FINAL
EXPEDITED SITE INSPECTION WORK PLAN FOR PER- AND POLYFLUOROALKYL SUBSTANCES (PFAS)

FORMER FORT DEVENS ARMY INSTALLATION
DEVENS, MA

MAY 2017

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

Prepared by:
KOMAN Government Solutions, LLC
Contract No: W912WJ-16-D-0008

EXPEDITED SITE INSPECTION WORK PLAN FOR PER- AND POLYFLUOROALKYL SUBSTANCES (PFAS)

Former Fort Devens Army Installation
Devens, Massachusetts

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May 2017

CERTIFICATION:

I hereby certify that the enclosed report, shown and marked in this submittal, is that proposed to be incorporated with Contract Number W912WJ-16-D-0008. This document was prepared in accordance with the U.S. Army Corps of Engineers (USACE) Scope of Work and is hereby submitted for Government approval.

Reviewed By:

5/4/17

KGS Project Manager **Date**

Received By:

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Digitally signed by REDDY.PENELOPE.W.1502105066
DN: c=US, o=U.S. Government, ou=DoD, ou=PKI, ou=USA,
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USACE Project Manager **Date**

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LIST OF ACRONYMS AND ABBREVIATIONS

AFFF	Aqueous Film Forming Foam
ADR	Automated Data Review
AOC	Areas of Contamination
Army	U.S. Army
bgs	below grade surface
BRAC	Base Realignment and Closure
CERCLA	Comprehensive Environmental Response, Compensation and Liability Act
DRFTA	Devens Reserve Forces Training Area
HAL	Health Advisory Level
KGS	KOMAN Government Solutions, LLC
LOQ	Limit of Quantitation
MAAF	Moore Army Airfield
MassDEP	Massachusetts Department of Environmental Protection
MassDevelopment	Massachusetts Development and Finance Agency
NAE	North Atlantic Division, New England District
NPL	National Priorities List
ng/L	nanograms per liter (parts per trillion)
PFAS	Per- and Polyfluoroalkyl Substances
PFOA	Perfluorooctanoic Acid
PFOS	Perfluorooctanesulfonic Acid
PVC	Polyvinyl Chloride
QA/QC	Quality Assurance / Quality Control
QAPP	Quality Assurance Project Plan
QSM	Quality Systems Manual
SA	Study Area
SEDD	Staged Electronic Data Deliverable
SI	Site Inspection
SOP	Standard Operating Procedure
USACE	U.S. Army Corps of Engineers
USEPA	U.S. Environmental Protection Agency
µg/L	micrograms per liter (parts per billion)

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1.0 INTRODUCTION

KOMAN Government Solutions (KGS), on behalf of the U.S. Army Corps of Engineers New England District (USACE-NAE), has prepared this Work Plan for conducting a Site Inspection (SI) of potential groundwater contamination by per- and polyfluoroalkyl substances (together, "PFAS") at the Former Fort Devens Army Installation (Fort Devens) in Devens, Massachusetts.

The United States Environmental Protection Agency (USEPA) has identified PFAS as an "emerging contaminant of concern" and, in January 2009, established provisional Health Advisory Levels (HALs) for Perfluorooctanesulfonic Acid (PFOS), which is used in aqueous film forming foams (AFFF) to extinguish fires, and Perfluorooctanoic Acid (PFOA), which is used in a variety of consumer products. In May 2016, the USEPA issued a lifetime drinking water HAL of 0.07 micrograms per liter (µg/L) for both PFOS and PFOA following toxicity studies (USEPA, 2016a, 2016b).

Based on historical U.S. Army (Army) operations at Fort Devens, the USEPA has requested that groundwater samples be collected from areas where PFAS may have been used or released to the environment. In 2016, the Army conducted a Preliminary Assessment of PFAS at Fort Devens and found that additional areas warranted further investigation based upon previous use and disposal of PFAS (KGS, 2016a). It was concluded that potential PFAS impacts should be further investigated under an SI, pursuant to the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA).

1.1 SCOPE AND PURPOSE

The objective of this SI work plan is to assess the potential presence of PFAS compounds in environmental media that may pose potential risks to receptors at the Former Fort Devens Army Installation. The SI describes the methodology that will be implemented to properly collect and analyze the groundwater samples from the subject site. Additional details of field sampling, analytical procedures, standard operating procedures (SOPs), and quality control requirements are presented in the Quality Assurance Project Plan (QAPP) (KGS, 2016b).

1.2 SITE DESCRIPTION AND HISTORY

1.2.1 Site History

The Former Fort Devens Army Installation is located in the towns of Ayer and Shirley in Middlesex County, and the towns of Harvard and Lancaster in Worcester County, Massachusetts, approximately 35 miles northwest of Boston, Massachusetts (**Figure 1**). The installation occupied approximately 9,260 acres. Prior to the official base closure, Devens was divided into the North Post, Main Post, and South Post. Route 2 divides the South Post from the Main Post. The Nashua River runs through the North, Main, and South Posts. The area surrounding Fort Devens is primarily comprised of rural residential properties. Portion of the Former Fort Devens have been redeveloped for commercial/industrial use.

Camp Devens was established in 1917 as a temporary training area for soldiers during World War I. Prior to 1917, the area was occupied by residential homes and farmland. In 1932, the site was named Fort Devens and made a permanent installation with the primary mission of commanding, training, and providing logistical support for non-divisional troop units. The installation also supported the Army Readiness Regional and National Guard units in the New England area. Fort Devens was used for a variety of training missions between 1917 and 1990. Pursuant to CERCLA, as amended by the Superfund Amendments and Reauthorization Act of 1986, Fort Devens was placed on the National Priorities List (NPL) on November 21, 1989, due to areas of identified environmental contamination.

Fort Devens was identified for cessation of operations and closure under Public Law 101-510 and the Defense Base Realignment and Closure (BRAC) Act of 1990 and was officially closed in March 1996. As part of the Devens BRAC program, portions of the property formerly occupied by Fort Devens were retained by the Army for reserve forces training and renamed the Defense Reserve Force Training Area (DRFTA). Areas not retained as part of DRFTA were, or are in the process of being, transferred to new owners for reuse and redevelopment.

In May 1996, portions of the Main and North Posts, and all of the South Post, were realigned as DRFTA. A total of 5,181.64 acres (344.94 acres of the Main Post enclave and 4,836.70 acres of the South Post) were retained for DRFTA with an additional 444.10 acres pending lease or transfer. Also in 1996, 3,040.4 acres were either leased (686.4 acres) or transferred (2,354 acres) to the Massachusetts Development and Finance Agency (MassDevelopment), Devens Commerce Center. A total of 1,079.62 acres was transferred to other federal agencies in 1997, including 221.62 acres to the Department of Justice Bureau of Prisons and 22 acres to the Department of Labor Job Corps Center.

1.2.2 Physical Property Characteristics

Fort Devens is located within the Nashua River basin, which encompasses 529 square miles within New Hampshire and Massachusetts. The Nashua River flows north through Fort Devens to the Merrimack River at Nashua, New Hampshire. The geography of Fort Devens is characterized by about 10,000 acres of undulating glacial terrain. Land surface elevations within Fort Devens range from about 200 feet (ft) above mean sea level (msl) along the Nashua River on the northern boundary to 450 ft above msl in the southern portion of the installation.

The Nashua River forms the eastern installation boundary on the South Post and much of the western boundary of the Main Post. The river flows through the North Post in a channel within a broad floodplain. The river meanders extensively through the Oxbow National Wildlife Refuge in the area of the South Post.

Much of the terrain at Devens is dominated by accumulations of glaciofluvial and glaciolacustrine deposits originating in glacial meltwater streams and lakes. These deposits underlie the extensive flat areas at the Moore Army Airfield on the North Post. Kame and kettle topography is present on the South Post and on the Main Post near Mirror Lake.

1.2.3 Base Wide Preliminary Assessment

On 18 March 2016, USEPA issued Former Fort Devens Installation Dispute Resolution Issues No. 6-8. The letter required the Army to conduct a base wide evaluation of PFAS due to the emerging contaminant status of these compounds and potential historical use. The Army submitted a draft Preliminary Assessment for the Former Fort Devens to USEPA on 27 September 2016. It was concluded that potential PFAS impacts should be further investigated at the Former Moore

Army Airfield (Area of Concern [AOC] 50) drum storage area (Study Area [SA] 31) and the fire training area (SA 30), the former Defense Reuse and Marketing Office (DRMO) AOC 32 under an SI, pursuant to the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA).

On 01 November 2016 EPA issued a letter requesting a SI Work Plan be expedited based upon potential PFAS impacts to groundwater. The letter included additional investigation areas at AOC 50, Shepley's Hill Landfill (AOC 5), the Devens Waste Water Treatment Plant (SA 19, SA 20, and SA 21), a potential disposal site at the end of Barnum Road and a potential disposal site located on Antietam Street. The letter requested sampling be conducted at these areas using existing monitoring wells.

On 15 November 2016, USEPA issued comments on the draft Preliminary Assessment which included the additional investigation areas requested in the 01 November 2016 USEPA letter. The Army conducted additional interviews and research into the investigation areas recommended by USEPA to further pinpoint the potential PFAS locations. The Army Response to Comments, issued on 30 December 2016, indicated additional samples would be collected at AOC 50, Shepley's Hill Landfill, the Devens Waste Water Treatment Plant, an area on Barnum Road and at the location of former Building T-1445, where a fire occurred, which was previously identified as Antietam Road.

The Barnum Road location is identified in the Army's Response to Comment as new SA 74 and the Building T-1445 location is identified as new SA 75.

The locations of the subject Study Areas and AOCs at the former Fort Devens are presented on **Figure 2**.

1.2.4 Conceptual Site Model

An initial Conceptual Site Model (CSM) will be developed based on examination and evaluation of the analytical data collected under this SI Work Plan. The CSM will consider PFAS historical use and disposal at the former Fort Devens facility, the potential nature and extent of potential PFAS impacts and any potential pathways of exposure to current and future human and ecological receptors.

1.3 SELECT SAMPLING AREAS

The areas of investigation (**Figure 2**) presented below were selected based upon historical site use, proximity to potential former fire training areas, and suspected disposal sites identified in the Preliminary Assessment (KGS, 2016). Proposed sample locations and the rationale for each area discussed below are summarized in **Table 1.**

- Shepley's Hill Landfill (AOC 5) (**Figure 3)**

Shepley's Hill Landfill was not identified as a potential release site during the Preliminary Assessment (KGS, 2016a); however, it is a location of municipal waste disposal during the operational period of Fort Devens. As such, it may have received materials containing PFAS. As indicated in the 01 November 2016 USEPA Expedited Site Inspections for PFAS letter, Shepley's Hill Landfill was requested to be included in the evaluation due to its historical use as a municipal landfill. Eighteen existing monitoring wells and two extraction wells within and surrounding Shepley's Hill Landfill, as presented in **Figure 9,** will be sampled to determine if PFAS are present in groundwater.

- Devens Wastewater Treatment Plant (WWTP) (SAs 20 and 21) (**Figure 4)**

The Devens Waste Water Treatment Plant was not identified as a potential release site during the Preliminary Assessment (KGS, 2016a); however, it is a location of industrial and residential wastewater disposal during the operational period of Fort Devens and may be a continual source of PFAS. As indicated in the 01 November 2016 USEPA Expedited Site Inspections for PFAS letter, the Devens Waste Water Treatment Plant was requested to be included in the evaluation due to its historical use as a waste water treatment facility. Three soil and six groundwater locations (three from existing monitoring wells and three from temporary well points), as shown on **Figure 10,** will be sampled to determine if PFAS are present in soil or groundwater. In addition, the treatment plant influent and effluent will be sampled to determine if PFAS are present.

- SA 74 (Barnum Road Devens Fire Historical Dump Site) (**Figure 5**)

The Preliminary Assessment (KGS, 2016a) included interviews with persons having knowledge of past and present operations at Fort Devens. The initial interview with the Devens Fire Chief Joseph LeBlanc and the Deputy Fire Chief Scott Adams indicated that excess firefighting foam may have been disposed of in the area at the end of Barnum Road; however, a second interview was conducted with Fire Chief LeBlanc on 22 December 2016 and additional details regarding the exact location of foam disposal and use were obtained. Fire Chief LeBlanc explained that past training exercises with firefighting foam were conducted behind former Building 3773. As a result of this clarification, Study Area 74 was initiated and sampling will be conducted at this location to determine if PFAS are present in soil or groundwater. Three soil and five groundwater locations (all from temporary well points), as shown on **Figure 11,** will be sampled to determine if PFAS are present in soil or groundwater at SA 74.

- SA 75 (Building T-1445 Warehouse Fire) (**Figure 6**)

The Preliminary Assessment (KGS, 2016a) included interviews with persons having knowledge of past and present operations at Fort Devens. The initial interview with the Devens Fire Chief Joseph LeBlanc and the Deputy Fire Chief Scott Adams indicated that excess firefighting foam may have been disposed of in the area at the end of Barnum Road; however, a second interview was conducted with Fire Chief LeBlanc on 22 December 2016 and additional details regarding the exact location of foam disposal and use were obtained. Fire Chief LeBlanc explained that a large warehouse fire had occurred at former Building T-1445 (around the late 1980s/early 1990s). Due to the storage of flammable substances, the nature of the fire, and for purposes of firefighter safety, any available foam at that time was used to suppress the fire. As a result of this clarification, SA 75 was initiated and sampling will be conducted at locations topographically downgradient from the former building location to determine if PFAS are present in soil or groundwater. Three soil and seven groundwater locations (three from existing monitoring wells and four from temporary well points), as shown on **Figure 12,** will be sampled to determine if PFAS are present in soil or groundwater at SA 75.

- AOC 50 – Former Moore Army Airfield (**Figure 7**)

The Preliminary Assessment (KGS, 2016a) concluded that the Former Drum Storage Area and the Firefighting/Crash Site Training Area warranted further investigation. The Former Drum

Storage Area, former SA 30, is comprised of two locations north of the main airfield runway. These areas were used for drum storage, including 55 gallon drums of firefighting foam concentrate. Soil and groundwater sampling will be conducted at select locations within and downgradient of the former drum storage area. Six soil and six groundwater locations (all from temporary well points), as shown on **Figure 13,** will be sampled to determine if PFAS are present in soil or groundwater at SA 30.

The Firefighting/Crash Site Training Area, former SA 31, is located west of the main runway. The area was used between 1975 and 1986 and consists of a 50- by 50-ft asphalt-covered concrete pad that is 8 inches thick. The pad is surrounded by a 12-inch high by 24-inch wide earthen containment berm.

The shell of a U-8 aircraft was placed in the center of the bermed area to be used as a target during the past firefighting training exercises. Fuels burned and then extinguished on the aircraft shell during the training included contaminated fuel and paint thinner (DEH, 1985b). No discharge of fuel from the training pit has been reported (McMaster et al., 1982). Other disposal activities at SA 31 included burning of fuel samples from the laboratory about once per year (McMaster et al., 1982). One soil and one groundwater sample will be collected from within the former Training Area; and three groundwater samples from temporary well points will be collected downgradient of the former Training Area to determine whether PFAS are present. Two existing monitoring wells will also be sampled to assess deeper groundwater downgradient of potential airfield source areas. Proposed sampling locations are depicted on **Figure 13**.

In addition, the 01 November 2016 USEPA Expedited Site Inspections for PFAS letter requested additional areas be investigated at AOC 50, including the main runway, the former airfield hangars, and the former airfield fire station building. The former airfield hangars (Buildings 3813 and 3818) and fire station were not identified as a potential release site during the Preliminary Assessment (KGS, 2016a); however, these locations may have potentially stored PFAS compounds during the operational period of Fort Devens airfield. As a result, soil and groundwater at and downgradient of the former airfield hangars and fire station have been selected for PFAS sampling. Four soil and five groundwater locations (all from temporary well points), as shown on **Figure 13,** will be sampled to determine if PFAS are present in soil or groundwater at the former airfield hangars. Two soil and two groundwater locations (both from temporary well points), as shown on **Figure 13,** will be sampled to determine if PFAS are present in soil or groundwater at the former fire station.

Interviews conducted during the Preliminary Assessment (KGS, 2016) indicated the main airfield runway may have been foamed during firefighting and crash training. An additional interview conducted with Fire Chief LeBlanc on 22 December 2016 indicated during training it was possible that some of the main runway may have been foamed. As a result, six soil and six groundwater locations (all from temporary well points) are included in this work plan to evaluate the potential presence of PFAS in soil and groundwater adjacent to the former airfield runway. In addition, the foam runoff may have been collected in the airfield storm drainage system (refer to airfield drainage plan in Attachment A) and discharged at storm drain outfalls around the perimeter of the airfield; therefore, soil and groundwater samples will be collected at four storm drain outfalls. Proposed sampling locations are depicted on **Figure 13**.

- AOC 32 (Defense Reutilization and Marketing Office [DRMO] Yards) (**Figure 8**)

The former DRMO Yard was identified as a location to be further investigated in the Preliminary Assessment (KGS, 2016a). Building 204, the former DRMO yard, was researched based upon an interview conducted with the Devens Fire Chief. The Fire Chief indicated that disposal of waste foam may have occurred in this area. The DRMO yard is located near Shepley's Hill Landfill on Cook Street. A review was conducted of historical documents and the yard, included storing scrap metal vehicles, tires, batteries, and used office equipment. All the items stored were for re-use or sale. Hazardous materials were not stored or received at this location (MEP, 1992). No documentation was found indicating that waste firefighting foam was disposed here.

A second interview was conducted with Fire Chief LeBlanc on 22 December 2016 to clarify the previous interview. It was stated that no waste foam was disposed at this location. However, the 01 November 2016 USEPA Expedited Site Inspections for PFAS letter requested that this location be investigated due to historical storage of materials for recycling. Therefore, groundwater samples for PFAS analysis will be collected from eight existing monitoring wells, as shown on **Figure 14**, located at and downgradient of AOC 32.

2.0 FIELD ACTIVITIES

This section presents the specific field procedures that will be used to collect samples and to minimize potential PFAS cross-contamination during sampling. Sample locations and their rationale are summarized in **Table 1** and are depicted on **Figures 9** through **14**[1]. Supporting information regarding past conditions at selected SA/AOCs are presented on **Figure 15**, **Figure 16**, and in **Attachment A**. Data Quality Objectives for PFAS sampling at each SA/AOC are summarized in **Tables 2** through **7**.

2.1 GROUNDWATER SAMPLE COLLECTION

Strict precautions will be followed during PFAS sample collection in order to avoid potential cross-contamination, as described in **Section 2.5** and **Attachment B**.

Groundwater monitoring wells and temporary well point locations were selected based upon information obtained during the Preliminary Assessment (KGS, 2016), historic groundwater flow direction was obtained from annual reports and/or topographical features. Proposed monitoring points located downgradient, or at lower elevations, were selected near potential PFAS use or disposal areas.

Groundwater samples will be collected from existing wells where possible, and analyzed for PFAS using modified Method 537. In locations where monitoring wells are not present, temporary well points will be installed. Groundwater samples will be collected from these temporary well points and analyzed for PFAS using modified Method 537. **Table 1** indicates the sample locations selected for each AOC and SA listed in **Section 1.3. Figures 9** through **14** indicate the sample locations.

Temporary wells will be advanced using a Geoprobe® drill rig and SP16® groundwater sampler. Direct Push technology will be used to advance the SP16® sampler to the water table. **Attachment C** includes Standard Operating Procedures (SOP) for the Geoprobe® SP16® sampling device. Temporary well groundwater samples shall be collected using the following procedure:

- Advance a 2-foot, screened-tip into the water table using direct-push tooling and drill rig;
- Expose the screened-tip by raising the tooling 2 feet;
- Install ¼-inch polyethylene tubing through the tooling to the center of the screen interval;
- Attach tubing to peristaltic pump[2] at the ground surface and purge groundwater at a minimum rate of 100 milliliters per minute (mL/min) using USEPA Region 1 Low Stress Purging and Sampling Procedures (USEPA, 2010);
- Collect groundwater sample by filling sample containers directly from tubing. In accordance with the QAPP Addendum, groundwater samples shall be collected in two

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[1] Sample locations (as shown in figures) may be adjusted based on actual field conditions (e.g., accessibility issues or to better target a drainage channel).

[2] If the groundwater sample cannot be collected using a peristaltic pump (e.g., due to the depth of the sampling interval), then a bladder pump will be used instead, provided no Teflon-containing materials are used (e.g., no Teflon-lined tubing. See also the field sampling protocols to avoid cross-contamination of PFAS in Appendix B.

250 mL High Density Polyethylene (HDPE) jars with non-Teflon lids containing no preservative and stored on ice;

- Remove tubing and direct-push tooling with screened-tip from the borehole and decontaminate equipment with Alconox and de-ionized water; dispose of tubing in accordance with **Section 2.6**.

As feasible, the borehole for the groundwater sample will be a continuation of the borehole used to collect the collocated shallow soil sample (**Section 2.3**); otherwise, the groundwater sample borehole will be installed within 3 feet of the soil sample borehole.

As noted in Attachment C, most of the components of the Geoprobe® SP16® sampling device are comprised of stainless steel; however, several O-rings of unknown construction are depicted. Prior to sampling, the drilling subcontractor will be consulted regarding the O-ring material and its potential to cause false-positive PFAS detection in groundwater samples. If the potential for false positives is uncertain, then a field blank sample may be collected of de-ionized water run through the sampling device.

Boreholes will be abandoned after sample collection by filling the entire length of the borehole with cement grout.

Groundwater samples will be collected using low-flow procedures for both existing monitoring wells and temporary well points using USEPA Region 1 Low Stress Purging and Sampling Procedure (USEPA, 2010).

Groundwater sample collection will include using disposable non-Teflon tubing and pumps. Samples will be collected from all locations and submitted for PFAS analysis. Sample bottles will be filled to below the bottle lip and will be capped and agitated gently by inverting the bottles a few times.

All samples to be submitted for PFAS analysis in accordance with modified Method 537. Samples will be stored separately on ice upon collection and delivered by courier to the TestAmerica[3]-Boston service center located in Waltham, Massachusetts for logging and subsequent shipment to TestAmerica-Sacramento for laboratory analysis.

The target analyte lists, methods, and project reporting limits are summarized in **Table 8.** QC samples are summarized in **Table 9**. Laboratory reporting limits are summarized in **Table 10**.

2.2 WATER QUALITY MEASUREMENTS

Samples will be collected for water quality parameters during low flow purging and prior to PFAS sample collection. A multi-parameter meter will be inserted into the sample to measure pH, dissolved oxygen, specific conductance, temperature, and oxygen reduction potential. Turbidity will be measured separately with a turbidity meter. Water quality parameters from the groundwater wells will be collected following established procedures used for long-term groundwater monitoring[4]. Data will be recorded on field forms included as **Attachment D**.

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[3] TestAmerica, or a similarly qualified and Massachusetts/DoD-certified laboratory approved by USACE.

[4] See low-flow sampling procedures in Attachment C. Also per established groundwater sampling methodologies at Fort Devens (e.g., Sovereign, 2015).

2.3 SOIL SAMPLE COLLECTION

Samples for soils will be collected using Geoprobe® MacroCore® soil sampler (or equivalent) from 0 to 5 feet below grade surface at the locations indicated in **Table 1**. Soil logging will be performed from the recovered soil cores. A composite sample shall be collected from the sample interval. In accordance with the QAPP Addendum included as **Attachment E,** soil samples shall be collected in a 250-mL wide mouth HDPE bottle with a non-Teflon lid. Samples will be filled to below the bottle lip and capped tightly.

All soil samples will be submitted for PFAS analysis in accordance with USEPA Modified Method 537. Samples will be stored separately on ice upon collection and delivered by courier to the TestAmerica-Boston[5] service center located in Waltham, Massachusetts for logging and subsequent shipment to TestAmerica-Sacramento for laboratory analysis.

The target analyte lists, methods, and project reporting limits are summarized in **Table 8.** QC samples are summarized in **Table 9**. Laboratory reporting limits are summarized in **Table 10**.

2.4 QUALITY CONTROL SAMPLES

Field samples will be collected from the locations listed in **Section 1.3**. The specific QC samples to be collected are summarized below and in **Table 9**:

Field Duplicate Samples

Field duplicate samples will be collected one for every ten samples collected.

Laboratory Duplicate Sample

Two samples (selected by the laboratory) will be prepared in duplicate and analyzed for PFAS with the field samples. These results will be used to assess the PFAS sample preparation procedures.

Matrix Spike/Matrix Spike Duplicate Samples

Matrix spike/matrix spike duplicate samples will be collected for every twenty samples collected.

Field Blank Samples

Field blank (FB) samples will be collected for every ten samples collected. PFAS-free DI water will be obtained from the laboratory and shipped to the field and used to prepare the field blanks.

The bottle will be sealed and labeled as FB- X and submitted for PFAS analysis.

Equipment Blank Sample

One equipment blank sample will be collected from cleaned and decontaminated groundwater sampling equipment daily. Each equipment blank will be collected by pouring PFAS-free DI water over the sample equipment into a preserved sample bottle. The bottle will be sealed and labeled as EB- X and submitted for the full suite of analyses. Additional equipment blanks may be collected if warranted to evaluate if PFAS is present in sampling equipment.

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[5] TestAmerica, or a similarly qualified and Massachusetts/DoD-certified laboratory approved by USACE.

The field blanks collected with the PFAS samples will be packaged, shipped with the PFAS samples and analyzed to ensure that PFAS were not introduced into samples during sample collection and handling.

2.5 PREVENTION OF PFAS CROSS-CONTAMINATION

PFAS cross-contamination during sampling can occur from a number of common sources, and proper sampling procedures will aid in minimizing accidental cross-contamination of the samples. Given the low detection limits associated with PFAS analysis and the many potential sources of trace levels of PFAS; field personnel will be advised to act on the side of caution by strictly following the protocols outlined in the "Field Sampling Protocols to Avoid Cross-Contamination at PFAS Sites" SOP included as **Attachment B**. A summary of the SOP is provided below.

No Teflon®-containing materials, which themselves contain fluorinated compounds, will be permitted at the job site during sampling activities.

To avoid plastic coating or glue materials, waterproof field books will not be used during sampling activities. Field logs will be documented on loose paper on aluminum clipboards (i.e., plastic clipboards, binders, or spiral hard cover notebooks are not acceptable) using a pen. Sharpies®/markers are not permitted.

Post-It Notes™ will not be allowed on the project site during sampling activities.

Chemical (blue) ice packs will not be used during the sampling program. This includes the use of ice packs for the storage of food and/or samples.

2.5.1 Field Clothing and Personal Protective Equipment

Water resistant, waterproof, stain-treated, Gore-Tex™, and/or Tyvek clothing will not be worn during the field program as these contain fluorinated compounds. Field clothing made of synthetic and natural fibers (preferably cotton) are acceptable. Field clothing will be laundered avoiding the use of fabric softener. Preferably, field gear will be cotton construction and well-laundered (six or more washes) because new clothing may contain PFAS-related treatments.

Safety footwear will consist of steel-toed boots made with polyurethane and polyvinyl chloride (PVC).

Disposable nitrile gloves will be worn at all times. A new pair of nitrile gloves will be donned prior to the following activities at each sample location:

- Prior to contact with sample bottles or water containers;
- Handling of any quality assurance/quality control samples including field blanks and/or equipment blanks; and,
- After the handling of any sampling equipment, contact with non-decontaminated surfaces, or when judged necessary by field personnel.

2.5.2 Sample Containers

All samples to be submitted for PFAS analysis will be collected in polypropylene or HDPE bottles provided by the laboratory and fitted with an unlined (no Teflon®), polypropylene HDPE screw cap.

Container labels will be completed using pen (no markers) after the caps have been placed back on each bottle.

2.5.3 Wet Weather

Field sampling occurring during wet weather will be conducted while wearing appropriate clothing that will not pose a risk for cross-contamination. The sampling team will not use synthetic gear (such as Gore-Tex™) that has been treated with water-repellant finishes containing PFAS.

2.5.4 Personnel Hygiene

The sample handler will wash their hands before sampling and wear nitrile gloves while filling and sealing the sample bottles.

Field personnel will not use cosmetics, moisturizers, hand cream, or other related products as part of their personal cleaning/showering routine on the morning of a sampling event, as these products may contain surfactants and represent a potential source of PFAS.

Manufactured sunblock and insect repellants that may contain PFAS (see **Attachment B**) will not be brought or used on-site.

2.5.5 Food Considerations

No food or drink shall be brought on-site, with the exception of bottled water and hydration drinks (i.e., Gatorade® and Powerade®).

2.6 DECONTAMINATION

Disposal tubing, bladder pumps and peristaltic pumps will be used to sample groundwater monitoring wells and temporary wells. Water quality equipment will be decontaminated prior to initial and after each subsequent use using a deionized water rinse. Detergents will not be used to avoid potential cross-contamination.

Equipment or supplies that cannot be effectively decontaminated will be disposed of after sampling. Gauging/sampling equipment will be decontaminated at the site before use, between sampling locations, and after its last use at the site. Decontamination of field equipment will be noted in the project logbook. If it is necessary to make decontamination procedural changes in the field, the changes will be noted in the logbook. Otherwise, a notation will be made each day that decontamination was conducted as specified in the project documents. Procedures for decontaminating sampling equipment that may be used at the Fort Devens site will be conducted in accordance with guidance in USEPA Region 1, 2010, “Low Stress (low-flow) Purging and Sampling Procedure for the Collection of Ground Water Samples from Monitoring Wells” and is summarized below.

- Groundwater gauging equipment and non-dedicated sampling equipment and materials (including the SP16® sampler device) will be decontaminated using the following procedure:
- Physical removal, rinse with tap water immediately after use.

- Scrub with brushes immediately after use. Rinse with non-PFAS laboratory supplied deionized water.
- Light spray down with isopropyl alcohol, if needed.
- Air dry.
- Rinse with deionized water.
- Cover with aluminum foil (if not to be used immediately).

The water level probe and tape will be decontaminated by the above referenced procedure, substituting air drying with drying the probe tape with a clean paper towel. Equipment that cannot be adequately cleaned will be discarded.

Bladder pumps that are used for groundwater sampling will be taken apart and the steel pump parts will be decontaminated by the procedures above. The plastic bladder will be discarded and a new plastic bladder will be used at each location.

2.7 INVESTIGATION DERIVED WASTE

All IDW will be handled in a manner consistent with USACE and USEPA guidance for managing IDW and applicable Federal and state regulations.

3.0 SAMPLE CHAIN-OF-CUSTODY AND DOCUMENTATION

This section documents chain-of-custody and sample documentation procedures.

3.1 FIELD LOG

As discussed in **Section 2.4**, waterproof field books will not be used during PFAS sampling activities to avoid potential cross-contamination. Field logs will be documented on loose paper on aluminum clipboards using a pen. Logs will be kept in the possession of the field member responsible for sampling activities during fieldwork. The following information will be recorded in the field log:

- Project name and number,
- Arrival and departure times,
- Personnel on-site and their affiliation,
- Date and time,
- Tasks for the day,
- Weather conditions,
- Health and safety meetings and issues,
- Names and affiliations of visitors,
- Sample location and ID (including field sketches, if appropriate),
- Sample depth,
- Sample time,
- Number of aliquots,
- Media type,
- Sampling personnel present,
- Sampling equipment used,
- PPE level, clothing, and equipment used,
- Analyses requested,
- Sample preservation,
- Associated QC samples,
- Decontamination procedures,
- Field observations,
- Photographic records,
- Other project specific information, and
- Changes or deviations to the project scope or the procedures specified in this Work Plan.

All entries will be in ink with any corrections crossed out with a single line, initialed and dated. Daily entries will be signed and dated at the bottom by each individual making an entry. At the completion of field activities, copies of the logbook pages will be maintained in the project files.

Soil logging will be performed from recovered soil cores (**Section 2.3**), including descriptions of soil types and any debris encountered, for the development of soil boring logs to be included in the ESI report (**Section 4.2**).

3.2 SAMPLE NUMBERING PROCEDURES

The system for identifying and tracking the samples, associated field data, and the method of relating the data to the proper samples is provided below. Team members will record all information related to sampling procedures, time, field and weather conditions, unusual events, sample descriptions, instrument readings, and chain-of-custody data in the field log.

Well-specific sample identification numbers will be assigned prior to sample collection. Each sample will be identified in the field log by adding the date to the sample ID, for example: SHM-10-12_DDMM17. Temporary well and soil sample locations will be identified using their site name-year-sample number (e.g., SA74-17-01). Groundwater samples names from these temporary wells will add "GW" and the date (e.g., SA74-17-01-GW051517 for a groundwater sample collected at SA 74 on May 15, 2017). Soil sample names from soil borings will add "SO" and the depth interval in feet (e.g., SA74-17-01-SO0005 for a soil sample collected at SA 74 from 0 to 5 feet bgs).

3.3 SAMPLE DOCUMENTATION

3.3.1 Sample Labels

Field personnel will be responsible for identifying, labeling, providing proper preservation, and packaging samples to prevent breakage during shipment. Each sample will be labeled with the following information:

- Unique sample number
- Sampling date and time
- Initials of sampling technician
- Sample preservative
- Analytical method to be performed

3.3.2 Chain-of-Custody Records

Sample custody will be maintained at all times. A sample is considered to be in custody under the following situations:

- The sample is directly in your possession;
- The sample is clearly in your view;
- The sample is placed in a locked location; and
- The sample is in a designated secure area.

Documentation of the chain of custody of the samples is necessary to demonstrate that the integrity of the samples has not been compromised between collection and delivery to the laboratory. A chain-of-custody record will accompany each sample cooler to document the transfer of custody from the field to the laboratory. All information requested in the chain-of-custody record will be completed. If samples are shipped by an overnight courier, the air bill number assigned by the overnight courier will be listed on the chain-of-custody record or the general logbook. One copy of the custody form will be retained by the samplers and placed in the project records file. The remaining pages will be sealed in a plastic bag and placed inside the cooler. Upon receipt at the laboratory, the chain-of-custody forms will be completed. It is the responsibility of the laboratory to document the condition of custody seals and sample integrity upon receipt. The laboratory will provide a copy of the completed chain-of-custody back to KGS to be included in the project records.

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4.0 DATA REPORTING AND SCHEDULE

This section documents data validation and reporting procedures and outlines the project schedule.

4.1 DATA VALIDATION

Laboratory data will be reported in analytical packages (produced in PDF format) that will, at a minimum, contain all necessary information to allow for validation in accordance with the USEPA Tier II protocols. The laboratory will "J" qualify results below the limit of quantitation (LOQ), where applicable.

The Automated Data Review software (ADR.Net) will be used to review the analytical data. The laboratory will produce SEDD Stage 2a data deliverables, consistent with Department of Defense QSM valid values that have been screened against the ADR.Net project electronic-QAPP. The laboratory will provide error-free SEDD Stage 2a deliverables (.xml file with warning log files). ADR will qualify the data results based on method performance criteria and list any QC sample deviation. The project chemist will prepare a data validation report incorporating the ADR.net report output.

Additional information regarding data validation is provided in the project Work Plan and QAPP (KGS, 2016b), submitted under separate cover.

4.2 DATA REPORTING

In accordance with the 18 March 2016 Dispute Resolution Issues 6-8 and USEPA 01 November 2016 Expedited Site Inspections for PFAS, the Army must complete additional work to assure protection of human health and the environment. Analytical data will be provided 60 days after sample collection. A Site Inspection Report detailing the sampling will be provided to USEPA for comment.

4.3 SCHEDULE

The following schedule is planned for collecting PFAS samples and reporting the results in accordance with this ESI Work Plan:

- Final Work Plan Approval by Agencies – May 5, 2017
- Final Health and Safety Plan – May 15, 2017
- Mobilize, Mark Location, Utility Clearance – by May 22, 2017
- Field Work – May 22, 2017 through June 30, 2017
- Submittal of Validated Laboratory Data to Agencies (within 60 days of field work completion date) – August 29, 2017
- Draft SI Report to Agencies (within 90 days of field work completion date) – September 28, 2017
- Draft Final SI Report to Agencies (within 135 days of the Draft SI Report submittal) – February 10, 2018

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5.0 REFERENCES

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TABLES

Table 1
Proposed PFAS Sample Locations
Former Fort Devens Army Installation, Devens, MA

Location	Description	Sample Location	Sample Type	Approximate Depth to Groundwater (ft bgs)	Proposed Sample Depth or Well Screen Interval (ft bgs)**	Sample and Location Rationale
AOC 5	Shepley's Hill Landfill	SHM-10-11*	Groundwater	40	50-60	Determine presence or absence of PFAS in groundwater in potential source area
		SHM-10-12*	Groundwater	35	45-55	Determine presence or absence of PFAS in groundwater in potential source area
		SHM-10-14*	Groundwater	20	60-80	Determine presence or absence of PFAS in groundwater in potential source area
		SHM-10-15*	Groundwater	25	45-55	Determine presence or absence of PFAS in groundwater downgradient of SHL
		SHP-95-27X*	Groundwater	17	30.5-40.5	Determine presence or absence of PFAS in groundwater downgradient of SHL
		SHL-15*	Groundwater	18	14-5-24.5	Determine presence or absence of PFAS in groundwater upgradient of SHL
		SHL-17*	Groundwater	9	6-16	Determine presence or absence of PFAS in groundwater upgradient of SHL
		SHL-18*	Groundwater	19	16-26	Determine presence or absence of PFAS in groundwater downgradient of SHL
		SHL-24*	Groundwater	17	110-120	Determine presence or absence of PFAS in deep overburden groundwater upgradient of SHL in Zone II area associated with Grove Pond water supply wells
		EW-01*	Groundwater	16	60-85	Determine presence or absence of PFAS in groundwater in extraction well downgradient of SHL
		EW-04*	Groundwater	16	70-95	Determine presence or absence of PFAS in groundwater in extraction well downgradient of SHL
		SHM-11-06*	Groundwater	20	25-35	Determine presence or absence of PFAS in groundwater downgradient of SHL
		SHM-96-5B*	Groundwater	7	80-90	Determine presence or absence of PFAS in groundwater downgradient of SHL
		SHM-05-40X*	Groundwater	14	32-34	Determine presence or absence of PFAS in groundwater downgradient of SHL
		SHM-05-41A*	Groundwater	11	42-44	Determine presence or absence of PFAS in groundwater downgradient of SHL toward the NIA
		SHM-05-41B*	Groundwater	11	62-64	Determine presence or absence of PFAS in groundwater downgradient of SHL toward the NIA
		SHM-05-41C*	Groundwater	11	88-93	Determine presence or absence of PFAS in groundwater downgradient of SHL toward the NIA
		SHM-13-06*	Groundwater	18	36-46	Determine presence or absence of PFAS in groundwater downgradient of SHL
		SHP-01-38A*	Groundwater	4	1.5-6.5	Determine presence or absence of PFAS in shallow groundwater downgradient of SHL toward Plow Shop Pond.
		SHP-01-38B*	Groundwater	4	18-23	Determine presence or absence of PFAS in groundwater downgradient of SHL toward Plow Shop Pond.

Table 1
Proposed PFAS Sample Locations
Former Fort Devens Army Installation, Devens, MA

Location	Description	Sample Location	Sample Type	Approximate Depth to Groundwater (ft bgs)	Proposed Sample Depth or Well Screen Interval (ft bgs)**	Sample and Location Rationale
SA 20 and 21	Devens WWTP	SA21-17-01	Soil	20	0-5	Determine presence or absence of PFAS in soil in potential source area (former sludge beds)
			Groundwater	20	20-22	Determine presence or absence of PFAS in groundwater in potential source area (former sludge beds)
		SA21-17-02	Soil	20	0-5	Determine presence or absence of PFAS in soil in potential source area (former sludge beds)
			Groundwater	20	20-22	Determine presence or absence of PFAS in groundwater in potential source area (former sludge beds)
		SA20-17-01	Soil	65	0-2	Determine presence or absence of PFAS in soil at sand filter bed
		SA20-17-02	Groundwater	20	20-22	Determine presence or absence of PFAS in groundwater downgradient of the Devens WWTP sand filter beds
		WWTP-Influent	Influent Wastewater	NA	NA	Determine presence or absence of PFAS in influent wastewater at WWTP
		WWTP-Effluent	Effluent Wastewater	NA	NA	Determine presence or absence of PFAS in influent wastewater at WWTP
		MW-01A*	Groundwater	23	~18-33***	Determine presence or absence of PFAS in groundwater downgradient of the Devens WWTP sand filter beds
		MW-02A*	Groundwater	20	~15-30***	Determine presence or absence of PFAS in groundwater downgradient of the Devens WWTP sand filter beds
		MW-04*	Groundwater	12	~7-22***	Determine presence or absence of PFAS in groundwater downgradient of the Devens WWTP sand filter beds
SA 74	Barnum Road	SA74-17-01	Soil	12	0-5	Determine presence or absence of PFAS in soil in potential source area
			Groundwater	12	12-14	Determine presence or absence of PFAS in groundwater in potential source area
		SA74-17-02	Soil	5	0-5	Determine presence or absence of PFAS in soil in potential source area / drainage swale
			Groundwater	5	5-7	Determine presence or absence of PFAS in groundwater in potential source area
		SA74-17-03	Soil	5	0-5	Determine presence or absence of PFAS in soil in potential source area / drainage swale
			Groundwater	5	5-7	Determine presence or absence of PFAS in groundwater in potential source area
		SA74-17-04	Groundwater	3	3-5	Determine presence or absence of PFAS in groundwater downgradient of the potential source area
		SA74-17-05	Groundwater	3	3-5	Determine presence or absence of PFAS in groundwater downgradient of the potential source area (by discharge location of site drainage swales)

Table 1
Proposed PFAS Sample Locations
Former Fort Devens Army Installation, Devens, MA

Location	Description	Sample Location	Sample Type	Approximate Depth to Groundwater (ft bgs)	Proposed Sample Depth or Well Screen Interval (ft bgs)**	Sample and Location Rationale
SA 75	Building 1445 Warehouse Fire	SA75-17-01	Soil	15	0-5	Determine presence or absence of PFAS in soil in potential source area (north of building)
			Groundwater	15	15-17	Determine presence or absence of PFAS in groundwater in potential source area (north of building)
		SA75-17-02	Groundwater	5	0-5	Determine presence or absence of PFAS in groundwater downgradient of the potential source area (in drainage swale)
		SA75-17-03	Soil	15	0-5	Determine presence or absence of PFAS in soil in potential source area (east and topographically downgradient of building)
			Groundwater	15	15-17	Determine presence or absence of PFAS in groundwater in potential source area (east and topographically downgradient of building)
		SA75-17-04	Soil	15	0-5	Determine presence or absence of PFAS in soil in potential source area (south of building)
			Groundwater	15	15-17	Determine presence or absence of PFAS in groundwater in potential source area (south of building)
		MNG-3*	Groundwater	35	53-63	Determine presence or absence of PFAS in groundwater downgradient of the potentail source area and upgradient of Grove Pond Wells. Note: Data from well MNG-3 will also be used to support the evaluation of potential PFAS from nearby SA 74.
		CSMS-11-01*	Groundwater	36	30-40	Determine presence or absence of PFAS in groundwater downgradient of the potentail source area and upgradient of Grove Pond Wells. Note: Data from the CSMS wells will also be used to support the evaluation of potential PFAS from nearby SA 74.
		CSMS-11-02*	Groundwater	35	30-40	Determine presence or absence of PFAS in groundwater downgradient of the potentail source area and upgradient of Grove Pond Wells. Note: Data from the CSMS wells will also be used to support the evaluation of potential PFAS from nearby SA 74.

Table 1
Proposed PFAS Sample Locations
Former Fort Devens Army Installation, Devens, MA

Location	Description	Sample Location	Sample Type	Approximate Depth to Groundwater (ft bgs)	Proposed Sample Depth or Well Screen Interval (ft bgs)**	Sample and Location Rationale
AOC 50	Former Moore Airfield					
	Former Moore Airfield Fire Station	AOC50-17-01	Soil	60	0-5	Determine presence or absence of PFAS in soil around potential source area
			Groundwater	60	60-62	Determine presence or absence of PFAS in groundwater by/downgradient of potential source area
		AOC50-17-02	Soil	60	0-5	Determine presence or absence of PFAS in soil around potential source area
			Groundwater	60	60-62	Determine presence or absence of PFAS in groundwater by/downgradient of potential source area
	Former Moore Airfield Hangar	AOC50-17-03	Soil	60	0-5	Determine presence or absence of PFAS in soil around potential source area
			Groundwater	60	60-62	Determine presence or absence of PFAS in groundwater by potential source area
		AOC50-17-04	Soil	60	0-5	Determine presence or absence of PFAS in soil in potential source area
			Groundwater	60	60-62	Determine presence or absence of PFAS in groundwater in potential source area
		AOC50-17-05	Groundwater	60	60-62	Determine presence or absence of PFAS in groundwater downgradient of potential source area
		AOC50-17-06	Soil	60	0-5	Determine presence or absence of PFAS in soil around potential source area
			Groundwater	60	60-62	Determine presence or absence of PFAS in groundwater by potential source area
		AOC50-17-07	Soil	60	0-5	Determine presence or absence of PFAS in soil around potential source area
			Groundwater	60	60-62	Determine presence or absence of PFAS in groundwater by potential source area

Table 1
Proposed PFAS Sample Locations
Former Fort Devens Army Installation, Devens, MA

Location	Description	Sample Location	Sample Type	Approximate Depth to Groundwater (ft bgs)	Proposed Sample Depth or Well Screen Interval (ft bgs)**	Sample and Location Rationale
AOC 50	Former Airfield Runway	AOC50-17-08	Soil	60	0-5	Determine presence or absence of PFAS in soil in potential source area
			Groundwater	60	60-62	Determine presence or absence of PFAS in groundwater in potential source area
		AOC50-17-09	Soil	60	0-5	Determine presence or absence of PFAS in soil in potential source area
			Groundwater	60	60-62	Determine presence or absence of PFAS in groundwater in potential source area
		AOC50-17-10	Soil	60	0-5	Determine presence or absence of PFAS in soil in potential source area
			Groundwater	60	60-62	Determine presence or absence of PFAS in groundwater in potential source area
		AOC50-17-11	Soil	60	0-5	Determine presence or absence of PFAS in soil in potential source area
			Groundwater	60	60-62	Determine presence or absence of PFAS in groundwater in potential source area
		AOC50-17-12	Soil	60	0-5	Determine presence or absence of PFAS in soil in potential source area
			Groundwater	60	60-62	Determine presence or absence of PFAS in groundwater in potential source area
		AOC50-17-13	Soil	60	0-5	Determine presence or absence of PFAS in soil in potential source area
			Groundwater	60	60-62	Determine presence or absence of PFAS in groundwater in potential source area
		AOC50-17-14****	Soil	30	0-5	Determine presence or absence of PFAS in soil by stormwater outfall (west end of E-W runway & SA 31)
			Groundwater	30	30-32	Determine presence or absence of PFAS by stormwater outfall (west end of E-W runway & SA 31)
		AOC50-17-15****	Soil	50	0-5	Determine presence or absence of PFAS in soil by stormwater outfall (south end of N-S runway)
			Groundwater	50	50-52	Determine presence or absence of PFAS in groundwater by stormwater outfall (south end of N-S runway)
		AOC50-17-16****	Soil	30	0-5	Determine presence or absence of PFAS in soil by stormwater outfall (southeast end of W-SE runway)
			Groundwater	30	30-32	Determine presence or absence of PFAS in groundwater by stormwater outfall (southeast end of W-SE runway)
		AOC50-17-17****	Soil	30	0-5	Determine presence or absence of PFAS in soil by stormwater outfall (north end of N-S runway)
			Groundwater	30	30-32	Determine presence or absence of PFAS in groundwater by stormwater outfall (north end of N-S runway)

Table 1
Proposed PFAS Sample Locations
Former Fort Devens Army Installation, Devens, MA

Location	Description	Sample Location	Sample Type	Approximate Depth to Groundwater (ft bgs)	Proposed Sample Depth or Well Screen Interval (ft bgs)**	Sample and Location Rationale
SA 30	SA 30 Drum Storage Area	SA30-17-01	Soil	60	0-5	Determine presence or absence of PFAS in soil adjacent to potential western source area
			Groundwater	60	60-62	Determine presence or absence of PFAS in groundwater adjacent to potential western source area
		SA30-17-02	Soil	60	0-5	Determine presence or absence of PFAS in soil in the center of the potential western source area (paved area)
			Groundwater	60	60-62	Determine presence or absence of PFAS in groundwater in the center of the potential western source area (paved area)
		SA30-17-03	Soil	60	0-5	Determine presence or absence of PFAS in soil at drainage outlet from paved area of potential western source area
			Groundwater	60	60-62	Determine presence or absence of PFAS in groundwater beneath drainage outlet from paved area of potential western source area
		SA30-17-04	Soil	60	0-5	Determine presence or absence of PFAS in soil adjacent to potential eastern source area
			Groundwater	60	60-62	Determine presence or absence of PFAS in groundwater adjacent to potential eastern source area
		SA30-17-05	Soil	60	0-5	Determine presence or absence of PFAS in soil in the center of the potential eastern source area
			Groundwater	60	60-62	Determine presence or absence of PFAS in groundwater in the center of the potential eastern source area
		SA30-17-06	Soil	60	0-5	Determine presence or absence of PFAS in soil adjacent to potential eastern source area
			Groundwater	60	60-62	Determine presence or absence of PFAS in groundwater adjacent to potential eastern source area
SA 31	SA 31 Fire Fighting Training Area	SA31-17-01	Soil	60	0-5	Determine presence or absence of PFAS in soil at the potential source area
			Groundwater	60	60-62	Determine presence or absence of PFAS in shallow groundwater at the potential source area
		SA31-17-02	Groundwater	60	60-62	Determine presence or absence of PFAS in shallow groundwater downgradient of potential source area
		SA31-17-03	Groundwater	60	60-62	Determine presence or absence of PFAS in shallow groundwater downgradient of potential source area
		SA31-17-04	Groundwater	60	60-62	Determine presence or absence of PFAS in shallow groundwater downgradient of potential source area
		G6M-13-01X*	Groundwater	65	125-135	Determine presence or absence of PFAS in deeper groundwater downgradient of potential airfield source areas including the hangars and the runway
		XSA-12-97X	Groundwater	65	120-130	Determine presence or absence of PFAS in deeper groundwater downgradient of potential airfield source areas including the hangars and the runway

Table 1
Proposed PFAS Sample Locations
Former Fort Devens Army Installation, Devens, MA

Location	Description	Sample Location	Sample Type	Approximate Depth to Groundwater (ft bgs)	Proposed Sample Depth or Well Screen Interval (ft bgs)**	Sample and Location Rationale
AOC 32	Former DRMO	32M-92-03X*	Groundwater	28	23.2-33.2	Determine presence or absence of PFAS in groundwater in potential source area
		32M-92-01X*	Groundwater	18	13.7-23.7	Determine presence or absence of PFAS in groundwater between the Former DRMO and SHL
		32Z-01-07XOB*	Groundwater	17	12.7-22.7	Determine presence or absence of PFAS in groundwater between the Former DRMO and SHL
		32M-01-14XOB*	Groundwater	25	17.3-27.3	Determine presence or absence of PFAS in groundwater downgradient of potential source area
		32M-01-17XBR*	Groundwater	25	41.4-51.4	Determine presence or absence of PFAS in groundwater downgradient of potential source area (bedrock groundwater)
		SHL-25*	Groundwater	25	23.5-33.5	Determine presence or absence of PFAS in groundwater downgradient of potential source area
		43M-01-20XOB*	Groundwater	27	24-34	Determine presence or absence of PFAS in groundwater downgradient of potential source area
		43M-01-20XBR*	Groundwater	26	68.3-78.3	Determine presence or absence of PFAS in groundwater downgradient of potential source area (bedrock groundwater)

Notes:
ft bgs = feet below ground surface
SHL = Shepley's Hill Landfill
Sample locations (as shown in figures) may be adjusted based on actual field conditions (e.g., accessibility issues or to target a drainage area). Changes require approval by the Army, USACE, EPA, and MassDEP prior to sampling.
* = Existing well
** = Temporary wells will be screened (2 foot) into the water table observed in the field. Cited depths are estimated.
*** = Monitoring well screens were set approximately 5 feet above and 10 feet below the water table elevation at time of installation.
**** = Runway stormwater outfalls are located on hillsides. Associated samples will be collected at the bottom of the hill directly below the outfall (target observed runoff channel).

Table 2

Data Quality Objectives

AOC 5 – Shepley's Hill Landfill (SHL)

Former Fort Devens Army Installation, Devens, MA

STEP 1: State the Problem (define the problem that necessitates the study; identify the planning team, examine budget, schedule)

- Due to the detection of PFAS compounds in a drinking water supply well by Grove Pond, and the known use of PFAS-containing compounds during past operations at Fort Devens, the Army needs to assess the potential presence of PFAS compounds at the site that may impact a public drinking water supply and pose. potential risks to receptors at the Former Fort Devens Army Installation.
- The investigation at AOC 5 is to determine whether the past disposal of municipal-type wastes at SHL during the operational period of Fort Devens has resulted in residual PFAS contamination at the site.
- Groundwater is the primary medium of concern due to the high solubility and mobility of PFAS.

STEP 2: Identify the Decision (state how the environmental data will be used in meeting objectives and solving the problem, identify study questions, define alternative outcomes)

PRIMARY DECISION

- Are PFAS compounds present in groundwater at levels above the USEPA Health Advisory Levels (HAL)?

STEP 3: Identify Inputs to the Decision (identify data & information needed to answer study questions)

- Groundwater samples are needed to determine the presence/absence of PFAS.
- Field measurements (temperature, DO, pH, specific conductivity, ORP, and turbidity) will be collected during groundwater sampling to determine when purge stabilization is complete.
- Groundwater levels will be measured from existing monitoring wells identified for sampling to provide information about the potentiometric surface of the water table during the sampling event (i.e., discrete water levels collected for purposes of comparison to previous sampling events and/or groundwater contours previously prepared as part of the long-term monitoring program).
- Information regarding historical site features, source areas, topography, and groundwater flow.
- Interviews and review of historical records regarding use of AFFF documented in the Preliminary Assessment.
- USEPA HAL for groundwater (70 parts per trillion) for PFOS and PFOA, respectively or combined concentrations.

STEP 4: Define the Study Boundaries (specify the target population & characteristics of interest, define spatial & temporal limits, scale of inference)

- AOC 5 includes the landfill area and hydraulically downgradient areas which may have received impacted groundwater from the landfill. The landfill was in operation by Fort Devens beginning in the early 1940s and was closed in five phases between 1987 and 1993.
- Groundwater samples are needed for PFAS analysis from locations within, and downgradient of, the landfill. Existing monitoring wells will be used.

STEP 5: Develop a Decision Rule (define the parameter of interest, specify the type of inference, and develop the logic for drawing conclusions from findings)

PRIMARY DECISION RULE (sampling design quantitatively focuses on this decision rule)

- If PFAS is detected in groundwater samples from AOC 5, then conduct further evaluation of the potential impact to existing nearby drinking water supply well(s) (i.e., the MacPherson Well).
- If PFAS is not detected in groundwater samples at AOC 5, then no further action will be recommended for PFAS at AOC 5.

STEP 6: Specify Performance or Acceptance Criteria (specify probability limits/develop performance criteria)

- Use proper QA/QC methods and a DoD-approved laboratory (ELAP certified) to minimize potential sampling and measurement errors.

STEP 7: Optimize the Design for Obtaining Data (select the resource-effective sampling and analysis plan that meets the performance criteria

- Sample locations will be selected based on the most likely areas to find PFAS, if present; therefore, groundwater samples will be collected within the footprint of the landfill and downgradient of the landfill.

Table 3

Data Quality Objectives

SA 20 and SA 21 – Devens Wastewater Treatment Plant (WWTP)

Former Fort Devens Army Installation, Devens, MA

STEP 1: State the Problem (define the problem that necessitates the study; identify the planning team, examine budget, schedule)

- Due to the detection of PFAS compounds in a drinking water supply well by Grove Pond, and the known use of PFAS-containing compounds during past operations at Fort Devens, the Army needs to assess the potential presence of PFAS compounds at the site that may impact a public drinking water supply and pose potential risks to receptors at the Former Fort Devens Army Installation.
- The investigation at SA 20/21 is to determine whether PFAS has impacted the WWTP site due to the plant's effluent which is from wastewater generated by industrial and residential activities across Fort Devens.
- Groundwater is the primary medium of concern due to the high solubility and mobility of PFAS. Soil is a potential medium of concern as sorbed PFAS may act as a continuing source for groundwater contamination.

STEP 2: Identify the Decision (state how the environmental data will be used in meeting objectives and solving the problem, identify study questions, define alternative outcomes)

PRIMARY DECISION

- Are PFAS compounds present in groundwater at levels above the USEPA Health Advisory Levels (HAL)?
- Are PFAS compounds present in soil that may act as a source of groundwater contamination?

STEP 3: Identify Inputs to the Decision (identify data & information needed to answer study questions)

- Groundwater samples are needed to determine the presence/absence of PFAS.
- Soil samples are needed to determine the presence/absence of PFAS.
- WWTP effluent samples are needed to determine the presence/absence of PFAS in the current discharge to the environment.
- Field measurements (temperature, DO, pH, specific conductivity, ORP, and turbidity) will be collected during groundwater sampling to determine when purge stabilization is complete.
- Groundwater levels will be measured from existing monitoring wells identified for sampling to provide information about the potentiometric surface of the water table during the sampling event (i.e., discrete water levels collected just for purposes of comparison to previous sampling events and/or groundwater contours previously prepared under separate monitoring programs).
- Information regarding historical site features, source areas, topography, and groundwater flow.

- Interviews and review of historical records regarding use of AFFF documented in the Preliminary Assessment.
- USEPA HAL for groundwater (70 parts per trillion) for PFOS and PFOA, respectively or combined concentrations.

STEP 4: Define the Study Boundaries (specify the target population & characteristics of interest, define spatial & temporal limits, scale of inference)

- SA 20 comprises the WWTP's sand infiltration beds, where wastewater that currently enters the system receives its final treatment before reentering the groundwater aquifer. SA 21 comprises the former sludge drying beds for the WWTP.
- Representative groundwater sample is needed for PFAS analysis from locations downgradient of the sand infiltration beds. Groundwater samples are also needed for PFAS analysis from locations within the former sludge drying beds. Existing monitoring wells will be used where available (otherwise temporary wells will be used with direct push methods).
- Soil samples are needed from the shallow soil zone (0 to 5 ft bgs) from locations within, and topographically downgradient of, SA 20 and SA 21.

STEP 5: Develop a Decision Rule (define the parameter of interest, specify the type of inference, and develop the logic for drawing conclusions from findings)

PRIMARY DECISION RULE (sampling design quantitatively focuses on this decision rule)

- If PFAS is detected in groundwater samples from SA 20/21, then conduct further evaluation of the potential impact to existing nearby drinking water supply well(s) (i.e., the MacPherson Well).
- If PFAS is not detected in groundwater samples at SA 20/21, then no further action will be recommended for PFAS at SA 20/21.
- If PFAS is detected in soil samples that are collocated with groundwater PFAS concentrations, then conduct further evaluation of whether that soil zone is acting as a continual source of PFAS to groundwater.
- If soil samples at SA 20/21 do not contain PFAS, then no further action will be recommended for PFAS in soil at SA 20/21.

STEP 6: Specify Performance or Acceptance Criteria (specify probability limits/develop performance criteria)

- Use proper QA/QC methods and a DoD-approved laboratory (ELAP certified) to minimize potential sampling and measurement errors.

STEP 7: Optimize the Design for Obtaining Data (select the resource-effective sampling and analysis plan that meets the performance criteria

- Sample locations will be selected based on the most likely areas to find PFAS, if present. This includes the areas immediately within and downgradient of the sand infiltration beds as well as within the footprint of the former sludge drying beds.
- Direct push methods will be used to collect soil cores from the target intervals, followed by a collocated temporary well point to collect groundwater from the water table.

Table 4

Data Quality Objectives

SA 74 – Barnum Road Devens Fire Historical Dump Site

Former Fort Devens Army Installation, Devens, MA

STEP 1: State the Problem (define the problem that necessitates the study; identify the planning team, examine budget, schedule)

- Due to the detection of PFAS compounds in a drinking water supply well by Grove Pond, and the known use of PFAS-containing compounds during past operations at Fort Devens, the Army needs to assess the potential presence of PFAS compounds at the site that may impact a public drinking water supply and pose potential risks to receptors at the Former Fort Devens Army Installation.
- The investigation at SA 74 is to determine whether the reported past disposal of AFFF behind building 3773 resulted in residual PFAS contamination at the site.
- Groundwater is the primary medium of concern due to the high solubility and mobility of PFAS. Soil is a potential medium of concern as sorbed PFAS may act as a continuing source for groundwater contamination.

STEP 2: Identify the Decision (state how the environmental data will be used in meeting objectives and solving the problem, identify study questions, define alternative outcomes)

PRIMARY DECISION

- Are PFAS compounds present in groundwater at levels above the USEPA Health Advisory Levels (HAL)?
- Are PFAS compounds present in soil that may act as a source of groundwater contamination?

STEP 3: Identify Inputs to the Decision (identify data & information needed to answer study questions)

- Groundwater samples are needed to determine the presence/absence of PFAS.
- Soil samples are needed to determine the presence/absence of PFAS.
- Field measurements (temperature, DO, pH, specific conductivity, ORP, and turbidity) will be collected during groundwater sampling to determine when purge stabilization is complete.
- Groundwater levels will be measured from existing monitoring wells identified for sampling to provide information about the potentiometric surface of the water table during the sampling event (i.e., discrete water levels collected just for purposes of comparison to previous sampling events).
- Information regarding historical site features, source areas, topography, and groundwater flow.
- Interviews and review of historical records regarding use of AFFF documented in the Preliminary Assessment.
- USEPA HAL for groundwater (70 parts per trillion) for PFOS and PFOA, respectively or combined concentrations.

STEP 4: Define the Study Boundaries (specify the target population & characteristics of interest, define spatial & temporal limits, scale of inference)

- SA 74 includes the area behind Building 3773 and topographically downgradient areas including the drainage swale and stream southeast of building, which may have received runoff from the reported disposal of AFFF.
- Groundwater samples are needed from the top of the water table for PFAS analysis from locations behind, and downgradient of, the building. Temporary wells will be used with direct push methods.
- Soil samples are needed from the shallow soil zone (0-5 ft bgs) from locations behind, and topographically downgradient of, the building.

STEP 5: Develop a Decision Rule (define the parameter of interest, specify the type of inference, and develop the logic for drawing conclusions from findings)

PRIMARY DECISION RULE (sampling design quantitatively focuses on this decision rule)

- If PFAS is detected in groundwater samples from SA 74, then conduct further evaluation of the potential impact to existing nearby drinking water supply well(s) (i.e., the Grove Pond well).
- If PFAS is not detected in groundwater samples at SA 74, then no further action will be recommended for PFAS at SA 74.
- If PFAS is detected in soil samples that are collocated with groundwater PFAS concentrations, then conduct further evaluation of whether that soil zone is acting as a continual source of PFAS to groundwater.
- If soil samples at SA 74 do not contain PFAS, then no further action will be recommended for PFAS in soil at SA 74.

STEP 6: Specify Performance or Acceptance Criteria (specify probability limits/develop performance criteria)

- Use proper QA/QC methods and a DoD-approved laboratory (ELAP certified) to minimize potential sampling and measurement errors.

STEP 7: Optimize the Design for Obtaining Data (select the resource-effective sampling and analysis plan that meets the performance criteria

- Sample locations will be selected based on the most likely areas to find PFAS, if present based on the reported release location. This includes the unpaved area behind Building 3773 and the topographically downgradient area where overland runoff of the disposed AFFF was likely to have reached. Groundwater and soil samples will be collected at the suspected source area and in the topographically and hydraulically downgradient areas (including drainage swales).
- Direct push methods will be used to collect soil cores from the target intervals, followed by a collocated temporary well point to collect groundwater from the water table.

Table 5

Data Quality Objectives

SA 75 – Building T-1445 Warehouse Fire

Former Fort Devens Army Installation, Devens, MA

STEP 1: State the Problem (define the problem that necessitates the study; identify the planning team, examine budget, schedule)

- Due to the detection of PFAS compounds in a drinking water supply well by Grove Pond, and the known use of PFAS-containing compounds during past operations at Fort Devens, the Army needs to assess the potential presence of PFAS compounds at the site that may impact a public drinking water supply and pose potential risks to receptors at the Former Fort Devens Army Installation.
- The investigation at SA 75 is to determine whether the use of AFFF during a past fire response action at former Building T-1445 resulted in residual PFAS contamination at the site.
- Groundwater is the primary medium of concern due to the high solubility and mobility of PFAS. Soil is a potential medium of concern as sorbed PFAS may act as a continuing source for groundwater contamination.

STEP 2: Identify the Decision (state how the environmental data will be used in meeting objectives and solving the problem, identify study questions, define alternative outcomes)

PRIMARY DECISION

- Are PFAS compounds present in groundwater at levels above the USEPA Health Advisory Levels (HAL)?
- Are PFAS compounds present in soil that may act as a source of groundwater contamination?

STEP 3: Identify Inputs to the Decision (identify data & information needed to answer study questions)

- Groundwater samples are needed to determine the presence/absence of PFAS.
- Soil samples are needed to determine the presence/absence of PFAS.
- Field measurements (temperature, DO, pH, specific conductivity, ORP, and turbidity) will be collected during groundwater sampling to determine when purge stabilization is complete.
- Groundwater levels will be measured from existing monitoring wells identified for sampling to provide information about the potentiometric surface of the water table during the sampling event (i.e., discrete water levels collected just for purposes of comparison to previous sampling events).
- Information regarding historical site features, source areas, topography, and groundwater flow.
- Interviews and review of historical records regarding use of AFFF documented in the Preliminary Assessment.
- USEPA HAL for groundwater (70 parts per trillion) for PFOS and PFOA, respectively or combined concentrations.

STEP 4: Define the Study Boundaries (specify the target population & characteristics of interest, define spatial & temporal limits, scale of inference)

- SA 75 includes the area surrounding the former Building T-1445 and topographically downgradient areas including the drainage ditch southeast of building, which may have received runoff from the spraying of AFFF to put out the building fire (AFFF was applied a single time in the early 1980s to extinguish fire at former Building T-1445).
- Groundwater samples are needed from the top of the water table for PFAS analysis from locations around, and downgradient of, the former building. Existing monitoring wells will be used where available (otherwise temporary wells will be used with direct push methods).
- Soil samples are needed from the shallow soil zone (0 to 5 ft bgs) from locations around, and topographically downgradient of, the former building.

STEP 5: Develop a Decision Rule (define the parameter of interest, specify the type of inference, and develop the logic for drawing conclusions from findings)

PRIMARY DECISION RULE (sampling design quantitatively focuses on this decision rule)

- If PFAS is detected in groundwater samples from SA 75, then conduct further evaluation of the potential impact to existing nearby drinking water supply well(s) (i.e., the Grove Pond well).
- If PFAS is not detected in groundwater samples at SA 75, then no further action will be recommended for PFAS at SA 75.
- If PFAS is detected in soil samples that are collocated with groundwater PFAS concentrations, then conduct further evaluation of whether that soil zone is acting as a continual source of PFAS to groundwater.
- If soil samples at SA 75 do not contain PFAS, then no further action will be recommended for PFAS in soil at SA 75.

STEP 6: Specify Performance or Acceptance Criteria (specify probability limits/develop performance criteria)

- Use proper QA/QC methods and a DoD-approved laboratory (ELAP certified) to minimize potential sampling and measurement errors.

STEP 7: Optimize the Design for Obtaining Data (select the resource-effective sampling and analysis plan that meets the performance criteria

- Sample locations will be selected based on the most likely areas to find PFAS, if present based on this historic application. This includes the unpaved area around the former building and topographically downgradient where overland runoff of AFFF from firefighting activities was likely to have contacted soil. Groundwater samples will be collected at the suspected source area and in the topographically and hydraulically downgradient area.
- Direct push methods will be used to collect soil cores from the target intervals, followed by a collocated temporary well point to collect groundwater from the water table.

Table 6

Data Quality Objectives

AOC 50 – Former Moore Army Airfield (includes SA 30 – Former Drum Storage Area and SA 31 – Former Firefighting/Crash Site Training Area)

Former Fort Devens Army Installation, Devens, MA

STEP 1: State the Problem (define the problem that necessitates the study; identify the planning team, examine budget, schedule) • Due to the detection of PFAS compounds in a drinking water supply well by Grove Pond, and the known use of PFAS-containing compounds during past operations at Fort Devens, the Army needs to assess the potential presence of PFAS compounds at the site that may impact a public drinking water supply and pose potential risks to receptors at the Former Fort Devens Army Installation. • The investigation at AOC 50 is to determine whether the past storage and use of AFFF has resulted in residual PFAS contamination at the site, including: o storage of AFFF concentrate at the SA 30 Drum Storage Areas o past firefighting training activities at SA 31 o potential use/storage of AFFF at the AOC 50 aircraft hangars o potential use/storage of AFFF at the former fire station o past application of AFFF along the runway. • Groundwater is the primary medium of concern due to the high solubility and mobility of PFAS. Soil is a potential medium of concern as sorbed PFAS may act as a continuing source for groundwater contamination.
STEP 2: Identify the Decision (state how the environmental data will be used in meeting objectives and solving the problem, identify study questions, define alternative outcomes) **PRIMARY DECISION** • Are PFAS compounds present in groundwater at levels above the USEPA Health Advisory Levels (HAL)? • Are PFAS compounds present in soil that may act as a source of groundwater contamination?
STEP 3: Identify Inputs to the Decision (identify data & information needed to answer study questions) • Groundwater samples are needed to determine the presence/absence of PFAS. • Soil samples are needed to determine the presence/absence of PFAS. • Field measurements (temperature, DO, pH, specific conductivity, ORP, and turbidity) will be collected during groundwater sampling to determine when purge stabilization is complete. • Groundwater levels will be measured from existing monitoring wells identified for sampling to provide information about the potentiometric surface of the water table during the sampling event (i.e., discrete water levels collected for purposes of comparison to previous sampling events and/or groundwater contours previously prepared as part of the long-term monitoring program).

- Information regarding historical site features, source areas, topography, and groundwater flow.
- Interviews and review of historical records regarding use of AFFF documented in the Preliminary Assessment; the runway was used for helicopters, not airplanes.
- USEPA HALs for groundwater (70 parts per trillion) for PFOS and PFOA, respectively or combined concentrations.

STEP 4: Define the Study Boundaries (specify the target population & characteristics of interest, define spatial & temporal limits, scale of inference)

- Moore Army Airfield was used from approximately 1929 to 1995. The boundaries of the facility for the investigation include the former storage area, fire-fighting training area, former hangars, former firefighting station and runway and areas downgradient of these areas where AFFF may have been applied.
- SA 30 includes two storage area; an asphalt-paved, bermed former drum storage area located by the airfield, which was used to store firefighting foam, and a concrete pad, which was used to store other materials. Study area includes topographically downgradient areas which may have received runoff or spills from the storage pad. Media of interest include soil and shallow groundwater.
- SA 31 includes a 50 ft by 50 ft, asphalt-covered concrete pad that is 8-inches thick. The pad is surrounded by a 12-inch high by 24-inch wide earthen containment berm. The area of interest also includes topographically downgradient areas which may have received overland runoff from the AFFF sprayed during firefighting training exercises, as well as hydraulically downgradient areas which receive groundwater from below the training area. Media of interest include soil and shallow groundwater.
- At AOC 50, AFFF may have been stored at the two aircraft hangars and the former fire station. The aircraft hangars reportedly used water-only fire suppression systems. Drainage structures from the hangars were connected to the stormwater conveyance system (see Appendix A and Arthur D Little, 1994). Therefore, the potential PFAS source at the hangars is associated with the storage and possible spillage of AFFF in the past. The AOC 50 area also includes three runways also serviced by the stormwater conveyance system (Appendix A). AFFF was reportedly sprayed onto the runway during firefighting and crash training exercises. Media of interest include soil and shallow groundwater around the hangars, former fire station, runways, and stormwater outfalls.
- Shallow and deep groundwater samples are needed for PFAS analysis from locations at and downgradient of the former drum storage areas, the firefighting training area, the former fire station, the hangars, and the runway. Existing monitoring wells will be used where available (otherwise temporary wells will be used with direct push methods).
- Soil samples are needed from the shallow soil zone (0-5 ft bgs) from locations at, and topographically downgradient of, the former drum storage areas, the firefighting training area, the former fire station, the hangars, and the runway (and its stormwater outfalls).
- Runway stormwater outfalls are located on steep hillsides; therefore, samples associated with outfalls will be collected from the flat area at the bottom of the hill below the outfall.

STEP 5: Develop a Decision Rule (define the parameter of interest, specify the type of inference, and develop the logic for drawing conclusions from findings)

PRIMARY DECISION RULE (sampling design quantitatively focuses on this decision rule)

- If PFAS is detected in groundwater samples from a particular SA/AOC, then conduct further evaluation of the potential impact to existing nearby drinking water supply well(s) (i.e., the MacPherson Well).
- If PFAS is not detected in groundwater samples at a particular SA/AOC, then no further action will be recommended for PFAS at that SA/AOC.
- If PFAS is detected in soil samples that are collocated with groundwater PFAS concentrations, then conduct further evaluation of whether that soil zone is acting as a continual source of PFAS to groundwater.
- If soil samples at a particular SA/AOC do not contain PFAS, then no further action will be recommended for PFAS in soil at that SA/AOC.

STEP 6: Specify Performance or Acceptance Criteria (specify probability limits/develop performance criteria)

- Use proper QA/QC methods and a DoD-approved laboratory (ELAP certified) to minimize potential sampling and measurement errors.

STEP 7: Optimize the Design for Obtaining Data (select the resource-effective sampling and analysis plan that meets the performance criteria

- Sample locations will be selected based on the most likely areas to find PFAS, if present. This includes the potential source areas at the former drum storage areas, the firefighting training area, the former fire station, the hangars, and the runway, as well as topographically downgradient areas where overland runoff was likely to have contacted soil. Groundwater samples will be collected at the suspected source areas and in the hydraulically downgradient areas.
- Direct push methods will be used to collect soil cores from the target intervals, followed by a collocated temporary well point to collect groundwater from the water table.

Table 7

Data Quality Objectives

AOC 32 – DRMO Yard

Former Fort Devens Army Installation, Devens, MA

STEP 1: State the Problem (define the problem that necessitates the study; identify the planning team, examine budget, schedule)

- Due to the detection of PFAS compounds in a drinking water supply well by Grove Pond, and the known use of PFAS-containing compounds during past operations at Fort Devens, the Army needs to assess the potential presence of PFAS compounds at the site that may impact a public drinking water supply and pose potential risks to receptors at the Former Fort Devens Army Installation.
- The investigation at AOC 32 is to determine whether the historical storage of materials, including potential PFAS-containing materials, resulted in residual PFAS contamination at the site.
- Groundwater is the primary medium of concern due to the high solubility and mobility of PFAS.

STEP 2: Identify the Decision (state how the environmental data will be used in meeting objectives and solving the problem, identify study questions, define alternative outcomes)

PRIMARY DECISION

- Are PFAS compounds present in groundwater at levels above the USEPA Health Advisory Levels (HAL)?

STEP 3: Identify Inputs to the Decision (identify data & information needed to answer study questions)

- Groundwater samples are needed to determine the presence/absence of PFAS.
- Field measurements (temperature, DO, pH, specific conductivity, ORP, and turbidity) will be collected during groundwater sampling to determine when purge stabilization is complete.
- Groundwater levels will be measured from existing monitoring wells identified for sampling to provide information about the potentiometric surface of the water table during the sampling event (i.e., discrete water levels collected for purposes of comparison to previous sampling events and/or groundwater contours previously prepared as part of the long-term monitoring program).
- Information regarding historical site features, source areas, topography, and groundwater flow.
- Interviews and review of historical records regarding use of AFFF documented in the Preliminary Assessment.
- USEPA HAL for groundwater (70 parts per trillion) for PFOS and PFOA, respectively or combined concentrations.

STEP 4: Define the Study Boundaries (specify the target population & characteristics of interest, define spatial & temporal limits, scale of inference)

- AOC 32 includes the DRMO yard and hydraulically downgradient areas which may have received impacted groundwater from the yard. Operational records indicate that the DRMO facility was active from at least 1964 to 1995.
- Groundwater samples are needed for PFAS analysis from locations around, and downgradient of, the DRMO yard. Existing monitoring wells will be used.

STEP 5: Develop a Decision Rule (define the parameter of interest, specify the type of inference, and develop the logic for drawing conclusions from findings)

PRIMARY DECISION RULE (sampling design quantitatively focuses on this decision rule)

- If PFAS is detected in groundwater samples from AOC 32, then conduct further evaluation of the potential impact to existing nearby drinking water supply well(s) (i.e., the Grove Pond well).
- If PFAS is not detected in groundwater samples at AOC 32, then no further action will be recommended for PFAS at AOC 32.

STEP 6: Specify Performance or Acceptance Criteria (specify probability limits/develop performance criteria)

- Use proper QA/QC methods and a DoD-approved laboratory (ELAP certified) to minimize potential sampling and measurement errors.

STEP 7: Optimize the Design for Obtaining Data (select the resource-effective sampling and analysis plan that meets the performance criteria

- Sample locations will be selected based on the most likely areas to find PFAS, if present; therefore, groundwater samples will be collected around/downgradient of the storage yard.

Table 8
Sample Analyte List and Reference Limits
PFAS Site Investigation Work Plan
Former Fort Devens Army Installation, Devens, MA

Method Description	Analyte Description	CAS Number	Benchmarks (µg/L) [1]	Laboratory Specific				Laboratory Control Limits		
				LOQ	DL	LOD	Units	% Low	% High	RPD %
Perfluorinated Chemicals (LC/MS) modified method 537	Perfluorobutanesulfonic acid (PFBS)	375-73-5	--	0.0025	0.00092	0.0020	µg/L	70	130	30
	Perfluoroheptanoic acid (PFHpA)	375-85-9	--	0.0025	0.00080	0.0020	µg/L	70	130	30
	Perfluorohexanesulfonic acid (PfHxS)	355-46-4	--	0.0025	0.00087	0.0020	µg/L	70	130	30
	Perfluorononanoic acid (PFNA)	375-95-1	--	0.0025	0.00065	0.0020	µg/L	70	130	30
	Perfluorooctane sulfonate (PFOS)	1763-23-1	0.07	0.004	0.00128	0.0030	µg/L	70	130	30
	Perfluorooctanoic acid (PFOA)	335-67-1	0.07	0.0025	0.00075	0.0020	µg/L	70	130	30
	PFOS + PFOA (total)	--	0.07	--	--	--	µg/L	--	--	--

Notes:

[1] - EPA Lifetime Health Advisories (May 2016)

LOQ - Limit of Quantation

DL - Detection Limit

LOD - Limit of Detection

µg/L - microgram per liter

RPD - Relative Percent Difference

Table 9
PFAS QC Samples
Site Investigation Work Plan
Former Fort Devens Army Installation, Devens, MA

Location	Matrix	Field Blank	MS/MSD	Equipment Blank*	Field Duplicate	Analyses
AOC 5	GW	1	1 set (GW)	1	2 (GW)	Modified Method 537 - GW
SA 20 and 21	GW/SO		1 set (SO)	1	1 (GW)	Modified Method 537 - GW Modified Method 537 - SO
SA 74	GW/SO	1	1 set (GW)	1	1 (SO)	Modified Method 537 - GW Modified Method 537 - SO
SA 75	GW/SO			1	1 (GW)	Modified Method 537 - GW Modified Method 537 - SO
AOC 50	GW/SO	1	1 set (GW)	1	1 (GW) 1 (SO)	Modified Method 537 - GW Modified Method 537 - SO
SA30	GW/SO		1 set (SO)		1 (SO)	Modified Method 537 - GW Modified Method 537 - SO
SA31	GW/SO	1		1	1 (GW)	Modified Method 537 - GW Modified Method 537 - SO
AOC 32	GW	1		1	1 (GW)	Modified Method 537 - GW

GW = Groundwater
SO= Soil
MS/MSD = Matrix Spike/Matrix Spike Duplicate
* = Equipment Blanks will be collected from both groundwater and soil sampling equipment as listed in Worksheet#18.

Table 10
PFAS Reporting Limits for Soil and Aqueous Samples
Former Fort Devens Army Installation, Devens, MA

Analysis Method	CAS Registry Number	Analyte	Aqueous Laboratory RL (ng/L)	Soil Laboratory RL (µg/Kg)
Modified method 537 (aqueous and soil)	375-73-5	Perfluorobutanesulfonic acid (PFBS)	2.5	0.40
Modified method 537 (aqueous and soil)	375-85-9	Perfluoroheptanoic acid (PFHpA)	2.5	0.50
Modified method 537 (aqueous and soil)	355-46-4	Perfluorohexanesulfonic acid (PFHxS)	2.5	0.50
Modified method 537 (aqueous and soil)	375-95-1	Perfluorononanoic acid (PFNA)	2.5	0.50
Modified method 537 (aqueous and soil)	1763-23-1	Perfluorooctane sulfonic acid (PFOS)	4.0	0.50
Modified method 537 (aqueous and soil)	335-67-1	Perfluorooctanoic acid (PFOA)	2.5	0.50

Notes:

ng/L = nanograms per liter

µg/Kg = micrograms per kilogram

RL = Reporting Limit

FIGURES

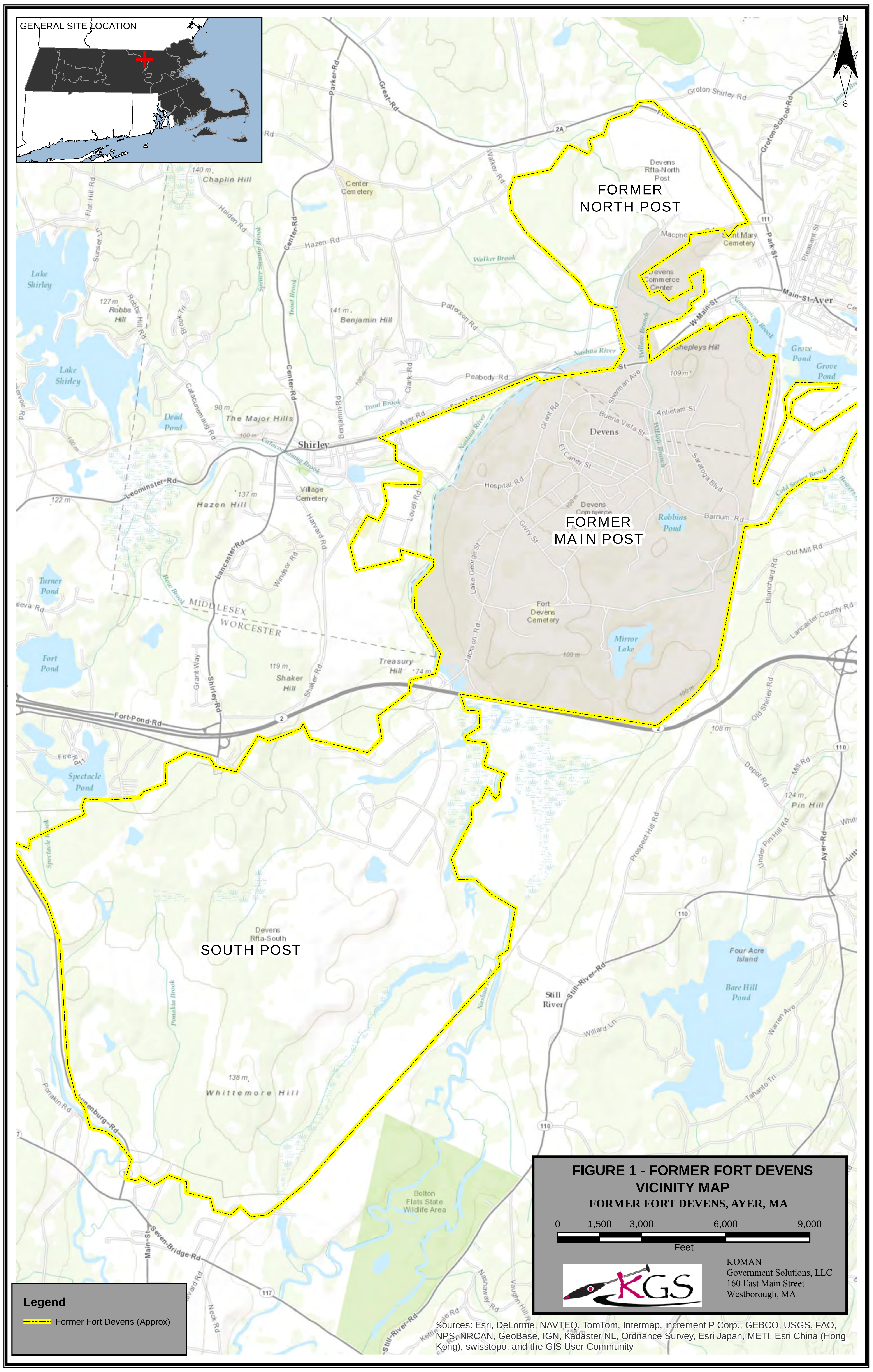

FIGURE 1 - FORMER FORT DEVENS VICINITY MAP

FORMER FORT DEVENS, AYER, MA

0 1,500 3,000 6,000 9,000
Feet

KOMAN
Government Solutions, LLC
160 East Main Street
Westborough, MA

Legend

Former Fort Devens (Approx)

Sources: Esri, DeLorme, NAVTEQ, TomTom, Intermap, increment P Corp., GEBCO, USGS, FAO, NPS, NRCAN, GeoBase, IGN, Kadaster NL, Ordnance Survey, Esri Japan, METI, Esri China (Hong Kong), swisstopo, and the GIS User Community

01/29/2014 ROV Updated 03/23/2015 ROV, 12/29/2016 JR

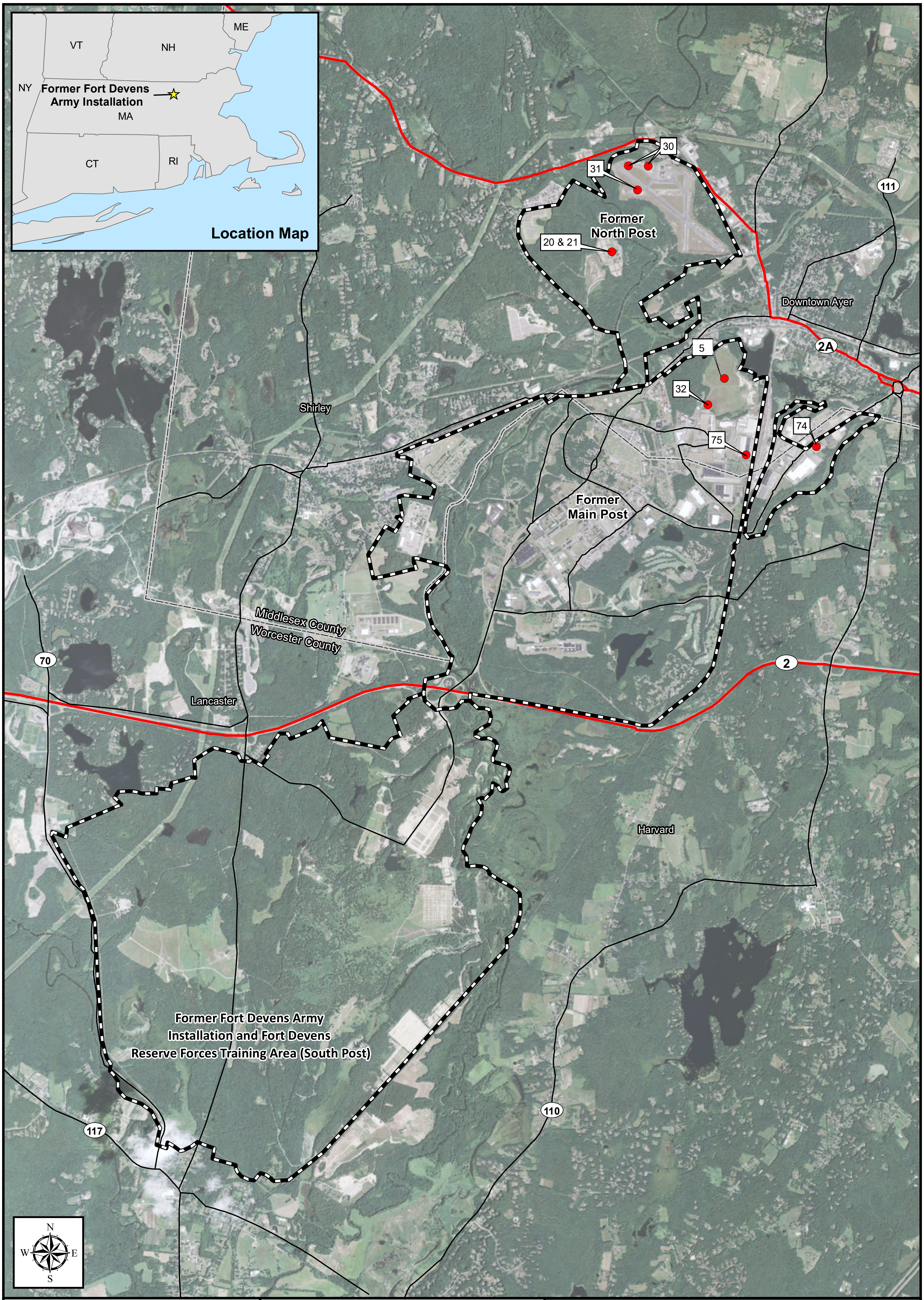

Figure 2
Site Location Map
Former Fort Devens Army Installation and Fort Devens Reserve Forces Training Area

References: HGL. LTMMP 2012.
Aerial Sources: 2011, Esri, DigitalGlobe, GeoEye, i-cubed, USDA FSA, USGS, AEX, Getmapping, Aerogrid, IGN, IGP, swisstopo, and the GIS User Community

Legend

● Study Area or AOC
— Highway
— Major Road
- - County Line
▭ Former Fort Devens Boundary

Site Inspection Work Plan
Study Areas and Areas of Concern

Former Fort Devens Army Installation and Fort Devens
Reserve Forces Training Area, Devens MA

KOMAN Government Solutions, LLC
160 East Main Street, Suite 2F, Westborough, MA 01581

0 1,750 3,500
Feet

Date:
01/12/2017

Figure
2

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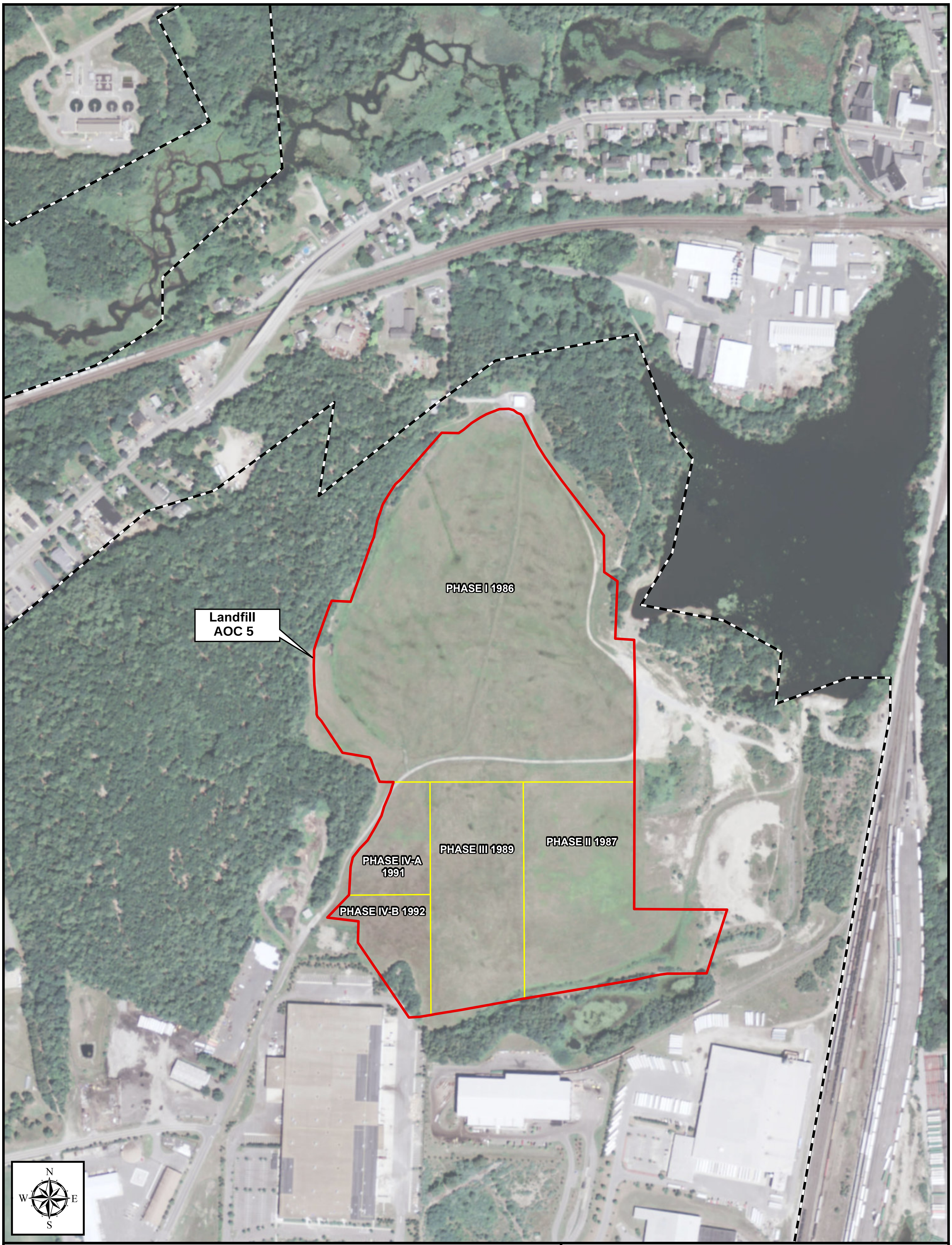

Legend

🟥 Study Area/AOC Boundary/ Potential Release Area

🟨 Landfill Phase Boundary

▭ Former Fort Devens Boundary

Aerial Sources: 2014, Esri, DigitalGlobe, GeoEye, i-cubed, USDA FSA, USGS, AEX, Getmapping, Aerogrid, IGN, IGP, swisstopo, and the GIS User Community

Figure 3
AOC 5
Shepley's Hill Landfill

Site Inspection Work Plan
Study Areas and Areas of Concern

Former Fort Devens Army Installation and Fort Devens
Reserve Forces Training Area, Devens MA

KOMAN Government Solutions, LLC
160 East Main Street, Suite 2F, Westborough, MA 01581

0 200 400
Feet

Date:
01/12/2017

Figure
3

File: SIWP_Fig3_SA_4_5_18.mxd

Legend

🟥 Study Area Boundary/Potential Release Area

Aerial Sources: 2014, Esri, DigitalGlobe, GeoEye, i-cubed, USDA FSA, USGS, AEX, Getmapping, Aerogrid, IGN, IGP, swisstopo, and the GIS User Community

Figure 4
Study Areas 20 and 21

Site Inspection Work Plan
Study Areas and Areas of Concern

Former Fort Devens Army Installation and Fort Devens
Reserve Forces Training Area, Devens MA

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0 125 250
Feet

Date:
01/05/2017

Figure
4

File: SIWP_Fig4_SA_20_21.mxd

Legend

- ◐ Monitoring Well
- ⊕ Public Well
- ▭ Study Area Boundary
- ▭ Former Fort Devens Boundary
- ☁ Potential Release Area

Aerial Sources: 2014, Esri, DigitalGlobe, GeoEye, i-cubed, USDA FSA, USGS, AEX, Getmapping, Aerogrid, IGN, IGP, swisstopo, and the GIS User Community

Figure 5
Study Area 74

Site Inspection Work Plan
Study Areas and Areas of Concern

Former Fort Devens Army Installation and Fort Devens
Reserve Forces Training Area, Devens MA

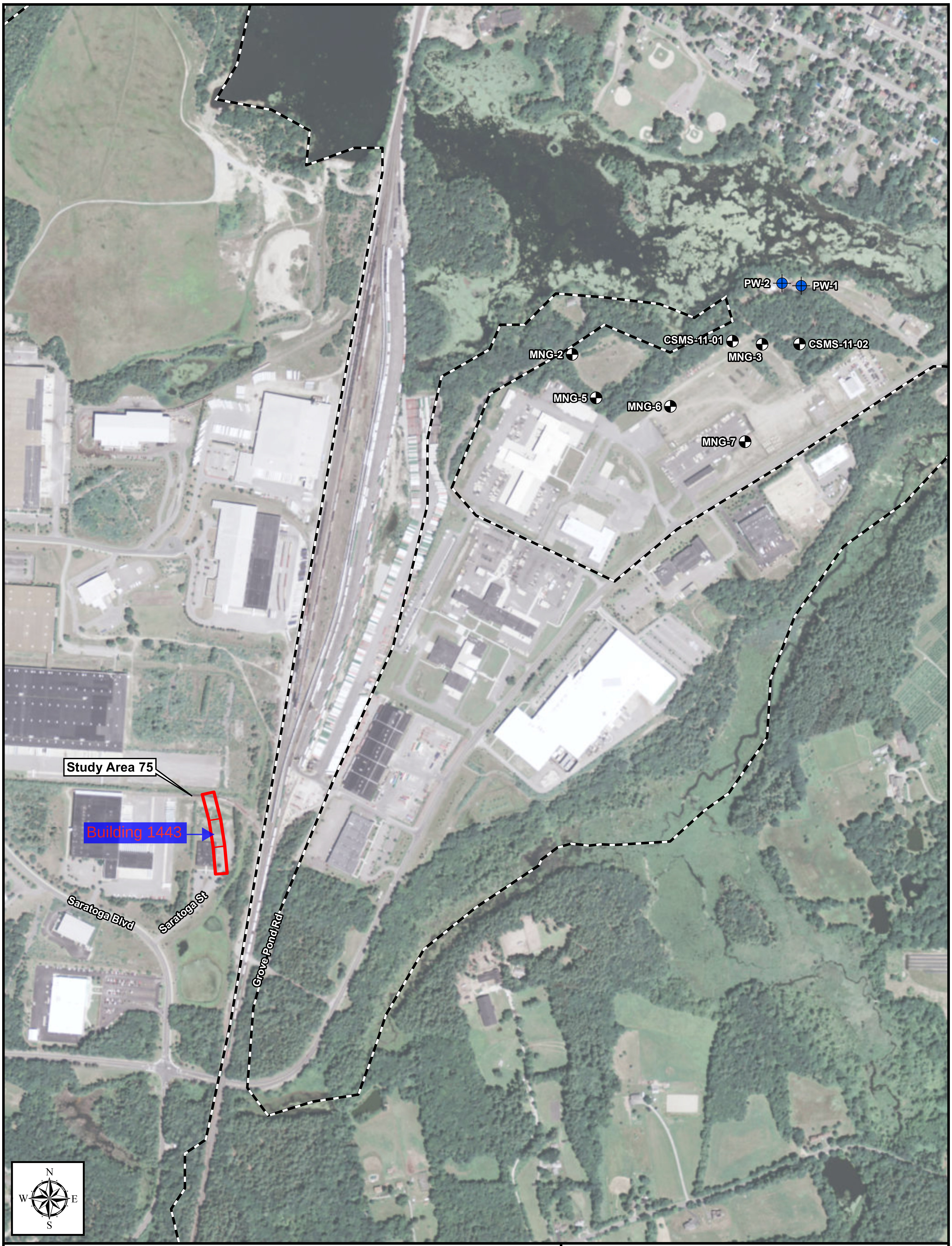
KOMAN Government Solutions, LLC
160 East Main Street, Suite 2F, Westborough, MA 01581

0 100 200
Feet

Date:
01/13/2017

Figure
5

File: SIWP_Fig5_SA_74.mxd



Legend

◐ Monitoring Well

⊕ Public Well

▭ Study Area Boundary/Potential Release Area

⬚ Former Fort Devens Boundary

Aerial Sources: 2014, Esri, DigitalGlobe, GeoEye, i-cubed, USDA FSA, USGS, AEX, Getmapping, Aerogrid, IGN, IGP, swisstopo, and the GIS User Community

Figure 6
Study Area 75

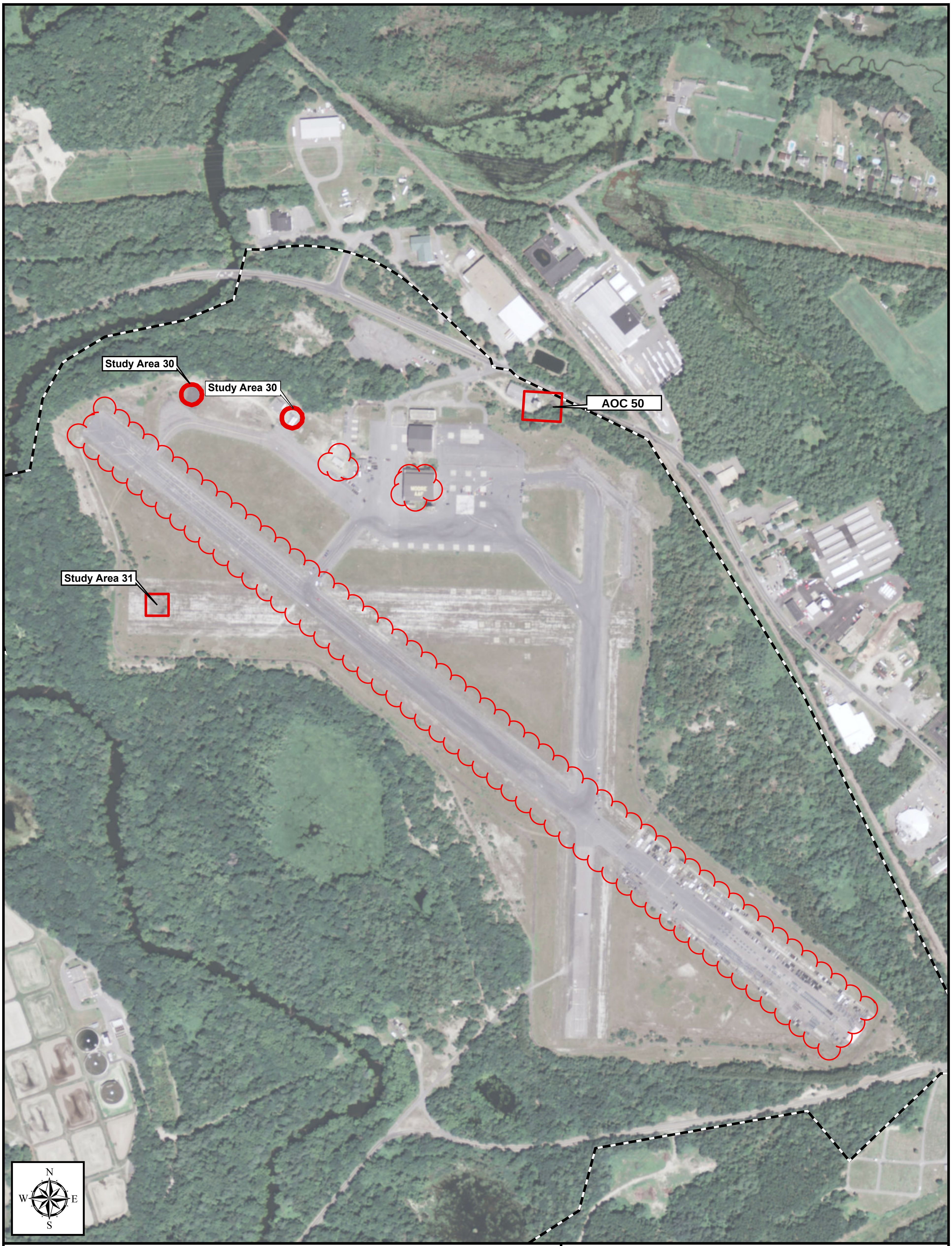
Site Inspection Work Plan
Study Areas and Areas of Concern

Former Fort Devens Army Installation and Fort Devens
Reserve Forces Training Area, Devens MA

KOMAN Government Solutions, LLC
160 East Main Street, Suite 2F, Westborough, MA 01581

0 300 600 Feet	Date: 01/13/2017	Figure 6	KGS

File: SIWP_Fig6_SA_75.mxd



Legend

🟥 Study Area Boundary/Potential Release Area

⬚ Former Fort Devens Boundary

Aerial Sources: 2014, Esri, DigitalGlobe, GeoEye, i-cubed, USDA FSA, USGS, AEX, Getmapping, Aerogrid, IGN, IGP, swisstopo, and the GIS User Community

Figure 7
Study Areas 30, 31 and AOC 50

Site Inspection Work Plan
Study Areas and Areas of Concern

Former Fort Devens Army Installation and Fort Devens
Reserve Forces Training Area, Devens MA

KOMAN Government Solutions, LLC
160 East Main Street, Suite 2F, Westborough, MA 01581

0 250 500
Feet

Date:
04/03/2017

Figure
7

KGS

File: SIWP_Fig7_SA_30_31_47_50.mxd

Legend

🟥 Study Area Boundary/Potential Release Area

Aerial Sources: 2014, Esri, DigitalGlobe, GeoEye, i-cubed, USDA FSA, USGS, AEX, Getmapping, Aerogrid, IGN, IGP, swisstopo, and the GIS User Community

Figure 8
AOC 32

Site Inspection Work Plan
Study Areas and Areas of Concern

Former Fort Devens Army Installation and Fort Devens
Reserve Forces Training Area, Devens MA

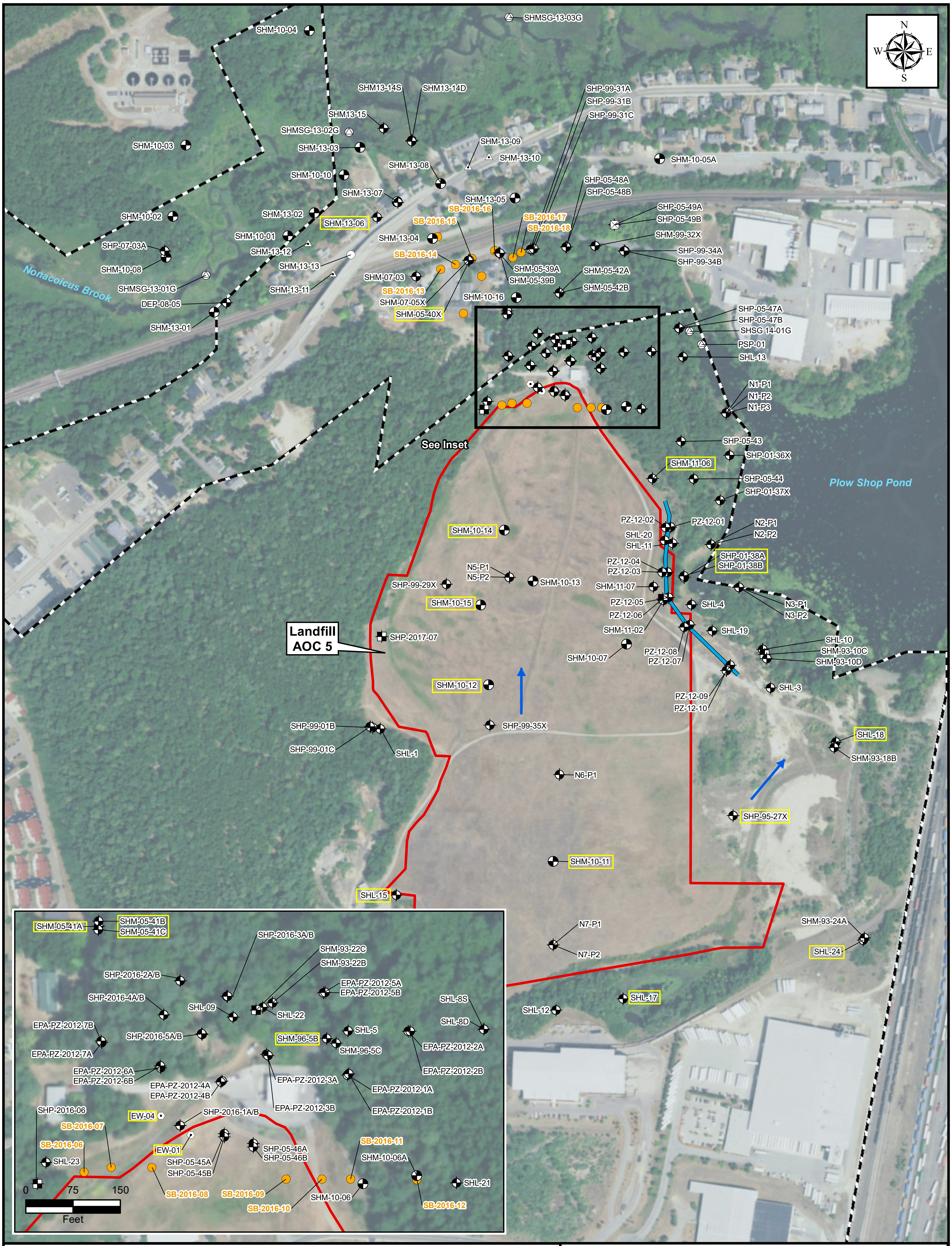
KOMAN Government Solutions, LLC
160 East Main Street, Suite 2F, Westborough, MA 01581

0 125 250
Feet

Date:
03/28/2017

Figure
8

File: SIWP_Fig8_SA_32_43A.mxd



Legend

- ● Soil Boring
- ⊕ Overburden Monitoring Well/Piezometer
- ☒ Monitoring Well - Destroyed
- ◑ Groundwater Profiling Location/Monitoring Well
- △ Groundwater Profiling Location
- ▣ Bedrock Monitoring Well
- ⊙ Extraction Well
- ○ Soil Boring
- ◬ Stream Gauge
- ▬ Barrier Wall
- ⬚ Former Fort Devens Boundary
- ▭ Study Area/AOC Boundary/Potential Release Area
- ← Estimated Groundwater Flow Direction
- **SHM-10-11** Proposed PFAS Sample Location

References: Sovereign/HGL LTMMP 2015

Aerial Sources: 2016, Esri, DigitalGlobe, GeoEye, i-cubed, USDA FSA, USGS, AEX, Getmapping, Aerogrid, IGN, IGP, swisstopo, and the GIS User Community

Figure 9
Sample Locations for AOC 5 Shepley's Hill Landfill Site

Site Inspection Work Plan
Study Areas and Areas of Concern

Former Fort Devens Army Installation and Sudbury Annex
Devens, Massachusetts

KOMAN Government Solutions, LLC
160 East Main Street, Suite 2F, Westborough, MA 01581

0 200 400
Feet

Date:
04/30/2017

Figure
9

KGS

File: SIWP_Fig9_SL_AOC5.mxd

Legend

◐	Monitoring Well Location
⊕	Proposed Temporary Well and Soil Sample Location
●	Sample Location
←	Estimated Groundwater Flow Direction
▭	Study Area Boundary
MW-WC1A	Proposed PFAS Sample Location

Aerial Sources: 2016, Esri, DigitalGlobe, GeoEye, i-cubed, USDA FSA, USGS, AEX, Getmapping, Aerogrid, IGN, IGP, swisstopo, and the GIS User Community

Figure 10
Sample Locations for Study Areas 20 and 21

Site Inspection Work Plan
Study Areas and Areas of Concern

Former Fort Devens Army Installation and Fort Devens
Reserve Forces Training Area, Devens MA

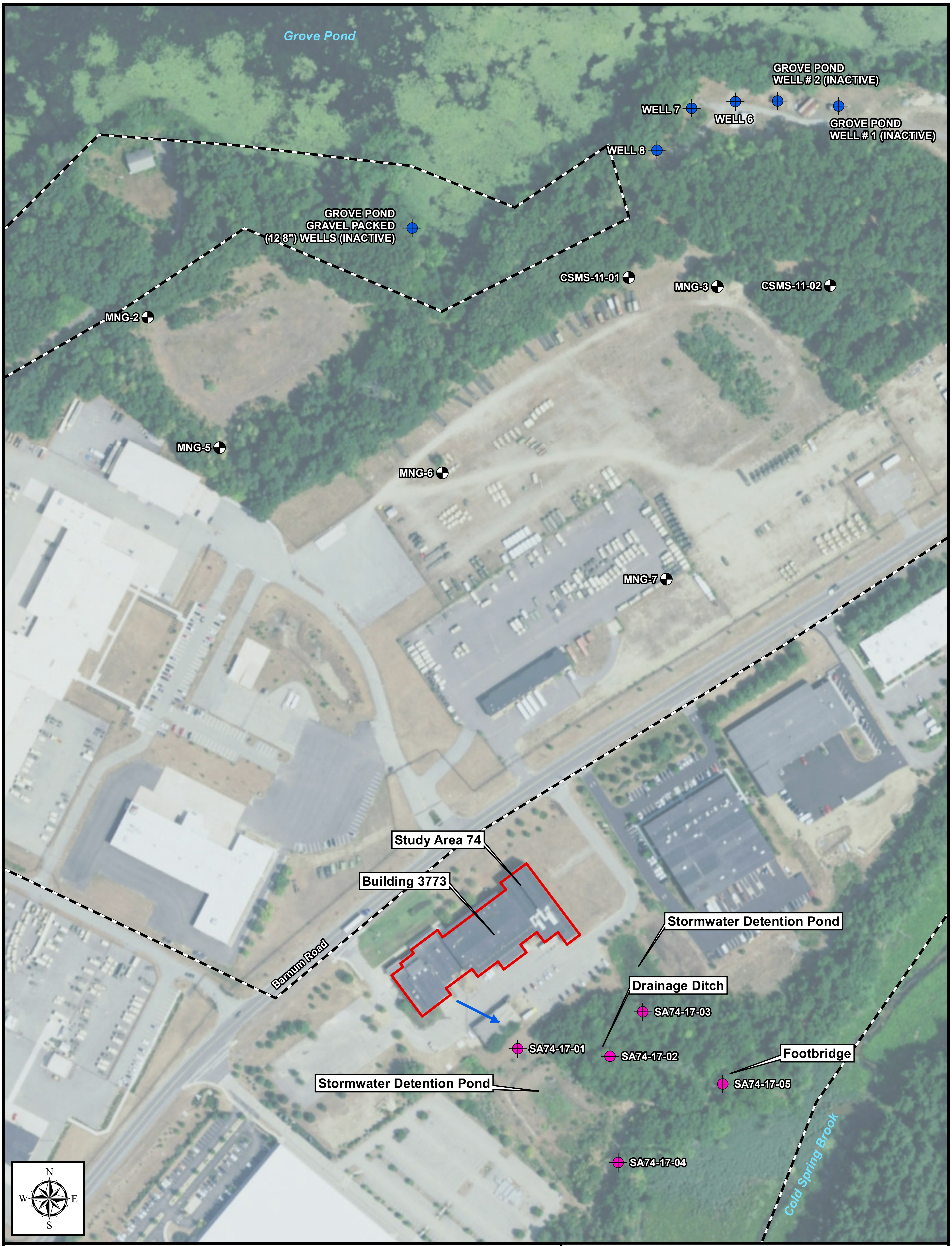
KOMAN Government Solutions, LLC
160 East Main Street, Suite 2F, Westborough, MA 01581

0 125 250
Feet

Date:
04/30/2017

Figure
10

File: SIWP_Fig10_SA_20_21.mxd



Legend

- ✚ Proposed Temporary Well and Soil Sample Location
- ◑ Monitoring Well
- ✚ Public Water Supply Well
- ← Estimated Groundwater Flow Direction
- ▭ Study Area Boundary
- ⬚ Former Fort Devens Boundary

Notes:
Grove Pond (Ayer) Supply Wells #1 and #2 were replaced by Wells #6 and #7

Elevated PFAS level was detected by MassDEP in Supply Well #8 (but PFAS did not exceed the health advisory level in the combined/finished water).

Aerial Sources: 2016, Esri, DigitalGlobe, GeoEye, i-cubed, USDA FSA, USGS, AEX, Getmapping, Aerogrid, IGN, IGP, swisstopo, and the GIS User Community

Figure 11
Sample Locations for Study Area 74

Site Inspection Work Plan
Study Areas and Areas of Concern

Former Fort Devens Army Installation and Fort Devens Reserve Forces Training Area, Devens MA

KOMAN Government Solutions, LLC
160 East Main Street, Suite 2F, Westborough, MA 01581

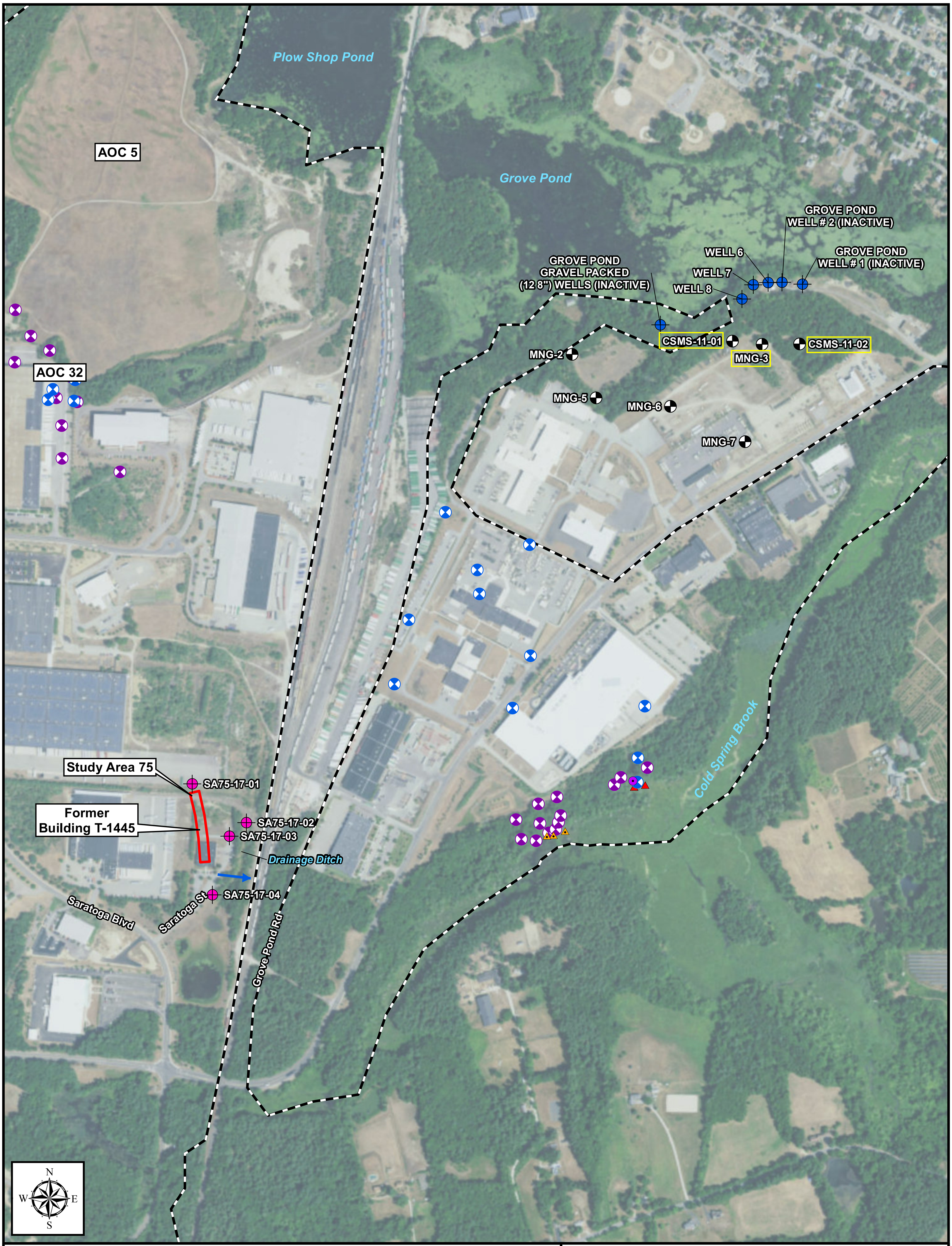
0 100 200
Feet

Date:
04/30/2017

Figure
11

KGS

File: SIWP_Fig11_SA_74.mxd



Legend

⊕	Proposed Temporary Well and Soil Sample Location
◑	Monitoring Well
⊕	Public Water Supply Well
←	Estimated Groundwater Flow Direction
▭	Study Area Boundary
▭	Former Fort Devens Boundary
●	Well Point - Gauge Only
▲	LTM Piezometer
▲	Staff Gauge
⊗	LTM Sample Well
⊗	LTM Well - Gauge Only
CSMS-11-01	Proposed PFAS Sample Location

Notes:
Grove Pond (Ayer) Supply Wells #1 and #2 were replaced by Wells #6 and #7

Elevated PFAS level was detected by MassDEP in Supply Well #8 (but PFAS did not exceed the health advisory level in the combined/finished water)

Aerial Sources: 2016, Esri, DigitalGlobe, GeoEye, i-cubed, USDA FSA, USGS, AEX, Getmapping, Aerogrid, IGN, IGP, swisstopo, and the GIS User Community

Figure 12
Sample Locations for Study Area 75

Site Inspection Work Plan
Study Areas and Areas of Concern

Former Fort Devens Army Installation and Fort Devens Reserve Forces Training Area, Devens MA

KOMAN Government Solutions, LLC
160 East Main Street, Suite 2F, Westborough, MA 01581

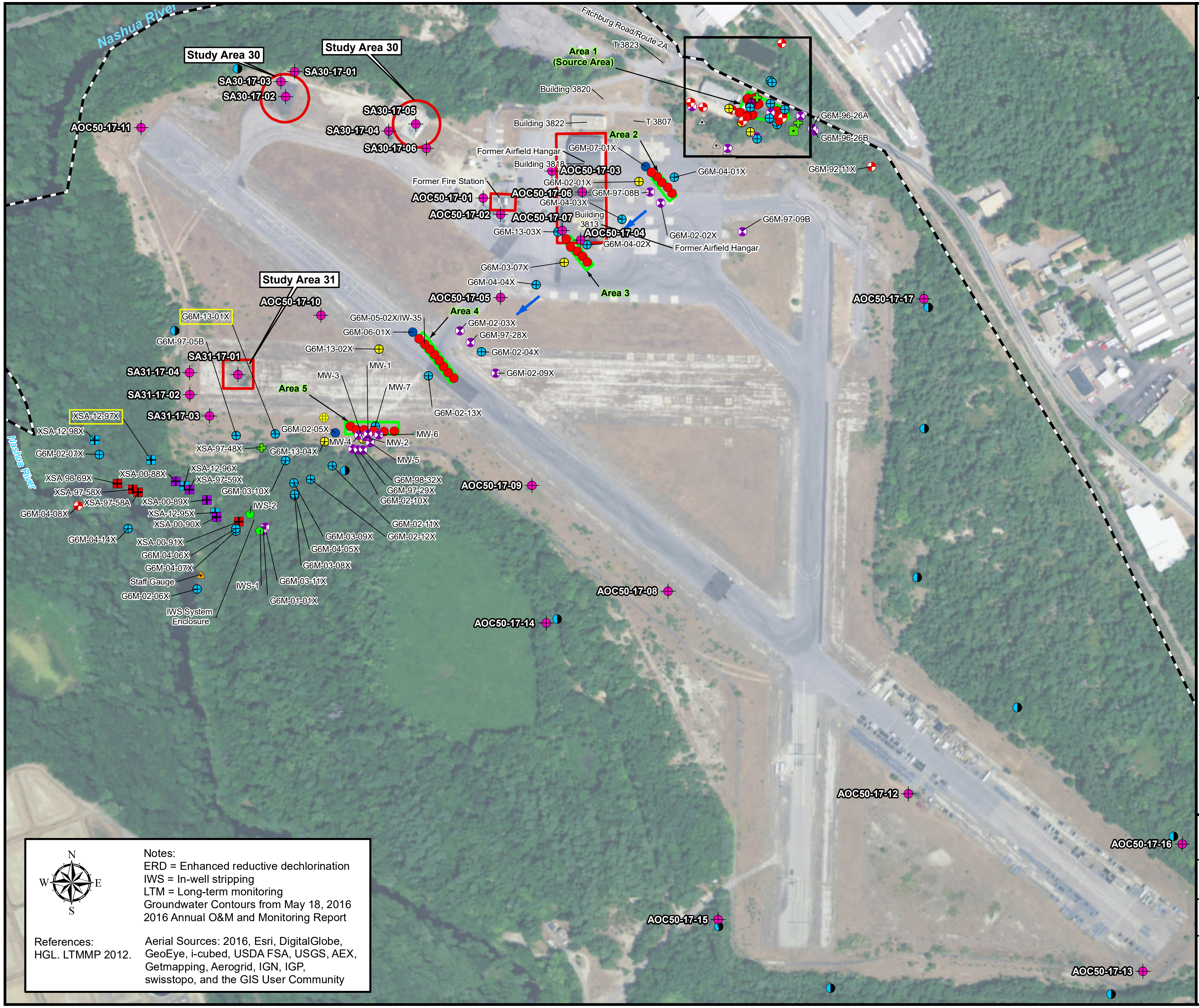
0 300 600
Feet

Date:
05/01/2017

Figure
12

KGS

File: SIWP_Fig12_SA_75.mxd



Notes:
ERD = Enhanced reductive dechlorination
IWS = In-well stripping
LTM = Long-term monitoring
Groundwater Contours from May 18, 2016
2016 Annual O&M and Monitoring Report

References:
HGL. LTMMP 2012.

Aerial Sources: 2016, Esri, DigitalGlobe, GeoEye, i-cubed, USDA FSA, USGS, AEX, Getmapping, Aerogrid, IGN, IGP, swisstopo, and the GIS User Community

Figure 13
Sample Locations for SA 30 & 31
Area of Contamination 50

Legend

- ⊕ Proposed Temporary Well and Soil Sample Location
- ◑ Runway Stormwater Drain Outlet
- ⊕ ERD LTM Well - Sampled Semi-Annually
- ⊕ ERD LTM Well - Sampled Annually
- ▲ ERD LTM Well - Sampled Biennially
- ⊕ ERD LTM Well - Sampled Every 3 Years
- ⊗ LTM Well - Gauge Only
- ⊕ Monitoring Well
- ● Monitoring Well Converted to Injection Well
- ⬟ In-Well Stripping System Well
- ⊞ MicroWell - Sampled Annually
- ⊞ MicroWell - Gauge Only
- ⊞ MicroWell
- ● Injection Well
- ▲ Staff Gauge
- ✚ Historic Vertical Groundwater Profiling Location
- ▣ Historic Soil Boring
- ⊕ Injection Well Installed 01/2014
- G6M-92-11X Well/Gauge/Piezometer Identification
- → Groundwater Flow Direction
- 🟥 Study Area Boundary
- ▭ Former Fort Devens Boundary
- 🟩 ERD Injection Well Transect
- G6M-04-02X Proposed PFAS Sample Location

Site Inspection Work Plan
Study Areas and Areas of Concern

Former Fort Devens Army Installation and Sudbury Annex
Devens, Massachusetts

KOMAN Government Solutions, LLC
160 East Main Street, Suite 2F, Westborough, MA 01581

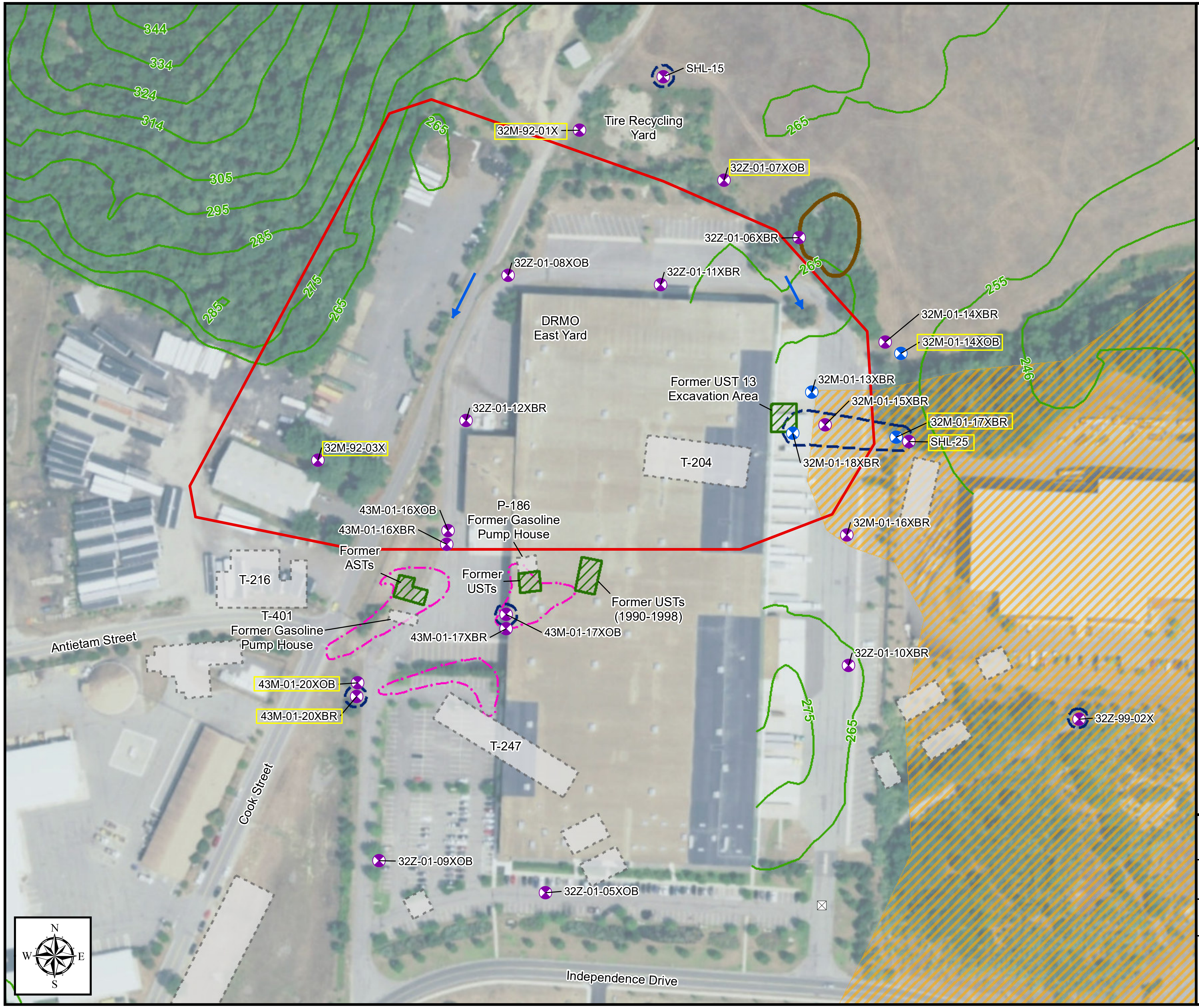
Date: 05/05/2017

Figure 13

KGS

File: SIWP_Fig13_SL_SA30_31_AOC50.mxd

Figure 14
Sample Locations for Area of Contamination 32 and 43A



Legend

⊗	LTM Sample Well
⊗	LTM Well - Periodic Gauge Only
☒	Monitoring Well - Paved Over
▨	DEP Approved Wellhead Protection Areas (Zone II)
32M-92-01X	Well Identification
▨	Former Storage Tank(s)
▨	Former Building
T-247	Former Building Number
▭	Approximate Historical Extent of Groundwater Contamination in Exceedance of Cleanup Goals (based on April 2002 to October 2011 analytical data)
▭	TPHC Soil Contamination
▭	Remaining Bedrock Outcrop
—	Topographic Contour (Ft AMSL)
←	Estimated Groundwater Flow Direction
□	Potential Release Area
SHL-25	Proposed PFAS Sample Location

Notes:
AST = Above ground storage tank
UST = Underground storage Tank
DRMO = Defense Reutilization and Marketing Office
LTM = Long-term monitoring
TPHC = Total petroleum hydrocarbons

References:
HGL. LTMMP 2012.

Aerial Sources: 2016, Esri, DigitalGlobe, GeoEye, i-cubed, USDA FSA, USGS, AEX, Getmapping, Aerogrid, IGN, IGP, swisstopo, and the GIS User Community

Site Inspection Work Plan
Study Areas and Areas of Concern

Former Fort Devens Army Installation and Sudbury Annex
Devens, Massachusetts

KOMAN Government Solutions, LLC
160 East Main Street, Suite 2F, Westborough, MA 01581

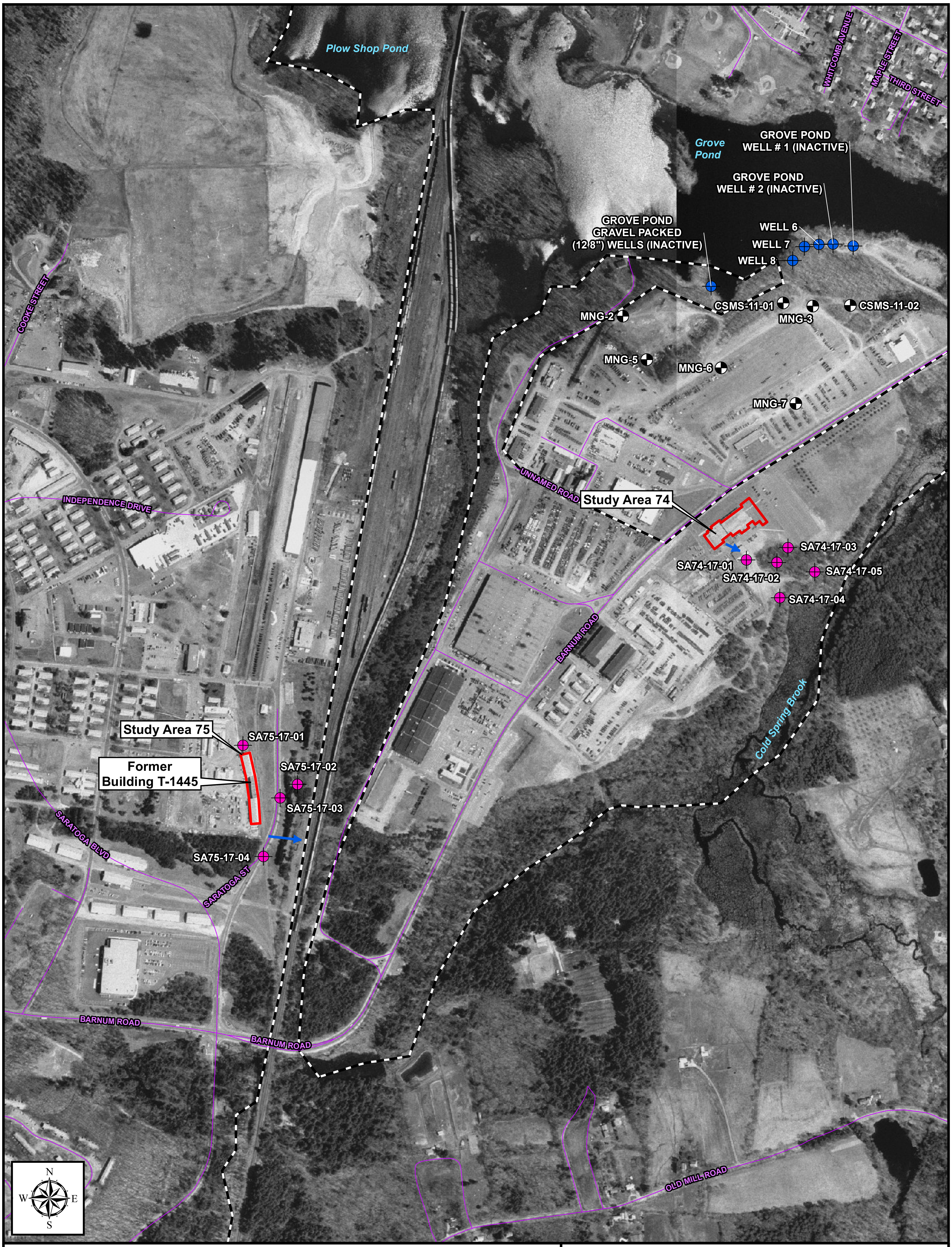
0 80 160
Feet

Date:
04/30/2017

Figure
14

KGS

File: SIWP_Fig14_AOC32_43A.mxd



Legend

- ⊕ Monitoring Well
- ⊕ Public Water Supply Well
- ⊕ Proposed Temporary Well and Soil Sample Location
- ▭ Study Area Boundary
- ← Estimated Groundwater Flow Direction
- — Current Road
- ⬚ Former Fort Devens Boundary

Note:
Grove Pond (Ayer) Supply Wells #1 and #2 were replaced by Wells #6 and #7

Aerial Source: MassGIS - 1:5,000 Black and White Digital Orthophoto Images - 1992

Figure 15
Study Area 75
1992 Aerial Imagery

Site Inspection Work Plan
Study Areas and Areas of Concern

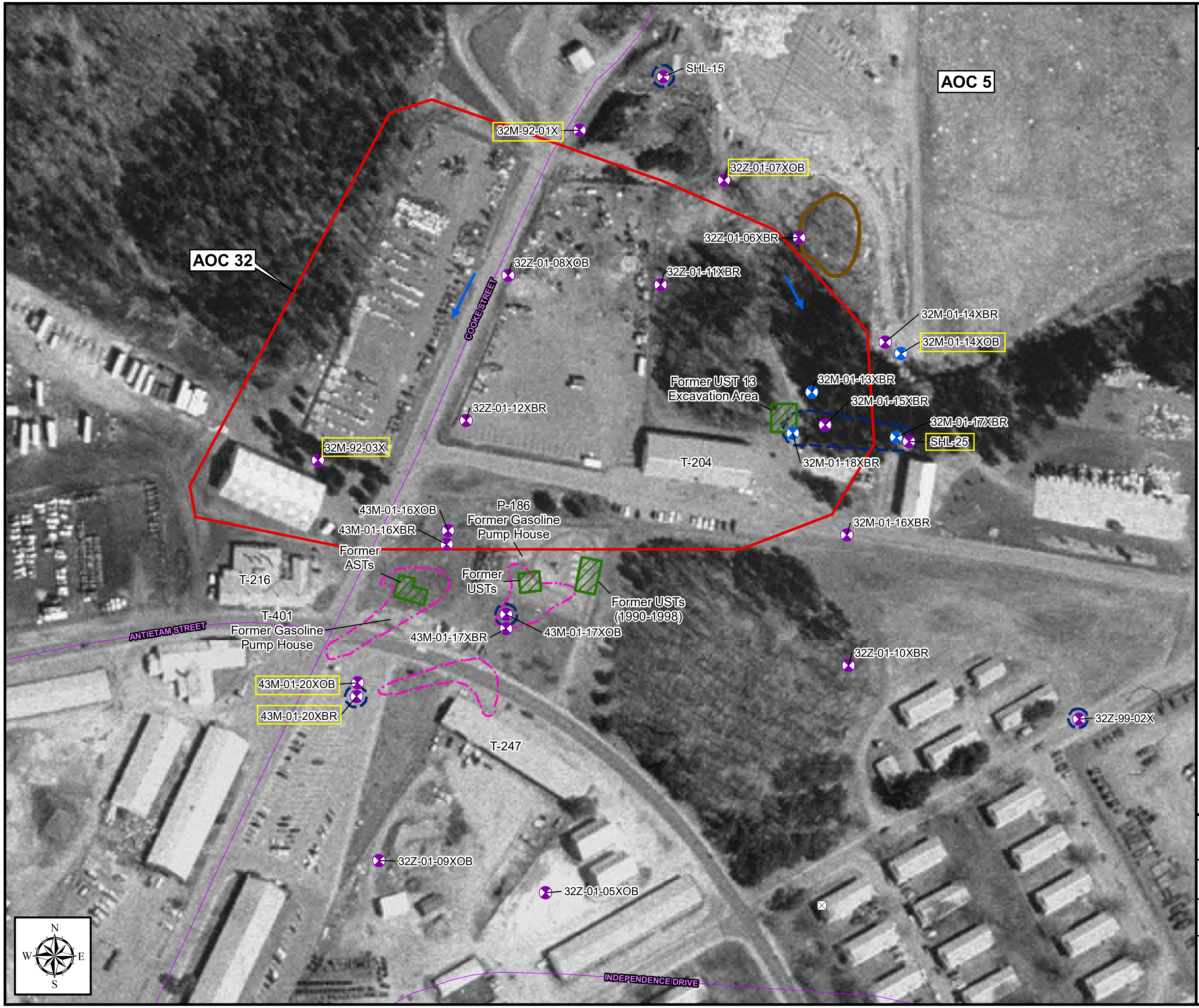
Former Fort Devens Army Installation and Fort Devens
Reserve Forces Training Area, Devens MA

KOMAN Government Solutions, LLC
160 East Main Street, Suite 2F, Westborough, MA 01581

0 300 600 Feet	Date: 03/29/2017	Figure 15	KGS

File: SIWP_SA_75_Historic.mxd

Figure 16
AOC 32
1992 Aerial Imagery



Legend

⊗	LTM Sample Well
⊗	LTM Well - Periodic Gauge Only
☒	Monitoring Well - Paved Over
▨	Former Storage Tank(s)
T-247	Former Building Number
▭	Approximate Historical Extent of Groundwater Contamination in Exceedance of Cleanup Goals (based on April 2002 to October 2011 analytical data)
▭	TPHC Soil Contamination
▭	Remaining Bedrock Outcrop
—	Current Road
←	Estimated Groundwater Flow Direction
▭	Potential Release Area
32M-92-01X	Well Identification
SHL-25	Proposed PFAS Sample Location

Notes:
AST = Above ground storage tank
UST = Underground storage Tank
DRMO = Defense Reutilization and Marketing Office
LTM = Long-term monitoring
TPHC = Total petroleum hydrocarbons

References:
HGL. LTMMP 2012.

Aerial Source: MassGIS - 1:5,000 Black and White Digital Orthophoto Images - 1992

Site Inspection Work Plan
Study Areas and Areas of Concern

Former Fort Devens Army Installation and Sudbury Annex
Devens, Massachusetts

KOMAN Government Solutions, LLC
160 East Main Street, Suite 2F, Westborough, MA 01581

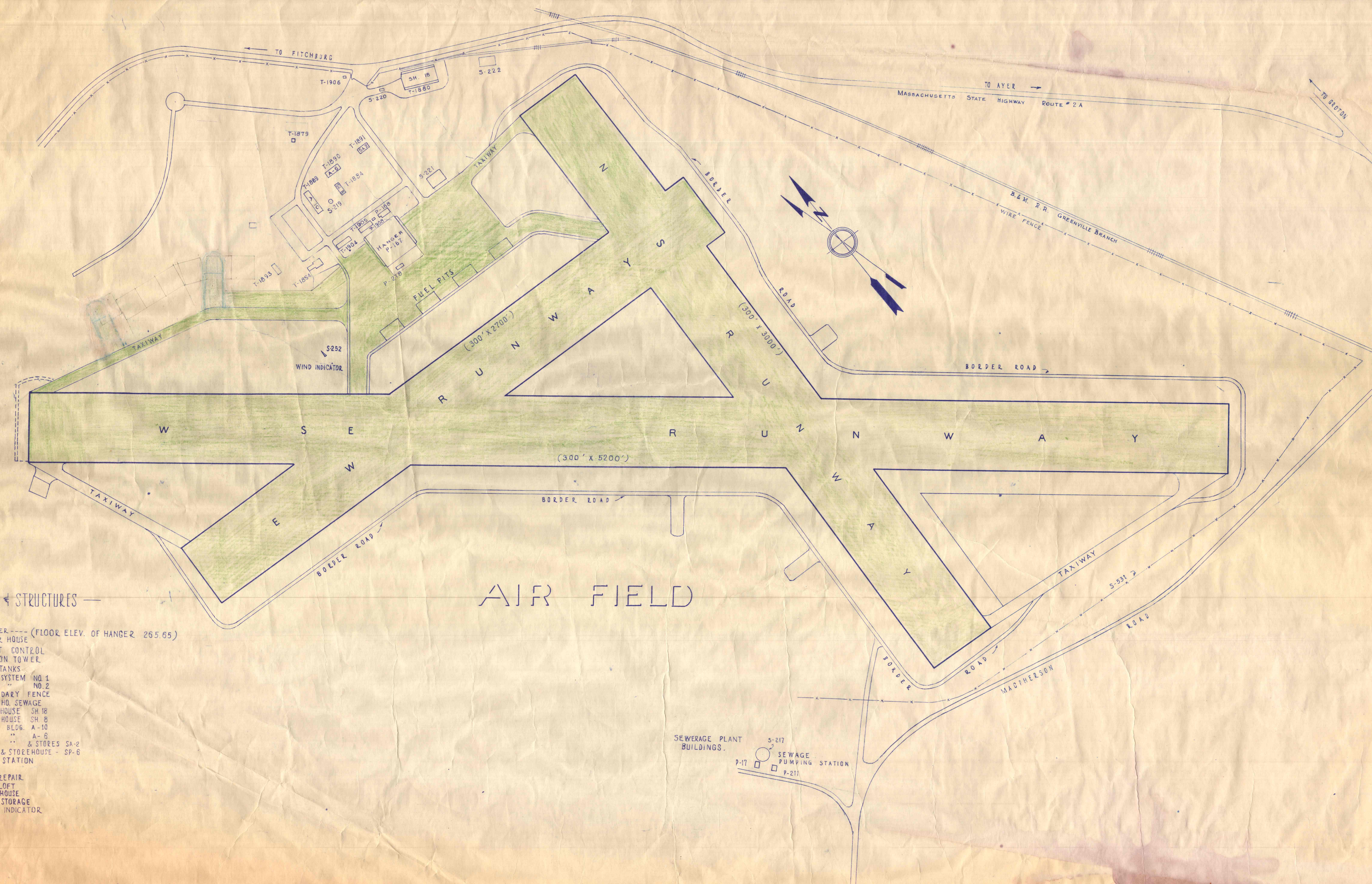
0 80 160
Feet

Date:
04/03/2017

Figure
16

File: SIWP_AOC32_Historic.mxd

ATTACHMENT A
Historical Drawings



SEWERAGE PLANT BUILDINGS.

S-217

SEWAGE PUMPING STATION

P-17

P-211

— BUILDINGS & STRUCTURES —

167 — HANGER ---- (FLOOR ELEV. OF HANGER 265.65)
168 — BOILER HOUSE
P-218 — LIGHT CONTROL
S-219 — BEACON TOWER
S-220 — GAS TANKS
S-221 — AQUA SYSTEM NO. 1
S-222 — AQUA " NO. 2
S-531 — BOUNDARY FENCE
T-1879 — PUMP HO. SEWAGE
T-1880 — WAREHOUSE SH. 18
T-1884 — STORE HOUSE SH. 8
T-1889 — ADM. BLDG. A-10
T-1890 — ADM. " A-6
T-1891 — ADM. " & STORES SA-2
T-1893 — SHOP & STOREHOUSE - SP-6
T-1894 — FIRE STATION

T-1904 — ORD. REPAIR
T-1905 — PAR. LOFT
T-1906 — GATE HOUSE
T-1908 — PAINT STORAGE
S- 252 — WIND INDICATOR

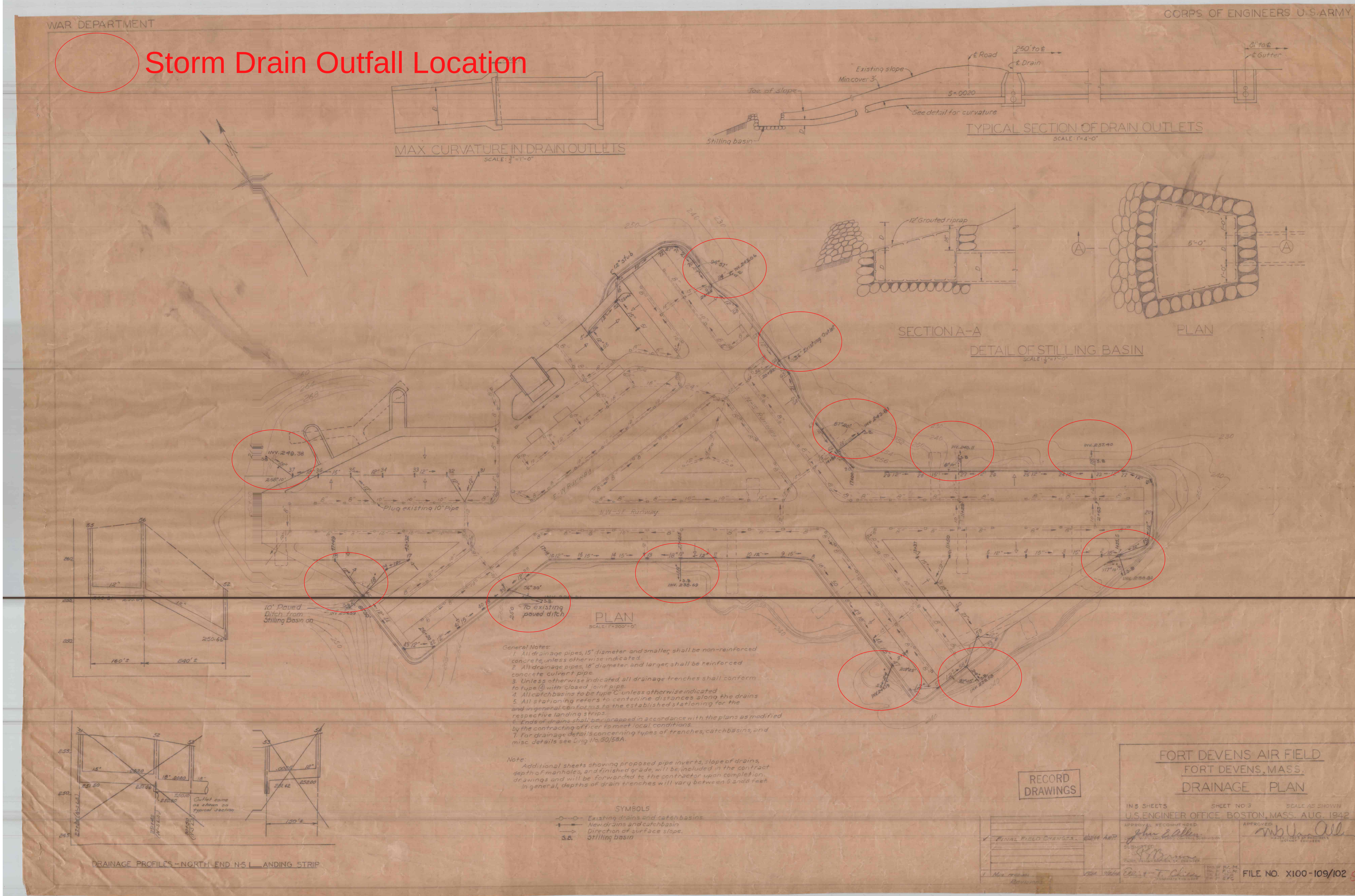
OFFICE OF THE **POST ENGINEER**
FORT DEVENS., MASSACHUSETTS.

DRAWN BY. H. W. NEWTON	PLAN OF FORT DEVENS AIRFIELD
DESIGNED BY.	
CHECKED BY. F. H. Ledgard	
PROJECT NR.	POST ENGINEER

APPROVAL RECOMMENDED Leon R. Briggs	SCALE 1 INCH = 200'	DRAWING NUMBER 655-1135
DATE: 9TH DECEMBER 1954		

WAR DEPARTMENT

CORPS OF ENGINEERS U.S. ARMY



General Notes:

1. All drainage pipes, 15" diameter and smaller, shall be non-reinforced concrete, unless otherwise indicated.
2. All drainage pipes, 18" diameter and larger, shall be reinforced concrete culvert pipe.
3. Unless otherwise indicated, all drainage trenches shall conform to type ④ with closed joint pipe.
4. All catchbasins to be type "C" unless otherwise indicated
5. All stationing refers to centerline distances along the drains and in general conforms to the established stationing for the respective landing strips.
6. Ends of drains shall be riprapped in accordance with the plans as modified by the contracting officer to meet local conditions.
7. For drainage details concerning types of trenches, catchbasins, and misc. details see Dwg. No. 60/58A.

Note:
Additional sheets showing proposed pipe inverts, slope of drains, depth of manholes, and finished grade, will be included in the contract drawings and will be forwarded to the contractor upon completion.
In general, depths of drain trenches will vary between 5 and 8 feet.

SYMBOLS

-o---o- Existing drains and catch basins
New drains and catchbasin
——> Direction of surface slope.
S.B. Stilling basin

RECORD DRAWINGS

✓	FINAL FIELD CHANGES.	8/28/44	AWP
1	Misc. revisions	FCM	9/2/42
	Revisions		

FORT DEVENS AIR FIELD
FORT DEVENS, MASS.
DRAINAGE PLAN

IN 5 SHEETS SHEET NO. 3 SCALE AS SHOWN
U.S. ENGINEER OFFICE BOSTON, MASS. AUG. 1942

APPROVAL RECOMMENDED:
John E Allen
CHIEF, WAR AND FLOOD CONTROL SUBDIVISION

SUBMITTED:
B. Brown
CHIEF, DESIGN SECTION, SR. ENGINEER

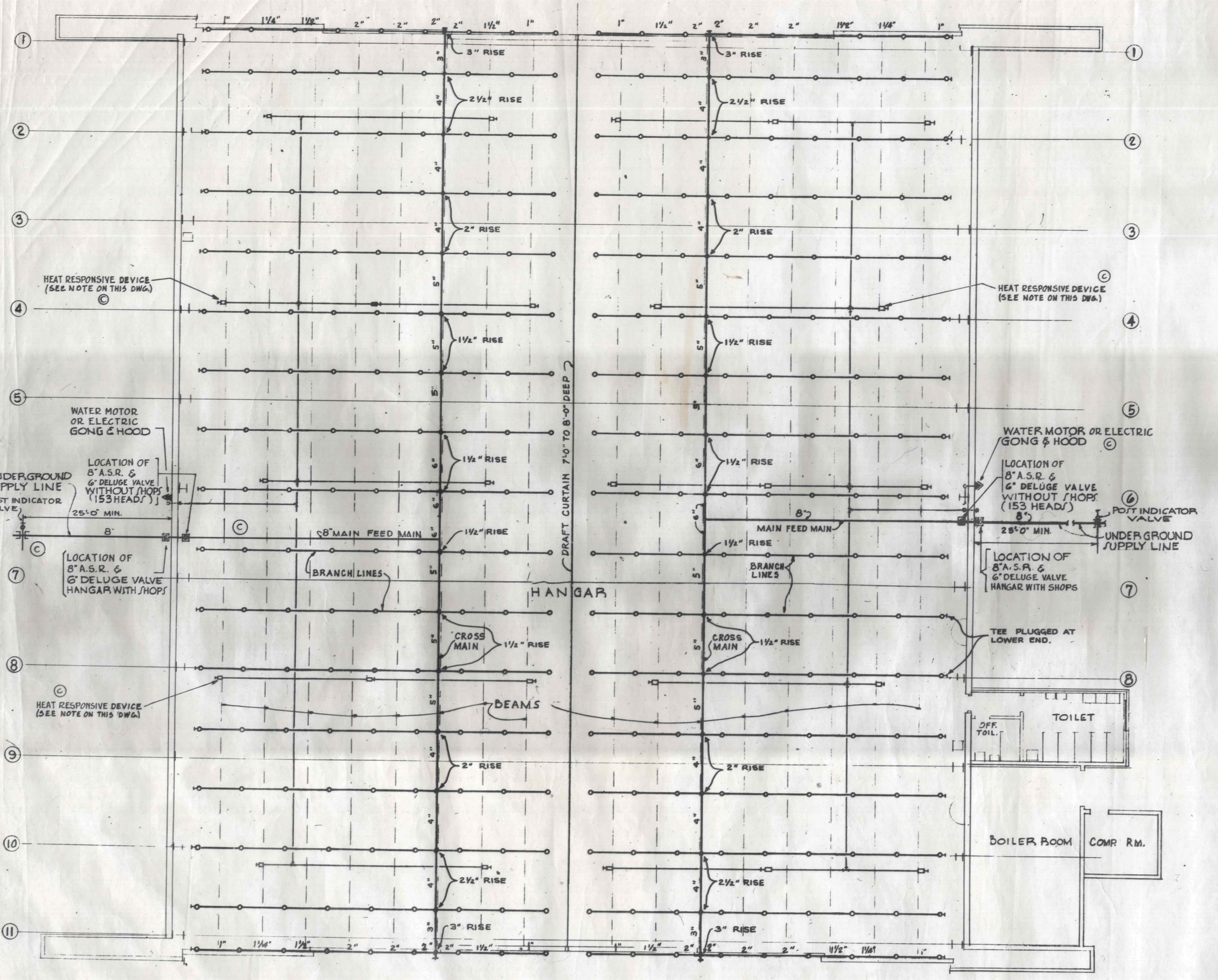
Elliott F. Childs
ASSOCIATE ENGINEER

DES. BY F.C.M.
DR. BY F.C.M.
TR. BY J.T.R.
CH. BY E.F.C.

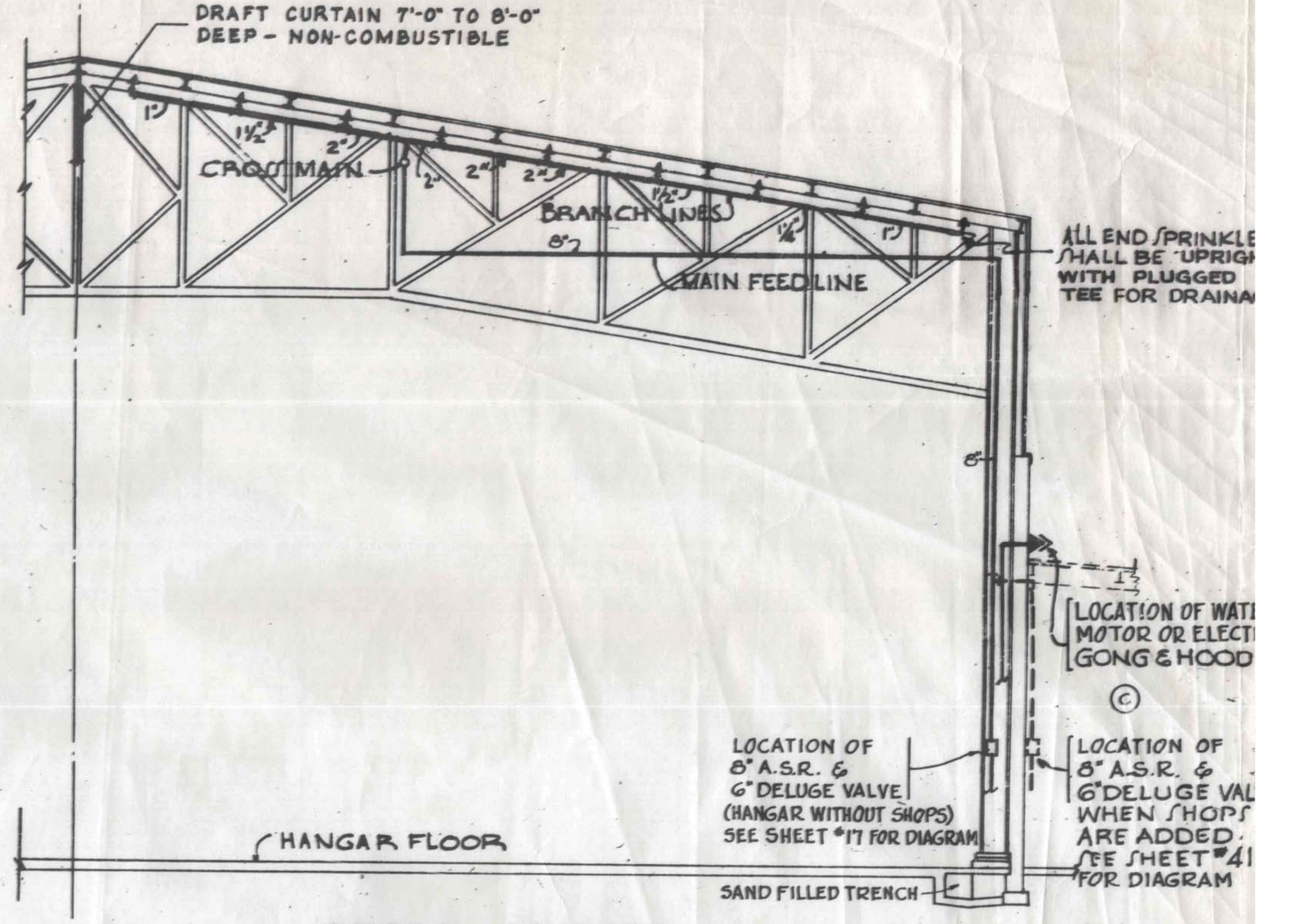
APPROVED:
MAJOR, CORPS OF ENGINEERS
DISTRICT ENGINEER

FILE NO. X100-109/102

Building 3813



PLAN
DELUGE SPRINKLER SYSTEM ⓑ
SCALE 1/8" = 1'-0"



CROSS SECTION SPRINKLER ⓑ
NO SCALE

NOTE:

ALL SPRINKLERS TO BE SPRAY PATTERN 1/2" ORIFICE - OPEN - TYPE UPRIGHT POSITION.

ⓑ

ⓒ HEAT RESPONSIVE DEVICE OF RATE OF RISE AND FIXED TEMPERATURE TYPE RELEASE SPACED AND CONNECTED TO DELUGE VALVE AS REQUIRED BY UNDERWRITERS LABORATORIES INC. FOR MAKE OF DEVICES AND VALVES USED.

GENERAL NOTE:

FOR DELUGE & ALARM VALVE DIAGAMS & REFERENCE NOTES, SEE DWG. 39-01-64 SHEET-41.

SYMBOL	DESCRIPTION	DATE	APPROVA
ⓒ	8" FEED MAIN RELOCATED - NOTES REVISED	8 JAN 60	ECO
ⓑ	GENERAL REVISIONS	27 JUN. '57	WLH
ⓐ	SPEC. NO. REVISED		

REVISIONS

STROBEL AND SALZMAN
ENGINEERS
NEW YORK, N. Y.

DEPARTMENT OF THE ARMY
OFFICE OF THE CHIEF OF ENGINEERS
MILITARY CONSTRUCTION - ENGINEERING DIVISION
Washington, D. C.

DRAWN BY: P. H. W. C. K.
TRACED BY: H. R.
CHECKED BY: W. C. K.
SUBMITTED BY: Joseph Salzman
STROBEL AND SALZMAN
APPROVED: Thomas W. Engle
CHIEF UTILITIES BRANCH
APPROVED: B. Jackson Jr.
CHIEF ENGINEERING DIVISION, MIL. CONSTR., O.C.E.
DATE:

ARMY AVIATION FACILITIES
HANGAR–20,000 SQ. FT.
(35,000 SQ. FT. WITH SHOPS ADDED)
SPRINKLER SYSTEM
PLAN & SECTION

APPROVED FOR
P-3813
DATE:

SCALE AS NOTED
SPEC. NO. 39-01-64-57
DRAWING NUMBER ⓐ
SHEET 35 39-01-64

Building 3813

S

Building 3818

GENERAL NOTES:
VENT TERMINALS PASSING THROUGH LOW ROOFS SHALL BE LOCATED 12 FEET REMOTE FROM WINDOWS
FLOOR DRAINS SHALL CONFORM WITH FED. SPEC. WW-P-541b -TYPE 220
FOR CONTINUATION AND INVERT ELEVATIONS OF ALL SERVICES (STORM, SANITARY AND WATER) SEE SHEET NO.
FOR LEGEND SEE SHEET NO. 1

FIXTURE CONNECTIONS				
ITEM	FIXTURE	C. W.	H. W.	WASTE
P-1	WATER CLOSET	1 1/4"	—	4"
P-2	URINAL	3/4"	—	2"
P-3	LAVATORY	1/2"	1/2"	1 1/2"
P-4	WASH FOUNTAIN	3/4"	3/4"	2"
P-5	SERVICE SINK	1/2"	1/2"	3"
P-6	DRINKING WATER DISPENSER	1/2"	—	1 1/2"
P-7	SINK	1/2"	1/2"	2"

Record Drawing
Contract No. DA-19-016-ENG-5933

*MODIFIED FOR FORT DEVENS
MAY 1958 SPEC. NO. ENG-19-016-58-170
APPROVED FOR N. E. D. BY SWDzyba

SYMBOL	DESCRIPTION	DATE	APPROVAL
	FINAL FIELD CORRECTIONS	1-13-61	CA
ⓐ	TRACK DRAIN ADDED SPEC NUMBER REVISED		

REVISIONS

STROBEL AND SALZMAN
ENGINEERS
NEW YORK, N. Y.

DEPARTMENT OF THE ARMY
OFFICE OF THE CHIEF OF ENGINEERS
MILITARY CONSTRUCTION - ENGINEERING DIVISION
Washington, D. C.

DRAWN BY: W.C.K.
TRACED BY: W.C.K.
CHECKED BY: W.C.K.
SUBMITTED BY:
STROBEL AND SALZMAN
APPROVED:
CHIEF UTILITIES BRANCH
APPROVED:
CHIEF ENGINEERING DIVISION, MIL. CONSTR., O.C.E.
APPROVED FOR
DATE:
DATE:

ARMY AVIATION FACILITIES
HANGAR ~~-12,000 SQ. FT.~~
(20,000 SQ. FT. WITH SHOPS ADDED)
PLUMBING
PLANS & DIAGRAMS

SCALE AS NOTED
SPEC. NO. ~~39-01-62=57-CE~~
DRAWING NUMBER
SHEET 31 39-01-62*ⓐ

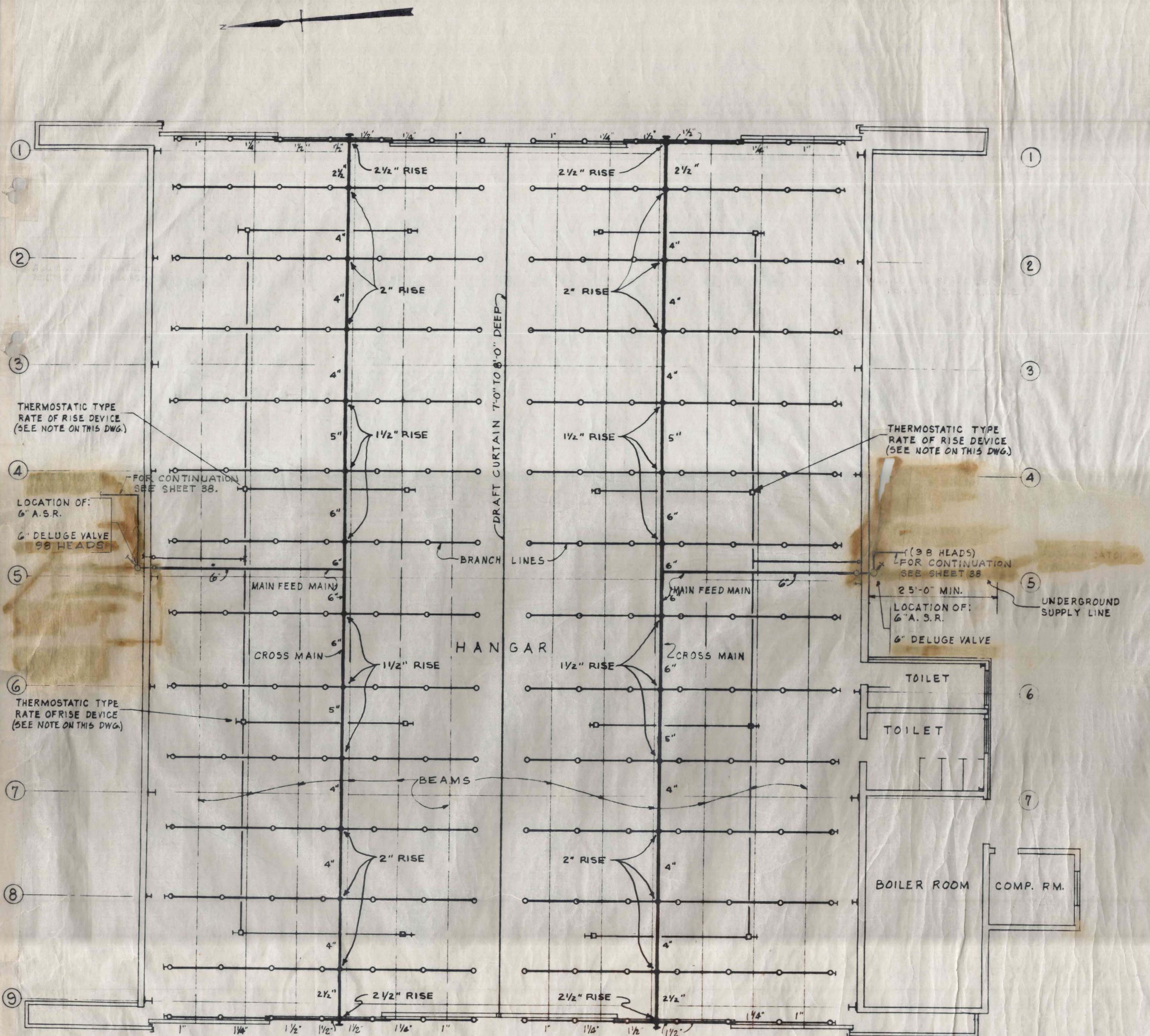
FORT DEVENS - HELIPORT

FILMED

Building 3818

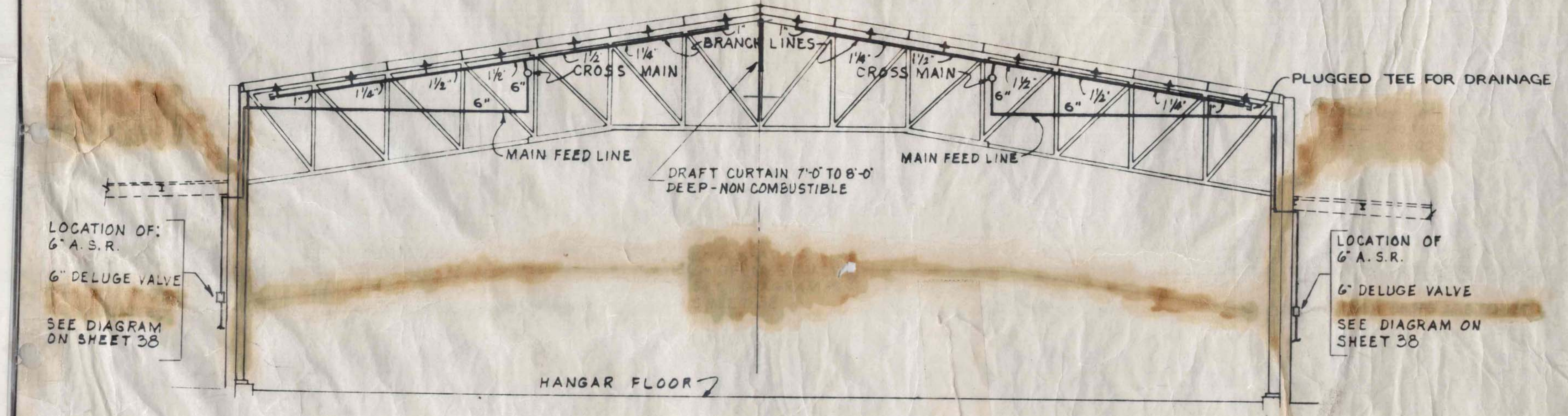
CORPS OF ENGINEERS

Building 3818



PLAN
DELUGE SPRINKLER SYSTEM ⓑ
SCALE 1/8"=1'-0"

Building 3818



CROSS SECTION ⓑ
SPRINKLER
NO SCALE

NOTE:
ALL SPRINKLERS TO BE SPRAY PATTERN 1/2" ORIFICE - OPEN TYPE UPRIGHT POSITION

ⓑ

THERMOSTATIC TYPE RATE OF RISE DEVICE AND FIXED TEMPERATURE RELEASE SPACED AND CONNECTED TO DELUGE VALVE AS REQUIRED BY UNDERWRITERS LABORATORIES INC. FOR MAKE OF DEVICES AND VALVES USED.

GENERAL NOTE:
FOR DELUGE & ALARM VALVE DIAGRAMS & REFERENCE NOTES, SEE DWG. 39-01-62 SHEET. 38

Record Drawing
Contract No. DA-19-016-ENG- 5933

*MODIFIED FOR FORT DEVENS
MAY 1958 SPEC. NO. ENG-19-016-58-170
APPROVED FOR N. E. D. BY

SYMBOL	DESCRIPTION	DATE	APPROVAL
ⓑ	GENERAL REVISIONS	27 JUN.'57	WLH
ⓐ	SPEC NUMBER REVISED		

REVISIONS

STROBEL AND SALZMAN
ENGINEERS
NEW YORK, N. Y.

DEPARTMENT OF THE ARMY
OFFICE OF THE CHIEF OF ENGINEERS
MILITARY CONSTRUCTION - ENGINEERING DIVISION
Washington, D. C.

DRAWN BY: W.C.K. H.R.
TRACED BY: H.R.
CHECKED BY: W.C.K.
SUBMITTED BY:
STROBEL AND SALZMAN
APPROVED:
CHIEF UTILITIES BRANCH
APPROVED:
CHIEF ENGINEERING DIVISION, MIL. CONSTR., O.C.E.
DATE: 2
APPROVED FOR
DATE:

ARMY AVIATION FACILITIES
HANGAR—~~12,000 SQ. FT~~
(20,000 SQ. FT. WITH SHOPS ADDE
SPRINKLER SYSTEM
PLAN & SECTION

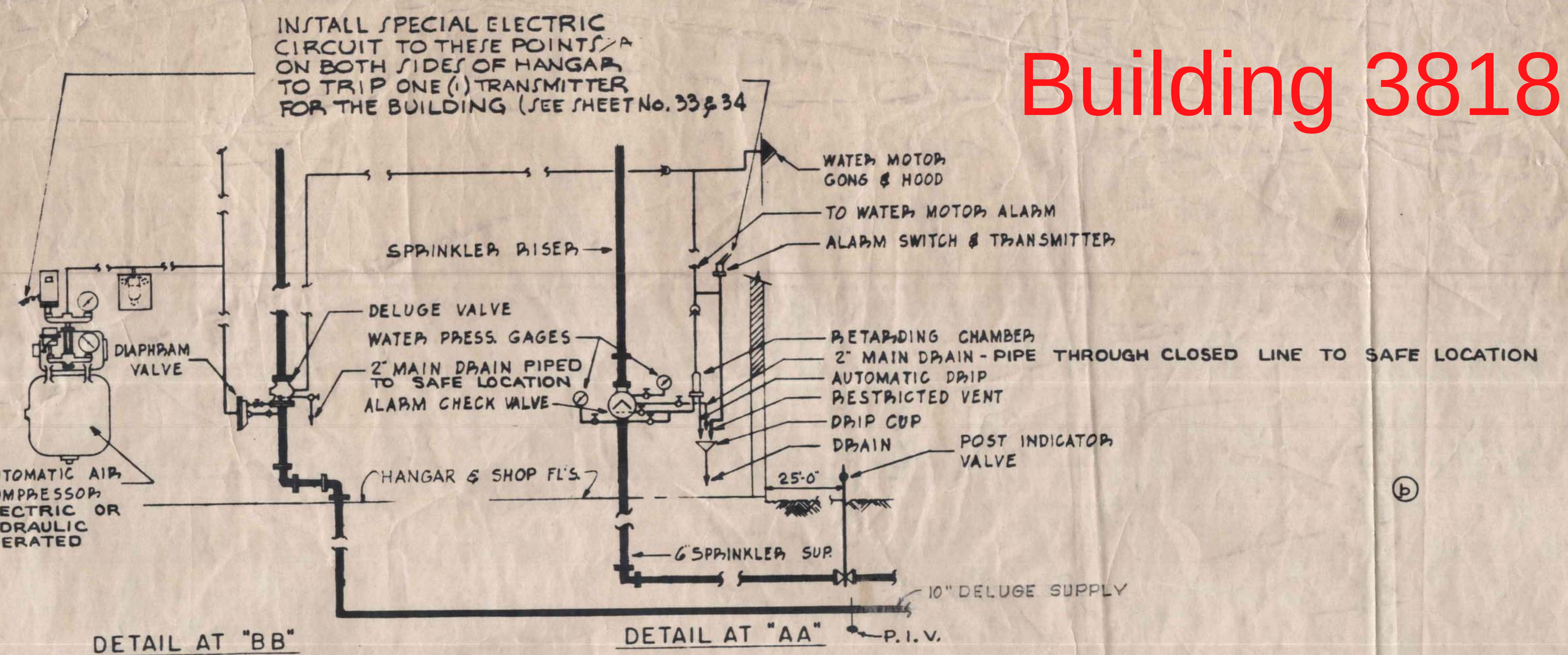
SCALE AS NOTED
SPEC. NO.
DRAWING NUMBE
SHEET 32 39-01-

FORT DEVENS - HELIPORT

CORPS OF ENGINEERS

U. S. ARMY

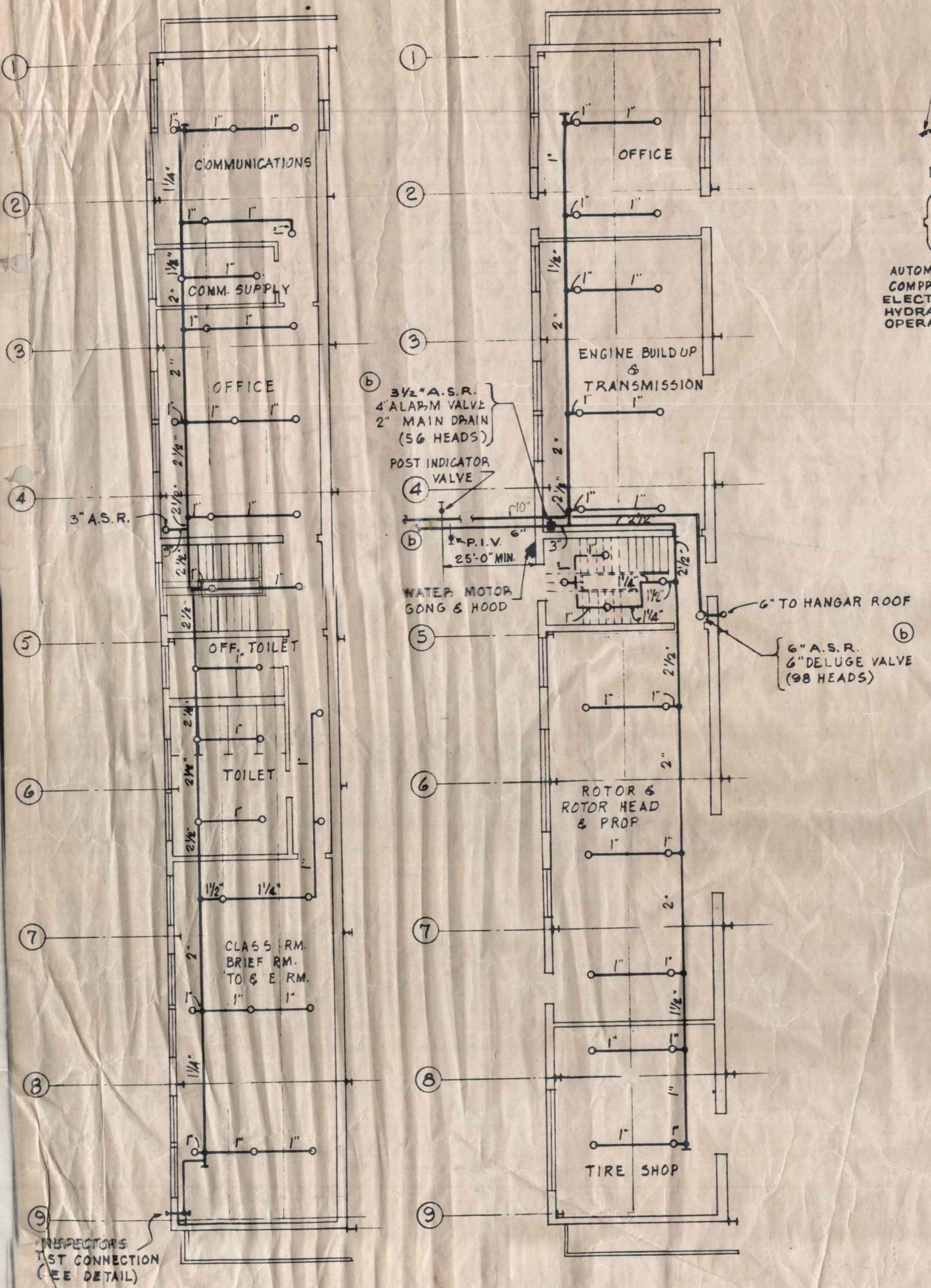
Building 3818



ALARM VALVE CONNECTION DIAGRAM ⓑ

NO SCALE

SEE NOTE "A" BELOW

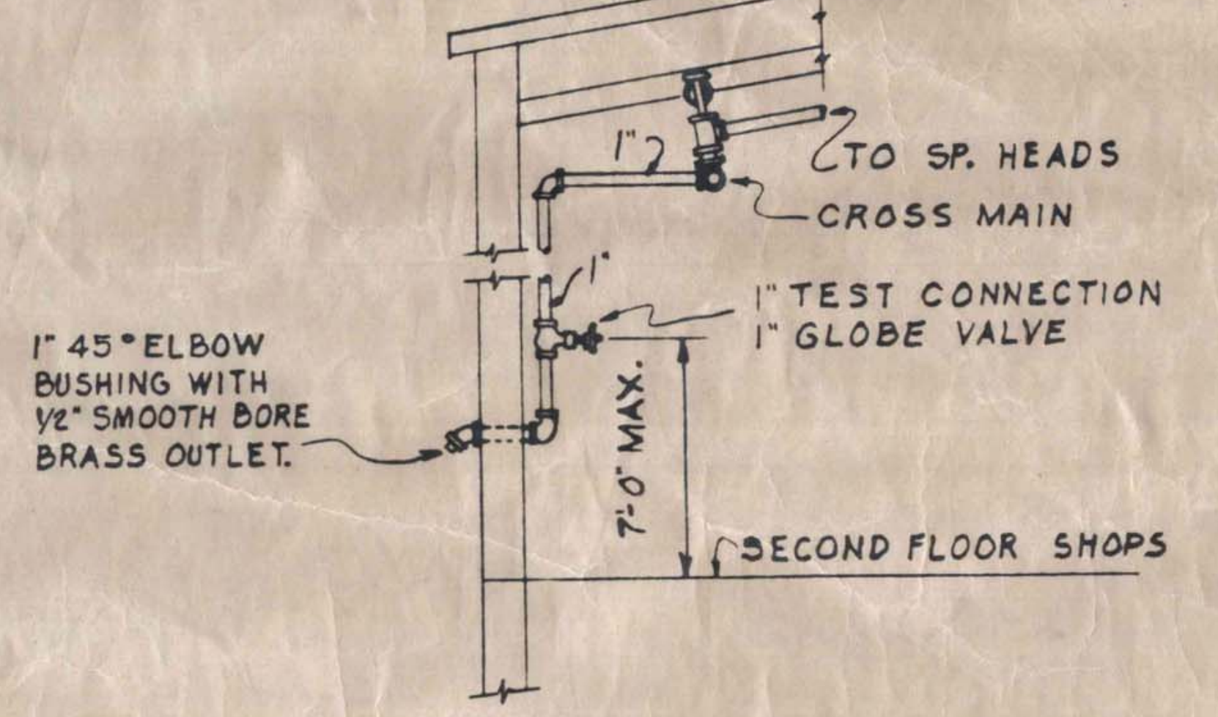


SECOND FLOOR

FIRST FLOOR

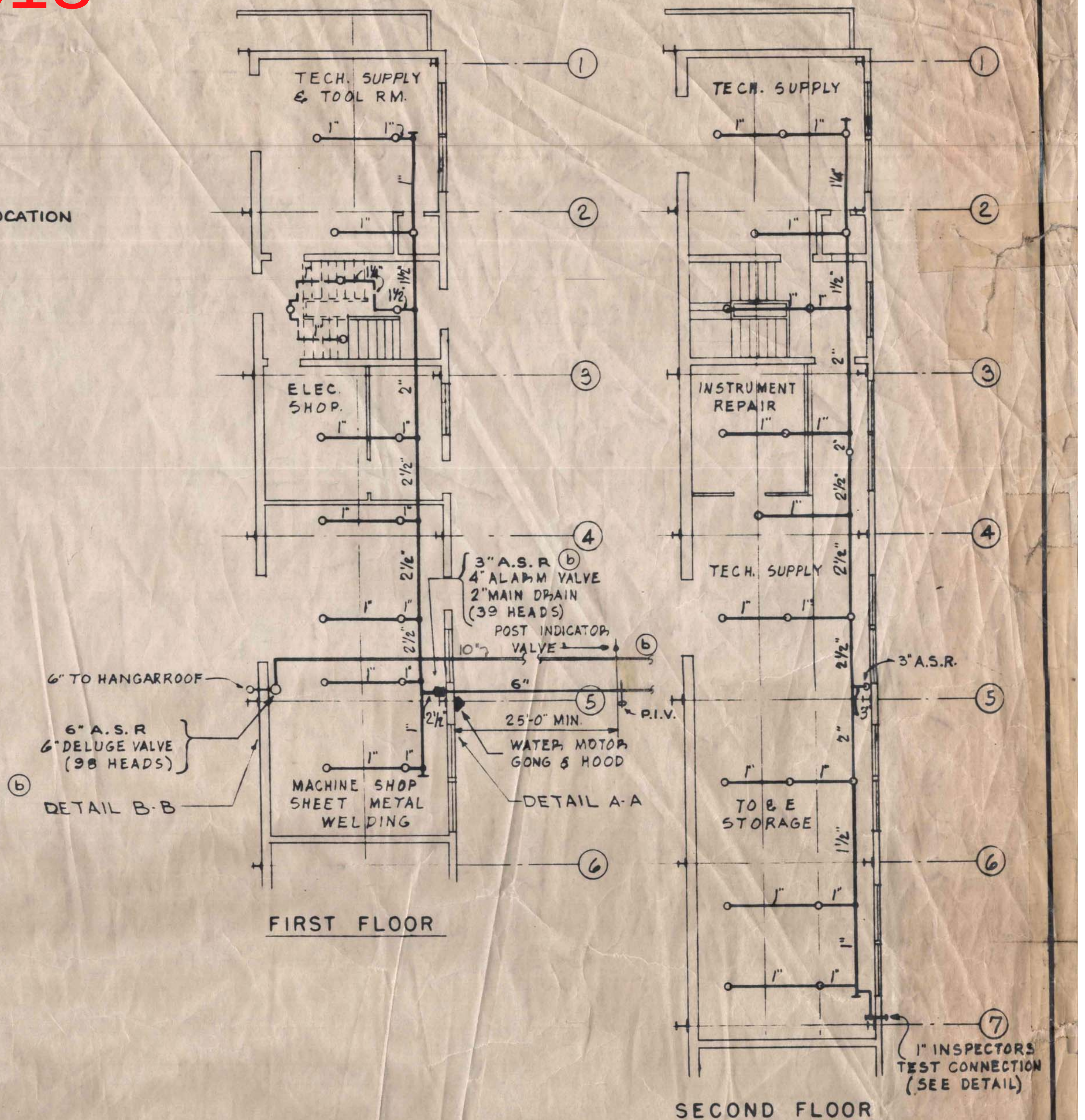
SHOP "A"

SCALE 1/8"=1'-0"



DETAIL OF INSPECTORS TEST CONNECTION

NO SCALE



FIRST FLOOR

SECOND FLOOR

SHOP "B"

SCALE 1/8"=1'-0"

Record Drawing
Contract No. DA-19-016-ENG-5933

NOTE "A" ⓑ

PIPE SIZES AND LENGTHS, LOCATION OF SPRINKLER HEADS, SIZE AND POINTS OF CONNECTION OF BRANCH, DISTRIBUTION AND FEED PIPING, SIZE AND TYPE OF FITTINGS AND RISER NIPPLES AS INDICATED ON SHEET 32 HAVE BEEN DETERMINED BY HYDRAULIC CALCULATIONS TO CONFORM WITH REQUIREMENTS OF NBFU PAMPHLET NO. 13, SECTION 1040. REQUIRED MINIMUM WATER SUPPLY IS 1,500 GPM FOR EACH SYSTEM AT 45 PSI RESIDUAL PRESSURE AT THE DELUGE VALVES. NO CHANGE OR MODIFICATION IN ANY OF THE ABOVE DETAILS MAY BE MADE WITHOUT HYDRAULIC JUSTIFICATION. TOTAL REQUIRED WATER FLOW FOR EACH BUILDING WILL BE 3,500 GPM TO ALLOW FOR 2 EXTERIOR FIRE HOSE STREAMS OF APPROXIMATELY 250 GPM EACH. BASED ON THE ABOVE, A MINIMUM STORAGE OF 200,000 GALLONS WILL BE ADEQUATE TO SUPPLY THE SYSTEMS FOR THE REQUIRED PERIOD OF 45 MINUTES.

WHERE THE REQUIREMENTS ARE SUCH THAT THE WATER SUPPLY MUST BE FURNISHED BY A SEPARATE FIRE PUMPING STATION AND A GROUND STORAGE FACILITY, THREE 1,000 GPM EACH SINGLE STAGE CENTRIFUGAL FIRE PUMPS CAPABLE OF DELIVERING WATER AT 80 PSI AT THE DELUGE VALVES AND MEETING THE REQUIREMENTS OF NBFU PAMPHLET NO. 20 WILL BE PROVIDED.

IN THE EVENT THE RESIDUAL PRESSURE AT THE DELUGE VALVES IS IN EXCESS OF THE DESIGNED 45 PSI DUE TO EITHER THE EXISTING WATER FACILITIES OR THE INSTALLATION OF FIRE PUMPS, THE REQUIRED STORAGE CAPACITY WILL BE COMPUTED BY THE FORMULA:

$$\text{TOTAL STORAGE} = \frac{\text{200,000 × SQUARE ROOT OF HIGHER RESIDUAL PRESSURE}}{\text{SQUARE ROOT OF 45 PSI}}$$

*MODIFIED FOR FORT DEVENS

MAY 1958 SPEC. NO. ENG-19-016-58-170

APPROVED FOR N. E. D. BY SWD

SYMBOL	DESCRIPTION	DATE	APPROVAL
ⓑ	GENERAL REVISIONS	27 JUN '57	WLH
ⓐ	SPEC NUMBER REVISED		

. REVISIONS

STROBEL AND SALZMAN
ENGINEERS
NEW YORK, N. Y.

DEPARTMENT OF THE ARMY
OFFICE OF THE CHIEF OF ENGINEERS
MILITARY CONSTRUCTION - ENGINEERING DIVISION
Washington, D. C.

DRAWN BY: W.C.K. H.R.
TRACED BY: H.R.
CHECKED BY: W.C.K.
SUBMITTED BY:
STROBEL AND SALZMAN
APPROVED:
CHIEF UTILITIES BRANCH
APPROVED:
CHIEF ENGINEERING DIVISION, MIL. CONSTR., O.C.E.
APPROVED FOR
DATE:

ARMY AVIATION FACILITIES
HANGAR—~~12,000 SQ. FT.~~
(20,000 SQ. FT. WITH SHOPS ADDED)
SPRINKLER SYSTEMS
PLANS & DIAGRAMS

DATE: 25 JAN 19

SCALE AS NOTED
SPEC. NO. 39-01-62-57-CE
DRAWING NUMBER
SHEET 38 39-01-62* ⓐ

Building 3818

FORT DEVENS - HELIPORT

FILMED

ATTACHMENT B
Field Sampling Protocols to Avoid Cross-Contamination at PFAS Sites

PFAS Sampling Checklist

Date: ______________________

Weather (*temp./precipitation*): _______________________ Site Name: _______________________________

Field Clothing and PPE:

- ☐ No clothing or boots containing Gore-Tex™
- ☐ All safety boots made from polyurethane and PVC
- ☐ No materials containing Tyvek®
- ☐ Field crew has not used fabric softener on clothing
- ☐ Field crew has not used cosmetics, moisturizers, hand cream, or other related products this morning
- ☐ Field crew has not applied unauthorized sunscreen or insect repellant

Field Equipment:

- ☐ No Teflon® or LDPE containing materials on-site
- ☐ All sample materials made from stainless steel, HDPE, acetate, silicon, or polypropylene
- ☐ No waterproof field books on-site
- ☐ No plastic clipboards, binders, or spiral hard cover notebooks on-site
- ☐ Coolers filled with regular ice only. No chemical (blue) ice packs in possession

Sample Containers:

- ☐ All sample containers made of HDPE or polypropylene
- ☐ Caps are unlined and made of HDPE or polypropylene

Wet Weather (as applicable):

- ☐ Wet weather gear made of polyurethane and PVC only

Equipment Decontamination:

- ☐ "PFC-free" water on-site for decontamination of sample equipment. No other water sources to be used.
- ☐ Alconox and Liquinox to be used as decontamination materials

Food Considerations:

- ☐ No food or drink on-site with exception of bottled water and/or hydration drinks (i.e., Gatorade and Powerade) that is available for consumption only in the staging area

If any applicable boxes cannot be checked, the Field Lead shall describe the noncompliance issues below and work with field personnel to address noncompliance issues prior to commencement of that day's work. Corrective action shall include removal of noncompliance items from the site or removal of worker offsite until in compliance.

Describe the noncompliance issues (include personnel not in compliance) and action/outcome of noncompliance:

____

____

____

Field Lead Name: __________________________________

Field Lead Signature: _________________________________ Time: ______________________

PFAS Sampling – Prohibited and Acceptable Items

Prohibited	Acceptable
Field Equipment	
Teflon® containing materials	High-density polyethylene (HDPE) materials
Low density polyethylene (LDPE) materials	Acetate Liners
	Silicon Tubing
Waterproof field books	Loose paper (non-waterproof)
Plastic clipboards, binders, or spiral hard cover notebooks	Aluminum field clipboards or with Masonite
Chemical (blue) ice packs	Regular ice
Field Clothing and PPE	
New cotton clothing or synthetic water resistant, waterproof, or stain-treated clothing, clothing containing Gore-Tex™	Well-laundered clothing made of natural fibers (preferable cotton)
Clothing laundered using fabric softener	No fabric softener
Boots containing Gore-Tex™	Boots made with polyurethane and PVC
Tyvek®	Cotton clothing
No cosmetics, moisturizers, hand cream, or other related products as part of personal cleaning/showering routine on the morning of sampling	**Sunscreens** - Alba Organics Natural Sunscreen, Yes To Cucumbers, Aubrey Organics, Jason Natural Sun Block, Kiss my face, Baby sunscreens that are “free” or “natural” **Insect Repellents** - Jason Natural Quit Bugging Me, Repel Lemon Eucalyptus Insect repellant, Herbal Armor, California Baby Natural Bug Spray, BabyGanics **Sunscreen and insect repellant -** Avon Skin So Soft Bug Guard Plus – SPF 30 Lotion
Sample Containers	
LDPE or glass containers	HDPE or polypropylene
Teflon-lined caps	Unlined polypropylene caps
Rain Events	
Waterproof or resistant rain gear	Gazebo tent that is only touched or moved prior to and following sampling activities
Equipment Decontamination	
Decon 90®	Alconox® and/or Liquinox®
Water from an on-site well	Potable water from municipal drinking water supply
Food Considerations	
All food and drink, with exceptions noted on right	Bottled water and hydration fluids (i.e, Gatorade® and Powerade®) to be brought and consumed only in the staging areas

ATTACHMENT C
Standard Operating Procedures

FIELD SAMPLING PROTOCOLS TO AVOID CROSS-CONTAMINATION AT PERFLUORINATED COMPOUNDS (PFCs) SITES

1.0 PURPOSE

The purpose of this Standard Operating Procedure (SOP) is to describe the procedures/considerations when collecting soil, sediment, surface water, and groundwater samples at potential PFC release sites. Sampling specific SOPs should also be reviewed prior to conducting field sampling activities at PFC sites.

2.0 SCOPE

This procedure applies to all personnel and subcontractors who collect or otherwise handle samples of soil, sediment, surface water, and groundwater for analysis of PFCs. This SOP should be reviewed by all on-site personnel prior to implementation of field activities.

3.0 REFERENCES

Transport Canada, 2013. *Perfluorochemical (PFC) Field Sampling Protocol*. May.

Delta Consultants, 2010. *Report of Investigation Activities at Select Firefighting Foam Training Areas and Foam Discharge Sites in Minnesota*. February.

MPCA, 2008. *Closed Landfill Program Sampling Protocol for Monitoring Wells.* October.

4.0 GENERAL

Given the low detection limits associated with PFC analysis and the many potential sources of trace levels of PFCs, field personnel are advised to act on the side of caution by strictly following these protocols, frequently replacing nitrile gloves, and rinsing field equipment to help mitigate the potential for false detections of PFCs. Specific items related to field sampling are discussed below.

5.0 PROCEDURES/CONSIDERATIONS

The following are procedures/considerations to be made during field activities at potential PFC release sites. A summary of the prohibited and acceptable items for PFC sites is included in Table 1. Table 1 shall be reviewed daily prior to the commencement of fieldwork to ensure the field team is in compliance with this protocol.

Field Equipment

- **Do not use Teflon®-containing materials** (e.g., Teflon® tubing, bailers, tape, plumbing paste, or other Teflon® materials) since Teflon® contains fluorinated compounds.
- High-density polyethylene (HDPE), low-density polyethylene (LDPE), and silicon materials are acceptable for sampling. Samples should not be stored in containers made of LDPE materials.
- When using liners to collect soil samples during direct-push technology (DPT) or conventional drilling methodologies, acetate liners are to be used.
- To avoid plastic coating or glue materials, **do not use waterproof field books**. Field reports will be documented on loose paper on masonite or aluminum clipboards (i.e. plastic clipboards, binders, or spiral hard cover notebooks are not acceptable) using a pen or pencil. Sharpies®/markers may NOT be used.

- **Post-It Notes are not allowed** on project sites.
- **Do not use markers.** Pens will be used when documenting field activities in the field log and on field forms as well as labeling sample containers and preparing the Chain of Custody.
- **Do not use chemical (blue) ice packs** during the sampling program. This includes the use of ice packs for the storage of food and/or samples.

Field Clothing and Personal Protective Equipment

- **Do not wear water resistant, waterproof, or stain-treated clothing** during the field program. Field clothing made of synthetic and natural fibers (preferably cotton) are acceptable. Field clothing should be laundered avoiding the use of fabric softener. Preferably, field gear should be cotton construction and well laundered (a minimum of 6 times from time of purchase). New clothing may contain PFC related treatments. **Do not use new clothing** while sampling or sample handling.
- **Do not wear clothing or boots containing Gore-Tex™** during the sampling program as it consists of a PFC membrane.
- All safety footwear will consist of steel-toed boots made with polyurethane and polyvinyl chloride (PVC).
- **Do not wear Tyvek® clothing** on-site since it contains fluorinated compounds.
- Disposable nitrile gloves must be worn at all times. Further, a new pair of nitrile gloves shall be donned prior to the following activities at each sample location:
  - Decontamination of re-usable sampling equipment;
  - Prior to contact with sample bottles or water containers;
  - Insertion of anything into the well (e.g. HDPE tubing, HydraSleeve bailer, etc.);
  - Insertion of silicon tubing into the peristaltic pump;
  - Completion of monitor well purging, prior to sample collection;
  - Handling of any quality assurance/quality control samples including field blanks and equipment blanks; and,
  - After the handling of any non-dedicated sampling equipment, contact with non-decontaminated surfaces, or when judged necessary by field personnel.

Sample Containers

- Different laboratories may supply sample collection containers of varying sizes dependent on the type of media to be sampled (e.g., soil, groundwater, etc.). However, all samples should be collected in polypropylene or HDPE bottles fitted with an unlined (no Teflon®), polypropylene HDPE screw cap.
- Container labels will be completed using pen (**NO MARKERS**) after the caps have been placed back on each bottle.
- Glass containers should also be avoided due to potential loss of analyte through adsorption.

Wet Weather

- Field sampling occurring during wet weather (e.g., rainfall and snowfall) should be conducted while wearing appropriate clothing that will not pose a risk for cross-contamination. Teams will

avoid synthetic gear that has been treated with water-repellant finishes containing PFCs. Use rain gear made from polyurethane and wax-coated materials.
- Teams should consider the use of a gazebo tent, which can be erected overtop of the sample location and provide shelter from the rain. It should be noted that the canopy material is likely a treated surface and should be treated as such; therefore, gloves should be worn when moving the tent, changed immediately afterwards and further contact with the tent should be avoided until all sampling activities have been finished and the team is ready to move on to the next sample location.

Equipment Decontamination

Field sampling equipment, including oil/water interface meters and water level indicators, that is utilized at each sample location will require cleaning between uses. Alconox® and Liquinox® soap is acceptable for use since the Material Safety Data Sheets do not list fluoro-surfactants as an ingredient. However, **Decon 90 will not be used** during decontamination activities. Water used for the decontamination of sampling equipment will be laboratory certified "PFC-free" water.

For larger equipment (e.g., drill rigs), decontamination will be conducted with potable water using a high-pressure washer and then rinsed using potable water.

Personnel Hygiene

- Field personnel will not use cosmetics, moisturizers, hand cream, or other related products as part of their personal cleaning/showering routine on the morning of a sampling event, as these products may contain surfactants and represent a potential source of PFCs.
- Many manufactured sunblock and insect repellants contain PFCs and should not be brought or used on-site. Sunblock and insect repellants that are used on-site should consist of 100% natural ingredients. A list of acceptable sunscreens and insect repellents are listed in Table 1.
- For washroom breaks, field personnel will leave the exclusion zone and then remove gloves and overalls. Field personnel should wash as normal with extra time for rinsing with water after soap use. When finished washing, the use of a mechanical dryer is preferred and the use of paper towel for drying is to be avoided (if possible).

Food Considerations

- No food or drink shall be brought on-site, with the exception of bottled water and hydration drinks (i.e., Gatorade® and Powerade®), which will only be allowed to be brought and consumed within the staging area.

Visitors

- Visitors to the site are asked to remain outside of the exclusion zone during sampling activities.

Table 1. Summary of Prohibited and Acceptable Items for PFC Sampling

Prohibited Items	Acceptable Items
Field Equipment	
Teflon® containing materials	High-density polyethylene (HDPE) and Low density polyethylene (LDPE) materials
Storage of samples in containers made of LDPE materials	Acetate liners
	Silicon tubing
Waterproof field books	Loose paper
Plastic clipboards, binders, or spiral hard cover notebooks	Masonite or aluminum clipboards
Sharpies® or markers	Pens
Post-It Notes	Loose paper
Chemical (blue) ice packs	Regular ice
Field Clothing and PPE	
New clothing or water resistant, waterproof, or stain-treated clothing, clothing containing Gore-Tex^{TM}	Well-laundered clothing made of synthetic or natural fibers (preferable cotton)
Clothing laundered using fabric softner	No fabric softener
Boots containing Gor-Tex^{TM}	Boots made with polyurethane and PVC
Tyvek®	Cotton Clothing
No cosmetics, moisturizers, hand cream, or other related products as part of personal cleaning/showering routine on the morning of sampling	**Sunscreens** - Alba Organics Natural Sunscreen, Yes To Cucumbers, Aubrey Organics, Jason Natural Sun Block, Kiss my face, Baby sunscreens that are "free" or "natural" **Insect Repellents** - Jason Natural Quit Bugging Me, Repel Lemon Eucalyptus Insect repellant, Herbal Armor, California Baby Natural Bug Spray, BabyGanics **Sunscreen and insect repellant** - Avon Skin So Soft Bug Guard Plus – SPF 30 Lotion
Sample Containers	
LDPE or glass containers	HDPE or polypropylene
Teflon®-lined caps	Unlined polypropylene caps
Rain Events	
Waterproof or resistant rain gear	Gazebo tent that is only touched or moved prior to and following sampling activities
Equipment Decontamination	
Decon 90	Alconox® and/or Liquinox®
Water from an on-site well	Potable water from municipal drinking water supply
Food Considerations	
All food and drink, with exceptions noted on the right	Bottled water and hydration drinks (i.e. Gatorade® and Powerade®) to be brought and consumed only in the staging area

Tier and Description	Action
Tier 1: Products that *will come into direct contact* with field samples include, but are not limited to, sampling equipment, sample containers, and well construction materials	These products will undergo the greatest scrutiny and requires chemist's input to help evaluate the materials as a possible source of contamination[A]
Tier 2: Products that *will not come into direct contact* with samples, but could be *reasonably expected to contain PFCs*, such as waterproof or nonstick products	Project team/affected person can review the Safety Data Sheet (SDS)[B] and if it shows PFCs, product should not be used. If product SDS does not indicate PFCs, confirm with chemist before use
Tier 3: Products that *will not come into direct contact* with samples and are *not expected to contain PFCs*, such as ballpoint pens, zipper bags, and body braces	Project team/affected person can review SDS and if no PFCs, then appropriate to use

[A] Tier 1 products will undergo the closest scrutiny. It may be necessary to have Tier 1 products analyzed for PFCs to confirm that a specific batch or lot number does not contain PFCs. Alternate products will need to be evaluated/used if PFCs are identified in the product.

[B] SDS Check: To evaluate product SDS and/or manufacturing specs, check if the product contains anything with "fluoro" in the name or the acronyms TPE, FEP, ETFE, and/or PFA. If fluorinated compounds are not listed in the manufacturing specs and/or on the SDSs, product can be used.

U.S. ENVIRONMENTAL PROTECTION AGENCY
REGION I

LOW STRESS (low flow) PURGING AND SAMPLING PROCEDURE FOR THE COLLECTION OF GROUNDWATER SAMPLES FROM MONITORING WELLS

Quality Assurance Unit
U.S. Environmental Protection Agency – Region 1
11 Technology Drive
North Chelmsford, MA 01863

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Prepared by: Charles Porfert 1/19/10
(Charles Porfert, Quality Assurance Unit) Date

Approved by: Gerard Sotolongo 1-19-10
(Gerard Sotolongo, Quality Assurance Unit) Date

Revision Page

Date	**Rev #**	**Summary of changes**	**Sections**
7/30/96	2	Finalized	
01/19/10	3	Updated	All sections

TABLE OF CONTENTS

USE OF TERMS

Equipment blank: The equipment blank shall include the pump and the pump's tubing. If tubing is dedicated to the well, the equipment blank needs only to include the pump in subsequent sampling rounds. If the pump and tubing are dedicated to the well, the equipment blank is collected prior to its placement in the well. If the pump and tubing will be used to sample multiple wells, the equipment blank is normally collected after sampling from contaminated wells and not after background wells.

Field duplicates: Field duplicates are collected to determine precision of the sampling procedure. For this procedure, collect duplicate for each analyte group in consecutive order (VOC original, VOC duplicate, SVOC original, SVOC duplicate, etc.).

Indicator field parameters: This SOP uses field measurements of turbidity, dissolved oxygen, specific conductance, temperature, pH, and oxidation/reduction potential (ORP) as indicators of when purging operations are sufficient and sample collection may begin.

Matrix Spike/Matrix Spike Duplicates: Used by the laboratory in its quality assurance program. Consult the laboratory for the sample volume to be collected.

Poteniometric Surface: The level to which water rises in a tightly cased well constructed in a confined aquifer. In an unconfined aquifer, the potentiometric surface is the water table.

QAPP: Quality Assurance Project Plan

SAP: Sampling and Analysis Plan

SOP: Standard operating procedure

Stabilization: A condition that is achieved when all indicator field parameter measurements are sufficiently stable (as described in the "Monitoring Indicator Field Parameters" section) to allow sample collection to begin.

Temperature blank: A temperature blank is added to each sample cooler. The blank is measured upon receipt at the laboratory to assess whether the samples were properly cooled during transit.

Trip blank (VOCs): Trip blank is a sample of analyte-free water taken to the sampling site and returned to the laboratory. The trip blanks (one pair) are added to each sample cooler that contains VOC samples.

SCOPE & APPLICATION

The goal of this groundwater sampling procedure is to collect water samples that reflect the total mobile organic and inorganic loads (dissolved and colloidal sized fractions) transported through the subsurface under ambient flow conditions, with minimal physical and chemical alterations from sampling operations. This standard operating procedure (SOP) for collecting groundwater samples will help ensure that the project's data quality objectives (DQOs) are met under certain low-flow conditions.

The SOP emphasizes the need to minimize hydraulic stress at the well-aquifer interface by maintaining low water-level drawdowns, and by using low pumping rates during purging and sampling operations. Indicator field parameters (e.g., dissolved oxygen, pH, etc.) are monitored during purging in order to determine when sample collection may begin. Samples properly collected using this SOP are suitable for analysis of groundwater contaminants (volatile and semi-volatile organic analytes, dissolved gases, pesticides, PCBs, metals and other inorganics), or naturally occurring analytes. This SOP is based on Puls, and Barcelona (1996).

This procedure is designed for monitoring wells with an inside diameter (1.5-inches or greater) that can accommodate a positive lift pump with a screen length or open interval ten feet or less and with a water level above the top of the screen or open interval (Hereafter, the "screen or open interval" will be referred to only as "screen interval"). This SOP is not applicable to other well-sampling conditions.

While the use of dedicated sampling equipment is not mandatory, dedicated pumps and tubing can reduce sampling costs significantly by streamlining sampling activities and thereby reducing the overall field costs.

The goal of this procedure is to emphasize the need for consistency in deploying and operating equipment while purging and sampling monitoring wells during each sampling event. This will help to minimize sampling variability.

This procedure describes a general framework for groundwater sampling. Other site specific information (hydrogeological context, conceptual site model (CSM), DQOs, etc.) coupled with systematic planning must be added to the procedure in order to develop an appropriate site specific SAP/QAPP. In addition, the site specific SAP/QAPP must identify the specific equipment that will be used to collect the groundwater samples.

This procedure does not address the collection of water or free product samples from wells containing free phase LNAPLs and/or DNAPLs (light or dense non-aqueous phase liquids). For this type of situation, the reader may wish to check: Cohen, and Mercer (1993) or other pertinent documents.

This SOP is to be used when collecting groundwater samples from monitoring wells at all Superfund, Federal Facility and RCRA sites in Region 1 under the conditions described herein. Request for modification of this SOP, in order to better address specific situations at individual wells, must include adequate technical justification for proposed changes. All changes and modifications must be approved and included in a revised SAP/QAPP before implementation in field.

BACKGROUND FOR IMPLEMENTATION

It is expected that the monitoring well screen has been properly located (both laterally and vertically) to intercept existing contaminant plume(s) or along flow paths of potential contaminant migration. Problems with inappropriate monitoring well placement or faulty/improper well installation cannot be overcome by even the best water sampling procedures. This SOP presumes that the analytes of interest are moving (or will potentially move) primarily through the more permeable zones intercepted by the screen interval.

Proper well construction, development, and operation and maintenance cannot be overemphasized. The use of installation techniques that are appropriate to the hydrogeologic setting of the site often prevent "problem well" situations from occurring. During well development, or redevelopment, tests should be conducted to determine the hydraulic characteristics of the monitoring well. The data can then be used to set the purging/sampling rate, and provide a baseline for evaluating changes in well performance and the potential need for well rehabilitation. Note: if this installation data or well history (construction and sampling) is not available or discoverable, for all wells to be sampled, efforts to build a sampling history should commence with the next sampling event.

The pump intake should be located within the screen interval and at a depth that will remain under water at all times. It is recommended that the intake depth and pumping rate remain the same for all sampling events. The mid-point or the lowest historical midpoint of the saturated screen length is often used as the location of the pump intake. For new wells, or for wells without pump intake depth information, the site's SAP/QAPP must provide clear reasons and instructions on how the pump intake depth(s) will be selected, and reason(s) for the depth(s) selected. If the depths to top and bottom of the well screen are not known, the SAP/QAPP will need to describe how the sampling depth will be determined and how the data can be used.

Stabilization of indicator field parameters is used to indicate that conditions are suitable for sampling to begin. Achievement of turbidity levels of less than 5 NTU, and stable drawdowns of less than 0.3 feet, while desirable, are not mandatory. Sample collection may still take place provided the indicator field parameter criteria in this procedure are met. If after 2 hours of purging indicator field parameters have not stabilized, one of three optional courses of action may be taken: a) continue purging until stabilization is achieved, b) discontinue purging, do not collect any samples, and record in log book that stabilization could not be achieved (documentation must describe attempts to achieve stabilization), c) discontinue purging, collect samples and provide full explanation of attempts to achieve stabilization (note: there is a risk that the analytical data obtained, especially metals and strongly hydrophobic organic analytes, may reflect a sampling bias and therefore, the data may not meet the data quality objectives of the sampling event).

It is recommended that low-flow sampling be conducted when the air temperature is above 32°F (0°C). If the procedure is used below 32°F, special precautions will need to be taken to prevent the groundwater from freezing in the equipment. Because sampling during freezing temperatures may adversely impact the data quality objectives, the need for water sample collection during months when these conditions are likely to occur should be evaluated during site planning and special sampling measures may need to be developed. Ice formation in the flow-through-cell will cause the monitoring probes to act erratically. A transparent flow-through-cell needs to be used to observe if ice is forming in the cell. If ice starts to form on the other pieces of the sampling equipment, additional problems may occur.

HEALTH & SAFETY

When working on-site, comply with all applicable OSHA requirements and the site's health/safety procedures. All proper personal protection clothing and equipment are to be worn. Some samples may contain biological and chemical hazards. These samples should be handled with suitable protection to skin, eyes, etc.

CAUTIONS

The following cautions need to be considered when planning to collect groundwater samples when the below conditions occur.

If the groundwater degasses during purging of the monitoring well, dissolved gases and VOCs will be lost. When this happens, the groundwater data for dissolved gases (e.g., methane, ethene, ethane, dissolved oxygen, etc.) and VOCs will need to be qualified. Some conditions that can promote degassing are the use of a vacuum pump (e.g., peristaltic pumps), changes in aperture along the sampling tubing, and squeezing/pinching the pump's tubing which results in a pressure change.

When collecting the samples for dissolved gases and VOCs analyses, avoid aerating the groundwater in the pump's tubing. This can cause loss of the dissolved gases and VOCs in the groundwater. Having the pump's tubing completely filled prior to sampling will avoid this problem when using a centrifugal pump or peristaltic pump.

Direct sun light and hot ambient air temperatures may cause the groundwater in the tubing and flow-through-cell to heat up. This may cause the groundwater to degas which will result in loss of VOCs and dissolved gases. When sampling under these conditions, the sampler will need to shade the equipment from the sunlight (e.g., umbrella, tent, etc.). If possible, sampling on hot days, or during the hottest time of the day, should be avoided. The tubing exiting the monitoring well should be kept as short as possible to avoid the sun light or ambient air from heating up the groundwater.

Thermal currents in the monitoring well may cause vertical mixing of water in the well bore. When the air temperature is colder than the groundwater temperature, it can cool the top of the water column. Colder water which is denser than warm water sinks to the bottom of the well and the warmer water at the bottom of the well rises, setting up a convention cell. "During low-flow sampling, the pumped water may be a mixture of convecting water from within the well casing and aquifer water moving inward through the screen. This mixing of water during low-flow sampling can substantially increase equilibration times, can cause false stabilization of indicator parameters, can give false indication of redox state, and can provide biological data that are not representative of the aquifer conditions" (Vroblesky 2007).

Failure to calibrate or perform proper maintenance on the sampling equipment and measurement instruments (e.g., dissolved oxygen meter, etc.) can result in faulty data being collected.

Interferences may result from using contaminated equipment, cleaning materials, sample containers, or uncontrolled ambient/surrounding air conditions (e.g., truck/vehicle exhaust nearby).

Cross contamination problems can be eliminated or minimized through the use of dedicated sampling equipment and/or proper planning to avoid ambient air interferences. Note that the use of dedicated sampling equipment can also significantly reduce the time needed to complete each sampling event, will promote consistency in the sampling, and may reduce sampling bias by having the pump's intake at a constant depth.

Clean and decontaminate all sampling equipment prior to use. All sampling equipment needs to be routinely checked to be free from contaminants and equipment blanks collected to ensure that the equipment is free of contaminants. Check the previous equipment blank data for the site (if they exist) to determine if the previous cleaning procedure removed the contaminants. If contaminants were detected and they are a concern, then a more vigorous cleaning procedure will be needed.

PERSONNEL QUALIFICATIONS

All field samplers working at sites containing hazardous waste must meet the requirements of the OSHA regulations. OSHA regulations may require the sampler to take the 40 hour OSHA health and safety training course and a refresher course prior to engaging in any field activities, depending upon the site and field conditions.

The field samplers must be trained prior to the use of the sampling equipment, field instruments, and procedures. Training is to be conducted by an experienced sampler before initiating any sampling procedure.

The entire sampling team needs to read, and be familiar with, the site Health and Safety Plan, all relevant SOPs, and SAP/QAPP (and the most recent amendments) before going onsite for the sampling event. It is recommended that the field sampling leader attest to the understanding of these site documents and that it is recorded.

EQUIPMENT AND SUPPLIES

A. Informational materials for sampling event

A copy of the current Health and Safety Plan, SAP/QAPP, monitoring well construction data, location map(s), field data from last sampling event, manuals for sampling, and the monitoring instruments' operation, maintenance, and calibration manuals should be brought to the site.

B. Well keys.

C. Extraction device

Adjustable rate, submersible pumps (e.g., centrifugal, bladder, etc.) which are constructed of stainless steel or Teflon are preferred. Note: if extraction devices constructed of other materials are to be used, adequate information must be provided to show that the substituted materials do not leach contaminants nor cause interferences to the analytical procedures to be used. Acceptance of these materials must be obtained before the sampling event.

If bladder pumps are selected for the collection of VOCs and dissolved gases, the pump setting should be set so that one pulse will deliver a water volume that is sufficient to fill a 40 mL VOC vial. This is not mandatory, but is considered a "best practice". For the proper operation, the bladder pump will need a minimum amount of water above the pump; consult the manufacturer for the recommended submergence. The pump's recommended submergence value should be determined during the planning stage, since it may influence well construction and placement of dedicated pumps where water-level fluctuations are significant.

Adjustable rate, peristaltic pumps (suction) are to be used with caution when collecting samples for VOCs and dissolved gases (e.g., methane, carbon dioxide, etc.) analyses. Additional information on the use of peristaltic pumps can be found in Appendix A. If peristaltic pumps are used, the inside diameter of the rotor head tubing needs to match the inside diameter of the tubing installed in the monitoring well.

Inertial pumping devices (motor driven or manual) are not recommended. These devices frequently cause greater disturbance during purging and sampling, and are less easily controlled than submersible pumps (potentially increasing turbidity and sampling variability, etc.). This can lead to sampling results that are adversely affected by purging and sampling operations, and a higher degree of data variability.

D. Tubing

Teflon or Teflon-lined polyethylene tubing are preferred when sampling is to include VOCs, SVOCs, pesticides, PCBs and inorganics. Note: if tubing constructed of other materials is to be used, adequate information must be provided to show that the substituted materials do not leach contaminants nor cause interferences to the analytical procedures to be used. Acceptance of these materials must be obtained before the sampling event.

PVC, polypropylene or polyethylene tubing may be used when collecting samples for metal and other inorganics analyses.

The use of 1/4 inch or 3/8 inch (inside diameter) tubing is recommended. This will help ensure that the tubing remains liquid filled when operating at very low pumping rates when using centrifugal and peristaltic pumps.

Silastic tubing should be used for the section around the rotor head of a peristaltic pump. It should be less than a foot in length. The inside diameter of the tubing used at the pump rotor head must be the same as the inside diameter of tubing placed in the well. A tubing connector is used to connect the pump rotor head tubing to the well tubing. Alternatively, the two pieces of tubing can be connected to each other by placing the one end of the tubing inside the end of the other tubing. The tubing must not be reused.

E. The water level measuring device

Electronic "tape", pressure transducer, water level sounder/level indicator, etc. should be capable of measuring to 0.01 foot accuracy. Recording pressure transducers, mounted above the pump, are especially helpful in tracking water levels during pumping operations, but their use must include check measurements with a water level "tape" at the start and end of each sampling event.

F. Flow measurement supplies

Graduated cylinder (size according to flow rate) and stopwatch usually will suffice.

Large graduated bucket used to record total water purged from the well.

G. Interface probe

To be used to check on the presence of free phase liquids (LNAPL, or DNAPL) before purging begins (as needed).

H. Power source (generator, nitrogen tank, battery, etc.)

When a gasoline generator is used, locate it downwind and at least 30 feet from the well so that the exhaust fumes do not contaminate samples.

I. Indicator field parameter monitoring instruments

Use of a multi-parameter instrument capable of measuring pH, oxidation/reduction potential (ORP), dissolved oxygen (DO), specific conductance, temperature, and coupled with a flow-through-cell is required when measuring all indicator field parameters, except turbidity. Turbidity is collected using a separate instrument. Record equipment/instrument identification (manufacturer, and model number).

Transparent, small volume flow-through-cells (e.g., 250 mLs or less) are preferred. This allows observation of air bubbles and sediment buildup in the cell, which can interfere with the operation of the monitoring instrument probes, to be easily detected. A small volume cell facilitates rapid turnover of water in the cell between measurements of the indicator field parameters.

It is recommended to use a flow-through-cell and monitoring probes from the same manufacturer and model to avoid incompatibility between the probes and flow-through-cell.

Turbidity samples are collected before the flow-through-cell. A "T" connector coupled with a valve is connected between the pump's tubing and flow-through-cell. When a turbidity measurement is required, the valve is opened to allow the groundwater to flow into a container. The valve is closed and the container sample is then placed in the turbidimeter.

Standards are necessary to perform field calibration of instruments. A minimum of two standards are needed to bracket the instrument measurement range for all parameters except ORP which use a Zobell solution as a standard. For dissolved oxygen, a wet sponge used for the 100% saturation and a zero dissolved oxygen solution are used for the calibration.

Barometer (used in the calibration of the Dissolved Oxygen probe) and the conversion formula to convert the barometric pressure into the units of measure used by the Dissolved Oxygen meter are needed.

J. Decontamination supplies

Includes (for example) non-phosphate detergent, distilled/deionized water, isopropyl alcohol, etc.

K. Record keeping supplies

Logbook(s), well purging forms, chain-of-custody forms, field instrument calibration forms, etc.

L. Sample bottles

M. Sample preservation supplies (as required by the analytical methods)

N. Sample tags or labels

O. PID or FID instrument

If appropriate, to detect VOCs for health and safety purposes, and provide qualitative field evaluations.

P. Miscellaneous Equipment

Equipment to keep the sampling apparatus shaded in the summer (e.g., umbrella) and from freezing in the winter. If the pump's tubing is allowed to heat up in the warm weather, the cold groundwater may degas as it is warmed in the tubing.

EQUIPMENT/INSTRUMENT CALIBRATION

Prior to the sampling event, perform maintenance checks on the equipment and instruments according to the manufacturer's manual and/or applicable SOP. This will ensure that the equipment/instruments are working properly before they are used in the field.

Prior to sampling, the monitoring instruments must be calibrated and the calibration documented. The instruments are calibrated using U.S Environmental Protection Agency Region 1 *Calibration of Field Instruments (temperature, pH, dissolved oxygen, conductivity/specific conductance, oxidation/reduction [ORP], and turbidity),* January 19, 2010, or latest version or from one of the methods listed in 40CFR136, 40CFR141 and SW-846.

The instruments shall be calibrated at the beginning of each day. If the field measurement falls outside the calibration range, the instrument must be re-calibrated so that all measurements fall within the calibration range. At the end of each day, a calibration check is performed to verify that instruments remained in calibration throughout the day. This check is performed while the instrument is in measurement mode, not calibration mode. If the field instruments are being used to monitor the natural attenuation parameters, then a calibration check at mid-day is highly recommended to ensure that the instruments did not drift out of calibration. Note: during the day if the instrument reads zero or a negative number for dissolved oxygen, pH, specific conductance, or turbidity (negative value only), this indicates that the instrument drifted out of calibration or the instrument is malfunctioning. If this situation occurs the data from this instrument will need to be qualified or rejected.

PRELIMINARY SITE ACTIVITIES (as applicable)

Check the well for security (damage, evidence of tampering, missing lock, etc.) and record pertinent observations (include photograph as warranted).

If needed lay out sheet of clean polyethylene for monitoring and sampling equipment, unless equipment is elevated above the ground (e.g., on a table, etc.).

Remove well cap and if appropriate measure VOCs at the rim of the well with a PID or FID instrument and record reading in field logbook or on the well purge form.

If the well casing does not have an established reference point (usually a V-cut or indelible mark in the well casing), make one. Describe its location and record the date of the mark in the logbook (consider a photographic record as well). All water level measurements must be recorded relative to this reference point (and the altitude of this point should be determined using techniques that are appropriate to site's DQOs.

If water-table or potentiometric surface map(s) are to be constructed for the sampling event, perform synoptic water level measurement round (in the shortest possible time) before any purging and sampling activities begin. If possible, measure water level depth (to 0.01 ft.) and total well depth (to 0.1 ft.) the day before sampling begins, in order to allow for re-settlement of any particulates in the water column. This is especially important for those wells that have not been recently sampled because sediment buildup in the well may require the well to be redeveloped. If measurement of total well depth is not made the day before, it should be measured after sampling of the well is complete. All measurements must be taken from the established referenced point. Care should be taken to minimize water column disturbance.

Check newly constructed wells for the presence of LNAPLs or DNAPLs before the initial sampling round. If none are encountered, subsequent check measurements with an interface probe may not be necessary unless analytical data or field analysis signal a worsening situation. This SOP cannot be used in the presence of LNAPLs or DNAPLs. If NAPLs are present, the project team must decide upon an alternate sampling method. All project modifications must be approved and documented prior to implementation.

If available check intake depth and drawdown information from previous sampling event(s) for each well. Duplicate, to the extent practicable, the intake depth and extraction rate (use final pump dial setting information) from previous event(s). If changes are made in the intake depth or extraction rate(s) used during previous sampling event(s), for either portable or dedicated extraction devices, record new values, and explain reasons for the changes in the field logbook.

PURGING AND SAMPLING PROCEDURE

Purging and sampling wells in order of increasing chemical concentrations (known or anticipated) are preferred.

The use of dedicated pumps is recommended to minimize artificial mobilization and entrainment of particulates each time the well is sampled. Note that the use of dedicated sampling equipment can also significantly reduce the time needed to complete each sampling event, will promote consistency in the sampling, and may reduce sampling bias by having the pump's intake at a constant depth.

A. Initial Water Level

Measure the water level in the well before installing the pump if a non-dedicated pump is being used. The initial water level is recorded on the purge form or in the field logbook.

B. Install Pump

Lower pump, safety cable, tubing and electrical lines slowly (to minimize disturbance) into the well to the appropriate depth (may not be the mid-point of the screen/open interval). The Sampling and Analysis Plan/Quality Assurance Project Plan should specify the sampling depth (used previously), or provide criteria for selection of intake depth for each new well. If possible keep the pump intake at least two feet above the bottom of the well, to minimize mobilization of particulates present in the bottom of the well.

Pump tubing lengths, above the top of well casing should be kept as short as possible to minimize heating the groundwater in the tubing by exposure to sun light and ambient air temperatures. Heating may cause the groundwater to degas, which is unacceptable for the collection of samples for VOC and dissolved gases analyses.

C. Measure Water Level

Before starting pump, measure water level. Install recording pressure transducer, if used to track drawdowns, to initialize starting condition.

D. Purge Well

From the time the pump starts purging and until the time the samples are collected, the purged water is discharged into a graduated bucket to determine the total volume of groundwater purged. This information is recorded on the purge form or in the field logbook.

Start the pump at low speed and slowly increase the speed until discharge occurs. Check water level. Check equipment for water leaks and if present fix or replace the affected equipment. Try to match pumping rate used during previous sampling event(s). Otherwise, adjust pump speed until there is little or no water level drawdown. If the minimal drawdown that can be achieved exceeds 0.3 feet, but remains stable, continue purging.

Monitor and record the water level and pumping rate every five minutes (or as appropriate) during purging. Record any pumping rate adjustments (both time and flow rate). Pumping rates should, as needed, be reduced to the minimum capabilities of the pump to ensure stabilization of the water level. Adjustments are best made in the first fifteen minutes of pumping in order to help minimize purging time. During pump start-up, drawdown may exceed the 0.3 feet target and then "recover" somewhat as pump flow adjustments are made. Purge volume calculations should utilize stabilized drawdown value, not the initial drawdown. If the initial water level is above the top of the screen do not allow the water level to fall into the well screen. The final purge volume must be greater than the stabilized drawdown volume plus the pump's tubing volume. If the drawdown has exceeded 0.3 feet and stabilizes, calculate the volume of water between the initial water level and the stabilized water level. Add the volume of the water which occupies the pump's tubing to this calculation. This combined volume of water needs to be purged from the well after the water level has stabilized before samples are collected.

Avoid the use of constriction devices on the tubing to decrease the flow rate because the constrictor will cause a pressure difference in the water column. This will cause the groundwater to degas and result in a loss of VOCs and dissolved gasses in the groundwater samples.

Note: the flow rate used to achieve a stable pumping level should remain constant while monitoring the indicator parameters for stabilization and while collecting the samples.

Wells with low recharge rates may require the use of special pumps capable of attaining very low pumping rates (e.g., bladder, peristaltic), and/or the use of dedicated equipment. For new monitoring wells, or wells where the following situation has not occurred before, if the recovery rate to the well is less than 50 mL/min., or the well is being essentially dewatered during purging, the well should be sampled as soon as the water level has recovered sufficiently to collect the volume needed for all anticipated samples. The project manager or field team leader will need to make the decision when samples should be collected, how the sample is to be collected, and the reasons recorded on the purge form or in the field logbook. A water level measurement needs to be performed and recorded before samples are collected. If the project manager decides to collect the samples using the pump, it is best during this recovery period that the pump intake tubing not be removed, since this will aggravate any turbidity problems. Samples in this specific situation may be collected without stabilization of indicator field parameters. Note that field conditions and efforts to overcome problematic situations must be recorded in order to support field decisions to deviate from normal procedures described in this SOP. If this type of problematic situation persists in a well, then water sample collection should be changed to a passive or no-purge method, if consistent with the site's DQOs, or have a new well installed.

E. Monitor Indicator Field Parameters

After the water level has stabilized, connect the "T" connector with a valve and the flow-through-cell to monitor the indicator field parameters. If excessive turbidity is anticipated or encountered with the pump startup, the well may be purged for a while without connecting up the flow-through-cell, in order to minimize particulate buildup in the cell (This is a judgment call made by the sampler). Water level drawdown measurements should be made as usual. If possible, the pump may be installed the day before purging to allow particulates that were disturbed during pump insertion to settle.

During well purging, monitor indicator field parameters (turbidity, temperature, specific conductance, pH, ORP, DO) at a frequency of five minute intervals or greater. The pump's flow rate must be able to "turn over" at least one flow-through-cell volume between measurements (for a 250 mL flow-through-cell with a flow rate of 50 mLs/min., the monitoring frequency would be every five minutes; for a 500 mL flow-through-cell it would be every ten minutes). If the cell volume cannot be replaced in the five minute interval, then the time between measurements must be increased accordingly. <u>Note: during the early phase of purging emphasis should be put on minimizing and stabilizing pumping stress, and recording those adjustments followed by stabilization of indicator parameters. Purging is considered complete and sampling may begin when all the above indicator field parameters have stabilized. Stabilization is considered to be achieved when three consecutive readings are within the following limits:</u>

Turbidity (10% for values greater than 5 NTU; if three Turbidity values are less than 5 NTU, consider the values as stabilized),
Dissolved Oxygen (10% for values greater than 0.5 mg/L, if three Dissolved Oxygen values are less than 0.5 mg/L, consider the values as stabilized),
Specific Conductance (3%),
Temperature (3%),
pH (± 0.1 unit),
Oxidation/Reduction Potential (±10 millivolts).

All measurements, except turbidity, must be obtained using a flow-through-cell. Samples for turbidity measurements are obtained before water enters the flow-through-cell. Transparent flow-through-cells are preferred, because they allow field personnel to watch for particulate build-up within the cell. This build-up may affect indicator field parameter values measured within the cell. If the cell needs to be cleaned during purging operations, continue pumping and disconnect cell for cleaning, then reconnect after cleaning and continue monitoring activities. Record start and stop times and give a brief description of cleaning activities.

The flow-through-cell must be designed in a way that prevents gas bubble entrapment in the cell. Placing the flow-through-cell at a 45 degree angle with the port facing upward can help remove bubbles from the flow-through-cell (see Appendix B Low-Flow Setup Diagram). All during the measurement process, the flow-through-cell must remain free of any gas bubbles. Otherwise, the monitoring probes may act erratically. When the pump is turned off or cycling on/off (when using a bladder pump), water in the cell must not drain out. Monitoring probes must remain submerged in water at all times.

F. Collect Water Samples

When samples are collected for laboratory analyses, the pump's tubing is disconnected from the "T" connector with a valve and the flow-through-cell. The samples are collected directly from the pump's tubing. Samples must not be collected from the flow-through-cell or from the "T" connector with a valve.

VOC samples are normally collected first and directly into pre-preserved sample containers. However, this may not be the case for all sampling locations; the SAP/QAPP should list the order in which the samples are to be collected based on the project's objective(s). Fill all sample containers by allowing the pump discharge to flow gently down the inside of the container with minimal turbulence.

If the pump's flow rate is too high to collect the VOC/dissolved gases samples, collect the other samples first. Lower the pump's flow rate to a reasonable rate and collect the VOC/dissolved gases samples and record the new flow rate.

During purging and sampling, the centrifugal/peristaltic pump tubing must remain filled with water to avoid aeration of the groundwater. It is recommended that 1/4 inch or 3/8 inch (inside diameter) tubing be used to help insure that the sample tubing remains water filled. If the pump tubing is not completely filled to the sampling point, use the following procedure to collect samples: collect non-VOC/dissolved gases samples first, then increase flow rate slightly until the water completely fills the tubing, collect the VOC/dissolved gases samples, and record new drawdown depth and flow rate.

For bladder pumps that will be used to collect VOC or dissolved gas samples, it is recommended that the pump be set to deliver long pulses of water so that one pulse will fill a 40 mL VOC vial.

Use pre-preserved sample containers or add preservative, as required by analytical methods, to the samples immediately after they are collected. Check the analytical methods (e.g. EPA SW-846, 40 CFR 136, water supply, etc.) for additional information on preservation.

If determination of filtered metal concentrations is a sampling objective, collect filtered water samples using the same low flow procedures. The use of an in-line filter (transparent housing preferred) is required, and the filter size (0.45 μm is commonly used) should be based on the sampling objective. Pre-rinse the filter with groundwater prior to sample collection. Make sure the filter is free of air bubbles before samples are collected. Preserve the filtered water sample immediately. Note: filtered water samples are not an acceptable substitute for unfiltered samples when the monitoring objective is to obtain chemical concentrations of total mobile contaminants in groundwater for human health or ecological risk calculations.

Label each sample as collected. Samples requiring cooling will be placed into a cooler with ice or refrigerant for delivery to the laboratory. Metal samples after acidification to a pH less than 2 do not need to be cooled.

G. Post Sampling Activities

If a recording pressure transducer is used to track drawdown, re-measure water level with tape.

After collection of samples, the pump tubing may be dedicated to the well for re-sampling (by hanging the tubing inside the well), decontaminated, or properly discarded.

Before securing the well, measure and record the well depth (to 0.1 ft.), if not measured the day before purging began. Note: measurement of total well depth annually is usually sufficient after the initial low stress sampling event. However, a greater frequency may be needed if the well has a "silting" problem or if confirmation of well identity is needed.

Secure the well.

DECONTAMINATION

Decontaminate sampling equipment prior to use in the first well and then following sampling of each well. Pumps should not be removed between purging and sampling operations. The pump, tubing, support cable and electrical wires which were in contact with the well should be decontaminated by one of the procedures listed below.

The use of dedicated pumps and tubing will reduce the amount of time spent on decontamination of the equipment. If dedicated pumps and tubing are used, only the initial sampling event will require decontamination of the pump and tubing.

Note if the previous equipment blank data showed that contaminant(s) were present after using the below procedure or the one described in the SAP/QAPP, a more vigorous procedure may be needed.

Procedure 1

Decontaminating solutions can be pumped from either buckets or short PVC casing sections through the pump and tubing. The pump may be disassembled and flushed with the decontaminating solutions. It is recommended that detergent and alcohol be used sparingly in the decontamination process and water flushing steps be extended to ensure that any sediment trapped in the pump is removed. The pump exterior and electrical wires must be rinsed with the decontaminating solutions, as well. The procedure is as follows:

Flush the equipment/pump with potable water.

Flush with non-phosphate detergent solution. If the solution is recycled, the solution must be changed periodically.

Flush with potable or distilled/deionized water to remove all of the detergent solution. If the water is recycled, the water must be changed periodically.

Optional - flush with isopropyl alcohol (pesticide grade; must be free of ketones {e.g., acetone}) or with methanol. This step may be required if the well is highly contaminated or if the equipment blank data from the previous sampling event show that the level of contaminants is significant.

Flush with distilled/deionized water. This step must remove all traces of alcohol (if used) from the equipment. The final water rinse must not be recycled.

Procedure 2

Steam clean the outside of the submersible pump.

Pump hot potable water from the steam cleaner through the inside of the pump. This can be accomplished by placing the pump inside a three or four inch diameter PVC pipe with end cap. Hot water from the steam cleaner jet will be directed inside the PVC pipe and the pump exterior will be cleaned. The hot water from the steam cleaner will then be pumped from the PVC pipe through the pump and collected into another container. Note: additives or solutions should not be added to the steam cleaner.

Pump non-phosphate detergent solution through the inside of the pump. If the solution is recycled, the solution must be changed periodically.

Pump potable water through the inside of the pump to remove all of the detergent solution. If the solution is recycled, the solution must be changed periodically.

Pump distilled/deionized water through the pump. The final water rinse must not be recycled.

FIELD QUALITY CONTROL

Quality control samples are required to verify that the sample collection and handling process has not compromised the quality of the groundwater samples. All field quality control samples must be prepared the same as regular investigation samples with regard to sample volume, containers, and preservation. Quality control samples include field duplicates, equipment blanks, matrix spike/matrix spike duplicates, trip blanks (VOCs), and temperature blanks.

FIELD LOGBOOK

A field log shall be kept to document all groundwater field monitoring activities (see Appendix C, example table), and record the following for each well:

Site name, municipality, state.

Well identifier, latitude-longitude or state grid coordinates.

Measuring point description (e.g., north side of PVC pipe).

Well depth, and measurement technique.

Well screen length.

Pump depth.

Static water level depth, date, time and measurement technique.

Presence and thickness of immiscible liquid (NAPL) layers and detection method.

Pumping rate, drawdown, indicator parameters values, calculated or measured total volume pumped, and clock time of each set of measurements.

Type of tubing used and its length.

Type of pump used.

Clock time of start and end of purging and sampling activity.

Types of sample bottles used and sample identification numbers.

Preservatives used.

Parameters requested for analyses.

Field observations during sampling event.

Name of sample collector(s).

Weather conditions, including approximate ambient air temperature.

QA/QC data for field instruments.

Any problems encountered should be highlighted.

Description of all sampling/monitoring equipment used, including trade names, model number, instrument identification number, diameters, material composition, etc.

DATA REPORT

Data reports are to include laboratory analytical results, QA/QC information, field indicator parameters measured during purging, field instrument calibration information, and whatever other field logbook information is needed to allow for a full evaluation of data usability.

Note: the use of trade, product, or firm names in this sampling procedure is for descriptive purposes only and does not constitute endorsement by the U.S. EPA.

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APPENDIX A
PERISTALTIC PUMPS

Before selecting a peristaltic pump to collect groundwater samples for VOCs and/or dissolved gases (e.g., methane, carbon dioxide, etc.) consideration should be given to the following:

- The decision of whether or not to use a peristaltic pump is dependent on the intended use of the data.
- If the additional sampling error that may be introduced by this device is NOT of concern for the VOC/dissolved gases data's intended use, then this device may be acceptable.
- If minor differences in the groundwater concentrations could effect the decision, such as to continue or terminate groundwater cleanup or whether the cleanup goals have been reached, then this device should NOT be used for VOC/dissolved gases sampling. In these cases, centrifugal or bladder pumps are a better choice for more accurate results.

EPA and USGS have documented their concerns with the use of the peristaltic pumps to collect water sample in the below documents.

- "Suction Pumps are not recommended because they may cause degassing, pH modification, and loss of volatile compounds" *A Compendium of Superfund Field Operations Methods*, EPA/540/P-87/001, December 1987.
- "The agency does not recommend the use of peristaltic pumps to sample ground water particularly for volatile organic analytes" *RCRA Ground-Water Monitoring Draft Technical Guidance*, EPA Office of Solid Waste, November 1992.
- "The peristaltic pump is limited to shallow applications and can cause degassing resulting in alteration of pH, alkalinity, and volatiles loss", *Low-flow (Minimal drawdown) Ground-Water Sampling Procedures*, by Robert Puls & Michael Barcelona, April 1996, EPA/540/S-95/504.
- "Suction-lift pumps, such as peristaltic pumps, can operate at a very low pumping rate; however, using negative pressure to lift the sample can result in the loss of volatile analytes", USGS Book 9 Techniques of Water-Resources Investigation, Chapter A4. (Version 2.0, 9/2006).

APPENDIX B

SUMMARY OF SAMPLING INSTRUCTIONS

These instructions are for using an adjustable rate, submersible pump or a peristaltic pump with the pump's intake placed at the midpoint of a 10 foot or less well screen or an open interval. The water level in the monitoring well is above the top of the well screen or open interval, the ambient temperature is above 32°F, and the equipment is not dedicated. Field instruments are already calibrated. The equipment is setup according to the diagram at the end of these instructions.

1. Review well installation information. Record well depth, length of screen or open interval, and depth to top of the well screen. Determine the pump's intake depth (e.g., mid-point of screen/open interval).

2. On the day of sampling, check security of the well casing, perform any safety checks needed for the site, lay out a sheet of polyethylene around the well (if necessary), and setup the equipment. If necessary a canopy or an equivalent item can be setup to shade the pump's tubing and flow-through-cell from the sun light to prevent the sun light from heating the groundwater.

3. Check well casing for a reference mark. If missing, make a reference mark. Measure the water level (initial) to 0.01 ft. and record this information.

4. Install the pump's intake to the appropriate depth (e.g., midpoint) of the well screen or open interval. Do not turn-on the pump at this time.

5. Measure water level and record this information.

6. Turn-on the pump and discharge the groundwater into a graduated waste bucket. Slowly increase the flow rate until the water level starts to drop. Reduce the flow rate slightly so the water level stabilizes. Record the pump's settings. Calculate the flow rate using a graduated container and a stop watch. Record the flow rate. Do not let the water level drop below the top of the well screen.

If the groundwater is highly turbid or colored, continue to discharge the water into the bucket until the water clears (visual observation); this usually takes a few minutes. The turbid or colored water is usually from the well being disturbed during the pump installation. If the water does not clear, then you need to make a choice whether to continue purging the well (hoping that it will clear after a reasonable time) or continue to the next step. Note, it is sometimes helpful to install the pump the day before the sampling event so that the disturbed materials in the well can settle out.

If the water level drops to the top of the well screen during the purging of the well, stop purging the well, and do the following:

> Wait for the well to recharge to a sufficient volume so samples can be collected. This may take awhile (pump maybe removed from well, if turbidity is not a problem). The project manager will need to make the decision when samples should be collected and the reasons recorded in the site's log book. A water level measurement needs to be performed and recorded before samples are collected. When samples are being collected, the water level must not drop below the top of the screen or open interval. Collect the samples from the pump's tubing. Always collect the VOCs and dissolved gases samples first. Normally, the samples requiring a small volume are collected before the large volume samples are collected just in case there is not sufficient water in the well to fill all the sample containers. All samples must be collected, preserved, and stored according to the analytical method. Remove the pump from the well and decontaminate the sampling equipment.

If the water level has dropped 0.3 feet or less from the initial water level (water level measure before the pump was installed); proceed to Step 7. If the water level has dropped more than 0.3 feet, calculate the volume of water between the initial water level and the stabilized water level. Add the volume of the water which occupies the pump's tubing to this calculation. This combined volume of water needs to be purged from the well after the water level has stabilized before samples are be collected.

7. Attach the pump's tubing to the "T" connector with a valve (or a three-way stop cock). The pump's tubing from the well casing to the "T" connector must be as short as possible to prevent the groundwater in the tubing from heating up from the sun light or from the ambient air. Attach a short piece of tubing to the other end of the end of the "T" connector to serve as a sampling port for the turbidity samples. Attach the remaining end of the "T" connector to a short piece of tubing and connect the tubing to the flow-through-cell bottom port. To the top port, attach a small piece of tubing to direct the water into a calibrated waste bucket. Fill the cell with the groundwater and remove all gas bubbles from the cell. Position the flow-through-cell in such a way that if gas bubbles enter the cell they can easily exit the cell. If the ports are on the same side of the cell and the cell is cylindrical shape, the cell can be placed at a 45-degree angle with the ports facing upwards; this position should keep any gas bubbles entering the cell away from the monitoring probes and allow the gas bubbles to exit the cell easily (see Low-Flow Setup Diagram). Note,

make sure there are no gas bubbles caught in the probes' protective guard; you may need to shake the cell to remove these bubbles.

8. Turn-on the monitoring probes and turbidity meter.

9. Record the temperature, pH, dissolved oxygen, specific conductance, and oxidation/reduction potential measurements. Open the valve on the "T" connector to collect a sample for the turbidity measurement, close the valve, do the measurement, and record this measurement. Calculate the pump's flow rate from the water exiting the flow-through-cell using a graduated container and a stop watch, and record the measurement. Measure and record the water level. Check flow-through-cell for gas bubbles and sediment; if present, remove them.

10. Repeat Step 9 every 5 minutes or as appropriate until monitoring parameters stabilized. Note at least one flow-through-cell volume must be exchanged between readings. If not, the time interval between readings will need to be increased. Stabilization is achieved when three consecutive measurements are within the following limits:

> **Turbidity** (10% for values greater than 5 NTUs; if three Turbidity values are less than 5 NTUs, consider the values as stabilized),
> **Dissolved Oxygen** (10% for values greater than 0.5 mg/L, if three Dissolved Oxygen values are less than 0.5 mg/L, consider the values as stabilized),
> **Specific Conductance** (3%),
> **Temperature** (3%),
> **pH** (± 0.1 unit),
> **Oxidation/Reduction Potential** (±10 millivolts).

If these stabilization requirements do not stabilize in a reasonable time, the probes may have been coated from the materials in the groundwater, from a buildup of sediment in the flow-through-cell, or a gas bubble is lodged in the probe. The cell and the probes will need to be cleaned. Turn-off the probes (not the pump), disconnect the cell from the "T" connector and continue to purge the well. Disassemble the cell, remove the sediment, and clean the probes according to the manufacturer's instructions. Reassemble the cell and connect the cell to the "T" connector. Remove all gas bubbles from the cell, turn-on the probes, and continue the measurements. Record that the time the cell was cleaned.

11. When it is time to collect the groundwater samples, turn-off the monitoring probes, and disconnect the pump's tubing from the "T" connector. If you are using a centrifugal or peristaltic pump check the pump's tubing to determine if the tubing is completely filled with water (no air space).

All samples must be collected and preserved according to the analytical method. VOCs and dissolved gases samples are normally collected first and directly into pre-preserved sample containers. However, this may not be the case for all sampling locations; the SAP/QAPP should list the order in which the samples are to be collected based on the project's objective(s). Fill all sample containers by allowing the pump discharge to flow gently down the inside of the container with minimal turbulence.

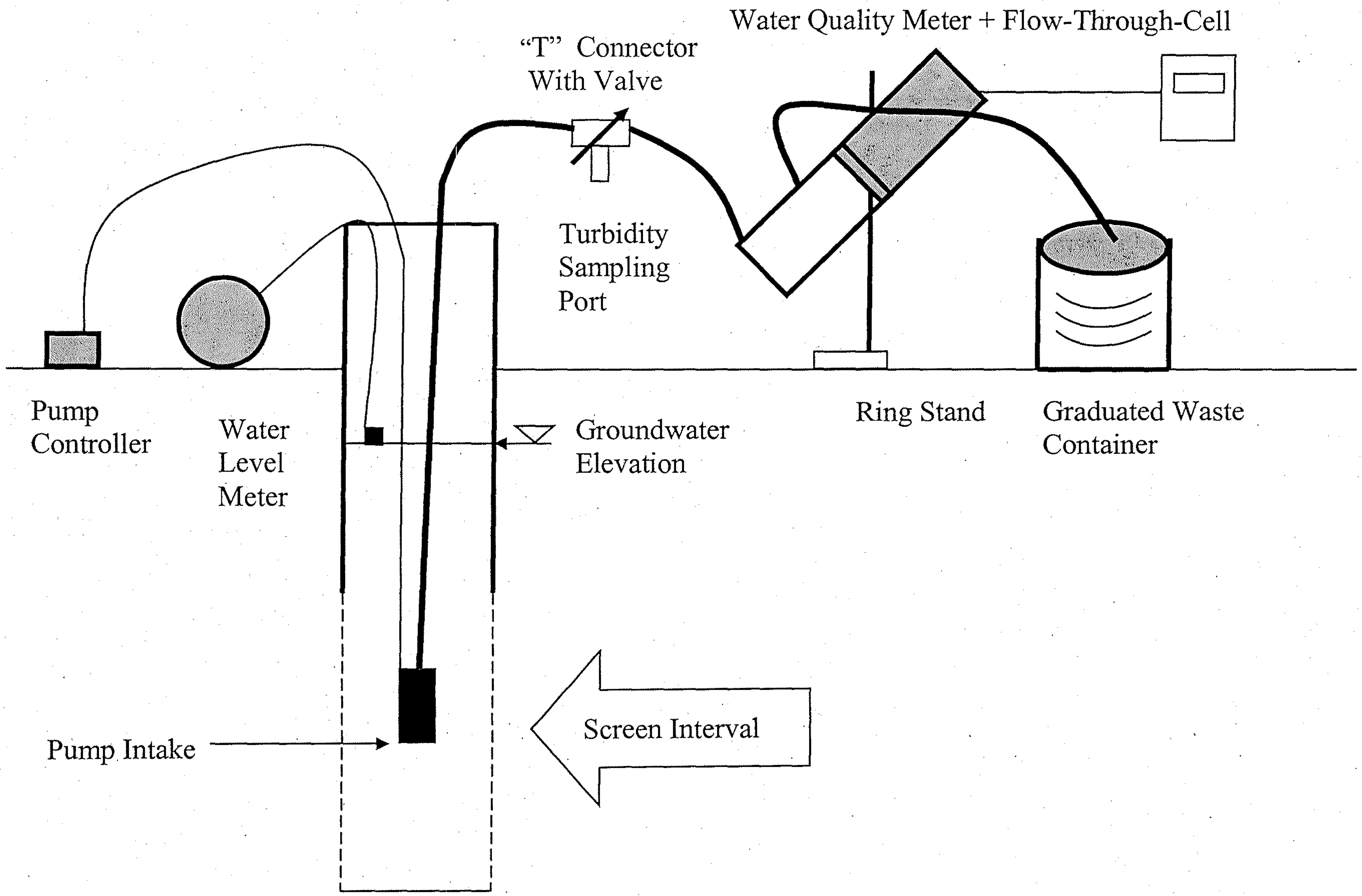
If the pump's tubing is not completely filled with water and the samples are being collected for VOCs and/or dissolved gases analyses using a centrifugal or peristaltic pump, do the following:

> All samples must be collected and preserved according to the analytical method. The VOCs and the dissolved gases (e.g., methane, ethane, ethene, and carbon dioxide) samples are collected last. When it becomes time to collect these samples increase the pump's flow rate until the tubing is completely filled. Collect the samples and record the new flow rate.

12. Store the samples according to the analytical method.

13. Record the total purged volume (graduated waste bucket). Remove the pump from the well and decontaminate the sampling equipment.

Low-Flow Setup Diagram



APPENDIX C
EXAMPLE (Minimum Requirements)
WELL PURGING-FIELD WATER QUALITY MEASUREMENTS FORM

Location (Site/Facility Name)______________________________
Well Number_________________Date_____________________
Field Personnel______________________________________
Sampling Organization_________________________________
Identify MP____

Depth to ________/________ of screen
(below MP) top bottom
Pump Intake at (ft. below MP)_________
Purging Device; (pump type)_________
Total Volume Purged ______________

Clock Time 24 HR	Water Depth below MP ft	Pump Dial[1]	Purge Rate ml/min	Cum. Volume Purged liters	Temp. °C	Spec. Cond.[2] µS/cm	pH	ORP[3] mv	DO mg/L	Turb-idity NTU	Comments
Stabilization Criteria					3%	3%	±0.1	± 10 mv	10%	10%	

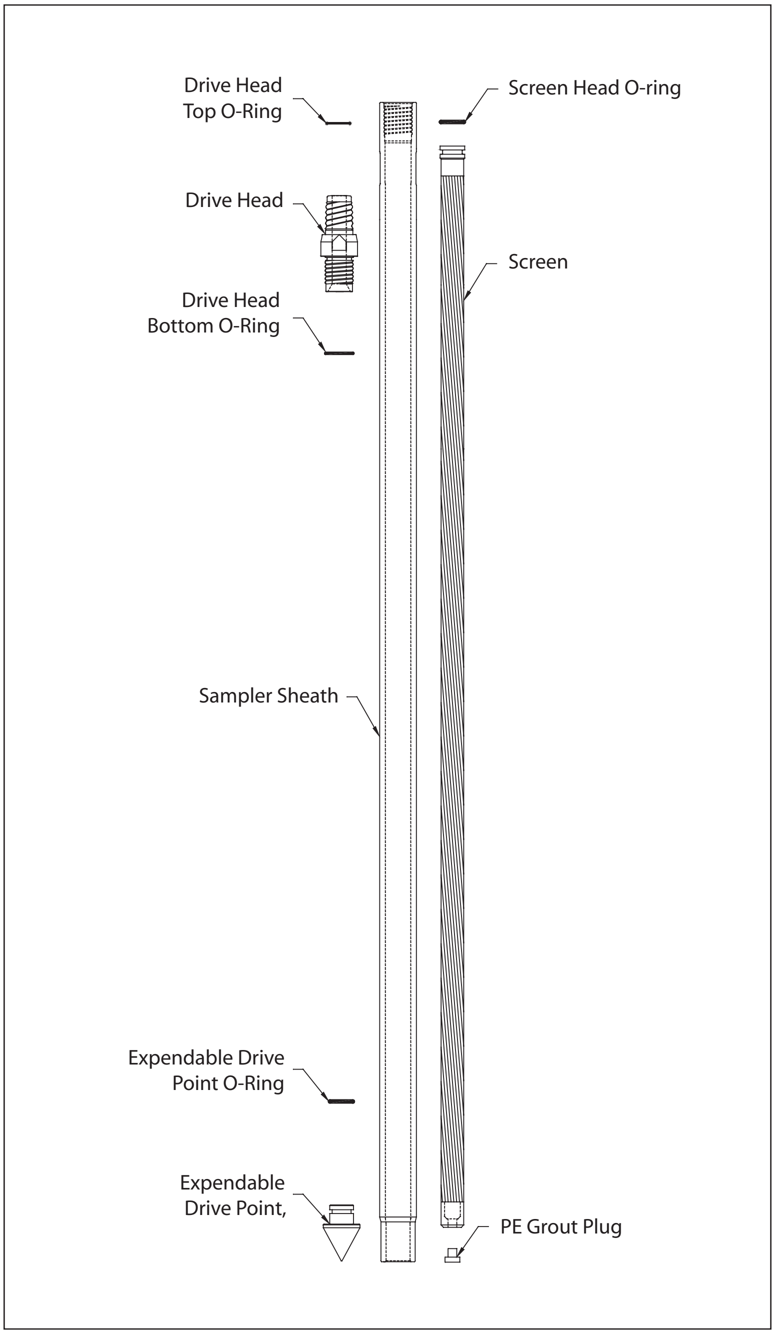
1. Pump dial setting (for example: hertz, cycles/min, etc).
2. µSiemens per cm(same as µmhos/cm)at 25°C.
3. Oxidation reduction potential (ORP)

GEOPROBE® SCREEN POINT 16 GROUNDWATER SAMPLER

STANDARD OPERATING PROCEDURE

Technical Bulletin No. MK3142

PREPARED: November, 2006



GEOPROBE® SCREEN POINT 16 GROUNDWATER SAMPLER PARTS

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Screen Point 16 Groundwater Sampler is manufactured under U.S. Patent 5,612,498

1.0 OBJECTIVE

The objective of this procedure is to drive a sealed stainless steel or PVC screen to depth, deploy the screen, obtain a representative water sample from the screen interval, and grout the probe hole during abandonment. The Screen Point 16 Groundwater Sampler enables the operator to conduct abandonment grouting that meets American Society for Testing and Materials (ASTM) Method D 5299 requirements for decommissioning wells and borings for environmental activities (ASTM 1993).

2.0 BACKGROUND

2.1 Definitions

Geoprobe®: A brand name of high quality, hydraulically powered machines that utilize both static force and percussion to advance sampling and logging tools into the subsurface. The Geoprobe® brand name refers to both machines and tools manufactured by Geoprobe Systems®, Salina, Kansas. Geoprobe® tools are used to perform soil core and soil gas sampling, groundwater sampling and monitoring, soil conductivity and contaminant logging, grouting, and materials injection.

Screen Point 16 (SP16) Groundwater Sampler: A direct push device consisting of a PVC or stainless steel screen that is driven to depth within a sealed, steel sheath and then deployed for the collection of representative groundwater samples. The assembled SP16 Sampler is approximately 51.5 inches (1308 mm) long with an OD of 1.625 inches (41 mm). Upon deployment, up to 41 inches (1041 mm) of screen can be exposed to the formation. The Screen Point 16 Groundwater Sampler is designed for use with 1.5-inch probe rods and machines equipped with the more powerful GH60 Hydraulic Hammer. Operators with GH40 Series hammers may chose to use this sampler in soils where driving is difficult.

Rod Grip Pull System: An attachment mounted on the hydraulic hammer of a direct push machine which makes it possible to retract the tool string with extension rods or flexible tubing protruding from the top of the probe rods. The Rod Grip Pull System includes a pull block with rod grip jaws that are bolted directly to the machine. A removable handle assembly straddles the tool string while hooking onto the pull block to effectively grip the probe rods as the hammer is raised. A separate handle assembly is required for each probe rod diameter.

2.2 Discussion

In this procedure, the assembled Screen Point 16 Groundwater Sampler (Fig. 2.1A) is threaded onto the leading end of a Geoprobe® probe rod and advanced into the subsurface with a Geoprobe® direct push machine. Additional probe rods are added incrementally and advanced until the desired sampling interval is reached. While the sampler is advanced to depth, O-ring seals at each rod joint, the drive head, and the expendable drive point provide a watertight system. This system eliminates the threat of formation fluids entering the screen before deployment and assures sample integrity.

Once at the desired sampling interval, extension rods are sent downhole until the leading rod contacts the bottom of the sampler screen. The tool string is then retracted approximately 44 inches (1118 mm) while the screen is held in place with the extension rods (Fig. 2.1B). As the tool string is retracted, the expendable point is released from the sampler sheath. The tool string and sheath may be retracted the full length of the screen or as little as a few inches if a small sampling interval is desired.

There are three types of screens that can be used in the Screen Point 16 Groundwater Sampler. Two of the these, a stainless steel screen with a standard slot size of 0.004 inches (0.10 mm) and a PVC screen with a standard slot size of 0.010 inches (0.25 mm), are recovered with the tool string after sampling. The third screen is also manufactured from PVC with a standard slot size of 0.010 inches (0.25 mm), but is designed to be left downhole when sampling is complete. This disposable screen has an exposed screen length of approximately 43 inches (1092 mm). The two screens that are recovered with the sampler both have an exposed screen length of approximately 41 inches (1041 mm).

(continued on following page)

An O-ring on the head of the stainless steel screens maintains a seal at the top of the screen. As a result, any liquid entering the sampler during screen deployment must first pass through the screen. PVC screens do not require an O-ring because the tolerance between the screen head and sampler sheath is near that of the screen slot size.

The screens are constructed such that flexible tubing, a mini-bailer, or a small-diameter bladder pump can be inserted into the screen cavity. This makes direct sampling possible from anywhere within the saturated zone. A removable plug in the lower end of the screens allows the user to grout as the sampler is extracted for further use.

Groundwater samples can be obtained in a number of ways. A common method utilizes polyethylene (TB25L) or Teflon® (TB25T) tubing and a Check Valve Assembly (GW4210). The check valve (with check ball) is attached to one end of the tubing and inserted down the casing until it is immersed in groundwater. Water is pumped through the tubing and to the ground surface by oscillating the tubing up and down.

An alternative means of collecting groundwater samples is to attach a peristaltic or vacuum pump to the tubing. This method is limited in that water can be pumped to the surface from a maximum depth of approximately 26 feet (8 m). Another technique for groundwater sampling is to use a stainless steel Mini-Bailer Assembly (GW41). The mini-bailer is lowered down the inside of the casing below the water level where it fills with water and is then retrieved from the casing.

The latest option for collecting groundwater from the SP16 sampler is to utilize a Geoprobe® MB470 Series Mechanical Bladder Pump (MBP)*. The MBP may be used to meet requirements of the low-flow sampling protocol (Puls and Barcelona 1996, ASTM 2003). Through participation in a U.S. EPA Environmental Technology Verification study, it was confirmed that the MB470 can provide representative samples (EPA 2003).

**The Mechanical Bladder Pump is manufactured under U.S. Patent No. 6,877,965 issued April 12, 2005.*

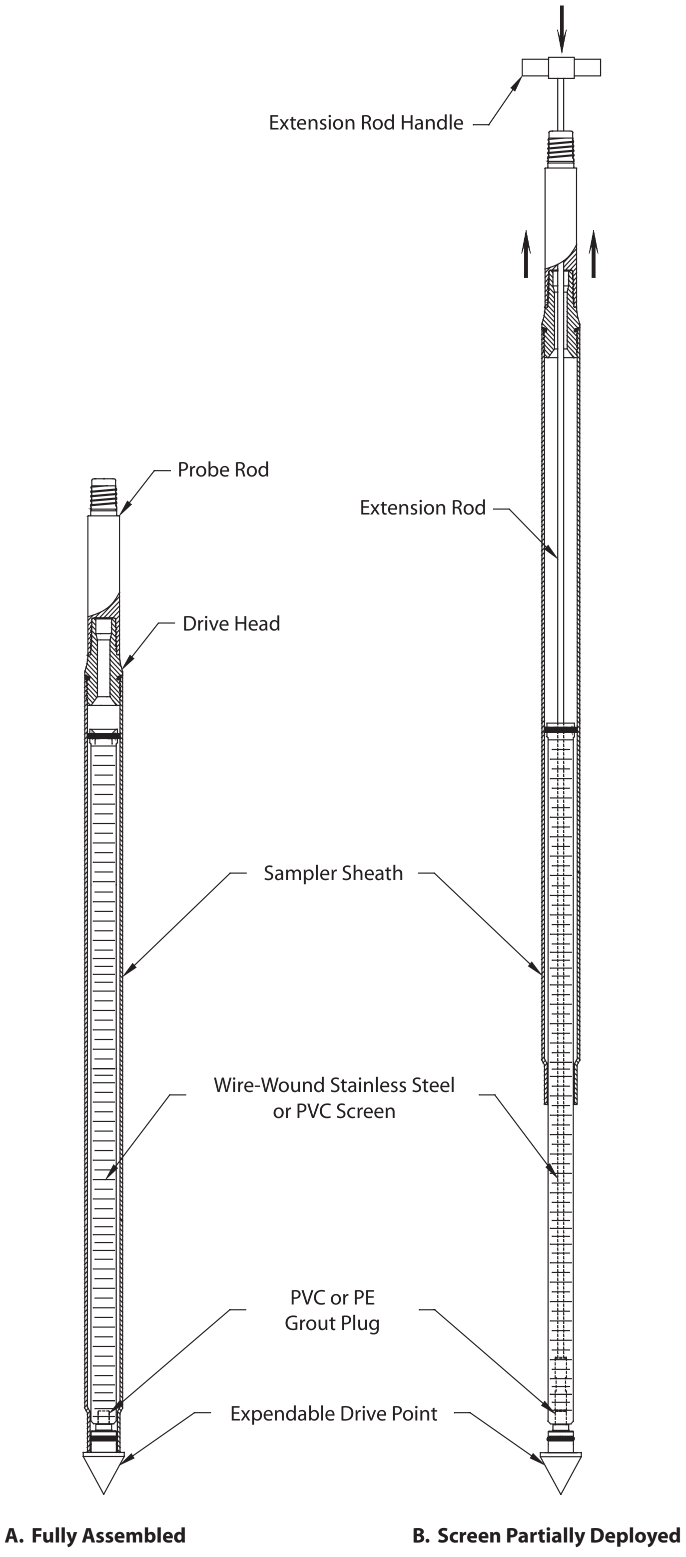


FIGURE 2.1
Screen Point 16 Groundwater Sampler

3.0 TOOLS AND EQUIPMENT

The following tools and equipment can be used to successfully recover representative groundwater samples with the Geoprobe® Screen Point 16 Groundwater Sampler. Refer to Figures 3.1 and 3.2 for identification of the specified parts. Tools are listed below for the most common SP16 / 1.5-inch probe rod configurations. Additional parts for optional rod sizes and accessories are listed in Appendix A.

SP16 Sampler Parts	**Part Number**
SP16 Sampler Sheath	15187
SP16 Drive Head, 0.5-inch bore, 1.5-inch rods*	18307
SP16 O-ring Service Kit, 1.5-inch rods *(includes 4 each of the O-ring packets below)*	15844
O-rings for Top of SP16 Drive Head, 1.5-inch rods only (Pkt. of 25)	*15389*
O-rings for Bottom of SP16 Drive Head (Pkt. of 25)	*13196*
O-rings for GW1520 Screen Head (Pkt. of 25)	*GW1520R*
O-rings for SP16 Expendable Drive Point (Pkt. of 25)	*GW1555R*
Screen, Wire-Wound Stainless Steel, 4-Slot*	GW1520
Grout Plugs, PE (Pkg. of 25)	GW1552K
Expendable Drive Points, steel, 1.625-inch OD (Pkg. of 25)*	GW1555K
Screen Point 16 Groundwater Sampler Kit, 1.5-inch Probe Rods *(includes 1 each of: 15187, 18307, 15844, GW1520, GW1535, GW1540, GW1555K, and GW1552K)*	15770

Probe Rods and Probe Rod Accessories	**Part Number**
Drive Cap, 1.5-inch probe rods, threadless, (for GH60 Hammer)	12787
Pull Cap, 1.5-inch probe rods	15090
Probe Rod, 1.5-inch x 60-inch*	11121

Extension Rods and Extension Rod Accessories	**Part Number**
Screen Push Adapter	GW1535
Grout Plug Push Adapter	GW1540
Extension Rod, 60-inch*	10073
Extension Rod Coupler	AT68
Extension Rod Handle	AT69
Extension Rod Jig	AT690
Extension Rod Quick Link Coupler, pin	AT695
Extension Rod Quick Link Coupler, box	AT696

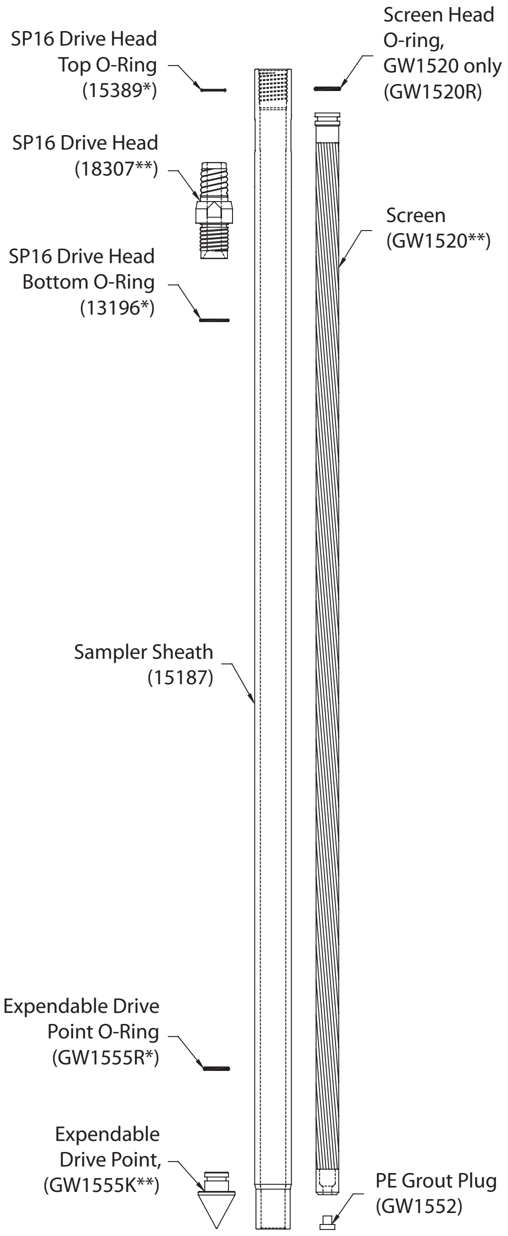
Grout Accessories	**Part Number**
Grout Nozzle, for 0.375-inch OD tubing	GW1545
High-Pressure Nylon Tubing, 0.375-inch OD / 0.25-inch ID, 100-ft. (30 m)	11633
Grout Machine, self-contained*	GS1000
Grout System Accessories Package, 1.5-inch rods	GS1015

Groundwater Purging and Sampling Accessories	**Part Number**
Polyethylene Tubing, 0.375-inch OD, 500 ft.*	TB25L
Check Valve Assembly, 0.375-inch OD Tubing*	GW4210
Water Level Meter, 0.438-inch OD Probe, 100 ft. cable*	GW2000
Mechanical Bladder Pump**	MB470
Mini Bailer Assembly, stainless steel	GW41

Additional Tools	**Part Number**
Adjustable Wrench, 6.0-inch	FA200
Adjustable Wrench, 10.0-inch	FA201
Pipe Wrenches	NA

* See Appendix A for additional tooling options.

** Refer to the Standard Operating Procedure (SOP) for the Mechanical Bladder Pump (Technical Bulletin No. MK3013) for additional tooling needs.



* Included in the SP16 O-ring Service Kit (15844)
** Part numbers show most common tool configuration. See Appendix A for alternative parts.

FIGURE 3.1
SP16 Sampler Parts

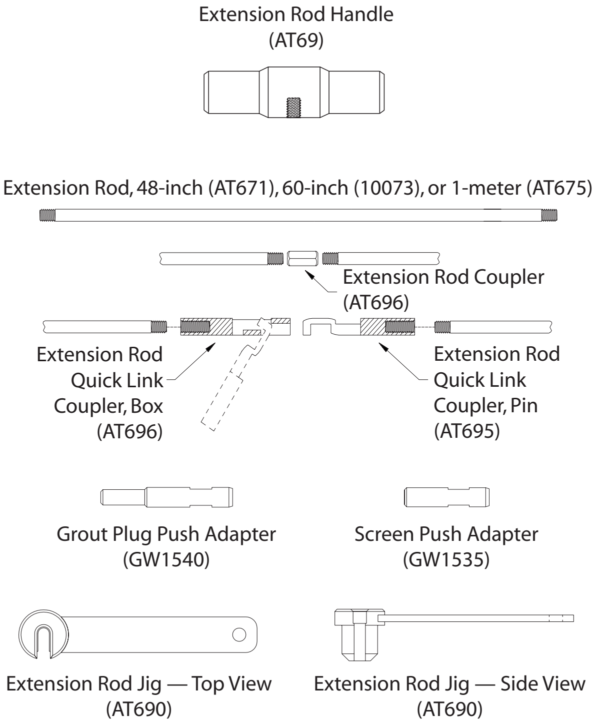


FIGURE 3.2
Geoprobe® Extension Rods and Accessories

4.0 OPERATION

4.1 Basic Operation

The SP16 sampler utilize a stainless steel or PVC screen which is encased in an alloy steel sampler sheath. An expendable drive point is placed in the lower end of the sheath while a drive head is attached to the top. O-rings on the drive head and expendable point provide a watertight sheath which keeps contaminants out of the system as the sampler is driven to depth.

Once the sampling interval is reached, extension rods equipped with a screen push adapter are inserted down the ID of the probe rods. The tool string is then retracted up to 44 inches (1118 mm) while the screen is held in place with the extension rods. The system is now ready for groundwater sampling. When sampling is complete, a removable plug in the bottom of the screen allows for grouting below the sampler as the tool string is retrieved.

4.2 Sampler Options

The Screen Point 15 and Screen Point 16 Groundwater Samplers are nearly identical. Subtle differences in the design of the SP16 sampler make it more durable than the earlier SP15 system. Operators of GH60-equipped machines should always utilize SP16 tooling. Operators of machines equipped with GH40 Series hammers may also choose SP16 tooling when sampling in difficult probing conditions.

A 1.75-inch OD Expendable Drive Point (17066K) and Disposable PVC Screen (16089) provide two useful options for the SP16 sampler. The 1.75-inch drive point may be used when soil conditions make it difficult to remove the sampler after driving to depth. The disposable PVC screen may be left downhole after sampling (when regulations permit) to eliminate the time required for screen decontamination.

4.3 Decontamination

In order to collect representative groundwater samples, all sampler parts must be thoroughly cleaned before and after each use. Scrub all metal parts using a stiff brush and a nonphosphate soap solution. Steam cleaning may be substituted for hand-washing if available. Rinse with distilled water and allow to air-dry before assembly.

4.4 SP16 Sampler Assembly (Figure 4.1)

Part numbers are listed for a standard SP16 sampler using 1.5-inch probe rods. Refer to Page 6 for screen and drive head alternatives.

1. Place an O-ring on a steel expendable drive point (GW1555K). Firmly seat the expendable point in the necked end of a sampler sheath (15187).

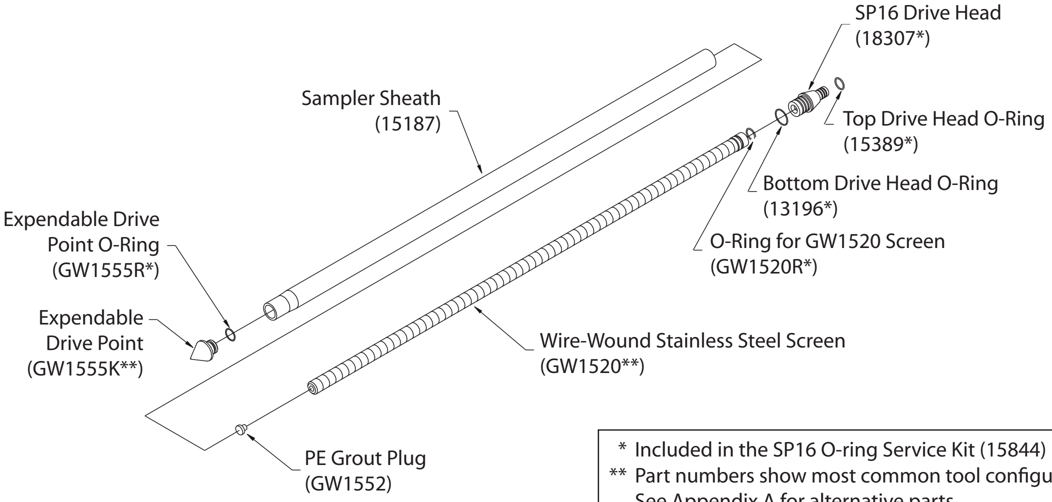
2. Install a PE Grout Plug (GW1552) in the bottom end of a Wire-wound Stainless Steel Screen (GW1520). Place a GW1520R O-ring in the groove on the top end of the screen.

3. Slide the screen inside of the sampler sheath with the grout plug toward the bottom of the sampler. Ensure that the expendable point was not displaced by the screen.

4. Install a bottom O-ring (13196) on a Drive Head (18307 or 15188). Thread the drive head into the sampler sheath using an adjustable wrench if necessary to ensure complete engagement of the threads. Attach a Drive Cap (12787 or 15590) to the top of the drive head.

NOTE: The 18307 drive head should be used whenever possible as the smaller 0.5-inch ID provides a greater material cross-section for increased durability.

Sampler assembly is complete.



* Included in the SP16 O-ring Service Kit (15844)
** Part numbers show most common tool configuration.
See Appendix A for alternative parts.

FIGURE 4.1
Screen Point 16 Groundwater Sampler Assembly

4.5 Advancing the SP16 Sampler

To provide adequate room for screen deployment with the Rod Grip Pull System, the probe derrick should be extended a little over halfway out of the carrier vehicle when positioning for operation.

1. Begin by placing the assembled sampler (Fig. 2.1.A) in the driving position beneath the hydraulic hammer of the direct push machine as shown in Figure 4.2.

2. Advance the sampler with the throttle control at slow speed for the first few feet to ensure that the sampler is aligned properly. Switch to fast speed for the remainder of the probe stroke.

3. Completely raise the hammer assembly. Remove the drive cap and place an O-ring in the top groove of the drive head. Distilled water may be used to lubricate the O-ring if needed.

   Add a probe rod (length to be determined by operator) and reattach the drive cap to the rod string. Drive the sampler the entire length of the new rod with the throttle control at fast speed.

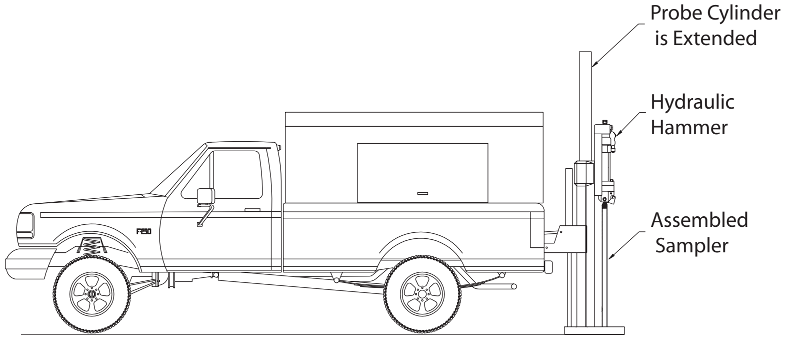


FIGURE 4.2
Screen Point 16 Groundwater Sampler in Driving Position

4. Repeat Step 3 until the desired sampling interval is reached. Approximately 12 inches (305 mm) of the last probe rod must extend above the ground surface to allow attachment of the puller assembly. A 12-inch (305 mm) rod may be added if the tool string is over-driven.

5. Remove the drive cap and retract the probe derrick away from the tool string.

4.6 Screen Deployment

1. Thread a screen push adapter (GW1535) on an extension rod of suitable length (AT671, 10073, or AT675). Attach a threaded coupler (AT68) to the other end of the extension rod. Lower the extension rod inside of the probe rod taking care not to drop it down the tool string. An extension rod jig (AT690) may be used to hold the rods.

2. Add extension rods until the adapter contacts the bottom of the screen. To speed up this step, it is recommended that Extension Rod Quick Links (AT695 and AT696) are used at every other rod joint.

3. Ensure that at least 48 inches (1219 mm) of extension rod protrudes from the probe rod. Thread an extension rod handle (AT69) on the top extension rod.

4. Maneuver the probe assembly into position for pulling.

5. Raise (pull) the tool string while physically holding the screen in place with the extension rods (Fig. 4.3.B). A slight knock with the extension rod string will help to dislodge the expendable point and start the screen moving inside the sheath.

   Raise the hammer and tool string about 44 inches (1118 cm) if using a GW1520 or GW1530 screen. At this point the screen head will contact the necked portion of the sampler sheath (Fig. 4.3.C.) and the extension rods will rise with the probe rods. Use care when deploying a PVC screen so as not to break the screen when it contacts the bottom of the sampler sheath.

   The Disposable Screen (16089) will extend completely out of the sheath if the tool string is raised more than 45 inches (1143 mm). Measure and mark this distance on the top extension rod to avoid losing the screen during deployment.

6. Remove the rod grip handle, lower the hammer assembly, and retract the probe derrick. Remove the top extension rod (with handle) and top probe rod. Finally, extract all extension rods.

7. Groundwater samples can now be collected with a mini-bailer, peristaltic or vacuum pump, tubing bottom check valve assembly, bladder pump, or other acceptable small diameter sampling device.

   When inserting tubing or a bladder pump down the rod string, ensure that it enters the screen interval. The leading end of the tubing or bladder pump will sometimes catch at the screen head giving the illusion that the bottom of the screen has been reached. An up-and-down motion combined with rotation helps move the tubing or bladder pump past the lip and into the screen.

4.7 Abandonment Grouting for GW1520 and GW1530 Screens

The SP16 Sampler can meet ASTM D 5299 requirements for abandoning environmental wells or borings when grouting is conducted properly. A removable grout plug makes it possible to deploy tubing through the bottom of GW1520 and GW1530 screens. A GS500 or GS1000 Grout Machine is then used to pump grout into the open probe hole as the sampler is withdrawn. The following procedure is presented as an example only and should be modified to satisfy local abandonment grouting regulations.

1. Maneuver the probe assembly into position for pulling. Attach the rod grip puller to the top probe rod. Raise the tool string approximately 4 to 6 inches (102 to 152 cm) to allow removal of the grout plug.

2. Thread the Grout Plug Push Adapter (GW1540) onto an extension rod. Insert the adapter and extension rod inside the probe rod string. Add extension rods until the adapter contacts the grout plug at the bottom of the screen. Attach the handle to the top extension rod. When the extension rods are slightly raised and lowered, a relatively soft rebound should be felt as the adapter contacts the grout plug. This is especially true when using a PVC screen.

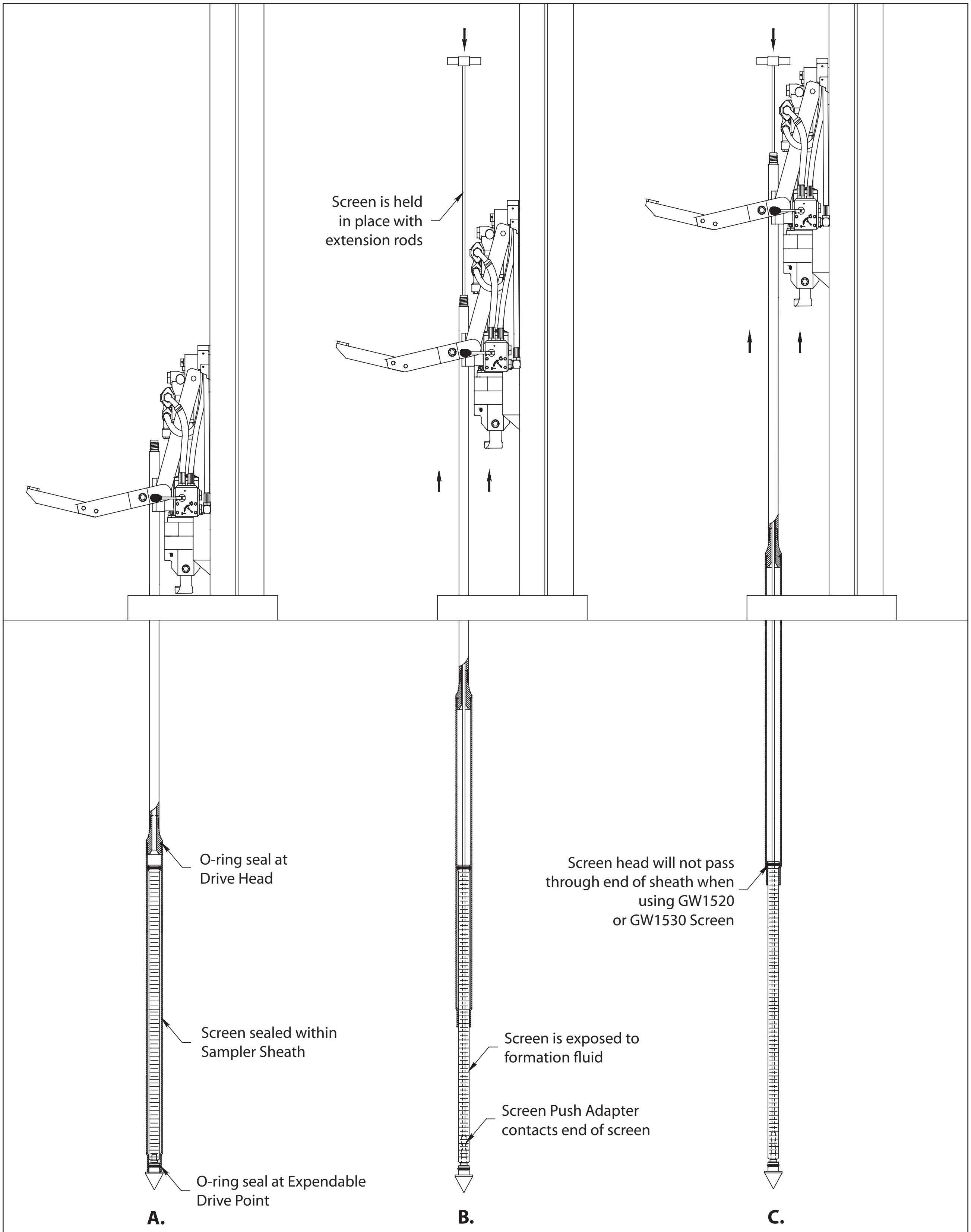


FIGURE 4.3
Screen Deployment for SP16 Sampler

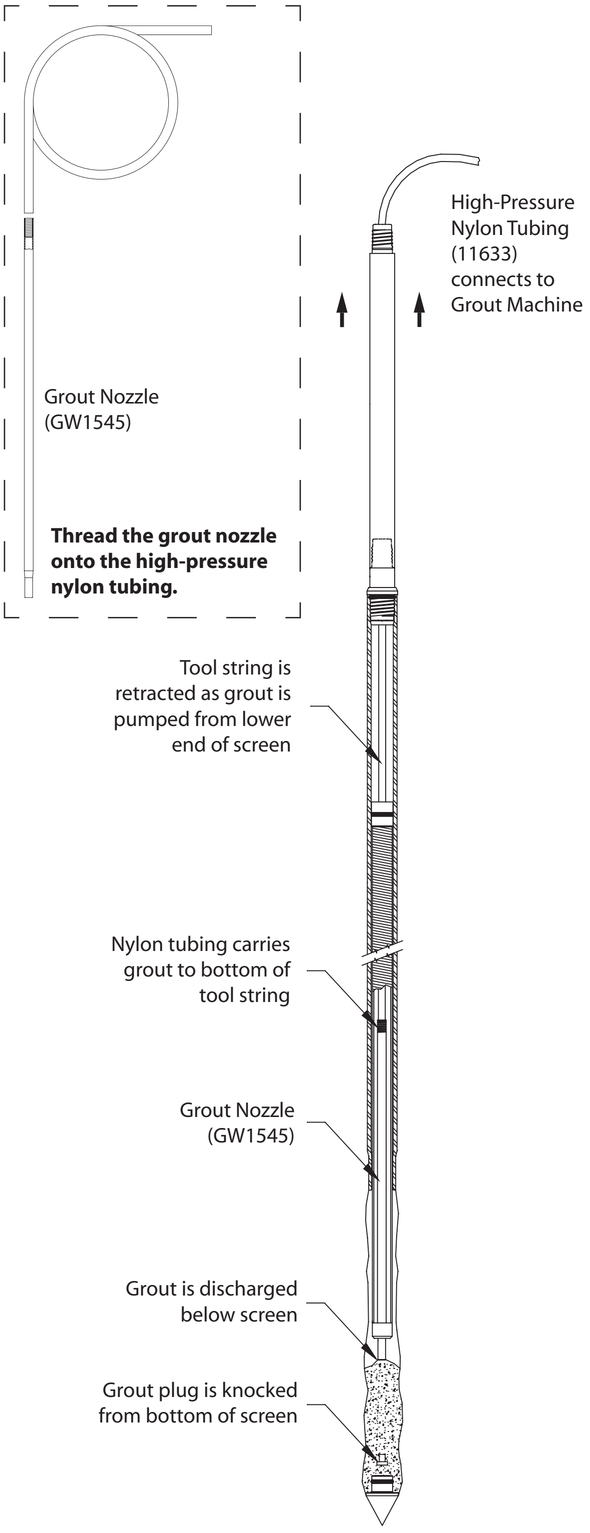


FIGURE 4.4

Grouting the SP16 Sampler With a GW1520 or GW1530 Screen

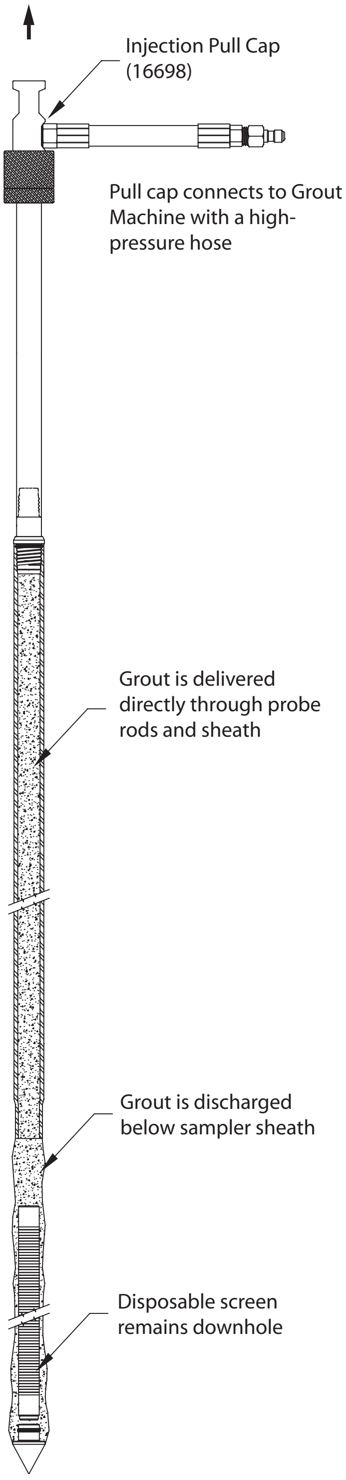


FIGURE 4.5

Grouting the SP16 Sampler With a 16089 Disposable Screen

3. Place a mark on the extension rod even with the top of the probe rod. Apply downward pressure on the extension rods and push the grout plug out of the screen. The mark placed on the extension rod should now be below the top of the probe rod. Remove all extension rods.

   Note: When working with a stainless steel screen, it may be necessary to raise and quickly lower the extension rods to jar the grout plug free. When the plug is successfully removed, a metal-on-metal sensation may be noted as the extension rods are gently "bounced" within the probe rods.

4. A Grout Nozzle (GW1545) is now connected to High-Pressure Nylon Tubing (11633) and inserted down through the probe rods to the bottom of the screen (Fig. 4.4). It may be necessary to pump a small amount of clean water through the tubing during deployment to jet out sediments that settled in the bottom of the screen. Resistance will sometimes be felt as the grout nozzle passes through the drive head. Rotate the tubing while moving it up-and-down to ensure that the nozzle has reached the bottom of the screen and is not hung up on the drive head.

   Note: *All probe rods remain strung on the tubing as the tool string is pulled. Provide extra tubing length to allow sufficient room to lay the rods on the ground as they are removed. An additional 20 feet is generally enough.*

5. Operate the grout pump while pulling the first rod with the rod grip pull system. Coordinate pumping and pulling rates so that grout fills the void left by the sampler. After pulling the first rod, release the rod grip handle, fully lower the hammer, and regrip the tool string. Unthread the top probe and slide it over the tubing placing it on the ground near the end of the tubing.

6. Repeat Step 5 until the sampler is retrieved. Do not bend or kink the tubing when pulling and laying out the probe rods. Sharp bends create weak spots in the tubing which may burst when pumping grout. Remember to operate the grout pump only when pulling the rod string. The probe hole is thus filled with grout from the bottom up as the rods are extracted.

7. Promptly clean all probe rods and sampler parts before the grout sets up and clogs the equipment.

4.8 Abandonment Grouting for the 16089 Disposable Screen

ASTM D 5299 requirements can also be met for the SP16 samplers when using the 16089 disposable screen. Because the screen remains downhole after sampling, the operator may choose either to deliver grout to the bottom of the tool string with nylon tubing or pump grout directly through the probe rods using an Injection Pull Cap (16698). A GS500 or GS1000 Grout Machine is needed to pump grout into the open probe hole as the sampler is withdrawn. The following procedure is presented as an example only and should be modified to satisfy local abandonment grouting regulations.

1. Maneuver the probe assembly into position for pulling with the rod grip puller.

2. Thread the screen push adapter onto an extension rod. Insert the adapter and extension rod inside the probe rod string. Add extension rods until the adapter contacts the bottom of the screen. Attach the handle to the top extension rod.

3. The disposable screen must be extended at least 46 inches (1168 mm) to clear the bottom of the sampler sheath. Considering the length of screen deployed in Section 4.7, determine the remaining distance required to fully extend the screen from the sheath. Mark this distance on the top extension rod.

4. Pull the tool string up to the mark on the top extension rod while holding the disposable screen in place.

   The screen is now fully deployed and the sampler is ready for abandonment grouting. Apply grout to the bottom of the tool string during retrieval using either flexible tubing (as described in Section 4.7) or an injection pull cap (Fig. 4.5). This section continues with a description of grouting with a pull cap.

5. Remove the rod grip handle and maneuver the probe assembly directly over the tool string. Thread an Injection Pull Cap (16698) onto the top probe rod and close the hammer pull latch over the top of the pull cap.

6. Connect the pull cap to a Geoprobe® grout machine using a high-pressure grout hose.

7. Operate the pump to fill the entire tool string with grout. When a sufficient volume has been pumped to fill the tool string, begin pulling the rods and sampler while continuing to operate the grout pump. Considering the known pump volume and sampler cross-section, time tooling withdrawal to slightly "overpump" grout into the subsurface. This will ensure that all voids are filled during sampler retrieval.

   The grouting process can lubricate the probe hole sufficiently to cause the tool string to slide back downhole when disconnected from the pull cap. Prevent this by withdrawing the tool string with the rod grip puller while maintaining a connection to the grout machine with the pull cap.

4.9 Retrieving the Screen Point 16 Sampler

If grouting is not required, the Screen Point 16 Sampler can be retrieved by pulling the probe rods as with most other Geoprobe® applications. The Rod Grip Pull System should be used for this process as it allows the operator to remove rods without completely releasing the tool string. This avoids having the probe rods fall back downhole when released during the pulling procedure. A standard Pull Cap (15164) may still be used if preferred. Refer to the Owner's Manual for your Geoprobe® direct push machine for specific instructions on pulling the tool string.

5.0 REFERENCES

American Society of Testing and Materials (ASTM), 2003. D6771-02 Standard Practice for Low-Flow Purging and Sampling for Wells and Devices Used for Ground-Water Quality Investigations. ASTM, West Conshocken, PA. (www.astm.org)

American Society of Testing and Materials (ASTM), 1993. ASTM 5299 *Standard Guide for Decommissioning of Groundwater Wells, Vadose Zone Monitoring Devices, Boreholes, and Other Devices for Environmental Activities.* ASTM West Conshohocken, PA. (www.astm.org)

Geoprobe Systems®, 2003, *Tools Catalog, V.6.*

Geoprobe Systems®, 2006, *Model MB470 Mechanical Bladder Pump Standard Operating Procedure (SOP), Technical Bulletin No. MK3013.*

Puls, Robert W., and Michael J. Barcelona, 1996. Ground Water Issue: Low-Flow (Minimal Drawdown) Ground Water Sampling Procedures. EPA/540/S-95/504. April.

U.S. Environmental Protection Agency (EPA), 2003. Environmental Technology Verification Report: Geoprobe Inc., Mechanical Bladder Pump Model MB470. Office of Research and Development, Washington, D.C. EPA/600R-03/086. August.

Appendix A
ALTERNATIVE PARTS

The following parts are available to meet unique soil conditions. See section 3.0 for a complete listing of the common tool configurations for the Geoprobe® Screen Point 16 Groundwater Sampler.

SP16 Sampler Parts and Accessories	**Part Number**
SP16 Drive Head, 0.625-inch bore, 1.5-inch rods	15188
Expendable Drive Points, aluminum, 1.625-inch OD (Pkg. of 25)	GW1555ALK
Expendable Drive Points, steel, 1.75-inch OD (Pkg. of 25)	17066K
Screen, PVC, 10-Slot	GW1530
Screen, Disposable, PVC, 10-Slot	16089

Groundwater Purging and Sampling Accessories	**Part Number**
Polyethylene Tubing, 0.25-inch OD, 500 ft.	TB17L
Polyethylene Tubing, 0.5-inch OD, 500 ft.	TB37L
Polyethylene Tubing, 0.625-inch OD, 50 ft.	TB50L
Check Valve Assembly, 0.25-inch OD Tubing	GW4240
Check Valve Assembly, 0.5-inch OD Tubing	GW4220
Check Valve Assembly, 0.625-inch OD Tubing	GW4230
Water Level Meter, 0.375-inch OD Probe, 100-ft. cable	GW2001
Water Level Meter, 0.438-inch OD Probe, 200-ft. cable	GW2002
Water Level Meter, 0.375-inch OD Probe, 200-ft. cable	GW2003
Water Level Meter, 0.438-inch OD Probe, 30-m cable	GW2005
Water Level Meter, 0.438-inch OD Probe, 60-m cable	GW2007
Water Level Meter, 0.375-inch OD Probe, 60-m cable	GE2008

Grouting Accessories	**Part Number**
Grout Machine, auxiliary-powered	GS500

Probe Rods, Extension Rods, and Accessories	**Part Number**
Probe Rod, 1.5-inch x 1-meter	17899
Probe Rod, 1.5-inch x 48-inch	13359
Drive Cap, 1.5-inch rods (for GH40 Series Hammer)	15590
Rod Grip Pull Handle, 1.5-inch Probe Rods (for GH40 Series Hammer)	GH1555
Extension Rod, 48-inch	AT671
Extension Rod, 1-meter	AT675

Geoprobe Systems®

A DIVISION OF KEJR, INC.

Corporate Headquarters
601 N. Broadway • Salina, Kansas 67401
1-800-GEOPROBE (1-800-436-7762) • Fax (785) 825-2097
www.geoprobe.com

ATTACHMENT D
Field Forms

KOMAN Government Solutions, LLC
SOIL BORING LOG

Project: Fort Devens	Boring No.:
Project No.:	Drilling Co.:
Address:	Driller:
Logger:	Drilling Method:
Dates:	Drilling Equip:
Total Boring Depth:	Static Water:

Core Section	Recovery (ft)	Interval (ft)	PID (ppm)	Soil Profile	GEOLOGIC LOG

Notes:

1. Borehole grouted to surface upon completion and sealed with cement pad. 2.
PID readings not collected for soil characterization of metals.

Soil Characterization

▨	Top soil	▨	Primarily Clay	▨	Gravel
▨	Primarily Sand	▨	Till	▨	Heterogeneous Mixture
▨	Primarily Silt	▨	Shale	▨	Bedrock

KGS

KOMAN Government Solutions, LLC
160 East Main Street
Westboro, MA 01581

FEDERAL SOP MONITORING WELL LOW FLOW SAMPLING LOG

Federal Projects EPA SOP
Low Flow Sampling Log
v.24 Sept 2014

Project Name: ______________________ Date: ________

Project Location: ______________________ Project #: ________

Personnel: ______________________ ______________________

WELL IDENTIFICATION: ______________________

Headspace (PID) ________

WELL INTEGRITY

	YES	NO	N/A
Protective Casing Secure	☐	☐	☐
Concrete Pad Intact	☐	☐	☐
PVC Casing Intact	☐	☐	☐
Well Gripper Present	☐	☐	☐
Bolts Present (Pad Wells)	☐	☐	☐
Locked (Stickup Wells)	☐	☐	☐

Photograph

Well Information

Diameter: ________ Depth to Water: ________

Material: ________ Depth to Bottom: ________

Screen Interval: 18.3 – 33.3

SAMPLING TYPE, TUBING DETAILS

Purging Method: ________ 1 Well Volume (gal): ________ Tubing Type ________ Pump S/N ________

Purge Start Time: ________ Air Source: ________ Tubing Diameter ________

STABILIZATION PARAMETERS

TIME	FLOW RATE (mL/min)	DEPTH TO WATER (feet)	TEMP (°C)	SPECIFIC COND (μS/cm)	DISSOLVED OXYGEN (mg/L)	pH	ORP (mV)	TURBIDITY (NTU)	COLOR/ CLARITY
(min)*	(100-500 mL/min)**	(+/- 0.3')**	(+/- 3%)**	(+/- 3%)**	(+/- 10%)or <0.5**	(+/- 0.1)**	(+/- 10mV)**	(+/- 10%)or <5**	

* every 5 to 10 minutes, depending on volume of flow-through cell, from EPA Region 1 Low-Flow SOP version 3: 1-19-2010

SAMPLING DETAILS

FIELD-FILTERED: Y N

FILTER SIZE:________μm

DUPLICATE: Y N

MS/MSD: Y N

SAMPLED BY (PRINT):

SAMPLER(S) SIGNATURES:

SAMPLING START TIME:

SAMPLING END TIME:

NOTES: ______________________

____

____

Instrument Calibration Log

Project/Site Name: _________________________

Calibrated By: ______________________________

Instrument/Serial Number	Pre-Cal 0-AM (NTU)	Pre-Cal 0-PM (NTU)	Pre-Cal 10-AM (NTU)	Pre-Cal 10-PM (NTU)	Post-Cal 0-AM (NTU)	Post-Cal 0-PM (NTU)	Post-Cal 10-AM (NTU)	Post-Cal 10-PM (NTU)	Date

Signature: ____

Date: _________________________

Instrument Calibration Log

Project/Site Name: ____________________ **Date:** ______________________ **Weather:** ______________________

Calibrated By: _______________________ **Instrument:** _________________ **Serial Number:** _________________

___________________________ ______________________________

Parameters	Morning Calibration	Cal. Temperature ºC	Afternoon Cal. Check	Comments
Conductivity (µS/cm^c)				
pH (7)				
pH (4)				
pH (10)				
ORP (mv)				
Dissolved Oxygen (%)				
Zero Dissolved Oxygen (mg/L)				
Barometric Pressure (mmHg)				

Signature: ____ Date: ______________________________

ATTACHMENT E
2016 QAPP Addendum

PFAS QAPP Addendum Table of Contents

Worksheet	Comment
Worksheets #1 through #9	Reference: Annual LTMMP QAPP (June 2016)
Worksheet #10	Reference: PFAS ESI Work Plan
Worksheets #11 through 14 and #16	Reference: Annual LTMMP QAPP (June 2016)
Worksheet #15	PFAS Analytical Method Reporting Limits and Control Limits
Worksheet #17	Reference: PFAS ESI Work Plan
Worksheet #18	Reference: PFAS ESI Work Plan
Worksheet #19/30	PFAS Sample Containers, Preservation and Hold Times
Worksheet #20	PFAS Field QC Sample Summary
Worksheets #21 through #23	Reference: Annual LTMMP QAPP (June 2016)
Worksheet #24	PFAS Analytical Instrument Calibration
Worksheet #25	Reference: Annual LTMMP QAPP (June 2016)
Worksheet #26/27	Reference: PFAS ESI Work Plan
Worksheet #28	PFAS Analytical Quality Control and Corrective Action
Worksheet #29 through #37	Reference: Annual LTMMP QAPP (June 2016)

Worksheet # 15
PFAS Analytical Method Reporting Limits and Control Limits

Method Code	CAS Number	PFAS Compound	RL	MDL	LOD	Units	LCS Low	LCS High	LCS RPD %	MS Low	MS High	MS RPD %
Soil												
Method 537Modified	375-73-5	Perfluorobutanesulfonic acid (PFBS)	0.40	0.103	0.300	ug/Kg	50	150	30	50	150	30
Lab SOP WS-LC-0025 Rev2.1 (12/9/2016)	355-46-4	Perfluorohexanesulfonic acid (PFHxS)	0.50	0.118	0.300	ug/Kg	60	140	30	60	140	30
	375-85-9	Perfluoroheptanoic acid (PFHpA)	0.50	0.0880	0.300	ug/Kg	60	140	30	60	140	30
	335-67-1	Perfluorooctanoic acid (PFOA)	0.50	0.102	0.300	ug/Kg	60	140	30	60	140	30
	1763-23-1	Perfluorooctanesulfonic acid (PFOS)	0.50	0.126	0.300	ug/Kg	60	140	30	60	140	30
	375-95-1	Perfluorononanoic acid (PFNA)	0.50	0.0830	0.300	ug/Kg	60	140	30	60	140	30
	STL00993	13C2 PFHxA				ug/Kg	25	150		25	150	
	STL00994	18O2 PFHxS				ug/Kg	25	150		25	150	
	STL01892	13C4-PFHpA				ug/Kg	25	150		25	150	
	STL00990	13C4 PFOA				ug/Kg	25	150		25	150	
	STL00991	13C4 PFOS				ug/Kg	25	150		25	150	
Groundwater												
Method 537Modified	375-73-5	Perfluorobutanesulfonic acid (PFBS)	2.5	0.918	2.00	ng/L	50	150	30	50	150	30
Lab SOP WS-LC-0025 Rev2.1 (12/9/2016)	355-46-4	Perfluorohexanesulfonic acid (PFHxS)	2.5	0.870	2.00	ng/L	60	140	30	60	140	30
	375-85-9	Perfluoroheptanoic acid (PFHpA)	2.5	0.802	2.00	ng/L	60	140	30	60	140	30
	335-67-1	Perfluorooctanoic acid (PFOA)	2.5	0.748	2.00	ng/L	60	140	30	60	140	30
	1763-23-1	Perfluorooctanesulfonic acid (PFOS)	4.0	1.28	3.00	ng/L	60	140	30	60	140	30
	375-95-1	Perfluorononanoic acid (PFNA)	2.5	0.654	2.00	ng/L	60	140	30	60	140	30
	STL00993	13C2 PFHxA				ng/L	25	150				
	STL00994	18O2 PFHxS				ng/L	25	150				
	STL01892	13C4-PFHpA				ng/L	25	150				
	STL00990	13C4 PFOA				ng/L	25	150				
	STL00991	13C4 PFOS				ng/L	25	150				

QAPP WORKSHEET #18
PFAS Sampling Locations and Field QC Samples

Groundwater and soil samples will be collected from designated locations following PFAS sample collection procedures described in Section 2 of the Expedited Site Inspection Work Plan.

Location/Description	Sample Location	Matrix	Approximate Depth to Groundwater (ft bgs)	Proposed Sample Depth or Well Screen Interval (ft bgs)**	Sample Type ****
AOC 5/Shepley's Hill Landfill	SHM-10-11*	Groundwater	40	50-60	Native Sample
	SHM-10-12*	Groundwater	35	45-55	Native Sample
	SHM-10-14*	Groundwater	20	60-80	Native Sample
	SHM-10-15*	Groundwater	25	45-55	Native Sample
	SHP-95-27X*	Groundwater	17	30.5-40.5	Native Sample
	SHL-15*	Groundwater	18	14-5-24.5	Native Sample
	SHL-17*	Groundwater	9	6-16	Native Sample
	SHL-18*	Groundwater	19	16-26	Native Sample
	SHL-24*	Groundwater	17	110-120	Native Sample
	EW-01*	Groundwater	16	60-85	Native Sample
	EW-04*	Groundwater	16	70-95	Native Sample
	SHM-11-06*	Groundwater	20	25-35	Native Sample
	SHM-96-5B*	Groundwater	7	80-90	Native Sample
	SHM-05-40X*	Groundwater	14	32-34	Native Sample
	SHM-05-41A*	Groundwater	11	42-44	Native Sample
	SHM-05-41B*	Groundwater	11	62-64	Native Sample
	SHM-05-41C*	Groundwater	11	88-93	Native Sample
	SHM-13-06*	Groundwater	18	36-46	Native Sample
	SHP-01-38A*	Groundwater	4	1.5-6.5	Native Sample
	SHP-01-38B*	Groundwater	4	18-23	Native Sample
AOC5/SHL QC Samples	SHL-DUP01	Groundwater			Field Duplicate (GW)
	SHL-DUP02	Groundwater			Field Duplicate (GW)
	SHM-05-40X MS/MSD	Groundwater			MS/MSD (GW)
	SHL-EB01	Aqueous			Equipment Blank
	SHL-FB01	Aqueous			Field Blank

QAPP WORKSHEET #18
PFAS Sampling Locations and Field QC Samples

Groundwater and soil samples will be collected from designated locations following PFAS sample collection procedures described in Section 2 of the Expedited Site Inspection Work Plan.

Location/Description	Sample Location	Matrix	Approximate Depth to Groundwater (ft bgs)	Proposed Sample Depth or Well Screen Interval (ft bgs)**	Sample Type ****
SA 20 and 21/Devens WWTP	SA21-17-01	Soil	20	0-5	Native Sample
		Groundwater	20	20-22	Native Sample
	SA21-17-02	Soil	20	0-5	Native Sample
		Groundwater	20	20-22	Native Sample
	SA20-17-01	Soil	65	0-2	Native Sample
	SA20-17-02	Groundwater	20	20-22	Native Sample
	WWTP-Influent	Influent Wastewater	NA	NA	Native Sample
	WWTP-Effluent	Effluent Wastewater	NA	NA	Native Sample
	MW-01A*	Groundwater	23	~18-33***	Native Sample
	MW-02A*	Groundwater	20	~15-30***	Native Sample
	MW-04*	Groundwater	12	~7-22***	Native Sample
SA 20 and 21 QC Samples	SA21-DUP01	Groundwater			Field Duplicate (GW)
	SA21-17-01MS/MSD	Soil			MS/MSD (soil)
	SA21-EB01	Aqueous			Equipment Blank (from soil sampling equipment)

QAPP WORKSHEET #18
PFAS Sampling Locations and Field QC Samples

Groundwater and soil samples will be collected from designated locations following PFAS sample collection procedures described in Section 2 of the Expedited Site Inspection Work Plan.

Location/Description	Sample Location	Matrix	Approximate Depth to Groundwater (ft bgs)	Proposed Sample Depth or Well Screen Interval (ft bgs)**	Sample Type ****
SA 74/Barnum Road	SA74-17-01	Soil	12	0-5	Native Sample
		Groundwater	12	12-14	Native Sample
	SA74-17-02	Soil	5	0-5	Native Sample
		Groundwater	5	5-7	Native Sample
	SA74-17-03	Soil	5	0-5	Native Sample
		Groundwater	5	5-7	Native Sample
	SA74-17-04	Groundwater	3	3-5	Native Sample
	SA74-17-05	Groundwater	3	3-5	Native Sample
SA 74 QC Samples	SA74-DUP01	Soil			Field Duplicate (Soil)
	SA74-17-01MS/MSD	Groundwater			MS/MSD (GW)
	SA74-EB01	Aqueous			Equipment Blank (from GW sampling equipment)
	SA74-FB01	Aqueous			Field Blank
SA 75/Building T-1445 Warehouse Fire	SA75-17-01	Soil	15	0-5	Native Sample
		Groundwater	15	15-17	Native Sample
	SA75-17-02	Groundwater	5	0-5	Native Sample
	SA75-17-03	Soil	15	0-5	Native Sample
		Groundwater	15	15-17	Native Sample
	SA75-17-04	Soil	15	0-5	Native Sample
		Groundwater	15	15-17	Native Sample
	MNG-3*	Groundwater	35	53-63	Native Sample
	CSMS-11-01*	Groundwater	36	30-40	Native Sample
	CSMS-11-02*	Groundwater	35	30-40	Native Sample
SA 75 QC Samples	SA75-DUP01	Groundwater			Field Duplicate (GW)
	SA75-EB01	Aqueous			Equipment Blank (from soil sampling equipment)

QAPP WORKSHEET #18
PFAS Sampling Locations and Field QC Samples

Groundwater and soil samples will be collected from designated locations following PFAS sample collection procedures described in Section 2 of the Expedited Site Inspection Work Plan.

Location/Description	Sample Location	Matrix	Approximate Depth to Groundwater (ft bgs)	Proposed Sample Depth or Well Screen Interval (ft bgs)**	Sample Type ****
Former Moore Airfield					
AOC 50/Former Moore Airfield Fire Station	AOC50-17-01	Soil	60	0-5	Native Sample
		Groundwater	60	60-62	Native Sample
	AOC50-17-02	Soil	60	0-5	Native Sample
		Groundwater	60	60-62	Native Sample
AOC 50/Former Moore Airfield Hangar	AOC50-17-03	Soil	60	0-5	Native Sample
		Groundwater	60	60-62	Native Sample
	AOC50-17-04	Soil	60	0-5	Native Sample
		Groundwater	60	60-62	Native Sample
	AOC50-17-05	Groundwater	60	60-62	Native Sample
	AOC50-17-06	Soil	60	0-5	Native Sample
		Groundwater	60	60-62	Native Sample
	AOC50-17-07	Soil	60	0-5	Native Sample
		Groundwater	60	60-62	Native Sample

QAPP WORKSHEET #18
PFAS Sampling Locations and Field QC Samples

Groundwater and soil samples will be collected from designated locations following PFAS sample collection procedures described in Section 2 of the Expedited Site Inspection Work Plan.

Location/Description	Sample Location	Matrix	Approximate Depth to Groundwater (ft bgs)	Proposed Sample Depth or Well Screen Interval (ft bgs)**	Sample Type ****
AOC 50/Former Airfield Runway	AOC50-17-08	Soil	60	0-5	Native Sample
		Groundwater	60	60-62	Native Sample
	AOC50-17-09	Soil	60	0-5	Native Sample
		Groundwater	60	60-62	Native Sample
	AOC50-17-10	Soil	60	0-5	Native Sample
		Groundwater	60	60-62	Native Sample
	AOC50-17-11	Soil	60	0-5	Native Sample
		Groundwater	60	60-62	Native Sample
	AOC50-17-12	Soil	60	0-5	Native Sample
		Groundwater	60	60-62	Native Sample
	AOC50-17-13	Soil	60	0-5	Native Sample
		Groundwater	60	60-62	Native Sample
	AOC50-17-14	Soil	30	0-5	Native Sample
		Groundwater	30	30-32	Native Sample
	AOC50-17-15	Soil	50	0-5	Native Sample
		Groundwater	50	50-52	Native Sample
	AOC50-17-16	Soil	30	0-5	Native Sample
		Groundwater	30	30-32	Native Sample
	AOC50-17-17	Soil	30	0-5	Native Sample
		Groundwater	30	30-32	Native Sample
AOC 50 QC Samples	AOC 50-DUP01	Soil			Field Duplicate (soil)
	AOC 50-DUP02	Groundwater			Field Duplicate (GW)
	AOC50-17-08 MS/MSD	Groundwater			MS/MSD (GW)
	AOC50-EB01	Aqueous			Equipment Blank (from GW sampling equipment)
	AOC50-FB01	Aqueous			Field Blank

QAPP WORKSHEET #18
PFAS Sampling Locations and Field QC Samples

Groundwater and soil samples will be collected from designated locations following PFAS sample collection procedures described in Section 2 of the Expedited Site Inspection Work Plan.

Location/Description	Sample Location	Matrix	Approximate Depth to Groundwater (ft bgs)	Proposed Sample Depth or Well Screen Interval (ft bgs)**	Sample Type ****
SA 30/Former Drum Storage Area	SA30-17-01	Soil	60	0-5	Native Sample
		Groundwater	60	60-62	Native Sample
	SA30-17-02	Soil	60	0-5	Native Sample
		Groundwater	60	60-62	Native Sample
	SA30-17-03	Soil	60	0-5	Native Sample
		Groundwater	60	60-62	Native Sample
	SA30-17-04	Soil	60	0-5	Native Sample
		Groundwater	60	60-62	Native Sample
	SA30-17-05	Soil	60	0-5	Native Sample
		Groundwater	60	60-62	Native Sample
	SA30-17-06	Soil	60	0-5	Native Sample
		Groundwater	60	60-62	Native Sample
SA 30 QC Samples	SA30-DUP01	Soil			Field Duplicate (soil)
	SA30-17-01 MS/MSD	Soil			MS/MSD (soil)

QAPP WORKSHEET #18
PFAS Sampling Locations and Field QC Samples

Groundwater and soil samples will be collected from designated locations following PFAS sample collection procedures described in Section 2 of the Expedited Site Inspection Work Plan.

Location/Description	Sample Location	Matrix	Approximate Depth to Groundwater (ft bgs)	Proposed Sample Depth or Well Screen Interval (ft bgs)**	Sample Type ****
SA 31/Former Fire Fighting Training Area	SA31-17-01	Soil	60	0-5	Native Sample
		Groundwater	60	60-62	Native Sample
	SA31-17-02	Groundwater	60	60-62	Native Sample
	SA31-17-03	Groundwater	60	60-62	Native Sample
	SA31-17-04	Groundwater	60	60-62	Native Sample
	G6M-13-01X*	Groundwater	65	125-135	Native Sample
	XSA-12-97X	Groundwater	65	120-130	Native Sample
SA31 QC Samples	SA31-DUP01	Groundwater			Field Duplicate (GW)
	SA31-EB01	Aqueous			Equipment Blank (from GW sampling equipment)
	SA31-FB01	Aqueous			Field Blank

QAPP WORKSHEET #18
PFAS Sampling Locations and Field QC Samples

Groundwater and soil samples will be collected from designated locations following PFAS sample collection procedures described in Section 2 of the Expedited Site Inspection Work Plan.

Location/Description	Sample Location	Matrix	Approximate Depth to Groundwater (ft bgs)	Proposed Sample Depth or Well Screen Interval (ft bgs)**	Sample Type ****
AOC 32/DRMO Yard	32M-92-03X*	Groundwater	28	23.2-33.2	Native Sample
	32M-92-01X*	Groundwater	18	13.7-23.7	Native Sample
	32Z-01-07XOB*	Groundwater	17	12.7-22.7	Native Sample
	32M-01-14XOB*	Groundwater	25	17.3-27.3	Native Sample
	32M-01-17XBR*	Groundwater	25	41.4-51.4	Native Sample
	SHL-25*	Groundwater	25	23.5-33.5	Native Sample
	43M-01-20XOB*	Groundwater	27	24-34	Native Sample
	43M-01-20XBR*	Groundwater	26	68.3-78.3	Native Sample
AOC 32 QC Samples	32M-DUP01	Groundwater			Field Duplicate (GW)
	AOC32-EB01	Aqueous			Equipment Blank (from GW sampling equipment)
	AOC32-FB01	Aqueous			Field Blank

Notes:
ft bgs = feet below ground surface
SHL = Shepley's Hill Landfill
* = Existing well
** = Temporary wells will be screened (2 foot) into the water table observed in the field. Cited depths are estimated.
*** = Monitoring well screens were set approximately 5 feet above and 10 feet below the water table elevation at time of installation.
**** = Field duplicate samples will be selected in the field from representative locations.

QAPP WORKSHEET #19 AND #30

PFAS Sample Containers, Preservation and Hold Times

Primary Analytical Laboratory **Test America Laboratory; 880 Riverside Parkway;** **West Scaramento, CA 95605**	Project Manager: Jerry Lanier Email: jerry.lanier@testamericainc.com Certifications: DoD ELAP Sample Delivery Method: FedEx overnight

Matrix	**Analytical Group**	**Analytical / Preparation Method SOP Reference**	**Containers** (number, size, and type)	**Sample volume** (units)	**Preservation Requirements** (chemical, temperature)	**Maximum Holding Time** (preparation/analysis)
ORGANIC ANALYSES						
Water	PFAS Modified Method 537	WS-LC-0025 Rev 2.1 (12/09/2016) (TAL-Sacramento)	2 x 250 ml HDPE Bottles - (**NO Teflon lids**)	100mL	Cool < 6°C	Extraction: 14 Days from Collection Analysis: 40 days from Extraction
Soil	PFAS Modified Method 537	WS-LC-0025 Rev 2.1 (12/09/2016) (TAL-Sacramento)	1 x wide mouth 250-ml HDPE Bottle (**NO Teflon lids**)	50 grams	Cool < 6°C	Extraction:14 Days from Collection Analysis: 40 days from Extraction

QAPP WORKSHEET #20
PFAS Field QC Sample Summary

Matrix	Analyte/Analytical Group	Field Samples	Field Duplicates	Matrix Spikes/Matrix Spike Duplicates	Equipment Blanks *	Ambient Blank **
Groundwater	PFAS	See PFAs Work Plan	10%	5%	1 per day	1 per event
Soil	PFAS	See PFAs Work Plan	10%	5%	1 per day	1 per event

* - Equipment blanks will be prepared by pouring PFAS-free water over decontaminated sampling equipment into preserved sample jars.
** - Ambient blanks (AB) will be prepared by pouring PFAS-free water into a preserved sample jar. The AB will be prepared near representative soil and groundwater sampling locations to monitor for possible airborne contamination during

Worksheet #24

PFAS Analytical Instrument Calibration - PFAS Lab SOP WC-LC-0025

Instrument	Calibration Procedure	Frequency of Calibration	Acceptance Criteria	Corrective Action (CA)	Person Responsible for CA [1]
LC/MS/MS	Tune Check	Prior to ICAL and after any mass calibration or maintenance is performed.	Tuning standard must contain analytes of interest or appropriate substitute. Mass assignments of tuning standard within 0.5 amu of true value.	Retune instrument. If the tuning will not meet acceptance criteria, an instrument mass calibration must be performed and the tuning redone.	Lab Manager/Analyst
LC/MS/MS	Minimum five-point initial calibration for target analytes, lowest concentration standard at or below the reporting limit	Initial calibration prior to sample analysis	Each calibration point for each analyte must calculate to be within 75-125%, except the lowest cal point which must calculate to within 70-130%.	Evaluate standards, chromatography, and mass spectrometer response. If problem found with above, correct as appropriate, then repeat initial calibration.	Lab Manager/Analyst+F4+F5:F7
LC/MS/MS	Second-source calibration verification	Once per initial calibration, following initial calibration.	All reported analytes and labelled compounds within ± 25% of true value.	Evaluate data. If problem (e.g., concentrated standard, plugged transfer line) found, correct, then repeat second source verification. If it still fails, then repeat initial calibration.	Lab Manager / Analyst [b]

Worksheet #24

PFAS Analytical Instrument Calibration - PFAS Lab SOP WC-LC-0025

LC/MS/MS	Daily calibration verification	Before sample analysis, after every 10 samples, and at the end of the sequence.	All reported analytes and labelled compounds within ± 25% of true value.	Evaluate failure and impact on samples. If samples non-detect for analytes which have a high bias, report non-detect results with case narrative comment. For closing CCVs, if compounds are not identified as critical compounds of concern report results with qualifiers. For closing CCVs, if the compound is identified as a critical compound of concern, then recalibrate, and reanalyze all affected samples since the last acceptable CCV; or Immediately analyze two additional consecutive CCVs. If both pass, samples may be reported without reanalysis. If either fails, take corrective action(s) and re-calibrate; then reanalyze all affected samples since the last acceptable CCV.	Lab Manager/Analyst

[b] *The analyst initiates the corrective action and the lab manager and analyst are responsible for the corrective action.*

WORKSHEET #28
PFAS Analytical Quality Control and Corrective Action

Matrix	Aqueous and Solid
Analytical Group	PFAS
Analytical Method/ SOP Reference	Method 537M WS-LC-0025

QC Sample	Frequency / Number	Method / SOP QC Acceptance Limits	Corrective Action	Person(s) Responsible for Corrective Action	Data Quality Indicator (DQI)	Measurement Performance Criteria
Method Blank	One per preparation batch	No target analytes ≥ ½ RL and > 1/10 the amount measured in any sample or 1/10 the regulatory limit (whichever is greater).	Verify instrument clean (evaluate calibration blank & samples prior to method blank), then reanalyze. Evaluate to determine if systematic issue within laboratory, correct, then re- prepare and reanalyze the method blank and all samples processed with the contaminated blank in accordance with DoD QSM requirements.	Lab Manager / Analyst	Accuracy/Bias Contamination	No target analytes ≥ RL
Internal Standards (Isotope Dilution Analytes, spiked prior to extration)	Every sample, spiked sample, standard, and method blank	% recovery for each IS in the original sample (prior to dilutions) must be within 25- 150%	Reanalyze once. Assess matrix, dilute and/or re-extract as needed. Evaluate impact on data.	Lab Manager / Analyst	Accuracy/Bias	25-150 %R
LCS	One LCS per preparation batch	Laboratory statistically derived control limits (See Worksheet #15).	Reanalyze LCS once. If acceptable, report. Evaluate samples for detections, and LCS for high bias. If LCS has high bias, and samples non-detect, report with case narrative comment. If LCS has low bias, or if there are detections for critical chemicals of concern, evaluate and reprep and reanalyze the LCS and all samples in the associated prep batch for failed analytes, if sufficient sample material is available.	Lab Manager / Analyst	Precisions and Accuracy/Bias	Laboratory statistically derived control limits
MS/MSD for all analytes	One MS/MSD pair per preparation batch	Laboratory statistically derived control limits (See Worksheet #15).	Evaluate the data, and re- prepare/reanalyze the native sample and MS/MSD pair if laboratory error is indicated.	Lab Manager / Analyst	Precision and Accuracy/Bias	Laboratory statistically derived control limits

Title: Perfluorinated Compounds (PFCs) in Water, Soils, Sediments and Tissue
[Method 537 Modified]

Approvals (Signature/Date):

12/9/16
Robert Hrabak — Date
Technical Manager

12/9/16
Joe Schairer — Date
Health & Safety Manager / Coordinator

12/9/16
Lisa Stafford — Date
Quality Assurance Manager

for 12/9/16
Crystal Pollock — Date
Laboratory Manager

Facility Distribution No. Uncontrolled **Distributed To:** Sacramento Bids folder

1. SCOPE AND APPLICATION

1.1. This procedure describes the analysis of water, soil, sediment and tissue samples for the following compounds using liquid chromatography / tandem mass spectrometry (LC/MS/MS).

Compound Name	Abbreviation	CAS #
Perfluoroalkylcarboxylic acids (PFCAs)		
Perfluoro-n-butanoic acid	PFBA	375-22-4
Perfluoro-n-pentanoic acid	PFPeA	2706-90-3
Perfluoro-n-hexanoic acid	PFHxA	307-24-4
Perfluoro-n-heptanoic acid	PFHpA	375-85-9
Perfluoro-n-octanoic acid	PFOA	335-67-1
Perfluoro-n-nonanoic acid	PFNA	375-95-1
Perfluoro-n-decanoic acid	PFDA	335-76-2
Perfluoro-n-undecanoic acid	PFUdA	2058-94-8
Perfluoro-n-dodecanoic acid	PFDoA	307-55-1
Perfluoro-n-tridecanoic acid	PFTrDA	72629-94-8
Perfluoro-n-tetradecanoic acid	PFTeDA	376-06-7
Perfluoro-n-hexadecanoic acid	PFHxDA	67905-19-5
Perfluoro-n-octadecanoic acid	PFODA	16517-11-6
Perfluorinated sulfonic acids (PFSAs)		
Perfluoro-1-butanesulfonic acid	PFBS	375-73-5
Perfluoro-1-hexanesulfonic acid	PFHxS	355-46-4
Perfluoro-1-heptanesulfonic acid	PFHpS	375-92-8
Perfluoro-1-octanesulfonic acid	PFOS	1763-23-1
Perfluoro-1-decanesulfonic acid	PFDS	335-77-3
Perfluorinated sulfonamides (FOSA)		
Perfluoro-1-octanesulfonamide	FOSA	754-91-6
N-ethylperfluoro-1-octanesulfonamide	EtFOSA	4151-50-2
N-methylperfluoro-1-octanesulfonamide	MeFOSA	31506-32-8
Perfluorinated sulfonamidoacetic acids (FOSAA)		
N-ethylperfluoro-1-octanesulfonamidoacetic acid	EtFOSAA	2991-50-6
N-methylperfluoro-1-octanesulfonamidoacetic acid	MeFOSAA	2355-31-9
Fluorotelomer sulfonates (FTS)		
1H,1H,2H,2H-perfluorooctane sulfonate *(6:2)*	6:2 FTS	27619-97-2
1H,1H,2H,2H-perfluorodecane sulfonate *(8:2)*	8:2 FTS	39108-34-4

Sample results for PFOA may also be reported as APFO, at the request of the client. (See Section 12.7)

1.2. The working range of the method is listed below. The linear range can be extended by diluting the extracts.

Matrix	Nominal Sample Size	Reporting Limit	Working Range
Water	250 mL	2.0 ng/L – 100 ug/L	2 ng/L to 400 ug/L
Soil/Sediment/Tissue	5 g	0.2 ug/kg – 20 ug/kg	0.2 to 100 ug/kg

1.3. Due to poor chromatographic peak shape which degraded with repeated injections for Perfluoro-1-octanesulfonamidoamide (FOSSA), this analyte is no longer included in the method.

1.4. The procedure for the analysis of water samples via direct aqueous injection (DAI) for a subset of the list in Section 1.1 using liquid chromatography / tandem mass spectrometry (LC/MS/MS) on a SCIEX 5500 is described in the Appendix to this SOP.

1.5. When undertaking projects for Department of Defense (DoD) and/or Department of Energy (DOE) the relevant criteria in QA Policy WS-PQA-021, “Federal Program Requirements” must be checked and incorporated.

2. SUMMARY OF METHOD

2.1. Water samples are extracted using a solid phase extraction (SPE) cartridge, unless EtFOSA and MeFOSA are requested. PFCs are eluted from the cartridge with ammonium hydroxide/methanol solution.

2.2. Soil samples are extracted with KOH/methanol solution using an orbital shaker for 3 hours followed by sonication for 12 hours. The mixture is centrifuged and the solvent filtered.

2.2.1. Optional cleanups may include sample freezing and/or cleanup by SPE cartridge, unless EtFOSA and MeFOSA are requested.

2.3. The final 80:20 methanol:water extracts are analyzed by LC/MS/MS. PFCs are separated from other components on a C18 column with a solvent gradient program using 20 mM Ammonium Acetate/water and methanol. The mass spectrometer detector is operated in the electrospray (ESI) negative ion mode for the analysis of PFC.

2.4. Isotope dilution technique is employed with this method for most compounds of interest. The isotope dilution analytes (IDA’s) consist of carbon-13 labeled analogs, oxygen-18 labeled analogs or deuterated analogs of the compounds of interest, and they are spiked into the samples at the time of extraction. This technique allows correction for analytical bias encountered when analyzing more chemically complex environmental samples, because the isotopically labeled compounds are chemically similar to the compounds of concern and are therefore affected by sample-related interferences to the same extent as the compounds of concern. Compounds that do not have a labeled analog are quantitated by IDA method using a closely related labeled analog.

2.5. Quantitation by the external standard method is employed for the IDA analytes and assumes a proportional relationship between the initial calibration and the analyte in the extract. The ratio of the peak response to mass or concentration injected is used to prepare a calibration curve. Peak response is measured as the area of the peak. Isotope dilution technique is employed with this method for most compounds of interest. The IDA's consist of carbon-13 labeled analogs or oxygen-18 labeled analogs of the compounds of interest, and they are spiked to the samples at the time of extraction. This technique allows correction for analytical bias encountered when analyzing more chemically complex environmental samples, because the isotopically labeled compounds are chemically similar to the compounds of concern and are therefore affected by sample-related interferences to the same extent as the compounds of concern. Compounds that do not have a labeled analog are quantitated by IDA method using a closely related labeled analog.

3. DEFINITIONS

3.1. PFCAs: Perfluorocarboxylic acids

3.2. PFSAs: Perfluorinated sulfonates

3.3. FOSA: Perfluorinated sulfonamides

3.4. PFOA: Perfluorooctanoic acid (may also be written PHOA).

3.5. APFO: Ammonium perfluorooctanoate

3.6. PFOS: Perfluorooctane sulfonate (may also be written PHOS)

3.7. MPFOA: Perfluoro-n-[1,2,3,4-13C4]octanoic acid. Carbon-13 labeled PFOA

3.8. MPFOS: Perfluoro-1-[1,2,3,4-13C4]octanesulfonate. Carbon-13 labeled PFOS

3.9. PTFE: Polytetrafluoroethylene (e.g., Teflon®)

3.10. SPE: Solid phase extraction.

3.11. PP: Polypropylene

3.12. PE: Polyethylene

3.13. HDPE: High density polyethylene

3.14. IDA: Isotope dilution analytes

3.15. Further definitions of terms used in this SOP may be found in the glossary of the Laboratory Quality Assurance Manual (QAM).

4. INTERFERENCES

4.1. PFCs have been used in a wide variety of manufacturing processes, and laboratory supplies should be considered potentially contaminated until they have been tested and shown to be otherwise. The materials and supplies used during the method validation process have been tested and shown to be clean. These items are listed below in Section 6.

4.2. To avoid contamination of samples, standards are prepared in a ventilation hood in an area separate from where samples are extracted.

4.3. PTFE products can be a source of PFOA contamination. The use of PTFE in the procedure should be avoided or at least thoroughly tested before use. Polypropylene (PP) products may be used in place of PTFE products to minimize PFOA contamination.

4.3.1. Standards and samples are injected from polypropylene autosampler vials with polypropylene screw caps once. Multiple injections may be performed on Primers when conditioning the instrument for analysis.

4.3.2. Random evaporation losses have been observed with the polypropylene caps causing high IDA recovery after the vial was punctured and sample re-injected. For this reason, it is best to inject standards and samples once in the analytical sequence.

4.3.3. Teflon-lined screw caps have detected PFCs at low concentrations. Repeated injection from the same teflon-lined screw cap have detected PFNA at increasing concentration as each repeated injection was performed, therefore, it is best to use polypropylene screw caps.

4.4. Volumetric glassware and syringes are difficult to clean after being used for solutions containing high levels of PFOA. These items should be labeled for use only with similarly concentrated solutions or verified clean prior to re-use. To the extent possible, disposable labware is used.

4.5. Commercial sources of PFOS may produce several peaks in the PFOS chromatogram. These adjacent peaks are either completely resolved or not resolved but with a profound deflection that can be resolved during peak integration. The later of the peaks matches the retention time of the single labeled PFOS peak. Earlier peaks are branched isomers of PFOS, rather than a result of peak splitting. The earlier peak is included during peak integration.

4.6. The phenomenon of the linear and branched isomers of PFOS exists for other PFAS, such as PFHxS and PFBS. Thus, in an attempt to reduce PFOS bias, it is required that *m/z* 449>80 transition be used as the quantitation transition.

4.7. Both branched and linear PFAAs can potentially be found in the environment. For the compounds that give rise to more than one peak, all the chromatographic peaks observed in the standard and/or sample must be integrated and the areas included.

5. SAFETY

Employees must abide by the policies and procedures in the Corporate Safety Manual, Sacramento Supplement to the CSM, and this document. All work must be stopped in the event of a known or potential compromise to the health or safety of an associate. The situation must be reported **immediately** to a supervisor, the EH&S Staff, or a senior manager.

5.1. Specific Safety Concerns

5.1.1. Preliminary toxicity studies indicate that PFCs could have significant toxic effects. In the interest of keeping exposure levels as low as reasonably achievable, PFCs must be handled in the laboratory as hazardous and toxic chemicals.

5.1.2. Exercise caution when using syringes with attached filter disc assemblies. Application of excessive force has, upon occasion, caused a filter disc to burst during the process.

5.1.3. Laboratory procedures such as repetitive use of pipets, repetitive transferring of extracts and manipulation of filled separatory funnels and other glassware represent a significant potential for repetitive motion or other ergonomic injuries. Laboratory associates performing these procedures are in the best position to realize when they are at risk for these types of injuries. Whenever a situation is found in which an employee is performing the same repetitive motion, the employee shall immediately bring this to the attention of their supervisor, manager, or the EH&S staff. The task will be analyzed to determine a better means of accomplishing it.

5.1.4. Eye protection that satisfies ANSI Z87.1 (as per the TestAmerica Corporate Safety Manual), laboratory coat, and nitrile gloves must be worn while handling samples, standards, solvents, and reagents. Disposable gloves that have been contaminated will be removed and discarded; other gloves will be cleaned immediately.

5.1.5. Perfluorocarboxylic acids are acids and are not compatible with strong bases.

5.1.6. The use of vacuum systems presents the risk of imploding glassware. All glassware used during vacuum operations must be thoroughly inspected prior to each use. Glass that is chipped, scratched, cracked, rubbed or marred in any manner must not be used under vacuum. It must be removed from service and replaced.

5.1.7. Glass containers are not to be used for "tumbling" soil samples.

5.2. Primary Materials Used

The following is a list of the materials used in this method, which have a serious or significant hazard rating. NOTE: This list does not include all materials used in the method. The table contains a summary of the primary hazards listed in the SDS for each of the materials listed in the table. A complete list of materials used in the method can be found in the reagents and materials section. Employees must review the information in the SDS for each material before using it for the first time or when there are major changes to the SDS.

Material(1)	**Hazards**	**Exposure Limit(2)**	**Signs and Symptoms of Exposure**
Acetic Acid (3-2-1)	Corrosive Poison Flammable	10 ppm-TWA 15 ppm-STEL	Contact with concentrated solution may cause serious damage to the skin and eyes. Inhalation of concentrated vapors may cause serious damage to the lining of the nose, throat, and lungs. Breathing difficulties may occur.
Ammonium Hydroxide	Corrosive Poison	50 ppm-TWA	Severe irritant. Effects from inhalation of dust or mist vary from mild irritation to serious damage to the upper respiratory tract. Symptoms may include sneezing, sore throat or runny nose. Contact with skin can cause irritation or severe burns and scarring with greater exposures. Causes irritation of eyes, and with greater exposures it can cause burns that may result in permanent damage, including blindness. Brief exposure to 5000 PPM can be fatal.
Hexane (2-3-0)	Flammable Irritant	500 ppm-TWA	Inhalation of vapors irritates the respiratory tract. Overexposure may cause lightheadedness, nausea, headache, and blurred vision. Vapors may cause irritation to the skin and eyes.

Material(1)	**Hazards**	**Exposure Limit**(2)	**Signs and Symptoms of Exposure**
Hydrochloric Acid	Corrosive Poison	5 ppm (Ceiling)	Can cause pain and severe burns upon inhalation, ingestion, eye or skin contact. Exposure to concentrated solutions may cause deep ulcerations to skin, permanent eye damage, circulatory failure and swallowing may be fatal.
Methanol	Flammable Poison Irritant	200 ppm (TWA)	A slight irritant to the mucous membranes. Toxic effects exerted upon nervous system, particularly the optic nerve. Symptoms of overexposure may include headache, drowsiness and dizziness. Methyl alcohol is a defatting agent and may cause skin to become dry and cracked. Skin absorption can occur; symptoms may parallel inhalation exposure. Irritant to the eyes.
Potassium Hydroxide	Corrosive Poison		Severe irritant. Can cause severe burns upon inhalation, ingestion, eye or skin contact. Exposure to concentrated solutions may cause severe scarring of tissue, blindness, and may be fatal if swallowed.
Sodium Hydroxide	Corrosive Poison	2 mg/cm^3 (Ceiling)	Severe irritant. Can cause severe burns upon inhalation, ingestion, eye or skin contact. Exposure to concentrated solutions may cause severe scarring of tissue, blindness, and may be fatal if swallowed.
(1) Always add acid to water to prevent violent reactions. (2) Exposure limit refers to the OSHA regulatory exposure limit.			

6. EQUIPMENT AND SUPPLIES

6.1. 8 mL test tubes, screw thread, with caps.

6.2. 15 mL polypropylene test tubes with polypropylene screw caps.

6.3. 50 mL graduated plastic centrifuge tubes.

6.4. 125 mL PPE wide-mouth bottles.

6.5. 16 oz or 500 mL PPE bottles with PPE screw caps.

6.6. Analytical balance capable of accurately weighing to the nearest 0.0001g, and checked for accuracy each day it is used in accordance with WS-QA-0041.

6.7. Syringe filter, Millipore Millex-HV 0.45 um, or equivalent. Do not use PTFE type filters.

6.8. 300-µL autosampler vials, polypropylene, with polypropylene screw caps, Waters PN 1860004112, or equivalent.

6.9. SPE columns

6.9.1. Phenomenex Strata SPE C18, 6 mL, 500 mg, part number 8B-S002-HCH, Waters SepPak C18, 1 to 10g, or equivalent.

6.9.2. Waters Oasis WAX 150 mg/6 cc (PN 186002493) for the cleanup of solids.

6.9.3. Waters Oasis WAX 500 mg/6 cc (PN 186004647) for extraction of PFC from aqueous sample.

6.9.4. Phenomonex Gemini 3 µm C18 110Å, 50 X 2 mm, Part No. 00B-4439-B0.

6.9.5. Phenomonex Luna 5 µm C18(2) 100Å, 30 X 3 mm, Part No. 00A-4252-Y0.

6.10. PFC Isolator column, Waters PN 186004476, plumbed between the UPLC pumps and autosampler valve to minimize PFC background from the UPLC solvent lines and filters.

6.11. Granulated carbon.

6.12. Vacuum manifold for Solid Phase Extraction (SPE).

6.13. Miscellaneous laboratory apparatus (beakers, test tubes, volumetric flasks, pipettes, etc.). These should be disposable where possible, or marked and segregated for high-level versus low-level use.

6.14. WATERS Acquity UPLC system connected to Triple Quad MS such as Waters Micromass Quattro Premier XE or SOILEX 5500 Triple Quad MS. These systems utilize Chrom Peak Review, version 2.1 or equivalent.

6.15. Acquity UPLC BEH C18 1.7 um, 3.0 mm x 150 mm, Part No. 186004690, Phenomenex Gemini-NX C18 3 um, 3.0 mm x 100 mm, Part No. 00D-4453-Y0, Shimadzu CTO-20AC HPLC equipped with 3 LC-20D pumps and one DGU-20 degassing unit or equivalent.

6.16. Bottle rotating apparatus for soil extractions.

6.17. Glass fiber filter, Whatman GF/F, catalog number 1825 090 or equivalent.

6.18. Preventive and routine maintenance is described in the table below

HPLC/MS/MS Preventative Maintenance
As Needed: Change pump seals. Change in-line filters in autosampler (HPLC). Check/replace in-line frit if excessive pressure or poor performance. Replace column if no change following in-line frit change. Clean corona needle. Replace sample inlet tube in APCI (10.1 cm). Replace fused silica tube in ESI interface. Clean lenses. Clean skimmer. Ballast rough pump 30 minutes.
Daily (When in use) Check solvent reservoirs for sufficient level of solvent. Verify that pump is primed, operating pulse free. Check needle wash reservoir for sufficient solvent. Verify capillary heater temperature functioning. Verify vaporizer heater temperature. Verify rough pump oil levels. Verify turbo-pump functioning. Verify nitrogen pressure for auxiliary and sheath gasses. Verify that corona and multiplier are functioning.
Semi-Annually Replace rough-pump oil (4-6 months). Replace oil mist and odor elements. Replace activated alumina filter if applicable.
Annually Vacuum system components including fans and fan covers. Clean/replace fan filters, if applicable.

7. REAGENTS AND STANDARDS

7.1. Reagent grade chemicals shall be used in all tests whenever available. Unless otherwise indicated, it is intended that all reagents shall conform to the specifications of the Committee on the Analytical Reagents of the American Chemical Society, where such specifications are available. Other grades may be used, provided it is first ascertained that the reagent is of sufficiently high purity to permit its use without lessening the accuracy of the determination.

7.1.1. Acetic Acid, glacial

7.1.2. Ammonium acetate (20 mM in water)

7.1.3. Ammonium Hydroxide (NH4OH), 0.3% in methanol

7.1.4. Hexane

7.1.5. Hydrochloric Acid (HCl), 2.0 M solution in water

7.1.6. Methanol

7.1.7. Potassium Hydroxide (KOH), 0.4% in methanol

7.1.8. Ottawa Sand

7.1.9. Sodium Hydroxide (NaOH), 0.1N, in water

7.1.10. Water, Nanopure or Millipore, must be free of interference and target analytes

7.2. Standards

7.2.1. PFCs are purchased as a high purity solids (96% or greater) or as certified concentration in solution. Standard materials are verified compared to a second source material at the time of initial calibration. The solid stock material is stored at room temperature or as specified by manufacturer or vendor.

7.2.2. If solid material is used for preparing a standard, stock standard solutions are prepared from the solids and are stored at 4 ± 2°C. Stock standard solutions should be brought to room temperature before using. Standards are monitored for signs of degradation or evaporation. Standard solutions must be replaced at least annually from the date of preparation.

7.2.3. PFBS, PFHxS, PFHpS, PFOS, PFDS, MPFOS, and many other PFASs are not available as the acids, but rather as their corresponding salts, such as sodium or potassium. The standards are prepared and corrected for their salt content according to the equation below.

7.2.4. $\text{Mass}_{\text{acid}} = \text{Measured Mass}_{\text{salt}} \times \text{MW}_{\text{acid}} / \text{MW}_{\text{salt}}$

7.2.5. Where: MW_{acid} is the molecular weight of PFAA

7.2.6. MW_{salt} is the molecular weight of the purchased salt.

7.2.7. For example, the molecular weight of PFOS is 500.1295 and the molecular weight of NaPFOS is 523.1193. Therefore, the amount of NaPFOS used must be adjusted by a factor of 1.046

7.3. Calibration Standards

The calibration stock solution is prepared by diluting the appropriate amounts of PFOA and PFOS stock solutions in 80% methanol/water. The calibration stock solution is diluted with methanol to produce initial calibration standards. These are the normal calibration levels used. A different range can be used if needed to achieve lower reporting limits or a higher linear range.

7.4. Initial Calibration (ICAL) Levels (ng/mL)

Compound	CS-1	CS-2	CS-3	CS-4	CS-5	CS-6	CS-7
Perfluoroalkylcarboxylic acids (PFCAs)							
PFBA	0.5	1.0	5.0	20	50	200	400
PFPeA	0.5	1.0	5.0	20	50	200	400
PFHxA	0.5	1.0	5.0	20	50	200	400
PFHpA	0.5	1.0	5.0	20	50	200	400
PFOA *	0.5	1.0	5.0	20	50	200	400
PFNA	0.5	1.0	5.0	20	50	200	400
PFDA	0.5	1.0	5.0	20	50	200	400
PFUdA	0.5	1.0	5.0	20	50	200	400
PFDoA	0.5	1.0	5.0	20	50	200	400
PFTrDA	0.5	1.0	5.0	20	50	200	400
PFTeDA	0.5	1.0	5.0	20	50	200	400
PFHxDA	0.5	1.0	5.0	20	50	200	400
PFODA	0.5	1.0	5.0	20	50	200	400
Perfluorinated sulfonic acids (PFSAs)							
PFBS	0.5	1.0	5.0	20	50	200	400
PFHxS *	0.5	1.0	5.0	20	50	200	400
PFHpS	0.5	1.0	5.0	20	50	200	400
PFOS	0.5	1.0	5.0	20	50	200	400
PFDS	0.5	1.0	5.0	20	50	200	400
Perfluorinated sulfonamides (FOSA)							
FOSA	0.5	1.0	5.0	20	50	200	400
EtFOSA	0.5	1.0	5.0	20	50	200	400
MeFOSA	0.5	1.0	5.0	20	50	200	400
Perfluorinated sulfonamidoacetic acids (FOSAA)							
EtFOSAA	0.5	1.0	5.0	20	50	200	400
MeFOSAA	0.5	1.0	5.0	20	50	200	400
Fluorotelomer sulfonates (FTS)							
6:2 FTS	0.5	1.0	5.0	20	50	200	400
8:2 FTS	0.5	1.0	5.0	20	50	200	400
Labeled Isotope Dilution Analytes (IDA)							
MPFBA	50	50	50	50	50	50	50
M5PFPeA	50	50	50	50	50	50	50
MPFHxA	50	50	50	50	50	50	50
MPFHpA	50	50	50	50	50	50	50

Compound	**CS-1**	**CS-2**	**CS-3**	**CS-4**	**CS-5**	**CS-6**	**CS-7**
M4PFOA	50	50	50	50	50	50	50
MPFNA	50	50	50	50	50	50	50
MPFDA	50	50	50	50	50	50	50
MPFUdA	50	50	50	50	50	50	50
MPFDoA	50	50	50	50	50	50	50
MPFHxS	50	50	50	50	50	50	50
MPFOS	50	50	50	50	50	50	50
M8FOSA	50	50	50	50	50	50	50
D5-EtFOSA	50	50	50	50	50	50	50
D3-MeFOSA	50	50	50	50	50	50	50
D5-EtFOSAA	50	50	50	50	50	50	50
D3-MeFOSAA	50	50	50	50	50	50	50
M2-6:2FTS	50	50	50	50	50	50	50
M2-8:2FTS	50	50	50	50	50	50	50

* both branched and linear isomers are used.

Note: Sample extracts are in 80% MeOH/H_2O.

FOSAA may be added to the mix and are added at the same concentration as FOSA.

Note- The above calibration limits are provided only as an example. The actual ICAL level used for each analytical batch will depend upon the LOQ requirements of the program.

7.4.1. A technical (qualitative) grade PFOA standard is analyzed initially, then after ICAL when a new column is installed or when significant changes are made to the HPLC parameters. This solution is used as a reference for the PFOA isomers (branched and linear) retention times.

7.5. Initial Calibration Verification Standard (ICV).

A second source solution for PFC is purchased from the same vendor; the PFC-MXB contains most of the target analytes in this mixture and is used as an ICV. A few compounds are not available in this mixture, may not be available as another lot, and are not available from another vendor. For these analytes only, a second analyst may prepare a second source standard from the same source as the ICAL to produce an ICV. The recommended concentration of the ICV standard should be in the mid-range of the calibration curve. The concentration may be adjusted if the initial calibration levels are changed or altered. The IS is added at a fixed concentration of 50 ng/mL.

7.6. LCS/Matrix PFC Spike Solution, 500 ng/mL.

The PFC spike solution is prepared by diluting all PFCs to produce a solution containing PFCs each at 500 ng/mL in methanol.

7.7. PFC Isotope Dilution Analyte Solution, 1000 ng/mL.

The PFC-IS solution is prepared by diluting all labeled PFCs to produce a solution each at 1000 ng/mL in methanol.

8. SAMPLE COLLECTION, PRESERVATION, AND STORAGE

8.1. Water samples are collected in pre-cleaned 250 mL HDPE containers. Soil samples are collected in pre-cleaned 250 mL HDPE containers. Other containers may also be suitable. Samples are chilled to 0 - 6°C for shipment to the laboratory.

8.2. Samples are logged in following normal laboratory procedures and are stored under refrigeration at 0 - 6°C. Water samples must be extracted within 14 days of collection. Soil samples must also be extracted within 14 days of collection. Tissue samples must be extracted within 1 year of collection if stored at -20°C. Extracts must be refrigerated at 0 - 6°C, and analyzed within 40 days from extraction.

NOTE: As of this writing, Method 537 provides for a 14 day holding time for water samples preserved with Trizma buffer. The scientific literature indicates that perfluorinated substances are highly persistent in the environment. TestAmerica Sacramento has conducted holding time studies that support a 14 day holding time for aqueous samples with and without Trizma preservation. TestAmerica Denver has conducted stability studies indicating that medium- and low-level solutions of PFOA are stable for at least three months in polystyrene and polypropylene plastics at 0-6C. The 14 days/40 day holding times given above are based on the holding time study and general EPA convention for the holding time of extractable organic compounds in water and soil.

9. QUALITY CONTROL

9.1. Initial Demonstration of Capability (IDOC)

The initial demonstration and method detection limit (MDL) studies described in Section 13 must be acceptable before analysis of samples may begin.

9.2. Batches are defined at the sample preparation step. Batches should be kept together through the whole analytical process as far as possible, but it is not mandatory to analyze prepared extracts on the same instrument or in the same sequence. Refer to the QC program document (WS-PQA-003) for further details of the batch definition.

9.2.1. The quality control batch is a set of up to 20 samples of the same matrix processed using the same procedure and reagents within the same time period. The quality control batch must contain a matrix spike/matrix spike duplicate (MS/MSD), a laboratory control sample (LCS) and a method blank. Laboratory generated QC samples (Blank, LCS, MS/MSD) do not count toward the maximum 20 samples in a batch. Field QC samples are included in the batch count. In some cases, at client request, the MS/MSD may be replaced with a matrix spike and sample duplicate. If insufficient sample is available for an MS/MSD, an LCSD may be substituted if batch precision is required by the program or client. In the event that multiple MS/MSDs are run with a batch due to client requirements, the additional MS/MSDs do not count toward the maximum 20 samples in a batch.

9.3. One method blank (MB, laboratory reagent blank) must be extracted with every process batch of similar matrix, not to exceed twenty (20) samples. For aqueous samples, the method blank is an aliquot of laboratory reagent water. For solid sample, the method blank is an aliquot of Ottawa sand. The method blank is processed in the same manner and at the same time as the associated samples. Corrective actions must be documented on a Non-Conformance memo, then implemented when target analytes are detected in the method blank above the reporting limit or when surrogate recoveries are outside of the control limits. Re-extraction of the blank, other batch QC, and the affected samples are required when the method blank is deemed unacceptable. See policy WS-PQA-003 for specific acceptance criteria.

9.3.1. If the MB produces a peak within the retention time window of any of the analytes determine the source of the contamination and eliminate the interference before processing samples.

9.3.2. The method blank must not contain any analyte at or above the reporting limit, or at or above 10% of the measured concentration of that analyte in the associated samples, whichever is higher.

9.3.3. If there is no target analyte greater than the RL in the samples associated with an unacceptable method blank, the data may be reported with qualifiers. Such action should be taken in consultation with the client.

9.3.4. Re-extraction and re-analysis of samples associated with an unacceptable method blank is required when reportable concentrations are determined in the samples.

9.3.5. Refer to WS-PQA-003 for further details of the corrective actions.

9.3.6. Projects performed under the auspices of the DOD/DOE must meet QSM specific criteria for method blanks. Results are acceptable if the blank contamination is less than ½ of the reporting limit for each analyte, or less than 1/10 of the regulatory limit, or less than 1/10 of the sample result for the same analyte, whichever is greater. If the method blank does not meet the acceptance criteria, the source of contamination must be investigated and measures taken to correct, minimize or eliminate the problem. If contamination remains, the contaminated samples should be re-prepared and reanalyzed with a new MB and batch-specific QC samples.

9.4. A laboratory control sample (LCS) must be extracted with every process batch of similar matrix, not to exceed twenty (20) samples. The LCS is an aliquot of laboratory matrix (e.g. water for aqueous samples and Ottawa sand for solids) spiked with analytes of known identity and concentration. The LCS must be processed in the same manner and at the same time as the associated samples. Corrective actions must be documented on a Non-Conformance memo, then implemented when recoveries of any spiked analyte is outside of the control limits. Re-extraction of the blank, other batch QC and all associated samples are required if the LCS is deemed unacceptable. See WS-PQA-0003 for specific acceptance criteria. The control limits for the LCS are stored in TALS.

9.5. A matrix spike/matrix spike duplicate (MS/MSD or MS/SD) pair must be extracted with every process batch of similar matrix, not to exceed twenty (20) samples. An MS/MSD pair is aliquots of a selected field sample spiked with analytes of known identity and concentration. The MS/MSD pair must be processed in the same manner and at the same time as the associated samples. Spiked analytes with recoveries or precision outside of the control limits must be within the control limits in the LCS. Corrective actions must be documented on a nonconformance memo, then implemented when recoveries of any spiked analyte are outside of the control limits provided by the LIMS or by the client.

9.6. A duplicate control sample (LCSD or DCS) may be added when insufficient sample volume is provided to process an MS/MSD pair, or is requested by the client. The LCSD is evaluated in the same manner as the LCS. See WS-PQA-003 for specific acceptance criteria.

9.7. Initial calibration verification (ICV) – When available, a second source standard is analyzed with the initial calibration curve. The concentration should be at the mid range of the curve.

Corrective actions for the ICV include:

- Rerun the ICV.
- Remake or acquire a new ICV.
- Evaluate the instrument conditions.
- Evaluate the initial calibration standards.

9.8. Isotope Dilution Analytes

9.8.1. The IDA solution is added to each field and QC sample at the time of extraction, as described in Section 11. As described in Section 7, this solution consists of isotopically labeled analogs of the analytes of interest.

9.8.2. IDA recoveries are flagged if they are outside of the acceptance limits (25–150%). Quantitation by isotope dilution generally precludes any adverse effect on data quality due to IDA recoveries being outside of the acceptance limits as long as the signal-to-nose ratio is greater than 10:1.

9.8.2.1. Evaluate data quality for usability, flag and submit a non-conformance memo for any analytes outside of the recovery criteria, and report if data is deemed not adversely effected.

9.8.2.2. Re-extraction of samples should be performed if the signal-to-noise for any IDA is less than 10:1 or if the IDA recoveries fall below 10%.

9.8.2.2.1. Re-extraction may be necessary under other circumstances when data quality has been determined to be adversely affected.

10. CALIBRATION

10.1. For details of the calculations used to generate the regression equations, and how to use the factors generated by these equations, refer to SOP CA-Q-P-003 “Calibration Curves and Selection of Calibration Points”.

10.2. Routine instrument operating conditions are listed in the table in Section 11.6.1.

10.3. Instrument Tuning

Instrument tuning is done initially when the method is first developed and thereafter as needed to maintain the sensitivity and selectivity of the method. Tuning is done by infusing each individual compound (native, IDA and recovery) into the mobile phase using a tee fitting at a point just before the entrance to the electrospray probe. The responses for the parent and daughter ions for each compound are observed and optimized for sensitivity and resolution. Mass assignments are reviewed and calibrated if necessary. The mass assignments must be within ± 0.5 amu of the values shown in the table in Section 11.5.1.

10.4. A new calibration curve must be generated after major changes to the system or when the continuing calibration criteria cannot be met. Major changes include, but are not limited to new columns or pump seals. A new calibration is not required after minor maintenance.

10.5. With the exception of the circumstances delineated in policy P-T-001, it is not acceptable to remove points from a calibration curve. In any event, at least five points must be included in the calibration curve. Average Response Factor and linear fit calibrations require five points, whereas Quadratic (second order) calibrations require six points.

10.6. A fixed injection volume is used for quantitation purposes and is to be the same for both the sample and standards.

10.7. All units used in the calculations must be consistently uniform, such as concentration in ng/mL.

10.8. Initial Calibration

10.8.1. A number of analytical standards of different analyte concentrations are used to generate the curve. Each standard is injected once to obtain the peak response for each analyte at each concentration. These standards define the working range of the analysis.

10.8.1.1. A minimum of five analytical standards is used when using average response factor and or linear calibration fits.

10.8.1.2. A minimum of six analytical standards is used for quadratic fit to generate the curve.

10.8.2. Calibration is by average response factor, linear fit, or by quadratic fit. Quadratic fit is used for the analyte if the response is non-linear.

10.8.2.1. For average response factor (RFa), the relative standard deviation (RSD) for all compounds quantitated by isotope dilution must be < 35% for the curve to be valid.

10.8.2.2. For average response factor (RFa), the relative standard deviation (RSD) for all compounds quantitated by IDA must be < 50% for the curve to be valid.

10.8.2.3. For linear fit, the intercept of the line must be less than ½ the reporting limit, and the coefficient of determination (r2) must be greater than or equal to 0.990 for the curve to be considered valid (or the correlation coefficient (r) > 0.995).

10.9. Calibration Curve Fits

10.9.1. Linear regression or quadratic curves may be used to fit the data to a calibration function. Detailed descriptions and formulas for each fitting type can be found in SOP CA-Q-S-005, “Calibration Curves (General)”.-

10.9.2. The linear curve uses the following function:

Equation 1

$$y = bx + c$$

Where:

$$y = \frac{\text{Area (analyte)}}{\text{Area (IS)}} \times \text{Concentration (IS)}$$

x = concentration
b = slope
c = intercept

10.9.3. The quadratic curve uses the following function:

Equation 2

$$y = ax^2 + bx + c$$

Where y, x, b, and c are the same as above, and a = curvature.

10.9.4. The external standard method uses the following equation:

Equation 3

$$\text{Response Factor} = \frac{\text{Peak Area}}{\text{Concentration of Solution } (ng/mL)}$$

10.9.5. Evaluation of Calibration Curves

The following requirements must be met for any calibration to be used:

- Response must increase with increasing concentration.
- The absolute value of the intercept of a regression line (linear or non-linear) at zero response must be less than the reporting limit.
- There should be no carryover at or above 1/2 MRL after a high CAL standard.

If these criteria are not met, instrument conditions and standards will be checked, and the ICAL successfully repeated before continuing.

10.9.6. Weighting of Calibration Points

In linear and quadratic calibration fits, the points at the lower end of the calibration curve have less absolute variance than points at the high concentration end of the curve. This can cause severe errors in quantitation at the low end of the calibration. Because accuracy at the low end of the curve is very important for this analysis, it is preferable to increase the weighting of the lower concentration points. 1/concentration or 1/x weighting is encouraged. Visual inspection of the line fitted to the data is important in selecting the best fit.

10.10. Initial Calibration Blank (ICB)

10.10.1. Immediately following the ICAL, a calibration blank is analyzed that consists of an injection of 80:20 methanol:water blank.

10.10.2. The result for the calibration blank must be less than the reporting limit.

10.10.3. If the ICB is greater than the reporting limit then the source of contamination must be identified and any necessary cleaning completed, and then the instrument should be recalibrated.

10.11. Initial Calibration Verification (ICV)

10.11.1. Following the ICAL and the ICB, an ICV standard obtained from a different source or vendor than the ICAL standards is analyzed. This ICV standard is a mid-range standard.

10.11.2. The recovery for the ICV must meet the appropriate following criteria;

10.11.2.1. The native analyte must be within or equal to 60-140% for all natives quantitated by isotope dilution.

10.11.2.2. The native must be within or equal to 50-150% for all natives quantitated by IDA.

10.11.2.3. The IDA must be $\geq$ 50 and $\leq$ 150%.

10.11.3. See Section 9.7 for corrective actions in the event that the ICV does not meet the criteria above.

10.12. Continuing Calibration Verification (CCV) – At the beginning of a run, the end of a run, and after every 10 samples are analyzed a CCV must be injected to determine if the calibration is still valid. The exception is after an acceptable curve and ICV are run 10 samples can be analyzed before a CCV is required. The CCVs are usually at the mid level range of the curve and should vary throughout the run. The curve and ICV do not need to be run every day. To start an analytical run a CCV can be analyzed and if it meets acceptance criteria a run can be started. In addition the low standard in the curve must be analyzed and must be within ± 50% of the expected value.

10.12.1. The recovery for the CCV standards must be equal to or within 60-140% for all natives quantitated by isotope dilution and equal to or within 50% to 150% for all natives quantitated by IDA. The recovery for the IDA $\geq$50 to $\leq$150%.

10.12.2. If this is not achieved, the instrument has drifted outside the calibration limits. The instrument must be recalibrated.

11. PROCEDURE

11.1. One-time procedural variations are allowed only if deemed necessary in the professional judgment of a supervisor to accommodate variation in sample matrix, chemistry, sample size, or other parameters. Any variation in procedure shall be completely documented using an Non-Conformance Memo (NCM). The NCM process is described in more detail in SOP WS-QA-0023. The NCM shall be filed in the project file and addressed in the case narrative.

11.2. Any deviations from this procedure identified after the work has been completed must be documented in an NCM, with a cause and corrective action described.

11.3. Water Sample Preparation

11.3.1. Visually inspect samples for the presence of settled and or suspended sediment. If sediment is apparent, filter the water sample through a glass fiber filter (Whatman GF/F Cat No 1825 090 or equivalent). Gravity or vacuum can be used to pass the sample through the filter. Prepare a filtration blank with any samples requiring filtration.

Warning: The use of a vacuum system creates the risk of glassware implosion. Inspect all glassware prior to use. Glassware with chips, scratches, rub marks or cracks must not be used.

11.3.2. Measure 250 mL of each sample using a graduated cylinder and pour into a labeled 16 oz polypropylene (PP) bottle. *Prepare separate aliquots of 1.0 mL if EtFOSA and/or MeFOSA are requested.)*

11.3.3. Prepare additional aliquots of a field sample for the MS/MSD, if requested.

11.3.4. Prepare two 250 mL aliquots of HPLC-grade water for the method blank and LCS. (or 1.0 mL if EtFOSA and/or MeFOSA are requested.)

11.3.5. Spike the LCS and MS/MSD (if requested) with 0.020 mL (20 uL) of the LCS/Matrix PFC Spike solution (Section 7.6). This will result in a sample concentration of 40 ng/L. If EtFOSA and/or MeFOSA are required, increase the amount of LCS Matrix PFC spike solution added to 200 uL.

11.3.6. Add 0.025 mL (25 uL) of the IDA PFC solution (Section 7.7) into each sample and QC sample, for a fixed concentration of 50 ng/mL in the final sample vial. If EtFOSA and/or MeFOSA are requested increase the amount of IDA added to 125 uL.

11.3.7. If EtFOSA and/or MeFOSA are requested adjust the final volume (FV) of these aliquots to 5.0 mL with MeOH. Vortex each sample. Then transfer a portion of the extract to a 300 uL polypropylene autosampler vial (7 drop-wise or approximately ½ filled is sufficient). Archive the rest of the extracts for re-injection and dilution.

11.4. **Solid Phase Extraction (SPE)** – (Do not perform SPE clean up if EtFOSA and/or MeFOSA are requested.)

The automated Zymark Auto-Trace Workstation can be used as long as the program follows these conditions and passes the PFC background check.

11.4.1. Condition the SPE cartridges (Waters WAX, 500 mg/6 cc) by passing the following without drying the column.

***NOTE:** The cartridges should not be allowed to go dry until the final elution step with methanol. At all of the other transition steps, the solvent/sample level should be stopped at the top of the column before the next liquid is added.*

WARNING: The use of a vacuum system creates the risk of glassware implosion. Inspect all glassware prior to use. Glassware with chips, scratches, rub marks or cracks must not be used.

11.4.2. Wash with 5.0 mL of 0.3% NH4OH/methanol.

11.4.3. Wash with 5.0 mL of 0.1N NaOH/water. Close valve when ~ 200 uL remains on top to keep column wet. After this step, the columns cannot go dry until the completion of loading and rinsing samples.

11.4.4. Appropriately label the columns and add the reservoir to the column.

11.4.5. Add samples to the columns and with vacuum, pull the entire 250 mL aliquot of the sample through the cartridge at rate of approximately 2 to 5 drops per second.

11.4.6. After the final loading of the sample but before completely passed through the column, rinse the SPE column with 1 mL of water.

11.4.7. After the sample and water rinse has completely passed through the cartridge, allow the column to dry well with vacuum for 15 minutes.

11.5. SPE Column Wash of Aqueous with hexane –

11.5.1. Load the first 5 mL of hexane to soak for five minutes, then elute to waste.

11.5.2. Load the second 5 mL of hexane and elute to waste (without a soaking period).

11.5.3. Allow the column to dry with vacuum for 5 to 10 minutes. Columns must be dried before continuing.

11.6. **SPE Elution** – using 15 mL polypropylene test tube as receiving tube in the SPE manifold.

11.6.1. Rinse samples bottles with 5 mL of 0.3% NH_4OH/methanol and transfer to the column reservoir onto the cartridge. Allow the solution to soak for 5 minutes and then elute into the 15 mL collection tube.

11.6.2. Repeat sample bottle to column reservoir rinse and cartridge elution with a second 5 mL aliquot of 0.3% NH_4OH/methanol. The total collection should be approximately 10 mL.

11.7. Extract Concentration

11.7.1. Concentrate each sample under a gentle stream of nitrogen to near dryness.

11.7.2. Add 400 uL of methanol to each extract, soak and vortex to mix well to reconstitute extract.

11.7.3. Add 100 uL of water to each sample for a final solvent composition of 80:20 Methanol:Water and vortex to mix the mixture well.

11.7.4. Transfer a portion of the extract to a 300 uL polypropylene autosampler vial (7 drop-wise or approximately ½ filled is sufficient). Archive the rest of the extracts for re-injection and dilution.

11.7.5. Seal the vial with a polypropylene screw cap. Note: Teflon lined caps can not be used due to detection of low level concentration of PFCs.

11.8. Soil, Sediment and Tissue Sample Preparation and Extraction

11.8.1. Visually inspect soil samples for homogeneity.

11.8.2. Weigh a representative 5 g aliquot of soil, sediment or tissue sample into a 50 mL polypropylene wide-mouth bottle. Weigh additional sample amounts for the matrix spike and matrix spike duplicate analyses if they are requested. *(Prepare separate aliquots if EtFOSA and/or MeFOSA are requested.)*

11.8.3. For the method blank and LCS matrix, use 5 g each of Ottawa sand.

11.8.4. Spike the LCS and MS/MSD (if requested) with 0.040 mL (40 uL) of the LCS/Matrix PFC Spike solution (Section 7.6). This will result in a sample concentration of 4.0 ng/g.

11.8.5. Add 0.05 mL (50 uL) of the IDA PFC solution (Section 7.7) into each sample and QC sample, for a fixed concentration of 50 ng/mL in the final sample vial.

11.8.6. Cap the bottles and allow the spike to settle into the sample matrix. Gently shake the bottles to mix the spike into the matrix.

11.8.7. Add 20 mL of 0.4% KOH/methanol to each sample.

11.8.8. Shake each sample on an orbital shaker at room temperature for 3 hours.

11.8.9. Following the shaking, extract the samples in an ultrasonic water bath for an additional 12 hours.

11.8.10. After the completion of extraction, centrifuge each sample at 3500 rpm for 15 minutes.

11.8.11. Collect and decant the KOH/methanol extract to a new 50-mL centrifuge tube.

11.8.12. Add another 2 mL of 0.4% KOH/methanol solution to the residue, briefly shake to mix and centrifuge at 3500 rpm for 15 minutes.

11.8.13. Combine the rinsate to the first corresponding tubes.

11.8.14. To the final KOH/methanol extract, add 2 mL of water to each. *(Omit this step if EtFOSA and/or MeFOSA are requested.)*

11.8.15. Concentrate the KOH/methanol/water extract under nitrogen to less than 2 mL, and dilute with water to 15 mL final volume. *(Omit this step if EtFOSA and/or MeFOSA are requested.)*

11.8.16. Acidify with 80 uL of glacial acetic acid, and mix the contents well with vortex mixer. Check the pH to ensure pH is between 6 to 8.

11.8.17. Centrifuge at 3500 rpm for 15 minutes.

11.9. **Solid Cleanup by SPE.** (Do not perform SPE clean up if EtFOSA and/or MeFOSA are requested. Proceed directly to Section 11.12)

11.9.1. Set up WAX 150 mg/6 cc SPE columns for sample cleanup using vacuum manifold.

11.9.2. Condition the SPE cartridges by passing the following without drying the column.

NOTE: *The cartridges should not be allowed to go dry until the final elution step with methanol. At all of the other transition steps, the solvent/sample level should be stopped at the top of the column before the next liquid is added.*

WARNING: The use of a vacuum system creates the risk of glassware implosion. Inspect all glassware prior to use. Glassware with chips, scratches, rub marks or cracks must not be used.

11.9.3. Wash with 5.0 mL of 0.3% NH4OH/methanol.

11.9.4. Wash with 10 mL of 0.1N NaOH/water. Close valve when ~ 500uL remains on top of column to keep column wet. *After this step, the columns cannot go dry until the completion of loading and rinsing samples.*

11.9.5. Add extracts to the columns and with vacuum, pull the entire extracts through the cartridge at rate of approximately 3 to 5 drops per second.

11.9.6. Rinse the sample tube with 5 mL of water and add to the SPE column.

11.9.7. Dry the columns with vacuum for 15 minutes.

11.10. SPE Column Wash of solids with hexane –

11.10.1. Load the first 5 mL of hexane to soak for five minutes, and elute to waste.

11.10.2. Load the second 5 mL of hexane and elute to waste (without a soaking period).

11.10.3. Allow the column to dry with vacuum for 10 minutes. Columns must be dried before continuing.

11.11. **SPE Elution** – using 15 mL polypropylene test tube as receiving tube in the SPE manifold.

11.11.1. Elute the analytes from the cartridge with 5.0 mL of 0.3% NH4OH/methanol, first allow the solution to soak for 5 minutes, and then elute into the 15 mL collection tube.

11.11.2. Add a second 5 mL of 0.3% NH4OH/methanol and collect the eluant into the collection tube. The total collection should be approximately 10 mL.

11.12. Extract Concentration

11.12.1. Concentrate each sample under a gentle stream of nitrogen to near dryness.

11.12.2. Add 800 uL of methanol to each extract, soak and vortex to mix well to reconstitute extract.

11.12.3. Add 200 uL of water to each sample for a final solvent composition of 80:20 Methanol:Water and vortex to mix the mixture well.

11.12.4. Transfer a portion of the extract to a 300 uL polypropylene autosampler vial (7 drop-wise or approximately ½ filled is sufficient). Archive the rest of the extracts for re-injection and dilution.

11.12.5. Seal the vial with a polypropylene screw cap. Note: Teflon lined caps can not be used due to detection of low level concentration of PFCs.

11.13. Other types of Sample Cleanup

11.13.1. **Freezing technique** to remove lipids.

11.13.1.1. If samples contain lipids then freeze the methanolic extract and QC extracts at -20^{o}C for at least 1 hour. Collect the solvent layer.

11.13.2. **Cleanup with graphitized carbon** which may also be used to remove organic interferences.

11.13.2.1. Add 100 mg of graphitized carbon to each sample extract and QC extracts.

11.13.2.2. Shake vigorously and then let sit for 10 minutes.

11.13.2.3. Centrifuge each sample for 2 minutes at 1000 rpm.

11.13.2.4. Decant the solvent layer

11.13.3. Concentrate each sample under a gentle stream of nitrogen to approximately 0.5 mL.

11.13.4. Add 200 uL of Millipore water to each sample.

11.13.5. Bring the final volume to 1.0 mL with methanol (80% methanol/20% water).

11.13.6. Filter through a 0.45 µm syringe filter as necessary or centrifuge the extracts to obtain a clear supernant. *Note: Syringe filter should be checked for PFC background before using.*

WARNING: Application of excessive pressure has caused disc filters to rupture and burst. Exercise discretion when filtering.

11.14. Instrument Analysis

11.14.1. Suggested operation conditions are listed below:

Waters Acquity UPLC

Routine Instrument Operating Conditions					
HPLC Conditions (Waters Acquity UPLC)					
Column (Column temp = 50°C)	Waters Acquity BEH 1.7µm C18, 3.0 x 150 mm				
Mobile Phase Composition	A = 20 mM Ammonium Acetate in Water B = Methanol				
Gradient Program	**Time**	**%A**	**%B**	**Curve**	**Flow Rate mL/min.**
	0	98	2	6	0.30
	1	98	2	6	0.30
	2	50	50	6	0.30

	12	10	90	6	0.30
	12.5	0	100	6	0.30
	16	0	100	6	0.30
	16.2	98	2	6	0.30
	Maximum Pressure limit = 15,000 psi				
Injection Size	10 µL (fixed amount throughout the sequence)				
Run Time	~20 minutes				

Mass Spectrometer Interface Settings (Quattro Premier XE)	
MS Interface Mode	ESI Negative Ion
Capillary (kV)	2.8
Cone (V)	Varies from 8.0 to 65
Extractor (V)	3
Source Temp	135ºC
Desolvation Temp	350ºC
Cone Gas (nitrogen) Flow	25 L/hour
Desolvation Gas (nitrogen) Flow	1100 L/hour

Mass Spectrometer Scan Settings						
Compound	Comments	Reaction (MRM)	Dwell (sec)	Cone Volt.	Col. Energy	Function Number
PFBA	Perfluorobutanoic acid	213 > 169	0.02	8	10	1
13C4-PFBA	IDA	217 > 172	0.02	12	10	1
PFPeA	Perfluoropentanoic acid	263 > 219	0.02	10	10	2
13C5PFPeA	IDA	268 > 223	0.02	11	9	2
PFBS	PerfluorobutanesulfonIc acid	299 > 80	0.02	45	35	2
PFHxA	Perfluorohexanoic acid	313 > 269	0.02	10	10	3
13C2-PFHxA	IDA	315 > 270	0.02	12	9	3
PFHpA	Perfluoroheptanoic acid	363 > 319	0.02	10	10	4
13C4-PFHpA	IDA	367 > 322	0.02	12	10	4
PFHxS	Perfluorohexanesulfonic acid	399 > 80	0.02	55	35	4
18O2-PFHxS	IDA	403 > 84	0.02	50	40	4
PFOA	Perfluorooctanoic acid	413 > 369	0.02	12	10	5
13C4PFOA	IDA	417 > 372	0.02	12	12	5
PFHpS	Perfluoroheptanesulfonate	449 > 80	0.02	60	38	5
PFNA	Perfluorononanoic acid	463 > 419	0.02	16	10	7
13C5-PFNA	IDA	468 > 423	0.02	12	12	7
PFOS	Perfluorooctanesulfonic acid	499 > 80	0.02	60	40	6
13C4-PFOS	IDA	503 > 80	0.02	35	48	6
PFDA	Perfluorodecanoic acid	513 > 469	0.02	16	12	8
813C2-PFDA	IDA	515 > 470	0.02	14	12	8
PFUdA	Perfluoroundecanoic acid	563 > 519	0.02	15	12	10

Mass Spectrometer Scan Settings						
Compound	Comments	Reaction (MRM)	Dwell (sec)	Cone Volt.	Col. Energy	Function Number
13C2-PFUdA	IDA	565 > 520	0.02	14	12	10
PFDS	Perfluorodecanesulfonic acid	599 > 80	0.02	74	48	10
FOSA	Perfluorooctanesulfonamide	498 > 78	0.02	40	32	9
13C8-FOSA	IDA	506 > 78	0.02	48	32	9
PFDoA	Perfluorododecanoic acid	613 > 569	0.02	15	14	11
13C2-PFDoA	IDA	615 > 570	0.02	16	12	11
PFTrDA	Perfluorotridecanoic acid	663 > 619	0.02	12	12	11
PFTeDA	Perfluorotetradecanoic acid	713 > 669	0.02	12	18	11
PFHxDA	Perfluorohexadecanoic acid	813 > 769	0.02	18	15	12
PFODA	Perfluorooctadecanoic acid	913 > 869	0.02	20	16	12
13C2-PFTeDA	IDA	715 > 670	0.02	15	15	11
13C2-PFHxDA	IDA	815 > 770	0.02	18	15	12
EtFOSA	N-ethylperfuoro-1-octanesulfonamide	526 > 169	0.02	45	36	11
d5EtFOSA	IDA for EtFOSA	531 >169	0.02	40	30	11
MeFOSA	N-methylperfuoro-1-octanesulfonamide	512 > 169	0.02	45	25	11
d5MeFOSA	IDA	515 > 169	0.02	40	30	11
EtFOSAA	N-ethylperfluoro-1-octanesulfonamidoacetic acid	584 > 419	0.02	35	20	9
d5-EtFOSAA	IDA	589 > 419	0.02	30	25	9
MeFOSAA	N-methylperfluoro-1-octanesulfonamidoacetic acid	570 > 419	0.02	30	28	9
d5-MeFOSAA	IDA	573 > 419	0.02	30	25	9
6:2FTS	1H,1H,2H,2H-perfluorooctane sulfonate	427 > 407	0.02	40	30	5
M2-6:2FTS	IDA	429 > 409	0.02	40	28	5
8:2FTS	1H,1H,2H,2H-perfluorodecane sulfonate	527 > 507	0.02	40	28	8
M2-8:2FTS	IDA	529 > 509	0.02	40	28	8

Native Compounds	Native RT (minutes)	IS analog	IS RT (minutes)	Quantitation Method
PFBA	4.77	13C4-PFBA	4.79	Isotope Dilution
PFPeA	5.90	13C5-PFPeA	5.92	Isotope Dilution
PFBS	6.01	18O2-PFHxS	8.64	IS calculation
PFHxA	7.22	13C2-PFHxA	7.25	Isotope Dilution
PFHpA	8.57	13C4-PFHpA	8.59	Isotope Dilution
PFHxS	8.60	18O2-PFHxS	8.64	Isotope Dilution
PFOA	9.80	13C4-PFOA	9.83	Isotope Dilution
PFHpS	9.80	13C4-PFOS	10.90	IS calculation
PFNA	10.88	13C5-PFNA	10.92	Isotope Dilution
PFOS	10.87	13C4-PFOS	10.90	Isotope Dilution
PFDA	11.82	13C2-PFDA	11.86	Isotope Dilution
FOSA	12.41	13C8-FOSA	12.46	Isotope Dilution
PFDS	12.57	13C4-PFOS	10.90	IS calculation
PFUdA	12.62	13C2-PFUdA	12.66	Isotope Dilution
PFDoA	13.32	13C2-PFDoA	13.34	Isotope Dilution
PFTrDA	13.91	13C2-PFDoA	13.34	IS calculation
PFTeDA	14.39	13C2-PFDoA	13.34	IS calculation
PFHxDA	15.16	13C2-PFDoA	13.34	IS calculation
PFODA	15.57	13C2-PFDoA	13.34	IS calculation
EtFOSA	14.13	d-EtFOSA	14.11	Isotope Dilution
MeFOSA	13.73	d-MeFOSA	13.73	Isotope Dilution
EtFOSAA	12.63	D5-EtFOSAA	12.62	Isotope Dilution
MeFOSAA	12.3	D3-MeFOSAA	12.28	Isotope Dilution
6:2FTS	10.08	M2-6:FTS	10.08	Isotope Dilution
8:2FTS	11.95	M2-8:FTS	11.95	Isotope Dilution

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Shimadzu HPLC

Routine Instrument Operating Conditions					
HPLC Conditions (Shimadzu HPLC)					
Column (Column temp = 45°C)	Phenomenex Gemini 3 µm C18 110Å, 50 X 2 mm				
Mobile Phase Composition	A = 20 mM Ammonium Acetate in Water		B = Methanol		
Gradient Program	**Time**	**%A**	**%B**		**Flow Rate mL/min.**
	0	90	10		0.60
	0.1	45	55		0.60
	4.5	1	99		0.60
	4.95	1	99		0.60
	5	90	10		0.60
	Maximum Pressure limit = 5,000 psi				
Injection Size	2 μL (fixed amount throughout the sequence)				
Run Time	~6.6 minutes				
Mass Spectrometer Interface Settings (SCIEX 5500)					
MS Interface Mode	ESI Negative Ion				
Ion Spray Voltage (kV)	4.5				
Entrance Potential (V)	5				
Declustering Potential (V)	25				
Desolvation Temp	600ºC				
Curtain Gas	35 psi				
Collision Gas	8 psi				

Compound	Comments	Reaction (MRM)	Dwell (sec)	Ent. Pot. (V)	Col. Energy (V)	Declu. Pot. (V)	Cell Exit Pot. (V)	RT (Min)
PFBA	Perfluorobutanoic acid	212.9 > 169	0.011	-5	-12	-25	-31	1.74
13C4_PFBA	IDA	217 > 172	0.011	-5	-12	-25	-31	1.74
PFBS	Perfluorobutanesulfonic acid	298.9 > 80	0.011	-6	-58	-55	-37	1.76
PFBS_2	Perfluorobutanesulfonic acid	298.9 > 99	0.011	-5	-40	-55	-12	1.76
PFPeA	Perfluoropentanoic acid	262.9 > 219	0.011	-7	-12	-20	-34	1.99
13C5_PFPeA	IDA	267.9 > 223	0.011	-7	-12	-20	-35	1.99
PFHxA	Perfluorohexanoic acid	313 > 269	0.011	-5	-12	-25	-37	2.25
13C2_PFHxA	IDA	315 > 270	0.011	-5	-12	-25	-38	2.25
PFHpA	Perfluoroheptanoic acid	363 > 319	0.011	-6	-12	-25	-41	2.57
13C4_PFHpA	IDA	367 > 322	0.011	-6	-12	-25	-41	2.57

PFHxS	Perfluorohexanesulfonic acid	399 > 80	0.011	-12	-74	-60	-43	2.59
18O2_PFHxS	IDA	403 > 84	0.011	-12	-74	-60	-43	2.59
6:2 FTS	Sodium 1H,1H,2H,2H-perfluorooctane sulfonate	427 > 407	0.011	-7	-32	-50	-10	2.91
M2-6:2FTS	IDA	429 > 409	0.011	-7	-32	-50	-10	2.91
PFOA	Perfluorooctanoic acid	413 > 369	0.011	-6	-14	-25	-44	2.93
PFOA_2	Perfluorooctanoic acid	413 > 169	0.011	-5	-22	-25	-12	2.93
13C4_PFOA	IDA	417 > 372	0.011	-6	-14	-25	-44	2.93
PFHpS	Perfluoroheptanesulfonic acid	449 > 80	0.011	-11	-88	-65	-46	2.94
PFNA	Perfluorononanoic acid	463 > 419	0.011	-6	-14	-25	-47	3.29
13C5_PFNA	IDA	468 > 423	0.011	-6	-14	-25	-48	3.29
PFOS	Perfluorooctanesulfonic acid	499 > 80	0.011	-9	-108	-65	-50	3.29
PFOS_2	Perfluorooctanesulfonic acid	499 > 99	0.011	-5	-58	-65	-12	3.29
13C4_PFOS	IDA	503 > 80	0.011	-9	-108	-65	-50	3.29
PFDA	Perfluorodecanoic acid	513 > 469	0.011	-6	-16	-25	-51	3.65
13C2_PFDA	IDA	515 > 470	0.011	-6	-16	-25	-51	3.65
8:2 FTS	Sodium 1H,1H,2H,2H-perfluorodecane sulfonate	527 > 507	0.011	-7	-40	-50	-15	3.65
M2-8:2FTS	IDA	529 > 509	0.011	-7	-40	-50	-15	3.65
PFOSA	Perfluorooctanesulfonamide	498 > 78	0.011	-8	-85	-60	-50	3.7
13C8_PFOSA	IDA	506 > 78	0.011	-8	-85	-60	-50	3.7
N-MeFOSAA	N-methylperfluoro-1-octanesulfonamidoacetic acid	570 > 419	0.011	-7	-36	-40	-15	3.82
d3-MeFOSAA	IDA	573 > 419	0.011	-7	-36	-40	-15	3.82
PFDS	Perfluorodecanesulfonic acid	599 > 80	0.011	-11	-118	-85	-54	3.96
PFUdA	Perfluoroundecanoic acid	563 > 519	0.011	-7	-18	-25	-54	3.97
13C2_PFUdA	IDA	565 > 520	0.011	-7	-18	-25	-54	3.97
N-EtFOSAA	N-ethylperfluoro-1-octanesulfonamidoacetic acid	584 > 419	0.011	-7	-36	-50	-15	3.99
d5-EtFOSAA	IDA	589 > 419	0.011	-7	-36	-50	-15	3.99
MeFOSA	N-methylperfuoro-1-octanesulfonamide	512 > 169	0.011	-7	-37	-75	-15	4.21
d3MeFOSA	IDA	515 > 169	0.011	-7	-37	-75	-15	4.21
PFDoA	Perfluorododecanoic acid	613 > 569	0.011	-5	-18	-25	-54	4.3
13C2_PFDoA	IDA	615 > 570	0.011	-5	-18	-25	-54	4.3

EtFOSA	N-ethylperfuoro-1-octanesulfonamide	526 > 169	0.011	-7	-37	-75	-15	4.39
d5EtFOSA	IDA	531 > 169	0.011	-7	-37	-75	-15	4.39
PFTrDA	Perfluorotridecanoic acid	663 > 619	0.011	-7	-20	-25	-54	4.56
PFTeDA	Perfluorotetradecanoic acid	713 > 669	0.011	-2	-22	-25	-10	4.79
PFTeDA_2	Perfluorotetradecanoic acid	713 > 169	0.011	-7	-36	-25	-30	4.79
13C2_PFTeDA	IDA	715 > 670	0.011	-2	-22	-25	-10	4.79
PFHxDA	Perfluorohexadecanoic acid	813 > 769	0.011	-7	-24	-25	-54	5.25
13C2_PFHxDA	IDA	815 > 770	0.011	-7	-24	-25	-54	5.25
PFODA	Perfluorooctadecanoic acid	913 > 869	0.011	-7	-26	-25	-54	5.55

11.14.2. Tune and calibrate the instrument as described in Section 10.

11.14.3. A typical run sequence is as follows:

- Primer (A number of primers are injected for conditioning of the instrument before analysis, especially when the instrument was idled or changed from a different analysis).
- Blank
- Calibration Curve
- ICB
- ICV
- MB
- LCS
- LCSD (if applicable)
- Sample 1
- Sample 1 MS (if applicable)
- Sample 1 MSD (if applicable)
- Sample 2 (up to sample 10 before next CCV)
- CCV
- Up to 10 samples.
- End sequence with CCV

12. CALCULATIONS

12.1. If the concentration of the analyte ions exceeds the working range as defined by the calibration standards, then the sample must be diluted and reanalyzed. It may be necessary to dilute samples due to matrix.

12.2. Qualitative Identification

12.2.1. The retention times of PFC's with labeled standards must be the same as that of the labeled IDA's to within 0.05 min. For PFC's with no labeled standards, the RT must be within ± 0.3 minutes of the ICV and CCV standards. *Note: The IS RT and native RT may be offset by 0.02 to 0.04 minutes.*

12.3. The ICAL established in Section 10 is used to calculate concentrations for the extracts.

12.4. Extract concentrations are calculated as below. The first equation applies to the linear fit, the second to the quadratic line fit.

Equation 4

$$\text{Concentration, ng/mL} = \frac{y - c}{b}$$

Equation 5

$$\text{Concentration, ng/mL} = \frac{-b + \sqrt{b^2 - 4a(c - y)}}{2a}$$

Where:

$$y = \frac{\text{Area (analyte)}}{\text{Area (IS)}} \times \text{Concentration (IS)}$$

x = concentration
a = curvature
b = slope
c = intercept

12.5. Water Sample Result Calculation:

Equation 6

$$\text{Concentration, ng/L} = \frac{C_{ex} V_t}{V_o}$$

Where:
C_{ex} = Concentration measured in sample extract (ng/mL)
V_t = Volume of total extract (mL)
V_o = Volume of water extracted (L)

12.6. Soil Sample Result Calculation:

Equation 7

$$\text{Concentration, } ng / g = \frac{C_{ex} V_t}{W_s D}$$

Where ng/g = µg/kg and:
C_{ex} = Concentration measured in sample extract (ng/mL)

V_t = Volume of total extract (mL)
W_s = Weight of sample extracted (g)
D = Fraction of dry solids, which is calculated as follows:

$$\frac{100 - \%\text{ moisture in sample}}{100} \quad \text{(for dry weight result)}$$

12.7. IDA Recovery Calculation:

Equation 8

$$\%\,Recovery = \frac{RF_{ex} A_t}{Amt}$$

Where ng/g = µg/kg and:

RF_{ex} = Response Factor for IDA compound
A_t = Area response for IDA compound
Amt = Amount spike of IDA

12.8. If results are to be reported as ammonium perfluorooctanoate (APFO), instead of PFOA, apply a multiplier of 1.0406 to the sample results to correct for the molecular weight differences between PFOA and APFO or this adjustment can be made during the preparation of the standards used for calibration. (Use one, not both.)

12.9. Raw data, calibration summaries, QC data, and sample results are reviewed by the analyst. These must also be reviewed thoroughly by a second qualified person. See the Data Review Policy (WS-PQA-0012). These reviews are documented on the Data Review Checklist.

13. METHOD PERFORMANCE

13.1. The group/team leader has the responsibility to ensure that this procedure is performed by an associate who has been properly trained in its use and has the required expertise.

13.2. Method Detection Limit

The laboratory must generate a valid method detection limit for each analyte of interest. The MDL must be below the reporting limit for each analyte. The procedure for determination of the method detection limit is given in 40 CFR Part 136, Appendix B, and further defined in SOP WS-QA-0006. MDLs are available in the Quality Assurance Department.

13.3. Initial Demonstration of Capability (IDOC)

Each analyst performing this procedure must successfully analyze four LCS QC samples using current laboratory LCS control limits. IDOCs are approved by the Quality Assurance Manager and the Technical Director. IDOC records are maintained by the QA staff in the central training files.

13.4. The laboratory must generate a valid method detection limit for each analyte of interest. The MDL must be below the reporting limit for each analyte. The procedure for determination of the method detection limit is given in 40 CFR Part 136, Appendix B, and further defined in WS-QA-0006 and policy WS-PQA-003.

14. POLLUTION PREVENTION

14.1. All waste will be disposed of in accordance with Federal, State and Local regulations.

14.2. Solid phase extraction used for water samples greatly reduces the amount of solvent used compared to liquid-liquid extraction.

14.3. Standards and reagents are purchased and prepared in volumes consistent with laboratory use to minimize the volume of expired standards and reagents requiring disposal.

14.4. Where reasonably feasible, technological changes have been implemented to minimize the potential for pollution of the environment. Employees will abide by this method and the policies in Section 13 of the Corporate Safety Manual for “Waste Management and Pollution Prevention.”

14.5. Do not allow waste solvent to vent into the hoods. All solvent waste is stored in capped containers unless waste is being transferred.

14.6. Transfer waste solvent from collection cups (tri-pour and similar containers) to jugs and/or carboys as quickly as possible to minimize evaporation.

15. WASTE MANAGEMENT

The following waste streams are produced when this method is carried out:

15.1. Assorted test tubes, autovials, syringes, filter discs and cartridges. Dump the solid waste into a yellow contaminated lab trash bucket. When the bucket is full or after no more than one year, tie the plastic bag liner shut and put the lab trash into the hazardous waste – landfill steel collection drum in the H3 closet. When the drum is full or after no more than 75 days, move it to the waste collection area for shipment.

15.2. Extracted soil samples, used sodium sulfate, paper funnel filters, glass wool, thimbles, and extracted solids contaminated with solvents. Dump these materials into an orange contaminated lab trash bucket. When the bucket is full or after no more than one year, tie the plastic bag liner shut and put the lab trash into the incineration steel collection drum in the H3 closet. When the drum is full or after no more than 75 days, move it to the waste collection area for shipment.

15.3. Waste Methanol. Collect the waste solvents in tripours during use. Empty the tripours into a 1-liter to 4-liter carboy at the fume hood. When the carboy is full, or at the end of your shift, whichever comes first, empty the carboy into the steel solvent drum in the H3 closet. When full to no less than six inches of the top, or after no more than 75 days, move the steel drum to the waste collection area for shipment.

15.4. Mixed water/methanol waste from soil extraction. Collect the waste in the HPLC waste carboy. When full, or after no more than one year, dump into the blue plastic HPLC collection drum in the H3 closet. When the drum is full, to no less than six inches of the top, or after no more than 75 days, move it to the waste collection area for shipment.

15.5. Aqueous acidic waste from the LCMS instrument contaminated with methanol. This is collected in a 1-gallon carboy at the instrument. When the carboy is full, or after no more than one year, it is emptied into the blue plastic HPLC collection drum in the H3 closet. When the drum is full to between two and six inches of the top, or after no more than 75 days, move it to the waste collection area for shipment.

15.6. Autovials contaminated with methanol. As the autovials are removed from the instrument after analysis, they are collected in open containers at the instrument. After all autovials are removed, the open container must be dumped into a closed satellite collection container in a fume hood, as the punctured septa in the autovial can allow methanol and other contaminants to evaporate into the atmosphere. The satellite collection containers are transferred to the waste disposal area when full or after no more than one year, where they are disposed through the vial eater.

16. REFERENCES

16.1. Cheryl Moody, Wai Chi Kwan, Johnathan W. Martin, Derek C. G. Muir, Scott A. Mabury, "Determination of Perfluorinated Surfactants in Surface Water Samples by Two Independent Analytical Techniques: Liquid Chromatography/Tandem Mass Spectrometry and 19FNMR," Analytical Chemistry 2001, 73, 2200-2206.

16.2. John Giesy et al., "Accumulation of Perfluorooctane Sulfonate in Marine Mammals", Environmental Science & Technology, 2001 Vol. 35, No. 8, pages 1593-1598.

16.3. U.S. EPA, "Residue Chemistry Test Guidelines, OPPTS 860.1340, Residue Analytical Method", EPA 712-C-95-174, August 1995.

16.4. STL Denver White Paper DEN-W-LC-002, "Method Validation Study for Analysis of Ammonium Perfluorooctanate in Soil Matrices by High Performance Liquid Chromatography/Mass Spectrometry (HPLC/MS/MS)", Mark Dymerski, September 5, 2003.

16.5. STL Denver White Paper DEN-W-LC-003, "Addendum A to Method Validation Study for Analysis of Ammonium Perfluorooctanate in Soil Matrices by High Performance

Liquid Chromatography/Mass Spectrometry (HPLC/MS/MS)", Mark Dymerski, August 6, 2003.

16.6. STL Denver White Paper DEN-W-LC-004, "Method Validation Study for Analysis of Perfluorooctanoic Acid in Waters by High Performance Liquid Chromatography/Tandem Mass Spectrometry (HPLC/MS/MS)", Mark Dymerski, January 26, 2005.

16.7. Waters application note; "Acquity UPLC System for Quantifying Trace Levels of Perfluorinated Compounds with an Acquity PFC Analysis Kit", Peter J. Lee, Evan T. Bernier, Gordon T. Fujimoto, Jeremy Shia, Michael S. Young, and Alice J. Di Gloia, Waters Corporation, Milford, MA. USA.

16.8. US EPA, "Method 537 - Determination of Selected Perfluorinated alkyl acids in Drinking Water by Solid Phase Extraction and Liquid Chromatography/Tandem Mass Spectrometery (LC/MS/MS)", Version 1.1, September 2009, J.A. Shoemaker, P.E. Grimmett, B.K. Boutin, EPA Document #: EPA/600/R-08/092

17. METHOD MODIFICATIONS

Modifications from Method 537 are detailed below:

17.1. Water sample containers are not preserved with Trizma.

17.2. The method has been modified to address soil/solid matrices. The extraction holding time is set at 14 days.

17.3. The analyte list has been expanded. The number of labeled analytes has been expanded as well to improve quantitation.

17.4. The reporting limits differ as they are all set at one consistent value.

17.5. Calibration levels differ from the referenced method.

17.6. More labeled analytes are fortified into the samples prior to the extraction process. Most target analytes are quantitated against a labeled analyte.

17.7. There is no symmetry requirement.

17.8. Calibration, both initial and continuing, has different acceptance criteria due to the longer list of analytes, and the use of IDA/external standard quantitation.

17.9. The eluents and HPLC configuration differs. As a result the final extract is in 80:20 methanol: water.

17.10. The LCS and MS/MSD are spiked at one concentration and do not rotate between a low to high levels.

17.11. Samples are not checked for residual chlorine or pH.

17.12. A different SPE cartridge (Waters OASIS WAX) is used for the extraction process. As a result solvents and elution procedures are different.

18. ATTACHMENTS

18.1. Attachment 1 - Analysis of Perfluorinated Compounds (PFCs) in Water via Direct Aqueous Injection (DAI).

19. REVISION HISTORY

19.1. WS-LC-0025, Revision 2.1, Effective 12/09/2016

19.1.1. Section 8.2, second sentence, changed 7 days to 14 days.

19.1.2. Note following Section 8.2, changed to read: "NOTE: As of this writing, Method 537 provides for a 14 day holding time for water samples preserved with Trizma buffer. The scientific literature indicates that perfluorinated substances are highly persistent in the environment. TestAmerica Sacramento has conducted holding time studies that support a 14 day holding time for aqueous samples with and without Trizma preservation. TestAmerica Denver has conducted stability studies indicating that medium- and low-level solutions of PFOA are stable for at least three months in polystyrene and polypropylene plastics at 0-6C. The 14 day/40 day holding times given above are based on the holding time study and general EPA convention for the holding time of extractable organic compounds in water and soil."

19.1.3. Section 17.1, removed the second sentence "Holding time has been changed to 7 days for extraction."

19.1.4. Editorial Changes

19.2. WS-LC-0025, Revision 2.0, Effective 11/18/2016

19.2.1. Replace "internal standard" with "IDA" throughout SOP.

19.2.2. Section 4.7, changed last sentence of paragraph to include "…in the standard **and/or sample** must…".

19.2.3. Section 6.9.4, added - "Phenomenex Gemini 3 µm C18 110Å, 50 X 2 mm, Part No. 00B-4439-B0."

19.2.4. Section 6.9.5, added – "Phenomonex Luna 5 µm C18(2) 100Å, 30 X 3 mm, Part No. 00A-4252-Y0."

19.2.5. Section 6.14, added – "SCIEX 5500 Triple Quad MS. The system utilizes Chrom Peak Review, version 2.1 or equivalent."

19.2.6. Section 7.4.1, added - "A technical (qualitative) grade PFOA standard is analyzed after an initial calibration initially, when a new column is installed or when significant changes are made to the HPLC parameters. This solution is used as a reference for the PFOA isomers (branched and linear) retention times."

19.2.7. Section 11.14.1, HPLC settings, gradient time 1, corrected flow rate from 0330 mL/min to 0.30 mL/min.

19.2.8. Section 11.14.1, MS Settings, removed the following lines for Waters instrument and added additional Table for Shimadzu HPLC.

PFPeS	Perfluoropentanesulfonate	3749 > 80	0.02	55	32	3
PFNS	Perfluorononanesulfonate	549 > 80	0.02	65	54	8
PFDoS	Perfluorododecanesulfonate	699 > 80	0.02	80	55	11

19.2.9. Section 15, added – "Shimadzu CTO-20AC HPLC equipped with 3 LC-20AD pumps and one DGU-20 degassing unit or equivalent."

19.2.10. Editorial chamges.

19.3. WS-LC-0025, Revision 1.9, Effective 05/27/2016

19.3.1. Editorial Changes.

19.3.2. Added Attachment 1.

19.4. WS-LC-0025, Rev 1.8, Effective 05/19/2016

19.4.1. Section 1.2, changed water sample volume from 500 to 250 mL.

19.4.2. Section 7.6, change the LCS solution from 1000 ng/mL to 500 ng/mL

19.4.3. Section 8.1, changed the sample container from 500 mL volume to 250 mL volume for water samples.

19.4.4. Section 11.3.2, 11.3.4, and 11.4.5, changed water sample volume from 500 to 250 mL.

19.4.5. Section 11.3.5, change the volume of spike added for EtFOSA/MeFOSA from 100 uL to 200 uL.

19.4.6. Section 11.3.6, change the volume of solution added from 0.050mL (50 uL) to 0.025 ml (25 ul), and from 250 to 125 uL if EtFOSA/MeFOSA is requested.

19.4.7. Section 11.7.2, change the volume of methanol from 800 uL to 400 uL.

19.4.8. Section 11.7.3, change the volume of water added from 200 uL to 100 uL.

19.4.9. Section 11.8.4, changed the volume of spike added from 20 uL to 40 uL.

19.4.10. Editorial Changes

19.5. WS-LC-0025 Rev. 1.7, Effective 03/18/2016

19.5.1. Section 4.5 – Deleted the last sentence in this section: “Until more information is available” and changed “excluded” to “included”.

19.5.2. Section 4.7 - Deleted the last sentence. “Chromatographic peaks in a sample must be integrated in the same way as the CAL standard.”

19.5.3. Section 7.4 – Changed upper calibration limit (CS-7) for all analytes from 500 ng/mL to 400 ng/mL

19.5.4. Section 9.8.2 – Revised 1st sentence to “IDA recoveries are flagged if they are outside of the acceptance limits (25–150%) “

19.5.5. Section 11.3.5 – Added to end of Section, “If EtFOSA and/or MeFOSA are required, increase the amount of LCS Matrix PFC spike solution added to 100 uL.”

19.5.6. Editorial changes.

19.6. WS-LC-0025 Rev. 1.6, Effective January 22, 2016

19.6.1. Section 11.6.1 – Revised to include rinse of sample container

19.6.2. Section 11.6.2 – Revised to include rinse of sample container.

19.6.3. Editorial changes

19.7. WS-LC-0025 Rev. 1.5, Effective November 1, 2015

19.7.1. Added the analytes EtFOSA, MeFOSA, EtFOSAA, MeFOSAA, 6:2FTS and 8:2FTS to Sections 1.1, 7.4 and 11.14.

19.7.2. Added Sections 2.5, 10.9.4 and 12.7 to address external standard quantitation.

19.7.3. Section 9.8 was updated and Section 12.7 added to address the calibration and quantitation of IDA compounds.

19.7.4. Added verbiage to Section 11 to address specifics if EtFOSA and/or MeFOSA are requested.

19.7.5. Added Section 11.3.7 for the specific processing of aqueous samples for EtFOSA and/or MeFOSA.

19.7.6. Added analytes and pertinent information to Section 11.14.1.

19.7.7. Editorial changes

19.8. WS-LC-0025 Rev. 1.4, Effective August 28, 2015

19.8.1. Updated copyright statement on cover page.

19.8.2. Section 1.1 – Renamed sulfonates to sulfonic acids and corrected the CAS# for PFHpS and PFOS. Removed FOSSA from table.

19.8.3. Section 7.4 – Renamed sulfonates to sulfonic acids and removed FOSSA remark.

19.8.4. Section 6.18 – Routine and Preventative maintenance table added.

19.8.5. Added Section(s) 17.1 thru 17.13 - Method modifications to Method 537.

19.8.6. Editorial changes.

19.9. WS-LC-0025 Rev. 1.3, Effective Oct. 31, 2014

19.9.1. Removed references to glass containers in Section 8.1, 8.2 and Notes following Section 8.

19.9.2. Editorial changes

19.10. WS-LC-0025 Rev. 1.2, Effective July 5, 2013

19.10.1. Updated Tables in Section 11.14 with current specifications.

19.10.2. Editorial changes.

19.11. WS-LC-0025 Rev. 1.1, Effective May 25, 2012

19.11.1. Editorial revisions.

19.12. WS-LC-0025 revision 1.0, Effective May 3, 2011

19.12.1. This is the original SOP. SOP was created from WS-LC-0020.

1. SCOPE AND APPLICATION

1.1. This procedure describes the analysis of water samples via direct aqueous injection (DAI) for the following compounds using liquid chromatography / tandem mass spectrometry (LC/MS/MS) on a SCIEX 5500.

Compound Name	**Abbreviation**	**CAS #**
Perfluoroalkylcarboxylic acids (PFCAs)		
Perfluoro-n-heptanoic acid	PFHpA	375-85-9
Perfluoro-n-octanoic acid	PFOA	335-67-1
Perfluoro-n-nonanoic acid	PFNA	375-95-1
Perfluorinated sulfonic acids (PFSAs)		
Perfluoro-1-butanesulfonic acid	PFBS	375-73-5
Perfluoro-1-hexanesulfonic acid	PFHxS	355-46-4
Perfluoro-1-octanesulfonic acid	PFOS	1763-23-1

1.2. The working range of the method is listed below. The linear range can be extended by diluting the extracts.

Matrix	**Nominal Sample Size**	**Reporting Limit**	**Working Range**
Water	1.0 mL	2.0 ng/L	2 to 200 ng/L

2. SUMMARY OF METHOD

2.1. A 1 mL aliquot of sample is diluted to a 40:60 methanol:water extract and analyzed by LC/MS/MS. PFCs are separated from other components on a C18 column with a solvent gradient program using 20mM Ammonium Acetate/water and methanol.

3. DEFINITIONS

Refer to Section 3 of the main body of this SOP for a summary of definitions.

4. INTERFERENCES

Refer to Section 4 of the main body of this SOP for interferences.

5. SAFETY

Refer to Section 5 of the main body of this SOP for safety information.

6. EQUIPMENT AND SUPPLIES

Refer to Section 6 of the main body of this SOP for supplies, other than those listed below specific to the DAI analysis.

6.1. 2 mL auto sampler vials, clear glass, Thermo Scientific Nation surestop vial, part no. C5000-1, or equivalent**.**

6.2. Vial caps, Thermo Scientific National AVCS blue cap, pre slit TEF/STL septa, part no. C5000-55B or equivalent.

6.3. Eppendorf 1000 uL epTIPS, part no. 022491954 or equivalent.

6.4. Eppendorf 200 uL epTIPS, part no. 022491938 or equivalent.

6.5. 50 mL graduated plastic centrifuge tubes, SCP Science DigiTUBES part no. 010-500-263 or equivalent

The 5 items above are to be maintained in the drawer labeled "Segregated Supplies for DAI Analysis" in the LC/MS instrument room

6.6. 1000 uL Pipette: Eppendorf Research Plus

6.7. 100 uL Pipette: Rainin EDP3-Plus

6.8. 250 mL HDPE bottles with PPE screw caps, ESS part no. 0250-1902-QC or equivalent.

6.9. Analytical columns

6.9.1. Phenomenex Gemini C18 3 um, 3.0 mm x 100 mm, Part No. 00D-4439-Y0, or equivalent.

6.9.2. PFC Isolator column, Phenomenex Luna C18 5 um, 50 mm x 4.6 mm, part no. 00B-4252-E 0 or equivalent.

6.10. SCIEX 5500 Triple Quad MS. The system utilizes Chrom Peak Review, version 2.1 or equivalent.

6.11. Shimadzu CTO-20AC HPLC equipped with 3 LC-20AD pumps and one DGU-20 degassing unit or equivalent.

7. REAGENTS AND STANDARDS

Refer to Section 7 of the main body of this SOP for reagents and standards, other than those listed below specific to the DAI analysis.

7.1. Reagent grade chemicals shall be used in all tests whenever available. Unless otherwise indicated, it is intended that all reagents shall conform to the specifications of the Committee on the Analytical Reagents of the American Chemical Society, where such specifications are available. Other grades may be used, provided it is first ascertained that the reagent is of sufficiently high purity to permit its use without lessening the accuracy of the determination.

7.1.1. Ammonium acetate, Fisher Optima LCMS grade (20 mM in water), part no. A114-50, or equivalent.

7.1.2. Methanol, Baker HPLC grade, part no. 9093-03.

7.1.3. Water, Nanopure or Millipore or Fisher Optima LCMS grade, part no. W6-4, must be free of interference and target analytes.

7.2. Calibration Standards

The calibration stock solution is prepared by diluting the appropriate amounts of the stock solutions (Section 7.2 of the main body of this SOP) in 40:60 methanol:water. The calibration stock solution is diluted with methanol to produce initial calibration standards. These are the normal calibration levels used. A different range can be used if needed to achieve lower reporting limits or a higher linear range.

7.3. Initial Calibration (ICAL) Levels (ng/L)

Compound	**CS-1**	**CS-2**	**CS-3**	**CS-4**	**CS-5**	**CS-6**	**CS-7**	**CS-8**
Perfluoroalkylcarboxylic acids (PFCAs)								
PFHpA	1.0	2.0	5.0	10	20	50	100	200
PFOA	1.0	2.0	5.0	10	20	50	100	200
PFNA	1.0	2.0	5.0	10	20	50	100	200
Perfluorinated sulfonic acids (PFSAs)								
PFBS	1.0	2.0	5.0	10	20	50	100	200
PFHxS	1.0	2.0	5.0	10	20	50	100	200
PFOS	1.0	2.0	5.0	10	20	50	100	200
Labeled Isotope Dilution Analytes (IDA)								
13C4-PFHpA	50	50	50	50	50	50	50	50
13C4-PFOA	50	50	50	50	50	50	50	50
13C5-PFNA	50	50	50	50	50	50	50	50
18O2-PFHxS	50	50	50	50	50	50	50	50
13C4-PFOS	50	50	50	50	50	50	50	50

Note- The above calibration levels are provided only as an example. The actual ICAL level used for each analytical batch will depend upon the LOQ requirements of the program.

7.4. LCS/Matrix PFC Spike Solution, 100 ng/mL.

The PFC spike solution is prepared by diluting all PFCs to produce a solution containing PFCs each at 100 ng/mL in methanol.

7.5. PFC Isotope Dilution Analyte (IDA) Spike Solution, 1 ng/mL.

The PFC-IDA solution is prepared by diluting all labeled PFCs to produce a solution each at 1 ng/mL in methanol.

8. SAMPLE COLLECTION, PRESERVATION, AND STORAGE

8.1. Water samples are collected in pre-cleaned 250 mL HDPE containers. Other containers may also be suitable. Samples are chilled to 0 - 6 °C for shipment to the laboratory.

8.2. Samples are logged in following normal laboratory procedures and are stored under refrigeration at 0 - 6 °C Water samples must be analyzed within 28 days of collection.

9. QUALITY CONTROL

Refer to Section 9 of the main body of this SOP for Quality Control information.

10. CALIBRATION

Refer to Section 10 of the main body of the SOP for calibration information.

11. PROCEDURE

Refer to Section 11 of the main body of this SOP for procedures, other than those listed below specific to the DAI analysis.

11.1. Water Sample Preparation

11.1.1. Visually inspect samples for the presence of settled and or suspended sediment. If sediment is apparent, remove the aliquot for testing from the aqueous layer. If the sediment concentration is too high centrifuge the sample first or filter the water sample through a glass fiber filter (Whatman GF/F Cat No 1825 090 or equivalent). Gravity or vacuum can be used to pass the sample through the filter. Prepare a filtration blank with any samples requiring filtration.

Warning: The use of a vacuum system creates the risk of glassware implosion. Inspect all glassware prior to use. Glassware with chips, scratches, rub marks or cracks must not be used.

11.1.2. Prepare an LCS and method blank by adding 250 mL of HPLC grade water into a 250 mL HDPE bottle.

11.1.3. If requested, find the client assigned sample for MS/MSD.

11.1.4. Spike directly into the sample bottles for the LCS and MS/MSD (if requested) with 0.050 mL (50 uL) of the LCS/Matrix PFC Spike solution (Section 7.4). This will result in a sample concentration of 20 ng/L. Shake well to disperse spike.

11.1.5. Measure 1 mL of each sample using an Eppendorf pipette and pour into a labeled 2.0 mL injection vial. This includes the LCS and method blank samples as well.

11.1.6. Be sure to "prepare" the pipette by collecting two 1 mL aliquots and disposing of them, and then collect the aliquot for testing.

11.1.7. Add 83 uL of surrogate solution (PFC IDA Spike Solution, Section 7.5) into each vial for each sample and QC sample. This will result in an extract concentration of 50 ng/L for the surrogate.

11.1.8. Add 577 uL of methanol to each sample for a final solvent composition of 40:60 methanol:water.

11.1.9. Seal the vial with a polypropylene screw cap. Note: Teflon lined caps can not be used due to detection of low level concentration of PFCs.

11.1.10. Vortex to mix the mixture well.

11.2. Instrument Analysis

11.2.1. Suggested operation conditions are listed below:

<table>
<tr><th colspan="6">Routine Instrument Operating Conditions</th></tr>
<tr><th colspan="6"><i>HPLC Conditions (Shimadzu HPLC)</i></th></tr>
<tr><td>Column (Column temp = 35°C)</td><td colspan="5">Phenomenex Gemini C18 3 um, 3.0 mm x 100 mm</td></tr>
<tr><td>Mobile Phase Composition</td><td colspan="5">A = 20 mM Ammonium Acetate in Water B = Methanol</td></tr>
<tr><td rowspan="9">Gradient Program</td><td>Time (min)</td><td>%A</td><td>%B</td><td>Curve</td><td>Flow Rate (mL/min)</td></tr>
<tr><td>0</td><td>90</td><td>10</td><td>6</td><td>0.60</td></tr>
<tr><td>1</td><td>90</td><td>10</td><td>6</td><td>0.60</td></tr>
<tr><td>1.5</td><td>35</td><td>65</td><td>6</td><td>0.60</td></tr>
<tr><td>8</td><td>5</td><td>95</td><td>6</td><td>0.60</td></tr>
<tr><td>8.1</td><td>1</td><td>99</td><td>6</td><td>0.60</td></tr>
<tr><td>12</td><td>1</td><td>99</td><td>6</td><td>0.60</td></tr>
<tr><td>12.5</td><td>90</td><td>10</td><td>6</td><td>0.60</td></tr>
<tr><td colspan="5">Maximum Pressure limit = 5,000 psi</td></tr>
<tr><td>Injection Size</td><td colspan="5">950 uL (fixed amount throughout the sequence)</td></tr>
<tr><td>Run Time</td><td colspan="5">17.1 minutes</td></tr>
</table>

Mass Spectrometer Interface Settings (SCIEX 5500))	
MS Interface Mode	ESI Negative Ion
Ion Spray Voltage (kV)	4.5
Entrance Potential (V)	5
Declustering Potential (V)	25
Desolvation Temp	550 °C
Curtain Gas (nitrogen) Flow	35 psi
Collision Gas (nitrogen) Flow	8 psi

Mass Spectrometer Scan Settings

Compound	**Comments**	**Reaction (MRM)**	**Dwell (sec)**	**Ent. Pot. (V)**	**Col. Energy (V)**	**Declu. Pot. (V)**
PFBS	Perfluorobutanesulfonate	299 > 80	0.02	6	58	55
18O2-PFHxS	IS	403 > 84	0.02	12	74	60
PFHpA	Perfluoroheptanoic acid	363 > 319	0.02	6	12	25
13C4-PFHpA	IS	367 > 322	0.02	6	12	25
PFHxS	Perfluorohexanesulfonate	399 > 80	0.02	12	74	60
18O2-PFHxS	IS	403 > 84	0.02	12	74	60
PFOA	Perfluorooctanoic acid	413 > 369	0.02	6	14	25
13C4PFOA	IS	417 > 372	0.02	6	14	25
PFNA	Perfluorononanoic acid	463 > 419	0.02	6	14	25
13C5-PFNA	IS	468 > 423	0.02	6	14	25
PFOS	Perfluorooctanesulfonate	499 > 80	0.02	9	108	65
13C4-PFOS	IS	503 > 80	0.02	9	108	65

Native Compounds	**Native RT (minutes)**	**IS analog**	**IS RT (minutes)**	**Quantitation Method**
PFBS	6.68	18O2-PFHxS	7.76	IS calculation
PFHpA	7.77	13C4-PFHpA	7.77	Isotope Dilution
PFHxS	7.76	18O2-PFHxS	7.76	Isotope Dilution
PFOA	8.44	13C4-PFOA	8.44	Isotope Dilution
PFNA	9.10	13C5-PFNA	9.10	Isotope Dilution
PFOS	9.06	13C4-PFOS	9.06	Isotope Dilution

11.2.2. Tune and calibrate the instrument as described in Section 10.

12. CALCULATIONS

Refer to Section 12 of the main body of this SOP for calculation information.

13. METHOD PERFORMANCE

Refer to Section 13 of the main body of this SOP for method performance information.

14. POLLUTION PREVENTION

Refer to Section 14 of the main body of this SOP for pollution prevention information.

15. WASTE MANAGEMENT

Refer to Section 15 of the main body of this SOP for waste management information.

16. REFERENCES

Refer to Section 16 of the main body of this SOP for reference information.

17. METHOD MODIFICATIONS

Refer to Section 17 of the main body of this SOP for modifications from Method 537, except as detailed below:

17.1. Water samples are prepared at 1.0mL, not 250mL.

17.2. Water sample containers are not preserved with Trizma. Holding time has been changed to 28 days for analysis.

17.3. The eluents and HPLC configuration differs. As a result the final extract is in 40:60 methanol: water.

18. ATTACHMENTS

There are no attachments to this SOP.

19. REVISION HISTORY

19.1. WS-LC-0025, Revision 2.1, Effective 12/09/2016

- 19.1.1. Revised section 8.2. Changed the holding time for water samples from 7 to 14 days.
- 19.1.2. Revised section 17.1. Removed the line “Holding time has been changed to 7 days for extraction.”

19.2. WS-LC-0025 Attachment 1, Revision 1.9, Effective 05/27/2016

- 19.2.1. This is the first version of this Appendix.

SCOPE OF ACCREDITATION TO ISO/IEC 17025:2005

TESTAMERICA LABORATORIES SACRAMENTO
880 Riverside Parkway
West Sacramento, CA 95605
Lisa Stafford Phone: 916 374 4308

ENVIRONMENTAL

Valid To: January 31, 2017 Certificate Number: 2928.01

In recognition of the successful completion of the A2LA evaluation process, (including an assessment of the laboratory's compliance with ISO IEC 17025:2005, the 2009 TNI Standard, and the requirements of the DoD Environmental Laboratory Accreditation Program (DoD ELAP) as detailed in version 5.0 of the DoD Quality Systems Manual for Environmental Laboratories) accreditation is granted to this laboratory to perform recognized EPA methods using the following testing technologies and in the analyte categories identified below:

Testing Technologies

Inductively Coupled Plasma (ICP), ICP-Mass Spectroscopy, Atomic Absorption Spectroscopy (flame), Gas Chromatography(GC), GC- Mass Spectroscopy, High Resolution Gas Chromatography/High Resolution Mass Spectroscopy, Liquid Chromatography(LC),LC- Mass Spectroscopy, Ion Chromatography, Spectrophotometry, Misc.-Electronic Probes

Parameter/Analyte	Non-Potable Water	Solid/Hazardous Waste	Air
Metals			
Aluminum	EPA 6010B/6010C/6020/6020A	EPA 6010B/6010C/6020/6020A	EPA 6020/6020A
Antimony	EPA 6010B/6010C/6020/6020A	EPA 6010B/6010C/6020/6020A	EPA 6020/6020A
Arsenic	EPA 6010B/6010C/6020/6020A	EPA 6010B/6010C/6020/6020A	EPA 6020/6020A
Barium	EPA 6010B/6010C/6020/6020A	EPA 6010B/6010C/6020/6020A	EPA 6020/6020A
Beryllium	EPA 6010B/6010C/6020/6020A	EPA 6010B/6010C/6020/6020A	EPA 6020/6020A
Boron	EPA 6010B/6020/6010C/6020A	EPA 6010B/6020/6010C/6020A	---------------------
Cadmium	EPA 6010B/6010C/6020/6020A	EPA 6010B/6010C/6020/6020A	EPA 6020/6020A
Calcium	EPA 6010B/6010C/6020/6020A	EPA 6010B/6010C/6020/6020A	EPA 6020/6020A
Chromium (Total)	EPA 6010B/6010C/6020/6020A	EPA 6010B/6010C/6020/6020A	EPA 6020/6020A
Chromium (Hexavalent)	EPA 7196A	EPA 7196A	---------------------
Cobalt	EPA 6010B/6010C/6020/6020A	EPA 6010B/6010C/6020/6020A	EPA 6020/6020A
Copper	EPA 6010B/6010C/6020/6020A	EPA 6010B/6010C/6020/6020A	EPA 6020/6020A
Iron	EPA 6010B/6010C/6020/6020A	EPA 6010B/6010C/6020/6020A	EPA 6020/6020A
Lead	EPA 6010B/6010C/6020/6020A	EPA 6010B/6010C/6020/6020A	EPA 6020/6020A
Magnesium	EPA 6010B/6010C/6020/6020A	EPA 6010B/6010C/6020/6020A	EPA 6020/6020A
Manganese	EPA 6010B/6010C/6020/6020A	EPA 6010B/6010C/6020/6020A	EPA 6020/6020A

Parameter/Analyte	Non-Potable Water	Solid/Hazardous Waste	Air
Mercury	EPA 7470A	EPA 7471A/7471B	---------------------
Molybdenum	EPA 6010B/6010C/6020/6020A	EPA 6010B/6010C/6020/6020A	EPA 6020/6020A
Nickel	EPA 6010B/6010C/6020/6020A	EPA 6010B/6010C/6020/6020A	EPA 6020/6020A
Phosphorus	EPA 6020/6020A	EPA 6020/6020A	---------------------
Potassium	EPA 6010B/6010C/6020/6020A	EPA 6010B/6010C/6020/6020A	EPA 6020/6020A
Selenium	EPA 6010B/6010C/6020/6020A	EPA 6010B/6010C/6020/6020A	EPA 6020/6020A
Silica	EPA 6010B/6010C	---------------------------------------	---------------------
Silicon	EPA 6010B/6010C	---------------------------------------	---------------------
Silver	EPA 6010B/6010C/6020/6020A	EPA 6010B/6010C/6020/6020A	EPA 6020/6020A
Sodium	EPA 6010B/6010C/6020/6020A	EPA 6010B/6010C/6020/6020A	EPA 6020/6020A
Strontium	EPA 6020/6020A	EPA 6020/6020A	---------------------
Thallium	EPA 6010B/6020/6010C/6020A	EPA 6010B/6020/6010C/6020A	EPA 6020/6020A
Tin	EPA 6010B/6020/6010C/6020A	EPA 6010B/6020/6010C/6020A	---------------------
Titanium	EPA 6010B/6020/6010C/6020A	EPA 6010B/6020/6010C/6020A	---------------------
Uranium	EPA 6020/6020A	EPA 6020/6020A	---------------------
Vanadium	EPA 6010B/6010C/6020/6020A	EPA 6010B/6010C/6020/6020A	EPA 6020/6020A
Zinc	EPA 6010B/6010C/6020/6020A	EPA 6010B/6010C/6020/6020A	EPA 6020/6020A
Nutrients			
Nitrate	EPA 353.2/9056A/300.0	EPA 353.2/ 9056A/300.0	---------------------
Nitrate-nitrite	EPA 353.2	EPA 353.2	---------------------
Nitrite	EPA 353.2/9056A/300.0	EPA 353.2/9056A/300.0	---------------------
Orthophosphate	EPA 9056A/300.0	EPA 9056A/300.0	---------------------
Wet Chemistry			
Alkalinity	SM 2320B (1997)	---------------------------------------	---------------------
Chemical Oxygen Demand	EPA 410.4	---------------------------------------	---------------------
Nitrocellulose	WS-WC-0050/353.2 Modified	WS-WC-0050/353.2 Modified	---------------------
Perchlorate	EPA 6850	EPA 6850	---------------------
pH	EPA 9040B/9040C	EPA 9045C/9045D	---------------------
Bromide	EPA 9056A/300.0	EPA 9056A/300.0	---------------------
Chloride	EPA 9056A/300.0	EPA 9056A/300.0	---------------------
Fluoride	EPA 9056A/300.0	EPA 9056A/300.0	---------------------
Sulfate	EPA 9056A/300.0	EPA 9056A/300.0	---------------------
Solids, Total	SM2540B (1997)	---------------------------------------	---------------------
Solids, Total Suspended	SM2540D (1997)	---------------------------------------	---------------------
Solids, Total Dissolved	SM2540C (1997)	---------------------------------------	---------------------
%Moisture	---------------------------------------	ASTM D2216	
TSP (Total Suspended Particulate)	---------------------------------------	---------------------------------------	40CFR Part 50 App B
PM10	---------------------------------------	---------------------------------------	40CFR Part 50 App J

Parameter/Analyte	Non-Potable Water	Solid/Hazardous Waste	Air
Hazardous Waste Characteristics			
TCLP Extractables	--------------------------------------	EPA 1311	--------------------
TCLP Inorganics	--------------------------------------	EPA 1311	--------------------
Purgeable Organics (volatiles)			
1,1,1,2-Tetrachloroethane	EPA 8260B/8260C	EPA 8260B/8260C	--------------------
1,1,1-Trichloroethane	EPA 8260B/8260C	EPA 8260B/8260C	TO14A/TO15/ TO15 SIM
1,1,2,2-Tetrachloroethane	EPA 8260B/8260C	EPA 8260B/8260C	TO14A/TO15/ TO15 SIM
1,1,2-Trichloroethane	EPA 8260B/8260C	EPA 8260B/8260C	TO14A/TO15/ TO15 SIM
1,1-2-Trichloro-1,2-2-trifluorethane	EPA 8260B/8260C	EPA 8260B/8260C	TO14A/TO15/ TO15-SIM
1,1-Dichloroethane	EPA 8260B/8260C	EPA 8260B/8260C	TO14A/TO15/ TO15 SIM
1,1-Dichloroethene	EPA 8260B/8260C	EPA 8260B/8260C	TO14A/TO15/ TO15 SIM
1,1-Dichloropropene	EPA 8260B/8260C	EPA 8260B/8260C	---------------------
1,2,3-Trichlorobenzene	EPA 8260B/8260C	EPA 8260B/8260C	TO14A/TO15
1,2,3-Trichloropropane	EPA 8260B/8260C	EPA 8260B/8260C	TO14A/TO15/ TO15 SIM
1,2,4-Trichlorobenzene	EPA 8260B/8260C	EPA 8260B/8260C	TO14A/TO15/ TO15 SIM
1,2,4-Trimethylbenzene	EPA 8260B/8260C	EPA 8260B/8260C	TO14A/TO15
1,2-Dibromo-3-chloropropane	EPA 8260B/8260C	EPA 8260B/8260C	---------------------
1,2-Dibromoethane	EPA 8260B/8260C	EPA 8260B/8260C	TO14A/TO15/ TO15 SIM
1,2-Dichlorobenzene	EPA 8260B/8260C	EPA 8260B/8260C	TO14A/TO15/ TO15 SIM
1,2-Dichloroethane	EPA 8260B/8260C	EPA 8260B/8260C	TO14A/TO15/ TO15 SIM
1,2-Dichloropropane	EPA 8260B/8260C	EPA 8260B/8260C	TO14A/TO15/ TO15 SIM
1,3,5-Trimethylbenzene	EPA 8260B/8260C	EPA 8260B/8260C	TO14A/TO15
1,3-Dichlorobenzene	EPA 8260B/8260C	EPA 8260B/8260C	TO14A/TO15/ TO15 SIM
1,3-Dichloropropane	EPA 8260B/8260C	EPA 8260B/8260C	---------------------
1,4-Dichlorobenzene	EPA 8260B/8260C	EPA 8260B/8260C	TO14A/TO15/ TO15 SIM
1,4-Dioxane	--------------------------------------	--------------------------------------	TO14A/TO15/ TO15 SIM
1-Chlorocyclohexane	EPA 8260B/8260C	EPA 8260B/8260C	---------------------
2,2-Dichloropropane	EPA 8260B/8260C	EPA 8260B/8260C	---------------------
2-Butanone (MEK)	EPA 8260B/8260C	EPA 8260B/8260C	TO14A/TO15
2-Chlorotoluene	EPA 8260B/8260C	EPA 8260B/8260C	TO14A/TO15
2-Hexanone (MBK)	EPA 8260B/8260C	EPA 8260B/8260C	TO14A/TO15

Parameter/Analyte	Non-Potable Water	Solid/Hazardous Waste	Air
2-Methyl-2-propanol (tert-Butyl Alcohol, TBA)	EPA 8260B/8260C	EPA 8260B/8260C	TO14A/TO15
4-Chlorotoluene	EPA 8260B/8260C	EPA 8260B/8260C	----------------------
4-Ethyltoluene	--	--	TO14A/TO15
4-Isopropyltoluene	EPA 8260B/8260C	EPA 8260B/8260C	TO14A/TO15
4-Methyl-2-pentanone (MIBK)	EPA 8260B/8260C	EPA 8260B/8260C	TO14A/TO15
Acetone	EPA 8260B/8260C	EPA 8260B/8260C	TO14A/TO15
Acrolein	--	--	TO14A/TO15/ TO15 SIM
Allyl Chloride	EPA 8260B/8260C	EPA 8260B/8260C	TO14A/TO15
Alpha Methyl Styrene	--	--	TO14A/TO15
Benzene	EPA 8260B/8260C	EPA 8260B/8260C	TO14A/TO15/ TO15 SIM
Benzyl Chloride	--	--	TO14A/TO15/ TO15 SIM
Bromobenzene	EPA 8260B/8260C	EPA 8260B/8260C	----------------------
Bromochloromethane	EPA 8260B/8260C	EPA 8260B/8260C	----------------------
Bromodichloromethane	EPA 8260B/8260C	EPA 8260B/8260C	TO14A/TO15/ TO15 SIM
Bromoform	EPA 8260B/8260C	EPA 8260B/8260C	TO14A/TO15
Bromomethane	EPA 8260B/8260C	EPA 8260B/8260C	TO14A/TO15
Butadiene (1,3-Butadiene)	--	--	TO14A/TO15/ TO15 SIM
Butane	--	--	TO14A/TO15
Carbon Disulfide	EPA 8260B/8260C	EPA 8260B/8260C	TO14A/TO15
Carbon Tetrachloride	EPA 8260B/8260C	EPA 8260B/8260C	TO14A/TO15/ TO15 SIM
Chlorobenzene	EPA 8260B/8260C	EPA 8260B/8260C	TO14A/TO15/ TO15 SIM
Chlorodifluoromethane	--	--	TO14A/TO15
Chloroethane	EPA 8260B/8260C	EPA 8260B/8260C	TO14A/TO15/ TO15 SIM
Chloroform	EPA 8260B/8260C	EPA 8260B/8260C	TO14A/TO15/ TO15 SIM
Chloromethane	EPA 8260B/8260C	EPA 8260B/8260C	TO14A/TO15/ TO15 SIM
cis-1,2-Dichloroethene	EPA 8260B/8260C	EPA 8260B/8260C	TO14A/TO15/ TO15 SIM
cis-1,3-Dichloropropene	EPA 8260B/8260C	EPA 8260B/8260C	TO14A/TO15/ TO15 SIM
Cyclohexane	EPA 8260B/8260C	EPA 8260B/8260C	TO14A/TO15
Dibromochloromethane	EPA 8260B/8260C	EPA 8260B/8260C	TO14A/TO15/ TO15 SIM
Dibromomethane	EPA 8260B/8260C	EPA 8260B/8260C	TO14A/TO15
Dichlorodifluoromethane	EPA 8260B/8260C	EPA 8260B/8260C	TO14A/TO15/ TO15 SIM
Diisopropyl Ether (DIPE)	EPA 8260B/8260C	EPA 8260B/8260C	----------------------
Dimethyl Disulfide	WS-MS-0003	WS-MS-0003	EPA 15/16

Parameter/Analyte	Non-Potable Water	Solid/Hazardous Waste	Air
Ethyl Acetate	---------------------------------------	---------------------------------------	TO14A/TO15
Ethylbenzene	EPA 8260B/8260C	EPA 8260B/8260C	TO14A/TO15/ TO15 SIM
Ethylmethacrylate	EPA 8260B/8260C	EPA 8260B/8260C	----------------------
Ethyl tert-butyl Ether (ETBE)	EPA 8260B/8260C	EPA 8260B/8260C	----------------------
Hexachlorobutadiene	EPA 8260B/8260C	EPA 8260B/8260C	TO14A/TO15/ TO15 SIM
Hexane	EPA 8260B/8260C	EPA 8260B/8260C	TO14A/TO15
Iodomethane	EPA 8260B/8260C	EPA 8260B/8260C	----------------------
Isobutanol (2-Methyl-1-propanol)	EPA 8260B/8260C	EPA 8260B/8260C	----------------------
Isooctane (2,2,4-Trimethylpentane)	---------------------------------------	---------------------------------------	TO14A/TO15
Isopropyl Alcohol	---------------------------------------	---------------------------------------	TO14A/TO15
Isopropylbenzene	EPA 8260B/8260C	EPA 8260B/8260C	TO14A/TO15
m & p Xylene	EPA 8260B/8260C	EPA 8260B/8260C	TO14A/TO15/ TO15 SIM
Methyl tert-butyl Ether (MTBE)	EPA 8260B/8260C	EPA 8260B/8260C	TO14A/TO15/ TO15 SIM
Methylene Chloride	EPA 8260B/8260C	EPA 8260B/8260C	TO14A/TO15/ TO15 SIM
Naphthalene	EPA 8260B/8260C	EPA 8260B/8260C	TO14A/TO15/ TO15 SIM
n-Butanol	---------------------------------------	---------------------------------------	TO14A/TO15
n-Butylbenzene	EPA 8260B/8260C	EPA 8260B/8260C	TO14A/TO15
n-Heptane	---------------------------------------	---------------------------------------	TO14A/TO15
n-Nonane	---------------------------------------	---------------------------------------	TO14A/TO15
n-Octane	---------------------------------------	---------------------------------------	TO14A/TO15
n-Propylbenzene	EPA 8260B/8260C	EPA 8260B/8260C	TO14A/TO15
o-Xylene	EPA 8260B/8260C	EPA 8260B/8260C	TO14A/TO15/ TO15 SIM
Pentane	---------------------------------------	---------------------------------------	TO14A/TO15
Propene	---------------------------------------	---------------------------------------	TO14A/TO15
sec-Butylbenzene	EPA 8260B/8260C	EPA 8260B/8260C	TO14A/TO15
Styrene	EPA 8260B/8260C	EPA 8260B/8260C	TO14A/TO15/ TO15 SIM
t-Amyl methyl Ether (TAME)	EPA 8260B/8260C	EPA 8260B/8260C	----------------------
t-1,4-Dichloro-2-Butene	EPA 8260B/8260C	EPA 8260B/8260C	----------------------
tert-Butylbenzene	EPA 8260B/8260C	EPA 8260B/8260C	TO14A/TO15
Tetrachloroethene	EPA 8260B/8260C	EPA 8260B/8260C	TO14A/TO15/ TO15 SIM
Tetrahydrofuran	---------------------------------------	---------------------------------------	TO14A/TO15
Toluene	EPA 8260B/8260C	EPA 8260B/8260C	TO14A/TO15/ TO15 SIM
trans-1,2-Dichloroethene	EPA 8260B/8260C	EPA 8260B/8260C	TO14A/TO15/ TO15 SIM
trans-1,3-Dichloropropene	EPA 8260B/8260C	EPA 8260B/8260C	TO14A/TO15/ TO15 SIM

Parameter/Analyte	Non-Potable Water	Solid/Hazardous Waste	Air
Trichloroethene	EPA 8260B/8260C	EPA 8260B/8260C	TO14A/TO15/ TO15 SIM
Trichlorofluoromethane	EPA 8260B/8260C	EPA 8260B/8260C	TO14A/TO15/ TO15 SIM
Vinyl Acetate	EPA 8260B/8260C	EPA 8260B/8260C	TO14A/TO15
Vinyl Bromide	---------------------------------------	---------------------------------------	TO14A/TO15
Vinyl Chloride	EPA 8260B/8260C	EPA 8260B/8260C	TO14A/TO15/ TO15 SIM
Xylenes, Total	EPA 8260B/8260C	EPA 8260B/8260C	TO14A/TO15/ TO15 SIM
Carbon Dioxide	---------------------------------------	---------------------------------------	ASTM1946D/3C
Nitrogen	---------------------------------------	---------------------------------------	ASTM1946D/3C
Oxygen	---------------------------------------	---------------------------------------	ASTM1946D/3C
Helium	---------------------------------------	---------------------------------------	ASTM1946D/3C
Hydrogen	---------------------------------------	---------------------------------------	ASTM1946D/3C
Methane	---------------------------------------	---------------------------------------	ASTM1946D/3C
Gasoline Range Organics (GRO)	EPA 8260B/AK101MS	EPA 8260B/AK101MS	TO14A/TO15
TPH as Gasoline	EPA 8260B/AK101MS	EPA 8260B/AK101MS	TO14A/TO15
Extractable Organics **(semivolatiles)**			
1,2,4,5-Tetrachlorobenzene	EPA 8270C/8270D	EPA 8270C/8270D	----------------------
1,2,4-Trichlorobenzene	EPA 8270C/8270D	EPA 8270C/8270D	TO-13A
1,2-Dichlorobenzene	EPA 8270C/8270D	EPA 8270C/8270D	TO-13A
1,2-Diphenylhydrazine (as Azobenzene)	EPA 8270C/8270D	EPA 8270C/8270D	----------------------
1,3-Dichlorobenzene	EPA 8270C/8270D	EPA 8270C/8270D	TO-13A
1,3-Dinitrobenzene	EPA 8270C/8270D	EPA 8270C/8270D	TO-13A
1,4-Dichlorobenzene	EPA 8270C/8270D	EPA 8270C/8270D	TO-13A
1-Methylnaphthalene	EPA 8270C/8270D/8270C-SIM/ 8270D-SIM	EPA 8270C/8270D/8270C-SIM/ 8270D-SIM	WS-MS-0006/ TO-13A/ TO-13A Modified
2,3,4,6-Tetrachlorophenol	EPA 8270C/8270D	EPA 8270C/8270D	TO-13A
2,4,5-Trichlorophenol	EPA 8270C/8270D	EPA 8270C/8270D	TO-13A
2,4,6-Trichlorophenol	EPA 8270C/8270D	EPA 8270C/8270D	TO-13A
2,4-Dichlorophenol	EPA 8270C/8270D	EPA 8270C/8270D	TO-13A
2,4-Dimethylphenol	EPA 8270C/8270D	EPA 8270C/8270D	TO-13A
2,4-Dinitrophenol	EPA 8270C/8270D	EPA 8270C/8270D	TO-13A
2,4-Dinitrotoluene	EPA 8270C/8270D	EPA 8270C/8270D	TO-13A
2,6-Dichlorophenol	EPA 8270C/8270D	EPA 8270C/8270D	TO-13A
2,6-Dinitrotoluene	EPA 8270C/8270D	EPA 8270C/8270D	TO-13A
2-Chloronaphthalene	EPA 8270C/8270D	EPA 8270C/8270D	TO-13A
2-Chlorophenol	EPA 8270C/8270D	EPA 8270C/8270D	TO-13A
2-Methylnaphthalene	EPA 8270C/8270D/8270C-SIM/ 8270D-SIM	EPA 8270C/8270D/8270C-SIM/ 8270D-SIM	WS-MS-0006/ TO-13A/ TO-13A Modified

Parameter/Analyte	Non-Potable Water	Solid/Hazardous Waste	Air
2-Methylphenol	EPA 8270C/8270D	EPA 8270C/8270D	TO-13A
2-Nitroaniline	EPA 8270C/8270D	EPA 8270C/8270D	TO-13A
2-Nitrophenol	EPA 8270C/8270D	EPA 8270C/8270D	TO-13A
3&4-Methylphenol	EPA 8270C/8270D	EPA 8270C/8270D	TO-13A
3,3'-Dichlorobenzidine	EPA 8270C/8270D	EPA 8270C/8270D	TO-13A
3-Nitroaniline	EPA 8270C/8270D	EPA 8270C/8270D	TO-13A
4,6-Dinitro-2-methylphenol	EPA 8270C/8270D	EPA 8270C/8270D	TO-13A
4-Bromophenyl phenyl ether	EPA 8270C/8270D	EPA 8270C/8270D	TO-13A
4-Chloro-3-methylphenol	EPA 8270C/8270D	EPA 8270C/8270D	TO-13A
4-Chloroaniline	EPA 8270C/8270D	EPA 8270C/8270D	TO-13A
4-Chlorophenyl phenyl ether	EPA 8270C/8270D	EPA 8270C/8270D	TO-13A
4-Nitroaniline	EPA 8270C/8270D	EPA 8270C/8270D	TO-13A
4-Nitrophenol	EPA 8270C/8270D	EPA 8270C/8270D	TO-13A
Acenaphthene	EPA 8270C/8270D/8270C-SIM/ 8270D-SIM	EPA 8270C/8270D/8270C-SIM/ 8270D-SIM	WS-MS-0006/ TO-13A/ TO-13A Modified
Acenaphthylene	EPA 8270C/8270D/8270C-SIM/ 8270D-SIM	EPA 8270C/8270D/8270C-SIM/ 8270D-SIM	WS-MS-0006/ TO-13A/ TO-13A Modified
Aniline	EPA 8270C/8270D	EPA 8270C/8270D	TO-13A
Anthracene	EPA 8270C/8270D/8270C-SIM/ 8270D-SIM	EPA 8270C/8270D/8270C-SIM/ 8270D-SIM	WS-MS-0006/ TO-13A/ TO-13A Modified
Benzo(a)anthracene	EPA 8270C/8270D/8270C-SIM/ 8270D-SIM	EPA 8270C/8270D/8270C-SIM/ 8270D-SIM	WS-MS-0006/ TO-13A/ TO-13A Modified
Benzo(a)pyrene	EPA 8270C/8270D/8270C-SIM/ 8270D-SIM	EPA 8270C/8270D/8270C-SIM/ 8270D-SIM	WS-MS-0006/ TO-13A/ TO-13A Modified
Benzo(b)fluoranthene	EPA 8270C/8270D/8270C-SIM/ 8270D-SIM	EPA 8270C/8270D/8270C-SIM/ 8270D-SIM	WS-MS-0006/ TO-13A/ TO-13A Modified
Benzo(g,h,i)perylene	EPA 8270C/8270D/8270C-SIM/ 8270D-SIM	EPA 8270C/8270D/8270C-SIM/ 8270D-SIM	WS-MS-0006/ TO-13A/ TO-13A Modified
Benzo(k)fluoranthene	EPA 8270C/8270D/8270C-SIM/ 8270D-SIM	EPA 8270C/8270D/8270C-SIM/ 8270D-SIM	WS-MS-0006/ TO-13A/ TO-13A Modified
Benzoic Acid	EPA 8270C/8270D	EPA 8270C/8270D	TO-13A
Benzyl Alcohol	EPA 8270C/8270D	EPA 8270C/8270D	TO-13A
Benzyl butyl Phthalate	EPA 8270C/8270D	EPA 8270C/8270D	TO-13A
Biphenyl	EPA 8270C/8270D	EPA 8270C/8270D	TO-13A
Bis(2-chloroethoxy) Methane	EPA 8270C/8270D	EPA 8270C/8270D	TO-13A
Bis(2-chloroethyl) Ether	EPA 8270C/8270D	EPA 8270C/8270D	TO-13A
Bis(2-chloroisopropyl) Ether	EPA 8270C/8270D	EPA 8270C/8270D	TO-13A
Carbazole	EPA 8270C/8270D	EPA 8270C/8270D	TO-13A
Chrysene	EPA 8270C/8270D/8270C-SIM/ 8270D-SIM	EPA 8270C/8270D/8270C-SIM/ 8270D-SIM	WS-MS-0006/ TO-13A/

Parameter/Analyte	Non-Potable Water	Solid/Hazardous Waste	Air
			TO-13A Modified
Bis (2-ethylhexyl) Phthalate	EPA 8270C/8270D	EPA 8270C/8270D	TO-13A
Dibenz(a,h)anthracene	EPA 8270C/8270D/8270C-SIM/ 8270D-SIM	EPA 8270C/8270D/8270C-SIM/ 8270D-SIM	WS-MS-0006/ TO-13A/ TO-13A Modified
Dibenzofuran	EPA 8270C/8270D	EPA 8270C/8270D	TO-13A
Diethyl Phthalate	EPA 8270C/8270D	EPA 8270C/8270D	TO-13A
Dimethyl Phthalate	EPA 8270C/8270D	EPA 8270C/8270D	TO-13A
Di-n-butyl Phthalate	EPA 8270C/8270D	EPA 8270C/8270D	TO-13A
Di-n-octyl Phthalate	EPA 8270C/8270D	EPA 8270C/8270D	TO-13A
Fluoranthene	EPA 8270C/8270D/8270C-SIM/ 8270D-SIM	EPA 8270C/8270D/8270C-SIM/ 8270D-SIM	WS-MS-0006/ TO-13A/ TO-13A Modified
Fluorene	EPA 8270C/8270D/8270C-SIM/ 8270D-SIM	EPA 8270C/8270D/8270C-SIM/ 8270D-SIM	WS-MS-0006/ TO-13A/ TO-13A Modified
Hexachlorobenzene	EPA 8270C/8270D	EPA 8270C/8270D	TO-13A
Hexachlorobutadiene	EPA 8270C/8270D	EPA 8270C/8270D	TO-13A
Hexachlorocyclopentadiene	EPA 8270C/8270D	EPA 8270C/8270D	TO-13A
Hexachloroethane	EPA 8270C/8270D	EPA 8270C/8270D	TO-13A
Indeno(1,2,3-c,d) Pyrene	EPA 8270C/8270D/8270C-SIM/ 8270D-SIM	EPA 8270C/8270D/8270C-SIM/ 8270D-SIM	WS-MS-0006/ TO-13A/ TO-13A Modified
Isophorone	EPA 8270C/8270D	EPA 8270C/8270D	TO-13A
Naphthalene	EPA 8270C/8270D/8270C-SIM/ 8270D-SIM	EPA 8270C/8270D/8270C-SIM/ 8270D-SIM	WS-MS-0006/ TO-13A/ TO-13A Modified
Nitrobenzene	EPA 8270C/8270D	EPA 8270C/8270D	TO-13A
n-Nitrosodimethylamine	EPA 8270C/8270D	EPA 8270C/8270D	TO-13A
n-Nitrosodi-n-propylamine	EPA 8270C/8270D	EPA 8270C/8270D	TO-13A
n-Nitrosodiphenylamine	EPA 8270C/8270D	EPA 8270C/8270D	TO-13A
Pentachlorophenol	EPA 8270C/8270D	EPA 8270C/8270D	TO-13A
Phenanthrene	EPA 8270C/8270D/8270C-SIM/ 8270D-SIM	EPA 8270C/8270D/8270C-SIM/ 8270D-SIM/	WS-MS-0006/ TO-13A/ TO-13A Modified
Phenol	EPA 8270C/8270D	EPA 8270C/8270D	TO-13A
Pyrene	EPA 8270C/8270D/8270C-SIM/ 8270D-SIM	EPA 8270C/8270D/8270C-SIM/ 8270D-SIM	WS-MS-0006/ TO-13A/ TO-13A Modified
Pyridine	WS-MS-0005	WS-MS-0005	---------------------
1,4-Dioxane	WS-MS-0011/8270C-SIM Modified	WS-MS-0011/8270C-SIM Modified	----------------------
Diesel Range Organics (DRO)	EPA 8015B/8015C/8015D/ AK102	EPA 8015B/8015C8015D/ AK102	----------------------
Residual Range Organics	AK103	AK103	----------------------
Motor Oil Range Organics (MRO)	EPA 8015B/8015C8015D	EPA 8015B/8015C8015D	----------------------

Parameter/Analyte	Non-Potable Water	Solid/Hazardous Waste	Air
Dioxins			
2,3,7,8-TeCDD	EPA 8280A/8280B/8290/8290A/1613B	EPA 8280A/8280B/ 8290/8290A/1613B	----------------------
1,2,3,7,8-PeCDD	EPA 8280A/8280B/8290/8290A/1613B	EPA 8280A/8280B/ 8290/8290A/1613B	----------------------
1,2,3,4,7,8-HxCDD	EPA 8280A/8280B/8290/8290A/1613B	EPA 8280A/8280B/ 8290/8290A/1613B	----------------------
1,2,3,6,7,8-HxCDD	EPA 8280A/8280B/8290/8290A/1613B	EPA 8280A/8280B/ 8290/8290A/1613B	----------------------
1,2,3,7,8,9-HxCDD	EPA 8280A/8280B/8290/8290A/1613B	EPA 8280A/8280B/ 8290/8290A/1613B	----------------------
1,2,3,4,6,7,8-HpCDD	EPA 8280A/8280B/8290/8290A/1613B	EPA 8280A/8280B/ 8290/8290A/1613B	----------------------
OCDD	EPA 8280A/8280B/8290/8290A/1613B	EPA 8280A/8280B/ 8290/8290A/1613B	----------------------
2,3,7,8-TeCDF	EPA 8280A/8280B/8290/8290A/1613B	EPA 8280A/8280B/ 8290/8290A/1613B	----------------------
1,2,3,7,8-PeCDF	EPA 8280A/8280B/8290/8290A/1613B	EPA 8280A/8280B/ 8290/8290A/1613B	----------------------
2,3,4,7,8-PeCDF	EPA 8280A/8280B/8290/8290A/1613B	EPA 8280A/8280B/ 8290/8290A/1613B	----------------------
1,2,3,4,7,8-HxCDF	EPA 8280A/8280B/8290/8290A/1613B	EPA 8280A/8280B/ 8290/8290A/1613B	----------------------
1,2,3,6,7,8-HxCDF	EPA 8280A/8280B/8290/8290A/1613B	EPA 8280A/8280B/ 8290/8290A/1613B	----------------------
1,2,3,7,8,9-HxCDF	EPA 8280A/8280B/8290/8290A/1613B	EPA 8280A/8280B/ 8290/8290A/1613B	----------------------
2,3,4,6,7,8-HxCDF	EPA 8280A/8280B/8290/8290A/1613B	EPA 8280A/8280B/ 8290/8290A/1613B	----------------------
1,2,3,4,6,7,8-HpCDF	EPA 8280A/8280B/8290/8290A/1613B	EPA 8280A/8280B/ 8290/8290A/1613B	----------------------
1,2,3,4,7,8,9-HpCDF	EPA 8280A/8280B/8290/8290A/1613B	EPA 8280A/8280B/ 8290/8290A/1613B	----------------------
OCDF	EPA 8280A/8280B/8290/8290A/1613B	EPA 8280A/8280B/ 8290/8290A/1613B	----------------------
Total TCDD	EPA 8280A/8280B/8290/8290A/1613B	EPA 8280A/8280B/ 8290/8290A/1613B	----------------------
Total PeCDD	EPA 8280A/8280B/8290/8290A/1613B	EPA 8280A/8280B/ 8290/8290A/1613B	----------------------
Total HxCDD	EPA 8280A/8280B/8290/8290A/1613B	EPA 8280A/8280B/ 8290/8290A/1613B	----------------------
Total HeptaCDD	EPA 8280A/8280B/8290/8290A/1613B	EPA 8280A/8280B/ 8290/8290A/1613B	----------------------
Total TCDF	EPA 8280A/8280B/8290/8290A/1613B	EPA 8280A/8280B/ 8290/8290A/1613B	----------------------
Total PeCDF	EPA 8280A/8280B/8290/8290A/1613B	EPA 8280A/8280B/ 8290/8290A/1613B	----------------------
Total HxCDF	EPA 8280A/8280B/8290/8290A/1613B	EPA 8280A/8280B/ 8290/8290A/1613B	----------------------
Total HpCDF	EPA 8280A/8280B/8290/8290A/1613B	EPA 8280A/8280B/ 8290/8290A/1613B	----------------------

Parameter/Analyte	Non-Potable Water	Solid/Hazardous Waste	Air
Chemical Warfare Degradates			
1,4-Dithiane	WS-MS-0003/8270C-SIM Modified	WS-MS-0003/8270C-SIM Modified	----------------------
Benzothiazole	WS-MS-0003/8270C-SIM Modified	WS-MS-0003/8270C-SIM Modified	----------------------
p-Chlorophenyl methylsulfide	WS-MS-0003/8270C-SIM Modified	WS-MS-0003/8270C-SIM Modified	----------------------
p-Chlorophenyl methylsulfoxide	WS-MS-0003/8270C-SIM Modified	WS-MS-0003/8270C-SIM Modified	----------------------
p-Chlorophenyl methylsulfone	WS-MS-0003/8270C-SIM Modified	WS-MS-0003/8270C-SIM Modified	----------------------
Chloropicrin	WS-MS-0003/8270C-SIM Modified	WS-MS-0003/8270C-SIM Modified	----------------------
Acetophenone	WS-MS-0003/8270C-SIM Modified	WS-MS-0003/8270C-SIM Modified	----------------------
2-Chloroacetophenone	WS-MS-0003/8270C-SIM Modified	WS-MS-0003/8270C-SIM Modified	----------------------
1,4-Oxathiane	WS-MS-0003/8270C-SIM Modified	WS-MS-0003/8270C-SIM Modified	----------------------
Diisopropylmethylphosphate (DIMP)	WS-LC-0004/8321A Modified	WS-LC-0004/8321A Modified	----------------------
Dimethylmethylphosphonate (DMMP)	WS-LC-0004/8321A Modified	WS-LC-0004/8321A Modified	----------------------
Ethyl methylphosphonic acid (EMPA)	WS-LC-0004/8321A Modified	WS-LC-0004/8321A Modified	----------------------
Isopropyl methylphosphonic acid (IMPA)	WS-LC-0004/8321A Modified	WS-LC-0004/8321A Modified	----------------------
Methylphosphonic acid (MPA)	WS-LC-0004/8321A Modified	WS-LC-0004/8321A Modified	----------------------
Thiodiglycol (2,2'-Thiodiethanol) (TDG)	WS-LC-0004/8321A Modified	WS-LC-0004/8321A Modified	----------------------
Nitroaromatics			----------------------
2-Amino-4,6-dinitrotoluene	EPA 8330A/8330B	EPA 8330A/8330B	----------------------
4-Amino-2,6-dinitrotoluene	EPA 8330A/8330B	EPA 8330A/8330B	----------------------
3,5-Dinitroaniline	EPA 8330A/8330B	EPA 8330A/8330B	----------------------
1,3-Dinitrobenzene	EPA 8330A/8330B	EPA 8330A/8330B	----------------------
2,4-Dinitrotoluene	EPA 8330A/8330B	EPA 8330A/8330B	----------------------
2,6-Dinitrotoluene	EPA 8330A/8330B	EPA 8330A/8330B	----------------------
Glycerol trinitrate (Nitroglycerin)	EPA 8330A/8330B	EPA 8330A/8330B	----------------------
Hexahydro-1,3,5-trinitro-1,3,5-triazine (Hexogen)	EPA 8330A/8330B	EPA 8330A/8330B	----------------------
Methyl-2,4,6-trinitrophenylnitramine	EPA 8330A/8330B	EPA 8330A/8330B	----------------------
Nitrobenzene	EPA 8330A/8330B	EPA 8330A/8330B	----------------------
2-Nitrotoluene (o-Nitrotoluene)	EPA 8330A/8330B	EPA 8330A/8330B	----------------------

Parameter/Analyte	Non-Potable Water	Solid/Hazardous Waste	Air
3-Nitrotoluene (m-Nitrotoluene)	EPA 8330A/8330B	EPA 8330A/8330B	----------------------
4-Nitrotoluene (p-Nitrotoluene)	EPA 8330A/8330B	EPA 8330A/8330B	----------------------
Octahydro-1,3,5,7-tetranitro1,3,5,7-tetracine (Octogen)	EPA 8330A/8330B	EPA 8330A/8330B	----------------------
Picric acid	EPA 8330A/8330B	EPA 8330A/8330B	----------------------
Pentaerythritol Tetranitrate	EPA 8330A/8330B	EPA 8330A/8330B	----------------------
1,3,5-Trinitrobenzene	EPA 8330A/8330B	EPA 8330A/8330B	----------------------
2,4,6-Trinitrotoluene	EPA 8330A/8330B	EPA 8330A/8330B	----------------------
Hexahydro-1,3-dinitroso-5-nitro-1,3,5,triazine (DNX)	EPA 8330A/8330B	EPA 8330A/8330B	----------------------
Hexahydro-1,3,5-trinitroso-1,3,5-triazine (TNX)	EPA 8330A/8330B	EPA 8330A/8330B	----------------------
1-Nitroso-3,5-dinitro-1,3,5-triazacyclohexane (MNX)	EPA 8330A/8330B	EPA 8330A/8330B	----------------------
Nitroguanidine	WS-LC-0010/8330A Modified	WS-LC-0010/8330A Modified	----------------------
Nitrosamines			
N-Nitrosodimethyl amine (NDMA)	WS-MS-0012/521 Modified	WS-MS-0012/521 Modified	----------------------
Perfluoro Compounds			----------------------
6:2 Fluorotelomer sulfonate (6:2 FTS)	WS-LC-0025/537 Modified	WS-LC-0025/537 Modified	----------------------
8:2 Fluorotelomer sulfonate (8:2 FTS)	WS-LC-0025/537 Modified	WS-LC-0025/537 Modified	----------------------
2-(N-ethylperfluoro-1-octanesulfonamido)-ethanol [N-Et-FOSE]	WS-ID-0021/8290 Modified	WS-ID-0021/8290 Modified	----------------------
2-(N-Methylperfluoro-1-octanesulfonamido)-ethanol [N-Me-FOSE]	WS-ID-0021/8290 Modified	WS-ID-0021/8290 Modified	----------------------
N-Ethyl perfluorooctane sulfonamide (EtFOSA)	WS-LC-0025/537 Modified	WS-LC-0025/537 Modified	----------------------
N-Ethyl perfluorooctanesulfon amidacetic acid (EtFOSAA)	WS-LC-0025/537 Modified	WS-LC-0025/537 Modified	----------------------
N-Methyl perfluorooctane sulfonamide (MeFOSA)	WS-LC-0025/537 Modified	WS-LC-0025/537 Modified	----------------------
N-Methyl perfluorooctanesulfon amidoacetic acide (MeFOSAA)	WS-LC-0025/537 Modified	WS-LC-0025/537 Modified	----------------------
Perfluorooctanoic acid	WS-LC-0025/537 Modified	WS-LC-0025/537 Modified	----------------------
Perfluorooctane Sulfonate	WS-LC-0025/537 Modified	WS-LC-0025/537 Modified	----------------------
Perfluorobutyric acid (PFBA)	WS-LC-0025/537 Modified	WS-LC-0025/537 Modified	----------------------
Perfluoropentanoic acid (PFPA)	WS-LC-0025/537 Modified	WS-LC-0025/537 Modified	----------------------

Parameter/Analyte	Non-Potable Water	Solid/Hazardous Waste	Air
Perfluorohexanoic acid (PFHxA)	WS-LC-0025/537 Modified	WS-LC-0025/537 Modified	----------------------
Perfluoroheptanoic acid (PFHpA)	WS-LC-0025/537 Modified	WS-LC-0025/537 Modified	----------------------
Perfluorononanoic acid (PFNA)	WS-LC-0025/537 Modified	WS-LC-0025/537 Modified	----------------------
Perfluorodecanoic acid (PFDA)	WS-LC-0025/537 Modified	WS-LC-0025/537 Modified	----------------------
Perfluoroundecanoic acid (PFUDA)	WS-LC-0025/537 Modified	WS-LC-0025/537 Modified	----------------------
Perfluorododecanoic acid (PFDoDA)	WS-LC-0025/537 Modified	WS-LC-0025/537 Modified	----------------------
Perfluorotridecanoic acid (PFTriA)	WS-LC-0025/537 Modified	WS-LC-0025/537 Modified	----------------------
Perfluorotetradecanoic acid (PDTeA)	WS-LC-0025/537 Modified	WS-LC-0025/537 Modified	----------------------
Perfluorobutane Sulfonate (PFBS)	WS-LC-0025/537 Modified	WS-LC-0025/537 Modified	----------------------
Perfluorohexane Sulfonate (PFHxS)	WS-LC-0025/537 Modified	WS-LC-0025/537 Modified	----------------------
Perfluoroheptane Sulfonate (PFHpS)	WS-LC-0025/537 Modified	WS-LC-0025/537 Modified	----------------------
Perfluorodecane Sulfonate (PFDS)	WS-LC-0025/537 Modified	WS-LC-0025/537 Modified	----------------------
Perfluoroocatane Sulfonamide (FOSA)	WS-LC-0025/537 Modified	WS-LC-0025/537 Modified	----------------------
Pesticides/PCBs			
Aldrin	EPA 8081A/8081B	EPA 8081A/8081B	----------------------
a-BHC	EPA 8081A/8081B	EPA 8081A/8081B	----------------------
b-BHC	EPA 8081A/8081B	EPA 8081A/8081B	----------------------
d-BHC	EPA 8081A/8081B	EPA 8081A/8081B	----------------------
g-BHC (Lindane)	EPA 8081A/8081B	EPA 8081A/8081B	----------------------
a-Chlordane	EPA 8081A/8081B	EPA 8081A/8081B	----------------------
g-Chlordane	EPA 8081A/8081B	EPA 8081A/8081B	----------------------
4,4'-DDD	EPA 8081A/8081B	EPA 8081A/8081B	----------------------
4,4'-DDE	EPA 8081A/8081B	EPA 8081A/8081B	----------------------
4,4'-DDT	EPA 8081A/8081B	EPA 8081A/8081B	----------------------
Dieldrin	EPA 8081A/8081B	EPA 8081A/8081B	----------------------
Endosulfan I	EPA 8081A/8081B	EPA 8081A/8081B	----------------------
Endosulfan II	EPA 8081A/8081B	EPA 8081A/8081B	----------------------
Endosulfan sulfate	EPA 8081A/8081B	EPA 8081A/8081B	----------------------
Endrin	EPA 8081A/8081B	EPA 8081A/8081B	----------------------
Endrin Aldehyde	EPA 8081A/8081B	EPA 8081A/8081B	----------------------
Endrin Ketone	EPA 8081A/8081B	EPA 8081A/8081B	----------------------
Heptachlor	EPA 8081A/8081B	EPA 8081A/8081B	----------------------
Heptachlor Epoxide	EPA 8081A/8081B	EPA 8081A/8081B	----------------------
Methoxychlor	EPA 8081A/8081B	EPA 8081A/8081B	----------------------

Parameter/Analyte	Non-Potable Water	Solid/Hazardous Waste	Air
Toxaphene	EPA 8081A/8081B	EPA 8081A/8081B	----------------------
Chlordane (technical)	EPA 8081A/8081B	EPA 8081A/8081B	----------------------
PCB (Aroclors)			
PCB-1016	EPA 8082/8082A	EPA 8082/8082A	TO-4A/TO-10A
PCB-1221	EPA 8082/8082A	EPA 8082/8082A	TO-4A/TO-10A
PCB-1232	EPA 8082/8082A	EPA 8082/8082A	TO-4A/TO-10A
PCB-1242	EPA 8082/8082A	EPA 8082/8082A	TO-4A/TO-10A
PCB-1248	EPA 8082/8082A	EPA 8082/8082A	TO-4A/TO-10A
PCB-1254	EPA 8082/8082A	EPA 8082/8082A	TO-4A/TO-10A
PCB-1260	EPA 8082/8082A	EPA 8082/8082A	TO-4A/TO-10A
PCB-1262	EPA 8082/8082A	EPA 8082/8082A	TO-4A/TO-10A
PCB-1268	EPA 8082/8082A	EPA 8082/8082A	TO-4A/TO-10A
PCB (congeners) – removed references to BZ and IUPAC numbers.			
PCB 1	EPA 1668A/1668C	EPA 1668A/1668C	----------------------
PCB 2	EPA 1668A/1668C	EPA 1668A/1668C	----------------------
PCB 3	EPA 1668A/1668C	EPA 1668A/1668C	----------------------
PCB 4	EPA 1668A/1668C	EPA 1668A/1668C	----------------------
PCB 5	EPA 1668A/1668C	EPA 1668A/1668C	----------------------
PCB 6	EPA 1668A/1668C	EPA 1668A/1668C	----------------------
PCB 7	EPA 1668A/1668C	EPA 1668A/1668C	----------------------
PCB 8	EPA 1668A/1668C	EPA 1668A/1668C	----------------------
PCB 9	EPA 1668A/1668C	EPA 1668A/1668C	----------------------
PCB 10	EPA 1668A/1668C	EPA 1668A/1668C	----------------------
PCB 11	EPA 1668A/1668C	EPA 1668A/1668C	----------------------
PCB 12	EPA 1668A/1668C	EPA 1668A/1668C	----------------------
PCB 13	EPA 1668A/1668C	EPA 1668A/1668C	----------------------
PCB 14	EPA 1668A/1668C	EPA 1668A/1668C	----------------------
PCB 15	EPA 1668A/1668C	EPA 1668A/1668C	----------------------
PCB 16	EPA 1668A/1668C	EPA 1668A/1668C	----------------------
PCB 17	EPA 1668A/1668C	EPA 1668A/1668C	----------------------
PCB 18	EPA 1668A/1668C	EPA 1668A/1668C	----------------------
PCB 19	EPA 1668A/1668C	EPA 1668A/1668C	----------------------
PCB 20	EPA 1668A/1668C	EPA 1668A/1668C	----------------------
PCB 21	EPA 1668A/1668C	EPA 1668A/1668C	----------------------
PCB 22	EPA 1668A/1668C	EPA 1668A/1668C	----------------------
PCB 23	EPA 1668A/1668C	EPA 1668A/1668C	----------------------
PCB 24	EPA 1668A/1668C	EPA 1668A/1668C	----------------------
PCB 25	EPA 1668A/1668C	EPA 1668A/1668C	----------------------
PCB 26	EPA 1668A/1668C	EPA 1668A/1668C	----------------------
PCB 27	EPA 1668A/1668C	EPA 1668A/1668C	----------------------

Parameter/Analyte	Non-Potable Water	Solid/Hazardous Waste	Air
PCB 28	EPA 1668A/1668C	EPA 1668A/1668C	----------------------
PCB 29	EPA 1668A/1668C	EPA 1668A/1668C	----------------------
PCB 30	EPA 1668A/1668C	EPA 1668A/1668C	----------------------
PCB 32	EPA 1668A/1668C	EPA 1668A/1668C	----------------------
PCB 31	EPA 1668A/1668C	EPA 1668A/1668C	----------------------
PCB 33	EPA 1668A/1668C	EPA 1668A/1668C	----------------------
PCB 34	EPA 1668A/1668C	EPA 1668A/1668C	----------------------
PCB 35	EPA 1668A/1668C	EPA 1668A/1668C	----------------------
PCB 36	EPA 1668A/1668C	EPA 1668A/1668C	----------------------
PCB 37	EPA 1668A/1668C	EPA 1668A/1668C	----------------------
PCB 38	EPA 1668A/1668C	EPA 1668A/1668C	----------------------
PCB 39	EPA 1668A/1668C	EPA 1668A/1668C	----------------------
PCB 40	EPA 1668A/1668C	EPA 1668A/1668C	----------------------
PCB 41	EPA 1668A/1668C	EPA 1668A/1668C	----------------------
PCB 42	EPA 1668A/1668C	EPA 1668A/1668C	----------------------
PCB 43	EPA 1668A/1668C	EPA 1668A/1668C	----------------------
PCB 44	EPA 1668A/1668C	EPA 1668A/1668C	----------------------
PCB 45	EPA 1668A/1668C	EPA 1668A/1668C	----------------------
PCB 46	EPA 1668A/1668C	EPA 1668A/1668C	----------------------
PCB 47	EPA 1668A/1668C	EPA 1668A/1668C	----------------------
PCB 48	EPA 1668A/1668C	EPA 1668A/1668C	----------------------
PCB 49	EPA 1668A/1668C	EPA 1668A/1668C	----------------------
PCB 50	EPA 1668A/1668C	EPA 1668A/1668C	----------------------
PCB 51	EPA 1668A/1668C	EPA 1668A/1668C	----------------------
PCB 52	EPA 1668A/1668C	EPA 1668A/1668C	----------------------
PCB 53	EPA 1668A/1668C	EPA 1668A/1668C	----------------------
PCB 54	EPA 1668A/1668C	EPA 1668A/1668C	----------------------
PCB 55	EPA 1668A/1668C	EPA 1668A/1668C	----------------------
PCB 56	EPA 1668A/1668C	EPA 1668A/1668C	----------------------
PCB 57	EPA 1668A/1668C	EPA 1668A/1668C	----------------------
PCB 58	EPA 1668A/1668C	EPA 1668A/1668C	----------------------
PCB 59	EPA 1668A/1668C	EPA 1668A/1668C	----------------------
PCB 60	EPA 1668A/1668C	EPA 1668A/1668C	----------------------
PCB 61	EPA 1668A/1668C	EPA 1668A/1668C	----------------------
PCB 62	EPA 1668A/1668C	EPA 1668A/1668C	----------------------
PCB 63	EPA 1668A/1668C	EPA 1668A/1668C	----------------------
PCB 64	EPA 1668A/1668C	EPA 1668A/1668C	----------------------
PCB 65	EPA 1668A/1668C	EPA 1668A/1668C	----------------------
PCB 66	EPA 1668A/1668C	EPA 1668A/1668C	----------------------
PCB 67	EPA 1668A/1668C	EPA 1668A/1668C	----------------------
PCB 68	EPA 1668A/1668C	EPA 1668A/1668C	----------------------
PCB 69	EPA 1668A/1668C	EPA 1668A/1668C	----------------------
PCB 70	EPA 1668A/1668C	EPA 1668A/1668C	----------------------

Parameter/Analyte	Non-Potable Water	Solid/Hazardous Waste	Air
PCB 71	EPA 1668A/1668C	EPA 1668A/1668C	----------------------
PCB 72	EPA 1668A/1668C	EPA 1668A/1668C	----------------------
PCB 73	EPA 1668A/1668C	EPA 1668A/1668C	----------------------
PCB 74	EPA 1668A/1668C	EPA 1668A/1668C	----------------------
PCB 75	EPA 1668A/1668C	EPA 1668A/1668C	----------------------
PCB 76	EPA 1668A/1668C	EPA 1668A/1668C	----------------------
PCB 77	EPA 1668A/1668C	EPA 1668A/1668C	----------------------
PCB 78	EPA 1668A/1668C	EPA 1668A/1668C	----------------------
PCB 79	EPA 1668A/1668C	EPA 1668A/1668C	----------------------
PCB 80	EPA 1668A/1668C	EPA 1668A/1668C	----------------------
PCB 81	EPA 1668A/1668C	EPA 1668A/1668C	----------------------
PCB 82	EPA 1668A/1668C	EPA 1668A/1668C	----------------------
PCB 83	EPA 1668A/1668C	EPA 1668A/1668C	----------------------
PCB 84	EPA 1668A/1668C	EPA 1668A/1668C	----------------------
PCB 85	EPA 1668A/1668C	EPA 1668A/1668C	----------------------
PCB 86	EPA 1668A/1668C	EPA 1668A/1668C	----------------------
PCB 87	EPA 1668A/1668C	EPA 1668A/1668C	----------------------
PCB 88	EPA 1668A/1668C	EPA 1668A/1668C	----------------------
PCB 89	EPA 1668A/1668C	EPA 1668A/1668C	----------------------
PCB 90	EPA 1668A/1668C	EPA 1668A/1668C	----------------------
PCB 91	EPA 1668A/1668C	EPA 1668A/1668C	----------------------
PCB 92	EPA 1668A/1668C	EPA 1668A/1668C	----------------------
PCB 93	EPA 1668A/1668C	EPA 1668A/1668C	----------------------
PCB 94	EPA 1668A/1668C	EPA 1668A/1668C	----------------------
PCB 95	EPA 1668A/1668C	EPA 1668A/1668C	----------------------
PCB 96	EPA 1668A/1668C	EPA 1668A/1668C	----------------------
PCB 97	EPA 1668A/1668C	EPA 1668A/1668C	----------------------
PCB 98	EPA 1668A/1668C	EPA 1668A/1668C	----------------------
PCB 99	EPA 1668A/1668C	EPA 1668A/1668C	----------------------
PCB 100	EPA 1668A/1668C	EPA 1668A/1668C	----------------------
PCB 101	EPA 1668A/1668C	EPA 1668A/1668C	----------------------
PCB 102	EPA 1668A/1668C	EPA 1668A/1668C	----------------------
PCB 103	EPA 1668A/1668C	EPA 1668A/1668C	----------------------
PCB 104	EPA 1668A/1668C	EPA 1668A/1668C	----------------------
PCB 105	EPA 1668A/1668C	EPA 1668A/1668C	----------------------
PCB 106	EPA 1668A/1668C	EPA 1668A/1668C	----------------------
PCB 107	EPA 1668A/1668C	EPA 1668A/1668C	----------------------
PCB 108	EPA 1668A/1668C	EPA 1668A/1668C	----------------------
PCB 109	EPA 1668A/1668C	EPA 1668A/1668C	----------------------
PCB 110	EPA 1668A/1668C	EPA 1668A/1668C	----------------------
PCB 111	EPA 1668A/1668C	EPA 1668A/1668C	----------------------
PCB 112	EPA 1668A/1668C	EPA 1668A/1668C	----------------------
PCB 113	EPA 1668A/1668C	EPA 1668A/1668C	----------------------

Parameter/Analyte	Non-Potable Water	Solid/Hazardous Waste	Air
PCB 114	EPA 1668A/1668C	EPA 1668A/1668C	----------------------
PCB 115	EPA 1668A/1668C	EPA 1668A/1668C	----------------------
PCB 116	EPA 1668A/1668C	EPA 1668A/1668C	----------------------
PCB 117	EPA 1668A/1668C	EPA 1668A/1668C	----------------------
PCB 118	EPA 1668A/1668C	EPA 1668A/1668C	----------------------
PCB 119	EPA 1668A/1668C	EPA 1668A/1668C	----------------------
PCB 120	EPA 1668A/1668C	EPA 1668A/1668C	----------------------
PCB 121	EPA 1668A/1668C	EPA 1668A/1668C	----------------------
PCB 122	EPA 1668A/1668C	EPA 1668A/1668C	----------------------
PCB 123	EPA 1668A/1668C	EPA 1668A/1668C	----------------------
PCB 124	EPA 1668A/1668C	EPA 1668A/1668C	----------------------
PCB 125	EPA 1668A/1668C	EPA 1668A/1668C	----------------------
PCB 126	EPA 1668A/1668C	EPA 1668A/1668C	----------------------
PCB 127	EPA 1668A/1668C	EPA 1668A/1668C	----------------------
PCB 128	EPA 1668A/1668C	EPA 1668A/1668C	----------------------
PCB 129	EPA 1668A/1668C	EPA 1668A/1668C	----------------------
PCB 130	EPA 1668A/1668C	EPA 1668A/1668C	----------------------
PCB 131	EPA 1668A/1668C	EPA 1668A/1668C	----------------------
PCB 132	EPA 1668A/1668C	EPA 1668A/1668C	----------------------
PCB 133	EPA 1668A/1668C	EPA 1668A/1668C	----------------------
PCB 134	EPA 1668A/1668C	EPA 1668A/1668C	----------------------
PCB 135	EPA 1668A/1668C	EPA 1668A/1668C	----------------------
PCB 136	EPA 1668A/1668C	EPA 1668A/1668C	----------------------
PCB 137	EPA 1668A/1668C	EPA 1668A/1668C	----------------------
PCB 138	EPA 1668A/1668C	EPA 1668A/1668C	----------------------
PCB 139	EPA 1668A/1668C	EPA 1668A/1668C	----------------------
PCB 140	EPA 1668A/1668C	EPA 1668A/1668C	----------------------
PCB 141	EPA 1668A/1668C	EPA 1668A/1668C	----------------------
PCB 142	EPA 1668A/1668C	EPA 1668A/1668C	----------------------
PCB 143	EPA 1668A/1668C	EPA 1668A/1668C	----------------------
PCB 144	EPA 1668A/1668C	EPA 1668A/1668C	----------------------
PCB 145	EPA 1668A/1668C	EPA 1668A/1668C	----------------------
PCB 146	EPA 1668A/1668C	EPA 1668A/1668C	----------------------
PCB 147	EPA 1668A/1668C	EPA 1668A/1668C	----------------------
PCB 148	EPA 1668A/1668C	EPA 1668A/1668C	----------------------
PCB 149	EPA 1668A/1668C	EPA 1668A/1668C	----------------------
PCB 150	EPA 1668A/1668C	EPA 1668A/1668C	----------------------
PCB 151	EPA 1668A/1668C	EPA 1668A/1668C	----------------------
PCB 152	EPA 1668A/1668C	EPA 1668A/1668C	----------------------
PCB 153	EPA 1668A/1668C	EPA 1668A/1668C	----------------------
PCB 154	EPA 1668A/1668C	EPA 1668A/1668C	----------------------
PCB 155	EPA 1668A/1668C	EPA 1668A/1668C	----------------------
PCB 156	EPA 1668A/1668C	EPA 1668A/1668C	----------------------

Parameter/Analyte	Non-Potable Water	Solid/Hazardous Waste	Air
PCB 157	EPA 1668A/1668C	EPA 1668A/1668C	----------------------
PCB 158	EPA 1668A/1668C	EPA 1668A/1668C	----------------------
PCB 159	EPA 1668A/1668C	EPA 1668A/1668C	----------------------
PCB 160	EPA 1668A/1668C	EPA 1668A/1668C	----------------------
PCB 161	EPA 1668A/1668C	EPA 1668A/1668C	----------------------
PCB 162	EPA 1668A/1668C	EPA 1668A/1668C	----------------------
PCB 163	EPA 1668A/1668C	EPA 1668A/1668C	----------------------
PCB 164	EPA 1668A/1668C	EPA 1668A/1668C	----------------------
PCB 165	EPA 1668A/1668C	EPA 1668A/1668C	----------------------
PCB 166	EPA 1668A/1668C	EPA 1668A/1668C	----------------------
PCB 167	EPA 1668A/1668C	EPA 1668A/1668C	----------------------
PCB 168	EPA 1668A/1668C	EPA 1668A/1668C	----------------------
PCB 169	EPA 1668A/1668C	EPA 1668A/1668C	----------------------
PCB 170	EPA 1668A/1668C	EPA 1668A/1668C	----------------------
PCB 171	EPA 1668A/1668C	EPA 1668A/1668C	----------------------
PCB 172	EPA 1668A/1668C	EPA 1668A/1668C	----------------------
PCB 173	EPA 1668A/1668C	EPA 1668A/1668C	----------------------
PCB 174	EPA 1668A/1668C	EPA 1668A/1668C	----------------------
PCB 175	EPA 1668A/1668C	EPA 1668A/1668C	----------------------
PCB 176	EPA 1668A/1668C	EPA 1668A/1668C	----------------------
PCB 177	EPA 1668A/1668C	EPA 1668A/1668C	----------------------
PCB 178	EPA 1668A/1668C	EPA 1668A/1668C	----------------------
PCB 179	EPA 1668A/1668C	EPA 1668A/1668C	----------------------
PCB 180	EPA 1668A/1668C	EPA 1668A/1668C	----------------------
PCB 181	EPA 1668A/1668C	EPA 1668A/1668C	----------------------
PCB 182	EPA 1668A/1668C	EPA 1668A/1668C	----------------------
PCB 183	EPA 1668A/1668C	EPA 1668A/1668C	----------------------
PCB 184	EPA 1668A/1668C	EPA 1668A/1668C	----------------------
PCB 185	EPA 1668A/1668C	EPA 1668A/1668C	----------------------
PCB 186	EPA 1668A/1668C	EPA 1668A/1668C	----------------------
PCB 187	EPA 1668A/1668C	EPA 1668A/1668C	----------------------
PCB 188	EPA 1668A/1668C	EPA 1668A/1668C	----------------------
PCB 189	EPA 1668A/1668C	EPA 1668A/1668C	----------------------
PCB 190	EPA 1668A/1668C	EPA 1668A/1668C	----------------------
PCB 191	EPA 1668A/1668C	EPA 1668A/1668C	----------------------
PCB 192	EPA 1668A/1668C	EPA 1668A/1668C	----------------------
PCB 193	EPA 1668A/1668C	EPA 1668A/1668C	----------------------
PCB 194	EPA 1668A/1668C	EPA 1668A/1668C	----------------------
PCB 195	EPA 1668A/1668C	EPA 1668A/1668C	----------------------
PCB 196	EPA 1668A/1668C	EPA 1668A/1668C	----------------------
PCB 197	EPA 1668A/1668C	EPA 1668A/1668C	----------------------
PCB 198	EPA 1668A/1668C	EPA 1668A/1668C	----------------------
PCB 199	EPA 1668A/1668C	EPA 1668A/1668C	----------------------

Parameter/Analyte	Non-Potable Water	Solid/Hazardous Waste	Air
PCB 200	EPA 1668A/1668C	EPA 1668A/1668C	----------------------
PCB 201	EPA 1668A/1668C	EPA 1668A/1668C	----------------------
PCB 202	EPA 1668A/1668C	EPA 1668A/1668C	----------------------
PCB 203	EPA 1668A/1668C	EPA 1668A/1668C	----------------------
PCB 204	EPA 1668A/1668C	EPA 1668A/1668C	----------------------
PCB 205	EPA 1668A/1668C	EPA 1668A/1668C	----------------------
PCB 206	EPA 1668A/1668C	EPA 1668A/1668C	----------------------
PCB 207	EPA 1668A/1668C	EPA 1668A/1668C	----------------------
PCB 208	EPA 1668A/1668C	EPA 1668A/1668C	----------------------
PCB 209	EPA 1668A/1668C	EPA 1668A/1668C	----------------------
Metals Digestion			
Acid Digestion Total Rcoverable or Dissolved Metals	EPA 3005A	--------------------------------------	----------------------
Acid Digestion for Total Metals	EPA 3010A	--------------------------------------	----------------------
Acid Digestion of Sediments, Sludges and Soils	--------------------------------------	EPA 3050B	EPA 3050B
Organic Preparation Methods			
Separatory Funnel Liquid-Liquid Extraction	--------------------------------------	EPA 3510C	----------------------
Ultrasonic Extraction	--------------------------------------	EPA 3550B/3550C	----------------------
Waste Dilution	EPA 3580A	EPA 3580A	----------------------
Solid-Phase Extraction	EPA 3535A	--------------------------------------	----------------------
Volatiles Purge and Trap	EPA 5030B/5030C	EPA 5030B	----------------------
Volatiles Purge and Trap for Solids	--------------------------------------	EPA 5035/5035A	----------------------
Semivolatiles in Air	--------------------------------------	--------------------------------------	TO-13
Chemical Warfare Degradates (in solid)	--------------------------------------	WS-OP-0005	----------------------
Microwave Assisted Extraction	--------------------------------------	EPA 3546	----------------------
Organic Cleanup Procedures			
Florisil Cleanup	EPA 3620B/3620C	EPA 3620B/3620C	EPA 3620B/ 3620C
Sulfur Cleanup	EPA 3660A	EPA 3660A	EPA 3660A
Sulfuric Acid Cleanup	EPA 3665A	EPA 3665A	EPA 3665A
Silica Gel Cleanup	EPA 3630C	EPA 3630C	----------------------

Parameter/Analyte	Potable Water
Perfluoro Compunds	
Perfluorobutane Sulfonate (PFBS)	EPA 537
Perfluoroheptanoic acid (PFHpA)	EPA 537
Perfluorohexane Sulfonate (PFHxS)	EPA 537
Perfluorononanoic acid (PFNA)	EPA 537
Perfluorooctanoic acid (PFOA)	EPA 537
Perfluoroocatane Sulfonate (PFOS)	EPA 537

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(refer to joint ISO-ILAC-IAF Communiqué dated 8 January 2009).

Presented this 30th day of December 2015.

Senior Director of Quality & Communications
For the Accreditation Council
Certificate Number 2928.01
Valid to January 31, 2017
Revised May 6, 2016

For the tests to which this accreditation applies, please refer to the laboratory's Environmental Scope of Accreditation.

ATTACHMENT F
Responses to Comments

U.S. ARMY RESPONSES TO U.S. EPA COMMENTS ON THE DRAFT EXPEDITED SITE INVESTIGATION WORK PLAN FOR PERFLUOROALKYL SUBSTANCES (PFAS) FORMER FORT DEVENS ARMY INSTALLATION, DEVENS, MASSACHUSETTS

MARCH 2017

The following U.S. Army responses pertain to the U.S. Environmental Protection Agency (EPA) comments dated March 3, 2017 on the *Draft Expedited Site Inspection Work Plan for Perfluoroalkyl Substances (PFAS)* for the Former Fort Devens, submitted January 16, 2017. To expedite finalization of the Site Inspection (ESI) Work Plan, a teleconference was conducted among the U.S. Army, USACE, EPA, MassDEP, and KGS on March 24, 2017 to discuss responses to EPA and MassDEP comments. As appropriate, revisions and clarifications to the responses are provided beneath the response based on the teleconference and subsequent research and evaluation.

GENERAL COMMENTS

1. As recently agreed to in an email from Army to EPA dated January 26, 2017, the Army will include a formal schedule for the SI activities in the Draft Final Expedited SI (SI) Work Plan.

Response: The document will be revised to include a formal schedule of SI activities to be conducted. The Army will begin field work once EPA and DEP approves the final work plan. The Army has contracted the work with an assumed start date for field work on or before April 30, 2017. This assumes EPA approval of the Final ESI Work Plan a minimum of 14 calendar days before the start of field work.

March 24, 2017 Teleconference: The Army indicated that the contracting for the field investigation work may take longer than anticipated due to the number of samples added and revisions to the work plan and that the start date for field work would be mid-May 2017.

2. There are numerous PFAS compounds with varying physical and chemical properties that control their potential fate and transport in the environment. EPA's May 2016 Drinking Water Health Advisories apply to two compounds: perfluorooctanoic acid (PFOA) and perfluorooctane sulfonate (PFOS). Design of the SI sampling program needs to take into consideration the physical and chemical properties of PFAS compounds, which generally have relatively high water solubility, low-to-moderate absorption to soil and sediments (depending on organic carbon content), and are resistant to biological and chemical degradation due to the presence of carbon-fluorine bonds. With such variability in both chemical properties and in soil properties (i.e., organic carbon content, presence of silts and fines, etc.), past releases of PFAS compounds at Devens could still result in the presence of these chemicals in both unsaturated and saturated soil, and in groundwater. EPA requests that the ESI Work Plan be amended to include sampling for PFAS in unsaturated and saturated soil and in groundwater at each of the areas to be investigated, with the exception of AOC 5 – Shepley's Hill Landfill and AOC 32 – Defense Reutilization and Marketing Office, at which groundwater samples are considered sufficient at this time.

Response: The Draft ESI Work Plan includes collection of unsaturated soil (composite sample from 0 to 5 ft bgs) and/or groundwater samples at the subject sites. The ESI Work Plan will be modified to include the collection of a saturated soil samples just below the water table at the potential source areas at Study Area (SA) 20/21, SA 74, SA 75, SA 30, SA 31, and AOC 50.

The Army believes that the combination of shallow soil sampling at potential source areas and historic drainage swales/channels, and groundwater sampling at and downgradient of the potentials source areas is appropriate to meet the objectives of the SI (presence or absence of PFAS). The Army would like EPA to provide the rationale and purpose for collecting saturated soil samples collocated with groundwater samples. Collection of saturated soil samples in areas where the groundwater table is deep, such as at AOC 50, for the number of sample locations requested by EPA will significantly increase the cost of the program.

Data Quality Objectives (DQO) tables for each site will be included in the Draft Final ESI Work Plan (attached).

For the purpose of the response to comments, the sample location naming convention remains consistent with the Draft ESI Work Plan. However, in the Draft Final ESI Work Plan the naming convention will be revised to more clearly identify the site (SA or AOC) being sampled. For example, sample locations at SA 74 Barnum Road will be identified as SA74-17-01 and will be consecutively numbered for each site.

March 24, 2017 Teleconference: EPA agreed that saturated soil samples are not required for the ESI Work Plan, but may be warranted in the future if PFAS are detected in shallow soil sampling or groundwater at a site. The Army will remove all saturated soil samples from the ESI Work Plan.

3. A more thorough explanation of proposed sampling locations is needed. The Draft ESI Work Plan only identifies locations to be sampled in tables and figures. For most areas, the ESI Work Plan indicates that samples will be collected downgradient of potential PFAS release areas, without providing sufficient rationale as to why those locations are considered appropriate. EPA requests that the ESI Work Plan be amended to include the following information for each Area of Concern (AOC) or Study Area (SA): (Also see Specific Comments.)

    - Identify potential source/release areas;

    - Potential PFAS compounds migration pathways (e.g., downslope, downgradient, runoff from pavement, etc.), with information on groundwater flow direction and depth to groundwater;

    - Topographic plans and potentiometric surface maps, or ensure directions of downslope or downgradient are marked with arrows on the sampling location figures, with reference to the source of this information;

- Identify each building/structure within or in close proximity to each SA/AOC;
- Identify historic and/or current CERCLA/MCP sites within or in close proximity to each SA/AOCs;
- Identify existing groundwater monitoring points within or in close proximity to each of the SA/AOCs;
- Identification of any downgradient surface water bodies and drainage discharge locations as surface water or sediment porewater samples may be needed to provide initial data to evaluate contaminant fate and transport.
- Potential receptors (e.g., drinking water supply, water body, etc.);
- Sample description (media to be sampled, depths, screened intervals, etc.);
- Well construction details of monitoring wells to be sampled (needed to determine whether the screened intervals are situated in the appropriate depths to assess potential contaminant transport); and
- Rationale for sample location selection.

Response: The ESI Work Plan will be modified to include further explanations of the sampling sites' setting and the rationale for the individual sample locations. Please see the attached data quality objectives (DQO) tables, which provide the inputs and decision rules regarding the sampling.

4. The main Devens Fire Department appears to currently be located at 182 Jackson Road. Please confirm if AFFF was stored and/or mixed at this location and if not, identify where the AFFF used by the main Devens Fire Department was stored and/or mixed. If the AFFF storage/mixing location is unknown, this should be clearly stated in the text.

Response: The Fire Department at 182 Jackson Road has stored only small quantities of AFFF, which are then mixed and used elsewhere. Discussion with the Fire Chief indicated that they have a sealed, 5-gallon container of a stock AFFF product ("National Foam"). They also have 5-gallon container of a non-AFFF training foam. When needed, the container is connected to the truck sprayer and mixed with water at the point of use. There is no mixed foam stored on the truck or at the Fire Department building. There are no reported releases of AFFF at the building; therefore, no sampling is proposed at this location. Please note that MassDevelopment is the point of contract for current operations at the Fire Department.

March 24, 2017 Teleconference: EPA asked where AFFF product was stored after the Airfield closed and the quantity that was stored. The Army followed up with MassDevelopment who provided the following information from the Fire Chief. Currently,

Engine #3 has a 30-gallon holding tank of AFFF; Engine #5 carries four 5-gallon pails; and 22 5-gallon pails are stored at the warehouse. No AFFF is stored on the South Post. The fire department indicated that 60 5-gallon pails of AFFF were used for the May 2015 fire at the Devens Recycling Center located at 45 Independence Drive.

SPECIFIC COMMENTS

1. Page 1-1, Section 1.1 – This section states the objective of the ESI Work Plan as: "to describe the methodology that will be implemented to properly collect and analyze the groundwater samples from the subject site". To more accurately reflect specific concerns related to the evaluation and characterization of possible PFAS contamination at Devens, the stated objective should be changed to: "to assess the potential presence of PFAS compounds in environmental media that may pose potential risks to receptors at the Former Fort Devens Army Installation".

Response: Section 1.1 will be revised to read as follows:

> ***"The objective of this SI work plan is to assess the potential presence of PFAS compounds in environmental media that may pose potential risks to receptors at the Former Fort Devens Army Installation. The SI describes the methodology that will be implemented to properly collect and analyze the groundwater samples from the subject site. Additional details of field sampling, analytical procedures, standard operating procedures (SOPs), and quality control requirements are presented in the Quality Assurance Project Plan (QAPP) (KGS, 2016b)."***

2. Page 1-3, Section 1.2.3, last paragraph – The text in this section refers to the Antietam Road (Warehouse Fire) location as SA 74 and the Barnum Road location as SA 75, whereas within the rest of the text, as well as the figures, the Barnum Road location is referred to as SA 74 and the Building 1445 Warehouse Fire (Antietam Street) as SA 75. Please address this discrepancy.

Response: The text will be corrected to cite the Barnum Road location as SA 74 and the Building 1445 Warehouse Fire (Antietam Street) as SA 75.

3. Pages 1-3 through 1-5, Section 1.3 - As discussed in General Comment #3, a brief explanation of historic activities, potential PFAS sources, selection of environmental media and locations to be sampled, and potential receptors should be included for each AOC or SA. While specifics can be detailed in the QAPP, sufficient information needs to be included in the ESI Work Plan to assess whether the number and locations of proposed samples are appropriate to determine whether PFAS compounds are present in potential source/release areas and whether they have migrated away from the sources/releases. Also, the rationale for the collection of soil and/or groundwater samples needs to be discussed.

Response: The ESI Work Plan will be modified to include further explanations of the sampling sites' setting and the rationale for the individual sample locations.

4. Page 1-3 through 1-5, Section 1.3 - Although the section heading "Select Sampling Locations" implies that details on sampling locations will be provided, the text describes sampling areas with only general descriptions (e.g., downgradient) of sampling locations. Specific Comments below detail EPA's concerns with specific AOCs/SAs.

Response: The ESI Work Plan will be modified to include further explanations of the sampling sites' setting and the rationale for the individual sample locations (e.g., expanded descriptions in Table 1 and addition of Data Quality Objective tables for each SA/AOC).

5. Page 1-3, Section 1.3 Shepley's Hill Landfill and Figure 9 - Groundwater underlying the landfill is migrating to the north, northeast and northwest. Since groundwater is periodically sampled at Shepley's Hill Landfill as part of Long Term Monitoring (LTM), EPA requests that Army target LTM wells that are known to be in good working condition. As discussed in the general comments above, EPA is requesting that additional well construction details be provided in the revised ESI Work Plan. To ensure adequate characterization of PFAS in the SHL groundwater plume, EPA requests that samples for PFAS analysis be collected from the following monitoring and extraction wells:
   - SHL-12, SHL-15, and SHL-17
   - SHM-10-11 (instead ofN6-Pl)
   - SHM-95-27X and SHL-18 (as proposed by Army)
   - SHM-10-12 (as proposed by Army)
   - SHM-10-14 (instead of SHM 10-13)
   - SHM-10-15
   - SHM-11-06
   - EW-01 and EW-04
   - SHM-96-SB
   - SHM-05-40X
   - SHM-05-41A, SHM-05-41B and SHM-05-41C
   - SHM-13-06

Response: Based on EPA and MassDEP comments, the wells listed below will be sampled to assess the presence or absence of PFAS at Shepley's Hill Landfill and will be added to Table 1 and Figure 9 of the ESI Work Plan. The approximate depth to the water table, based on historical data, and well screen depth below ground surface will be added to Table 1 for the existing wells proposed to be sampled.

- **SHM-10-11**
- **SHM-95-27X**
- **SHL-18**
- **SHM-10-12**
- **SHM-10-14**
- **SHM-10-15**
- **SHM-11-06**
- **EW-01**
- **EW-04**

- **SHL-12**
- **SHL-15**
- **SHL-17**
- **SHM-96-5B**
- **SHM-05-40X**
- **SHM-05-41A**
- **SHM-05-41B**
- **SHM-05-41C**
- **SHM-13-06**
- **SHP-01-38A**
- **SHP-01-38B**
- **SHL-24**

The Army believes that the number of PFAS samples requested by the regulatory agencies is excessive for a solid waste landfill. For example, the rationale for sampling upgradient wells SHL-12, SHL-15, and SHL-17 (located between SHL and the former DRMO yard) is unknown. In addition, samples are proposed to be collected from existing wells 32M-92-01X and 32Z-01-07XOB, which are also located between SHL and the former DRMO yard. PFAS are routinely present in solid waste landfill leachate (Lang, 2016) due to numerous potential sources associated with solid waste disposed in the landfill. The objective of the SI is to determine the presence or absence of PFAS.

March 24, 2017 Teleconference: EPA agreed to eliminate sampling of monitoring well SHL-12 since it is upgradient of SHL and is redundant with other wells being sampled at SHL and DRMO. The Army will delete sampling of SHL-12.

6. Page 1-3, Section 1.3, Devens Wastewater Treatment Plant and Figure 10 – It is recommended that a soil sample be collected from the sand infiltration beds. Treated water is likely discharged into these beds. If PFAS is present in the treated water, the beds may be continuing sources of PFAS to groundwater.

   Also, please show existing monitoring wells on Figure 10.

Response: The wastewater treatment plant (WWTP) is currently active and receives wastewater from multiple sources. The WWTP utilizes sand filter beds as a final treatment step. As noted in EPA General Comment 2, PFAS generally have relatively high water solubility and low-to-moderate absorption to soil and sediments. Therefore, it is unlikely that PFAS will be sorbed to the sand in the filters based on the water volumes passing through this media. However, a representative soil/sediment sample of the sand filter beds will be collected and analyzed, as requested by EPA (TP-2017-26). In addition, a sample of the influent and effluent from the WWTP will be collected and analyzed for PFAS.

The Army recently conducted a site walk of SA 20/21 and identified several existing monitoring wells in use by the treatment plant operators that can also be used for sampling of PFAS and would be more representative of any potential exposure that is

currently occurring to groundwater. Existing monitoring wells have been added to Figure 10. The ESI Work Plan will be modified to replace samples TP-2017-01, -02, -03 with groundwater samples from downgradient wells MW-01A, MW-02A, MW-04, MW WC1A to evaluate whether the filter beds are impacting groundwater in this area. At SA 21, samples TP-2017-04 and -05 will be retained to evaluate whether the former sludge beds have impacted soil and/or groundwater in that area

The Army believes that this level of investigation at an active WWTP is excessive to meet the objectives of an SI (see attached DQO table). Sampling and analysis of existing downgradient monitoring wells currently used for WWTP compliance (MW-01A, MW-02A, MW-04, MW-WC1A) would be sufficient to determine if PFAS are present in downgradient groundwater at unacceptable concentrations.

March 24, 2017 Teleconference: EPA proposed substituting sampling of existing well WWTMW-03 for MW-WC1A since WWTMW-03 is downgradient of the WWTP. The Army indicated that well WWTMW-03 may have been abandoned in 2012. EPA suggested installing a temporary well point if the well was no longer available to be sampled. The Army has since determined that WWTMW-03 has been abandoned; therefore, a temporary point will be added adjacent to the location of former well WWTMW-03 and MW-WC1A will not be sampled.

7. Page 1-4, Section 1.3, SA 74 – Barnum Road Devens Fire Historical Dump Site and Figure 11 – To address this SA, Army is proposing to collect soil and groundwater samples from three temporary well/soil locations. The text on Page 1-4 states that "Additional details regarding the exact locations of foam disposal were obtained". Since Figure 11 shows three sampling locations approximately 20 feet off the (current) paved surface, details on the discharge locations are pertinent to the evaluation of sampling locations and should be provided in the document. Additionally, information on the current/former presence of storm drains or other drainage features on the property (e.g., the small "pond" located northeast of proposed point TP-2017-08 and the detention pond southeast of proposed point TP-2017-06) that may have affected PFAS migration should be provided.

   Since this is a known point of excess AFFF discharge, EPA requests that Army advance three additional temporary well locations between those proposed and Cold Spring Brook. For ease of access, the temporary well points could be advanced along the access road shown in Figure 11. Also, if there are any existing monitoring wells for other AOCs (e.g., AOC 57) within this area, please show the wells on Figure 11.

Response: The additional details obtained from the Fire Chief directed the investigation to the area behind Building 3773 (as opposed to an undefined location "at the end of Barnum Road"). Further details are not available. Therefore, the sample locations are proposed at the pavement edge where the past disposals may have occurred. A map of the past site conditions will be added to the ESI Work Plan (see attached) which shows that the stormwater detention ponds visible in Figures 5 and 11 were not present until later redevelopment of the site.

The Army inspected the site further based on the request to add additional samples along the access road. Sampling locations were modified as shown on the attached figure based on these field observations. As shown in the revised Figure 11, sample location TP-2017-07 is proposed to be moved southeast (topographically downgradient) to a drainage ditch which may have received runoff. Sample location TP-2017-08 will be moved southeast (topographically downgradient) to an area which may have received runoff from past disposals. Two additional samples will be added along the access road noted by EPA, including TP-2017-25 (a potential open/downhill area based on the historical aerial photo, and downgradient of the current stormwater detention basin), and TP-2017-27 (an area where current drainage ditches connect to wetlands associated with Cold Spring Brook).

March 24, 2017 Teleconference: EPA requested clarification regarding whether AFFF training or disposal was conducted at this site. Based on further review of information, it is possible that both disposal and training were conducted. EPA requested that all public water supply wells (Grove Pond Wells) be shown on Figure 11 and indicate the wells that have had exceedances of the EPA health advisory level for PFAS and which wells are currently being used for water supply. The Army has made the requested changes to Figure 11. MassDEP's recent PFOS/PFOA data for the Grove Pond Wells are summarized below (only well #8 exceeds the HAL):

Well ID	Date	HAL (ug/L)	PFOS (ug/L)	PFOA (ug/L)	PFOS+PFOA
Ayer Mult 4 Grove finished	9/1/2016	0.07	0.028	0.01	0.038
	11/15/2016	0.07	0.029	0.011	0.04
	1/11/2017	0.07	0.025	0.01	0.035
Ayer RW-06G/GW 6	9/1/2016	0.07	<0.004	0.006	0.006
	11/15/2016	0.07	<0.004	0.006	0.006
	1/11/2017	0.07	<0.004	0.007	0.007
Ayer RW-07G/GW 7	9/1/2016	0.07	0.007	0.009	0.016
	11/15/2016	0.07	0.006	0.009	0.015
	1/11/2017	0.07	0.005	0.008	0.013
Ayer RW-08G/GW 8	9/1/2016	0.07	0.085	0.018	0.103
	11/15/2016	0.07	0.077	0.017	0.094
	1/11/2017	0.07	0.07	0.017	0.087

8. <u>Page 1-4, Section 1.3, SA 75 – Building 1445 Warehouse Fire and Figure 12</u> - The second sentence of the bullet discusses the initial interview with Devens Fire Department personnel and refers to an area "at the end of Barnum Road". EPA believes the text should refer to Antietam Street. Also, on Figure 12, Building 1443 is labeled, which should apparently be 1445. Please correct.

   Army has proposed the collection of soil and groundwater samples at four temporary well/soil locations to investigate SA 75. All four locations have been proposed to the east, "topographically downgradient from the former building location" (according to text on Page 1-4), with an estimated groundwater flow direction shown to the east on Figure 12.

Further detail on the application of foam to suppress the fire is needed to support the collection of samples on only one side of the former building. In addition, it appears as though there was a rail spur in the vicinity of, and perhaps adjacent to, Former Building 1445, based on Figure 1-2 of the Environmental Baseline Survey for Proposed Lease and/or Transfer, dated April 1996. The Army should verify that the topography of this area has not been changed. Also, other potential migration pathways of PFAS in this area, such as stormwater drainage features and any small streams/ditches that could have impacted migration, must be identified.

Response: The text will be revised to clarify the location and figures will be revised to show the historic road layout. The building number will be corrected.

Details of the foam application and local topography during that fire response are not available. However, the large drainage ditch to the southeast of the building, which is shown on the historical layout of the SA75 Area, would appear to be the most likely place for migration of the foam during the firefighting activities.

Sampling locations were modified as shown on the attached figure. Sample TP-2017-09 will be moved northwest to the corner of the parking lot to test for PFAS north of the former building in the presumed direction of groundwater flow. Sample TP-2017-12 will be moved south, just past the southern end of the former building to test for PFAS in that area. Sample TP-2017-10 will be moved east into the nearby drainage ditch. The ditch will be labeled on Figure 12. Sample TP-2017-11 will remain in its currently proposed location to test for PFAS in what appears to be topographically and hydraulically downgradient of the former building.

A map showing the historical layout of the SA 75 area has been added to the ESI Work Plan.

9. Page 1-4, Section 1.3, SA 75 – Former Drum Storage Area (under AOC 50 – Former Moore Army Airfield) and Figure 13 – Army proposes "soil and groundwater sampling will be conducted at select locations downgradient of the former drum storage area" (former SA 30), stating that drums, including 55 gallon drums of firefighting foam concentrate, were stored within two locations within this area. Further justification for soil sampling downgradient of the locations is warranted, as conceptually, soil sampling within the footprint of storage locations is more appropriate to identify source locations.

   Samples should be collected at both drum storage locations, shown as "Study Area 30" on Figure 13. In addition, in order to verify that the groundwater sampling locations have been appropriately placed, groundwater flow directions within the vicinity of the former drum storage areas need to be shown on Figure 13, with reference to report(s) from which the information was obtained in the legend. If groundwater flow directions are uncertain, a minimum of two temporary well locations must be advanced to address each of the identified drum storage areas.

Response: Although the Fire Chief stated that containers with PFAS were only stored at the western location, the work plan will be revised to indicate that samples are proposed at both

portions of AOC 30, as requested by EPA. Three soil and groundwater sample locations are proposed in each area with one location within the footprint of each storage area. At the western area, the proposed location for sample TP-2017-17 will be moved to the center of the paved storage area. The proposed location for sample TP-2017-18 will be moved closer to the northwest corner of the paved storage area, where there is a drainage outlet from the bermed pavement. TP-2017-18 is likely on the downgradient side of the storage pad, given the proximity to the Nashua River. Please see attached Figure 13 for proposed sampling locations.

The Army believes that the total number of samples and sampling locations combined for the airfield sites is excessive to meet the objectives for an SI. The DQOs for the SI could be achieved with a subset of the sampling locations targeting the most likely and documented potential sources (e.g., SA 31) and downgradient groundwater from other potential historic sources.

10. <u>Page 1-4, Section 1.3, Firefighting/Crash Site Training Area (under AOC 50 – Former Moore Army Airfield) and Figure 13</u> – Similar to the drum storage area, Army is proposing soil (and groundwater) sampling at select locations downgradient of the Firefighting/Crash Site Training Area (former SA 31). This area is described as a 50 by 50-foot asphalt-covered concrete pad (8-inches thick), surrounded by a 1-foot high, 2-foot wide earthen berm. Further justification for soil sampling downgradient of the locations is warranted, as conceptually, soil sampling just outside of the concrete pad and <u>within</u> the earthen berm is more appropriate to determine if PFAS are present in soils at this location. If penetrating the berm is a concern, soil samples should be collected just downgradient of the berm.

    Within the 2015 AOC 50 OMM Report dated August 2016, Figure 3.1b shows groundwater flow directions to the southwest near SA 31 (Firefighting Training Area) during October 2015. Another temporary well location is needed southwest of SA 31, between proposed temporary location TP-2017-24 and existing monitoring well G6M-97-05B, to assess PFAS along this flow path. In addition, Army proposes to sample groundwater collected from existing wells G6M-97-05B, screened at a depth of 130-135 feet below ground surface, and G6M-13-01X, screened at a depth of 125-135 feet below ground surface, while the water table is approximately 70 feet below ground in this area (according to Figure 6-7 of the AOC 50 RI Report). Considering PFAS fate and transport properties in the subsurface, please discuss why is it appropriate to sample these deep wells to evaluate PFAS in groundwater at these locations. In order to address groundwater discharging to the Nashua River, EPA requests that monitoring wells screened at the water table be added to the sampling program. If none exist in the appropriate locations, temporary well locations must be advanced to collect shallow groundwater.

Response: The proposed location for sample TP-2017-19 will be moved to just outside the concrete pad to the west of the bermed area, as requested. Sample location TP-2017-24, which is only 130 feet from the bermed area, will be used for groundwater sampling only. Another temporary well point will be added in between TP-2017-24 and G6M-97-05B, as requested. Each of these groundwater samples will be collected at the water table. No sample will be collected from the deep wells G6M-97-05B. However, Wells XSA-12-97X

and G6M-13-01X will be sampled to evaluate deeper groundwater to assess overall potential sources in upgradient areas of the airfield (e.g., hangars and runway).

March 24, 2017 Teleconference: Based on review of historic airfield drawings, it was determined that the airfield runways were 300 feet wide; therefore, if the sample TP-2017-19 were moved outside the former runway it would be approximately 100 feet from the edge of the bermed area. Therefore, sample location TP-2017-19 will be placed within the bermed area and the concrete will be cored prior to advancing the geoprobe.

11. Page 2-5, Section 1.3, Former Airfield Hangars and Former Airfield Fire Station Building (under AOC 50 – Former Moore Army Airfield) and Figure 13 – The two former airfield hangars, former airfield fire station and encircled area near TP-2017-13 through 15, need to be labeled on this figure in order to evaluate the appropriateness of proposed sampling locations. In addition, EPA requests that a site visit be conducted with the regulators (EPA and MassDEP) to inspect the former hangars and fire station for the presence of fire suppression systems. The AOC 50 Remedial Investigation Report, dated January 2000, contains, within Appendix P, Design Drawings for Building 3840 (the Parachute Tower building). For reasons discussed during the January 19, 2017 Devens RAB meeting, EPA requests that Army provide design drawings for the hangars and former airfield fire station. The drawings should include details regarding former underground drainage/piping structures that may have been used in conjunction with hangar and fire station operations.

Response: Figure 13 was modified to label the hangars (Buildings 3813 and 3818) and the former fire station in the area of TP-2017-13 to -15.

Based on past discussions with site personnel (Draft Final Base-Wide Preliminary Assessment for Evaluation of Perfluoroalkyl Substances, page 2-5), the hangars used water-only fire suppression systems. Drainage structures from the hangars were previously investigated by ADL (Storm Sewer System Evaluation [AREE70] Report, Arthur D Little, 1994), and it was determined that none of the floor drains were connected to the sewer system. Floor drains and catch basins were routed to the Nashua River via various outfalls present at the facility. Army is not able to locate design drawings for the hangars. The field visit that was scheduled for March 14, 2017 with regulators was cancelled due to snow. The field visit can be rescheduled once the snow is no longer an issue.

March 24, 2017 Teleconference: The Army indicated that they would search for drawings of the hangars to determine location of floor drains; storm water drainage network and outfalls; and overall airfield layout. The drawings will be included as Attachment A of the ESI Work Plan. The hangar drawing indicates that only water was used in the fire suppression system in the hangar and the floor drains were connected to the storm drainage system. The storm drain network drawing indicates that there are 12 storm drain outfalls located around the perimeter of the airfield and that the catch basins were located throughout the runways to collect any water/liquids falling on the runways. The overall airfield layout indicates that there were originally three runways (W-SE Runway [300 ft x 5200 ft], N-S Runway [300 ft x 3000 ft], and E-W Runway [300 ft x 2700 ft]). The Fire Chief indicated that only one runway was used. Sampling along the runway as proposed and

downgradient locations should be sufficient to evaluate the presence or absence of PFAS resulting from any foaming of the runways.

Given the lack of current details regarding the site history, use, and facilities, MassDEP requested that additional temporary points be included to investigate the presence or absence of PFAS at the hangars. MassDEP provided mark up of existing figure showing the proposed locations. The Army indicated that relocating existing point TP-2017-13 to the east between hangar buildings 3818 and 3813 would be appropriate to characterize groundwater downgradient of building 3818 and upgradient of building 3813. The Army has added the sampling locations requested by MassDEP. There may be an issue with concrete coring and drilling through the hangar floor location if all utilities beneath the flooring cannot be identified.

To highlight the hangars and fire station on Figure 13, EPA requested that they be outlined in red. The red box on Figure 13 labelled AOC 50 was requested to be deleted. Figure 11 has been updated accordingly.

12. <u>Page 2-5, Section 1.3. Main Airfield Runway (under AOC 50 – Former Moore Army Airfield) and Figure 13</u> – In response to information gathered during an interview that indicated that the airfield runway may have been foamed during firefighting and crash training, the Army proposes to collect soil and groundwater samples along the runway for PFAS analysis. Sample locations are shown on Figure 13 in the middle of the runway, through the pavement, which would not likely be the migration pathway for AFFF following a release if the pavement was intact. Therefore, samples along the main runway should be collected off of the pavement, where AFFF would have run off into soils. Based on groundwater flow direction, it appears that TP-2017-20 through 22 should be collected on the southern, downgradient side of the runway.

    In addition, the January 2000 AOC 50 Remedial Investigation, within Section 6.1 regarding Surficial Hydrology, indicates that "Runoff from the runways and other paved areas flows onto unpaved areas and is largely collected by an extensive stormwater-drainage system. The runoff is collected in catch basins and routed through the storm drain system to outfalls along the perimeter of the airfield. The closest outfall to AOC 50 is located at the base of the hill, approximately 200 feet east of AOC 50." The locations of outfalls must be shown on Figure 13 (or another figure). Army must consider the outfalls as a potential release point for PFAS migration.

Response: Sample locations TP-2017-20, -21, and -22 will be moved southward to the edge of the runway (off-pavement). Sample locations may be adjusted slightly further in the field (or based on an upcoming site walk) based on observed runoff channels or topography. The project team will be notified of any changes to the proposed sampling locations based on observed field conditions.

March 24, 2017 Teleconference: MassDEP requested that the Army confirm and label which of the paved/concrete areas were used as runways. In addition, MassDEP requested additional sample locations be included to address all of the runways. The historic overall

airfield layout drawing indicates that there were originally three runways (W-SE Runway [300 ft x 5200 ft], N-S Runway [300 ft x 3000 ft], and E-W Runway [300 ft x 2700 ft]). The Army included additional sampling locations to address the eastern end of the main runway (W-SE Runway). In addition, sampling will be conducted at four key outfalls that collect runoff from each of the runways as indicated on revised Figure 13 to determine if the outfalls were a release point of PFAS.

13. Page 2-5, Section 1.3, AOC 32 – Defense Reutilization and Marketing Office and Figure 14 - EPA requests the addition of groundwater sampling of monitoring wells 43M-O1-20XOB and 43M-01-20XBR to assess both overburden and bedrock groundwater at this downgradient location.

Response: The ESI Work Plan will be modified to include groundwater samples from these two locations.

14. Page 2-5 – Page numbers jump from 1-4 to 2-5, which appears to be an editorial error.

Response: Page numbering will be corrected.

15. Page 2-5. Section 2.1, 1st paragraph – Section 2.5, not 2.4, describes the measures to avoid potential cross-contamination of samples. Please correct the reference.

Response: The text will be corrected to refer to Section 2.5.

16. Pages 2-5 through 2-7. Sections 2.1 and 2.3, Groundwater and Soil Sample Collection – For sample locations where both soil and groundwater samples will be collected, it is unclear if both sets of samples will be collected from the same borehole, or if separate boreholes be advanced to collect each environmental medium. Please edit the text to clarify the intent.

Response: The plan is to collect soil and groundwater from the same borehole; however, the text has been modified to indicate that separate boreholes may be used to collect the soil and groundwater samples if necessary. The boreholes will be located within 3 feet of each other.

17. Page 2-5. Section 2.1, 3rd paragraph – For groundwater samples collected from non-potable monitoring wells and temporary well points, EPA requests that samples be analyzed by Modified Method 537. This method allows for the detection of both branched and chained isomers of PFOA. Previously, EPA had required (unmodified) Method 537 for the sampling of potable (drinking water) sources at Devens, to be consistent with drinking water analytical procedures. Since the Site Inspection work does not include the sampling of potable sources, the modified method is more appropriate.

Response: The ESI Work Plan will be modified to specify the use of Modified Method 537 for analysis of groundwater (including text, tables 2, 3, and 4, the SOP in Attachment B, and the related QAPP worksheets in Attachment D).

18. Page 2-6, Temporary Well Point Groundwater Sampling – For samples to be collected from temporary wells, at what depth interval frequency will groundwater be collected? The procedure described on Page 2-6 calls for the advancement of the probe, sampling of groundwater, decontamination of equipment, and then advancement to the next depth interval, and repeat of the steps until all groundwater samples have been collected at each location. Information on depth/intervals for temporary well point sampling must be provided in the document. Also, please describe what will determine termination of groundwater sample collection at a borehole.

Response: The text will be modified to indicate that the temporary wells will only be used to collect groundwater samples from the top of the water table (no vertical profiling).

19. Page 2-6, 5th bullet - Per Modified Method 537, collected groundwater samples should be unpreserved. Please correct the text in the bullet to indicate that groundwater samples will be collected in unpreserved bottles.

Response: The text of the 5th Bullet on page 2-6 will be changed to read as follows:

"Collect groundwater sample by filling sample containers directly from tubing. In accordance with the QAPP Addendum, groundwater samples shall be collected in two 250 milliliter (mL) High Density Polyethylene (HDPE) jars with non-Teflon lids containing no preservative and stored on ice."

20. Page 2-6, 4th bullet – The procedure described calls for the advancement of the probe and pumping of groundwater via a peristaltic pump. According to the Geoprobe Screen Point 16 Groundwater Sampler procedures outlined in the SOP in Attachment B (page 4, 4th paragraph), "An alternate means of collecting groundwater samples is to attach a peristaltic or vacuum pump to the tubing. This method is limited in that water can be pumped to the surface from a maximum depth of approximately 26 feet". Please discuss an alternate method of collecting groundwater samples if the depth limitations on the peristaltic pump do not allow for the pumping of groundwater to the surface for collection of samples.

Response: The text will be modified to indicate that a bladder pump will be used to collect the groundwater sample if the use of a peristaltic pump is not feasible at a given location.

21. Page 2-7, Section 2.2 - The text describes that water quality parameters will be collected immediately following PFAS sample collection and "prior to collecting samples for other parameters". Please identify the other parameters for which Army plans to collect samples.

Response: The cited phrase will be deleted. No additional parameters are to be analyzed.

22. Page 2-7, Section 2.3 - The collection of soil samples at a depth of 0 to 5 feet below ground surface is proposed. Considering the mobility of PFAS compounds and low sorption to organic carbon, it is likely that these chemicals can be readily mobilized and sampling at depth is recommended. Therefore, EPA requests that soil samples be collected below the

water table to provide assessment of PFAS presence in saturated soil, in addition to the surficial soil samples proposed.

Response: See the response to General Comment 2. The first sentence of the first paragraph of Section 2.3 will be revised to read as follows:

"Samples for soils will be collected using Geoprobe® MacroCore® soil sampler (or equivalent) from 0 to 5 feet below grade surface (for an unsaturated soil sample) and the first 5 feet below the water table (for a saturated soil sample) at the locations indicated in Table 1."

23. Page 3-1, Section 3.1 – For sample locations where soil cores will be retrieved, boring logs should be maintained. Descriptions of soils, debris, etc. encountered may be useful for interpreting potential PFAS detections.

Response: Section 3.1 will be modified to indicate that soil logging will be performed from the recovered soil cores.

24. Table 1 – For AOC 5, groundwater monitoring well SHP-05-46A is listed twice, and TP-2017-23 is missing from the AOC 50 list under the Former Airfield Runway description. Please correct.

    In addition, Table 1 is not adequate to replace QAPP Worksheet #18. This table needs to be expanded to include additional columns that present: identification of sample types (soil or groundwater), proposed sample depth intervals, and sample and location rationale. The expanded Table 1 may be used to describe the sample location basis and sampling rationale (described in General Comment #3 above).

Response: Table 1 will be corrected. The table also will be expanded to include sample type, proposed sample depth intervals, and sample location rationale.

25. Appendix B, Geoprobe SOP - The SOP provides schematics of samplers. Most of the components are stainless steel; however, several O-rings of unknown construction are depicted. The contractor should verify that the O-rings materials will not result in PFAS false-positive detections.

Response: The drilling subcontractor will be consulted regarding potential false-positives of PFAS resulting from use of their drilling/sampling equipment. If needed, a field blank of water which contacted the O-rings can be collected.

26. Appendix D, QAPP Addendum – Please revise all applicable worksheets to refer to Modified Method 537 for groundwater samples.

Response: As noted in the response to Specific Comment 17, the applicable Worksheets in Appendix D have been revised to refer to Modified Method 537 for groundwater samples.

27. Appendix D, QAPP Addendum - Please provide Worksheet #18 which should identify each groundwater sample collected (multiple intervals at each location) and each soil sample collected, including QC samples. The Work Plan needs to specifically list each sample and the total number of groundwater and soil samples (including QC samples) that are planned for collection.

Response: Worksheet #18 will be added.

U.S. ARMY RESPONSES TO MASSDEP COMMENTS ON THE DRAFT EXPEDITED SITE INVESTIGATION WORK PLAN FOR PERFLUOROALKYL SUBSTANCES (PFAS) FORMER FORT DEVENS ARMY INSTALLATION, DEVENS, MASSACHUSETTS

MARCH 2017

The following U.S. Army responses pertain to the Massachusetts Department of Environmental Protection (MassDEP) comments dated February 27, 2017 on the *Draft Expedited Site Inspection Work Plan for Perfluoroalkyl Substances (PFAS)* for the Former Fort Devens, dated January 16, 2017. To expedite finalization of the Site Inspection (ESI) Work Plan, a teleconference was conducted among the U.S. Army, USACE, EPA, MassDEP, and KGS on March 24, 2017 to discuss responses to MassDEP and EPA comments. As appropriate, revisions and clarifications to the responses are provided beneath the response based on the teleconference and subsequent research and evaluation.

1. Table 1 should list sample TP-2017-23 (refer to Figure 13).

Response: TP-2017-23 has been added to Table 1 for the Former Airfield Runway sampling summary.

2. Table 4: The listed reporting limits appear to be inconsistent with those listed in Attachment D (QAPP Addendum); please confirm/correct.

Response: The reporting limits in Table 4 has been corrected to match Attachment D, as shown below.

Analysis Method	CAS	Analyte	Aqueous Laboratory RL (ng/L)	Soil Laboratory RL (µg/Kg)
537/537M (soils)	375-73-5	Perfluorobutanesulfonic acid (PFBS)	2.5	0.40
537/537M (soils)	375-85-9	Perfluoroheptanoic acid (PFHpA)	2.5	0.50
537/537M (soils)	355-46-4	Perfluorohexanesulfonic acid (PFHxS)	2.5	0.50
537/537M (soils)	375-95-1	Perfluorononanoic acid (PFNA)	2.5	0.50
537/537M (soils)	1763-23-1	Perfluorooctane sulfonic acid (PFOS)	4.0	0.50
537/537M (soils)	335-67-1	Perfluorooctanoic acid (PFOA)	2.5	0.50

3. Figure 9: The plan should explain the rationale for selecting sampling points at Shepley's Hill Landfill. In particular, the rationale for sampling the proposed wells near the extraction wells and downgradient of the site is not apparent:

   Response: The ESI Work Plan has been clarified to explain the rationale for the sampling locations.

- To assess the potential presence of PFAS within the landfill, groundwater produced by the extraction wells should be sampled (individually or composite). The extraction wells capture groundwater from a substantial portion of the landfill, providing a straight-forward means to screen a substantial portion of the landfill for PFAS.

  Response: Groundwater samples will be collected from EW-01 and EW-04.

- To assess the potential for current and historic migration of PFAS from the landfill to the North Impact Area, shallow and deep overburden groundwater should be sampled downgradient of the landfill (none of the proposed downgradient wells and piezometers is screened in the arsenic plume, a known contaminant migration pathway). To accomplish this, MassDEP recommends that wells SHM-05-41A, SHM-05-41B, and SHM-05-41C be sampled. Well 41A is screened in shallow overburden, and wells 41B and 41C intercept the arsenic plume and are screened in deep and intermediate depth overburden, respectively.

  Response: Groundwater samples will be collected from SHM-05-41A, SHM-05-41B, and SHM-05-41C.

- To assess the potential for current and historic migration of PFAS from the landfill to Plow Shop Pond, shallow and deep overburden groundwater downgradient of the barrier wall should be sampled. To accomplish this, MassDEP recommends that wells SHP-01-38A and SHP-01-38B be sampled. Well SHP-01-38A is screened in shallow overburden. Well SHP-01-38B is screened in deep overburden.

  Response: Groundwater samples will be collected from SHP-01-38A and SHP-01-38B.

- Assuming good condition and appropriate screen depths, wells SHL-24 and/or SHM-93-24A should be sampled to assess downgradient groundwater within the Zone II area associated with the Grove Pond water supply wells.

  Response: A groundwater sample will be collected from SHL-24.

4. Figure 11: Please include a figure that shows site conditions at the time PFAS may have been released behind Building 3773.

Response: A figure has been added showing past site conditions (see attached).

5. Figure 12: Please include a figure that shows site conditions at the time of the Building 1445 fire.

Response: A figure has been added showing past site conditions (see attached).

6. Figure 13: Both of the SA 30 areas should be sampled, or the report should explain why both areas need not be sampled.

Response: Although the Fire Chief stated that containers with PFAS were only stored at the western location, the ESI Work Plan has been revised to indicate that samples are proposed at both the portions of AOC 30, as requested by EPA. Three soil and groundwater sample locations are proposed in each area with one location within the footprint of each storage area. At the western area, the proposed location for sample TP-2017-17 has been be moved to the center of the paved storage area. The proposed location for sample TP-2017-18 has been moved closer to the northwest corner of the paved storage area, where there is a drainage outlet from the bermed pavement. TP-2017-18 is likely on the downgradient side of the storage pad, given the proximity to the Nashua River. Please see attached Figure 13 for proposed sampling locations.

7. Figure 13: The plan should explain the rationale for the sampling proposed to assess potential releases from the runway. Samples should be collected at locations where foam was most likely to have run-off or been washed off the runway. While the proposed sample spacing is reasonable, it is essential to target the drainage swales and/or drainage structures most likely to have received run-off and the most probable pathways to groundwater. In addition, the full extent of the runway should be evaluated (the runway extends approximately 2,000 feet southeast of the area shown in Figure 13). To ensure the runway sampling will be adequate, MassDEP recommends that a joint Army-EPA-DEP walkover be conducted to determine sampling locations.

Response: The ESI Work Plan has been clarified to indicate the rationale for the proposed sample locations. Sample locations TP-2017-20, -21, and -22 have been moved southward to the edge of the runway (i.e., off-pavement where runoff would first contact exposed soil). Sample locations may be adjusted slightly further in the field (or based on an upcoming site walk) based on observed runoff channels or topography. The project team will be notified of any changes to the proposed sampling locations based on observed field conditions.

The southeastern portion of the runway is not proposed for sampling as it is actively used by the Massachusetts State Police for vehicle training. It is expected that PFAS, if present, would be detected in the proposed locations along the central portion of the runway (where more airfield operations took place overall and which is closer to the fire training area at SA 31) as well as the downgradient points toward the Nashua River.

March 24, 2017 Teleconference: MassDEP requested that the Army confirm and label which of the paved/concrete areas were used as runways. In addition, MassDEP requested additional sample locations be included to address all of the runways. The historic overall airfield layout drawing (to be included in an appendix) indicates that there were originally three runways (W-SE Runway [300 ft x 5200 ft], N-S Runway [300 ft x 3000 ft], and E-W Runway [300 ft x 2700 ft]). The Army included additional sampling locations to address the eastern end of the main runway (W-SE Runway). In addition, sampling will be conducted at four key outfalls that collect runoff from each of the runways, as indicated on revised Figure 13, to determine if the outfalls were a release point of PFAS. The Fire Chief indicated

that only one runway was used. Sampling along the runway as proposed and downgradient locations should be sufficient to evaluate the presence or absence of PFAS resulting from any foaming of the runways.

Given the lack of current details regarding the site history, use, and facilities, MassDEP requested that additional temporary points be included to investigate the presence or absence of PFAS at the hangars. MassDEP provided mark up of existing figure showing the proposed locations. The Army indicated that relocating existing point TP-2017-13 to the east between hangar buildings 3818 and 3813 would be appropriate to characterize groundwater downgradient of building 3818 and upgradient of building 3813. The Army has added the sampling locations requested by MassDEP. There may be an issue with concrete coring and drilling through the hangar floor location if all utilities beneath the flooring cannot be identified.

8. Figure 13: To assess the airfield hangar, groundwater samples should be collected from the shallowest downgradient groundwater; the proposed wells (G6M-04-02X and G6M-04-04X) are screened to intercept the AOC 50 PCE plume, which is deeper in the overburden (PCE is a "sinker"). In addition, potential migration pathways from the hangar should be identified and assessed to ensure that sampling coverage is adequate to screen the hangar. In particular, available drawings should be reviewed and a site visit should be conducted to determine if foam storage equipment and foam-based fire suppression equipment are located in the hangar and to identify the floor drains and associated pipelines and oil-water separators that could have conveyed foam beneath and away from the hangar. MassDEP recommends that a joint Army-EPA-DEP inspection be conducted to determine whether or not a foam-based fire suppression system exists in the hangar, to assess floor drains, and to determine sampling locations.

Response: Shallow wells are not available in this area as the existing monitoring wells in this area are screened in the deeper intervals in order to monitor the PCE plume. G6M-04-02X and G6M-04-04X have been removed from the sampling list and two new temporary wells will be sampled immediately downgradient of the hangars.

Based on past discussions with site personnel (Draft Final Base-Wide Preliminary Assessment for Evaluation of Perfluoroalkyl Substances, page 2-5), the hangars used water-only fire suppression systems. Drainage structures from the hangars were previously investigated by ADL (Storm Sewer System Evaluation [AREE70] Report, Arthur D Little, 1994), and it was determined that none of the floor drains were connected to the sewer system. Floor drains and catch basins were routed to the Nashua River via various outfalls present at the facility.

The Army is not able to locate design drawings for the hangars. The field visit that was scheduled for March 14, 2017 with regulators was cancelled due to snow. The field visit can be rescheduled once the snow is no longer an issue.

March 24, 2017 Teleconference: The Army indicated that they would search for drawings of the hangars to determine location of floor drains; storm water drainage network and

outfalls; and overall airfield layout. The drawings have been included in Attachment A of the ESI Work Plan. The hangar drawing indicates that only water was used in the fire suppression system in the hangar and the floor drains were connected to the storm drainage system. The storm drain network drawing indicates that there are 12 storm drain outfalls located around the perimeter of the airfield and that the catch basins were located throughout the runways to collect any water/liquids falling on the runways. The overall airfield layout indicates that there were originally three runways (W-SE Runway [300 ft x 5200 ft], N-S Runway [300 ft x 3000 ft], and E-W Runway [300 ft x 2700 ft]).

Given the lack of current details regarding the site history, use, and facilities, MassDEP requested that additional temporary points be included to investigate the presence or absence of PFAS at the hangars. MassDEP provided mark up of existing figure showing the proposed locations. The Army indicated that relocating existing point TP-2017-13 to the east between hangar buildings 3818 and 3813 would be appropriate to characterize groundwater downgradient of building 3818 and upgradient of building 3813. The Army will add the locations requested by MassDEP to the sampling program.

9. Figure 13: Any other hangars that exist at the airfield should also be assessed as outlined in Comment 8.

Response: There are two former hangars at the airfield (Buildings 3813 and 3818). As indicated in response to comment 8, two new temporary wells will be sampled immediately downgradient of the hangars (see attached Figure 13). Based on interviews, the hangars did not use a foam-based fire suppression systems. The potential source at the hangars is associated with storage and possible spillage of firefighting foam. Sampling of downgradient groundwater at the water table will be used to assess the presence or absence of PFAS at the hangars.

10. Figure 13: To assess SA 31, groundwater samples should be collected from the shallowest downgradient groundwater; the proposed wells (G6M-13-01X and G6M-97-05B) are screened to intercept the AOC 50 PCE plume, which is deeper in the overburden.

Response: Shallow wells are not available as the existing monitoring wells in this area are screened in the deeper intervals in order to monitor the PCE plume. A temporary well point will be added in the open area directly west of G6M-97-05B to collect groundwater from the water table instead of from those two deeper wells. Wells XSA-12-97X and G6M-13-01X will be sampled to evaluate deeper groundwater to assess overall potential sources in upgradient areas of the airfield (e.g., hangars and runway). As proposed in the ESI Work Plan, groundwater samples from TP-2017-19 and -24 also will be collected from the water table.

11. Figure 14: Please include a figure that shows the DRMO yards as they were configured when foam might have been released there.

Response: A figure has been added showing past site conditions (see attached).

U.S. ARMY RESPONSES TO U.S. EPA COMMENTS ON THE DRAFT FINAL EXPEDITED SITE INSPECTION WORK PLAN FOR PER- AND POLYFLUOROALKYL SUBSTANCES (PFAS)
FORMER FORT DEVENS ARMY INSTALLATION, DEVENS, MASSACHUSETTS
APRIL 26, 2017

The following U.S. Army responses pertain to the U.S. Environmental Protection Agency (EPA) comments dated April 20, 2017 on the *Draft Final Expedited Site Inspection Work Plan for Per- and Polyfluoroalkyl Substances (PFAS)* at the Former Fort Devens Army Installation dated April 2017.

COMMENTS

Pages 1-3 to 1-5, Select Sampling Areas: The text for several AOCs/SAs in this section needs to be revised to reflect the updated sampling plan. For example, the text describing the former airfield hangar and fire station states that "existing monitoring wells located downgradient of the former airfield hangar and fire station have been selected for PFAS sampling". However, following the EPA/MassDEP/Army conference call on March 24, 2017, Army revised the plan to sample more appropriately placed temporary groundwater sampling points, rather than existing wells. Another example is that for the former airfield runway, only sampling along its extent is described, whereas sampling of the runway drainage system outfalls has now been included. Please review and revise.

Response: The text was updated.

Page 2-1, Groundwater Sample Collection: Within the bullets, the text states to "Attach tubing to peristaltic pump at the ground surface and at minimum purge 100 milliliters (mL) of groundwater using USEPA Region 1 Low Stress Purging and Sampling Procedures". It is unclear if the procedure is calling for a volumetric purge of at least 100 mL, or a purge rate of 100 mL/minute. Please clarify.

Response: The text was revised to indicate: "…surface and purge groundwater at a minimum rate of 100 milliliters per minute (mL/min) using USEPA Region 1 Low Stress Purging and Sampling Procedures".

Page 2-2, Water Quality Measurements: This section describes that water quality parameters will be collected following PFAS sample collection by inserting a multi-parameter meter into the sample to measure dissolved oxygen, specific conductance, temperature, and oxygen reduction potential. However, within Section 2.1 regarding groundwater sample collection, the Army states that they will use USEPA Region 1 Low Stress Purging and Sampling Procedures (low stress procedure) for both existing wells and temporary well points. This low stress procedure includes the monitoring of those water quality parameters to ensure stabilization prior to collection of the sample. Therefore, the procedures that Army is proposing are unclear. Please clarify.

Response: The text was revised to state: "Samples will be collected for water quality parameters during low flow purging and prior to PFAS sample collection".

Figure 10 - Study Area 20, Sand Infiltration Beds: Sample location SA20-17-03 is shown on the figure, but listed as SA20-17-01 in the text. Please correct the discrepancy.

Response: The sample location was revised on the Figure 10 to SA20-17-01.

Figure 12 - Study Area 75: The figure shows that CSMS-11-01 and CSMS-11-02 will be sampled to evaluate potential impacts to groundwater upgradient of the Grove Pond potable wells. Table 1 lists that CSMS-11-01 and CSMS-11-02 are screened from 30-40 feet below ground surface. In order for EPA to fully evaluate locations and screened intervals of sampling locations, please provide the depths of the Grove Pond potable wells and the screened interval for monitoring well MNG-3 within Army's Response to Comments.

Response: The depths of the Grove Pond Wells are:

- **Grove Pond Well #1 (2019000-01G) (inactive) = 40 - 50 ft bgs**
- **Grove Pond Well #2 (2019000-02G) (inactive) = 40 - 58 ft bgs**
- **Ayer RW-06G/GW 6 (2019000-06G) = 47 - 57 ft bgs**
- **Ayer RW-07G/GW 7 (2019000-07G) = 56 - 71 ft bgs**
- **Ayer RW-08G/GW 8 (2019000-08G) = 60 - 73 ft bgs**

Existing monitoring well MNG-3 is screened at a depth of approximately 53-63 feet (ft) below ground surface (bgs). This well will be added to the sampling program for SA 75.

Figure 13 – AOC 50, Firefighting Training Area: In order for more complete coverage in evaluating impacts from the firefighting training area, EPA requests one additional temporary point be advanced west of the training area (north of SA31-17-02) for the collection of a groundwater sample.

Respones: New sample location SA31-17-04 will be added west of the Firefighting Training Area.

Figure 14- AOC 32, Former DRMO: In order to evaluate deeper groundwater within the eastern portion of AOC 32, EPA requests that Army add an additional monitoring well screened in bedrock, if available, to the sampling program.

Response: The bedrock wells and approximate screened intervals (feet below ground surface) located in eastern portion of AOC 32 are listed below.

- **32M-01-13XBR = 13.7 - 23.7 ft bgs**
- **32M-01-17XBR = 41.4 - 51.4 ft bgs**
- **32M-01-18XBR = 14.0 - 24.0 ft bgs**

The Army proposes to add 32M-01-17XBR to the PFAS sampling program, which is a current LTM well to the sampling program.

U.S. ARMY RESPONSES TO MassDEP COMMENTS ON THE DRAFT FINAL EXPEDITED SITE INSPECTION WORK PLAN FOR PER- AND POLYFLUOROALKYL SUBSTANCES (PFAS)
FORMER FORT DEVENS ARMY INSTALLATION, DEVENS, MASSACHUSETTS
APRIL 26, 2017

The following U.S. Army responses pertain to the Massachusetts Department of Environmental Protection (MassDEP) comments dated April 20, 2017 on the *Draft Final Expedited Site Inspection Work Plan for Per- and Polyfluoroalkyl Substances (PFAS)* at the Former Fort Devens Army Installation dated April 2017.

COMMENTS

1. Figure 9: Please confirm/correct the location of well SHM-10-15 (should be located on the landfill?).

Response: Location of well SHM-10-15 was corrected.

2. Figure 10: Please confirm/correct the SA20-17-03 sample ID (should be SA20-17-01?).

Response: Sample ID was corrected.

3. Figure 13 should identify sample location AOC50-17-14.

Response: Sample location AOC50-17-14 is shown on Figure 13 north of the injection well transect in Area 5.

4. Figure 13: MassDEP recommends that a joint Army-EPA-DEP site visit be conducted to confirm that the AOC 50 samples will be collected from locations where PFAS releases were most likely to occur.

Response: A joint site visit will be conducted in May 2017 to review the proposed sampling locations.

5. Attachment A: Please identify which hangar (Building 3813 or Building 3818) is represented in the plumbing and sprinkler system drawings.

Response: The appropriate hanger building numbers will be added to the two drawings in Attachment A.