE 7-1
UNKNOWN COMPOUNDS DETECTED IN SUBSURFACE SOIL
AOC 69W

REMEDIAL INVESTIGATION REPORT
DEVENS, MASSACHUSETTS

Site ID:	ZWS-95-39X		ZWS-95-38X		ZWS-95-45X		ZWS-95-46X		ZWS-95-47X	
Field Sample Number:	SXZW3900		SXZW3800		SXZW4500		SXZW4600		SXZW4700	
Sample Date:	09/18/95		09/18/95		09/18/95		09/18/95		09/18/95	
Depth:	0		0		0		0		0	
Units:	µg/g		µg/g		µg/g		µg/g		µg/g	
Unk600										
Unk601										
Unk602										
Unk603										
Unk604										
Unk605										
Unk607										
Unk608										
Unk609										
Unk610										
Unk611										
Unk612										
Unk613										
Unk614										
Unk615										
Unk616										
Unk617										
Unk618										
Unk619										
Unk620										
Unk621										
Unk622										
Unk623										
Unk624										
Unk625										
Unk626										
Unk627			4	S						
Unk628										
Unk629										
Unk630									3	S
Unk631										
Unk632			3	S					3	S
Unk633										
Unk635			5	S					0.9	S
Unk636										
Unk637			6	S	0.8	S			1	S
Unk638										
Unk641										
Unk642									1	S
Unk643					1	S				
Unk644										
Unk645			3	S						
Unk650									1	S
Unk651			3	S						
Unk654										

TABLE 7-1
UNKNOWN COMPOUNDS DETECTED IN SUBSURFACE SOIL
AOC 69W

REMEDIAL INVESTIGATION REPORT
DEVENS, MASSACHUSETTS

Site ID: Field Sample Number: Sample Date: Depth: Units:	ZWS-95-39X SXZW3900 09/18/95 0 µg/g	ZWS-95-38X SXZW3800 09/18/95 0 µg/g	ZWS-95-45X SXZW4500 09/18/95 0 µg/g	ZWS-95-46X SXZW4600 09/18/95 0 µg/g	ZWS-95-47X SXZW4700 09/18/95 0 µg/g
VOLATILE ORGANICS					
1,1,3-trimethylcyclohexane					
1,2,3-trimethylbenzene					
1,2,4-trimethylbenzene					
1,3,5-trimethylcyclohexane					
1,4,6-trimethyl-naphthalene					
1,4-dihydro-1,4-methanonaphthalene		0.0071 S			
1,7-dimethylnaphthalene					
1-ethylidene-1h-indene					
1-methyl-3-(1-methylethyl)benzene / M-cymene					
1-methylethylcyclohexane					
1-methylnaphthalene					
2,3,5-trimethyldecane					
2,3-dimethylnaphthalene					
2,3-dimethyloctane					
2,6-dimethylundecane					
2,7-dimethylnaphthalene					
2-ethyl-1-hexanol					
2-methyldecane					
2-methylheptane / Isooctane					
2-methylnaphthalene					
26dmo					
3,7-dimethylnonane					
3-methyl-5-propylnonane					
3-methyldecane					
3-methyloctane					
3-methylundecane					
3-propyltoluene					
4-(1-methylethyl)toluene / P-cymene					
4-methyldecane					
6-methyldodecane					
Cumene / Isopropylbenzene					
Decahydro-2-methylnapthalene					
Decane					
Dodecane					
Hendecane / Undecane					
Heptacosane					
Nonane					
Omctsx		0.24 S			
Octane					
Pentadecane					
Trans-1-ethyl-4-methylcyclohexane					
Unk011					
Unk130					
Unk135					
Unk136					
Unk143					
Unk147					
Unk151					

TABLE 7-1
UNKNOWN COMPOUNDS DETECTED IN SUBSURFACE SOIL
AOC 69W

REMEDIAL INVESTIGATION REPORT
DEVENS, MASSACHUSETTS

Site ID:	ZWS-95-39X		ZWS-95-38X		ZWS-95-45X		ZWS-95-46X		ZWS-95-47X	
Field Sample Number:	SXZW3900		SXZW3800		SXZW4500		SXZW4600		SXZW4700	
Sample Date:	09/18/95		09/18/95		09/18/95		09/18/95		09/18/95	
Depth:	0		0		0		0		0	
Units:	µg/g		µg/g		µg/g		µg/g		µg/g	
Unk152										
Unk158										
Unk162										
Unk166										
Unk172										
Unk173										
Unk175			0.006	S						
Unk178										
Unk179			0.007	S						
Unk182										
Unk183										
Unk186										
Unk187			0.06	S						
Unk188	0.02				0.008	S	0.006	S	0.03	S
Unk189										
Unk190										
Unk191										
Unk193										
Unk194										
Unk196										
Unk200										
Unk202										
Unk205										
Unk206			0.007	S						
Unk215										

TABLE 7-1
UNKNOWN COMPOUNDS DETECTED IN GROUNDWATER
AOC 69W

REMEDIAL INVESTIGATION REPORT
DEVENS, MASSACHUSETTS

Site ID:	69W--94-10	69W--94-10	69W--94-11	69W--94-11	69W--94-12	69W--94-12
Field Sample Number:	MXZW10X3	MXZW10X4	MDZW11X4	MXZW11X4	MXZW12X3	MXZW12X4
Sample Date:	11/02/95	02/14/96	02/14/96	02/14/96	11/02/95	02/13/96
Depth:	9.5	9.5	9.5	9.5	8	8
Units:	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L
SEMIVOLATILE ORGANICS						
1,2,3,4-tetrahydronaphthalene / Tetranap / Tetralin						
1,2,3,4-tetramethylbenzene		400 S				
1,2,3,5-tetramethylbenzene / Isodurene						
1,2-dimethylnaphthalene						
1,3,5-trimethylbenzene						
1,3-dimethyl-5-(1-methylethyl) Benzene						
1,3-dimethylnaphthalene		2000 S				
1,4,6-trimethyl-naphthalene		700 S				
1,4-dimethylnaphthalene	800 S					
1,5-dimethylnaphthalene	500 S					
1,6,7-trimethylnaphthalene		800 S				
1,6-dimethylindan						
1,6-dimethylnaphthalene	600 S	2000 S				
1,7-dimethylnaphthalene		2000 S				
1,8-dimethylnaphthalene						
1-methyl-3-(1-methylethyl)benzene / M-cymene						
1-methylnaphthalene	300 S	2000 S				
2,3,6-trimethylnaphthalene		500 S				
2,3-dimethylnaphthalene						
2,6,10,14-tetramethylpentadecane		5000 S				
2,6-dimethylnonane	600 S					
2,7-dimethylnaphthalene						
2-methyldecane	500 S					
3-methyldecane	500 S					
4,7-dimethylindan / 2,3-dihydro-4,7-dimethyl-1h-indene						
4-(1-methylethyl)toluene / P-cymene						
Heptadecane						
Hexadecane						
Indan / 2,3-dihydro-1h-indene						
Nonadecane		700 S				
Octadecanoic Acid						
Pentadecane						
Tetradecane						
Toluene			4 SD			
Tridecane						

TABLE 7-1
UNKNOWN COMPOUNDS DETECTED IN GROUNDWATER
AOC 69W

REMEDIAL INVESTIGATION REPORT
DEVENS, MASSACHUSETTS

Site ID:	69W-94-10	69W-94-10	69W-94-11	69W-94-11	69W-94-12	69W-94-12
Field Sample Number:	MXZW10X3	MXZW10X4	MDZW11X4	MXZW11X4	MXZW12X3	MXZW12X4
Sample Date:	11/02/95	02/14/96	02/14/96	02/14/96	11/02/95	02/13/96
Depth:	9.5	9.5	9.5	9.5	8	8
Units:	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L
Unk525						
Unk543		700 S				
Unk544		300 S				
Unk546		800 S				
Unk547		400 S				
Unk548		500 S				
Unk549		600 S				
Unk550		400 S				
Unk551		500 S				
Unk552		400 S				
Unk553						
Unk554	200 S	600 S				
Unk555		600 S				
Unk556		600 S				
Unk557		400 S				
Unk558	200 S	700 S				
Unk559	200 S	600 S				
Unk560	200 S	600 S				
Unk561		700 S				
Unk562		600 S				
Unk563	500 S	2000 S				
Unk564		400 S				
Unk565		400 S				
Unk566		600 S				
Unk567	700 S	600 S				
Unk568		800 S				
Unk569		600 S				
Unk570		300 S				
Unk571		2000 S				
Unk572	800 S	400 S				
Unk573		600 S				
Unk574		500 S				
Unk575	800 S	2000 S				
Unk576		2000 S				
Unk577		600 S				
Unk578		600 S				
Unk579		600 S				
Unk580	500 S	2000 S				
Unk581	2000 S					
Unk582						
Unk583	9000 S	500 S				
Unk584		3000 S				
Unk585		300000 S				

TABLE 7-1
UNKNOWN COMPOUNDS DETECTED IN GROUNDWATER
AOC 69W

REMEDIAL INVESTIGATION REPORT
DEVENS, MASSACHUSETTS

Site ID:	69W--94-10		69W--94-10		69W--94-11		69W--94-11		69W--94-12		69W--94-12	
Field Sample Number:	MXZW10X3		MXZW10X4		MDZW11X4		MXZW11X4		MXZW12X3		MXZW12X4	
Sample Date:	11/02/95		02/14/96		02/14/96		02/14/96		11/02/95		02/13/96	
Depth:	9.5		9.5		9.5		9.5		8		8	
Units:	µg/L		µg/L		µg/L		µg/L		µg/L		µg/L	
Unk586			800	S								
Unk587			2000	S								
Unk588			400	S								
Unk589			800	S								
Unk590			500	S								
Unk591			2000	S								
Unk592	2000	S	600	S								
Unk593			400	S								
Unk594			400	S								
Unk595	3000	S	2000	S								
Unk596			600	S								
Unk597			600	S								
Unk598			600	S								
Unk599			500	S								
Unk600	2000	S										
Unk601			2000	S								
Unk602			400	S								
Unk603			400	S								
Unk610			300	S								
Unk614												
Unk645					5	SD						
Unk649					50	SD	20	S			9	S
VOLATILE ORGANICS												
1,2,3,4-tetrahydronaphthalene / Tetranap / Tetralin	40	S							20	S		
1,2,3,4-tetramethylbenzene												
1,2,3,5-tetramethylbenzene / Isodurene	20	S										
1,2,3-trimethylbenzene									20	S		
1,2,4-trimethylbenzene												
1,3,5-trimethylbenzene	20	S										
1,3-diethylbenzene												
1-methyl-3-(1-methylethyl)benzene / M-cymene												
4-(1-methylethyl)toluene / P-cymene	30	S										
C2aee							6	S			30	S
Cumene / Isopropylbenzene	60	S										
Indan / 2,3-dihydro-1h-indene	50	S	10	S					20	S		
Sec-butylbenzene / (1-methylpropyl)benzene												
Unk162									7	S		
Unk173									7	S		
Unk185	10	S							10	S		
Unk187									20	S		
Unk188	30	S							20	S		
Unk193	20	S							30	S		
Unk197	30	S							10	S		

TABLE 7-1
UNKNOWN COMPOUNDS DETECTED IN GROUNDWATER
AOC 69W

REMEDIAL INVESTIGATION REPORT
DEVENS, MASSACHUSETTS

Site ID:	69W-94-10	69W-94-10	69W-94-11	69W-94-11	69W-94-12	69W-94-12
Field Sample Number:	MXZW10X3	MXZW10X4	MDZW11X4	MXZW11X4	MXZW12X3	MXZW12X4
Sample Date:	11/02/95	02/14/96	02/14/96	02/14/96	11/02/95	02/13/96
Depth:	9.5	9.5	9.5	9.5	8	8
Units:	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L
Unk198					10 S	
Unk199	90 S					
Unk200					50 S	
Unk202						
Unk206						
Unk211		20 S				
Unk212						
Unk213						
Unk214						
Unk216						
Unk217						
Unk218						
Unk220						
Unk222						
Unk224						
Unk225						
Unk226						
Unk227		10 S				
Unk229		5 S				
Unk236						
Unk237		5 S				

TABLE 7-1
UNKNOWN COMPOUNDS DETECTED IN GROUNDWATER
AOC 69W

REMEDIAL INVESTIGATION REPORT
DEVENS, MASSACHUSETTS

Site ID:	69W--94-13		69W--94-13		69W--94-14		69W--94-14		ZWM-95-15X		ZWM-95-15X	
Field Sample Number:	MXZW13X3		MXZW13X4		MXZW14X3		MXZW14X4		MXZW15X1		MXZW15X2	
Sample Date:	11/02/95		02/13/96		11/03/95		02/13/96		11/01/95		02/13/96	
Depth:	8		8		8		8		8		8	
Units:	µg/L		µg/L		µg/L		µg/L		µg/L		µg/L	
SEMIVOLATILE ORGANICS												
1,2,3,4-tetrahydronaphthalene / Tetranap / Tetralin	10	S	10	S								
1,2,3,4-tetramethylbenzene	6	S										
1,2,3,5-tetramethylbenzene / Isodurene	6	S	6	S								
1,2-dimethylnaphthalene	6	S										
1,3,5-trimethylbenzene			6	S								
1,3-dimethyl-5-(1-methylethyl) Benzene			7	S								
1,3-dimethylnaphthalene	20	S	6	S								
1,4,6-trimethyl-naphthalene												
1,4-dimethylnaphthalene	10	S										
1,5-dimethylnaphthalene	10	S										
1,6,7-trimethylnaphthalene												
1,6-dimethylindan			4	S								
1,6-dimethylnaphthalene			20	S								
1,7-dimethylnaphthalene												
1,8-dimethylnaphthalene			8	S								
1-methyl-3-(1-methylethyl)benzene / M-cymene			7	S								
1-methylnaphthalene	40	S	40	S								
2,3,6-trimethylnaphthalene												
2,3-dimethylnaphthalene	6	S	7	S								
2,6,10,14-tetramethylpentadecane					10	S						
2,6-dimethylnonane												
2,7-dimethylnaphthalene			6	S								
2-methyldecane												
3-methyldecane												
4,7-dimethylindan / 2,3-dihydro-4,7-dimethyl-1h-indene			7	S								
4-(1-methylethyl)toluene / P-cymene												
Heptadecane												
Hexadecane												
Indan / 2,3-dihydro-1h-indene	20	S	10	S								
Nonadecane												
Octadecanoic Acid									5	S		
Pentadecane												
Tetradecane												
Toluene												
Tridecane												

TABLE 7-1
UNKNOWN COMPOUNDS DETECTED IN GROUNDWATER
AOC 69W

REMEDIAL INVESTIGATION REPORT
DEVENS, MASSACHUSETTS

Site ID:	69W--94-13		69W--94-13		69W--94-14		69W--94-14		ZWM-95-15X		ZWM-95-15X	
Field Sample Number:	MXZW13X3		MXZW13X4		MXZW14X3		MXZW14X4		MXZW15X1		MXZW15X2	
Sample Date:	11/02/95		02/13/96		11/03/95		02/13/96		11/01/95		02/13/96	
Depth:	8		8		8		8		8		8	
Units:	µg/L		µg/L		µg/L		µg/L		µg/L		µg/L	
Unk525												
Unk543												
Unk544												
Unk546			6	S								
Unk547			5	S								
Unk548												
Unk549			6	S								
Unk550												
Unk551												
Unk552												
Unk553	5	S	9	S								
Unk554												
Unk555			9	S								
Unk556			5	S								
Unk557	20	S	20	S								
Unk558												
Unk559			10	S								
Unk560			7	S								
Unk561	9	S	9	S								
Unk562			6	S								
Unk563	6	S	6	S								
Unk564			7	S								
Unk565												
Unk566												
Unk567	10	S										
Unk568	8	S										
Unk569												
Unk570							6	S				
Unk571	6	S	6	S								
Unk572												
Unk573												
Unk574												
Unk575												
Unk576	9	S										
Unk577												
Unk578			5	S								
Unk579												
Unk580					6	S						
Unk581												
Unk582			9	S								
Unk583			5	S								
Unk584												
Unk585												

TABLE 7-1
UNKNOWN COMPOUNDS DETECTED IN GROUNDWATER
AOC 69W

REMEDIAL INVESTIGATION REPORT
DEVENS, MASSACHUSETTS

Site ID: Field Sample Number: Sample Date: Depth: Units:	69W-94-13 MXZW13X3 11/02/95 8 µg/L	69W-94-13 MXZW13X4 02/13/96 8 µg/L	69W-94-14 MXZW14X3 11/03/95 8 µg/L	69W-94-14 MXZW14X4 02/13/96 8 µg/L	ZWM-95-15X MXZW15X1 11/01/95 8 µg/L	ZWM-95-15X MXZW15X2 02/13/96 8 µg/L
Unk586						
Unk587						
Unk588						
Unk589						
Unk590		8 S				
Unk591						
Unk592	2000 S		600 S			
Unk593				5 S	4 S	
Unk594						
Unk595		8 S				
Unk596						
Unk597						
Unk598						
Unk599	9 S					
Unk600						
Unk601			5 S		1000 S	
Unk602						
Unk603						
Unk610						
Unk614						
Unk645						
Unk649		9 S		20 S		10 S
VOLATILE ORGANICS						
1,2,3,4-tetrahydronaphthalene / Tetranap / Tetralin						
1,2,3,4-tetramethylbenzene						
1,2,3,5-tetramethylbenzene / Isodurene						
1,2,3-trimethylbenzene						
1,2,4-trimethylbenzene						
1,3,5-trimethylbenzene						
1,3-diethylbenzene						
1-methyl-3-(1-methylethyl)benzene / M-cymene						
4-(1-methylethyl)toluene / P-cymene						
C2aee		10 S		20 S		50 S
Cumene / Isopropylbenzene						
Indan / 2,3-dihydro-1h-indene		20 S				
Sec-butylbenzene / (1-methylpropyl)benzene						
Unk162						
Unk173						
Unk185						
Unk187						
Unk188						
Unk193						
Unk197						

TABLE 7-1
UNKNOWN COMPOUNDS DETECTED IN GROUNDWATER
AOC 69W

REMEDIAL INVESTIGATION REPORT
DEVENS, MASSACHUSETTS

Site ID:	69W--94-13		69W--94-13		69W--94-14		69W--94-14		ZWM-95-15X		ZWM-95-15X	
Field Sample Number:	MXZW13X3		MXZW13X4		MXZW14X3		MXZW14X4		MXZW15X1		MXZW15X2	
Sample Date:	11/02/95		02/13/96		11/03/95		02/13/96		11/01/95		02/13/96	
Depth:	8		8		8		8		8		8	
Units:	µg/L		µg/L		µg/L		µg/L		µg/L		µg/L	
Unk198												
Unk199												
Unk200												
Unk202			8	S								
Unk206			7	S								
Unk211												
Unk212												
Unk213												
Unk214												
Unk216			8	S								
Unk217											6	S
Unk218												
Unk220												
Unk222												
Unk224												
Unk225												
Unk226												
Unk227			20	S								
Unk229			20	S								
Unk236			10	S								
Unk237			8	S								

TABLE 7-1
UNKNOWN COMPOUNDS DETECTED IN GROUNDWATER
AOC 69W

REMEDIAL INVESTIGATION REPORT
DEVENS, MASSACHUSETTS

Site ID:	ZWM-95-16X	ZWM-95-16X	ZWM-95-17X	ZWM-95-18X	ZWM-95-18X
Field Sample Number:	MXZW16X1	MXZW16X2	MXZW17X2	MXZW18X1	MXZW18X2
Sample Date:	11/01/95	02/13/96	02/12/96	11/02/95	02/12/96
Depth:	11.3	11.3	17.2	8	8
Units:	µg/L	µg/L	µg/L	µg/L	µg/L
SEMIVOLATILE ORGANICS					
1,2,3,4-tetrahydronaphthalene / Tetranap / Tetralin					
1,2,3,4-tetramethylbenzene					
1,2,3,5-tetramethylbenzene / Isodurene	5 S				
1,2-dimethylnaphthalene					
1,3,5-trimethylbenzene					
1,3-dimethyl-5-(1-methylethyl) Benzene					
1,3-dimethylnaphthalene					
1,4,6-trimethyl-naphthalene					
1,4-dimethylnaphthalene					
1,5-dimethylnaphthalene					
1,6,7-trimethylnaphthalene					
1,6-dimethylindan					
1,6-dimethylnaphthalene					
1,7-dimethylnaphthalene					
1,8-dimethylnaphthalene					
1-methyl-3-(1-methylethyl)benzene / M-cymene					
1-methylnaphthalene					
2,3,6-trimethylnaphthalene					
2,3-dimethylnaphthalene					
2,6,10,14-tetramethylpentadecane					
2,6-dimethylnonane					
2,7-dimethylnaphthalene					
2-methyldecane					
3-methyldecane					
4,7-dimethylindan / 2,3-dihydro-4,7-dimethyl-1h-indene	4 S				
4-(1-methylethyl)toluene / P-cymene	6 S				
Heptadecane	8 S				
Hexadecane	8 S				
Indan / 2,3-dihydro-1h-indene					
Nonadecane					
Octadecanoic Acid					
Pentadecane	8 S				
Tetradecane	10 S				
Toluene					
Tridecane	6 S				

TABLE 7-1
UNKNOWN COMPOUNDS DETECTED IN GROUNDWATER
AOC 69W

REMEDIAL INVESTIGATION REPORT
DEVENS, MASSACHUSETTS

Site ID:	ZWM-95-16X	ZWM-95-16X	ZWM-95-17X	ZWM-95-18X	ZWM-95-18X
Field Sample Number:	MXZW16X1	MXZW16X2	MXZW17X2	MXZW18X1	MXZW18X2
Sample Date:	11/01/95	02/13/96	02/12/96	11/02/95	02/12/96
Depth:	11.3	11.3	17.2	8	8
Units:	µg/L	µg/L	µg/L	µg/L	µg/L
Unk525	3 S				
Unk543					
Unk544					
Unk546					
Unk547					
Unk548					
Unk549					
Unk550					
Unk551					
Unk552					
Unk553					
Unk554					
Unk555					
Unk556					
Unk557	5 S				
Unk558					
Unk559					
Unk560					
Unk561	4 S				
Unk562					
Unk563					
Unk564					
Unk565					
Unk566					
Unk567					
Unk568	4 S				
Unk569	5 S				
Unk570					
Unk571					
Unk572					
Unk573					
Unk574	4 S				
Unk575					
Unk576	4 S				
Unk577					
Unk578					
Unk579					
Unk580					
Unk581					
Unk582					
Unk583					
Unk584					
Unk585					

TABLE 7-1
UNKNOWN COMPOUNDS DETECTED IN GROUNDWATER
AOC 69W

REMEDIAL INVESTIGATION REPORT
DEVENS, MASSACHUSETTS

Site ID:	ZWM-95-16X	ZWM-95-16X	ZWM-95-17X	ZWM-95-18X	ZWM-95-18X
Field Sample Number:	MXZW16X1	MXZW16X2	MXZW17X2	MXZW18X1	MXZW18X2
Sample Date:	11/01/95	02/13/96	02/12/96	11/02/95	02/12/96
Depth:	11.3	11.3	17.2	8	8
Units:	µg/L	µg/L	µg/L	µg/L	µg/L
Unk586					
Unk587					
Unk588					
Unk589					
Unk590	5 S				
Unk591					
Unk592					
Unk593					
Unk594					
Unk595					
Unk596					
Unk597					
Unk598					
Unk599					
Unk600					
Unk601	4 S				
Unk602					
Unk603					
Unk610					
Unk614				200 S	
Unk645		4 S			
Unk649		40 S	10 S		7 S
VOLATILE ORGANICS					
1,2,3,4-tetrahydronaphthalene / Tetranap / Tetralin					
1,2,3,4-tetramethylbenzene	20 S				
1,2,3,5-tetramethylbenzene / Isodurene	10 S				
1,2,3-trimethylbenzene					
1,2,4-trimethylbenzene	6 S				
1,3,5-trimethylbenzene	7 S				
1,3-diethylbenzene	6 S				
1-methyl-3-(1-methylethyl)benzene / M-cymene	20 S				
4-(1-methylethyl)toluene / P-cymene	10 S				
C2aee	10 S	40 S	7 S		20 S
Cumene / Isopropylbenzene					
Indan / 2,3-dihydro-1h-indene					
Sec-butylbenzene / (1-methylpropyl)benzene	7 S				
Unk162					
Unk173					
Unk185					
Unk187					
Unk188					
Unk193					
Unk197					

TABLE 7-1
UNKNOWN COMPOUNDS DETECTED IN GROUNDWATER
AOC 69W

REMEDIAL INVESTIGATION REPORT
DEVENS, MASSACHUSETTS

Site ID:	ZWM-95-16X	ZWM-95-16X	ZWM-95-17X	ZWM-95-18X	ZWM-95-18X
Field Sample Number:	MXZW16X1	MXZW16X2	MXZW17X2	MXZW18X1	MXZW18X2
Sample Date:	11/01/95	02/13/96	02/12/96	11/02/95	02/12/96
Depth:	11.3	11.3	17.2	8	8
Units:	µg/L	µg/L	µg/L	µg/L	µg/L
Unk198					
Unk199					
Unk200					
Unk202					
Unk206					
Unk211					
Unk212	9 S				
Unk213	20 S				
Unk214	20 S				
Unk216					
Unk217					
Unk218	10 S				
Unk220	10 S				
Unk222	30 S				
Unk224	10 S				
Unk225	7 S				
Unk226	8 S				
Unk227					
Unk229	10 S				
Unk236					
Unk237					

TABLE 7-1
UNKNOWN COMPOUNDS DETECTED IN SEDIMENT
AOC 69W

REMEDIAL INVESTIGATION REPORT
DEVENS, MASSACHUSETTS

Site ID:	ZWD-95-04X		ZWD-95-05X	
Field Sample Number:	DXZW0400		DXZW0500	
Sample Date:	09/12/95		09/12/95	
Depth:	0		0	
Units:	µg/g		µg/g	
SEMIVOLATILE ORGANICS				
Alpha-pinene			8	S
Beta-pinene			20	S
Gamma-sitosterol	5	S		
Unk541			8	S
Unk618			50	S
Unk619			20	S
Unk620			8	S
Unk621			30	S
Unk622			30	S
Unk652	3	S		
VOLATILE ORGANICS				
Unk187			.03	S

TABLE 7-2
ANALYTES DETECTED IN METHOD BLANKS
AOC 69W

REMEDIAL INVESTIGATION REPORT
DEVENS, MASSACHUSETTS

PARAMETER	COMPOUND/ELEMENT
SVOCs in Water Blanks	Diethylphthalate[1] bis(2-ethylhexyl)phthalate[2] Dioctyladipate (TIC)[1]
SVOCs in Soil Blanks	di-n-butylphthalate[1] nonacosane (TIC)[1] Dioctyladipate (TIC)[3] Heptacosane (TIC)[3]
VOCs in Water Blanks	Acetone[1] Methylene Chloride[1] Chloroform[1] Ethanol (TIC)[2]
VOCs in Soil Blanks	Toluene[1] Acetone[3] Methylene Chloride[3] Trifluoromethane[3]
Pesticides in Water Blanks	Malathion[3]
Pesticides in Soil Blanks	alpha-chlordane[3] gamma-chlordane[3]
Water Quality Parameters	TSS[1,2] TDS[1,2] Alkalinity[1,2]
TPHC in Soil Blanks	TPHC (USEPA Method 9071)[1]

1 = Detected in samples from the 1995 Field Investigations
2 = Detected in samples from the 1995 Round 2 Groundwater Sampling Event
3 = Detected in samples from the 1996 Round 3 Field Investigations
TIC = Tentatively Identified Compound

TABLE 7-3
ANALYTES DETECTED IN RINSE BLANKS
AOC 69W

REMEDIAL INVESTIGATION REPORT
DEVENS, MASSACHUSETTS

PARAMETER	COMPOUND/ELEMENT
SVOCs	bis(2-ethylhexyl)phthalate[2]
VOC	1,1,1-Trichloroethane[1] Methylene Chloride[1] Acetone[1] Chloroform[1] Carbon Tetrachloride[1]
INORGANICS	Mercury[1] Lead[1] Iron[1] Potassium[1] Manganese[1]

1 = Detected in samples from the 1995 Field Investigations
2 = Detected in samples from the 1996 Field Investigations
Rinse blank data was not required for the Round 2 Groundwater Sampling Event

TABLE 7-4
ANALYTES DETECTED IN TRIP BLANKS
AOC 69W

REMEDIAL INVESTIGATION REPORT
DEVENS, MASSACHUSETTS

PARAMETER	COMPOUND/ELEMENT
VOCs in Water Blanks	Acetone[2] Methylene Chloride[1,2] Chloroform[1] Tetrachloroethane[1] Carbon Tetrachloride[1] Hexane (TIC)[1]

1 = Detected in samples from the 1995 Field Investigations
2 = Detected in samples from the 1995 Round 2 Groundwater Sampling Event
VOCs were not detected in trip blanks from the 1996 Field Investigations
TIC = Tentatively Identified Compound

TABLE 7–5
ADL AREE 69W FIELD ANALYTICAL RESULTS
AOC 69W

REMEDIAL INVESTIGATION REPORT
DEVENS, MASSACHUSETTS

SAMPLE POINT	FIELD SCREENING SAMPLE ID	MEDIA	DEPTH (feet below ground surface)	TPH (ppm)
GP–01	69W–94–01–2W	Groundwater	5–7	663
GP–02	69W–94–02–2W	Groundwater	4–6	354
GP–02(Dup)	69W–94–01–2WD	Groundwater	5–7	208
GP–03	69W–94–03–2W	Groundwater	5–7	110
GP–04	69W–94–04–2W	Groundwater	5–7	12
GP–05	69W–94–05–2W	Groundwater	5–7	126
GP–06	69W–94–06–2W	Groundwater	5–7	188
GP–07	69W–94–07–2W	Groundwater	4–6	3
GP–08	69W–94–08–2W	Groundwater	4–6	95
GP–08(Dup)	69W–94–08–2WD	Groundwater	4–6	75
GP–09	69W–94–09–2W	Groundwater	4–6	2
GP–10	69W–94–10–2W	Groundwater	4–6	25
GP–11	69W–94–11–2W	Groundwater	4–6	37
GP–11(Dup)	69W–94–11–2WD	Groundwater	4–7	2
GP–12	69W–94–12–2W	Groundwater	3–5	20
GP–13	69W–94–13–2W	Groundwater	3–5	460
GP–14	69W–94–14–2W	Groundwater	3–5	2
GP–15	69W–94–15–2W	Groundwater	3–5	438
GP–15(Dup)	69W–94–15–2WD	Groundwater	3–5	110
GP–16	69W–94–16–2W	Groundwater	2–5	7
GP–16(Dup)	69W–94–16–2WD	Groundwater	2–5	4
GP–17	69W–94–17–2W	Groundwater	5–7	1,015
GP–17(Filtered)	69W–94–17F	Groundwater	5–7	22
GP–18	69W–94–18–2W	Groundwater	5–7	19
GP–18(Filtered)	69W–94–18F	Groundwater	5–7	12
GP–19	69W–94–19–2W	Groundwater	5–7	15
GP–19(Filtered)	69W–94–19F	Groundwater	5–7	12
GP–20	69W–94–20–2W	Groundwater	5–7	650
GP–20(Filtered)	69W–94–20F	Groundwater	5–7	15
GP–21	69W–94–21–2W	Groundwater	5–7	119
GP–21(Filtered)	69W–94–21F	Groundwater	5–7	11
GP–22	69W–94–22–2W	Groundwater	5–7	1,087
GP–22(Filtered)	69W–94–22F	Groundwater	5–7	17
GP–23	69W–94–23–2W	Groundwater	5–7	45
GP–23(Filtered)	69W–94–23F	Groundwater	5–7	4
GP–24	69W–94–24–2W	Groundwater	5–7	10
GP–24(Filtered)	69W–94–24F	Groundwater	5–7	4
GP–25	69W–94–25–2W	Groundwater	5–7	15
GP–25(Filtered)	69W–94–25F	Groundwater	5–7	5
GP–1	69W–94–01–1	Soil	0–2	123
GP–1(Dup)	69W–94–01–1D	Soil	0–2	120
GP–1	69W–94–01–2	Soil	3–5	226
GP–2	69W–94–02–1	Soil	0–2	1,050
GP–2	69W–94–02–2	Soil	3–5	15,500
GP–3	69W–94–03–1	Soil	0–2	1,150
GP–3	69W–94–03–2	Soil	3–5	387

TABLE 7–5
ADL AREE 69W FIELD ANALYTICAL RESULTS
AOC 69W

REMEDIAL INVESTIGATION REPORT
DEVENS, MASSACHUSETTS

SAMPLE POINT	FIELD SCREENING SAMPLE ID	MEDIA	DEPTH (feet below ground surface)	TPH (ppm)
GP–4	69W–94–04–1	Soil	0–2	1,230
GP–4	69W–94–04–2	Soil	3–5	1,010
GP–5	69W–94–05–1	Soil	0–2	201
GP–5	69W–94–05–2	Soil	3–5	102
GP–6	69W–94–06–1	Soil	0–2	806
GP–6	69W–94–06–2	Soil	3–5	53
GP–7	69W–94–07–1	Soil	0–2	38
GP–7(Dup)	69W–94–07–1D	Soil	0–2	38
GP–7	69W–94–07–2	Soil	3–5	11
GP–8	69W–94–08–1	Soil	0–2	291
GP–8(Dup)	69W–94–08–1D	Soil	0–2	272
GP–8	69W–94–08–2	Soil	3–5	48
GP–9	69W–94–09–1	Soil	0–2	219
GP–9	69W–94–09–2	Soil	3–5	11
GP–10	69W–94–10–1	Soil	0–2	19
GP–10	69W–94–10–2	Soil	3–5	51
GP–11	69W–94–11–1	Soil	0–2	20
GP–11	69W–94–11–2	Soil	3–5	74
GP–12	69W–94–12–1	Soil	0–2	40
GP–12	69W–94–12–2	Soil	3–5	8
GP–13	69W–94–13–1	Soil	0–2	25
GP–13	69W–94–13–2	Soil	3–5	157
GP–14	69W–94–14–1	Soil	0–2	51
GP–14	69W–94–14–2	Soil	3–5	8
GP–15	69W–94–15–1	Soil	0–2	95
GP–15	69W–94–15–2	Soil	3–5	13
GP–16	69W–94–16–1	Soil	0–2	607
GP–16	69W–94–16–2	Soil	3–5	18
GP–17	69W–94–17–1	Soil	3–5	51
GP–17(Dup)	69W–94–17–2D	Soil	3–5	53
GP–18	69W–94–18–2	Soil	3–5	22
GP–19	69W–94–19–2	Soil	3–5	12
GP–20	69W–94–20–2	Soil	3–5	420
GP–21	69W–94–21–2	Soil	3–5	1,497
GP–22	69W–94–22–2	Soil	3–5	14,484
GP–23	69W–94–23–2	Soil	3–5	12
GP–24	69W–94–24–2	Soil	3–5	1,520
GP–25	69W–94–25–2	Soil	3–5	21
69W–94–09	69W–94–09–1	Soil (Boring)	0–2	70
69W–94–09(Dup)	69W–94–09–1D	Soil (Boring)	0–2	71
69W–94–09	69W–94–09–2	Soil (Boring)	2–4	14
69W–94–09	69W–94–09–3	Soil (Boring)	4–6	11
69W–94–09	69W–94–09–4	Soil (Boring)	11–13	12
69W–94–10	69W–94–10–1	Soil (Boring)	0–2	664
69W–94–10	69W–94–10–2	Soil (Boring)	2–4	631
69W–94–10	69W–94–10–3	Soil (Boring)	4–6	7,675

TABLE 7–5
ADL AREE 69W FIELD ANALYTICAL RESULTS
AOC 69W

REMEDIAL INVESTIGATION REPORT
DEVENS, MASSACHUSETTS

SAMPLE POINT	FIELD SCREENING SAMPLE ID	MEDIA	DEPTH (feet below ground surface)	TPH (ppm)
69W–94–10	69W–94–10–4	Soil (Boring)	11–13	164
69W–94–11	69W–94–11–1	Soil (Boring)	0–2	1,735
69W–94–11	69W–94–11–2	Soil (Boring)	2–4	386
69W–94–11	69W–94–11–3	Soil (Boring)	4–6	125
69W–94–11	69W–94–11–4	Soil (Boring)	11–13	55
69W–94–12	69W–94–12–1	Soil (Boring)	0–2	11
69W–94–12	69W–94–12–2	Soil (Boring)	2–4	30
69W–94–12	69W–94–12–3	Soil (Boring)	4–6	667
69W–94–12	69W–94–12–4	Soil (Boring)	11–13	40
69W–94–13	69W–94–13–1	Soil (Boring)	0–2	1,140
69W–94–13	69W–94–13–2	Soil (Boring)	2–4	19
69W–94–13	69W–94–13–3	Soil (Boring)	4–6	2,900
69W–94–13	69W–94–13–4	Soil (Boring)	11–13	71
69W–94–14	69W–94–14–1	Soil (Boring)	0–2	25
69W–94–14	69W–94–14–2	Soil (Boring)	2–4	83
69W–94–14	69W–94–14–3	Soil (Boring)	4–6	1,990
69W–94–14	69W–94–14–4	Soil (Boring)	11–13	49
HA–1	69W–94–01	Soil	0–1	14
HA–1(Dup)	69W–94–01D	Soil	0–1	53
HA–2	69W–94–02	Soil	0–1	16
HA–3	69W–94–03	Soil	0–1	10
HA–4	69W–94–04	Soil	0–1	56
HA–5	69W–94–05	Soil	0–1	131
HA–6	69W–94–06	Soil	0–1	36

Notes:
TPH = Total petroleum hydrocarbons
ppm = Parts per million by weight
Dup = Duplicate sample

TABLE 7-6
ADL, AREE 69W SOIL OFF-SITE ANALYTICAL RESULTS
AOC 69W

REMEDIAL INVESTIGATION REPORT
DEVENS, MASSACHUSETTS

Site ID:	69W-94-01	69W-94-02	69W-94-02	69W-94-03	69W-94-04	69W-94-05	69W-94-09	69W-94-09	69W-94-10	69W-94-10
Field Sample Number:	BXC9W-1U	BXC9W-2U	BXC9W-2L	BXC9W-3U	BXC9W-4U	BXC9W-5U	BXD9W-1U	BXD9W-AL	BXD9W-BU	BXD9W-CL
Field ID:	HA-5	GP-2	GP-2	GP-3	GP-4	GP-13	69W-94-09	69W-94-09	69W-94-10	69W-94-10
Sample Date:	03/30/94	05/02/94	05/02/94	05/02/94	05/02/94	05/02/94	06/06/94	06/06/94	06/06/94	06/06/94
Depth:	5	4	4	9	5	8	2	4	2	4
Units:	µg/g	µg/g	µg/g	µg/g	µg/g	µg/g	µg/g	µg/g	µg/g	µg/g
PAL METALS										
Aluminum	9690	7310 D	10600	7590	7710	10400	7260	5870	8120	8440
Arsenic	12.4	11.5 D	13.7	12.6	11.6	13.8	9.08	11.4	10.2	25.9
Barium	17.4	19.6 D	21.1	19.8	19.7	15.1	20.9	13.2	21.5	13.1
Boron	10	< 6.64 D	< 6.64	< 6.64	< 6.64	< 6.64	< 6.64	< 6.64	13.6	11.8
Calcium	880	1060 D	1060	1510	974	638	894	792	894	1570
Chromium	25.2	15.2 D	22.7	14.5	15.6	16.1	16.1	10.6	13.7	24.6
Cobalt	5.49	5.24 D	5.98	4.73	4.23	< 2.5	5.47 I	3.04 I	3.8 I	4.16 I
Copper	13.2	9.1 D	9.07	7.8	7.81	8.94	10.8	7.78	7.86	6.28
Iron	15300	13200 D	23300	14100	12700	15700	11300	8400	11300	14200
Lead	56	12 D	13.4	9.41	8.78	12.1	2.95	2.86	7.5	6.08
Magnesium	3940	2400 D	4040	2860	2420	2850	2940	1530	1910	3150
Manganese	194	169 D	248	186	173	143	160	109	197	181
Nickel	15.1	15.3 D I	20.2 I	15.8 I	12.6 I	15.6 I	11.9	8.41	10.4	14.5
Potassium	948	903 D	868	950	803	838	1600	581	719	745
Sodium	98.2	154 D	170	183	214	106	285	255	139	252
Thallium	< 34.3	< 34.3 D	< 34.3	< 34.3	< 34.3	< 34.3	< 34.3	< 34.3	< 34.3	45.9
Tin	< 7.43 7	< 7.43 D	< 7.43	11	< 7.43	< 7.43	< 7.43	< 7.43	< 7.43	15.2
Vanadium	20.7	12.2 D	18.9	12.6	11.7	16.4	12.9	6.35	11.6	13.4
Zinc	32.9	26.1 D	30.4	23.8	22.6	25.6	28.9	14.7	27.3	20.3
SEMIVOLATILE ORGANICS										
2-methylnaphthalene	< .032	.1 D	< .032	< .032	< .032	< .032	< .032	< .032	8.4	70
Acenaphthene	< .041	< .041 D	< .041	< .041	< .041	< .041	< .041	< .041	.56	5
Acenaphthylene	< .033	< .033 D	< .033	< .033	.13	< .033	< .033	< .033	< .033	< .3
Benzo[a]anthracene	.13	.12 D	.58	< .041	.81	< .041	< .041	< .041	.47	< .4
Benzo[b]fluoranthene	< .31	< .31 D	.75	< .31	1.1	< .31	< .31	< .31	1	< 3
Benzo[ghi]perylene	< .18	< .18 D	.51	< .18	.69	< .18	< .18	< .18	.44	< 2
Benzo[k]fluoranthene	< .13	< .13 D	.34	< .13	.43	< .13	< .13	< .13	.36	< 1
Benzyl Alcohol	< .032	.042 D	< .032	< .032	< .032	< .032	.07	.077	< .032	< 3
Chrysene	.16	.14 D	.53	< .032	.72	< .032	< .032	< .032	.76	< .3
Diethyl Phthalate	< .24	< .24 D	< .24	< .24	< .24	< .24	< .24	< .24	< .24	< 2
Fluoranthene	.2	.12 D	.9	< .032	.7	< .032	< .032	< .032	.61	< .3
Fluorene	< .065	< .065 D	< .065	< .065	< .065	< .065	< .065	< .065	1	9
Naphthalene	< .74	< .74 D	< .74	< .74	< .74	< .74	< .74	< .74	3.2	30
Phenanthrene	.42	.15 D	.95	< .032	.15	< .032	< .032	< .032	2	20
Phenol	< .052	< .052 D	< .052	< .052	< .052	< .052	< .052	< .052	< .052	< .5
Pyrene	.28	.25 D	1.1	< .083	1	< .083	< .083	< .083	.91	< .8
Di-n-butyl Phthalate	< 1.3	< 1.3 D	< 1.3	< 1.3	< 1.3	< 1.3	3.5	1.8	2.6	< 10
VOLATILE ORGANICS										
Chlorobenzene	< .1	< .1 D	< .1	< .1	< .1	< .1	< .1	< .1	< .1	< .1
Chloroform	< .24	< .24 D	< .24	< .24	< .24	< .24	< .24	< .24	< .24	< .24
Ethylbenzene	< .19	< .19 D	< .19	< .19	< .19	< .19	< .19	< .19	< .19	1.1
Toluene	< .1	< .1 D	< .1	< .1	< .1	< .1	< .1	< .1	< .1	< .1
OTHER										
Total Organic Carbon	18600	7600 D	10800	2930	4310	15100	1360	< 1000	7800	9750
Total Petroleum Hydrocarbons	176	2760 D	2780	1550	1070	323	103	18.6	425	4350

TABLE 7-6
ADL AREE 69W SOIL OFF-SITE ANALYTICAL RESULTS
AOC 69W

REMEDIAL INVESTIGATION REPORT
DEVENS, MASSACHUSETTS

Site ID:	69W-94-11	69W-94-11	69W-94-11	69W-94-12	69W-94-12	69W-94-13	69W-94-13	69W-94-14	69W-94-14
Field Sample Number:	BXD9W-DU	BDD9W-EL	BXD9W-EL	BXD9W-FU	BXD9W-GL	BXD9W-HU	BXD9W-IL	BXD9W-JU	BXD9W-KL
Field ID:	69W-94-11	69W-94-11	69W-94-11	69W-94-12	69W-94-12	69W-94-13	69W-94-13	69W-94-14	69W-94-14
Sample Date:	06/06/94	06/06/94	06/06/94	06/02/94	06/02/94	06/01/94	06/01/94	06/02/94	06/02/94
Depth:	2	4	4	2	4	2	4	2	4
Units:	µg/g	µg/g	µg/g	µg/g	µg/g	µg/g	µg/g	µg/g	µg/g
PAL METALS									
Aluminum	8200	8220 D	7550	8770	7390	8790	8810	11500	9820
Arsenic	14.4	11.1 D	15.8	9.19	28.6	8.21	22.1	14.2	16.1
Barium	16	17.2 D	15.2	14.8	19	19.6	16.5	18.8	17.2
Boron	9.78	9.65 D	< 6.64	9.44	11	< 6.64	9.03	9.86	15.7
Calcium	1030	876 D	971	430	981	1370	1030	518	981
Chromium	16.1	15.5 D	11.7	13.5	19.6	14.4	32.6	23.8	21.9
Cobalt	4.85 I	3.85 D I	4.79 I	3.08 I	4.8 I	< 2.5 I	4.03 I	10.2 I	5.31 I
Copper	22.4	6.95 D	8.81	6.74	4.9	6.01	10.4	16.8	10.1
Iron	17500	14600 D	13500	11200	13100	11200	14500	28500	18200
Lead	7.37	4.03 D	5.92	8.35	6.1	9.7	2.75	4.97	4.35
Magnesium	3400	3070 D	2510	2250	3370	2160	4140	4530	4480
Manganese	166	143 D	147	158	174	127	127	640	187
Nickel	15	13.7 D	14.2	10.3	13.4	10.6	16.4	44.4	17.9
Potassium	605	690 D	603	402	1280	414	856	427	991
Sodium	234	224 D	219	125	194	196	246	137	223
Thallium	< 34.3	46.8 D	44.7	< 34.3	40.8	< 34.3	58.6	52.7	< 34.3
Tin	< 7.43	< 7.43 D	< 7.43	< 7.43	< 7.43	< 7.43	10.7	< 7.43	< 7.43
Vanadium	13.1	11.1 D	9.13	12.4	13.8	11.5	15	14.6	15.9
Zinc	52.6	23.7 D	21.6	22.9	26.7	21.1	20.9	44	28.3
SEMIVOLATILE ORGANICS									
2-methylnaphthalene	< .032	.67 D	.32	< .032	< .032	< .032	7.2	< .032	< .032
Acenaphthene	< .041	< .041 D	< .041	< .041	< .041	< .041	< .041	< .041	< .041
Acenaphthylene	< .033	< .033 D	< .033	< .033	< .033	.17	< .033	< .033	< .033
Benzo[a]anthracene	< .041	< .041 D	< .041	.12	< .041	.64	.13	.092	< .041
Benzo[b]fluoranthene	< .31	< .31 D	< .31	< .31	< .31	.98	< .31	< .31	< .31
Benzo[ghi]perylene	< .18	< .18 D	< .18	< .18	< .18	.58	< .18	< .18	< .18
Benzo[k]fluoranthene	< .13	< .13 D	< .13	< .13	< .13	.37	< .13	< .13	< .13
Benzyl Alcohol	< .032	.06 D	.08	< .032	< .032	< .032	< .032	< .032	< .032
Chrysene	.071	< .032 D	.067	.11	< .032	.63	.15	.13	< .032
Diethyl Phthalate	< .24	< .24 D	< .24	< .24	< .24	< .24	3.3	< .24	< .24
Fluoranthene	.048	< .032 D	< .032	.13	< .032	.26	< .032	.11	< .032
Fluorene	< .065	.15 D	< .065	< .065	< .065	< .065	.74	< .065	< .065
Naphthalene	< .74	< .74 D	< .74	< .74	< .74	< .74	2.4	< .74	< .74
Phenanthrene	.078	.3 D	.23	.12	< .032	.45	1.4	.28	< .032
Phenol	< .052	< .052 D	< .052	< .052	.17	< .052	< .052	< .052	< .052
Pyrene	< .083	< .083 D	< .083	.19	< .083	.4	< .083	.22	.16
Di-n-butyl Phthalate	20	2.1 D	2.7	< 1.3	< 1.3	< 1.3	< 1.3	< 1.3	< 1.3
VOLATILE ORGANICS									
Chlorobenzene	< .1	< .1 D	< .1	< .1	< .1	< .1	.18	.33	< .1
Chloroform	< .24	< .24 D	< .24	< .24	.4	< .24	< .24	< .24	.44
Ethylbenzene	< .19	< .19 D	< .19	< .19	< .19	< .19	.23	< .19	< .19
Toluene	< .1	< .1 D	< .1	< .1	< .1	< .1	< .1	< .1	.11
OTHER									
Total Organic Carbon	6850	2020 D	2450	11600	3040	19000	4110	3430	< 1000
Total Petroleum Hydrocarbons	865	176 D	101	23.4	1390	34.1	2270	123	2430

Notes:
< = The concentration was less than the certified reported limit.
µg/g = micrograms per gram.
D = Duplicate analysis.
I = The low spike recovery for this lot was high.

TABLE 7-7
ADL AREE 69W GROUNDWATER OFF-SITE ANALYTICAL RESULTS
AOC 69W

REMEDIAL INVESTIGATION REPORT
DEVENS, MASSACHUSETTS

Site ID:	69W--94-02	69W--94-05	69W--94-06	69W--94-07	69W--94-08	69W--94-09	69W--94-09	69W--94-09	69W--94-10	69W--94-10
Field Sample Number:	MXC9W-2X	MXC9W-5X	MXC9W-6X	MXC9W-7X	MXC9W-8X	MDE9W-9X	MXD9W-9X	MXE9W-9X	MXD9W-AX	MXE9W-AX
Field ID:	GP-2	GP-13	GP-1	GP-15	GP-6	69W-94-09	69W-94-09	69W-94-09	69W-94-10	69W-94-10
Sample Date:	05/02/94	05/02/94	05/02/94	05/02/94	05/02/94	09/19/94	06/24/94	09/19/94	06/24/94	09/20/94
Units:	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L
PAL METALS										
Aluminum	140000	45700	27600	150000	105000	1740 D	13400	7590	85200	4200
Antimony	116	< 60	< 60	132	< 60	< 60 D	< 60	< 60	< 60	< 60
Arsenic	< 2.35	< 2.35	320	37.8	170	14.5 D	19.5	20.6	470	350
Barium	605	122	143	374	268	40.5 D	76.2	57.7	347	53.3
Beryllium	7.22	1.6	< 1.12	5.34	5.09	< 1.12 D	< 1.12	1.39	4.41	< 1.12
Cadmium	< 6.78	< 6.78	< 6.78	< 6.78	< 6.78	< 6.78 D	< 6.78	< 6.78	11.4	< 6.78
Calcium	99700	24200	63700	41000	21100	19400 D	20000	19900	34700	21100
Chromium	347	131	83.8	513	312	< 16.8 D	17	< 16.8	192	17.6
Cobalt	114	28.3	28.7	86.5	82.3	< 25 D	< 25	< 25	83.3	< 25
Copper	207	63.8	47.1	230	211	< 18.8 D	< 18.8	< 18.8	165	< 18.8
Iron	225000	58400	137000	177000	172000	868 D	11700	7630	148000	35100
Lead	201	12.8	52.1	71.5	152	< 4.47 D	7.18	5.59	102	6.06
Magnesium	38900	12800	11000	48500	35500	1920 D	3990	3120	24900	3410
Manganese	6460	2850	9880	3630	3550	158 D	265	248	13000	3950
Mercury	.219	< .1	< .1	.295	< .1	< .1 D	< .1	< .1	.112	< .1
Nickel	318	93.6	67.7	333	278	< 32.1 DH	< 32.1	< 32.1 H	234	< 32.1 H
Potassium	24700	5260	9710	20300	14800	1750 D	5460	3540	14700	5240
Selenium	< 2.53	< 2.53	< 2.53	< 2.53	< 2.53	< 2.53 D	< 2.53	< 2.53	4.05	< 2.53
Sodium	280000	31800	40700	46600	45400	26900 D	28500	27600	32700	23700
Vanadium	195	43.9	44.1	191	137	< 27.6 D	< 27.6	< 27.6	129	< 27.6
Zinc	483 I	132 I	129 I	432 I	344 I	< 18 D	34	22.6	245	20
SEMIVOLATILE ORGANICS										
2-methylnaphthalene	1000	< 1.3	600	< 1.3	400	< 1.3 D	< 1.3	< 1.3	700	400
Acenaphthene	< 60	< 5.8	< 60	< 5.8	< 60	< 5.8 D	< 5.8	< 5.8	34	< 30
Fluorene	< 90	< 9.2	< 90	< 9.2	< 90	< 9.2 D	< 9.2	< 9.2	35	< 50
Naphthalene	600	1.1	300	< .5	500	< .5 D	< .5	< .5	500	300
Phenanthrene	< 100	< 9.9	< 100	< 9.9	< 100	< 9.9 D	< 9.9	< 9.9	64	< 50
VOLATILE ORGANICS										
1,1,1-trichloroethane	< 1	30	20	< 1	< 1	< 1 D	2.6 B	< 1	< 1	< 1
1,1-dichloroethane	< 1	< 1	10	< 1	< 1	< 1 D	< 1	< 1	< 1	< 1
1,1-dichloroethene	< 1	< 1	20	< 1	< 1	< 1 D	< 1	< 1	< 1	< 1
Acetone	< 8	< 8	< 80	37	< 8	< 8 D	< 8	< 8	< 8	< 8
Benzene	< 1	< 1	9	< 1	< 1	< 1 D	< 1	< 1	< 1	< 1
Carbon Tetrachloride	< 1	< 1	10	< 1	< 1	< 1 D	< 1	< 1	< 1	< 1
Chlorobenzene	< 1	< 1	10	< 1	< 1	< 1 D	< 1	< 1	< 1	< 1
Chloroform	< 1	< 1	10	< 1	< 1	< 1 D	< 1	< 1	< 1	< 1
Chloromethane	< 1.2	< 1.2	20	< 1.2	< 1.2	< 1.2 D	< 1.2	< 1.2	< 1.2	< 1.2
Ethylbenzene	80	< 1	40	< 1	< 1	< 1 D	< 1	< 1	52	57
Tetrachloroethene	< 1	< 1	10	< 1	< 1	< 1 D	< 1	< 1	< 1	< 1
Toluene	< 1	< 1	10	< 1	< 1	< 1 D	< 1	< 1	< 1	< 1
Trichloroethylene	< 1	< 1	10	< 1	< 1	< 1 D	3.2	< 1	< 1	< 1
Trichlorofluoromethane	< 1	< 1	20	< 1	< 1	< 1 D	< 1	< 1	< 1	< 1
Xylenes	< 20	< 2	< 20	< 2	< 2	< 2 D	< 2	< 2	8	2.4
WET CHEMISTRY										
Alkalinity							21000		97400	
Chloride						34000	36000	34000	30000	22000
Nitrite, Nitrate-non Specific	14.6	22.9	20	3100	22.3	2100 D	3800	1800	210	310
Nitrogen By Kjeldahl Method	3200	764	5000	1260	2200	< 64 D N	88	< 64 N	810	1180 N
Phosphorus	1800	1900	457	5200	1400	51.2 D		174	1300	330
Sulfate						19000	23000	20000	4000	3660
Total Hardness						55400 D	64900	61200	183000	65300
Total Suspended Solids						344000 D	290000	348000	1620000	174000
OTHER										
Total Petroleum Hydrocarbons	23600 V	522 V	66000 V	< 100 V	21500 V	< 100 D	333	< 100	18500	15700

TABLE 7-7
ADL, AREE 69W GROUNDWATER OFF-SITE ANALYTICAL RESULTS
AOC 69W

REMEDIAL INVESTIGATION REPORT
DEVENS, MASSACHUSETTS

Site ID:	69W–94-11	69W–94-11	69W–94-11	69W–94-12	69W–94-12	69W–94-13	69W–94-13	69W–94-14	69W–94-14
Field Sample Number:	MDD9W-BX	MXD9W-BX	MXE9W-BX	MXD9W-CX	MXE9W-CX	MXD9W-DX	MXE9W-DX	MXD9W-EX	MXE9W-EX
Field ID:	69W-94-11	69W-94-11	69W-94-11	69W-94-12	69W-94-12	69W-94-13	69W-94-13	69W-94-14	69W-94-14
Sample Date:	06/23/94	06/23/94	09/20/94	06/23/94	09/19/94	06/23/94	09/19/94	06/23/94	09/19/94
Units:	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L
PAL METALS									
Aluminum	2790 D	2610	447	11300	7290	537	4610	18100	8330
Antimony	< 60 D	< 60	< 60	< 60	< 60	< 60	< 60	< 60	< 60
Arsenic	38 D	37.8	62.1	25.6	36	60.4	400	70.4	270
Barium	34.4 D	32	22.1	56.5	54.4	25.6	42.9	76	65.3
Beryllium	< 1.12 D	< 1.12	< 1.12	< 1.12	1.96	< 1.12	1.4	< 1.12	< 1.12
Cadmium	< 6.78 D	< 6.78	< 6.78	< 6.78	< 6.78	< 6.78	< 6.78	< 6.78	< 6.78
Calcium	27900 D	26200	26000	24400	18700	19200	20200	18900	18500
Chromium	< 16.8 D	< 16.8	< 16.8	22.2	20.5	< 16.8	< 16.8	39.5	< 16.8
Cobalt	< 25 D	< 25	< 25	< 25	< 25	< 25	< 25	28.8	< 25
Copper	< 18.8 D	< 18.8	< 18.8	< 18.8	< 18.8	< 18.8	< 18.8	27.8	< 18.8
Iron	5430 D	5150	2470	12100	9160	4730	28400	25200	23600
Lead	< 4.47 D	< 4.47	< 4.47	8.92	9.65	< 4.47	11	23.3	15.2
Magnesium	3630 D	3440	2920	4680	3740	2040	3770	5280	2850
Manganese	3340 D	3140	2330	395	409	3910	2920	1850	994
Mercury	< .1 D	< .1	< .1	< .1	< .1	< .1	< .1	.108	< .1
Nickel	< 32.1 D	< 32.1	< 32.1 H	< 32.1	< 32.1 H	< 32.1	< 32.1 H	49.8	< 32.1
Potassium	3270 D	3110	< 1240	4250	4360	2430	2780	3460	2230
Selenium	< 2.53 D	< 2.53	< 2.53	< 2.53	< 2.53	< 2.53	< 2.53	< 2.53	< 2.53
Sodium	37500 D	35500	34900	47300	34300	16700	28900	28000	38300
Vanadium	< 27.6 D	< 27.6	< 27.6	< 27.6	< 27.6	< 27.6	< 27.6	< 27.6	< 27.6
Zinc	32.5 D	45.5	29.1	38.5	29.1	19	22.6	50.8	20
SEMIVOLATILE ORGANICS									
2-methylnaphthalene	37 D	42	7.2	< 1.3	< 1.3	69	29	< 6	< 1.3
Acenaphthene	< 5.8 D	< 5.8	< 5.8	< 5.8	< 5.8	< 5.8	< 5.8	< 30	< 5.8
Fluorene	< 9.2 D	< 9.2	< 9.2	< 9.2	< 9.2	< 9.2	< 9.2	< 50	< 9.2
Naphthalene	8.8 D	11	2.7	< .5	< .5	64	47	< 2	< .5
Phenanthrene	< 9.9 D	< 9.9	< 9.9	< 9.9	< 9.9	< 9.9	< 9.9	< 50	< 9.9
VOLATILE ORGANICS									
1,1,1-trichloroethane	1.5 DB	< 1	< 1	3.1 B	1.7	4.1 B	< 1	< 1	< 1
1,1-dichloroethane	< 1 D	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
1,1-dichloroethene	< 1 D	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
Acetone	< 8 D	< 8	< 8	< 8	< 8	< 8	< 8	< 8	< 8
Benzene	< 1 D	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
Carbon Tetrachloride	< 1 D	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
Chlorobenzene	< 1 D	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
Chloroform	< 1 D	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
Chloromethane	< 1.2 D	< 1.2	< 1.2	< 1.2	< 1.2	< 1.2	< 1.2	< 1.2	< 1.2
Ethylbenzene	< 1 D	< 1	< 1	< 1	< 1	19	9.1	< 1	< 1
Tetrachloroethene	< 1 D	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
Toluene	< 1 D	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
Trichloroethylene	< 1 D	< 1	< 1	3.9	< 1	< 1	< 1	< 1	< 1
Trichlorofluoromethane	< 1 D	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
Xylenes	< 2 D	< 2	< 2	< 2	< 2	< 2	< 2	< 2	< 2
WET CHEMISTRY									
Alkalinity	52600 D	56000		21200		43300		31500	
Chloride	58000 D	58000	48000	81000	41000	35000	40000	40000	52000
Nitrite, Nitrate-non Specific	500 D	350	1100	3100	2000	20.7	162	182	1600
Nitrogen By Kjeldahl Method	627 D	681	145 N	330	203 N	635	1100 N	423	456
Phosphorus	77 D	73.9	45.2	225	400	30.9	560	620	740
Sulfate	17000 D	17000	13000	18000	19000	2520	1850	17000	15000
Total Hardness	83000 D	78000	75400	78600	60600	55300	64600	67200	56700
Total Suspended Solids	47000 D	36000	61000	397000	815000	10000	2190000	640000	545000
OTHER									
Total Petroleum Hydrocarbons	543 D	750	784	815	314	925	2140	11800	50000

Notes:
< = The concentration was less than the certified reported limit.
µg/g = micrograms per gram.
D = Duplicate analysis.
I = The low spike recovery for this lot was high.
H = Lot out of control but data accepted due to high recoveries.
V = Sample was not correctly preserved.
N = The high spike recovery for this lot was low.
B = Analyte found in method blank or QC sample.

TABLE 7-8
ADL, AREE 69W SURFACE WATER OFF-SITE ANALYTICAL RESULTS
AOC 69W

REMEDIAL INVESTIGATION REPORT
DEVENS, MASSACHUSETTS

Site ID:	69W–94-15	69W–94-16
Field Sample Number:	WXD9W-FX	WXD9W-GX
Sample Number:	06/24/94	06/24/94
Units:	µg/L	µg/L
PAL METALS		
Aluminum	658	< 112
Arsenic	2.92	< 2.35
Barium	17.5	13.1
Calcium	26600	23900
Iron	1470	276
Lead	7.65	< 4.47
Magnesium	4480	3750
Manganese	164	38.8
Potassium	1920	1920
Sodium	42700	40000
Zinc	24.6	< 18
VOLATILE ORGANICS		
1,1,1-trichloroethane	3.7 B	2.2 B
WET CHEMISTRY		
Alkalinity	< 10000	42300
Chloride	77000	75000
Nitrite, Nitrate-non Specific	930	1100
Nitrogen By Kjeldahl Method	353	214
Phosphorus	91.2	24.1
Sulfate	14000	15000
Total Hardness	83000	73700

Notes:
µg/L = micrograms per liter
< + Concentration is less than the certified reporting limit.
B = Analyte found in method blank or QC sample.

TABLE 7-9
ADL, AREE 69W SEDIMENT OFF-SITE ANALYTICAL RESULTS
AOC 69W

REMEDIAL INVESTIGATION REPORT
DEVENS, MASSACHUSETTS

Site ID:		69W--94-15		69W--94-16			69W--94-16
Field Sample Number:		DXD9W-FO		DDD9W-GO			DXD9W-GO
Sample Date:		06/24/94		06/24/94			06/24/94
Depth:		0		0			0
Units:		µg/g		µg/g			µg/g
PAL METALS							
Aluminum		6280		6130	D		7920
Arsenic		6.46		13.2	D		20.3
Barium		15.4		11.2	D		19.8
Boron	<	6.64		12.9	D	<	6.64
Calcium		1200		2660	D		1650
Chromium		18.2		14.6	D		23.6
Cobalt		5.5	<	2.5	D		5.79
Copper		13.1		43.2	D		14.2
Iron		15100		14400	D		16200
Lead		20.7		20.7	D		23.6
Magnesium		3080		3990	D		4470
Manganese		195		259	D		203
Nickel		13.4		12.8	D		18.1
Potassium		842		581	D		979
Sodium		104		79	D		132
Vanadium		12.2		11.5	D		15.3
Zinc		49.5		41.6	D		48.1
SEMIVOLATILE ORGANICS							
Acenaphthylene		.34		.098	D	<	.033
Benzo[a]anthracene		1.9		.3	D		.16
Benzo[b]fluoranthene		2.2	<	.31	D	<	.31
Benzo[ghi]perylene		.95	<	.18	D	<	.18
Benzo[k]fluoranthene		.99	<	.13	D	<	.13
Benzyl Alcohol	<	.032		.073	D	<	.032
Chrysene		2		.36	D		.19
Fluoranthene		2.5		.44	D		.21
Fluorene		.55	<	.065	D	<	.065
Phenanthrene		3.8		.59	D		.13
Pyrene		3.8		.5	D		.27
Bis(2-ethylhexyl) Phthalate	<	.48	<	.48	D		1.4
OTHER							
Total Organic Carbon		2580		1320	D		1670
Total Petroleum Hydrocarbons		188		123	D		131

Notes:
µg/g = micrograms per gram.
< = Concentration is less than the certified reporting limit.
D = Duplicate analysis.

TABLE 7-10
SUBSURFACE SOIL FIELD ANALYTICAL RESULTS
AOC 69W

REMEDIAL INVESTIGATION REPORT
DEVENS, MASSACHUSETTS

	Site ID:	**ZWB-96-03X**	**ZWB-96-03X**	**ZWB-96-03X**	**ZWB-96-03X**	**ZWB-96-03X**	**ZWB-96-03X**	**ZWB-96-03X**
	Depth (ft bgs):	**2**	**4**	**4(Dup)**	**6**	**6(Dup)**	**8**	**10**
	Date analyzed:	**4-Sep-96**	**4-Sep-96**	**4-Sep-96**	**4-Sep-96**	**4-Sep-96**	**4-Sep-96**	**4-Sep-96**
	Dilution:	**134**	**144**	**144**	**141**	**148**	**161**	**151**
ANALYTES	**Reporting Limit**							
Vinyl Chloride	2 µg/kg/250µg/kg	270 U	290 U	290 U	280 U	300 U	320 U	300 U
1,1-DCE	5 µg/kg/250µg/kg	270 UJ	290 UJ	290 UJ	280 UJ	300 UJ	320 UJ	300 UJ
t-1,2-DCE	2 µg/kg/250µg/kg	270 U	290 U	290 U	280 U	300 U	320 U	300 U
c-1,2-DCE	2 µg/kg/250µg/kg	270 U	290 U	290 U	280 U	300 U	320 U	300 U
Chloroform	2 µg/kg/250µg/kg	270 U	290 U	290 U	280 U	300 U	320 U	300 U
1,1,1-TCA	2 µg/kg/250µg/kg	270 U	290 U	290 U	280 U	300 U	320 U	300 U
Carbon Tetrachloride	2 µg/kg/250µg/kg	270 U	290 U	290 U	280 U	300 U	320 U	300 U
Trichloroethene	2 µg/kg/250µg/kg	270 U	290 U	290 U	280 U	300 U	320 U	300 U
Tetrachloroethene	2 µg/kg/250µg/kg	270 U	290 U	290 U	280 U	300 U	320 U	300 U
1,3-DCB	2 µg/kg/250µg/kg	270 U	290 U	290 U	280 U	300 U	320 U	300 U
1,4-DCB	2 µg/kg/250µg/kg	270 U	290 U	290 U	280 U	300 U	320 U	300 U
1,2-DCB	2 µg/kg/250µg/kg	270 U	290 U	290 U	280 U	300 U	320 U	300 U
Benzene	2 µg/kg/250µg/kg	270 U	290 U	290 U	280 U	300 U	320 U	300 U
Toluene	2 µg/kg/250µg/kg	270 U	290 U	290 U	280 U	300 U	320 U	300 U
Chlorobenzene	2 µg/kg/250µg/kg	270 U	290 U	290 U	280 U	300 U	320 U	300 U
Ethylbenzene	2 µg/kg/250µg/kg	270 U	290 U	290 U	280 U	300 U	320 U	300 U
m/p-Xylene	4 µg/kg/500µg/kg	540 U	580 U	580 U	560 U	590 U	640 U	600 U
o-Xylene	2 µg/kg/250µg/kg	270 U	290 U	290 U	280 U	300 U	320 U	300 U
Naphthalene	2 µg/kg/250µg/kg	270 U	290 U	290 U	280 U	300 U	320 U	300 U
TPH-dro	100 mg/kg	NA	NA	NA	NA	NA	NA	NA
TPH-gro	100 µg/kg	NA	NA	NA	NA	NA	NA	NA
TPH-ir (95)	50 mg/kg	NA	NA	NA	NA	NA	NA	NA
TPHC (96)	50 mg/kg	54 U	58 U	58 U	56 U	59 U	64 U	60 U

Notes:

U = Concentrations Less than Reporting Limit
J = Value is Estimated
E = Concentration Exceeds the Maximum Reporting Limit
NA = Not Analyzed

TABLE 7-10
SUBSURFACE SOIL FIELD ANALYTICAL RESULTS
AOC 69W

REMEDIAL INVESTIGATION REPORT
DEVENS, MASSACHUSETTS

	Site ID:	**ZWB-96-03X**	**ZWB-96-03X**	**ZWM-96-19X**	**ZWM-96-19X**	**ZWM-96-19X**	**ZWM-96-19X**	**ZWM-96-19X**
	Depth (ft bgs):	**10(Dup)**	**12**	**1**	**1(Dup)**	**3**	**5**	**7**
	Date analyzed:	**4-Sep-96**	**4-Sep-96**	**27-Aug-96**	**27-Aug-96**	**3-Sep-96**	**28-Aug-96**	**3-Sep-96**
	Dilution:	**149**	**146**	**131**	**131**	**130**	**133**	**140**
ANALYTES	**Reporting Limit**							
Vinyl Chloride	2 µg/kg/250µg/kg	300 U	290 U	260 U	260 U	260 U	270 U	280 U
1,1-DCE	5 µg/kg/250µg/kg	300 UJ	290 UJ	260 U	260 U	260 U	270 U	280 U
t-1,2-DCE	2 µg/kg/250µg/kg	300 U	290 U	260 U	260 U	260 U	270 U	280 U
c-1,2-DCE	2 µg/kg/250µg/kg	300 U	290 U	260 U	260 U	260 U	270 U	280 U
Chloroform	2 µg/kg/250µg/kg	300 U	290 U	260 U	260 U	260 U	270 U	280 U
1,1,1-TCA	2 µg/kg/250µg/kg	300 U	290 U	260 U	260 U	260 U	270 U	280 U
Carbon Tetrachloride	2 µg/kg/250µg/kg	300 U	290 U	260 U	260 U	260 U	270 U	280 U
Trichloroethene	2 µg/kg/250µg/kg	300 U	290 U	260 U	260 U	260 U	270 U	280 U
Tetrachloroethene	2 µg/kg/250µg/kg	300 U	290 U	260 U	260 U	260 U	270 U	280 U
1,3-DCB	2 µg/kg/250µg/kg	300 U	290 U	260 U	260 U	260 U	270 U	280 U
1,4-DCB	2 µg/kg/250µg/kg	300 U	290 U	260 U	260 U	260 U	270 U	280 U
1,2-DCB	2 µg/kg/250µg/kg	300 U	290 U	260 U	260 U	260 U	270 U	280 U
Benzene	2 µg/kg/250µg/kg	300 U	290 U	260 U	260 U	260 U	270 U	280 U
Toluene	2 µg/kg/250µg/kg	300 U	290 U	260 U	260 U	260 U	270 U	280 U
Chlorobenzene	2 µg/kg/250µg/kg	300 U	290 U	260 U	260 U	260 U	270 U	280 U
Ethylbenzene	2 µg/kg/250µg/kg	300 U	290 U	260 U	260 U	260 U	270 U	280 U
m/p-Xylene	4 µg/kg/500µg/kg	600 U	580 U	520 U	520 U	520 U	530 U	560 U
o-Xylene	2 µg/kg/250µg/kg	300 U	290 U	260 U	260 U	260 U	270 U	280 U
Naphthalene	2 µg/kg/250µg/kg	300 U	290 U	260 U	260 U	680	270 U	280 U
TPH-dro	100 mg/kg	NA	NA	NA	NA	NA	NA	NA
TPH-gro	100 µg/kg	NA	NA	NA	NA	NA	NA	NA
TPH-ir (95)	50 mg/kg	NA	NA	NA	NA	NA	NA	NA
TPHC (96)	50 mg/kg	NA	58 U	54 U	53	150	52 U	56

TABLE 7-10
SUBSURFACE SOIL FIELD ANALYTICAL RESULTS
AOC 69W

REMEDIAL INVESTIGATION REPORT
DEVENS, MASSACHUSETTS

	Site ID:	ZWM-96-19X	ZWM-96-19X	ZWM-96-19X	ZWM-96-20X	ZWM-96-20X	ZWM-96-20X	ZWM-96-20X
	Depth (ft bgs):	9	11	13	2	4	6	8
	Date analyzed:	3-Sep-96	10-Sep-96	3-Sep-96	3-Sep-96	3-Sep-96	3-Sep-96	3-Sep-96
	Dilution:	143	154	156	154	155	158	159
ANALYTES	Reporting Limit							
Vinyl Chloride	2 µg/kg/250µg/kg	290 U	310 U	310 U	310 U	310 U	320 U	320 U
1,1-DCE	5 µg/kg/250µg/kg	290 U	310 U	310 U	310 U	310 U	320 U	320 U
t-1,2-DCE	2 µg/kg/250µg/kg	290 U	310 U	310 U	310 U	310 U	320 U	320 U
c-1,2-DCE	2 µg/kg/250µg/kg	290 U	310 U	310 U	310 U	310 U	320 U	320 U
Chloroform	2 µg/kg/250µg/kg	290 U	310 U	310 U	310 U	310 U	320 U	320 U
1,1,1-TCA	2 µg/kg/250µg/kg	290 U	310 U	310 U	310 U	310 U	320 U	320 U
Carbon Tetrachloride	2 µg/kg/250µg/kg	290 U	310 U	310 U	310 U	310 U	320 U	320 U
Trichloroethene	2 µg/kg/250µg/kg	290 U	310 U	310 U	310 U	310 U	320 U	320 U
Tetrachloroethene	2 µg/kg/250µg/kg	290 U	310 U	310 U	310 U	310 U	320 U	320 U
1,3-DCB	2 µg/kg/250µg/kg	290 U	310 U	310 U	310 U	310 U	320 U	320 U
1,4-DCB	2 µg/kg/250µg/kg	290 U	310 U	310 U	310 U	310 U	320 U	320 U
1,2-DCB	2 µg/kg/250µg/kg	290 U	310 U	310 U	310 U	310 U	320 U	320 U
Benzene	2 µg/kg/250µg/kg	290 U	310 U	310 U	310 U	310 U	320 U	320 U
Toluene	2 µg/kg/250µg/kg	290 U	310 U	310 U	310 U	310 U	320 U	320 U
Chlorobenzene	2 µg/kg/250µg/kg	290 U	310 U	310 U	310 U	310 U	320 U	320 U
Ethylbenzene	2 µg/kg/250µg/kg	290 U	310 U	310 U	310 U	310 U	320 U	320 U
m/p-Xylene	4 µg/kg/500µg/kg	580	620 U	620 U	620 U	620 U	630 U	640 U
o-Xylene	2 µg/kg/250µg/kg	290 U	310 U	310 U	310 U	310 U	320 U	320 U
Naphthalene	2 µg/kg/250µg/kg	3800 E	4500	1400	310 U	310 U	320 U	320 U
TPH-dro	100 mg/kg	NA	NA	NA	NA	NA	NA	NA
TPH-gro	100 µg/kg	NA	NA	NA	NA	NA	NA	NA
TPH-ir (95)	50 mg/kg	NA	NA	NA	NA	NA	NA	NA
TPHC (96)	50 mg/kg	840	790	63	62	62 U	63 U	64 U

TABLE 7-10
SUBSURFACE SOIL FIELD ANALYTICAL RESULTS
AOC 69W

REMEDIAL INVESTIGATION REPORT
DEVENS, MASSACHUSETTS

	Site ID: Depth (ft bgs): Date analyzed: Dilution:	ZWM-96-21X 0 3-Sep-96 134	ZWM-96-21X 2 4-Sep-96 134	ZWM-96-21X 4 5-Sep-96 138	ZWM-96-21X 6 5-Sep-96 136	ZWM-96-21X 8 5-Sep-96 143	ZWM-96-21X 10 4-Sep-96 143	ZWM-96-21X 12 5-Sep-96 154
ANALYTES	**Reporting Limit**							
Vinyl Chloride	2 µg/kg/250µg/kg	270 U	270 U	280 U	270 U	290 U	290 U	310 U
1,1-DCE	5 µg/kg/250µg/kg	270 U	270 UJ	280 UJ	270 UJ	290 UJ	290 UJ	310 UJ
t-1,2-DCE	2 µg/kg/250µg/kg	270 U	270 U	280 U	270 U	290 U	290 U	310 U
c-1,2-DCE	2 µg/kg/250µg/kg	270 U	270 U	280 U	270 U	290 U	290 U	310 U
Chloroform	2 µg/kg/250µg/kg	270 U	270 U	280 U	270 U	290 U	290 U	310 U
1,1,1-TCA	2 µg/kg/250µg/kg	270 U	270 U	280 U	270 U	290 U	290 U	310 U
Carbon Tetrachloride	2 µg/kg/250µg/kg	270 U	270 U	280 U	270 U	290 U	290 U	310 U
Trichloroethene	2 µg/kg/250µg/kg	270 U	270 U	280 U	270 U	290 U	290 U	310 U
Tetrachloroethene	2 µg/kg/250µg/kg	270 U	270 U	280 U	270 U	290 U	290 U	310 U
1,3-DCB	2 µg/kg/250µg/kg	270 U	270 U	280 U	270 U	290 U	290 U	310 U
1,4-DCB	2 µg/kg/250µg/kg	270 U	270 U	280 U	270 U	290 U	290 U	310 U
1,2-DCB	2 µg/kg/250µg/kg	270 U	270 U	280 U	270 U	290 U	290 U	310 U
Benzene	2 µg/kg/250µg/kg	270 U	270 U	280 U	270 U	290 U	290 U	310 U
Toluene	2 µg/kg/250µg/kg	270 U	270 U	280 U	270 U	290 U	290 U	310 U
Chlorobenzene	2 µg/kg/250µg/kg	270 U	270 U	280 U	270 U	290 U	290 U	310 U
Ethylbenzene	2 µg/kg/250µg/kg	270 U	270 U	280 U	270 U	290 U	290 U	310 U
m/p-Xylene	4 µg/kg/500µg/kg	540 U	540 U	550 U	540 U	570 U	570 U	620 U
o-Xylene	2 µg/kg/250µg/kg	270 U	270 U	280 U	270 U	290 U	290 U	310 U
Naphthalene	2 µg/kg/250µg/kg	270 U	270 U	280 U	270 U	290 U	290 U	310 U
TPH-dro	100 mg/kg	NA	NA	NA	NA	NA	NA	NA
TPH-gro	100 µg/kg	NA	NA	NA	NA	NA	NA	NA
TPH-ir (95)	50 mg/kg	NA	NA	NA	NA	NA	NA	NA
TPHC (96)	50 mg/kg	54 U	54 U	55 U	54 U	57	57 U	62 U

TABLE 7-10
SUBSURFACE SOIL FIELD ANALYTICAL RESULTS
AOC 69W

REMEDIAL INVESTIGATION REPORT
DEVENS, MASSACHUSETTS

	Site ID:	**ZWE-95-01X**	**ZWE-95-01X**	**ZWE-95-01X**	**ZWR-96-26X**	**ZWR-95-26X**	**ZWR-95-26X**	**ZWR-95-27X**
	Depth (ft bgs):	**3**	**4**	**5**	**4**	**7**	**10**	**4**
	Date analyzed:	**6-Oct-95**	**6-Oct-95**	**6-Oct-95**	**19-Sep-95**	**20-Sep-95**	**20-Sep-95**	**19-Sep-95**
	Dilution:	**1.1**	**1.07**	**1.08**	**1.04**	**1.15**	**1.3**	**1.06**
ANALYTES	**Reporting Limit**							
Vinyl Chloride	2 µg/kg/250µg/kg	NA	NA	NA	NA	NA	NA	NA
1,1-DCE	5 µg/kg/250µg/kg	5.5 U	5.4 U	5.4 U	5.2 U	5.8 U	6.5 U	5.3 U
t-1,2-DCE	2 µg/kg/250µg/kg	NA	NA	NA	NA	NA	NA	NA
c-1,2-DCE	2 µg/kg/250µg/kg	NA	NA	NA	NA	NA	NA	NA
Chloroform	2 µg/kg/250µg/kg	2.2 U	2.1 U	2.2 U	2.1 U	2.3 U	2.6 U	2.1 U
1,1,1-TCA	2 µg/kg/250µg/kg	2.2 U	2.1 U	2.2 U	2.1 U	2.3 U	2.6 U	2.1 U
Carbon Tetrachloride	2 µg/kg/250µg/kg	2.2 U	2.1 U	2.2 U	2.1 UJ	2.3 U	2.6 U	2.1 UJ
Trichloroethene	2 µg/kg/250µg/kg	2.2 U	2.1 U	2.2 U	2.1 U	2.3 U	2.6 U	2.1 U
Tetrachloroethene	2 µg/kg/250µg/kg	2.2 U	2.1 U	2.2 U	2.1 U	2.3 U	2.6 U	2.1 U
1,3-DCB	2 µg/kg/250µg/kg	NA	NA	NA	NA	NA	NA	NA
1,4-DCB	2 µg/kg/250µg/kg	NA	NA	NA	NA	NA	NA	NA
1,2-DCB	2 µg/kg/250µg/kg	NA	NA	NA	NA	NA	NA	NA
Benzene	2 µg/kg/250µg/kg	2.2 U	2.1 U	2.2 U	2.1 U	2.3 U	2.6 U	2.1 U
Toluene	2 µg/kg/250µg/kg	2.2 U	2.1 U	2.2 U	2.1 U	2.3 U	2.6 U	2.1 U
Chlorobenzene	2 µg/kg/250µg/kg	2.2 U	2.1 U	2.2 U	2.1 U	2.3 U	2.6 U	2.1 U
Ethylbenzene	2 µg/kg/250µg/kg	2.2 U	2.1 U	2.2 U	2.1 U	2.3 U	2.6 U	2.1 U
m/p-Xylene	4 µg/kg/500µg/kg	4.4 U	4.3 U	4.3 U	4.2 UJ	4.6 UJ	5.2 UJ	4.2 UJ
o-Xylene	2 µg/kg/250µg/kg	2.2 U	2.1 U	2.2 U	2.1 U	2.3	2.6 U	2.1 U
Naphthalene	2 µg/kg/250µg/kg	NA	NA	NA	NA	NA	NA	NA
TPH-dro	100 mg/kg	NA	NA	NA	NA	710	NA	NA
TPH-gro	100 µg/kg	55 U	110 U	110 U	NA	45000 E	130 U	NA
TPH-ir (95)	50 mg/kg	82	67	270	130	2100	65 U	53 U
TPHC (96)	50 mg/kg	NA	NA	NA	NA	NA	NA	NA

TABLE 7-10
SUBSURFACE SOIL FIELD ANALYTICAL RESULTS
AOC 69W

REMEDIAL INVESTIGATION REPORT
DEVENS, MASSACHUSETTS

	Site ID:	**ZWR-95-27X**	**ZWR-95-27X**	**ZWR-95-28X**	**ZWR-95-28X**	**ZWR-95-28X**	**ZWR-95-30X**	**ZWR-95-30X**
	Depth (ft bgs):	**7**	**10**	**4**	**6**	**10**	**2**	**6**
	Date analyzed:	**18-Sep-95**	**21-Sep-95**	**23-Sep-95**	**23-Sep-95**	**23-Sep-95**	**19-Sep-95**	**20-Sep-95**
	Dilution:	**1.09**	**1.3**	**275**	**550**	**320**	**1.1**	**5.7**
ANALYTES	**Reporting Limit**							
Vinyl Chloride	2 µg/kg/250µg/kg	NA	NA	NA	NA	NA	NA	NA
1,1-DCE	5 µg/kg/250µg/kg	5.5 U	6.5 U	1400 UJ	2800 UJ	1600 UJ	5.5 U	29 U
t-1,2-DCE	2 µg/kg/250µg/kg	NA	NA	NA	NA	NA	NA	NA
c-1,2-DCE	2 µg/kg/250µg/kg	NA	NA	NA	NA	NA	NA	NA
Chloroform	2 µg/kg/250µg/kg	2.2 U	2.6 U	550 U	1100 U	640 U	NA	11 U
1,1,1-TCA	2 µg/kg/250µg/kg	2.2 U	2.6 U	550 U	1100 U	640 U	2.2 U	11 U
Carbon Tetrachloride	2 µg/kg/250µg/kg	2.2 UJ	2.6 U	550 U	1100 U	640 U	2.2 UJ	11 U
Trichloroethene	2 µg/kg/250µg/kg	2.2 U	2.6 U	550 U	1100 U	640 U	2.2 U	11 U
Tetrachloroethene	2 µg/kg/250µg/kg	2.2 U	2.6 U	550 U	1100 U	640 U	2.2 U	11 U
1,3-DCB	2 µg/kg/250µg/kg	NA	NA	NA	NA	NA	NA	NA
1,4-DCB	2 µg/kg/250µg/kg	NA	NA	NA	NA	NA	NA	NA
1,2-DCB	2 µg/kg/250µg/kg	NA	NA	NA	NA	NA	NA	NA
Benzene	2 µg/kg/250µg/kg	2.2 U	2.6 U	550 U	1100 U	640 U	2.2 U	11 U
Toluene	2 µg/kg/250µg/kg	2.2 U	2.6 U	550 U	1100 U	640 U	2.2 U	26
Chlorobenzene	2 µg/kg/250µg/kg	2.2 U	2.6 U	550 U	1100 U	640 U	2.2 U	31
Ethylbenzene	2 µg/kg/250µg/kg	2.2 U	2.6 U	550 U	1100 U	2200	2.2 U	260 E
m/p-Xylene	4 µg/kg/500µg/kg	4.4 UJ	5.2 UJ	1100 UJ	2200 UJ	3200 J	4.4 UJ	300 J
o-Xylene	2 µg/kg/250µg/kg	2.2 U	2.6 U	550 U	1100 U	1200	2.2 U	6200 E
Naphthalene	2 µg/kg/250µg/kg	NA	NA	NA	NA	NA	NA	NA
TPH-dro	100 mg/kg	NA	NA	NA	NA	NA	110 U	3400
TPH-gro	100 µg/kg	NA	130 U	600000 E	1.1 e+6E	3.5 e+6E	NA	540000 E
TPH-ir (95)	50 mg/kg	55 U	65 U	7500	4500	3100	55	7700
TPHC (96)	50 mg/kg	NA	NA	NA	NA	NA	NA	NA

TABLE 7-10
SUBSURFACE SOIL FIELD ANALYTICAL RESULTS
AOC 69W

REMEDIAL INVESTIGATION REPORT
DEVENS, MASSACHUSETTS

	Site ID:	ZWR-95-30X	ZWR-95-31X	ZWR-95-31X	ZWR-95-31X	ZWR-95-32X	ZWR-95-32X	ZWR-95-32X
	Depth (ft bgs):	10	4	7	10	4	7	10
	Date analyzed:	20-Sep-95	20-Sep-95	20-Sep-95	20-Sep-95	19-Sep-95	20-Sep-95	20-Sep-95
	Dilution:	1.15	1.05	139	1.24	1.05	1.18	1.18
ANALYTES	**Reporting Limit**							
Vinyl Chloride	2 µg/kg/250µg/kg	NA	NA	NA	NA	NA	NA	NA
1,1-DCE	5 µg/kg/250µg/kg	5.8 U	5.3 U	700 U	6.2 U	5.3 U	5.9 U	5.9 U
t-1,2-DCE	2 µg/kg/250µg/kg	NA	NA	NA	NA	NA	NA	NA
c-1,2-DCE	2 µg/kg/250µg/kg	NA	NA	NA	NA	NA	NA	NA
Chloroform	2 µg/kg/250µg/kg	NA	2.1 U	280 U	2.5 U	NA	2.4 U	2.4 U
1,1,1-TCA	2 µg/kg/250µg/kg	2.3 U	2.1 U	280 U	2.5 U	2.1 U	2.4 U	2.4 U
Carbon Tetrachloride	2 µg/kg/250µg/kg	2.4	2.1 U	280 U	2.5 U	2.1 UJ	2.4 U	2.4 U
Trichloroethene	2 µg/kg/250µg/kg	2.3 U	2.1 U	280 U	2.5 U	2.1 U	2.4 U	2.4 U
Tetrachloroethene	2 µg/kg/250µg/kg	2.3 U	2.1 U	280 U	2.5 U	2.1 U	2.4 U	2.4 U
1,3-DCB	2 µg/kg/250µg/kg	NA	NA	NA	NA	NA	NA	NA
1,4-DCB	2 µg/kg/250µg/kg	NA	NA	NA	NA	NA	NA	NA
1,2-DCB	2 µg/kg/250µg/kg	NA	NA	NA	NA	NA	NA	NA
Benzene	2 µg/kg/250µg/kg	2.3 U	2.1 U	280 U	2.5 U	2.1 U	2.4 U	2.4 U
Toluene	2 µg/kg/250µg/kg	NA	2.1 U	280 U	2.5 U	2.1 U	2.4 U	2.4 U
Chlorobenzene	2 µg/kg/250µg/kg	2.3 U	2.3 J	280 U	2.5 UJ	2.1 U	2.4 U	2.4 UJ
Ethylbenzene	2 µg/kg/250µg/kg	2.3 U	2.1 U	280 U	2.5 U	2.1 U	2.4 U	2.4 U
m/p-Xylene	4 µg/kg/500µg/kg	4.6 UJ	4.2 UJ	560 UJ	5.0 UJ	4.2 UJ	4.7 UJ	4.7 UJ
o-Xylene	2 µg/kg/250µg/kg	2.3 U	2.1 U	550	2.5 U	2.1 U	2.4 U	2.4 U
Naphthalene	2 µg/kg/250µg/kg	NA	NA	NA	NA	NA	NA	NA
TPH-dro	100 mg/kg	NA	1400	5200	120 U	NA	120 U	120 U
TPH-gro	100 µg/kg	120 U	32000 E	220000 E	1100	NA	120 U	120 U
TPH-ir (95)	50 mg/kg	58 U	3700	4900	110 J	68 J	59 U	88 J
TPHC (96)	50 mg/kg	NA	NA	NA	NA	NA	NA	NA

TABLE 7-10
SUBSURFACE SOIL FIELD ANALYTICAL RESULTS
AOC 69W

REMEDIAL INVESTIGATION REPORT
DEVENS, MASSACHUSETTS

	Site ID:	ZWR-95-33X	ZWR-95-33X	ZWR-95-33X	ZWR-95-34X	ZWR-95-34X	ZWR-95-34X	ZWR-95-35X
	Depth (ft bgs):	4	7	10	4	7	10	4
	Date analyzed:	20-Sep-95	20-Sep-95	20-Sep-95	20-Sep-95	21-Sep-95	20-Sep-95	21-Sep-95
	Dilution:	1.09	1.3	1.35	1.17	1.14	1.18	1.11
ANALYTES	**Reporting Limit**							
Vinyl Chloride	2 µg/kg/250µg/kg	NA	NA	NA	NA	NA	NA	NA
1,1-DCE	5 µg/kg/250µg/kg	5.5 U	6.5 U	6.8 U	5.9 U	5.7 U	5.9 U	5.6 U
t-1,2-DCE	2 µg/kg/250µg/kg	NA	NA	NA	NA	NA	NA	NA
c-1,2-DCE	2 µg/kg/250µg/kg	NA	NA	NA	NA	NA	NA	NA
Chloroform	2 µg/kg/250µg/kg	3.8	NA	NA	2.3 U	2.3 U	2.4 U	NA
1,1,1-TCA	2 µg/kg/250µg/kg	2.2 U	2.6 U	2.7 U	2.3 U	2.3 U	2.4 U	2.2 U
Carbon Tetrachloride	2 µg/kg/250µg/kg	2.2 U	2.6 U	2.7 U	2.3 U	2.3 U	2.4 U	2.2 U
Trichloroethene	2 µg/kg/250µg/kg	2.2 U	2.6 U	2.7 U	2.3 U	2.3 U	2.4 U	2.2 U
Tetrachloroethene	2 µg/kg/250µg/kg	2.2 U	2.6 U	2.7 U	2.3 U	2.3 U	2.4 U	2.2 U
1,3-DCB	2 µg/kg/250µg/kg	NA	NA	NA	NA	NA	NA	NA
1,4-DCB	2 µg/kg/250µg/kg	NA	NA	NA	NA	NA	NA	NA
1,2-DCB	2 µg/kg/250µg/kg	NA	NA	NA	NA	NA	NA	NA
Benzene	2 µg/kg/250µg/kg	2.2 U	2.6 U	2.7 U	2.3 U	2.3 U	2.4 U	2.2 U
Toluene	2 µg/kg/250µg/kg	2.2 U	2.6 U	2.7 U	2.3 U	2.3 U	2.4 U	2.2 U
Chlorobenzene	2 µg/kg/250µg/kg	2.2 UJ	2.6 UJ	2.7 UJ	2.3 UJ	2.3 U	2.4 U	2.2 U
Ethylbenzene	2 µg/kg/250µg/kg	2.2 U	2.6 U	2.7 U	2.3 U	2.3 U	2.4 U	2.2 U
m/p-Xylene	4 µg/kg/500µg/kg	4.4 UJ	5.2 UJ	5.4 UJ	4.7 UJ	4.6 UJ	4.7 UJ	4.4 UJ
o-Xylene	2 µg/kg/250µg/kg	2.2 U	2.6 U	2.7 U	2.3 U	2.3 U	2.4 U	2.2 U
Naphthalene	2 µg/kg/250µg/kg	NA	NA	NA	NA	NA	NA	NA
TPH-dro	100 mg/kg	NA	NA	NA	NA	NA	NA	NA
TPH-gro	100 µg/kg	110 U	130 U	140 U	120 U	110 U	120 U	110 U
TPH-ir (95)	50 mg/kg	66	160	45	59 U	57	59 U	55
TPHC (96)	50 mg/kg	NA	NA	NA	NA	NA	NA	NA

TABLE 7-10
SUBSURFACE SOIL FIELD ANALYTICAL RESULTS
AOC 69W

REMEDIAL INVESTIGATION REPORT
DEVENS, MASSACHUSETTS

ANALYTES	Site ID: Depth (ft bgs): Date analyzed: Dilution: Reporting Limit	ZWR-95-35X 6 19-Sep-95 1.18	ZWR-95-36X 4 20-Sep-95 1.06	ZWR-95-36X 7 24-Sep-95 2.28	ZWR-95-36X 10 20-Sep-95 1.19	ZWR-95-37X 4 23-Sep-95 145	ZWR-95-37X 6 20-Sep-95 1.22	ZWR-95-37X 10 18-Sep-95 1.16
Vinyl Chloride	2 µg/kg/250µg/kg	NA	NA	NA	NA	NA	NA	NA
1,1-DCE	5 µg/kg/250µg/kg	5.9 U	5.3 U	11 U	6.0 U	730 UJ	6.1 U	5.8 U
t-1,2-DCE	2 µg/kg/250µg/kg	NA	NA	NA	NA	NA	NA	NA
c-1,2-DCE	2 µg/kg/250µg/kg	NA	NA	NA	NA	NA	NA	NA
Chloroform	2 µg/kg/250µg/kg	2.4 U	2.1 U	4.6 U	NA	290 U	NA	2.3 U
1,1,1-TCA	2 µg/kg/250µg/kg	2.4 U	2.1 U	4.6 U	2.4 U	290 U	2.4 U	2.3 U
Carbon Tetrachloride	2 µg/kg/250µg/kg	2.4 UJ	2.1 U	4.6 U	2.4 U	290 U	2.4 U	2.3 UJ
Trichloroethene	2 µg/kg/250µg/kg	2.4 U	2.1 U	4.6 U	2.4 U	290 U	2.4 U	2.3 U
Tetrachloroethene	2 µg/kg/250µg/kg	2.4 U	2.1 U	4.6 UJ	2.4 U	290 U	2.4 U	2.3 U
1,3-DCB	2 µg/kg/250µg/kg	NA	NA	NA	NA	NA	NA	NA
1,4-DCB	2 µg/kg/250µg/kg	NA	NA	NA	NA	NA	NA	NA
1,2-DCB	2 µg/kg/250µg/kg	NA	NA	NA	NA	NA	NA	NA
Benzene	2 µg/kg/250µg/kg	2.4 U	2.1 U	4.6 U	2.4 U	290 U	2.4 U	2.3 U
Toluene	2 µg/kg/250µg/kg	2.4 U	2.1 U	4.6 U	2.4 U	290 U	2.4 U	2.3 U
Chlorobenzene	2 µg/kg/250µg/kg	2.4 U	2.1 U	4.6 UJ	2.4 UJ	290 U	2.4 UJ	2.3 U
Ethylbenzene	2 µg/kg/250µg/kg	2.4 U	2.1 U	4.6 U	2.4 U	290 U	2.4 U	2.3 U
m/p-Xylene	4 µg/kg/500µg/kg	4.7 UJ	4.2 UJ	9.1 UJ	4.8 UJ	580 UJ	4.9 UJ	4.6 UJ
o-Xylene	2 µg/kg/250µg/kg	2.4 U	2.1 U	4.6 U	2.4 U	290 U	2.4 U	2.3 U
Naphthalene	2 µg/kg/250µg/kg	NA	NA	NA	NA	NA	NA	NA
TPH-dro	100 mg/kg	120 U	540	NA	NA	NA	NA	NA
TPH-gro	100 µg/kg	NA	14000 E	22000 E	120 U	530000 E	120 U	NA
TPH-ir (95)	50 mg/kg	59 U	1200	1100	53	1800	61 U	58 U
TPHC (96)	50 mg/kg	NA	NA	NA	NA	NA	NA	NA

TABLE 7-10
SUBSURFACE SOIL FIELD ANALYTICAL RESULTS
AOC 69W

REMEDIAL INVESTIGATION REPORT
DEVENS, MASSACHUSETTS

	Site ID:	ZWR-95-38X	ZWR-95-38X	ZWR-95-38X	ZWR-95-39X	ZWR-95-39X	ZWR-95-39X	ZWR-95-40X
	Depth (ft bgs):	3	6	10	4	6	10	0
	Date analyzed:	24-Sep-95	24-Sep-95	18-Sep-95	23-Sep-95	20-Sep-95	21-Sep-95	24-Sep-95
	Dilution:	2.44	1.18	1.22	1.14	1.19	1.3	1.09
ANALYTES	**Reporting Limit**							
Vinyl Chloride	2 µg/kg/250µg/kg	NA	NA	NA	NA	NA	NA	NA
1,1-DCE	5 µg/kg/250µg/kg	12 U	5.9 U	6.1 U	5.7 UJ	6.0 U	6.5 U	5.5 U
t-1,2-DCE	2 µg/kg/250µg/kg	NA	NA	NA	NA	NA	NA	NA
c-1,2-DCE	2 µg/kg/250µg/kg	NA	NA	NA	NA	NA	NA	NA
Chloroform	2 µg/kg/250µg/kg	4.9 U	2.4 U	2.4 U	2.3 U	2.4 U	NA	2.2 U
1,1,1-TCA	2 µg/kg/250µg/kg	4.9 U	2.4 U	2.4 U	2.3 U	2.4 U	2.6 U	2.2 U
Carbon Tetrachloride	2 µg/kg/250µg/kg	4.9 U	2.4 U	2.4 UJ	2.3 U	2.4 U	2.6 U	2.2 U
Trichloroethene	2 µg/kg/250µg/kg	4.9 U	2.4 U	2.5	2.3 U	2.4 U	2.6 U	2.2 U
Tetrachloroethene	2 µg/kg/250µg/kg	4.9 UJ	2.4 UJ	2.4 U	2.3 U	2.4 U	2.6 U	2.2 UJ
1,3-DCB	2 µg/kg/250µg/kg	NA	NA	NA	NA	NA	NA	NA
1,4-DCB	2 µg/kg/250µg/kg	NA	NA	NA	NA	NA	NA	NA
1,2-DCB	2 µg/kg/250µg/kg	NA	NA	NA	NA	NA	NA	NA
Benzene	2 µg/kg/250µg/kg	4.9 U	2.4 U	2.4 U	2.3 U	2.4 U	2.6 U	2.2 U
Toluene	2 µg/kg/250µg/kg	4.9 U	2.4 U	2.4 U	2.3 U	2.4 U	2.6 U	2.2 U
Chlorobenzene	2 µg/kg/250µg/kg	4.9 UJ	2.4 UJ	2.4 U	2.3 U	2.4 UJ	2.6 U	2.2 UJ
Ethylbenzene	2 µg/kg/250µg/kg	4.9 U	2.4 U	2.4 U	2.3 U	2.4 U	2.6 U	2.2 U
m/p-Xylene	4 µg/kg/500µg/kg	9.8 UJ	4.7 UJ	4.9 UJ	4.6 UJ	4.8 UJ	5.2 UJ	4.4 UJ
o-Xylene	2 µg/kg/250µg/kg	4.9 U	2.4 U	2.4 U	2.3 U	2.4 U	2.6 U	2.2 U
Naphthalene	2 µg/kg/250µg/kg	NA	NA	NA	NA	NA	NA	NA
TPH-dro	100 mg/kg	NA	NA	120 U	NA	NA	NA	NA
TPH-gro	100 µg/kg	240 U	120 U	NA	110 U	120 U	130 U	110 U
TPH-ir (95)	50 mg/kg	120 U	59 U	61 U	57 U	60 U	64	55 U
TPHC (96)	50 mg/kg	NA	NA	NA	NA	NA	NA	NA

TABLE 7-10
SUBSURFACE SOIL FIELD ANALYTICAL RESULTS
AOC 69W

REMEDIAL INVESTIGATION REPORT
DEVENS, MASSACHUSETTS

	Site ID:	**ZWR-95-40X**	**ZWR-95-40X**	**ZWR-95-40X**	**ZWR-95-41X**	**ZWR-95-41X**	**ZWR-95-41X**	**ZWR-95-42X**
	Depth (ft bgs):	**3**	**6**	**10**	**3**	**6**	**10**	**3**
	Date analyzed:	**24-Sep-95**	**24-Sep-95**	**19-Sep-95**	**23-Sep-95**	**18-Sep-95**	**19-Sep-95**	**23-Sep-95**
	Dilution:	**1.11**	**1.15**	**1.13**	**1.23**	**1.23**	**1.19**	**1.22**
ANALYTES	**Reporting Limit**							
Vinyl Chloride	2 µg/kg/250µg/kg	NA	NA	NA	NA	NA	NA	NA
1,1-DCE	5 µg/kg/250µg/kg	5.6 U	5.8 U	5.7 U	6.2 UJ	6.2 U	6.0 U	6.1 UJ
t-1,2-DCE	2 µg/kg/250µg/kg	NA	NA	NA	NA	NA	NA	NA
c-1,2-DCE	2 µg/kg/250µg/kg	NA	NA	NA	NA	NA	NA	NA
Chloroform	2 µg/kg/250µg/kg	2.2 U	2.3 U	NA	2.5 U	2.5 U	2.4 U	2.4 U
1,1,1-TCA	2 µg/kg/250µg/kg	2.2 U	2.3 U	2.3 U	2.5 U	2.5 U	2.4 U	2.4 U
Carbon Tetrachloride	2 µg/kg/250µg/kg	2.2 U	2.3 U	2.3 UJ	2.5 U	2.5 UJ	2.4 UJ	2.4 U
Trichloroethene	2 µg/kg/250µg/kg	2.2 U	2.3 U	2.3 U	2.5 U	2.5 U	2.4 U	2.4 U
Tetrachloroethene	2 µg/kg/250µg/kg	2.2 UJ	2.3 UJ	2.3 U	2.5 U	2.5 U	2.4 U	2.4 U
1,3-DCB	2 µg/kg/250µg/kg	NA	NA	NA	NA	NA	NA	NA
1,4-DCB	2 µg/kg/250µg/kg	NA	NA	NA	NA	NA	NA	NA
1,2-DCB	2 µg/kg/250µg/kg	NA	NA	NA	NA	NA	NA	NA
Benzene	2 µg/kg/250µg/kg	2.2 U	2.3 U	2.3 U	2.5 U	2.5 U	2.4 U	2.4 U
Toluene	2 µg/kg/250µg/kg	2.2 U	2.3 U	2.3 U	2.5 U	2.5 U	2.4 U	2.4 U
Chlorobenzene	2 µg/kg/250µg/kg	2.2 UJ	2.3 UJ	2.3 U	2.5 U	2.5 U	2.4 U	2.4 U
Ethylbenzene	2 µg/kg/250µg/kg	2.2 U	2.3 U	2.3 U	2.5 U	2.5 U	2.4 U	2.4 U
m/p-Xylene	4 µg/kg/500µg/kg	4.4 UJ	4.6 UJ	4.5 UJ	4.9 UJ	4.9 UJ	4.8 UJ	4.9 UJ
o-Xylene	2 µg/kg/250µg/kg	2.2 U	2.3 U	2.3 U	2.5 U	2.5 U	2.4 U	2.4 U
Naphthalene	2 µg/kg/250µg/kg	NA	NA	NA	NA	NA	NA	NA
TPH-dro	100 mg/kg	NA	NA	NA	NA	NA	120 U	NA
TPH-gro	100 µg/kg	110 U	120 U	NA	120 U	NA	NA	120 U
TPH-ir (95)	50 mg/kg	56 U	73 J	57 J	62 U	62 U	60 U	61 U
TPHC (96)	50 mg/kg	NA	NA	NA	NA	NA	NA	NA

TABLE 7-10
SUBSURFACE SOIL FIELD ANALYTICAL RESULTS
AOC 69W

REMEDIAL INVESTIGATION REPORT
DEVENS, MASSACHUSETTS

	Site ID:	**ZWR-95-42X**	**ZWR-95-42X**	**ZWR-95-43X**	**ZWR-95-43X**	**ZWR-95-43X**	**ZWR-95-44X**	**ZWR-95-44X**
	Depth (ft bgs):	**6**	**10**	**3**	**6**	**10**	**0**	**4**
	Date analyzed:	**24-Sep-95**	**19-Sep-95**	**18-Sep-95**	**18-Sep-95**	**24-Sep-95**	**25-Sep-95**	**18-Sep-95**
	Dilution:	**1.21**	**1.21**	**1.04**	**1.25**	**1.2**	**1.04**	**1.1**
ANALYTES	**Reporting Limit**							
Vinyl Chloride	2 µg/kg/250µg/kg	NA	NA	NA	NA	NA	NA	NA
1,1-DCE	5 µg/kg/250µg/kg	6.1 U	6.1 U	5.2 U	6.3 U	6.0 U	5.2 U	5.5 U
t-1,2-DCE	2 µg/kg/250µg/kg	NA	NA	NA	NA	NA	NA	NA
c-1,2-DCE	2 µg/kg/250µg/kg	NA	NA	NA	NA	NA	NA	NA
Chloroform	2 µg/kg/250µg/kg	2.4 U	2.4 U	2.1 U	2.5 U	2.4 U	2.1 U	2.2 U
1,1,1-TCA	2 µg/kg/250µg/kg	2.4 U	2.4 U	2.1 U	2.5 U	2.4 U	2.1 U	2.2 U
Carbon Tetrachloride	2 µg/kg/250µg/kg	2.4 U	2.4 UJ	2.1 UJ	2.5 UJ	2.4 U	2.1 U	2.2 UJ
Trichloroethene	2 µg/kg/250µg/kg	2.4 U	2.4 U	2.1 U	2.5 U	2.4 U	2.1 U	2.2 U
Tetrachloroethene	2 µg/kg/250µg/kg	2.4 UJ	2.4 U	2.1 U	2.5 U	2.4 UJ	2.1 U	2.2 U
1,3-DCB	2 µg/kg/250µg/kg	NA	NA	NA	NA	NA	NA	NA
1,4-DCB	2 µg/kg/250µg/kg	NA	NA	NA	NA	NA	NA	NA
1,2-DCB	2 µg/kg/250µg/kg	NA	NA	NA	NA	NA	NA	NA
Benzene	2 µg/kg/250µg/kg	2.4 U	2.4 U	2.1 U	2.5 U	2.4 U	2.1 U	2.2 U
Toluene	2 µg/kg/250µg/kg	2.4 U	2.4 U	2.1 U	2.5 U	2.4 U	2.6	2.2 U
Chlorobenzene	2 µg/kg/250µg/kg	2.4 UJ	2.4 U	2.1 U	2.5 U	2.4 UJ	2.2	2.2 U
Ethylbenzene	2 µg/kg/250µg/kg	2.4 U	2.4 U	2.1 U	2.5 U	2.4 U	2.1 U	2.2 U
m/p-Xylene	4 µg/kg/500µg/kg	4.8 UJ	4.8 UJ	4.2 UJ	5.0 UJ	4.8 UJ	4.2 U	4.4 UJ
o-Xylene	2 µg/kg/250µg/kg	2.4 U	2.4 U	2.1 U	2.5 U	2.4 U	2.1 U	2.2 U
Naphthalene	2 µg/kg/250µg/kg	NA	NA	NA	NA	NA	NA	NA
TPH-dro	100 mg/kg	NA	120 U	100 U	NA	NA	NA	NA
TPH-gro	100 µg/kg	120 U	NA	NA	NA	120 U	100 U	NA
TPH-ir (95)	50 mg/kg	61 U	61 U	52 U	63 U	53	86	55 U
TPHC (96)	50 mg/kg	NA	NA	NA	NA	NA	NA	NA

TABLE 7-10
SUBSURFACE SOIL FIELD ANALYTICAL RESULTS
AOC 69W

REMEDIAL INVESTIGATION REPORT
DEVENS, MASSACHUSETTS

	Site ID:	**ZWR-95-44X**	**ZWR-95-44X**	**ZWR-95-45X**	**ZWR-95-45X**	**ZWR-95-45X**	**ZWR-95-45X**	**ZWR-95-45X**
	Depth (ft bgs):	**6**	**10**	**0**	**1**	**4**	**6**	**10**
	Date analyzed:	**18-Sep-95**	**18-Sep-95**	**24-Sep-95**	**25-Sep-95**	**25-Sep-95**	**18-Sep-95**	**18-Sep-95**
	Dilution:	**1.18**	**1.22**	**1.31**	**1.17**	**1.22**	**1.19**	**1.19**
ANALYTES	**Reporting Limit**							
Vinyl Chloride	2 µg/kg/250µg/kg	NA	NA	NA	NA	NA	NA	NA
1,1-DCE	5 µg/kg/250µg/kg	5.9 U	6.1 U	6.6 U	5.9 U	6.1 U	6.0 U	6.0 U
t-1,2-DCE	2 µg/kg/250µg/kg	NA	NA	NA	NA	NA	NA	NA
c-1,2-DCE	2 µg/kg/250µg/kg	NA	NA	NA	NA	NA	NA	NA
Chloroform	2 µg/kg/250µg/kg	2.4 U	2.4 U	2.6 U	2.3 U	2.4 U	2.4 U	2.4 U
1,1,1-TCA	2 µg/kg/250µg/kg	2.4 U	2.4 U	2.6 U	2.3 U	2.4 U	2.4 U	2.4 U
Carbon Tetrachloride	2 µg/kg/250µg/kg	2.4 UJ	2.4 UJ	2.6 U	2.3 U	2.4 U	2.4 UJ	2.4 UJ
Trichloroethene	2 µg/kg/250µg/kg	2.4 U	2.4 U	2.6 U	2.3 U	2.4 U	2.4 U	2.4 U
Tetrachloroethene	2 µg/kg/250µg/kg	2.4 U	2.4 U	2.6 U	2.3 U	2.4 U	2.4 U	2.4 U
1,3-DCB	2 µg/kg/250µg/kg	NA	NA	NA	NA	NA	NA	NA
1,4-DCB	2 µg/kg/250µg/kg	NA	NA	NA	NA	NA	NA	NA
1,2-DCB	2 µg/kg/250µg/kg	NA	NA	NA	NA	NA	NA	NA
Benzene	2 µg/kg/250µg/kg	2.4 U	2.4 U	2.6 U	2.3 U	2.4 U	2.4 U	2.4 U
Toluene	2 µg/kg/250µg/kg	2.4 U	2.4 U	2.6 U	2.4	2.4 U	2.4 U	2.4 U
Chlorobenzene	2 µg/kg/250µg/kg	2.4 U	2.4 U	2.6 U	4.1	2.4 U	2.4 U	2.4 U
Ethylbenzene	2 µg/kg/250µg/kg	2.4 U	2.4 U	2.6 U	12	2.4 U	2.4 U	2.4 U
m/p-Xylene	4 µg/kg/500µg/kg	4.7 UJ	4.9 UJ	5.2 UJ	13	4.9 U	4.8 UJ	4.8 UJ
o-Xylene	2 µg/kg/250µg/kg	2.4 U	2.4 U	2.6 U	12	2.4 U	2.4 U	2.4 U
Naphthalene	2 µg/kg/250µg/kg	NA	NA	NA	NA	NA	NA	NA
TPH-dro	100 mg/kg	NA	NA	NA	2400	120 U	NA	NA
TPH-gro	100 µg/kg	NA	NA	130 U	83000 E	11000 E	NA	NA
TPH-ir (95)	50 mg/kg	59 U	61 U	66 U	3400	61 U	59 J	59 J
TPHC (96)	50 mg/kg	NA	NA	NA	NA	NA	NA	NA

TABLE 7-10
SUBSURFACE SOIL FIELD ANALYTICAL RESULTS
AOC 69W

REMEDIAL INVESTIGATION REPORT
DEVENS, MASSACHUSETTS

	Site ID:	ZWR-95-46X	ZWR-95-46X	ZWR-95-46X	ZWR-95-46X	ZWR-95-47X	ZWR-95-47X	ZWR-95-47X
	Depth (ft bgs):	0	4	6	10	0	4	6
	Date analyzed:	23-Sep-95	19-Sep-95	19-Sep-95	20-Sep-95	18-Sep-95	25-Sep-95	18-Sep-95
	Dilution:	1.04	1.12	1.18	1.14	1.04	1.15	1.18
ANALYTES	**Reporting Limit**							
Vinyl Chloride	2 µg/kg/250µg/kg	NA	NA	NA	NA	NA	NA	NA
1,1-DCE	5 µg/kg/250µg/kg	5.2 UJ	5.6 U	5.9 U	5.7 U	5.2 U	5.8 U	5.9 U
t-1,2-DCE	2 µg/kg/250µg/kg	NA	NA	NA	NA	NA	NA	NA
c-1,2-DCE	2 µg/kg/250µg/kg	NA	NA	NA	NA	NA	NA	NA
Chloroform	2 µg/kg/250µg/kg	2.1 U	2.2 U	2.4 U	2.3 U	2.1 U	2.5	2.4 U
1,1,1-TCA	2 µg/kg/250µg/kg	2.1 U	2.2 U	2.4 U	2.3 U	2.1 U	2.3 U	2.4 U
Carbon Tetrachloride	2 µg/kg/250µg/kg	2.1 U	2.2 UJ	2.4 UJ	2.3 U	2.1 UJ	2.3 U	2.4 UJ
Trichloroethene	2 µg/kg/250µg/kg	2.1 U	2.2 U	2.4 U	2.3 U	2.1 U	2.3 U	2.4 U
Tetrachloroethene	2 µg/kg/250µg/kg	2.1 U	2.2 U	2.4 U	2.3 U	2.1 U	2.3 U	2.4 U
1,3-DCB	2 µg/kg/250µg/kg	NA	NA	NA	NA	NA	NA	NA
1,4-DCB	2 µg/kg/250µg/kg	NA	NA	NA	NA	NA	NA	NA
1,2-DCB	2 µg/kg/250µg/kg	NA	NA	NA	NA	NA	NA	NA
Benzene	2 µg/kg/250µg/kg	2.1 U	2.2 U	2.4 U	2.3 U	2.1 U	2.3 U	2.4 U
Toluene	2 µg/kg/250µg/kg	2.1 U	2.2 U	2.4 U	2.3 U	2.1 U	2.3 U	2.4 U
Chlorobenzene	2 µg/kg/250µg/kg	6.7	2.2 U	2.4 U	2.3 UJ	2.1 U	2.3 U	2.4 U
Ethylbenzene	2 µg/kg/250µg/kg	5.6	2.2 U	2.4 U	2.3 U	2.1 U	2.3 U	2.4 U
m/p-Xylene	4 µg/kg/500µg/kg	7.2 J	4.5 UJ	4.7 UJ	4.6 UJ	4.2 UJ	4.6 U	4.7 UJ
o-Xylene	2 µg/kg/250µg/kg	11	2.2 U	2.4 U	2.3 U	2.1 U	2.3 U	2.4 U
Naphthalene	2 µg/kg/250µg/kg	NA	NA	NA	NA	NA	NA	NA
TPH-dro	100 mg/kg	NA	NA	NA	NA	NA	NA	NA
TPH-gro	100 µg/kg	100 U	NA	NA	110 U	NA	120 U	NA
TPH-ir (95)	50 mg/kg	460	56 U	59 U	57 U	98	58 U	59 U
TPHC (96)	50 mg/kg	NA	NA	NA	NA	NA	NA	NA

TABLE 7-10
SUBSURFACE SOIL FIELD ANALYTICAL RESULTS
AOC 69W

REMEDIAL INVESTIGATION REPORT
DEVENS, MASSACHUSETTS

	Site ID:	**ZWR-95-47X**	**ZWR-95-48X**	**ZWR-95-48X**	**ZWR-95-48X**	**ZWR-95-48X**	**ZWR-95-49X**	**ZWR-95-49X**
	Depth (ft bgs):	**10**	**0**	**1**	**3**	**8**	**0**	**2**
	Date analyzed:	**18-Sep-95**	**25-Sep-95**	**18-Sep-95**	**25-Sep-95**	**28-Sep-95**	**28-Sep-95**	**25-Sep-95**
	Dilution:	**1.18**	**1.41**	**1.15**	**1.2**	**1.28**	**1.32**	**1.23**
ANALYTES	**Reporting Limit**							
Vinyl Chloride	2 µg/kg/250µg/kg	NA	NA	NA	NA	NA	NA	NA
1,1-DCE	5 µg/kg/250µg/kg	5.9 U	7.1 U	5.8 U	6.0 U	6.4 U	6.6 U	6.2 U
t-1,2-DCE	2 µg/kg/250µg/kg	NA	NA	NA	NA	NA	NA	NA
c-1,2-DCE	2 µg/kg/250µg/kg	NA	NA	NA	NA	NA	NA	NA
Chloroform	2 µg/kg/250µg/kg	2.4 U	2.8 U	2.3 U	2.4 U	2.6 U	2.6 U	2.5 U
1,1,1-TCA	2 µg/kg/250µg/kg	2.4 U	2.8 U	2.3 U	2.4 U	2.6 U	2.6 U	2.5 U
Carbon Tetrachloride	2 µg/kg/250µg/kg	2.4 UJ	2.8 U	2.3 UJ	2.4 U	2.6 U	2.6 U	2.5 U
Trichloroethene	2 µg/kg/250µg/kg	2.4 U	2.8 U	2.3 U	2.4 U	2.6 U	2.6 U	2.5 U
Tetrachloroethene	2 µg/kg/250µg/kg	2.4 U	2.8 U	2.3 U	2.4 U	2.6 U	2.6 U	2.5 U
1,3-DCB	2 µg/kg/250µg/kg	NA	NA	NA	NA	NA	NA	NA
1,4-DCB	2 µg/kg/250µg/kg	NA	NA	NA	NA	NA	NA	NA
1,2-DCB	2 µg/kg/250µg/kg	NA	NA	NA	NA	NA	NA	NA
Benzene	2 µg/kg/250µg/kg	2.4 U	2.8 U	2.3 U	2.4 U	2.6 U	2.6 U	2.5 U
Toluene	2 µg/kg/250µg/kg	2.4 U	2.8 U	2.3 U	2.4 U	2.6 U	2.6 U	2.5 U
Chlorobenzene	2 µg/kg/250µg/kg	2.4 U	2.8 U	2.3 U	2.4 U	2.6 U	2.6 U	2.5 U
Ethylbenzene	2 µg/kg/250µg/kg	2.4 U	2.8 U	2.3 U	2.4 U	2.6 U	2.6 U	2.5 U
m/p-Xylene	4 µg/kg/500µg/kg	4.7 UJ	5.6 U	4.6 UJ	4.8 U	5.1 U	5.3 U	4.9 U
o-Xylene	2 µg/kg/250µg/kg	2.4 U	2.8 U	2.3 U	2.4 U	2.6 U	2.6 U	2.5 U
Naphthalene	2 µg/kg/250µg/kg	NA	NA	NA	NA	NA	NA	NA
TPH-dro	100 mg/kg	NA	NA	NA	NA	NA	NA	NA
TPH-gro	100 µg/kg	NA	140 U	NA	120 U	130 U	130 U	2500 E
TPH-ir (95)	50 mg/kg	59 U	71 U	58 U	130	64 U	140	62 U
TPHC (96)	50 mg/kg	NA	NA	NA	NA	NA	NA	NA

TABLE 7-10
SUBSURFACE SOIL FIELD ANALYTICAL RESULTS
AOC 69W

REMEDIAL INVESTIGATION REPORT
DEVENS, MASSACHUSETTS

	Site ID: **Depth (ft bgs):** **Date analyzed:** **Dilution:**	**ZWR-95-49X** **4** **28-Sep-95** **1.25**	**ZWR-95-49X** **10** **28-Sep-95** **1.21**	**ZWR-95-50X** **4** **25-Sep-95** **1.1**	**ZWR-95-50X** **6** **28-Sep-95** **1.12**	**ZWR-95-50X** **10** **28-Sep-95** **1.22**	**ZWR-95-51X** **4** **28-Sep-95** **1.03**	**ZWR-95-51X** **10** **28-Sep-95** **1.02**
ANALYTES	**Reporting Limit**							
Vinyl Chloride	2 µg/kg/250µg/kg	NA	NA	NA	NA	NA	NA	NA
1,1-DCE	5 µg/kg/250µg/kg	6.3 U	6.1 U	5.5 U	5.6 U	6.1 U	5.2 U	5.1 U
t-1,2-DCE	2 µg/kg/250µg/kg	NA	NA	NA	NA	NA	NA	NA
c-1,2-DCE	2 µg/kg/250µg/kg	NA	NA	NA	NA	NA	NA	NA
Chloroform	2 µg/kg/250µg/kg	2.5 U	2.4 U	2.2 U	2.2 U	2.4 U	2.1 U	2.0 U
1,1,1-TCA	2 µg/kg/250µg/kg	2.5 U	2.4 U	2.2 U	2.2 U	2.4 U	2.1 U	2.0 U
Carbon Tetrachloride	2 µg/kg/250µg/kg	2.5 U	2.4 U	2.2 U	2.2 U	2.4 U	2.1 U	2.0 U
Trichloroethene	2 µg/kg/250µg/kg	2.5 U	2.4 U	2.2 U	2.2 U	2.4 U	2.1 U	2.0 U
Tetrachloroethene	2 µg/kg/250µg/kg	2.5 U	2.4 U	2.2 U	2.2 U	2.4 U	2.1 U	2.0 U
1,3-DCB	2 µg/kg/250µg/kg	NA	NA	NA	NA	NA	NA	NA
1,4-DCB	2 µg/kg/250µg/kg	NA	NA	NA	NA	NA	NA	NA
1,2-DCB	2 µg/kg/250µg/kg	NA	NA	NA	NA	NA	NA	NA
Benzene	2 µg/kg/250µg/kg	2.5 U	2.4 U	2.2 U	2.2 U	2.4 U	2.1 U	2.0 U
Toluene	2 µg/kg/250µg/kg	2.5 U	2.4 U	2.2 U	2.2 U	2.4 UJ	2.1 UJ	2.0 UJ
Chlorobenzene	2 µg/kg/250µg/kg	2.5 U	2.4 U	2.2 U	2.2 U	2.4 U	2.1 U	2.0 U
Ethylbenzene	2 µg/kg/250µg/kg	2.5 U	2.4 U	2.2 U	2.2 U	2.4 U	2.1 U	2.0 U
m/p-Xylene	4 µg/kg/500µg/kg	5.0 U	4.8 U	4.4 U	4.5 U	4.9 U	4.1 U	4.1 U
o-Xylene	2 µg/kg/250µg/kg	2.5 U	2.4 U	2.2 U	2.2 U	2.4 U	2.1 U	2.0 U
Naphthalene	2 µg/kg/250µg/kg	NA	NA	NA	NA	NA	NA	NA
TPH-dro	100 mg/kg	130 U	NA	110 U	NA	NA	NA	NA
TPH-gro	100 µg/kg	130 U	120 U	110 U	110 U	120 U	100 U	100 U
TPH-ir (95)	50 mg/kg	63 U	61 U	160	56 U	61 U	52 U	79
TPHC (96)	50 mg/kg	NA	NA	NA	NA	NA	NA	NA

TABLE 7-10
SUBSURFACE SOIL FIELD ANALYTICAL RESULTS
AOC 69W

REMEDIAL INVESTIGATION REPORT
DEVENS, MASSACHUSETTS

	Site ID:	ZWR-95-51X	ZWR-95-52X	ZWR-95-52X	ZWR-95-52X	ZWR-95-53X	ZWR-95-53X	ZWR-95-53X
	Depth (ft bgs):	18	4	6	10	3	7	10
	Date analyzed:	28-Sep-95	21-Sep-95	21-Sep-95	21-Sep-95	21-Sep-95	21-Sep-95	21-Sep-95
	Dilution:	1.25	1.19	1.19	1.22	1.22	1.23	1.3
ANALYTES	**Reporting Limit**							
Vinyl Chloride	2 µg/kg/250µg/kg	NA	NA	NA	NA	NA	NA	NA
1,1-DCE	5 µg/kg/250µg/kg	6.3 U	6.0 U	6.0 U	6.1 U	6.1 U	6.2 U	6.5 U
t-1,2-DCE	2 µg/kg/250µg/kg	NA	NA	NA	NA	NA	NA	NA
c-1,2-DCE	2 µg/kg/250µg/kg	NA	NA	NA	NA	NA	NA	NA
Chloroform	2 µg/kg/250µg/kg	2.5 U	NA	2.4 U	2.4 U	NA	2.5 U	NA
1,1,1-TCA	2 µg/kg/250µg/kg	2.5 U	2.4 U	2.4 U	2.4 U	2.4 U	2.5 U	2.6 U
Carbon Tetrachloride	2 µg/kg/250µg/kg	2.5 U	2.4 U	2.4 U	2.4 U	2.4 U	2.5 U	2.6 U
Trichloroethene	2 µg/kg/250µg/kg	2.5 U	2.4 U	2.4 U	2.4 U	2.4 U	2.5 U	2.6 U
Tetrachloroethene	2 µg/kg/250µg/kg	2.5 U	2.4 U	2.4 U	2.4 U	2.4 U	2.5 U	2.6 U
1,3-DCB	2 µg/kg/250µg/kg	NA	NA	NA	NA	NA	NA	NA
1,4-DCB	2 µg/kg/250µg/kg	NA	NA	NA	NA	NA	NA	NA
1,2-DCB	2 µg/kg/250µg/kg	NA	NA	NA	NA	NA	NA	NA
Benzene	2 µg/kg/250µg/kg	2.5 U	2.4 U	2.4 U	2.4 U	2.4 U	2.5 U	2.6 U
Toluene	2 µg/kg/250µg/kg	2.5 U	2.4 U	2.4 U	2.4 U	2.4 U	2.5 U	2.6 U
Chlorobenzene	2 µg/kg/250µg/kg	2.5 U	2.4 U	2.4 U	2.4 U	2.4 U	2.5 U	2.6 U
Ethylbenzene	2 µg/kg/250µg/kg	2.5 U	2.4 U	2.4 U	2.4 U	2.4 U	2.5 U	2.6 U
m/p-Xylene	4 µg/kg/500µg/kg	5.0 U	4.8 UJ	4.8 UJ	4.9 UJ	4.9 UJ	4.9 UJ	5.2 UJ
o-Xylene	2 µg/kg/250µg/kg	2.5 U	2.4 U	2.4 U	2.4 U	2.4 U	2.5 U	2.6 U
Naphthalene	2 µg/kg/250µg/kg	NA	NA	NA	NA	NA	NA	NA
TPH-dro	100 mg/kg	NA	NA	NA	120 U	NA	NA	NA
TPH-gro	100 µg/kg	130 U	120 U	120 U	120 U	120 U	120 U	130 U
TPH-ir (95)	50 mg/kg	63 U	59	60 U	61 U	54	62 U	65 U
TPHC (96)	50 mg/kg	NA	NA	NA	NA	NA	NA	NA

TABLE 7-10
SUBSURFACE SOIL FIELD ANALYTICAL RESULTS
AOC 69W

REMEDIAL INVESTIGATION REPORT
DEVENS, MASSACHUSETTS

	Site ID:	ZWR-95-54X	ZWR-95-54X	ZWR-95-55X	ZWR-95-55X
	Depth (ft bgs):	6	8	6	8
	Date analyzed:	11-Oct-95	11-Oct-95	11-Oct-95	11-Oct-95
	Dilution:	1.22	1.26	1.1	1.13
ANALYTES	**Reporting Limit**				
Vinyl Chloride	2 µg/kg/250µg/kg	NA	NA	NA	NA
1,1-DCE	5 µg/kg/250µg/kg	6.1 UJ	6.3 UJ	5.5 UJ	5.7 UJ
t-1,2-DCE	2 µg/kg/250µg/kg	NA	NA	NA	NA
c-1,2-DCE	2 µg/kg/250µg/kg	NA	NA	NA	NA
Chloroform	2 µg/kg/250µg/kg	2.4 U	2.5 UJ	2.2 U	2.3 U
1,1,1-TCA	2 µg/kg/250µg/kg	2.4 U	2.5 U	2.2 U	2.3 U
Carbon Tetrachloride	2 µg/kg/250µg/kg	2.4 U	2.5 U	2.2 U	2.3 U
Trichloroethene	2 µg/kg/250µg/kg	2.4 U	2.5 U	2.2 U	2.3 U
Tetrachloroethene	2 µg/kg/250µg/kg	2.4 U	2.5 U	2.2 U	2.3 U
1,3-DCB	2 µg/kg/250µg/kg	NA	NA	NA	NA
1,4-DCB	2 µg/kg/250µg/kg	NA	NA	NA	NA
1,2-DCB	2 µg/kg/250µg/kg	NA	NA	NA	NA
Benzene	2 µg/kg/250µg/kg	2.4 U	2.5 U	2.2 U	2.3 U
Toluene	2 µg/kg/250µg/kg	2.4 U	2.5 U	2.2 U	2.3 U
Chlorobenzene	2 µg/kg/250µg/kg	2.4 U	2.5 U	2.2 U	2.3 U
Ethylbenzene	2 µg/kg/250µg/kg	2.4 U	2.5 U	2.2 U	2.3 U
m/p-Xylene	4 µg/kg/500µg/kg	4.9 U	5.0 U	4.4 U	4.5 U
o-Xylene	2 µg/kg/250µg/kg	2.4 U	2.5 U	2.2 U	2.3 U
Naphthalene	2 µg/kg/250µg/kg	NA	NA	NA	NA
TPH-dro	100 mg/kg	NA	NA	NA	NA
TPH-gro	100 µg/kg	120 U	130 U	110 U	110 U
TPH-ir (95)	50 mg/kg	61 U	63 U	55 U	57 U
TPHC (96)	50 mg/kg	NA	NA	NA	NA

TABLE 7 - 11
RI SOIL OFF-SITE ANALYTICAL RESULTS
AOC 69W

REMEDIAL INVESTIGATION REPORT
DEVENS, MASSACHUSETS

Site ID:		ZWB-95-01X		ZWB-95-01X	ZWB-95-01X	ZWB-95-02X	ZWB-95-02X	ZWB-96-03X
Field Sample Number:		BDZW0100		BXZW0100	BXZW0107	BXZW0200	BXZW0205	BXZW0306
Lab Sample Number:	DEVENS	DV4S*435		DV4S*246	DV4S*247	DV4S*248	DV4S*250	DV4S*500
Sample Date:	BACKGROUND	09/19/95		09/19/95	09/19/95	09/19/95	09/19/95	08/23/96
Depth:	CONCENTRATION	0		0	7	0	5	6
Units:	(µg/g)	(µg/g)		(µg/g)	(µg/g)	(µg/g)	(µg/g)	(µg/g)
PAL METALS								
Aluminum	18,000	5690	D	6140	13700	7180	6140	
Arsenic	19	10.6	D	14	28.2	11	16	
Barium	54	17	D	19	32.9	18.4	14.1	
Beryllium	0.81	< .5	D	.565	< .5	< .5	.568	
Calcium	810	600	D	803	1410	478	522	
Chromium	33	14.1	D	16.4	28.8	15.7	16.3	
Cobalt	4.7	4.81	D	4.08	45	4.98	4.09	
Copper	13.5	7.47	D	9.43	18.9	8.4	10.6	
Iron	18,000	10300	D	8070	16300	10700	10600	
Lead	48	7.53	D	6.91	14.9	21.7	8.57	
Magnesium	5,500	1990	D	2150	4060	2130	2520	
Manganese	380	228	D	152	367	249	117	
Mercury		< .05	D	< .05	< .05	< .05	< .05	
Nickel	14.6	14	D	13.3	33.3	13.7	16.1	
Potassium	2,400	684	D	872	1430	483	724	
Selenium		< .25	D	< .25	< .25	< .25	< .25	
Sodium	131	305	D	374	1470	323	317	
Vanadium	32.2	10	D	10.7	20.5	12.9	12.6	
Zinc	43.9	18.8	D	20.8	48.5	26.1	21.6	
SEMIVOLATILE ORGANICS								
2-methylnaphthalene		< .2	D	< .2	80	< .2	< .049	
Acenaphthene		< .2	D	< .2	8	< .2	< .036	
Acenaphthylene		< .2	D	< .2	< .2	< .2	< .033	
Anthracene		< .2	D	< .2	< .2	< .2	< .033	
Benzo[k]fluoranthene		< .3	D	< .3	< .3	< .3	< .066	
Chrysene		< .6	D	< .6	< .6	< .6	< .12	
Fluoranthene		< .3	D	< .3	< .3	< .3	< .068	
Fluorene		< .2	D	< .2	9	< .2	.37	
Naphthalene		< .2	D	< .2	40	< .2	< .037	
Phenanthrene		< .2	D	< .2	10	< .2	.56	
Pyrene		< .2	D	< .2	2	< .2	.12	
Bis(2-ethylhexyl) Phthalate		< 3	D	< 3	< 3	< 3	< .62	
VOLATILE ORGANICS								
1,1,2,2-tetrachloroethane		< .0024	D	< .0024	< .0024	< .0024	.009	
Acetone		< .017	D	< .017	< .017	< .017	< .017	
Dichloromethane		< .012	D	< .012	< .012	< .012	< .012	
Ethylbenzene		< .0017	D	< .0017	.31	< .0017	< .0017	
Styrene		< .0026	D	< .0026	< .0026	< .0026	< .0026	
Toluene		< .00078	D	.0035	< .00078	< .00078	< .00078	
Trichlorofluoromethane		.0063	D	.014	.022	.0077	.0059	
Xylenes		< .0015	D	< .0015	.17	< .0015	< .0015	
OTHER								
Total Organic Carbon								
Total Petroleum Hydrocarbons		598	D	661	14400	98	1390	57.5

TABLE 7 - 11
RI SOIL OFF-SITE ANALYTICAL RESULTS
AOC 69W

REMEDIAL INVESTIGATION REPORT
DEVENS, MASSACHUSETS

Site ID:	DEVENS BACKGROUND CONCENTRATION	ZWM-95-15X	ZWM-95-16X	ZWM-95-18X	ZWM-96-19X	ZWM-96-20X	ZWM-96-21X
Field Sample Number:		BXZW1504	BXZW1607	BXZW1804	BXZW1909	BXZW2004	BXZW2108
Lab Sample Number:		DV4S*265	DV4S*266	DV4S*268	DV4S*505	DV4S*507	DV4S*509
Sample Date:		09/19/95	09/20/95	10/02/95	08/21/96	08/22/96	08/26/96
Depth:		4	7	4	9	4	8
Units:	(µg/g)	(µg/g)	(µg/g)	(µg/g)	(µg/g)	(µg/g)	(µg/g)
PAL METALS							
Aluminum	18,000						
Arsenic	19						
Barium	54						
Beryllium	0.81						
Calcium	810						
Chromium	33						
Cobalt	4.7						
Copper	13.5						
Iron	18,000						
Lead	48						
Magnesium	5,500						
Manganese	380						
Mercury							
Nickel	14.6						
Potassium	2,400						
Selenium							
Sodium	131						
Vanadium	32.2						
Zinc	43.9						
SEMIVOLATILE ORGANICS							
2-methylnaphthalene							
Acenaphthene							
Acenaphthylene							
Anthracene							
Benzo[k]fluoranthene							
Chrysene							
Fluoranthene							
Fluorene							
Naphthalene							
Phenanthrene							
Pyrene							
Bis(2-ethylhexyl) Phthalate							
VOLATILE ORGANICS							
1,1,2,2-tetrachloroethane							
Acetone							
Dichloromethane							
Ethylbenzene							
Styrene							
Toluene							
Trichlorofluoromethane							
Xylenes							
OTHER							
Total Organic Carbon		8740	671	758	2140	622	1180
Total Petroleum Hydrocarbons					1740	< 27.8	< 27.8

TABLE 7 - 11
RI SOIL OFF-SITE ANALYTICAL RESULTS
AOC 69W

REMEDIAL INVESTIGATION REPORT
DEVENS, MASSACHUSETS

Site ID:		ZWR-95-26X	ZWR-95-30X	ZWR-95-35X	ZWR-95-36X	ZWR-95-37X	ZWR-95-38X
Field Sample Number:		**RXZW2607**	**RXZW3006**	**RXZW3504**	**RXZW3607**	**RXZW3704**	**RXZW3803**
Lab Sample Number:	**DEVENS**	**DV4S*245**	**DV4S*249**	**DV4S*254**	**DV4S*255**	**DV4S*256**	**DV4S*257**
Sample Date:	**BACKGROUND**	**09/11/95**	**09/11/95**	**09/12/95**	**09/13/95**	**09/13/95**	**09/14/95**
Depth:	**CONCENTRATION**	**0**	**0**	**0**	**0**	**0**	**3**
Units:	**(µg/g)**	**(µg/g)**	**(µg/g)**	**(µg/g)**	**(µg/g)**	**(µg/g)**	**(µg/g)**
PAL METALS							
Aluminum	18,000	2910	5760	6270	4440	12100	3740
Arsenic	19	4.74	14	26	17	23	10.7
Barium	54	8.21	13	31.1	12.4	13.6	7.72
Beryllium	0.81	< .5	< .5	< .5	< .5	< .5	< .5
Calcium	810	369	848	610	660	1100	544
Chromium	33	< 4.05	19.1	18.1	11.8	15.4	10.2
Cobalt	4.7	2.88	3.61	5.88	3.52	6.43	2.44
Copper	13.5	4.6	7.26	10.8	12.6	41.4	3.4
Iron	18,000	5880	7440	12600	10200	26000	6200
Lead	48	1.87	3.93	5.34	5.48	88	2.98
Magnesium	5,500	1090	2550	3740	2230	5450	1860
Manganese	380	56.4	92.5	366	236	430	67.9
Mercury		< .05	< .05	< .05	< .05	< .05	< .05
Nickel	14.6	8.57	19.2	23.1	18.4	26.7	10.3
Potassium	2,400	515	735	773	485	370	390
Selenium		< .25	< .25	< .25	< .25	< .25	< .25
Sodium	131	299	336	309	282	322	306
Vanadium	32.2	4.5	11.7	11	8.25	18.8	7
Zinc	43.9	14	16.9	25.3	21.3	55.9	12.6
SEMIVOLATILE ORGANICS							
2-methylnaphthalene		.12	.9	< .049	< .049	< .049	< .049
Acenaphthene		16	1.5	< .036	< .036	.2	< .036
Acenaphthylene		< .033	< .033	< .033	< .033	< .033	< .033
Anthracene		< .033	.16	< .033	< .033	.053	< .033
Benzo[k]fluoranthene		< .066	< .066	< .066	< .066	< .066	< .066
Chrysene		< .12	< .12	< .12	< .12	< .12	< .12
Fluoranthene		< .068	< .068	< .068	< .068	< .068	< .068
Fluorene		< .033	2.4	< .033	< .033	.53	< .033
Naphthalene		< .037	.18	< .037	< .037	< .037	< .037
Phenanthrene		.43	4	< .033	< .033	.89	< .033
Pyrene		.078	< .033	< .033	< .033	.096	< .033
Bis(2-ethylhexyl) Phthalate		< .62	< .62	< .62	3.1	< .62	< .62
VOLATILE ORGANICS							
1,1,2,2-tetrachloroethane		< .0024	< .0024	< .0024	< .0024	< .0024	< .0024
Acetone		.022	.024	< .017	.033	.03	< .017
Dichloromethane		< .012	< .012	< .012	< .012	< .012	< .012
Ethylbenzene		< .0017	< .0017	< .0017	< .0017	< .0017	< .0017
Styrene		< .0026	.0034	< .0026	< .0026	< .0026	< .0026
Toluene		< .00078	.0044	< 00078	< .00078	.0024	< .00078
Trichlorofluoromethane		< .0059	< .0059	< .0059	< .0059	< .0059	< .0059
Xylenes		< .0015	.0023	< .0015	< .0015	< .0015	< .0015
OTHER							
Total Organic Carbon							
Total Petroleum Hydrocarbons		902	3240	< 27.8	566	1400	34.4

TABLE 7 - 11
RI SOIL OFF-SITE ANALYTICAL RESULTS
AOC 69W

REMEDIAL INVESTIGATION REPORT
DEVENS, MASSACHUSETS

Site ID:		ZWR-95-39X	ZWR-95-45X	ZWS-95-35X	ZWS-95-37X	ZWS-95-37X	ZWS-95-38X
Field Sample Number:		RXZW3904	RXZW4504	SXZW3500	SXZW3700	SXZW3700	SXZW3800
Lab Sample Number:	DEVENS	DV4S*258	DV4S*264	DV4S*251	DV4S*252	DV4S*401	DV4S*253
Sample Date:	BACKGROUND	09/13/95	09/15/95	09/18/95	09/18/95	09/28/95	09/18/95
Depth:	CONCENTRATION	0	4	0	0	0	0
Units:	(µg/g)	(µg/g)	(µg/g)	(µg/g)	(µg/g)	(µg/g)	(µg/g)
PAL METALS							
Aluminum	18,000	9570	3060	5940	4520		5930
Arsenic	19	26	7.32	8.6	10.9		8.94
Barium	54	23.1	8.14	22.4	9.97		14.3
Beryllium	0.81	< .5	< .5	< .5	.757		.62
Calcium	810	1260	463	908	548		546
Chromium	33	27.7	10.3	17.8	14.3		11.4
Cobalt	4.7	6.15	2.22	3.16	2.16		2.17
Copper	13.5	10.3	5.14	7.94	4.42		6.87
Iron	18,000	17700	5460	7980	6590		5680
Lead	48	6.79	1.91	45.8	15		45.7
Magnesium	5,500	5600	1430	2600	1650		943
Manganese	380	239	90.3	156	134		99.8
Mercury		< .05	< .05	< .05	< .05		< .05
Nickel	14.6	27.8	8.26	12.2	8.45		6.4
Potassium	2,400	1260	460	993	384		230
Selenium		< .25	< .25	< .25	< .25		508
Sodium	131	339	398	377	313		358
Vanadium	32.2	20.5	6.47	16.1	10.1		13.6
Zinc	43.9	38.4	< 8.03	28.3	16.4		21.1
SEMIVOLATILE ORGANICS							
2-methylnaphthalene		< .049	< .049	< 1	< .049		< .2
Acenaphthene		< .036	< .036	< .7	< .036		< .2
Acenaphthylene		< .033	< .033	< .7	< .033		< .2
Anthracene		< .033	< .033	< .7	< .033		< .2
Benzo[k]fluoranthene		< .066	< .066	< 1	< .066		< .3
Chrysene		< .12	< .12	< 2	< .12		< .6
Fluoranthene		< .068	< .068	< 1	.089		.7
Fluorene		< .033	< .033	< .7	< .033		< .2
Naphthalene		< .037	< .037	< .7	< .037		< .2
Phenanthrene		< .033	< .033	< .7	.068		.4
Pyrene		< .033	< .033	< .7	.078		.6
Bis(2-ethylhexyl) Phthalate		< .62	< .62	< 10	< .62		< 3
VOLATILE ORGANICS							
1,1,2,2-tetrachloroethane		< .0024	< .0024	< .0024	< .0024		< .0024
Acetone		< .017	< .017	< .017	< .017		< .017
Dichloromethane		< .012	.025	< .012	< .012		< .012
Ethylbenzene		< .0017	< .0017	< .0017	< .0017		< .0017
Styrene		< .0026	< .0026	< .0026	< .0026		< .0026
Toluene		< .00078	.0013	.0021	.00096		.0015
Trichlorofluoromethane		< .0059	< .0059	.0072	< .0059		< .0059
Xylenes		< .0015	< .0015	.0027	< .0015		< .0015
OTHER							
Total Organic Carbon							
Total Petroleum Hydrocarbons		< 27.5	< 27.5	936	160		222

TABLE 7 - 11
RI SOIL OFF-SITE ANALYTICAL RESULTS
AOC 69W

REMEDIAL INVESTIGATION REPORT
DEVENS, MASSACHUSETS

Site ID:		ZWS-95-39X	ZWS-95-42X	ZWS-95-45X	ZWS-95-46X	ZWS-95-47X
Field Sample Number:		SXZW3900	SXZW4200	SXZW4500	SXZW4600	SXZW4700
Lab Sample Number:	DEVENS	DV4S*259	DV4S*260	DV4S*261	DV4S*263	DV4S*262
Sample Date:	BACKGROUND	09/18/95	09/18/95	09/18/95	09/18/95	09/18/95
Depth:	CONCENTRATION	0	0	0	0	0
Units:	(µg/g)	(µg/g)	(µg/g)	(µg/g)	(µg/g)	(µg/g)
PAL METALS						
Aluminum	18,000	6150	6110	6160	5210	5930
Arsenic	19	15	14.5	7.66	18	8.47
Barium	54	15.6	20.8	14.1	16.3	20
Beryllium	0.81	< .5	.85	< .5	< .5	< .5
Calcium	810	771	821	470	796	333
Chromium	33	15.4	28.1	12.1	17.5	17.2
Cobalt	4.7	5.36	5.11	2.51	4.81	3.82
Copper	13.5	9.25	29.9	5.59	10.5	7.54
Iron	18,000	10300	9390	6780	10200	8260
Lead	48	22	238	11.4	31.6	18.1
Magnesium	5,500	2670	2670	1360	2620	2510
Manganese	380	230	240	52.4	204	122
Mercury		< .05	.0755	.0784	< .05	< .05
Nickel	14.6	18.1	14.4	5.98	17.7	11.5
Potassium	2,400	600	436	367	601	784
Selenium		< .25	< .25	< .25	< .25	364
Sodium	131	318	506	387	241	256
Vanadium	32.2	13.2	19.1	10.6	12.9	12.5
Zinc	43.9	27.2	71.7	21.6	27.2	18.9
SEMIVOLATILE ORGANICS						
2-methylnaphthalene		< 1	< 1	< .049	< 5	< .049
Acenaphthene		< .7	< .7	< .036	< 4	< .036
Acenaphthylene		2	< .7	< .033	< 3	< .033
Anthracene		1	< .7	< .033	< 3	< .033
Benzo[k]fluoranthene		2	< 1	< .066	< 7	< .066
Chrysene		5	< 2	< .12	< 10	.17
Fluoranthene		5	5	< .068	9	.19
Fluorene		1	< .7	< .033	< 3	< .033
Naphthalene		< .7	< .7	< .037	< 4	< .037
Phenanthrene		7	2	.065	9	.14
Pyrene		8	4	.075	10	.22
Bis(2-ethylhexyl) Phthalate		< 10	< 10	< .62	< 60	< .62
VOLATILE ORGANICS						
1,1,2,2-tetrachloroethane		< .0024	< .0024	< .0024	< .0024	< .0024
Acetone		< .017	.069	< .017	< .017	< .017
Dichloromethane		< .012	< .012	< .012	< .012	< .012
Ethylbenzene		< .0017	< .0017	< .0017	< .0017	< .0017
Styrene		< .0026	< .0026	< .0026	< .0026	< .0026
Toluene		< .00078	.0011	< .00078	< .00078	.001
Trichlorofluoromethane		< .0059	< .0059	< .0059	< .0059	.0055
Xylenes		< .0015	< .0015	< .0015	< .0015	< .0015
OTHER						
Total Organic Carbon						
Total Petroleum Hydrocarbons		310	378	< 27.5	652	52.5

Notes:
µg/g = micrograms per gram
< = Concentrations are less than the certified reporting limit
D = Duplicate analysis
Shading indicates exceedance of established Devens background concentrations

TABLE 7-12
EPH - VPH SUBSURFACE SOIL OFF-SITE ANALYTICAL RESULTS
AOC 69W

REMEDIAL INVESTIGATION REPORT
DEVENS, MASSACHUSETTS

Site ID: Field Sample Number: Sample Date: Depth (Feet BGS):	ZWM-96-19X BXZW1905 8/21/96 5	ZWM-96-19X BXZW1909 8/21/96 9	ZWM-96-20X BXZW2002 08/22/96 2	ZWM-96-20X BXZW2004 8/22/96 4	ZWB-96-03X BXZW0306 8/23/96 6	ZWB-96-03X BXZW0306 8/23/96 6	ZWB-96-03X BXZW0310 08/23/96 10	ZWM-96-21X BXZW2104 8/26/96 4	ZWM-96-21X BXZW2108 08/26/96 8
EPH (mg/kg)	< 0.15	150	< 0.15	< 0.17	< 0.15	< 0.17	< 0.17	< 0.17	< 0.16
ALIPHATIC									
n-C 9 to n-C 18	< 1.5	560	< 1.5	< 1.7	< 1.5	< 1.7	< 1.7	< 1.7	< 1.6
n-C 19 to n-C 36	< 0.15	110	< 0.15	< 0.17	< 0.15	< 0.17	< 0.17	< 0.17	< 0.16
AROMATICS									
n-C 10 to n-C 22	< 30	120	< 30	< 34	< 30	< 34	< 34	< 34	< 32
TARGETED PAH ANALYTES (mg/kg)									
Naphthalene	< 0.5	< 0.5	< 0.51	< 0.57	< 0.51	< 0.57	< 0.57	< 0.56	< 0.53
2-Methylnaphthalene	< 0.5	< 0.5	< 0.51	< 0.57	< 0.51	< 0.57	< 0.57	< 0.56	< 0.53
Acenaphthylene	< 0.5	< 0.5	< 0.51	< 0.57	< 0.51	< 0.57	< 0.57	< 0.56	< 0.53
Acenaphthene	< 0.5	< 0.5	< 0.51	< 0.57	< 0.51	< 0.57	< 0.57	< 0.56	< 0.53
Fluorene	< 0.5	< 0.5	< 0.51	< 0.57	< 0.51	< 0.57	< 0.57	< 0.56	< 0.53
Phenanthrene	< 0.5	< 0.5	< 0.51	< 0.57	< 0.51	< 0.57	< 0.57	< 0.56	< 0.53
Anthracene	< 0.5	< 0.5	< 0.51	< 0.57	< 0.51	< 0.57	< 0.57	< 0.56	< 0.53
Fluoranthene	< 0.5	< 0.5	< 0.51	< 0.57	< 0.51	< 0.57	< 0.57	< 0.56	< 0.53
Pyrene	< 0.5	< 0.5	< 0.51	< 0.57	< 0.51	< 0.57	< 0.57	< 0.56	< 0.53
Benzo(a)anthracene	< 0.5	< 0.5	< 0.51	< 0.57	< 0.51	< 0.57	< 0.57	< 0.56	< 0.53
Chrysene	< 0.5	< 0.5	< 0.51	< 0.57	< 0.51	< 0.57	< 0.57	< 0.56	< 0.53
Benzo(b)fluoranthene	< 0.5	< 0.5	< 0.51	< 0.57	< 0.51	< 0.57	< 0.57	< 0.56	< 0.53
Benzo(k)fluoranthene	< 0.5	< 0.5	< 0.51	< 0.57	< 0.51	< 0.57	< 0.57	< 0.56	< 0.53
Benzo(a)pyrene	< 0.5	< 0.5	< 0.51	< 0.57	< 0.51	< 0.57	< 0.57	< 0.56	< 0.53
Indeno(1,2,3-c,d)pyrene	< 0.5	< 0.5	< 0.51	< 0.57	< 0.51	< 0.57	< 0.57	< 0.56	< 0.53
Dibenzo(a,h)anthracene	< 0.5	< 0.5	< 0.51	< 0.57	< 0.51	< 0.57	< 0.57	< 0.56	< 0.53
Benzo(g,h,i)perylene	< 0.5	< 0.5	< 0.51	< 0.57	< 0.51	< 0.57	< 0.57	< 0.56	< 0.53
VPH (µg/kg)	< 13	4100	< 13	< 13	< 13	< 13	< 13	< 13	< 13
ALIPHATICS									
n-C 5 to n-C 8	< 130	270	< 130	< 130	< 130	< 130	< 130	< 130	< 130
n-C 9 to n-C 12	< 13	8300	< 13	< 13	< 13	< 13	< 13	< 13	< 13
AROMATICS									
n-C 9 to n-C 10	< 250	3500	< 250	< 250	< 250	< 250	< 250	< 250	< 250
TARGETED VOAs (µg/kg)									
Methyl tert-butyl Ether	< 250	< 250	< 250	< 250	< 250	< 250	< 250	< 250	< 250
Benzene	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50
Toluene	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50
Ethylbenzene	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50
m/p-Xylene	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50
o-Xylene	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50
Naphthalene	< 250	< 250	< 250	< 250	< 250	< 250	< 250	< 250	< 250

Notes: < = Less than certified reporting limits

TABLE 7-13
SOIL REMEDIAL ACTION OFF-SITE ANALYTICAL RESULTS
AOC 69W

REMEDIAL INVESTIGATION REPORT
DEVENS, MASSACHUSETTS

	MCP S1/GW1	69W-HS-SSW1	69W-HS-SSW-2	69W-HS-OB-15	69W-HS-WSW	69W-HS-FL-2	69W-HS-FL-1
DEPTH in feet (bgs)	**Standards**	**7-10**	**7-10**	**6**	**7-10**	**11**	**11**
EPH PARAMETERS							
Aliphatics/Aromatics (µg/g)							
C9-C18 Aliphatics	**1,000**	3,600	5,400	1,800	480	10,000	560
C19-C36 Aliphatics	**2,500**	360	670	310	91	1,200	67
C11-C22 Aromatics	**200**	1,100	1,200	700	44	2,300	110
EPH					610		
Target PAH Analytes (µg/g)							
2-Methylnaphthalene	**4**	26	42	18	<0.56	81	2.5
Acenaphthene	**20**	7.6	7.4	4.1	<0.56	16	1.4
Acenaphthylene	**100**	16	<0.064	9.6	<0.56	<0.076	<0.61
Anthracene	**1,000**	<0.068	<0.064	0.24	<0.56	E2.2	<0.61
Benzo (a) anthracene	**0.7**	<0.068	0.099	<0.07	<0.56	0.096	<0.61
Benzo (b) fluoranthene	**0.7**	<0.068	0.064	<0.07	<0.56	<0.076	<0.61
Benzo (k) fluoranthene	**7**	<0.068	<0.064	<0.07	<0.56	<0.076	<0.61
Benzo (a) pyrene	**0.7**	<0.068	<0.064	<0.07	<0.56	<0.076	<0.61
Benzo (g,h.i) perylene	**1,000**	<0.068	<0.064	<0.07	<0.56	<0.076	<0.61
Chrysene	**7**	J0.039	0.076	<0.07	<0.56	0.089	<0.61
Dibenz (a,h) anthracene	**0.7**	<0.068	<0.064	<0.07	<0.56	<0.076	<0.61
Fluoranthene	**1,000**	0.24	<0.064	0.13	<0.56	E1.8	<0.61
Flourene	**400**	20	26	E0.68	<0.56	44	2.8
Indeno (1,2,3-cd) pyrene	**0.7**	<0.068	<0.064	<0.07	<0.56	<0.076	<0.61
Napthalene	**4**	7.1	8.5	12	<0.56	17	<0.61
Phenanthrene	**700**	7	9	4.6	<0.56	14	1
Pyrene	**700**	E0.44	<0.064	0.18	<0.56	E.5	<0.61
VPH PARAMETERS							
Aliphatics/Aromatics (µg/g)							
C5-C8 Aliphatics	**100**	<96	<120	<9.8	<11	<110	<13
C-9-C12 Aliphatics	**1,000**	770	670	21	14	1300	140
C9-C10 Aromatics	**100**	650	560	20	15	960	100
VPH					30		
Target VPH Analytes (µg/g)							
Benzene	**10**	<12	<14	<1.2	<1.3	<13	<1.6
Ethylbenzene	**80**	<12	<14	<1.2	<1.3	<13	<1.6
m,p-Xylenes	**500**	<48	<58	<4.9	<5.4	<54	<6.4
Methyl-tert-butyl ether	**0.3**	<36	<43	<3.6	<4.0	<40	<4.8
Naphthalene	**4**	<24	<29	2.6	<2.7	<27	<3.2
o-Xylene	**500**	<24	<29	<2.5	<2.7	<27	<3.2
Toluene	**90**	<36	<43	<3.6	<4.0	<40	<4.8

TABLE 7-13
SOIL REMEDIAL ACTION OFF-SITE ANALYTICAL RESULTS
AOC 69W

REMEDIAL INVESTIGATION REPORT
DEVENS, MASSACHUSETTS

	MCP S1/GW1	69W-HS-SE-FL	69W-HS-ESW-1	69W-HS-WSW-1	69W-HS-WSW-1 DUP	69W-UST-ESW	69W-UST-FL
DEPTH in feet (bgs)	**Standards**	**11**	**7-10**	**7-10**	**7-10**	**7-10**	**12-13**
EPH PARAMETERS							
Aliphatics/Aromatics (ug/g)							
C9-C18 Aliphatics	1,000	13	<3.4	69	75	11	97
C19-C36 Aliphatics	2,500	10	<4.6	25	23	8.3	23
C11-C22 Aromatics	200	<11	<9.7	26	33	12	48
EPH				120	130		
Target PAH Analytes (ug/g)							
2-Methylnaphthalene	4	<0.63	<0.57	<0.58	<0.57	<0.62	<0.60
Acenaphthene	20	<0.63	<0.57	<0.58	<0.57	<0.62	<0.60
Acenaphthylene	100	<0.63	<0.57	<0.58	<0.57	<0.62	<0.60
Anthracene	1,000	<0.63	<0.57	<0.58	<0.57	<0.62	<0.60
Benzo (a) anthracene	0.7	<0.63	<0.57	<0.58	<0.57	<0.62	<0.60
Benzo (b) fluoranthene	0.7	<0.63	<0.57	<0.58	<0.57	<0.62	<0.60
Benzo (k) fluoranthene	7	<0.63	<0.57	<0.58	<0.57	<0.62	<0.60
Benzo (a) pyrene	0.7	<0.63	<0.57	<0.58	<0.57	<0.62	<0.60
Benzo (g,h,i) perylene	1,000	<0.63	<0.57	<0.58	<0.57	<0.62	<0.60
Chrysene	7	<0.63	<0.57	<0.58	<0.57	<0.62	<0.60
Dibenz (a,h) anthracene	0.7	<0.63	<0.57	<0.58	<0.57	<0.62	<0.60
Fluoranthene	1,000	<0.63	<0.57	<0.58	<0.57	<0.62	<0.60
Flourene	400	<0.63	<0.57	<0.58	<0.57	<0.62	<0.60
Indeno (1,2,3-cd) pyrene	0.7	<0.63	<0.57	<0.58	<0.57	<0.62	<0.60
Napthalene	4	<0.63	<0.57	<0.58	<0.57	<0.62	<0.60
Phenanthrene	700	<0.63	<0.57	<0.58	<0.57	<0.62	<0.60
Pyrene	700	<0.63	<0.57	<0.58	<0.57	<0.62	<0.60
VPH PARAMETERS							
Aliphatics/Aromatics (ug/g)							
C5-C8 Aliphatics	100	<10	<12	<14	<12	<10	<10
C-9-C12 Aliphatics	1,000	<2.7	5.5	<3.5	<3.1	<2.6	26
C9-C10 Aromatics	100	<5.3	<6.1	<6.9	<6.2	<5.3	31
VPH				< 24	<21		
Target VPH Analytes (ug/g)							
Benzene	10	<1.3	<1.5	<1.7	<1.5	<1.	<1.2
Ethylbenzene	80	<1.3	<1.5	<1.7	<1.5	<1.3	<1.2
m,p-Xylenes	500	<5.3	<6.1	<6.9	<6.2	<5.3	<5.1
Methyl-tert-butyl ether	0.3	<4.0	<4.5	<5.1	<4.6	<3.9	<3.8
Naphthalene	4	<2.7	<3.1	<3.5	<3.1	<2.6	<2.6
o-Xylene	500	<2.7	<3.1	<3.5	<3.1	<2.6	<2.6
Toluene	90	<4.0	<4.5	<5.1	<4.6	<3.9	<3.8

TABLE 7-13
SOIL REMEDIAL ACTION OFF-SITE ANALYTICAL RESULTS
AOC 69W

REMEDIAL INVESTIGATION REPORT
DEVENS, MASSACHUSETTS

	MCP S1/GW1	69W-HS-FL-3	69W-HS-WSW-2	69W-HS-WSW-2-2	69W-PL-FL-5	69W-HS-FL-4	69W-PL-ESW-1
DEPTH in feet (bgs)	**Standards**	**7-10**	**6-9**	**5-6**	**7-10**	**5-8**	**5-8**
EPH PARAMETERS							
Aliphatics/Aromatics (µg/g)							
C9-C18 Aliphatics	1,000	36	2,200	14	310	16	120
C19-C36 Aliphatics	2,500	15	290	19	56	17	44
C11-C22 Aromatics	200	24	520	21	80	14	20
EPH		75	3,000	54	450	47	180
Target PAH Analytes (µg/g)							
2-Methylnaphthalene	4	<0.60	14	< 0.58	<0.58	<0.61	<0.58
Acenaphthene	20	<0.60	3.3	< 0.58	<0.58	<0.61	<0.58
Acenaphthylene	100	<0.60	<2.1	< 0.58	<0.58	<0.61	<0.58
Anthracene	1,000	<0.60	<2.1	< 0.58	<0.58	<0.61	<0.58
Benzo (a) anthracene	0.7	<0.60	<2.1	< 0.58	<0.58	<0.61	<0.58
Benzo (b) fluoranthene	0.7	<0.60	<2.1	< 0.58	<0.58	<0.61	<0.58
Benzo (k) fluoranthene	7	<0.60	<2.1	< 0.58	<0.58	<0.61	<0.58
Benzo (a) pyrene	0.7	<0.60	<2.1	< 0.58	<0.58	<0.61	<0.58
Benzo (g,h.i) perylene	1,000	<0.60	<2.1	< 0.58	<0.58	<0.61	<0.58
Chrysene	7	<0.60	<2.1	< 0.58	<0.58	<0.61	<0.58
Dibenz (a,h) anthracene	0.7	<0.60	<2.1	< 0.58	<0.58	<0.61	<0.58
Fluoranthene	1,000	<0.60	<2.1	< 0.58	<0.58	<0.61	<0.58
Flourene	400	<0.60	6.8	< 0.58	<0.58	<0.61	<0.58
Indeno (1,2,3-cd) pyrene	0.7	<0.60	<2.1	< 0.58	<0.58	<0.61	<0.58
Napthalene	4	<0.60	2.4	< 0.58	<0.58	<0.61	<0.58
Phenanthrene	700	<0.60	4.1	< 0.58	<0.58	<0.61	<0.58
Pyrene	700	<0.60	<2.1	< 0.58	<0.58	<0.61	<0.58
VPH PARAMETERS							
Aliphatics/Aromatics (µg/g)							
C5-C8 Aliphatics	100	<13	<46	< 15	<13	<13	<14
C-9-C12 Aliphatics	1,000	5.8	200	< 3.9	130	3.8	<3.6
C9-C10 Aromatics	100	<6.5	290	< 7.8	62	<6.5	<7.3
VPH		< 22	500	< 27	200	< 23	< 25
Target VPH Analytes (µg/g)							
Benzene	10	<1.6	<5.6	< 1.9	<1.5	<1.6	<1.7
Ethylbenzene	80	<1.6	<5.6	< 1.9	<1.5	<1.6	<1.7
m,p-Xylenes	500	<6.5	<23	< 7.8	<6.4	<6.5	<7.3
Methyl-tert-butyl ether	0.3	<4.8	<17	< 5.8	<4.7	<4.8	<5.4
Naphthalene	4	<3.2	<12	< 3.9	<3.2	<3.3	<3.6
o-Xylene	500	<3.2	<12	< 3.9	<3.2	<3.3	<3.6
Toluene	90	<4.8	<17	< 5.8	<4.7	<4.8	<5.4

TABLE 7-13
SOIL REMEDIAL ACTION OFF-SITE ANALYTICAL RESULTS
AOC 69W

REMEDIAL INVESTIGATION REPORT
DEVENS, MASSACHUSETTS

	MCP S1/GW1	69W-HS-WSW-3	69W-PL-NSW-2	69W-HS-NSW-1	69W-UP-G3-WSW	69W-UP-G3-FL	69W-UP-G3-ESW
DEPTH in feet (bgs)	**Standards**	**5-8**	**3-6**	**3-6**	**4-5**	**5**	**4-5**
EPH PARAMETERS							
Aliphatics/Aromatics (µg/g)							
C9-C18 Aliphatics	**1,000**	860	3.3	410	13	10	<3.8
C19-C36 Aliphatics	**2,500**	130	8.1	68	11	19	5.4
C11-C22 Aromatics	**200**	220	9	120	10	27	<11
EPH		1,200	20	600	35	57	< 20
Target PAH Analytes (µg/g)							
2-Methylnaphthalene	**4**	<0.55	<0.53	1.9	<0.55	<0.58	<0.64
Acenaphthene	**20**	0.83	<0.53	0.79	<0.55	<0.58	<0.64
Acenaphthylene	**100**	<0.55	<0.53	<0.61	<0.55	<0.58	<0.64
Anthracene	**1,000**	<0.55	<0.53	<0.61	<0.55	<0.58	<0.64
Benzo (a) anthracene	**0.7**	<0.55	<0.53	<0.61	<0.55	<0.58	<0.64
Benzo (b) fluoranthene	**0.7**	<0.55	<0.53	<0.61	<0.55	<0.58	<0.64
Benzo (k) fluoranthene	**7**	<0.55	<0.53	<0.61	<0.55	<0.58	<0.64
Benzo (a) pyrene	**0.7**	<0.55	<0.53	<0.61	<0.55	<0.58	<0.64
Benzo (g,h,i) perylene	**1,000**	<0.55	<0.53	<0.61	<0.55	<0.58	<0.64
Chrysene	**7**	<0.55	<0.53	<0.61	<0.55	<0.58	<0.64
Dibenz (a,h) anthracene	**0.7**	<0.55	<0.53	<0.61	<0.55	<0.58	<0.64
Fluoranthene	**1,000**	<0.55	<0.53	<0.61	<0.55	<0.58	<0.64
Flourene	**400**	2.1	<0.53	1.4	<0.55	<0.58	<0.64
Indeno (1,2,3-cd) pyrene	**0.7**	<0.55	<0.53	<0.61	<0.55	<0.58	<0.64
Napthalene	**4**	<0.55	<0.53	<0.61	<0.55	<0.58	<0.64
Phenanthrene	**700**	1.5	<0.53	0.98	<0.55	<0.58	<0.64
Pyrene	**700**	<0.55	<0.53	<0.61	<0.55	<0.58	<0.64
VPH PARAMETERS							
Aliphatics/Aromatics (µg/g)							
C5-C8 Aliphatics	**100**	<12	<12	<13	<9.2	<9.8	<11
C-9-C12 Aliphatics	**1,000**	150	<2.9	7.4	<2.3	<2.5	<2.7
C9-C10 Aromatics	**100**	100	<5.8	<6.6	<4.7	<5.0	<5.4
VPH		250	< 20	< 23	< 16	< 17	< 19
Target VPH Analytes (µg/g)							
Benzene	**10**	<1.4	<1.4	<1.6	<1.1	<1.2	<1.3
Ethylbenzene	**80**	<1.4	<1.4	<1.6	<1.1	<1.2	<1.3
m,p-Xylenes	**500**	<6.0	<5.8	<6.6	<4.7	<5.0	<5.4
Methyl-tert-butyl ether	**0.3**	<4.4	<4.3	<4.9	<3.5	<3.7	<4.0
Naphthalene	**4**	<3.0	<2.9	<3.3	<2.3	<2.5	<2.7
o-Xylene	**500**	<3.0	<2.9	<3.3	<2.3	<2.5	<2.7
Toluene	**90**	<4.4	<4.3	<4.9	<3.5	<3.7	<4.0

TABLE 7-13
SOIL REMEDIAL ACTION OFF-SITE ANALYTICAL RESULTS
AOC 69W

REMEDIAL INVESTIGATION REPORT
DEVENS, MASSACHUSETTS

	MCP S1/GW1	69W-UP-G2-WSW	69W-UP-G2-FL	69W-UP-G2-FL-2	69W-UP-G2-ESW	69W-UP-G1-WSW
DEPTH in feet (bgs)	**Standards**	4-5		5	4-5	
EPH PARAMETERS						
Aliphatics/Aromatics (µg/g)						
C9-C18 Aliphatics	1,000	43	1,300	4.3	3.4	2,000
C19-C36 Aliphatics	2,500	28	300	6.1	<4.2	460
C11-C22 Aromatics	200	17	130	<10	<8.9	190
EPH		88	1,700	< 18	< 16	2,700
Target PAH Analytes (µg/g)						
2-Methylnaphthalene	4	<0.52	<0.56	<0.59	<0.52	<0.57
Acenaphthene	20	<0.52	<0.56	<0.59	<0.52	<0.57
Acenaphthylene	100	<0.52	<0.56	<0.59	<0.52	<0.57
Anthracene	1,000	<0.52	<0.56	<0.59	<0.52	<0.57
Benzo (a) anthracene	0.7	<0.52	<0.56	<0.59	<0.52	<0.57
Benzo (b) fluoranthene	0.7	<0.52	<0.56	<0.59	<0.52	<0.57
Benzo (k) fluoranthene	7	<0.52	<0.56	<0.59	<0.52	<0.57
Benzo (a) pyrene	0.7	<0.52	<0.56	<0.59	<0.52	<0.57
Benzo (g,h.i) perylene	1,000	<0.52	<0.56	<0.59	<0.52	<0.57
Chrysene	7	<0.52	<0.56	<0.59	<0.52	<0.57
Dibenz (a,h) anthracene	0.7	<0.52	<0.56	<0.59	<0.52	<0.57
Fluoranthene	1,000	<0.52	<0.56	<0.59	<0.52	<0.57
Flourene	400	<0.52	<0.56	<0.59	<0.52	<0.57
Indeno (1,2,3-cd) pyrene	0.7	<0.52	<0.56	<0.59	<0.52	<0.57
Napthalene	4	<0.52	<0.56	<0.59	<0.52	<0.57
Phenanthrene	700	<0.52	<0.56	<0.59	<0.52	<0.57
Pyrene	700	<0.52	<0.56	<0.59	<0.52	<0.57
VPH PARAMETERS						
Aliphatics/Aromatics (µg/g)						
C5-C8 Aliphatics	100	<9	<9.5	<13	<8.9	<13
C-9-C12 Aliphatics	1,000	<2.3	<2.4	<3.2	<2.2	180
C9-C10 Aromatics	100	<4.5	<4.8	<6.5	<4.5	120
VPH		< 16	<17	< 22	< 16	300
Target VPH Analytes (µg/g)						
Benzene	10	<1.1	<1.2	<1.6	<1.1	<1.5
Ethylbenzene	80	<1.1	<1.2	<1.6	<1.1	<1.5
m,p-Xylenes	500	<4.5	<4.8	<6.5	<4.5	<6.4
Methyl-tert-butyl ether	0.3	<3.4	<3.6	<4.8	<3.3	<4.7
Naphthalene	4	<2.3	<2.4	<3.2	<2.2	<3.2
o-Xylene	500	<2.3	<2.4	<3.2	<2.2	<3.2
Toluene	90	<3.4	<3.6	<4.8	<3.3	<4.7

TABLE 7-13
SOIL REMEDIAL ACTION OFF-SITE ANALYTICAL RESULTS
AOC 69W

REMEDIAL INVESTIGATION REPORT
DEVENS, MASSACHUSETTS

	MCP S1/GW1	69W-UP-G1-WSW-2	69W-UP-G1-FL	69W-UP-G1-ESW	69W-V-WSW-1	69W-V-FL-1	69W-V-ESW-1
DEPTH in feet (bgs)	**Standards**	**3-4**	**4**	**4-6**	**5-7**	**7**	**6-8**
EPH PARAMETERS							
Aliphatics/Aromatics (μg/g)							
C9-C18 Aliphatics	**1,000**	720	14	120	1,200	600	1,700
C19-C36 Aliphatics	**2,500**	350	10	68	380	130	480
C11-C22 Aromatics	**200**	39	12	28	82	77	180
EPH		1,100	36	220	1,600	800	2,300
Target PAH Analytes (μg/g)							
2-Methylnaphthalene	**4**	<0.54	<0.59	<0.54	<0.70	<0.59	<0.60
Acenaphthene	**20**	<0.54	<0.59	<0.54	<0.70	<0.59	<0.60
Acenaphthylene	**100**	<0.54	<0.59	<0.54	<0.70	<0.59	<0.60
Anthracene	**1,000**	<0.54	<0.59	<0.54	<0.70	<0.59	<0.60
Benzo (a) anthracene	**0.7**	<0.54	<0.59	<0.54	<0.70	<0.59	<0.60
Benzo (b) fluoranthene	**0.7**	<0.54	<0.59	<0.54	<0.70	<0.59	<0.60
Benzo (k) fluoranthene	**7**	<0.54	<0.59	<0.54	<0.70	<0.59	<0.60
Benzo (a) pyrene	**0.7**	<0.54	<0.59	<0.54	<0.70	<0.59	<0.60
Benzo (g,h,i) perylene	**1,000**	<0.54	<0.59	<0.54	<0.70	<0.59	<0.60
Chrysene	**7**	<0.54	<0.59	<0.54	<0.70	<0.59	<0.60
Dibenz (a,h) anthracene	**0.7**	<0.54	<0.59	<0.54	<0.70	<0.59	<0.60
Fluoranthene	**1,000**	<0.54	<0.59	<0.54	<0.70	<0.59	<0.60
Flourene	**400**	<0.54	<0.59	<0.54	<0.70	<0.59	<0.60
Indeno (1,2,3-cd) pyrene	**0.7**	<0.54	<0.59	<0.54	<0.70	<0.59	<0.60
Napthalene	**4**	<0.54	<0.59	<0.54	<0.70	<0.59	<0.60
Phenanthrene	**700**	<0.54	<0.59	<0.54	<0.70	<0.59	<0.60
Pyrene	**700**	<0.54	<0.59	<0.54	<0.70	<0.59	<0.60
VPH PARAMETERS							
Aliphatics/Aromatics (μg/g)							
C5-C8 Aliphatics	**100**	<12	<12	<11	<16	<13	<15
C-9-C12 Aliphatics	**1,000**	<3	43	<2.9	<4	43	36
C9-C10 Aromatics	**100**	<6	24	<5.8	<8.1	37	35
VPH		<21	67	< 20	< 28	80	71
Target VPH Analytes (μg/g)							
Benzene	**10**	<1.4	<1.5	<1.4	<2.0	<1.6	<1.8
Ethylbenzene	**80**	<1.4	<1.5	<1.4	<2.0	<1.6	<1.8
m,p-Xylenes	**500**	<6.0	<6.2	<5.8	<8.1	<6.5	<7.4
Methyl-tert-butyl ether	**0.3**	<4.4	<4.6	<4.3	<6.0	<4.8	<5.5
Naphthalene	**4**	<3.0	<3.1	<2.9	<4.0	<3.2	<3.7
o-Xylene	**500**	<3.0	<3.1	<2.9	<4.0	<3.2	<3.7
Toluene	**90**	<4.4	<4.6	<4.3	<6.0	<4.8	<5.5

TABLE 7-13
SOIL REMEDIAL ACTION OFF-SITE ANALYTICAL RESULTS
AOC 69W

REMEDIAL INVESTIGATION REPORT
DEVENS, MASSACHUSETTS

	MCP S1/GW1	69W-V-NSW-1	69W-PL-FL-6	69W-PL-FL-7	69W-PL-ESW-2
DEPTH in feet (bgs)	**Standards**	**6-8**	**7**	**6**	**4-6**
EPH PARAMETERS					
Aliphatics/Aromatics (µg/g)					
C9-C18 Aliphatics	1,000	74	310	370	5.6
C19-C36 Aliphatics	2,500	120	36	110	7.9
C11-C22 Aromatics	200	22	120	23	< 11
EPH		210	460	500	<20
Target PAH Analytes (µg/g)					
2-Methylnaphthalene	4	<0.58	1.2	< 0.61	< 0.65
Acenaphthene	20	<0.58	0.92	< 0.61	< 0.65
Acenaphthylene	100	<0.58	< 0.61	< 0.61	< 0.65
Anthracene	1,000	<0.58	< 0.61	< 0.61	< 0.65
Benzo (a) anthracene	0.7	<0.58	< 0.61	< 0.61	< 0.65
Benzo (b) fluoranthene	0.7	<0.58	< 0.61	< 0.61	< 0.65
Benzo (k) fluoranthene	7	<0.58	< 0.61	< 0.61	< 0.65
Benzo (a) pyrene	0.7	<0.58	< 0.61	< 0.61	< 0.65
Benzo (g,h,i) perylene	1,000	<0.58	< 0.61	< 0.61	< 0.65
Chrysene	7	<0.58	< 0.61	< 0.61	< 0.65
Dibenz (a,h) anthracene	0.7	<0.58	< 0.61	< 0.61	< 0.65
Fluoranthene	1,000	<0.58	< 0.61	< 0.61	< 0.65
Flourene	400	<0.58	1.4	< 0.61	< 0.65
Indeno (1,2,3-cd) pyrene	0.7	<0.58	< 0.61	< 0.61	< 0.65
Napthalene	4	<0.58	< 0.61	< 0.61	< 0.65
Phenanthrene	700	<0.58	< 0.61	< 0.61	< 0.65
Pyrene	700	<0.58	< 0.61	< 0.61	< 0.65
VPH PARAMETERS					
Aliphatics/Aromatics (µg/g)					
C5-C8 Aliphatics	100	<13	< 13	< 13	< 14
C-9-C12 Aliphatics	1,000	<3.2	52	< 3.2	< 3.5
C9-C10 Aromatics	100	<6.5	33	< 6.5	< 7.0
VPH		< 23	84	<22	<24
Target VPH Analytes (µg/g)					
Benzene	10	<1.6	< 1.6	< 1.6	< 1.7
Ethylbenzene	80	<1.6	< 1.6	< 1.6	< 1.7
m,p-Xylenes	500	<6.5	< 6.5	< 6.5	< 7.0
Methyl-tert-butyl ether	0.3	<4.8	< 4.8	< 4.8	< 5.2
Naphthalene	4	<3.2	< 3.2	< 3.2	< 3.5
o-Xylene	500	<3.2	< 3.2	< 3.2	< 3.5
Toluene	90	<4.8	< 4.8	< 4.8	< 5.2

TABLE 7-14
RI GROUNDWATER FIELD ANALYTICAL RESULTS
AOC 69W

REMEDIAL INVESTIGATION REPORT
DEVENS, MASSACHUSETTS

	Site ID	ZWR-96-35X	ZWR-95-36X	ZWR-95-37X	ZWR-95-38X	ZWR-95-39R	ZWR-95-40X	ZWR-95-41X	ZWR-95-42X
	Depth (ft bgs)	7	7	7	5	5	6	6	6
	Date Analyzed:	14-Sep-95	15-Sep-95	15-Sep-95	14-Sep-95	14-Sep-95	15-Sep-95	15-Sep-95	15-Sep-95
	Dilution:	1	1	1	1	1	1	1	1
ANALYTES	**Reporting Limit**								
1,1-DCE	5 μg/l	5.0 U	5.0 U	5.0 U	5.0 U	5.0 U	5.0 U	5.0 U	5.0 U
Chloroform	2 μg/l	2.0 U	2.0 U	2.0 U	2.0 U	2.0 U	2.0 U	2.0 U	2.0 U
1,1,1-TCA	2 μg/l	2.0 U	2.0 U	2.0 U	2.0 U	2.0 U	2.0 U	2.0 U	2.0 U
Carbon Tetrachloride	2 μg/l	2.0 UJ	2.0 UJ	2.0 UJ	2.0 UJ	2.0 UJ	2.0 UJ	2.0 UJ	2.0 UJ
Trichloroethene	2 μg/l	2.0 U	2.0 U	2.0 U	2.0 U	2.0 U	2.0 U	2.0 U	2.0 U
Tetrachloroethene	2 μg/l	2.0 U	2.0 U	2.0 U	2.0 U	2.0 U	2.0 U	2.0 U	2.0 U
Benzene	2 μg/l	2.0 U	2.0 U	2.0 U	2.0 U	2.0 U	2.0 U	2.0 U	2.0 U
Toluene	2 μg/l	2.0 U	2.0 U	2.0 U	2.0 U	2.0 U	2.0 U	2.0 U	2.0 U
Chlorobenzene	2 μg/l	2.0 U	2.0 U	2.0 U	2.0 U	2.0 U	2.0 U	2.0 U	2.0 U
Ethylbenzene	2 μg/l	2.0 U	2.0 U	2.0 U	2.0 U	2.0 U	2.0 U	2.0 U	2.0 U
m/p-Xylene	4 μg/l	4.0 U	4.0 U	7	4.0 U	4.0 U	4.0 U	4.0 U	4.0 U
o-Xylene	2 μg/l	2.0 U	2.0 U	5.2	2.0 U	2.0 U	2.0 U	2.0 U	2.0 U
TPH-dro	100 mg/l	NA	NA	NA	NA	NA	NA	NA	NA
TPH-gro	100 μg/l	NA	NA	NA	NA	NA	NA	NA	NA

TABLE 7-14
RI GROUNDWATER FIELD ANALYTICAL RESULTS
AOC 69W

REMEDIAL INVESTIGATION REPORT
DEVENS, MASSACHUSETTS

	Site ID	ZWR-95-43X	ZWR-95-44X	ZWR-95-45X	ZWR-95-46X	ZWR-95-47X	ZWR-95-48X	ZWR-96-49X	ZWR-95-50X
	Depth (ft bgs)	5	6	6	6	6	4	4	10
	Date Analyzed:	15-Sep-95	15-Sep-95	15-Sep-95	15-Sep-95	22-Sep-95	22-Sep-96	22-Sep-95	22-Sep-95
	Dilution:	1	1	1	1	1	1	1	1
ANALYTES	**Reporting Limit**								
1,1-DCE	5 μg/l	5.0 U	5.0 U	5.0 U	5.0 U	5.0 U	5.0 U	5.0 U	5.0 U
Chloroform	2 μg/l	2.0 U	2.0 U	2.0 U	2.0 U	2.0 U	2.0 U	2.0 U	2.0 U
1,1,1-TCA	2 μg/l	2.0 U	2.0 U	2.0 U	2.0 U	2.0 U	2.0 U	2.0 U	2.0 U
Carbon Tetrachloride	2 μg/l	2.0 UJ	2.0 UJ	2.0 UJ	2.0 UJ	2.0 U	2.0 U	2.0 U	2.0 U
Trichloroethene	2 μg/l	2.0 U	2.0 U	2.0 U	2.0 U	2.0 U	2.0 U	2.0 U	2.0 U
Tetrachloroethene	2 μg/l	2.0 U	2.0 U	2.0 U	2.0 U	2.0 U	2.0 U	2.0 U	2.0 U
Benzene	2 μg/l	2.0 U	2.0 U	2.0 U	2.0 U	2.0 U	2.0 U	2.0 U	2.0 U
Toluene	2 μg/l	2.0 U	2.0 U	2.0 U	2.0 U	2.0 U	2.0 U	2.0 U	2.0 U
Chlorobenzene	2 μg/l	2.0 U	2.0 U	2.0 U	2.0 U	2.0 U	2.0 U	2.0 U	2.0 U
Ethylbenzene	2 μg/l	2.0 U	2.0 U	2.0 U	2.0 U	2.0 U	2.0 U	2.0 U	2.0 U
m/p-Xylene	4 μg/l	4.0 U	4.0 U	7.3	4.0 U	4.0 UJ	4.0 UJ	4.0 UJ	4.0 UJ
o-Xylene	2 μg/l	2.0 U	2.0 U	2.0 U	2.0 U	2.0 U	2.0 U	2.0 U	2.0 U
TPH-dro	100 mg/l	NA	NA	NA	NA	NA	NA	NA	NA
TPH-gro	100 μg/l	NA	NA	NA	NA	250	120	100 U	100 U

TABLE 7-14
RI GROUNDWATER FIELD ANALYTICAL RESULTS
AOC 69W

REMEDIAL INVESTIGATION REPORT
DEVENS, MASSACHUSETTS

	Site ID	ZWR-95-51X	ZWR-95-52X	ZWR-95-53X	ZWR-95-54X	ZWR-95-55X
	Depth (ft bgs)	15	5	5	9	9
	Date Analyzed:	22-Sep-95	22-Sep-95	22-Sep-95	29-Sep-95	29-Sep-95
	Dilution:	1	1	1	1	1
ANALYTES	**Reporting Limit**					
1,1-DCE	5 µg/l	5.0 U	5.0 U	5.0 U	5.0 U	5.0 U
Chloroform	2 µg/l	2.0 U	2.0 U	2.0 U	2.0 U	2.0 U
1,1,1-TCA	2 µg/l	2.0 U	2.0 U	2.0 U	2.0 U	2.0 U
Carbon Tetrachloride	2 µg/l	2.0 U	2.0 U	2.0 U	2.0 U	2.0 U
Trichloroethene	2 µg/l	2.0 U	2.0 U	2.0 U	2.0 U	2.0 U
Tetrachloroethene	2 µg/l	2.0 U	2.0 U	2.0 U	2.0 U	2.0 U
Benzene	2 µg/l	2.0 U	2.0 U	2.0 U	2.0 U	2.0 U
Toluene	2 µg/l	2.0 U	2.0 U	2.0 U	2.0 UJ	2.0 UJ
Chlorobenzene	2 µg/l	2.0 U	2.0 U	2.0 U	2.0 U	2.0 U
Ethylbenzene	2 µg/l	2.0 U	2.0 U	2.0 U	2.0 U	2.0 U
m/p-Xylene	4 µg/l	4.0 UJ	4.0 UJ	4.0 UJ	4.0 U	4.0 U
o-Xylene	2 µg/l	2.0 U	2.0 U	2.0 U	2.0 U	2.0 U
TPH-dro	100 mg/l	NA	NA	NA	NA	NA
TPH-gro	100 µg/l	100 U	100 U	100 U	100 U	100 U

NOTES:

U = Concentration is less than reporting limit

J = Concentration is estimated

NA = Not Analyzed

TABLE 7 - 15
RI GROUNDWATER OFF-SITE ANALYTICAL RESULTS [a]
AOC 69W

REMEDIAL INVESTIGATION REPORT
DEVENS, MASSACHUSETS

Site ID: Field Sample Number: Lab Sample Number: Sample Date: Depth: Units:	DEVENS BACKGROUND CONCENTRATIONS (µg/L)	69W-94-09 MXZW09X3 DV4F*269 11/02/95 8.5 (µg/L)	69W-94-09 MXZW09X3 DV4W*269 11/02/95 8.5 (µg/L)	69W-94-09 MXZW09X3 DV4W*269 11/03/95 8.5 (µg/L)	69W-94-09 MXZW09X4 12/18/97 8.5 (µg/L)	69W-94-10 MXZW10X3 DV4F*271 11/02/95 9.5 (µg/L)	69W-94-10 MXZW10X3 DV4W*271 11/02/95 9.5 (µg/L)	69W-94-10 MXZW10X4 DV4F*272 02/14/96 9.5 (µg/L)	69W-94-10 MXZW10X4 DV4W*272 02/14/96 9.5 (µg/L)
PAL METALS									
Aluminum	6870	< 141 F	448	448		141 F	< 141	< 141 F	< 141
Arsenic	10.5	< 2.54 F	< 2.54	< 2.54		160 F	180	150 F	160
Barium	39.6	16.3 F	17.2	17.2		14 F	15.2	16.5 F	18.4
Calcium	14700	17300 F	17400	17400		19300 F	21100	26300 F	29000
Copper	8.09	< 8.09 F	< 8.09	< 8.09		8.09 F	< 8.09	< 8.09 F	< 8.09
Iron	9100	< 38.8 F	443	443		16300 F	18600	28800 F	34200
Lead	4.25	2.17 F	1.41	1.41		1.26 F	3.36	< 1.26 F	< 1.26
Magnesium	3480	1690 F	1800	1800		1880 F	2030	2660 F	3020
Manganese	291	3.89 F	13	13		1210 F	1440	3070 F	4010
Potassium	2370	2400 F	2580	2580		4790 F	5040	4720 F	5130
Sodium	10800	27800 F	27100	27100		23100 F	23500	21300 F	23500
PESTICIDES/PCBS									
Chlordane - Gamma			< .075 T	< .075 T			< .075 T		.115 CZ
Heptachlor Epoxide			< .0245	< .0245			< .0245		.0586 C
SVOCs									
2-Methylnaphthalene			< 1.7	< 1.7			500 X		600
Acenaphthene			< 1.7	< 1.7			< 20		< 100
Dibenzofuran			< 1.7	< 1.7			< 20		< 100
Diethyl Phthalate			< 2	< 2			< 20		< 200
Fluorene			< 3.7	< 3.7			80		< 300
Naphthalene			< .5	< .5			200 X		200
Phenanthrene			< .5	< .5			100		200
Bis(2-ethylhexyl) Phthalate			4.5	4.5			500		500
VOCs									
1,1,1-Trichloroethane			< .5	< .5			< .5		< 2
Acetone			14	14			< 13		< 60
Chloroform			< .5	< .5			< .5		< 2
Ethylbenzene			< .5	< .5	5 U		14		20
Toluene			< .5	< .5			3		< 2
Trichloroethylene			< .5	< .5			< .5		< 2
Xylenes			< .84	< .84			1.4		< 4
WET CHEMISTRY									
Alkalinity			36000	36000			38000		89000
Chloride			44000	44000			46000		42000
Nitrite, Nitrate-non Specific			1700	1700			1100		570
Nitrogen By Kjeldahl Method			286	286			952		200
Phosphate			1900	1900			500		< 13.3
Sulfate			18000	18000			10000		< 10000
Total Dissolved Solids			112000	112000			128000		202000
Total Hardness			52000	52000			24000		80800
Total Suspended Solids			1660000	1660000			259000		35000
							285000 D		
OTHER									
Total Organic Carbon									
Total Petroleum Hydrocarbons			< 185	< 185			159000		228000

[a] The data for 1995 and 1996 are for AEC methods; non-detects reflect the Certified Reporting Limit (CRL). The data for 1997 are for SW-846 methods; non-detects reflect the Practical Quantitation Limit (PQL).

TABLE 7 - 15
RI GROUNDWATER OFF-SITE ANALYTICAL RESULTS [a]
AOC 69W

REMEDIAL INVESTIGATION REPORT
DEVENS, MASSACHUSETS

Site ID:		69W--94-10	69W--94-10	69W--94-11	69W--94-11	69W--94-11	69W--94-11	69W--94-11	69W--94-11
Field Sample Number:		MXZW10X5	MXZW10X6	MDZW11X4	MDZW11X4	MXZW11X3	MXZW11X3	MXZW11X4	MXZW11X4
Lab Sample Number:	DEVENS	DV4W*513		DV4F*456	DV4W*456	DV4F*273	DV4W*273	DV4F*274	DV4W*274
Sample Date:	BACKGROUND	10/01/96	12/11/97	02/14/96	02/14/96	11/03/95	11/03/95	02/14/96	02/14/96
Depth:	CONCENTRATIONS	0	9.5	9.5	9.5	9.5	9.5	9.5	9.5
Units:	(µg/L)	(µg/L)	(µg/L)	(µg/L)	(µg/L)	(µg/L)	(µg/L)	(µg/L)	(µg/L)
PAL METALS									
Aluminum	6870			< 141 F	< 141 D	< 141 F	616	< 141 F	< 141
Arsenic	10.5			14.7 DF	13 D	11.3 F	15.8	9.38 F	11.3
Barium	39.6			7.69 F	7.44 D	8.68 F	11	6.18 F	6.93
Calcium	14700			22300 F	21800 D	22300 F	21900	20100 F	21600
Copper	8.09			< 8.09 F	< 8.09 D	< 8.09 F	< 8.09	< 8.09 F	< 8.09
Iron	9100			615 F	599 D	241 F	845	484 F	807
Lead	4.25			< 1.26 DF	< 1.26 D	< 1.26 F	< 1.26	< 1.26 F	< 1.26
Magnesium	3480			2510 F	2430 D	2460 F	2520	2240 F	2430
Manganese	291			507 F	493 D	464 F	517	405 F	505
Potassium	2370			2090 F	1560 D	2080 F	2110	2110 F	1670
Sodium	10800			30800 F	30000 D	33300 F	32700	27400 F	29800
PESTICIDES/PCBS									
Chlordane - Gamma					< .075 DT		< .075 T		< .075 T
Heptachlor Epoxide					< .0245 D		< .0245		< .0245
SVOCs									
2-Methylnaphthalene			73		< 1.7 D		< 1.7		< 1.7
Acenaphthene					< 1.7 D		< 1.7		< 1.7
Dibenzofuran					< 1.7 D		< 1.7		< 1.7
Diethyl Phthalate					< 2 D		< 2		5.1
Fluorene			4 J		< 3.7 D		< 3.7		< 3.7
Naphthalene			39		< .5 D		< .5		< .5
Phenanthrene			3 J		< .5 D		< .5		< .5
Bis(2-ethylhexyl) Phthalate					< 4.8 D		< 4.8		< 4.8
VOCs									
1,1,1-Trichloroethane					< .5 D		1.5		< .5
Acetone					< 13 D		< 13		< 13
Chloroform					< .5 D		< .5		< .5
Ethylbenzene			16		< .5 D		< .5		< .5
Toluene					< .5 D		< .5		< .5
Trichloroethylene					< .5 D		3.3		< .5
Xylenes					< .84 D		< .84		< .84
WET CHEMISTRY									
Alkalinity					45000 D		92000		44000
Chloride					50000 D		44000		50000
Nitrite, Nitrate-non Specific					2000 D		1300		< 10
Nitrogen By Kjeldahl Method		1710			< 183 D		400		< 183
Phosphate		36.2			< 13.3 D		30.3		22.7
Sulfate					15000 D		14000		15000
Total Dissolved Solids		139000			166000 D		163000		163000
Total Hardness		137000000			61200 D		2000		66200
Total Suspended Solids		37000			5000 D		26000		< 4000
OTHER									
Total Organic Carbon		6070							
Total Petroleum Hydrocarbons		< 170			< 175 D		< 169		2420

[a] The data for 1995 and 1996 are for AEC methods; non-detects reflect the Certified Reporting Limit (CRL). The data for 1997 are for SW-846 methods; non-detects reflect the Practical Quantitation Limit (PQL).

TABLE 7 - 15
RI GROUNDWATER OFF-SITE ANALYTICAL RESULTS [a]
AOC 69W

REMEDIAL INVESTIGATION REPORT
DEVENS, MASSACHUSETS

Site ID:		**69W–94-11**	**69W–94-11**	**69W–94-12**	**69W–94-12**	**69W–94-12**	**69W–94-12**	**69W–94-12**
Field Sample Number:		**MXZW11X5**	**MXZW11X6**	**MDZW12X3**	**MDZW12X3**	**MXZW12X3**	**MXZW12X3**	**MXZW12X4**
Lab Sample Number:	**DEVENS**	**DV4W*515**		**DV4F*450**	**DV4W*450**	**DV4F*275**	**DV4W*275**	**DV4F*276**
Sample Date:	**BACKGROUND**	**10/01/96**	**12/11/97**	**11/02/95**	**11/02/95**	**11/02/95**	**11/02/95**	**02/13/96**
Depth:	**CONCENTRATIONS**	**0**	**9.5**	**8**	**8**	**8**	**8**	**8**
Units:	**(µg/L)**	**(µg/L)**	**(µg/L)**	**(µg/L)**	**(µg/L)**	**(µg/L)**	**(µg/L)**	**(µg/L)**
PAL METALS								
Aluminum	6870			< 141 DF	185 D	< 141 F	198	< 141 F
Arsenic	10.5			< 2.54 DF	< 2.54 D	< 2.54 F	< 2.54	< 2.54 F
Barium	39.6			< 5 DF	< 5 D	< 5 F	< 5	< 5 F
Calcium	14700			19600 DF	18700 D	20900 F	19300	18000 F
Copper	8.09			< 8.09 DF	< 8.09 D	< 8.09 F	< 8.09	< 8.09 F
Iron	9100			< 38.8 DF	188 D	44.1 F	249	< 38.8 F
Lead	4.25			1.74 DF	3.9 D	3.36 F	< 1.26	< 1.26 F
Magnesium	3480			2010 DF	1970 D	2160 F	2040	1870 F
Manganese	291			3.64 DF	10.9 D	< 2.75 F	9	4.29 F
Potassium	2370			1690 DF	1750 D	1770 F	1650	1660 F
Sodium	10800			28200 DF	26500 D	28700 F	27500	19500 F
PESTICIDES/PCBS								
Chlordane - Gamma					< .075 TD		< .075 T	
Heptachlor Epoxide					< 0245 D		< .0245	
SVOCs								
2-Methylnaphthalene			10 U		< 1.7 D		< 1.7	
Acenaphthene					< 1.7 D		< 1.7	
Dibenzofuran					< 1.7 D		< 1.7	
Diethyl Phthalate					< 2 D		< 2	
Fluorene			10 U		< 3.7 D		< 3.7	
Naphthalene			10 U		< .5 D		< .5	
Phenanthrene			10 U		< .5 D		< .5	
Bis(2-ethylhexyl) Phthalate					< 4.8 D		< 4.8	
VOCs								
1,1,1-Trichloroethane					< .5 D		< .5	
Acetone					< 13 D		< 13	
Chloroform					< .5 D		.55	
Ethylbenzene			5 U		< .5 D		6	
Toluene					< .5 D		< .5	
Trichloroethylene					< .5 D		< .5	
Xylenes					< .84 D		< .84	
WET CHEMISTRY								
Alkalinity					48000 D		41000	
Chloride					42000 D		44000	
Nitrite, Nitrate-non Specific					3100 D		3400	
Nitrogen By Kjeldahl Method		< 183			1050 D		952	
Phosphate		< 13.3			2000 D		2200	
Sulfate					16000 D		16000	
Total Dissolved Solids		136000			117000 D		116000	
Total Hardness		74200000			60000 D		60000	
Total Suspended Solids		< 4000			1580000 D		1520000	
OTHER								
Total Organic Carbon		< 1000						
Total Petroleum Hydrocarbons		< 172			< 180 D		< 176	

[a] The data for 1995 and 1996 are for AEC methods; non-detects reflect the Certified Reporting Limit (CRL). The data for 1997 are for SW-846 methods; non-detects reflect the Practical Quantitation Limit (PQL).

TABLE 7 - 15
RI GROUNDWATER OFF-SITE ANALYTICAL RESULTS [a]
AOC 69W

REMEDIAL INVESTIGATION REPORT
DEVENS, MASSACHUSETS

Site ID:		69W–94-12	69W–94-12	69W–94-13	69W–94-13	69W–94-13	69W–94-13	69W–94-13
Field Sample Number:		MXZW12X4	MXZW12X5	MXZW13X3	MXZW13X3	MXZW13X4	MXZW13X4	MXZW13X5
Lab Sample Number:	DEVENS	DV4W*276		DV4F*277	DV4W*277	DV4F*278	DV4W*278	
Sample Date:	BACKGROUND	02/13/96	12/19/97	11/02/95	11/02/95	02/13/96	02/13/96	12/12/97
Depth:	CONCENTRATIONS	8	8	8	8	8	8	8
Units:	(µg/L)	(µg/L)	(µg/L)	(µg/L)	(µg/L)	(µg/L)	(µg/L)	(µg/L)
PAL METALS								
Aluminum	6870	591		< 141 F	< 141	< 141 F	< 141	
Arsenic	10.5	< 2.54		150 F	260	110 F	120	
Barium	39.6	6.74		15.7 F	16.7	10.5 F	10.8	
Calcium	14700	19300		25900 F	16300	22600 F	23800	
Copper	8.09	< 8.09		< 8.09 F	< 8.09	< 8.09 F	< 8.09	
Iron	9100	664		20100 F	21200	15200 F	16200	
Lead	4.25	< 1.26		2.71 F	< 1.26	< 1.26 F	< 1.26	
Magnesium	3480	2180		2860 F	2960	2490 F	2610	
Manganese	291	22.6		2110 F	2070	1870 F	1980	
Potassium	2370	1610		2740 F	2570	2080 F	2190	
Sodium	10800	21400		29600 F	29100	18400 F	19400	
PESTICIDES/PCBS								
Chlordane - Gamma		< .075 T			< .075 T		< .075 T	
Heptachlor Epoxide		< .0245			< .0245		< .0245	
SVOCs								
2-Methylnaphthalene		< 1.7			8.7		7.6	13 J
Acenaphthene		< 1.7			2.3		2.1	
Dibenzofuran		< 1.7			2.4		2.3	
Diethyl Phthalate		4.1			< 2		< 2	
Fluorene		< 3.7			< 3.7		< 3.7	3 J
Naphthalene		< .5			16		15	10 J
Phenanthrene		< .5			2.6		1.8	2 J
Bis(2-ethylhexyl) Phthalate		< 4.8			< 4.8		< 4.8	
VOCs								
1,1,1-Trichloroethane		< .5			< .5		< .5	
Acetone		< 13			< 13		< 13	
Chloroform		< .5			1.1		< .5	
Ethylbenzene		< .5	5 U		< .5		3.6	3 J
Toluene		1.1			< .5		< .5	
Trichloroethylene		< .5			< .5		< .5	
Xylenes		< .84			< .84		< .84	
WET CHEMISTRY								
Alkalinity		27000			104000		72000	
Chloride		43000			26300		35000	
Nitrite, Nitrate-non Specific		3000			1400		111	
Nitrogen By Kjeldahl Method		257			714		352	
Phosphate		16.6			111		15.8	
Sulfate		14000			< 10000		< 10000	
Total Dissolved Solids		149000			165000		165000	
Total Hardness		58000			10000		72800	
Total Suspended Solids		16000			74000		18000	
OTHER								
Total Organic Carbon								
Total Petroleum Hydrocarbons		< 175			523		< 181	

[a] The data for 1995 and 1996 are for AEC methods; non-detects reflect the Certified Reporting Limit (CRL). The data for 1997 are for SW-846 methods; non-detects reflect the Practical Quantitation Limit (PQL).

TABLE 7 - 15
RI GROUNDWATER OFF-SITE ANALYTICAL RESULTS [a]
AOC 69W

REMEDIAL INVESTIGATION REPORT
DEVENS, MASSACHUSETS

Site ID:		69W-94-14	69W-94-14	69W-94-14	69W-94-14	69W-94-14	ZWM-95-15X	ZWM-95-15X
Field Sample Number:		MXZW14X3	MXZW14X3	MXZW14X4	MXZW14X4	MXZW14X5	MXZW15X1	MXZW15X1
Lab Sample Number:	DEVENS	DV4F*279	DV4W*279	DV4F*280	DV4W*280		DV4F*281	DV4W*281
Sample Date:	BACKGROUND	11/03/95	11/03/95	02/13/96	02/13/96	12/12/97	11/01/95	11/01/95
Depth:	CONCENTRATIONS	8	8	8	8	8	8	8
Units:	(µg/L)	(µg/L)	(µg/L)	(µg/L)	(µg/L)	(µg/L)	(µg/L)	(µg/L)
PAL METALS								
Aluminum	6870	< 141 F	< 141	< 141 F	< 141		< 141 F	< 141
Arsenic	10.5	12.8 F	17.9	10.3 F	10.3		3.73 F	4.8
Barium	39.6	16 F	16.1	10.6 F	11.3		14.4 F	13.9
Calcium	14700	19000 F	18800	17500 F	17800		18600 F	18000
Copper	8.09	< 8.09 F	< 8.09	< 8.09 F	< 8.09		< 8.09 F	10.3
Iron	9100	2000 F	2920	3720 F	3840		1030 F	1120
Lead	4.25	< 1.26 F	< 1.26	< 1.26 F	< 1.26		< 1.26 F	< 1.26
Magnesium	3480	2130 F	2060	2040 F	2090		1780 F	1720
Manganese	291	255 F	299	325 F	348		405 F	457
Potassium	2370	2270 F	1980	1560 F	1880		2200 F	2380
Sodium	10800	37000 F	36700	23500 F	23700		43800 F	42700
PESTICIDES/PCBS								
Chlordane - Gamma			< .075 T		< .075 T			< .075 T
Heptachlor Epoxide			< .0245		< .0245			< .0245
SVOCs								
2-Methylnaphthalene			< 1.7		< 1.7	11 UJ		< 1.7
Acenaphthene			< 1.7		< 1.7			< 1.7
Dibenzofuran			< 1.7		< 1.7			< 1.7
Diethyl Phthalate			< 2		< 2			< 2
Fluorene			< 3.7		< 3.7	11 UJ		< 3.7
Naphthalene			< .5		< .5	11 UJ		< .5
Phenanthrene			< .5		< .5	11 UJ		< .5
Bis(2-ethylhexyl) Phthalate			< 4.8		< 4.8			< 4.8
VOCs								
1,1,1-Trichloroethane			< .5		< .5			< .5
Acetone			< 13		< 13			< 13
Chloroform			< .5		< .5			< .5
Ethylbenzene			< .5		< .5	5 U		< .5
Toluene			3.2		.61			< .5
Trichloroethylene			< .5		< .5			< .5
Xylenes			< .84		< .84			< .84
WET CHEMISTRY								
Alkalinity			27000		44000			43000
Chloride			26300		28500			55000
Nitrite, Nitrate-non Specific			1700		450			2000
Nitrogen By Kjeldahl Method			848		210			324
Phosphate			1700		< 13.3			143
Sulfate			< 10000		28000			30000
Total Dissolved Solids			129000		158000			158000
Total Hardness			58000		52800			42000
Total Suspended Solids			970000		8000			113000
OTHER								
Total Organic Carbon								
Total Petroleum Hydrocarbons			1960		< 175			281

[a] The data for 1995 and 1996 are for AEC methods; non-detects reflect the Certified Reporting Limit (CRL). The data for 1997 are for SW-846 methods; non-detects reflect the Practical Quantitation Limit (PQL).

TABLE 7 - 15
RI GROUNDWATER OFF-SITE ANALYTICAL RESULTS [a]
AOC 69W

REMEDIAL INVESTIGATION REPORT
DEVENS, MASSACHUSETS

Site ID:		ZWM-95-15X	ZWM-95-15X	ZWM-95-15X	ZWM-95-16X	ZWM-95-16X	ZWM-95-16X	ZWM-95-16X
Field Sample Number:		MXZW15X2	MXZW15X2	MXZW15X3	MXZW16X1	MXZW16X1	MXZW16X2	MXZW16X2
Lab Sample Number:	DEVENS	DV4F*282	DV4W*282		DV4F*283	DV4W*283	DV4F*284	DV4W*284
Sample Date:	BACKGROUND	02/13/96	02/13/96	12/12/97	11/01/95	11/01/95	02/13/96	02/13/96
Depth:	CONCENTRATIONS	8	8	8	11.3	11.3	11.3	11.3
Units:	(µg/L)	(µg/L)	(µg/L)	(µg/L)	(µg/L)	(µg/L)	(µg/L)	(µg/L)
PAL METALS								
Aluminum	6870	< 141 F	< 141		< 141 F	< 141	< 141 F	< 141
Arsenic	10.5	5.44 F	5.65		11.2 F	11.8	< 2.54 F	< 2.54
Barium	39.6	10 F	10.6		9.81 F	10.2	9.91 F	10.8
Calcium	14700	16700 F	17200		21000 F	21000	14600 F	15300
Copper	8.09	< 8.09 F	< 8.09		< 8.09 F	< 8.09	< 8.09 F	< 8.09
Iron	9100	1080 F	1300		1180 F	1290	391 F	326
Lead	4.25	< 1.26 F	< 1.26		< 1.26 F	< 1.26	< 1.26 F	< 1.26
Magnesium	3480	1610 F	1690		2200 F	2230	1480 F	1580
Manganese	291	256 F	285		992 F	1010	151 F	145
Potassium	2370	1860 F	2000		3100 F	3050	2430 F	2860
Sodium	10800	32400 F	33600		26400 F	26700	20600 F	21700
PESTICIDES/PCBS								
Chlordane - Gamma			< .075 T			< .075 T		< .075 T
Heptachlor Epoxide			< .0245			< .0245		< .0245
SVOCs								
2-Methylnaphthalene			< 1.7			< 1.7		< 1.7
Acenaphthene			< 1.7			< 1.7		< 1.7
Dibenzofuran			< 1.7			< 1.7		< 1.7
Diethyl Phthalate			< 2			< 2		< 2
Fluorene			< 3.7			< 3.7		< 3.7
Naphthalene			< .5			< .5		< .5
Phenanthrene			< .5			< .5		< .5
Bis(2-ethylhexyl) Phthalate			< 4.8			< 4.8		4.5
VOCs								
1,1,1-Trichloroethane			< .5			< .5		< .5
Acetone			< 13			< 13		< 13
Chloroform			< .5			< .5		< .5
Ethylbenzene			< .5	5 U		< .5		< .5
Toluene			1.2			< .5		.9
Trichloroethylene			< .5			1.2		< .5
Xylenes			< .84			< .84		< .84
WET CHEMISTRY								
Alkalinity			40000			50000		24000
Chloride			48000			46000		37000
Nitrite, Nitrate-non Specific			2300			47		2100
Nitrogen By Kjeldahl Method			257			219		210
Phosphate			< 13.3			147		< 13.3
Sulfate			18000			10000		14000
Total Dissolved Solids			167000			120000		142000
Total Hardness			52000			< 1000		43600
Total Suspended Solids			8000			214000		7000
OTHER								
Total Organic Carbon								
Total Petroleum Hydrocarbons			< 177			1340		< 175

[a] The data for 1995 and 1996 are for AEC methods; non-detects reflect the Certified Reporting Limit (CRL). The data for 1997 are for SW-846 methods; non-detects reflect the Practical Quantitation Limit (PQL).

TABLE 7 - 15
RI GROUNDWATER OFF-SITE ANALYTICAL RESULTS [a]
AOC 69W

REMEDIAL INVESTIGATION REPORT
DEVENS, MASSACHUSETS

Site ID:		ZWM-95-16X	ZWM-95-16X	ZWM-95-17X	ZWM-95-17X	ZWM-95-17X	ZWM-95-17X	ZWM-95-17X
Field Sample Number:		MXZW16X3	MXZW16X4	MXZW17X1	MXZW17X1	MXZW17X2	MXZW17X2	MXZW17X3
Lab Sample Number:	DEVENS	DV4W*514		DV4F*285	DV4W*285	DV4F*286	DV4W*286	
Sample Date:	BACKGROUND	10/01/96	12/18/97	11/03/95	11/03/95	02/12/96	02/12/96	12/16/97
Depth:	CONCENTRATIONS	0	11.3	17.2	17.2	17.2	17.2	17.2
Units:	(µg/L)	(µg/L)	(µg/L)	(µg/L)	(µg/L)	(µg/L)	(µg/L)	(µg/L)
PAL METALS								
Aluminum	6870			< 141 F	650	< 141 F	< 141	
Arsenic	10.5			< 2.54 F	< 2.54	< 2.54 F	< 2.54	
Barium	39.6			4.94 F	7.14	< 5 F	< 5	
Calcium	14700			14500 F	23800	22300 F	23700	
Copper	8.09			< 8.09 F	< 8.09	< 8.09 F	< 8.09	
Iron	9100			88.5 F	853	< 38.8 F	< 38.8	
Lead	4.25			< 1.26 F	2.39	< 1.26 F	< 1.26	
Magnesium	3480			3240 F	3290	2680 F	2720	
Manganese	291			8.26 F	26.9	< 2.75 F	< 2.75	
Potassium	2370			2070 F	1790	1610 F	1480	
Sodium	10800			26800 F	25800	32400 F	34800	
PESTICIDES/PCBS								
Chlordane - Gamma					< .075 T		< .075 T	
Heptachlor Epoxide					< .0245		< .0245	
SVOCs								
2-Methylnaphthalene					< 1.7		< 1.7	
Acenaphthene					< 1.7		< 1.7	
Dibenzofuran					< 1.7		< 1.7	
Diethyl Phthalate					< 2		< 2	
Fluorene					< 3.7		< 3.7	
Naphthalene					< .5		< .5	
Phenanthrene					< .5		< .5	
Bis(2-ethylhexyl) Phthalate					4.9		6.5	
VOCs								
1,1,1-Trichloroethane					< .5		< .5	
Acetone					< 13		< 13	
Chloroform					< .5		< .5	
Ethylbenzene			5 U		< .5		< .5	5 U
Toluene					.52		< .5	
Trichloroethylene					< .5		< .5	
Xylenes					< .84		< .84	
WET CHEMISTRY								
Alkalinity					48000		18000	
Chloride					50000		66000	
Nitrite, Nitrate-non Specific					1500		3000	
Nitrogen By Kjeldahl Method		< 183			248		229	
Phosphate		< 13.3			99		< 13.3	
Sulfate					17000		17000	
Total Dissolved Solids		165000			130000 138000 D		209000	
Total Hardness		56800000			74000		68800	
Total Suspended Solids		< 4000			120000 116000 D		10000	
OTHER								
Total Organic Carbon		< 1000						
Total Petroleum Hydrocarbons		< 172			< 167		< 181	

[a] The data for 1995 and 1996 are for AEC methods; non-detects reflect the Certified Reporting Limit (CRL). The data for 1997 are for SW-846 methods; non-detects reflect the Practical Quantitation Limit (PQL).

TABLE 7 - 15
RI GROUNDWATER OFF-SITE ANALYTICAL RESULTS [a]
AOC 69W

REMEDIAL INVESTIGATION REPORT
DEVENS, MASSACHUSETS

Site ID:		ZWM-95-18X	ZWM-95-18X	ZWM-95-18X	ZWM-95-18X	ZWM-95-18X	ZWM-96-19X	ZWM-96-19X
Field Sample Number:		MXZW18X1	MXZW18X1	MXZW18X2	MXZW18X2	MXZW18X3	MDZW19X1	MXZW19X1
Lab Sample Number:	DEVENS	DV4F*287	DV4W*287	DV4F*288	DV4W*288		DV4W*304	DV4W*510
Sample Date:	BACKGROUND	11/02/95	11/02/95	02/12/96	02/12/96	12/16/97	09/30/96	09/30/96
Depth:	CONCENTRATIONS	8	8	8	8	8	0	0
Units:	(µg/L)	(µg/L)	(µg/L)	(µg/L)	(µg/L)	(µg/L)	(µg/L)	(µg/L)
PAL METALS								
Aluminum	6870	< 141 F	< 141	< 141 F	< 141			
Arsenic	10.5	< 2.54 F	< 2.54	< 2.54 F	< 2.54			
Barium	39.6	7.47 F	7.03	6.46 F	7.02			
Calcium	14700	15000 F	15600	15500 F	15500			
Copper	8.09	< 8.09 F	< 8.09	< 8.09 F	< 8.09			
Iron	9100	< 38.8 F	< 38.8	< 38.8 F	< 38.8			
Lead	4.25	< 1.26 F	< 1.26	< 1.26 F	< 1.26			
Magnesium	3480	1690 F	1780	1730 F	1750			
Manganese	291	27.4 F	25.5	5.97 F	6.47			
Potassium	2370	1590 F	1610	1590 F	1730			
Sodium	10800	38100 F	38300	37000 F	37200			
PESTICIDES/PCBS								
Chlordane - Gamma			< .075 T		< .075 T			
Heptachlor Epoxide			< .0245		< .0245			
SVOCs								
2-Methylnaphthalene			< 1.7		< 1.7			
Acenaphthene			< 1.7		< 1.7			
Dibenzofuran			< 1.7		< 1.7			
Diethyl Phthalate			< 2		5			
Fluorene			< 3.7		< 3.7			
Naphthalene			< .5		< .5			
Phenanthrene			< .5		< .5			
Bis(2-ethylhexyl) Phthalate			< 4.8		< 4.8			
VOCs								
1,1,1-Trichloroethane			< .5		< .5			
Acetone			< 13		20			
Chloroform			< .5		< .5			
Ethylbenzene			< .5		< .5	5 U		
Toluene			< .5		.64			
Trichloroethylene			< .5		< .5			
Xylenes			< .84		< .84			
WET CHEMISTRY								
Alkalinity			44000		20000			
Chloride			50000		59000			
Nitrite, Nitrate-non Specific			2300		3000		250 D	
Nitrogen By Kjeldahl Method			210		219		< 183 D	< 183
Phosphate			55.1		< 13.3		18.6 D	19.8
Sulfate			18000		20000			
Total Dissolved Solids			109000		183000		177000 D	175000
Total Hardness			46000		46800		85000000 D	82400000
Total Suspended Solids			23000		< 4000		8000 D	< 4000
OTHER								
Total Organic Carbon							< 1000 D	< 1000
Total Petroleum Hydrocarbons			< 172		< 175		< 170 D	< 174

[a] The data for 1995 and 1996 are for AEC methods; non-detects reflect the Certified Reporting Limit (CRL). The data for 1997 are for SW-846 methods; non-detects reflect the Practical Quantitation Limit (PQL).

TABLE 7 - 15
RI GROUNDWATER OFF-SITE ANALYTICAL RESULTS [a]
AOC 69W

REMEDIAL INVESTIGATION REPORT
DEVENS, MASSACHUSETS

Site ID:		ZWM-96-19X	ZWM-96-19X	ZWM-96-20X	ZWM-96-20X	ZWM-96-21X	ZWM-96-21X
Field Sample Number:		MXZW19X2	MDZW19X2	MXZW20X1	MXZW20X2	MXZW21X1	MXZW21X2
Lab Sample Number:	DEVENS BACKGROUND CONCENTRATIONS			DV4W*511		DV4W*512	
Sample Date:		12/18/97	12/18/97	10/01/96	12/16/97	09/30/96	12/18/97
Depth:		0	0	0	0	0	0
Units:	(µg/L)	(µg/L)	(µg/L)	(µg/L)	(µg/L)	(µg/L)	(µg/L)
PAL METALS							
Aluminum	6870						
Arsenic	10.5						
Barium	39.6						
Calcium	14700						
Copper	8.09						
Iron	9100						
Lead	4.25						
Magnesium	3480						
Manganese	291						
Potassium	2370						
Sodium	10800						
PESTICIDES/PCBS							
Chlordane - Gamma							
Heptachlor Epoxide							
SVOCs							
2-Methylnaphthalene							
Acenaphthene							
Dibenzofuran							
Diethyl Phthalate							
Fluorene							
Naphthalene							
Phenanthrene							
Bis(2-ethylhexyl) Phthalate							
VOCs							
1,1,1-Trichloroethane							
Acetone							
Chloroform							
Ethylbenzene		5 U	5 U		5 U		5 U
Toluene							
Trichloroethylene							
Xylenes							
WET CHEMISTRY							
Alkalinity							
Chloride							
Nitrite, Nitrate-non Specific							
Nitrogen By Kjeldahl Method				< 183		< 183	
Phosphate				< 13.3		< 13.3	
Sulfate							
Total Dissolved Solids				218000		170000	
Total Hardness				89200000		73200000	
Total Suspended Solids				< 4000		< 4000	
OTHER							
Total Organic Carbon				< 1000		< 1000	
Total Petroleum Hydrocarbons				< 167		< 178	

[a] The data for 1995 and 1996 are for AEC methods; non-detects reflect the Certified Reporting Limit (CRL). The data for 1997 are for SW-846 methods; non-detects reflect the Practical Quantitation Limit (PQL).

TABLE 7-15
RI GROUNDWATER OFF-SITE ANALYTICAL RESULTS[a]
AOC 69W

REMEDIAL INVESTIGATION REPORT
DEVENS, MASSACHUSETTS

Sample Key:

Measurement Boolean	Concentration	Data Qualifier (Upper case letters)	Flagging Codes (Lower case letters or #)
ND	300	J	adf

Measurement Boolean

< = Concentration was less than the certified reporting limit
ND = Not detectable above the indicated value
EQ = Equal to the certified reporting limit

Data Qualifiers

? = Control chart for corresponding lot not yet reviewed by AEC Chemist. This qualifier is automatically set when a lot file has been uploaded to the database, but a corresponding control chart has not been approved.
I = The low spike recovery for this lot was high
M = The high spike recovery for this lot was high
J = The low spike recovery for this lot was low
K = Missed holding time for extraction or preparation
L = Missed analysis holding time
N = The high spike recovery for this lot was low
O = Low spike recoveries excessively different
R = Data is rejected and is not useable

Flagging Codes

1 = Result was less than the certified reporting limit but greater than the criteria of detection (COD) for 1990 QA Plan methods
2 = Ending calibration not within acceptable limits
3 = Internal standard not within acceptable limits
7 = Low spike recovery not within control limits
8 = Analyte recovery outside certified range but within acceptable limits. This code is used when analyte concentrations exceeded the certified range by <15 % and the laboratory felt a dilution was not warranted
a = Analyte found in trip blank as well as the sample
b = Analyte found in method blank or QC sample as well as the sample
c = Analysis was confirmed by a different column or technique
d = Duplicate analysis
f = Sample was filtered prior to analysis
g = Analyte found in that day's rinsate blank as well as the sample
h = Lot out of control but data accepted due to high recoveries
i = Interences in the sample caused the quantitation and/or identification to be suspect
j = Value is estimated
k = Reported results affected by interferences or high background. An elevated quantitation limit is reported
l = Out of control. Data rejected due to low recoveries
m= High duplicate spike not within control limits
n = Tentatively-identified compound (TIC) by GC/MC with a match greater than 70 %
p = Value is less than the method reporting limit but greater than the instrument detection limit
q = Confirmatory analysis was performed, however sample interferences prevented confirmation
r = Non-target analyte analyzed for but not detected by GC/MS. Laboratory is not certified for this analyte by the given method Analyte was not performance demonstrated or validated
s = Non-target compound analyzed for and detected by GC/MS. Laboratory is not certified for this anlayte by the given method. Analyte was not performance demonstrated or validated
t = Non-target compound analyzed for and not detected (non-GC/MS method).
u = Analysis is unconfirmed. Confirmatory analysis was run but did not verify original result
v = Sample was not correctly preserved (i.e. > 4 degrees C or improperly preserved)
z = Non-target analyte analyzed for and detected by non-GC/MS method

TABLE 7 – 16
EPH – VPH GROUNDWATER OFF–SITE LABORATORY RESULTS
AOC 69W

REMEDIAL INVESTIGATION REPORT
DEVENS, MASSACHUSETTS

Site ID:	**69W––94–09**	**69W––94–10**	**69W––94–10**	**69W––94–11**	**69W––94–11**	**69W––94–12**
Field Sample Number:	**MXZW0904**	**MXZW10X5**	**MXZW10X6**	**MXZW11X5**	**MXZW11X6**	**MXZW12X5**
Sample Date:	**12/18/97**	**10/02/96**	**12/11/97**	**10/01/96**	**12/11/97**	**12/19/97**
Depth:	**8.5**	**9.5**	**9.5**	**11**	**11**	**8**
EPH (µg/L)		740		< 2.5		
ALIPHATICS						
n–C 9 to n–C 18	37 UJ	590	32 J	< 25	75 J	39 UJ
n–C 19 to n–C 36	49 U	< 2.5	41 U	< 2.5	38 U	52 U
AROMATICS						
n–C 11 to n–C 22	100 U	710	480	< 500	84	110 U
TARGETED PAH ANALYTES (µg/L)						
2–Methylnaphthalene	6.2 UJ	89	81 J	< 10	4.8 UJ	6.5 UJ
Acenaphthene	6.2 U	15	5.7	< 10	4.8 U	6.5 U
Acenaphthylene	6.2 U	< 10	6.9	< 10	4.8 U	6.5 U
Anthracene		< 10		< 10		
Benzo(a)anthracene		< 10		< 10		
Benzo(a)pyrene		< 10		< 10		
Benzo(b)fluoranthene		< 10		< 10		
Benzo(g,h,i)perylene		< 10		< 10		
Benzo(k)fluoranthene		< 10		< 10		
Chyrsene		< 10		< 10		
Dibenzo(a,h)anthracene		< 10		< 10		
Fluoranthene	6.2 U	< 10	5.1 U	< 10	8.1	6.5 U
Fluorene		< 10		< 10		
Indeno(1,2,3–c,d)pyrene		< 10		< 10		
Naphthalene	6.2 UJ	45	37 J	< 10	4.8 UJ	6.5 UJ
Phenanthrene		< 10		< 10		
Pyrene		< 10		< 10		
VPH (µg/L)		830		< 0.25		
ALIPHATICS						
n–C 5 to n–C 8		17		< 2.5		
n–C 9 to n–C 12	65 U	550	120	< 0.25	65 U	65 U
AROMATICS						
n–C 9 to n–C 10	20 U	790	430	< 5	20 U	20 U
TARGETED VOCs (µg/L)						
Benzene		< 5		< 5		
Ethylbenzene	5 U	35	15	< 5	5 U	5 U
Methyl tert–butly Ether		< 25		< 25		
Naphthalene	10 U	94	100	< 10	10 U	10 U
Toluene		< 5		< 5		
m/p–Xylene		< 5		< 5		
o–Xylene		< 5		< 5		

Notes:
J = Estimated value, below quantitation limit.
U = Compound was not detected above the method detection limit shown.

TABLE 7 – 16
EPH – VPH GROUNDWATER OFF–SITE LABORATORY RESULTS
AOC 69W

REMEDIAL INVESTIGATION REPORT
DEVENS, MASSACHUSETTS

Site ID:	69W––94–13	69W––94–14	ZWM–95–15X	ZWM–95–16X	ZWM–95–16X	ZWM–95–17X
Field Sample Number:	MXZW13X5	MXZW14X5	MXZW15X3	MXZW16X3	MXZW16X4	MXZW17X3
Sample Date:	12/12/97	12/12/97	12/12/97	10/01/96	12/18/97	12/16/97
Depth:	8	8	8	16	16	17.2
EPH (µg/L)				< 2.5		
ALIPHATICS						
n–C 9 to n–C 18	43 J	72 J	84 J	< 25	37 UJ	35 UJ
n–C 19 to n–C 36	41 U	44 U	44 U	< 2.5	49 U	47 U
AROMATICS						
n–C 11 to n–C 22	210	93 U	93 U	< 500	100 U	100 U
TARGETED PAH ANALYTES (µg/L)						
2–Methylnaphthalene	19 J	5.5 UJ	5.5 UJ	< 10	6.1 UJ	5.9 UJ
Acenaphthene	5.2 U	5.5 U	5.5 U	< 10	6.1 U	5.9 U
Acenaphthylene	5.2 U	5.5 U	5.5 U	< 10	6.1 U	5.9 U
Anthracene				< 10		
Benzo(a)anthracene				< 10		
Benzo(a)pyrene				< 10		
Benzo(b)fluoranthene				< 10		
Benzo(g,h,i)perylene				< 10		
Benzo(k)fluoranthene				< 10		
Chyrsene				< 10		
Dibenzo(a,h)anthracene				< 10		
Fluoranthene	5.2 U	8.3	5.5 U	< 10	6.1 U	5.9 U
Fluorene				< 10		
Indeno(1,2,3–c,d)pyrene				< 10		
Naphthalene	8.5 J	5.5 UJ	5.5 UJ	< 10	6.1 UJ	5.9 UJ
Phenanthrene				< 10		
Pyrene				< 10		
VPH (µg/L)				7		
ALIPHATICS						
n–C 5 to n–C 8				< 2.5		
n–C 9 to n–C 12	140	65 U	65 U	< 0.25	65 U	65 U
AROMATICS						
n–C 9 to n–C 10	330	20 U	20 U	7	75	20 U
TARGETED VOCs (µg/L)						
Benzene				< 5		
Ethylbenzene	5 U	5 U	5 U	< 5	5 U	5 U
Methyl tert–butly Ether				< 25		
Naphthalene	26	10 U	10 U	< 10	10 U	10 U
Toluene				< 5		
m/p–Xylene				< 5		
o–Xylene				< 5		

Notes:
J = Estimated value, below quantitation limit.
U = Compound was not detected above the method detection limit shown.

TABLE 7 – 16
EPH – VPH GROUNDWATER OFF–SITE LABORATORY RESULTS
AOC 69W

REMEDIAL INVESTIGATION REPORT
DEVENS, MASSACHUSETTS

Site ID:	ZWM–95–18X	ZWM–96–19X	ZWM–96–19X	ZWM–96–19X	ZWM–96–19X	ZWM–96–20X
Field Sample Number:	MXZW18X3	MDZW19X1	MXZW19X1	MXZW19X2	MDZW19X2	MXZW20X2
Sample Date:	12/16/97	09/30/96	09/30/96	12/18/97	12/18/97	12/16/97
Depth:	8	19	19	19	19	0
EPH (µg/L)		< 2.5	< 2.5			
ALIPHATICS						
n–C 9 to n–C 18	37 UJ	< 25	< 25	39 UJ	33 UJ	38 UJ
n–C 19 to n–C 36	49 U	< 2.5	< 2.5	53 U	44 U	51 U
AROMATICS						
n–C 11 to n–C 22	100 U	< 500	< 500	110 U	93 U	110 U
TARGETED PAH ANALYTES (µg/L)						
2–Methylnaphthalene	6.2 UJ	< 10	< 10	6.6 UJ	5.5 UJ	6.3 UJ
Acenaphthene	6.2 U	< 10	< 10	6.6 U	5.5 U	6.3 U
Acenaphthylene	6.2 U	< 10	< 10	6.6 U	5.5 U	6.3 U
Anthracene		< 10	< 10			
Benzo(a)anthracene		< 10	< 10			
Benzo(a)pyrene		< 10	< 10			
Benzo(b)fluoranthene		< 10	< 10			
Benzo(g,h,i)perylene		< 10	< 10			
Benzo(k)fluoranthene		< 10	< 10			
Chyrsene		< 10	< 10			
Dibenzo(a,h)anthracene		< 10	< 10			
Fluoranthene	6.2 U	< 10	< 10	6.6 U	5.5 U	6.3 U
Fluorene		< 10	< 10			
Indeno(1,2,3–c,d)pyrene		< 10	< 10			
Naphthalene	6.2 UJ	< 10	< 10	6.6 UJ	5.5 UJ	6.3 UJ
Phenanthrene		< 10	< 10			
Pyrene		< 10	< 10			
VPH (µg/L)		42	47			
ALIPHATICS						
n–C 5 to n–C 8		< 2.5	< 2.5			
n–C 9 to n–C 12	65 U	28	34	65 U	65 U	65 U
AROMATICS						
n–C 9 to n–C 10	20 U	41	45	20 U	20 U	20 U
TARGETED VOCs (µg/L)						
Benzene		< 5	< 5			
Ethylbenzene	5 U	< 5	< 5	5 U	5 U	5 U
Methyl tert–butly Ether		< 25	< 25			
Naphthalene	10 U	< 10	< 10	10 U	10 U	10 U
Toluene		< 5	< 5			
m/p–Xylene		< 5	< 5			
o–Xylene		< 5	< 5			

Notes:
J = Estimated value, below quantitation limit.
U = Compound was not detected above the method detection limit shown.

TABLE 7 – 16
EPH – VPH GROUNDWATER OFF–SITE LABORATORY RESULTS
AOC 69W

REMEDIAL INVESTIGATION REPORT
DEVENS, MASSACHUSETTS

Site ID:	ZWM–96–21X	ZWM–96–21X
Field Sample Number:	MXZW21X1	MXZW21X2
Sample Date:	10/01/96	12/18/97
Depth:	21	21
EPH (µg/L)	< 2.5	
ALIPHATICS		
n–C 9 to n–C 18	< 25	38 UJ
n–C 19 to n–C 36	< 2.5	51 U
AROMATICS		
n–C 11 to n–C 22	< 500	110 U
TARGETED PAH ANALYTES (µg/L)		
2–Methylnaphthalene	< 10	6.3 UJ
Acenaphthene	< 10	6.3 U
Acenaphthylene	< 10	6.3 U
Anthracene	< 10	
Benzo(a)anthracene	< 10	
Benzo(a)pyrene	< 10	
Benzo(b)fluoranthene	< 10	
Benzo(g,h,i)perylene	< 10	
Benzo(k)fluoranthene	< 10	
Chyrsene	< 10	
Dibenzo(a,h)anthracene	< 10	
Fluoranthene	< 10	6.3 U
Fluorene	< 10	
Indeno(1,2,3–c,d)pyrene	< 10	
Naphthalene	< 10	6.3 UJ
Phenanthrene	< 10	
Pyrene	< 10	
VPH (µg/L)	< 0.25	
ALIPHATICS		
n–C 5 to n–C 8	< 2.5	
n–C 9 to n–C 12	< 0.25	65 U
AROMATICS		
n–C 9 to n–C 10	< 5	20 U
TARGETED VOCs (µg/L)		
Benzene	< 5	
Ethylbenzene	< 5	5 U
Methyl tert–butly Ether	< 25	
Naphthalene	< 10	10 U
Toluene	< 5	
m/p–Xylene	< 5	
o–Xylene	< 5	

Notes:
J = Estimated value, below quantitation limit.
U = Compound was not detected above the method detection limit shown.

TABLE 7 - 17
RI SEDIMENT OFF-SITE ANALYTICAL RESULTS
AOC 69W

REMEDIAL INVESTIGATION REPORT
DEVENS, MASSACHUSETS

Site ID:	ZWD-95-01X	ZWD-95-01X	ZWD-95-01X	ZWD-95-02X	ZWD-95-02X	ZWD-95-03X	ZWD-95-03X	ZWD-95-04X	ZWD-95-05X	ZWD-95-06X
Field Sample Number:	DDZW0100	DXZW0100	DXZW0102	DXZW0200	DXZW0202	DXZW0300	DXZW0302	DXZW0400	DXZW0500	DXZW0600
Lab Sample Number:	DV4S*400	DV4S*289	DV4S*390	DV4S*391	DV4S*392	DV4S*393	DV4S*394	DV4S*395	DV4S*396	DV4S*397
Sample Date:	09/11/95	09/11/95	09/11/95	09/11/95	09/11/95	09/11/95	09/11/95	09/12/95	09/12/95	09/12/95
Depth:	0	0	2	0	2	2	0	0	0	0
Units:	µg/g	µg/g	µg/g	µg/g	µg/g	µg/g	µg/g	µg/g	µg/g	µg/g
PAL METALS										
Aluminum	6010 D	5240	5600	4120	6270	4840	4480	3390	3120	2930
Arsenic	8.42 D	9.95	21	13	8.64	6.39	5.46	9.43	6.43	14
Barium	18.6 D	14.7	15.5	11.4	22.9	10.7	10.3	9.52	12.9	7.13
Calcium	992 D	957	1050	736	1500	570	527	674	888	536
Chromium	26.7 D	35.8	15.4	16.1	12.3	11.5	11.2	10.5	10.5	13.9
Cobalt	4.17 D	3.56	5.87	3.85	3.15	2.82	2.23	2.55	2.02	6.93
Copper	22.8 D	25.1	8.43	10.9	8.79	10.4	6.56	7.92	16.5	23.4
Iron	15400 D	12400	12800	10900	5980	8030	7010	7020	7150	10200
Lead	35.9 D	55	7.12	21	29	15	11.4	29	33	30
Magnesium	3100 D	2810	2630	2630	1740	2110	2160	1750	1670	1580
Manganese	230 D	172	475	161	81.4	93.9	70.7	93.6	96.6	186
Nickel	17.3 D	15.9	18.1	18.1	9.97	11.7	10.5	9.95	8.72	9.55
Potassium	783 D	525	639	415	388	426	425	371	486	364
Sodium	314 D	330	321	259	402	307	307	309	312	260
Vanadium	15.2 D	12.5	10.7	10.4	8.95	9.16	7.91	7.4	8.28	8.49
Zinc	71.4 D	69.5	29.8	39.6	40	27.9	22.8	41.4	39.7	31
PESTICIDES/PCBS										
4,4'-ddd	0.15 C	0.11 C	0.00808 C	0.0174 C	< 0.00826	0.12 C	0.027 C	0.027 C	2.1 C	0.066 C
4,4'-dde	0.0172 C	0.0137 C	< 0.00765	< 0.00765	< 0.00765	< 0.00765	< 0.00765	0.0122 C	0.081 C	0.0152 C
4,4'-ddt	0.14 C	0.094 C	< 0.00707	0.021 C	< 0.00707	0.025 C	< 0.00707	0.044 C	0.4 C	0.046 C
Chlordane - Alpha	< 0.005 TD	< 0.005 T	< 0.005 T	< 0.005 T	< 0.005 T	< 0.005 T	< 0.005 T	< 0.005 T	0.0129 CZ	< 0.005 T
Chlordane - Gamma	< 0.005 TD	< 0.005 T	< 0.005 T	< 0.005 T	< 0.005 T	< 0.005 T	< 0.005 T	< 0.005 T	0.024 CZ	< 0.005 T
Dieldrin	< 0.00629 D	< 0.00629	< 0.00629	< 0.00629	< 0.00629	< 0.00629	< 0.00629	< 0.00629	0.06 C	< 0.00629
Endosulfan Ii	< 0.00663 D	< 0.00663	< 0.00663	< 0.00663	< 0.00663	< 0.00663	< 0.00663	< 0.00663	0.05 C	< 0.00663
Pcb 1260	< 0.0804 D	< 0.0804	< 0.0804	< 0.0804	< 0.0804	< 0.0804	< 0.0804	< 0.0804	0.51 C	< 0.0804
SEMIVOLATILE ORGANICS										
Anthracene	< 0.2 D	< 0.2	< 0.2	< 0.2	0.7	< 0.2	< 0.2	< 0.3	< 0.8	< 0.2
Benzo[a]anthracene	< 0.8 D	< 0.8	< 0.8	< 0.8	2	< 0.8	1	< 2	< 4	< 0.8
Benzo[a]pyrene	< 1 D	< 1	< 1	< 1	3	< 1	< 1	< 2	< 6	< 1
Benzo[b]fluoranthene	< 1 D	< 1	< 1	< 1	3	< 1	< 1	< 2	< 5	< 1
Benzo[k]fluoranthene	< 0.3 D	< 0.3	< 0.3	< 0.3	< 0.3	< 0.3	< 0.3	0.8	< 2	0.4
Chrysene	0.9 D	1	< 0.6	< 0.6	4	< 0.6	2	< 1	< 3	< 0.6
Fluoranthene	1 D	2	1	< 0.3	6	1	3	2	< 2	1
Phenanthrene	0.6 D	0.8	0.7	< 0.2	3	0.5	2	0.6	< 0.8	0.9
Pyrene	1 D	2	0.9	< 0.2	6	1	3	1	2	1
TPH BY GC										
Diesel	9.35 D	23.7	8.98	< 8	49.2	< 8	185	19.6	52.2	12.6
Tphgas	< 8 D	< 8	< 8	< 8	< 8	< 8	< 8	21.5	16.5	19.4
VOLATILE ORGANICS										
Dichloromethane	0.014 D	< 0.012	< 0.012	< 0.012	< 0.012	< 0.012	< 0.012	< 0.012	< 0.012	< 0.012
Trichlorofluoromethane	0.011 D	0.011	0.014	0.0096	0.0087	0.0094	0.0089	0.008	< 0.0059	0.0082
OTHER										
Total Organic Carbon	7420 D	12400	1560	2400	59200	5430	5170	3430	5950	3100
Total Petroleum Hydrocarbons	360 D	896	97	132	131	190	66.8	368	1230	287

Notes:
U = Concentrations Less than Reporting Limit
J = Value is Estimated
E = Concentration Exceeds the Maximum Reporting Limit
NA = Not Analyzed

Shading indicated exceedance of established Devens background concentrations

TA ; 7-18
RI AIR OFF-SITE ANALYTICAL RESULTS
AOC 69W

REMEDIAL INVESTIGATION REPORT
DEVENS, MASSACHUSETTS

Site ID:	ZWA-97-01X	ZWA-97-02X	ZWA-97-03X	ZWA-97-04X	ZWA-97-05X	ZWA-97-06X	ZWA-97-07X	Inhalation Toxicity Value (ug/m3)
Canister:	A230	A209	A210	B239	70	B237	B246	
Location:	Classroom N of new boiler room	Kitchen/ Cafeteria	1st Classr'm NE Wing	-03X Duplicate	Crawl space near old boiler room	Crawl space under kitchen	SW classr'm (indoor backgrnd)	
COMPOUND ($\mu g/m^3$)								
1,2,4 Trimethylbenzene	< 4.4 J	< 4.4 J	< 4.4 J	< 4.4 R	< 4.4 J	< 4.4 J	< 4.4 J	180
1,3,5 Trimethylbenzene	< 4.4 J	< 4.4 J	< 4.4 J	< 4.4 R	< 4.4 J	< 4.4 J	< 4.4 J	180
2-Methylheptane	8	< 4.4	19	6.3 R	< 4.4	< 4.4	7.2	200
3-Methylheptane	< 4.4	< 4.4	8.7	< 4.4 R	< 4.4	< 4.4	8.9	200
Decane	< 4.4	< 4.4 J	< 4.4 J	< 4.4 R	< 4.4 J	< 4.4	< 4.4 J	2000
Dodecane	< 22 J	< 22	< 22	< 22 R	< 22	< 22 J	< 22	2000
Ethylbenzene	7.9	470	27	7.6 R	< 4.4	5.2	9.9	1000
Methyl tert-butly Ether	< 4.4 J	< 4.4 J	< 4.4 J	< 4.4 R	< 4.4 J	< 4.4 J	< 4.4 J	3000
Nonane	< 4.4	< 4.4	7.2	< 4.4 R	< 4.4	< 4.4	5	2000
Octane	< 4.4	< 4.4	21	8.4 R	< 4.4	5.5 J	9.1	200
Toluene	260	72	1000	350 R	< 13	< 150	< 36	400
Xylene	30.4	< 8.8	92	28.1 JR	< 8.8	< 18.3 J	34.8	310
Acetone	470	< 200	< 82	< 54 R	< 38	< 81	< 30	—
Tetrachloroethylene	< 4.4	< 4.4	< 4.4	< 4.4 R	< 4.4	< 4.4	< 4.4	—

Site ID:	ZWA-97-08X	ZWA-97-09X	ZWA-97-10X	ZWA-97-11X	ZWA-97-12X	ZWA-97-13X	Inhalation Toxicity Value (ug/m3)
Canister:	A211	92	62	A207	A221	B233	
Location:	Classr'm S of new boiler room	Boiler room well head sample	NW classroom	Front parking lot downwind (bkgrnd)	Near wells upwind (bkgrnd)	Playground upwind (backgrnd)	
COMPOUND ($\mu g/m^3$)							
1,2,4 Trimethylbenzene	< 4.4 J	< 22	< 4.4 J	< 4.4 J	< 4.4 J	< 4.4 J	180
1,3,5 Trimethylbenzene	< 4.4 J	< 22	< 4.4 J	< 4.4 J	< 4.4 J	< 4.4 J	180
2-Methylheptane	< 4.4	< NA	5.2	< 4.4	< 4.4	< 4.4	200
3-Methylheptane	< 4.4	< NA	< 4.4	< 4.4	< 4.4	< 4.4	200
Decane	< 4.4	< NA	< 4.4	< 4.4	< 4.4	< 4.4	2000
Dodecane	< 22 J	< NA	< 22 J	< 22 J	< 22 J	< 22 J	2000
Ethylbenzene	< 4.3 J	< 22	< 2.8 J	< 3.2 J	< 4.4	< 4.4	1000
Methyl tert-butly Ether	< 4.4 J	< NA	< 4.4 J	< 4.4 J	< 4.4 J	< 4.4 J	3000
Nonane	< 4.4	< NA	< 4.4	< 4.4	< 4.4	< 4.4	2000
Octane	< 4.4	< NA	< 4.4	< 4.4	< 4.4	< 4.4	200
Toluene	70	< 22	82	63	< 38	< 19	400
Xylene	17.1 J	< 44	8	< 8.2	< 8.8	< 8.8	310
Acetone	< 54	< 210 J	< 52	< 440	< 27	< 31	—
Tetrachloroethylene	< 4.4	360	< 4.4	< 4.4	< 4.4	< 4.4	—

Notes: < = Undetected at specified detection limit

B - Analyte detected in quality control blank

J - Estimated value, below detection limit

NA - Not analyzed

TABLE 8-1
CHEMICAL AND PHYSICAL PROPERTIES OF COMPOUNDS DETECTED[1]
AOC 69W

REMEDIAL INVESTIGATION REPORT
DEVENS, MASSACHUSETTS

CONTAMINANT	MOLECULAR WEIGHT	DENSITY (g/cm^3)	WATER SOLUBILITY (mg/L)	VAPOR PRESSURE (mm Hg)	HENRY'S CONSTANT, H_c ($atm\ m^3\ mol^{-1}$)	ORGANIC CARBON PARTITION COEFFICIENT K_{oc} (mL/g)
VOLATILE ORGANIC COMPOUNDS						
1,2-DICHLOROETHANE	98.98	1.28	8.52E+03	6.40E+01	9.78E-04	1.40E+01
BENZENE	78.12	1.87	1.75E+05	9.52E+01	5.59E-03	8.30E+01
CARBON TETRACHLORIDE	153.82	1.58	7.57E+02	9.00E+01	2.41E-02	4.39E+02
ETHYLBENZENE	106.16	0.87	1.52E+02	7.00E+00	6.43E-03	1.10E+03
TOLUENE	92.13	0.86	5.35E+02	2.81E+01	6.37E-03	3.00E+02
XYLENES[2]	106.16	0.88	1.75E+02	6.60E+00	5.10E-03	8.30E+02
SEMIVOLATILE ORGANIC COMPOUNDS						
1,2-DICHLOROBENZENE	1.4701	1.3	1.00E+02	1.00E+00	1.70E-03	1.70E+03
2-METHYLNAPHTHALENE	142.2	1.02	2.54E+01	NA	NA	8.50E+03
o-CRESOL	108.14	1.03	2.50E+04	2.43E-01	1.50E-06	NA
P-CRESOL	108.14	1.01	NA	1.14E-01	NA	NA
NAPHTHALENE	128.2	0.98	3.17E+01	2.30E-01	1.15E-03	1.30E+03
PHENANTHRENE	178.2	1.03	1.00E+00	6.80E-04	1.59E-04	1.40E+04
PYRENE	202.3	1.27	1.30E-01	2.50E-06	5.04E-06	3.80E+04

Notes:

1. Primary Source: USEPA, 1990. "Basics of Pump-and-Treat Ground-Water Remediation Technology." Robert S. Kerr, Environmental Research Laboratory, Ada, OK. EPA/600/8-90/003.

2. Data presented is for o-xylene.

Aubrey, D.C., 1993. "Encyclopedia of Chemical Technology," Fourth Edition. John Wiley and Sons, New York, NY.

Verschueren, Karel, 1983. "Handbook of Environmental Data on Organic Chemicals."
Van Nostrand Reinhold Company, Inc.

Howard, Philip, 1990. "Handbook of Environmental Fate and Exposure Data for Organic
Chemicals; Volume II, Solvents." Lewis Publishers, Inc.

$atm\ m^3\ mol^{-1}$ = cubic meter at an atmospher of pressure per mole
g/cm^3 = gram per cubic centimeter
K_{oc} = organic carbon partition coefficient
mg/L = miligram per liter
mL/g = milliliters per gram
mm Hg = pressure as millimeters of mercury
NA = Not available

TABLE 8-2
MOBILITIES OF INORGANIC ELEMENTS
AOC 69W

REMEDIAL INVESTIGATION REPORT
DEVENS, MASSACHUSETTS

Relative Mobility	Environment		
	Oxidizing (pH 5 to 8)	Oxidizing (pH <4)	Reducing
Highly mobile	Anions, B, Mo	Anions, B	Anions
Moderately mobile	Ca, Na, Mg, Sb, As, V, Zn, Be	Ca, Na, Mg, Pb, Zn, Cu, Hg, Co, Ni, V, As, Mn, Cd, Sb	Ca, Na, Mg, Ba, Mn, As*
Slightly mobile	K, Ba, Mn, Pb, Cu, Cd, Ni	K, Ba, Cr	K, Fe^{2+}
Immobile	Fe, Al, Cr, Hg	Fe, Al	Fe^{3+}, Al, Cu, Zn, Pb, Cr, V, Ni, As*, Sb, Cd, Hg, Ba

*As^{+3} mobile under reducing conditions in absence of sulfides. As^{+5} immobile under reducing conditions.

As = Arsenic
Al = Aluminum
B = Boron
Ba = Barium
Be = Beryllium
Ca = Calcium
Cd = Cadmium
Co = Cobalt
Cr = Chromium
Cu = Copper
Fe = Iron
Hg = Mercury
K = Potassium
Mg = Magnesium
Mn = Manganese
Mo = Molybdenum
Nd = Sodium
Ni = Nickel
Pb = Lead
Sb = Antimony
V = Vanadium
Z = Zinc

Source:

Rose, A.W., H.E. Hawkes, and J.S. Webb, 1979. Geochemistry in Mineral Exploration. Academic Press.

TABLE 9-1
SUMMARY OF HUMAN HEALTH RISK ASSESSMENT SAMPLE LOCATIONS
AOC 69W

REMEDIAL INVESTIGATION REPORT
DEVENS, MASSACHUSETTS

MEDIA	EXPLORATION	SAMPLE LOCATION	DEPTH (feet bgs)
Surface Soil[1]	Remedial Investigation	ZWS-95-35X	0
		ZWS-95-39X	0
		ZWS-95-42X	0
		ZWS-95-45X	0
		ZWS-95-46X	0
		ZWS-95-47X	0
Subsurface Soil[1]	Remedial Investigation and Removal Action	69W-HS-ESW	10
		69W-HS-FL-3	10
		69W-HS-FL-4	8
		69W-HS-NSW	6
		69W-HS-OB-1	6
		69W-HS-SSW	10
		69W-HS-SSW1	10
		69W-HS-WSW	10
		69W-HS-WSW	10
		69W-HS-WSW	8
		69W-HS-WSW	9
		69W-PL-ESW	8
		69W-PL-FL-5	10
		69W-PL-NSW	6
		69W-UP-G1-E	6
		69W-UP-G1-F	4
		69W-UP-G1-W	4
		69W-UP-G2-E	5
		69W-UP-G2-F	5
		69W-UP-G2-W	5
		69W-UP-G3-E	5
		69W-UP-G3-F	5
		69W-UP-G3-W	5
		69W-UST-ESW	10
		69W-V-ESW-1	8
		69W-V-FL-1	7
		69W-V-NSW-1	8
		69W-V-WSW-1	7
		ZWB-96-03X	6
		ZWB-96-21X	4
		ZWB-96-21X	8
		ZWR-95-26X	0
		ZWR-95-45X	4
Sediment	Downgradient	ZWD-95-02X	0
		ZWD-95-03X	0
		ZWD-95-06X	0
Groundwater[2]	Remedial Investigation Rounds 1 (October 1995), 2 & 3 (February 1996 & October 1996)		**ROUND**
		69W-94-09	1,2,4
		69W-94-10	1,2,3,4
		69W-94-11	1,2,3,4
		69W-94-11 (dup)	1,2
		69W-94-12	1,2,4
		69W-94-13	1,2,4
		69W-94-14	1,2,4
		ZWM-95-15X	1,2,4
		ZWM-95-16X	1,2,3,4
		ZWM-95-18X	1,2,4
		ZWM-96-19X	2,3,4
		ZWM-96-19X (dup)	2,3,4
		ZWM-96-20X	2,3,4
		ZWM-96-21X	2,3,4
Indoor Air	Supplemental Air Sampling	ZWA-97-01X	--
		ZWA-97-10X	--
		ZWA-97-02X	--
		ZWA-97-08X	--
		ZWA-97-03X	--

TABLE 9-1
SUMMARY OF HUMAN HEALTH RISK ASSESSMENT SAMPLE LOCATIONS
AOC 69W

REMEDIAL INVESTIGATION REPORT
DEVENS, MASSACHUSETTS

MEDIA	EXPLORATION	SAMPLE LOCATION	DEPTH (feet bgs)

Notes:

1 Surface soil is defined as soil between 0 and 1 foot bgs. Subsurface soil is defined as soil between 1 and 10 feet bgs

2 Unfiltered data from each sample location were used to develop data sets

bgs = below ground surface

TABLE 9-2
DATA SUMMARY AND SELECTIONOF CHEMICALS OF POTENTIAL CONCERN
AOC 69W

REMEDIAL INVESTIGATION REPORT
DEVENS, MASSACHUSETTS

	Range of SQLs	Frequency of Detection	Minimum Detected	Concentration Maximum Detected	Arithmetic Mean	95% UCL	Background*	Region III RBC**	ARARs	CPC?	Notes
SURFACE SOIL (0 - 1 feet bgs)[a] (mg/kg)											
PAL METALS											
Aluminum	NA	6 / 6	5210	6160	5916.667	NC	18000	7800	NA	No	Less than RBC[1], Background[2]
Arsenic	NA	6 / 6	7.66	18	12.0383	NC	19	0.43	NA	Yes	Exceeds RBC[3], Background[2]
Barium	NA	6 / 6	14.1	22.4	18.2	NC	54	550	NA	No	Less than RBC[1], Background[2]
Beryllium	0.50-0.50	1 / 6	0.85	0.85	0.35	NC	0.81	0.15	NA	Yes	Exceeds RBC[3]
Calcium	NA	6 / 6	333	908	683.1667	NC	810	NA	NA	No	Essential Nutrient[4]
Chromium	NA	6 / 6	12.1	28.1	18.0167	NC	33	39	NA	No	Less than RBC[1], Background[2]
Cobalt	NA	6 / 6	2.51	5.36	4.1283	NC	4.7	470	NA	No	Less than RBC[1]
Copper	NA	6 / 6	5.59	29.9	11.7867	NC	13.5	310	NA	No	Less than RBC[1]
Iron	NA	6 / 6	6780	10300	8818.333	NC	18000	2300	NA	Yes	Exceeds RBC[3], Background[2]
Lead	NA	5 / 6	11.4	238	71.1	NC	61.1	NA	400 e	No	Less than ARAR[6]
Magnesium	NA	6 / 6	1360	2670	2405	NC	5500	NA	NA	No	Essential Nutrient[4], Background[2]
Manganese	NA	6 / 6	52.4	240	167.4	NC	380	180	NA	Yes	Exceeds RBC[3], Background[2]
Mercury	0.050-0.050	2 / 6	0.0755	0.0784	0.0423	NC	NA	2.3	NA	No	Less than RBC[1]
Nickel	NA	6 / 6	5.98	18.1	13.3133	NC	14.6	160	NA	No	Less than RBC[1]
Potassium	NA	6 / 6	367	993	630.1667	NC	2400	NA	NA	No	Background[2], Essential Nutrient[4]
Selenium	0.25-0.25	1 / 6	0.364	0.364	0.1648	NC	ND	39	NA	No	Less than RBC[1]
Sodium	NA	6 / 6	241	506	347.5	NC	131	NA	NA	No	Essential Nutrient[4]
Vanadium	NA	6 / 6	10.6	19.1	14.0667	NC	32.3	55	NA	No	Less than RBC[1], Background[2]
Zinc	NA	6 / 6	18.9	71.7	32.4833	NC	43.9	2300	NA	No	Less than RBC[1]
PAL SEMIVOLATILE ORGANICS											
Acenaphthylene	0.033-3	1 / 6	2	2	0.7055	NC	-	310 h	NA	No	Less than RBC[1]
Anthracene	0.033-3	1 / 6	1	1	0.5388	NC	-	2300	NA	No	Less than RBC[1]
Benzo[k]fluoranthene	0.066-7	1 / 6	2	2	1.0943	NC	-	8.8	NA	No	Less than RBC[1]
Chrysene	0.12-10	2 / 6	0.17	5	2.0383	NC	-	88	NA	No	Less than RBC[1]
Fluoranthene	0.068-1	4 / 6	0.19	9	3.2873	NC	-	310	NA	No	Less than RBC[1]
Fluorene	0.033-3	1 / 6	1	1	0.5388	NC	-	310	NA	No	Less than RBC[1]
Phenanthrene	0.20-0.70	5 / 6	0.065	9	3.0925	NC	-	310 h	NA	No	Less than RBC[1]
Pyrene	0.20-0.70	5 / 6	0.075	10	3.7742	NC	-	230	NA	No	Less than RBC[1]
PAL VOLATILE ORGANICS											
Acetone	0.017-0.017	1 / 6	0.069	0.069	0.0186	NC	-	780	NA	No	Less than RBC[1]
Toluene	0.00078-0.0007	3 / 6	0.001	0.0021	0.0009	NC	-	1600	NA	No	Less than RBC[1]
Trichlorofluoromethane	0.0059-0.0059	2 / 6	0.0055	0.0072	0.0041	NC	-	2300	NA	No	Less than RBC[1]
Xylenes	0.0015-0.0015	1 / 6	0.0027	0.0027	0.0011	NC	-	16000	NA	No	Less than RBC[1]

TABLE 9-2
DATA SUMMARY AND SELECTIONOF CHEMICALS OF POTENTIAL CONCERN
AOC 69W

REMEDIAL INVESTIGATION REPORT
DEVENS, MASSACHUSETTS

	Range of SQLs	Frequency of Detection	Minimum Detected	Concentration Maximum Detected	Concentration Arithmetic Mean	Concentration 95% UCL	Concentration Background*	Region III RBC**	ARARs	CPC?	Notes
SURFACE SOIL (0 - 1 feet bgs)[a] (mg/kg) - CONTINUED											
OTHER											
Total Petroleum Hydrocarbons	28-28	5 / 6	52.5	936	390.375	NC	-	NA	NA	Yes	No standard available[7]
SUBSURFACE SOIL (1 - 10 feet bgs)[b] (mg/kg)											
PAL METALS											
Aluminum	NA	2 / 2	2910	3060	2985	NC	18000	7800	NA	No	Less than RBC[1], Background[2]
Arsenic	NA	2 / 2	4.74	7.32	6.03	NC	19	0.43	NA	Yes	Exceeds RBC[3], Background[2]
Barium	NA	2 / 2	8.14	8.21	8.175	NC	54	550	NA	No	Less than RBC[1], Background[2]
Calcium	NA	2 / 2	369	463	416	NC	810	NA	NA	No	Essential Nutrient[4], Background[2]
Chromium	4.1-4.1	1 / 2	10.3	10.3	6.1625	NC	33	39	NA	No	Less than RBC[1], Background[2]
Cobalt	NA	2 / 2	2.22	2.88	2.55	NC	4.7	470	NA	No	Less than RBC[1], Background[2]
Copper	NA	2 / 2	4.6	5.14	4.87	NC	13.5	310	NA	No	Less than RBC[1], Background[2]
Iron	NA	2 / 2	5460	5880	5670	NC	18000	2300	NA	Yes	Exceeds RBC[3], Background[2]
Lead	NA	2 / 2	1.87	1.91	1.89	NC	48	NA	400 e	No	Less than ARAR[5], Background[2]
Magnesium	NA	2 / 2	1090	1430	1260	NC	5500	NA	NA	No	Essential Nutrient[4], Background[2]
Manganese	NA	2 / 2	56.4	90.3	73.35	NC	380	180	NA	No	Less than RBC[1], Background[2]
Nickel	NA	2 / 2	8.26	8.57	8.415	NC	14.6	160	NA	No	Less than RBC[1], Background[2]
Potassium	NA	2 / 2	460	515	487.5	NC	2400	NA	NA	No	Essential Nutrient[4], Background[2]
Sodium	NA	2 / 2	299	398	348.5	NC	131	NA	NA	No	Essential Nutrient[4],
Vanadium	NA	2 / 2	4.5	6.47	5.485	NC	32.3	55	NA	No	Less than RBC[1], Background[2]
Zinc	8.0-8.0	1 / 2	14	14	9.0075	NC	43.9	2300	NA	No	Less than RBC[1], Background[2]
PAL SEMIVOLATILE ORGANICS											
2-Methylnaphthalene	0.51-0.7	4 / 30	1.9	42	3.1797	2.858	-	310 h	NA	No	Less than RBC[1]
Acenaphthene	0.51-0.7	5 / 30	0.79	7.6	0.9312	1	-	470	NA	No	Less than RBC[1]
Acenaphthylene	0.06-0.7	2 / 30	9.6	16	1.1142	0.98	-	2300	NA	No	Less than RBC[1]
Benzo(a)anthracene	0.07-0.7	1 / 30	0.1	0.1	0.2655	0.35	-	0.88	NA	No	Less than RBC[1]
Benzo(b)fluoranthene	0.07-0.7	1 / 30	0.06	0.06	0.2642	0.354	-	0.88	NA	No	Less than RBC[1]
Chrysene	0.51-0.7	3 / 30	0.08	0.08	0.2652	0.347	-	88	NA	No	Less than RBC[1]
Fluoranthene	0.06-0.7	2 / 30	0.13	0.24	0.2732	0.333	-	310	NA	No	Less than RBC[1]
Fluorene	0.51-0.7	5 / 30	0.68	26	1.9132	1.584	-	310	NA	No	Less than RBC[1]
Naphthalene	0.51-0.7	3 / 30	7.1	12	1.1798	1.15	-	310	NA	No	Less than RBC[1]
Phenanthrene	0.51-7	3 / 30	1.5	9	0.8707	0.932	-	310 h	NA	No	Less than RBC[1]
Pyrene	0.06-0.7	2 / 30	0.18	0.18	0.2815	0.34	-	230	NA	No	Less than RBC[1]

TABLE 9-2
DATA SUMMARY AND SELECTIONOF CHEMICALS OF POTENTIAL CONCERN
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REMEDIAL INVESTIGATION REPORT
DEVENS, MASSACHUSETTS

	Range of SQLs	Frequency of Detection	Minimum Detected	Concentration Maximum Detected	Arithmetic Mean	95% UCL	Back-ground*	Region III RBC**	ARARs	CPC?	Notes
PAL VOLATILE ORGANICS											
Acetone	0.017-0.017	1 / 2	0.022	0.022	0.0153	NC	-	780	NA	No	Less than RBC[1]
Dichloromethane	0.012-0.012	1 / 2	0.025	0.025	0.0155	NC					
Toluene	0.0008-0.0008	1 / 2	0.0013	0.0013	0.0008	NC	-	1600	NA	No	Less than RBC[1]
SUBSURFACE SOIL (1 - 10 feet bgs)[b] (mg/kg) - CONTINUED											
OTHER											
Total Petroleum Hydrocarbons	28-28	2 / 5	57.5	902	27.8	NC	-	NA	NA	Yes	No standard available[7]
Extractable Petroleum Hydrocarbons (EPH)											
C11-C22 Aromatics	8.9-34	24 / 30	9	1,200	138	268	-	NA	NA	Yes	No standard available[7]
C19-C36 Aliphatics	0.15-4.6	26 / 30	5.4	670	119	1,998	-	NA	NA	Yes	No standard available[7]
C9-C18 Aliphatics	1.5-3.8	26 / 30	3.3	5,400	588	18,563	-	NA	NA	Yes	No standard available[7]
Volatile Petroleum Hydrocarbons (VPH)											
C-9-C12 Aliphatics	0.01-670	12 / 30	3.8	770	52.9	1,261	-	NA	NA	Yes	No standard available[7]
C9-C10 Aromatics	0.25-560	8 / 30	15	650	42.7	119	-	NA	NA	Yes	No standard available[7]
GROUNDWATER [a] (mg/L) - UNFILTERED											
PAL METALS											
Aluminum	0.141-0.141	4 / 10	0.39	0.448	0.2	NC	6.87	3.7	0.05 g	Yes	Exceeds ARAR[6], Background[2]
Arsenic	0.0025-0.0025	6 / 10	0.0052	0.19	0.04	NC	0.0105	0.000045	0.05 f	Yes	Exceeds RBC[3], Exceeds ARAR[6]
Barium	NA	10 / 10	0.0046	0.017	0.01	NC	0.0396	0.26	2 f	No	Less than RBC[1], Less than ARAR[5], Background[2]
Calcium	NA	10 / 10	15.5	25	20	NC	14.7	NA	NA	No	Essential Nutrient[4]
Copper	NA	1 / 10	0.01	0.01	0.004	NC		1.5	1.3	No	Less than RBC[1], Less than ARAR[5], Background[2]
Iron	0.0388-0.0388	9 / 10	0.44	26	5.2	NC	9.1	1.1	0.3 g	Yes	Exceeds RBC[3], Exceeds ARAR[6]
Lead	0.001 - 0.001	4 / 10	0.001	0.002	0.001	NC		NA	0.015	No	Less than ARAR[5]· Background[2]
Magnesium	NA	10 / 10	1.7	3.02	2.2	NC	3.48	NA	NA	No	Essential Nutrient[4], Background[2]
Manganese		10 / 10	0.013	2.7	0.86	NC	0.291	0.084	0.05 g	Yes	Exceeds RBC[3], Exceeds ARAR[6]
Potassium	NA	10 / 10	1.6	5.1	2.3	NC	2.37	NA	NA	No	Essential Nutrient[4]
Sodium	NA	10 / 10	23.5	38	29	NC	10.8	NA	NA	No	Essential Nutrient[4]
PAL SEMIVOLATILE ORGANICS											
2-Methylnaphthalene (i)	0.0017-0.0017	2 / 10	0.008	0.6	0.06	NC	-	0.15 h	NA	Yes	Exceeds RBC[3]
Acenaphthene (j)	0.0017-0.06	1 / 13	0.01	0.01	0.004	NC	-	0.22	NA	No	Less than RBC[1]
Bis(2-ethylhexyl)phthalate (i)	0.0048-0.0048	4 / 10	0.0034	0.5	0.053	NC	-	0.0048	0.006 f	Yes	Exceeds RBC[3], Exceeds ARAR[6]
Dibenzofuran (i)	0.0017-0.06	1 / 10	0.0023	0.0023	0.004	NC	-	0.015	NA	No	Less than RBC[1]
Diethylphthalate (i)	0.002-0.11	3 / 10	0.002	0.003	0.007	NC	-	2.9	NA	No	Less than RBC[1]
Fluoranthene (j)	0.0052-0.01	2 / 13	0.0066	0.008	0.004	NC	-	0.15	NA	No	Less than RBC[1]

TABLE 9-2
DATA SUMMARY AND SELECTIONOF CHEMICALS OF POTENTIAL CONCERN
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DEVENS, MASSACHUSETTS

	Range of SQLs	Frequency of Detection	Minimum Detected	Concentration				Region III RBC**	ARARs	CPC?	Notes
				Maximum Detected	Arithmetic Mean	95% UCL	Back-ground*				
Fluorene (j)	0.01-0.011	2 / 8	0.003	0.007	0.005	NC	-	0.15	NA	No	Less than RBC[1]
Naphthalene (i)	0.0005-0.0005	2 / 10	0.015	0.2	0.021	NC	-	0.15	NA	Yes	Exceeds RBC[3]
Phenanthrene (i)	0.0005-0.0005	2 / 10	0.002	0.15	0.015	NC	-	0.15 h	NA	No	Less than RBC[1]
PAL VOLATILE ORGANICS											
1,1,1-Trichloroethane (k)	0.0005-0.0013	1 / 10	0.0015	0.002	0.00035	NC	-	0.079	NA	No	Less than RBC[1]
Acetone (k)	0.013-0.036	2 / 10	0.013	0.014	0.009	NC	-	0.37	NA	No	Less than RBC[1]
Chloroform (k)	0.0005-0.0013	2 / 10	0.00055	0.00055	0.00034	NC	-	0.00015	NA	Yes	Exceeds RBC[3]
Ethylbenzene (l)	0.005-0.005	1 / 13	0.026	0.026	0.0047	NC	-	0.13	0.7 f	No	Less than RBC[1], Less than ARAR[5]
Toluene (k)	0.0005-0.0005	7 / 10	0.00045	0.0019	0.0007	NC	-	0.075	1 f	No	Less than RBC[1], Less than ARAR[5]
Trichloroethylene (k)	0.0005-0.0013	2 / 10	0.0033	0.0033	0.0005	NC	-	0.0016	NA	Yes	Exceeds RBC[3]
Xylenes (k)	0.00084-0.0008	1 / 10	0.0014	0.0014	0.00055	NC	-	1.2	NA	No	Less than RBC[1]
GROUNDWATER [c] (mg/L) - UNFILTERED - CONTINUED											
OTHER											
Extractable Petroleum Hydrocarbons (EPH)											
C9-C18 Aliphatics (j)	0.09-0.3	3 / 13	0.21	0.6	0.15	NC	-	NA	NA	Yes	No standard available[7]
C11-C22 Aromatics (j)	0.03-0.04	3 / 13	0.043	0.3	0.053	NC	-	NA	NA	Yes	No standard available[7]
Volatile Petroleum Hydrocarbons (VPH)											
C5-C8 Aliphatics (l)	0.0025-0.075	1 / 8	0.047	0.047	0.02	NA	-	NA	NA	Yes	No standard available[7]
C9-C12 Aliphatics (l)	0.032-0.065	4 / 13	0.032	0.34	0.061	NC	-	NA	NA	Yes	No standard available[7]
C9-C10 Aromatics (l)	0.012-0.02	4 / 13	0.014	0.61	0.082	NC	-	NA	NA	Yes	No standard available[7]
DOWNGRADIENT SEDIMENT [d] (mg/kg)											
PAL METALS											
Aluminum	NA	3 / 3	2930	4840	3843	NC	18000	7800	NA	No	Less than RBC[1], Background[2]
Arsenic	NA	3 / 3	5.46	14.0	10.8	NC	19	0.43	NA	Yes	Exceeds RBC[3], Background[2]
Barium	NA	3 / 3	7.13	11.4	9.5	NC	54	550	NA	No	Less than RBC[1], Background[2]
Calcium	NA	3 / 3	10.3	736	427	NC	810	NA	NA	No	Essential Nutrient[4], Background[2]
Chromium	NA	3 / 3	11.2	16.1	13.8	NC	33	39	NA	No	Less than RBC[1], Background[2]
Cobalt	NA	3 / 3	2.23	6.9	4.3	NC	4.7	470	NA	No	Less than RBC[1]
Copper	NA	3 / 3	6.56	23.4	13.6	NC	13.5	310	NA	No	Less than RBC[1]
Iron	NA	3 / 3	7010	10900	9370	NC	18000	2300	NA	Yes	Exceeds RBC[3], Background[2]
Lead	NA	3 / 3	11.4	30.0	20.7	NC	48	NA	400 e	No	Less than ARAR[5], Background[2]
Magnesium	NA	3 / 3	1580	2630	2123	NC	5500	NA	NA	No	Essential Nutrient[4], Background[2]
Manganese	NA	3 / 3	70.7	186	139	NC	380	180	NA	Yes	Exceeds RBC[3], Background[2]

TABLE 9-2
DATA SUMMARY AND SELECTIONOF CHEMICALS OF POTENTIAL CONCERN
AOC 69W

REMEDIAL INVESTIGATION REPORT
DEVENS, MASSACHUSETTS

	Range of SQLs	Frequency of Detection	Minimum Detected	Concentration					Region III RBC**	ARARs	CPC?	Notes
				Maximum Detected	Arithmetic Mean	95% UCL	Back-ground*					
Nickel	NA	3 / 3	9.55	18.1	12.7	NC	14.6		160	NA	No	Less than RBC[1]
Potassium	NA	3 / 3	364	426	402	NC	2400		NA	NA	No	Essential Nutrient[4], Background[2]
Sodium	NA	3 / 3	259	307	275	NC	234		NA	NA	No	Essential Nutrient[4]
Vanadium	NA	3 / 3	7.91	10.4	8.9	NC	32.3		55	NA	No	Less than RBC[1], Background[2]
Zinc	NA	3 / 3	22.8	39.6	31.4	NC	43.9		2300	NA	No	Less than RBC[1]
PAL SEMIVOLATILE ORGANICS												
Benzo[k]fluoranthene	0.30-0.30	1 / 3	0.4	0.40	0.23	NC	-		8.8	NA	No	Less than RBC[1]
Chrysene	0.60-0.60	1 / 3	2	2	0.86	NC	-		88	NA	No	Less than RBC[1]
Fluoranthene	0.30-0.30	2 / 3	1	3	1.04	NC	-		310	NA	No	Less than RBC[1]
Phenanthrene	0.20-0.20	2 / 3	0.9	2	1	NC	-		310 h	NA	No	Less than RBC[1]
Pyrene	0.20-0.20	2 / 3	1	3	1.4	NC	-		230	NA	No	Less than RBC[1]
PAL VOLATILE ORGANICS												
Trichlorofluoromethane	NA	3 / 3	0.0082	0.0096	0.0091	NC	-		2300	NA	No	Less than RBC[1]
PESTICIDES/PCBS												
4,4-DDD	NA	3 / 3	0.0174	0.12	0.068	NC	-		2.7	NA	No	Less than RBC[1]
4,4-DDE	0.0077-0.0077	1 / 3	0.015	0.015	0.0076	NC	-		1.9	NA	No	Less than RBC[1]
4,4-DDT	NA	2 / 3	0.02	0.046	0.024	NC	-		1.9	NA	No	Less than RBC[1]
OTHER												
Total Petroleum Hydrocarbons	NA	3 / 3	66.8	290	162	NC			NA	NA	Yes	No standard available[3]
INDOOR AIR [m] (ug/m^3)												
VOLATILE ORGANICS												
2-Methylheptane	4.4	2 / 5	5.2	19	7.3	NC	(n)		200	NA	No	Less than RBC[1]
Ethylbenzene	NA	5 / 5	2.8	470	102	NC			100	NA	Yes	
Nonane	4.4	1 / 5	7.2	7.2	3.2	NC	(n)		200	NA	No	Less than RBC[1]
Octane	4.4	1 / 5	21	21	5.9	NC	(o)		20	NA	Yes	
Toluene	NA	5 / 5	70	1000	297	NC			42	NA	Yes	
Acetone	NA	5 / 5	52	470	172	NC			37	NA	Yes	
Xylene	8.8	4 / 5	8	92	30.4	NC			730	NA	No	Less than RBC[1]
2-Methylheptane	4.4	1 / 5	8.7	8.7	3.5	NC	(n)		200	NA	No	Less than RBC[1]

NOTES:

a Samples included in data set are listed on Table 9-1

b Samples included in data set are listed on Table 9-1

Chemicals selected as CPCs are shaded.

TABLE 9-2

DATA SUMMARY AND SELECTIONOF CHEMICALS OF POTENTIAL CONCERN

AOC 69W

REMEDIAL INVESTIGATION REPORT

DEVENS, MASSACHUSETTS

	Range of SQLs	Frequency of Detection	Minimum Detected	Concentration				Region III RBC**	ARARs	CPC?	Notes
				Maximum Detected	Arithmetic Mean	95% UCL	Back-ground*				

c Samples included in data set are listed on Table 9-1

d Samples included in data set are listed on Table 9-1

e USEPA soil lead screening level (OSWER Directive 9355.4-12, 1994b)

f MCL (USEPA, 1996b)

g Secondary MCL (USEPA, 1996b)

h Value for naphthalene used as surrogate

i Data for SVOC analysis

j Data for EPH analysis

k Data for VOC analysis

l Data for VPH analysis

m Samples included in data set are listed on Table 9-1

n Value is RfC for the C9-C12 aliphatic fraction published by MADEP (1997); adjusted to represent a value of 10% of the RfC.

o Value is the RfC for the C5-C8 aliphatic fraction published by MADEP (1997); adjusted to represent a value of 10% of the RfC.

Background: Maximum concentration in Fort Devens background listed;

95 percent UCL of Fort Devens background groundwater. See Appendix F for development of background.

**Region III RBCs (USEPA, 1997a): Residential RBC for soil used for sediment and surface and subsurface soil evaluation; tap water RBC used

for groundwater evaluation. Ambient Air RBCs used for indoor air evaluation. RBCs based on carcinogenic effects are associated with a 1x10^{-6} cancer risk level;

RBCs based on noncarcinogenic effects are associated with an adjusted HQ of 0.1.

Less than RBC[1] - Maximum detected concentration less than risk-based concentration

Background[2] - Sample concentrations detected are at or below background concentrations.

Exceeds RBC [3] - Maximum detected concentration exceeds risk-based concentration

Essential Nutrient[4] - Analyte is an essential human nutrient (magnesium, calcium, potassium, sodium) and is not considered a CPC.

Less than ARAR[5] - Maximum detected concentration is less than concentration shown in ARARs column.

Exceeds ARAR[6] - Maximum detected concentration is greater than concentration shown in ARARs column.

No standard available[7] - No standards available for comparison, analyte is considered a CPC.

RBC - Risk-based concentration

mg - milligrams

kg - kilograms

L - liter

ARARs - Applicable or Relevant and Appropriate Requirements

MCL - Maximum Contaminant Level

CPC - chemical of potential concern

bgs - below ground surface

SQL - Sample Quantitation Limit

- - not applicable for organics

NC - 95 percent UCL not calculated for data sets with less then 10 samples or groundwater

NA - No value available

UCL - upper confidence limit

TABLE 9-3
HUMAN HEALTH RISK ASSESSMENT SUMMARY OF POTENTIAL PATHWAYS
AOC 69W

REMEDIAL INVESTIGATION REPORT
DEVENS, MASSACHUSETTS

POTENTIALLY EXPOSED POPULATION	EXPOSURE MEDIUM AND POINT	EXPOSURE ROUTE	EVALUATED?	REASON FOR SELECTION OR EXCLUSION
CURRENT LAND USE				
Site Maintenance Worker	Surface soil in grassy area	Incidental ingestion	Yes	Maintaining the grassy area may expose current and future site maintenance workers to contaminated surface soil via ingestion and dermal contact.
		Dermal contact	Yes	
		Inhalation of particulates	Yes	Maintaining the grassy area may expose current and future site maintenance workers to particulates via inhalation.
		Inhalation of VOCs	No	VOCs were not selected as CPCs in surface soil.
	Groundwater	Incidental ingestion, dermal contact, and inhalation of VOCs	No	Maintaining the grassy area would not expose the site maintenance workers to groundwater.
	Subsurface soil beneath grassy area	Incidental ingestion, dermal contact, and inhalation of VOCs and particulates	No	No excavation presently occurring
	Surface water	Incidental ingestion, dermal contact, and inhalation of VOCs and particulates	No	Maintaining the grassy area would not expose the site maintenance workers to surface water.
	Sediment	Incidental ingestion, dermal contact, and inhalation of VOCs and particulates	No	Maintaining the grassy area would not expose the site maintenance workers to sediment.
School Occupants (Children/Faculty)	Groundwater	Incidental ingestion of and dermal contact with groundwater	No	The groundwater is not considered a conductive aquifer and is very shallow. Currently the school is not occupied.
		Inhalation of VOCs from groundwater	No	The school is not currently open. No students or faculty are present.
	Surface soil in grassy area	Incidental ingestion, dermal contact, and inhalation of VOCs and particulates	No	The school is not currently open. No students or faculty are present.
	Subsurface soil beneath grassy area	Incidental ingestion, dermal contact, and inhalation of VOCs and particulates	No	The school is not currently open. No students or faculty are present.
	Surface water	Incidental ingestion, dermal contact, and inhalation of VOCs and particulates	No	The school is not currently open. No students or faculty are present.
	Sediment	Incidental ingestion, dermal contact, and inhalation of VOCs and particulates	No	The school is not currently open. No students or faculty are present.

TABLE 9-3
HUMAN HEALTH RISK ASSESSMENT SUMMARY OF POTENTIAL PATHWAYS
AOC 69W

REMEDIAL INVESTIGATION REPORT
DEVENS, MASSACHUSETTS

POTENTIALLY EXPOSED POPULATION	EXPOSURE MEDIUM AND POINT	EXPOSURE ROUTE	EVALUATED?	REASON FOR SELECTION OR EXCLUSION
Child Trespasser	Surface water (as groundwater discharge)	Incidental ingestion	Yes	Children may incidentally ingest surface water while wading in the wetland area when surface water is present.
		Dermal contact	Yes	Wading may expose children to surface water in the wetland area.
		Inhalation of VOCs	No	VOCs were not selected as CPCs in shallow groundwater.
	Surface soil in grassy area	Incidental ingestion	Yes	Currently the school is not open. However, child trespassers might play in the unpaved (grassy) areas and may be exposed to contaminated surface soil via ingestion and dermal contact.
		Dermal contact	Yes	
		Inhalation of particulates	Yes	Playing could genearte dust in the grassy area.
		Inhalation of VOCs	No	VOCs were not selected as CPCs in surface soil.
	Subsurface soil beneath grassy area	Incidental ingestion, dermal contact, and inhalation of VOCs and particulates	No	No excavation presently occurring
	Sediment	Incidental ingestion	Yes	Children may incidentally ingest and contact sediment while wading in the wetland area during the spring months.
		Dermal contact	Yes	
		Inhalation of particulates and VOCs	No	VOCs were not selected as CPCs in sediment; no dust from sediment

TABLE 9-3
HUMAN HEALTH RISK ASSESSMENT SUMMARY OF POTENTIAL PATHWAYS
AOC 69W

REMEDIAL INVESTIGATION REPORT
DEVENS, MASSACHUSETTS

POTENTIALLY EXPOSED POPULATION	EXPOSURE MEDIUM AND POINT	EXPOSURE ROUTE	EVALUATED?	REASON FOR SELECTION OR EXCLUSION
FUTURE LAND USE				
Utility/Construction Worker	Surface soil and subsurface soil beneath grassy area	Incidental ingestion	Yes	Performing repairs to utility lines or during excavation activities may expose utility workers to contaminated surface and subsurface soil via ingestion and dermal contact.
		Dermal contact	Yes	
		Inhalation of particulates	Yes	Excavation work is likely to generate dust; therefore, this exposure pathway may be significant.
		Inhalation of VOCs	Yes	Performing repairs to utility lines or during excavation activities may expose utility workers to VOCs in surface and subsurface soil via inhalation.
	Groundwater	Incidental ingestion and dermal contact	No	Workers will be wearing protective clothing, which will mitigate exposure via these routes.
		Inhalation of VOCs	No	VOCs were not selected as CPCs in shallow groundwater
	Surface water	Incidental ingestion, dermal contact, and inhalation of VOCs and particulates	No	Excavation at the grassy area would not expose excavation workers to surface water.
	Sediment	Incidental ingestion, dermal contact, and inhalation of VOCs and particulates	No	Excavation at the grassy area would not expose excavation workers to surface water.
School Occupants (Children/Faculty)	Groundwater	Incidental ingestion of and dermal contact	No	The groundwater is not considered a conductive aquifer and is very shallow. The planned reuse of AOC 69W is to reopen the school, which will rely on existing public water supplies in the future.
	Air in school	Inhalation of VOCs migrating from soil and/or shallow groundwater beneath the school to indoor air	Yes	Children and faculty may be exposed to VOCs which have a potentially complete migration pathway from soil and/or shallow groundwater to air within the rooms of the school.
	Surface water (as groundwater discharge)	Incidental ingestion	Yes	Children may incidentally ingest surface water while wading in the wetland area when surface water is present.
		Dermal contact	Yes	Wading may expose children to surface water in the wetland area.
		Inhalation of VOCs	No	VOCs were not selected as CPCs in shallow groundwater.

TABLE 9-3
HUMAN HEALTH RISK ASSESSMENT SUMMARY OF POTENTIAL PATHWAYS
AOC 69W

REMEDIAL INVESTIGATION REPORT
DEVENS, MASSACHUSETTS

POTENTIALLY EXPOSED POPULATION	EXPOSURE MEDIUM AND POINT	EXPOSURE ROUTE	EVALUATED?	REASON FOR SELECTION OR EXCLUSION
	Surface soil in grassy area	Incidental ingestion	Yes	Students might play in the unpaved (grassy) areas and may be exposed to contaminated surface soil via ingestion and dermal contact.
		Dermal contact	Yes	
		Inhalation of particulates	Yes	Playing could genearte dust in the grassy area.
		Inhalation of VOCs	No	VOCs were not selected as CPCs in surface soil.
	Subsurface soil beneath grassy area	Incidental ingestion, dermal contact, and inhalation of VOCs and particulates	No	Excavations would not be left open or unfilled
	Sediment	Incidental ingestion	Yes	Students may incidentally ingest and contact sediment while wading in the wetland area during the spring months.
		Dermal contact	Yes	
		Inhalation of particulates and VOCs	No	VOCs were not selected as CPCs in sediment; no dust from sediment
General public	Groundwater	Potable use (ingestion, dermal contact, inhalation of VOCs during showering)	Yes	Although the groundwater is not anticipated to be used as a source of potable water, potable water use is evaluated.

TABLE 9-4
EXPOSURE PARAMETERS
AOC 69W

REMEDIAL INVESTIGATION REPORT
DEVENS, MASSACHUSETTS

		CURRENT LAND USE		FUTURE LAND USE					
PARAMETER		SITE MAINTENANCE WORKER	CHILD TRESPASSER (6-18 YEARS)	PUPIL (6-18 YEARS)	EXCAVATION WORKER	ADULT RESIDENT (POTABLE WATER)	CHILD RESIDENT (POTABLE WATER)	UNITS	SOURCE [1]
Sediment/Soil Ingestion Rate									
	RME	100	100	100	480	Not Applicable	Not Applicable	mg/day	USEPA, 1994
	Central Tendency	50	50	50	200 [7]	Not Applicable	Not Applicable	mg/day	USEPA, 1994
Surface Water Ingestion Rate									
	RME	Not Applicable	0.05	0.05	Not Applicable	Not Applicable	Not Applicable	L/hour	USEPA, 1986
	Central Tendency	Not Applicable	0.025	0.025	Not Applicable	Not Applicable	Not Applicable	L/hour	Assumption
Groundwater Ingestion Rate									
	RME	Not Applicable	Not Applicable	Not Applicable	Not Applicable	2	1	L/day	USEPA, 1994
	Central Tendency	Not Applicable	Not Applicable	Not Applicable	Not Applicable	1.4	0.7	L/day	Assumption
Surface Area Exposed [2]		5,200	5,053	5,053	5,200	5,200	Not Applicable	cm2/day	USEPA, 1989a / 1992
Fraction Ingested From Site		100%	100%	100%	100%	100%	100%		Assumption
Relative Absorption Factor		100%	100%	100%	100%	100%	100%		USEPA, 1995
Inhalation Rate [5]									
	RME	2.5	2.3	2.3	4.8	Not Applicable	Not Applicable	m3/hour	USEPA, 1989
	Central Tendency	Not Applicable	2	2	1.5	Not Applicable	Not Applicable	m3/hour	USEPA, 1996
Soil Exposure Time		8	8	8	8	Not Applicable	Not Applicable	hours/day	Assumption
Soil Exposure Frequency [3]		64	96	140	90	Not Applicable	Not Applicable	days/year	Assumption
Surface Water/Sediment Exposure Time		Not Applicable	2.6	2.6	Not Applicable	Not Applicable	Not Applicable	hours/day	USEPA, 1989a
Surface Water/Sediment Exposure Frequency [4]		Not Applicable	24	24	Not Applicable	Not Applicable	Not Applicable	days/year	Assumption
Groundwater Exposure Frequency		Not Applicable	Not Applicable	Not Applicable	Not Applicable	350	350	days/year	USEPA, 1994
Exposure Duration									
	RME	25	13	13	0.35	30	6	years	USEPA, 1994, Assumption
	Central Tendency [6]	9	9	9	—	9	2	years	USEPA, 1994, Assumption
Body Weight		70	45	45	70	70	15	kg	USEPA, 1989a, USEPA, 1994
Averaging Time									
Cancer		70	70	70	70	70	70	years	USEPA, 1989b
Noncancer		equal ED	equals ED	equals ED	equals ED	equals ED	equals ED	years	USEPA, 1989b
Particulate Emission Factor		1.32+09	Not Applicable	Not Applicable	1.32+09	Not Applicable	Not Applicable	m3/kg	USEPA, 1996
Soil-to-Air Volatilization Factor		No volatile CPCs	No volatile CPCs	No volatile CPCs	No volatile CPCs	Not Applicable	Not Applicable		
Permeability Constant		Not Applicable	Chemical-specific	Chemical-specific	Not Applicable	Not Applicable	Not Applicable	cm/hour	USEPA, 1992

TABLE 9-4
EXPOSURE PARAMETERS
AOC 69W

REMEDIAL INVESTIGATION REPORT
DEVENS, MASSACHUSETTS

	CURRENT LAND USE		FUTURE LAND USE					
PARAMETER	SITE MAINTENANCE WORKER	CHILD TRESPASSER (6-18 YEARS)	PUPIL (6-18 YEARS)	EXCAVATION WORKER	ADULT RESIDENT (POTABLE WATER)	CHILD RESIDENT (POTABLE WATER)	UNITS	SOURCE[1]

Notes:

1 - Exposure variables with source listed as "assumption" are site specific; the remainder are default values. RME and central tendency parameters listed separately only when they differ from each other.

2 - body area = hands, arms, lowerlegs, and feet (trespasser & pupil); head, hands, arms (maintenance worker / utility worker).

3 - 2 days per week for 32 weeks for site maintenance worker (Apr-Nov); 3 days per week for 32 weeks for child trespasser (Apr-Nov);
5 days per week for 18 weeks for construction worker; 5 days per week for 22 weeks for pupil (Sept-Nov; Apr-mid Jun) plus 3 days per week for 10 weeks (mid Jun - Aug).

4 - 2 days per week for 12 weeks.

5 - Inhalation rate for excavation worker based on the heavy activity rate listed in the Exposure Factors Handbook (USEPA, 1989c)

6 - ED for residents used for pupil and trespasser

7 - Assumption, value based on RME child.

cm2 = square centimeters

mg - milligrams

m3 - cubic meters

kg - kilograms

CPC - Chemical of Potential Concern

NA - not applicable

USEPA, 1986 - Superfund Exposure Assessment Manual

USEPA, 1989a - Exposure Factors Handbook

USEPA, 1989b - Risk Assessment Guidance for Superfund, Part A

USEPA, 1992 - Dermal Exposure Assessment

USEPA, 1994 - USEPA Region I Risk Updates, Number 2

USEPA, 1995 - USEPA Region I Risk Updates, Number 3

USEPA, 1996 - USEPA Soil Screening Level Guidance

TABLE 9–5
PERMEABILITY COEFFICIENTS FOR CPCs IN SURFACE WATER
AOC 69W

REMEDIAL INVESTIGATION REPORT
DEVENS, MASSACHUSETTS

Compound	Exposure Time (ET) (hr/day)	log K_{ow} [1]	MW[1]	Kp [2] (cm/hr)	T [2] (hr)	t* [2] (hr)	B [2]	Kp_{event} (cm/day)
ORGANICS [3]								
TPHC*	2.6	5.18E+00	202	5.3E−01	1.5E+00	7.2E+00	1.5E+01	2.9E+00
bis(2−Ethylhexyl)phthalate	2.6			3.3E−02	2.1E+01	1.0E+02	1.3E+01	6.7E−01
Chloroform	2.6			1.3E−01	4.7E−01	1.1E+00	9.3E−03	4.6E−01
2−Methylnaphthalene	2.6	4.11E+00	142.2	2.1E−01	6.4E−01	4.5E+00	1.3E+00	7.7E−01
Trichloroethene	2.6			2.3E−01	5.5E−01	1.3E+00	2.6E−02	8.6E−01
n−Hexane**	2.6	3.9E+00	86.17	3.3E−01	2.9E−01	1.3E+01	7.9E−01	8.1E−01
Naphthalene	2.6			6.9E−02	5.3E−01	2.2E+00	2.0E−01	2.8E−01
INORGANICS [4]								
Aluminum	2.6			1.0E−03	NA	NA	NA	2.6E−03
Arsenic	2.6			1.0E−03	NA	NA	NA	2.6E−03
Iron	2.6			1.0E−03	NA	NA	NA	2.6E−03
Manganese	2.6			1.0E−03	NA	NA	NA	2.6E−03

Notes:

[1] Needed only for compounds not included on USEPA, 1992c, Table 5−8, these values obtained from USEPA, 1993.

[2] Values from USEPA, 1992c, Table 5−8 or calculated as follows:

1. $\text{Log } Kp = -2.72 + 0.71 \times \log K_{ow} - 0.0061 \times MW$
2. $B = K_{ow} / 10^4$
3. $r = l_{sc}^2 / (6 \times (l_{sc} \times 10^{(-2.72 - 0.0061 \times MW)}))$
   where $l_{sc} = 10\ \mu m = 0.001$ cm
4. If $B \leq 0.1$, then $t^* = 2.4 \times r$
   If $0.1 \leq B \leq 1.17$, then $t^* = (8.4 + 6 \log B) \times r$
   If $B \geq 1.17$, then $t^* = 6 \times (b - (b^2 - c^2)^{0.5}) \times r$
   where $b = (2/\pi) \times (1 + B)^2 - c$
   and $c = (1 + 3B) / 3$

[3] For organics; Kp from USEPA, 1992c, Table 5−8, estimated values
Kp_{event} calculated as follows:
If $ET < t^*$, then;
Kp_{event} (cm/event) $= 2 \times Kp \times [(6 \times T \times ET) / \pi]^{0.5}$
If $ET > t^*$, then;
Kp_{event} (cm/event) $= Kp \times [(ET/1 + B) + 2 \times T \times ((1 + 3\,B)/1 + B)]$

[4] For inorganics, Kp from USEPA, 1992c, Table 5−3 or default value of 1E−03 cm/hr
Kp_{event} calculated as follows:
Kp_{event} (cm/day) $= Kp \times ET$

Acronyms:
hr = hour
cm = centimeter
Kp = Permeability Coefficient
K_{ow} = Octanol/water partitioning coefficient
MW = molecular weight
r = lag time
t* = time to reach steady state
B = partitioning factor
NA = not applicable
TPHC = Total Petroleum Hydrocarbons
5.3E−01 = 0.53

* – Pyrene used as a surrogate to calculate the K_p for TPHC. Also, this calculated K_p is used as a surrogate for all three Extractable Petroleum Hydrocarbon fractions (C9−C18 and C19−C36 aliphatic and C10−C22 aromatics) and the Volatile Petroleum Hydrocarbon (VPH) C9−C12 aliphatics and C9−C10 aromatics fractions.

** – n−Hexane's calculated K_p is used as a surrogate for the VPH C5−C8 aliphatics fraction.

TABLE 9–6
ORAL DOSE/RESPONSE DATA FOR CARCINOGENIC EFFECTS
AOC 69W

REMEDIAL INVESTIGATION REPORT
DEVENS, MASSACHUSETTS

Compound	Weight of Evidence	Oral Slope Factor $(mg/kg/day)^{-1}$	Test Species	Study Type	Tumor Type	Source
2–Methylnaphthalene	ND					IRIS
Aluminum	Not Listed					HEAST
Arsenic	A	1.5E+00	Human	Oral–DW	Skin	IRIS
Beryllium	B2	4.3E+00 (w)	Rat	Oral–DW	Total	IRIS
Bis(2–ethylhexyl)phthalate (BEHP)	B2	1.4E–02	Mouse	Oral–diet	Liver	IRIS
Chloroform	B2	6.1E–03	Rat	Oral–drinking water	Kidney	IRIS
Trichloroethene	B2	1.1E–02 (w)	Rat	Oral–diet	Lung/Liver	HEAST
Iron	Not Listed					
Manganese	D					IRIS
Naphthalene	D					IRIS
Extractable Petroleum Hydrocarbons						
C9–C18 Aliphatics	Not Listed					
C19–C36 Aliphatics	Not Listed					
C10–C22 Aromatics	Not Listed					
Total Petroleum Hydrocarbons	Not Listed					
Volatile Petroleum Hydrocarbons						
C5–C8 Aliphatics	Not Listed					
C9–C12 Aliphatics	Not Listed					
C9–C10 Aromatics	Not Listed					

ND – Not Determined
W – Withdrawn from IRIS
DW – Drinking water
mg – milligram
kg – kilogram
IRIS – Integrated Risk Information System
HEAST – Health Effects Assessment Summary Tables
1.5E+00 = 1.5

Sources:
IRIS as of 4/98
HEAST, 1997

(w) = Withdrawn from HEAST in FY 1992 update

Weight of Evidence (Route–Specific):
A – Human carcinogen
B – Probable human carcinogen (B1 – limited evidence of cancer in humans;
B2 – sufficient evidence of carcinogenicity in animals with inadequate or lack of evidence in humans)
C – Possible human carcinogen
D – Not classifiable as to human carcinogenicity
E – Evidence of lack of carcinogenicity to humans

TABLE 9–7
INHALATION DOSE/RESPONSE INFORMATION FOR CARCINOGENIC EFFECTS
AOC 69W

REMEDIAL INVESTIGATION REPORT
DEVENS, MASSACHUSETTS

Compound	Weight of Evidence	Inhalation Slope Factor* $(mg/kg/day)^{-1}$	Unit Risk $(\mu g/m^3)^{-1}$	Test Species	Study Type	Tumor Type	Source
2–Methylnaphthalene	ND						IRIS
Aluminum	ND						HEAST
Arsenic	A	1.5E+01 +	4.3E–03	Human	Inhalation	Lung	IRIS
Beryllium	B2	8.4E+00	2.4E–03	Human	Inhalation	Lung	IRIS
Bis(2–ethylhexyl)phthalate (BEHP)	B2		ND				IRIS
Chloroform	B2	8.1E–02	2.3E–05	Mouse	Oral–gavage	Liver	IRIS
Trichloroethene	B2	6.0E–03 (N)	2.0E–06 (N)	NA	NA	NA	NCEA
Iron	Not Listed						
Manganese	D						IRIS
Naphthalene	D						IRIS
Extractable Petroleum Hydrocarbons							
C9–C18 Aliphatics	Not Listed						
C19–C36 Aliphatics	Not Listed						
C10–C22 Aromatics	Not Listed						
Total Petroleum Hydrocarbons	Not Listed						
Volatile Petroleum Hydrocarbons							
C5–C8 Aliphatics	Not Listed						
C9–C12 Aliphatics	Not Listed						
C9–C10 Aromatics	Not Listed						

* – Source of slope factor is HEAST, 1997 unless otherwise noted.

\+ – Source of slope factor is IRIS

(N) = This value has been provided in response to a specific request

ND – Not Determined
mg – milligram
kg – kilogram
µg – microgram
IRIS – Integrated Risk Information System
HEAST – Health Effects Assessment Summary Tables
1.5E+01 = 15

Sources:
IRIS as of 4/98
HEAST, 1997

Weight of Evidence (Route–Specific):
A – Human carcinogen
B – Probable human carcinogen (B1 – limited evidence of cancer in humans;
B2 – sufficient evidence of carcinogenicity in animals with inadequate or lack of evidence in humans)
C – Possible human carcinogen
D – Not classifiable as to human carcinogenicity
E – Evidence of lack of carcinogenicity to humans

TABLE 9-8
ORAL DOSE/RESPONSE INFORMATION FOR NONCARCINOGENIC EFFECTS
AOC 69W

REMEDIAL INVESTIGATION REPORT
DEVENS, MASSACHUSETTS

Compound	CHRONIC ORAL RfD (mg/kg-day)	SUBCHRONIC ORAL RfD[1] (mg/kg-day)	STUDY TYPE	CONFIDENCE LEVEL	CRITICAL EFFECT	TEST ANIMAL	UNCERTAINTY FACTOR	SOURCE
2-Methylnaphthalene	4E-02 *	4E-02 *						
Aluminum	1E+00	1E+00 #						NCEA, 1994a
Arsenic	3E-04	3E-04	Oral-DW	Medium	Keratosis and hyperpigmentation	Human	3 H	IRIS
Beryllium	2E-03	2E-03	Oral-DW	Low	No effects observed	Rat	100 H,A	IRIS
Bis(2-ethylhexyl)phthalate (BEHP)	2E-02	2E-02 #	Oral-diet	Medium	Increased liver weight	Guinea Pig	1,000 H,A,S	IRIS
Chloroform	1E-02	1E-02	Oral-capsule	Medium	Fatty cyst formation in liver	Dog	1,000 H,A, S	IRIS
Trichloroethene	6.0E-03 (N)	ND	NA	NA	NA	NA	NA	NCEA
Iron	3E-01	3E-01 #						NCEA, 1994c
Manganese (soil) USEPA Region 1	7.1E-02 ++	7.1E-02 #						Region 1
Manganese (drinking water) USEPA Region 1	2.4E-02 +++	2.4E-02 #						Region 1
Naphthalene	4E-02 W	4E-02						NCEA, 1994
Extractable Petroleum Hydrocarbons								
C9-C18 Aliphatics	6E-01	6E-01 #						MADEP, 1997
C19-C36 Aliphatics	6E+00	6E+00 #						MADEP, 1997
C10-C22 Aromatics	3E-02	3E-01						MADEP, 1997
Total Petroleum Hydrocarbons	3E-02	3E-01 **						
Volatile Petroleum Hydrocarbons								
C5-C8 Aliphatics	6E-02	6E-01						MADEP, 1997
C9-C12 Aliphatics	6E-01	6E-01 #						MADEP, 1997
C9-C10 Aromatics	3E-02	3E-01						MADEP, 1997

ND - No data available
W - RfD withdrawn from IRIS/HEAST
mg - milligram
kg - kilogram
DW - Drinking Water
IRIS - Integrated Risk Information System
HEAST - Health Effects Assessment Summary Tables
USEPA - United States Environmental Protection Agency
NCEA - National Center for Environmental Assessment
MADEP - Massachusetts Department of Environmental Protection

[1] - Source for all subchronic RfDs is HEAST, 1997
*RfD for naphthalene is used as surrogate for PAHs without assigned RfD
(N) = Value was provided in response to a special request
** Value for C10-C22 used as conservative surrogate
4.1E-02 = 0.041

Uncertainty factors:
H - variation in human sensitivity
A - animal to human extrapolation
S - extrapolation from subchronic to chronic NOAEL
L - extrapolation from LOAEL to NOAEL
N - NOEL not attained
D - Lack of supporting data
M - addition modifying factor

SOURCES:
MADEP, 1994: Interim Final Petroleum Report. Development of Health-based Alternative to the Total Petroleum Hydrocarbon Parameter
IRIS as of 4/98
NCEA, 1994a,b,c, 1995
HEAST, 1997
Region 1 Risk Update, 1996

++ RfD for manganese in food divided by 2 to account for dietary exposure
+++ RfD for manganese in food divided by 2 to account for dietary exposure, and by 3 as a modifying factor
# Subchronic RfD not available. Chronic RfD used as a surrogate

TABLE 9–9
INHALATION DOSE/RESPONSE DATA FOR NONCARCINOGENIC EFFECTS
AOC 69W

REMEDIAL INVESTIGATION REPORT
DEVENS, MASSACHUSETTS

COMPOUND	CHRONIC INHALATION RfC (mg/m^3)	SUBCHRONIC[1] INHALATION RfC (mg/m^3)	STUDY TYPE	CONFIDENCE LEVEL	CRITICAL EFFECT	TEST ANIMAL	UNCERTAINTY FACTOR	SOURCE
2–Methylnaphthalene	Not listed							
Acetone	ND	ND						MADEP
Aluminum	ND	ND						HEAST
Arsenic	ND	ND						IRIS
Beryllium	2E–05	2E–05						IRIS
Bis(2–ethylhexyl)phthalate (BEHP)	ND	ND						IRIS
Chloroform	ND	ND						IRIS
Ethylbenzene	1E+00	ND	Inhalation	Low	Development toxicity	Rat/Rabbit	300 H,A,S	IRIS
Trichloroethene	ND	ND						IRIS
Iron	Not Listed							
Manganese	5E–05	ND	Inhalation	Medium	Neurobehavioral impairment	Human	1,000 H,L,D	IRIS
Naphthalene	ND	ND						IRIS
Extractable Petroleum Hydrocarbons								
C9–C18 Aliphatics	2.0E+00	2.0E+00 #						MADEP, 1997
C19–C36 Aliphatics	ND	ND						MADEP, 1997
C10–C22 Aromatics	7.1E–02	7.1E–02 #						MADEP, 1997
Total Petroleum Hydrocarbons	6.0E–02 *	6.0E–02 #						
Toluene	4E–01	ND	Inhalation	Medium	Neurological effects	Human	300 H,L,D	IRIS
Volatile Petroleum Hydrocarbons								
C5–C8 Aliphatics	2.0E–01	2.0E–01 #						MADEP, 1997
C9–C12 Aliphatics	2.0E+00	2.0E+00 #						MADEP, 1997
C9–C10 Aromatics	6.0E–02	6.0E–02 #						MADEP, 1997

ND – No data available
mg – milligram
kg – kilogram
µg – microgram
DW – Drinking Water
IRIS – Integrated Risk Information System
HEAST – Health Effects Assessment Summary Tables
MADEP = Massachusetts Department of Environmental Protection
5E–05 = 0.00005

[1] – Source for all subchUncertainty factors:

* = Value for C9–C10 used as conservative surrogate.

– Subchronic RfD not available, chronic RfD used as surrogate.

H – variation in human sensitivity
A – animal to human extrapolation
S – extrapolation from subchronic to chronic NOAEL
L – extrapolation from LOAEL to NOAEL
N – NOEL not attained
D – Lack of supporting data
M – additional modifying factor

SOURCES:
IRIS as of 4/98
HEAST, 1997
MADEP, 1997 – Interim Final Petroleum Report: Developement of Health–Based Alternatives to the TPH Parameter.

TABLE 9-10
DERMAL DOSE/RESPONSE INFORMATION FOR CARCINOGENIC AND NONCARCINOGENIC EFFECTS
AOC 69W

REMEDIAL INVESTIGATION REPORT
DEVENS, MASSACHUSETTS

COMPOUND	CHRONIC ORAL RfD[1] (mg/kg-day)	SUBCHRONIC ORAL RfD[1] (mg/kg-day)	ORAL CSF[1] (mg/kg-day)$^{-1}$	ORAL ABSORPTION EFFICIENCY	REFERENCE FOR ORAL ABSORPTION EFFICIENCY	CHRONIC DERMAL RfD[2] (mg/kg-day)	SUBCHRONIC DERMAL RfD[2] (mg/kg-day)	DERMAL CSF[3] (mg/kg-day)$^{-1}$
Aluminum	1.0E+00	ND	ND	20%	Default[4]	2.0E-01	ND	ND
Arsenic	3.0E-04	3.0E-04	1.5E+00	98%	Vahter, 1983	2.9E-04	2.9E-04	1.5E+00
Bis(2-ethylhexyl)phthalate	2.0E-02	ND	1.4E-02	100%	Chadwick et al., 1982	2.0E-02	ND	1.4E-02
Chloroform	1.0E-02	1.0E-02	6.1E-03	100%	Brown et al., 1974	1.0E-02	1.0E-02	6.1E-03
Trichloroethene	6.0E-03	6.0E-03	1.1E-02	100%	Prout et al., 1985	6.0E-03	6.0E-03	1.1E-02
Iron	3.0E-01	ND	ND	2%	Goyer, 1991	6.0E-03	ND	ND
Manganese (water)	2.4E-02	ND	ND	4%	ATSDR, 1991	9.6E-04	ND	ND
2-Methylnaphthalene*	4.0E-02	4.0E-02	ND	100%	Chang, 1943	4.0E-02	4.0E-02	ND
Naphthalene	4.0E-02	4.0E-02	ND	100%	Chang, 1943	4.0E-02	4.0E-02	ND
Extractable Petroleum Hydrocarbons (EPH)[6]								
C9-C18 Aliphatics	6.0E-01	ND	ND	50%	Default[4]	3.0E-01	ND	ND
C19-C36 Aliphatics	6.0E+00	ND	ND	50%	Default[4]	3.0E+00	ND	ND
C10-C22 Aromatics	3.0E-02	3.0E-01	ND	91%	B(a)P[7]	2.7E-02	2.7E-01	ND
Total Petroleum Hydrocarbons**	3.0E-02	3.0E-01	ND	91%	B(a)P[7]	2.7E-02	2.7E-01	ND
Volatile Petroleum Hydrocarbons (VPH)[6]								
C5-C8 Aliphatics	6.0E-02	ND	ND	80%	Default[4]	4.8E-02	ND	ND
C9-C12 Aliphatics	6.0E-01	ND	ND	80%	Default[4]	4.8E-01	ND	ND
C9-C10 Aromatics	3.0E-02	3.0E-01	ND	91%	B(a)P[7]	2.7E-02	2.7E-01	ND

NOTES:

[1] – See preceding Dose/Response Tables

[2] – Dermal RfD = Oral RfD x Oral Absorption Efficiency

[3] – Dermal CSF = Oral CSF / Oral Absorption Efficiency

Default[4] –Compounds lacking specific absorption efficiencies are assigned the following default efficiencies: volatiles and VPH – 80%, semivolatiles, EPH, and pesticides – 50%, inorganics 20%

Heptachlor[5] – Based on structural analogy to heptachlor

[6]The proposed alternate oral RfDs from the Interim Final Petroleum Report: Development of Health-Based Alternatives to the Total Petroleum Hydrocarbon (TPH) Parameter (MADEP, 1997) are used as surrogates for the EPH and VPH fractions, see the oral RfD dose/response table.

B(a)P[7] – Based on structural analogy to benzo(a)pyrene

* – Naphthalene used as a surrogate

** – Pyrene used as a surrogate

1E+00 = 1

ACRONYMS:

RfD – Reference Dose
CSF – Cancer Slope Factor
mg – milligram
kg – kilogram
ND – Not determined
ATSDR – Agency for Toxic Substances and Disease Registry

TABLE 9-11
QUANTITATIVE RISK SUMMARY
AOC 69W

REMEDIAL INVESTIGATION REPORT
DEVENS, MASSACHUSETTS

	CENTRAL TENDENCY		RME	
	ELCR	HI	ELCR	HI
CURRENT AND FUTURE USE				
SURFACE SOIL (0 - 1 feet bgs)				
Incidental Ingestion of Surface Soil: Site Maintenance Worker	5E-07	0.02	3E-06	0.03
Dermal Contact with Surface Soil: Site Maintenance Worker	8E-07	0.05	2E-06	0.07
Inhalation of Particulates from Soil: Site Maintenance Worker	1E-09	0.0006	4E-09	0.0006
TOTAL: SITE MAINTENANCE WORKER	**1E-06**	**0.07**	**5E-06**	**0.1**
Incidental Ingestion of Surface Soil: Child Trespasser (6-18 years)	1E-06	0.04	3E-06	0.08
Dermal Contact with Surface Soil: Child Trespasser (6-18 years)	2E-06	0.1	3E-06	0.1
Inhalation of Particulates from Soil: Child Trespasser (6-18 years)	1E-09	0.0007	3E-09	0.0007
TOTAL: CHILD TRESPASSER	**3E-06**	**0.1**	**6E-06**	**0.2**
SEDIMENT				
Incidental Ingestion of Downgradient Sediment: Child Trespasser (6-18 years)	2E-07	0.01	6E-07	0.03
Dermal Contact with Downgradient Sediment: Child Trespasser (6-18 years)	3E-07	0.04	4E-07	0.04
TOTAL: CHILD TRESPASSER	**5E-07**	**0.05**	**1E-06**	**0.07**
GROUNDWATER (DISCHARGES TO SURFACE WATER)				
Incidental Ingestion of Surface Water: Child Trespasser (6-18 years) Wading	7E-07	0.02	2E-06	0.04
Dermal Contact with Surface Water: Child Trespasser (6-18 years) Wading	6E-07	0.2	9E-07	0.2
TOTAL: CHILD TRESPASSER	**1E-06**	**0.2**	**2E-06**	**0.2**
TOTAL RISK TO CHILD TRESPASSER EXPOSED TO SURFACE SOIL, SEDIMENT, and GROUNDWATER (DISCHARGES TO SURFACE WATER)	**6E-06**	**0.4**	**1E-05**	**0.6**
FUTURE USE				
SURFACE SOIL (0 - 1 feet bgs)				
Incidental Ingestion of Surface Soil: Pupil (6-18 years)	2E-06	0.06	5E-06	0.1
Dermal Contact with Surface Soil: Pupil (6-18 years)	3E-06	0.2	4E-06	0.2
Inhalation of Particulates from Surface Soil: Pupil (6-18 years)	4E-09	0.002	6E-09	0.002
TOTAL: PUPIL	**5E-06**	**0.3**	**9E-06**	**0.3**
Incidental Ingestion of Surface Soil: Excavation Worker	1E-07	0.07	3E-07	0.2
Dermal Contact with Surface Soil: Excavation Worker	4E-08	0.04	4E-08	0.04
Inhalation of Particulates from Soil: Excavation Worker	4E-11	0.0009	1E-10	0.0009
TOTAL: EXCAVATION WORKER	**1E-07**	**0.1**	**3E-07**	**0.2**
SUBSURFACE SOIL (1 - 10 feet bgs)				
Incidental Ingestion of Subsurface Soil: Excavation Worker	4E-08	0.04	9E-08	0.1
Dermal Contact with Subsurface Soil: Excavation Worker	2E-08	0.04	2E-08	0.04
Inhalation of Particulates and Volatiles from Subsurface Soil: Excavation Worker	2E-11	0.8	6E-11	0.8
TOTAL: EXCAVATION WORKER	**6E-08**	**0.9**	**1E-07**	**0.9**
TOTAL EXCAVATION WORKER EXPOSURE TO SURFACE AND SUBSURFACE SOIL	**2E-07**	**1**	**4E-07**	**1**

TABLE 9-11
QUANTITATIVE RISK SUMMARY
AOC 69W

REMEDIAL INVESTIGATION REPORT
DEVENS, MASSACHUSETTS

	CENTRAL TENDENCY		RME	
	ELCR	HI	ELCR	HI
FUTURE USE (cont)				
SEDIMENT				
Incidental Ingestion of Downgradient Sediment: Pupil (6-18 years)	2E-07	0.01	6E-07	0.03
Dermal Contact with' Downgradient Sediment: Pupil (6-18 years)	3E-07	0.04	4E-07	0.04
TOTAL: PUPIL	**5E-07**	**0.05**	**1E-06**	**0.07**
GROUNDWATER (DISCHARGES TO SURFACE WATER)				
Incidental Ingestion of Surface Water: Pupil (6-18 years) Wading	7E-07	0.02	2E-06	0.04
Dermal Contact with Surface Water: Pupil (6-18 years) Wading	6E-07	0.2	9E-07	0.2
TOTAL: PUPIL	**1E-06**	**0.2**	**2E-06**	**0.2**
INDOOR AIR				
Inhalation of Vapors in Building: Pupil (6-18 years)]	NC	0.4	NC	0.4
TOTAL: PUPIL	**NC**	4E-04 **0.4**	**NC**	**0.4**
TOTAL RISK TO PUPIL EXPOSED TO SURFACE SOIL, SEDIMENT, GROUNDWATER (DISCHARGES TO SURFACE WATER), and INDOOR AIR	**6E-06**	**1.0**	**1E-05**	**1**
GROUNDWATER (POTABLE USE)				
Ingestion of Groundwater: Adult Resident	1E-04	4	3E-03	25
Ingestion of Groundwater: Child Resident	8E-05	8	2E-03	57
TOTAL: RESIDENT	**1E-04**	**NA**	**5E-03**	**NA**

NOTES:
RME = Reasonable Maximum Exposure
NC = Not Calculated because there were no potentially carcinogenic CPCs.
NA = Not Additive
1E-06 = 1 in 1,000,000
ELCR = Excess Lifetime Cancer Risk
HI = Hazard Index

TABLE 9–12
POTENTIAL SOURCES OF UNCERTAINTY
AOC 69W

REMEDIAL INVESTIGATION REPORT
FORT DEVENS, MA

UNCERTAINTY	EFFECT	JUSTIFICATION
Likelihood of exposure pathways	Overestimate	Future exposures may not actually occur
Degradation of chemicals not considered	Overestimate	Risk estimates are based on recent chemical concentrations. Concentrations will tend to decrease over time as a result of degradation, so future exposures may be to lower concentrations.
Extrapolation of animal toxicity data to humans	Unknown, probably overestimate	Animals and humans differ with respect to absorption, metabolism, distribution, and excretion of chemicals. The magnitude and direction of the difference will vary with each chemical. Animal studies typically involve high–dose exposures, whereas humans are exposed to low doses in the environment.
Use of linearized, multistage model to derive cancer slope factors	Overestimate	Model assumes a non–threshold, linear–at–low–dose relationship for carcinogens. Many compounds induce cancer by non–genotoxic mechanisms. Model results in a 95% upper confidence limit of the cancer risk. The true risk is unlikely to be higher and may be as low as zero.
Summation of effects (cancer risks and hazard indices) from multiple substances	Unknown	The assumption that effects are additive ignores potential synergistic and/or antagnonistic effects. Assumes similarity in mechanism of action, which is not the case for many substances. Compounds may induce tumors or other toxic effects in different organs or systems.
Use of uncertainty factors in the derivation of reference doses.	Unknown	Ten–fold uncertainty factors are incorporated to account for various sources of uncertainty. Although some data seem to support the ten–fold factor, its selection is somewhat arbitrary.
Exclusion of analytes, such as TPHC and lead, from quantitative evaluation because no toxicity information is available.	Underestimate	The exclusion of analytes without toxicity values from quantitative evaluation may bias estimates of risk low.
The use of an oral absorption factor of 1	Overestimate	The assumption of 100% gastrointestinal absorption of chemicals on soil is conservative.
Dermal exposure to soil and sediment not evaluated because of lack of dermal absorption factors.	Underestimate	Dermal contact with soils and sediment may produce some incremental risk and the inability to quantify the risk may bias the total risk estimate low.

Table 9-13
Endpoints for Ecological Assessment
AOC 69W

Remedial Investigation Report
Devens, Massachusetts

Medium	Receptor	Assessment Endpoint	Measurement Endpoint
Surface Soil	Wildlife	Survival and propagation of wildlife populations.	Oral contaminant doses (mg/kg BW-day) based on measured adverse effects on growth, reproduction, or survival (e.g., LD_{50} studies, LOAELs, and NOAELs) of mammalian or avian laboratory test populations.
	Terrestrial invertebrates	Survival and propagation of terrestrial invertebrate populations.	Contaminant concentrations in surface soil (µg/g) that correlate with adverse effects on survival (e.g., LC_{50} studies) of terrestrial invertebrates. When no survival studies are available, measured adverse effects on reproduction and growth are used.
	Terrestrial plants	Survival and propagation of plant populations.	Contaminant concentrations in surface soil (µg/kg) that correlate with adverse effects on growth, reproduction, or survival of terrestrial plants.
Sediment	Wildlife	Survival and propagation of wildlife populations.	Oral contaminant doses (mg/kg BW-day) based on measured adverse effects on growth, reproduction, or survival (e.g., LD_{50} studies, LOAELs, or NOAELs) of mammalian or avian laboratory test populations.
	Aquatic organisms (invertebrates, plants, and amphibians)	Survival and propagation of invertebrate, amphibian, and aquatic plant populations.	Chemical concentrations in sediment (µg/g) associated with adverse effects to growth, reproduction, and survival of aquatic organisms.
	Aquatic invertebrates	Survival and propagation of benthic macroinvertebrate populations.	Direct measurement of survival and growth of the midge (*Chironomus tentans*) and amphipod (*Hyalella azteca*) in laboratory toxicity tests.
Groundwater Discharge	Aquatic organisms (invertebrates, plants, and amphibians)	Future survival and propagation of invertebrate, amphibian, and aquatic plant populations.	Chemical concentrations in surface water (µg/l) associated with adverse effects to growth, reproduction, survival, and biodiversity of aquatic organisms.

NOTES:

AOC = Area of contamination
µg/g = micrograms per gram
µg /l = micrograms per liter
mg/kg BW-day = milligrams per kilogram body weight per day
LD_{50} = lethal dose to 50 percent of a test population
LC_{50} = lethal concentration to 50 percent of a test population
LOAEL = Lowest observable adverse effects level
NOAEL = No observable adverse effects level

TABLE 9-14
ECOLOGICAL CONTAMINANTS OF POTENTIAL CONCERN IN SURFACE SOIL[1]
AOC 69W

REMEDIAL INVESTIGATION
DEVENS, MASSACHUSETTS

Analyte	Frequency of Detection[2]	Range of SQLs[3]	Range of Detected Concentrations	Background Surface Soil Concentration[4]	Contaminant of Potential Ecological Concern?[5]	Average of All Concentrations[6]	Exposure Point Concentrations	
							RME[7]	Average[8]
PAL METALS (ug/g)								
Aluminum	6/6	NA	5,210 - 6,160	18,000	NO[9]	6,160		
Arsenic	6/6	NA	7.7 - 18.0	19	NO[9]	12		
Barium	6/6	NA	14.1 - 22.4	54	NO[9]	18.2		
Beryllium	1/6	0.50	0.62 - 0.85	0.81	YES	0.41	0.85	0.41
Calcium	6/6	NA	333 - 908	810	NO[10]	680		
Chromium	6/6	NA	12.1 - 28.1	33	NO[9]	18		
Cobalt	6/6	NA	2.5 - 5.4	4.7	YES	4.1	5.4	4.1
Copper	6/6	NA	5.6 - 29.9	13.5	YES	12	29.9	12
Iron	6/6	NA	6,780 - 10,300	18,000	NO[9,10]	8,820		
Lead	6/6	NA	11.4 - 238	48	YES	61.2	238	61.2
Magnesium	6/6	NA	1,360 - 2,670	5,500	NO[9,10]	2,405		
Manganese	6/6	NA	52.4 - 240	380	NO[9]	167		
Mercury	2/6	0.050	0.076 - 0.078	NA	YES	0.042	0.078	0.042
Nickel	6/6	NA	6.0 - 18.1	14.6	YES	13.3	18.1	13.3
Potassium	6/6	NA	367 - 993	2,400	NO[9,10]	630		
Selenium	1/6	0.25	0.36	NA	YES	0.16	0.51	0.16
Sodium	6/6	NA	241 - 506	131	NO[10]	347		
Vanadium	6/6	NA	10.6 - 19.1	32.3	NO[9]	14.1		
Zinc	6/6	NA	18.9 - 71.7	43.9	YES	32.5	71.7	32.5
PAL SEMIVOLATILE ORGANICS (ug/g)								
Acenaphthylene	1/6	0.033 - 3.0	2.0	NA	YES	0.71	2.0	0.71
Anthracene	1/6	0.033 - 3.0	1.0	NA	YES	0.54	1.0	0.54
Benzo[k]fluoranthene	1/6	0.066 - 7.0	2.0	NA	YES	1.09	2.0	1.09
Chrysene	2/6	0.12 - 10	0.17 - 5.0	NA	YES	2.04	5.0	2.04
Fluoranthene	4/6	0.068 - 1.0	0.19 - 9.0	NA	YES	3.3	9.0	3.3
Fluorene	1/6	0.033 - 3.0	1.0	NA	YES	0.54	1.0	0.54
Phenanthrene	5/6	0.20 - 0.70	0.065 - 9.0	NA	YES	3.09	9.0	3.09
Pyrene	5/6	0.20 - 0.70	0.075 - 10	NA	YES	3.8	10	3.8

TABLE 9-14

ECOLOGICAL CONTAMINANTS OF POTENTIAL CONCERN IN SURFACE SOIL[1]

AOC 69W

REMEDIAL INVESTIGATION
DEVENS, MASSACHUSETTS

Analyte	Frequency of Detection[2]	Range of SQLs[3]	Range of Detected Concentrations	Background Surface Soil Concentration[4]	Contaminant of Potential Ecological Concern?[5]	Average of All Concentrations[6]	Exposure Point Concentrations	
							RME[7]	Average[8]
PAL VOLATILE ORGANICS (ug/g)								
Acetone	1/6	0.017	0.069	NA	YES	0.019	0.069	0.019
Toluene	3/6	0.00078	0.00096 - 0.0021	NA	YES	0.00091	0.0021	0.00091
Trichlorofluoromethane	2/6	0.0059	0.0055 - 0.0072	NA	YES	0.0041	0.0077	0.0041
Xylenes	1/6	0.0015	0.0027	NA	YES	0.0011	0.0027	0.0011
OTHER (ug/g)								
TPH	5/6	28	53 - 940	NA	YES	390	940	390

NOTES:

[1] Sample locations include ZWS-95-35X, ZWS-95-39X, ZWS-95-42X, ZWS-95-45X, ZWS-95-46X, and ZWS-95-47X.

[2] Frequency of detection is equal to the number of samples in which the analyte is detected in relation to the total number of samples analyzed.

[3] Sample Quantitation Limits (SQLs) are equal to the detection limit adjusted for percent moisture (solid media only) and dilutions (if any are performed).

[4] 95th percentiles of inorganic background concentrations from the Ft. Devens background surface soil database (developed in 1993) were used to screen CPCs.

[5] Contaminant of Potential Concern (CPC) for wildlife receptors.

[6] The average of all concentrations assigns a value of 1/2 the detection limit to all non-detects.

[7] Reasonable Maximum Exposure (RME) concentrations are equal to the maximum detected concentration; the 95th percent UCL was not calculated because there are fewer than 10 samples in the data set.

[8] Average Exposure Point Concentrations (EPCs) are equal to the average of all concentrations. If the average is greater than the RME, then the RME was used instead.

[9] Maximum analyte concentration is less than the background concentration.

[10] Analyte is an essential nutrient, and not considered toxic except at high concentrations.

AOC = Area of Contamination
NA = Not available
ug/g = micrograms per gram
EPC = exposure point concentration
TPH = total petroleum hydrocarbons

TABLE 9-15

ECOLOGICAL CONTAMINANTS OF POTENTIAL CONCERN IN UPGRADIENT SEDIMENT[1]

AOC 69W

REMEDIAL INVESTIGATION
DEVENS, MASSACHUSETTS

Analyte	Frequency of Detection[2]	Range of SQLs[3]	Range of Detected Concentrations	Background Surface Soil Concentration[4]	Contaminant of Potential Ecological Concern?[5]	Average of All Concentrations[6]	Exposure Point Concentrations	
							RME[7]	Average[8]
PAL METALS (ug/g)								
Aluminum	3/3	NA	3,120 - 6,010	18,000	NO[9]			
Arsenic	3/3	NA	6.4 - 10.0	19	NO[9]			
Barium	3/3	NA	9.5 - 18.6	54	NO[9]			
Calcium	3/3	NA	674 - 992	810	NO[10]			
Chromium	3/3	NA	10.5 - 35.5	33	YES	17.4	35.5	17.4
Cobalt	3/3	NA	2.0 - 4.2	4.7	NO[9]			
Copper	3/3	NA	7.9 - 25.1	13.5	YES	16.1	25.1	16.1
Iron	3/3	NA	7,020 - 15,400	18,000	NO[9]			
Lead	3/3	NA	29.0 - 55.9	48	YES	39.2	55.9	39.2
Magnesium	3/3	NA	1,670 - 3,100	5,500	NO[9,10]			
Manganese	3/3	NA	93.6 - 230	380	NO[9]			
Nickel	3/3	NA	8.7 - 17.3	14.6	YES	11.8	17.3	11.8
Potassium	3/3	NA	371 - 783	2,400	NO[9,10]			
Sodium	3/3	NA	309 - 330	131	NO[10]			
Vanadium	3/3	NA	7.4 - 15.2	32.3	NO[9]			
Zinc	3/3	NA	39.7 - 71.4	43.9	YES	50.5	71.4	50.5
PESTICIDES/PCBs (ug/g)								
alpha-Chlordane	1/3	0.0050	0.013	NA	YES	0.0060	0.013	0.0060
Aroclor-1260	1/3	0.080	0.51	NA	YES	0.20	0.51	0.20
4,4'-DDD	3/3	NA	0.027 - 2.1	NA	YES	0.75	2.1	0.75
4,4'-DDE	3/3	NA	0.012 - 0.081	NA	YES	0.036	0.081	0.036
4,4'-DDT	3/3	NA	0.044 - 0.40	NA	YES	0.19	0.40	0.19
Dieldrin	1/3	0.0063	0.060	NA	YES	0.022	0.060	0.022
Endosulfan II	1/3	0.0066	0.050	NA	YES	0.019	0.050	0.019
gamma-Chlordane	1/3	0.0050	0.024	NA	YES	0.0097	0.024	0.0097

TABLE 9-15

ECOLOGICAL CONTAMINANTS OF POTENTIAL CONCERN IN UPGRADIENT SEDIMENT[1]

AOC 69W

REMEDIAL INVESTIGATION
DEVENS, MASSACHUSETTS

Analyte	Frequency of Detection[2]	Range of SQLs[3]	Range of Detected Concentrations	Background Surface Soil Concentration[4]	Contaminant of Potential Ecological Concern?[5]	Average of All Concentrations[6]	Exposure Point Concentrations	
							RME[7]	Average[8]
PAL SEMIVOLATILE ORGANICS (ug/g)								
Benzo[k]fluoranthene	1/3	0.30 - 2.0	0.80	NA	YES	0.65	0.80	0.65
Chrysene	1/3	1.0 - 3.0	0.90 - 1.0	NA	YES	0.98	1.0	0.98
Fluoranthene	2/3	2.0	1.0 - 2.0	NA	YES	1.5	2.0	1.5
Phenanthrene	2/3	0.80	0.60 - 0.80	NA	YES	0.57	0.80	0.57
Pyrene	3/3	NA	1.0 - 2.0	NA	YES	1.5	2.0	1.5
PAL VOLATILE ORGANICS (ug/g)								
Methylene chloride	1/3	0.012	0.014	NA	YES	0.0073	0.014	0.0073
Trichlorofluoromethane	2/3	0.0059	0.0080 - 0.011	NA	YES	0.0073	0.011	0.0073
TPH BY GC (ug/g)								
Diesel Fuel	3/3	NA	9.4 - 52	NA	YES	29	52	29
TPH, Gas Fraction	2/3	8.0	17 - 22	NA	YES	14	22	14
OTHER (ug/g)			-					
TOC	3/3	NA	3,400 - 12,000	NA	NA			
TPH	3/3	NA	360 - 1,200	NA	YES	740	1,200	740

NOTES:

[1] Sample locations include ZWD-95-01X, ZWD-95-04X, and ZWD-95-05X. A duplicate sample was collected at ZWD-95-01X.

[2] Frequency of detection is equal to the number of samples in which the analyte is detected in relation to the total number of samples analyzed.

[3] Sample Quantitation Limits (SQLs) are equal to the detection limit adjusted for percent moisture (solid media only) and dilutions (if any are performed).

[4] 95th percentiles of inorganic background concentrations from the Ft. Devens background surface soil database (developed in 1993) were used to screen CPCs.

[5] Contaminant of Potential Concern (CPC) for wildlife and aquatic receptors.

[6] The average of all concentrations assigns a value of 1/2 the detection limit to all non-detects.

[7] Reasonable Maximum Exposure (RME) concentrations are equal to the maximum detected concentration; the 95th percent UCL was not calculated because there are fewer than 10 samples in the data set.

[8] Average Exposure Point Concentrations (EPCs) are equal to the average of all concentrations. If the average is greater than the RME, then the RME was used instead.

[9] Maximum analyte concentration is less than the background concentration.

[10] Analyte is an essential nutrient, and not considered toxic except at high concentrations.

AOC = Area of Contamination
NA = not available
GC = gas chromatography
TOC = total organic carbon
TPH = total petroleum hydrocarbons
ug/g = micrograms per gram
EPC = exposure point concentration

TABLE 9-16

ECOLOGICAL CONTAMINANTS OF POTENTIAL CONCERN IN DOWNGRADIENT SEDIMENT[1]

AOC 69W

REMEDIAL INVESTIGATION
DEVENS, MASSACHUSETTS

Analyte	Frequency of Detection[2]	Range of SQLs[3]	Range of Detected Concentrations	Background Surface Soil Concentration[4]	Contaminant of Potential Ecological Concern?[5]	Average of All Concentrations[6]	Exposure Point Concentrations RME[7]	Exposure Point Concentrations Average[8]
PAL METALS (ug/g)								
Aluminum	3/3	NA	2,930 - 4,840	18,000	NO[9]			
Arsenic	3/3	NA	6.4 - 14.0	19	NO[9]			
Barium	3/3	NA	7.1 - 11.4	54	NO[9]			
Calcium	3/3	NA	536 - 736	810	NO[9,10]			
Chromium	3/3	NA	11.5 - 16.1	33	NO[9]			
Cobalt	3/3	NA	2.8 - 6.9	4.7	YES	4.5	6.9	4.5
Copper	3/3	NA	10.4 - 23.4	13.5	YES	14.9	23.4	14.9
Iron	3/3	NA	8,030 - 10,900	18,000	NO[9]			
Lead	3/3	NA	15.0 - 30.0	48	NO[9]			
Magnesium	3/3	NA	1,580 - 2,630	5,500	NO[9,10]			
Manganese	3/3	NA	93.9 - 186	380	NO[9]			
Nickel	3/3	NA	9.6 - 18.1	14.6	YES	13.1	18.1	13.1
Potassium	3/3	NA	364 - 426	2,400	NO[9,10]			
Sodium	3/3	NA	259 - 307	131	NO[10]			
Vanadium	3/3	NA	8.5 - 10.4	32.3	NO[9]			
Zinc	3/3	NA	27.9 - 39.6	43.9	NO[9]			
PESTICIDES/PCBs (ug/g)								
4,4'-DDD	3/3	NA	0.017 - 0.12	NA	YES	0.068	0.12	0.068
4,4'-DDE	1/3	0.0077	0.015	NA	YES	0.0076	0.015	0.0076
4,4'-DDT	3/3	NA	0.021 - 0.046	NA	YES	0.031	0.046	0.031
PAL SEMIVOLATILE ORGANICS (ug/g)								
Benzo[k]fluoranthene	1/3	0.30	0.40	NA	YES	0.23	0.40	0.23
Fluoranthene	2/3	0.30	1.0	NA	YES	0.72	1.0	0.72
Phenanthrene	2/3	0.20	0.50 - 0.90	NA	YES	0.50	0.90	0.50
Pyrene	2/3	0.20	1.0	NA	YES	0.70	1.0	0.70

TABLE 9-16

ECOLOGICAL CONTAMINANTS OF POTENTIAL CONCERN IN DOWNGRADIENT SEDIMENT[1]

AOC 69W

REMEDIAL INVESTIGATION
DEVENS, MASSACHUSETTS

Analyte	**Frequency of Detection**[2]	**Range of SQLs**[3]	**Range of Detected Concentrations**	**Background Surface Soil Concentration**[4]	**Contaminant of Potential Ecological Concern?**[5]	**Average of All Concentrations**[6]	**Exposure Point Concentrations**	
							RME[7]	**Average**[8]
PAL VOLATILE ORGANICS (ug/g)								
Trichlorofluoromethane	3/3	NA	0.0082 - 0.0096	NA	YES	0.0091	0.0096	0.0091
TPH BY GC (ug/g)								
Diesel Fuel	1/3	8.0	13	NA	YES	6.9	13	6.9
TPH, Gas Fraction	1/3	8.0	19	NA	YES	9.1	19	9.1
OTHER (ug/g)								
TOC	3/3	NA	2,400 - 5,400	NA	NA			
TPH	3/3	NA	130 - 290	NA	YES	200	290	200

NOTES:

[1] Sample locations include ZWD-95-02X, ZWD-95-03X, and ZWD-95-06X.

[2] Frequency of detection is equal to the number of samples in which the analyte is detected in relation to the total number of samples analyzed.

[3] Sample Quantitation Limits (SQLs) are equal to the detection limit adjusted for percent moisture (solid media only) and dilutions (if any are performed).

[4] 95th percentiles of inorganic background concentrations from the Ft. Devens background surface soil database (developed in 1993) were used to screen CPCs.

[5] Contaminant of Potential Concern (CPC) for wildlife and aquatic receptors.

[6] The average of all concentrations assigns a value of 1/2 the detection limit to all non-detects.

[7] Reasonable Maximum Exposure (RME) concentrations are equal to the maximum detected concentration; the 95th percent UCL was not calculated because there are fewer than 10 samples in the data set.

[8] Average Exposure Point Concentrations (EPCs) are equal to the average of all concentrations. If the average is greater than the RME, then the RME was used instead.

[9] Maximum analyte concentration is less than the background concentration.

[10] Analyte is an essential nutrient, and not considered toxic except at high concentrations.

AOC = Area of Contamination
NA = not available
GC = gas chromotography
TOC = total organic carbon
TPH = total petroleum hydrocarbons
ug/g = micrograms per gram
EPC = exposure point concentration

TABLE 9-17

ECOLOGICAL CONTAMINANTS OF POTENTIAL CONCERN IN GROUNDWATER[1]

AOC 69W

REMEDIAL INVESTIGATION
DEVENS, MASSACHUSETTS

Analyte	Frequency of Detection[2]	Range of SQLs[3]	Range of Detected Concentrations	Background Groundwater Concentration[4]	Average Upgradient Concentration[5]	Contaminant of Potential Ecological Concern?[6]	Average of All Concentrations[7]	Exposure Point Concentrations RME[8]	Exposure Point Concentrations Average[9]
PAL UNFILTERED METALS (ug/L)									
Aluminum	2/8	141	207 - 390	6,870	NA	NO[10]			
Arsenic	6/8	2.5	5.2 - 190	10.5	NA	YES	50.1	190	50.1
Barium	8/8	NA	4.6 - 16.8	39.6	NA	NO[10]			
Calcium	8/8	NA	16,000 - 25,000	14,700	22,700	NO[11]			
Iron	7/8	38.8	441 - 26,400	9,100	NA	YES	6,500	26,400	6,500
Lead	2/8	1.3	1.45 - 2	4	NA	NO[10]			
Magnesium	8/8	NA	1,700 - 2,800	3,480	2,720	NO[10,11]			
Manganese	8/8	NA	16 - 2,700	291	NA	YES	820	2,700	820
Potassium	8/8	NA	1,700 - 5,000	2,370	1,480	NO[11]			
Sodium	8/8	NA	23,500 - 38,000	10,800	34,800	NO[11]			
PAL FILTERED METALS (ug/L)									
Arsenic	6/8	2.5	4.6 - 180	10.5	NA	YES	46.6	150	46.6
Barium	7/8	5.0	7 - 15.3	39.6	NA	NO[10]			
Calcium	8/8	NA	15,300 - 24,300	14,700	22,300	NO[11]			
Iron	7/8	38.8	447 - 22,600	9,100	NA	YES	5,670	22,600	5,670
Lead	2/8	1.3	1.64 - 1.67	4	NA	NO[10]			
Magnesium	8/8	NA	1,700 - 2,680	3,480	2,680	NO[9,10,11]			
Manganese	8/8	NA	3.5 - 2,140	291	NA	YES	730	2,140	730
Potassium	8/8	NA	90 - 4,760	2,370	1,610	NO[11]			
Sodium	8/8	NA	21,700 - 38,100	10,800	32,400	NO[11]			
PESTICIDES/PCBs (ug/L)									
gamma-Chlordane	1/8	0.075	0.12	NA	NA	YES	0.047	0.12	0.047
Heptachlor epoxide	1/8	0.025	0.059	NA	NA	YES	0.018	0.059	0.018
PAL SEMIVOLATILE ORGANICS (ug/L)									
2-Methylnaphthalene	2/8	1.7	8.2 - 550	NA	NA	YES	70	550	70
Acenaphthene	1/8	1.7 - 60	2.2	NA	NA	YES	4.7	2.2	2.2
Bis(2-ethylhexyl)phthalate	2/8	4.8	3.5 - 500	NA	6.5	YES	65	500	65
Dibenzofuran	1/8	1.7 - 60	2.4	NA	NA	YES	4.7	2.4	2.4
Diethylphthalate	3/8	2.0 - 110	2.03 - 3	NA	NA	YES	8.3	3	3
Naphthalene	2/8	0.50	16 - 200	NA	NA	YES	27	200	27
Phenanthrene	2/8	0.50	2.2 - 150	NA	NA	YES	19	150	19

TABLE 9-17

ECOLOGICAL CONTAMINANTS OF POTENTIAL CONCERN IN GROUNDWATER[1]

AOC 69W

REMEDIAL INVESTIGATION
DEVENS, MASSACHUSETTS

Analyte	Frequency of Detection[2]	Range of SQLs[3]	Range of Detected Concentrations	Background Groundwater Concentration[4]	Average Upgradient Concentration[5]	Contaminant of Potential Ecological Concern?[6]	Average of All Concentrations[7]	Exposure Point Concentrations RME[8]	Exposure Point Concentrations Average[9]
PAL VOLATILE ORGANICS (ug/L)									
1,1,1-Trichloroethane	1/8	0.5 - 1.25	0.88	NA	NA	YES	0.38	0.88	0.38
Acetone	1/8	13 - 37	13	NA	NA	YES	8.8	13	8.8
Ethylbenzene	3/8	0.50	1.9 - 17	NA	NA	YES	2.7	17	2.7
Toluene	6/8	0.50	0.45 - 9	NA	NA	YES	0.85	9	0.85
Trichloroethylene	2/8	0.5 - 1.25	0.73 - 1.8	NA	NA	YES	0.55	1.8	0.55
Xylene	1/8	0.84 - 4	1.7	NA	NA	YES	0.58	1.7	0.58
WET CHEMISTRY (ug/L)									
Alkalinity	8/8	NA	20,000 - 89,000	NA	18,000	YES	45,000	89,000	45,000
Chloride	8/8	NA	27,000 - 55,000	NA	66,000	NO[10]			
Nitrite	8/8	NA	760 - 3,000	NA	3,000	NA			
Nitrogen	10/13	180	200 - 1,200	NA	160	NA			
Phosphate	10/13	13	19 - 1060	NA	NA	NA			
Sulfate	7/8	10,000	7,500 - 24,000	NA	17,000	NA			
Total Dissolved Solids	13/13	NA	140,000 - 220,000	NA	190,000	NA			
Total Hardness	13/13	NA	44,000 - 137,000,000	NA	36,000,000	NA			
Total Suspended Solids	9/13	4,000	5,000 - 37,000	NA	6,000	YES	11,000	37,000	11,000
OTHER (ug/L)									
Total Organic Carbon	1/5	1,000	6,100	NA	NA	NA			
Total Petroleum Hydrocarbons	11/16	170 - 170,000	185 - 194,000	NA	NA	YES	35,000	194,000	35,000

[1] Sample locations include 69W-94-10 through 69W-94-14, ZWM-95-15X, ZWM-95-16X, and ZWM-95-18X through ZWM-95-20X. Duplicate samples were collected at 69W-94-11 and ZWM-96-19X. Data from two different rounds of sampling were available for 69W-94-10, 69W-94-11, and ZWM-95-16X. Filtered data are not available for ZWM-95-19X and ZWM-95-20X.

[2] Frequency of detection is equal to the number of samples in which the analyte is detected in relation to the total number of samples analyzed.

[3] Sample Quantitation Limits (SQLs) are equal to the detection limit adjusted for percent moisture (solid media only) and dilutions (if any are performed).

[4] 95th percentiles of inorganic background concentrations from the Ft. Devens background groundwater database (developed in 1993) were used to screen CPCs.

[5] Average upgradient groundwater concentration from monitoring wells ZWM-95-17X and ZWM-96-21X.

[6] Contaminant of Potential Concern (CPC) for aquatic receptors.

[7] The average of all concentrations assigns a value of 1/2 the detection limit to all non-detects.

[8] Reasonable Maximum Exposure (RME) concentration is equal to the maximum detected concentration; the 95th percent UCL is not presented.

[9] Average EPCs are equal to the arithmetic mean of all concentrations. When the arithmetic mean is greater than the RME, the RME is used instead.

[10] Maximum analyte concentration is less than the background concentration.

[11] Analyte is an essential nutrient, and not considered toxic except at high concentrations.

[12] Maximum analyte concentration is less than the upgradient concentration.

NOTES:
AOC = Area of Contamination
NA = not available/not applicable
ug/L = micrograms per Liter
EPC = exposure point concentration
UCL = upper confidence limit

Table 9-18

Ecological Receptors Evaluated at AOC 69W

Remedial Investigation Report
Devens, Massachusetts

	Receptor Evaluated		Media	
Method of Evaluation	Common Name	Scientific Name	Surface Soil	Sediment
Food Web Modeling	White-footed mouse	*Peromyscus leucopus*	X	
	Short-tailed shrew	*Blarina brevicauda*	X	X
	American robin	*Turdus migratorius*	X	
	Red-winged blackbird	*Agelaius phoeniceus*	X	X
	Raccoon	*Procyon lotor*	X	X
Benchmark Comparison	Terrestrial plants		X	
	Soil invertebrates		X	
	Aquatic plants			X
	Benthic invertebrates			X
	Amphibians			X
Toxicity Testing	Midge	*Chironomus tentans*		X
	Amphipod	*Hyalella azteca*		X

Table 9-19
Model for Estimation of Contaminant Exposures for Representative Wildlife Species
AOC 69W

Remedial Investigation Report
Devens, Massachusetts

Estimation of Contaminant Exposures Related to Surface Soil

Description: Estimates the amount (dose) of a contaminant ingested and accumulated by a species via incidental ingestion of contaminated surface soil and ingestion of contaminated food items.

Soil Contaminant Concentration:

Maximum: The maximum detected concentration of the ecological chemicals of potential concern (CPC) when the sample size is ≤ 9, and the lesser of the maximum detected concentration or the 95th percent upper confidence limit (UCL) when the sample size is ≥ 10.

Average: Average of all concentrations. If the average is greater than the maximum exposure point concentration (EPC), the maximum EPC was selected.

Soil Exposure:

$$\underset{(mg/kg)}{\text{Soil Exposure}} = \left(\begin{matrix}\text{\% of Diet}\\ \text{as Soil}\end{matrix} \times \underset{(mg/kg)}{\text{Soil Concentration}} \right)$$

Concentration of a Contaminant in Primary Prey Items (T_N):

$$\underset{(mg/kg)}{\text{Primary Prey Item Concentration}} = \left(BAF_{inv\ or\ plant} \times \underset{(mg/kg)}{\text{Soil Concentration}} \right)$$

Concentration of a Contaminant in Secondary Prey Items (T_N):

$$\underset{(mg/kg)}{\text{Secondary Prey Item Concentration}} = \left(BAF_{mam\ or\ bird} \times \underset{(mg/kg)}{\text{Tissue Concentration of Prey Items}^{*}} \right)$$

where BAF = Bioaccumulation Factor or mg/kg fresh weight tissue over mg/kg dry weight soil for invertebrates and plants, and mg/kg fresh weight tissue over mg/kg fresh weight food for small mammals and small birds.

* For a discussion of the weighted contaminated concentration in prey items, see explanation of the PDE term below

Total Exposure Related to Surface Soil:

$$\underset{(mg/kgBW\text{-}day)}{PDE} = \frac{\left[P_1 \times T_1 + \ldots + P_N \times T_N + \begin{matrix}\text{soil}\\ \text{exposure}\end{matrix}\right] \times IR_{Diet} \times SFF \times ED}{BW}$$

where PDE = Potential Dietary Exposure (mg/kgBW-day),

P_N = percent of diet composed of food item N,

T_N = contaminant concentration in food item N (mg/kg),

IR_{Diet} = food ingestion rate of receptor (kg of food or dietary item per day),

BW = body weight (kg) of receptor,

SFF = Site Foraging Frequency (site area [acres] divided by home range [acres]), which cannot exceed 1, and

ED = Exposure Duration (fraction of year species is expected to occur onsite).

See notes at end of table

Table 9-19
Model for Estimation of Contaminant Exposures for Representative Wildlife Species
AOC 69W

Remedial Investigation Report
Devens, Massachusetts

Estimation of Contaminant Exposures Related to Sediment

Description: Estimates the amount of a contaminant ingested and accumulated by a species resulting from incidental ingestion of sediment.

Contaminant Concentration: Same as described above for soil.

Sediment Exposure:

$$\begin{matrix}\text{Sediment}\\ \text{Exposure}\\ (mg/day)\end{matrix} = \left(\begin{matrix}\text{\% of Diet}\\ \text{as Sediment}\end{matrix} \times \begin{matrix}\text{Sediment}\\ \text{Concentration}\\ (mg/kg)\end{matrix} \times \begin{matrix}IR_{DIET}\\ (kg/day)\end{matrix} \right)$$

where IR_{DIET} = dietary ingestion rate of receptors (kg of diet per day)

Total Exposure Related to Sediment:

$$\begin{matrix}PDE\\ (mg/kgBW\text{-}day)\end{matrix} = \frac{\left(\begin{matrix}\text{Sediment}\\ \text{Exposure}\\ (mg/day)\end{matrix} + P_A \times T_A \times IR_{DIET} \right) \times SFF \times ED}{BW}$$

where P_A = percent of diet comprised of aquatic prey items
T_A = tissue concentration in aquatic prey items (mg/kg)

Note: Food chain exposures from incidental ingestion of sediment are expected to be minimal. Food chain exposures from ingestion of aquatic prey items are evaluated in the same way as primary prey items. Food chain exposures for consumers eating secondary prey items (i.e., small mammals and birds) are estimated by adding the body-weight normalized doses of the prey items.

Notes:

AOC = Area of contamination
mg/kg = milligrams per kilogram
kg/day = kilograms per day
kg = kilograms
% = percent
mg/kg BW-day = milligrams per kilogram of body weight per day

Table 9-20
Estimation of Bioaccumulation Factors
AOC 69W

Remedial Investigation Report
Devens, Massachusetts

Receptor Group	Nature of Approach	General Approach
Terrestrial Receptors		
Plants		
Unit: mg/kg wet tissue per mg/kg dry soil	Literature Values	When available, literature values were used to estimate plant BAFs. Evidence from the literature (Levine et al., 1989) suggests that lead does not bioaccumulate in plant tissue; therefore, a BAF of zero was assigned (i.e., a zero does not imply that literature information is lacking).
	SAR	When literature values were not available, plant BAFs for semivolatile organic compounds (SVOCs) were calculated using a regression equation based on the uptake of organic chemicals into plant tissue from Travis and Arms (1988).[1]
	Extrapolation and Empirical Data	When literature values were not available, plant BAFs for inorganic compounds were obtained from Baes et al. (1984).[2]
	Assumption	Although evidence suggests that plants may transport organic analytes with log K_{ow}s < 5 (i.e., volatile organic compounds [VOCs]) from the roots into leafy portions (Briggs et al., 1982; Briggs et al., 1983), bioaccumulation data for VOCs is generally lacking in the scientific literature. In addition, evidence in the literature (Suter, 1993; Maughan, 1993) suggests that analytes with log K_{ow}s < 3.5 are not bioaccumulated into animal tissue. Therefore, it was assumed that transfer of VOCs from plant tissue to animal tissue does not occur.
Terrestrial Invertebrates		
Unit: mg/kg wet tissue per mg/kg dry soil	Literature Values	Literature values were used to estimate BAFs for invertebrates.
	Assumption	Earthworm data were used to represent all invertebrates.
	Empirical Data and Assumption	A single BAF for PAHs was calculated using data presented in Beyer (1990); dry weight was converted to wet weight assuming earthworms are 80 percent water.
	Surrogate Values	When no literature values for invertebrates were available, mammal values were used as surrogates.
	Assumption	Bioaccumulation data for VOCs is generally lacking in the scientific literature. In addition, evidence in the literature (Suter, 1993; Maughan, 1993) suggests that analytes with log K_{ow}s < 3.5 are not bioaccumulated into animal tissue. Therefore, it was assumed that soil invertebrates do not bioaccumulate VOCs.

See notes at end of table

Table 9-20
Estimation of Bioaccumulation Factors
AOC 69W

Remedial Investigation Report
Devens, Massachusetts

Receptor Group	Nature of Approach	General Approach
Small Mammals Unit: mg/kg wet tissue per mg/kg wet food	Literature Values	When available, literature values were used to estimate BAFs for small mammals.
	SAR	When literature values were not available for SVOCs, BAFs for small mammals were estimated using a regression equation based on the uptake of organic chemicals into beef tissue from Travis and Arms (1988) [3].
	Extrapolation/ Empirical Data	When literature values were not available, BAFs for small mammals for inorganics were derived from ingestion-to-beef biotransfer factors (BTFs) presented in Baes et al. (1984) [4].
	Assumption	Bioaccumulation data for VOCs are generally lacking in the scientific literature. In addition, evidence in the literature (Suter, 1993; Maughan, 1993) suggests that analytes with log K_{ow}s < 3.5 are not bioaccumulated into animal tissue. Therefore, it was assumed that small mammals do not bioaccumulate VOCs because of their generally low K_{ow}s.
Small Birds Unit: mg/kg wet tissue per mg/kg wet food	Literature Values	When available, literature values were used to estimate BAFs for small birds.
	Surrogate Values	BAFs were not available for many SVOCs or inorganic compounds as there is little bioaccumulation data available for birds. In these situations, mammal data were used as surrogates. It was assumed that small birds do not accumulate VOCs because of their generally low K_{ow}s.
Semi-aquatic Receptors **Sediment** Unit: mg/kg wet tissue per mg/kg wet sediment	Literature Values	Literature values were used to estimate BAFs for aquatic plants and macroinvertebrates. When literature values were not available, terrestrial plant and invertebrate BAFs were used instead.
	Assumption and Surrogate Values	Bioaccumulation data for VOCs are generally lacking in the scientific literature. Therefore, it was assumed that semi-aquatic wildlife do not bioaccumulate VOCs. Little to no literature values exist for sediment to biota accumulation; when these data were not available, small mammal values were used as surrogates.

See notes at end of table

Table 9-20
Estimation of Bioaccumulation Factors
AOC 69W

Remedial Investigation Report
Devens, Massachusetts

Receptor Group	Nature of Approach	General Approach

[1] Plant BAFs calculated using the following Travis and Arms (1988) regression:
log BAF = 1.588 to 0.578 log K_{ow}

[2] BAFs derived from Baes et al. (1984). Values are based on analysis of literature references, correlations with other chemical and physical parameters, or comparisons of observed and predicted elemental concentrations in vegetative and reproductive plant material and soil. Data are based on dry weight and were converted to a fresh weight basis assuming that plants are 80 percent water. This is generally consistent with the water content of berries (82 to 87 percent water) and leafy vegetables (87 to 95 percent water) presented in Suter (1993). Grains contain a much lower percentage of water (approximately 10 percent), therefore, this assumption likely underestimates exposure to graminivores.

[3] Small mammal BAFs calculated using the following Travis and Arms (1988) regression:
log BTF = log K_{ow} - 7.6
where BTF = biotransfer factor (mg/kg tissue divided by mg chemical ingested per day).

[4] BTFs were converted to a BAF (mg/kg tissue divided by mg/kg food) by multiplying by a food ingestion rate of 12 kg (dry weight) per day (average intake for lactating and non-lactating cattle reported in Travis and Arms, 1988).

Notes:
mg/kg = milligrams per kilogram
AOC = Area of contamination
BAFs = bioaccumulation factors
PAH = polycyclic aromatic hydrocarbons
SAR = Structural Activity Relationship
K_{ow} = octanol/water partition coefficient

Table 9-21
Results of Sediment Toxicity Testing [1]
AOC 69W

Remedial Investigation Report
Devens, Massachusetts

Sample Location	Midge (*Chironomus tentans*) 10-day Subchronic Toxicity Test		Amphipod (*Hyalella azteca*) 10-day Acute Toxicity Test	
	Mean % Survival (Standard Deviation)	Mean Growth (mg dry weight) (Standard Deviation)	Mean % Survival (Standard Deviation)	Mean Growth (mg dry weight) (Standard Deviation)
Control	74 (19)	1.70 (0.32)	64 (18) [2]	0.10 (0.05)
ZWD-95-02X	75 (15)	2.24 (0.85)	55 (24) [3]	0.15 (0.07)
ZWD-95-03X	88 (14)	2.94 (0.67)	66 (18)	0.10 (0.05)
ZWD-95-06X	60 (19)	2.41 (0.93)	36 (23) [3,4]	0.11 (0.07)
57D-95-08X (reference)	84 (12)	1.81 (0.30)	80 (21)	0.10 (0.03)

[1] Toxicity testing methods and results (including controls and references) are described in Appendix P.

[2] The control survival did not meet the acceptance criteria of 80%.

[3] Amphipod survival in this sample was significantly less than the reference sample (57D-95-08X).

[4] Amphipod survival in this sample was significantly less than the control.

Notes:
AOC = Area of contamination
% = percent
mg = milligrams

Table 9-22
Results of Food-Web Modelling for Surface Soil and Sediment [a]
AOC 69W

Remedial Investigation Report
Devens, Massachusetts

Media Evaluated Ecological Receptor	Risk from Exposure to RME Concentrations	Risk from Exposure to Average Exposure Concentrations	Primary Risk Contributors
Surface Soil			
White-footed mouse	0.47	0.15	NA
Short-tailed shrew	2.8	0.88	Lead
American robin	0.29	0.14	NA
Red-winged blackbird	0.20	0.099	NA
Raccoon	0.0017	0.00051	NA
Sediment			
Short-tailed shrew	0.040	NE	NA
Red-winged blackbird	0.024	NE	NA
Raccoon	0.0000069	NE	NA

[a] The values presented in this table are summary HIs that were calculated in Tables P-8 through P-10 in Appendix P.
NA = Not applicable.
NE = Not evaluated.

Table 9-23
Summary of Ecological Risk for Plants and Invertebrates in Surface Soil
AOC 69W

Remedial Investigation Report
Devens, Massachusetts

Analyte	Exposure Point Concentrations [1]		RTV (µg/g)		RTV Exceeded? [3] (by Max./by Ave.)	
	RME	Average	Plant [2]	Invertebrate [2]	Plant	Invertebrate
PAL Metals (µg/g)						
Beryllium	0.85	0.41	10	NA	No/No	NA
Cobalt	5.4	4.1	20	NA	No/No	NA
Copper	29.9	12.0	100	30	No/No	No/No
Lead	238	61.2	50	1,190	Yes/Yes	No/No
Mercury	0.078	0.042	0.3	36	No/No	No/No
Nickel	18.1	13.3	30	400	No/No	No/No
Selenium	0.51	0.16	1	NA	No/No	NA
Zinc	71.7	32.5	50	130	Yes/No	No/No
PAL Semivolatile Organics (µg/g)						
Acenaphthylene	2.0	0.71	25	34	No/No	No/No
Anthracene	1.0	0.54	25	34	No/No	No/No
Benzo(k)fluoranthene	2.0	1.09	25	34	No/No	No/No
Chrysene	5.0	2.04	25	34	No/No	No/No
Fluoranthene	9.0	3.3	25	34	No/No	No/No
Flourene	1.0	0.54	25	34	No/No	No/No
Phenanthrene	9.0	3.09	25	34	No/No	No/No
Pyrene	10	3.8	25	34	No/No	No/No
PAL Volatile Organics (µg/g)						
Acetone	0.069	0.019	NA	NA	NA	NA
Toluene	0.0021	0.00091	200	21	No/No	No/No
Trichlorofluoromethane	0.0077	0.0041	NA	NA	NA	NA
Xylenes	0.0027	0.0011	>1,000	21	No/No	No/No
Other (µg/g)						
Total Petroleum Hydrocarbons	940	390	NA	NA	NA	NA

See notes at end of table

Table 9-23
Summary of Ecological Risk for Plants and Invertebrates in Surface Soil
AOC 69W

Remedial Investigation Report
Devens, Massachusetts

Analyte	Exposure Point Concentrations [1]		RTV (mg/g)		RTV Exceeded? [3] (by Max./by Ave.)	
	RME	Average	Plant [2]	Invertebrate [2]	Plant	Invertebrate

[1] Exposure Point Concentrations (EPCs) are presented in Table 9-13.

[2] Plant and invertebrate RTVs are presented in Appendix P, Tables P-5 and P-6 (respectively). Generally, the plant RTVs are the lowest LOEC from among plant growth studies on plants in solid media, and invertebrate RTVs are the lowest LC_{50} (14-day soil test on *Eisenia foetida*) from among chemicals in the same chemical class (applies to organic compounds). A conservative factor of 0.2 was applied to invertebrate RTVs; the resultant value should be protective of 99.9% of the population from lethal effects (USEPA, 1986).

[3] Comparison shown is maximum EPC to RTV/average EPC to RTV.

AOC = Area of contamination
RTV = Reference toxicity value
μg/g = micrograms per gram
LC_{50} = concentration lethal to 50% of the test population
LOEC = lowest observed effect concentration
NA = Not available
RME = Reasonable maximum exposure
Shading indicates exceedances

Table 9-24
Comparison of Downgradient Sediment Exposure Concentrations with Toxicity Benchmark Values [1]
AOC 69W

Remedial Investigation Report
Devens, Massachusetts

Analyte	Exposure Point Concentrations		USEPA Sediment Quality Guidelines [2]	NOAA [3]		OME LEL [4]	NYSDEC LEL [5]	Result
	Maximum	Average		ER-L	ER-M			
PAL Metals (µg/g)								
Cobalt	6.9	4.5	NA	NA	NA	NA	NA	No benchmark available
Copper	23.4	14.9	NA	34	270	16	16	Exceeded
Nickel	18.1	13.1	NA	20.9	51.6	16	16	Exceeded
Pesticides/PCBs (µg/g)								
4,4'-DDD	0.12	0.068	[6]0.00828	[6]0.00158	[6]0.0461	0.008	[6]0.01	Exceeded
4,4'-DDE	0.015	0.0076	[6]0.00828	0.0022	0.027	0.005	[6]0.01	Exceeded
4,4'-DDT	0.046	0.031	0.00828	0.00158	0.0461	0.007	0.01	Exceeded
PAL Semivolatile Organics (µg/g)								
Benzo(k)fluoranthene	0.40	0.23	NA	NA	NA	0.240	NA	Exceeded
Fluoranthene	1.0	0.72	6.2	0.6	5.1	0.750	10.2	Exceeded
Phenanthrene	0.90	0.50	1.8	0.24	1.5	0.560	1.19	Exceeded
Pyrene	1.0	0.70	NA	0.665	2.6	0.490	NA	Exceeded
PAL Volatile Organics (µg/g)								
Trichlorofluoromethane	0.0096	0.0091	NA	NA	NA	NA	NA	No benchmark available
TPH by GC (µg/g)								
Diesel Fuel	13	6.9	NA	NA	NA	NA	NA	No benchmark available
TPH Gas Fraction	19	9.1	NA	NA	NA	NA	NA	No benchmark available
Other (µg/g)								
TPH	290	200	NA	NA	NA	NA	NA	No benchmark available

Table 9-24
Comparison of Downgradient Sediment Exposure Concentrations with Toxicity Benchmark Values [1]
AOC 69W

Remedial Investigation Report
Devens, Massachusetts

Analyte	Exposure Point Concentrations		USEPA Sediment Quality Guidelines [2]	NOAA [3]		OME LEL [4]	NYSDEC LEL [5]	Result
	Maximum	Average		ER-L	ER-M			

[1] Only those analytes selected as CPCs in Table 9-15 are presented.

[2] U.S. Environmental Protection Agency (USEPA, 1988) mean Sediment Quality Criteria (SQCs) adjusted values using total organic carbon (TOC) of 1%. All values represent Final Chronic Values (FCVs); when no FCVs were available, Final Residue Values (FRVs) were used instead.

[3] National Oceanic and Atmospheric Administration (NOAA) Effects Range-Low (ER-L) and Effects Range-Median (ER-M) Sediment Guidelines correspond to the concentration that is protective of the 90th percentile and the 50th percentile of the test populations, respectively (Long et al., 1994).

[4] Ontario Ministry of the Environment (OME) Low Effects Level (LEL) Provincial Sediment Quality Guidelines (Persaud et al., 1996) correspond to a concentration that can be tolerated by the majority of benthic organisms.

[5] New York State Department of Environmental Conservation (NYSDEC) sediment criteria for evaluating chronic toxicity to benthic aquatic life (NYSDEC, 1994). These values are adjusted by the TOC content of 1%. The lowest effect levels (LELs) for metals are also presented.

[6] Value for 4,4'-DDT used as a surrogate.

Notes:
Shading indicates that the concentration exceeds a toxicity benchmark value.
AOC = Area of contamination
μg/g = micrograms per gram
NA = Not available

Table 9-25
Comparison of Groundwater Exposure Concentrations with Toxicity Benchmark Values [1]
AOC 69W

Remedial Investigation Report
Devens, Massachusetts

Analyte	Exposure Point Concentrations		AWQC [2] (μg/l)	AQUIRE Lowest Reported Adverse Effect Concentration [3] (μg/l) Test Species	Result
	Maximum	Average			
PAL Unfiltered Metals (μg/l)					
Arsenic	190	50.1	190	1,700/water flea LC$_{50}$	Not exceeded
Iron	26,400	6,500	1,000	3,700/duckweed growth	Exceeded
Manganese	2,700	820	NA	280/phytoplankton population endpoints	Exceeded
PAL Filtered Metals (μg/l)					
Arsenic	150	46.6	190	1,700/water flea LC$_{50}$	Not exceeded
Iron	22,600	5,670	1,000	3,700/duckweed growth	Exceeded
Manganese	2,140	730	NA	280/photoplankton population endpoints	Exceeded
Pesticides/PCBs (μg/l)					
gamma-Chlordane	0.12	0.047	[4] 0.0043	7.1/bluegill LC$_{50}$	Exceeded
Heptachlor epoxide	0.059	0.018	0.0038	NA	Exceeded
PAL Semivolatile Organics (μg/l)					
2-Methylnaphthalene	550	70	NA	2,000,000/green algae growth	Not exceeded
Acenaphthalene	2.2	2.2	520	NA	Not exceeded
Bis(2-ethylhexyl)phthalate	500	65	[5]160	0.89/moorfrog hatchability	Exceeded
Dibenzofuran	2.4	2.4	NA	280	Not exceeded
Diethylphthalate	3	3	NA	NA	No benchmark available
Naphthalene	200	27	620	NA	Not exceeded
Phenanthrene	150	19	[5]6.3	NA	Exceeded
PAL Volatile Organics (μg/l)					
1,1,1-Trichlorothane	0.88	0.38	NA	1,300/Water flea reproduction	Not exceeded
Acetone	13	8.8	NA	550,000/water flea mortality	Not exceeded
Ethylbenzene	17	2.7	NA	4,600/green algae growth	Not exceeded
Toluene	9	0.85	NA	1,000/water flea reproduction	Not exceeded
Trichloroethylene	1.8	0.55	21,900	1,900/medaka mortality	Not exceeded
Xylene	1.7	0.58	NA	NA	No benchmark available

Table 9-25
Comparison of Groundwater Exposure Concentrations with Toxicity Benchmark Values [1]
AOC 69W

Remedial Investigation Report
Devens, Massachusetts

Analyte	Exposure Point Concentrations		AWQC [2] (µg/l)	AQUIRE Lowest Reported Adverse Effect Concentration [3] (µg/l) Test Species	Result
	Maximum	Average			
Wet Chemistry (µg/l)					
Alkalinity	89,000	45,000	20,000	NA	Exceeded
Chloride	55,000	42,000	230,000	NA	Not exceeded
Total Suspended Solids	37,000	11,000	NA	NA	No benchmark available
Other (µg/l)					
Total Petroleum Hydrocarbons	194,000	35,000	NA	NA	No benchmark available

[1] Only those analytes selected as aquatic CPCs in Table 9-16 are presented.
[2] Chronic Federal Ambient Water Quality Criteria (USEPA, 1991b and 1988).
[3] From Appendix P, Table P-7. Only growth, mortality, reproductive, and biomass effects to plants, invertebrates, and amphibians were considered. However, for gamma-Chlordane, data was only available for bluegill.
[4] Value for chlordane used as a surrogate.
[5] Proposed criterion.

Notes:

AOC = Area of contamination
CPC = contaminant of potential concern
µg/l = micrograms per liter
AWQC = Ambient Water Quality Criteria (guidance criteria established under the Clean Water Act)
NA = Not available

Shading indicates an exceedance of a toxicity benchmark value.

Table 9-26
Potential Sources of Uncertainty in Ecological Risk Assessment
AOC 69W

Remedial Investigation Report
Devens, Massachusetts

Potential source	Direction of Effect on Risk	Justification
Uncertainties Associated with CPC Selection Process		
Degradation of chemicals not considered	Overestimate	Risk estimates are based on recent chemical concentrations. Concentrations will tend to decrease over time from degradation and the formation of daughter products.
No evaluation of Tentatively Identified Compound (TIC) data	Underestimate	Risk was not calculated for potential exposure to TICs.
Use of estimated data	Unknown	Using estimated data in the risk assessment may over- or underestimate the actual concentration of an analyte in site media.
Uncertainties Associated with Exposure Assessment		
Surface soil sampling depths	Underestimate	Most terrestrial receptors wil be exposed only within the first six inches of soil where contaminant concentrations are typically greatest. Sampling the upper two feet of soil provides a diluted soil exposure concentration.
Food chain assumed to occur at site	Unknown	Occurrence of the food chain used in the models at the sites is unknown.
Food chain model exposure parameter assumptions	Unknown	Some exposure parameters are from the literature and some are estimated. Efforts were made to select exposure parameters representative of a variety of species or feeding guilds, so that exposure estimates would be representative of more than a single species.
Assumption that receptor species will spend equal time at all habitats within home range	Unknown	Organisms will spend varying amounts of time in different habitats, thus affecting their overall exposures.
Extrapolation of literature values from test species to representative wildlife species	Unknown	Species differ with respect to absorption, metabolism, distribution, and excretion of chemicals. The magnitude and direction of the difference will vary with each chemical.
Organism-specific state variables	Underestimate	Surrogate laboratory animals are well-maintained and kept under controlled conditions. Field species must tolerate general environmental stressors that can exacerbate contaminant-induced stress.

Table 9-26
Potential Sources of Uncertainty in Ecological Risk Assessment
AOC 69W

Remedial Investigation Report
Devens, Massachusetts

Potential source	Direction of Effect on Risk	Justification
Consumption of contaminated prey	Unknown	Toxicity to receptors may result in sickness or mortality, thus making fewer prey items available to predators. Predators may stop foraging in areas with reduced prey populations, or discriminate against, or, conversely, select contaminated prey. Furthermore, anthropogenic sources of contamination may not even have as great an impact on the predator-prey relationship as do broader environmental stressors (e.g., climatic effects).
No evaluation of dermal or inhalation exposure pathways	Underestimate	The dermal and inhalation exposure pathways are generally considered insignificant due to protective fur, feathers, chitinous exoskeletons, and the low concentration of contaminants under natural atmospheric conditions. However, under certain conditions, these exposure pathways may occur.
Maximum exposure scenarios	Overestimate	It is unlikely any receptor would be exposed concurrently to maximum concentrations of all CPCs.
Use of surrogate values for invertebrate BAFs	Underestimate	Bioaccumulation data for earthworms are lacking for several metals (e.g., aluminum, antimony, barium, cobalt, manganese, and vanadium); therefore, mammal BAFs were used as surrogates. However, earthworms may actually bioaccumulate these metals to a greater degree than mammals.
Continuous uptake and bioaccumulation of CPCs by soil biota	Unknown	Tissue and organ responses to CPC uptake are represented by a linear function which is an oversimplification of a more complex system (i.e., trophic states and lipid concentrations may affect bioaccumulation, or contaminants may only be seasonally available).
Bioaccumulation of CPCs in leafy portions of plants	Overestimate	Ryan et al. (1988) states that compounds with log K_{ow}s > 5 are unavailable to plants due to soil sorption. Compounds with log K_{ow}s > 5 will be taken into the roots of plants, but are not easily transported into the leafy parts of plants (Briggs et al., 1982; 1983). The surface soil ingestion exposure model overestimates CPC exposure via plant ingestion to those receptors that only eat the leafy portions of plants. Levine et. al. (1989) suggests that lead does not bioaccumulate in plant tissue and so a BAF of zero was assigned.

Table 9-26
Potential Sources of Uncertainty in Ecological Risk Assessment
AOC 69W

Remedial Investigation Report
Devens, Massachusetts

Potential source	Direction of Effect on Risk	Justification
Seasonal changes in receptor foraging habits	Unknown	The food-chain model does not consider variations in a receptor's foraging habits due to seasonal changes and breeding.
Relative uptake of inorganics by different plant species	Unknown	Estimated plant BAFs for certain inorganics were based on BAF data for leafy produce grown in sewage sludge. Variability in type of plant and substrate may make the chosen BAF values an overestimate or underestimate of actual uptake.
Assumption of 1% TOC	Unknown	For simplicity, a 1% TOC is assumed, although a TOC of less than 1% exists at AOC 69W. This assumption may affect toxicity benchmark value adjustments and the number of benchmark exceedances.
Uncertainties Associated with Effects		
Lack of ingestion toxicity information for reptile and amphibian species	Unknown	Information is not available on the toxicity of contaminants to reptiles or amphibians resulting from dietary exposures; as a result, dietary exposures to these receptors were not quantitatively evaluated in the AOC 69W ERA. Assuming the toxicities of analytes to mammals and birds are similar for these receptors, and to the extent that the dietary exposures for reptiles and amphibians are the same as for the tertiary consumers evaluated in the AOC 69W ERA, an assumption can be made that dietary exposures to reptiles and amphibians would result in similar risk levels that were predicted for predatory mammals. However, risks to reptiles and amphibians are unknown.
Use of measurement endpoints	Overestimate	Although an attempt was made to have measurement endpoints reflect assessment endpoints, limited available ecotoxicological literature resulted in the selection of certain measurement endpoints that may overestimate assessment endpoints.
Failure to address potential population-level effects	Underestimate	Bulk toxicity studies to assess population risks to the midge (*Chironomus tentans*) and amphipod (*Hyalella azteca*) do not address the issue of effects on community structure and biodiversity.

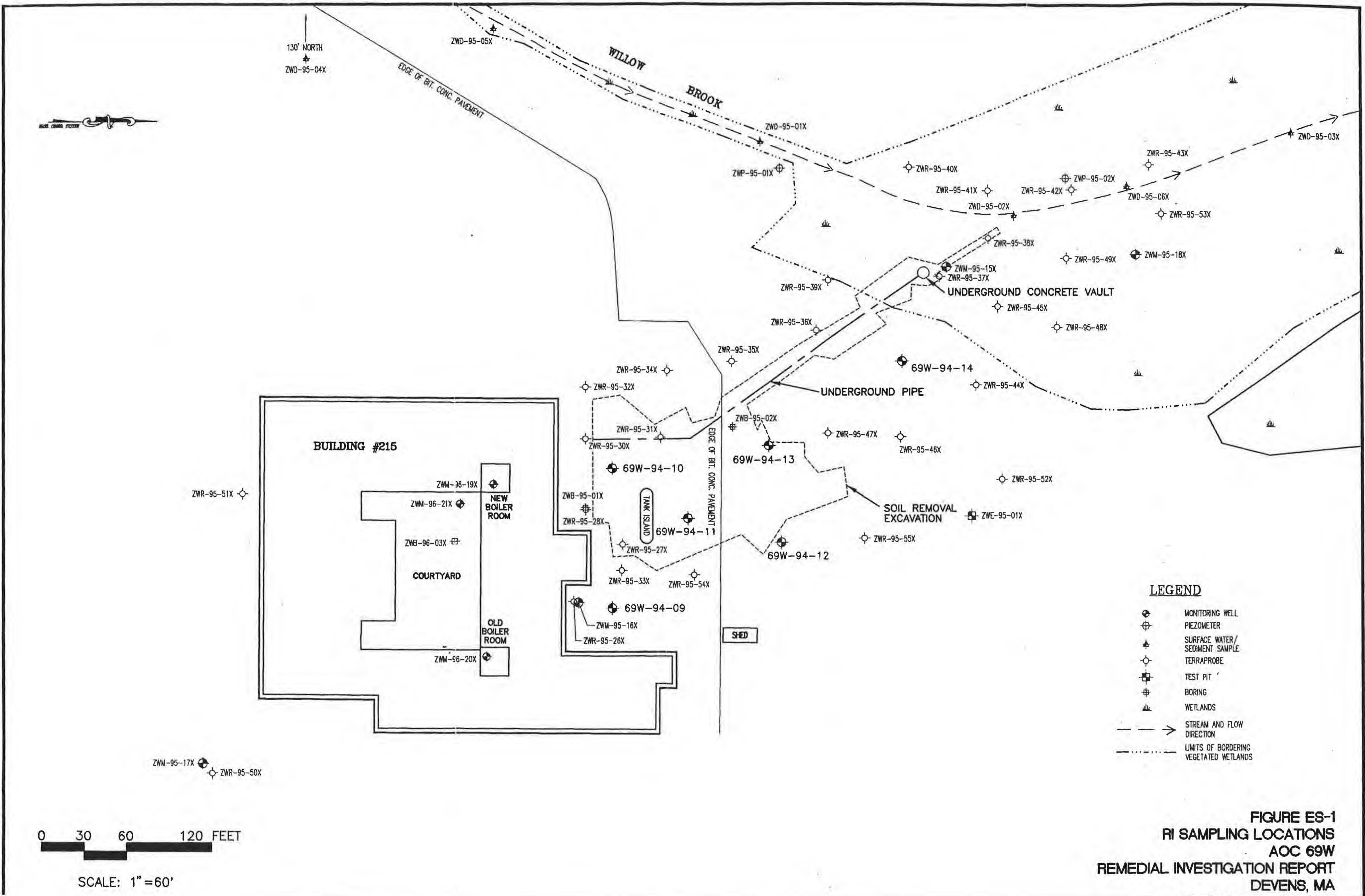

FIGURE ES-1
RI SAMPLING LOCATIONS
AOC 69W
REMEDIAL INVESTIGATION REPORT
DEVENS, MA
Harding Lawson Associates

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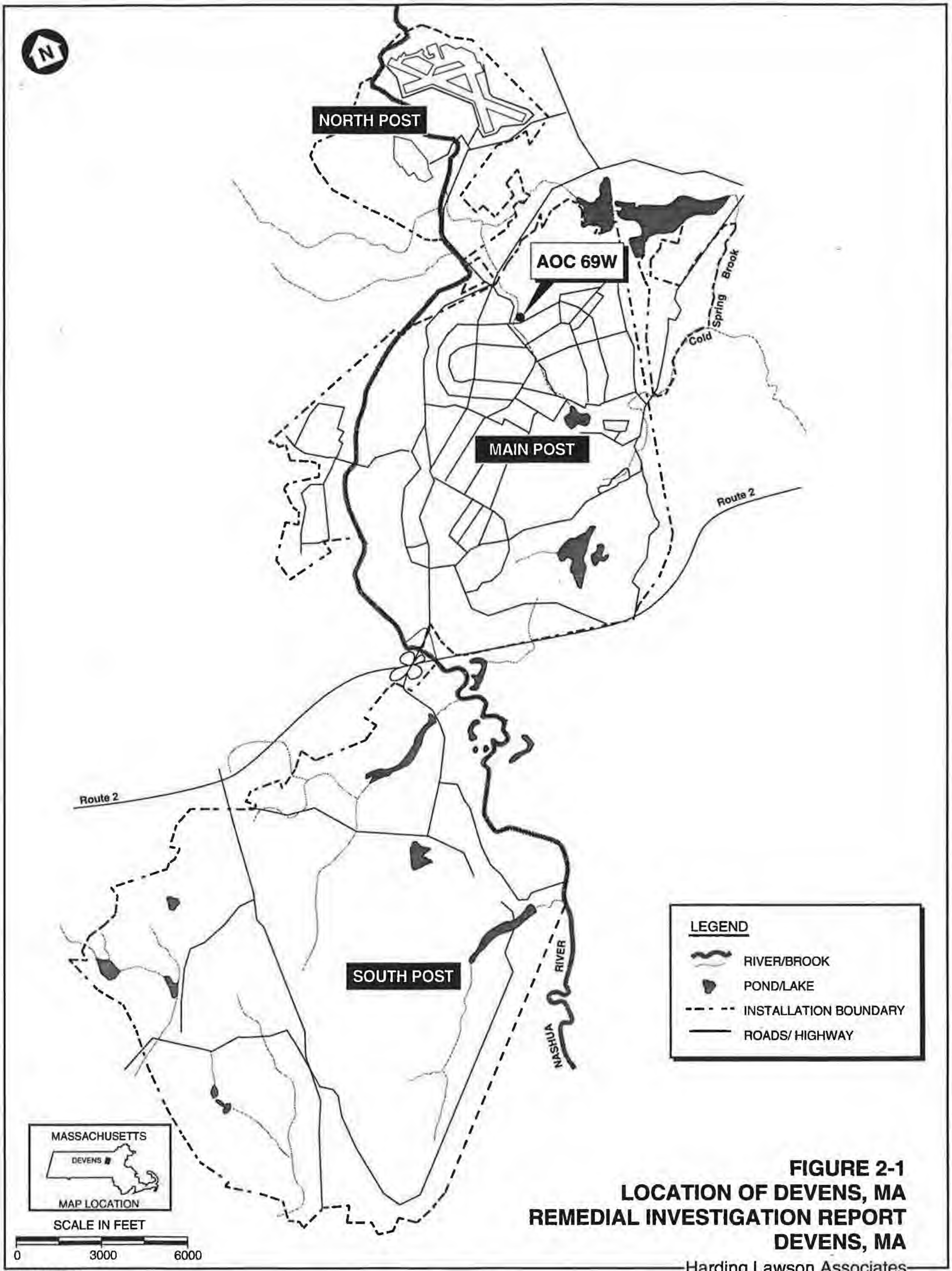


FIGURE 2-1
LOCATION OF DEVENS, MA
REMEDIAL INVESTIGATION REPORT
DEVENS, MA

Harding Lawson Associates

9808002D(a)1

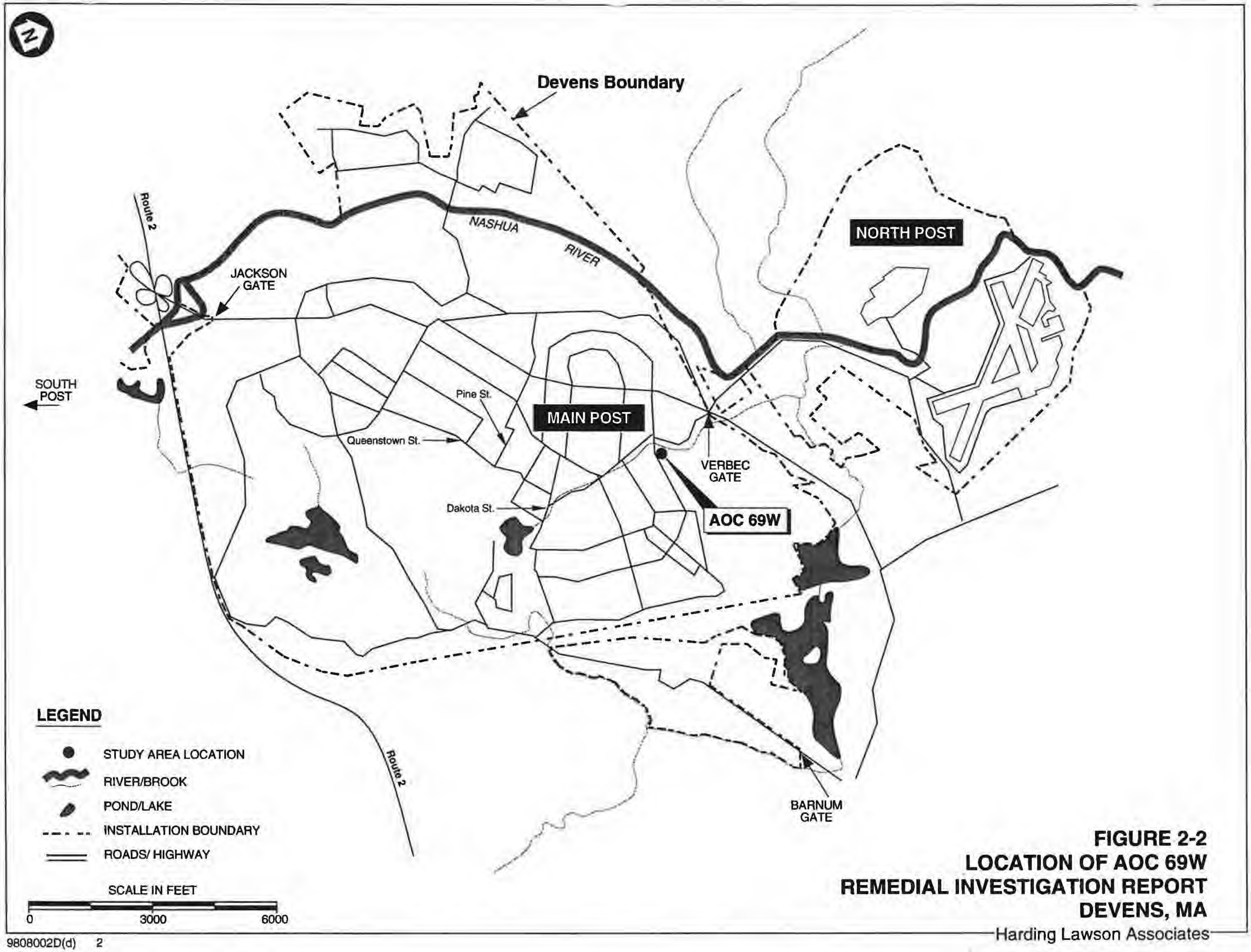
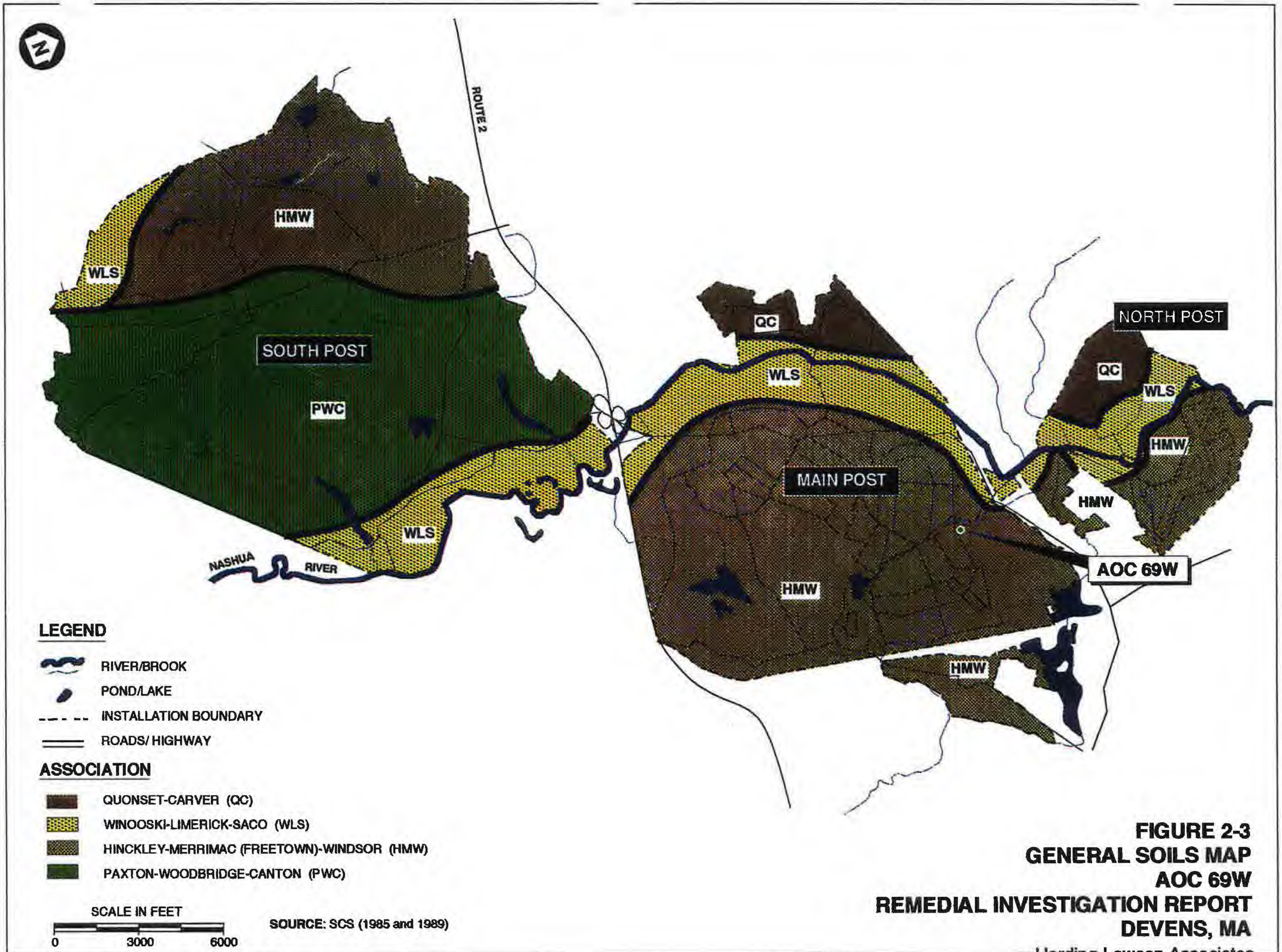


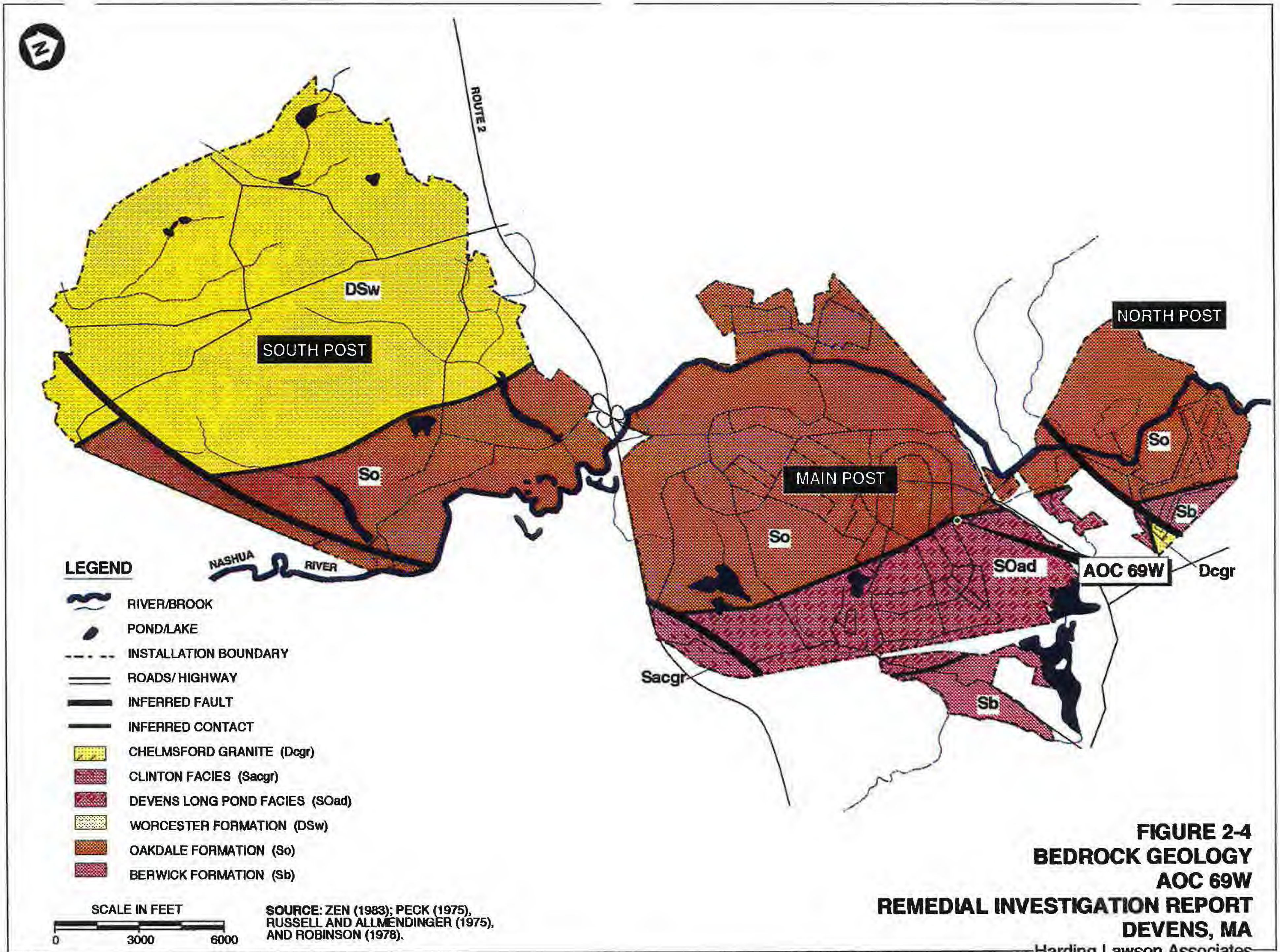
FIGURE 2-2
LOCATION OF AOC 69W
REMEDIAL INVESTIGATION REPORT
DEVENS, MA



SOURCE: SCS (1985 and 1989)

FIGURE 2-3
GENERAL SOILS MAP
AOC 69W
REMEDIAL INVESTIGATION REPORT
DEVENS, MA
Harding Lawson Associates

9808002D(e) 2,2b

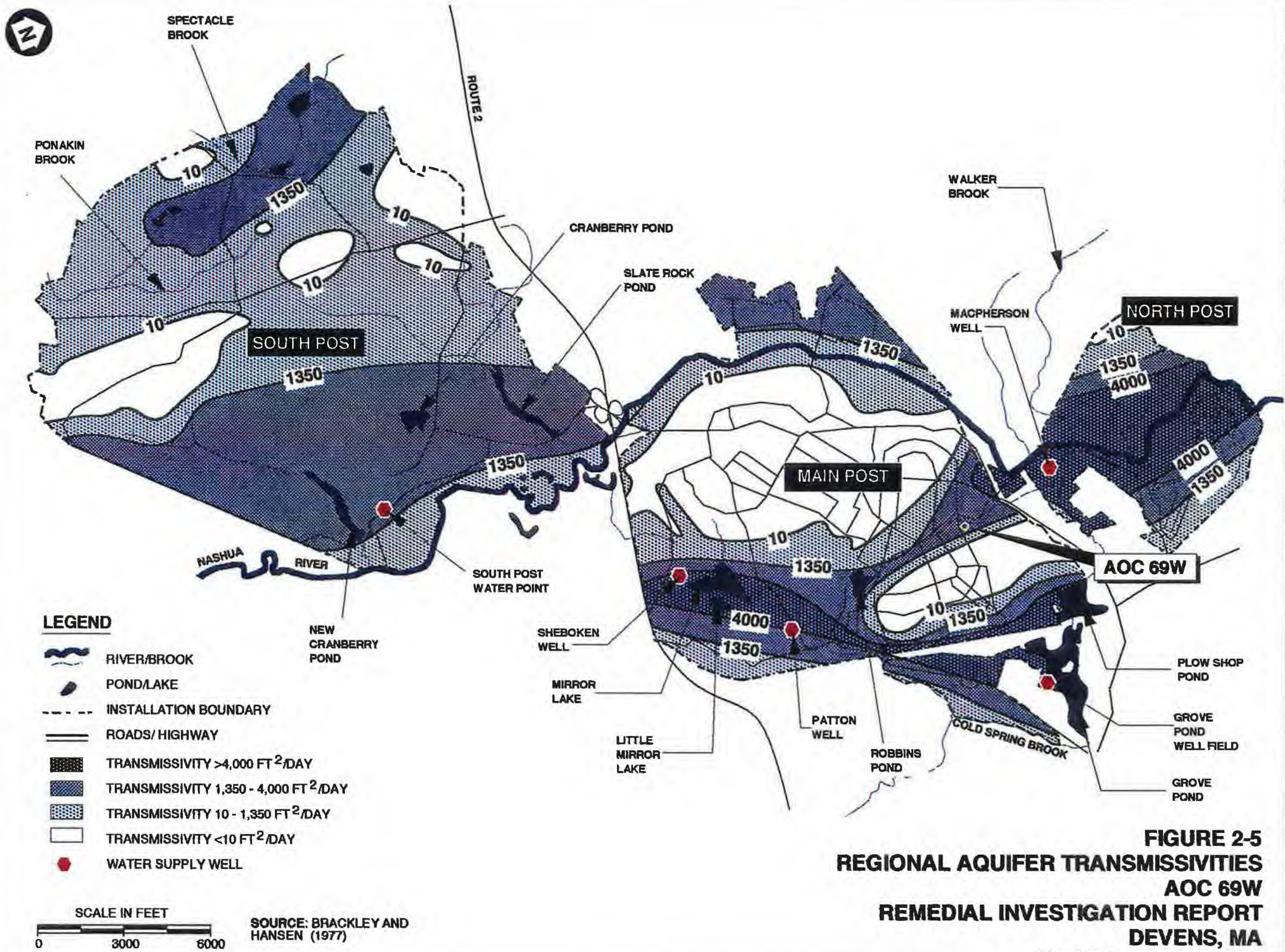


SOURCE: ZEN (1983); PECK (1975), RUSSELL AND ALLMENDINGER (1975), AND ROBINSON (1978).

FIGURE 2-4
BEDROCK GEOLOGY
AOC 69W
REMEDIAL INVESTIGATION REPORT
DEVENS, MA

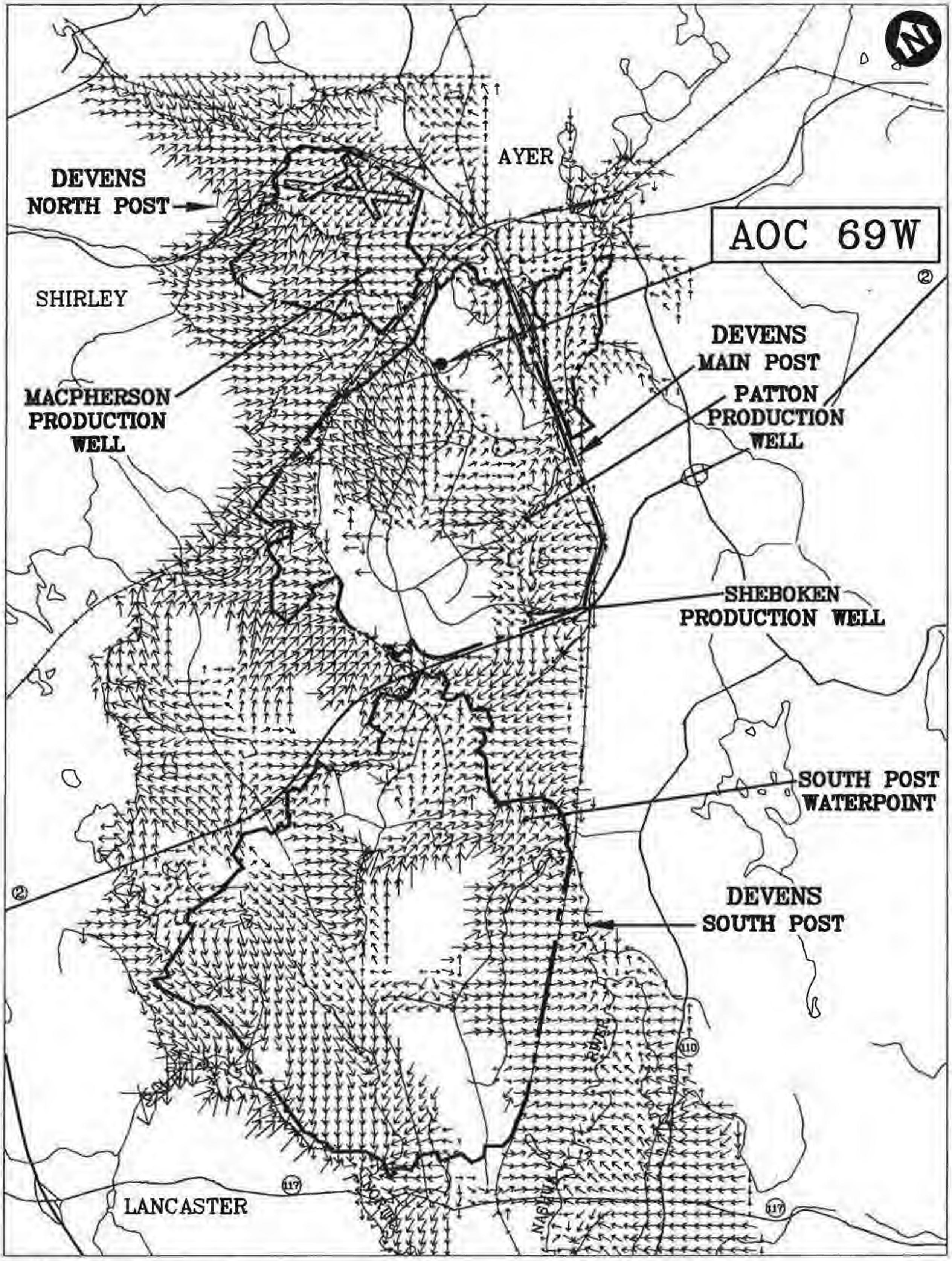
Harding Lawson Associates

9808002D(e) A,A2



SOURCE: BRACKLEY AND HANSEN (1977)

FIGURE 2-5
REGIONAL AQUIFER TRANSMISSIVITIES
AOC 69W
REMEDIAL INVESTIGATION REPORT
DEVENS, MA



SOURCE:
DRAFT FINAL GROUNDWATER FLOW MODEL AT FORT DEVENS, MA, ETA, INC. MAY, 1995.

LEGEND

↗ GROUNDWATER FLOW VECTORS

0 3000 6000 12000 FEET

SCALE: 1" =6000'

FIGURE 2-6
REGIONAL OVERBURDEN
GROUNDWATER FLOW MAP
AOC 69W
REMEDIAL INVESTIGATION REPORT
DEVENS, MA

Harding Lawson Associates

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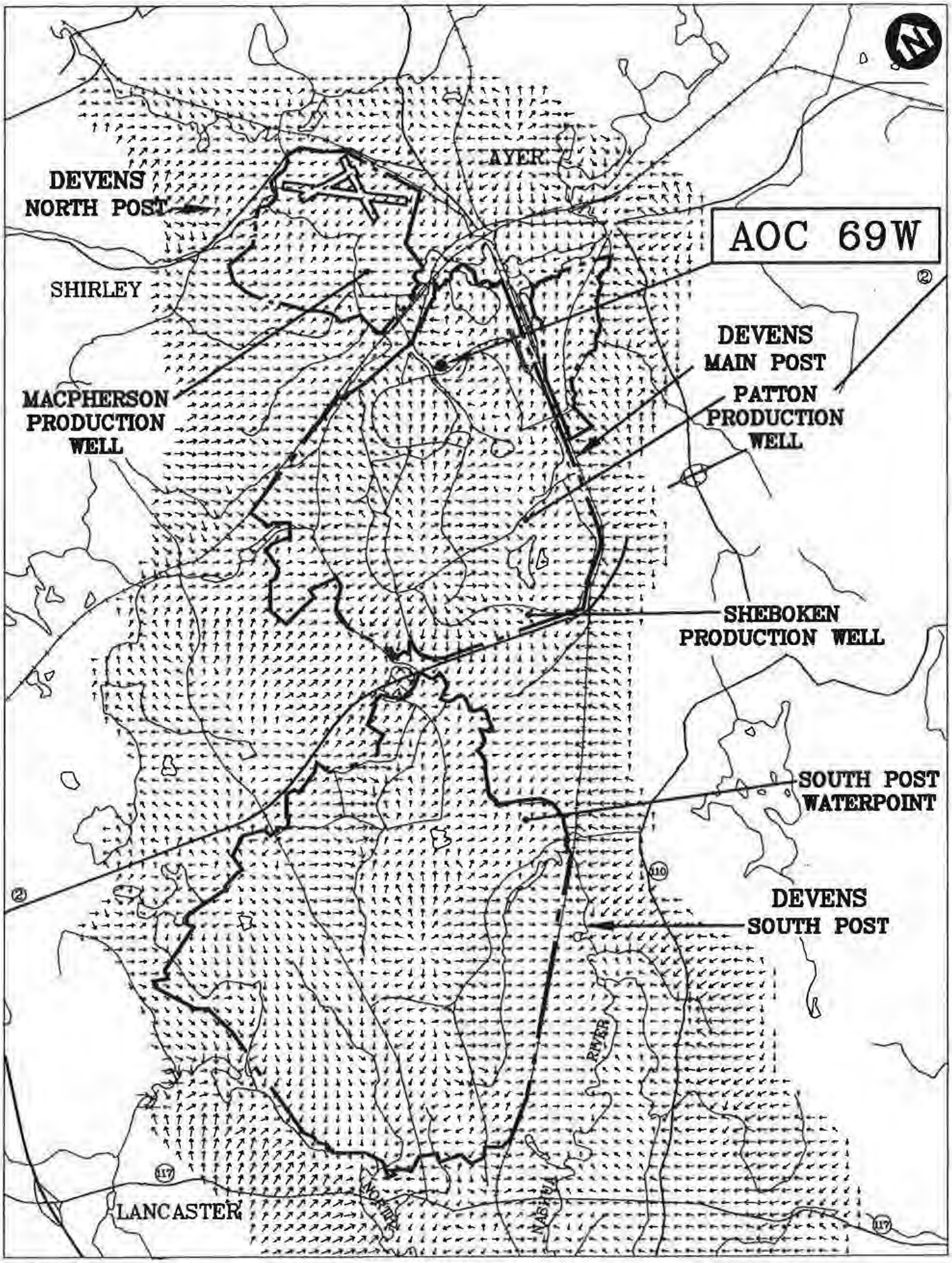

SOURCE:
DRAFT FINAL GROUNDWATER FLOW MODEL AT FORT DEVENS, MA, ETA, INC. MAY, 1995.

LEGEND

GROUNDWATER FLOW VECTORS

0 3000 6000 12000 FEET

SCALE: 1" =6000'

FIGURE 2-7
REGIONAL BEDROCK GROUNDWATER FLOW MAP
AOC 69W
REMEDIAL INVESTIGATION REPORT
DEVENS, MA

Harding Lawson Associates

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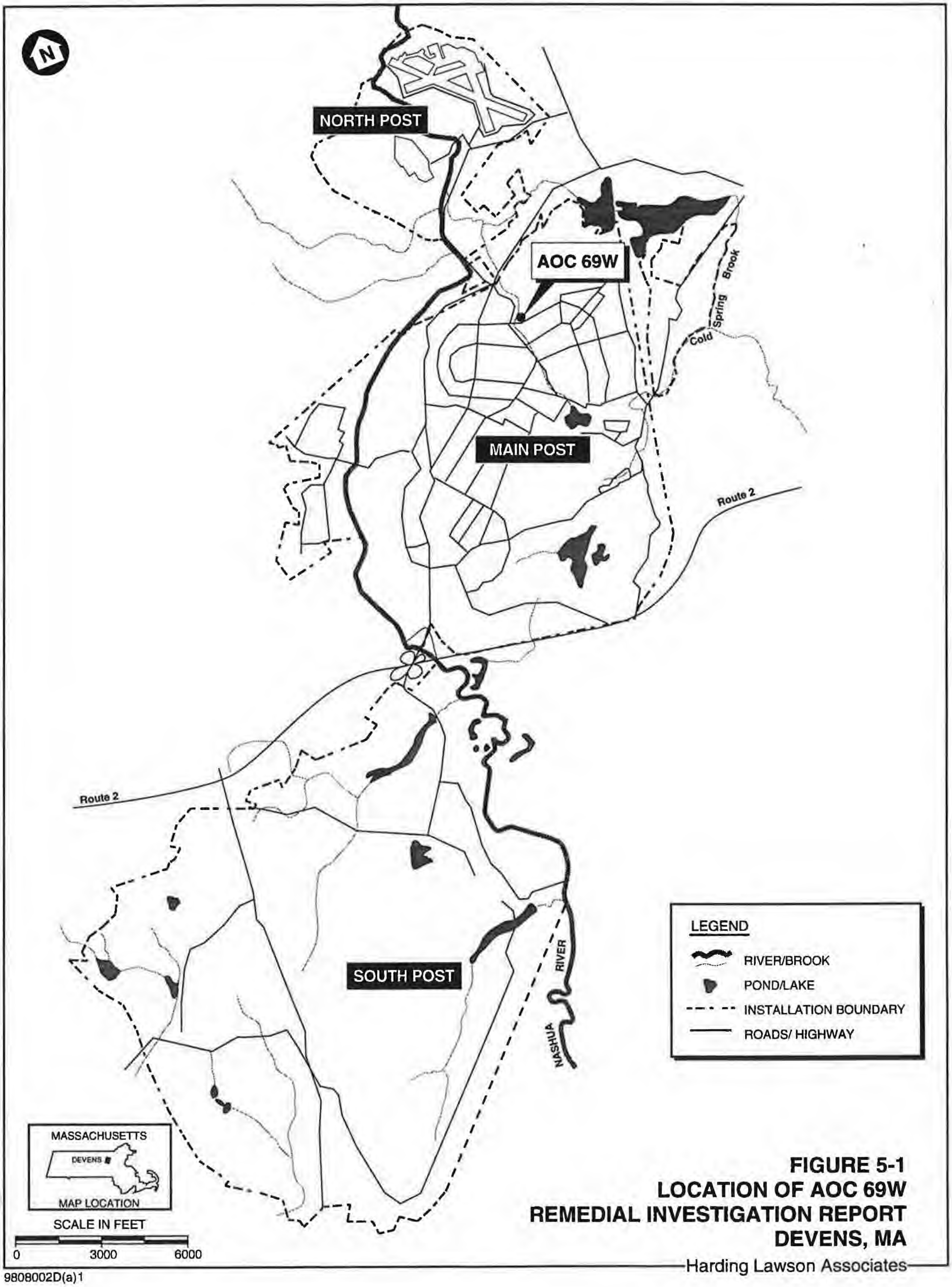

FIGURE 5-1
LOCATION OF AOC 69W
REMEDIAL INVESTIGATION REPORT
DEVENS, MA

Harding Lawson Associates

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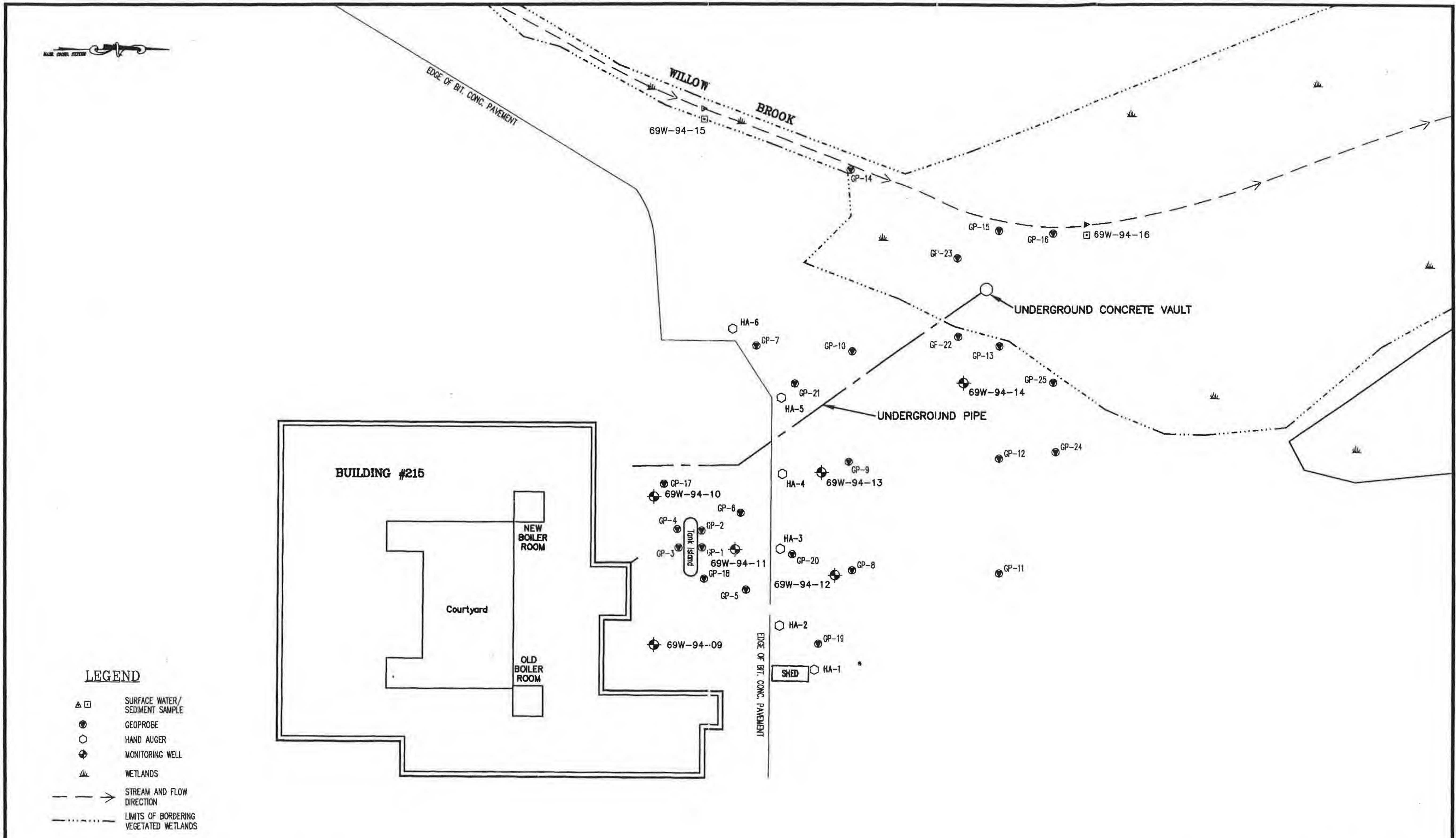


0 30 60 120 FEET

SCALE: 1"=60'

NOTE:

1. ADL = AURTHER D. LITTLE
2. AREE = AREA REQUIRING ENVIRONMENTAL EVALUATION
3. ADL SAMPLING LOCATIONS ARE NOT BASED ON SURVEY DATA EXCEPT THE MONITORING WELL LOCATIONS.

FIGURE 5-2
ADL AREE 69W EXPLORATION LOCATIONS
AOC 69W
REMEDIAL INVESTIGATION REPORT
DEVENS, MA

Harding Lawson Associates

T:\9144-03\9144F028.DWG 8/03/98

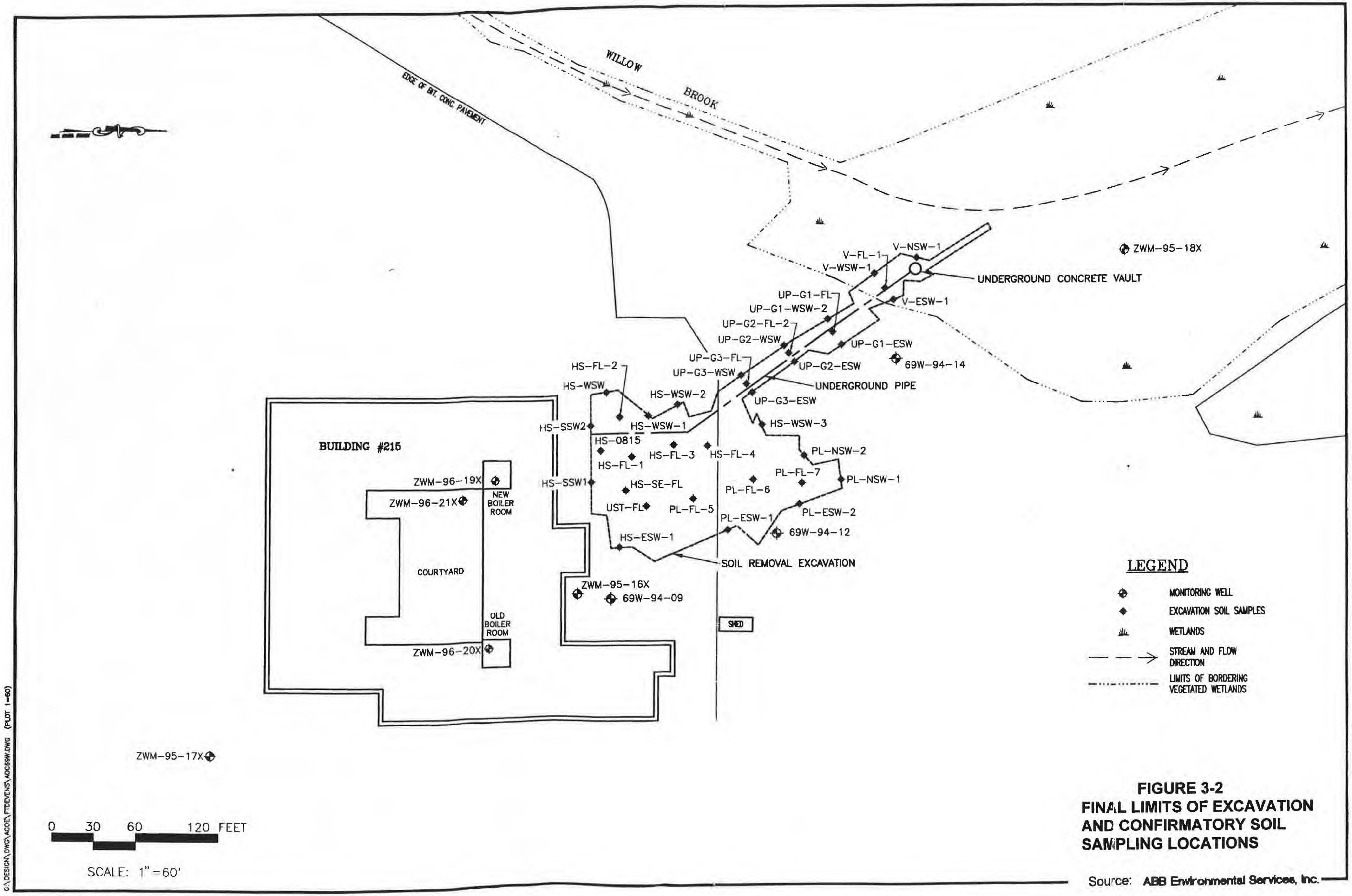


FIGURE 3-2
FINAL LIMITS OF EXCAVATION AND CONFIRMATORY SOIL SAMPLING LOCATIONS

Source: ABB Environmental Services, Inc.

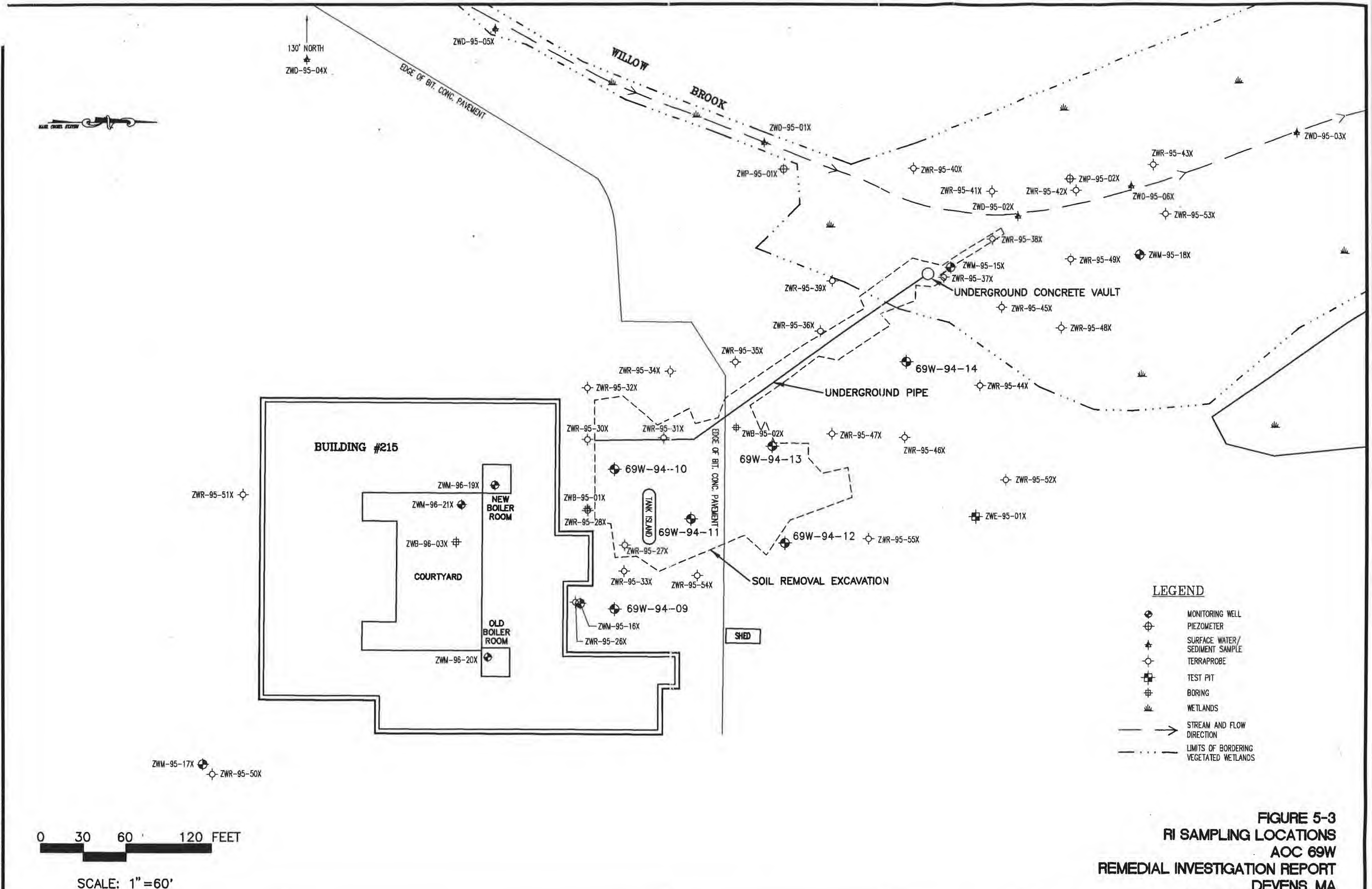


FIGURE 5-3
RI SAMPLING LOCATIONS
AOC 69W
REMEDIAL INVESTIGATION REPORT
DEVENS, MA

Harding Lawson Associates

T:\9144-03\9144F037.DWG 8/03/98

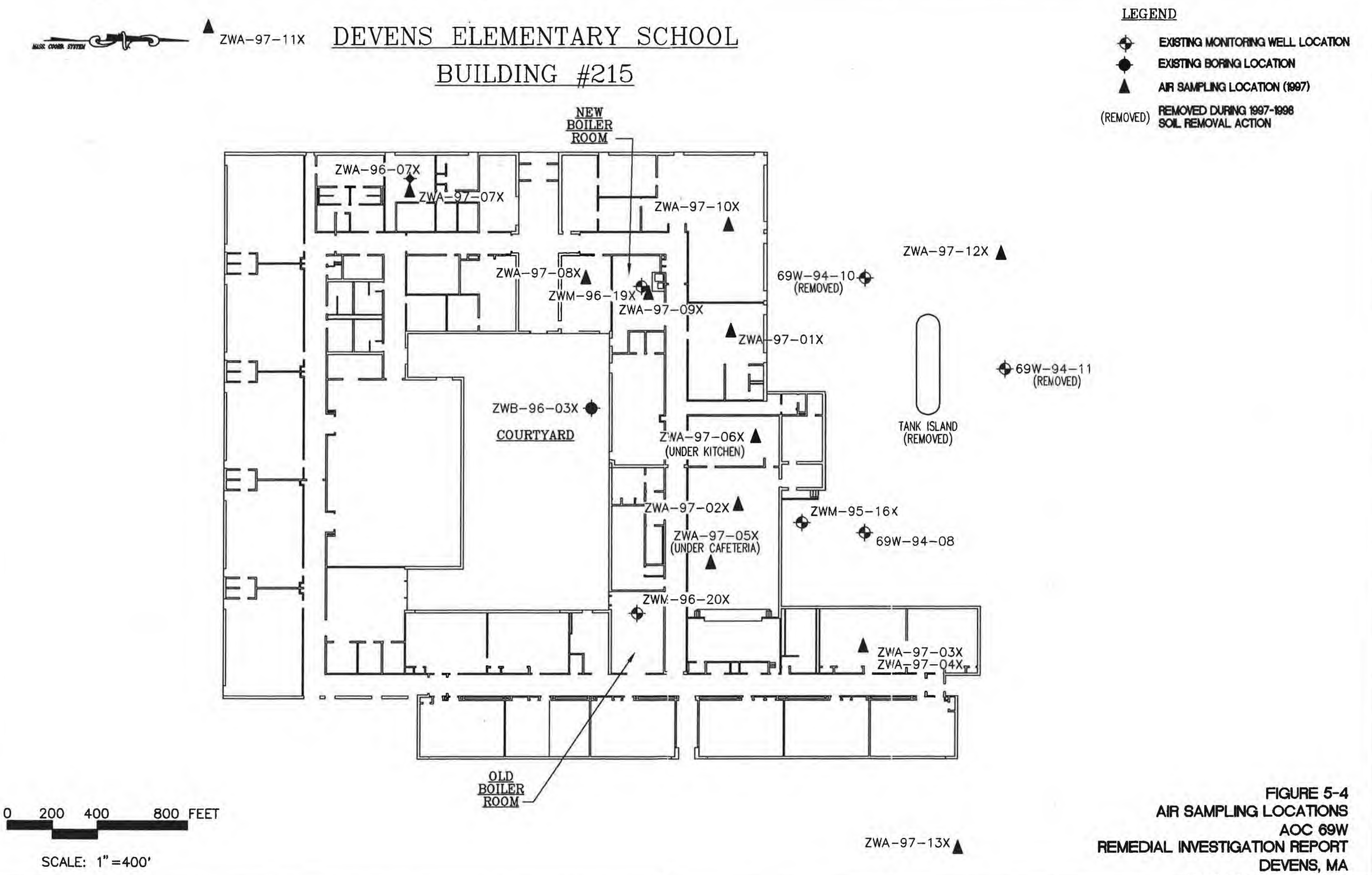
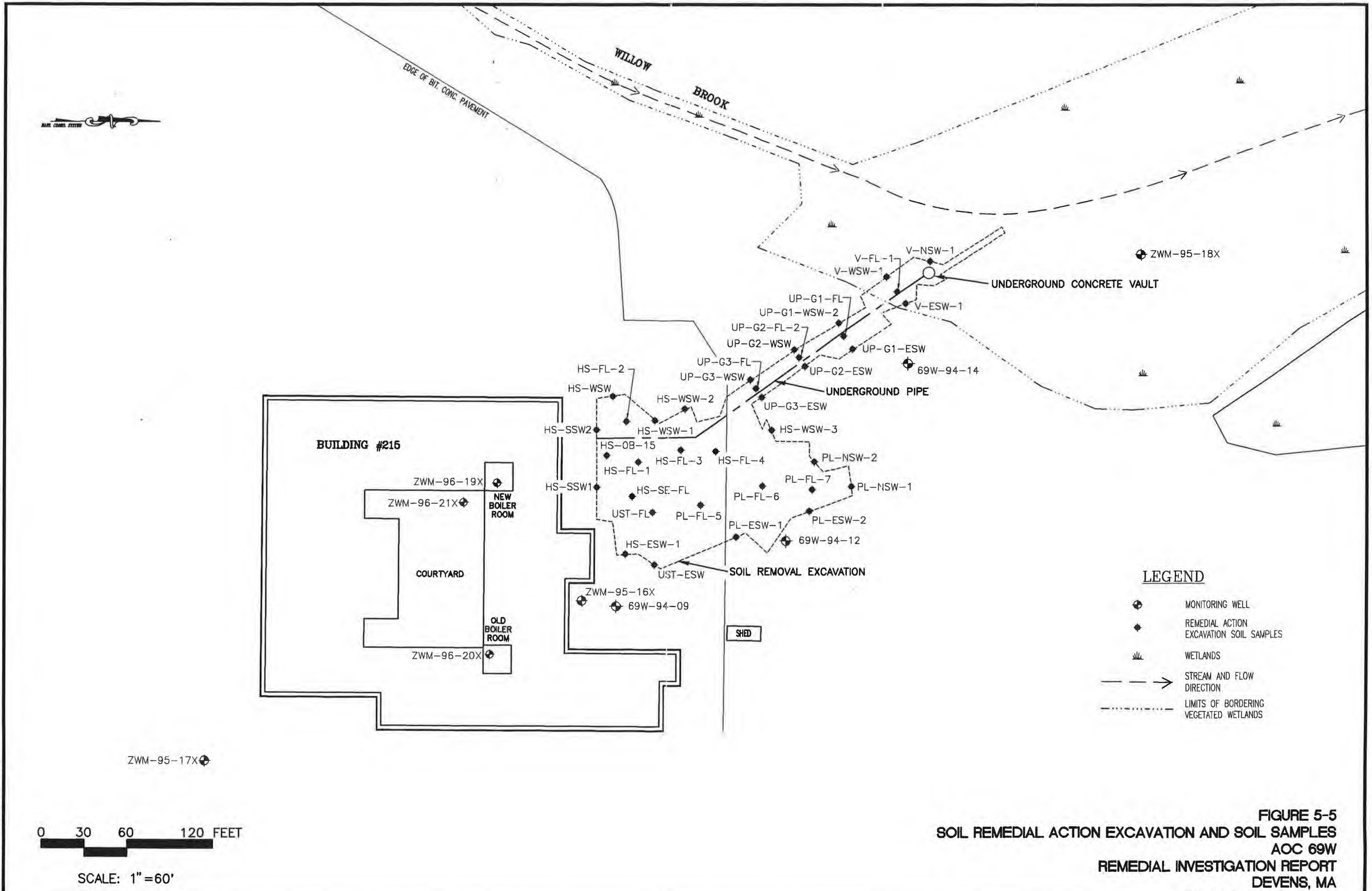


FIGURE 5-4
AIR SAMPLING LOCATIONS
AOC 69W
REMEDIAL INVESTIGATION REPORT
DEVENS, MA

Harding Lawson Associates

T:\9144-03\9144F050.DWG 8-04-98



T:\9144-03\9144F052.DWG 8-03-98

FIGURE 5-5
SOIL REMEDIAL ACTION EXCAVATION AND SOIL SAMPLES
AOC 69W
REMEDIAL INVESTIGATION REPORT
DEVENS, MA

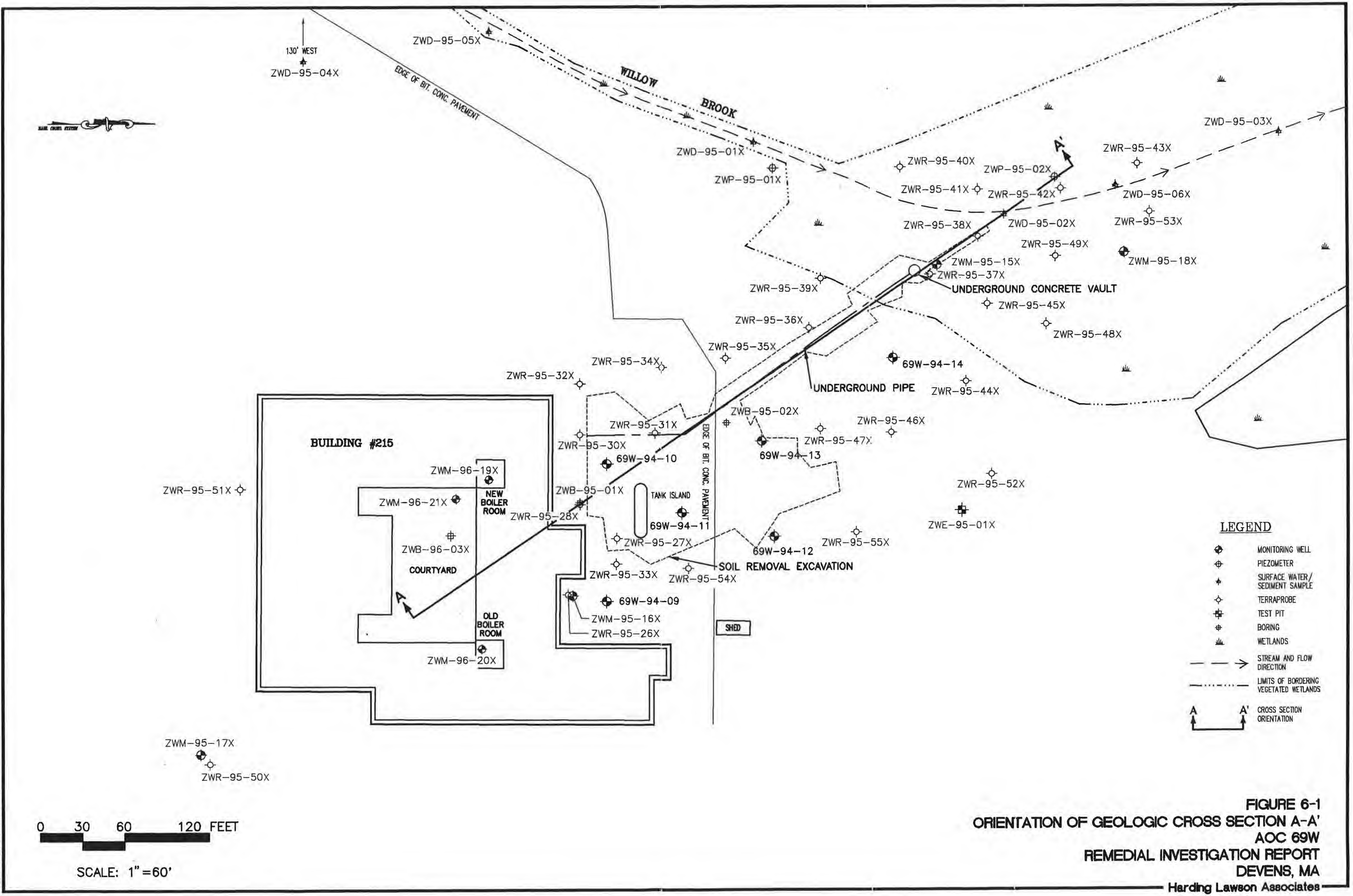


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FIGURE 6-1
ORIENTATION OF GEOLOGIC CROSS SECTION A-A'
AOC 69W
REMEDIAL INVESTIGATION REPORT
DEVENS, MA

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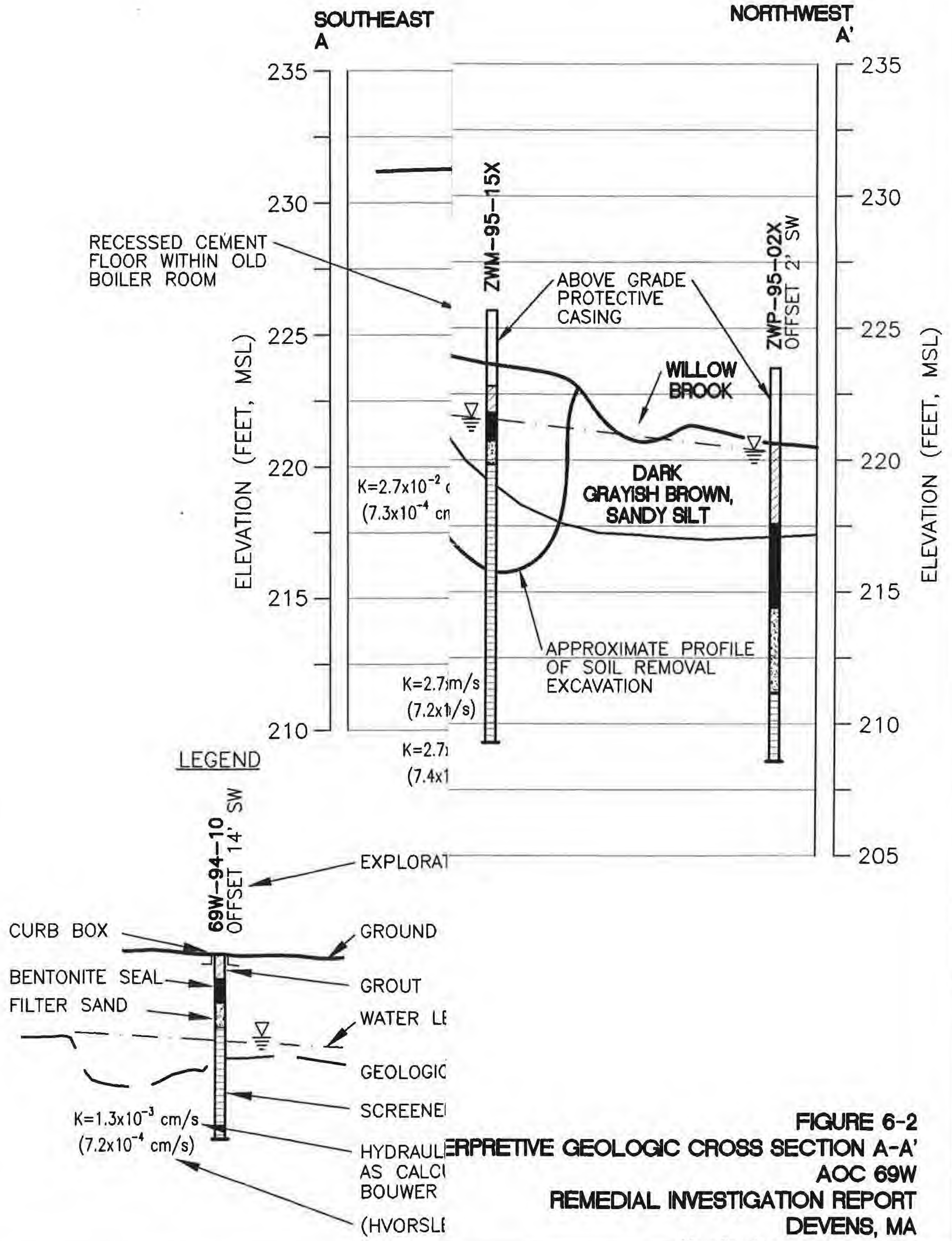

FIGURE 6-2
ERPRETIVE GEOLOGIC CROSS SECTION A-A'
AOC 69W
REMEDIAL INVESTIGATION REPORT
DEVENS, MA
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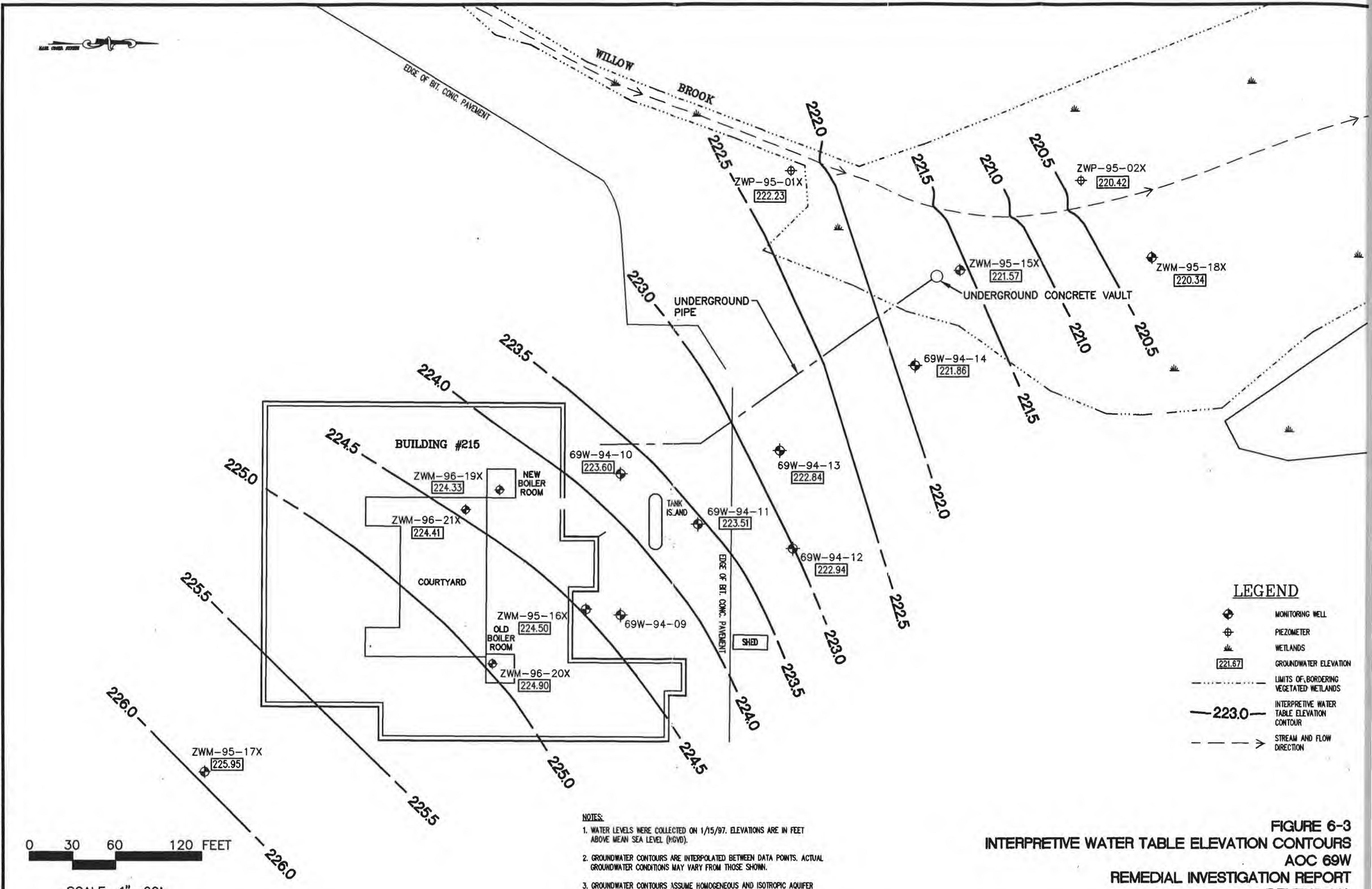
T:\9144-03\9144XS05.DWG 5/03/98



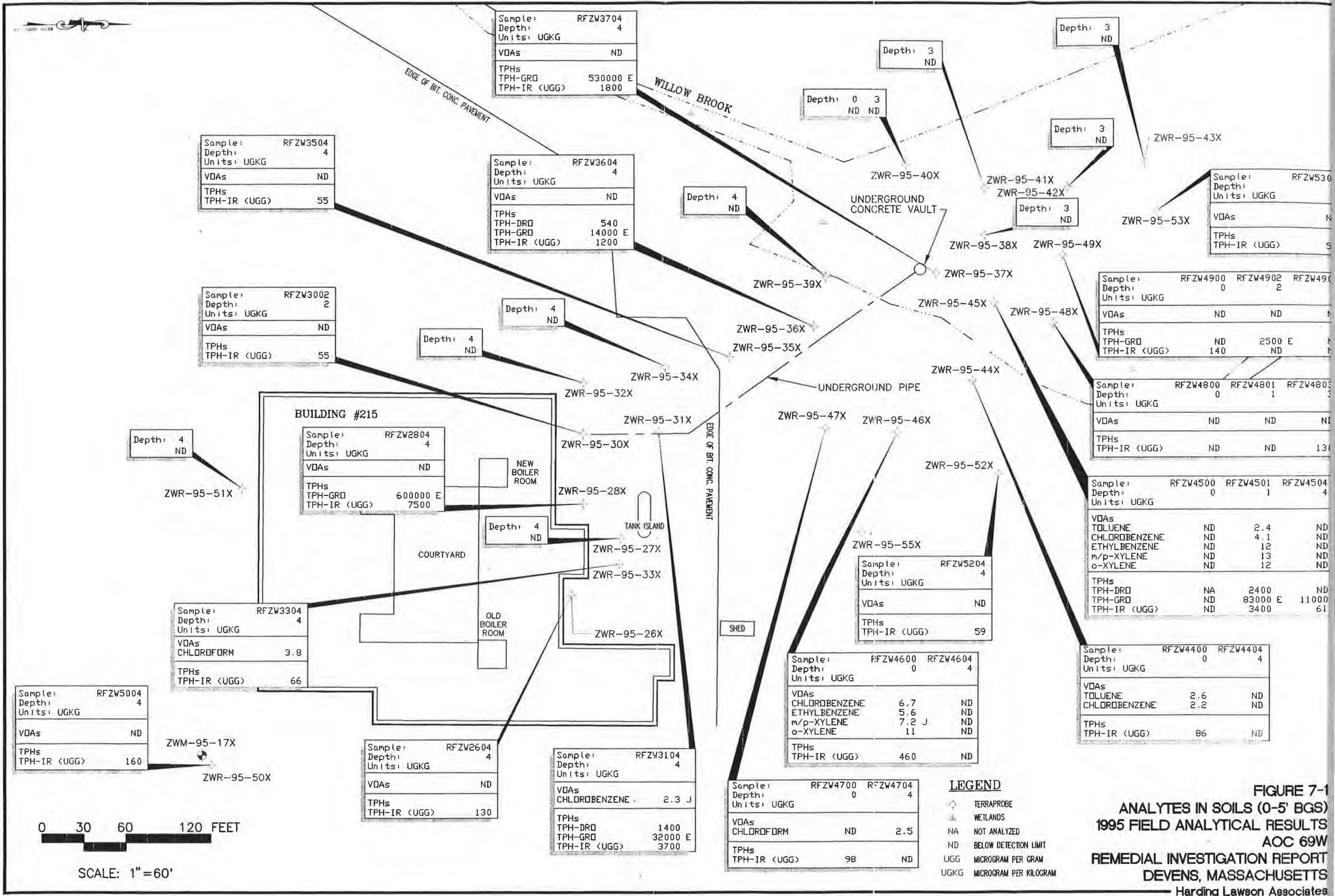
NOTES:

1. WATER LEVELS WERE COLLECTED ON 1/15/97. ELEVATIONS ARE IN FEET ABOVE MEAN SEA LEVEL (NGVD).
2. GROUNDWATER CONTOURS ARE INTERPOLATED BETWEEN DATA POINTS. ACTUAL GROUNDWATER CONDITIONS MAY VARY FROM THOSE SHOWN.
3. GROUNDWATER CONTOURS ASSUME HOMOGENEOUS AND ISOTROPIC AQUIFER CONDITIONS AND HORIZONTAL FLOW.

FIGURE 6-3
INTERPRETIVE WATER TABLE ELEVATION CONTOURS
AOC 69W
REMEDIAL INVESTIGATION REPORT
DEVENS, MA

Harding Lawson Associates

T:\9144-03\9144F023.DWG 8/03/98 ROTATE 90'



Sample:	RFZW3704
Depth:	4
Units: UGKG	
VOAs	ND
TPHs	
TPH-GRO	530000 E
TPH-IR (UGG)	1800

Sample:	RFZW3504
Depth:	4
Units: UGKG	
VOAs	ND
TPHs	
TPH-IR (UGG)	55

Sample:	RFZW3604
Depth:	4
Units: UGKG	
VOAs	ND
TPHs	
TPH-DRO	540
TPH-GRO	14000 E
TPH-IR (UGG)	1200

Sample:	RFZW3002
Depth:	2
Units: UGKG	
VOAs	ND
TPHs	
TPH-IR (UGG)	55

Depth:	0	3
	ND	ND

Depth:	3
	ND

Depth: 3 ND

Depth: 3 ND

Depth: 3 ND

Depth: 3 ND

Depth: 4 ND

Depth: 4 ND

Depth: 4 ND

Depth: 4 ND

Depth: 4 ND

Sample:	RFZW530
Depth:	
Units: UGKG	
VOAs	N
TPHs	
TPH-IR (UGG)	5

Sample:	RFZW4900	RFZW4902	RFZW49
Depth:	0	2	
Units: UGKG			
VOAs	ND	ND	N
TPHs			
TPH-GRO	ND	2500 E	N
TPH-IR (UGG)	140	ND	N

Sample:	RFZW4800	RFZW4801	RFZW480
Depth:	0	1	
Units: UGKG			
VOAs	ND	ND	NI
TPHs			
TPH-IR (UGG)	ND	ND	13

Sample:	RFZW2804
Depth:	4
Units: UGKG	
VOAs	ND
TPHs	
TPH-GRO	600000 E
TPH-IR (UGG)	7500

Sample:	RFZW4500	RFZW4501	RFZW4504
Depth:	0	1	4
Units: UGKG			
VOAs			
TOLUENE	ND	2.4	ND
CHLOROBENZENE	ND	4.1	ND
ETHYLBENZENE	ND	12	ND
m/p-XYLENE	ND	13	ND
o-XYLENE	ND	12	ND
TPHs			
TPH-DRO	NA	2400	ND
TPH-GRO	ND	83000 E	11000
TPH-IR (UGG)	ND	3400	61

Sample:	RFZW5204
Depth:	4
Units: UGKG	
VOAs	ND
TPHs	
TPH-IR (UGG)	59

Sample:	RFZW3304
Depth:	4
Units: UGKG	
VOAs	
CHLOROFORM	3.8
TPHs	
TPH-IR (UGG)	66

Sample:	RFZW4600	RFZW4604
Depth:	0	4
Units: UGKG		
VOAs		
CHLOROBENZENE	6.7	ND
ETHYLBENZENE	5.6	ND
m/p-XYLENE	7.2 J	ND
o-XYLENE	11	ND
TPHs		
TPH-IR (UGG)	460	ND

Sample:	RFZW4400	RFZW4404
Depth:	0	4
Units: UGKG		
VOAs		
TOLUENE	2.6	ND
CHLOROBENZENE	2.2	ND
TPHs		
TPH-IR (UGG)	86	ND

Sample:	RFZW5004
Depth:	4
Units: UGKG	
VOAs	ND
TPHs	
TPH-IR (UGG)	160

Sample:	RFZW2604
Depth:	4
Units: UGKG	
VOAs	ND
TPHs	
TPH-IR (UGG)	130

Sample:	RFZW3104
Depth:	4
Units: UGKG	
VOAs	
CHLOROBENZENE	2.3 J
TPHs	
TPH-DRO	1400
TPH-GRO	32000 E
TPH-IR (UGG)	3700

Sample:	RFZW4700	RFZW4704
Depth:	0	4
Units: UGKG		
VOAs		
CHLOROFORM	ND	2.5
TPHs		
TPH-IR (UGG)	98	ND

LEGEND

⌖	TERRAPROBE
⫫	WETLANDS
NA	NOT ANALYZED
ND	BELOW DETECTION LIMIT
UGG	MICROGRAM PER GRAM
UGKG	MICROGRAM PER KILOGRAM

FIGURE 7-1
ANALYTES IN SOILS (0-5' BGS)
1995 FIELD ANALYTICAL RESULTS
AOC 69W
REMEDIAL INVESTIGATION REPORT
DEVENS, MASSACHUSETTS
Harding Lawson Associates

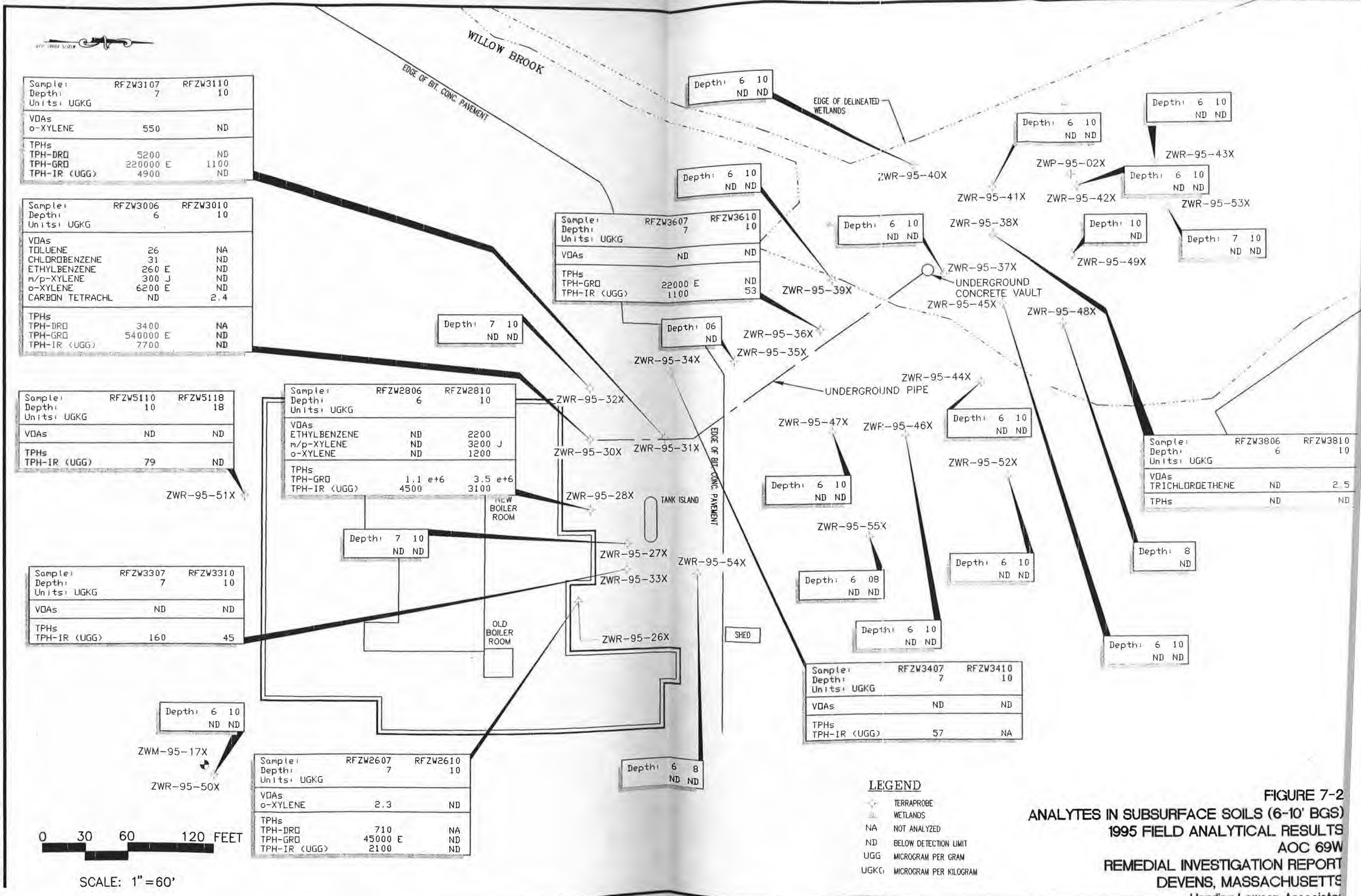


FIGURE 7-2
ANALYTES IN SUBSURFACE SOILS (6-10' BGS)
1995 FIELD ANALYTICAL RESULTS
AOC 69W
REMEDIAL INVESTIGATION REPORT
DEVENS, MASSACHUSETTS
Harding Lawson Associates

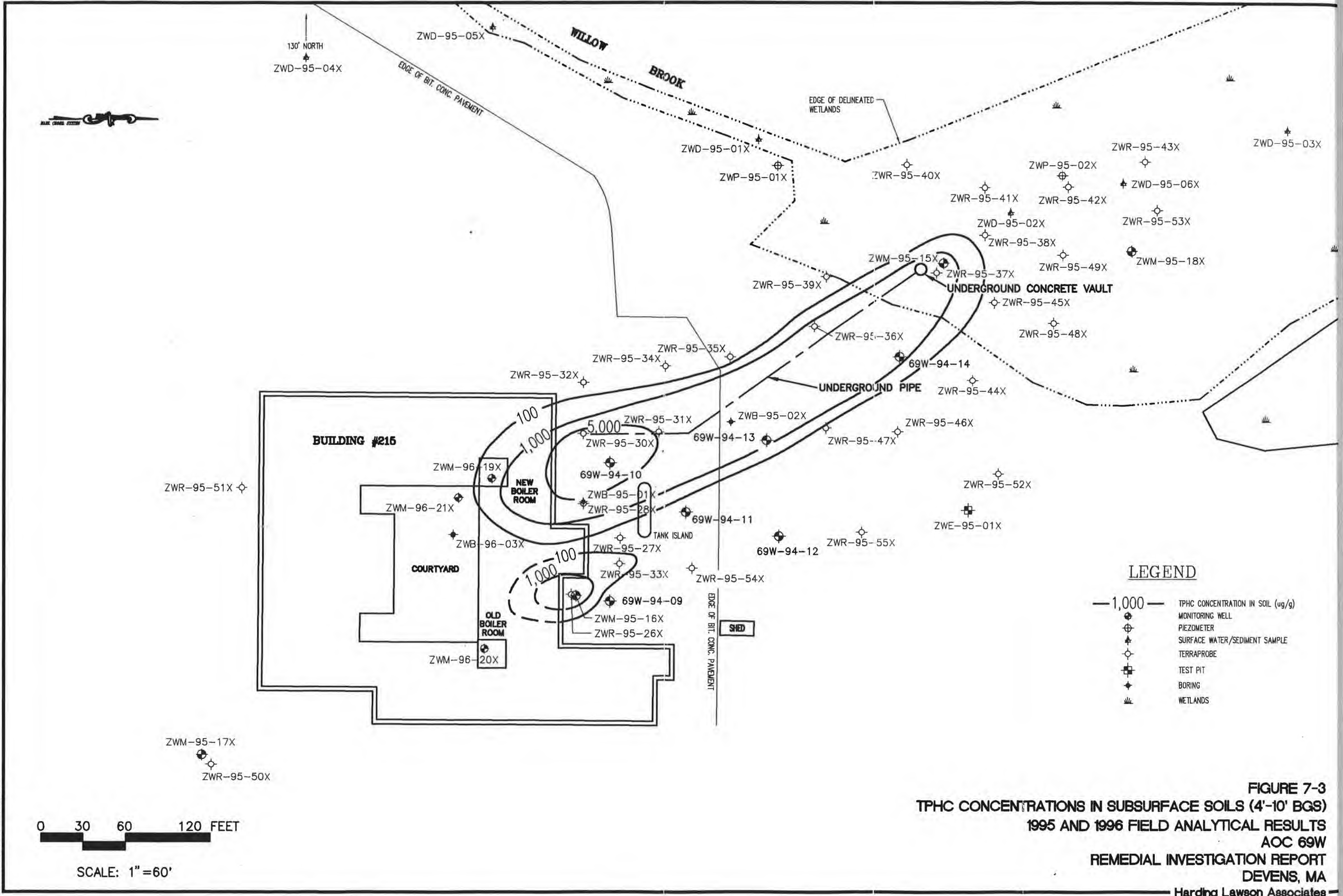


FIGURE 7-3
TPHC CONCENTRATIONS IN SUBSURFACE SOILS (4'-10' BGS)
1995 AND 1996 FIELD ANALYTICAL RESULTS
AOC 69W
REMEDIAL INVESTIGATION REPORT
DEVENS, MA

Harding Lawson Associates

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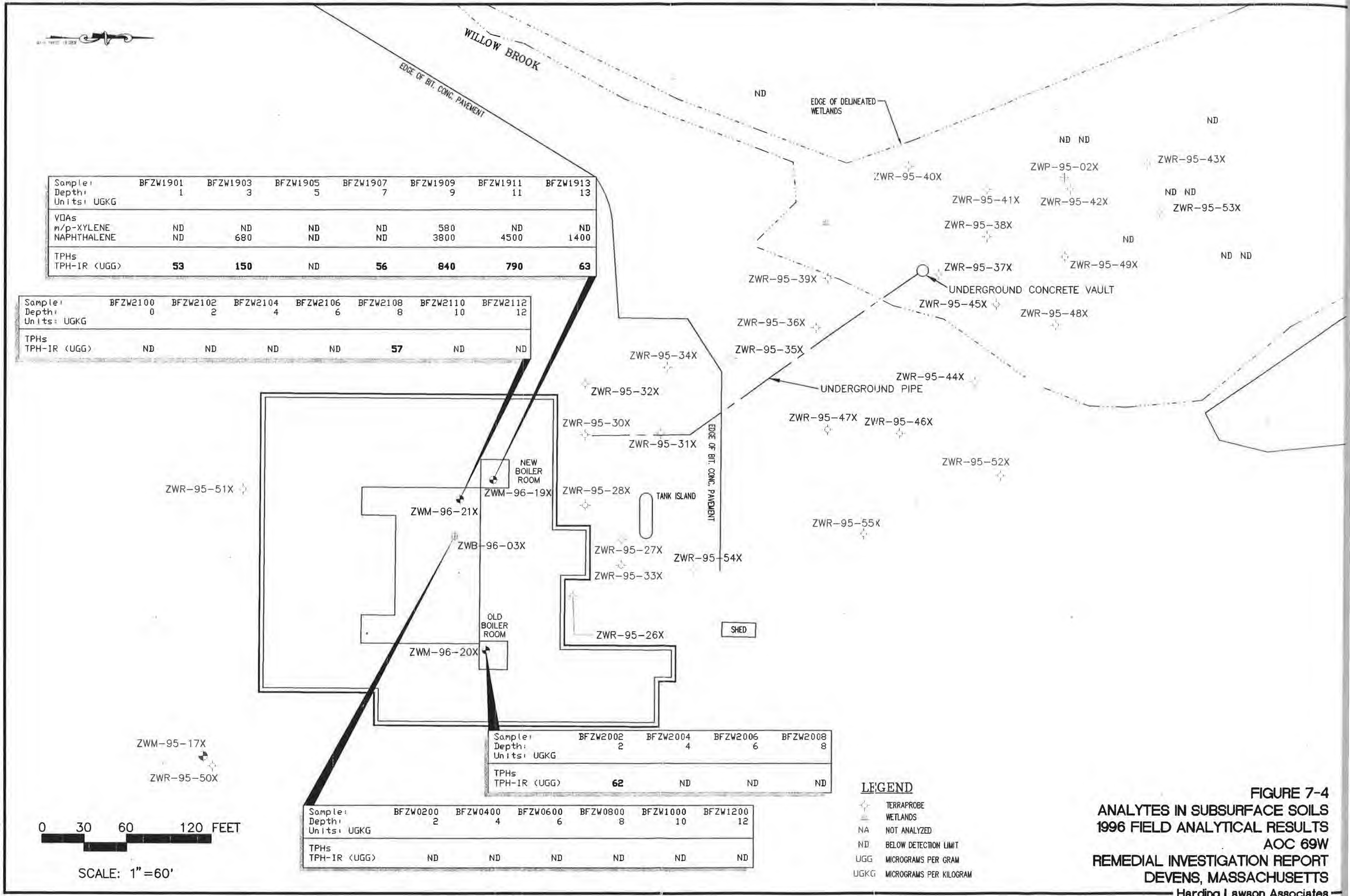


Sample:	BFZW1901	BFZW1903	BFZW1905	BFZW1907	BFZW1909	BFZW1911	BFZW1913
Depth:	1	3	5	7	9	11	13
Units: UGKG							
VOAs							
m/p-XYLENE	ND	ND	ND	ND	580	ND	ND
NAPHTHALENE	ND	680	ND	ND	3800	4500	1400
TPHs							
TPH-IR (UGG)	**53**	**150**	ND	**56**	**840**	**790**	**63**

Sample:	BFZW2100	BFZW2102	BFZW2104	BFZW2106	BFZW2108	BFZW2110	BFZW2112
Depth:	0	2	4	6	8	10	12
Units: UGKG							
TPHs							
TPH-IR (UGG)	ND	ND	ND	ND	**57**	ND	ND

Sample:	BFZW2002	BFZW2004	BFZW2006	BFZW2008
Depth:	2	4	6	8
Units: UGKG				
TPHs				
TPH-IR (UGG)	**62**	ND	ND	ND

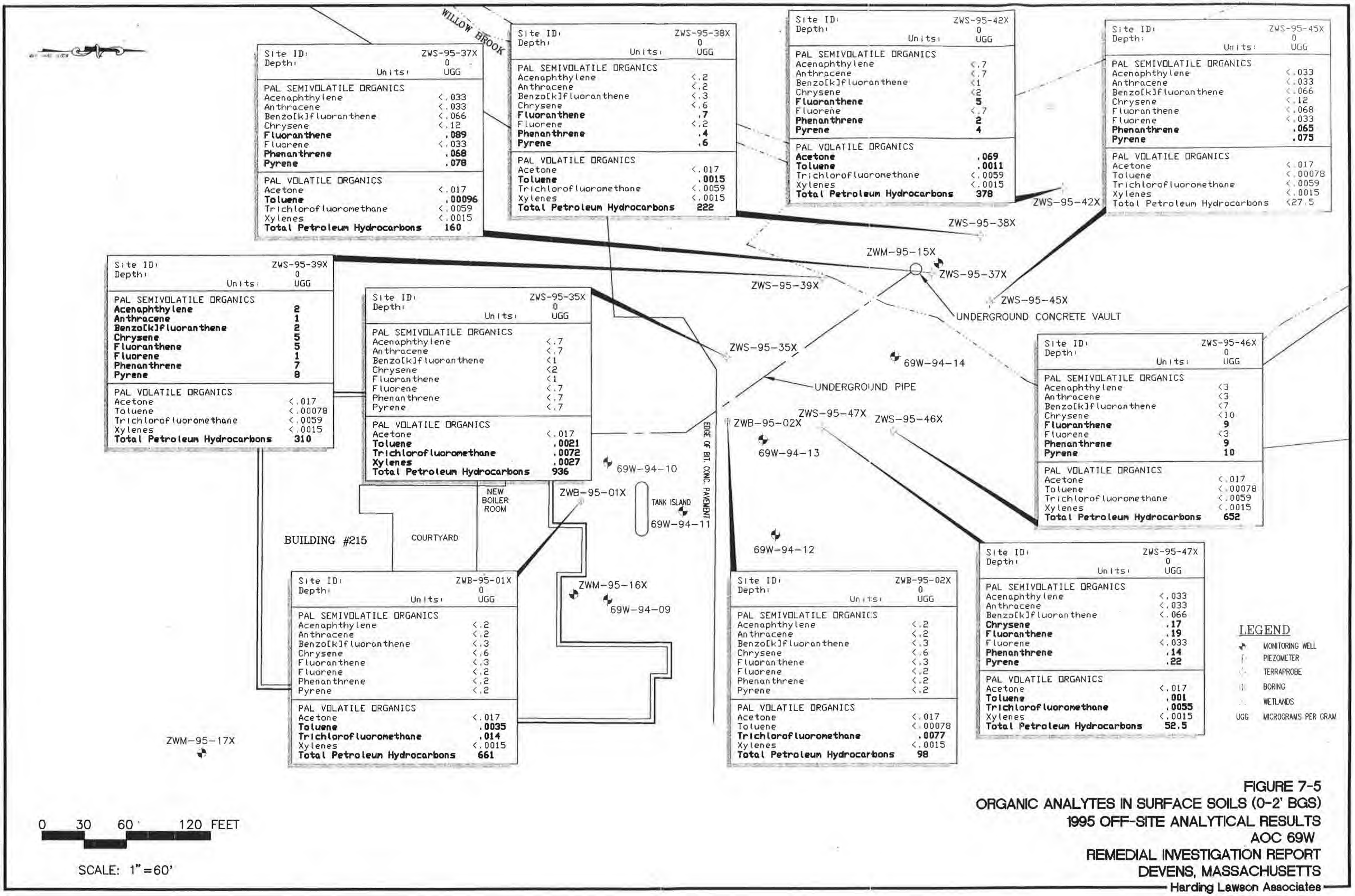
Sample:	BFZW0200	BFZW0400	BFZW0600	BFZW0800	BFZW1000	BFZW1200
Depth:	2	4	6	8	10	12
Units: UGKG						
TPHs						
TPH-IR (UGG)	ND	ND	ND	ND	ND	ND

LEGEND

✧	TERRAPROBE
⩸	WETLANDS
NA	NOT ANALYZED
ND	BELOW DETECTION LIMIT
UGG	MICROGRAMS PER GRAM
UGKG	MICROGRAMS PER KILOGRAM

FIGURE 7-4
ANALYTES IN SUBSURFACE SOILS
1996 FIELD ANALYTICAL RESULTS
AOC 69W
REMEDIAL INVESTIGATION REPORT
DEVENS, MASSACHUSETTS

Harding Lawson Associates



Site ID:	ZWS-95-37X
Depth:	0
Units:	UGG
PAL SEMIVOLATILE ORGANICS	
Acenaphthylene	<.033
Anthracene	<.033
Benzo[k]fluoranthene	<.066
Chrysene	<.12
Fluoranthene	**.089**
Fluorene	<.033
Phenanthrene	**.068**
Pyrene	**.078**
PAL VOLATILE ORGANICS	
Acetone	<.017
Toluene	**.00096**
Trichlorofluoromethane	<.0059
Xylenes	<.0015
Total Petroleum Hydrocarbons	**160**

Site ID:	ZWS-95-38X
Depth:	0
Units:	UGG
PAL SEMIVOLATILE ORGANICS	
Acenaphthylene	<.2
Anthracene	<.2
Benzo[k]fluoranthene	<.3
Chrysene	<.6
Fluoranthene	**.7**
Fluorene	<.2
Phenanthrene	**.4**
Pyrene	**.6**
PAL VOLATILE ORGANICS	
Acetone	<.017
Toluene	**.0015**
Trichlorofluoromethane	<.0059
Xylenes	<.0015
Total Petroleum Hydrocarbons	**222**

Site ID:	ZWS-95-42X
Depth:	0
Units:	UGG
PAL SEMIVOLATILE ORGANICS	
Acenaphthylene	<.7
Anthracene	<.7
Benzo[k]fluoranthene	<1
Chrysene	<2
Fluoranthene	**5**
Fluorene	<.7
Phenanthrene	**2**
Pyrene	**4**
PAL VOLATILE ORGANICS	
Acetone	**.069**
Toluene	**.0011**
Trichlorofluoromethane	<.0059
Xylenes	<.0015
Total Petroleum Hydrocarbons	**378**

Site ID:	ZWS-95-45X
Depth:	0
Units:	UGG
PAL SEMIVOLATILE ORGANICS	
Acenaphthylene	<.033
Anthracene	<.033
Benzo[k]fluoranthene	<.066
Chrysene	<.12
Fluoranthene	<.068
Fluorene	<.033
Phenanthrene	**.065**
Pyrene	**.075**
PAL VOLATILE ORGANICS	
Acetone	<.017
Toluene	<.00078
Trichlorofluoromethane	<.0059
Xylenes	<.0015
Total Petroleum Hydrocarbons	<27.5

Site ID:	ZWS-95-39X
Depth:	0
Units:	UGG
PAL SEMIVOLATILE ORGANICS	
Acenaphthylene	**2**
Anthracene	**1**
Benzo[k]fluoranthene	**2**
Chrysene	**5**
Fluoranthene	**5**
Fluorene	**1**
Phenanthrene	**7**
Pyrene	**8**
PAL VOLATILE ORGANICS	
Acetone	<.017
Toluene	<.00078
Trichlorofluoromethane	<.0059
Xylenes	<.0015
Total Petroleum Hydrocarbons	**310**

Site ID:	ZWS-95-35X
Depth:	0
Units:	UGG
PAL SEMIVOLATILE ORGANICS	
Acenaphthylene	<.7
Anthracene	<.7
Benzo[k]fluoranthene	<1
Chrysene	<2
Fluoranthene	<1
Fluorene	<.7
Phenanthrene	<.7
Pyrene	<.7
PAL VOLATILE ORGANICS	
Acetone	<.017
Toluene	**.0021**
Trichlorofluoromethane	**.0072**
Xylenes	**.0027**
Total Petroleum Hydrocarbons	**936**

Site ID:	ZWS-95-46X
Depth:	0
Units:	UGG
PAL SEMIVOLATILE ORGANICS	
Acenaphthylene	<3
Anthracene	<3
Benzo[k]fluoranthene	<7
Chrysene	<10
Fluoranthene	**9**
Fluorene	<3
Phenanthrene	**9**
Pyrene	**10**
PAL VOLATILE ORGANICS	
Acetone	<.017
Toluene	<.00078
Trichlorofluoromethane	<.0059
Xylenes	<.0015
Total Petroleum Hydrocarbons	**652**

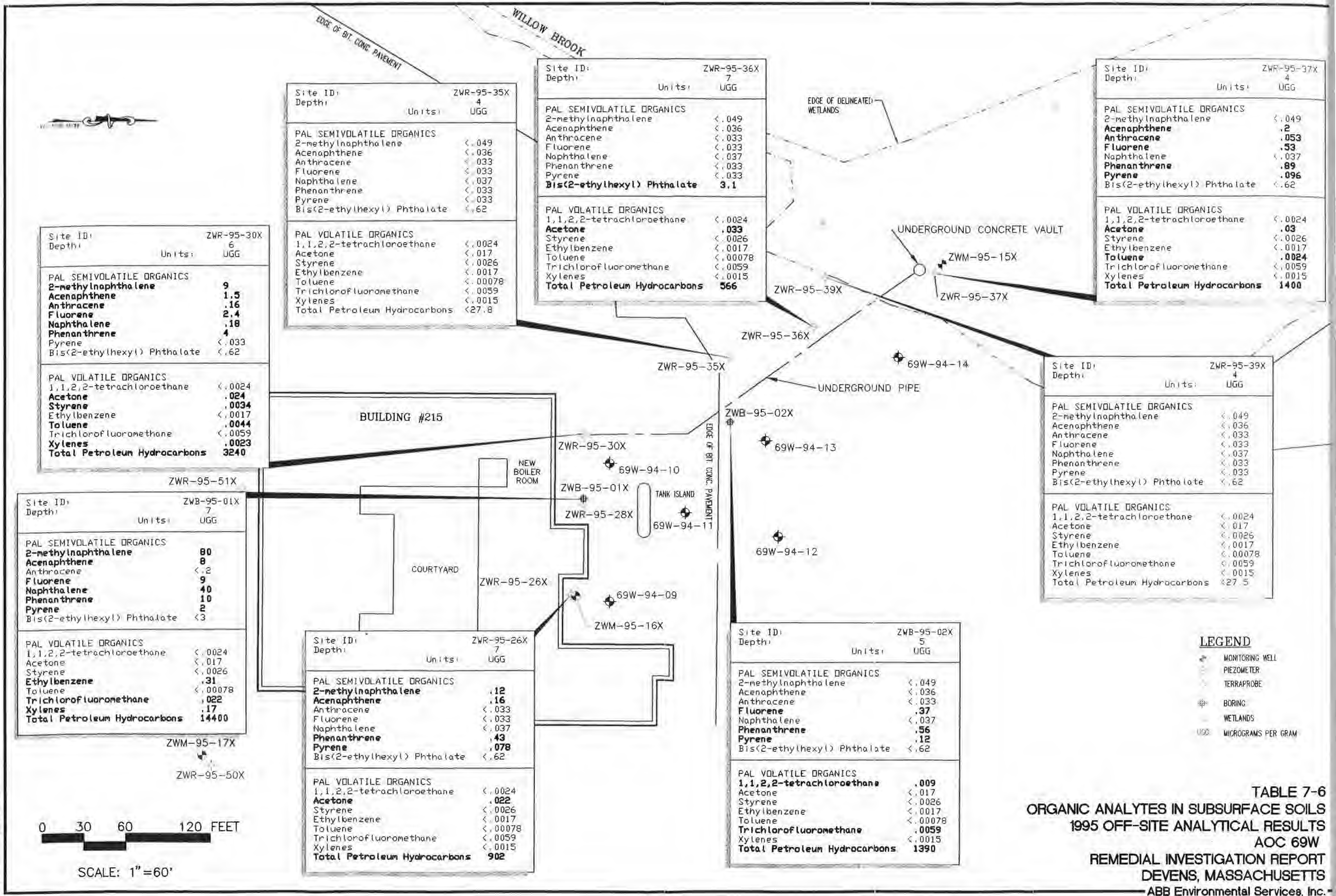
Site ID:	ZWB-95-01X
Depth:	0
Units:	UGG
PAL SEMIVOLATILE ORGANICS	
Acenaphthylene	<.2
Anthracene	<.2
Benzo[k]fluoranthene	<.3
Chrysene	<.6
Fluoranthene	<.3
Fluorene	<.2
Phenanthrene	<.2
Pyrene	<.2
PAL VOLATILE ORGANICS	
Acetone	<.017
Toluene	**.0035**
Trichlorofluoromethane	**.014**
Xylenes	<.0015
Total Petroleum Hydrocarbons	**661**

Site ID:	ZWB-95-02X
Depth:	0
Units:	UGG
PAL SEMIVOLATILE ORGANICS	
Acenaphthylene	<.2
Anthracene	<.2
Benzo[k]fluoranthene	<.3
Chrysene	<.6
Fluoranthene	<.3
Fluorene	<.2
Phenanthrene	<.2
Pyrene	<.2
PAL VOLATILE ORGANICS	
Acetone	<.017
Toluene	<.00078
Trichlorofluoromethane	**.0077**
Xylenes	<.0015
Total Petroleum Hydrocarbons	**98**

Site ID:	ZWS-95-47X
Depth:	0
Units:	UGG
PAL SEMIVOLATILE ORGANICS	
Acenaphthylene	<.033
Anthracene	<.033
Benzo[k]fluoranthene	<.066
Chrysene	**.17**
Fluoranthene	**.19**
Fluorene	<.033
Phenanthrene	**.14**
Pyrene	**.22**
PAL VOLATILE ORGANICS	
Acetone	<.017
Toluene	**.001**
Trichlorofluoromethane	**.0055**
Xylenes	<.0015
Total Petroleum Hydrocarbons	**52.5**

FIGURE 7-5
ORGANIC ANALYTES IN SURFACE SOILS (0-2' BGS)
1995 OFF-SITE ANALYTICAL RESULTS
AOC 69W
REMEDIAL INVESTIGATION REPORT
DEVENS, MASSACHUSETTS

Harding Lawson Associates



Site ID:	ZWR-95-35X
Depth:	4
Units:	UGG
PAL SEMIVOLATILE ORGANICS	
2-methylnaphthalene	<.049
Acenaphthene	<.036
Anthracene	<.033
Fluorene	<.033
Naphthalene	<.037
Phenanthrene	<.033
Pyrene	<.033
Bis(2-ethylhexyl) Phthalate	<.62
PAL VOLATILE ORGANICS	
1,1,2,2-tetrachloroethane	<.0024
Acetone	<.017
Styrene	<.0026
Ethylbenzene	<.0017
Toluene	<.00078
Trichlorofluoromethane	<.0059
Xylenes	<.0015
Total Petroleum Hydrocarbons	<27.8

Site ID:	ZWR-95-36X
Depth:	7
Units:	UGG
PAL SEMIVOLATILE ORGANICS	
2-methylnaphthalene	<.049
Acenaphthene	<.036
Anthracene	<.033
Fluorene	<.033
Naphthalene	<.037
Phenanthrene	<.033
Pyrene	<.033
Bis(2-ethylhexyl) Phthalate	**3.1**
PAL VOLATILE ORGANICS	
1,1,2,2-tetrachloroethane	<.0024
Acetone	**.033**
Styrene	<.0026
Ethylbenzene	<.0017
Toluene	<.00078
Trichlorofluoromethane	<.0059
Xylenes	<.0015
Total Petroleum Hydrocarbons	**566**

Site ID:	ZWR-95-37X
Depth:	4
Units:	UGG
PAL SEMIVOLATILE ORGANICS	
2-methylnaphthalene	<.049
Acenaphthene	**.2**
Anthracene	**.053**
Fluorene	**.53**
Naphthalene	<.037
Phenanthrene	**.89**
Pyrene	**.096**
Bis(2-ethylhexyl) Phthalate	<.62
PAL VOLATILE ORGANICS	
1,1,2,2-tetrachloroethane	<.0024
Acetone	**.03**
Styrene	<.0026
Ethylbenzene	<.0017
Toluene	**.0024**
Trichlorofluoromethane	<.0059
Xylenes	<.0015
Total Petroleum Hydrocarbons	**1400**

Site ID:	ZWR-95-30X
Depth:	6
Units:	UGG
PAL SEMIVOLATILE ORGANICS	
2-methylnaphthalene	**9**
Acenaphthene	**1.5**
Anthracene	**.16**
Fluorene	**2.4**
Naphthalene	**.18**
Phenanthrene	**4**
Pyrene	<.033
Bis(2-ethylhexyl) Phthalate	<.62
PAL VOLATILE ORGANICS	
1,1,2,2-tetrachloroethane	<.0024
Acetone	**.024**
Styrene	**.0034**
Ethylbenzene	<.0017
Toluene	**.0044**
Trichlorofluoromethane	<.0059
Xylenes	**.0023**
Total Petroleum Hydrocarbons	**3240**

Site ID:	ZWR-95-39X
Depth:	4
Units:	UGG
PAL SEMIVOLATILE ORGANICS	
2-methylnaphthalene	<.049
Acenaphthene	<.036
Anthracene	<.033
Fluorene	<.033
Naphthalene	<.037
Phenanthrene	<.033
Pyrene	<.033
Bis(2-ethylhexyl) Phthalate	<.62
PAL VOLATILE ORGANICS	
1,1,2,2-tetrachloroethane	<.0024
Acetone	<.017
Styrene	<.0026
Ethylbenzene	<.0017
Toluene	<.00078
Trichlorofluoromethane	<.0059
Xylenes	<.0015
Total Petroleum Hydrocarbons	<27.5

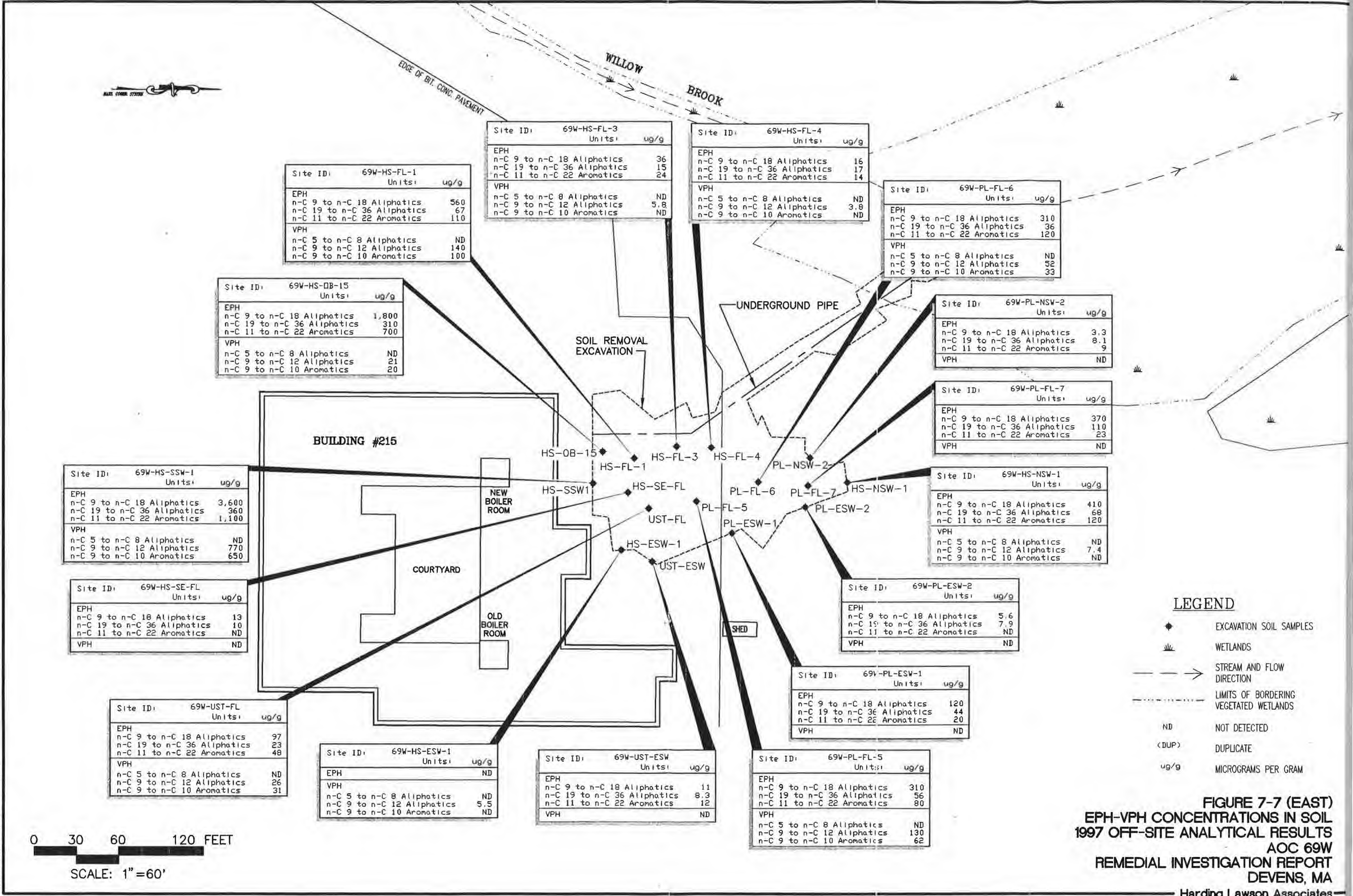
Site ID:	ZWB-95-01X
Depth:	7
Units:	UGG
PAL SEMIVOLATILE ORGANICS	
2-methylnaphthalene	**80**
Acenaphthene	**8**
Anthracene	<.2
Fluorene	**9**
Naphthalene	**40**
Phenanthrene	**10**
Pyrene	**2**
Bis(2-ethylhexyl) Phthalate	<3
PAL VOLATILE ORGANICS	
1,1,2,2-tetrachloroethane	<.0024
Acetone	<.017
Styrene	<.0026
Ethylbenzene	**.31**
Toluene	<.00078
Trichlorofluoromethane	**.022**
Xylenes	**.17**
Total Petroleum Hydrocarbons	**14400**

Site ID:	ZWR-95-26X
Depth:	7
Units:	UGG
PAL SEMIVOLATILE ORGANICS	
2-methylnaphthalene	**.12**
Acenaphthene	**.16**
Anthracene	<.033
Fluorene	<.033
Naphthalene	<.037
Phenanthrene	**.43**
Pyrene	**.078**
Bis(2-ethylhexyl) Phthalate	<.62
PAL VOLATILE ORGANICS	
1,1,2,2-tetrachloroethane	<.0024
Acetone	**.022**
Styrene	<.0026
Ethylbenzene	<.0017
Toluene	<.00078
Trichlorofluoromethane	<.0059
Xylenes	<.0015
Total Petroleum Hydrocarbons	**902**

Site ID:	ZWB-95-02X
Depth:	5
Units:	UGG
PAL SEMIVOLATILE ORGANICS	
2-methylnaphthalene	<.049
Acenaphthene	<.036
Anthracene	<.033
Fluorene	**.37**
Naphthalene	<.037
Phenanthrene	**.56**
Pyrene	**.12**
Bis(2-ethylhexyl) Phthalate	<.62
PAL VOLATILE ORGANICS	
1,1,2,2-tetrachloroethane	**.009**
Acetone	<.017
Styrene	<.0026
Ethylbenzene	<.0017
Toluene	<.00078
Trichlorofluoromethane	**.0059**
Xylenes	<.0015
Total Petroleum Hydrocarbons	**1390**

TABLE 7-6
ORGANIC ANALYTES IN SUBSURFACE SOILS
1995 OFF-SITE ANALYTICAL RESULTS
AOC 69W
REMEDIAL INVESTIGATION REPORT
DEVENS, MASSACHUSETTS

ABB Environmental Services, Inc.



Site ID: 69W-HS-FL-1	Units: ug/g
EPH	
n-C 9 to n-C 18 Aliphatics	560
n-C 19 to n-C 36 Aliphatics	67
n-C 11 to n-C 22 Aromatics	110
VPH	
n-C 5 to n-C 8 Aliphatics	ND
n-C 9 to n-C 12 Aliphatics	140
n-C 9 to n-C 10 Aromatics	100

Site ID: 69W-HS-FL-3	Units: ug/g
EPH	
n-C 9 to n-C 18 Aliphatics	36
n-C 19 to n-C 36 Aliphatics	15
n-C 11 to n-C 22 Aromatics	24
VPH	
n-C 5 to n-C 8 Aliphatics	ND
n-C 9 to n-C 12 Aliphatics	5.8
n-C 9 to n-C 10 Aromatics	ND

Site ID: 69W-HS-FL-4	Units: ug/g
EPH	
n-C 9 to n-C 18 Aliphatics	16
n-C 19 to n-C 36 Aliphatics	17
n-C 11 to n-C 22 Aromatics	14
VPH	
n-C 5 to n-C 8 Aliphatics	ND
n-C 9 to n-C 12 Aliphatics	3.8
n-C 9 to n-C 10 Aromatics	ND

Site ID: 69W-PL-FL-6	Units: ug/g
EPH	
n-C 9 to n-C 18 Aliphatics	310
n-C 19 to n-C 36 Aliphatics	36
n-C 11 to n-C 22 Aromatics	120
VPH	
n-C 5 to n-C 8 Aliphatics	ND
n-C 9 to n-C 12 Aliphatics	52
n-C 9 to n-C 10 Aromatics	33

Site ID: 69W-HS-OB-15	Units: ug/g
EPH	
n-C 9 to n-C 18 Aliphatics	1,800
n-C 19 to n-C 36 Aliphatics	310
n-C 11 to n-C 22 Aromatics	700
VPH	
n-C 5 to n-C 8 Aliphatics	ND
n-C 9 to n-C 12 Aliphatics	21
n-C 9 to n-C 10 Aromatics	20

Site ID: 69W-PL-NSW-2	Units: ug/g
EPH	
n-C 9 to n-C 18 Aliphatics	3.3
n-C 19 to n-C 36 Aliphatics	8.1
n-C 11 to n-C 22 Aromatics	9
VPH	ND

Site ID: 69W-PL-FL-7	Units: ug/g
EPH	
n-C 9 to n-C 18 Aliphatics	370
n-C 19 to n-C 36 Aliphatics	110
n-C 11 to n-C 22 Aromatics	23
VPH	ND

Site ID: 69W-HS-SSW-1	Units: ug/g
EPH	
n-C 9 to n-C 18 Aliphatics	3,600
n-C 19 to n-C 36 Aliphatics	360
n-C 11 to n-C 22 Aromatics	1,100
VPH	
n-C 5 to n-C 8 Aliphatics	ND
n-C 9 to n-C 12 Aliphatics	770
n-C 9 to n-C 10 Aromatics	650

Site ID: 69W-HS-NSW-1	Units: ug/g
EPH	
n-C 9 to n-C 18 Aliphatics	410
n-C 19 to n-C 36 Aliphatics	68
n-C 11 to n-C 22 Aromatics	120
VPH	
n-C 5 to n-C 8 Aliphatics	ND
n-C 9 to n-C 12 Aliphatics	7.4
n-C 9 to n-C 10 Aromatics	ND

Site ID: 69W-HS-SE-FL	Units: ug/g
EPH	
n-C 9 to n-C 18 Aliphatics	13
n-C 19 to n-C 36 Aliphatics	10
n-C 11 to n-C 22 Aromatics	ND
VPH	ND

Site ID: 69W-PL-ESW-2	Units: ug/g
EPH	
n-C 9 to n-C 18 Aliphatics	5.6
n-C 19 to n-C 36 Aliphatics	7.9
n-C 11 to n-C 22 Aromatics	ND
VPH	ND

Site ID: 69W-PL-ESW-1	Units: ug/g
EPH	
n-C 9 to n-C 18 Aliphatics	120
n-C 19 to n-C 36 Aliphatics	44
n-C 11 to n-C 22 Aromatics	20
VPH	ND

Site ID: 69W-UST-FL	Units: ug/g
EPH	
n-C 9 to n-C 18 Aliphatics	97
n-C 19 to n-C 36 Aliphatics	23
n-C 11 to n-C 22 Aromatics	48
VPH	
n-C 5 to n-C 8 Aliphatics	ND
n-C 9 to n-C 12 Aliphatics	26
n-C 9 to n-C 10 Aromatics	31

Site ID: 69W-HS-ESW-1	Units: ug/g
EPH	ND
VPH	
n-C 5 to n-C 8 Aliphatics	ND
n-C 9 to n-C 12 Aliphatics	5.5
n-C 9 to n-C 10 Aromatics	ND

Site ID: 69W-UST-ESW	Units: ug/g
EPH	
n-C 9 to n-C 18 Aliphatics	11
n-C 19 to n-C 36 Aliphatics	8.3
n-C 11 to n-C 22 Aromatics	12
VPH	ND

Site ID: 69W-PL-FL-5	Units: ug/g
EPH	
n-C 9 to n-C 18 Aliphatics	310
n-C 19 to n-C 36 Aliphatics	56
n-C 11 to n-C 22 Aromatics	80
VPH	
n-C 5 to n-C 8 Aliphatics	ND
n-C 9 to n-C 12 Aliphatics	130
n-C 9 to n-C 10 Aromatics	62

LEGEND

◆	EXCAVATION SOIL SAMPLES
⚶	WETLANDS
— — →	STREAM AND FLOW DIRECTION
—··—··—	LIMITS OF BORDERING VEGETATED WETLANDS
ND	NOT DETECTED
(DUP)	DUPLICATE
ug/g	MICROGRAMS PER GRAM

FIGURE 7-7 (EAST)
EPH-VPH CONCENTRATIONS IN SOIL
1997 OFF-SITE ANALYTICAL RESULTS
AOC 69W
REMEDIAL INVESTIGATION REPORT
DEVENS, MA

Harding Lawson Associates

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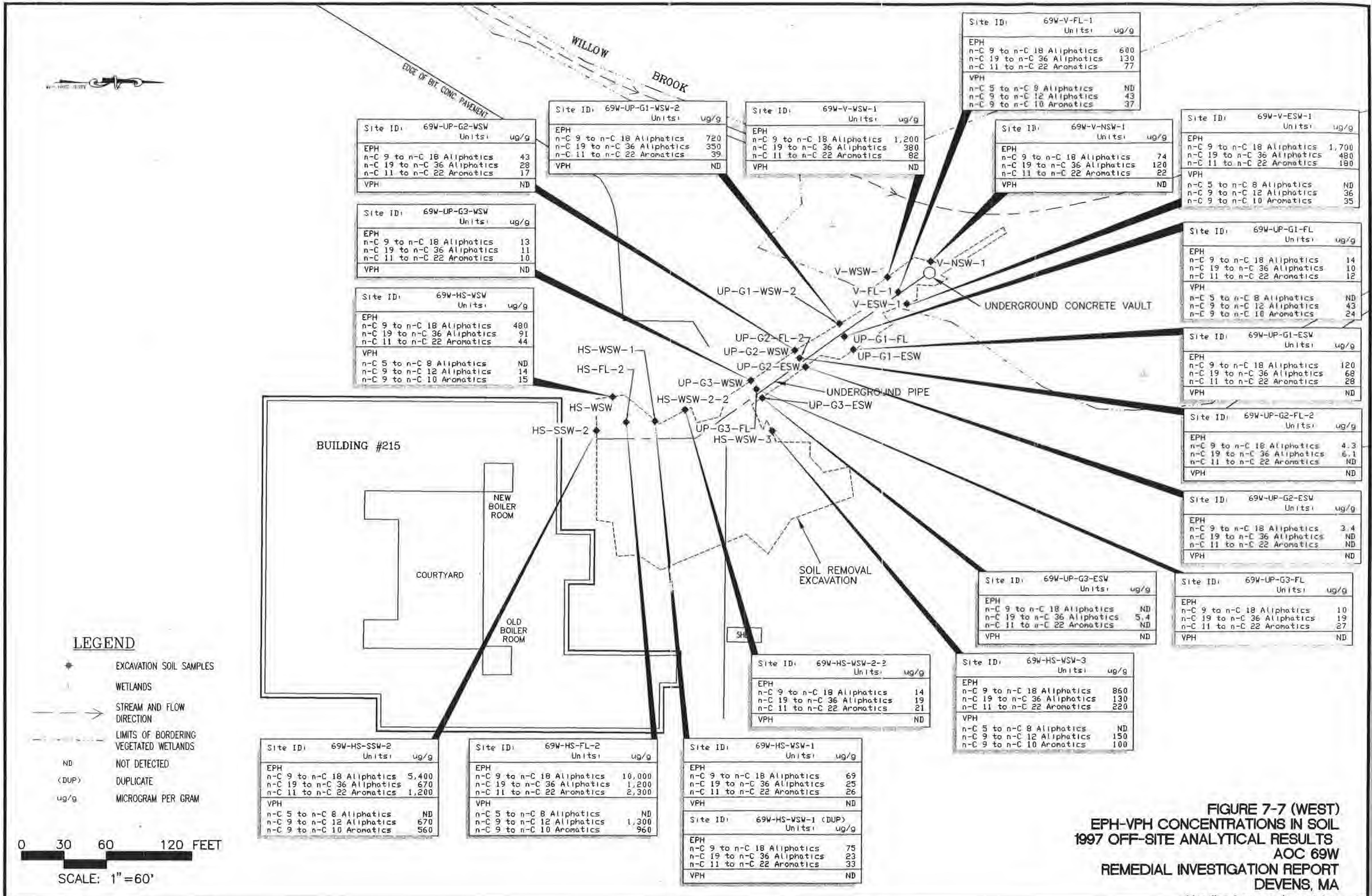

Site ID: 69W-UP-G2-WSW	Units: ug/g
EPH	
n-C 9 to n-C 18 Aliphatics	43
n-C 19 to n-C 36 Aliphatics	28
n-C 11 to n-C 22 Aromatics	17
VPH	ND

Site ID: 69W-UP-G3-WSW	Units: ug/g
EPH	
n-C 9 to n-C 18 Aliphatics	13
n-C 19 to n-C 36 Aliphatics	11
n-C 11 to n-C 22 Aromatics	10
VPH	ND

Site ID: 69W-HS-WSW	Units: ug/g
EPH	
n-C 9 to n-C 18 Aliphatics	480
n-C 19 to n-C 36 Aliphatics	91
n-C 11 to n-C 22 Aromatics	44
VPH	
n-C 5 to n-C 8 Aliphatics	ND
n-C 9 to n-C 12 Aliphatics	14
n-C 9 to n-C 10 Aromatics	15

Site ID: 69W-UP-G1-WSW-2	Units: ug/g
EPH	
n-C 9 to n-C 18 Aliphatics	720
n-C 19 to n-C 36 Aliphatics	350
n-C 11 to n-C 22 Aromatics	39
VPH	ND

Site ID: 69W-V-WSW-1	Units: ug/g
EPH	
n-C 9 to n-C 18 Aliphatics	1,200
n-C 19 to n-C 36 Aliphatics	380
n-C 11 to n-C 22 Aromatics	82
VPH	ND

Site ID: 69W-V-FL-1	Units: ug/g
EPH	
n-C 9 to n-C 18 Aliphatics	600
n-C 19 to n-C 36 Aliphatics	130
n-C 11 to n-C 22 Aromatics	77
VPH	
n-C 5 to n-C 8 Aliphatics	ND
n-C 9 to n-C 12 Aliphatics	43
n-C 9 to n-C 10 Aromatics	37

Site ID: 69W-V-NSW-1	Units: ug/g
EPH	
n-C 9 to n-C 18 Aliphatics	74
n-C 19 to n-C 36 Aliphatics	120
n-C 11 to n-C 22 Aromatics	22
VPH	ND

Site ID: 69W-V-ESW-1	Units: ug/g
EPH	
n-C 9 to n-C 18 Aliphatics	1,700
n-C 19 to n-C 36 Aliphatics	480
n-C 11 to n-C 22 Aromatics	180
VPH	
n-C 5 to n-C 8 Aliphatics	ND
n-C 9 to n-C 12 Aliphatics	36
n-C 9 to n-C 10 Aromatics	35

Site ID: 69W-UP-G1-FL	Units: ug/g
EPH	
n-C 9 to n-C 18 Aliphatics	14
n-C 19 to n-C 36 Aliphatics	10
n-C 11 to n-C 22 Aromatics	12
VPH	
n-C 5 to n-C 8 Aliphatics	ND
n-C 9 to n-C 12 Aliphatics	43
n-C 9 to n-C 10 Aromatics	24

Site ID: 69W-UP-G1-ESW	Units: ug/g
EPH	
n-C 9 to n-C 18 Aliphatics	120
n-C 19 to n-C 36 Aliphatics	68
n-C 11 to n-C 22 Aromatics	28
VPH	ND

Site ID: 69W-UP-G2-FL-2	Units: ug/g
EPH	
n-C 9 to n-C 18 Aliphatics	4.3
n-C 19 to n-C 36 Aliphatics	6.1
n-C 11 to n-C 22 Aromatics	ND
VPH	ND

Site ID: 69W-UP-G2-ESW	Units: ug/g
EPH	
n-C 9 to n-C 18 Aliphatics	3.4
n-C 19 to n-C 36 Aliphatics	ND
n-C 11 to n-C 22 Aromatics	ND
VPH	ND

Site ID: 69W-UP-G3-ESW	Units: ug/g
EPH	
n-C 9 to n-C 18 Aliphatics	ND
n-C 19 to n-C 36 Aliphatics	5.4
n-C 11 to n-C 22 Aromatics	ND
VPH	ND

Site ID: 69W-UP-G3-FL	Units: ug/g
EPH	
n-C 9 to n-C 18 Aliphatics	10
n-C 19 to n-C 36 Aliphatics	19
n-C 11 to n-C 22 Aromatics	27
VPH	ND

Site ID: 69W-HS-WSW-2-2	Units: ug/g
EPH	
n-C 9 to n-C 18 Aliphatics	14
n-C 19 to n-C 36 Aliphatics	19
n-C 11 to n-C 22 Aromatics	21
VPH	ND

Site ID: 69W-HS-WSW-3	Units: ug/g
EPH	
n-C 9 to n-C 18 Aliphatics	860
n-C 19 to n-C 36 Aliphatics	130
n-C 11 to n-C 22 Aromatics	220
VPH	
n-C 5 to n-C 8 Aliphatics	ND
n-C 9 to n-C 12 Aliphatics	150
n-C 9 to n-C 10 Aromatics	100

Site ID: 69W-HS-SSW-2	Units: ug/g
EPH	
n-C 9 to n-C 18 Aliphatics	5,400
n-C 19 to n-C 36 Aliphatics	670
n-C 11 to n-C 22 Aromatics	1,200
VPH	
n-C 5 to n-C 8 Aliphatics	ND
n-C 9 to n-C 12 Aliphatics	670
n-C 9 to n-C 10 Aromatics	560

Site ID: 69W-HS-FL-2	Units: ug/g
EPH	
n-C 9 to n-C 18 Aliphatics	10,000
n-C 19 to n-C 36 Aliphatics	1,200
n-C 11 to n-C 22 Aromatics	2,300
VPH	
n-C 5 to n-C 8 Aliphatics	ND
n-C 9 to n-C 12 Aliphatics	1,300
n-C 9 to n-C 10 Aromatics	960

Site ID: 69W-HS-WSW-1	Units: ug/g
EPH	
n-C 9 to n-C 18 Aliphatics	69
n-C 19 to n-C 36 Aliphatics	25
n-C 11 to n-C 22 Aromatics	26
VPH	ND

Site ID: 69W-HS-WSW-1 (DUP)	Units: ug/g
EPH	
n-C 9 to n-C 18 Aliphatics	75
n-C 19 to n-C 36 Aliphatics	23
n-C 11 to n-C 22 Aromatics	33
VPH	ND

FIGURE 7-7 (WEST)
EPH-VPH CONCENTRATIONS IN SOIL
1997 OFF-SITE ANALYTICAL RESULTS
AOC 69W
REMEDIAL INVESTIGATION REPORT
DEVENS, MA

Harding Lawson Associates

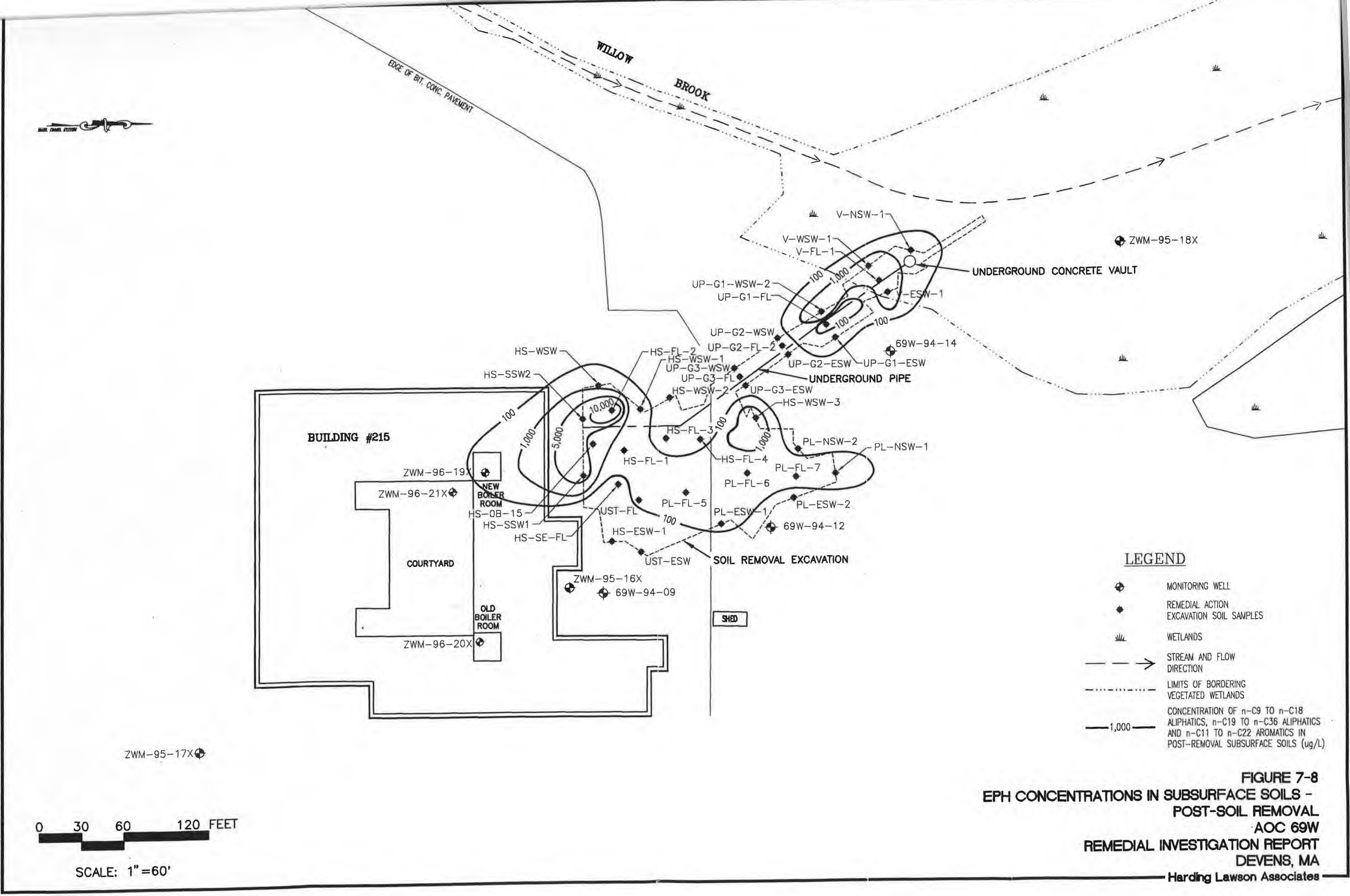

FIGURE 7-8
EPH CONCENTRATIONS IN SUBSURFACE SOILS -
POST-SOIL REMOVAL
AOC 69W
REMEDIAL INVESTIGATION REPORT
DEVENS, MA

Harding Lawson Associates

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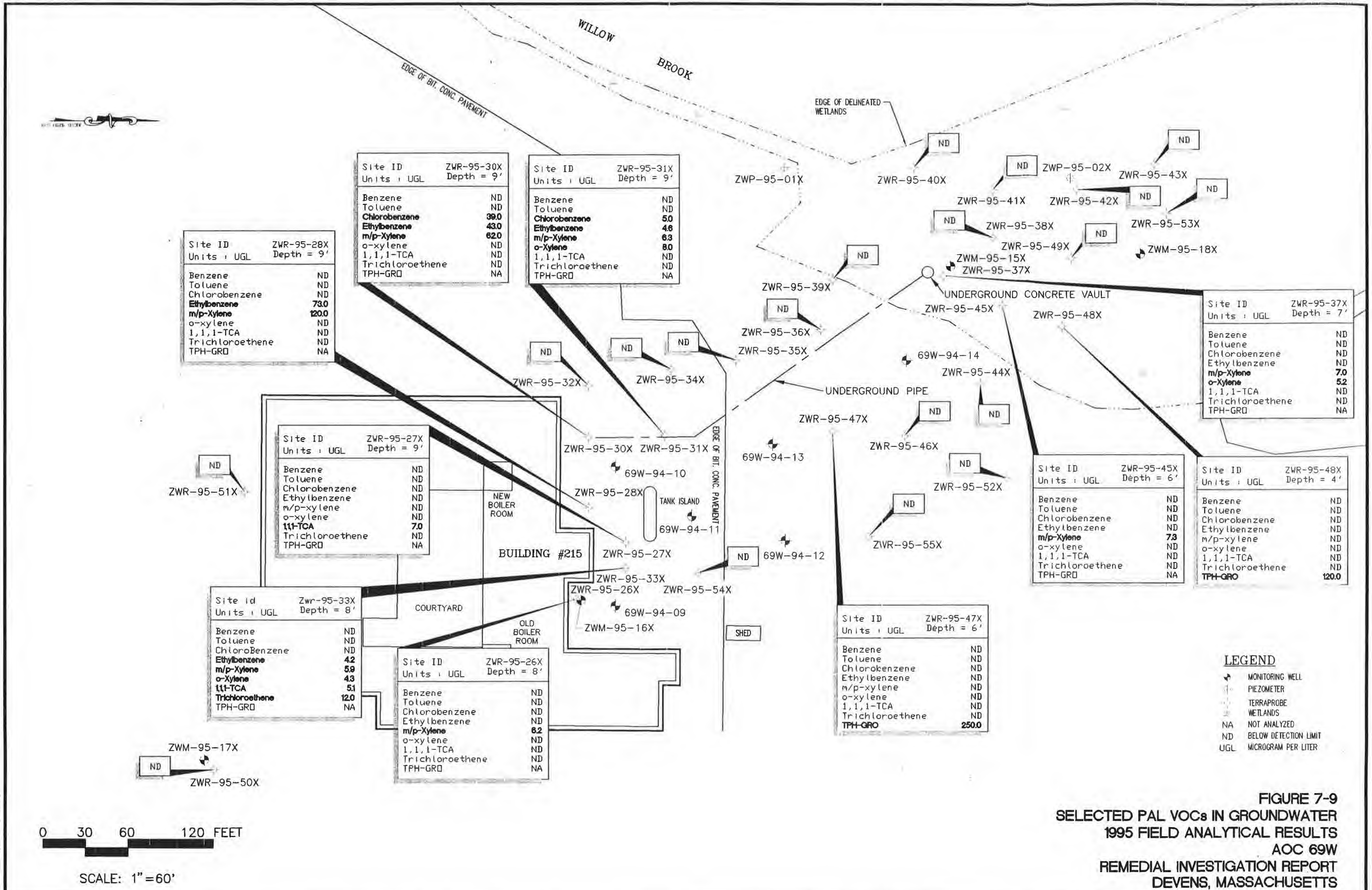

Site ID	ZWR-95-28X
Units : UGL	Depth = 9'
Benzene	ND
Toluene	ND
Chlorobenzene	ND
Ethylbenzene	**73.0**
m/p-Xylene	**120.0**
o-xylene	ND
1,1,1-TCA	ND
Trichloroethene	ND
TPH-GRO	NA

Site ID	ZWR-95-30X
Units : UGL	Depth = 9'
Benzene	ND
Toluene	ND
Chlorobenzene	**39.0**
Ethylbenzene	**43.0**
m/p-Xylene	**62.0**
o-xylene	ND
1,1,1-TCA	ND
Trichloroethene	ND
TPH-GRO	NA

Site ID	ZWR-95-31X
Units : UGL	Depth = 9'
Benzene	ND
Toluene	ND
Chlorobenzene	**5.0**
Ethylbenzene	**4.6**
m/p-Xylene	**6.3**
o-Xylene	**8.0**
1,1,1-TCA	ND
Trichloroethene	ND
TPH-GRO	NA

Site ID	ZWR-95-37X
Units : UGL	Depth = 7'
Benzene	ND
Toluene	ND
Chlorobenzene	ND
Ethylbenzene	ND
m/p-Xylene	**7.0**
o-Xylene	**5.2**
1,1,1-TCA	ND
Trichloroethene	ND
TPH-GRO	NA

Site ID	ZWR-95-27X
Units : UGL	Depth = 9'
Benzene	ND
Toluene	ND
Chlorobenzene	ND
Ethylbenzene	ND
m/p-xylene	ND
o-xylene	ND
1,1,1-TCA	**7.0**
Trichloroethene	ND
TPH-GRO	NA

Site ID	ZWR-95-45X
Units : UGL	Depth = 6'
Benzene	ND
Toluene	ND
Chlorobenzene	ND
Ethylbenzene	ND
m/p-Xylene	**7.3**
o-xylene	ND
1,1,1-TCA	ND
Trichloroethene	ND
TPH-GRO	NA

Site ID	ZWR-95-48X
Units : UGL	Depth = 4'
Benzene	ND
Toluene	ND
Chlorobenzene	ND
Ethylbenzene	ND
m/p-xylene	ND
o-xylene	ND
1,1,1-TCA	ND
Trichloroethene	ND
TPH-GRO	**120.0**

Site Id	Zwr-95-33X
Units : UGL	Depth = 8'
Benzene	ND
Toluene	ND
ChloroBenzene	ND
Ethylbenzene	**4.2**
m/p-Xylene	**5.9**
o-Xylene	**4.3**
1,1,1-TCA	**5.1**
Trichloroethene	**12.0**
TPH-GRO	NA

Site ID	ZWR-95-26X
Units : UGL	Depth = 8'
Benzene	ND
Toluene	ND
Chlorobenzene	ND
Ethylbenzene	ND
m/p-Xylene	**6.2**
o-xylene	ND
1,1,1-TCA	ND
Trichloroethene	ND
TPH-GRO	NA

Site ID	ZWR-95-47X
Units : UGL	Depth = 6'
Benzene	ND
Toluene	ND
Chlorokenzene	ND
Ethylbenzene	ND
m/p-xylene	ND
o-xylene	ND
1,1,1-TCA	ND
Trichloroethene	ND
TPH-GRO	**250.0**

LEGEND

●	MONITORING WELL
	PIEZOMETER
	TERRAPROBE
	WETLANDS
NA	NOT ANALYZED
ND	BELOW DETECTION LIMIT
UGL	MICROGRAM PER LITER

FIGURE 7-9
SELECTED PAL VOCs IN GROUNDWATER
1995 FIELD ANALYTICAL RESULTS
AOC 69W
REMEDIAL INVESTIGATION REPORT
DEVENS, MASSACHUSETTS

Harding Lawson Associates

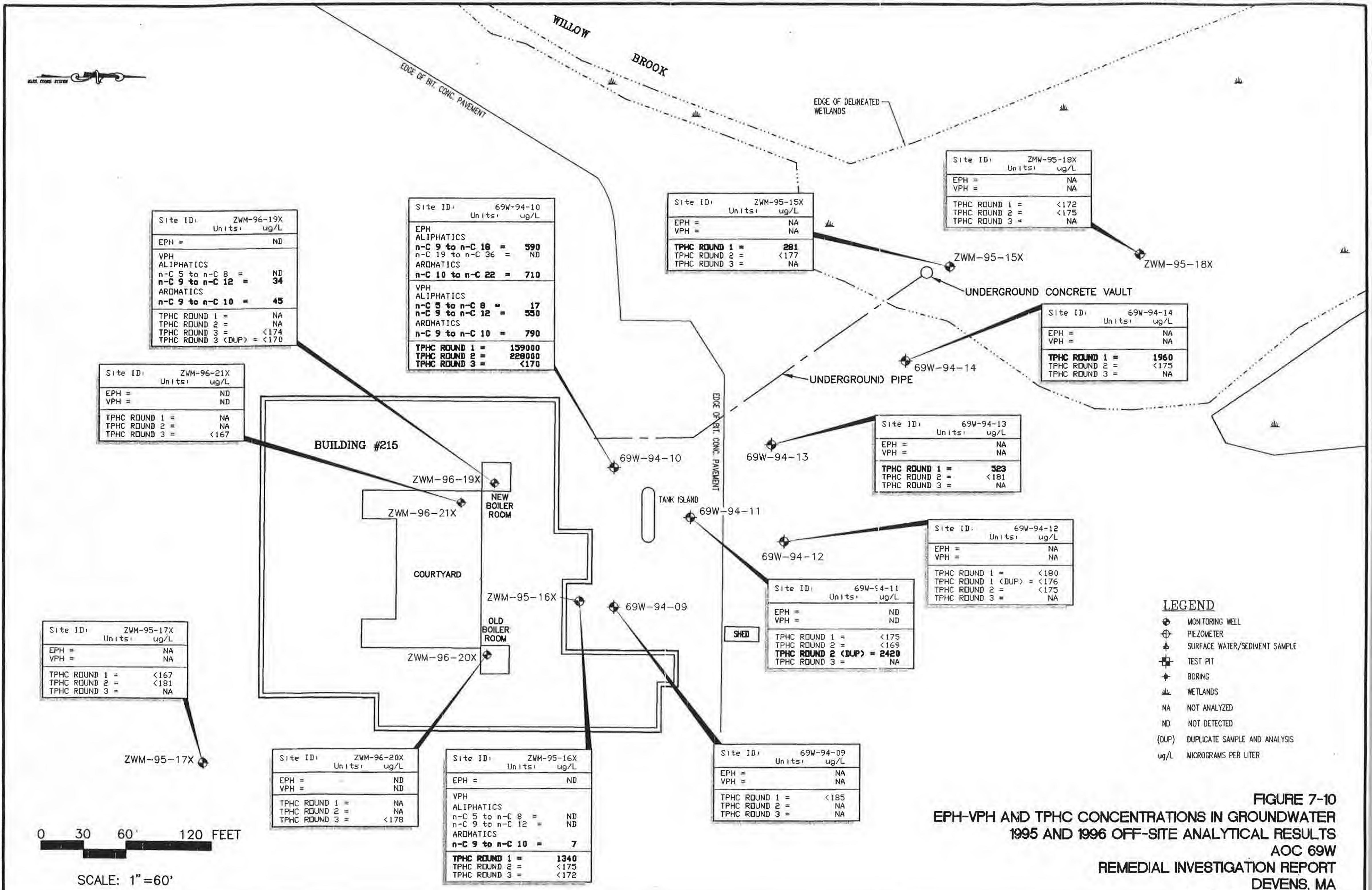

FIGURE 7-10
EPH-VPH AND TPHC CONCENTRATIONS IN GROUNDWATER
1995 AND 1996 OFF-SITE ANALYTICAL RESULTS
AOC 69W
REMEDIAL INVESTIGATION REPORT
DEVENS, MA

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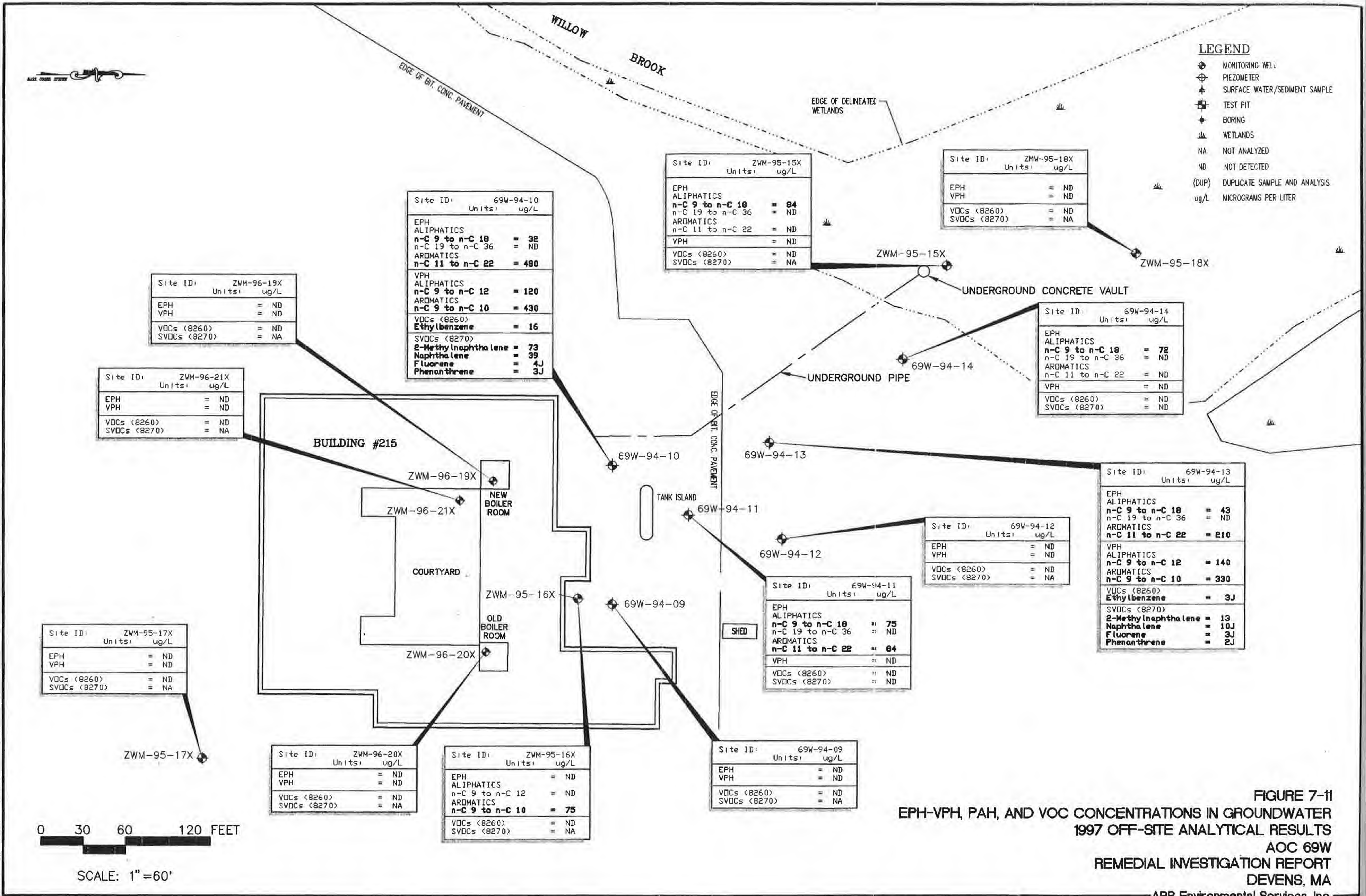


LEGEND

⊕	MONITORING WELL
⊕	PIEZOMETER
✦	SURFACE WATER/SEDIMENT SAMPLE
▣	TEST PIT
✦	BORING
⩊	WETLANDS
NA	NOT ANALYZED
ND	NOT DETECTED
(DUP)	DUPLICATE SAMPLE AND ANALYSIS
ug/L	MICROGRAMS PER LITER

Site ID:	ZWM-95-15X
Units:	ug/L
EPH	
ALIPHATICS	
n-C 9 to n-C 18	**= 84**
n-C 19 to n-C 36	= ND
AROMATICS	
n-C 11 to n-C 22	= ND
VPH	= ND
VOCs (8260)	= ND
SVOCs (8270)	= NA

Site ID:	ZMW-95-18X
Units:	ug/L
EPH	= ND
VPH	= ND
VOCs (8260)	= ND
SVOCs (8270)	= NA

Site ID:	69W-94-10
Units:	ug/L
EPH	
ALIPHATICS	
n-C 9 to n-C 18	**= 32**
n-C 19 to n-C 36	= ND
AROMATICS	
n-C 11 to n-C 22	**= 480**
VPH	
ALIPHATICS	
n-C 9 to n-C 12	**= 120**
AROMATICS	
n-C 9 to n-C 10	**= 430**
VOCs (8260)	
Ethylbenzene	**= 16**
SVOCs (8270)	
2-Methylnaphthalene	**= 73**
Naphthalene	**= 39**
Fluorene	**= 4J**
Phenanthrene	**= 3J**

Site ID:	ZWM-96-19X
Units:	ug/L
EPH	= ND
VPH	= ND
VOCs (8260)	= ND
SVOCs (8270)	= NA

Site ID:	ZWM-96-21X
Units:	ug/L
EPH	= ND
VPH	= ND
VOCs (8260)	= ND
SVOCs (8270)	= NA

Site ID:	69W-94-14
Units:	ug/L
EPH	
ALIPHATICS	
n-C 9 to n-C 18	**= 72**
n-C 19 to n-C 36	= ND
AROMATICS	
n-C 11 to n-C 22	= ND
VPH	= ND
VOCs (8260)	= ND
SVOCs (8270)	= ND

Site ID:	69W-94-13
Units:	ug/L
EPH	
ALIPHATICS	
n-C 9 to n-C 18	**= 43**
n-C 19 to n-C 36	= ND
AROMATICS	
n-C 11 to n-C 22	**= 210**
VPH	
ALIPHATICS	
n-C 9 to n-C 12	**= 140**
AROMATICS	
n-C 9 to n-C 10	**= 330**
VOCs (8260)	
Ethylbenzene	**= 3J**
SVOCs (8270)	
2-Methylnaphthalene	**= 13**
Naphthalene	**= 10J**
Fluorene	**= 3J**
Phenanthrene	**= 2J**

Site ID:	69W-94-12
Units:	ug/L
EPH	= ND
VPH	= ND
VOCs (8260)	= ND
SVOCs (8270)	= NA

Site ID:	69W-94-11
Units:	ug/L
EPH	
ALIPHATICS	
n-C 9 to n-C 18	**= 75**
n-C 19 to n-C 36	= ND
AROMATICS	
n-C 11 to n-C 22	**= 84**
VPH	= ND
VOCs (8260)	= ND
SVOCs (8270)	= ND

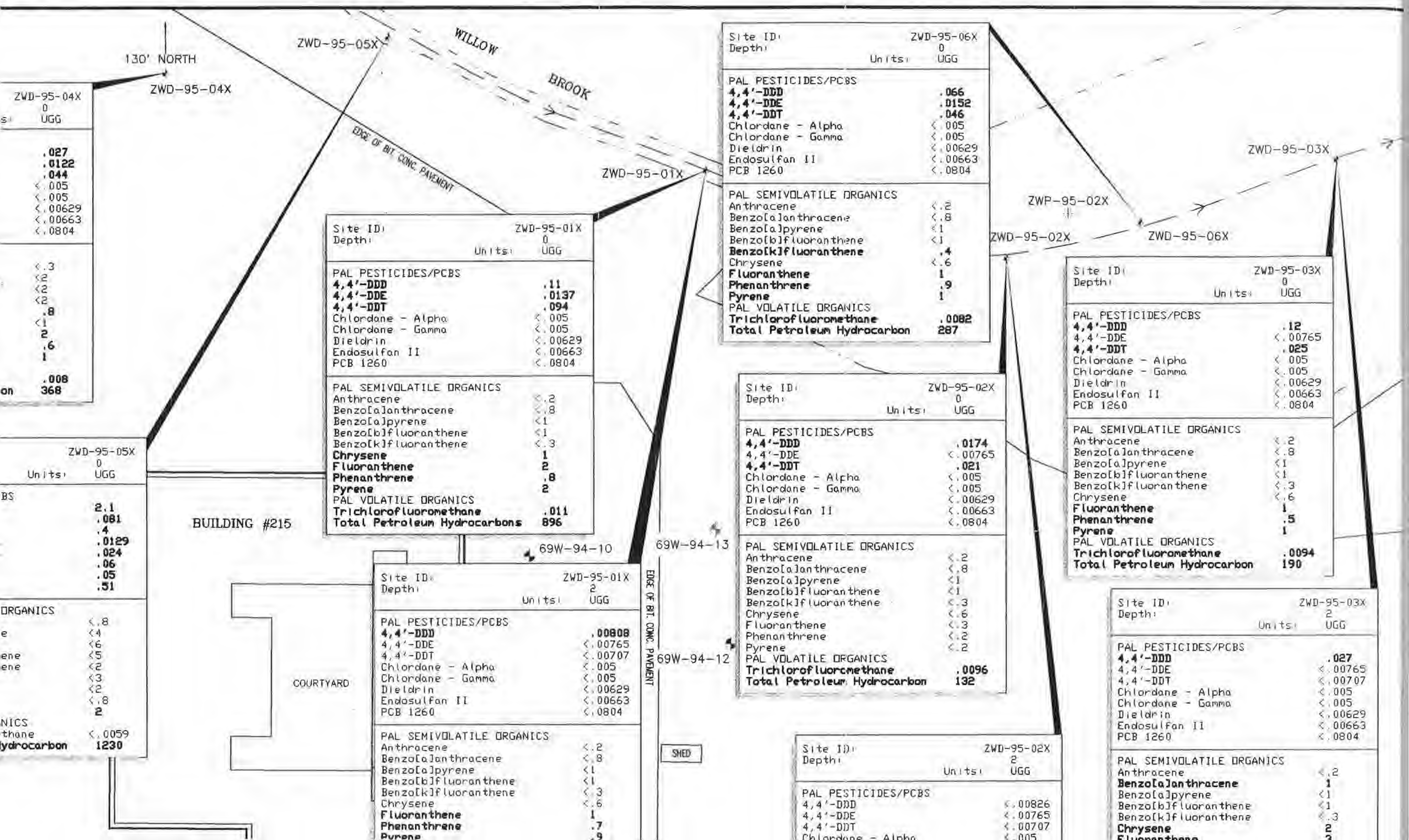
Site ID:	ZWM-95-17X
Units:	ug/L
EPH	= ND
VPH	= ND
VOCs (8260)	= ND
SVOCs (8270)	= NA

Site ID:	ZWM-96-20X
Units:	ug/L
EPH	= ND
VPH	= ND
VOCs (8260)	= ND
SVOCs (8270)	= NA

Site ID:	ZWM-95-16X
Units:	ug/L
EPH	= ND
ALIPHATICS	
n-C 9 to n-C 12	= ND
AROMATICS	
n-C 9 to n-C 10	**= 75**
VOCs (8260)	= ND
SVOCs (8270)	= NA

Site ID:	69W-94-09
Units:	ug/L
EPH	= ND
VPH	= ND
VOCs (8260)	= ND
SVOCs (8270)	= NA

FIGURE 7-11
EPH-VPH, PAH, AND VOC CONCENTRATIONS IN GROUNDWATER
1997 OFF-SITE ANALYTICAL RESULTS
AOC 69W
REMEDIAL INVESTIGATION REPORT
DEVENS, MA
ABB Environmental Services, Inc.



	ZWD-95-04X
	0
s:	UGG
	.027
	.0122
	.044
	<.005
	<.005
	<.00629
	<.00663
	<.0804
	<.3
	<2
	<2
	<2
	.8
	<1
	2
	.6
	1
	.008
on	**368**

	ZWD-95-05X
	0
Units:	UGG
BS	
	2.1
	.081
	.4
	.0129
	.024
	.06
	.05
	.51
ORGANICS	
	<.8
e	<4
	<6
ene	<5
ene	<2
	<3
	<2
	<.8
	2
NICS	
thane	<.0059
ydrocarbon	**1230**

Site ID:	ZWD-95-01X
Depth:	0
Units:	UGG
PAL PESTICIDES/PCBS	
4,4'-DDD	**.11**
4,4'-DDE	**.0137**
4,4'-DDT	**.094**
Chlordane - Alpha	<.005
Chlordane - Gamma	<.005
Dieldrin	<.00629
Endosulfan II	<.00663
PCB 1260	<.0804
PAL SEMIVOLATILE ORGANICS	
Anthracene	<.2
Benzo[a]anthracene	<.8
Benzo[a]pyrene	<1
Benzo[b]fluoranthene	<1
Benzo[k]fluoranthene	<.3
Chrysene	**1**
Fluoranthene	**2**
Phenanthrene	**.8**
Pyrene	**2**
PAL VOLATILE ORGANICS	
Trichlorofluoromethane	**.011**
Total Petroleum Hydrocarbons	**896**

Site ID:	ZWD-95-06X
Depth:	0
Units:	UGG
PAL PESTICIDES/PCBS	
4,4'-DDD	**.066**
4,4'-DDE	**.0152**
4,4'-DDT	**.046**
Chlordane - Alpha	<.005
Chlordane - Gamma	<.005
Dieldrin	<.00629
Endosulfan II	<.00663
PCB 1260	<.0804
PAL SEMIVOLATILE ORGANICS	
Anthracene	<.2
Benzo[a]anthracene	<.8
Benzo[a]pyrene	<1
Benzo[b]fluoranthene	<1
Benzo[k]fluoranthene	**.4**
Chrysene	<.6
Fluoranthene	**1**
Phenanthrene	**.9**
Pyrene	**1**
PAL VOLATILE ORGANICS	
Trichlorofluoromethane	**.0082**
Total Petroleum Hydrocarbon	**287**

Site ID:	ZWD-95-02X
Depth:	0
Units:	UGG
PAL PESTICIDES/PCBS	
4,4'-DDD	**.0174**
4,4'-DDE	<.00765
4,4'-DDT	**.021**
Chlordane - Alpha	<.005
Chlordane - Gamma	<.005
Dieldrin	<.00629
Endosulfan II	<.00663
PCB 1260	<.0804
PAL SEMIVOLATILE ORGANICS	
Anthracene	<.2
Benzo[a]anthracene	<.8
Benzo[a]pyrene	<1
Benzo[b]fluoranthene	<1
Benzo[k]fluoranthene	<.3
Chrysene	<.6
Fluoranthene	<.3
Phenanthrene	<.2
Pyrene	<.2
PAL VOLATILE ORGANICS	
Trichlorofluoromethane	**.0096**
Total Petroleum Hydrocarbon	**132**

Site ID:	ZWD-95-03X
Depth:	0
Units:	UGG
PAL PESTICIDES/PCBS	
4,4'-DDD	**.12**
4,4'-DDE	<.00765
4,4'-DDT	**.025**
Chlordane - Alpha	<.005
Chlordane - Gamma	<.005
Dieldrin	<.00629
Endosulfan II	<.00663
PCB 1260	<.0804
PAL SEMIVOLATILE ORGANICS	
Anthracene	<.2
Benzo[a]anthracene	<.8
Benzo[a]pyrene	<1
Benzo[b]fluoranthene	<1
Benzo[k]fluoranthene	<.3
Chrysene	<.6
Fluoranthene	**1**
Phenanthrene	**.5**
Pyrene	**1**
PAL VOLATILE ORGANICS	
Trichlorofluoromethane	**.0094**
Total Petroleum Hydrocarbon	**190**

Site ID:	ZWD-95-01X
Depth:	2
Units:	UGG
PAL PESTICIDES/PCBS	
4,4'-DDD	**.00808**
4,4'-DDE	<.00765
4,4'-DDT	<.00707
Chlordane - Alpha	<.005
Chlordane - Gamma	<.005
Dieldrin	<.00629
Endosulfan II	<.00663
PCB 1260	<.0804
PAL SEMIVOLATILE ORGANICS	
Anthracene	<.2
Benzo[a]anthracene	<.8
Benzo[a]pyrene	<1
Benzo[b]fluoranthene	<1
Benzo[k]fluoranthene	<.3
Chrysene	<.6
Fluoranthene	**1**
Phenanthrene	**.7**
Pyrene	**.9**

Site ID:	ZWD-95-02X
Depth:	2
Units:	UGG
PAL PESTICIDES/PCBS	
4,4'-DDD	<.00826
4,4'-DDE	<.00765
4,4'-DDT	<.00707
Chlordane - Alpha	<.005

Site ID:	ZWD-95-03X
Depth:	2
Units:	UGG
PAL PESTICIDES/PCBS	
4,4'-DDD	**.027**
4,4'-DDE	<.00765
4,4'-DDT	<.00707
Chlordane - Alpha	<.005
Chlordane - Gamma	<.005
Dieldrin	<.00629
Endosulfan II	<.00663
PCB 1260	<.0804
PAL SEMIVOLATILE ORGANICS	
Anthracene	<.2
Benzo[a]anthracene	**1**
Benzo[a]pyrene	<1
Benzo[b]fluoranthene	<1
Benzo[k]fluoranthene	<.3
Chrysene	**2**
Fluoranthene	**3**

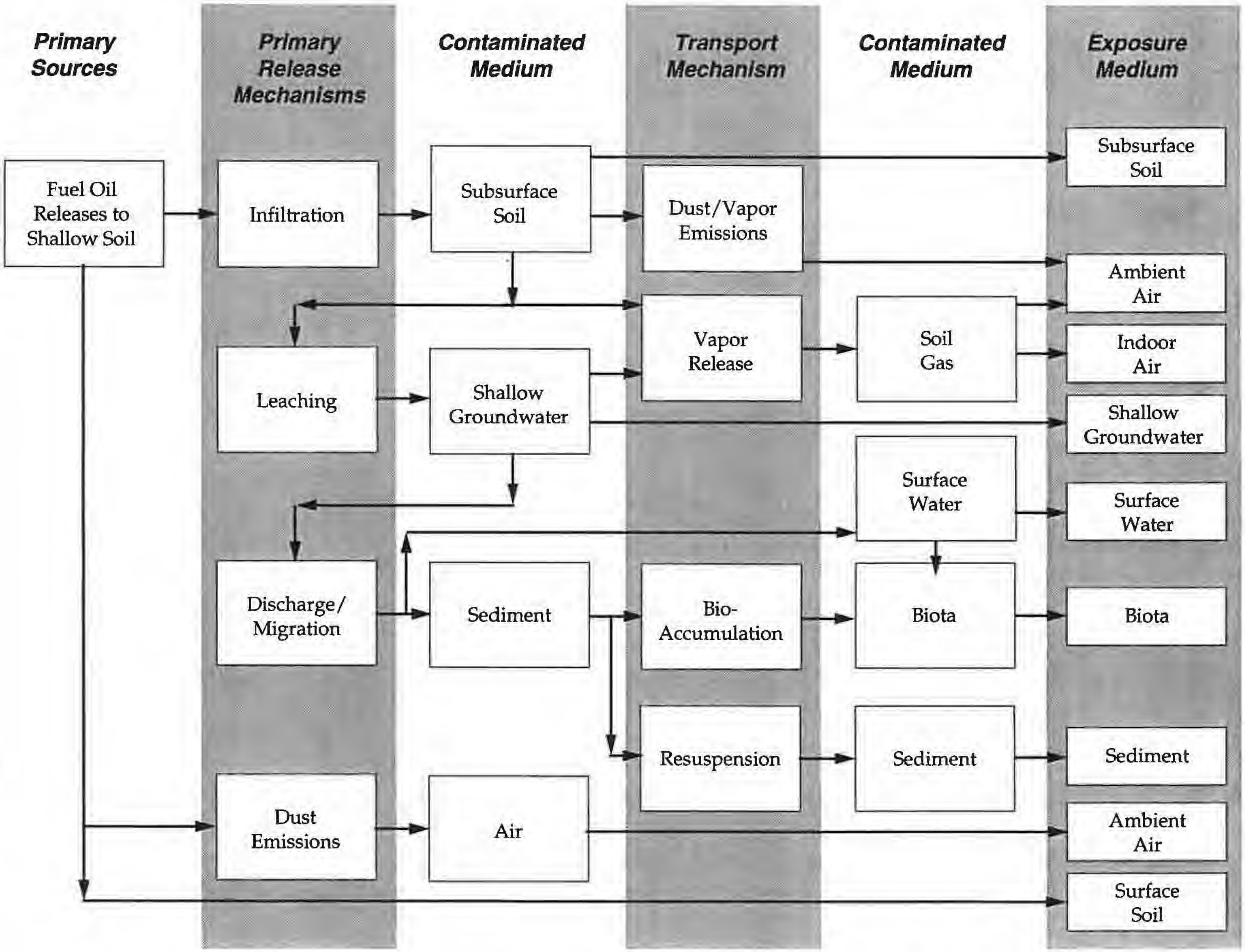


FIGURE 8-1
CONCEPTUAL MODEL FLOW DIAGRAM
AOC 69W
REMEDIAL INVESTIGATION REPORT
DEVENS, MASSACHUSETTS

9808002D(b)

Harding Lawson Associates

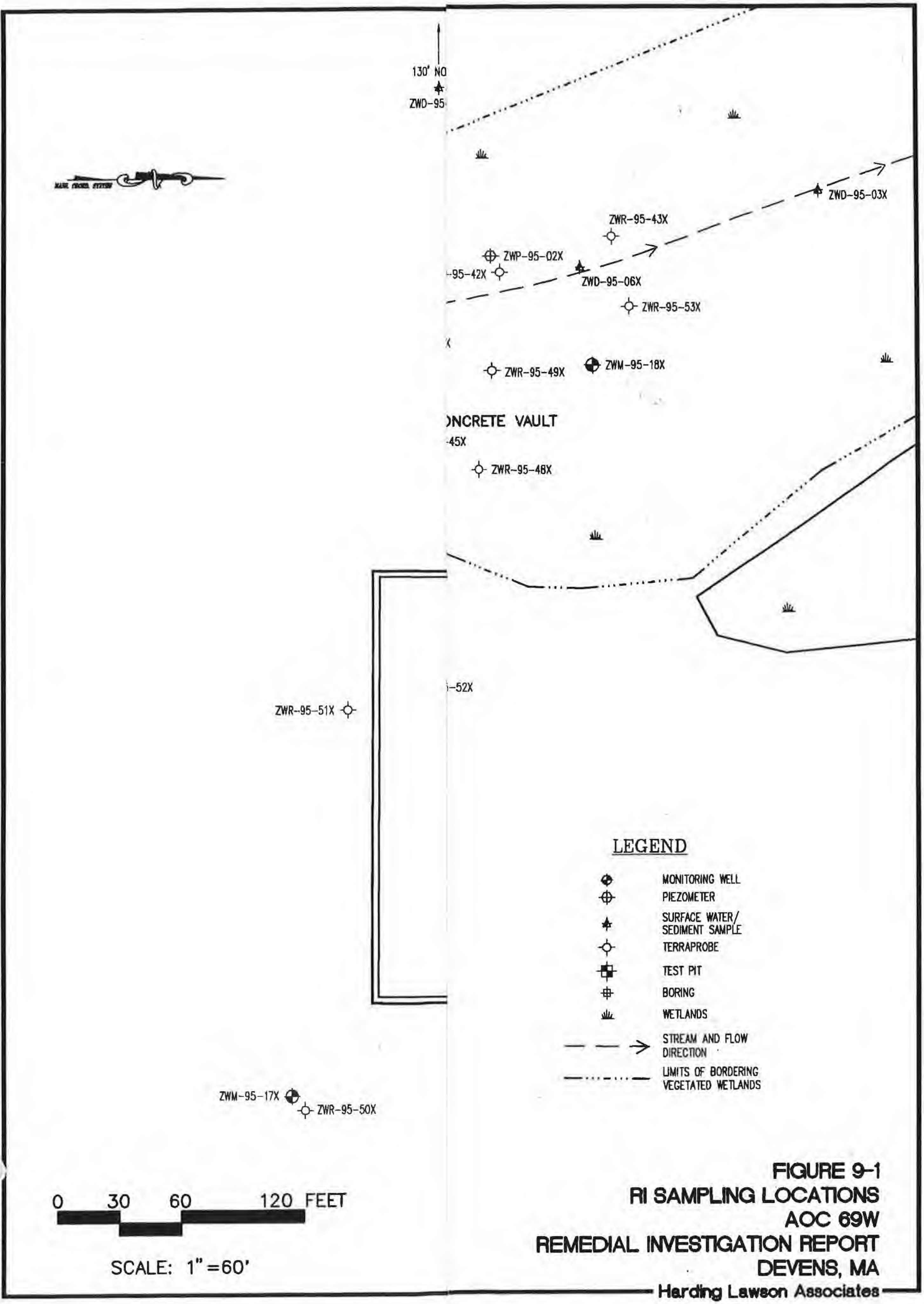


FIGURE 9-1
RI SAMPLING LOCATIONS
AOC 69W
REMEDIAL INVESTIGATION REPORT
DEVENS, MA

Harding Lawson Associates

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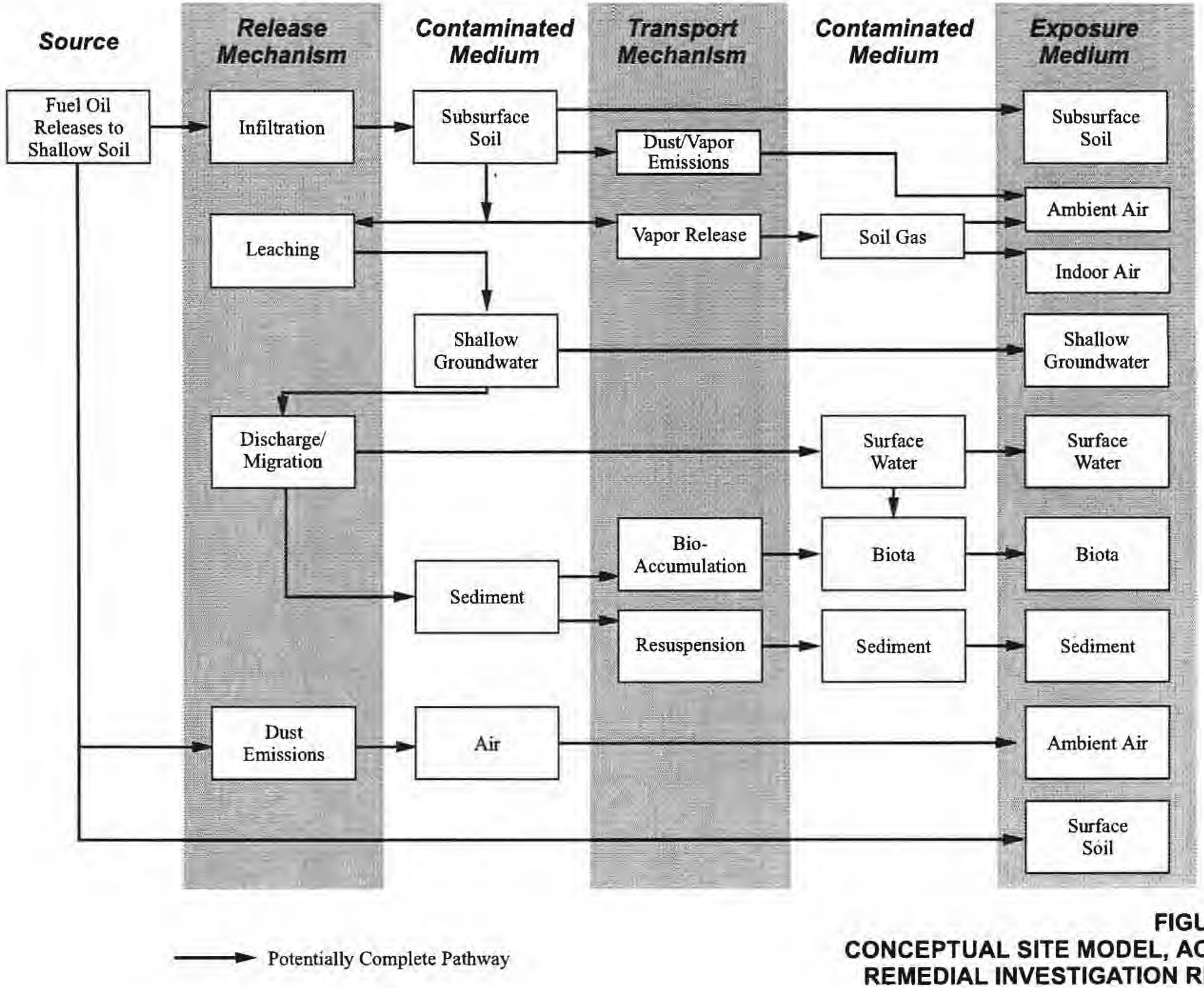
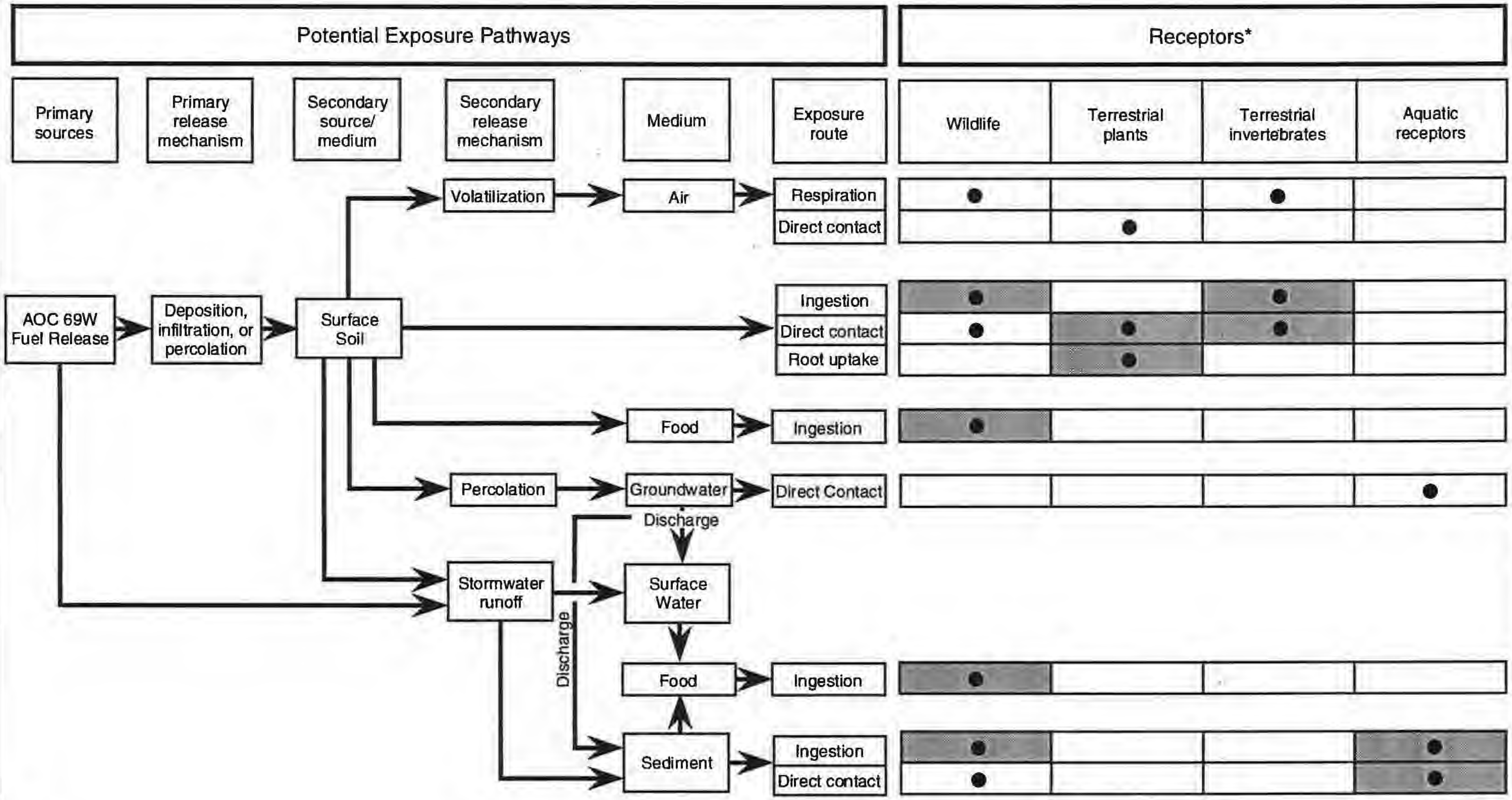


FIGURE 9-2
CONCEPTUAL SITE MODEL, AOC 69W
REMEDIAL INVESTIGATION REPORT
DEVENS MASSACHUSETTS
Harding Lawson Associates

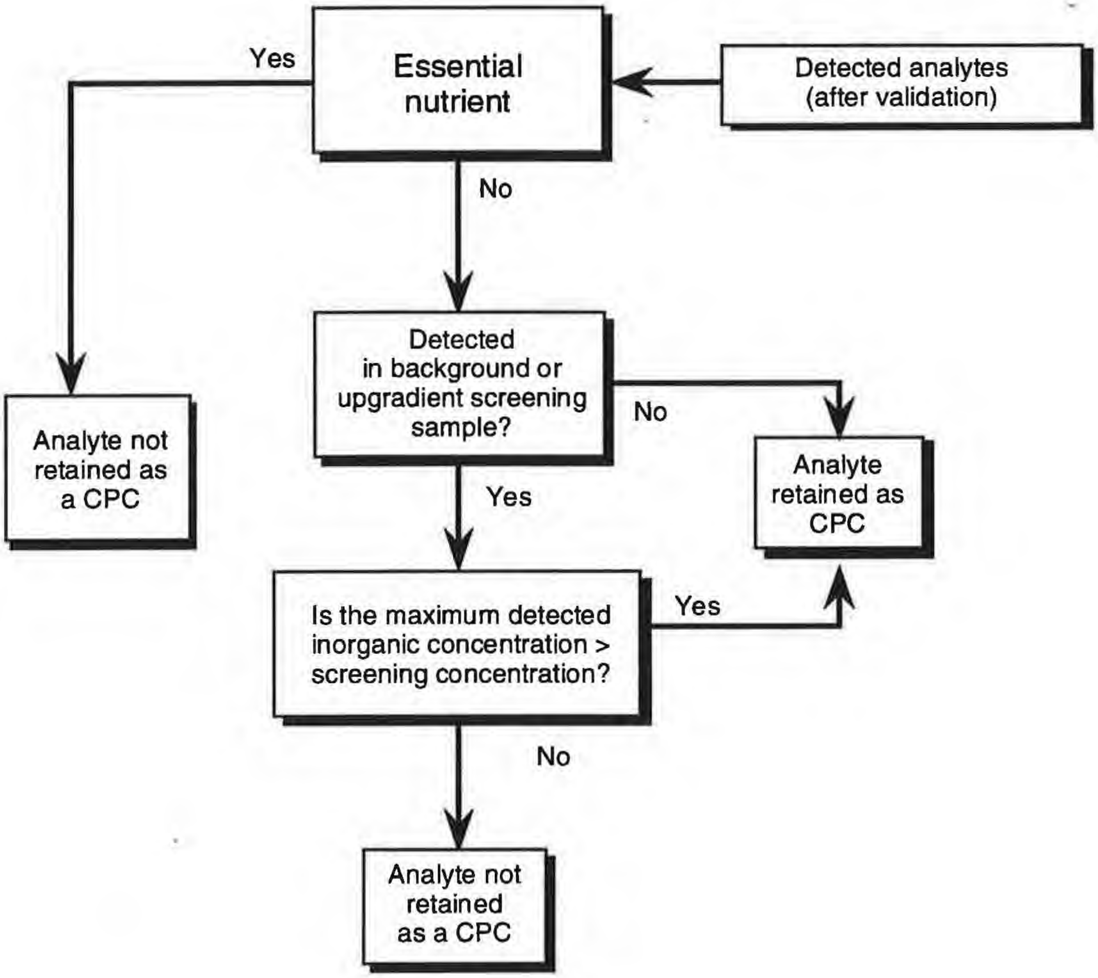
W9804011(g)



Key

ERA = ecological risk assessment
AOC = Area of contamination
* = Shading indicates the exposure pathways that are quantitatively evaluated for receptors in the AOC 69W ERA. Nonshaded pathways are evaluated qualitatively, not evaluated due to the lack of toxicity information, or not evaluated because it is not considered a significant pathway.

FIGURE 9-3
CONTAMINANT PATHWAY MODEL FOR ECOLOGICAL RECEPTORS EXPOSED TO AOC 69W SURFACE SOIL, SEDIMENT, AND GROUNDWATER
REMEDIAL INVESTIGATION REPORT
AOC 69W
DEVENS, MA



Key

CPC = Contaminant of potential concern
AOC = Area of contamination
\> = greater than

FIGURE 9-4
ECOLOGICAL CONTAMINANT OF POTENTIAL CONCERN SELECTION PROCESS
REMEDIAL INVESTIGATION REPORT
AOC 69W
DEVENS, MA