3.05 5/5/98 485

SIGNATURE PAGE

Final Work Plan
Remedial Investigation and Feasibility Study

Site 11: Production Well "F"
Allegany Ballistics Laboratory
Rocket Center, West Virginia

Navy CLEAN II Program
Contract Number N62470-95-D-6007
Contract Task Order 0013

Prepared by

CH2M HILL

May 5, 1998

Approved by: [signature] Date: 5-5-98
Brett Doerr, P.G.
Project Manager

Approved by: [signature] Date: 5-5-98
J. Greg Mott, P.G.
Activity Manager

Approved by: [signature] for Date: 5-5-98
Robert W. Root, Jr., PhD., P.G.
Sr. Reviewer

Final

Work Plan
Remedial Investigation and Feasibility Study of Site 11

for

Allegany Ballistics Laboratory
Rocket Center, West Virginia

Contract Task Order 0013

May 1998

Prepared for

Department of the Navy
Atlantic Division
Naval Facilities Engineering Command

Under the

LANTDIV CLEAN II Program
Contract N62470-95-D-6007

Prepared by

CH2MHILL

Herndon, Virginia

Contents

Table of Contents (Continued)

Tables **Page**

Figures

Section 1
Introduction

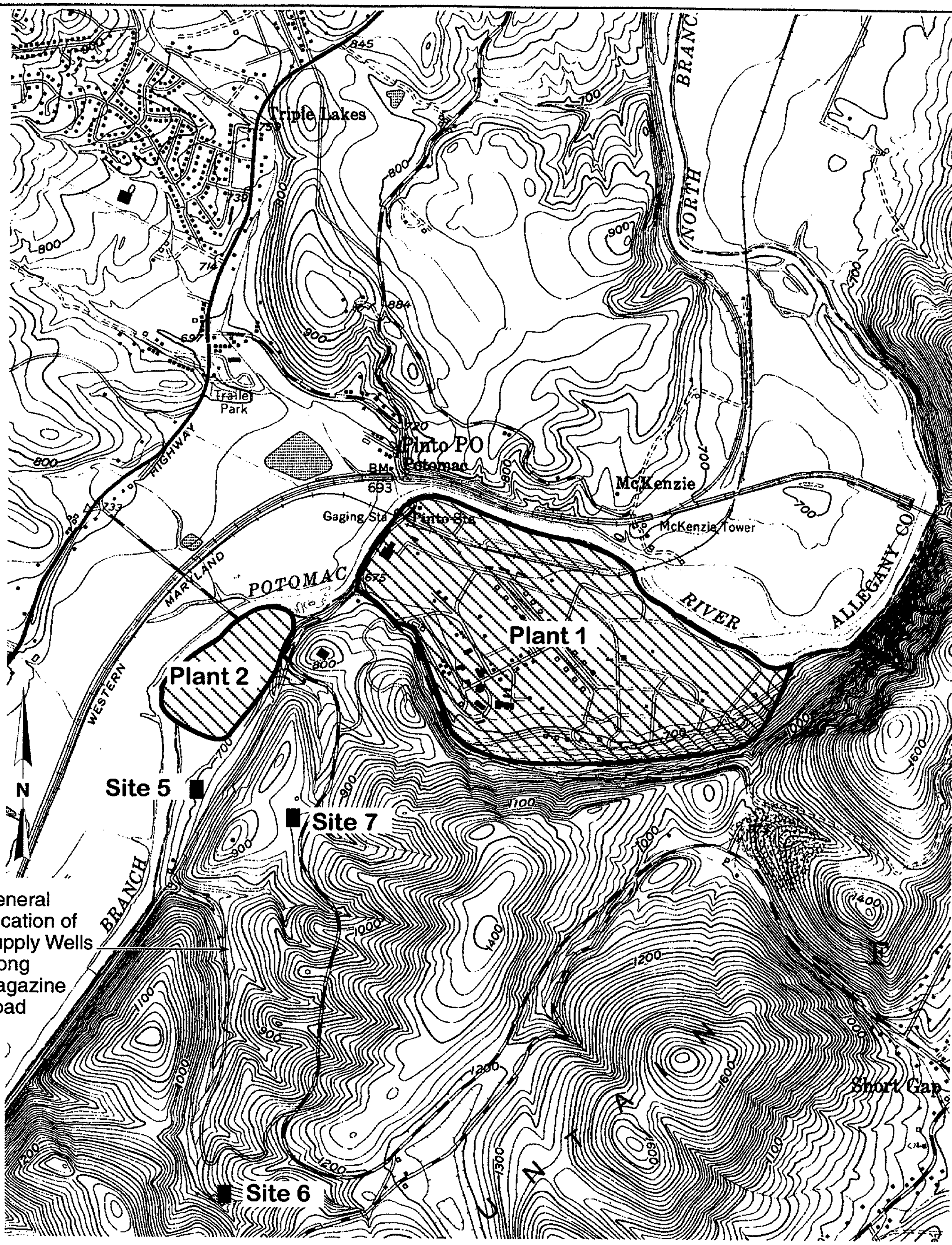
This work plan describes the work necessary to conduct a remedial investigation and feasibility study (RI/FS) of Installation Restoration Program (IRP) Site 11 at Allegany Ballistics Laboratory (ABL) in Rocket Center, West Virginia. This work plan is based (with some changes) on a scope of work provided by the Atlantic Division of the Naval Facilities Engineering Command (NAVFAC) on March 11, 1996 as part of Navy Contract N62470-95-D-6007, Comprehensive Long-Term Environmental Action Navy (C.L.E.A.N.), District III, Contract Task Order - 0013.

Because the activities to be conducted under this work plan are intended to support recommendations made in the *Advanced Site Inspection of Site 11 at Allegany Ballistics Laboratory Superfund Site* (ASI) (CH2M HILL, February 1996), the ASI will be referenced throughout the work plan, as appropriate. Documents for other investigations conducted at ABL also will be referenced, as appropriate.

Section 2 of this work plan provides a brief description of the history of Site 11 and references the appropriate documents containing descriptions of the site physical setting and data gathered to date. Section 3 discusses the current understanding of the nature and extent of contamination at Site 11. Section 4 discusses the rationale and justification for conducting the work described in this work plan, including presentation of the current conceptual model of Site 11 and data gaps to be filled during the RI. Section 5 describes the technical approach to achieving the objectives of the RI/FS and Section 6 presents the estimated schedule for achieving these objectives.

sufficient soil cleanup had been achieved; however, samples collected during the ASI indicated deeper contamination.

Additional Site 11 background information, including topography, surface hydrology, geology, hydrogeology, and nature and extent of contamination is discussed in Section 2 of the ASI. Information regarding previous investigations at ABL is presented in the *Remedial Investigation of the Allegany Ballistics Laboratory* (RI), January, 1996, the *Focused Remedial Investigation of Site 1 at Allegany Ballistics Laboratory* (Focused RI), August 1995, and the *Phase II Remedial Investigation at Allegany Ballistics Laboratory* (Phase II RI) August, 1996. Copies of both Hercules Letter Reports are included as Appendix A of this Work Plan.



Source: USGS 7.5 minute Cresaptown, WV-MD quadrangle map.

0 1000 2000

Scale in Feet

Figure 2-1
LOCATION MAP
Site II RI/FS
Allegany Ballistics Laboratory

CH2M HILL

LEGEND

- ALLUVIAL EXTRACTION WELL
- BEDROCK EXTRACTION WELL
- ALLUVIAL MONITORING WELL
- BEDROCK MONITORING WELL
- MONITORING WELL SCREENED ACROSS THE ALLUVIUM/BEDROCK CONTACT
- FORMER PRODUCTION WELL

NOTES:

1. SITE 1 ALLUVIAL EXTRACTION WELLS ARE NUMBERED CONSECUTIVELY FROM 1EW1 TO 1EW27. ONLY WELLS 1EW1 AND 1E27 ARE LABELED ON THIS FIGURE.

Figure 2-2
PLANT 1 FEATURES AND SITE LOCATIONS
SITE 11 RI/FS
ALLEGANY BALLISTICS LABORATORY

CH2MHILL

22-DEC-1997 8722f018.dlv

Section 3
Initial Evaluation

Much of the information concerning the nature and extent of contamination at Site 11 was gathered during the ASI. Additional information was gathered during activities related to decommissioning of the former oil storage area at the site. A detailed discussion of this information is documented in the ASI Report (CH2M HILL, February 1996) and summarized below.

The results of the ASI and previous activities at Site 11 indicate groundwater and soil have been impacted by total petroleum hydrocarbons-diesel range organics (TPH-DRO) and volatile organic compounds (VOCs), semivolatile organic compounds (SVOCs), and/or inorganics at concentrations exceeding EPA Region III risk-based concentrations (RBCs [as of January 1996]).

Bedrock Groundwater

To date, the only bedrock groundwater data at Site 11 has been obtained from F-Well. The investigation of this well involved downhole video and geophysical logging and light non-aqueous phase liquid (LNAPL), dense non-aqueous phase liquid (DNAPL), and groundwater sampling and analysis. During the ASI, F-Well was reamed from the surface to a depth of 230 feet to remove a blockage in the borehole. At 200 feet, the reaming process encountered loose sand. Four days after reaming, video logging of the borehole revealed at least 1.5 feet of a LNAPL layer at the top of the water column. Additionally, sand was found to have refilled the borehole to a depth of 178 feet and a 6-foot-thick layer of black, oily DNAPL was detected just above the sand. Both NAPLs were sampled, followed by removal of as much of the product as possible using a pump and bailer.

The downhole logging of F-Well also revealed the presence of several major and minor fracture zones. The largest fracture zone (i.e., up to about 7 inches wide) was identified between approximately 80 and 86 feet bgs (elevation of about 584 to 590 feet above mean sea level (msl)). This is similar to the fracture set elevation identified in bedrock well GGW2, located approximately 500 feet northwest of F-Well and between the North Branch Potomac River and F-Well. A somewhat smaller fracture set (i.e., up to about 3 inches wide) was identified in F-Well between about 30 and 36 feet bgs (i.e., between 634 and 640 feet msl). Possible minor fractures were identified at depths of 126, 129, 63, 112, 148, and 158 feet bgs (i.e., 544, 541, 607, 558, 522, and 512 feet msl).

Figure 3-1 shows the concentration of TPH-DRO and other constituents detected at concentrations above RBCs in both the LNAPL and DNAPL samples collected from F-Well during the ASI. Validated analytical results of the LNAPL sample showed RBC exceedances for 1,2-dichlorobenzene, 1,4-dichlorobenzene, N-nitrosodiphenylamine, tetrachloroethene (PCE), and manganese. In addition, TPH-DRO was detected in the LNAPL sample at a concentration of 42 mg/l.

Validated analytical results of the DNAPL sample showed RBC exceedances for 1,2-dichorobenzene, 1,4-dichlorobenzene, 1,2,4-trichlorobenzene, naphthalene, PCE, chloromethane, and manganese. TPH-DRO was detected in the DNAPL sample at a concentration of 4,600 mg/l (Figure 3-1).

As Figure 2-2 shows, the closest Plant 1 monitoring wells to Site 11 are alluvial/bedrock well pair GGW1/GGW2. The Plant 1 piezometric-surface map of the bedrock aquifer (Figure 3-2) indicates the direction of flow from Site 11 is toward the North Branch Potomac River, possibly by way of well pair GGW1/GGW2. (However, F-well was the only Site 11 bedrock well used in developing the piezometric surface and because of the LNAPL water level measurements are suspect.) The bedrock well in this well pair, GGW2, was sampled in 1992. Trichloroethene (TCE), which was not detected in the NAPL samples collected from F-Well during the ASI, was the only VOC detected in the well; it was found at a concentration of 5 µg/l.

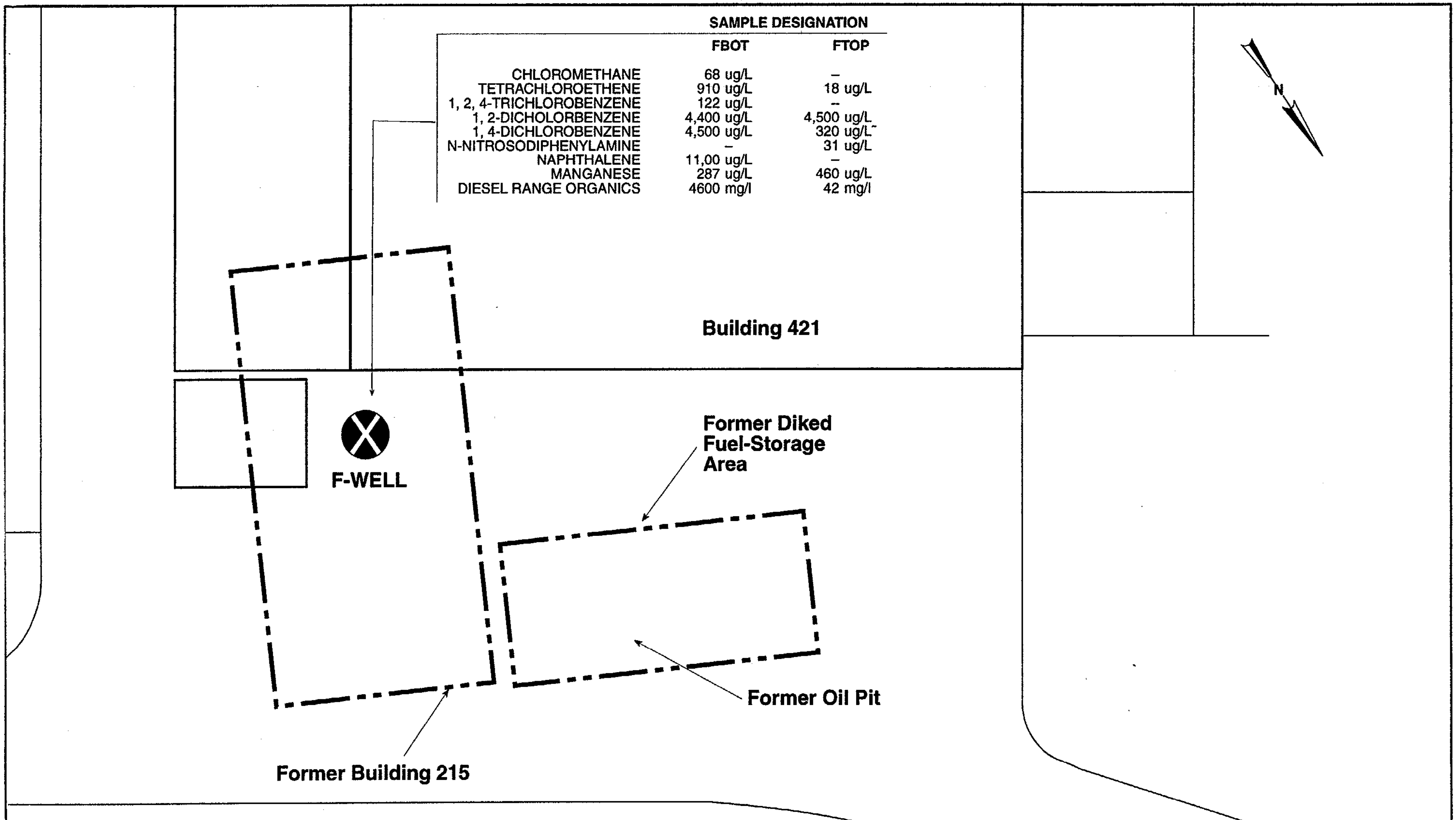
Alluvial Groundwater

The piezometric-surface map in Figure 3-3 shows that, like its bedrock-aquifer counterpart, alluvial groundwater from Site 11 may flow toward well pair GGW1/GGW2 and the North Branch Potomac River. The alluvial well in this well pair, GGW1, was sampled in 1992 and again in 1994. TCE (9 µg/l) was the only VOC detected in the well in 1992; no VOCs were detected in the well in 1994. Figure 3-4 shows the concentrations of VOC, SVOC, and inorganic constituents detected above tap water RBCs in the alluvial piezometers at Site 11 during the ASI. TCE was detected in three of the six alluvial piezometers, including 44 µg/l in the most downgradient piezometers. Figure 3-4 also shows no analytes were detected at levels above RBCs in the groundwater sample collected from the upgradient piezometer, TP-1. However, several VOCs, SVOCs, and manganese were detected above tap water RBCs in groundwater samples collected downgradient and proximate to F-Well and the former oil storage area.

Soil

During decommissioning activities, soil samples collected from within the diked oil storage area contained TPH at concentrations as high as 1,400 mg/kg. After removal of the dike walls, oil pit, and much of the soil within the diked area, no TPH-DRO concentrations in the confirmatory samples collected from within the former diked area were above 90 mg/kg. Furthermore, no TPH-DRO was detected in confirmatory samples collected from the excavated area of the former boiler house (Building 215).

138649.PP.QS.3_1/ZIP 001



SAMPLE DESIGNATION	FBOT	FTOP
CHLOROMETHANE	68 ug/L	–
TETRACHLOROETHENE	910 ug/L	18 ug/L
1, 2, 4-TRICHLOROBENZENE	122 ug/L	–
1, 2-DICHOLORBENZENE	4,400 ug/L	4,500 ug/L
1, 4-DICHLOROBENZENE	4,500 ug/L	320 ug/L
N-NITROSODIPHENYLAMINE	–	31 ug/L
NAPHTHALENE	11,00 ug/L	–
MANGANESE	287 ug/L	460 ug/L
DIESEL RANGE ORGANICS	4600 mg/l	42 mg/l

FBOT = sample collected at bottom of water column in F-Well
FTOP = sample collected at top of water column in F-Well

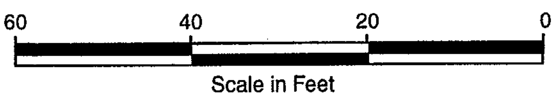


Figure 3-1
DIESEL RANGE ORGANICS AND CONTAMINANTS DETECTED IN BEDROCK-AQUIFER GROUNDWATER AT CONCENTRATIONS ABOVE EPA RISK-BASED VALUES FOR INGESTION OF TAP WATER
Site 11 RI/FS Work Plan – Allegany Ballistics Laboratory

CH2M HILL

Document Page Holder

BOX

DOC. NAME: 00485 H B1 Z

FIGURE NO.: 3-2 & 3-3

BOX

DOC. NAME:

FIGURE NO.:

BOX

DOC. NAME:

FIGURE NO.:

BOX

DOC. NAME:

FIGURE NO.:

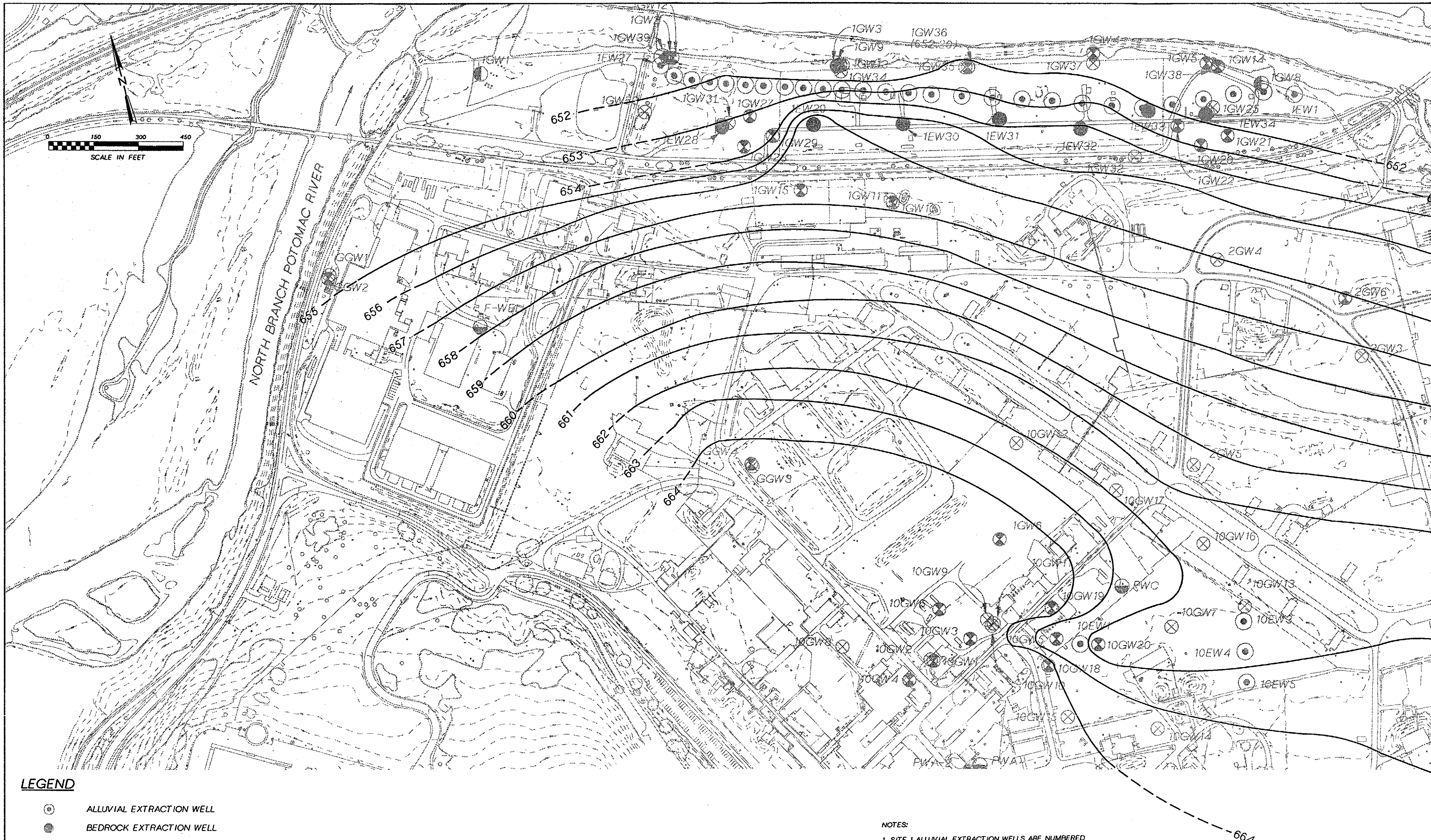
BOX

DOC. NAME:

FIGURE NO.:

Z = B & W 11 X 17　　Y = COLOR　　X = OVERSIZE

00485 H B12



LEGEND

- ALLUVIAL EXTRACTION WELL
- BEDROCK EXTRACTION WELL
- ALLUVIAL MONITORING WELL
- BEDROCK MONITORING WELL
- MONITORING WELL SCREENED ACROSS THE ALLUVIUM/BEDROCK CONTACT
- FORMER PRODUCTION WELL

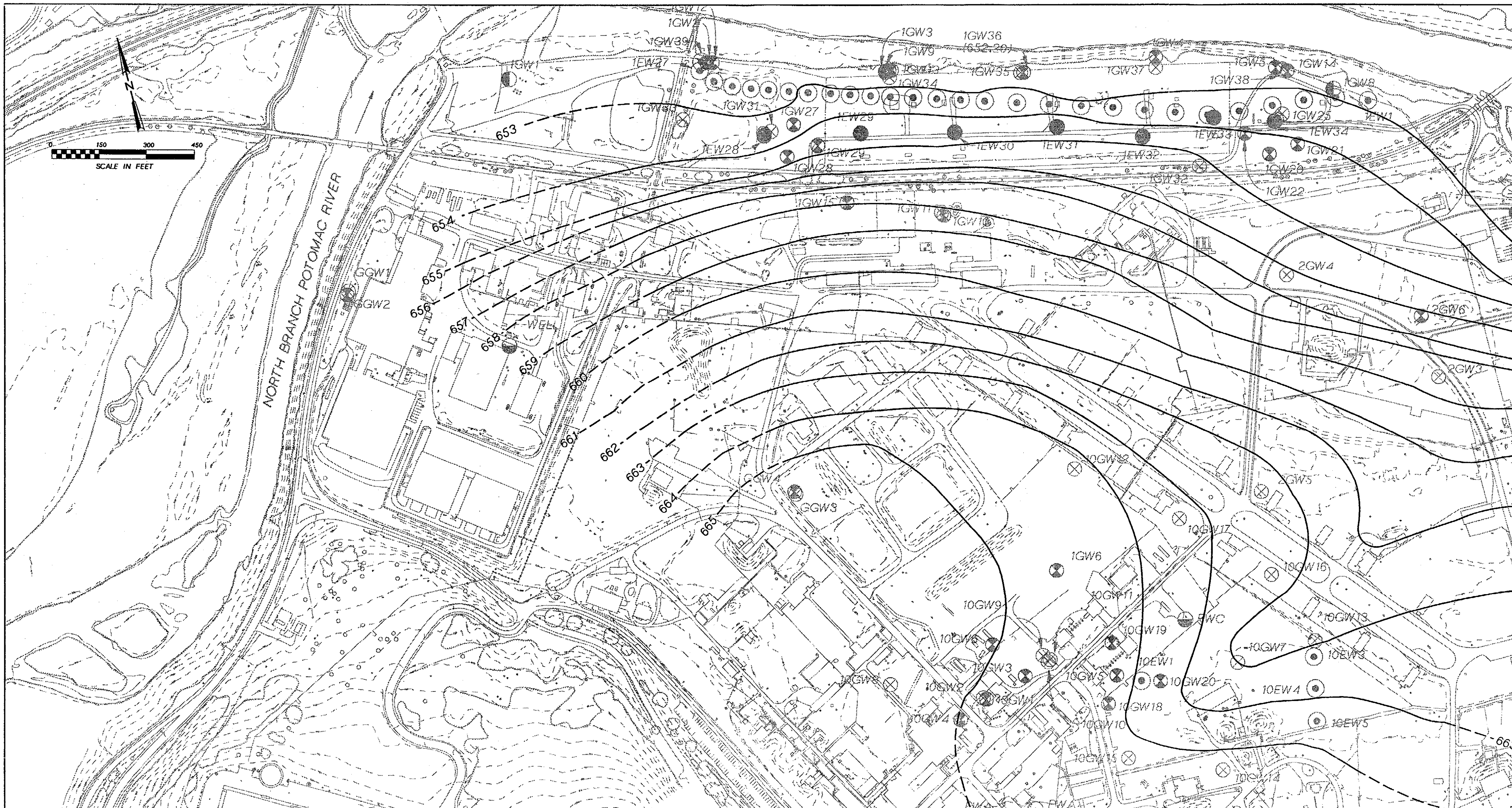
NOTES:

1. SITE 1 ALLUVIAL EXTRACTION WELLS ARE NUMBERED CONSECUTIVELY FROM 1EW1 TO 1EW27. ONLY WELLS 1EW1 AND 1E27 ARE LABELED ON THIS FIGURE.

Figure 3-2
ESTIMATED PIEZOMETRIC SURFACE IN BEDROCK AQUIFER
DECEMBER 23, 1996
SITE II RI/FS
ALLEGANY BALLISTICS LABORATORY

CH2MHILL

22-DEC-1997 87221020.dlv



LEGEND

- ALLUVIAL EXTRACTION WELL
- BEDROCK EXTRACTION WELL
- ALLUVIAL MONITORING WELL
- BEDROCK MONITORING WELL
- MONITORING WELL SCREENED ACROSS THE ALLUVIUM/BEDROCK CONTACT
- FORMER PRODUCTION WELL

NOTES:

1. SITE 1 ALLUVIAL EXTRACTION WELLS ARE NUMBERED CONSECUTIVELY FROM 1EW1 TO 1EW27. ONLY WELLS 1EW1 AND 1E27 ARE LABELED ON THIS FIGURE.

Figure 3-3

ESTIMATED PIEZOMETRIC SURFACE IN ALLUVIAL AQUIFER
DECEMBER 23, 1996
SITE 11 RI/FS
ALLEGANY BALLISTICS LABORATORY

CH2MHILL

22-DEC-1997 8722f019.dlv

During the ASI, soil samples were collected from five locations within the former oil storage area. Up to approximately 1,800 mg/kg of TPH-DRO were detected in these samples. Additional soil samples were collected around the perimeter of the former boiler house. Only one sample contained detectable TPH-DRO. An oily film was observed on cobbles near the bottom (approximately 10 feet bgs) of some borings within the former diked oil storage area. Figure 3-5 shows the TPH-DRO results for all soil samples collected during the Site 11 ASI.

Figure 3-5 also shows the concentrations of constituents detected in Site 11 soil samples during the ASI above RBCs. Beryllium was detected in soil borings in the vicinity of the former oil storage area at concentrations as high as 1.5 mg/kg. Relatively low VOC and SVOC soil contaminants including PCE, xylenes, 1,4-dichlorobenzene, 2-methylnaphthalene, naphthalene, phenanthrene, and bis(2-ethylhexyl)phthalate also were detected. Soil boring SBF2, located closest to the former oil pit, had the greatest number and highest concentrations of SVOC detections.

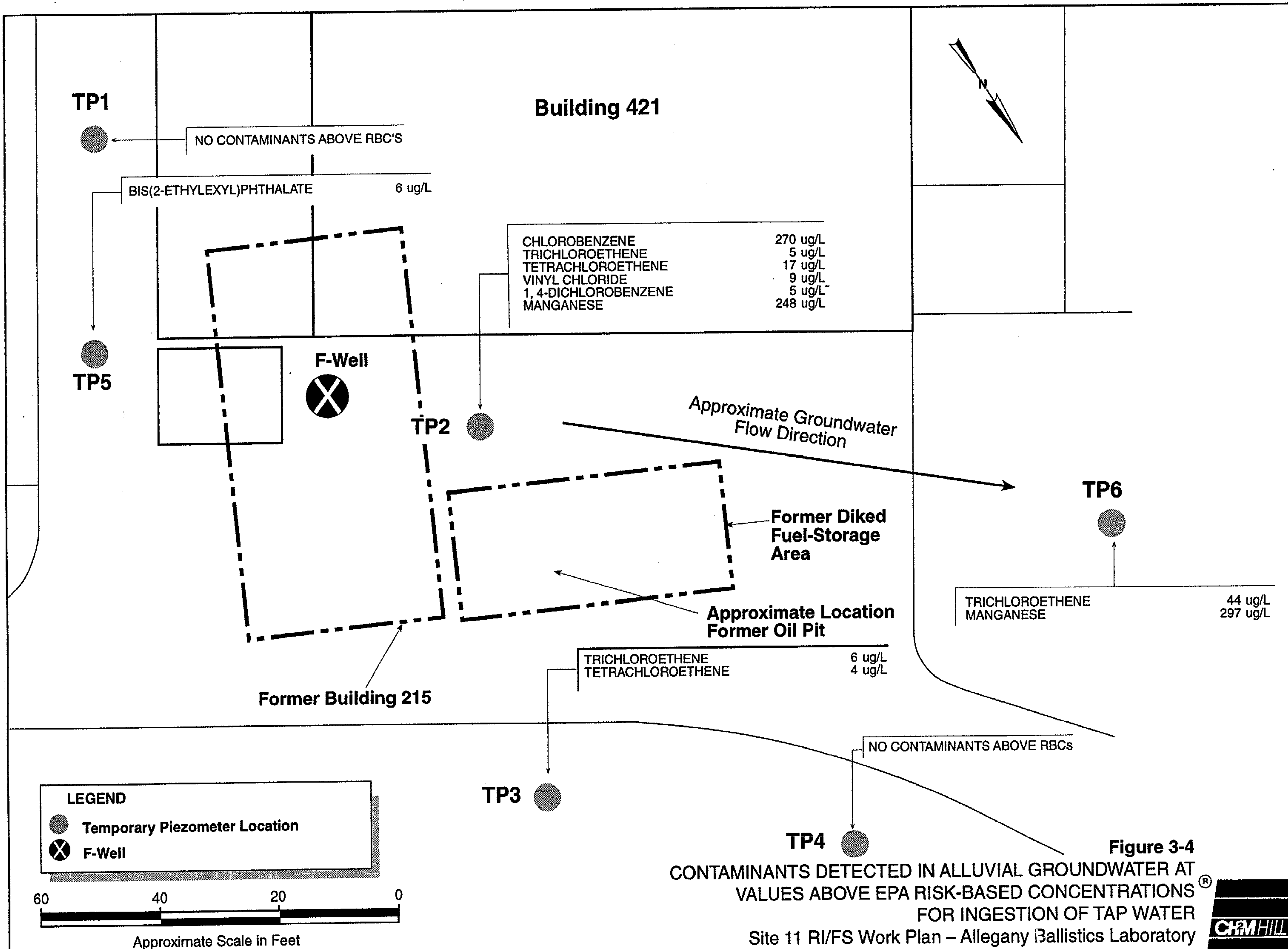


Figure 3-4
CONTAMINANTS DETECTED IN ALLUVIAL GROUNDWATER AT VALUES ABOVE EPA RISK-BASED CONCENTRATIONS FOR INGESTION OF TAP WATER
Site 11 RI/FS Work Plan – Allegany Ballistics Laboratory

CH2M HILL

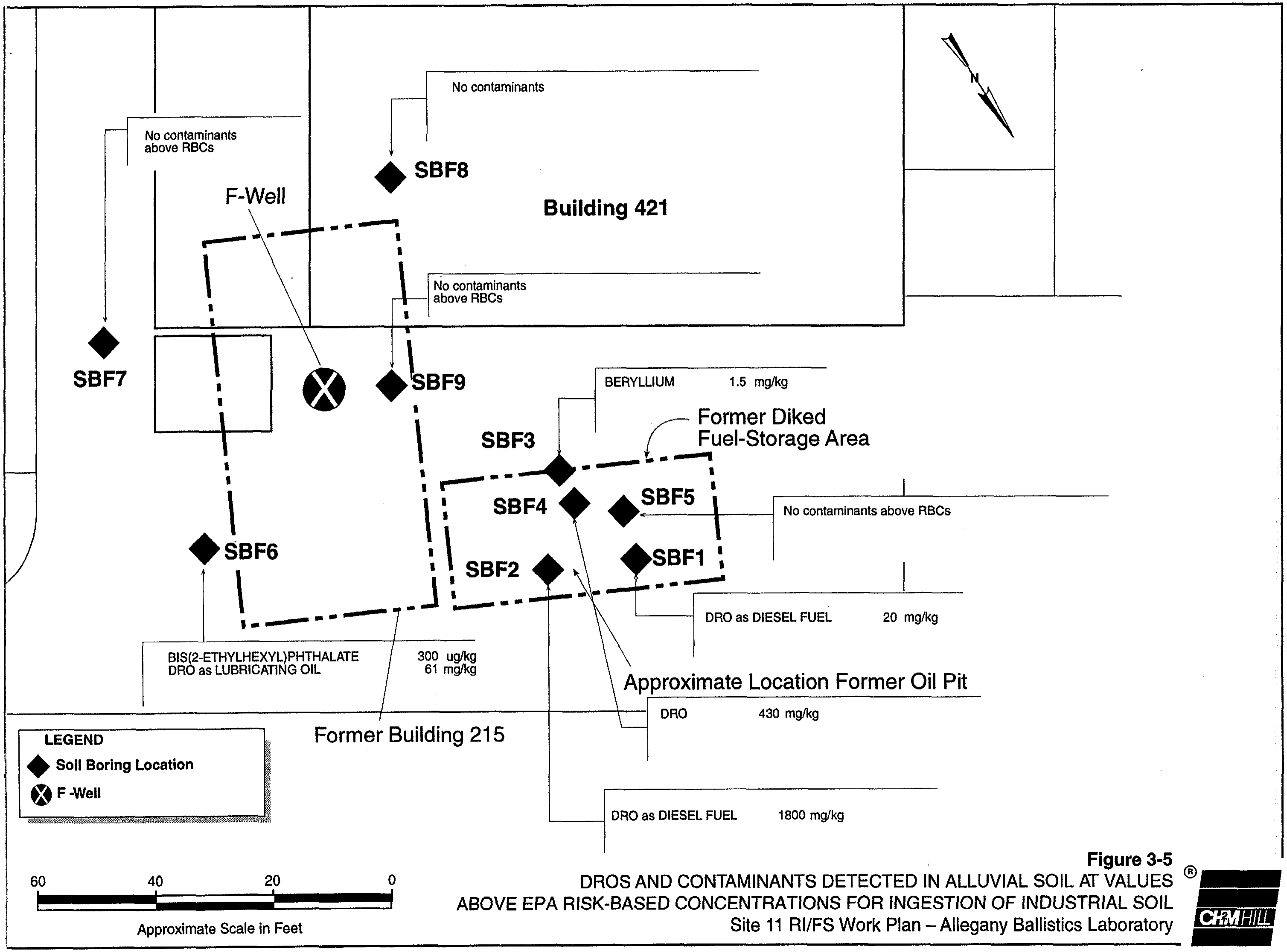


Figure 3-5
DROS AND CONTAMINANTS DETECTED IN ALLUVIAL SOIL AT VALUES ABOVE EPA RISK-BASED CONCENTRATIONS FOR INGESTION OF INDUSTRIAL SOIL
Site 11 RI/FS Work Plan – Allegany Ballistics Laboratory

CH2MHILL

Section 4
Work Plan Rationale and Justification

The ASI and related activities conducted at Site 11 identified the presence of VOC, SVOC, metal, and petroleum-hydrocarbon contamination in soil and/or groundwater. Potential sources of the contamination were identified, but the extent of contamination in both soil and groundwater at the site was not sufficiently discerned. Based on these findings, performance of an RI/FS at Site 11 was recommended.

Based on the information gathered to date, a conceptual model for Site 11 was developed. This model, graphically depicted in Figure 4-1, identifies F-Well and the former fuel storage area as the primary potential sources of contaminants found at the site. Both are considered individual sources because of some marked constituent differences between F-Well and the soil and alluvial groundwater. As discussed in Section 3, DRO, low concentrations of several VOCs, and relatively high concentrations of primarily chlorinated benzene SVOCs were detected in NAPL samples collected from F-Well. These findings contrast the results for groundwater samples collected from the alluvial aquifer, which contained different VOCs, relatively low SVOC concentrations, and no DRO. Further, the types of VOCs detected in alluvial groundwater were similar to those detected in the soil samples.

Based on the identification of two primary sources of contamination, the conceptual model for Site 11 shows the most likely migration pathways and exposure scenarios (Figure 4-1). Although not documented, it is suspected that F-Well was used to dispose of an unknown quantity of waste fuels, oils, and/or solvents as a result of activities at former Building 215 (boiler house). Existing as NAPLs, these waste products can migrate through the subsurface under the influence of gravity. In addition, the NAPLs can provide a continuous source of dissolved-phase contamination which can migrate following the hydraulic gradient to potential receptors such as the North Branch Potomac River.

The other primary source of contamination at Site 11 is the former fuel storage area, which reportedly was a diked area within which two 10,000-gallon above-ground storage tanks (AST) and an underground 55-gallon storage tank (UST) were located. The 10,000-gallon tanks reportedly were used to store No. 5 fuel oil. Over the years, these tanks experienced leaks. Furthermore, the UST was simply a 55-gallon drum buried to its neck and, therefore, overflowed its contents during wet periods. These spills and leaks resulted in releases of contaminants to surrounding soil. Once in the soil, the contamination can be leached by infiltrating precipitation and transported to the underlying groundwater.

Currently, the area around F-Well and the former fuel storage area is mostly asphalt-covered. Therefore, potential exposure to soil contamination is minimal; exposure risk is limited to on-site construction workers in the event of excavation. Potential exposure to contaminated groundwater also is minimal. Currently, no groundwater at or downgradient of Site 11 is used for potable water. In addition, wells GGW1 and GGW2, alluvial and bedrock monitoring wells located in the approximate downgradient direction between Site 11 and the North Branch

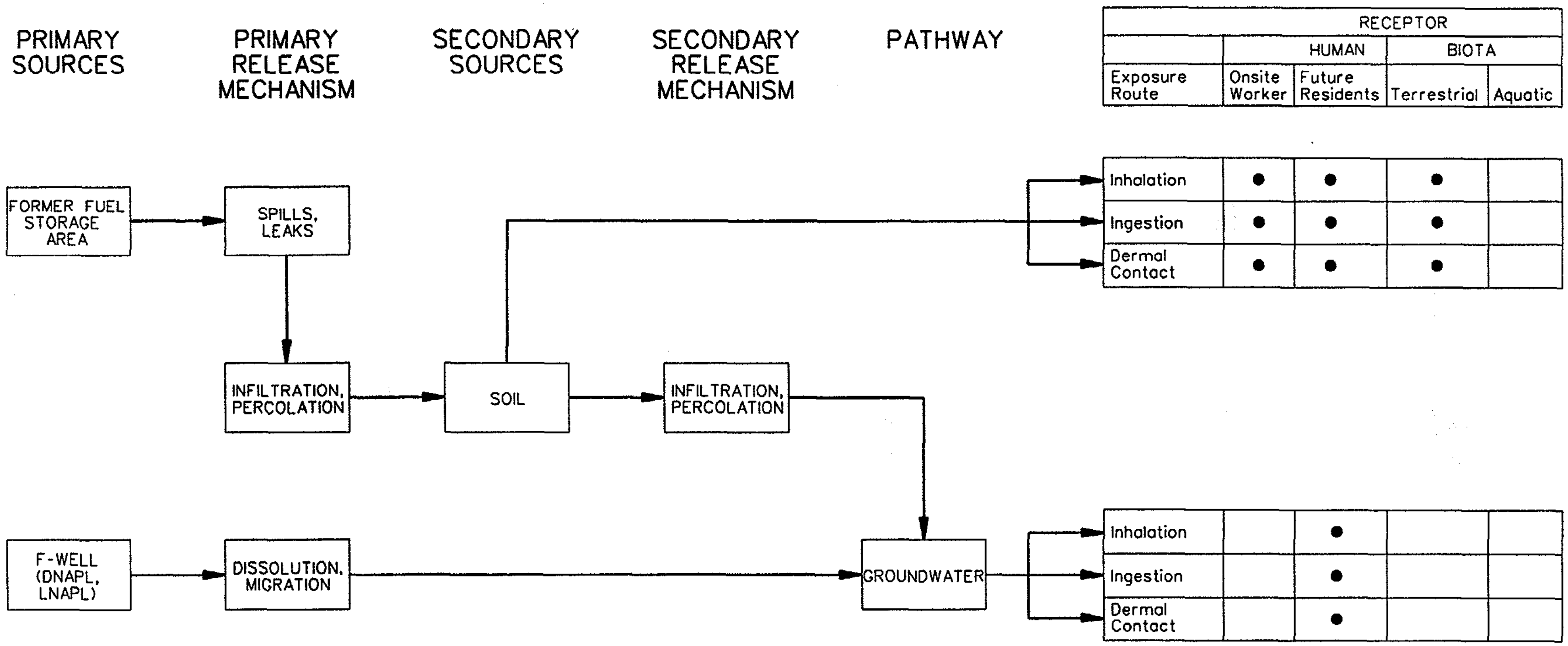


FIGURE 4-1
Site 11 Conceptual Model
Site 11 RI/FS
ALLEGANY BALLISTICS LABORATORY

CH2MHILL

Potomac River do not appear to have been impacted by alluvial or bedrock contamination observed at Site 11. Therefore, exposure risk is limited to primarily future residential use.

Potential contaminants of concern (PCCs) at Site 11 are similar for both soil and groundwater. In common to both media are DRO and several VOCs, SVOCs, and inorganics. In soil, the primary PCCs were DRO and beryllium. Several chlorinated hydrocarbons and manganese were the primary PCCs in alluvial and bedrock groundwater. In addition, DRO was identified as a PCC for bedrock groundwater at Site 11. Preliminary remediation goals (PRGs) for soil are those indicated in the Risk-Based Concentration (RBC) tables produced by USEPA Region III (January 1996) for VOCs, SVOCs, and inorganics. PRGs for groundwater are the maximum contaminant levels (MCLs) for VOCs, SVOCs, and inorganics.

The scope of the RI must be sufficient to support baseline human health and ecological risk assessments (HHRA and ERA, respectively) and an FS and/or a decision document that addresses applicable or relevant and appropriate requirements (ARARs) and mitigating confirmed contamination at Site 11. Therefore, this RI is intended to fill data gaps remaining after completion of the Site 11 ASI. The data gaps remaining for Site 11 and the RI activities proposed to fill them are discussed by medium below.

Soil

As discussed in Section 3, various contaminants were detected in soil samples collected during the ASI and other activities. Soil contamination was limited to primarily the area within the former diked oil storage area and between this area and former Building 215. In order to perform risk assessments and an FS and to determine the volume of soil, if any, requiring remediation, additional soil data to the north and northeast of the former oil storage area is necessary. In this way, the horizontal extent of soil contamination at Site 11 can be sufficiently estimated.

Alluvial Aquifer

As discussed in Section 3, a number of chlorinated hydrocarbons were detected above RBCs in the alluvial groundwater downgradient of F-Well and the former oil storage area during the ASI. To sufficiently evaluate the extent of alluvial aquifer contamination at Site 11 and to perform risk assessments, additional groundwater data is required near the suspected sources, in side-gradient directions (estimate width of plume) from the suspected sources, and at a downgradient location not impacted by contamination from the site.

In addition to collecting more data concerning the nature and extent of alluvial aquifer contamination at Site 11, additional alluvial monitoring points will be necessary to adequately define the horizontal gradient and direction of flow in the alluvial aquifer. Together with the contaminant nature and extent data, direction of flow data can be used to evaluate whether Site 11 is a potential source of the TCE contamination detected in well pair GGW1/GGW2.

Bedrock Aquifer

To date, the only information concerning bedrock aquifer characteristics at Site 11 has been derived from F-Well. Information such as nature and extent of bedrock aquifer contamination, vertical and horizontal hydraulic gradients in the bedrock, direction of bedrock groundwater flow, and upgradient bedrock groundwater quality, represents the primary data gaps remaining for Site 11. In order to adequately evaluate the nature and extent of bedrock aquifer contamination resulting from contaminant releases at Site 11 and to evaluate potential risks, these data gaps should be filled during the RI.

Section 5
Technical Approach

This section details the technical approach developed to perform the RI/FS activities at Site 11. The technical approach comprises the tasks listed below. Each task is discussed in detail in the remainder of this section.

Task 1:	Project Planning
Task 2:	Fieldwork Support
Task 3:	Field Investigation
Task 4:	Data Validation and Sample Analysis
Task 5:	Risk Assessment
Task 6:	Remedial Investigation Report
Task 7:	Feasibility Study Report
Task 8:	Proposed Plan and Record of Decision

Task 1: Project Planning

This task consists of preparing the work plan, sampling and analysis plan (SAP). Meetings and project management activities also are included in this task.

Work Plan

This work plan thoroughly defines the rationale for conducting the Site 11 RI/FS and the activities proposed for achieving the RI/FS objectives.

Sampling and Analysis Plan

The SAP comprises a quality assurance project plan (QAPP), a field sampling plan (FSP), a health and safety plan (HASP), and an investigation-derived waste management plan (IDWMP). The SAP is developed in compliance with all requirements of the U.S. Navy QA/QC program manual. The SAP is provided under the same cover as this work plan.

The QAPP meets the requirements specified by the Navy. The QAPP describes the quality assurance and quality control (QA/QC) procedures used for sampling soil, sediment, and groundwater during the Site 11 RI/FS.

CH2M HILL will not begin field sampling at the site until the Naval Technical Representative (NTR) receives confirmation that the requirements of the Laboratory Quality Assurance Plan (LQAP) have been met for the site. The subcontracted analytical laboratory will be certified by the Navy and will conform to the Navy's approved LQAP.

The FSP will be referenced during field activities as procedural guidance for all sampling and data collection activities. The FSP includes the following sections: "Site Background," "Sampling Objectives," "Sample Locations and Frequency," "Sample Designations," "Sampling Equipment and Procedures," and "Sample Handling and Analysis."

The HASP contains guidance for the health and safety of CH2M HILL employees and subcontractors during all RI/FS field activities. The HASP includes health and safety assessments for identifying problem areas where exposure to hazardous substances in water, soil, and air may occur. The assessments address safe working procedures, restrictions that will apply to site work, and potential human exposure to hazardous substances and the toxicological effects of those substances.

The HASP will be used by CH2M HILL personnel and subcontractors during fieldwork for the project. All Site 11 investigations will proceed under Level D personal protection. If field conditions warrant, protection will be upgraded to Level B or C. Upgrade to a higher level of protection will be considered an out-of-scope cost and will not be undertaken without prior authorization.

The IDWMP describes the procedures used for handling and disposing of waste materials generated during the RI field program. The waste materials will include health and safety disposable items, soil, and fluids. The plan also describes the chemical analyses that will be performed to characterize the IDW materials and the potential means of disposal. The potential disposal sites also will be identified.

Meetings

Two meetings are planned at ABL during which issues related to Site 11 will be discussed. A 1-day meeting will be held to discuss the contents of the draft RI/FS report and site-specific recommendations before the final report is submitted. CH2M HILL also will attend one Restoration Advisory Board (RAB) meeting to discuss the results of the investigation. CH2M HILL will submit the minutes of meetings to LANTDIV.

Project Management

The activities of project management include daily technical support and guidance, budget and schedule review and tracking, preparation and review of invoices, personnel-resource planning and allocation, subcontractor coordination, preparation of monthly progress reports, and communication and coordination of events with LANTDIV and ABL. Project management will occur over the duration of the project.

Task 2: Fieldwork Support

This task comprises procedures for subcontractor procurement, mobilization and demobilization, and utility-clearance procedures.

Subcontractor Procurement

As part of the RI/FS fieldwork at Site 11, CH2M HILL will procure drilling, surveying, analytical laboratory, data validation, and waste management services. The analytical laboratory will meet Navy Level D QC.

Mobilization and Demobilization

Mobilization includes the procurement and initial transport of field equipment to the site. Equipment and supplies will be transported during the CH2M HILL field team mobilization for field activities.

Demobilization activities will include time for IDW sampling and general site restoration before the return transport of field equipment and crew. Field equipment will be recalibrated and stored after the fieldwork. All soil and fluid IDW generated during field activities will be put in 55-gallon drums or large-capacity containers such as Baker tanks. All 55-gallon drums will be labeled properly and stored at a location designated by the LANTDIV and ABL before disposal. The disposal method will depend on the results of analytical characterization.

Utility Clearances

Utility clearances will be performed before the start of subsurface investigation activities at the site. CH2M HILL will coordinate subsurface utility clearances with public works personnel at ABL. CH2M HILL will be responsible for ensuring that all appropriate contacts have been made with ABL personnel and that clearances have been given for proposed drilling locations, including marking of utilities near the areas of potential drilling, before field operations begin.

Task 3: Field Investigation

The field investigation task includes all RI/FS activities associated with collecting soil and groundwater samples and installing and sampling alluvial and bedrock monitoring wells. It also includes an additional investigation of F-Well and surveying of all Site 11 well locations. A description of these activities follows.

Alluvial Monitoring-Well Installation

Three additional alluvial monitoring wells are proposed for the RI, as shown in Figure 5-1. The six existing temporary piezometers installed during the ASI (at that time designated TP-1 through TP-6) will be redesignated wells 11GW1 through 11GW6. Each alluvial monitoring well proposed for the RI and the rationale for its location are described below.

- One monitoring well, designated 11GW7, will be installed approximately 30 feet northeast of F-Well to determine if the source of contamination detected in F-Well has affected the alluvial aquifer in the area. The well also will be just downgradient of ASI soil sample SBF6, which contained detectable concentrations of PCE, TCE, 1,2-DCE, and DRO.

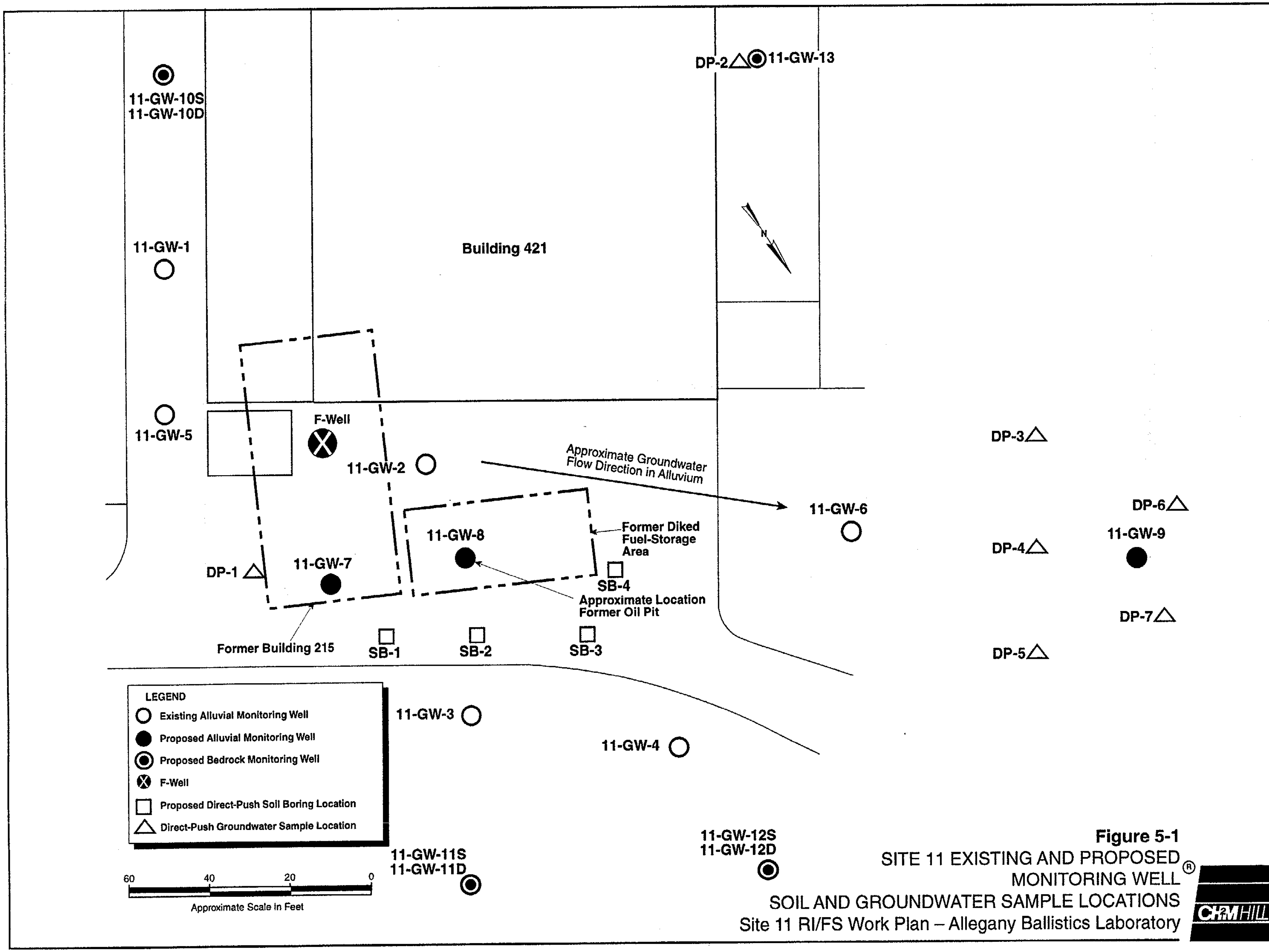


Figure 5-1
SITE 11 EXISTING AND PROPOSED MONITORING WELL
SOIL AND GROUNDWATER SAMPLE LOCATIONS
Site 11 RI/FS Work Plan – Allegany Ballistics Laboratory

- One monitoring well, designated 11GW8, will be installed in the area formerly occupied by the oil storage area to evaluate the nature and extent of alluvial groundwater contamination at this suspected source area. An attempt will be made to install this well at the location of the former 55-gallon UST.
- One monitoring well, designated 11GW9, will be installed in the presumed hydraulically downgradient direction from F-Well, the former oil storage area, and well 11GW6 at the downgradient extent of contamination detected in the alluvial aquifer. The downgradient extent of alluvial aquifer contamination will be determined by collecting approximately five direct-push groundwater samples and analyzing them for TCL VOCs.

All three new alluvial wells will be installed to the base of the alluvial aquifer using 6 ¼-inch-ID hollow-stem auger drilling techniques with split-spoon sampling. All split-spoon samples for well 11GW7 will be screened with an organic vapor monitor. If organic vapors are detected, the interval with the highest detection will be sampled and analyzed for TCL VOCs and SVOCs. The construction of the new alluvial monitoring wells will differ from that of the existing temporary piezometers only in the consistency of the annular seals, which are hydrated granular bentonite in the existing piezometers and will be cement-bentonite grout for the new monitoring wells. This small difference in construction will not affect the performance of the TPs as permanent monitoring wells.

All three new alluvial monitoring well wills be constructed of 2-inch-diameter PVC risers and screens. The screens will be installed from the base of the alluvial aquifer to above the water table. The wells will be approximately 20 feet deep. Geologic and well-construction logs will be prepared for each well.

The newly installed monitoring wells will be developed after the grout has cured for at least 24 hours. Wells will be developed by removing at least three borehole volumes of groundwater and until temperature, pH, and specific conductivity have stabilized or until the well has been pumped or bailed dry multiple times. Well development procedures are described in detail in the Monitoring Well Installation Standard Operating Procedure (SOP) in Attachment A of the FSP.

New monitoring-well locations identified in this work plan are subject to change in the event of utility clearance problems or other unforeseen circumstances. Alluvial monitoring-well installation is described in detail in the Monitoring Well Installation SOP in Attachment A of the FSP. Because the location of several of the bedrock wells depends on the downgradient direction determined for the alluvial aquifer, all alluvial monitoring wells will be installed before any bedrock well is installed.

Bedrock Monitoring-Well Installation

Four bedrock monitoring well sets are proposed for the RI at Site 11, as shown in Figure 5-1. Three of the well sets will consist of two bedrock wells (one shallow and one deep). At one of the four locations, only one well is proposed. The bedrock well designations will be consistent with the designations assigned to the alluvial monitoring wells. Each bedrock monitoring well proposed for the RI and the rationale for its location are described below.

- One bedrock well set, designated 11GW10S/D, will be installed in the presumed upgradient direction from F-Well. Because of existing structures, the well set location is restricted to the area between buildings 421 and 438 and, therefore, may not lie in the directly upgradient direction. However, chemical data from the well should adequately represent background conditions for Site 11. At this well set location, both a shallow and deep bedrock well will be installed according to the procedures outlined under ***Bedrock Well Set Construction*** below.

- Two bedrock well sets, designated 11GW11S/D and 11GW12S/D, will be installed downgradient of F-Well. Their locations will be based on determination of the direction of groundwater flow in the alluvium at Site 11 and on projections of the predominant fracture traces identified at ABL (i.e., approximately N30°E and N37°W) through F-Well. To clarify, if the downgradient direction in the alluvial aquifer is determined to be coincident (or nearly coincident) with one of the predominant fracture trace orientations projected through F-Well, then one bedrock well set will be installed downgradient of F-Well along each predominant fracture trace projected through the well. However, if the downgradient direction in the alluvial aquifer is found not to be coincident with a fracture trace orientation, then one bedrock well set will be installed in the alluvial aquifer downgradient direction and the other bedrock well set will be installed along whichever fracture trace orientation is closest to the alluvial aquifer downgradient direction. The alluvial aquifer downgradient direction will be determined from water-level measurements taken in the six existing alluvial wells.

  After site-specific fracture orientation and alluvial groundwater flow direction information are obtained, a memorandum will be prepared which suggests the locations of the two bedrock well sets. A conference call among EPA, WVDEP, Navy, and CH2M HILL then will be scheduled to come to concurrence on the final bedrock well set locations.

  At each bedrock well set location, both a shallow and deep bedrock well will be installed according to the procedures outlined under ***Bedrock Well Set Construction*** below. These wells are intended to help determine if contamination detected in F-Well has migrated downgradient.

- One bedrock well, designated 11GW13, will be installed to the southwest of F-Well to adequately evaluate the nature and extent of bedrock-groundwater contamination in this direction from F-Well. Only a single bedrock well will be installed at this location and its construction will be in accordance with the Bedrock Monitoring Well SOP presented in Attachment A of the FSP.

Bedrock Well Set Construction

The bedrock monitoring well sets will be constructed in four stages as follows:

Stage 1 - A pilot hole will be drilled using hollow-stem augers (or similar method) with continuous split-spoon sampling from the ground surface to auger refusal to characterize the physical profile of the overburden. The pilot hole will be reamed out to 12-inches in diameter and deepened approximately 5 feet into competent bedrock using air-rotary drilling. An 8-inch diameter temporary surface casing will be installed and grouted in place. Each borehole then will be drilled to 250 feet bgs using 8-inch nominal air-rotary.

If flowing sands are encountered, drilling will proceed unless the flowing sands prevent downward progress, at which time drilling will cease and the borehole tested.

After drilling, the presence of NAPL(s) in each borehole will be determined. The purpose of evaluating the presence of a NAPL is to prevent the downhole logging equipment from being ruined. The presence of an LNAPL will be evaluated using an oil/water interface probe. The presence of a DNAPL will be evaluated using a bailer. If found to be present, an attempt will be made to remove the NAPLs. If no LNAPL is present or can be removed, and a DNAPL is found to be present and unable to be removed, the DNAPL zone will not be tested. The final determination for extent of testing in each borehole will be made in the field.

Stage 2 - After determining the presence of NAPL(s), each borehole will be characterized using downhole geophysical surveys. A downhole video, caliper log, temperature log, and fluid resistivity log will be used to locate bedrock fractures and areas of groundwater through-flow in each borehole.

Stage 3 - Up to five of the most significant zones of groundwater through-flow in each borehole will be sampled using an inflatable straddle packer assembly. The samples will be analyzed on a 2-day quick turn-around basis for VOCs and SVOCs.

Stage 4 - For each of the two most contaminated zones in each bedrock borehole, a 2-inch-ID PVC monitoring well will be constructed, each with 20-foot screened intervals centered across the selected zone. Both PVC wells will be constructed within the same 8-inch diameter bedrock borehole. The two zones will be selected such that there is sufficient separation between the bottom of the shallow bedrock well screen and the top of the deep bedrock well screen to enable grouting between the two screens. Grout entry into the screened intervals will be prevented by installing bentonite seals and sand pack above and below the grouted interval. The screened interval will be sand packed and the remaining annulus will be sealed with bentonite and cement-bentonite grout. If no contamination is detected during packer sampling the lowermost and uppermost significant water-producing zones in the borehole will be screened.

By installing two wells in each bedrock borehole, the groundwater quality of short bedrock-aquifer intervals can be monitored without the dilution effects that would occur if groundwater samples were collected from the open bedrock borehole. The dual well construction method also will facilitate the measurement of vertical hydraulic head gradients within the bedrock aquifer.

As discussed above, it is anticipated the two bedrock monitoring well pairs downgradient of F-Well will be installed along projections of the predominant fracture traces projected through F-

Well. These two well pairs will be drilled, tested, and sampled before installing the upgradient bedrock monitoring well pair. The upgradient bedrock well pair will be installed along the same fracture trace through F-Well as the downgradient bedrock well containing the highest concentration of contaminants. If neither downgradient bedrock well pair contains site-specific contaminants, the upgradient bedrock well pair will be installed along the fracture trace through F-Well that produces the most significant quantity of water. If one or both downgradient well pairs contains F-Well-specific contaminants, additional bedrock wells may be installed further downgradient to determine the extent of the bedrock contaminant plume.

F-Well Investigation

CH2M HILL proposes to sample the top and bottom of the water column in the F-Well using a bailer to determine if additional LNAPL and DNAPL products have entered the borehole. The samples will be visually inspected for the presence of product. If product is detected in the well borehole, the well will be bailed and swabbed to remove the product. Bailing and swabbing will continue until the bail water and swabs are free of visible product. All bailed water, swabs, and personal protective equipment (PPE) will be contained in 55-gallon drums. These wastes will be considered hazardous.

If no DNAPL is detected above the sand at the bottom of F-Well, one sediment sample will be collected from the top of the column of sand that occupies the bottom of the borehole to check for the presence of DNAPL product in the sand. The sample will be collected using a drilling rig with a 5-foot split spoon attached to the bottom of the drill rod.

Groundwater Sampling and Analysis

Several types of groundwater sampling activities will be conducted during the Site 11 RI. Each of these methods and the objective accomplished are discussed below:

Direct-Push Groundwater Sampling

Approximately seven discrete-depth groundwater samples will be collected from the alluvial aquifer using direct-push sampling techniques. The samples are discussed below and the approximate sample locations are shown in Figure 5-1.

- One direct-push groundwater sample, designated DP-1, will be collected in the vicinity of ASI soil sample location SBF6, where DRO and several chlorinated hydrocarbons were detected. The purpose of this sample is to determine if contaminants detected in soil have impacted the underlying shallow groundwater.

- One direct-push groundwater sample, designated DP-2, will be collected to the southwest of F-Well to evaluate the nature and extent of alluvial-groundwater contamination in this direction from F-Well. The location of this Hydropunch® sample and the bedrock monitoring well proposed for this location may coincide. If so, the Hydropunch® sample will be collected during overburden drilling for the bedrock well installation.

- Approximately five direct-push groundwater samples will be collected in the assumed downgradient direction from F-Well to determine the downgradient extent of alluvial aquifer contamination and the location of proposed well 11-GW-9.

All direct-push samples will be collected in accordance with the ***Geoprobe® Groundwater Sampling*** SOP in Attachment A of the FSP. At all direct-push locations other than the former oil pit, the direct-push sampler will be pushed to refusal and then retracted enough to collect a groundwater sample. At the former oil pit location, the sample will be collected just below the water table.

Monitoring Well Groundwater Sampling

Groundwater samples will be collected from each newly installed monitoring well and well set at Site 11 following installation and development. Groundwater samples also will be collected from the six existing alluvial monitoring wells at Site 11 and wells GGW1 and GGW2, located approximately 500 feet northwest of the site. In addition, as many as five groundwater samples will be collected from each of the four bedrock wells to characterize the vertical distribution of any groundwater contamination in the fractured bedrock aquifer. Finally, a bailer will be used to collect two samples from the F-Well, one at the bottom of the water column and one at the top, to check for the continued presence of LNAPL and DNAPL products.

If practical, monitoring well sampling will employ low-flow purging and sampling techniques to reduce sample turbidity and volume of groundwater IDW generated.

Groundwater Analysis

Analysis of the 47 groundwater samples (7 direct-push, 20 packer, 10 alluvial monitoring well, 8 bedrock monitoring well, and 2 F-Well) will be performed in accordance Navy guidance for Level D and the *USEPA Contract Laboratory Program (CLP) Statement of Work (SOW) for Organics Analysis Multi-Media, Multi-Concentration* (OLM03.2 or latest version) for Target Compound List (TCL) organics (including semivolatiles, pesticides, and PCBs). The volatile fraction of the organic sample will be analyzed using the EPA low concentration method OLC02.1. The Target Analyte List (TAL) inorganics (including total and dissolved metals and cyanide) will be analyzed by a similar SOW for inorganics (ILM04.0 or latest version). All samples also will be analyzed for TPH-DRO and TPH-GRO using modified Method 8015B. Standard EPA methods will be followed during sample analysis. Table 5-1 identifies the groundwater samples to be collected and the analyses to be performed for each sample. Figure 5-1 depicts the proposed locations of the wells and samples listed in Table 5-1.

Soil Sampling

Soil samples will be collected in the vicinity of the former oil storage area to further define the nature and extent of soil contaminants detected during the ASI. The locations, numbers, and depths of soil samples and sample analytical methods are specified below. All soil samples will be collected using direct-push sampling techniques, as described in the attached FSP. Sample locations depicted in this work plan are subject to change in the event of utility clearance problems or other unforeseen circumstances.

Continuous soil samples will be collected from four locations in the vicinity of the former oil storage area (Figure 5-1) from below the asphalt to the water table. The entire interval collected will be screened with an organic vapor monitor (OVM) to detect the presence of vapors. The interval exhibiting the highest level of organic vapors will be sampled and submitted for offsite analysis of TPH-DRO, TCL VOCs, TCL SVOCs, and TAL metals. If no vapors are detected, the interval directly above the water table will be sampled and analyzed as above. Because the sampling area has been regraded and is covered by asphalt no surface soil samples will be collected.

Soil and Sediment Sample Analysis

The designations of soil and sediment samples collected and specific analyses performed are shown in Table 5-2. Figure 5-1 shows the locations of the soil samples listed in Table 5-2. The sediment sample is from the sand at the bottom of F-Well.

Investigation-Derived Waste

Soil and water drill cuttings, as well as groundwater generated during well development, well sampling, and packer sampling will be containerized in individual 55-gallon drums or a large-volume container such as a Baker tank. All IDW will be handled, containerized, and disposed of in accordance with the IDWMP, contained in the SAP.

Water swabs and PPE generated during the product removal operations in F-Well will be drummed and labeled and composite samples of the water will be submitted for toxicity characteristics leaching procedure (TCLP) analysis. CH2M HILL anticipates that all F-Well wastes will be characterized as hazardous, based upon the characterization results of similar IDW generated during the ASI.

Surveying

A subcontracted surveyor, licensed in the State of West Virginia, will provide horizontal and vertical coordinates for the newly installed monitoring wells. The ground surface, top of casing, and top of PVC elevations will be established for the monitoring wells during this task. In addition, all soil sampling locations will be surveyed for horizontal control

Table 5-1
SUMMARY OF GROUNDWATER SAMPLES TO BE SUBMITTED FOR ANALYSIS - SITE 11

Matrix	Laboratory Parameter	Samples	Field Duplicates[1]	Field Blanks[2]	Trip Blanks[3]	Matrix Spikes[4]	Equipment Blanks[5]	Matrix Total
Groundwater	TPH-DRO	47	5	3	0	6	10	65
	TPH-GRO	47	5	3	0	6	10	65
	Low Concentration Volatiles	47	5	3	10	6	10	75
	TCL Semivolatiles	47	5	3	0	6	10	65
	TCL Pesticides/PCBs	47	5	3	0	6	10	65
	TAL Metals (total) / Cyanide	47	5	3	0	6	10	65
	TAL Metals (dissolved)	47	5	3	0	6	10	65

Notes:
[1]Field duplicates are collected at a frequency of 1 per 10.
[2]Field blanks are collected at a frequency of 1 per source per event.
[3]Trip blanks are shipped with water samples submitted for volatiles analysis. Trip blanks are used to monitor contamination that could be introduced during transportation. Trip blanks are collected at a frequency of 1 per cooler of volatiles samples.
[4]Matrix spike/matrix spike duplicates (MS/MSD) are collected at a frequency of 1 per 20. MS/MSDs represent samples for which extra volume must be collected for the laboratory to perform required QC analyses. Triple the normal volumes will be collected for all analyses.
[5]Equipment blanks are collected and analyzed at a frequency of 1 every day. They are not required when disposable sampling equipment is used.
Note: This table is based on Navy Level D QA/QC requirements.

Table 5-2
SUMMARY OF SOIL SAMPLES TO BE SUBMITTED FOR ANALYSIS - SITE 11

Matrix	Laboratory Parameter	Samples	Field Duplicates[1]	Field Blanks[2]	Trip Blanks[3]	Matrix Spikes[4]	Equipment Blank[5]	Matrix Total
Soil	TPH-DRO	4	1	1	0	1	1	7
	TCL Volatiles	4	1	1	1	1	1	8
	TCL Semivolatiles	4	1	1	0	1	1	7
	TAL Metals and Cyanide	4	1	1	0	1	1	7
Sediment	TPH-DRO	1	1	1	0	1	1	4
	TPH-GRO	1	1	1	0	1	1	4
	TCL Volatiles	1	1	1	1	1	1	5
	TCL Semivolatiles	1	1	1	0	1	1	4
	TCL Pesticides/PCBs	1	1	1	0	1	1	4
	TAL Metals and Cyanide	1	1	1	0	1	1	4

Notes:
[1]Field duplicates are collected at a frequency of 1 per 10.
[2]Field blanks are collected at a frequency of 1 per source per event (1 per week of sampling).
[3]Trip blanks are shipped with samples submitted for volatiles analysis. Trip blanks are used to monitor contamination that could be introduced during transportation. Trip blanks are collected at a frequency of 1 per cooler of volatiles samples.
[4]Matrix spike/matrix spike duplicates (MS/MSD) are collected at a frequency of 1 per 20. MS/MSDs represent samples for which extra volume must be collected for the laboratory to perform required QC analyses. Triple the normal volumes will be collected for all analyses.
[5]Equipment blanks are collected and analyzed at a frequency of 1 every day.
Note: This table is based on Navy Level D QA/QC requirements.

Task 4: Data Validation and Sample Analysis

CH2M HILL will be responsible for tracking sample analyses and obtaining results from the laboratory. The analytical data generated during the RI/FS field program will be validated by an independent data validation subcontractor following Navy guidance for Level D and according to EPA standard procedures.

Data Validation

All data will be validated before the project staff performs an interpretation. The data validation will be performed by an independent subcontractor, and will conform to the Navy guidance for Level D. Data that should be qualified will be flagged with the appropriate symbol. Results for QA/QC samples will be reviewed and the data will be qualified further, if necessary. Finally, the data set as a whole will be examined for consistency, anomalous results, and reasonableness.

Sample Analysis

All analyses of soil and groundwater will be conducted at a contracted laboratory that fulfills all requirements of the U.S. Navy's QA/QC Program Manual and EPA's Contract Laboratory Program. A signed certificate of analysis will be provided with each laboratory analysis, along with a certificate of compliance certifying that all work was performed in accordance with the applicable federal, state, and local regulations. All analyses will be performed following Navy guidance for Level D.

Field Quality Control Procedures

Quality control duplicate samples and blanks are used to provide a measure of the internal consistency of the samples and to provide an estimate of the components of variance and the bias in the analytical process. Table 10-1 in the QAPP provides a summary of the collection frequencies of the field QC samples.

Blanks

Blanks provide a measure of cross-contamination sources, decontamination efficiency, and other potential errors that can be introduced from sources other than the sample. ASTM Type II water will be used for blanks. Three types of blanks will be generated during sampling activities: trip blanks, field blanks, and equipment blanks.

One trip blank will be included in each cooler containing samples for VOC analysis. Pre-prepared trip blanks will be obtained from the laboratory, if possible. Otherwise, the trip blanks will be prepared prior to each sampling event, shipped or transported to the field with the sampling bottles, and sent to the laboratory unopened for analysis. Trip blanks will not be prepared or handled in the field. Trip blanks will indicate if any contamination occurred during shipment to the field, field storage, or during shipment from the field to the analytical laboratory.

One field blank will be collected each week of sampling. The field blanks will indicate if any contaminants were introduced during the handling of the sample containers in the field or during sample analysis at the laboratory. The sample container will be filled with ASTM Type II water in the field at the time of sampling. Pre-preserved bottles will be obtained from the laboratory, if possible, otherwise, preservatives will be added in the field. Field blank sample containers will be capped, packed, and shipped with the samples.

One equipment blank will be collected and analyzed every day during sampling activities. The equipment blanks will indicate the efficiency of equipment decontamination procedures. Pre-preserved bottles will be obtained from the laboratory, if possible; otherwise, preservatives will be added in the field. Equipment blank sample containers will be capped, packed, and shipped with the samples.

Duplicates

Field duplicate samples will be collected at a frequency of 1 per 10 field samples per matrix. The location from which the duplicates are taken will be randomly selected. The duplicate sample will be submitted for analysis as an independent sample. The sample and its duplicate will be numbered non-sequentially.

Matrix Spike/Matrix Spike Duplicate (MS/MSD)

Matrix spike/matrix spike duplicate (MS/MSD) samples will be collected at a frequency of 1 per 20 field samples. Analytical results of these samples indicate the impact the matrix (water, soil, sediment) has on extracting the analyte for analysis. Data validators will use these results to evaluate the accuracy of the analytical data.

Task 5: Risk Assessment

This task includes the preparation of an HHRA and an ERA. The risk assessments will be conducted in accordance with current EPA national and Region III guidance.

Baseline Human Health Risk Assessment

An HHRA will be performed at Site 11 to assess the potential human health risks posed by the site. The risk assessment will evaluate the potential effects of existing site contamination on both current and potential future exposed populations. Future risks will be based on current site conditions, assuming no additional remedial action is conducted at the site. The future use of the site is expected to remain industrial, but a future residential use scenario will be evaluated for information and decision-making. Preliminary federal and state chemical-specific ARARs will be identified and compared with the RI data under this task.

The HHRA will be completed in accordance with EPA's *Risk Assessment Guidance for Superfund (RAGS), Volume I - Human Health Evaluation Manual (Part A),* dated December 1989, *RAGS* Parts B and C dated December 1989, RAGS Part D, dated January 1998, and EPA Region III guidance. The exposure factors in RAGS have been superseded by OSWER Directive 9285.6-03, *Human Health Evaluation Manual, Supplemental Guidance: Standard Default Exposure Factors,* dated March 1991. Dermal permeability coefficients will be taken from *EPA's Interim Guidance for Dermal Exposure Assessment,* dated January 1992. Other required exposure factors may be taken from *Exposure Factors Handbook* (EPA, 1996) and the American Industrial Health Council's *Exposure Factors Sourcebook* (AIHC, May 1994). The HHRA will contain the following major components:

- Data evaluation and identification of chemicals of potential concern
- Exposure assessment
- Toxicity assessment
- Risk characterization
- Uncertainty analysis

The first step of the HHRA will be to select contaminants of potential concern (COPCs). The selection criteria in EPA Region III's *Selecting Exposure Routes and Contaminants of Concern by Risk-Based Screening*, January 1993, will be followed to determine which chemicals will be evaluated quantitatively. This methodology includes evaluating data quality, reducing the data set using risk-based concentrations (based on a target cancer risk of 1×10^{-6} and a target hazard index of 0.1), and further reducing the data set according to frequency of detection, comparison to background, and evaluation as human nutrients. Data collected during this investigation and data collected during previous investigations that have been validated will be evaluated for use in the HHRA.

The second step of the HHRA will be to identify actual or potential exposure pathways and to determine the probable magnitude of human exposure. The decisions on how the risk assessment will be conducted and how scenarios will be evaluated will be made after the data have been collected, during a conference call among the EPA toxicologist, WVDEP, Navy, and CH2M HILL. Only plausible and complete pathways will be carried through the exposure-quantification section to the risk characterization. A complete pathway contains a source of chemical release, a medium for environmental transport, a point of contact with the contaminated medium, and an exposure route at the point of contact. The pathways that are anticipated to be complete at Site 11 are those listed in Table 5-3. Exposure to surface soil, subsurface soil, and groundwater will be evaluated in the HHRA.

Table 5-3 Site 11, Allegany Ballistics Laboratory Summary of Exposure Pathways and Potentially Exposed Populations		
Scenario	**Exposure Route**	**Baseline Risk Assessment**
Current Site Use		
Worker		
Surface Soil (site worker)	Ingestion Dermal Inhalation	X X X
Future Use		
Worker		
Surface and Subsurface Soil (construction worker)	Ingestion Dermal Inhalation	X X X
Resident		
Surface and Subsurface Soil (child and adult)	Ingestion Dermal Inhalation	X X X
Groundwater (child and adult)	Ingestion Dermal Inhalation	X X[1] X[2]
Notes: [1] only evaluate for child [2] only evaluate for adult X designates pathway that will be evaluated		

Quantification of exposure involves determining the exposure concentration and exposure parameters. The sources that will be consulted for the exposure parameters are discussed above. The exposure concentrations will be calculated for each scenario. The 95 percent upper confidence limit of the mean (95UCL) will be used as the exposure concentration for soil. The 95UCL calculation is dependent on the distribution of the data. A W-test will be used to determine if the data are lognormally or normally distributed. If the 95UCL is greater than the maximum detected concentration, the maximum detected concentration will be used as the exposure concentration. The exposure concentration for groundwater will be the concentration of each constituent detected in the well or group of wells that are the most contaminated or are located in the center of the plume.

For the purpose of calculating the exposure concentrations for the risk assessment, the following data handling methodology will be used. When a primary and duplicate sample are collected, the maximum concentration will be used as the sample concentration. One-half the sample quantitation limit (SQL) or sample detection limit (DL) will be used for cases where no detectable contaminant quantities were found in that specific sample, but the contaminant was detected in that medium for that group of samples. Data that have been qualified with a J (estimated value) during data validation will be treated as unqualified detected concentrations. Data qualified with an R (rejected) will not be used for risk assessment and will not be included in the total count of samples analyzed for a constituent. It will be assumed that the blank-related concentration of a constituent qualified with a B is the sample quantitation limit.

The next step of the risk assessment is the toxicity assessment. The primary source of toxicological data to be used in the analysis will be EPA's Integrated Risk Information System (IRIS) database. If toxicological data for a particular constituent are not available in IRIS, EPA's Health Effects Assessment Summary Tables (HEAST) will be consulted. This section will include a brief discussion of the toxicological characteristics of the major site contaminants and the quantitative approach used to assess the potential effects of the carcinogenic and noncarcinogenic effects on human health.

Risk characterization is the next step in the baseline HHRA. It combines the results of the exposure assessment with the critical toxicity values in the appropriate media for each COPC. For quantitative risk estimation from carcinogenic chemicals, excess lifetime cancer risks will be estimated. Potential risks from noncarcinogenic chemicals will be presented using the hazard index approach. If estimated risks approach the EPA threshold values, a Monte Carlo risk analysis will be performed.

EPA guidance calls for a "Monte Carlo risk analysis" on an as needed basis as determined by the quantitative risk assessment. If the Monte Carlo risk analysis is proposed, the Navy will submit a separate work plan that documents the proposed methodology, including all distributions, as documented in the Region III Technical Guidance Manual for Risk Assessment "Use of Monte Carlo Simulation in Risk Assessments."

The last section will be a discussion of uncertainty that provides the limits and assumptions for the results of the risk characterization. The discussion will include a qualitative sensitivity analysis of the exposure assumptions.

The results of the BLRA will be documented in the RI report. The risk assessment will be used to help determine whether remediation is necessary and to aid in the development of preliminary remediation goals for the media of concern.

RI Baseline Ecological Risk Assessment

An ERA will be performed at Site 11. The ERA will identify and evaluate the potential effects of the contamination on biota in the area. The characterization of environmental risks will involve identifying potential exposures to the surrounding ecological receptors and evaluating potential effects associated with such exposures. The BERA will be conducted in accordance with *Risk Assessment Guidance for Superfund Volume II: Environmental Evaluation Manual* (EPA, 1997), Region III's supplementary risk assessment guidance, and other appropriate guidance.

The BERA will include the following activities:

- Collection of existing data for use in the characterization of land use, soil, topography, and flora and fauna

- Identification of habitats in potentially exposed areas through review of reports, aerial photography, contacts with resource agencies having knowledge of environmental resources in the vicinity of the site, and site reconnaissance

- Collection of existing information to determine the presence of historical or archaeological resources, threatened or endangered species, critical habitats, wetlands, or other features

- Inventory of terrestrial species

- Selection of contaminants of concern on the basis of calculation of environmental effects quotients, toxicity characteristics, bioaccumulation potential, and environmental persistence

- Determination of contaminants of concern for ecological resources by using Biological Technical Assistance Group screening criteria

- Assessment of exposure pathways and toxicity for the contaminants of concern

- Assessment of risk to ecological receptors

Site 11 is currently an industrial area, the majority of which is covered by buildings and asphalt paving; therefore, the ERA may be limited.

Task 6: Remedial Investigation Report

The results of the RI, HHRA, and ERA for Site 11 will be presented in the RI report. This report will include the following sections:

- Introduction
- Site Background
- RI Activities
- Site Geology and Hydrogeology
- Nature and Extent of Contamination
- Contaminant Fate and Transport
- Human Health Risk Assessment
- Ecological Risk Assessment

The RI report will include, as appropriate, site maps with sampling locations, boring logs, cross sections, validated analytical data, and figures that depict the extent of soil and groundwater contamination. The information collected and presented in the RI report will be used to prepare the FS. A draft and final RI document will be prepared as part of this task.

Task 7: Feasibility Study Report

A FS report for Site 11 will be developed in accordance with the "Guidance for Conducting Remedial Investigations and Feasibility Studies Under CERCLA" (U.S. EPA, 1988 *Interim* Final). The FS report will contain four sections:

- Section 1 - Introduction and Site Background
- Section 2 - Remedial Action Objectives and ARARs
- Section 3 - Identification, Screening, and Evaluation of Remedial Technologies
- Section 4 - Detailed Analysis of Remedial Alternatives

The introduction will summarize the conclusions of the RI and RA. Section 2 will present the remedial action objectives and the ARARs. In Section 3, feasible technologies and process options for site remediation will be identified for each remedial action objective and the results of the remedial technologies screening will be described. Remedial alternatives for specific media (i.e., groundwater) will be developed and evaluated. In Section 4 sitewide remedial alternatives will be developed by combining the media-specific remedial alternatives developed in Section 2. Each sitewide remedial alternative will be evaluated in detail with respect to seven of the nine criteria listed below:

- Overall protection of human health and the environment
- Compliance with ARARs
- Long-term effectiveness and permanence
- Reduction of toxicity, mobility, or volume through treatment
- Implementability
- Short-term effectiveness implementability
- Cost
- State acceptance
- Community acceptance

State acceptance and community acceptance will be evaluated and documents as part of the Record of Decision (ROD). A comparative analysis of each sitewide remedial alternative using these seven criteria will also be performed.

Task 8: Proposed Plan and Record of Decision

A draft and final proposed plan (PP) will be prepared as part of this task. The PP will summarize the selected remedial action, as described in *Guidance for Preparing Superfund Decision Documents*, EPA/540/G-89/007, July 1989; EPA Region III guidance; and other appropriate guidance.

A draft and final record of decision (ROD) will be prepared in accordance with USEPA guidance, as noted above. The ROD will document the selected remedial action and responses to community comments on the PP. A public notice announcing the issuance of the PP will be prepared and presented in 2 local newspapers.

Section 6
Project Schedule

Figure 6-1 presents the anticipated schedule to complete tasks 1 through 8 described in Section 5. Included in the schedule are time periods set aside for EPA and State review. For scheduling purposes, a 30-day review period for all submittals is assumed. Longer review periods will result in an extended schedule.

ID	Task Name	Duration	Start	Finish
1	Notice to Proceed	0d	5/18/98	5/18/98
2	**Project Planning (PP)**	**572d**	**5/18/98**	**12/10/99**
3	Project Management (PP.PM)	572d	5/18/98	12/10/99
4	Meetings (PP.MG)	572d	5/18/98	12/10/99
5	**RI Field Investigation (FI)**	**51d**	**5/18/98**	**7/7/98**
6	Fieldwork Support/Subcontractor Procurement (FI.FK)	15d	5/18/98	6/1/98
7	Monitoring Well Installation (FI.WI)	25d	6/2/98	6/26/98
8	Groundwater Sampling (FI.FQ)	8d	6/27/98	7/4/98
9	Soil Sampling (FI.FS)	10d	6/27/98	7/6/98
10	Surveying (FI.FM)	1d	7/7/98	7/7/98
11	**Sample Analysis and Validation (SA)**	**90d**	**7/7/98**	**10/4/98**
12	Sample Managment (SA.SM)	60d	7/7/98	9/4/98
13	Data Validation (SA.DV)	30d	9/5/98	10/4/98
14	**RI Report (RI)**	**245d**	**7/27/98**	**3/28/99**
15	Prepare Draft RI Report (RI.DR)	120d	7/27/98	11/23/98
16	Submit Draft RI Report	0d	11/23/98	11/23/98
17	Government Review of Draft RI Report	60d	11/24/98	1/22/99
18	Prepare Final RI Report (RI.FR)	65d	1/23/99	3/28/99
19	Submit Final RI Report	0d	3/28/99	3/28/99
20	**FS Report (FS)**	**225d**	**1/23/99**	**9/4/99**
21	Prepare Draft FS Report (FS.DR)	105d	1/23/99	5/7/99
22	Submit Draft FS Report	0d	5/7/99	5/7/99
23	Government Review of Draft FS Report	60d	5/8/99	7/6/99
24	Prepare Final FS Report (FS.FR)	60d	7/7/99	9/4/99
25	Submit Final FS Report	0d	9/4/99	9/4/99
26	**Post RI/FS Support (PS)**	**157d**	**7/7/99**	**12/10/99**
27	Prepare Draft PP and ROD (PS.PS)	30d	7/7/99	8/5/99
28	Submit Draft PP and ROD	0d	8/5/99	8/5/99
29	Government Review of PP and ROD	30d	8/6/99	9/4/99
30	Prepare Final PP and ROD	37d	9/5/99	10/11/99
31	Public Notice (PS.PN)	60d	10/12/99	12/10/99
32	Submit Final PP and ROD	0d	12/10/99	12/10/99

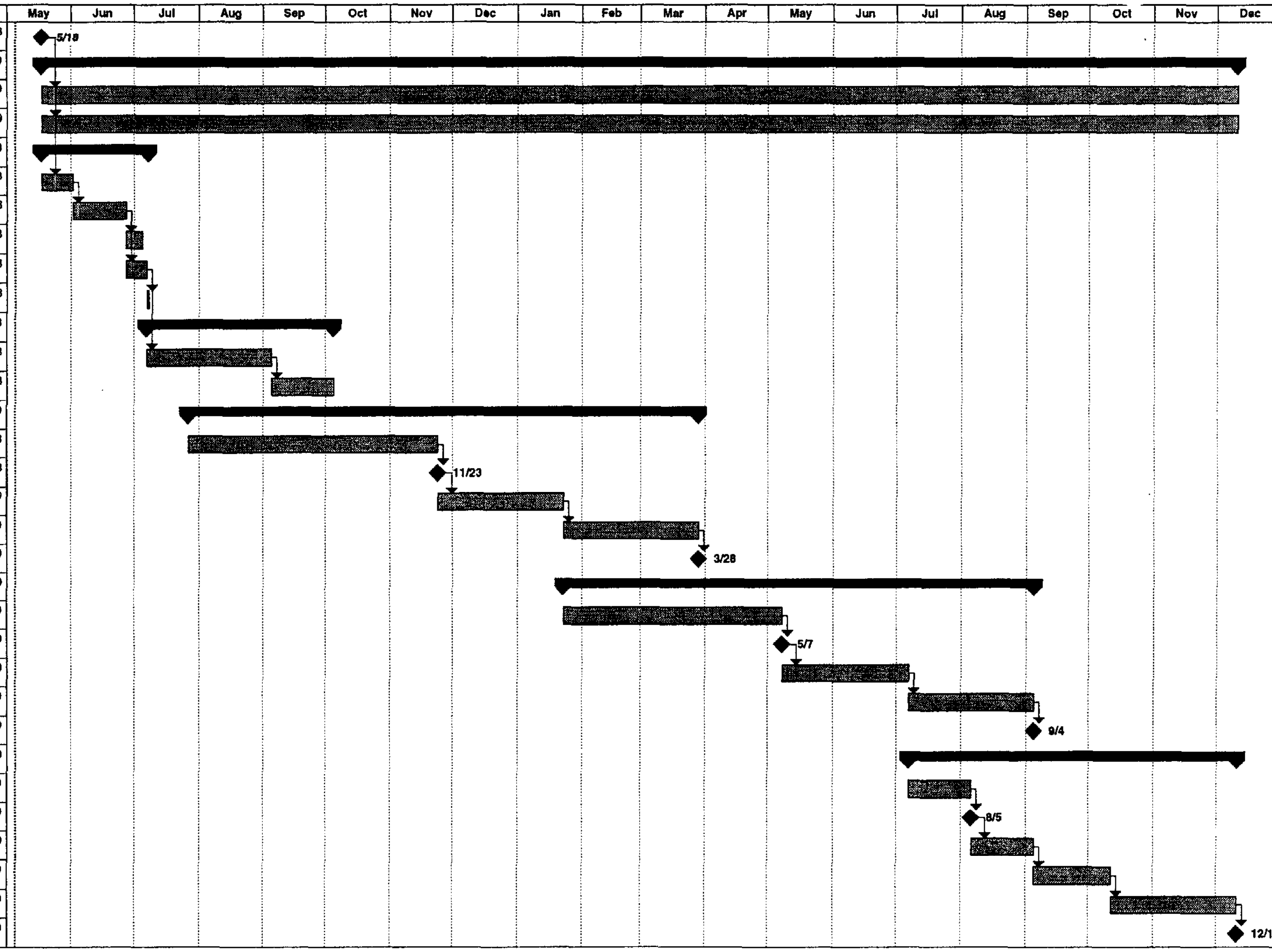


Figure 6-1
Project Schedule
Site 11 RI/FS

Date 5/5/98
S11RIFS.MPP

Task | Progress | Milestone | Summary | Rolled Up Task | Rolled Up Milestone | Rolled Up Progress

Appendix A

HERCULES

Hercules Aerospace Company
Allegany Ballistics Laboratory
P. O. Box 210
Rocket Center, WV 26726-0210
(304) 726-5000

October 6, 1994

US EPA Region III
841 Chestnut Building
Philadelphia, PA 19107-4431

Attention: Mr. Vincent E. Zenone, OSC
SPCC Coordinator
Oil & Title III Section(3HW34)

Ref: HI/ABL, DAMcBride Ltr., 8/23/94, to Region III USEPA,
VEZenone, Subj. Bldg. 215 Removal Plan

Dear Mr. Zenone:

Building 215 Fuel Storage Area Sampling Results

This letter provides additional information on our activity at the Building 215 heating fuel storage area to reclaim the area as we had outlined in the reference letter. We have sampled the soil inside the dike. Analysis results are presented below. A sketch showing sample location is attached.

SOIL SAMPLE ANALYSIS RESULTS

Sample No.	Depth (in.)	TPH (mg/Kg)	MDL (mg/Kg)
DM 830.1	6	43	40
DM 830.2	36	ND	40
DM 830.3	6	ND	40
DM 830.4	36	1400	40

It is noted that the area where sample DM-830.3 was taken encountered water at approximately one foot depth. Thus sample DM-830.4 was taken several yards to the west in an attempt to get away from the water. This location, however, had both water and oil present. The sample was taken from soil scooped up with a backhoe to minimize the water content. It appeared the water at location DM-830.3 was from a drain tile and was contained in crushed limestone which made up the upper layer of soil. At location DM-830.4, the oil and water again appeared to be primarily in the upper portion of the soil, but seemed to go deeper than the water at the previous location. Below the limestone the soil appeared to be a clay and the contamination appeared to be localized to a relatively small area. Post excavation sampling will define this.

US EPA Region III
Attention: Mr. Vincent E. Zenone
Building 215 Fuel Storage Area Sampling Results

October 6, 1994

If you have any questions or desire any additional information, please contact me at (304) 726-5354 or Steve Mullins at (304) 726-5244.

Sincerely,

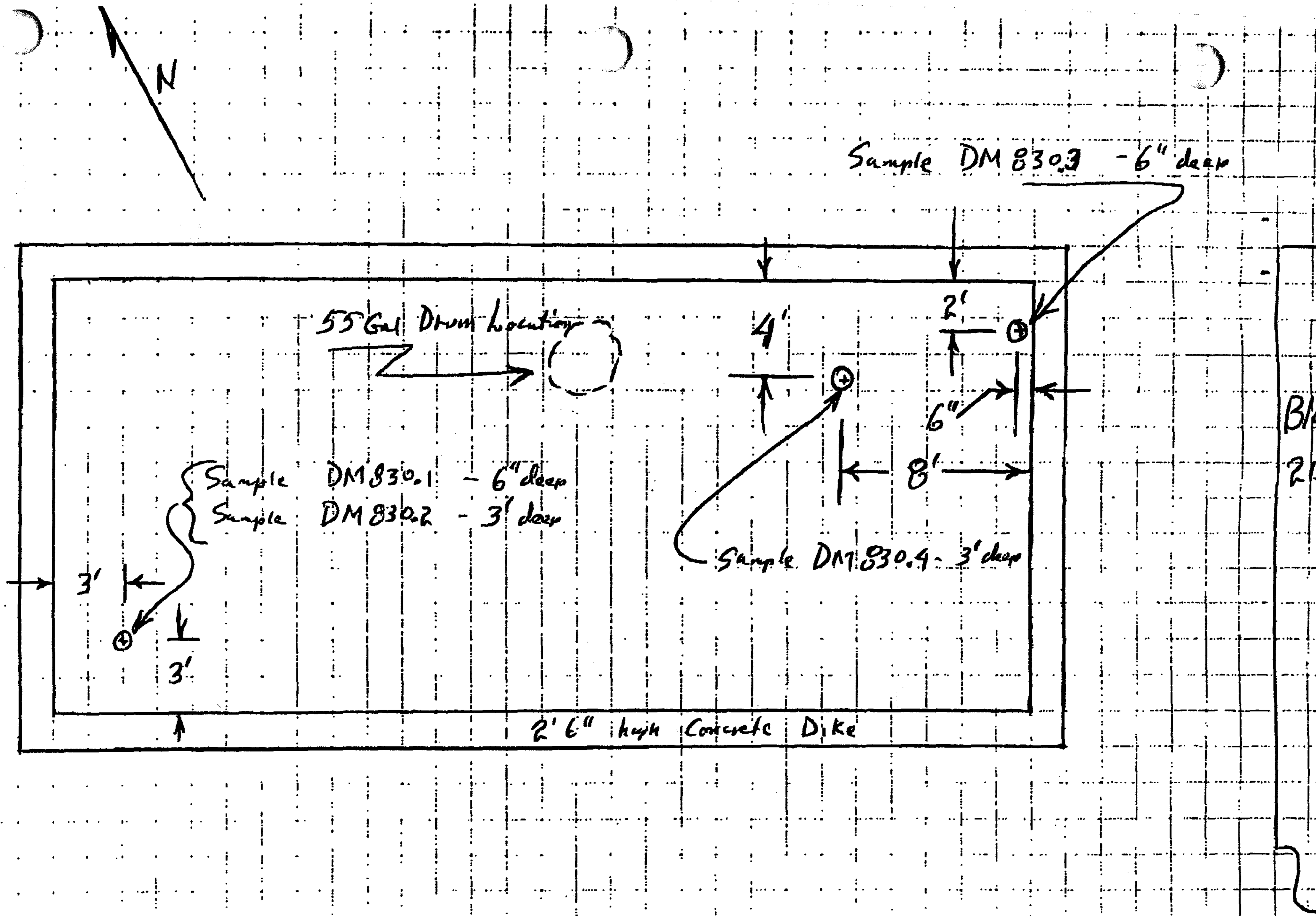
David A. McBride
Environmental Engineer

Attachment:

DAM:L100694.1

c: Mr. J. Fleshman, WV DEP/Romney
L. H. Mull
D. W. Campbell
B. R. Liedy
D. A. Hulburt
S. E. Mullins

JUL 17 '97 17:44 FR ABL FACILITIES ENG 304 726 5562 TO 8-17034810980-04 P.04



Building 215 Fuel Oil Storage Area

Soil Sampling Locations

1" = 6'

HERCULES
AEROSPACE

Hercules Aerospace Company
Allegany Ballistics Laboratory
P. O. Box 210
Rocket Center, WV 26726-0210
(304) 726-5000

February 14, 1995

Draft

Mr. Jack Fleshman
West Virginia Division of Environmental Protection
Office of Environmental Enforcement
1 Depot Street
Romney, WV 26757

Gentlemen:

Building 215 Fuel Storage Area Cleanup

This letter transmits analysis data from soil sampling in the diked fuel storage area at Building 215 in accord with the Removal Plan presented in my August 23, 1994 letter to Mr. Vincent Zenone, EPA Region III. Building 215 was a boiler house which housed two steam boilers. Fuel for these boilers was stored in two 10,000 gallon, above ground storage tanks. The fuel storage area was inclosed by a 18' X 42' dike which experienced No. 5 fuel oil contamination during the period of operation of this facility. The Removal Plan, noted above, outlined our plans for cleaning up all oil contamination in the area.

Dike excavation included removal of the dike wall, which extended several feet below the ground surface, removal of the tank saddles, which had footers three feet below the surface, and removal of all soil within the confines of the area down to a depth of about four feet. Agricultural lime had been mixed with the contaminated soil to help hold any free oil present. Most of this mixture was removed in the original excavation. An initial round of sampling was performed on December 2, 1994. Presence of some of the agricultural lime was evident at that time indicating incomplete soil removal during the excavation. Analytical results confirmed the incomplete cleanup. (See Table I, samples DM122.1 through DM122.6.)

Additional excavation was performed, with care exercised to remove all loose soil materials from the excavation site. Resampling was performed on December 9, 1994. This resampling included sampling the adjacent excavation resulting from the demolition of Building 215. Results of this sampling round were much improved with all samples showing less than 100 mg/Kg DRO. (Samples were analyzed for DRO by Method SW8015.) Again this data is presented in Table I. Sample location is shown in Figure 1, attached. It was noted during the sampling the soil in this area was a solid clay material and was uniform over the total area.

Allegany Ballistics Laboratory feels this cleanup effort has been sufficient to meet all requirements. However, an investigation of the area has been initiated due to the finding of an old abandoned potable water well. This additional investigation will include both soil and groundwater sampling in the area. It will have as it's objective the identification of any contaminant source (currently not anticipated) which may be in the general vicinity. After this investigation is completed, and hopefully a clean bill of health is provided, we will assure you get full investigation documentation. We would request at that time, that you would provide a written documentation of the acceptability of the remediation effort.

Sincerely,

David A. McBride
Environmental Engineer

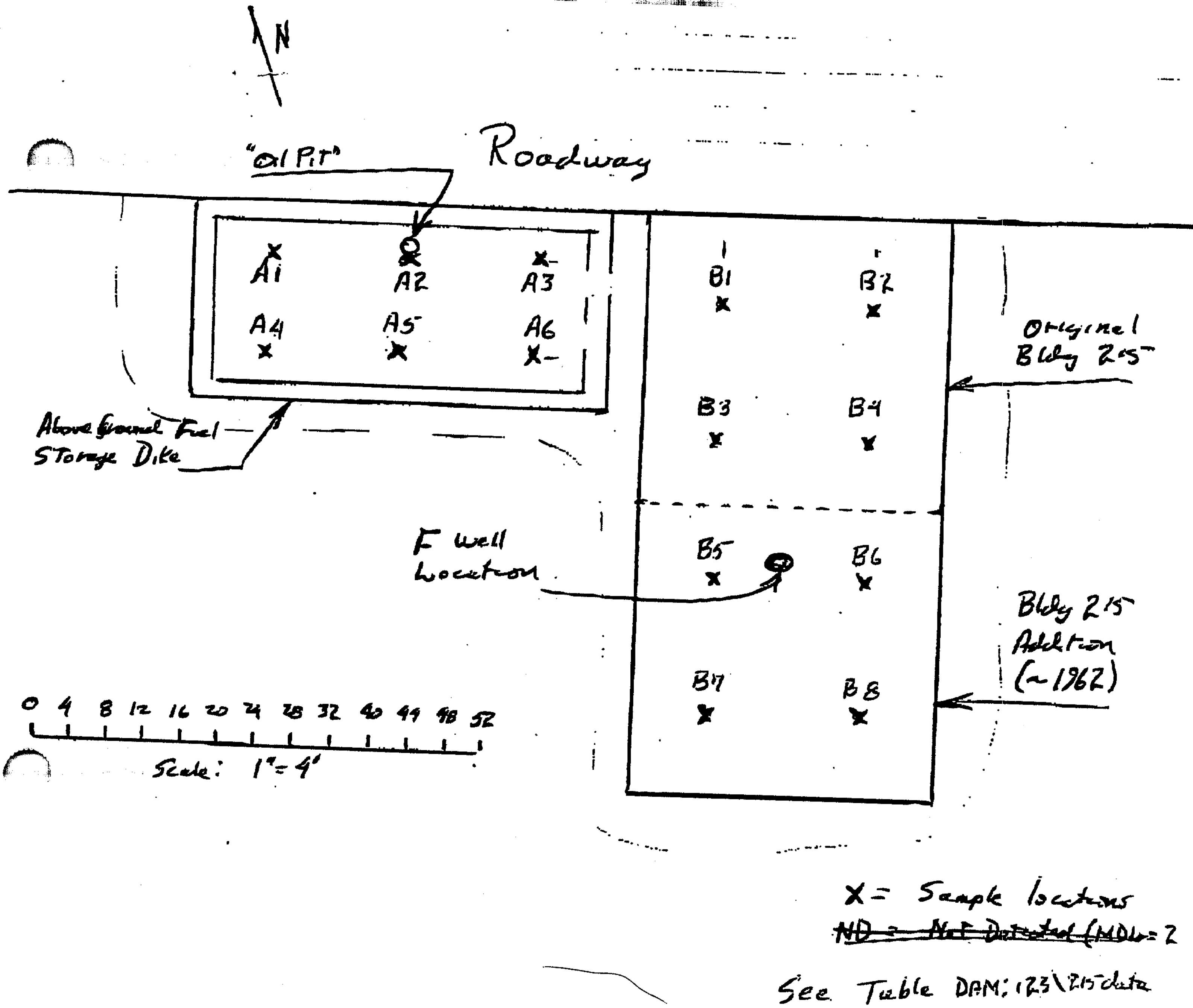
Attachments:

DAM:L0214.1

c: Vince Zenone

BUILDING 215 AND TANK DIKE ANALYSIS RESULTS				
Sample Number	Sample Location	Date Sampled	DRO (mg/Kg)	MDL (mg/Kg)
DM122.1	A1	12/2/94	14	2.0
DM122.2	A2	12/2/94	23	2.0
DM122.3	A3	12/2/94	320	5.0
DM122.4	A4	12/2/94	4.8	3.0
DM122.5	A5	12/2/94	320	10
DM122.6	A6	12/2/94	3.0	2.0
A129.1	A1	12/9/94	ND	2.0
A129.2	A2	12/9/94	89	5.0
A129.3	A3	12/9/94	15	2.0
A129.4	A4	12/9/94	ND	2.0
A129.5	A5	12/9/94	31	3.0
A129.6	A6	12/9/94	23	3.0
B129.1	B1	12/9/94	ND	2.0
B129.2	B2	12/9/94	ND	2.0
B129.3	B3	12/9/94	ND	2.0
B129.4	B4	12/9/94	ND	2.0
B129.5	B5	12/9/94	ND	2.0
B129.6	B6	12/9/94	ND	2.0
B129.7	B7	12/9/94	ND	2.0
B129.8	B8	12/9/94	ND	2.0

DAM:123\215data



Soil Sample locations at "Oil Pit" and F Well

Final

Sampling and Analysis Plan
Remedial Investigation and Feasibility Study of Site 11

for

Allegany Ballistics Laboratory
Rocket Center, West Virginia

Contract Task Order 0013

May 1998

Prepared for

Department of the Navy
Atlantic Division
Naval Facilities Engineering Command

Under the

LANTDIV CLEAN II Program
Contract N62470-95-D-6007

Prepared by

CH2MHILL

Herndon, Virginia

WDC981250003.DOC/1/LBT

Final

Quality Assurance Project Plan
Remedial Investigation and Feasibility Study of Site 11
for
Allegany Ballistics Laboratory
Rocket Center, West Virginia

Contract Task Order 0013

May 1998

Prepared for

Department of the Navy
Atlantic Division
Naval Facilities Engineering Command

Under the

LANTDIV CLEAN II Program
Contract N62470-95-D-6007

Prepared by

CH2MHILL

Herndon, Virginia

WDC981250003.DOC/1/LBT

Contents

Contents (Continued)

Contents (Continued)

Tables **Page**

Figures

Abbreviations and Acronyms

ABL	Allegany Ballistics Laboratory
BOA	basic ordering agreement
BTAG	Biological Technical Assistance Group
CLP	Contract Laboratory Program
CofC	chain-of-custody
DQOs	data quality objectives
EFA	Engineering Field Activity
EPA	U.S. Environmental Protection Agency
FSP	field sampling plan
GC/MS	gas chromatograph/mass spectrometer
HASP	health and safety plan
ILM04	EPA CLP SOW for multimedia, multiconcentration inorganic analysis
LANTDIV	U.S. Navy Naval Facilities Engineering Command, Atlantic Division
LQAP	Laboratory Quality Assurance Plan
MCL	maximum contaminant level
MS	matrix spike
MSD	matrix spike duplicate
µg/l	micrograms per liter
NAS	Naval Air Station
NFESC	Naval Facilities Engineering Service Center
OLC02	EPA analytical method for organic low-concentration water
OLM03	EPA CLP SOW for multimedia, multiconcentration organic analysis
OVA	organic vapor analyzer
OVM	organic vapor monitor
%R	percent recovery
PCB	polychlorinated biphenyl
QA	quality assurance
QAPP	quality assurance project plan
QC	quality control

RCRA	Resource Conservation and Recovery Act
RF	response factor
RI/FS	remedial investigation and feasibility study
RPD	relative percent difference
RPM	remedial project manager
RSD	relative standard deviation
SAP	sampling and analysis plan
SMC	system monitoring compound
SOP	standard operating procedure
SOW	statement of work
SVOC	semivolatile organic compound
TAL	target analyte list
TCL	target compound list
VOA	volatile organic analysis
VOC	volatile organic compound

Section 1
Introduction

This plan describes the quality assurance and quality control (QA/QC) procedures used for conducting monitoring well, soil boring, sediment, and direct-push sampling at Site 11, Allegany Ballistics Laboratory (ABL), Rocket Center, West Virginia. The quality assurance project plan (QAPP) focuses on the sampling activities for the remedial investigation and feasibility study (RI/FS). All field sampling and laboratory analyses will be conducted in accordance with the *Navy Installation Restoration Laboratory Quality Assurance Guide, Interim Guidance Document*, (NFESC, February 1996).

Section 2
Project Description

An RI/FS will be performed at Site 11 to determine the extent and magnitude of soil, alluvial and bedrock groundwater, and F-Well sediment and groundwater contamination. Results of a previous investigation are documented in the *Advanced Site Inspection of Site 11, Allegany Ballistics Laboratory Superfund Site*, CH2M HILL, February, 1996 (ASI).

The work plan for the RI/FS contains references for a detailed history of site use and disposal practices, an evaluation of the data collected during previous investigations at the site, and a description of the activities to be performed.

The objectives of the sampling activities to be performed are as follows:

- Select locations and analytical parameters that will help determine the nature and extent of the contamination at the site.
- Combine good sampling procedures with competent laboratory work so the results can be used in both ecological and human health risk assessments.

The quality of the data must be high to meet these objectives. Navy Level D quality control QC provides the highest level of data quality and is used for risk assessment and evaluation of remedial alternatives. Level D analyses require full documentation and the highest level of data validation procedures according to U.S. Environmental Protection Agency (EPA) protocol.

Whenever appropriate, samples will be analyzed for the full EPA suite of compounds according to the Contract Laboratory Program (CLP) statement of work (SOW) protocols for organic and inorganic compounds. The Target Compound List (TCL) for organics includes volatile organic compounds (volatiles or VOCs), semivolatile organic compounds (semivolatiles or SVOCs), pesticides, and polychlorinated biphenyls (PCBs). Groundwater samples will be analyzed using CLP SOW protocols for low-concentration organics. The individual compounds in each group are listed in Section 8, Table 8-2. The Target Analyte List (TAL) for inorganic analytes includes 24 metals and cyanide and also is in Table 8-2.

A brief description of the sampling plan and an analytical summary table for Site 11 follows:

Soil, sediment, and groundwater samples will be analyzed by the *USEPA Contract Laboratory Program (CLP) Statement of Work (SOW) for Organics Analysis Multi-Media, Multi-Concentration* (OLM03 or latest version) for the Target Compound List (TCL) organics (including volatiles, semivolatiles, pesticides, and PCBs). The Target Analyte List (TAL) inorganics (including total and dissolved metals and cyanide) will be analyzed by a similar SOW for inorganics (ILM04 or latest version). The chemicals analyzed under these methods are listed with their reporting limits in Section 8, Table 8-2. In order to achieve the lower detection limits required for the risk assessment associated with the Site 11 RI/FS, the volatile fraction of the groundwater organic sample will be analyzed by the *EPA Contract*

Laboratory Program (CLP) Statement of Work (SOW) for Low Concentration Water (OLC02.1). Table 2-1 summarizes the chemical analyses for Site 11.

Table 2-1
Summary of Chemical Analyses by Media
Site 11

Media	Analytical Parameters: Low-conc. VOCs	TCL VOCs	TCL SVOCs	TCL Pest/ PCBs	Dissolved Metals	Total Metals and Cyanide
Groundwater	47	0	47	47	47	47
F-Well Sediment	0	1	1	1	0	1
Soil	0	4	4	4	0	4

Project Schedule

A project schedule is attached as Figure 2-1.

ID	Task Name	Duration	Start	Finish
1	Notice to Proceed	0d	5/18/98	5/18/98
2	**Project Planning (PP)**	**572d**	**5/18/98**	**12/10/99**
3	Project Management (PP.PM)	572d	5/18/98	12/10/99
4	Meetings (PP.MG)	572d	5/18/98	12/10/99
5	**RI Field Investigation (FI)**	**51d**	**5/18/98**	**7/7/98**
6	Fieldwork Support/Subcontractor Procurement (FI.FK)	15d	5/18/98	6/1/98
7	Monitoring Well Installation (FI.WI)	25d	6/2/98	6/26/98
8	Groundwater Sampling (FI.FQ)	8d	6/27/98	7/4/98
9	Soil Sampling (FI.FS)	10d	6/27/98	7/6/98
10	Surveying (FI.FM)	1d	7/7/98	7/7/98
11	**Sample Analysis and Validation (SA)**	**90d**	**7/7/98**	**10/4/98**
12	Sample Managment (SA.SM)	60d	7/7/98	9/4/98
13	Data Validation (SA.DV)	30d	9/5/98	10/4/98
14	**RI Report (RI)**	**245d**	**7/27/98**	**3/28/99**
15	Prepare Draft RI Report (RI.DR)	120d	7/27/98	11/23/98
16	Submit Draft RI Report	0d	11/23/98	11/23/98
17	Government Review of Draft RI Report	60d	11/24/98	1/22/99
18	Prepare Final RI Report (RI.FR)	65d	1/23/99	3/28/99
19	Submit Final RI Report	0d	3/28/99	3/28/99
20	**FS Report (FS)**	**225d**	**1/23/99**	**9/4/99**
21	Prepare Draft FS Report (FS.DR)	105d	1/23/99	5/7/99
22	Submit Draft FS Report	0d	5/7/99	5/7/99
23	Government Review of Draft FS Report	60d	5/8/99	7/6/99
24	Prepare Final FS Report (FS.FR)	60d	7/7/99	9/4/99
25	Submit Final FS Report	0d	9/4/99	9/4/99
26	**Post RI/FS Support (PS)**	**157d**	**7/7/99**	**12/10/99**
27	Prepare Draft PP and ROD (PS.PS)	30d	7/7/99	8/5/99
28	Submit Draft PP and ROD	0d	8/5/99	8/5/99
29	Government Review of PP and ROD	30d	8/6/99	9/4/99
30	Prepare Final PP and ROD	37d	9/5/99	10/11/99
31	Public Notice (PS.PN)	60d	10/12/99	12/10/99
32	Submit Final PP and ROD	0d	12/10/99	12/10/99

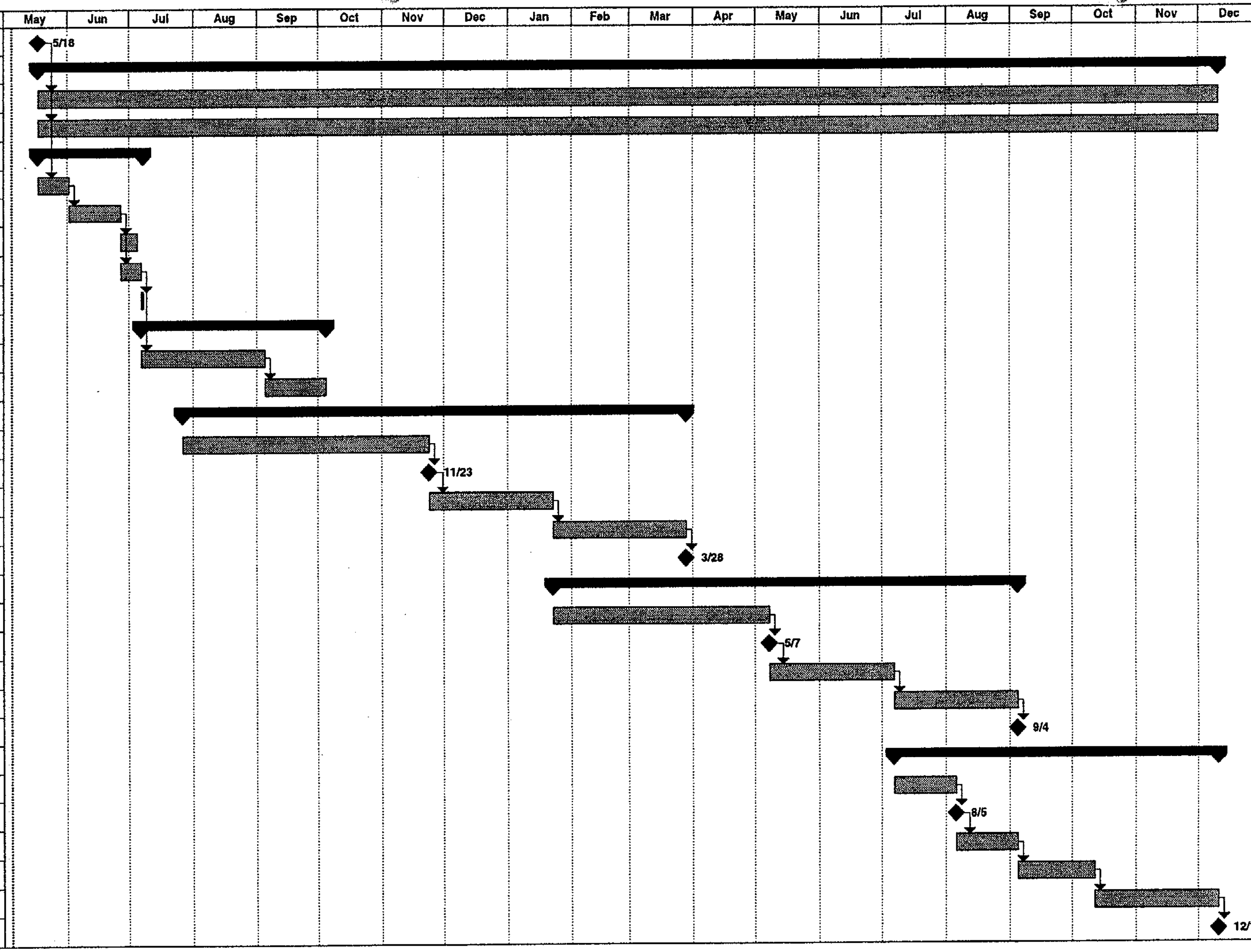


Figure 2-1
Project Schedule
Site 11 RI/FS

Date 5/5/98
S11RIFS.MPP

Task | Progress | Milestone | Summary | Rolled Up Task | Rolled Up Milestone | Rolled Up Progress

Section 3
Project Organization

Mr. Greg Mott will serve as the activity manager and the primary contact at CH2M HILL. Mr. Mott will assume primary responsibility for ensuring that the work is performed in a manner that is acceptable to LANTDIV, ABL, and government regulatory agencies. With the activity manager's oversight, the RI project manager, Mr. Brett Doerr, will be responsible for such activities as budget and schedule review and tracking, preparation and review of invoices, personnel-resource planning and allocation, and coordination with LANTDIV, ABL, and subcontractors. Dr. Robert Root, Mr. Steve Romanow, and Mr. Doug Dronfield will perform senior review. Figure 3-1 shows the project organization.

The RI/FS field investigation tasks for soil, sediment, and groundwater will be performed by CH2M HILL personnel. CH2M HILL will notify LANTDIV and ABL before initiating field activities for which CH2M HILL personnel will mobilize to the site. A field task manager will be assigned to lead all field activities. That person will be responsible for maintaining the field log book, ensuring that the SAP is being followed, monitoring the site for all releases, and other activities. The responsibilities of the field staff will include collecting the samples, supervising subcontractors, completing sample paperwork, and shipping samples.

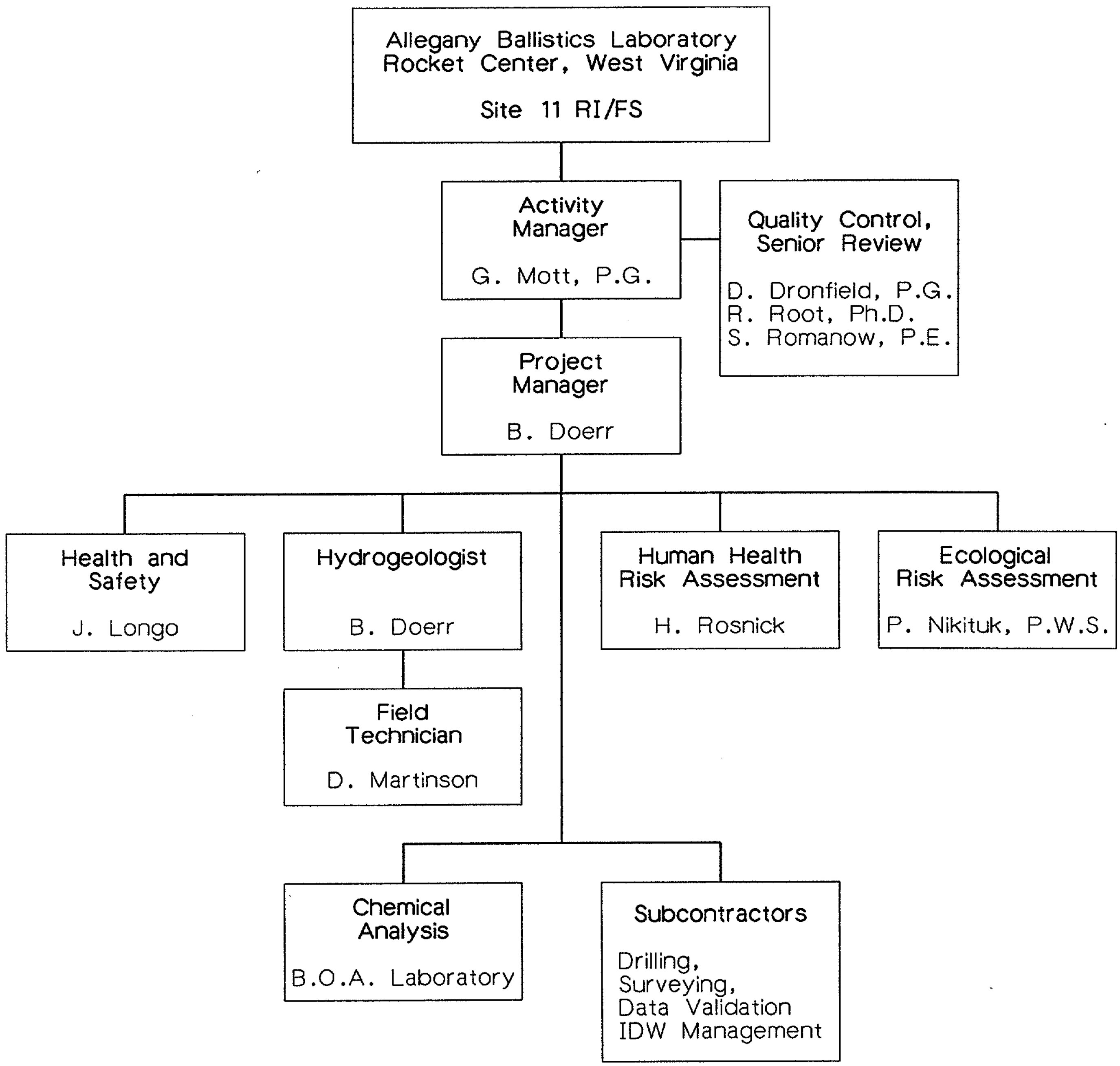


Figure 3-1
PROJECT ORGANIZATION WORK PLAN
ABL Site 11 RI/FS

07-JAN-1998 8649f001.dlv

Section 4
Quality Assurance Objectives

Data Quality Objectives (DQOs) will be established for each major sample collection effort as specified in the *Data Quality Objectives for Remedial Response Activities*, EPA, March 1987. DQOs are the quantitative and qualitative descriptions of the quality of data required to support an environmental decision or action. As target values for data quality, they are not necessarily criteria for acceptance or rejection of individual analytical results. DQOs for a site vary according to the end use of the data. Everyone, from the data gatherer to the analytical laboratory, is involved in the DQO development process from the beginning.

The following fundamental mechanisms will be used to achieve quality goals:

- Prevention of errors through planning, documented instructions and procedures, and careful selection and training of personnel
- Assessment of data through field and laboratory audits and data validation of the analytical results
- Correction of errors through a corrective-action program.

The four documents in the SAP (QAPP, FSP, HASP, and IDWMP) contain the plans and procedures for safe, competent sampling and for effective management of the data. Each laboratory providing analytical data for the RI/FS has developed its own laboratory quality assurance plan (LQAP). The SAP and the LQAP must address the elements of the Navy QA Program.

Audits in the field and in the laboratories will determine how the QA/QC procedures are being implemented. Discrepancies, if any, will be addressed through the corrective action programs described in the SAP and the LQAP.

The specific DQOs for this project as described in Section 2 are reliably determining the nature and extent of contamination at the site and assessing the ecological and human health risks. Risk assessments involve comparing detected concentrations of contaminants with standards and toxicological or biological criteria.

The detection limits achieved by the EPA's CLP TCL organics and TAL inorganics analyses are adequate to meet the DQOs in most cases.

A few of the drinking water standards are set below the detection limits for these methods. For example, the maximum contaminant level (MCL) for vinyl chloride is 2 micrograms per liter (µg/l), and the CLP VOC contract required quantitation limit for vinyl chloride is 10 µg/l. The experience of the Navy has been that requesting special analytical methods for lower detection limits has not been successful because the samples are not of drinking water quality. The presence of interference's in the matrix or high concentrations of target compounds causes the laboratory to dilute the sample, which raises the detection limits back to the CLP level or higher. No extra value or information is gained for the additional costs of most low-concentration analyses. Therefore, soil and sediment samples will be analyzed for CLP TCL organics and TAL inorganics.

The volatile portion of groundwater samples can be analyzed by *CLP Statement of Work (SOW) for Organics Analysis Low Concentration Water (OLC02)* at very little additional cost and no change in sampling technique. If the laboratory is able to achieve lower detection limits for volatiles, the risk assessment will be able to present risks more accurately. The same laboratory instrumentation is used, although the compound list is slightly longer (see the compound lists in Table 8-2), and the QC requirements are modified. The matrix spike/ matrix spike duplicate (MS/MSD) analysis is not part of the protocol in OLC02, because matrix interference is not expected in drinking water samples. For this project, extra volume for MS/MSDs will be submitted because matrix effects are expected. The laboratory will be informed that the samples first should be screened so that the proper dilution factor can be selected.

Navy Level D data validation for this project will ensure that the data obtained under the EPA protocols will be acceptable.

DQOs are measured by the degree of precision, accuracy, representativeness, completeness, and comparability of the data that is required for the project. The project's precision and accuracy objectives for laboratory analysis are in Table 4-1. The quality objectives for field parameters are included in Appendix A of the FSP (i.e., standard operating procedures [SOPs] for pH, conductivity, OVM).

Accuracy and Precision

Accuracy is a measure of the agreement between an experimental result and the true value of the parameter. Analytical accuracy can be determined by using known reference materials or matrix spikes. Spiking of reference materials into the actual sample matrix is the preferred technique because it quantifies the effects of the matrix on the analytical accuracy. Accuracy can be expressed as percent recovery (%R) determined by the following equation:

$$\%R = \frac{SSR - SR}{SA} \times 100$$

where: SSR = spiked sample result
SR = sample result (native)
SA = spike added

Table 4-1 Precision, Accuracy, and Completeness of Objectives			
Parameter	**Precision (Relative Percent Difference)**	**Accuracy (Percent Spike Recovery)**	**Intended Data Use**
Groundwater and Surface Water			
Low-concentration VOCs	< ±20	80-120	Determine extent of contamination. Human and ecological risk assessment.
TCL Semivolatile Organic Compounds (SVOCs)	< ±20	80-120	Determine extent of contamination Human and ecological risk assessment.
TCL Pesticides/PCBs	< ±20	80-120	Determine extent of contamination Human and ecological risk assessment.
TAL Metals and Cyanide	< ±20	80-120	Determine extent of contamination Human and ecological risk assessment.
Soil and Sediment			
TCL VOCs	< ±25	75-125	Determine extent of contamination Human and ecological risk assessment.
TCL SVOCs	< ±25	75-125	Determine extent of contamination Human and ecological risk assessment.
TCL Pesticides/PCBs	< ±25	75-125	Determine extent of contamination Human and ecological risk assessment.
TAL Metals and Cyanide	< ±30	70-130	Determine extent of contamination Human and ecological risk assessment.

Precision is the measure of the agreement or repeatability of a set of duplicate results obtained from repeat determinations made under the same conditions. The precision of a duplicate determination can be expressed as the relative percent difference (RPD), which is determined by the following equation:

$$RPD = \frac{|X1 - X2|}{X1 + X2} \times 200$$

where: X1 = first duplicate value
X2 = second duplicate value

For a given laboratory analysis, the duplicate RPD values are tabulated, and the mean and standard deviations of the RPD are calculated. Control limits for precision usually are plus or minus two standard deviations from the mean.

Accuracy and precision will be monitored by using field duplicate, MS, and MSD samples. These data alone cannot be used to evaluate the accuracy and precision of individual samples but will be used to assess the long-term accuracy and precision of the analytical method.

Completeness

Completeness is defined as the percentage of analytical measurements that are judged to be valid, validity being defined by the DQOs. Percent completeness is calculated as the number of analyses meeting all quality criteria divided by the total number of analyses performed multiplied by 100. The completeness goal for the project is 85 percent.

Representativeness

Representativeness expresses the degree to which sample data accurately and precisely represent parameter variations at a sampling point. Representativeness is a measure of how closely the measured results reflect the actual distribution and concentration of certain chemical compounds in the medium sampled. The FSP describes the procedures to be used for collecting samples. This process will generate samples that are as representative as possible. Documentation of laboratory and field procedures, as described in the FSP, will be used to verify that protocols have been followed and that sample identification and integrity have been maintained.

Comparability

Comparability is the term that describes the confidence with which one data set can be compared with another. Comparability refers to such issues as using standard field and analytical techniques, following the same QA/QC procedures, and reporting data in the same units. This criterion becomes important if more than one field team is collecting samples or more than one laboratory is analyzing samples. Consistency in sampling and laboratory procedures will be maintained throughout the project. (See the FSP for a discussion of sampling procedures.) In addition, accepted methodologies will be used for sample analysis, and these methods will not be changed during the project.

Section 5
Sample Collection Procedures

A detailed description of sampling procedures is in the attached FSP and Appendix A of the FSP. Procedures are included that describe the following, at a minimum:

- Sampling plan design considerations
- Sampling point selection
- Sample packing, handling, and shipment, including time considerations
- Special conditions for sample-container preparation and time requirements
- Preparation and use of trip blanks, field blanks, equipment blanks, and duplicate samples
- Documentation of sampling activities

Section 6
Sample Custody

Essential to a sampling and analysis program is maintaining the integrity of the sample, from collection to data reporting. This requires tracking the possession and handling of samples from the time of collection, through analysis, to final disposal. This documentation is referred to as chain-of-custody (CofC). Figure 6-1 shows an example of a CofC form. The essential components of the CofC are described in the FSP and summarized below.

Field Custody

The field team leader is responsible for the care and custody of samples until they are shipped or otherwise delivered to the laboratory custodian.

Transfer of Custody

The CofC form must be completed before samples are shipped. The persons involved in relinquishing and receiving the samples will sign, date, and note the time of sample receipt on the CofC form. The first such transfer may occur between the field sampler and the sample carrier. Another transfer may occur between the sample carrier and the laboratory's sample custodian. Each sample shipment will be accompanied by a CofC record that identifies the contents of the shipment.

Laboratory Custody

Laboratory custody procedures are detailed in each laboratory's LQAP. The laboratory custodian will verify that the custody seals on the sample shipment or the containers are intact and that the information on the CofC matches the actual contents. The laboratory custodian also will note anomalies, such as broken bottles, elevated temperatures, and missing labels. The project-specific procedures for sample custody are described fully in the FSP.

Sample Disposal

Unless otherwise instructed, the analytical laboratory will dispose of unused sample portions, according to Resource Conservation and Recovery Act (RCRA) regulations and the LQAP, after the analyses have been completed and outstanding issues between the contractor and the laboratory have been resolved.

CH2M HILL
QUALITY ANALYTICAL LABORATORIES

CHAIN OF CUSTODY RECORD AND AGREEMENT TO PERFORM SERVICES

CH2M HILL Project #	Purchase Order #
Project Name	
Company Name/CH2M HILL Office	
Project Manager & Phone # Mr. [ ] Ms. [ ] Dr. [ ]	Report Copy to:
Requested Completion Date:	Sampling Requirements: SDWA ☐ NPDES ☐ RCRA ☐ OTHER ____ — Sample Disposal: Dispose ☐ Return ☐

OF CONTAINERS

LAB TEST CODES

ANALYSES REQUESTED

SHADED AREA – FOR LAB USE ONLY

Lab 1 #	Lab 2 #
Quote #	Kit Request #
Project #	
No. of Samples	Page of
COC Rev / Login	LIMS Ver / Ack Gen

Sampling: Date	Sampling: Time	Type: COMP	Type: GRAB	Matrix: WATER	Matrix: SOIL	CLIENT SAMPLE ID (9 CHARACTERS)	# OF CONTAINERS	ANALYSES REQUESTED	REMARKS	LAB 1 ID	LAB 2 ID

Sampled By & Title (Please sign and print name)	Date/Time	Relinquished By (Please sign and print name)	Date/Time
Received By (Please sign and print name)	Date/Time	Relinquished By (Please sign and print name)	Date/Time
Received By (Please sign and print name)	Date/Time	Relinquished By (Please sign and print name)	Date/Time
Received By (Please sign and print name)	Date/Time	Shipped Via: UPS BUS Fed-Ex Hand Other____	Shipping #
Work Authorized By (Please sign and print name)	Remarks		

HAZWRAP/NESSA: Y N	
QC Level: 1 2 3 Other: ____	
COC Rec	ICE
Ana Req	TEMP
Cust Seal	Ph

Instructions and Agreement Provisions on Reverse Side

DISTRIBUTION: ORIGINAL - LAB, Yellow - LAB, Pink - Client
REV 11/92 FORM 340

Figure 6-1
Quality Assurance
Quality Control

Section 7
Equipment Calibration

Various instruments will be used in the field and in the laboratory to collect data and monitor site conditions. Proper calibration, maintenance, and use of the instruments is important for collecting high-quality data. A record of calibration and maintenance activities is as important as the data record itself for verifying the delivery of high-quality data.

Field Equipment Calibration

The following field equipment to be used during this investigation will require calibration:

- pH meter
- conductivity meter
- organic vapor monitor (OVM)
- explosivity meter

The pH meter, conductivity meter, OVM, and explosimeter will be calibrated before and during each day's use according to procedures and schedules outlined in the HASP and in the FSP. The standards that will be used to calibrate these instruments are shown in Table 7-1. Standards will be purchased as necessary from appropriate vendors.

If an individual suspects an equipment malfunction, the device will be removed from service and tagged so that it is not inadvertently used, and the equipment manager will be notified so that a substitute piece of equipment can be used. Some backup equipment will be available in the field for use in case of a malfunction.

Equipment that fails calibration or becomes inoperable during use will be removed from service and tagged so that it is not used inadvertently. Such equipment will be repaired and satisfactorily recalibrated. Equipment that cannot be repaired will be replaced.

The results of activities performed using equipment that has failed recalibration will be evaluated. If the results are adversely affected, the outcome of the evaluation will be documented and the task manager will be notified.

Laboratory Equipment Calibration

The laboratory itself is responsible for equipment and instrument calibration and maintenance. Manufacturer's guidance shall be followed for general upkeep. Laboratory calibration procedures are outlined in the LQAP.

Table 7-1 Calibration Standards				
Instrument	**Calibration Standard**	**Span**	**Reading**	**Method**
OVM (11.7 eV)	100 ppm isobutylene	RF = 0.68	68 ppm	1.5 L/min reg: T-tubing
pH Meter	pH 4, 7, and 10 buffers	N/A	N/A	N/A
Conductivity Meter	EC 225 and 1,000 µS/cm	N/A	N/A	N/A
Explosimeter	75% LEL Pentane	N/A	50% ±5% LEL Oxygen	1.5 L/min: Direct tubing

Section 8
Analytical Procedures

All laboratory analyses will be performed by an approved laboratory meeting U.S. Navy Level D quality control. The laboratories will be procured using basic ordering agreements (BOAs). Laboratory procedures to be used for the project are listed in Table 8-1. The list of chemicals analyzed by each method is located in Table 1-1 of the FSP.

Table 8-1
Analytical Procedures

Analysis	Methodology
TCL VOCs, SVOCs, and Pesticides/PCBs	U.S. EPA CLP Organics SOW OLM03 or latest version
Low-concentration VOCs (for groundwater samples)	U.S. EPA CLP SOW for Low-concentration Water OLC02.1 (2/96)
TAL Metals and Cyanide	U.S. EPA CLP Inorganics SOW IML04 or latest version

Section 9
Data Reduction, Validation, and Reporting

Data reduction and reporting are steps in the overall management and use of both field and laboratory data, and data validation is a step in the overall management and use of laboratory data. Figure 9-1 shows the flow of information and sample-tracking forms.

Data Reduction

Data reduction, validation, and reporting will ensure that all documents for the investigations can be accounted for when they are completed. Documents requiring accountability include logbooks, field data records, correspondence, CofC records, analytical reports, data packages, and reports.

Definition

Collected analytical data will be computerized. Electronic data will be requested for all TCL and TCL analyses from the laboratory in a format agreed upon by the data manager. Other types of analytical data will be entered and then verified by spot-checking procedures. The sample manager will handle data entries that are unverified.

Background Data

Background data produced for internal records and not reported as part of the analytical data include the following: laboratory worksheets, laboratory notebooks, sample-tracking system forms, maintenance records, calibration records, and associated QC records. These sources will be available for inspection and for determining the validity of data.

Data Validation

Validation of analytical data will be contracted by CH2M HILL in accordance with Navy Level D QA/QC and EPA QA/QC requirements. The project, its objectives, and the intended use of the data will be discussed with the data validation personnel.

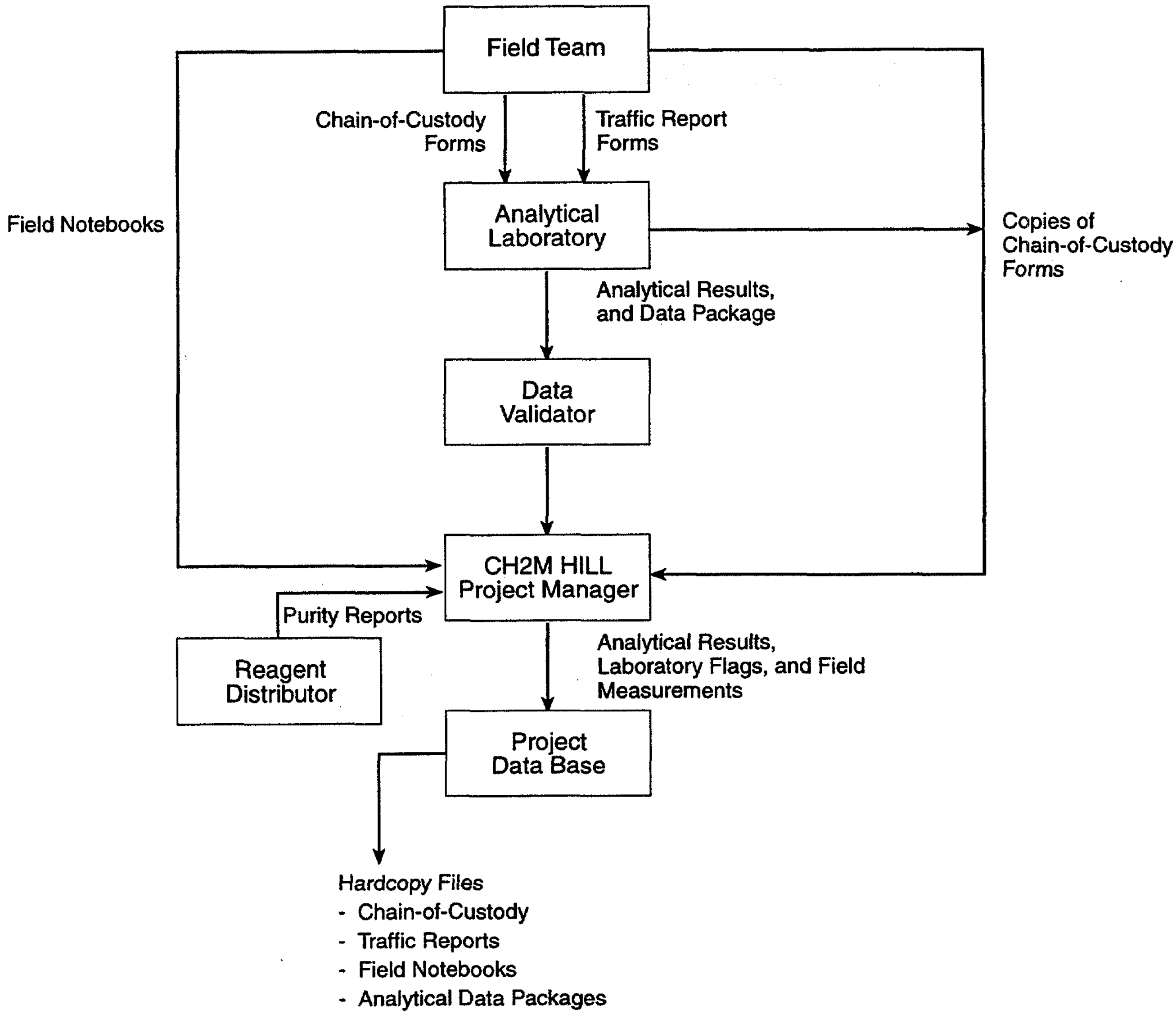


Figure 9-1
FLOW OF FORMS AND SAMPLE AND ANALYSIS INFORMATION

Data Records

The following procedures will be used for maintaining the project records:

- The task manager will determine the records to be generated before the start of work. The records will be listed in the site-specific FSP.
- Records of field activities that support the integrity of samples will be entered on bound and numbered pages. Such records will be dated and signed or otherwise authenticated on the day of entry.
- Records retained on file will be indexed. The indexing system will include the locations of records within the indexing system. (The indexing system will be in alphabetical, chronological, or numerical order or as otherwise indicated in written procedures.)
- There will be sufficient information in records to permit identification between the record and the item(s) or activity to which it applies. Identification of records will be by means that permit traceability.
- The record-storage system will provide for accurate retrieval of records without undue delay.

Section 10
Quality Control Checks

A number of QA/QC samples will be collected to check the adequacy of sample collection and analysis and to monitor laboratory performance. Duplicates, blanks, and spiked samples are used to determine if the sampling technique affects the analytical results, to measure the internal consistency of the samples, and estimate variances or biases in the analytical process. The field and laboratory QA/QC sampling procedures are described below.

Field Sampling QC Procedures

QC duplicate samples and blanks are used to provide a measure of the internal consistency of the samples and an estimate of variance and bias. Table 10-1 defines the protocol for QC sample collection. Table 10-2 summarizes the number of groundwater, soil, and sediment samples and their respective QC samples to be collected during the Site 11 RI.

Table 10-1
Summary of QC Collection Frequencies

Type of QC Sample	Frequency Collected
Field Duplicate	One per 10 samples per matrix
Trip Blank	One per cooler containing samples for VOC analysis
Field Blank	One per week (if very windy or dusty, collect one per day)
Equipment Blank	One every day per matrix.
Matrix Spike/Matrix Spike Duplicate	One per matrix for each group of up to 20 samples sent to a single laboratory.

One duplicate sample will be obtained for every 10 field samples collected. The sampling station from which the duplicate is taken will be selected with a bias toward locations where measurable concentrations are expected. Each duplicate sample will be split evenly into two sample containers and submitted for analysis as two independent samples.

MS/MSDs will be collected at the rate of 1 for every 20 field samples collected per matrix. MS/MSD samples give an indication of the laboratory's analysis accuracy and precision within the sample matrix.

Blanks provide a measure of cross-contamination sources, decontamination efficiency, and other potential errors that can be introduced from sources other than the sample. Three types of blanks can be generated during sampling activities: trip blanks, field blanks, and equipment rinsate blanks.

One trip blank will be included in each cooler used for the daily shipment of VOC samples. If more than one cooler is being sent on a given day, all of the VOC samples should be placed in one cooler, if possible, to minimize the number of trip blanks needed. The trip blanks will be prepared before each sampling event, shipped or transported to the field with

Table 10-2
SUMMARY OF SAMPLES SUBMITTED TO THE LABORTORY FOR ANALYSIS

Matrix	Laboratory Parameter	Samples	Field Duplicates[1]	Field Blanks[2]	Trip Blanks[3]	Equipment Blanks[4]	Total Samples	Matrix Spikes[5]
Groundwater	TPH-DRO	42	5	3	0	10	60	6
	TPH-GRO	42	5	3	0	10	60	6
	Low Concentration Volatiles	42	5	3	10	10	70	6
	TCL Semivolatiles	42	5	3	0	10	60	6
	TCL Pesticides/PCBs	42	5	3	0	10	60	6
	TAL metals (dissolved)	42	5	3	0	10	60	6
	TAL Metals (total)/Cyanide	42	5	3	0	10	60	6
Soil	TPH-DRO	8	1	1	0	1	11	1
Sediment	TPH-DRO	1	1	1	0	1	4	1
	TPH-GRO	1	1	1	0	1	4	1
	TCL Volatiles	1	1	1	1	1	5	1
	TCL Semivolatiles	1	1	1	0	1	4	1
	TCL Pesticides/PCBs	1	1	1	0	1	4	1
	TCL Metals (total)/Cyanide	1	1	1	0	1	4	1

Notes:
[1]Field duplicates are collected at a frequency of 1 per 10 samples.
[2]Field blanks are collected at a frequency of 1 per source per event (1 per week of sampling)
[3]Trip blanks are shipped with water samples submitted for volatiles analysis. Trip blanks are used to monitor contamination that could be introduced during transportation. Trip blanks are collected at a frequency of 1 per cooler of volatiles samples.
[4]Equipment blanks are collected at a frequency of 1 every day.
[5]Matrix spike/matrix spike duplicates (MS/MSD) are collected at a frequency of 1 per 20 samples. MS/MSDs represent samples for which extra volume must be collected for the laboratory to perform required QC analyses. Triple the normal volumes will be collected. This table is based on Navy Level D QA/QC requirements.

the sampling bottles, and returned unopened for analysis. Trip blanks will indicate if there is contamination during shipment to the field, from storage in the field, or from shipment from the field to the analytical laboratory.

One equipment blank per sample medium will be obtained for every day of sampling. Equipment blanks will give an indication of the efficiency of decontamination procedures. An equipment blank will not be collected if disposable sampling equipment is used.

One field blank will be collected for each week of sampling. Field blanks are used to determine the chemical quality of water used for such procedures as decontamination and blank collection.

A temperature blank will be required for collection and shipment of low-concentration volatile samples to minimize the handling of samples by the laboratory.

Laboratory Analytical QC Procedures

The analytical laboratory will use the QC elements, including method or laboratory blanks, initial and continuing calibrations, MS/MSDs, and surrogate spike standards as specified in the analytical methods, the laboratory LQAP, and in *Navy Installation Restoration Laboratory Quality Assurance Guide, Interim Guidance Document*, February, 1996.

Method blanks monitor potential contamination introduced during analysis. Calibration standards are used to calibrate the instrumentation, thereby controlling the accuracy of the results. Once an instrument has been calibrated, calibration is confirmed periodically by monitoring the instrument response to internal standards. For some analyses, such as those performed by gas chromatograph/mass spectrometer (GC/MS), a sample and a blank are spiked with a surrogate compound or a system-monitoring compound (SMC) chosen for properties similar to those of the analyte of interest. The surrogate spikes or SMCs evaluate the efficiency of the analytical procedure in recovering the true amount of a known compound. Laboratory duplicates are performed in certain instances (especially for inorganic analyses) to evaluate the reproducibility of the method.

MS/MSDs are spiked by the laboratory in two separate aliquots of a sample selected by the sampler from each batch of 20 field samples. The MS/MSDs will be used to assess accuracy and precision. The MSD is identical to the MS; both are analyzed to determine the reproducibility of the results. The sampler will collect a triple volume of one sample to give the laboratory enough material for analyzing the sample, the spiked sample, and the spiked sample duplicate.

Section 11
Performance and Systems Audits

Both field and laboratory audits will be conducted.

Laboratory Performance and Systems Audits

The analytical laboratory(ies) will conduct internal QC checks as indicated in the LQAP. The laboratory(ies) is subject to external audits by the Navy and CH2M HILL.

Field Team Performance and Systems Audits

The project manager will conduct a performance audit as needed during the sampling activities to verify that the proper sampling and documentation procedures presented in the QAPP and the FSP are followed and that subsequent sample data are valid. The audit will focus on the details of the QA program. The audit checklist is the guide for performing audits for field procedures and is shown in Figure 11-1. The audit will evaluate the following:

- Project responsibilities
- Sample-collection and sample-preservation procedures
- Equipment-decontamination procedures
- Field equipment-calibration procedures
- Sample-custody procedures
- Document control
- Sample-identification system
- QC corrective-action procedures

An audit report summarizing results and corrections will be prepared and filed in the project files. Significant variances from established procedures will be reported to the project manager.

Figure 11-1
FIELD PERFORMANCE AUDIT CHECKLIST

Project Responsibilities

Project No.: ____________________ Date: ____________________

Project Location: ____________________ Signature: ____________________

Team Members: ____________________

Yes __ No __ 1) Was a SAP Prepared?
Comments ____________________

Yes __ No __ 2) Was a briefing held for project participants?
Comments ____________________

Yes __ No __ 3) Were additional instructions given to project participants?
Comments ____________________

Yes __ No __ 4) Is the current approved SAP being used?
Comments ____________________

Sample Collection

Yes __ No __ 1) Is there a written list of sampling locations and descriptions?
Comments ____________________

Yes __ No __ 2) Are samples collected as stated in the FSP?
Comments ____________________

Yes __ No __ 3) Are samples collected in the type of containers specified in the FSP?
Comments ____________________

Figure 11-1
FIELD PERFORMANCE AUDIT CHECKLIST
(Continued)

Yes __ No __ 4) Are samples preserved as specified in the FSP?
Comments ____
____
____

Yes __ No __ 5) Are the number, frequency, and type of samples collected as specified in the FSP?
Comments ____
____
____

Yes __ No __ 6) Are quality assurance checks performed as specified in the FSP?
Comments ____
____
____

Yes __ No __ 7) Are photographs taken and documented as specified in the FSP?
Comments ____
____
____

Document Control

Yes __ No __ 1) Have any accountable documents been lost?
Comments ____
____
____

Yes __ No __ 2) Have any accountable documents been voided?
Comments ____
____
____

Yes __ No __ 3) Have any accountable documents been disposed of?
Comments ____
____
____

Yes __ No __ 4) Are the samples identified with sample tags?
Comments ____
____
____

Figure 11-1
FIELD PERFORMANCE AUDIT CHECKLIST
(Continued)

Yes __ No __ 5) Are blank and duplicate samples properly identified?
Comments ____
____
____

Yes __ No __ 6) Are samples listed on a chain-of-custody record?
Comments ____
____
____

Yes __ No __ 7) Is chain-of-custody documented and maintained?
Comments ____
____
____

Section 12
Preventive Maintenance

Routine maintenance procedures and schedules for sampling equipment are described in the manufacturer's instruction manuals. All records of inspection and maintenance will be dated and documented in the field notebook.

Maintenance procedures and schedules for all field and laboratory analytical instruments will follow the recommendations of the equipment manufacturers. Routine laboratory equipment maintenance will be performed by laboratory personnel as needed or as indicated in the LQAP. All records of inspection and maintenance will be dated and documented in laboratory record books.

Critical spare parts for the pH, the OVM, the conductivity meter, the dissolved oxygen (DO) meter, and the explosimeter include batteries, electrodes, and membranes. They will be included in the sampling kits to minimize downtime. In addition, backup meters will be available, if needed. Spare parts will be purchased from accepted vendors.

Section 13
Data Assessment Procedures

The precision and accuracy of data will be assessed routinely to ensure that they meet the requirements of the DQOs.

All data will be validated before interpretation by a subcontractor. The validation will be performed according to *USEPA Contract Laboratory Program National Functional Guidelines for Organic Data Review*, February 1994, and *USEPA Laboratory Data Validation Functional Guidelines for Evaluating Inorganic Analyses*, January 1993.

Data will be validated by an independent contractor, because it would not be appropriate for CH2M HILL to validate data collected by CH2M HILL staff. Data that should be qualified will be flagged with the appropriate symbol. The results for field and equipment blanks will be reviewed, and the data will be qualified further, if necessary. Finally, the data set as a whole will be examined for consistency, anomalous results, and reasonableness.

Section 14
Corrective Actions

The project manager is responsible for initiating corrective actions. Corrective actions will include problem identification, investigation-responsibility assignment, action for eliminating the problem, increased monitoring of the effectiveness of the corrective action, and verification that the problem has been eliminated.

Documenting the problem is important to the overall QA program. A memorandum to file will be written for a problem associated with sample collection. A copy will be sent to the laboratory, if appropriate, to document corrections to sample identification. The memo will be written by the person discovering the QA problem or the person responsible for the problem. The memo should identify the problem, establish possible causes, and designate the person responsible for action. The responsible person will be either the project manager or the field team leader. The responsible person will verify that initial action has been taken and appears to be effective and, at an appropriate later date, will recheck to see if the problem has been resolved fully.

Examples of corrective actions include, but are not limited to, correcting CofC forms, analysis reruns (if holding-time criteria permit), recalibration with fresh standards, replacement of sources of blank contamination, examination of calculation procedures, additional training in sample preparation and analysis, reassignment of analytical responsibilities using a different batch of containers, and recommending an audit of laboratory procedures. Additional approaches may include the following:

- Resampling and analyzing
- Evaluating and amending procedures for sampling and analysis
- Accepting the data and acknowledging the level of uncertainty or inaccuracy by flagging the data and providing an explanation for the qualification.

Section 15
Quality Assurance Reports

A QA report will be completed at the end of the field activity to summarize the QA/QC status of the project and problems, if any. The report will be an assessment of the measured QA parameters (for example, precision and accuracy), the results of performance audits, reported nonconformance, and significant QA problems and the recommended solutions. A change in the QAPP will be summarized in a report or a letter and will be sent to the NTR at LANTDIV and distributed to the CH2M HILL project team.

Final

Field Sampling Plan Remedial Investigation and Feasibility Study of Site 11 for Allegany Ballistics Laboratory Rocket Center, West Virginia

Contract Task Order 0013

May 1998

Prepared for

Department of the Navy
Atlantic Division
Naval Facilities Engineering Command

Under the

LANTDIV CLEAN II Program
Contract N62470-95-D-6007

Prepared by

CH2MHILL

Herndon, Virginia

WDC981250005.DOC/1/LBT

Contents

Contents (cont.)

Table **Page**

Figure

Appendix

Section 1
Sampling Program

This Field Sampling Plan (FSP) documents procedures and practices to be followed during the Remedial Investigation/Feasibility Study (RI/FS) of Production Well F (F-Well) at Site 11, Allegany Ballistics Laboratory (ABL) Superfund Site located in Rocket Center, West Virginia. Samples will be collected from soil and groundwater at Site 11 and sediment from F-Well. The following sections document the sampling program for each media. All sample analyses will be performed in accordance with standard EPA methods and procedures by a contracted laboratory that fulfills all requirements of the U.S. Navy's QA/QC Program Manual and EPA's Contract Laboratory Program. A signed certificate of analysis will be provided with each laboratory analysis, along with a certificate of compliance certifying that all work was performed in accordance with the applicable federal, state, and local regulations. All analyses will be performed following the Navy's guidance for Level D. Table 1-1 lists the analytical parameters included on EPA's Target Compound List (TCL) and Target Analyte List (TAL), the volatile compounds to be analyzed for by a low-concentration method, and total petroleum hydrocarbon (TPH) diesel-range organics (DRO) and gasoline-range organics (GRO).

Soil Investigation

The soil sampling program consists of direct-push soil sample collection to the north and northeast of the former oil storage area. Continuous soil samples will be collected from below the asphalt to the water table at locations using direct-push sampling techniques. At each location, the continuous soil interval will be screened with an OVM for the presence of organic vapors. The interval exhibiting the highest vapor concentration (or the interval directly above the water table in the event no vapors are detected) will be sampled for offsite analysis of TCL VOCs, TCL SVOCs, TAL metals, and TPH-DRO. The rationale for soil sampling is documented in the attached Work Plan. Table 1-2 summarizes the soil sampling program, giving the location and analyses to be performed for each sample. Figure 1-1 depicts the soil sample locations.

Groundwater Investigation

Forty-seven groundwater samples will be collected during the RI/FS field activities at Site 11. The rationale for the placement and sampling of monitoring wells is documented in the attached Work Plan. The groundwater investigation activities are discussed below. Table 1-3 summarizes the number of samples and specific analyses to be performed during the Site 11 RI/FS.

Table 1-1

Analytical Parameters and Reporting Limits

Volatile Organic Compounds on Target Compound List (TCL) (Method OLM03 or latest version)

Compound	Water µg/L	Soil/ Sediment µg/kg	Compound	Water µg/L	Soil/ Sediment µg/kg
Acetone	10	10	1,2-Dichloropropane	10	10
Benzene	10	10	cis-1,3-Dichloropropene	10	10
Bromoform	10	10	trans-1,3-Dichloropropene	10	10
Bromodichloromethane	10	10	Ethylbenzene	10	10
Bromomethane	10	10	2-Hexanone	10	10
2-Butanone	10	10	4-Methyl-2-pentanone	10	10
Carbon disulfide	10	10	Methylene chloride	10	10
Carbon tetrachloride	10	10	Styrene	10	10
Chlorobenzene	10	10	1,1,2,2-Tetrachloroethane	10	10
Chloroethane	10	10	Tetrachloroethene	10	10
Chloroform	10	10	Toluene	10	10
Chloromethane	10	10	1,1,1-Trichloroethane	10	10
Dibromochloromethane	10	10	1,1,2-Trichloroethane	10	10
1,1-Dichloroethane	10	10	Trichloroethene	10	10
1,2-Dichloroethane	10	10	Vinyl chloride	10	10
1,1-Dichloroethene	10	10	Xylenes (total)	10	10
1,2-Dichloroethene (total)	10	10			

Low-Concentration Volatile Organic Compounds (Method OLC02.1)

Compound	Water µg/L	Compound	Water µg/L
Acetone	5	1,1-Dichloroethene	1
Benzene	1	cis-1,2-Dichloroethene	1
Bromoform	1	trans-1,2-Dichloroethene	1
Bromochloromethane	1	1,2-Dichloropropane	1
Bromodichloromethane	1	cis-1,3-Dichloropropene	1
Bromomethane	1	trans-1,3-Dichloropropene	1
2-Butanone	5	1,2,4-Trichlorobenzene	1
Carbon disulfide	1	Ethylbenzene	1
Carbon tetrachloride	1	2-Hexanone	5

Table 1-1

Analytical Parameters and Reporting Limits

Chlorobenzene	1	4-Methyl-2-pentanone	5
Chloroethane	1	Methylene chloride	2
Chloroform	1	Styrene	1
Chloromethane	1	1,1,2,2-Tetrachloroethane	1
1,2-Dibromo-3-chloropropane	1	Tetrachloroethene	1
Dibromochloromethane	1	Toluene	1
1,2-Dibromoethane	1	1,1,1-Trichloroethane	1
1,2-Dichlorobenzene	1	1,1,2-Trichloroethane	1
1,3-Dichlorobenzene	1	Trichloroethene	1
1,4-Dichlorobenzene	1	Vinyl chloride	1
1,1-Dichloroethane	1	Xylenes (total)	1
1,2-Dichloroethane	1		

Semivolatile Organic Compounds on Target Compound List (TCL) (Method OLM03 or latest version)

Compound	Water µg/L	Soil/ Sediment µg/kg	Compound	Water µg/L	Soil/ Sediment µg/kg
1,2-Dichlorobenzene	10	330	2,4-Dinitrophenol	25	800
1,3-Dichlorobenzene	10	330	4-Nitrophenol	25	800
1,4-Dichlorobenzene	10	330	Dibenzofuran	10	330
Phenol	10	330	2,4-Dinitrotoluene	10	330
bis-(2-Chloroethyl)ether	10	330	Diethylphthalate	10	330
2-Chlorophenol	10	330	4-Chlorophenyl-phenylether	10	330
2-Methylphenol	10	330	Fluorene	10	6.7[1]
2,2'-oxybis(1-Chloropropane)	10	330	4-Nitroaniline	25	800
4-Methylphenol	10	330	4,6-Dinitro-2-methylphenol	25	800
N-Nitroso-di-n-propylamine	10	330	N-Nitrosodiphenylamine	10	330
Hexachloroethane	10	330	4-Bromophenyl-phenylether	10	330
Nitrobenzene	10	330	Hexachlorobenzene	10	330
Isophorone	10	330	Pentachlorophenol	25	800
2-Nitrophenol	10	330	Phenanthrene	10	6.7[1]
2,4-Dimethylphenol	10	330	Anthracene	10	3.3[1]
bis-(2-Chloroethoxy)methane	10	330	Di-n-butylphthalate	10	330
2,4-Dichlorophenol	10	330	Carbazole	10	330
1,2,4-Trichlorobenzene	10	330	Fluoranthene	10	3.3[1]

Table 1-1

Analytical Parameters and Reporting Limits

Naphthalene	10	67[1]	Pyrene	10	3.3[1]
4-Chloroaniline	10	330	Butylbenzylphthalate	10	330
Hexachlorobutadiene	10	330	3,3'-Dichlorobenzidine	10	330
4-Chloro-3-methylphenol	10	330	Benzo(a)anthracene	10	3.3[1]
2-Methylnaphthalene	10	330	Chrysene	10	3.3[1]
Hexachlorocyclopentadiene	10	330	bis-(2-Ethylhexyl)phthalate	10	330
2,4,6-Trichlorophenol	10	330	Di-n-octylphthalate	10	330
2,4,5-Trichlorophenol	25	800	Benzo(b)fluoranthene	10	3.3[1]
2-Chloronaphthalene	10	330	Benzo(k)fluoranthene	10	3.3[1]
2-Nitroaniline	25	800	Benzo(a)pyrene	10	3.3[1]
Dimethylphthalate	10	330	Indeno(1,2,3-cd)pyrene	10	6.7[1]
Acenaphthylene	10	67[1]	Dibenz(a,h)anthracene	10	6.7[1]
2,6-Dinitrotoluene	10	330	Benzo(g,h,i)perylene	10	6.7[1]
3-Nitroaniline	25	800	Acenaphthene	10	6.7[1]

Note:

[1]Polycyclic Aromatic Hydrocarbons (PAHs) for solids will be analyzed by SW-846 8310 method.

Table 1-1

Analytical Parameters and Reporting Limits

Low-Concentration Semivolatile Organic Compounds (Method OLC02.1)

Compound	Water µg/L	Compound	Water µg/L
Phenol	5	Dibenzofuran	5
bis-(2-Chloroethyl)ether	5	2,4-Dinitrotoluene	5
2-Chlorophenol	5	Diethylphthalate	5
2-Methylphenol	5	4-Chlorophenyl-phenylether	5
2,2'-oxybis(1-Chloropropane)	5	Fluorene	5
4-Methylphenol	5	4-Nitroaniline	20
N-Nitroso-di-n-propylamine	5	4,6-Dinitro-2-methylphenol	20
Hexachloroethane	5	N-Nitrosodiphenylamine	5
Nitrobenzene	5	4-Bromophenyl-phenylether	5
Isophorone	5	Hexachlorobenzene	5
2-Nitrophenol	5	Pentachlorophenol	5
2,4-Dimethylphenol	5	Phenanthrene	5
bis-(2-Chloroethoxy)methane	5	Anthracene	5
2,4-Dichlorophenol	5	Di-n-butylphthalate	5
Naphthalene	5	Fluoranthene	5
4-Chloroaniline	5	Pyrene	5
Hexachlorobutadiene	5	Butylbenzylphthalate	5
4-Chloro-3-methylphenol	5	3,3'-Dichlorobenzidine	5
2-Methylnaphthalene	5	Benzo(a)anthracene	5
Hexachlorocyclopentadiene	5	Chrysene	5
2,4,6-Trichlorophenol	5	bis-(2-Ethylhexyl)phthalate	5
2,4,5-Trichlorophenol	20	Di-n-octylphthalate	5
2-Chloronaphthalene	5	Benzo(b)fluoranthene	5
2-Nitroaniline	20	Benzo(k)fluoranthene	5
Dimethylphthalate	5	Benzo(a)pyrene	5
Acenaphthylene	5	Indeno(1,2,3-cd)pyrene	5
2,6-Dinitrotoluene	5	Dibenz(a,h)anthracene	5
3-Nitroaniline	20	Benzo(g,h,i)perylene	5
2,4-Dinitrophenol	20	Acenaphthene	5
4-Nitrophenol	20		

Table 1-1

Analytical Parameters and Reporting Limits

Pesticides and PCBs on Target Compound List (TCL) (Method OLM03 or latest version)

Compound	Water µg/L	Soil/ Sediment µg/kg	Compound	Water µg/L	Soil/ Sediment µg/kg
alpha-BHC	0.05	1.7	4,4'-DDT	0.10	3.3
beta-BHC	0.05	1.7	Methoxychlor	0.50	17.0
delta-BHC	0.05	1.7	Endrin ketone	0.10	3.3
gamma-BHC (Lindane)	0.05	1.7	Endrin aldehyde	0.10	3.3
Heptachlor	0.05	1.7	alpha-Chlordane	0.05	1.7
Aldrin	0.05	1.7	gamma-Chlordane	0.05	1.7
Heptachlor epoxide	0.05	1.7	Toxaphene	5.0	170
Endosulfan I	0.05	1.7	Aroclor-1016	1.0	33.0
Dieldrin	0.10	3.3	Aroclor-1221	2.0	67.0
4,4'-DDE	0.10	3.3	Aroclor-1232	1.0	33.0
Endrin	0.10	3.3	Aroclor-1242	1.0	33.0
Endosulfan II	0.10	3.3	Aroclor-1248	1.0	33.0
4,4'-DDD	0.10	3.3	Aroclor-1254	1.0	33.0
Endosulfan sulfate	0.10	3.3	Aroclor-1260	1.0	33.0

Low-Concentration Pesticides and PCBs (Method OLC02.1)

Compound	Water µg/L	Compound	Water µg/L
alpha-BHC	0.01	4,4'-DDT	0.02
beta-BHC	0.01	Methoxychlor	0.10
delta-BHC	0.01	Endrin ketone	0.02
gamma-BHC (Lindane)	0.01	Endrin aldehyde	0.02
Heptachlor	0.01	alpha-Chlordane	0.01
Aldrin	0.01	gamma-Chlordane	0.01
Heptachlor epoxide	0.01	Toxaphene	1.0
Endosulfan I	0.01	Aroclor-1016	0.20
Dieldrin	0.02	Aroclor-1221	0.40
4,4'-DDE	0.02	Aroclor-1232	0.20
Endrin	0.02	Aroclor-1242	0.20
Endosulfan II	0.02	Aroclor-1248	0.20

Table 1-1

Analytical Parameters and Reporting Limits

4,4'-DDD	0.02	Aroclor-1254	0.20
Endosulfan sulfate	0.02	Aroclor-1260	0.20

Metals and Cyanide on the Target Analyte List (TAL) (Method ILM03 or latest version)

Analyte	Water µg/L	Soil/ Sediment mg/kg	Analyte	Water µg/L	Soil/ Sediment mg/kg
Aluminum	200	40	Lead	3	0.6
Antimony	5	12	Magnesium	5,000	1,000
Arsenic	10	2	Manganese	15	3
Barium	200	40	Mercury	0.2	0.2
Beryllium	5	1	Nickel	40	8
Cadmium	5	1	Potassium	5,000	1,000
Calcium	5,000	1,000	Selenium	5	1
Chromium	10	2	Silver	10	2
Cobalt	50	10	Sodium	5,000	1,000
Copper	25	5	Thallium	2	2
Cyanide	10	2	Vanadium	50	10
Iron	100	20	Zinc	20	4

Additional Constituents

Total Petroleum Hydrocarbons - Diesel Range Organics (Method 8015B)		
Total Petroleum Hydrocarbons - Gasoline Range Organics (Method 8015B)		

Table 1-2 SOIL SAMPLING PROGRAM FOR SITE 11 RI/FS							
Site	Sampling Location	TPH-DRO	TPH-GRO	TCL VOC	TCL SVOC	TCL Pest/PCB	TAL Metals and Cyanide (total)
Soil Boring Samples							
11	ABLS-SB01	X		X	X		X
11	ABLS-SB02	X		X	X		X
11	ABLS-SB03	X		X	X		X
11	ABLS-SB04	X		X	X		X
F-Well Sediment Sample							
11	ABLS-SD01	X	X	X	X	X	X

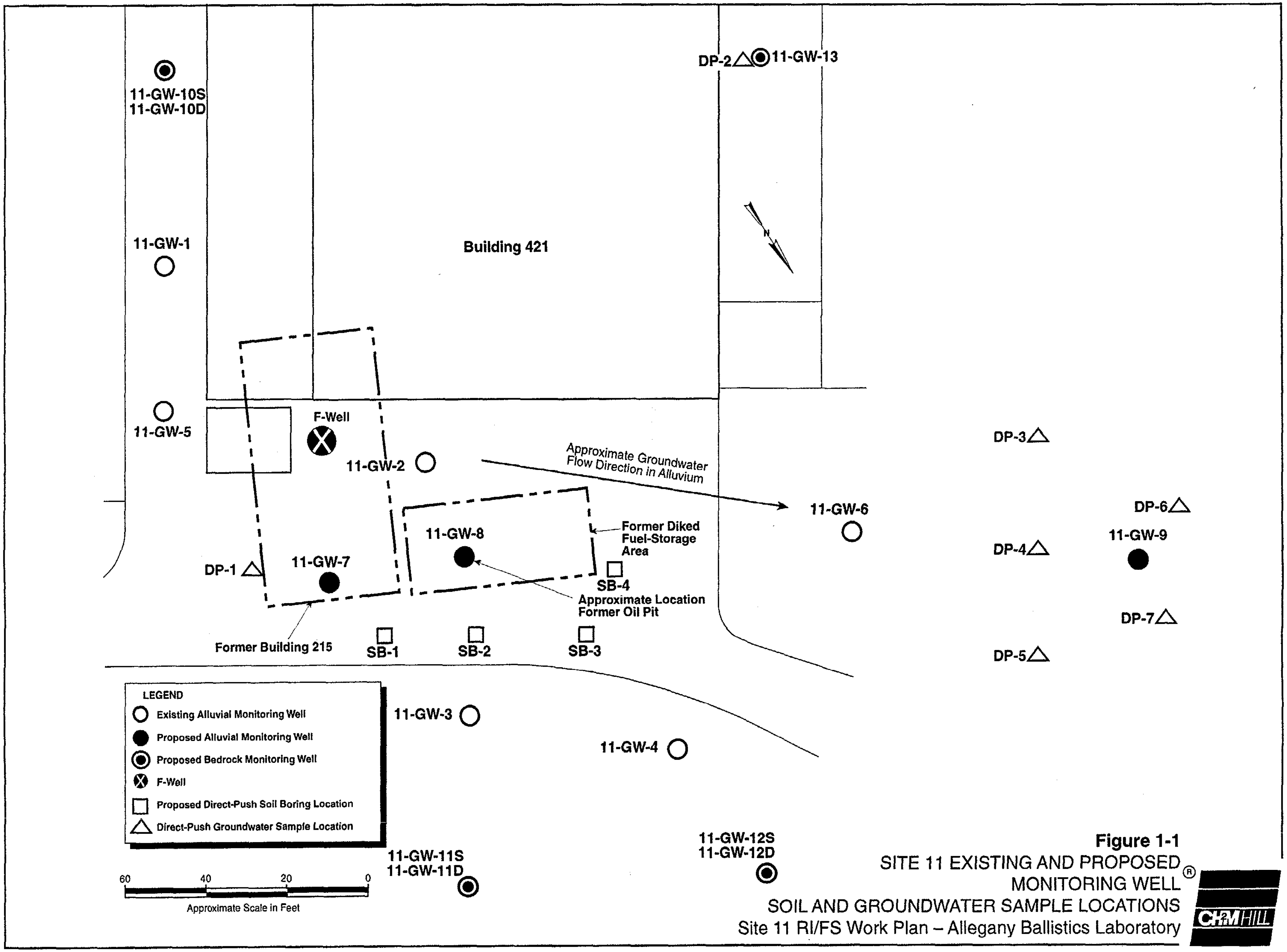


Figure 1-1
SITE 11 EXISTING AND PROPOSED MONITORING WELL
SOIL AND GROUNDWATER SAMPLE LOCATIONS
Site 11 RI/FS Work Plan – Allegany Ballistics Laboratory

CH2M HILL

Table 1-3 GROUNDWATER SAMPLING PROGRAM FOR SITE 11 RI/FS							
Site	Sampling Location	TPH-DRO	TPH-GRO	TCL VOC	TCL SVOC	Pest/PCB	TAL Metals and Cyanide (total and dissolved)
Alluvial Monitoring Well Samples							
11	ABLW-GW01	X	X	X	X	X	X
11	ABLW-GW02	X	X	X	X	X	X
11	ABLW-GW03	X	X	X	X	X	X
11	ABLW-GW04	X	X	X	X	X	X
11	ABLW-GW05	X	X	X	X	X	X
11	ABLW-GW06	X	X	X	X	X	X
11	ABLW-GW07	X	X	X	X	X	X
11	ABLW-GW08	X	X	X	X	X	X
11	ABLW-GW09	X	X	X	X	X	X
Plant 1	ABLW-GW14	X	X	X	X	X	X
Direct-Push Samples							
11	ABLW-DP1	X	X	X	X	X	X
11	ABLW-DP2	X	X	X	X	X	X
11	ABLW-DP3			X			
11	ABLW-DP4			X			
11	ABLW-DP5			X			
11	ABLW-DP6			X			
11	ABLW-DP7			X			
Bedrock Monitoring Well Samples							
11	ABLW-GW10-1	X	X	X	X	X	X
11	ABLW-GW10-2	X	X	X	X	X	X
11	ABLW-GW11-1	X	X	X	X	X	X
11	ABLW-GW11-2	X	X	X	X	X	X
11	ABLW-GW12-1	X	X	X	X	X	X
11	ABLW-GW12-2	X	X	X	X	X	X
11	ABLW-GW13	X	X	X	X	X	X
Plant 1	ABLW-GW15	X	X	X	X	X	X
Packer Testing Samples							
11	ABLW-GP10-1	X	X	X	X	X	X
11	ABLW-GP10-2	X	X	X	X	X	X
11	ABLW-GP10-3	X	X	X	X	X	X
11	ABLW-GP10-4	X	X	X	X	X	X
11	ABLW-GP10-5	X	X	X	X	X	X
11	ABLW-GP11-1	X	X	X	X	X	X
11	ABLW-GP11-2	X	X	X	X	X	X
11	ABLW-GP11-3	X	X	X	X	X	X
11	ABLW-GP11-4	X	X	X	X	X	X
11	ABLW-GP11-5	X	X	X	X	X	X
11	ABLW-GP12-1	X	X	X	X	X	X
11	ABLW-GP12-2	X	X	X	X	X	X
11	ABLW-GP12-3	X	X	X	X	X	X
11	ABLW-GP12-4	X	X	X	X	X	X
11	ABLW-GP12-5	X	X	X	X	X	X
11	ABLW-GP13-1	X	X	X	X	X	X

Table 1-3
GROUNDWATER SAMPLING PROGRAM FOR SITE 11 RI/FS

Site	Sampling Location	TPH-DRO	TPH-GRO	TCL VOC	TCL SVOC	Pest/PCB	TAL Metals and Cyanide (total and dissolved)
11	ABLW-GP13-2	X	X	X	X	X	X
11	ABLW-GP13-3	X	X	X	X	X	X
11	ABLW-GP13-4	X	X	X	X	X	X
11	ABLW-GP13-5	X	X	X	X	X	X
F-Well Samples							
11	ABLW-PWF-1	X	X	X	X	X	X
11	ABLW-PWF-2	X	X	X	X	X	X

Groundwater Sampling

During the Site 11 RI/FS, groundwater samples will be collected during monitoring well, direct-push, and packer sampling. Groundwater samples will be collected from each of the six existing and three newly-installed alluvial monitoring wells at Site 11. It is anticipated that two separate monitoring wells will be installed in three of the four bedrock boreholes and a single monitoring well will be installed in the fourth bedrock borehole. One groundwater sample will be collected from each of these wells. In addition, one groundwater sample will be collected from existing Plant 1 monitoring wells GGW1 and GGW2.

Prior to bedrock well installation, up to five groundwater samples will be collected during packer testing being performed in each of the four bedrock boreholes.

Finally, seven direct-push groundwater samples will be collected from the alluvial aquifer at Site 11.

All groundwater samples will be analyzed by the *USEPA Contract Laboratory Program (CLP) Statement of Work (SOW) for Organics Analysis Multi-Media, Multi-Concentration* (OLM03 or latest version) for the Target Compound List (TCL) organics (including semivolatiles, pesticides, and PCBs). The volatile fraction of the organic sample will be analyzed using the EPA low concentration method OLC02. The Target Analyte List (TAL) inorganics (including total and dissolved metals and cyanide) will be analyzed by a similar SOW for inorganics (ILM04 or latest version). All samples also will be analyzed for TPH-DRO and TPH-GRO using modified Method 8015B. Standard EPA methods will be followed during sample analysis. Figure 1-1 shows the Site 11 monitoring well locations.

F-Well Investigation

The F-Well will be investigated to check for the presence of DNAPL and LNAPL products in the water column and in the sediment (sand) that occupies the bottom of the borehole.

Groundwater Sampling

CH2M HILL proposes to sample the top and bottom of the water column in the F-Well using a bailer to determine if additional LNAPL and DNAPL products have entered the borehole. The samples will be visually inspected for the presence of product. If product is detected in the well borehole, the well will be bailed and swabbed to remove the product. Bailing and swabbing will continue until the bail water and swabs are free of visible product. All bailed water, swabs, and personal protective equipment (PPE) will be contained in 55-gallon drums. These wastes will be considered hazardous.

The two groundwater samples will be analyzed by the *USEPA CLP SOW for Organics Analysis Multi-Media, Multi-Concentration* (OLM03 or latest version) for the TCL organics. The volatile fraction of the organic sample will be analyzed using the EPA low concentration method OLC02. The TAL inorganics will be analyzed by a similar SOW for inorganics (ILM03 or latest version). All samples also will be analyzed for TPH-DRO and TPH-GRO using modified Method 8015B. Standard EPA methods will be followed during sample analysis. Figure 1-1 shows the location of F-Well at Site 11.

Sediment Sampling

If no DNAPL is detected above the sand at the bottom of F-Well, one sediment sample will be collected from the top of the column of sand that occupies the bottom of the borehole to check for the presence of DNAPL product in the sand. The sample will be collected using a drilling rig with a 5-foot split spoon attached to the bottom of the drill rod.

The sediment sample will be analyzed for the same constituents as those defined under ***Groundwater Sampling***, above.

Surveying

The newly installed monitoring wells will be surveyed for horizontal and vertical control by a subcontracted surveyor licensed in the State of West Virginia. In addition, all soil sampling locations will be surveyed for horizontal control.

Section 2
Sampling Operations

All aspects of the sampling operations will conform to U.S. Navy specifications and guidelines. This includes the frequency of collecting and providing QC samples: duplicates; trip, field, and equipment blanks; and matrix spike and matrix spike duplicates.

Soil Sampling Techniques

The Site 11 RI/FS will include the collection of soil samples. All soil samples will be collected using split-spoon sampling techniques (or similar method) in combination with HSA drilling (or similar method) and direct-push sampling techniques. A brief explanation of this sampling techniques are provided below. The Standard Operating Procedure (SOP) for the collection of soil samples is included in Attachment A.

Split-Spoon Sampling

Split-spoon or similar sampling techniques will be used to collect soil samples during Site 11 RI/FS well installation. A drill rig will be used to advance 6 ¼-inch HSAs to the top of the desired sampling interval. A stainless-steel split-spoon sampling device will be attached to the required length of drilling rod and inserted through the hollow stem augers. A 150-pound hammer will be used to advance the split-spoon sampling device the additional 2 feet required for sample collection. The split-spoon sampler will then be retrieved and the sample will be extruded. If necessary, several split-spoon samples will be collected at each location to acquire the volume of sample needed to fill all sample containers.

The split-spoon sampling of the F-Well sediment will be completed by pushing a spoon into the sand at the bottom of the well (approximately 178 feet bgs). A bedrock well drilling rig will be used and the spoon will be attached to the end of the drill rod.

Direct-Push Sampling

At several soil sampling locations, direct-push techniques will be employed to collect the soil samples. Under this method, a stainless-steel probe rod is advanced to the top of the desired sampling depth, where the probe rod is replaced with an acetate-lined, 2- or 3-inch hollow core sampler. The sampler is advanced an additional 2 to 4 feet and then withdrawn from the borehole. The acetate liner is withdrawn from the sampler, split open lengthwise, and the sample extruded into sample containers.

All samples will be placed in clean glass containers provided by the laboratory. Any sample that is split for duplicate analysis will be mixed thoroughly before being split. Table 2-1 presents the required containers, preservatives, and holding times for soil samples. Table 2-2 presents a summary of soil samples to be submitted for analyses.

The Investigation Derived Waste Management Plan (IDWMP) discusses treatment and disposal of the soil cuttings generated during the Site 11 RI/FS.

Table 2-1
REQUIRED CONTAINERS, PRESERVATIVES, AND HOLDING TIMES FOR SOIL SAMPLES

Analysis	Sample Container	Preservative	Holding Time	Volume of Sample Collected
TPH-DRO	8-oz glass bottle with teflon-lined cap	Cool to 4°C	28 days	Fill completely
TPH-GRO	4-oz glass bottle with teflon-lined cap	Cool to 4°C	7 days to extraction, 14 days to analysis	Fill completely
TCL Volatiles	4-oz glass bottle with teflon-lined cap	Cool to 4°C	7 days to extraction, 14 days to analysis	Fill completely
TCL Semivolatiles	Two 4-oz glass bottles with teflon-lined cap	Cool to 4°C	7 days to extraction, 40 days to analysis	Fill completely
TCL Pest/PCB	Two 4-oz glass bottles with teflon-lined cap	Cool to 4°C	7 days to extraction, 40 days to analysis	Fill completely
TAL Inorganics	4-oz glass bottle with teflon-lined cap	Cool to 4°C	6 months	Fill to shoulder

Note:
Refer to Table 2-3 for the required containers, preservatives, and holding times for the associated aqueous field quality control samples.

Table 2-2
SUMMARY OF SOIL SAMPLES TO BE SUBMITTED FOR ANALYSIS - SITE 11

Matrix	Laboratory Parameter	Samples	Field Duplicates[1]	Field Blanks[2]	Trip Blanks[3]	Matrix Spikes[4]	Equipment Blank[5]	Matrix Total
Soil	TPH-DRO	4	1	1	0	1	1	7
	TCL Volatiles	4	1	1	1	1	1	8
	TCL Semivolatiles	4	1	1	0	1	1	7
	TAL Metals and Cyanide	4	1	1	0	1	1	7
Sediment	TPH-DRO	1	1	1	0	1	1	4
	TPH-GRO	1	1	1	0	1	1	4
	TCL Volatiles	1	1	1	1	1	1	5
	TCL Semivolatiles	1	1	1	0	1	1	4
	TCL Pesticides/PCBs	1	1	1	0	1	1	4
	TAL Metals and Cyanide	1	1	1	0	1	1	4

Notes:
[1]Field duplicates are collected at a frequency of 1 per 10.
[2]Field blanks are collected at a frequency of 1 per source per event (1 per week of sampling).
[3]Trip blanks are shipped with samples submitted for volatiles analysis. Trip blanks are used to monitor contamination that could be introduced during transportation. Trip blanks are collected at a frequency of 1 per cooler of volatiles samples.
[4]Matrix spike/matrix spike duplicates (MS/MSD) are collected at a frequency of 1 per 20. MS/MSDs represent samples for which extra volume must be collected for the laboratory to perform required QC analyses. Triple the normal volumes will be collected for all analyses.
[5]Equipment blanks are collected and analyzed at a frequency of 1 every day.
Note: This table is based on Navy Level D QA/QC requirements.

Groundwater Sampling Techniques

The Site 11 RI/FS field activities include the collection of groundwater samples. Groundwater samples will be collected during packer testing activities at each of the four bedrock borings. In addition, groundwater samples will be collected from the alluvial aquifer from two Hydropunch® locations. Groundwater samples also will be collected from the six existing and three newly installed alluvial monitoring wells, as well as Plant 1 monitoring well GGW1 and GGW2. Two groundwater samples also will be collected from the F-Well. A brief explanation of the groundwater sampling techniques to be employed during the Site 11 RI/FS is provided below. Detailed descriptions of monitoring well sampling techniques are included in Attachment A.

Packer Sampling

At up to five zones in each of the four bedrock boreholes drilled during the Site 11 RI field activties, groundwater samples will be collected using a packer assembly. For each zone, a packer assembly, consisting of two inflatable packers separated by fixed distance (e.g., 20 feet), will be positioned to straddle the selected zone. Once both packers are inflated, the selected zone is isolated and a discrete groundwater sample can be collected.

The packer assembly will be thoroughly decontaminated by steam cleaning prior to introduction into the borehole and between borehole locations.

Direct-Push Sampling

At seven Site 11 locations, shallow groundwater samples will be collected using direct-push sampling techniques. At each location, the direct-push sampler will be driven to the desired depth and the groundwater sample collected from within the direct-push sampling rods.

The direct-push equipment will be thoroughly decontaminated according to the SOP ***Decontamination of Personnel and Equipment*** in Attachment A of this FSP prior to introduction into the borehole and between borehole locations. Any downhole equipment that cannot be decontaminated will be replaced between sample locations.

Monitoring Well Sampling

A decontaminated submersible pump will be used to purge groundwater from each of the six existing and three new Site 11 alluvial monitoring wells, the seven new bedrock Site 11 bedrock monitoring wells, and Plant 1 existing monitoring wells GGW1 and GGW2. If practical low-flow purging and sampling of the wells will be employed. This method purges groundwater from a well at a rate low enough to avoid significant drawdown in the well. Indicator parameters, such as pH, temperature, and conductivity, are monitored during purging, which is considered complete when the parameters stabilize. Once the field parameters have stabilized, the sampling will commence. Every attempt will be made to avoid pumping wells dry during purging. Wells that are pumped dry during purging will be allowed to recover before sampling; the sample will be obtained as soon as a sufficient volume of groundwater to fill all sample containers has entered the well.

In addition to the well sampling described above, two groundwater samples will be collected from the F-Well using a disposable bailer. Because the samples are intended to evaluate the presence of an LNAPL and DNAPL, the well will not be purged prior to sample collection.

Sample Collection

For VOCs, the sample containers will be filled so as to minimize the aeration of the samples. Sample vials will be filled completely and capped to prevent the entrapment of any air bubbles in the vial. The bottle cap should be removed carefully from the laboratory-cleaned sample bottle. The cap should not be laid down nor the inside touched. At no time should the inside of the bottle come into contact with anything other than the sample.

Dissolved metals samples will be collected by attaching a 0.45-µm particulate filter to the end of the pump's discharge line. Groundwater will be directed through the filter and into the bottle. The filter will be changed after each sample.

All appropriate preservatives will be added to the sample containers by the contracted laboratory before shipment to the CH2M HILL field team. VOC sample containers will be preserved with hydrochloric acid (HCl), TPH sample containers will be preserved with sulfuric acid (H_2SO_4), TAL metals sample containers will be preserved with nitric acid (HNO_3), and cyanide sample containers will be preserved with sodium hydroxide (NaOH). All samples will be kept cool at 4°C, using bagged ice.

The Investigation Derived Waste Management Plan (IDWMP) discusses treatment and disposal of purge water.

Table 2-3 presents the required containers, preservatives, and holding times for groundwater samples. Table 2-4 presents a summary of groundwater samples to be submitted for analyses.

Equipment Decontamination

All non-dedicated sampling equipment will be decontaminated prior to the beginning of sampling activities and after each use. Specific field decontamination procedures are presented in Attachment A.

Field Quality Control Procedures

Quality control duplicate samples and blanks are used to provide a measure of the internal consistency of the samples and to provide an estimate of the components of variance and the

Table 2-3
REQUIRED CONTAINERS, PRESERVATIVES,
AND HOLDING TIMES FOR GROUNDWATER SAMPLES

Analysis	Sample Container	Preservative	Holding Time	Volume of Sample Collected
TPH-DRO	1-liter amber bottle w/teflon lined cap	H_2SO_4 to pH < 2; Cool to 4°C	28 days	Fill to shoulder
TPH-GRO	Three 40-ml glass vial w/teflon lined cap	HCl to pH < 2; Cool to 4°C	7 days to extraction, 14 days to analysis	Fill completely; no air bubbles
Low Concentration Volatiles and TCL Volatiles	Three 40-ml glass vial w/teflon lined cap	HCl to pH < 2; Cool to 4°C	7 days to extraction, 14 days to analysis	Fill completely; no air bubbles
TCL Semivolatiles	2 1-liter amber bottle w/teflon lined cap	Cool to 4°C	7 days to extraction, 40 days to analysis	Fill to shoulder
TCL Pest/PCB	2 1-liter amber bottle w/teflon lined cap	Cool to 4°C	7 days to extraction, 40 days to analysis	Fill to shoulder
TAL Metals (total and dissolved)	1-liter polyethylene bottle for each analysis	HNO_3 to pH < 2; Cool to 4°C	6 months	Fill to shoulder
TAL Cyanide	1-liter bottle	NaOH to pH > 12, Cool to 4°C	14 days	Fill to shoulder

Table 2-4
SUMMARY OF GROUNDWATER SAMPLES TO BE SUBMITTED FOR ANALYSIS - SITE 11

Matrix	Laboratory Parameter	Samples	Field Duplicates[1]	Field Blanks[2]	Trip Blanks[3]	Matrix Spikes[4]	Equipment Blanks[5]	Matrix Total
Groundwater	TPH-DRO	47	5	3	0	6	10	65
	TPH-GRO	47	5	3	0	6	10	65
	Low Concentration Volatiles	47	5	3	10	6	10	75
	TCL Semivolatiles	47	5	3	0	6	10	65
	TCL Pesticides/PCBs	47	5	3	0	6	10	65
	TAL Metals (total) / Cyanide	47	5	3	0	6	10	65
	TAL Metals (dissolved)	47	5	3	0	6	10	65

Notes:

[1]Field duplicates are collected at a frequency of 1 per 10.

[2]Field blanks are collected at a frequency of 1 per source per event.

[3]Trip blanks are shipped with water samples submitted for volatiles analysis. Trip blanks are used to monitor contamination that could be introduced during transportation. Trip blanks are collected at a frequency of 1 per cooler of volatiles samples.

[4]Matrix spike/matrix spike duplicates (MS/MSD) are collected at a frequency of 1 per 20. MS/MSDs represent samples for which extra volume must be collected for the laboratory to perform required QC analyses. Triple the normal volumes will be collected for all analyses.

[5]Equipment blanks are collected and analyzed at a frequency of 1 every day. They are not required when disposable sampling equipment is used.

Note: This table is based on Navy Level D QA/QC requirements.

bias in the analytical process. Table 10-1 in the QAPP provides a summary of the collection frequencies of the field QC samples.

Blanks

Blanks provide a measure of cross-contamination sources, decontamination efficiency, and other potential errors that can be introduced from sources other than the sample. ASTM Type II water will be used for blanks. Three types of blanks will be generated during sampling activities: trip blanks, field blanks, and equipment blanks.

One trip blank will be included for each cooler containing samples for VOC analysis. The trip blanks will be prepared prior to each sampling event, shipped or transported to the field with the sampling bottles, and sent to the laboratory unopened for analysis. Trip blanks will not be prepared or handled in the field. Trip blanks will indicate if any contamination occurred during shipment to the field, field storage, or during shipment from the field to the analytical laboratory.

One field blank will be collected each week of a sampling event. The field blanks will indicate if any contaminants were introduced during the handling of the sample containers in the field or during sample analysis at the laboratory. The sample container will be filled with ASTM Type II water in the field at the time of sampling. The blanks will be capped, packed, and shipped with the samples.

One equipment blank will be collected and analyzed every day during sampling activities. The equipment blanks will indicate the efficiency of equipment decontamination procedures.

A temperature blank will be included in each cooler that contains low-concentration VOCs. The temperature blank permits the lab to measure the temperature without handling the samples.

Duplicates

Field duplicate samples will be collected at a frequency of 1 per 10 field samples per matrix. The duplicates will be collected at locations that are most likely to be contaminated. The duplicate sample will be submitted for analysis as two independent samples. These samples will be numbered non-sequentially.

Matrix Spike/Matrix Spike Duplicate (MS/MSD)

Matrix spike/matrix spike duplicate (MS/MSD) samples will be collected at a frequency of one per 20 field samples. Analytical results of these samples indicate the impact the matrix (water or soil) has on extracting the analyte for analysis. Data validators will use these results to evaluate the accuracy of the analytical data.

Section 3
Documentation

Sample Designation

Each sample will be assigned an alphanumeric code that will identify ABL, the Site number, the matrix sampled, and contain a sequential sample number. Site-specific procedures are elaborated below.

The Allegany Ballistics Laboratory code will be ABL. Location types will be identified by a two-letter code and each sampling location will be identified with a two-digit number corresponding to the sampling location.

The following is a general guide for sample identification:

First Segment of Sample Designation		Second Segment of Sample Designation		Third Segment of Sample Designation
Site Code	**Sample Type**	**Location Type**	**Sample Location Number**	**Depth Identifier**
AAA	A	AA	NNN	N/N

Symbol Definition:

A	=	Alphabetic
N	=	Numeric

Site Code

ABL	=	Allegany Ballistics Laboratory

Sample Type:

S	=	Soil
W	=	Water

Sample Type:

GS	=	Geoprobe Soil Sample
SB	=	Soil Boring Sample
GW	=	Groundwater Sample collected during packer testing
MW	=	Monitoring Well Groundwater Sample
TB	=	Trip Blank
EB	=	Equipment Blank
FB	=	Field Blank

Sample Location Number:

12	=	Well 12

Depth Identifier:

NN	=	Depth Identifier

Sample Shipping Procedures

Strict adherence to both personnel and equipment decontamination procedures will help ensure the safety of onsite workers as well as the acquisition of quality data.

All field sampling activities will be documented through the use of field logs and chain-of-custody procedures. Sample containers will be clean, first-quality containers provided by the contracted laboratory. A complete listing of the types of bottles and preservatives to be used is given in Tables 2-1 and 2-3 in Section 2 of this FSP. An identification label will be attached to each sample container indicating the sample number, station number, analysis to be performed, preservative used, date and time of sample collection, and the name of the responsible sampling team member.

After collection, samples will be packed in coolers with vermiculite and ice (if necessary) for shipment to the contracted laboratory via an overnight courier. Chain-of-custody forms will be taped to the inside of the lid of each cooler. Chain-of-custody forms contain general information about the location of the activity and the members of the sampling team, as well as specific information about the type of sample, sample location, number of sample containers from each station, and analyses to be performed. Each time the sample is relinquished or received, the party involved signs the form and indicates the time and date.

The coolers used to deliver the samples will be sealed with strapping tape. Evidence tape will be placed across the front and back of each lid to control tampering. The samples will be shipped to the laboratory at the end of each day of sampling to ensure that holding times are not exceeded.

Attachment A

Standard Operating Procedures

Field Measurement of pH and Eh

Field Measurement of Specific Conductance and Temperature

Field Measurement of Dissolved Oxygen

Field Measurement of Alkalinity

Explosimeter

Volatiles Monitoring by OVM

Soil Sampling

Soil Boring Drilling and Abandonment

Logging of Soil Borings

Geoprobe® Soil Sample Collection

Geoprobe® Groundwater Sample Collection

Installation of Shallow Monitoring Wells

Installation of Groundwater Monitoring Wells by Sonic Drilling

Bedrock Monitoring Well Installation

General Guidance for Monitoring Well Installation

Water-Level Measurements

Field Rinse Blank Preparation

Field Filtering

Homogenization of Soil and Sediment Samples

Packaging and Shipping Procedures

Decontamination of Drilling Rigs and Equipment

Decontamination of Personnel and Equipment

Disposal of Fluids and Solids

Civil Surveying

Groundwater Sampling from Monitoring Wells

Low-Flow Groundwater Sampling from Monitoring Wells

Downhole Geophysical Logging

STANDARD OPERATING PROCEDURE

Field Measurement of pH and Eh

I. Purpose and Scope

The purpose of this procedure is to provide a guideline for field measurement of pH and Eh.

II. Equipment and Materials

- pH buffer solution for pH 4, 7, and 10
- Deionized water in squirt bottle
- pH/Eh meter, calibration sheet, and instructions
- pH and redox electrodes
- Beakers
- Glassware that has been washed with soap and water, rinsed twice with hot water, and rinsed twice with deionized water
- 4 M KCl saturated with Ag/AgC1 solution, electrode filling solution.

III. Procedures and Guidelines

A. Calibration

Calibrate unit prior to initial daily use and check calibration throughout and at end of the day. There are no calibration procedures for the redox electrode. Calibrate with at least two solutions. Clean the probe according to the manufacturer's recommendations. Duplicate samples should be run once every 10 samples. The order of calibration solutions will be based on the instrument manufacturer's recommendation.

1. Place electrode in pH 7 buffer solution.
2. Allow meter to stabilize, and then turn calibration dial until a reading of 7.0 is obtained.
3. Rinse electrode with deionized water and place it in a pH 4 or pH 10 buffer solution.
4. Allow meter to stabilize again and then turn slope adjustment dial until a reading of 4.0 is obtained for the pH 4 buffer solution or 10.0 for the pH 10 buffer solution.

5. Rinse electrode with deionized water and place in pH 7 buffer. If meter reading is not 7.0, repeat sequence.

B. Procedure

1. Before going out into the field:
   a. Check batteries.
   b. Do a quick calibration at pH 7 and 4 to check electrode.
   c. Obtain fresh calibration solutions.
   d. Fill electrodes.
2. Calibrate meter using calibration procedure.
3. Pour the sample into a clean beaker.
4. Rinse electrode with deionized water between samples.
5. Immerse electrode in solution. Make sure the white KCl junction on the side of the electrode is in the solution. The level of electrode solution should be one inch above sample to be measured.
6. Recheck calibration with pH 7 buffer solution after every five samples.

C. General

1. When calibrating the meter, use pH buffers 4 and 7 for samples with pH <8, and buffers 7 and 10 for samples with pH >8. If meter will not read pH 4 or 10, something may be wrong with the electrode.
2. Measurement of pH is temperature dependent. Therefore, buffers temperatures should be within about 2 degrees C of sample temperatures. For refrigerated or cool samples, use refrigerated buffers to calibrate the pH meter.
3. Weak organic and inorganic salts and oil and grease interfere with pH measurements. If oil and grease are visible, note it on the data sheet. Clean electrode with soap and water and rinse with distilled water. Then recalibrate meter.
4. Following field measurements, report problems and compare with previous data. Clean dirt off meter and inside case and store electrode in pH 4 buffer.
5. Accuracy and precision are dependent on the instrument used; refer to manufacturer's manual. Expected accuracy and precision are +/- 0.1 pH unit.
6. The redox electrode should be checked prior to beginning site work and when anomalous readings suggest that the probe is malfunctioning. The procedure for checking the redox electrode is as below:

a. Prepare solution A (0.1 M potassium ferrocyanide and 0.005 M potassium ferricyanide): weigh out 4.22 g reagent-grade $K_4Fe(CN)_6 \cdot 3H_2O$ and 1.65 g reagent-grade $K_3Fe(CN)_6$. Place in a 100 ml volumetric flask. Add about 50 ml distilled water and swirl to dissolve solids. Dilute to volume with distilled water.

b. Prepare solution B (0.01 M potassium ferrocyanide, 0.05 M potassium ferricyanide, and 0.36 M potassium fluoride): Weigh out 0.42 g reagent-grade $K_4Fe(CN)_6 \bullet 3H_2O$ 1.65 g reagent-grade $K_3Fe(CN)_6$, and 3.39 g reagent-grade $KF \bullet 2H_2O$. Place in a 100 ml volumetric flask. Add 50 ml distilled water, and swirl to dissolve solids. Dilute to volume with distilled water.

c. Transfer solution A to a 150 ml beaker. Place electrode in the solution and wait until the reading stabilizes. The potential should be about 234 mV.

d. Rinse electrode and repeat the measurement with solution B. The potential should be about 66 mV greater in solution B than in solution A.

IV. Key Checks and Preventive Maintenance

- Check batteries, have a replacement set on hand.
- Calibrate meter and check calibration throughout and at end of day.
- Refer to operation manual for recommended maintenance.

STANDARD OPERATING PROCEDURE

Field Measurement of Specific Conductance and Temperature

I. Purpose and Scope

The purpose of this procedure is to provide a general guideline for field measurement of specific conductivity and temperature of groundwater samples. The following general discussion applies to most commonly used meters but may differ between specific brands. The operator's manual should be consulted for specific calibration and operating procedures.

II. Equipment and Materials

- Conductivity meter and electrode
- Distilled water in squirt bottle
- Standard potassium chloride (KCl) solution (0.01 N)

III. Procedures and Guidelines

A. Technical:

Detection limit = 1 µmho/cm @ 25°C; range = 0.1 to 100,000 µmho/cm

B. Calibration:

Calibrate prior to initial daily use with standard solution. Check calibration throughout and at end of the day. The standards should have different orders of conductance. Clean probe according to manufacturer's recommendations. Duplicates should be run once every 10 samples. Calibration procedure:

1. With mode switch in OFF position, check meter zero. If not zeroed, set with zero adjust.

2. Plug probe into meter.

3. Turn mode switch to red line and turn red line knob until needle aligns with red line on dial. If they cannot be aligned, change the batteries.

4. Immerse probe in 0.01 N standard KCl solution. Do not allow the probe to touch the sample container.

5. Set the mode control to TEMPERATURE. Record the temperature on the bottom scale of the meter in degrees C.

6. Turn the mode switch to appropriate conductivity scale (i.e., x100, x10, or x1). Use a scale that will give a midrange output on the meter.

7. Wait for the needle to stabilize. Multiply reading by scale setting and record the conductivity.

8. If the conductivity meter does not perform an automatic temperature adjustment, the conductivity may be adjusted to 25°C using the formula:

$$G_{25} = G_T / [1 + 0.02 (T - 25)]$$

Where:

G_{25} = conductivity at 25°C, µmho/cm

T = temperature of sample, degrees C

G_T = conductivity of sample at temperature T, µmho/cm

The table below lists the values of conductivity that the calibration solution would have if the distilled water were totally nonconductive; however, even water of high purity will possess a small amount of conductivity.

Temperature °C	Conductivity (µmho/cm)
15	1,141.5
16	1,167.5
17	1,193.6
18	1,219.9
19	1,246.4
20	1,273.0
21	1,299.7
22	1,326.6
24	1,380.8
26	1,436.5
28	1,490.9
30	1,546.7

9. Rinse the probe with deionized water.

C. Sample Measurement:

Pour the sample into a small beaker and place the probe in the sample. Note and record the reading. Rinse the probe with deionized water when done.

IV. Attachments

- Conductivity meter calibration sheet

V. Key Checks and Preventive Maintenance

- Check battery.
- Calibrate meter and check calibration throughout and at end of the day.
- Clean probe with deionized water when done.
- When reading results, note sensitivity settings.
- Refer to operations manual for recommended maintenance.
- Check batteries, and have a replacement set on hand.

CONDUCTIVITY METER CALIBRATION SHEET

			Instrument Readings		
Date	Time	Analyst Initials	Uncalibrated @ EC=225	Calibrated @ EC=225	Comments

STANDARD OPERATING PROCEDURE

Field Measurement of Dissolved Oxygen

I. Purpose

To provide general guidelines for the calibration and use of the Dissolved Oxygen (DO) meter.

II. Scope

The following general discussion applies to more commonly used meters but may differ between specific brands. The operator's manual should be consulted for specific calibration and operation procedures.

III. Equipment and Materials

- Operations manual
- A DO probe and readout/control unit with batteries
- Electrolyte solution (KCl dissolved in deionized water) and probe membrane

IV. Procedures and Guidelines

A. Calibration

Calibrate prior to initial daily use before any readings are taken. Check calibration throughout and at end of the day. Clean probe according to manufacturer's recommendations.

1. Prepare DO probe according to manufacturer's recommended procedures using electrolyte solution.
2. In the off position, set the pointer to zero using the screw in the center of the meter panel.
3. Turn function switch to red line and adjust using red line knob until the meter needle aligns with red mark at the 31 degrees C position.
4. Turn function switch to zero and adjust to zero using the zero control knob.
5. Attach prepared probe and adjust retaining ring finger tight.
6. Allow 15 minutes for optimum probe stabilization (when meter is off or during disconnection of the probe).

7. For YSI meters, place probe in hollow stopper that is supplied for use with the YSI Calibration Chamber.

8. Place approximately 1/2 inch of deionized water into a 4-ounce, wide mouth screw cap bottle. Keep this bottle capped and with the DO meter.

9. Just before use, shake the bottle to saturate the water with air.

10. Remove cap, place probe in bottle keeping an air-tight seal around the rubber stopper. Swirl water around in the bottle while waiting for conditions to reach equilibrium.

11. Shield chamber from sun and wind to avoid temperature fluctuations during calibration.

12. Turn function switch to temperature and record temperature reading. Determine calibration factor for that temperature and altitude correction factor from tables supplied by manufacturer.

13. Multiply the calibration factor by the correction factor to get a corrected calibration value.

14. Turn function switch to appropriate ppm range and adjust the calibrate knob until the meter reads the corrected calibration value. Wait two minutes to verify calibration value. Re-adjust as necessary.

B. Procedure

1. Before going out into the field:
   a) Check batteries
   b) Obtain fresh electrolyte solution
   c) Prepare DO probe

2. Calibrate meter using calibration procedure.

3. Place probe in water to be measured. The probe should be moved through the water at 1 ft/sec or use a probe with a built-in stirrer.

4. Allow sufficient time for probe to stabilize to water temperature and DO. Record DO meter reading.

V. Attachments

DO Meter Calibration Sheet.

VI. Key Checks and Items

- Battery check
- Calibration and calibration checks

VII. Preventive Maintenance

- Refer to operation manual for recommended maintenance.
- Check batteries, have replacement set on hand.

DO METER
CALIBRATION SHEET

Date	Time	Analyst's Signature	Temp (C)	Alt. (ft)	Predict (ppm 0_2)	Actual (ppm 0_2)	Comment

STANDARD OPERATING PROCEDURE

Field Measurement of Alkalinity

I. Purpose and Scope

The purpose of this SOP is to provide general guidance for field measurement of alkalinity.

II. Equipment and Materials

- Alkalinity titration reagent (0.05N sulfuric acid)
- Indicator tablets
- Titration tube
- Direct reading titrator
- Alkalinity kit instructions

III. Procedures and Guidelines

A. Procedures

1. Fill the titration tube to the 5 mL line with sample water.
2. Add one indicator tablet to the titration tube, cap, and shake until indicator tablet is completely dissolved.
3. Fill the direct reading titrator with alkalinity titration reagent.
4. Insert the titrator into the center hole of the titration tube cap.
5. While gently swirling the titration tube, slowly depress the plunger on the titrator to release the titration reagent into the sample. Continue until the sample color changes from blue-green to pink.
6. Read and record the test result where the titrator plunger tip meets the titrator scale

B. General

1. Be sure to release the titration reagent into the sample slowly until the color change is observed to prevent over titration of the sample.

Standard Operating Procedure

Explosimeter

I. Purpose and Scope

This SOP provides a guideline for field measurements of the levels of combustible gas and oxygen in air. The following general discussion applies to most explosimeter but may differ between specific brands. The operator's manual should be consulted fo specific calibration and operating procedures.

II. Equipment and Materials

- Industrial Scientific (MX251) Combustible Gas and Oxygen Indicator, or equivalent meter, which can be field calibrated
- Flow-control regulator and hose
- Calibration gas (50 percent LEL pentane—0.75 percent pentane and 15 percent oxygen in nitrogen)
- Equipment calibration data sheet

III. Procedures and Guidelines

A. **Calibration:** The explosimeter must be calibrated before initial daily use and throughout the day. Record calibration information on equipment calibration data sheet. Calibration will be performed according to the following procedure:

1. Turn instrument on
    - Unscrew knurled nut on bottom
    - Rotate metal cover 180°
    - Tighten knurled nut
2. Check battery
    - Check for no ``LoBatt" display—do not use if LoBatt displayed
3. Calibrate instrument

- Observe that instrument reads 0 percent LEL and 21 percent Oxygen (OX) (record readings)

- Connect sampling pump onto top of instrument

- Connect .75 percent Pentane/15 percent oxygen gas (with 1.5 LPM Regulator and direct tubing)

- Turn pump ON

- Turn gas ON

- Record LEL and O_2 after stabilized; LEL must read 50 percent +/-5 percent; O_2 must read 15 percent +/- 5 percent

- Disconnect sample pump and return to charger

B. **Sample Measurement:** The instrument is then ready for air sampling. Note and record the readings for percent LEL and percent O_2.

IV. Attachments

- Equipment calibration data sheet

V. Key Checks and Preventive Maintenance

Check that the batteries be adequately charged. Certain materials such as silicone, silicates, and organic lead compounds tend to poison the catalyst in the instrument, thereby giving erroneously low readings; calibration checks should be made frequently if such materials are suspected to be present.

If the CGI does not cal-check within ±5 percent of 50 percent LEL, an internal calibration must be performed, or the instrument replaced.

EXPLOSIMETER CALIBRATION SHEET

			Instrument Readings		
Date	Time	Analyst Initials	Uncalibrated @LEL=0% O_2=21%	Calibrated @LEL=50%±5 O_2=15%±5	Comments

Explos.doc

STANDARD OPERATING PROCEDURE

Volatiles Monitoring by OVM

I. Purpose and Scope

The purpose of this procedure is to provide guidelines for the calibration and use of an OVM Organic Vapor Monitor. This is a broad guideline for field use of an OVM; for specific instruction, refer to the operators manual.

II. Equipment and Materials

- Operations manual
- An OVM hand readout unit and side pack assembly
- 100 ppm isobutylene as calibration gas
- T-type feeder tube with 1.5 liter/min. regulator

III. Procedures and Guidelines

ONLY PROPERLY TRAINED PERSONNEL SHOULD USE THIS INSTRUMENT. FOR SPECIFIC INSTRUCTIONS, SEE OPERATIONS MANUAL.

OVM, Organic Vapor Monitor

1. Introduction

   The OVM Organic Vapor Monitor is designed to detect organic materials in air. It uses a photo-ionization detector (PID) as its detection principle. This detector allows the monitor to respond to a wide variety of organic compounds.

2. Operational Checks

   - See basic operating instructions in operations manual.

3. Calibration

   - See basic operating instructions in operations manual.

IV. Key Checks and Preventive Maintenance

- Check battery.
- Zero and calibrate.
- Verify sensor probe is working.
- Recharge unit after use.

A complete preventive maintenance program is beyond the scope of this document. For specific instructions, refer to the operations manual. Some key issues are discussed below:

- A complete spare instrument should be available whenever field operations require volatiles monitoring.
- Spare parts should be on hand so minor repairs may be made in the field.
- Batteries should be charged daily.
- Occasionally allow the batteries to totally discharge before recharging to prevent battery memory from occurring.

STANDARD OPERATING PROCEDURE

Soil Sampling

I. Purpose and Scope

The purpose of this procedure is to provide guidelines for obtaining samples of subsurface soils using hand and drilling-rig mounted equipment.

II. Equipment and Materials

- Stainless-steel trowel, shovel, scoopula, coring device, trier, hand auger, or other appropriate hand tool
- Stainless-steel, split-spoon samplers
- Drilling rig or soil-coring rig
- Stainless-steel pan or bowl
- Sample bottles
- Latex or surgical gloves
- Field notebook

III. Procedures and Guidelines

Before sampling begins, equipment will be decontaminated using the procedures described in SOP Decontamination of Drilling Rigs and Equipment. The sampling point is located and recorded in the field logbook. Debris should be cleared from the sampling location.

Using a drilling rig, a hole is advanced to the desired depth. For split-spoon sampling, the samples are then collected following the ASTM D 1586 standard (attached). The sampler is lowered into the hole and driven to a depth equal to the total length of the sampler; typically this is 24 inches. The 2-inch sampler is driven in 6-inch increments using a 140-pound weight (``hammer") dropped from a height of 30 inches. The number of hammer blows for each 6-inch interval is counted and recorded. To obtain enough volume of sample for subsequent laboratory analysis, use of a 3-inch ID sampler may be required. Blow counts obtained with a 3-inch ID spoon would not conform to ASTM D 1586 and would therefore not be used for geotechnical evaluations.

Once retrieved from the hole, the sampler is carefully split open. Care should be taken not to allow material in the sampler to fall out of the open end of the sampler. To collect the sample, the surface of the sample should be removed with a clean tool and disposed of. Samples collected for volatiles analysis should be placed directly into the sample containers from the desired depth in the split spoon. Material for samples for all other parameters should be removed to a decontaminated stainless steel tray. The sample for semivolatile organic and inorganic analyses should be homogenized according to Homogenization of Soil and Sediment Samples SOP. The homogenized sample should be placed in the sample containers. If sample volume requirements are not met by a single sample collection, additional sample volume may be obtained by collecting a sample from below the sample and compositing the sample for non-volatile parameters only.

IV. Attachments

ASTM D 1586.

V. Key Checks and Preventative Maintenance

- Check that decontamination of equipment is thorough.
- Check that sample collection is swift to avoid loss of volatile organics during sampling.

Designation: D 1586 – 84 (Reapproved 1992)$^{\epsilon 1}$

Standard Test Method for Penetration Test and Split-Barrel Sampling of Soils[1]

This standard is issued under the fixed designation D 1586; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval. A superscript epsilon (ε) indicates an editorial change since the last revision or reapproval.

This standard has been approved for use by agencies of the Department of Defense. Consult the DOD Index of Specifications and Standards for the specific year of issue which has been adopted by the Department of Defense.

$^{\epsilon 1}$ NOTE—Editorial changes were made throughout October 1992.

1. Scope

1.1 This test method describes the procedure, generally known as the Standard Penetration Test (SPT), for driving a split-barrel sampler to obtain a representative soil sample and a measure of the resistance of the soil to penetration of the sampler.

1.2 *This standard does not purport to address all of the safety problems, if any, associated with its use. It is the responsibility of the user of this standard to establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.* For a specific precautionary statement, see 5.4.1.

1.3 The values stated in inch-pound units are to be regarded as the standard.

2. Referenced Documents

2.1 *ASTM Standards:*

D 2487 Test Method for Classification of Soils for Engineering Purposes[2]

D 2488 Practice for Description and Identification of Soils (Visual-Manual Procedure)[2]

D 4220 Practices for Preserving and Transporting Soil Samples[2]

D 4633 Test Method for Stress Wave Energy Measurement for Dynamic Penetrometer Testing Systems[2]

3. Terminology

3.1 *Descriptions of Terms Specific to This Standard*

3.1.1 *anvil*—that portion of the drive-weight assembly which the hammer strikes and through which the hammer energy passes into the drill rods.

3.1.2 *cathead*—the rotating drum or windlass in the rope-cathead lift system around which the operator wraps a rope to lift and drop the hammer by successively tightening and loosening the rope turns around the drum.

3.1.3 *drill rods*—rods used to transmit downward force and torque to the drill bit while drilling a borehole.

3.1.4 *drive-weight assembly*—a device consisting of the hammer, hammer fall guide, the anvil, and any hammer drop system.

3.1.5 *hammer*—that portion of the drive-weight assembly consisting of the 140 ± 2 lb (63.5 ± 1 kg) impact weight which is successively lifted and dropped to provide the energy that accomplishes the sampling and penetration.

3.1.6 *hammer drop system*—that portion of the drive-weight assembly by which the operator accomplishes the lifting and dropping of the hammer to produce the blow.

3.1.7 *hammer fall guide*—that part of the drive-weight assembly used to guide the fall of the hammer.

3.1.8 *N-value*—the blowcount representation of the penetration resistance of the soil. The *N*-value, reported in blows per foot, equals the sum of the number of blows required to drive the sampler over the depth interval of 6 to 18 in. (150 to 450 mm) (see 7.3).

3.1.9 ΔN—the number of blows obtained from each of the 6-in. (150-mm) intervals of sampler penetration (see 7.3).

3.1.10 *number of rope turns*—the total contact angle between the rope and the cathead at the beginning of the operator's rope slackening to drop the hammer, divided by 360° (see Fig. 1).

3.1.11 *sampling rods*—rods that connect the drive-weight assembly to the sampler. Drill rods are often used for this purpose.

3.1.12 *SPT*—abbreviation for Standard Penetration Test, a term by which engineers commonly refer to this method.

4. Significance and Use

4.1 This test method provides a soil sample for identification purposes and for laboratory tests appropriate for soil obtained from a sampler that may produce large shear strain disturbance in the sample.

4.2 This test method is used extensively in a great variety of geotechnical exploration projects. Many local correlations and widely published correlations which relate SPT blowcount, or *N*-value, and the engineering behavior of earthworks and foundations are available.

5. Apparatus

5.1 *Drilling Equipment*—Any drilling equipment that provides at the time of sampling a suitably clean open hole before insertion of the sampler and ensures that the penetration test is performed on undisturbed soil shall be acceptable. The following pieces of equipment have proven to be

---

[1] This method is under the jurisdiction of ASTM Committee D-18 on Soil and Rock and is the direct responsibility of Subcommittee D18.02 on Sampling and Related Field Testing for Soil Investigations.

Current edition approved Sept. 11, 1984. Published November 1984. Originally published as D 1586 – 58 T. Last previous edition D 1586 – 67 (1974).

[2] *Annual Book of ASTM Standards*, Vol 04.08.

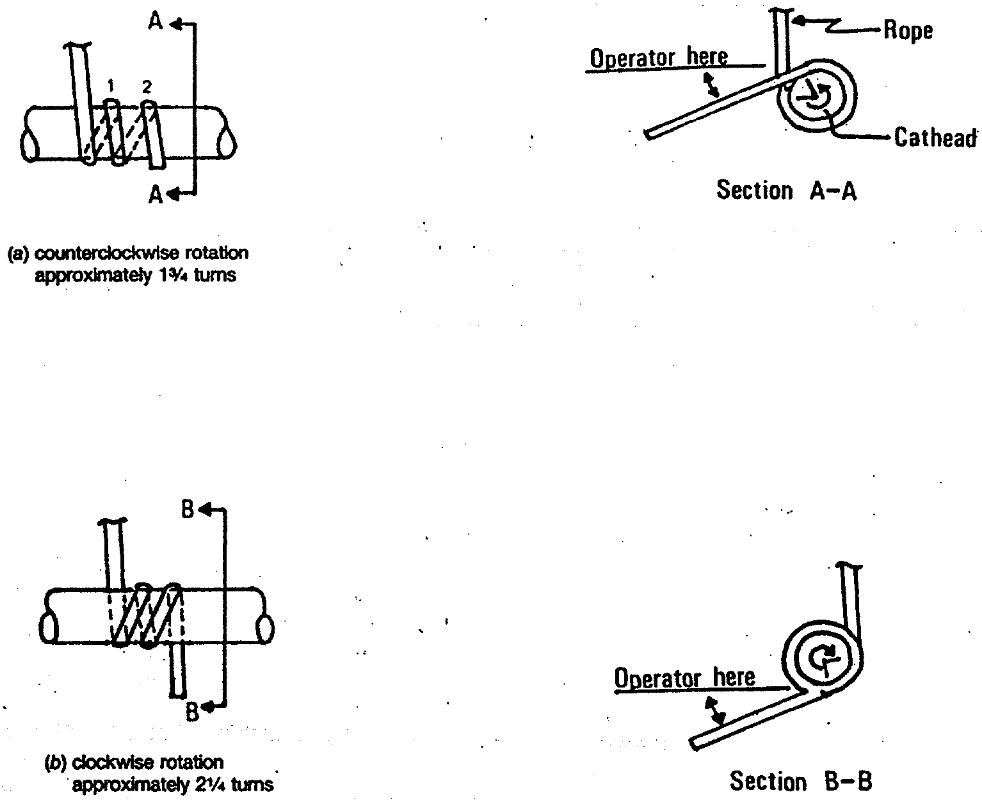


FIG. 1 Definitions of the Number of Rope Turns and the Angle for (*a*) Counterclockwise Rotation and (*b*) Clockwise Rotation of the Cathead

suitable for advancing a borehole in some subsurface conditions.

5.1.1 *Drag, Chopping, and Fishtail Bits*, less than 6.5 in. (162 mm) and greater than 2.2 in. (56 mm) in diameter may be used in conjuction with open-hole rotary drilling or casing-advancement drilling methods. To avoid disturbance of the underlying soil, bottom discharge bits are not permitted; only side discharge bits are permitted.

5.1.2 *Roller-Cone Bits*, less than 6.5 in. (162 mm) and greater than 2.2 in. (56 mm) in diameter may be used in conjunction with open-hole rotary drilling or casing-advancement drilling methods if the drilling fluid discharge is deflected.

5.1.3 *Hollow-Stem Continuous Flight Augers*, with or without a center bit assembly, may be used to drill the boring. The inside diameter of the hollow-stem augers shall be less than 6.5 in. (162 mm) and greater than 2.2 in. (56 mm).

5.1.4 *Solid, Continuous Flight, Bucket and Hand Augers*, less than 6.5 in. (162 mm) and greater than 2.2 in. (56 mm) in diameter may be used if the soil on the side of the boring does not cave onto the sampler or sampling rods during sampling.

5.2 *Sampling Rods*—Flush-joint steel drill rods shall be used to connect the split-barrel sampler to the drive-weight assembly. The sampling rod shall have a stiffness (moment of inertia) equal to or greater than that of parallel wall "A" rod (a steel rod which has an outside diameter of 1⅝ in. (41.2 mm) and an inside diameter of 1⅛ in. (28.5 mm).

NOTE 1—Recent research and comparative testing indicates the type rod used, with stiffness ranging from "A" size rod to "N" size rod, will usually have a negligible effect on the *N*-values to depths of at least 100 ft (30 m).

5.3 *Split-Barrel Sampler*—The sampler shall be constructed with the dimensions indicated in Fig. 2. The driving shoe shall be of hardened steel and shall be replaced or repaired when it becomes dented or distorted. The use of liners to produce a constant inside diameter of 1⅜ in. (35 mm) is permitted, but shall be noted on the penetration record if used. The use of a sample retainer basket is permitted, and should also be noted on the penetration record if used.

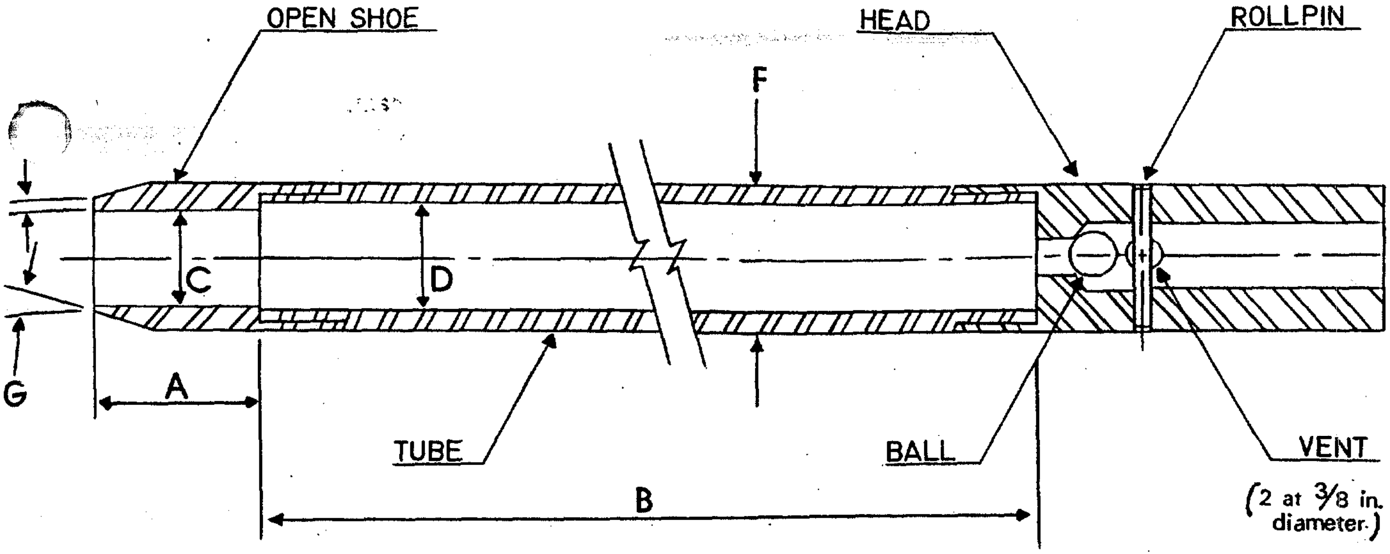
NOTE 2—Both theory and available test data suggest that *N*-values may increase between 10 to 30 % when liners are used.

5.4 *Drive-Weight Assembly:*

5.4.1 *Hammer and Anvil*—The hammer shall weigh 140 ± 2 lb (63.5 ± 1 kg) and shall be a solid rigid metallic mass. The hammer shall strike the anvil and make steel on steel contact when it is dropped. A hammer fall guide permitting a free fall shall be used. Hammers used with the cathead and rope method shall have an unimpeded overlift capacity of at least 4 in. (100 mm). For safety reasons, the use of a hammer assembly with an internal anvil is encouraged.

NOTE 3—It is suggested that the hammer fall guide be permanently marked to enable the operator or inspector to judge the hammer drop height.

5.4.2 *Hammer Drop System*—Rope-cathead, trip, semi-automatic, or automatic hammer drop systems may be used, providing the lifting apparatus will not cause penetration of



A = 1.0 to 2.0 in. (25 to 50 mm)
B = 18.0 to 30.0 in. (0.457 to 0.762 m)
C = 1.375 ± 0.005 in. (34.93 ± 0.13 mm)
D = 1.50 ± 0.05 − 0.00 in. (38.1 ± 1.3 − 0.0 mm)
E = 0.10 ± 0.02 in. (2.54 ± 0.25 mm)
F = 2.00 ± 0.05 − 0.00 in. (50.8 ± 1.3 − 0.0 mm)
G = 16.0° to 23.0°

The 1½ in. (38 mm) inside diameter split barrel may be used with a 16-gage wall thickness split liner. The penetrating end of the drive shoe may be slightly rounded. Metal or plastic retainers may be used to retain soil samples.

FIG. 2 Split-Barrel Sampler

the sampler while re-engaging and lifting the hammer.

5.— *Accessory Equipment*—Accessories such as labels, sa… containers, data sheets, and groundwater level measuring devices shall be provided in accordance with the requirements of the project and other ASTM standards.

6. Drilling Procedure

6.1 The boring shall be advanced incrementally to permit intermittent or continuous sampling. Test intervals and locations are normally stipulated by the project engineer or geologist. Typically, the intervals selected are 5 ft (1.5 mm) or less in homogeneous strata with test and sampling locations at every change of strata.

6.2 Any drilling procedure that provides a suitably clean and stable hole before insertion of the sampler and assures that the penetration test is performed on essentially undisturbed soil shall be acceptable. Each of the following procedures have proven to be acceptable for some subsurface conditions. The subsurface conditions anticipated should be considered when selecting the drilling method to be used.

6.2.1 Open-hole rotary drilling method.

6.2.2 Continuous flight hollow-stem auger method.

6.2.3 Wash boring method.

6.2.4 Continuous flight solid auger method.

6.3 Several drilling methods produce unacceptable borings. The process of jetting through an open tube sampler and then sampling when the desired depth is reached shall not be permitted. The continuous flight solid auger method shall not be used for advancing the boring below a water table or below the upper confining bed of a confined non-cohesive stratum that is under artesian pressure. Casing may not be advanced below the sampling elevation prior to sampling. Advancing a boring with bottom discharge bits is not permissible. It is not permissible to advance the boring for subsequent insertion of the sampler solely by means of previous sampling with the SPT sampler.

6.4 The drilling fluid level within the boring or hollow-stem augers shall be maintained at or above the in situ groundwater level at all times during drilling, removal of drill rods, and sampling.

7. Sampling and Testing Procedure

7.1 After the boring has been advanced to the desired sampling elevation and excessive cuttings have been removed, prepare for the test with the following sequence of operations.

7.1.1 Attach the split-barrel sampler to the sampling rods and lower into the borehole. Do not allow the sampler to drop onto the soil to be sampled.

7.1.2 Position the hammer above and attach the anvil to the top of the sampling rods. This may be done before the sampling rods and sampler are lowered into the borehole.

7.1.3 Rest the dead weight of the sampler, rods, anvil, and drive weight on the bottom of the boring and apply a seating blow. If excessive cuttings are encountered at the bottom of the boring, remove the sampler and sampling rods from the boring and remove the cuttings.

7.1.4 Mark the drill rods in three successive 6-in. (0.15-m) increments so that the advance of the sampler under the impact of the hammer can be easily observed for each 6-in. (0.15-m) increment.

7.2 Drive the sampler with blows from the 140-lb (63.5-

kg) hammer and count the number of blows applied in each 6-in. (0.15-m) increment until one of the following occurs:

7.2.1 A total of 50 blows have been applied during any one of the three 6-in. (0.15-m) increments described in 7.1.4.

7.2.2 A total of 100 blows have been applied.

7.2.3 There is no observed advance of the sampler during the application of 10 successive blows of the hammer.

7.2.4 The sampler is advanced the complete 18 in. (0.45 m) without the limiting blow counts occurring as described in 7.2.1, 7.2.2, or 7.2.3.

7.3 Record the number of blows required to effect each 6 in. (0.15 m) of penetration or fraction thereof. The first 6 in. is considered to be a seating drive. The sum of the number of blows required for the second and third 6 in. of penetration is termed the "standard penetration resistance," or the "*N*-value." If the sampler is driven less than 18 in. (0.45 m), as permitted in 7.2.1, 7.2.2, or 7.2.3, the number of blows per each complete 6-in. (0.15-m) increment and per each partial increment shall be recorded on the boring log. For partial increments, the depth of penetration shall be reported to the nearest 1 in. (25 mm), in addition to the number of blows. If the sampler advances below the bottom of the boring under the static weight of the drill rods or the weight of the drill rods plus the static weight of the hammer, this information should be noted on the boring log.

7.4 The raising and dropping of the 140-lb (63.5-kg) hammer shall be accomplished using either of the following two methods:

7.4.1 By using a trip, automatic, or semi-automatic hammer drop system which lifts the 140-lb (63.5-kg) hammer and allows it to drop 30 ± 1.0 in. (0.76 m ± 25 mm) unimpeded.

7.4.2 By using a cathead to pull a rope attached to the hammer. When the cathead and rope method is used the system and operation shall conform to the following:

7.4.2.1 The cathead shall be essentially free of rust, oil, or grease and have a diameter in the range of 6 to 10 in. (150 to 250 mm).

7.4.2.2 The cathead should be operated at a minimum speed of rotation of 100 RPM, or the approximate speed of rotation shall be reported on the boring log.

7.4.2.3 No more than 2¼ rope turns on the cathead may be used during the performance of the penetration test, as shown in Fig. 1.

NOTE 4—The operator should generally use either 1¾ or 2¼ rope turns, depending upon whether or not the rope comes off the top (1¾ turns) or the bottom (2¼ turns) of the cathead. It is generally known and accepted that 2¾ or more rope turns considerably impedes the fall of the hammer and should not be used to perform the test. The cathead rope should be maintained in a relatively dry, clean, and unfrayed condition.

7.4.2.4 For each hammer blow, a 30-in. (0.76-m) lift and drop shall be employed by the operator. The operation of pulling and throwing the rope shall be performed rhythmically without holding the rope at the top of the stroke.

7.5 Bring the sampler to the surface and open. Record the percent recovery or the length of sample recovered. Describe the soil samples recovered as to composition, color, stratification, and condition, then place one or more representative portions of the sample into sealable moisture-proof containers (jars) without ramming or distorting any apparent stratification. Seal each container to prevent evaporation of soil moisture. Affix labels to the containers bearing job designation, boring number, sample depth, and the blow count per 6-in. (0.15-m) increment. Protect the samples against extreme temperature changes. If there is a soil change within the sampler, make a jar for each stratum and note its location in the sampler barrel.

8. Report

8.1 Drilling information shall be recorded in the field and shall include the following:

8.1.1 Name and location of job,

8.1.2 Names of crew,

8.1.3 Type and make of drilling machine,

8.1.4 Weather conditions,

8.1.5 Date and time of start and finish of boring,

8.1.6 Boring number and location (station and coordinates, if available and applicable),

8.1.7 Surface elevation, if available,

8.1.8 Method of advancing and cleaning the boring,

8.1.9 Method of keeping boring open,

8.1.10 Depth of water surface and drilling depth at the time of a noted loss of drilling fluid, and time and date when reading or notation was made,

8.1.11 Location of strata changes,

8.1.12 Size of casing, depth of cased portion of boring,

8.1.13 Equipment and method of driving sampler,

8.1.14 Type sampler and length and inside diameter of barrel (note use of liners),

8.1.15 Size, type, and section length of the sampling rods, and

8.1.16 Remarks.

8.2 Data obtained for each sample shall be recorded in the field and shall include the following:

8.2.1 Sample depth and, if utilized, the sample number,

8.2.2 Description of soil,

8.2.3 Strata changes within sample,

8.2.4 Sampler penetration and recovery lengths, and

8.2.5 Number of blows per 6-in. (0.15-m) or partial increment.

9. Precision and Bias

9.1 *Precision*—A valid estimate of test precision has not been determined because it is too costly to conduct the necessary inter-laboratory (field) tests. Subcommittee D18.02 welcomes proposals to allow development of a valid precision statement.

9.2 *Bias*—Because there is no reference material for this test method, there can be no bias statement.

9.3 Variations in *N*-values of 100 % or more have been observed when using different standard penetration test apparatus and drillers for adjacent borings in the same soil formation. Current opinion, based on field experience, indicates that when using the same apparatus and driller, *N*-values in the same soil can be reproduced with a coefficient of variation of about 10 %.

9.4 The use of faulty equipment, such as an extremely massive or damaged anvil, a rusty cathead, a low speed cathead, an old, oily rope, or massive or poorly lubricated rope sheaves can significantly contribute to differences in *N*-values obtained between operator-drill rig systems.

9.5 The variability in N-values produced by different drill gs and operators may be reduced by measuring that part of ıe h mer energy delivered into the drill rods from the ım and adjusting N on the basis of comparative ıergies. A method for energy measurement and N-value adjustment is given in Test Method D 4633.

10. Keywords

10.1 blow count; in-situ test; penetration resistance; split-barrel sampling; standard penetration test

Soil Boring Drilling and Abandonment

I. Purpose and Scope

The purpose of this guideline is to describe methods to obtain samples of subsurface soil and then backfill boreholes to the surface.

II. Equipment and Materials

- Truck-mounted drilling rig
- Hollow-stem augers (4¼-inch, 6¼-inch, or 8¼-inch ID)
- Split-spoon samplers
- Downhole compacting tool (e.g., a pipe with a flat plate attached to the bottom)
- Cement
- Bentonite
- Hand augers, stainless steel

III. Procedures and Guidelines

Before sampling begins, equipment will be decontaminated according to the procedures identified in SOP Decontamination of Personnel and Equipment. The location to be sampled is cleared of debris and trash, and the location is noted in the logbook.

Continuous-fight hollow-stem augers with an inside diameter of at least 4.25 inches are used. The use of water or other fluid to assist in hollow-stem drilling will be avoided.

The bit of the auger is placed on the ground at the location to be drilled and then turned with the drilling or soil-coring rig. For split-spoon sampling, the auger is advanced to a depth just above the top of the interval to be sampled.

While advancing the augers to the full borehole depth, the soils removed from the boring will be screened using a portable volatile organics detector. The borehole will be grouted to the surface with bentonite-cement grout. The soil cuttings are to be drummed and managed as described in SOP Disposal of Waste Fluids and Soils.

The cement-bentonite grout will be installed continuously in one operation from the bottom of the space to be grouted to the ground surface. When installing grout in soil borings, the grout will be installed through a tremie pipe that is placed inside the augers. The grouting will be completed before the augers are removed.

Samples will be collected from the soil borings at 2-foot intervals. The soil samples will be collected from the surface continuously to the water table. Because some of the soil samples are being collected for chemical analysis, decontaminated stainless steel split-spoon samplers will be used for sample collection. The split-spoon samplers will be decontaminated according to the procedures outlined in SOP Decontamination of Personnel and Equipment. Sample collection will follow the general procedures outlined in SOP Soil Sampling.

Soil samples will be collected at 1-foot intervals. The soil samples will be placed in clean jars and a headspace measurement of the volatile organics in each of the samples determined. The headspace measurements will be used to identify the potentially most-contaminated samples which will be submitted for analysis through the CLP.

IV. Attachments

None.

V. Key Checks and Preventative Maintenance

Check that the drilling rig or soil-coring rig is in working order. Check that the borehole is grouted to the ground surface at the completion of drilling and sampling.

STANDARD OPERATING PROCEDURE

Logging of Soil Borings

I. Purpose and Scope

This SOP provides guidance to obtain accurate and consistent descriptions of soil characteristics during soil-sampling operations. The characterization is based on visual examination and manual tests, not on laboratory determinations.

II. Equipment and Materials

- Indelible pens
- Tape measure or ruler
- Field logbook
- Spatula
- HCl, 10 percent solution
- Squirt bottle with water
- Rock- or soil-color chart
- Grain-size chart
- Hand lens
- Unified Soil Classification System (USCS) index charts and tables to help with soil classification

III. Procedures and Guidelines

This section covers several aspects of the soil characterization: instructions for completing the CH2M HILL soil boring log Form D1586, field classification of soil, and standard penetration test procedures.

A. Instructions for Completing Soil Boring Logs

Soil boring logs will be completed in the field log books. Information collected will be consistent with that required for Form D1586 (attached), a standard CH2M HILL form or an equivalent form that supplies the same information.

The information collected in the field to perform the soil characterization is described below.

Field personnel should review completed logs for accuracy, clarity, and thoroughness of detail. Samples also should be checked to see that information is correctly recorded on both jar lids and labels and on the log sheets.

B. **Heading Information**

Boring/Well Number. Enter the boring/well number. A numbering system should be chosen that does not conflict with information recorded for previous exploratory work done at the site. Number the sheets consecutively for each boring.

Location. If stationing, coordinates, mileposts, or similar project layout information is available, indicate the position of the boring to that system using modifiers such as "approximate" or "estimated" as appropriate.

Elevation. Elevation will be determined at the conclusion of field activities.

Drilling Contractor. Enter the name of the drilling company and the city and state where the company is based.

Drilling Method and Equipment. Identify the bit size and type, drilling fluid (if used), and method of drilling (e.g., rotary, hollow-stem auger). Information on the drilling equipment (e.g., CME 55, Mobile B61) also is noted.

Water Level and Date. Enter the depth below ground surface to the apparent water level in the borehole. The information should be recorded as a comment. If free water is not encountered during drilling or cannot be detected because of the drilling method, this information should be noted. Record date and time of day (for tides, river stage) of each water level measurement.

Date of Start and Finish. Enter the dates the boring was begun and completed. Time of day should be added if several borings are performed on the same day.

Logger. Enter the first initial and full last name.

C. **Technical Data**

Depth Below Surface. Use a depth scale that is appropriate for the sample spacing and for the complexity of subsurface conditions.

Sample Interval. Note the depth at the top and bottom of the sample interval.

Sample Type and Number. Enter the sample type and number. SS-1 = split spoon, first sample. Number samples consecutively regardless of type. Enter a sample number even if no material was recovered in the sampler.

Sample Recovery. Enter the length to the nearest 0.1 foot of soil sample recovered from the sampler. Often, there will be some wash or caved material above the sample; do not include the wash material in the measurement. Record recovery in feet.

Standard Penetration Test Results. In this column, enter the number of blows required for each 6 inches of sampler penetration and the "N" value, which is the sum of the blows in the middle two 6-inch penetration intervals. A typical standard penetration test involving successive blow counts of 2, 3, 4, and 5 is recorded as 2-3-4-5 and (7). The standard penetration test is terminated if the sampler encounters refusal. Refusal is a penetration of less than 6 inches with a blow count of 50. A partial penetration of 50 blows for 4 inches is recorded as 50/4 inches. Penetration by the weight of the slide hammer only is recorded as "WOH."

Samples should be collected using a 140-pound hammer and 2-inch diameter split spoons.

Soil Description. The soil classification should follow the format described in the "Field Classification of Soil" subsection below.

Comments. Include all pertinent observations (changes in drilling fluid color, rod drops, drilling chatter, rod bounce as in driving on a cobble, damaged Shelby tubes, and equipment malfunctions). In addition, note if casing was used, the sizes and depths installed, and if drilling fluid was added or changed. You should instruct the driller to alert you to any significant changes in drilling (changes in material, occurrence of boulders, and loss of drilling fluid). Such information should be attributed to the driller and recorded in this column.

Specific information might include the following:

- The date and the time drilling began and ended each day
- The depth and size of casing and the method of installation
- The date, time, and depth of water level measurements
- Depth of rod chatter
- Depth and percentage of drilling fluid loss
- Depth of hole caving or heaving
- Depth of change in material
- Health and safety monitoring data
- Drilling interval through a boulder

D. Field Classification of Soil

This section presents the format for the field classification of soil. In general, the approach and format for classifying soils should conform to ASTM D 2488-93, Visual-Manual Procedure for Description and Identification of Soils.

The Unified Soil Classification System is based on numerical values of certain soil properties that are measured by laboratory tests (ASTM D 2487). It is possible, however, to estimate these values in the field with reasonable accuracy using visual-manual procedures (ASTM D 2488-93, attached). In addition, some elements of a complete soil description, such as the presence of cobbles or boulders, changes in strata, and the relative proportions of soil types in a bedded deposit, can be obtained only in the field.

Soil descriptions should be precise and comprehensive without being verbose. The correct overall impression of the soil should not be distorted by excessive emphasis on insignificant details. In general, similarities rather than differences between consecutive samples should be stressed.

Soil descriptions must be recorded for every soil sample collected. The format and order for soil descriptions should be as follows:

1. Soil name (synonymous with ASTM D 2488-93 Group Name) with appropriate modifiers. Soil name should be in all capitals in the log, for example "POORLY-GRADED SAND."

2. Group symbol, in parentheses, for example, "(SP)."

3. Color, using Munsell color designation

4. Moisture content

5. Relative density or consistency

6. Soil structure, mineralogy, or other descriptors

This order follows, in general, the format described in ASTM D 2488-93.

E. Soil Name

The basic name of a soil should be the ASTM D 2488-93 Group Name on the basis of visual estimates of gradation and plasticity. The soil name should be capitalized.

Examples of acceptable soil names are illustrated by the following descriptions:

- A soil sample is visually estimated to contain 15 percent gravel, 55 percent sand, and 30 percent fines (passing No. 200 sieve). The fines are estimated as either low or highly plastic silt. This visual classification is SILTY SAND WITH GRAVEL, with a Group Symbol of (SM).

- Another soil sample has the following visual estimate: 10 percent gravel, 30 percent sand, and 60 percent fines (passing the No. 200 sieve). The fines are estimated as low plastic silt. This visual classification is SANDY SILT. The gravel portion is not included in the soil name because the gravel portion was estimated as less than 15 percent. The Group Symbol is (ML).

The gradation of coarse-grained soil (more than 50 percent retained on No. 200 sieve) is included in the specific soil name in accordance with ASTM D 2488-93. There is no need to further document the gradation. However, the maximum size and angularity or roundness of gravel and sand-sized particles should be recorded. For fine-grained soil (50 percent or more passing the No. 200 sieve), the name is modified by the appropriate plasticity/elasticity term in accordance with ASTM D 2488-93.

Interlayered soil should each be described starting with the predominant type. An introductory name, such as "Interlayered Sand and Silt," should be used. In addition, the relative proportion of each soil type should be indicated (see Table 1 for example).

Where helpful, the evaluation of plasticity/elasticity can be justified by describing results from any of the visual-manual procedures for identifying fine-grained soils, such as reaction to shaking, toughness of a soil thread, or dry strength as described in ASTM D 2488-93.

F. Group Symbol

The appropriate group symbol from ASTM D 2488-93 must be given after each soil name. The group symbol should be placed in parentheses to indicate that the classification has been estimated.

In accordance with ASTM D 2488-93, dual symbols (e.g., GP-GM or SW-SC) can be used to indicate that a soil is estimated to have about 10 percent fines. Borderline symbols (e.g., GM/SM or SW/SP) can be used to indicate that a soil sample has been identified as having properties that do not distinctly place the soil into a specific group. Generally, the group name assigned to a soil with a borderline symbol should be the group name for the first symbol. The use of a borderline symbol should not be used indiscriminately. Every effort should be made to first place the soil into a single group. Grain size is estimated in accordance with ASTM D 2488-93 (Table 2).

G. Color

The color of a soil must be given. The color description should be based on the Munsell system. The color name and the hue, value, and chroma should be given.

H. Moisture Content

The degree of moisture present in a soil sample should be defined as dry, moist, or wet. Moisture content can be estimated from the criteria listed on Table 3.

I. Relative Density or Consistency

Relative density of a coarse-grained (cohesionless) soil is based on N-values (ASTM D 1586-84). If the presence of large gravel, disturbance of the sample, or non-standard sample collection makes determination of the in situ relative density or consistency difficult, then this item should be left out of the description and explained in the Comments column of the soil boring log.

Consistency of fine-grained (cohesive) soil is properly based on results of pocket penetrometer or torvane results. In the absence of this information, consistency can be estimated from N-values. Relationships for determining relative density or consistency of soil samples are given in Tables 4 and 5.

J. Soil Structure, Mineralogy, and Other Descriptors

Discontinuities and inclusions are important and should be described. Such features include joints or fissures, slickensides, bedding or laminations, veins, root holes, and wood debris.

Significant mineralogical information such as cementation, abundant mica, or unusual mineralogy should be described.

Other descriptors may include particle size range or percentages, particle angularity or shape, maximum particle size, hardness of large particles, plasticity of fines, dry strength, dilatancy, toughness, reaction to HCl, and staining, as well as other information such as organic debris, odor, or presence of free product.

K. Equipment and Calibration

Before starting the testing, the equipment should be inspected for compliance with the requirements of ASTM D 1586-84. The split-barrel sampler should measure 2-inch O.D., and should have a split tube at least 18 inches long. The minimum size sampler rod allowed is "A" rod (1-5/8-inch O.D.). A stiffer rod, such as an "N" rod (2-5/8-inch O.D.), is required for depths greater than 50 feet. The drive weight assembly should consist of a 140-pound hammer weight, a drive head, and a hammer guide that permits a free fall of 30 inches.

IV. Attachments

Soil Boring Log, CH2M HILL Form D1586, and a completed example

ASTM D 2488-90: Standard Practice for Description and Identification of Soils (Visual-Manual Procedures).

V. Key Checks and Preventive Maintenance

Check entries to the soil-boring log and field logbook in the field; because the samples will be disposed of at the end of fieldwork, confirmation and corrections cannot be made later. Check that sample numbers and intervals are properly specified. Check that drilling and sampling equipment is decontaminated using the procedures defined in SOP Decontamination of Drilling Rigs and Equipment.

CH2M HILL

PROJECT NUMBER	BORING NUMBER SHEET OF

SOIL BORING LOG

PROJECT ______ LOCATION ______
ELEVATION ______ DRILLING CONTRACTOR ______
DRILLING METHOD AND EQUIPMENT ______
WATER LEVELS ______ START ______ FINISH ______ LOGGER ______

DEPTH BELOW SURFACE (FT)	SAMPLE			STANDARD PENETRATION TEST RESULTS	SOIL DESCRIPTION	COMMENTS
	INTERVAL	NUMBER AND TYPE	RECOVERY (FT)	6"-6"-6" (N)	SOIL NAME, USCS GROUP SYMBOL, COLOR, MOISTURE CONTENT, RELATIVE DENSITY OR CONSISTENCY, SOIL STRUCTURE, MINERALOGY	DEPTH OF CASING, DRILLING RATE, DRILLING FLUID LOSS, TESTS AND INSTRUMENTATION

Figure 1
SOIL BORING LOG, FORM D1586

REV 11/89 FORM

CH2M HILL

PROJECT NUMBER DEN 22371.G5 | BORING NUMBER BL-3 | SHEET 1 OF 3

SOIL BORING LOG

PROJECT Howard Ave Landslide LOCATION Howard & 24th Ave, Centenn...

ELEVATION 5136 Feet DRILLING CONTRACTOR Kendall Explorations, Ashcan, C...

DRILLING METHOD AND EQUIPMENT 4"-inch H.S. Augers, Mobil B-61 rotary drilling rig

WATER LEVELS 3.2 Feet, 8/5/89 START August 4, 1989 FINISH August 8, 1989 LOGGER J.A. Michner

DEPTH BELOW SURFACE (FT)	SAMPLE INTERVAL	SAMPLE NUMBER AND TYPE	SAMPLE RECOVERY (FT)	STANDARD PENETRATION TEST RESULTS 6"-6"-6" (N)	SOIL DESCRIPTION: SOIL NAME, USCS GROUP SYMBOL, COLOR, MOISTURE CONTENT, RELATIVE DENSITY OR CONSISTENCY, SOIL STRUCTURE, MINERALOGY	COMMENTS: DEPTH OF CASING, DRILLING RATE, DRILLING FLUID LOSS, TESTS AND INSTRUMENTATION
0	2.5				Surface material consist of 4 inches AC underlain by 6 inches of 3/4 inch minus base rock	Start Drilling @ 3:00
	2.5–4.0	1-S	1.5	2-3-4 (7)	POORLY-GRADED SAND WITH SILT, (SP-SM), fine, light brown, wet, loose	Driller notes water at 4 feet
5	5.0–6.5	2-S	0.9	WOH/12"-1	ORGANIC SILT, (OL), very dark, gray to black, wet, very soft; strong H_2S odor, many fine roots up to about 1/4 inch	Driller notes very soft drilling 4ft, dark grey, wet silty cuttings.
	8.0–10.0	3-ST	1.3	———	ORGANIC SILT, similar to 2-S, except includes fewer roots (by volume)	
10	10.0–11.5	4-S	1.3	2-2-2 (4)	SILT, (ML), very dark gray to black, wet, soft	water level @ 3.2 feet on 8/5/89 @ 0730 Driller notes rough drilling action and chatter @ 13 ft
15	15.0–15.5	5-S	0.5	60/6"	SILTY GRAVEL, (GM), rounded gravel up to about 1 inch maximum observed size, wet, very dense	
20	20.0–21.0	6-S	1.0	12-50/6"	LEAN CLAY WITH SAND, (CL), medium to light green, moist, very stiff	Driller notes smoother, firm drilling @ 19 ft some angular rock chips @ bottom tip of 6-S, poss boulders or... Driller notes very hard, slow grinding, smooth drilling action from 21 to 23 ft, possibly bedrock
	23.0–23.1	7-S	0	50/1"	NO RECOVERY	
					END SOIL BORING @ 23.1 FEET SEE ROCK CORE LOG FOR CONTINUATION OF BL-3	

Figure 2
EXAMPLE OF COMPLETED LOG FORM

REV 11/89 FORM ...

Standard Practice for Description and Identification of Soils (Visual-Manual Procedure)[1]

This standard is issued under the fixed designation D 2488; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval. A superscript epsilon (ε) indicates an editorial change since the last revision or reapproval.

This standard has been approved for use by agencies of the Department of Defense. Consult the DoD Index of Specifications and Standards for the specific year of issue which has been adopted by the Department of Defense.

pe

1.1 This practice covers procedures for the description of r engineering purposes.

This practice also describes a procedure for identifying s, at the option of the user, based on the classification tem described in Test Method D 2487. The identification l on visual examination and manual tests. It must be stated in reporting an identification that it is based on ual-manual procedures.

2.1 When precise classification of soils for engineering es is required, the procedures prescribed in Test d D 2487 shall be used.

.2.2 In this practice, the identification portion assigning symbol and name is limited to soil particles smaller in. (75 mm).

.2.3 The identification portion of this practice is limited naturally occurring soils (disturbed and undisturbed).

-This practice may be used as a descriptive system applied materials as shale, claystone, shells, crushed rock, etc. (See endix X2).

The descriptive information in this practice may be ith other soil classification systems or for materials er than naturally occurring soils.

.4 *This standard does not purport to address all of the problems, if any, associated with its use. It is the sibility of the user of this standard to establish appro- ate safety and health practices and determine the applica- of regulatory limitations prior to use.* For specific ionary statements see Section 8.

.5 The values stated in inch-pound units are to be arded as the standard.

erenced Documents

.1 *ASTM Standards:*

3 Terminology Relating to Soil, Rock, and Contained uids[2]

1452 Practice for Soil Investigation and Sampling by Auger Borings[2]

86 Method for Penetration Test and Split-Barrel mpling of Soils[2]

D 1587 Practice for Thin-Walled Tube Sampling of Soils[2]

D 2113 Practice for Diamond Core Drilling for Site Investigation[2]

D 2487 Test Method for Classification of Soils for Engineering Purposes[2]

D 4083 Practice for Description of Frozen Soils (Visual-Manual Procedure)[2]

3. Terminology

3.1 *Definitions:*

3.1.1 Except as listed below, all definitions are in accordance with Terminology D 653.

NOTE 2—For particles retained on a 3-in. (75-mm) US standard sieve, the following definitions are suggested:

Cobbles—particles of rock that will pass a 12-in. (300-mm) square opening and be retained on a 3-in. (75-mm) sieve, and

Boulders—particles of rock that will not pass a 12-in. (300-mm) square opening.

3.1.1.2 *clay*—soil passing a No. 200 (75-μm) sieve that can be made to exhibit plasticity (putty-like properties) within a range of water contents, and that exhibits considerable strength when air-dry. For classification, a clay is a fine-grained soil, or the fine-grained portion of a soil, with a plasticity index equal to or greater than 4, and the plot of plasticity index versus liquid limit falls on or above the "A" line (see Fig. 3 of Test Method D 2487).

3.1.1.3 *gravel*—particles of rock that will pass a 3-in. (75-mm) sieve and be retained on a No. 4 (4.75-mm) sieve with the following subdivisions:

coarse—passes a 3-in. (75-mm) sieve and is retained on a ¾-in. (19-mm) sieve.

fine—passes a ¾-in. (19-mm) sieve and is retained on a No. 4 (4.75-mm) sieve.

3.1.1.4 *organic clay*—a clay with sufficient organic content to influence the soil properties. For classification, an organic clay is a soil that would be classified as a clay, except that its liquid limit value after oven drying is less than 75 % of its liquid limit value before oven drying.

3.1.1.5 *organic silt*—a silt with sufficient organic content to influence the soil properties. For classification, an organic silt is a soil that would be classified as a silt except that its liquid limit value after oven drying is less than 75 % of its liquid limit value before oven drying.

3.1.1.6 *peat*—a soil composed primarily of vegetable tissue in various stages of decomposition usually with an organic odor, a dark brown to black color, a spongy consistency, and a texture ranging from fibrous to amorphous.

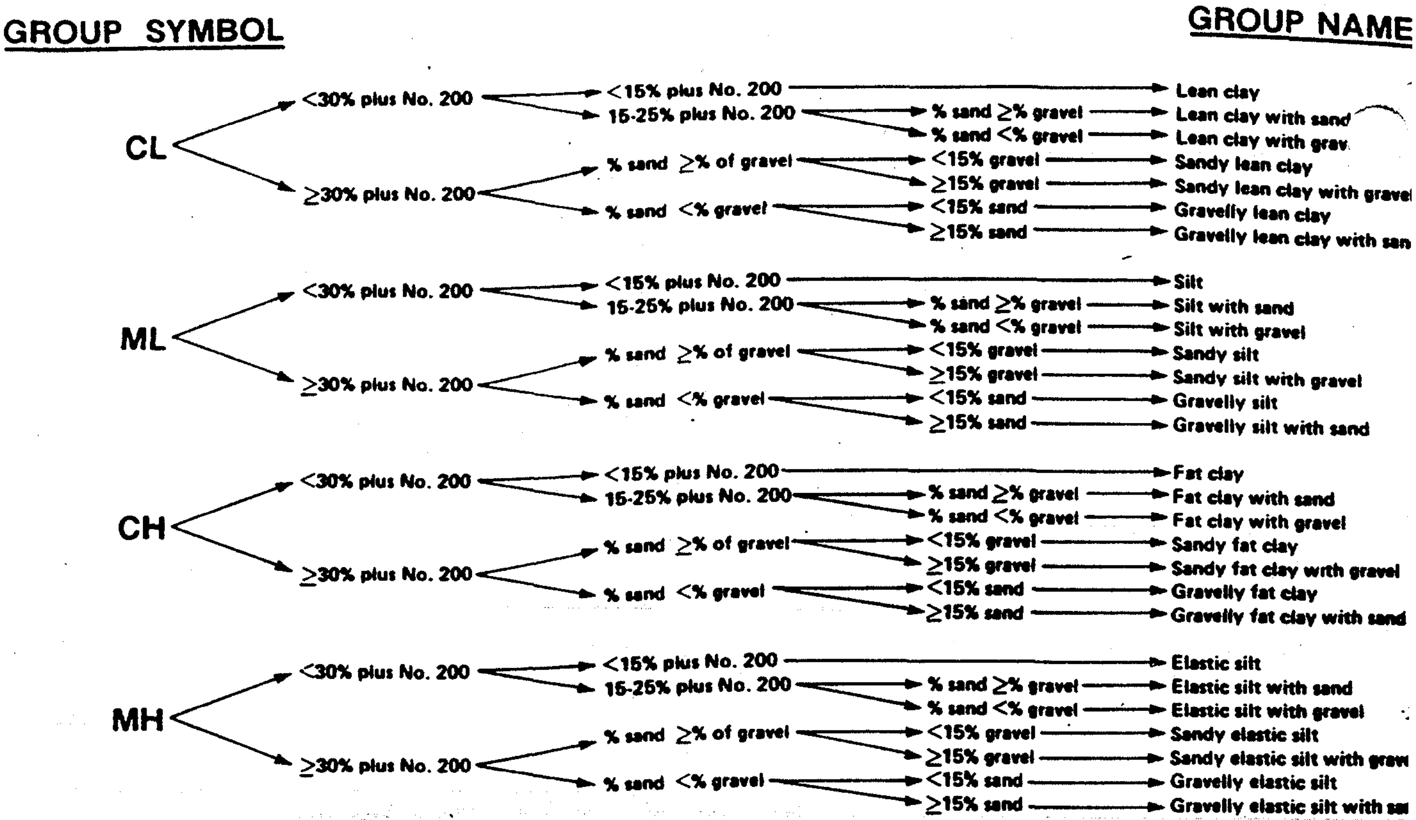
3.1.1.7 *sand*—particles of rock that will pass a No. 4

---

practice is under the jurisdiction of ASTM Committee D-18 on Soil and l is the direct responsibility of Subcommittee D18.07 on Identification tion of Soils.

lition approved June 29, 1990. Published August 1990. Originally – D 2488 – 66 T. Last previous edition D 2488 – 84[ε1].

ual Book of ASTM Standards, Vol 04.08.



NOTE—Percentages are based on estimating amounts of fines, sand, and gravel to the nearest 5 %.

FIG. 1a Flow Chart for Identifying Inorganic Fine-Grained Soil (50 % or more fines)

(4.75-mm) sieve and be retained on a No. 200 (75-μm) sieve with the following subdivisions:

coarse—passes a No. 4 (4.75-mm) sieve and is retained on a No. 10 (2.00-mm) sieve.

medium—passes a No. 10 (2.00-mm) sieve and is retained on a No. 40 (425-μm) sieve.

fine—passes a No. 40 (425-μm) sieve and is retained on a No. 200 (75-μm) sieve.

3.1.1.8 *silt*—soil passing a No. 200 (75-μm) sieve that is nonplastic or very slightly plastic and that exhibits little or no strength when air dry. For classification, a silt is a fine-grained soil, or the fine-grained portion of a soil, with a plasticity index less than 4, or the plot of plasticity index versus liquid limit falls below the "A" line (see Fig. 3 of Test Method D 2487).

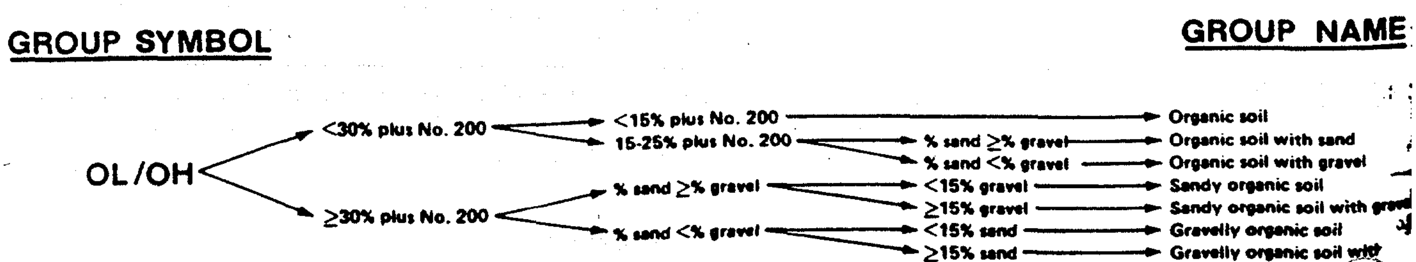
4. Summary of Practice

4.1 Using visual examination and simple manual tests this practice gives standardized criteria and procedures for describing and identifying soils.

4.2 The soil can be given an identification by assigning a group symbol(s) and name. The flow charts, Figs. 1a and 1b for fine-grained soils, and Fig. 2, for coarse-grained soils, can be used to assign the appropriate group symbol(s) and name. If the soil has properties which do not distinctly place it into a specific group, borderline symbols may be used, see Appendix X3.

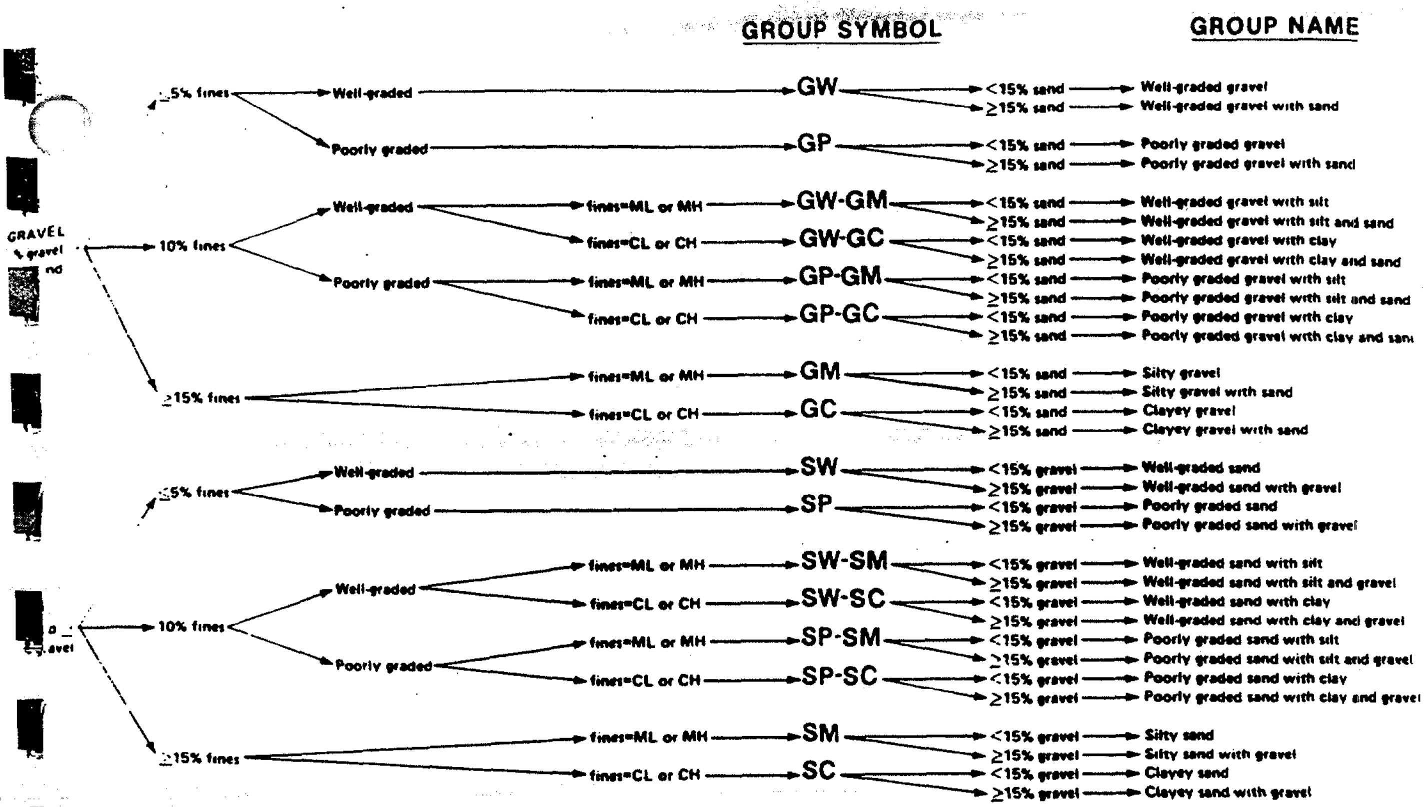
NOTE 3—It is suggested that a distinction be made between *dual symbols* and *borderline symbols.*

Dual Symbol—A dual symbol is two symbols separated by a hyphen, for example, GP-GM, SW-SC, CL-ML used to indicate that the soil has been identified as having the properties of a classification in accordance with Test Method D 2487 where two symbols are required. Two symbols are required when the soil has between 5 and 12 % fines o



NOTE—Percentages are based on estimating amounts of fines, sand, and gravel to the nearest 5 %.

FIG. 1b Flow Chart for Identifying Organic Fine-Grained Soil (50 % or more fines)



TE—Percentages are based on estimating amounts of fines, sand, and gravel to the nearest 5 %.

FIG. 2 Flow Chart for Identifying Coarse-Grained Soils (less than 50 % fines)

liquid limit and plasticity index values plot in the CL-ML area sticity chart.

Borderline Symbol—A borderline symbol is two symbols separated y a slash, for example. CL/CH. GM/SM. CL/ML. A borderline symbol ld be used to indicate that the soil has been identified as having erties that do not distinctly place the soil into a specific group (see endix X3).

Significance and Use

.1 The descriptive information required in this practice an be used to describe a soil to aid in the evaluation of its ificant properties for engineering use.

2 The descriptive information required in this practice ould be used to supplement the classification of a soil as etermined by Test Method D 2487.

3 This practice may be used in identifying soils using the ification group symbols and names as prescribed in Test lethod D 2487. Since the names and symbols used in this actice to identify the soils are the same as those used in Method D 2487. it shall be clearly stated in reports and other appropriate documents, that the classification mbol and name are based on visual-manual procedures.

4 This practice is to be used not only for identification oils in the field. but also in the office. laboratory, or erever soil samples are inspected and described.

5.5 This practice has particular value in grouping similar samples so that only a minimum number of laboratory need be run for positive soil classification.

—The ability to describe and identify soils correctly is learned readily under the guidance of experienced personnel. but it may be acquired systematically by comparing numerical laboratory test results for typical soils of each type with their visual and manual characteristics.

5.6 When describing and identifying soil samples from a given boring. test pit. or group of borings or pits, it is not necessary to follow all of the procedures in this practice for every sample. Soils which appear to be similar can be grouped together; one sample completely described and identified with the others referred to as similar based on performing only a few of the descriptive and identification procedures described in this practice.

5.7 This practice may be used in combination with Practice D 4083 when working with frozen soils.

6. Apparatus

6.1 *Required Apparatus:*

6.1.1 *Pocket Knife or Small Spatula.*

6.2 *Useful Auxiliary Apparatus:*

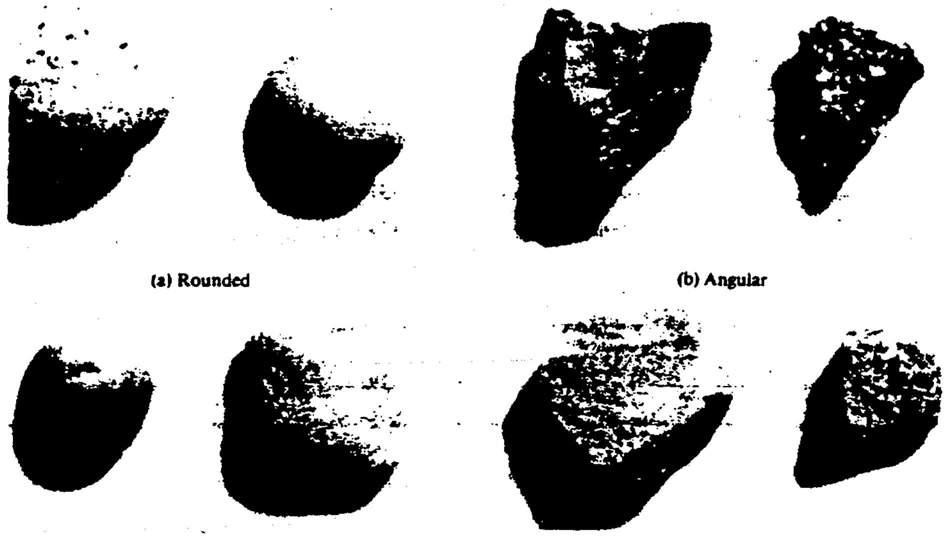
6.2.1 *Small Test Tube and Stopper* (or jar with a lid).

6.2.2 *Small Hand Lens.*

7. Reagents

7.1 *Purity of Water*—Unless otherwise indicated, references to water shall be understood to mean water from a city water supply or natural source, including non-potable water.

7.2 *Hydrochloric Acid*—A small bottle of dilute hydrochloric acid, HCl, one part HCl (10 *N*) to three parts water (This reagent is optional for use with this practice). See Section 8.



(a) Rounded (b) Angular

(c) Subrounded (d) Subangular

FIG. 3 Typical Angularity of Bulky Grains

8. Safety Precautions

8.1 When preparing the dilute HCl solution of one part concentrated hydrochloric acid (10 *N*) to three parts of distilled water, slowly add acid into water following necessary safety precautions. Handle with caution and store safely. If solution comes into contact with the skin, rinse thoroughly with water.

8.2 **Caution**—Do not add water to acid.

9. Sampling

9.1 The sample shall be considered to be representative of the stratum from which it was obtained by an appropriate, accepted, or standard procedure.

NOTE 5—Preferably, the sampling procedure should be identified as having been conducted in accordance with Practices D 1452, D 1587, or D 2113, or Method D 1586.

9.2 The sample shall be carefully identified as to origin.

NOTE 6—Remarks as to the origin may take the form of a boring number and sample number in conjunction with a job number, a geologic stratum, a pedologic horizon or a location description with respect to a permanent monument, a grid system or a station number and offset with respect to a stated centerline and a depth or elevation.

9.3 For accurate description and identification, the minimum amount of the specimen to be examined shall be in accordance with the following schedule:

Maximum Particle Size, Sieve Opening	Minimum Specimen Size, Dry Weight
4.75 mm (No. 4)	100 g (0..5 lb)
9.5 mm (⅜ in.)	200 g (0.5 lb)
19.0 mm (¾ in.)	1.0 kg (2.2 lb)
38.1 mm (1½ in.)	8.0 kg (18 lb)
75.0 mm (3 in.)	60.0 kg (132 lb)

NOTE 7—If random isolated particles are encountered t... significantly larger than the particles in the soil matrix, the soil can be accurately described and identified in accordance wi... preceeding schedule.

9.4 If the field sample or specimen being examined... smaller than the minimum recommended amount, ... report shall include an appropriate remark.

10. Descriptive Information for Soils

10.1 *Angularity*—Describe the angularity of the s... (coarse sizes only), gravel, cobbles, and boulders, as angu... subangular, subrounded, or rounded in accordance with... criteria in Table 1 and Fig. 3. A range of angularity ma... stated, such as: subrounded to rounded.

10.2 *Shape*—Describe the shape of the gravel, cob... and boulders as flat, elongated, or flat and elongated if... meet the criteria in Table 2 and Fig. 4. Otherwise, do... mention the shape. Indicate the fraction of the particles... have the shape, such as: one-third of the gravel particle... flat.

10.3 *Color*—Describe the color. Color is an impo... property in identifying organic soils, and within a g...

TABLE 1 Criteria for Describing Angularity of Coarse-Grained Particles (see Fig. 3)

Description	Criteria
Angular	Particles have sharp edges and relatively plane sides with unpolished surfaces
Subangular	Particles are similar to angular description but have rounded edges
Subrounded	Particles have nearly plane sides but have well-rounded corners and edges
Rounded	Particles have smoothly curved sides and no edges

TABLE 2 Criteria for Describing Particle Shape (see Fig...

The particle shape shall be described as follows where length, width... thickness refer to the greatest, intermediate, and least dimensions of a p... respectively.

Flat	Particles with width/thickness > 3
Elongated	Particles with length/width > 3
Flat and elongated	Particles meet criteria for both flat and elong...

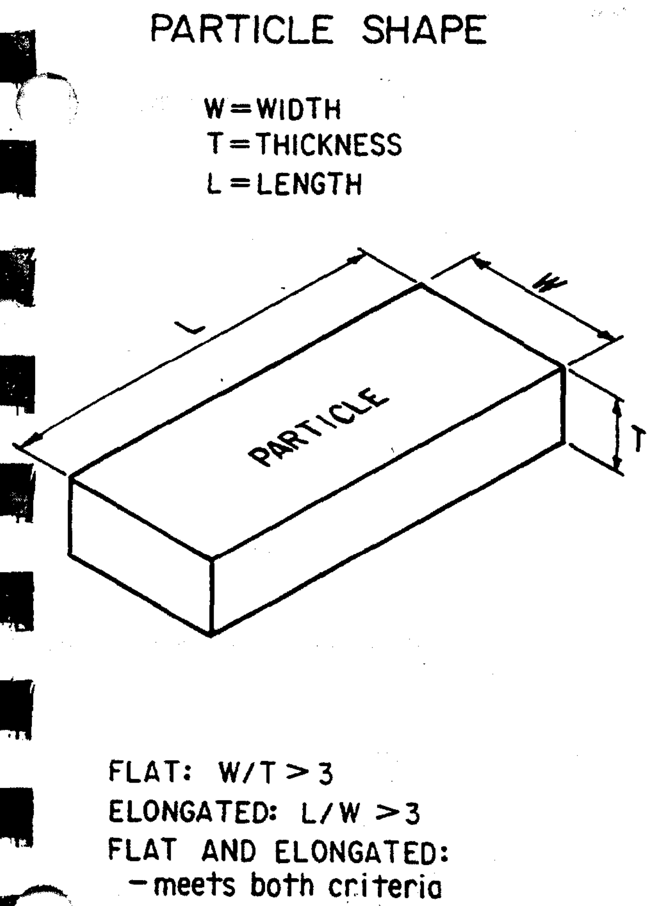


FIG. 4 Criteria for Particle Shape

TABLE 3 Criteria for Describing Moisture Condition

Description	Criteria
Dry	Absence of moisture, dusty, dry to the touch
Moist	Damp but no visible water
Wet	Visible free water, usually soil is below water table

locality it may also be useful in identifying materials of ...ar geologic origin. If the sample contains layers or ...hes of varying colors, this shall be noted and all representative colors shall be described. The color shall be described for moist samples. If the color represents a dry ...ition, this shall be stated in the report.

...4 *Odor*—Describe the odor if organic or unusual. Soils containing a significant amount of organic material usually ... a distinctive odor of decaying vegetation. This is ...cially apparent in fresh samples, but if the samples are dried, the odor may often be revived by heating a moistened sample. If the odor is unusual (petroleum product, chemical, ...the like), it shall be described.

...5 *Moisture Condition*—Describe the moisture condition as dry, moist, or wet, in accordance with the criteria in Table 3.

...6 *HCl Reaction*—Describe the reaction with HCl as ...weak, or strong, in accordance with the critera in ... Since calcium carbonate is a common cementing ... a report of its presence on the basis of the reaction ... dilute hydrochloric acid is important.

TABLE 4 Criteria for Describing the Reaction With HCl

Description	Criteria
None	No visible reaction
Weak	Some reaction, with bubbles forming slowly
Strong	Violent reaction, with bubbles forming immediately

TABLE 5 Criteria for Describing Consistency

Description	Criteria
Very soft	Thumb will penetrate soil more than 1 in. (25 mm)
Soft	Thumb will penetrate soil about 1 in. (25 mm)
Firm	Thumb will indent soil about ¼ in. (6 mm)
Hard	Thumb will not indent soil but readily indented with thumbnail
Very hard	Thumbnail will not indent soil

10.7 *Consistency*—For intact fine-grained soil, describe the consistency as very soft, soft, firm, hard, or very hard, in accordance with the criteria in Table 5. This observation is inappropriate for soils with significant amounts of gravel.

10.8 *Cementation*—Describe the cementation of intact coarse-grained soils as weak, moderate, or strong, in accordance with the criteria in Table 6.

10.9 *Structure*—Describe the structure of intact soils in accordance with the criteria in Table 7.

10.10 *Range of Particle Sizes*—For gravel and sand components, describe the range of particle sizes within each component as defined in 3.1.2 and 3.1.6. For example, about 20 % fine to coarse gravel, about 40 % fine to coarse sand.

10.11 *Maximum Particle Size*—Describe the maximum particle size found in the sample in accordance with the following information:

10.11.1 *Sand Size*—If the maximum particle size is a sand size, describe as fine, medium, or coarse as defined in 3.1.6. For example: maximum particle size, medium sand.

10.11.2 *Gravel Size*—If the maximum particle size is a gravel size, describe the maximum particle size as the smallest sieve opening that the particle will pass. For example, maximum particle size, 1½ in. (will pass a 1½-in. square opening but not a ¾-in. square opening).

10.11.3 *Cobble or Boulder Size*—If the maximum particle size is a cobble or boulder size, describe the maximum dimension of the largest particle. For example: maximum dimension, 18 in. (450 mm).

10.12 *Hardness*—Describe the hardness of coarse sand and larger particles as hard, or state what happens when the particles are hit by a hammer, for example, gravel-size particles fracture with considerable hammer blow, some gravel-size particles crumble with hammer blow. "Hard" means particles do not crack, fracture, or crumble under a hammer blow.

10.13 Additional comments shall be noted, such as the presence of roots or root holes, difficulty in drilling or augering hole, caving of trench or hole, or the presence of mica.

10.14 A local or commercial name or a geologic interpre-

TABLE 6 Criteria for Describing Cementation

Description	Criteria
Weak	Crumbles or breaks with handling or little finger pressure
Moderate	Crumbles or breaks with considerable finger pressure
Strong	Will not crumble or break with finger pressure

TABLE 7 Criteria for Describing Structure

Description	Criteria
Stratified	Alternating layers of varying material or color with layers at least 6 mm thick; note thickness
Laminated	Alternating layers of varying material or color with the layers less than 6 mm thick; note thickness
Fissured	Breaks along definite planes of fracture with little resistance to fracturing
Slickensided	Fracture planes appear polished or glossy, sometimes striated
Blocky	Cohesive soil that can be broken down into small angular lumps which resist further breakdown
Lensed	Inclusion of small pockets of different soils, such as small lenses of sand scattered through a mass of clay; note thickness
Homogeneous	Same color and appearance throughout

tation of the soil, or both, may be added if identified as such.

10.15 A classification or identification of the soil in accordance with other classification systems may be added if identified as such.

11. Identification of Peat

11.1 A sample composed primarily of vegetable tissue in various stages of decomposition that has a fibrous to amorphous texture, usually a dark brown to black color, and an organic odor, shall be designated as a highly organic soil and shall be identified as peat, PT, and not subjected to the identification procedures described hereafter.

12. Preparation for Identification

12.1 The soil identification portion of this practice is based on the portion of the soil sample that will pass a 3-in. (75-mm) sieve. The larger than 3-in. (75-mm) particles must be removed, manually, for a loose sample, or mentally, for an intact sample before classifying the soil.

12.2 Estimate and note the percentage of cobbles and the percentage of boulders. Performed visually, these estimates will be on the basis of volume percentage.

NOTE 8—Since the percentages of the particle-size distribution in Test Method D 2487 are by dry weight, and the estimates of percentages for gravel, sand, and fines in this practice are by dry weight, it is recommended that the report state that the percentages of cobbles and boulders are by volume.

12.3 Of the fraction of the soil smaller than 3 in. (75 mm), estimate and note the percentage, by dry weight, of the gravel, sand, and fines (see Appendix X4 for suggested procedures).

NOTE 9—Since the particle-size components appear visually on the basis of volume, considerable experience is required to estimate the percentages on the basis of dry weight. Frequent comparisons with laboratory particle-size analyses should be made.

12.3.1 The percentages shall be estimated to the closest 5 %. The percentages of gravel, sand, and fines must add up to 100 %.

12.3.2 If one of the components is present but not in sufficient quantity to be considered 5 % of the smaller than 3-in. (75-mm) portion, indicate its presence by the term *trace*, for example, trace of fines. A trace is not to be considered in the total of 100 % for the components.

13. Preliminary Identification

13.1 The soil is *fine grained* if it contains 50 % or more fines. Follow the procedures for identifying fine-grain[illegible] of Section 14.

13.2 The soil is *coarse grained* if it contains les[illegible] fines. Follow the procedures for identifying c[illegible] soils of Section 15.

14. Procedure for Identifying Fine-Grained Soils

14.1 Select a representative sample of the mater[illegible] examination. Remove particles larger than the No. 4[illegible] (medium sand and larger) until a specimen equival[illegible] about a handful of material is available. Use this spe[illegible] for performing the dry strength, dilatancy, and tou[illegible] tests.

14.2 *Dry Strength:*

14.2.1 From the specimen, select enough material t[illegible] into a ball about 1 in. (25 mm) in diameter. Mo[illegible] material until it has the consistency of putty, adding w[illegible] necessary.

14.2.2 From the molded material, make at least thr[illegible] specimens. A test specimen shall be a ball of material [illegible] ½ in. (12 mm) in diameter. Allow the test specimens [illegible] in air, or sun, or by artificial means, as long a[illegible] temperature does not exceed 60°C.

14.2.3 If the test specimen contains natural dry l[illegible] those that are about ½ in. (12 mm) in diameter may b[illegible] in place of the molded balls.

NOTE 10—The process of molding and drying usually pr[illegible] higher strengths than are found in natural dry lumps of soil.

14.2.4 Test the strength of the dry balls or lum[illegible] crushing between the fingers. Note the strength a[illegible] medium, high, or very high in accorance with th[illegible] Table 8. If natural dry lumps are used, do not use the r[illegible] of any of the lumps that are found to contain partic[illegible] coarse sand.

14.2.5 The presence of high-strength water-solubl[illegible] menting materials, such as calcium carbonate, may [illegible] exceptionally high dry strengths. The presence of cal[illegible] carbonate can usually be detected from the intensity [illegible] reaction with dilute hydrochloric acid (see 10.6).

14.3 *Dilatancy:*

14.3.1 From the specimen, select enough material to [illegible] into a ball about ½ in. (12 mm) in diameter. Mo[illegible] material, adding water if necessary, until it has a soft, bu[illegible] sticky, consistency.

14.3.2 Smooth the soil ball in the palm of one hand [illegible] the blade of a knife or small spatula. Shake horizon[illegible] striking the side of the hand vigorously against the [illegible] hand several times. Note the reaction of water appearin[illegible]

TABLE 8 Criteria for Describing Dry Strength

Description	Criteria
None	The dry specimen crumbles into powder with mere pr[illegible] of handling
Low	The dry specimen crumbles into powder with some [illegible] pressure
Medium	The dry specimen breaks into pieces or crumbles [illegible] considerable finger pressure
High	The dry specimen cannot be broken with finger pr[illegible] Specimen will break into pieces between th[illegible] surface
Very high	The dry specimen cannot be broken between the [illegible] hard surface

TABLE 9 Criteria for Describing Dilatancy

...ription	Criteria
...ne	No visible change in the specimen
...w	Water appears slowly on the surface of the specimen during shaking and does not disappear or disappears slowly upon squeezing
...pid	Water appears quickly on the surface of the specimen during shaking and disappears quickly upon squeezing

TABLE 10 Criteria for Describing Toughness

...cription	Criteria
...w	Only slight pressure is required to roll the thread near the plastic limit. The thread and the lump are weak and soft
...dium	Medium pressure is required to roll the thread to near the plastic limit. The thread and the lump have medium stiffness
...gh	Considerable pressure is required to roll the thread to near the plastic limit. The thread and the lump have very high stiffness

...rface of the soil. Squeeze the sample by closing the ...r pinching the soil between the fingers, and note the ...n as none, slow, or rapid in accordance with the ...a in Table 9. The reaction is the speed with which ...appears while shaking, and disappears while squeezing.

... *Toughness:*

...1 Following the completion of the dilatancy test, the ...ecimen is shaped into an elongated pat and rolled by ...n a smooth surface or between the palms into a thread ...⅛ in. (3 mm) in diameter. (If the sample is too wet to ...sily, it should be spread into a thin layer and allowed ... s... water by evaporation.) Fold the sample threads ...r... ...eatedly until the thread crumbles at a diameter ...ut ⅛ in. The thread will crumble at a diameter of ⅛ ...en the soil is near the plastic limit. Note the pressure ...ed to roll the thread near the plastic limit. Also, note ...ength of the thread. After the thread crumbles, the ... should be lumped together and kneaded until the ...crumbles. Note the toughness of the material during ...ing.

....2 Describe the toughness of the thread and lump as ...medium, or high in accordance with the criteria in ...10.

... *Plasticity*—On the basis of observations made during ...ughness test, describe the plasticity of the material in ...dance with the criteria given in Table 11.

... Decide whether the soil is an *inorganic* or an *organic* ...ained soil (see 14.8). If inorganic, follow the steps ...in 14.7.

... *Identification of Inorganic Fine-Grained Soils:*

TABLE 11 Criteria for Describing Plasticity

...cription	Criteria
...plastic	A ⅛-in. (3-mm) thread cannot be rolled at any water content
	The thread can barely be rolled and the lump cannot be formed when drier than the plastic limit
...dium	The thread is easy to roll and not much time is required to reach the plastic limit. The thread cannot be rerolled after reaching the plastic limit. The lump crumbles when drier than the plastic limit
	It takes considerable time rolling and kneading to reach the plastic limit. The thread can be rerolled several times after reaching the plastic limit. The lump can be formed without crumbling when drier than the plastic limit

14.7.1 Identify the soil as a *lean clay*, CL, if the soil has medium to high dry strength, no or slow dilatancy, and medium toughness and plasticity (see Table 12).

14.7.2 Identify the soil as a *fat clay*, CH, if the soil has high to very high dry strength, no dilatancy, and high toughness and plasticity (see Table 12).

14.7.3 Identify the soil as a *silt*, ML, if the soil has no to low dry strength, slow to rapid dilatancy, and low toughness and plasticity, or is nonplastic (see Table 12).

14.7.4 Identify the soil as an *elastic silt*, MH, if the soil has low to medium dry strength, no to slow dilatancy, and low to medium toughness and plasticity (see Table 12).

NOTE 11—These properties are similar to those for a lean clay. However, the silt will dry quickly on the hand and have a smooth, silky feel when dry. Some soils that would classify as MH in accordance with the criteria in Test Method D 2487 are visually difficult to distinguish from lean clays, CL. It may be necessary to perform laboratory testing for proper identification.

14.8 *Identification of Organic Fine-Grained Soils:*

14.8.1 Identify the soil as an *organic soil*, OL/OH, if the soil contains enough organic particles to influence the soil properties. Organic soils usually have a dark brown to black color and may have an organic odor. Often, organic soils will change color, for example, black to brown, when exposed to the air. Some organic soils will lighten in color significantly when air dried. Organic soils normally will not have a high toughness or plasticity. The thread for the toughness test will be spongy.

NOTE 12—In some cases, through practice and experience, it may be possible to further identify the organic soils as organic silts or organic clays, OL or OH. Correlations between the dilatancy, dry strength, toughness tests, and laboratory tests can be made to identify organic soils in certain deposits of similar materials of known geologic origin.

14.9 If the soil is estimated to have 15 to 25 % sand or gravel, or both, the words "with sand" or "with gravel" (whichever is more predominant) shall be added to the group name. For example: "lean clay with sand, CL" or "silt with gravel, ML" (see Figs. 1a and 1b). If the percentage of sand is equal to the percentage of gravel, use "with sand."

14.10 If the soil is estimated to have 30 % or more sand or gravel, or both, the words "sandy" or "gravelly" shall be added to the group name. Add the word "sandy" if there appears to be more sand than gravel. Add the word "gravelly" if there appears to be more gravel than sand. For example: "sandy lean clay, CL", "gravelly fat clay, CH", or "sandy silt, ML" (see Figs. 1a and 1b). If the percentage of sand is equal to the percent of gravel, use "sandy."

15. Procedure for Identifying Coarse-Grained Soils (Contains less than 50 % fines)

15.1 The soil is a *gravel* if the percentage of gravel is estimated to be more than the percentage of sand.

TABLE 12 Identification of Inorganic Fine-Grained Soils from Manual Tests

Soil Symbol	Dry Strength	Dilatancy	Toughness
ML	None to low	Slow to rapid	Low or thread cannot be formed
CL	Medium to high	None to slow	Medium
MH	Low to medium	None to slow	Low to medium
CH	High to very high	None	High

15.2 The soil is a *sand* if the percentage of gravel is estimated to be equal to or less than the percentage of sand.

15.3 The soil is a *clean gravel* or *clean sand* if the percentage of fines is estimated to be 5 % or less.

15.3.1 Identify the soil as a *well-graded gravel*, GW, or as a *well-graded sand*, SW, if it has a wide range of particle sizes and substantial amounts of the intermediate particle sizes.

15.3.2 Identify the soil as a *poorly graded gravel*, GP, or as a *poorly graded sand*, SP, if it consists predominantly of one size (uniformly graded), or it has a wide range of sizes with some intermediate sizes obviously missing (gap or skip graded).

15.4 The soil is either a *gravel with fines* or a *sand with fines* if the percentage of fines is estimated to be 15 % or more.

15.4.1 Identify the soil as a *clayey gravel*, GC, or a *clayey sand*, SC, if the fines are clayey as determined by the procedures in Section 14.

15.4.2 Identify the soil as a *silty gravel*, GM, or a *silty sand*, SM, if the fines are silty as determined by the procedures in Section 14.

15.5 If the soil is estimated to contain 10 % fines, give the soil a dual identification using two group symbols.

15.5.1 The first group symbol shall correspond to a clean gravel or sand (GW, GP, SW, SP) and the second symbol shall correspond to a gravel or sand with fines (GC, GM, SC, SM).

15.5.2 The group name shall correspond to the first group symbol plus the words "with clay" or "with silt" to indicate the plasticity characteristics of the fines. For example: "well-graded gravel with clay, GW-GC" or "poorly graded sand with silt, SP-SM" (see Fig. 2).

15.6 If the specimen is predominantly sand or gravel but contains an estimated 15 % or more of the other coarse-grained constituent, the words "with gravel" or "with sand" shall be added to the group name. For example: "poorly graded gravel with sand, GP" or "clayey sand with gravel, SC" (see Fig. 2).

15.7 If the field sample contains any cobbles or boulders, or both, the words "with cobbles" or "with cobbles and boulders" shall be added to the group name. For example: "silty gravel with cobbles, GM."

16. Report

16.1 The report shall include the information as to origin, and the items indicated in Table 13.

NOTE 13—*Example: Clayey Gravel with Sand and Cobbles, GC*—About 50 % fine to coarse, subrounded to subangular gravel; about 30 % fine to coarse, subrounded sand; about 20 % fines with medium plasticity, high dry strength, no dilatancy, medium toughness; weak reaction with HCl; original field sample had about 5 % (by volu[me]) subrounded cobbles, maximum dimension, 150 mm.

In-Place Conditions—Firm, homogeneous, dry, brown

Geologic Interpretation—Alluvial fan

NOTE 14—Other examples of soil descriptions and identific[ation are] given in Appendixes X1 and X2.

NOTE 15—If desired, the percentages of gravel, sand, and [fines may] be stated in terms indicating a range of percentages, as follows:

Trace—Particles are present but estimated to be less than 5 %

Few—5 to 10 %

Little—15 to 25 %

Some—30 to 45 %

Mostly—50 to 100 %

TABLE 13 Checklist for Description of Soils

1. Group name
2. Group symbol
3. Percent of cobbles or boulders, or both (by volume)
4. Percent of gravel, sand, or fines, or all three (by dry weight)
5. Particle-size range:
   Gravel—fine, coarse
   Sand—fine, medium, coarse
6. Particle angularity: angular, subangular, subrounded, rounded
7. Particle shape: (if appropriate) flat, elongated, flat and elongated
8. Maximum particle size or dimension
9. Hardness of coarse sand and larger particles
10. Plasticity of fines: nonplastic, low, medium, high
11. Dry strength: none, low, medium, high, very high
12. Dilatancy: none, slow, rapid
13. Toughness: low, medium, high
14. Color (in moist condition)
15. Odor (mention only if organic or unusual)
16. Moisture: dry, moist, wet
17. Reaction with HCl: none, weak, strong

For intact samples:

18. Consistency (fine-grained soils only): very soft, soft, firm, hard, very ha[rd]
19. Structure: stratified, laminated, fissured, slickensided, lensed, h[omo]geneous
20. Cementation: weak, moderate, strong
21. Local name
22. Geologic interpretation
23. Additional comments: presence of roots or root holes, presence of [mica,] gypsum, etc., surface coatings on coarse-grained particles, caving [or] sloughing of auger hole or trench sides, difficulty in augering or excava[ting,] etc.

16.2 If, in the soil description, the soil is identified usin[g a] classification group symbol and name as described in T[est] Method D 2487, it must be distinctly and clearly stated in lo[g] forms, summary tables, reports, and the like, that the symb[ol] and name are based on visual-manual procedures.

17. Precision and Bias

17.1 This practice provides qualitative information on[ly;] therefore, a precision and bias statement is not applicable.

18. Keywords

18.1 classification; clay; gravel; organic soils; sand; s[ilt;] soil classification; soil description; visual classification

APPENDIXES

(Nonmandatory Information)

X1. EXAMPLES OF VISUAL SOIL DESCRIPTIONS

.1 The following examples show how the information red in 16.1 can be reported. The information that is luded in descriptions should be based on individual umstances and need.

.1.1 *Well-Graded Gravel with Sand (GW)*—About fine to coarse, hard, subangular gravel; about 25 % fine coarse, hard, subangular sand; trace of fines; maximum 75 mm, brown, dry; no reaction with HCl.

.1.2 *Silty Sand with Gravel (SM)*—About 60 % predominantly fine sand; about 25 % silty fines with low ticity, low dry strength, rapid dilatancy, and low tough- about 15 % fine, hard, subrounded gravel, a few vel-size particles fractured with hammer blow; maximum , 25 mm; no reaction with HCl (Note—Field sample size er than recommended).

Place Conditions—Firm, stratified and contains lenses ilt 1 to 2 in. (25 to 50 mm) thick, moist, brown to gray; in-place density 106 lb/ft^3; in-place moisture 9 %.

X1.1.3 *Organic Soil (OL/OH)*—About 100 % fines with low plasticity, slow dilatancy, low dry strength, and low toughness; wet, dark brown, organic odor; weak reaction with HCl.

X1.1.4 *Silty Sand with Organic Fines (SM)*—About 75 % fine to coarse, hard, subangular reddish sand; about 25 % organic and silty dark brown nonplastic fines with no dry strength and slow dilatancy; wet; maximum size, coarse sand; weak reaction with HCl.

X1.1.5 *Poorly Graded Gravel with Silt, Sand, Cobbles and Boulders (GP-GM)*—About 75 % fine to coarse, hard, subrounded to subangular gravel; about 15 % fine, hard, subrounded to subangular sand; about 10 % silty nonplastic fines; moist, brown; no reaction with HCl; original field sample had about 5 % (by volume) hard, subrounded cobbles and a trace of hard, subrounded boulders, with a maximum dimension of 18 in. (450 mm).

USING THE IDENTIFICATION PROCEDURE AS A DESCRIPTIVE SYSTEM FOR SHALE, CLAYSTONE, SHELLS, SLAG, CRUSHED ROCK, AND THE LIKE

e identification procedure may be used as a criptive system applied to materials that exist in-situ as le, claystone, sandstone, siltstone, mudstone, etc., but rt to soils after field or laboratory processing (crushing, g, and the like).

2.2 Materials such as shells, crushed rock, slag, and the hould be identified as such. However, the procedures in this practice for describing the particle size and ticity characteristics may be used in the description of the terial. If desired, an identification using a group name and l according to this practice may be assigned to aid in bing the material.

2.3 The group symbol(s) and group names should be d in quotation marks or noted with some type of guishing symbol. See examples.

4 Examples of how group names and symbols can be orated into a descriptive system for materials that are turally occurring soils are as follows:

4.1 *Shale Chunks*—Retrieved as 2 to 4-in. (50 to 100-mm) pieces of shale from power auger hole, dry, brown, no reaction with HCl. After slaking in water for 24 h, material identified as "Sandy Lean Clay (CL)"; about 60 % fines with medium plasticity, high dry strength, no dilatancy, and medium toughness; about 35 % fine to medium, hard sand; about 5 % gravel-size pieces of shale.

X2.4.2 *Crushed Sandstone*—Product of commercial crushing operation; "Poorly Graded Sand with Silt (SP-SM)"; about 90 % fine to medium sand; about 10 % nonplastic fines; dry, reddish-brown, strong reaction with HCl.

X2.4.3 *Broken Shells*—About 60 % gravel-size broken shells; about 30 % sand and sand-size shell pieces; about 10 % fines; "Poorly Graded Gravel with Sand (GP)."

X2.4.4 *Crushed Rock*—Processed from gravel and cobbles in Pit No. 7; "Poorly Graded Gravel (GP)"; about 90 % fine, hard, angular gravel-size particles; about 10 % coarse, hard, angular sand-size particles; dry, tan; no reaction with HCl.

SUGGESTED PROCEDURE FOR USING A BORDERLINE SYMBOL FOR SOILS WITH TWO POSSIBLE IDENTIFICATIONS.

3.1 Since this practice is based on estimates of particle istribution and plasticity characteristics, it may be lt to clearly identify the soil as belonging to one o indicate that the soil may fall into one of two possible basic groups, a borderline symbol may be used with the two symbols separated by a slash. For example: SC/CL or CL/CH.

X3.1.1 A borderline symbol may be used when the percentage of fines is estimated to be between 45 and 55 %. One symbol should be for a coarse-grained soil with fines and the other for a fine-grained soil. For example: GM/ML or CL/SC.

X3.1.2 A borderline symbol may be used when the percentage of sand and the percentage of gravel are estimated to be about the same. For example: GP/SP, SC/GC, GM/SM. It is practically impossible to have a soil that would have a borderline symbol of GW/SW.

X3.1.3 A borderline symbol may be used when the soil could be either well graded or poorly graded. For example: GW/GP, SW/SP.

X3.1.4 A borderline symbol may be used when the soil could either be a silt or a clay. For example: CL/ML, CH/MH, SC/SM.

X3.1.5 A borderline symbol may be used when a fine-grained soil has properties that indicate that it is at boundary between a soil of low compressibility and a soi high compressibility. For example: CL/CH, MH/ML

X3.2 The order of the borderline symbols shoul similarity to surrounding or adjacent soils. For examp... s in a borrow area have been identified as CH. One sampl considered to have a borderline symbol of CL and CH. show similarity, the borderline symbol should be CH/CL

X3.3 The group name for a soil with a borderline syml should be the group name for the first symbol, except for

CL/CH lean to fat clay
ML/CL clayey silt
CL/ML silty clay

X3.4 The use of a borderline symbol should not be us indiscriminately. Every effort shall be made to first place t soil into a single group.

X4. SUGGESTED PROCEDURES FOR ESTIMATING THE PERCENTAGES OF GRAVEL, SAND, AND FINES IN A SOIL SAMPLE

X4.1 *Jar Method*—The relative percentage of coarse- and fine-grained material may be estimated by thoroughly shaking a mixture of soil and water in a test tube or jar, and then allowing the mixture to settle. The coarse particles will fall to the bottom and successively finer particles will be deposited with increasing time; the sand sizes will fall out of suspension in 20 to 30 s. The relative proportions can be estimated from the relative volume of each size separate. This method should be correlated to particle-size laboratory determinations.

X4.2 *Visual Method*—Mentally visualize the gravel size particles placed in a sack (or other container) or sacks. Then, do the same with the sand size particles and the fines. Then, mentally compare the number of sacks to estimate the percentage of plus No. 4 sieve size and minus No. 4 sieve size present. The percentages of sand and fines in the minus sie size No. 4 material can then be estimated from the wash te (X4.3).

X4.3 *Wash Test (for relative percentages of sand ar fines)*—Select and moisten enough minus No. 4 sieve si material to form a 1-in (25-mm) cube of soil. Cut the cube i half, set one-half to the side, and place the other half in small dish. Wash and decant the fines out of the material i the dish until the wash water is clear and then comp two samples and estimate the percentage of sand ar Remember that the percentage is based on weigh, n volume. However, the volume comparison will provide reasonable indication of grain size percentages.

X4.3.1 While washing, it may be necessary to break dow lumps of fines with the finger to get the correct percentage

X5. RATIONALE

X5.1 This practice was significantly revised in the D 2488 – 84 version from the previous version D 2488 – 69 (1975). The revisions are documented in the literature.[3]

X5.2 Changes in this version from the previous versio include rewording of 1.2.3 to say (disturbed and undi turbed), the addition of 5.7 to refer to the practice fo describing frozen soils, and the addition of Appendix X5 o Rationale.

[3] Howard, A. K. "The Revised ASTM Standard on the Description and Identification of Soils (Visual-Manual Procedure)," *Geotechical Testing Journal*, GTJODJ Vol. 10, No. 4, December 1987.

Geoprobe® Groundwater Sample Collection

I. Purpose

To provide a general guideline for the collection of groundwater samples using Geoprobe® sampling methods.

II. Scope

Standard Geoprobe® groundwater sampling methods.

III. Equipment and Materials

- Truck-mounted hydraulic percussion hammer.
- Geoprobe® sampling rods and slotted lead rod
- Polyethylene sampling tubing and stainless steel foot valve
- Pre-cleaned sample containers
- Clean latex or surgical gloves.

IV. Procedures and Guidelines

1. Decontaminate slotted lead rod and other non-dedicated downhole equipment in accordance to SOP Decontamination of Personnel and Equipment.
2. Drive slotted steel lead rod to the desired sampling depth using the truck-mounted hydraulic percussion hammer.
3. Insert the stainless steel foot valve into the end of the polyethylene sampling tubing and insert tubing through the rods.
4. Fill all sample containers, beginning with the containers for VOC analysis.
5. Remove polyethylene sampling tubing from the rods. Remove the foot valve and discard polyethylene tubing.
6. Decontaminate all non-dedicated downhole equipment (lead rod, foot valve, etc.) in accordance to SOP Decontamination of Personnel and Equipment.
7. Backfill bore hole at each sampling location with grout or bentonite and repair the surface with like material (bentonite, asphalt patch, concrete, etc.), as required.

V. Key Checks and Items

1. Verify that the hydraulic percussion hammer is clean and in proper working order.

2. Ensure that the Geoprobe® operator thoroughly completes the decontamination process between sampling locations.

3. Verify that the borehole made during sampling activities has been properly backfilled.

STANDARD OPERATING PROCEDURE

Geoprobe® Soil Sample Collection

I. Purpose

To provide a general guideline for the collection of soil samples using Geoprobe® sampling methods.

II. Scope

Standard Geoprobe® soil sampling methods.

III. Equipment and Materials

- Truck-mounted hydraulic percussion hammer.
- Geoprobe® sampling rods
- Geoprobe® sampling tubes and acetate liners (if desired)
- Pre-cleaned sample containers and stainless-steel sampling implements
- Clean latex or surgical gloves.

IV. Procedures and Guidelines

1. Decontaminate sampling tubes and other non-dedicated downhole equipment in accordance with SOP Decontamination of Personnel and Equipment.
2. Drive sampling tube to the desired sampling depth using the truck-mounted hydraulic percussion hammer. If soil above the desired depth is not to be sampled, first drive the lead rod, without a sampling tube, to the top of the desired depth.
3. Remove the rods and sampling tube from the borehole and remove the sample from the tube.
4. Fill all sample containers, beginning with the containers for VOC analysis, using a decontaminated or dedicated sampling implement.
5. Decontaminate all non-dedicated downhole equipment (rods, sampling tubes, etc.) in accordance with SOP Decontamination of Personnel and Equipment.
6. Backfill borehole at each sampling location with grout or bentonite and repair the surface with like material (bentonite, asphalt patch, concrete, etc.), as required.

V. Key Checks and Items

1. Verify that the hydraulic percussion hammer is clean and in proper working order.

2. Ensure that the Geoprobe® operator thoroughly completes the decontamination process between sampling locations.

3. Verify that the borehole made during sampling activities has been properly backfilled.

Installation of Shallow Monitoring Wells

I. Purpose and Scope

The purpose of this guideline is to describe methods for drilling and installation of shallow monitoring wells and piezometers in unconsolidated or poorly consolidated materials. Methods for drilling and installing bedrock monitoring wells are presented in SOP Installation of Bedrock Monitoring Wells.

II. Equipment and Materials

Drilling

- Drilling rig
- Hollow-stem augers

Well Riser/Screen

- Polyvinyl chloride (PVC), Schedule 40, minimum 2-inch ID, flush-threaded riser; alternatively, stainlesss steel riser
- PVC, Schedule 40, minimum 2-inch ID, flush-threaded, factory slotted screen; alternatively, stainless steel screen.

Bottom Cap

- PVC, threaded to match the well screen; alternatively, stainless steel
- Centering Guides (if used)

Well Cap

- Above-grade well completion: PVC, threaded or push-on type, vented
- Flush-mount well completion: PVC, locking, leak-proof seal
- Stainless steel to be used as appropriate

Sand

- Clean silica sand, provided in factory-sealed bags, well-rounded, containing no organic material, anhydrite, gypsum, mica, or calcareous material; primary (coarse) filter pack, and secondary (fine) filter pack. Grain size determined based on sediments observed during drilling.

Bentonite

- Pure, additive-free bentonite pellets
- Pure, additive-free powdered bentonite

- Coated bentonite pellets; coating must biodegrade within 7 days
- Cement-Bentonite Grout: proportion of 6 to 8 gallons of water per 94-pound bag of Portland cement; 3 to 6 pounds of bentonite added per bag of cement to reduce shrinkage

Protective Casing

- Above-grade well completion: 6-inch minimum ID steel pipe with locking cover, diameter at least 2 inches greater than the well casing, painted with epoxy paint for rust protection; heavy duty lock; protective posts if appropriate
- Flush-mount well completion: Morrison 9-inch or 12-inch 519 manhole cover, or equivalent; rubber seal to prevent leakage; locking cover inside of road box

Well Development

- Double surge block with solid bottom, top open, separated by 2 feet of slotted pipe
- Well-development pump, and associated equipment
- Containers (e.g., 55 gallon drums) for water produced from well.

III. Procedures and Guidelines

A. Drilling Method

Continuous-flight hollow-stem augers with a minimum 6-inch inside diameter (ID) will be used to drill shallow monitoring well boreholes. Split-spoon samples will be collected at selected intervals for chemical analysis and/or lithologic classification. Soil sampling procedures are detailed in SOP Soil Sampling.

The use of water to assist in hollow-stem auger drilling for monitoring well installation will be avoided, unless required for such conditions as running sands.

Hollow-stem augers, rods, split-spoon samplers, and other downhole drilling tools will be properly decontaminated prior to the initiation of drilling activities and between each borehole location. Split-spoon samplers and other downhole soil sampling equipment will also be properly decontaminated before and after each use. SOP Decontamination of Drilling Rigs and Personnel details proper decontamination procedures.

Drill cuttings and decontamination fluids generated during well drilling activities will be contained according to the procedures detailed in the Field Sampling Plan.

B. Monitoring Well Installation

Shallow monitoring wells will be constructed inside the hollow-stem augers, once the borehole has been advanced to the desired depth. If the borehole has been drilled to a depth greater than that at which the well is to be set, the borehole will be backfilled with bentonite pellets or a bentonite-cement slurry to a depth approximately 1 foot below the intended well depth. Approximately 1 foot of clean sand will be placed on top of the bentonite to return the borehole to the proper depth for well installation.

The appropriate lengths of well screen, nominally 10 feet (with bottom cap), and casing will be joined watertight and lowered inside the augers to the bottom of the borehole. Centering guides, if used, will be placed at the bottom of the screen and above the interval in which the bentonite seal is placed.

Selection of the filter pack and well screen intervals for the shallow monitoring wells shall be made in the field. Based on lithologic samples previously obtained at the site, and comparison with samples to be obtained in the well borings, standard well screen slot of 0.010-inch and silica sand gradations conforming to Morie No. 1 are anticipated.

A primary sand pack (Morie No. 1) consisting of clean silica sand will be placed around the well screen. The sand will be placed into the borehole at a uniform rate, in a manner that will allow even placement of the sand pack. The augers will be raised gradually during sand pack installation to avoid caving of the borehole wall; at no time will the augers be raised higher than the top of the sand pack during installation. During placement of the sand, the position of the top of the sand will be continuously sounded. The primary sand pack will be extended from the bottom of the borehole to a minimum height of 2 feet above the top of the well screen. A secondary, finer-grained, sand pack will be installed for a minimum of 1 foot above the coarse sand pack. Heights of the coarse and fine sand packs and bentonite seal may be modified in the field to account for the shallow water table and small saturated thickness of the surficial aquifer.

A bentonite pellet seal at least 2 feet thick will be placed above the sand pack. The pellets will be placed into the borehole in a manner that will prevent bridging. The position of the top of the bentonite seal will be verified using a weighted tape measure. If all or a portion of the bentonite seal is above the water table, clean water will be added to hydrate the bentonite. A hydration period of at least 30 minutes will be required following installation of the bentonite seal.

Above the bentonite seal, an annular seal of cement-bentonite grout will be placed. The cement-bentonite grout will be installed continuously in one operation from the bottom of the space to be grouted to the ground surface through a tremie pipe. The tremie pipe must be plugged at the bottom and have small openings along the sides of the bottom 1-foot length of pipe. This will allow the grout to diffuse laterally into the borehole and not disturb the bentonite pellet seal.

For monitoring wells that will be completed above-grade, a locking steel protective casing set in a concrete pad will be installed. The steel protective casing will extend at least 3 feet into the ground and 2 feet above ground but should not penetrate the bentonite seal. The concrete pad will be square or round, with a minimum radius of approximately 3.5 feet. The concrete will be sloped away from the protective casing.

Guard posts may be installed in high-traffic areas for additional protection. Four steel guard posts will be installed around the protective casing, within the edges of the concrete pad. Guard posts will be concrete-filled, at least 2 inches in diameter, and will extend at least 2 feet into the ground and 3 feet above the ground. The protective casing and guard posts will be painted with an epoxy paint to prevent rust.

For monitoring wells with flush-mount completions, Morrison 9-inch or 12-inch 519 manhole cover or equivalent, with a rubber-sealed cover and drain will be installed. The top of the manhole cover will be positioned approximately 1 inch above grade. A square concrete pad, approximately 3 feet per side, will be installed as a concrete collar surrounding the road box cover, and will slope uniformly downward to the adjacent grade. The road box and installation thereof will be of sufficient strength to withstand normal vehicular traffic.

Concrete pads installed at all wells will be a minimum of 6 inches below grade. The concrete pad will be 12-inches thick at the center and taper to 6-inch thick at the edge. The surface of the pad should slope away from the protective casing to prevent water from pooling around the casing. Protective casing, guard posts, and flush mounts will be installed into this concrete.

Each well will be properly labeled on the exterior of the locking cap or protective casing with a metal stamp indicating the permanent well number.

C. Well Development

Well development will be accomplished using a combination of surging throughout the well screen and pumping, until the physical and chemical parameters of the discharge water that are measured in the field have stabilized and the turbidity of the discharge water is substantially reduced. Fine-grained materials in the surficial aquifer at the site may not allow low turbidity results to be achieved.

The surging apparatus will include two surge blocks separated by approximately 2 feet of coarsely slotted pipe. The lower surge block will be solid; the upper surge block will be open and attached to riser pipe leading to the ground surface. Water will be pumped continuously from the surge block screened interval throughout the surging process. The pumping will be accomplished by airlift induction methods or using a centrifugal pump or equivalent.

Well development will begin by surging the well screen, starting at the bottom of the screen and proceeding upwards, throughout the screened zone.

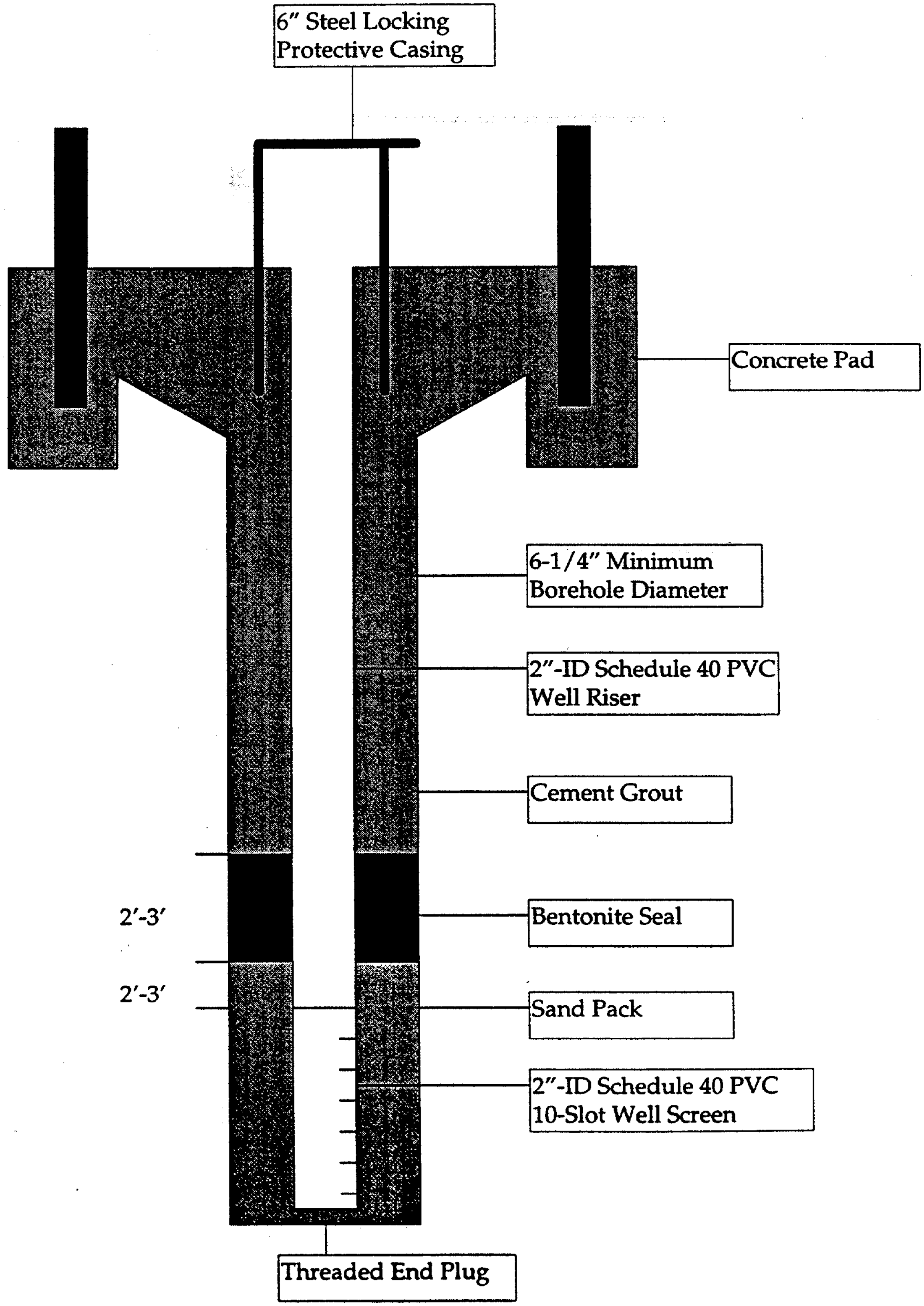
Following surging, the well will be pumped to remove the fine materials that have been drawn into the well. During pumping, measurements of pH, temperature, and specific conductance will be recorded.

Development will continue by alternately surging and pumping until the discharge water is free from sand and silt, the turbidity is substantially reduced, and the pH, temperature, and specific conductance have stabilized at regional background levels, based on historical data. Development will continue for a minimum of 30 minutes.

Well development equipment will be decontaminated prior to initial use and after the development of each well. Decontamination procedures are detailed in SOP Decontamination of Personnel and Equipment. Water generated during well development will be contained and managed as detailed in the Field Sampling Plan Investigation Derived Waste Management Plan.

IV. Attachments

Schematic diagram of shallow monitoring well construction



TYPICAL SHALLOW MONITORING WELL CONSTRUCTION

STANDARD OPERATING PROCEDURE

Installation of Groundwater Monitoring Wells by Sonic Drilling

I. Purpose and Scope

The purpose of this guideline is to describe methods for drilling and installation of groundwater monitoring wells and piezometers in unconsolidated or poorly consolidated materials using sonic drilling techniques. Sonic drilling technology eliminates telescoping monitoring wells, allowing the installation of aquifer penetrating, single-cased wells. Methods for drilling and installing bedrock monitoring wells are presented in SOP Installation of Bedrock Monitoring Wells.

II. Equipment and Materials

Drilling

- Sonic drilling rig
- Temporary outer steel casing
- Drill rods and core barrel

Well Riser/Screen

- Polyvinyl chloride (PVC), Schedule 40, minimum 2-inch ID, flush-threaded riser; alternatively, stainlesss steel riser
- PVC, Schedule 40, minimum 2-inch ID, flush-threaded, factory slotted screen; alternatively, stainless steel screen.

Bottom Cap

- PVC, threaded to match the well screen; alternatively, stainless steel
- Centering Guides (if used)

Well Cap

- Above-grade well completion: PVC, threaded or push-on type, vented
- Flush-mount well completion: PVC, locking, leak-proof seal
- Stainless steel to be used as appropriate

Sand

- Clean silica sand, provided in factory-sealed bags, well-rounded, containing no organic material, anhydrite, gypsum, mica, or calcareous material; primary (coarse) filter pack, and secondary (fine) filter pack. Grain size determined based on sediments observed during drilling.

Bentonite

- Pure, additive-free bentonite pellets
- Pure, additive-free powdered bentonite
- Coated bentonite pellets; coating must biodegrade within 7 days
- Cement-Bentonite Grout: proportion of 6 to 8 gallons of water per 94-pound bag of Portland cement; 3 to 6 pounds of bentonite added per bag of cement to reduce shrinkage

Protective Casing

- Above-grade well completion: 6-inch minimum ID steel pipe with locking cover, diameter at least 2 inches greater than the well casing, painted with epoxy paint for rust protection; heavy duty lock; protective posts if appropriate
- Flush-mount well completion: Morrison 9-inch or 12-inch 519 manhole cover, or equivalent; rubber seal to prevent leakage; locking cover inside of road box

Well Development

- Double surge block with solid bottom, top open, separated by 2 feet of slotted pipe
- Well-development pump, and associated equipment
- Containers (e.g., 55 gallon drums) for water produced from well.

III. Procedures and Guidelines

A. Drilling Method

Drill rods and core barrel with a minimum 8-inch inside diameter (ID) will be used to drill monitoring well boreholes. Continuous core soil samples (6-inches outside diameter) will be collected for lithologic classification and intervals selected for chemical analysis. Soil sampling procedures are detailed in SOP Shallow Soil Sampling.

The use of water and drilling fluid to assist in sonic drilling for monitoring well installation will be avoided, unless required for such conditions as running sands or drilling bedrock formations.

Temporary outer casing, drill rods, core barrels, and other downhole drilling tools will be properly decontaminated prior to the initiation of drilling activities and between each borehole location. Core barrels and other downhole soil sampling equipment will also be properly decontaminated before and after each use. SOP Decon details proper decontamination procedures.

Drill cuttings and decontamination fluids generated during well drilling activities will be contained according to the procedures detailed in the Field Sampling Plan.

B. Monitoring Well Installation

Sonic drilling technology eliminates the necessity to install double or triple cased wells since the borehole will be fully cased during drilling activities. Monitoring wells will be constructed inside the temporary outer casing, once the borehole has been advanced to the desired depth. Following setting the well screen, riser, filter pack, and bentonite seal, the well will be grouted as the temporary casing is withdrawn, preventing cross contamination. If the borehole has been drilled to a depth greater than that at which the well is to be set, the borehole will be backfilled with bentonite pellets or a bentonite-cement slurry to a depth approximately 1 foot below the intended well depth. Approximately 1 foot of clean sand will be placed on top of the bentonite to return the borehole to the proper depth for well installation.

The appropriate lengths of well screen, nominally 10 feet (with bottom cap), and casing will be joined watertight and lowered inside the temporary casing to the bottom of the borehole. Centering guides, if used, will be placed at the bottom of the screen and above the interval in which the bentonite seal is placed.

Selection of the filter pack and well screen intervals for the shallow monitoring wells shall be made in the field. Based on lithologic samples previously obtained at the site, and comparison with samples to be obtained in the well borings, standard well screen slot of 0.010-inch and silica sand gradations conforming to Morie No. 1 are anticipated.

A primary sand pack (Morie No. 1) consisting of clean silica sand will be placed around the well screen. The sand will be placed into the borehole at a uniform rate, in a manner that will allow even placement of the sand pack. The temporary casing will be raised gradually during sand pack installation to avoid caving of the borehole wall; at no time will the temporary casing be raised higher than the top of the sand pack during installation. During placement of the sand, the position of the top of the sand will be continuously sounded. The primary sand pack will be extended from the bottom of the borehole to a minimum height of 2 feet above the top of the well screen. A secondary, finer-grained, sand pack will be installed for a minimum of 1 foot above the coarse sand pack. Heights of the coarse and fine sand packs and bentonite seal may be modified in the field to account for the shallow water table and small saturated thickness of the surficial aquifer.

A bentonite pellet seal at least 2 feet thick will be placed above the sand pack. The pellets will be placed into the borehole in a manner that will prevent bridging. The position of the top of the bentonite seal will be verified using a weighted tape measure. If all or a portion of the bentonite seal is above the water table, clean water will be added to hydrate the bentonite. A hydration period of at least 30 minutes will be required following installation of the bentonite seal.

Above the bentonite seal, an annular seal of cement-bentonite grout will be placed. The cement-bentonite grout will be installed continuously in one operation from the bottom of the space to be grouted to the ground surface through a tremie pipe. The tremie pipe must be plugged at the bottom and have small openings along the sides of the bottom 1-foot length of pipe. This will allow the grout to diffuse laterally into the borehole and not disturb the bentonite pellet seal.

For monitoring wells that will be completed above-grade, a locking steel protective casing set in a concrete pad will be installed. The steel protective casing will extend at least 3 feet into the ground and 2 feet above ground but should not penetrate the bentonite seal. The concrete pad will be square or round, with a minimum radius of approximately 3.5 feet. The concrete will be sloped away from the protective casing.

Guard posts may be installed in high-traffic areas for additional protection. Four steel guard posts will be installed around the protective casing, within the edges of the concrete pad. Guard posts will be concrete-filled, at least 2 inches in diameter, and will extend at least 2 feet into the ground and 3 feet above the ground. The protective casing and guard posts will be painted with an epoxy paint to prevent rust.

For monitoring wells with flush-mount completions, Morrison 9-inch or 12-inch 519 manhole cover or equivalent, with a rubber-sealed cover and drain will be installed. The top of the manhole cover will be positioned approximately 1 inch above grade. A square concrete pad, approximately 3 feet per side, will be installed as a concrete collar surrounding the road box cover, and will slope uniformly downward to the adjacent grade. The road box and installation thereof will be of sufficient strength to withstand normal vehicular traffic.

Concrete pads installed at all wells will be a minimum of 6 inches below grade. The concrete pad will be 12-inches thick at the center and taper to 6-inch thick at the edge. The surface of the pad should slope away from the protective casing to prevent water from pooling around the casing. Protective casing, guard posts, and flush mounts will be installed into this concrete.

Each well will be properly labeled on the exterior of the locking cap or protective casing with a metal stamp indicating the permanent well number.

C. Well Development

Well development will be accomplished using a combination of surging throughout the well screen and pumping, until the physical and chemical parameters of the discharge water that are measured in the field have stabilized and the turbidity of the discharge water is substantially reduced.

Fine-grained materials in the surficial aquifer at the site may not allow low turbidity results to be achieved.

The surging apparatus will include two surge blocks separated by approximately 2 feet of coarsely slotted pipe. The lower surge block will be solid; the upper surge block will be open and attached to riser pipe leading to the ground surface. Water will be pumped continuously from the surge block screened interval throughout the surging process. The pumping will be accomplished by airlift induction methods or using a centrifugal pump or equivalent.

Well development will begin by surging the well screen, starting at the bottom of the screen and proceeding upwards, throughout the screened zone.

Following surging, the well will be pumped to remove the fine materials that have been drawn into the well. During pumping, measurements of pH, temperature, and specific conductance will be recorded.

Development will continue by alternately surging and pumping until the discharge water is free from sand and silt, the turbidity is substantially reduced, and the pH, temperature, and specific conductance have stabilized at regional background levels, based on historical data. Development will continue for a minimum of 30 minutes.

Well development equipment will be decontaminated prior to initial use and after the development of each well. Decontamination procedures are detailed in SOP Decontamination of Personnel and Equipment. Water generated during well development will be contained and managed as detailed in the Field Sampling Plan Investigation Denied Waste Management Plan.

IV. Attachments

Schematic diagram of shallow monitoring well construction

STANDARD OPERATING PROCEDURE

Bedrock Monitoring Well Installation

I. Purpose and Scope

The purpose of this procedure is to outline equipment and methods that will be used for bedrock well installation and development.

II. Equipment and Materials

- Drilling Rig
- Polyvinyl chloride (PVC), Schedule 40, minimum 2-inch ID, flush-threaded well casing
- PVC, Schedule 40, minimum 2-inch ID, flush-threaded, factory slotted well screen
- PVC, bottom cap, threaded to match the well screen.
- Centering Guides (if used). Same material as the casing, except stainless steel may be used in lieu of PVC.
- Above-grade well completion: PVC well cap, threaded or push-on type, vented.
- Flush-mount well completion: PVC well cap, locking, leak-proof seal.
- Clean silica sand, provided in factory-sealed bags, well-rounded, containing no organic material, anhydrite, gypsum, mica, or calcareous material; primary (coarse) filter pack, and secondary (fine) filter pack. Grain size determined based on sediments observed during drilling.
- Bentonite seal: Pure, additive-free bentonite pellets.
- Bentonite for grout: Pure, additive-free powdered bentonite.
- Cement-Bentonite Grout. Proportion 6 to 8 gallons of water per 94-pound bag of Portland cement; 3 to 10 pounds of bentonite added per bag of cement to reduce shrinkage.
- Above-grade protective casing: Permanent isolation casing with heavy duty locking cover, painted with epoxy paint for rust protection, industrial lock.
- Flush-mount protective casing: Morrison 9-inch or 12-inch 519 manhole cover; rubber seal for cover; heavy duty locking cap on permanent isolation casing.
- Double surge block with bottom solid, top open, separated by 2 feet of slotted pipe for well development

- Pump and associated development equipment
- Calibrated meters to ensure pH, temperature, specific conductance, Eh, and dissolved oxygen of development water
- Containerization for water produced from well

III. Procedures and Guidelines

A. Drilling Methods

Boreholes for the bedrock monitoring wells will be drilled in several stages.

Hollow-stem auger or rotasonic drilling, air rotary drilling, and surface casing installation procedures are detailed below.

1. Hollow Stem Auger Drilling

Hollow stem auger or rotasonic drilling techniques will be used to drill boreholes for installation of surface isolation casing. Eight-inch minimum ID HSA or 10-inch rotasonic drilling will be used to drill the borehole into competent bedrock. Lithologic samples also will be collected. Sampling procedures and frequency are outlined in the SAP.

The use of water or other fluid to assist in hollow stem drilling is to be avoided.

The bit of the auger is placed at the ground surface and then turned with the soil coring rig. To collect split spoon samples, the auger is advanced to the top of the sampling depth, and the split-spoon sample is collected from below the auger head. The split spoon is advanced through repeated blows from a 140- or 30-pound hammer dropped from a height of 30 inches.

During rotasonic drilling, a continuous core is collected, obviating the need to collect split-spoon samples.

Soil brought to the surface on the outside of the augers should be containerized at a convenient space away from the working area. Soil may be stored on plastic sheeting and containerized at the completion of activities at the well cluster.

2. Rotary Drilling

Air rotary or rotasonic drilling techniques will be used to install isolation casings and wells in each of the bedrock monitoring wells.

When the borehole is advanced from ground surface to bedrock for placement of a 8-inch ID surface casing, the borehole will have a minimum diameter of 10 inches. The borehole will extend a minimum of 5 feet into competent bedrock for seating of the surface casing.

When the borehole is advanced beyond the 8-inch surface casing, the borehole will have a nominal diameter of 8 inches.

The bit, drill rods, and other borehole rotary drilling equipment will be decontaminated prior to the initiation of drilling and between each borehole location, in accordance with the decontamination procedures detailed in SOP Decon. Prior to the continuation of rotary drilling in boreholes where a surface casing has been installed, the bit, drill rods, and other downhole rotary drilling equipment will be thoroughly decontaminated before being inserted into the borehole.

Drill cuttings and decontamination fluids generated during rotary drilling activities will be contained according to the procedures detailed in SOP Disposal of Waste Fluids and Solids and the IDWMP.

3. Surface Casing Installation

Surface casing will be constructed of 8-inch ID steel with a minimum wall thickness of 0.20 inches. Casing lengths will be welded or connected by threaded connections sealed with Teflon tape. The steel casing and threaded couplings must be free of paint, varnish, or coatings of any kind, both inside and outside. Threaded connections must be free of oils or grease. Welding of the casing is permissible provided that the welds meet the Standards of the American Welding Society. Surface casing will be decontaminated prior to installation in accordance with the procedures detailed in SOP Decontamination of Drilling Rigs and Equipment. The 8-inch ID surface casing will be installed in a minimum 10-inch diameter borehole, drilled at least 5 feet into competent bedrock.

The surface casing will be installed and grouted in place by a grout displacement method. The bottom of the surface casing is fitted with a tight, drillable plug. The borehole is then filled with the estimated volume of cement-bentonite grout to fill the annular space, and the casing is lowered to the bottom of the borehole (displacement method). If the weight of the casing is not sufficient to displace the grout and allow the casing to sink to the bottom of the borehole, the casing may be filled with clean water.

After the surface casing installation, the grout will be allowed to set up for at least 12 hours before drilling proceeds. The casings will be pressure tested by filling the casing with clean water to within a short distance of the top and pressurizing the casing to approximately 20 psi (net pressure above ambient groundwater). A pressure drop of less than 1 psi in 5 minutes will prove an adequate seal.

B. Monitoring Well Installation

The appropriate lengths of well screen, nominally 20 feet (with bottom cap), and casing will be joined watertight, and lowered to the bottom of the borehole. Centering guides they will be placed at intervals around the well casing, at the base of the screen, and 5 feet above the top of the well screen.

Selection of final filter pack and well screen depths for the wells shall be made in the field.

A primary sand pack consisting of clean Morie No. 1 silica sand will be placed around the well screen. The sand will be placed into the borehole at a uniform rate, in a manner that will allow even placement of the sand pack. During placement of the sand, the position of the top of the sand will be continuously sounded using a stainless steel weight attached to a fiberglass tape measure. The primary sand pack will be extended from the bottom of the borehole to a minimum height of 2 feet above the top of the well screen. A secondary (fine) sand pack will then be installed to a minimum of 1 foot above the primary sand pack.

A bentonite pellet seal at least 2 feet thick will be placed above the sand pack. The pellets will be placed into the borehole in a manner that will prevent bridging. The position of the top of the bentonite seal will be verified using a weighted tape measure. A hydration period of at least 30 minutes will be allowed following installation of the bentonite seal.

Above the bentonite seal, an annular seal of cement-bentonite grout will be placed. The cement-bentonite grout will be installed continuously in one operation from the top of the bentonite seal to the ground surface. The cement-bentonite grout will be installed through a tremie pipe. The tremie pipe must be plugged at the bottom. Small openings along the bottom 1-foot length of pipe will allow the grout to diffuse laterally into the borehole and to avoid disturbance the bentonite pellet seal.

For dual-well bedrock monitoring sets, two wells will be installed in the same bedrock borehole in four stages as follows:

Stage 1 - A pilot hole will be drilled using hollow-stem augers (or similar method) with continuous split-spoon sampling from the ground surface to auger refusal to characterize the physical profile of the overburden. The pilot hole will be reamed out to 10 to 12-inches in diameter and deepened approximately 5 feet into competent bedrock using air-rotary drilling. An 8-inch diameter temporary surface casing will be installed and grouted in place. Each borehole then will be drilled to 250 feet bgs using 8-inch nominal air-rotary.

Stage 2 - After determining the presence of NAPL(s), each borehole will be characterized using downhole geophysical surveys. A downhole video, caliper log, temperature log, and fluid resistivity log will be used to locate bedrock fractures and areas of groundwater through-flow in each borehole.

Stage 3 - Up to five of the most significant zones of groundwater through-flow in each borehole will be sampled using an inflatable straddle packer assembly. The samples will be analyzed on a 2-day quick turn-around basis for VOCs and SVOCs.

Stage 4 - For each of the two most contaminated zones in each bedrock borehole, a 2-inch-ID PVC monitoring well will be constructed, each with 20-foot screened intervals centered across the selected zone. Both PVC wells will be constructed within the same 8-inch diameter bedrock borehole. The two zones will be selected such that there is sufficient separation between the bottom of the shallow bedrock well screen and the top of the deep bedrock well screen to enable grouting between the two screens. Grout entry into the screened intervals will be prevented by installing bentonite seals and sand pack above and below the grouted interval. The screened interval will be sand packed and the remaining annulus will be sealed with bentonite and cement-bentonite grout. If no contamination is detected during packer sampling the lowermost and uppermost significant water-producing zones in the borehole will be screened.

For monitoring wells that will be completed above-grade, the surface casing itself will serve as the protective casing. The surface casing will be finished 2 to 3 feet above grade and fitted with a locking steel cap. A concrete pad with four guard posts will be installed.

The concrete pad will be square, approximately 3 feet per side, poured into wooden forms. The concrete will be sloped away from the protective casing. The concrete pad will extend at least 6 inches below and 6 inches above the ground surface.

Four steel guard posts will be installed around the locking casing, within the edges of the concrete pad. Guard posts would be concrete-filled, at least 2 inches in diameter, and would extend at least 2 feet into the ground and 3 feet above the ground. The protective casing and guard posts will be painted with an epoxy paint to prevent rust.

For monitoring wells with flush-mount completions, a Morrison 519 manhole cover with a rubber-sealed cover and drain will be installed. The top of the manhole will be positioned approximately 1 inch above grade. A square concrete pad, approximately 3 feet per side, will be installed as a concrete collar surrounding the road box cover, and will slope uniformly downward to the adjacent grade. The road box and installation thereof will be of sufficient strength to withstand normal vehicular traffic. The concrete pad will extend at least 12 inches below the ground surface.

Inside the manhole, a locking cap will be placed over the permanent casing.

Each well will be labeled on the exterior of the locking cap with a metal stamp indicating the permanent well number.

STANDARD OPERATING PROCEDURE

General Guidance for Monitoring Well Installation

I. Purpose

To provide site personnel with a review of the well installation procedures that will be performed. These procedures are to be considered general guidelines only and are in no way intended to supplement or replace the contractual specifications in the driller's subcontract.

II. Scope

Bedrock well installations and shallow unconsolidated well installations are planned.

III. Equipment and Materials

IV. Procedures and Guidelines

1. Wells will be installed in accordance with standard EPA procedures. Note that USEPA Region III requires any well penetrating a confining layer to be double cased.
2. The threaded connections will be water-tight.
3. Shallow well screens will be constructed of 0.010 slot Schedule 40 PVC and will be 5 to 10 feet in length depending on saturated thickness of unconsolidated sediments. The exact length will be determined by the field team supervisor.
4. Wells will be surrounded by three concrete-filled, 4-inch diameter guard posts.
5. A record of the finished well construction will be compiled.
6. All soils and liquids generated during well installations will be drummed for proper disposal.

Shallow Unconsolidated Well Installation

- Monitoring wells in unconsolidated materials will be installed in at least 6-inch-diameter boreholes to accommodate well completion materials in designated locations.
- Unconsolidated monitoring wells will be constructed of 2-inch-diameter, factory manufactured, flush-jointed, schedule 40 PVC screen with threaded bottom plug and riser.
- Screens will be filter packed with a proper sized and graded, thoroughly washed, sound, durable, well-rounded basalt or siliceous sand.
- The filter pack will extend from 1 to 2 feet below the base to 2 feet above the top of the screen; filter pack will be allowed to settle before final measurement is taken.
- Annular well seals will consist of 2 feet of pelletized bentonite clay and placed above the filter pack.
- The top of the annular seal will be measured after the pellets have been allowed to settle and before the grout is applied.
- The annular space above the bentonite seal will be filled to grade with a bentonite-cement slurry grout mixture.
- The grout mixture consists of 94 lbs of cement (1 bag) per 6 gallons of water and 2 to 3 lbs of powdered bentonite per bag of cement to reduce shrinkage.
- The grout mix will be carefully applied to avoid disturbing the bentonite seal; the method of grout placement must force grout from the bottom of the space to be grouted to the surface.
- After allowing the grout to settle overnight, additional grout will be added to maintain grade.
- A protective steel casing equipped with keyed alike locking caps will be grouted in place for each new well; the casing will extend at least 2 feet above grade and painted a bright color.

Well Development

- New monitoring wells will be developed after the well has been completely installed and the grout has hardened (at least 24 hours)
- The well will be developed by surging and pumping.
- Equipment placed in the well will be decontaminated before use.
- Development will include surging the well by abruptly stopping flow and allowing water in the well column to fall back into the well.

- Pipes and pumps must not be fitted with foot valves or other devices that might inhibit the return flow of water to the well.
- Surging should continue throughout the development process.
- The air lift method will be used to pump materials out of the well. The air compressor will be fitted with filters to remove all oil and the air lift hose used will be made of inert materials.
- Well development will continue until the water produced is free of turbidity, sand, and silt.
- Development water will be considered hazardous and placed in sealed 55-gallon U.S. DOT approved steel drums supplied by CH2M HILL. CH2M HILL will label and date the drums, and transport the drums to a designated site for storage.

V. Attachments

None.

VI. Key Check and Items

STANDARD OPERATING PROCEDURE

Water-Level Measurements

I. Purpose and Scope

The purpose of this procedure is to provide a guideline for the measurement of the depth to groundwater in monitoring wells, where a second phase of floating liquid (e.g., gasoline) is not encountered. This SOP includes guidelines for discrete measurements of static water levels and does not cover the use of continuously recording loggers.

II. Equipment and Materials

- Electronic water level meter, Solinst or equivalent, with a minimum 100-foot tape; the tape should have graduations in increments of 0.01 feet or less

III. Procedures and Guidelines

Verify that the unit is turned on and functioning properly. Slowly lower the probe on its cable into the well until the probe just contacts the water surface; the unit will respond with a tone or light signal. Sight across the top of the locking well casing adjacent to the measuring point, recording the position of the cable when the probe is at the water surface. The measuring point will be a standardized surveyed location on the top of each well casing, adjacent to the lock hasp, indicated by a notch, paint mark, or similar method. Measure the distance from this point to the closest interval marker on the tape, and record the water level reading in the log book.

Measure and record the three following additional readings: (1) the depth of the well; (2) the depth from the top of the casing to the top of the well riser; and (3) the distance to the surface of the concrete pad or to ground. Measurements are to be taken with respect to the measuring point on the top of the well casing. The depth of the well may be measured using the water-level probe with the instrument turned off.

IV. Attachments

None.

V. Key Checks and Preventative Maintenance

Prior to each use, verify that the battery is charged by pressing the test button on the water-level meter. Verify that the unit is operating correctly by testing the probe in distilled or deionized water. Leave the unit turned off when not in use.

STANDARD OPERATING PROCEDURE

Field Rinse Blank Preparation

I. Purpose

To prepare a blank to determine adequacy of decon procedures and whether any cross-contamination is occurring during sampling.

II. Scope

The general protocols for preparing the rinse blank are outlined. The actual equipment to be rinsed will depend on the requirements of the specific sampling procedure.

III. Equipment and Materials

- Blank liquid (use ASTM Type II grade water)
- Sample bottles as appropriate
- Gloves
- Preservatives as appropriate

IV. Procedures and Guidelines

A. Decontaminate all sampling equipment that has come in contact with sample according to SOP Decontamination of Personnel and Equipment.

B. To collect the sample for volatiles analysis, pour blank water over one piece of equipment and into 40-ml vials until there is a positive meniscus and seal vials. Note the sample number and associated piece of equipment in the field notebook.

For non-volatiles, one aliquot is to be used for equipment. For example, if a pan and trowel are used, place trowel in pan and pour blank fluid in pan such that pan and trowel surfaces which contacted the sample are contacted by the blank fluid. Pour blank fluid from pan into appropriate sample bottles.

Do not let the blank fluid come in contact with any equipment that has not been decontaminated.

C. Document and ship samples in accordance with the procedures for other samples.

D. Collect next field sample.

V. Attachments

None.

VI. Key Checks and Items

- Wear gloves.
- Do not use any non-decontaminated equipment to prepare blank.
- Use ASTM-Type II grade water.

STANDARD OPERATING PROCEDURE

Field Filtering

I. Purpose

To provide a general guideline for the field filtering of water samples for dissolved metals analysis.

II. Scope

This is a general discussion of the standard method of field filtering techniques. Operating manuals should be consulted regarding specific procedures.

III. Equipment and Materials

- Geotech Filtering apparatus or equivalent
- Pump
- nitric acid (HNO_3) solution - high grade - reagent grade not acceptable
- Glass fiber prefilters
- Vacuum source
- 45 µm cellulose acetate filters
- inline filters

IV. Procedures and Guidelines

A. REAGENT PREPARATION

1. 10% HNO_3 solution: Add about 900 ml of ASTM Type II water to a 1 liter Erlenmeyer flask. Using a graduated cylinder, ASTM Type II, add 100 ml concentrated HNO_3 to the DI water while stirring.

B. PROCEDURE

1. Attach a vacuum source (pump, syringe, etc.) or a Q.E.D. online filter or equivalent to the receiver assembly.

2. Flush the entire filter system with 10% HNO_3 solution. Open assembly, discard rinsate, and reassemble unit.

3. Flush the entire filter system with 60 ml ASTM Type II water. Open assembly, discard rinsate and reassemble unit (not required when using Q.E.D. online filter).

4. Filter sample and transfer to polyethylene bottle (with preservative) for shipment.

5. Discard filter assembly and prefilter.

V. Attachments

None.

VI. Key Checks and Items

- 10% HNO_3 solution for cleaning
- All water must be ASTM Type II
- Prefilter with glass fiber filters if sample is turbid
- Record lot number of nitric acid and water
- Note monitoring wells with high concentrations of suspended solids in field notebooks
- The equipment blank collected with the sample is called a filtration blank and is collected through the filter.

STANDARD OPERATING PROCEDURE

Homogenization of Soil and Sediment Samples

I. Purpose

The homogenization of soil and sediment samples is performed to minimize any bias of sample representativeness introduced by the natural stratification of constituents within the sample.

II. Scope

Standard techniques for soil and sediment homogenization and equipment are provided in this SOP. These procedures do not apply to aliquots collected for TCL VOCs or field GC screening; samples for these analyses should NOT be homogenized.

III. Equipment and Materials

Sample containers, stainless steel spoons or spatulas, and stainless steel pans.

IV. Procedures and Guidelines

Soil and sediment samples to be analyzed for semivolatiles, pesticides, PCBs, metals, cyanide, or field XRF screening should be homogenized in the field. After a sample is taken, a stainless steel spatula should be used to remove the sample from the split spoon or other sampling device. The sampler should not use fingers to do this, as gloves may introduce organic interferences into the sample.

Samples for VOCs should be taken immediately upon opening the spoon and should not be homogenized.

Prior to homogenizing the soil or sediment sample, any rocks, twigs, leaves, or other debris should be removed from the sample. The sample should be placed in a decontaminated stainless steel pan and thoroughly mixed using a stainless steel spoon. The soil or sediment material in the pan should be scraped from the sides, corners, and bottom, rolled into the middle of the pan, and initially mixed. The sample should then be quartered and moved to the four corners of the pan. Each quarter of the sample should be mixed individually, and then rolled to the center of the pan and mixed with the entire sample again.

All stainless steel spoons, spatulas, and pans must be decontaminated following procedures specified in SOP Decontamination of Personnel and Equipment prior to homogenizing the sample. A composite equipment rinse blank of homogenization equipment should be taken each day it is used.

STANDARD OPERATING PROCEDURE

Packaging and Shipping Procedures

I. Low-Concentration Samples

A. Prepare coolers for shipment:

- Tape drains shut.
- Affix "This Side Up" labels on all four sides and "Fragile" labels on at least two sides of each cooler.
- Place mailing label with laboratory address on top of coolers.
- Fill bottom of coolers with about 3 inches of vermiculite.

B. Arrange decontaminated sample containers in groups by sample number. Consolidate VOC samples into one cooler to minimize the need for trip blanks.

C. Affix appropriate adhesive sample labels to each container. Protect with clear label protection tape.

D. Seal each sample bottle within a separate ziplock plastic bag or bubble wrap, if available. Tape the bag around bottle. Sample label should be visible through the bag.

E. Arrange sample bottles in coolers so that they do not touch.

F. If ice is required to preserve the samples, cubes should be repackaged in zip-lock bags and placed on and around the containers.

G. Fill remaining spaces with vermiculite.

H. Complete and sign chain-of-custody form (or obtain signature) and indicate the time and date it was relinquished to Federal Express or the courier.

I. Separate copies of forms. Seal proper copies (traffic reports, packing lists) along with a return address label within a large zip-lock bag and tape to inside lid of cooler.

J Close lid and latch.

K. Carefully peel custody seals from backings and place intact over lid openings (right front and left back). Cover seals with clear protection tape.

L. Tape cooler shut on both ends, making several complete revolutions with strapping tape. **Do not** cover custody seals.

M. Relinquish to Federal Express or to a courier arranged with the laboratory. Place airbill receipt inside the mailing envelope and send to the sample documentation coordinator along with the other documentation.

II. Medium- and High-Concentration Samples:

Medium- and high-concentration samples are packaged using the same techniques used to package low-concentration samples, with several additional restrictions. First, a special airbill including a Shipper's Certification for Restricted Articles is required. Second, "Flammable Liquid N.O.S." or "Flammable Solid N.O.S." (as appropriate) labels must be placed on at least two sides of the cooler. Third, sample containers are packaged in metal cans with lids before being placed in the cooler, as indicated below:

- Place approximately ½ inch of vermiculite in the bottom of the can.
- Position the sample jar in the zip-loc bag so that the sample tags can be read through the plastic bag.
- Place the jar in the can and fill the remaining volume with vermiculite.
- Close the can and secure the lid with metal clips.
- Write the traffic report number on the lid.
- Place "This Side Up" and "Flammable Liquid N.O.S." or "Flammable Solid N.O.S." (as appropriate) labels on the can.
- Place the cans in the cooler.
- For medium concentration samples, ship samples with ice or "blue ice" inside the coolers. (Double bag ice in zip-lock plastic bags.)

III. Special Instructions for Shipping Medium and High Concentration Samples by Federal Express

A. Label cooler as hazardous shipment:

- Write shipper's address on outside of cooler. If address is stenciled on, just write "shipper" above it.
- Write or affix sticker saying "This Side Up" on two adjacent sides.
- Write or affix sticker saying "ORM-E" with box around it on two adjacent sides. Below ORM-E, write NA#9188.
- Label cooler with "Hazardous Substance, N.O.S." and "liquid" or "solid," as applicable.

B. Complete the special shipping bill for restricted articles.

- Under Proper Shipping Name, write "Hazardous Substance, N.O.S." and "liquid" or "solid," as applicable.
- Under Class, write "ORM-E.
- "Under Identification No., write NA No. 9188.

C. For high concentration samples, ship samples with "blue ice" only inside coolers.

STANDARD OPERATING PROCEDURE

Decontamination of Drilling Rigs and Equipment

I. Purpose and Scope

The purpose of this guideline is to provide methods for the decontamination of drilling rigs, downhole drilling tools, and water-level measurement equipment. Personnel decontamination procedures are not addressed in this SOP; refer to the site safety plan and SOP Decontamination of Personnel and Equipment. Sample bottles will not be field decontaminated; instead they will be purchased with certification of laboratory sterilization.

II. Equipment and Materials

- Portable steam cleaner and related equipment
- Potable water
- Phosphate-free detergent such as Alconox or Liquinox
- Buckets
- Brushes
- Distilled organic-free water
- Methanol, pesticide grade
- Six-molar nitric acid, analytical grade
- ASTM–Type II grade water
- Aluminum foil

III. Procedures and Guidelines

A. Drilling Rigs and Monitoring Well Materials

Prior to the onset of drilling, after each borehole, prior drilling through permanent isolation casing, and prior to leaving the site, heavy equipment and machinery will be decontaminated by steam cleaning at a designated area. The steam cleaning area will be designed to contain decontamination wastes and waste waters and can be a HDPE-lined, bermed pad. A pumping system will be used to convey decontaminated water from the pad to drums.

Surface casings may be steam cleaned in the field if they are exposed to contamination at the site prior to use.

B. Downhole Drilling Tools

Downhole tools will be steam cleaned prior to the onset of drilling, prior to drilling through permanent isolation casing, and between boreholes. This will include, but is not limited to, rods, split-spoons or similar samplers, coring equipment, augers, and casing.

Prior to the use of a sampling device such as a split-spoon sampler for the collection of a soil sample for physical characterization, the sampler shall be cleaned by scrubbing with a detergent solution followed by a potable water rinse.

Prior to the use of a sampling device such as a split-spoon sampler for the collection of a soil sample for chemical analysis, the sampler shall be decontaminated following the procedures outlined in the following subsection.

C. **Field Analytical Equipment**

1. Water Level Indicators

Water level indicators that consist of a probe that comes into contact with the groundwater must be decontaminated using the following steps:

a. Rinse with tap water
b. Rinse with deionized water
c. Solvent rinse with methanol
d. Rinse with deionized water

2. Probes

Probes, for example, pH or specific ion electrodes, geophysical probes, or thermometers that would come in direct contact with the sample, will be decontaminated using the procedures specified above unless manufacturer's instructions indicate otherwise. For probes that make no direct contact, for example, OVM equipment, the probe will be wiped with clean paper-towels or cloth wetted with methanol.

IV. Attachments

None.

V. Key Checks and Preventative Maintenance

The effectiveness of field cleaning procedures will be monitored by rinsing decontaminated equipment with organic-free water and submitting the rinse water in standard sample containers for analysis. Any time a sampling event occurs, at least one such quality control sample shall be collected. The total number of equipment blanks will be at least 5 percent of the number of samples collected during large-scale field sampling efforts.

At least one piece of field equipment shall be selected for this procedure each time equipment is washed. An attempt should be made to select different pieces of equipment for this procedure.

STANDARD OPERATING PROCEDURE

Decontamination of Personnel and Equipment

I. Purpose

To provide general guidelines for the decontamination of personnel, sampling equipment, and monitoring equipment used in potentially contaminated environments.

II. Scope

This is a general description of decontamination procedures.

III. Equipment and Materials

- Demonstrated analyte-free, deionized ("DI") water (specifically, ASTM Type II water)
- Distilled water
- Potable water; must be from a municipal water supplier, otherwise an analysis must be run for appropriate volatile and semivolatile organic compounds and inorganic chemicals (e.g., Target Compound List and Target Analyte List chemicals)
- 2.5% (W/W) trisodium phosphate ("TSP") and water solution
- Concentrated (V/V) pesticide grade methanol (DO NOT USE ACETONE)
- 10% (V/V) nitric acid (HNO_3) and water solution (only ultrapure grade HNO_3 is to be used)
- Large plastic pails or tubs for TSP and water, scrub brushes, squirt bottles for TSP, methanol and water, plastic bags and sheets
- DOT approved 55-gallon drum for disposal of waste
- Phthalate-free gloves
- Decontamination pad and steam cleaner/high pressure cleaner for large equipment

IV. Procedures and Guidelines

A. PERSONNEL DECONTAMINATION

To be performed after completion of tasks whenever potential for contamination exists, and upon leaving the exclusion zone.

1. Wash boots in TSP solution, then rinse with water. If disposable latex booties are worn over boots in the work area, rinse with TSP solution, remove, and discard into DOT approved 55-gallon drum.
2. Wash outer gloves in TSP solution, rinse, remove, and discard into DOT approved 55-gallon drum.
3. Remove disposable coveralls ("Tyveks") and discard into approved 55-gallon drum.
4. Remove respirator (if worn).
5. Remove inner gloves and discard.
6. At the end of the work day, shower entire body, including hair, either at the work site or at home.
7. Sanitize respirator if worn.

B. SAMPLING EQUIPMENT DECONTAMINATION—GROUNDWATER SAMPLING PUMPS

Sampling pumps are decontaminated after each use as follows.

1. Don phthalate-free gloves.
2. Spread plastic on the ground to keep hoses from touching the ground
3. Turn off pump after sampling. Remove pump from well and place pump in decontamination tube, making sure that tubing does not touch the ground
4. Turn pump back on and pump 1 gallon of TSP solution through the sampling pump.
5. Rinse with 1 gallon of 10% methanol solution pumped through the pump. (DO NOT USE ACETONE).
6. Rinse with 10% HNO_3 solution pumped through the pump, when sampling for inorganics (carbon steel split spoons will be rinsed with a 1% solution).
7. Rinse with 1 gallon of tap water.
8. Rinse with 1 gallon of deionized water.
9. Keep decontaminated pump in decontamination tube or remove and wrap in aluminum foil or clean plastic sheeting.

10. Collect all rinsate and dispose of in a DOT approved 55-gallon drum.

C. SAMPLING EQUIPMENT DECONTAMINATION—OTHER EQUIPMENT

Reusable sampling equipment is decontaminated after each use as follows.

1. Don phthalate-free gloves.
2. Prior to entering the potentially contaminated zone, wrap soil contact points in aluminum foil (shiny side out).
3. Rinse and scrub with potable water.
4. Wash all equipment surfaces that contacted the potentially contaminated soil/water with TSP solution.
5. Rinse with potable water.
6. Rinse with 10% HNO_3 solution when sampling for inorganics (carbon steel split spoons will be rinsed with a 1% solution).
7. Rinse with distilled or potable water and methanol solution (DO NOT USE ACETONE).
8. Air dry.
9. Rinse with deionized water.
10. Completely air dry and wrap exposed areas with aluminum foil (shiny side out) for transport and handling if equipment will not be used immediately.
11. Collect all rinsate and dispose of in a DOT approved 55-gallon drum.

D. HEALTH AND SAFETY MONITORING EQUIPMENT DECONTAMINATION

1. Before use, wrap soil contact points in plastic to reduce need for subsequent cleaning.
2. Wipe all surfaces that had possible contact with contaminated materials with a paper towel wet with TSP solution, then a towel wet with methanol solution, and finally three times with a towel wet with distilled water. Dispose of all used paper towels in a DOT approved 55-gallon drum.

E. SAMPLE CONTAINER DECONTAMINATION

The outsides of sample bottles or containers filled in the field may need to be decontaminated before being packed for shipment or handled by personnel without hand protection. The procedure is:

1. Wipe container with a paper towel dampened with TSP solution or immerse in the solution AFTER THE CONTAINERS HAVE BEEN

SEALED. Repeat the above steps using potable water.

2. Dispose of all used paper towels in a DOT approved 55-gallon drum.

F. HEAVY EQUIPMENT AND TOOLS

Heavy equipment such as drilling rigs, drilling rods/tools, and the backhoe will be decontaminated upon arrival at the site and between locations as follows:

1. Set up a decontamination pad in area designated by the Navy

2. Steam clean heavy equipment until no visible signs of dirt are observed. This may require wire or stiff brushes to dislodge dirt from some areas.

V. Attachments

None.

VI. Key Checks and Items

- Clean with solutions of TSP, methanol, nitric acid, and distilled water.
- Do not use acetone for decontamination.
- Drum all contaminated rinsate and materials.
- Decontaminate filled sample bottles before relinquishing them to anyone.

STANDARD OPERATING PROCEDURE

Disposal of Fluids and Solids

I. Purpose and Scope

This SOP describes the procedures used to dispose of hazardous fluid and solid materials generated as a result of the site operations. This SOP does not provide guidance on the details of Department of Transportation regulations pertaining to the transport of hazardous wastes; the appropriate Code of Federal Regulations (49 CFR 171 through 177) should be referenced.

II. Equipment and Materials

A. Fluids

- 55-gallon steel drums or Baker® Tanks
- Tools for securing drum lids
- Funnel for transferring liquid into drum
- Labels
- Marking pen for appropriate labels
- Seals for 55-gallon steel drums

B. Solids

- 55-gallon steel drums or rolloffs
- Tools for securing drum lids
- Plastic sheets
- Labels
- Marking pen for appropriate labels

III. Procedures and Guidelines

A. Methodology

Clean, empty drums or rolloffs or Baker® Tanks will be brought to the site by the drilling subcontractor for soil and groundwater collection and storage. The empty drums will be located at the field staging area and moved to drilling locations as required. The drums will be filled with the drilling and well installation wastes, capped, sealed, and moved to the onsite drum storage area by the drilling subcontractor. The full drums will separate types of wastes by media. The drums will be labeled as they are filled in the field and labels indicating that the contents are potentially hazardous affixed.

The drum contents will be sampled to determine the disposal requirements of the drilling wastes. The drum sampling will be accomplished through the collection and submittal of composite samples as a series of 10 drums containing the same media.

Similar compositing will be performed in each rolloff to obtain a representative sample. The compositing of the sample will be accomplished through the collection of a specific volume of the material in each drum into a large sample container. When samples from each of the drums being sampled in a single compositing are collected, the sample will be submitted for TCLP, ignitability, corrosivity, and reactivity analysis. The analysis will be used to determine if drilling wastes are covered by land disposal restrictions.

If rolloffs are used, compositing and sampling of soil will comply with applicable state and federal regulations.

B. Labels

Drums and other containers used for storing wastes from drilling operations will be labeled when accumulation in the container begins. Labels will include the following minimum information:

- Container number
- Container contents
- Origin (source area including individuals wells, piezometers, and soil borings)
- Date that accumulation began
- Date that accumulation ended
- When laboratory results are received, drum labels will be completed or revised to indicate the hazardous waste constituents in compliance with Title 40 of the Code of Federal Regulations, Part 262, Subpart C.

C. Fluids

Drilling fluids generated during soil boring and groundwater discharged during development and purging of the monitoring wells will be collected in 55-gallon, closed-top drums. When a drum is filled, the bung will be secured tightly. Fluids may also be transferred to Baker® Tanks after being temporarily contained in drums to minimize the amount of drums used.

When development and purging is completed, the water will be tested for appropriate hazardous waste constituents. Compositing and sampling of fluids will comply with applicable state and federal regulations.

D. Solids

The soil cuttings from well and boring drilling will constitute a large portion of the solids to be disposed of.

The solid waste stream also will include plastic sheeting used for decontamination pads, tyveks, disposable sampling materials, and any other disposable material used during the field operations that appears to be contaminated. These materials will be placed in designated drums.

E. Storage and Disposal

The wastes generated at the site at individual locations will be transported to the fenced drum storage area by the drilling services subcontractor.

Waste solid materials that contain hazardous constituents will be disposed of at an offsite location in a manner consistent with applicable solid waste, hazardous waste, and water quality regulations. Transport and disposal will be performed by a commercial firm under subcontract.

IV. Attachments

None.

V. Key Checks and Preventative Maintenance

Check that representative samples of the containerized materials are obtained.

STANDARD OPERATING PROCEDURE

Civil Surveying

I. Surveying: General

Modified third order survey procedures will be used for all surveying.

II. Records

All field notes should be kept in bound books. Each book should have an index. Each page of field notes should be numbered and dated and should show the initials of all crew members. The person talking field notes will be identified in the log. Information on weather (wind speed/wind direction, cloud cover, etc.) and on other site conditions should also be entered in the notes. Notes should also include instrument field I.D. number and environmental settings. Graphite pencils or waterproof ballpoint pens should be used. Erasing is not acceptable; use a single-strike-through and initial it. The notekeeping format should conform to the *Handbook of Survey Notekeeping* by William Pafford. A survey work drawing with grid lines and at the scale of the topographic map should be prepared for all survey field work. (Field notebooks will be available on site.)

III. Traverse Survey

Horizontal angular measurements shall be made with a 20-second or better theodolite or transit. When using a 20-second instrument the horizontal angles shall be turned 4 times, (2 each direct and inverted) with the mean of the fourth angle being within 5 seconds of the mean of the second angle. When using a 10 second or better instrument the angles shall be doubled, (once each direct and inverted) with the mean of the second angle within 5 seconds of the first angle. Minimum length of any traverse courses shall be 300 feet.

Distance measurements shall be made with a calibrated steel tape corrected for temperature and tension or a calibrated electronic distance meter (EDM). When using a EDM the parts per million (PPM), curvature and refraction corrections shall be made. Vertical angle measurements used for distance slope corrections shall be recorded to the nearest 20 seconds of arc deviation from the horizontal plane.

Horizontal traverse stations shall be established and referenced for future use. All stations shall be described in the field notes with sufficient detail to facilitate their recovery at a later date. The station shall consist of a permanent mark scribed on facilities such as sidewalks, curbs, concrete slabs, or iron rod and cap.

Vertical Survey

When practical, vertical control will be referenced to the National Geodetic Vertical Datum (NGVD) of 1929, obtained from a permanent bench mark. If practical, level circuits should close on a known bench mark other than the starting bench mark. The following criteria shall be met in conducting the survey:

- Instruments shall be pegged weekly or after any time it is dropped or severely jolted.
- Foresight and backsight distances shall be reasonably balanced and shall not be greater than 250 feet in length.
- No side shot shall be used as a beginning or ending point in another level loop.
- Rod readings shall be made to 0.01 foot and estimated to 0.005 feet.
- Elevations shall be adjusted and recorded to 0.01 foot.

Temporary bench marks (TBMs) shall be established and referenced for future use. All TBMs shall be described in the field notes with sufficient detail to facilitate their recovery at a later date. The TBMs shall consist of a permanent mark scribed on facilities such as sidewalks, curbs, concrete slabs, etc. or spikes set in the base of trees (not power poles), or tops of anchor bolts for transmission line towers, etc. (Horizontal traverse stations will not be considered as a TBM, but may be used as a permanent turning point.)

Traverse Computations and Adjustments

Traverses will be closed and adjusted in the following manner:

- Step One—Coordinate closures will be computed using unadjusted bearings and unadjusted field distances.
- Step Two—Coordinate positions will be adjusted (if the traverse closes within the specified limits) using the compass rule.
- Step Three—Final adjusted coordinates will be labeled as "adjusted coordinates." Field coordinates should be specifically identified as such.
- Step Four—The direction and length of the unadjusted error of closure, the ratio of error, and the method of adjustment shall be printed with the final adjusted coordinates.

Level Circuit Computations and Adjustments

Level circuits will be closed and adjusted in the following manner:

- For a single circuit, elevations will be adjusted proportionally, provided the raw closure is within the prescribed limits for the circuit.
- In a level net where the elevation of a point is established by more than one circuit, the method of adjustment should consider the length of each circuit, the

closure of each circuit, and the combined effect of all the separate circuit closures on the total net adjustments.

Monitoring Well Surveys

Monitoring well locations will be surveyed only after the installation of the well casing, (with its tamper-proof locking cover), which is set in concrete. The horizontal plane survey accuracy is ±1 foot and is measured to any point on the well casing cover. The vertical plane survey must be accurate to ±0.01 foot. The following two elevations will be measured:

- Top of the outer protective casing (on the lip next to the lock hasp, not the cap).
- Ground surface (on the north side of the well).

If no notch or mark exists, the point at which the elevation was measured on the inner casing, shall be described so that water level measurements may be taken from the same location. Wells will not be opened because of health and safety concerns.

Grid Surveys

Selected soil boring locations may be located by the survey crew after the soil borings are complete. The selected borings will be staked in the field by the field team leader. The stake will be marked with the boring number for reference. The horizontal plane survey accuracy is ± 1 foot and is measured to any point on the ground surface immediately adjacent to the stake.

Exhibit A
STANDARDS FOR MODIFIED THIRD-ORDER PLANE SURVEYS

Traverse

Max Number of bearing courses between azimuth checks	30
Astronomical bearings: standard error of results	6"
Azimuth closure at azimuth checkpoint not to exceed	20" $\sqrt{N}$
Standard error of the mean for length measurements	1 in 50,000
Position closure per loop in feet before azimuth adjustment	1:10,000

Leveling

Levels error of closure per loop in feet	0.05 $\sqrt{M}$

N = the number of stations for carrying bearing
M = the distance in miles

STANDARD OPERATING PROCEDURE

Groundwater Sampling from Monitoring Wells

I. Purpose and Scope

This procedure presents general guidelines for the collection of groundwater samples from monitoring wells. The procedure does not address purging and sampling using "low-flow" techniques. Operations manuals should be consulted for specific calibration and operating procedures.

II. Equipment and Materials

- Probe box with inlet/outlet ports for purged groundwater and watertight ports for each probe
- pH meter: Orion Model SA250 or equivalent
- Temperature/conductivity meter: YSI Model 33 or equivalent
- Dissolved oxygen meter: YSI Model 57 or equivalent
- In-line disposable 0.45µ filters: QED FF8100 or equivalent
- Bailer, teflon or stainless steel
- Peristaltic pump, bladder pump, or submersible sampling pump with tubing, support cables, and power supply (may not be required if well yield is low)

III. Procedures and Guidelines

A. Setup and Purging

1. For the well to be sampled, information is obtained on well location, diameter(s), depth, and screened interval(s), and the method for disposal of purged water.
2. A pump will be used for well purging if the well yield is adequate; otherwise, a bailer may be used.
3. Instruments are calibrated according to manufacturer's instructions.
4. The well number, site, date, and condition are recorded in the field logbook.
5. Plastic sheeting is placed on the ground, and the well is unlocked and opened. All decontaminated equipment to be used in sampling will be

placed only on the plastic sheeting until after the sampling has been completed.

6. Water level measurements are collected in accordance with SOP Water Level Measurements, and the total depth of the well is measured.

7. The volume in gallons of water in the well casing or sections of telescoping well casing is calculated as follows:

$0.052 (\pi r^2 h) = 0.163 (r^2 h) = \text{gallons}$

where: $\pi = 3.14$

r = Radius of the well pipe in inches
h = height of water in well in feet

The volume of water in typical well casings may be calculated as follows:

2-inch diameter well:
0.163 gal/ft x ___ (linear feet of water) = gallons

4-inch diameter well:
0.653 gal/ft x ___ (linear feet of water) = gallons

6-inch diameter well:
1.469 gal/ft x ___ (linear feet of water) = gallons

The initial field parameters of pH, specific conductance, and temperature of water are measured and recorded in the field logbook. The measurement probes are inserted into the probe box. The purged groundwater is directed through the box, allowing measurements to be collected before the water contacts the atmosphere.

8. Sampling equipment is cleaned and decontaminated prior to sampling in accordance with SOP Decon (Decontamination of Personnel and Equipment).

9. If a bailer is being used, it is removed from either its protective covering or the well casing and attached to a cord compatible with constituents and long enough to reach the bottom of the well. If a sampling pump is being used, the air line, discharge line, and support cable or rope are attached to the pump. The support line should bear the weight of the pump. If the well is purged using dedicated tubing, it is lowered into the well to the top of the screened zone.

10. The sampling device is lowered to the well interval from which the sample is to be collected. The pump intake will be placed above the top of the screen, where possible. If a bailer is being used, it is allowed to fill with a minimum of surface disturbance to prevent sample water aeration. When the bailer is raised, the bailer cord must not touch the ground.

During purging, the field parameters are measured at least once for each well volume. In productive wells, the well purging end point is determined using the field measurements. In nonproductive wells, the well is repeatedly bailed dry to obtain a minimum of three well volumes, then allowed to recover before sampling.

12. Three to five well volumes are purged (more may be purged if parameters do not stabilize). Purging is stopped when field parameters have stabilized over three consecutive well volumes. Field parameters are considered stabilized when pH measurements agree within 0.5 units, temperature measurements agree within 1°C, and specific conductance and dissolved oxygen measurements agree within 10 percent.

B. Sample Collection

Once purging has been completed, the well is ready to be sampled. The elapsed time between completion of purging and collection of the groundwater sample from the well should be minimized. Typically, the sample is collected immediately after the well has been purged, but this is also dependent on well recovery.

Samples will be placed in bottles that are appropriate to the respective analysis and that have been cleaned to laboratory standards. Each bottle typically will have been previously prepared with the appropriate preservative, if any.

The following information, at a minimum, will be recorded in the log book:

1. Sample identification (site name, location, and project number; sample name/number and location; sample type and matrix; time and date; sampler's identity)
2. Sample source and source description
3. Field observations and measurements (appearance, volatile screening, field chemistry, sampling method), volume of water purged prior to sampling, number of well volumes purged, and field parameter measurements
4. Sample disposition (preservatives added; laboratory sent to, date and time sent; laboratory sample number, chain-of-custody number, sample bottle lot number)
5. Additional remarks

The steps to be followed for sample collection are as follows:

1. The cap is removed from the sample bottle, and the bottle is tilted slightly.
2. The sample is slowly poured from the bailer or discharged from the pump so that it runs down the inside of the sample bottle with a minimum of splashing. The pumping rate should be reduced to approximately 100 ml per minute when sampling VOCs. Samples may

be field filtered before transfer to the sample bottle. Filtration must occur in the field immediately upon collection. Inorganics, including metals, are to be collected and preserved in the filtered form as well as the unfiltered form. The recommended method is through the use of a disposable in-line filtration module (0.45 micron filter) using the pressure provided by the pumping device for its operation. When a bailer is used, filtration may be driven by a peristaltic pump.

3. VOC samples from wells purged using dedicated tubing and a sampling pump will be collected using a bailer

4. Adequate space is left in the bottle to allow for expansion, except for VOC vials, which are filled to overflowing and capped.

5. The bottle is capped, then labeled clearly and carefully.

6. Samples are placed in appropriate containers and, if necessary, packed with ice in coolers as soon as practical.

7. If the sampler is dedicated, it is returned to the well and the well is capped and locked. Nondedicated samplers are cleaned and decontaminated in accordance with SOP Decontamination of Personnel and Equipment.

IV. Attachments

None.

V. Key Checks and Preventative Maintenance

Maintain field equipment in accordance with the manufacturer's recommendations. This will include, but is not limited to:

- Inspect sampling pump regularly and replace as warranted
- Bring supplies for replacing the bladder if using a positive-displacement bladder pump
- Inspect tubing regularly and replace as warranted
- Inspect air/sample line quick-connects regularly and replace as warranted
- Verify battery charge, calibration, and proper working order of field measurement equipment prior to initial mobilization and daily during field efforts

STANDARD OPERATING PROCEDURE

Low-Flow Groundwater Sampling from Monitoring Wells

I. Purpose and Scope

This procedure presents general guidelines for the collection of groundwater samples from monitoring wells. Low-flow purging and sampling procedures are specifically addressed. Operations manuals should be consulted for specific calibration and operating procedures.

II. Equipment and Materials

- Flow-through cell with inlet/outlet ports for purged groundwater and watertight ports for each probe
- pH/Eh meter: Orion Model SA250 or equivalent
- Temperature/conductivity meter: YSI Model 33 or equivalent
- Dissolved oxygen meter: YSI Model 57 or equivalent
- Water-level indicator
- In-line disposable 0.45µ filters: QED FF8100 or equivalent
- Bailer, teflon or stainless steel
- Adjustable-rate, positive-displacement pump
- Generator
- Disposable polyethylene tubing
- Plastic sheeting

III. Procedures and Guidelines

A. Setup and Purging

1. For the well to be sampled, information is obtained on well location, diameter(s), depth, and screened interval(s), and the method for disposal of purged water.
2. Instruments are calibrated according to manufacturer's instructions.
3. The well number, site, date, and condition are recorded in the field logbook.
4. Plastic sheeting is placed on the ground, and the well is unlocked and opened. All decontaminated equipment to be used in sampling will be placed only on the plastic sheeting until after the sampling has been completed.

5. Water level measurements are collected in accordance with SOP Water Level Measurements. **Do not measure the depth to the bottom of the well at this time** (in order to avoid disturbing any accumulated sediment). Obtain depth to bottom information from well installation log.

6. The volume in gallons of water in the well casing or sections of telescoping well casing is calculated as follows:

   $0.052\ (\pi\ r^2 h) = 0.163\ (r^2 h) = \text{gallons}$

   where: $\pi = 3.14$

   r = Radius of the well pipe in inches
   h = height of water in well in feet

   The volume of water in typical well casings may be calculated as follows:

   2-inch diameter well:
   0.163 gal/ft x ___ (linear feet of water) = gallons

   4-inch diameter well:
   0.653 gal/ft x ___ (linear feet of water) = gallons

   6-inch diameter well:
   1.469 gal/ft x ___ (linear feet of water) = gallons

   The initial field parameters of pH, specific conductance, and temperature of water are measured and recorded in the field logbook. The measurement probes are inserted into the probe box. The purged groundwater is directed through the box, allowing measurements to be collected before the water contacts the atmosphere.

7. Sampling equipment is cleaned and decontaminated prior to sampling in accordance with SOP Decon (Decontamination of Personnel and Equipment).

8. Lay out polyethylene sheeting and place all equipment on the sheeting. To avoid cross-contamination, do not let any downhole equipment touch the ground surface.

9. Attach and secure the polyethylene tubing to the low-flow pump. Lower the pump slowly into the well and set it at approximately the middle of the screen. Place the pump intake at least two feet above the bottom of the well to avoid mobilization of any sediment present in the bottom. Start purging the well at 0.2 to 0.5 liters per minute. Avoid surging. Purging rates for more transmissive formations could be started at 0.5 to 1 liter per minute.

10. The water level should be monitored during purging, and ideally, the purge rate should equal the well recharge rate so that there is little or no drawdown in the well. (The water level should stabilize for the

specific purge rate.) There should be at least one foot of water over the pump intake so there is no risk of the pump suction being broken, or entrainment of air in the sample. Record adjustments in the purge rate and changes in depth to water in the logbook. Purge rates should, if needed, be decreased to the minimum capabilities of the pump (0.1 to 0.2 liters per minute) to avoid affecting well drawdown. The well should not be purged dry. If the recharge rate of the well is so low that the well is purged dry, then the contractor may wait until the well has recharged to a sufficient level and collect the appropriate volume of water for the sample with the pump.

11. During purging, the field parameters are measured frequently (every three to five minutes) until the parameters have stabilized. Field parameters are considered stabilized when pH measurements agree within 0.5 units, temperature measurements agree within 1°C, and specific conductance, Eh, and dissolved oxygen measurements agree within 10 percent.

B. Sample Collection

Once purging has been completed, the well is ready to be sampled. The elapsed time between completion of purging and collection of the groundwater sample from the well should be minimized. Typically, the sample is collected immediately after the well has been purged, but this is also dependent on well recovery.

Samples will be placed in bottles that are appropriate to the respective analysis and that have been cleaned to laboratory standards. Each bottle typically will have been previously prepared with the appropriate preservative, if any.

The following information, at a minimum, will be recorded in the log book:

1. Sample identification (site name, location, and project number; sample name/number and location; sample type and matrix; time and date; sampler's identity)
2. Sample source and source description
3. Field observations and measurements (appearance, volatile screening, field chemistry, sampling method), volume of water purged prior to sampling, number of well volumes purged, and field parameter measurements
4. Sample disposition (preservatives added; laboratory sent to, date and time sent; laboratory sample number, chain-of-custody number, sample bottle lot number)

Additional remarks

The steps to be followed for sample collection are as follows:

1. The cap is removed from the sample bottle, and the bottle is tilted slightly.

2. The sample is slowly discharged from the pump so that it runs down the inside of the sample bottle with a minimum of splashing. The pumping rate should be reduced to approximately 100 ml per minute when sampling VOCs. Samples may be field filtered before transfer to the sample bottle. Filtration must occur in the field immediately upon collection. Inorganics, including metals, are to be collected and preserved in the filtered form as well as the unfiltered form. The recommended method is through the use of a disposable in-line filtration module (0.45 micron filter) using the pressure provided by the pumping device for its operation.

3. Adequate space is left in the bottle to allow for expansion, except for VOC vials, which are filled to overflowing and capped.

4. The bottle is capped, then labeled clearly and carefully following the procedures in SOP Packaging and Shipping Procedures.

5. Samples are placed in appropriate containers and, if necessary, packed with ice in coolers as soon as practical.

6. If the sampler is dedicated, it is returned to the well and the well is capped and locked. Nondedicated samplers are cleaned and decontaminated in accordance with SOP Decontamination of Personnel and Equipment. Disposable polyethylene tubing is disposed of with PPE and other site trash.

IV. Attachments

None.

V. Key Checks and Preventative Maintenance

Maintain field equipment in accordance with the manufacturer's recommendations. This will include, but is not limited to:

- Inspect sampling pump regularly and replace as warranted
- Inspect air/sample line quick-connects regularly and replace as warranted
- Verify battery charge, calibration, and proper working order of field measurement equipment prior to initial mobilization and daily during field efforts

Downhole Geophysical Logging

I. Purpose and Scope

The purpose of this procedure is to provide a general guideline for methods of downhole geophysical logging that are commonly used in investigations. The methods covered in this procedure are: fluid resistivity, temperature, caliper, and video. Such methods as natural gamma, spontaneous potential, electric resistivity of geologic materials, and flow logging are not covered.

Downhole geophysical logging normally is subcontracted to professionals who are experienced, and their expertise should be relied upon. The procedure focuses on key aspects of the work that should be observed and documented.

II. Equipment and Materials

- Caliper logging tool
- Temperature logging tool
- Fluid resistivity logging tool
- Video-camera logging tool
- Decontamination materials

III. Procedures and Guidelines

A. Fluid-Resistivity Logging

Fluid-resistivity logging provides a measurement of the resistivity of the borehole fluid between closely spaced electrodes in the probe. Abrupt and significant changes in fluid resistivity in the borehole may indicate the entry of groundwater of differing resistivity into the borehole via fractures and other openings in the geologic materials surrounding the borehole. The logging record is taken continuously in units of ohm-meters.

Fluid-resistivity logging should be run at slow speeds to assure the proper flow of water through the tool. As long a time as possible should be allowed between drilling and logging the borehole so that the fluid resistivity can equilibrate between borehole and surrounding geologic materials. The fluid-resistivity log should be one of the first logs run because other logging methods will disturb the water in the borehole.

The logging equipment should be adequately decontaminated before the first use on the site and between boreholes.

B. Temperature Logging

Temperature logs are the continuous records of the temperature of the water in a borehole. They can provide information on the source and movement of groundwater into and out of the borehole. Generally the temperature of the groundwater in the borehole will increase with depth with the geothermal gradient. Deviations from this general trend may indicate where groundwater is flowing up, down, into, or out of the borehole.

All temperature sensors have an inherent response lag, or time constant, so that the logging speed must be constant and slow enough that the temperatures are accurately reflected at the true depths on the log. The temperature log may be made using the same tool as the fluid-resistivity log. As long a time as possible should be allowed between drilling and logging the borehole so that the temperature can equilibrate between borehole and surrounding geologic materials. The temperature log should be one of the first logs run because other logging methods will disturb the water in the borehole.

The logging equipment should be adequately decontaminated before the first use on the site and between boreholes.

C. Caliper Logging

The caliper log is a record of the average diameter of the borehole. Caliper logs primarily are run to determine where fractures or other openings might intersect the borehole and whether or not squeezing or other effects may have reduced the diameter of the borehole.

A caliper log featuring arm-type devices is preferable to one featuring bow springs because of greater sensitivity of the arms. Logs should have at least 1 inch of chart width per inch of hole diameter to provide adequate sensitivity of recording. Several feet of casing should be logged so that the accuracy of the tool can be checked.

The logging equipment should be adequately decontaminated before the first use on the site and between boreholes.

D. Video Logging

Video logging provides a real-time and recorded image of the actual conditions in the borehole. The video log typically is used to identify the depths of fractures and other openings in the borehole.

The log should be run at a sufficiently slow speed that features can be accurately recorded. The field geologist, if possible, should observe the logging image so that the operator can be directed to stop or reduce logging speed at any critical locations, such as intervals where flow may be occurring as indicated by the movement of particles in the borehole. If a nonaqueous phase liquid (NAPL), particularly one that floats on the surface, is present in the borehole, the image may be so deleteriously affected that the NAPL may have to be removed from the borehole before logging can be completed.

The field geologist should obtain a copy of the video in VHS format while the operator is still in the field.

The logging equipment should be adequately decontaminated before the first use on the site and between boreholes.

IV. Attachments

- None

V. Key Checks and Preventive Maintenance

- Ensure that subcontractor follows their procedures, particularly those for calibration of the instruments and the rate of logging.
- Obtain copies of logs at the site.
- Temperature and fluid-resistivity logs should be run first so that the disturbance caused by the other logging methods does not disrupt the results of these two methods.
- Adequate development of the well is important so that fluids such as drilling mud that may have been used in the borehole do not provide false readings of changes in fluid resistivity.
- Decontaminate as necessary.

Final

Health and Safety Plan
Remedial Investigation and Feasibility Study of Site 11

for

Allegany Ballistics Laboratory
Rocket Center, West Virginia

Contract Task Order 0013

May 1998

Prepared for

Department of the Navy
Atlantic Division
Naval Facilities Engineering Command

Under the

LANTDIV CLEAN II Program
Contract N62470-95-D-6007

Prepared by

CH2MHILL

Herndon, Virginia

WDC981250002.DOC/1/LBT

TABLE OF CONTENTS

Section **Page**

Table of Contents (Continued)

CH2M HILL HEALTH AND SAFETY PLAN

(Reference CH2M HILL SOP 19, *Health and Safety Plans*)

This health and safety plan will be kept on the site during field activities and will be reviewed and updated as necessary. The plan adopts, by reference, the standards of practice (SOP) in the CH2M HILL *Corporate Health and Safety Program, Program and Training Manual,* and CH2M HILL's *Site safety Notebook* as appropriate. The site safety coordinator (SSC) is to be familiar with these SOPs and the content of this plan. Site personnel must sign Attachment 1. In addition, this plan adopts procedures in the work plan for the project.

1 PROJECT INFORMATION AND DESCRIPTION

CLIENT OR OWNER: Department of the Navy
Atlantic Division

PROJECT NO: 138649

CH2M HILL PROJECT MANAGER: Brett Doerr

OFFICE: WDC

SITE NAME: Allegany Ballistics Laboratory, IRP Site 11

SITE ADDRESS: Rocket Center, West Virginia

DATE HEALTH AND SAFETY PLAN PREPARED: March 19, 1996

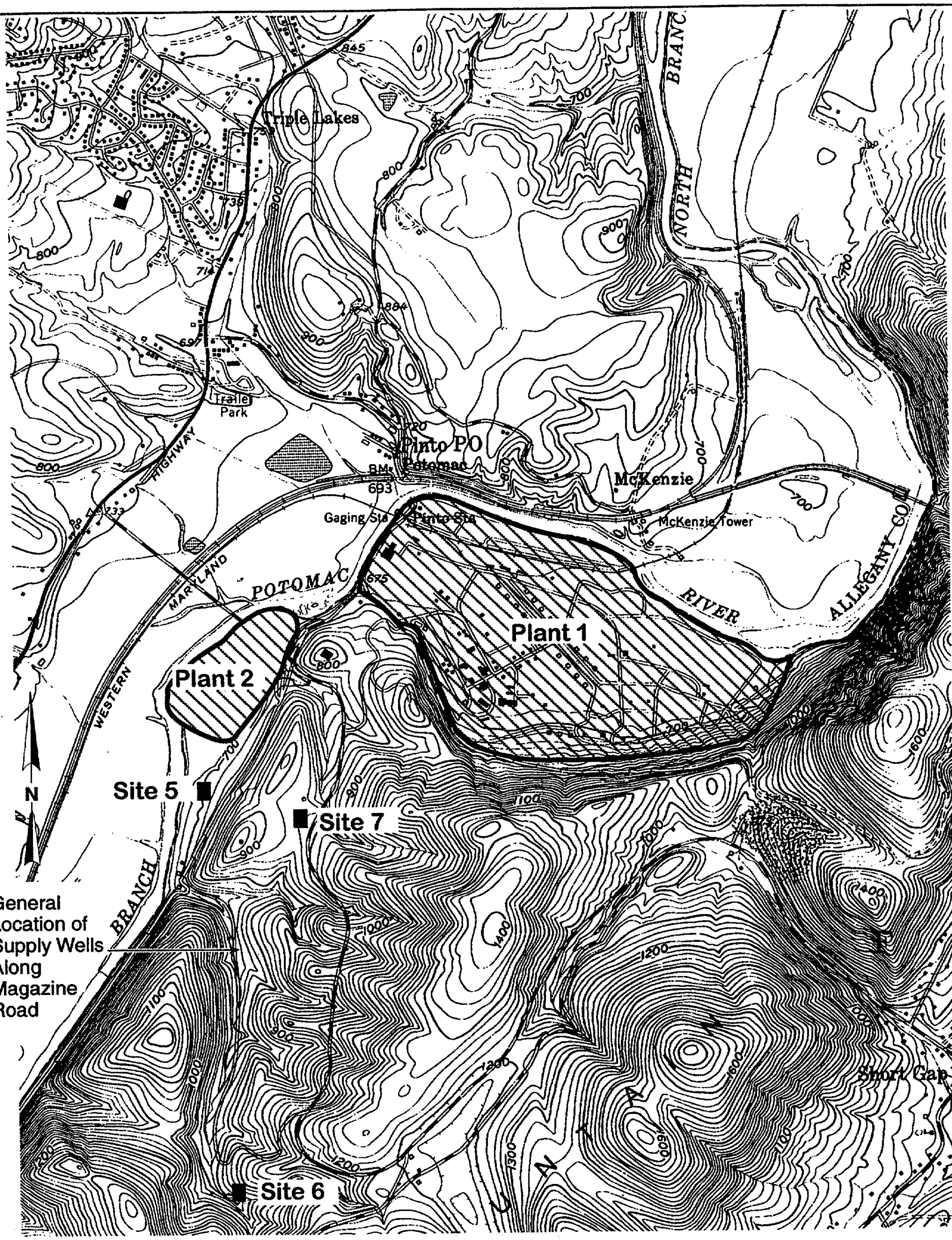
DATE(S) OF INITIAL VISIT:

DATE(S) OF SITE WORK:

SITE ACCESS: Site 11 at ABL is accessed through the Gate 5.

SITE DESCRIPTION AND HISTORY: ABL is a government-owned, contractor-operated research, development, and production facility located in Mineral County, West Virginia. Since 1943, the facility has been used primarily for research, development, testing and production of solid propellant rocket motors for the Department of Defense and NASA. The facility consists of two plants. Plant 1, occupying approximately 1,577 acres, is owned by the Navy and operated by Alliant Techsystems. Approximately 400 acres at Plant 1 is in the floodplain of the North Branch Potomac River, with the remaining acreage on forested mountainous land (Figure 2-1). Plant 2, a 57-acre area adjacent to Plant 1, is owned by Alliant Techsystems.

138649.PP.QS.2_1/ZIP 001



Source: USGS 7.5 minute Cresaptown, WV-MD quadrangle map.

0 1000 2000

Scale in Feet

Figure 2-1
LOCATION MAP
Site II RI/FS
Allegany Ballistics Laboratory

2 PROJECT ORGANIZATION AND TASKS TO BE PERFORMED UNDER THIS PLAN

2.1 PROJECT ORGANIZATION

CLIENT: Department of the Navy
Atlantic Division
Naval Facilities Engineering Command

CH2M HILL:
Project Manager: Brett Doerr
Field Team Leader: Technical Staff
Refer to Section 4 for field staff.

CONTRACTORS and SUBCONTRACTORS: Unidentified at this time.

2.2 DESCRIPTION OF TASKS (Reference Section 1, "Field Activity Start-up Form," of *Site Safety Notebook*

Refer to project documents (i.e., work plan) for detailed task information. A health and safety risk analysis has been performed for each task and is incorporated in this plan through task-specific hazard controls and requirements for monitoring and protection. Tasks in addition to those listed below require an approved amendment to this plan before additional work begins. Refer to Section 10.2 for procedures related to tasks that do not involve hazardous waste operations and emergency response (Hazwoper).

2.2.1 HAZWOPER-REGULATED TASKS

- Drilling
- Geoprobe boring
- Groundwater sampling
- Soil sampling
- Downhole Geophysical Surveys
- Surveying
- Investigation-derived waste (drum) sampling and disposal
- Observation of loading of material for offsite disposal
- Packer Sampling

2.2.2 NON-HAZWOPER-REGULATED TASKS

Under specific circumstances, the training and medical monitoring requirements of federal or state Hazwoper regulations are not applicable. It must be demonstrated that the tasks can be performed without the possibility of exposure in order to use non-Hazwoper-trained personnel. **Prior approval from the HSM is required before these tasks are conducted on regulated hazardous waste sites.**

TASK	RESTRICTIVE CONDITIONS
• Electrical installation	
• Iron work (installing rebar)	
• Masonry work	
• General heavy equipment work (excavation, grading, etc.)	
• Mechanical installations (equipment, pumps, etc.)	
• Engineering testing/evaluation	
• Building construction	

3 HAZARD EVALUATION AND CONTROL

3.1 HEAT AND COLD STRESS (Reference CH2M HILL SOP HS-09, *Heat and Cold Stress*)

3.1.1 PREVENTING HEAT STRESS

- Drink 16 ounces of water before beginning work, such as in the morning or after lunch. Disposable (e.g., 4-ounce) cups and water maintained at 50° to 60°F should be available. Under severe conditions, drink 1 to 2 cups every 20 minutes, for a total of 1 to 2 gallons per day. Take regular breaks in a cool, preferably air-conditioned, area. Do not use alcohol in place of water or other nonalcoholic fluids. Decrease your intake of coffee and caffeinated soft drinks during working hours. Monitor for signs of heat stress.
- Acclimate to site work conditions by slowly increasing workloads; e.g., do not begin site work with extremely demanding activities.
- Use cooling devices, such as cooling vests, to aid natural body ventilation. The devices add weight, so their use should be balanced against efficiency.
- Use mobile showers or hose-down facilities to reduce body temperature and cool protective clothing.
- During hot weather, conduct field activities in the early morning or evening if possible.
- Provide adequate shelter to protect personnel against radiant heat (sun, flames, hot metal), which can decrease physical efficiency and increase the probability of heat stress.
- In hot weather, rotate shifts of workers.
- Maintain good hygiene standards by frequently changing clothing and by showering. Clothing should be permitted to dry during rest periods. Persons who notice skin problems should consult medical personnel.

3.1.2 SYMPTOMS AND TREATMENT OF HEAT STRESS

	Heat Syncope	Heat Rash (*miliaria rubra*, "prickly heat")	Heat Cramps	Heat Exhaustion	Heat Stroke
Signs and Symptoms	Sluggishness or fainting while standing erect or immobile in heat.	Profuse tiny raised red blister-like vesicles on affected areas, along with prickling sensations during heat exposure.	Painful spasms in muscles used during work (arms, legs, or abdomen); onset during or after work hours.	Fatigue, nausea, headache, giddiness; skin clammy and moist; complexion pale, muddy, or flushed; may faint on standing; rapid thready pulse and low blood pressure; oral temperature normal or low	Red, hot, dry skin; dizziness; confusion; rapid breathing and pulse; high oral temperature.
Treatment	Remove to cooler area. Rest lying down. Increase fluid intake. Recovery usually is prompt and complete.	Use mild drying lotions and powders, and keep skin clean for drying skin and preventing infection.	Remove to cooler area. Rest lying down. Increase fluid intake.	Remove to cooler area. Rest lying down, with head in low position. Administer fluids by mouth. Seek medical attention.	Cool rapidly by soaking in cool–but not cold–water. Call ambulance, and get medical attention immediately!

3.1.3 HEAT-STRESS MONITORING

For field activities part of ongoing site work activities in hot weather, the following procedures should be used to monitor the body's physiological response to heat and to estimate the work-cycle/rest-cycle when workers are performing moderate levels of work. These procedures should be considered when the ambient air temperature exceeds 70°F, the relative humidity is high(>50%), or when the workers exhibit symptoms of heat stress.

The heart rate should be measured by the radial pulse for 30 seconds, as early as possible in the resting period. The HR at the beginning of the rest period should not exceed 110 beats/minute, or 20 beats/minute above resting pulse. If the HR is higher, the next work period should be shortened by 33 percent, while the length of the rest period stays the same. If the pulse rate still exceeds 110 beats/minute at the beginning of the next rest period, the following work cycle should be further shortened by 33 percent. The procedure is continued until the rate is maintained below 110 beats/minute, or 20 beats/minute above resting pulse.

3.1.4 PREVENTING COLD STRESS

- Be aware of the symptoms of cold-related disorders, and ***wear proper clothing for the anticipated fieldwork.***
- Consider monitoring the work conditions and adjusting the work schedule, using guidelines developed by the U.S. Army (wind-chill index) and the National Safety Council (NSC).
- ***Wind-Chill Index.*** This measure relates the dry bulb temperature and the wind velocity. It is used only to estimate the combined effect of wind and low air temperatures on exposed skin. The wind-chill index sometimes is limited in its usefulness because the index does not take into account the body part that is exposed, the level of activity, or the amount or type of clothing worn. For those reasons, it is used only as a guideline to warn workers when they are in a situation that can cause cold-related illnesses. Used in conjunction with the NSC guidelines, the wind-chill index provides a starting point for adjusting work and warm-up schedules.
- ***NSC Guidelines for Work and Warm-Up Schedules.*** The cold-exposure limits recommended by the NSC can be used in conjunction with the wind-chill index to estimate work and warm-up schedules for fieldwork. The guidelines are not absolute; ***workers should be monitored for symptoms of cold-related illness.*** If symptoms are not observed, the work duration can be increased.
- The wind-chill index and the NSC guidelines are in the CH2M HILL *Corporate Health and Safety Program, Program and Training Manual,* SOP HS-09.

3.1.5 SYMPTOMS AND TREATMENT OF COLD STRESS

	Immersion (Trench) Foot	Frostbite	Hypothermia
Signs and Symptoms	Feet discolored and painful; infection and swelling present.	Blanched, white, waxy skin, but tissue resilient; tissue cold and pale.	Shivering, apathy, sleepiness; rapid drop in body temperature; glassy stare; slow pulse; slow respiration.
Treatment	Seek medical treatment immediately.	Remove victim to a warm place. Rewarm area quickly in warm–but **not** hot–water. Have victim drink warm fluids, but **not** coffee or alcohol. Do not break blisters. Elevate the injured area, and get medical attention.	Remove victim to a warm place. Have victim drink warm fluids, but **not** coffee or alcohol. Get medical attention.

3.2 PROCEDURES FOR LOCATING BURIED UTILITIES

Local Utility Mark-Out Service
Name: Mr. Kirk Meyer
Phone: (4) 5161 (on-base phone)

- Where available, obtain utility diagrams for the facility.
- Review locations of sanitary and storm sewers, electrical conduits, water supply lines, natural-gas lines, and fuel tanks and lines.
- Review proposed locations of intrusive work with facility personnel knowledgeable of locations of utilities. Check locations against information from utility mark-out service.
- Where necessary, clear locations with a utility-locating instrument (e.g., metal detector).
- Where necessary (e.g., uncertainty about utility locations), excavation or drilling of the upper depth interval should be performed manually.
- Monitor for signs of utilities during advancement of intrusive work (e.g., sudden change in advancement of auger or split spoon).
- When the client or other onsite party is responsible for determining the presence and locations of buried utilities, the SSC should confirm that arrangement.

3.3 GENERAL PHYSICAL (SAFETY) HAZARDS AND CONTROLS

Engineering and administrative controls are to be implemented by the party in control of the site or the hazard (i.e., CH2M HILL, subcontractor, or contractor). CH2M HILL employees and subcontractors must, at a minimum, remain aware of hazards affecting them regardless of who is responsible for controlling the hazards. Specialty subcontractors are responsible for the safe operation of their equipment (e.g., drill rig, heavy equipment). CH2M HILL employees are not to operate, or assist in the operation of, any subcontractor or contractor equipment.

		Tasks									
Hazard (Refer to SOP, or HSP Section)	**Engineering Controls, Administrative Controls, and Work Practices**	**Test Pit and Excavation**	**Drilling, Geoprobe Installation, Well Installation and Abandonment**	**Groundwater Monitoring, Aquifer Testing, and Video Surveying of Wells**	**Surface Water and Sediment Sampling Using a Boat**	**Surface Water and Sediment Sampling from the Shore or Water**	**Hand Augering**	**Surveying**	**IDW Drum Sampling and Disposal[a]**	**Observation of Loading of Material for Offsite Disposal**	**Remediation and Construction Oversight**
Flying debris/objects (HS-07)	Provide shielding and PPE; maintain distance.	X	X		X	X	X		X	X	X
Noise > 85 dBA	Noise protection and monitoring required.	X	X		X					X	X
Gas cylinders (HS-21)	Instruct employees in the safe use of compressed gases. Make certain gas cylinders are properly anchored and chained. Keep cylinders away from ignition sources. Cap cylinders when not in use.	X	X								
Electrical	• Make certain third wire is properly grounded. Do not tamper with electrical wiring unless qualified to do so. Ground as appropriate. • Project field sites should have ground fault circuit interrupters (GFCIs) installed for all wiring, including extension cords. • Heavy equipment (e.g., drill rig) should remain at least 15 feet from overhead power line for power lines of 50 kV or less. For each 10 kV > 50, increase distance by ½ foot. • Operate and maintain equipment according to manufacturer's instructions. • Use only extension cords that are three-wire grounded. Cords passing through work areas must be covered or elevated to protect from damage. • Use only electrical tools and equipment that are either effectively grounded or double-insulated UL approved. • Properly label switches, fuses, and circuit breakers. • Remove cord from an outlet by grasping the plug, not pulling the cord. • Protect all electrical equipment, tools, switches, etc., from elements. • Avoid physical contact with power circuit. • Only qualified electricians are to install and work on electrical circuits and equipment.	X	X	X	X						X
Suspended loads	Work not permitted under suspended loads.	X	X		X					X	X
Buried utilities, drums, tanks, etc. (Section 3.3)	Locate buried utilities, drums, tanks, etc., before digging or drilling and mark location.	X	X				X				X
Slip, trip, fall hazards (e.g., wet/muddy surface, inadequate railing, unstable surface)	Provide slip-resistant surfaces, ropes, and/or other devices to be used. Brace and shore equipment	X	X	X	X	X	X	X	X	X	X
Back injury (HS-29)	Use proper lifting techniques, or provide mechanical lifting aids.	X	X	X	X	X	X		X		X
Confined space entry (Section 9.0)	Space must be evaluated by qualified person. Additional controls and monitoring, training, and an approved entry permit are generally required.			NOT		APPROVED					
Trenches/excavations (HS-32)	Make certain trench meets OSHA standard before entering. All excavations > 4 feet deep must be sloped or shored, and have a ladder every 25 feet. Personnel and equipment must remain at least 2 feet from edge of trench at all times.	X									X
Protruding objects	Flag visible objects.	X	X	X	X	X	X	X	X	X	X
Visible lightning	Stop work.	X	X	X	X	X	X	X	X	X	X
Vehicle traffic (HS-24)	Provide temporary traffic controls, including trained flaggers and lookouts. Implement traffic control program when required.									X	X
Stairways, ladders, and scaffolds (HS-25)	Stairways and ladders are generally required when there is a break in elevation of 19 inches or more. Keep access ways clear. Equipment must meet OSHA specifications. Document employee training.		X								X
Elevated work area/falls (HS-31)	Provide guardrail, safety net, floor covers, body harness, and monitoring system, where applicable. Document employee training.	X				X					X
Fire prevention and control (HS-22)	• No spark sources are allowed within exclusion or decontamination zones. • Appropriate firefighting equipment must be available on the site. • Extinguishers are to be inspected visually every month and undergo an annual maintenance check. • Post "Exit" signs over exiting doors, and post "Fire Extinguisher" signs over extinguisher locations. Keep areas near exits and extinguishers clear. Open flames are prohibited in the vicinity of flammable materials. • *Combustible materials stored outside should be at least 10 feet from the building.* • Unnecessary combustible materials and flammable or combustible liquids must not be allowed to accumulate. • Flammable or combustible liquids must be kept in approved containers, and must be stored in an approved storage cabinet.	X	X			X			X		X

3.3 GENERAL PHYSICAL (SAFETY) HAZARDS AND CONTROLS

Engineering and administrative controls are to be implemented by the party in control of the site or the hazard (i.e., CH2M HILL, subcontractor, or contractor). CH2M HILL employees and subcontractors must, at a minimum, remain aware of hazards affecting them regardless of who is responsible for controlling the hazards. Specialty subcontractors are responsible for the safe operation of their equipment (e.g., drill rig, heavy equipment). CH2M HILL employees are not to operate, or assist in the operation of, any subcontractor or contractor equipment.

		Tasks									
Hazard (Refer to SOP, or HSP Section)	**Engineering Controls, Administrative Controls, and Work Practices**	**Test Pit and Excavation**	**Drilling, Geoprobe Installation, Well Installation and Abandonment**	**Groundwater Monitoring, Aquifer Testing, and Video Surveying of Wells**	**Surface Water and Sediment Sampling Using a Boat**	**Surface Water and Sediment Sampling from the Shore or Water**	**Hand Augering**	**Surveying**	**IDW Drum Sampling and *Disposal*[a]**	**Observation of Loading of Material for *Offsite Disposal***	**Remediation and Construction *Oversight***
Inadequate illumination	Site work will be performed during daylight hours whenever possible. Work conducted during hours of darkness will require enough illumination intensity "to read a newspaper without difficulty."	X	X	X	X	X	X	X	X	X	X
Entanglement in rotating equipment	• Prohibit loose clothing and hair • Prohibit wearing jewelry		X				X				
Drilling	• The drill rig is not to be operated in inclement weather. • The driller is to verify that the rig is properly leveled and stabilized before raising the mast. • Personnel should be cleared from the sides and rear of the rig before the mast is raised. • The driller is not to drive the rig with the mast in the raised position. • The driller must check for overhead power lines before raising the mast. A minimum distance of 15 feet between mast and overhead lines (<50 kV) is recommended. Increased separation may be required for lines greater than 50 kV. • Personnel should stand clear before rig startup. • The driller is to verify that the rig is in neutral when the operator is not at the controls. • Become familiar with the hazards associated with the drilling method used (cable tool, air rotary, hollow-stem auger, etc.). • Do not wear loose-fitting clothing, watches, etc., that could get caught in moving parts. • Do not smoke or permit other spark-producing equipment around the drill rig. • The drill rig must be equipped with a kill wire or switch, and personnel are to be informed of its location. • Be aware and stand clear of heavy objects that are hoisted overhead. • The driller is to verify that the rig is properly maintained in accordance with the drilling company's maintenance program. • The driller is to verify that all machine guards are in place while the rig is in operation. • The driller is responsible for housekeeping (maintaining a clean work area). • The drill rig should be equipped with at least one fire extinguisher. • If the drill rig comes into contact with electrical wires and becomes electrically energized, do not touch any part of the rig or any person in contact with the rig, and stay as far away as possible. Notify emergency personnel immediately.		X								
Heavy equipment	• Become familiar with hazards specific to the equipment being used. • Always confirm that the operator is aware of your location, particularly when you approach or pass by equipment. • Backup alarm is required for heavy equipment. Do not count on backup alarms always functioning. Look around when alarm sounds. • Do not ride equipment not designed for passengers. • Do not climb on operating equipment. • Do not place yourself between fixed and moving parts or objects. • Do not stand adjacent to the equipment. • Stay clear of equipment on cross slopes and unstable terrain. • Stay clear of pile-driving operations. • Stay outside the turning radius of the equipment. • Operators using all-terrain vehicles (ATV) must be trained; other ATV requirements may apply. • Observer must remain in contact with operator and signal safe backup. • Personnel must remain outside the turning radius.	X	X		X					X	X
Working near water	• U.S. Coast Guard-approved personal flotation devices (PFDs–e.g., life jacket) provided for each employee will be worn. • PFDs will be inspected before and after each use. Defective equipment will not be used. • Sampling and other equipment will be used according to the manufacturer's instructions. • A minimum of one life-saving skiff will be provided for emergency rescue. • A minimum of one ring buoy with 90 feet of 3/8-inch solid-braid polypropylene (or equal) rope will be provided for emergency rescue. • Keep nonessential personnel 3 feet from edge of water					X					

3.3 GENERAL PHYSICAL (SAFETY) HAZARDS AND CONTROLS

Engineering and administrative controls are to be implemented by the party in control of the site or the hazard (i.e., CH2M HILL, subcontractor, or contractor). CH2M HILL employees and subcontractors must, at a minimum, remain aware of hazards affecting them regardless of who is responsible for controlling the hazards. Specialty subcontractors are responsible for the safe operation of their equipment (e.g., drill rig, heavy equipment). CH2M HILL employees are not to operate, or assist in the operation of, any subcontractor or contractor equipment.

		Tasks									
Hazard (Refer to SOP, or HSP Section)	**Engineering Controls, Administrative Controls, and Work Practices**	**Test Pit and Excavation**	**Drilling, Geoprobe Installation, Well Installation and Abandonment**	**Groundwater Monitoring, Aquifer Testing, and Video Surveying of Wells**	**Surface Water and Sediment Sampling Using a Boat**	**Surface Water and Sediment Sampling from the Shore or Water**	**Hand Augering**	**Surveying**	**IDW Drum Sampling and Disposal[a]**	**Observation of Loading of Material for Offsite Disposal**	**Remediation and Construction Oversight**
Working on water	• Safe means of boarding or leaving a boat or a platform will be provided to prevent slipping and falling. Boat/barge must be equipped with adequate railing. instructions/warnings (e.g., protect from pinch points, sharp objects, rope burns/entanglement). • Work requiring the use of a boat will take place only during daylight hours. • Work requiring the use of a boat will not take place during inclement weather. • The boat/barge must be operated according to U.S. Coast Guard regulations (speed, lightning, right-of-way, etc.). Shut off engine before refueling; do not smoke while refueling.				X						
IDW Drum sampling	Personnel are allowed to handle and/or sample drums containing investigation-derived waste (IDW) only; handling or sampling other drums requires a plan revision or amendment approved by the CH2M HILL HSM. The following control measures will be taken when sampling drums containing IDW: • Minimize transportation of drums. • Minimize number of people involved in the actual sampling. • Sample only labeled drums or drums known to contain IDW. • Use caution when sampling bulging or swollen drums. Relieve pressure slowly. • If drums contain, or potentially contain, flammable materials, use nonsparking tools to open. • Picks, chisels, and firearms may not be used to open drums. • Reseal bung holes or plugs whenever possible. • Avoid mixing incompatible drum contents. • Sample drums without leaning over the drum opening. • If there is evidence of contamination on the lid of the drum, cover the lid with plastic sheeting. • Transfer the content of drums using a method that minimizes contact with material. • Air monitoring and PPE requirements specified in sections 5 and 6 must address drum sampling. • Spill-containment procedures specified in Section 8 must be appropriate for the material to be handled.								X		

3.4 BIOLOGICAL HAZARDS AND CONTROLS

Hazard and Location	Control Measures
Snakes typically are found in underbrush and tall grassy areas.	If you encounter a snake, stay calm and look around; there may be other snakes. Turn around and walk away on the same path you used to approach the area. If a person is bitten by a snake, wash and immobilize the injured area, keeping it lower than the heart if possible. Seek medical attention immediately. **DO NOT** apply ice, cut the wound, or apply a tourniquet. Carry the victim or have him/her walk slowly if the victim must be moved. Try to identify the type of snake: note color, size, patterns, and markings.
Poison ivy, poison oak, and poison sumac typically are found in brush or wooded areas. They are more commonly found in moist areas or along the edges of wooded areas.	Become familiar with the identity of these plants. Wear protective clothing that covers exposed skin and clothes. Avoid contact with plants and the outside of protective clothing. If skin contacts a plant, wash the area with soap and water immediately. If the reaction is severe or worsens, seek medical attention.
Exposure to **bloodborne pathogens** may occur when rendering first aid or CPR, or when coming into contact with medical or other potentially infectious material, or when coming into contact with landfill waste or waste streams containing such infectious material.	Training is required before a task involving potential exposure is performed. Exposure controls and personal protective equipment (PPE) are required as specified in CH2M HILL SOP HS-36, *Bloodborne Pathogens*. Hepatitis B vaccination must be offered before the person participates in a task where exposure is a possibility.
Bees and other stinging insects may be encountered almost anywhere and may present a serious hazard, particularly to people who are allergic.	Watch for and avoid nests. Keep exposed skin to a minimum. Carry a kit if you have had allergic reactions in the past, and inform the SSC and/or the buddy. If a stinger is present, remove it carefully with tweezers. Wash and disinfect the wound, cover it, and apply ice. Watch for allergic reaction; seek medical attention if a reaction develops.

Other Potential Biological Hazards:

None known

3.5 TICK BITES (Reference CH2M HILL HS-03, *Tick Bites*)

Ticks typically are in wooded areas, bushes, tall grass, and brush. Ticks are black, black and red, or brown and can be up to one-quarter inch in size.

Prevention against tick bites includes avoiding tick areas; wearing tightly woven light-colored clothing with long sleeves and wearing pant legs tucked into boots or socks; spraying **only outside** of clothing with insect repellent containing permethrin or permanone, and spraying skin with DEET; and checking yourself frequently for ticks and showering as soon as possible. To prevent chemical repellents from interfering with sample analyses, exercise care while using repellents during the collection and handling of environmental samples.

If bitten by a tick, carefully remove the tick with tweezers, grasping the tick as close as possible to the point of attachment while being careful not to crush the tick. After removing the tick, wash your hands and disinfect and press the bite area. The removed tick should be saved. Report the bite to human resources personnel.

Look for symptoms of Lyme disease or Rocky Mountain spotted fever (RMSF). Lyme: a rash that looks like a bullseye with a small welt in the center. RMSF: a rash of red spots under the skin 3 to 10 days after the tick bite. In both cases, chills, fever, headache, fatigue, stiff neck, bone pain may develop. If symptoms appear, seek medical attention.

3.6 RADIOLOGICAL HAZARDS AND CONTROLS

Refer to CH2M HILL's *Corporate Health and Safety Program, Program and Training Manual*, and *Corporate Health and Safety Program, Radiation Protection Program Manual*, for standards of practice for operating in contaminated areas.

Hazards	Controls
None Known	None Required

3.7 HAZARDS POSED BY CHEMICALS BROUGHT ON THE SITE

3.7.1 HAZARD COMMUNICATION

(Reference CH2M HILL *Hazard Communication Manual* and Section 5 of the *Site Safety Notebook*)

CH2M HILL's *Hazard Communication Program Manual,* which is available from area or regional offices and from the Corporate Human Resources Department in Denver. The project manager is to request Material Safety Data Sheets (MSDSs) from the client or from the contractors and the subcontractors for chemicals to which CH2M HILL employees potentially are exposed. The SSC is to do the following:

- Give employees required site-specific HAZCOM training.
- Confirm that the inventory of chemicals brought on the site by subcontractors is available.
- Before or as the chemicals arrive on the site, obtain an MSDS for each hazardous chemical.
- Label chemical containers with the identity of the chemical and with hazard warnings, if any.

The chemical products listed below will be used on the site. Refer to Attachment 2 for MSDSs.

Chemical	Quantity	Location
Methane (calibration gas)	1 liter, compressed gas	Support Zone
Isobutylene (calibration gas)	1 liter, compressed gas	Support Zone
Pentane (calibration gas)	1 liter, compressed gas	Support Zone
Hydrochloric Acid (sample preservative)	< 500 ml	Support/Exclusion Zone
Nitric Acid (sample preservative)	< 500 ml	Support/Exclusion Zone
Sulfuric Acid (sample preservative)	< 500 ml	Support/Exclusion Zone
Sodium Hydroxide (sample preservative)	< 500 ml	Support/Exclusion Zone
Methanol (decontamination solvent)	< 1 gallon	Support/Decontamination Zone
Hexane (decontamination solvent)	< 1 gallon	Support/Decontamination Zone
Isopropanol (decontamination solvent)	< 1 gallon	Support/Decontamination Zone
pH Buffers (calibration standard)	< 500 ml	Support Zone
MSA Sanitizer (respirator cleaner)	< 1 liter, powder	Support/Decontamination Zone
Alconox/Liquinox (detergent)	< 1 liter, powder/liquid	Support/Decontamination Zone

3.7.2 SHIPPING AND TRANSPORTATION OF CHEMICAL PRODUCTS

(Reference CH2M HILL's *Procedures for Shipping and Transporting Dangerous Goods*)

Nearly all chemicals brought to the site are considered hazardous materials by the U.S. Department of Transportation (DOT). All staff who ship the materials or transport them by road must receive the CH2M HILL training in shipping dangerous goods. All hazardous materials that are shipped (e.g., via Federal Express) or are transported by road must be properly identified, labeled, packed, and documented by trained staff. Contact the HSM or the Equipment Coordinator for additional information.

3.8 **CONTAMINANTS OF CONCERN** (REFER TO PROJECT FILES FOR MORE-DETAILED CONTAMINANT INFORMATION)					
Contaminant	**Location and Highest[a] Concentration (ppm)**	**Exposure Limit[b]**	**IDLH[c]**	**Symptoms and Effects of Exposure**	**PIP[4] (eV)**
Acetone	1,300 mg/kg 11 mg/l	250 ppm	20,000 ppm	Inh: irrit eyes, nose, throat;Ing: head, dizz, derm	9.69
Arsenic	6.7 mg/kg140 mg/l	0.002 mg/m3	100 mg/m3	Ing: hyperpig of skin, [carc] Inh: ulceration of nasal septum Abs: derm, GI disturbances Con: peri neur, resp irrit	N/A
Beryllium	1.7 mg/kg	0.005 mg/m3	10 mg/m3	Inh: resp symptoms, weak, ftg, weight loss [carc]	N/A
Bis(2-ethylhexyl)phthalate	570 mg/kg	N/F	N/F	N/F	N/F
Cadmium	1 mg/kg	0.2 mg/m3	50 mg/m3	Inh: Polm edema, dysp; Ing: cough, chest tight, subs pain, head, chills, musc aches, nau, vomit, diarr, anos, emphy, prot, mild anemia, [carc]	N/A
Carbon Disulfide	5 mg/kg	1 ppm	500 ppm	Inh: dizz, head, poor sleep; Abs: ftg, ner, anor, low-wgt; Ing: psychosis, polyneur; Con: Parkinson-like syndrome, ocular changes, coronary heart disease, gastritis, kidney, liver damage, eye, skin burns, derm	10.08
Chlorobenzene	270 ug/L	75 ppm	2400 ppm	Inh: irrit skin, eyes, nose, Ing: drow, inco, Con: in animals, liver, lung, kidney damage	9.07
Chromium	15.7 mg/kg174 mg/l	0.5 mg/m3	N/F	Ing: lungsInh: histologic fibrosis of lungs	N/A
Copper	40.8 mg/kg667 mg/l	1 mg/m3	N/A	Inh: irrit nasal, musc memb; Ing: pharynx, nasal perforation; Con: eye irrit, metallic taste, derm, in animals: lung, liver, kidney damage, anemia	N/A
1,1-Dichloroethane	35 mg/kg920 mg/l	100 ppm	4,000 ppm	Inh: CNS depres, skin irrit;Ing: liver, kidney damage	11.06
1,2-Dichloroethene	12,000 mg/kg3 mg/l	200 ppm	4,000 ppm	Inh: irrit eyes, resp sys, CNS Ing: depres	9.65
1,2-dichlorobenzene	510 ug/L	50 ppm	1000 ppm	Inh: nose, eyes, liver, Abs: kidney damage, skin, Ing: blister	9.06
1,4-dichlorobenzene	58 ug/L	75 ppm	1000 ppm	Inh: head-eye irrit, swell, Ing: periorb, profuse rhintis; Con: anor, nau, vomit, low-wgt, jaun, cirr; [carc] in animals, liver, kidney damage	8.98
Lead	55 mg/kg128 mg/l	0.100 mg/m3	700 mg/m3	Ing: pallor, pal eye, anorInh: weak, lass, insom, facial Con: low-wght, malnut, constip, abdom pain, colic anemia; ginival lead line; tremor; paca wrist, ankles, encephalopathy, nephropathy; irrit eyes, hypotension	N/A
Manganese	460 ug/L	1 mg/m3	N.E.	Inh: Parkinson's, asthenia, Ing: insom, flume, fever, dry throat, couth, tight chest, dysp, rales, flu-like fever, low-back pain, vomit; mal; ftg	N/A
Mercury	0.11 mg/kg0.92 mg/l	0.01 mg/m3	10 mg/m3	Ing: spastic, jerky, dizzInh: pares, ataxia, dysarthria Abs: vision, hearing dist Con: salv; lac, nau, vomit, diarr, constip; skin burns, emotional dist	N/A
Methylene Chloride	540 mg/kg6 mg/l	50 ppm	5,000 ppm	Ing: li-head; limbs numbsInh: ftg, weak, sleepiness Con: tingle, naup; irrit eyes, skin; [carc]	11.32 eV

3.8 CONTAMINANTS OF CONCERN (REFER TO PROJECT FILES FOR MORE-DETAILED CONTAMINANT INFORMATION)					
Contaminant	**Location and Highest[a] Concentration (ppm)**	**Exposure Limit[b]**	**IDLH[c]**	**Symptoms and Effects of Exposure**	**PIP[d] (eV)**
N-nitrosodiphenylamine	31 ug/L	Ca	Ca	Inh: Nau, vomit, diar; Abs: abdom cramps, head; Ing: fever, enlarg liver; Con: jaun, resuced function of liver, kidneys, lungs [carc]	8.69
Naphthalene	11,000 ug/L	10 ppm	500 ppm	Inh: Eye irrit, head, conf; Abs: excitement, mal, nau; Ing: vomit, abdom pain, irrit; Con: bladder, profuse sweat, jaun, hema, hemog, renal shutdown, derm	8.12
Silver	12,800 mg/kg	0.01 mg/3	N/F	Ing: septum, throat, skin, irritInh: blue-gray eyes, nasal Con: skin, ulceration, GI dust	N/A
Tetrachloroethylene	25 mg/15 mg/kg	25 ppm	500 ppm	Ing: nau, flush face, neck Inh: irrit eyes, nose, throat; Con: verti, dizz, inco; head, som; skin eryt; liver damage [carc]	9.32 eV
Toluene	4 mg/kg	100 ppm	2,000 ppm	Ing: Lac; ner, musc fig, insomInh: ftg, weak; conf, euph Abs: dizz, head; dilated pupils Con: Pares; derm	8.82 eV
Trichlorethylene	33 mg/149,000 mg/kg	25 ppm	1,000 ppm	Ing: tremors, som, nauInh: head, verti, vis dist Con: vomit, irrit eyes, derm, card arrhy, pares [carc]	9.45 eV
1,1,1-Trichloroethane	100 mg/kg14 mg/l	350 ppm	1,000 ppm	Inh: head, lass, CNS depres;Ing: poor equi, irrit eyes; Con: derm, card arrhy	11.00
Vinyl Chloride	9 ug/L				
Xylenes	5 mg/kg	100 ppm	1,000 ppm	Inh: dizz, excitement, drow; Abs: inco, staggering gait; Ing: irrit eyes, nose, throat; Con: corneal vacuolization, anor, nau, vomit, abdom pain, derm	8.56

Footnotes:
a: Although past investigations related to petroleum contamination have been performed in the vicinity of SWMU06 and SWMU08, the concentration of any residual contaminats is unknown.
b: Appropriate value of PEL, REL, or TLV listed
c: IDLH = immediately dangerous to life and health (units are the same as specified "Exposure Limit" units for that contaminant); NL = No limit found in reference materials; CA = Potential occupational carcinogen
d: PIP = photoionization potential; NA = Not applicable; UK = Uknown

3.9 POTENTIAL ROUTES OF EXPOSURE

DERMAL: Contact with contaminated media. This route of exposure is minimized through proper use of PPE, as specified in Section 5.	**INHALATION:** Vapors and contaminated particulates. This route of exposure is minimized through proper respiratory protection and monitoring, as specified in sections 5 and 6, respectively.	**OTHER:** Inadvertent ingestion of contaminated media. This route should not present a concern if good hygiene practices are followed (e.g., wash hands and face before eating, drinking, or smoking).

4 PERSONNEL

4.1 CH2M HILL EMPLOYEE MEDICAL SURVEILLANCE AND TRAINING

(Reference CH2M HILL SOP HS-01, *Medical Surveillance*, and HS-02, *Health and Safety Training*)

The employees listed below are enrolled in the CH2M HILL Comprehensive Health and Safety Program and meet state and federal hazardous waste operations requirements for 40-hour initial training, 3-day on-the-job experience, and 8-hour annual refresher training. Employees designated "SSC" have received 8 hours of supervisor and instrument training and can serve as site safety coordinator (SSC) for the level of protection indicated. An SSC with a level designation (D, C, B) equal to or greater than the level of protection being used must be present during all tasks performed in exclusion or decontamination zones that involve the potential for exposure to health and safety hazards. Employees designated "FA-CPR" are currently certified by the American Red Cross, or equivalent, in first aid and CPR. At least one FA-CPR designated employee must be present during all tasks performed in exclusion or decontamination zones that involve the potential for exposure to health and safety hazards. The employees listed below are currently active in a medical surveillance program that meets state and federal regulatory requirements for hazardous waste operations. Certain tasks (e.g., confined-space entry) and contaminants (e.g., lead) may require additional training and medical monitoring.

Pregnant employees are to be informed of and are to follow the procedures in CH2M HILL's SOP HS-04, *Reproduction Protection*, including obtaining a physician's statement of the employee's ability to perform hazardous activities, before being assigned fieldwork.

Employee Name	Office	Responsibility	SSC/FA-CPR
J. Greg Mott	Reston, VA	Activity Manager	FA-CPR
Brett Doerr	Reston, VA	Project Manager	FA-CPR; Level D SSC
Richard Doucette	Reston, VA	Site Safety Coordinator	FA-CPR; Level D SSC
Don Martinson	Reston, VA	Technician	FA-CPR; Level B SSC
Mike Showalter	Reston, VA	Technician	FA-CPR; Level B SSC

4.2.1 CLIENT

Contact Name: Dawn Hayes, NTR/LANTDIV
Phone: (757) 322-4815

4.2.2 CH2M HILL

Program Manager:	J. Greg Mott (703) 471-1441
Project Manager:	Brett Doerr (703) 471-1441
Health and Safety Manager:	John Longo (201) 316-9300
Field Team Leader:	to be determined
Site Safety Coordinator:	to be determined

The SSC is responsible for contacting the field team leader and the project manager. In general, the project manager either will contact or will identify the client contact. The Health and Safety Manager (HSM) should be contacted as appropriate. The SSC or the project manager must notify the client and the HSM when a serious injury or a death occurs or when health and safety inspections by OSHA or other agencies are conducted. Refer to sections 10 through 12 for emergency procedures and phone numbers.

4.2.3 SUBCONTRACTORS

(Reference Section 3, *Corporate Health and Safety Program Manual*)

When specified in the project documents (e.g., contract), this plan may cover CH2M HILL subcontractors. However, this plan does not address hazards associated with tasks and equipment that the subcontractor has expertise in (e.g., operation of drill rig). Specialty subcontractors are responsible for health and safety procedures and plans specific to their work. Specialty subcontractors are to submit plans to CH2M HILL for review and approval before the start of fieldwork. Subcontractors must comply with the established health and safety plan(s). CH2M HILL must monitor and enforce compliance with the established plan(s).

Subcontractor: Drilling subcontractor had not been selected at the time of the writing of this HASP.
Subcontractor Contact:
Telephone:

General health and safety communication with subcontractors contracted with CH2M HILL and covered by this plan is to be conducted as follows:

- Request that the subcontractor, if a specialty subcontractor, submit a safety or health plan applicable to their expertise (e.g., drill-rig safety plan or nuclear density gauge [NDG] health plan); attach the reviewed plan.
- Supply subcontractors with a copy of this plan, and brief them on its provisions.
- Direct health and safety communication to the subcontractor-designated safety representative.
- Notify the subcontractor-designated representative if a violation of the plan(s) is observed. Specialty subcontractors are responsible for mitigating hazards in which they have expertise.
- If a hazard condition persists, inform the subcontractor. If the hazard is not mitigated, stop affected work as a last resort and notify the project manager.
- When an apparent imminent danger exists, promptly remove all affected personnel. Notify the project manager.
- Make clear that consistent violations of the health and safety plan by a subcontractor may result in termination of the subcontract.

4.2.4 CONTRACTORS

(Reference Section 3, *Corporate Health and Safety Program Manual*)

This plan does not cover contractors that are contracted directly to the client or the owner. CH2M HILL is not responsible for directing contractor personnel and is not to assume responsibility through their actions. When the contractor is in control of the site, ask the contractor to conduct a briefing of their health and safety practices and to describe how they apply to CH2M HILL's activities. Request a copy of the contractor's health and safety plan.

Contractor:	NA
Contact Name:	NA
Telephone:	NA

General health and safety communication with contractors *not* contracted with CH2M HILL is listed below. These procedures can also be applied to other third party communications (e.g., client personnel).

- Ask the contractor to brief CH2M HILL on the contractor's health and safety plan for how the plan affects CH2M HILL employees on the site.

- If acceptable to the client, communicate about health and safety directly with the contractor PM or other onsite contractor-designated representative. CH2M HILL employees are not to direct the details of the contractor's work or to advise on health and safety (e.g., how the contractor corrects unsafe conditions).

- If an observed hazard poses a risk to CH2M HILL personnel, notify the party controlling the work activity as soon as possible. Notify the project manager; the project manager will notify the client. Document oral notification in project records (i.e., the field logbook).

- If a hazardous condition endangering a CH2M HILL employee persists, inform the contractor and the project manager (the project manager will contact the client) that CH2M HILL cannot execute the assigned work until the hazard is mitigated.

- When an apparent imminent danger exists, orally warn the person(s) in danger and orally notify the contractor promptly. When an imminent danger involves a CH2M HILL employee, remove the employee and suspend CH2M HILL work immediately until the hazard has been mitigated. Inform the project manager and the contractor promptly.

- The SSC or the project manager must notify the client and CH2M HILL health and safety staff when (1) the contractor fails to remedy an unsafe condition affecting CH2M HILL personnel, (2) the contractor does not remedy the hazardous condition within a reasonable period of time, or (3) the contractor repeatedly creates the hazardous condition.

5 PERSONAL PROTECTIVE EQUIPMENT (PPE) (Reference CH2M HILL SOP HS-07, *Personal Protective Equipment*, HS-08, *Respiratory Protection*, Section 2 of the *Site Safety Notebook*)

5.1 PPE SPECIFICATIONS[a]

Task	Level	Body	Head	Respirator[b]
General work uniform when no chemical exposure is anticipated	D	Work clothes; steel-toe, steel-shank leather work boots; work gloves	Hardhat[c] Safety glasses Ear protection[d]	None required
Monitoring well installation, development, and sampling. All other sampling activities.	Modified D	**COVERALLS:** Uncoated Tyvek® **BOOTS:** Steel-toe, steel-shank chemical-resistant boots OR steel-toe, steel-shank leather work boots with outer rubber boot covers **GLOVES:** Inner surgical-style nitrile glove AND outer chemical-resistant nitrile glove.	Hardhat[c] Splash shield[c] Safety glasses Ear protection[d]	None required
None anticipated	C	**COVERALLS:** Polycoated Tyvek® **BOOTS:** Steel-toe, steel-shank chemical-resistant boots OR steel-toe, steel-shank leather work boots with outer rubber boot covers **GLOVES:** Inner surgical-style nitrile glove AND outer chemical-resistant nitrile glove.	Hardhat[c] Splash shield[c] Ear protection[d] Spectacle inserts	APR, full face, MSA Ultratwin or equivalent; with GME-H[e] cartridges or equivalent
None anticipated	B	**COVERALLS:** Polycoated Tyvek® **BOOTS:** Steel toe, steel-shank chemical-resistant boots OR steel-toe, steel-shank leather work boots with outer rubber boot covers **GLOVES:** Inner surgical-style nitrile glove AND outer chemical-resistant nitrile glove.	Hardhat[c] Splash shield[c] Ear protection[d] Spectacle inserts	Positive-pressure demand self-contained breathing apparatus (SCBA): MSA Ultralite, or equivalent

[a] Modifications are as indicated. CH2M HILL will provide PPE to only CH2M HILL employees.
[b] No facial hair that would interfere with respirator fit is permitted.
[c] Hardhat and splash-shield areas are to determined by the SSC.
[d] Ear protection should be worn while working around drill rigs or other noise-producing equipment or when conversations cannot be held at distances of 3 feet or less without shouting. Refer to Section 6 for other requirements.
[e]The GME-H cartridge is the new standard-issue cartridge. Available stock of the previously standard GMC-H cartridges may be used for tasks covered by this plan.

5.2 REASONS FOR UPGRADING OR DOWNGRADING LEVEL OF PROTECTION

Upgrade*	Downgrade
• Request from individual performing task. • Change in work task that will increase contact or potential contact with hazardous materials. • Occurrence or likely occurrence of gas or vapor emission. • Known or suspected presence of dermal hazards. • Instrument action levels (Section 6) exceeded.	• New information indicating that situation is less hazardous than originally thought. • Change in site conditions that decreases the hazard. • Change in work task that will reduce contact with hazardous materials.

*Performing a task that requires an upgrade to a higher level of protection (e.g., level D to level C) is permitted only when the PPE requirements have been specified in Section 5 and an SSC who meets the requirements specified in subsection 4.1 is present.

6 AIR MONITORING SPECIFICATIONS (Reference CH2M HILL SOP HS-06, *Air Monitoring*, and Section 2 of the *Site Safety Notebook*)

Instrument	Tasks	Action Levels[a]	Frequency[b]	Calibration
FID: OVA model 128 or equivalent	None anticipated	ppm Level D ppm Level C ppm Level B	Initially and periodically during task	Daily
PID: OVM with 11.7 eV lamp or equivalent	Monitoring well installation. Soil and groundwater sampling activities.	ppm Bkrnd - 1 Level D ppm 1- 5 Level C ppm > 5 Level B	Initially and periodically during task	Daily
CGI: MSA model 260 or 261 or equivalent	Monitoring well installation. Soil and groundwater sampling activities.	0-10%[c] LEL: No explosion hazard 10-25%[c] LEL: Potential explosion hazard >25%[c] LEL: Explosion hazard; evacuate or vent	Continuous during advancement of boring or trench	Daily
O_2 Meter: MSA model 260 or 261 or equivalent	None anticipated	>25.0%[c] O_2: Explosion hazard; evacuate or vent 20.9%[c] O_2: Normal O_2 <19.5%[c] O_2: O_2 deficient; vent or use SCBA	Continuous during advancement of boring or trench	Daily
Dust Monitor: Miniram model PDM-3 or equivalent	None anticipated	mg/m^3 Level D mg/m^3 Level C	Initially and periodically during task	Zero Daily
Detector Tube: Drager benzene specific 0.5/c (0.5 to 10 ppm range) with pretube, or equivalent	None anticipated	<0.5ppm Level D 0.5-1ppm Level C >1ppm Level B	Initially and periodically when PID/FID >1ppm	Not Applicable
Colormetric Tube: Drager vinyl chloride specific (0.5 to 30 ppm range) with pretube, or equivalent	None anticipated	<0.5ppm Level D 0.5ppm Level B	Initially and periodically when PID/FID >1ppm	Not Applicable
Radiation Meter[d]: Ludlum Model 3 with GM probe model 44-9, or equivalent	None anticipated	Background: Continue work >3x Background: Consult RHM >2 mR/Hr: Establish REZ	Initially, periodically, and at end of task	Daily
Noise-Level Monitor[c]:	None anticipated	< 85 dB(A) No action required 85 - 120 dB(A) Hearing protection required[5] 120 dB(A) Stop; re-evaluate	Initially and periodically during task	Daily

Note a: Action levels apply to sustained breathing-zone measurements above background.

Note b: The exact frequency of monitoring depends on field conditions and is to be determined by the SSC; generally, every 5 to 15 minutes is acceptable; more frequently may be appropriate. Monitoring results should be recorded. Documentation should include instrument and calibration information, time and measurement result, personnel monitored, and place/location where measurement is taken (e.g., "Breathing Zone/MW-3," "at surface/SB-2," etc.).

Note c: If the measured percent of O_2 is less than 10, an accurate LEL reading will not be obtained. Percent LEL and percent O_2 action levels apply to only ambient working atmospheres, and do not apply to confined-space entry. More-stringent percent LEL and O_2 action levels are required for confined-space entry; refer to Section 9.

Note d: Refer to SOP HS-10 for instructions and documentation on radiation monitoring and screening.

Note e: Contact HSM. Noise monitoring, training, and audiometric testing also are required.

6.1 CALIBRATION SPECIFICATIONS

(Refer to the respective manufacturer's instructions for proper instrument-maintenance procedures)

Instrument	Gas	Span	Reading	Method
PID: HNU, 10.2 eV probe	100 ppm isobutylene	9.8 ± 2.0	55 ppm	1.5 lpm reg T-tubing OR 0.25 lpm reg direct tubing
HNU, 11.7 eV probe		5.0 ± 2.0	68 ppm	
PID: OVM, 10.0 or 10.6 eV bulb	100 ppm isobutylene	RF = 0.55	55 ppm	1.5 lpm reg T-tubing
OVM, 11.8 eV bulb		RF = 0.68	68 ppm	
PID: MiniRAE, 10.6 eV bulb	100 ppm isobutylene	CF=53	53 ppm ±5 ppm	1.5 lpm REG T-Tubing
PID: TVA 1000	100 ppm isobutylene	CF=0.55	55 ppm ± 5 ppm	1.5 lpm REG T-Tubing
FID: OVA-128	100 ppm methane	3.0 ± 1.5	100 ppm	1.5 lpm reg T-tubing
FID: TVA 1000	100 ppm methane	CF=1.00	100 ppm ± 10	1.5 lpm reg T-tubing
Dust Monitor: Miniram-PDM3	Dust-free air	Not applicable	0.00 mg/m^3 in "Measure" mode	Dust-free area OR Z-bag with HEPA filter
CGI: MSA 260, 261, 360, or 361	0.75% pentane	N/A	50% LEL ± 5 % LEL	1.5 lpm reg direct tubing

6.2 AIR SAMPLING

Sampling may be required by other OSHA regulations where there may be exposure to certain contaminants. Air sampling typically is required when site contaminants include lead, cadmium, arsenic, asbestos, and certain volatile organic compounds. Contact the HSM immediately if these contaminants are encountered.

Method Description: Not applicable

Personnel and Areas

Results must be sent immediately to the HSM. Regulations may require reporting to monitored personnel. Results reported to:

HSM: John Longo/NJO
Other:

7 DECONTAMINATION (REFERENCE CH2M HILL SOP HS-13, *DECONTAMINATION*)

The SSC must monitor the effectiveness of the decontamination procedures. Decontamination procedures found to be ineffective will be modified by the SSC.

7.1 DECONTAMINATION SPECIFICATIONS

Personnel

- Boot wash/rinse
- Glove wash/rinse
- Outer-glove removal
- Body-suit removal
- Inner-glove removal
- Respirator removal
- Hand wash/rinse
- Face wash/rinse
- Shower ASAP
- **PPE-disposal method:**
- **Water-disposal method:**

Sample Equipment

- Wash/rinse equipment
- Solvent-rinse equipment
- **Solvent-disposal method:**

Heavy Equipment

- Power wash
- Steam clean
- **Water-disposal method:**

7.2 DIAGRAM OF PERSONNEL-DECONTAMINATION LINE

No eating, drinking, or smoking is permitted in contaminated areas and in exclusion or decontamination zones. The SSC should establish areas for eating, drinking, and smoking. Contact lenses are not permitted in exclusion or decontamination zones.

Figure 7-1 illustrates a typical establishment of work zones, including the decontamination line. Work zones are to be modified by the SSC to accommodate task-specific requirements.

8 SPILL-CONTAINMENT PROCEDURES

Sorbent material will be maintained in the support zone. Incidental spills will be contained with sorbent and will be disposed of properly.

9 CONFINED-SPACE ENTRY

(Reference CH2M HILL SOP HS-17, *Confined Space Entry*)

No confined-space entry will be permitted. Confined-space entry requires additional health and safety procedures, training, and a permit. If conditions change such that confined-space entry is necessary, contact the HSM to develop the required entry permit.

When planned activities will not include confined-space entry, permit-required confined spaces accessible to CH2M HILL personnel are to be identified before the task begins. The SSC is to confirm that permit spaces are properly posted or that employees are informed of their locations and informed of their hazards.

10 SITE-CONTROL PLAN

10.1 SITE-CONTROL PROCEDURES

- The site safety coordinator (SSC) will conduct a site safety briefing (see below) before starting field activities or as tasks and site conditions change.
- Topics for briefing on site safety: general discussion of health and safety plan, site-specific hazards, locations of work zones, PPE requirements, equipment, special procedures, emergencies. Refer to Section 8 of *Site Safety Notebook.*
- The SSC records attendance at safety briefings in a logbook and documents the topics discussed.
- Post the OSHA job-site poster in a central and conspicuous location at sites where project field offices, trailers, or equipment storage boxes are established. Posters can be obtained by calling either 800/548-4776 or 800/999-9111.
- Field Trailers: Post "Exit" signs above exit doors, and post "Fire Extinguisher" signs above locations of extinguishers. Keep areas near exits and extinguishers clear.
- Determine wind direction.
- Establish work zones: support, decontamination, and exclusion zones. Delineate work zones with flags or cones as appropriate. Support zone should be upwind of the site.
- Establish decontamination procedures, including respirator-decontamination procedures, and test the procedures.
- Use access control at the entry and exit from each work zone.
- Store chemicals in appropriate containers.
- Make MSDSs available for onsite chemicals to which employees are exposed.
- Establish onsite communication consisting of the following:
    - Line-of-sight and hand signals
    - Air horn
    - Two-way radio or cellular telephone if available
- Establish offsite communication.
- Establish and maintain the "buddy system."
- Establish procedures for disposing of material generated on the site.
- Initial air monitoring is conducted by the SSC in appropriate level of protection.
- The SSC is to conduct periodic inspections of work practices to determine the effectiveness of this plan -- refer to CH2M HILL SOP 18, *Health and Safety* Checklist, or Section 4 of *Site Safety Notebook.* Deficiencies are to be noted, reported to the HSM, and corrected.

10.2 HAZWOPER COMPLIANCE PLAN (Reference CH2M HILL SOP HS-17, *Health and Safety Plans*)

This section outlines procedures to be followed when certain activities do not require 24- or 40-hour training. ***Note, prior approval from the HSM is required before these tasks are conducted on regulated hazardous waste sites.***

- Certain parts of the site work may be covered by state or federal Hazwoper standards and therefore require training and medical monitoring. Anticipated tasks must be included in subsection 2.2.1.
- Air sampling must confirm that there is no exposure to gases or vapors before non-Hazwoper-trained personnel are allowed on the site. Other data (e.g., soil) also must document that there is no potential for exposure. The HSM must approve the interpretation of these data. Refer to subsections 3.8 and 6.2 for contaminant data and air sampling requirements, respectively.
- Non-Hazwoper-trained personnel must be informed of the nature of the existing contamination and its locations, the limits of their access, and the emergency action plan for the site. Non-Hazwoper-trained personnel also must be trained in accordance with all other state and federal OSHA requirements, including 29 CFR 1910.1200 (HAZCOM). Refer to subsection 3.7.1 for hazard communication requirements.
- Air monitoring with direct-reading instruments conducted during regulated tasks also should be used to ensure that non-Hazwoper-trained personnel (e.g., in an adjacent area) are not exposed to volatile contaminants. Non-Hazwoper-trained personnel should be monitored whenever the belief is that there may be a possibility of exposure (e.g., change in site conditions), or at some reasonable frequency to confirm that there is no exposure. Refer to Section 6.1 for air monitoring requirements.
- Treatment system start-ups: Once a treatment system begins to pump and treat contaminated media, the site is, for the purposes of applying the Hazwoper standard, considered a treatment, storage, and disposal facility (TSDF). Therefore, once the system begins operation, only Hazwoper-trained personnel (minimum of 24 hours of training) will be permitted to enter the site. All non-Hazwoper-trained personnel must leave the site.

If Hazwoper-regulated tasks are conducted concurrently with nonregulated tasks, non-Hazwoper-trained subcontractors must be removed from areas of exposure. If non-Hazwoper-trained personnel remain on the site while a Hazwoper-regulated task is conducted, the contaminant/exposure area (exclusion zone) must be posted, non-Hazwoper-trained personnel must be reminded of the locations of restricted areas and the limits of their access, and real-time monitoring must be conducted. Non-Hazwoper-trained personnel at risk of exposure must be removed from the site until it can be demonstrated that there is no longer a potential for exposure to health and safety hazards.

11 EMERGENCY RESPONSE PLAN (REFERENCE CH2M HILL SOP HS-12, *EMERGENCY RESPONSE*)

11.1 PRE-EMERGENCY PLANNING

The SSC performs the applicable pre-emergency planning tasks before starting field activities and coordinates emergency response with the facility and local emergency-service providers as appropriate.

- Review the facility emergency and contingency plans where applicable.
- Locate the nearest telephone; determine what onsite communication equipment is available (e.g., two-way radio, air horn).
- Identify and communicate chemical, safety, radiological, and biological hazards.
- Confirm and post emergency telephone numbers, evacuation routes, assembly areas, and route to hospital; communicate the information to onsite personnel.
- Post site map marked with locations of emergency equipment and supplies, and post OSHA job-site poster. The OSHA job-site poster is required at sites where project field offices, trailers, or equipment-storage boxes are established. Posters can be obtained by calling either 800/548-4776 or 800/999-9111.
- Field Trailers: Post "Exit" signs above exit doors, and post "Fire Extinguisher" signs above locations of extinguishers. Keep areas near exits and extinguishers clear.
- Review changed site conditions, onsite operations, and personnel availability in relation to emergency response procedures.
- Evaluate capabilities of local response teams where applicable.
- Where appropriate and acceptable to the client, inform emergency room and ambulance and emergency response teams of anticipated types of site emergencies.
- Designate one vehicle as the emergency vehicle; place hospital directions and map inside; keep keys in ignition during field activities.
- Inventory and check site emergency equipment, supplies, and potable water.
- Communicate emergency procedures for personnel injury, exposures, fires, explosions, chemical and vapor releases.
- Review notification procedures for contacting CH2M HILL's medical consultant and team member's occupational physician.
- Rehearse the emergency response plan once before site activities begin, including driving the route to the hospital.
- Brief new workers on the emergency response plan.
- The SSC will evaluate emergency response actions and initiate appropriate follow-up actions.

11.2 EMERGENCY EQUIPMENT AND SUPPLIES

The SSC should mark the locations of emergency equipment on the site map and should post the map.

Emergency Equipment and Supplies	Location
20 lb (or two 10-lb) fire extinguisher (A, B, and C classes)	CH2M HILL Field Vehicle
First aid kit	CH2M HILL Field Vehicle
Eye wash	CH2M HILL Field Vehicle
Potable water	CH2M HILL Field Vehicle
Bloodborne-pathogen kit	CH2M HILL Field Vehicle
Additional equipment (specify)	None anticipated

11.3 EMERGENCY MEDICAL TREATMENT

- Notify appropriate emergency response authorities listed in sections 12 and 13 (e.g., 911).
- During a time of no emergency, contact CH2M HILL's medical consultant for advice and guidance on medical treatment.
- The SSC will assume charge during a medical emergency until the ambulance arrives or until the injured person is admitted to the emergency room.
- Prevent further injury.
- Initiate first aid and CPR where feasible.
- Get medical attention immediately.
- Perform decontamination where feasible; lifesaving and first aid or medical treatment take priority.
- Notify the field team leader and the project manager of the injury.
- Make certain that the injured person is accompanied to the emergency room.
- Notify the health and safety manager.
- Notify the injured person's human resources department within 24 hours.
- Prepare an incident report -- refer to CH2M HILL SOP 12, *Emergency Response and First Aid*, and Section 6 of *Site Safety Notebook*. Submit the report to the corporate director of health and safety and the corporate human resources department (COR) within 48 hours.
- When contacting the medical consultant, state that you are calling about a CH2M HILL matter, and give your name, your telephone number, the name of the injured person, the extent of the injury or exposure, and the name and location of the medical facility where the injured person was taken.

11.4 NONEMERGENCY PROCEDURES

The procedures listed above may be applied to nonemergency incidents. Injuries and illnesses (including overexposure to contaminants) must be reported to Human Resources. If there is doubt about whether medical treatment is necessary, or if the injured person is reluctant to accept medical treatment, contact the CH2M HILL medical consultant.

- When contacting the medical consultant, state that the situation is a CH2M HILL matter, and give your name, your telephone number, the name of the injured person, the extent of the injury or exposure, and the name and location of the medical facility where the injured person was taken.
- Follow these procedures as appropriate.

11.5 INCIDENT RESPONSE

In fires, explosions, or chemical releases, actions to be taken include the following:

- Shut down CH2M HILL operations and evacuate the immediate work area.
- Account for personnel at the designated assembly area(s).
- Notify appropriate response personnel.
- Assess the need for site evacuation, and evacuate the site as warranted.

Instead of implementing a work-area evacuation, note that small fires or spills posing minimal safety or health hazards may be controlled.

11.6 EVACUATION

- Evacuation routes will be designated by the SSC before work begins.
- Onsite and offsite assembly points will be designated before work begins.
- Personnel will leave the exclusion zone and assemble at the onsite assembly point upon hearing the emergency signal for evacuation.
- Personnel will assemble at the offsite point upon hearing the emergency signal for a site evacuation.
- The SSC and a "buddy" will remain on the site after the site has been evacuated (if possible) to assist local responders and advise them of the nature and location of the incident.
- The SSC accounts for all personnel in the onsite assembly zone.
- A person designated by the SSC before work begins will account for personnel at the offsite assembly area.
- The SSC will write up the incident as soon as possible after it occurs and will submit a report to the corporate director of health and safety.

11.7 EVACUATION ROUTES AND ASSEMBLY POINTS

Refer to the site map in Section 1. Evacuation routes and assembly areas (and alternative routes and assembly areas) are specified on the site map.

11.8 EVACUATION SIGNALS

Signal	Meaning
Grasping throat with hand	Emergency–help me.
Thumbs up	OK; understood.
Grasping buddy's wrist	Leave area now.
Continuous sounding of horn	Emergency; leave site now.
Client/Facility: No site-specific signals applicable	

12 EMERGENCY RESPONSE

12.1 EMERGENCY RESPONSE TELEPHONE NUMBERS

SITE ADDRESS: State Route 956, Rocket Center, West Virginia 26726 — **Phone:** 304-726-5000
Cellular Phone:

Security (ABL): Response Operator — **Phone:**

Fire: Cresaptown Volunteer Fire Department — **Phone:** 911

Ambulance: Memorial Hospital — **Phone:** 911 or 301-777-4000

600 Memorial Drive

Cumberland, MD 21502

Public Works Department (Utility Clearances): — **Phone:**

Emergency: — **Phone:** 911

*When using a cellular phone outside the telephone's normal calling area, exercise caution in relying on the cellular phone to activate 911. When the caller is outside the normal calling area, the cellular service carrier should connect the caller with emergency services in the area where the call originated, but this may not occur. Telephone numbers of backup emergency services should be provided if a cellular phone is relied on to activate 911.

Hospital: Memorial Hospital — **Phone:** 301-777-4000 or 911
Address: 600 Memorial Drive, Cumberland, MD 21502

Route to Hospital: (Refer to Figure 12-1)

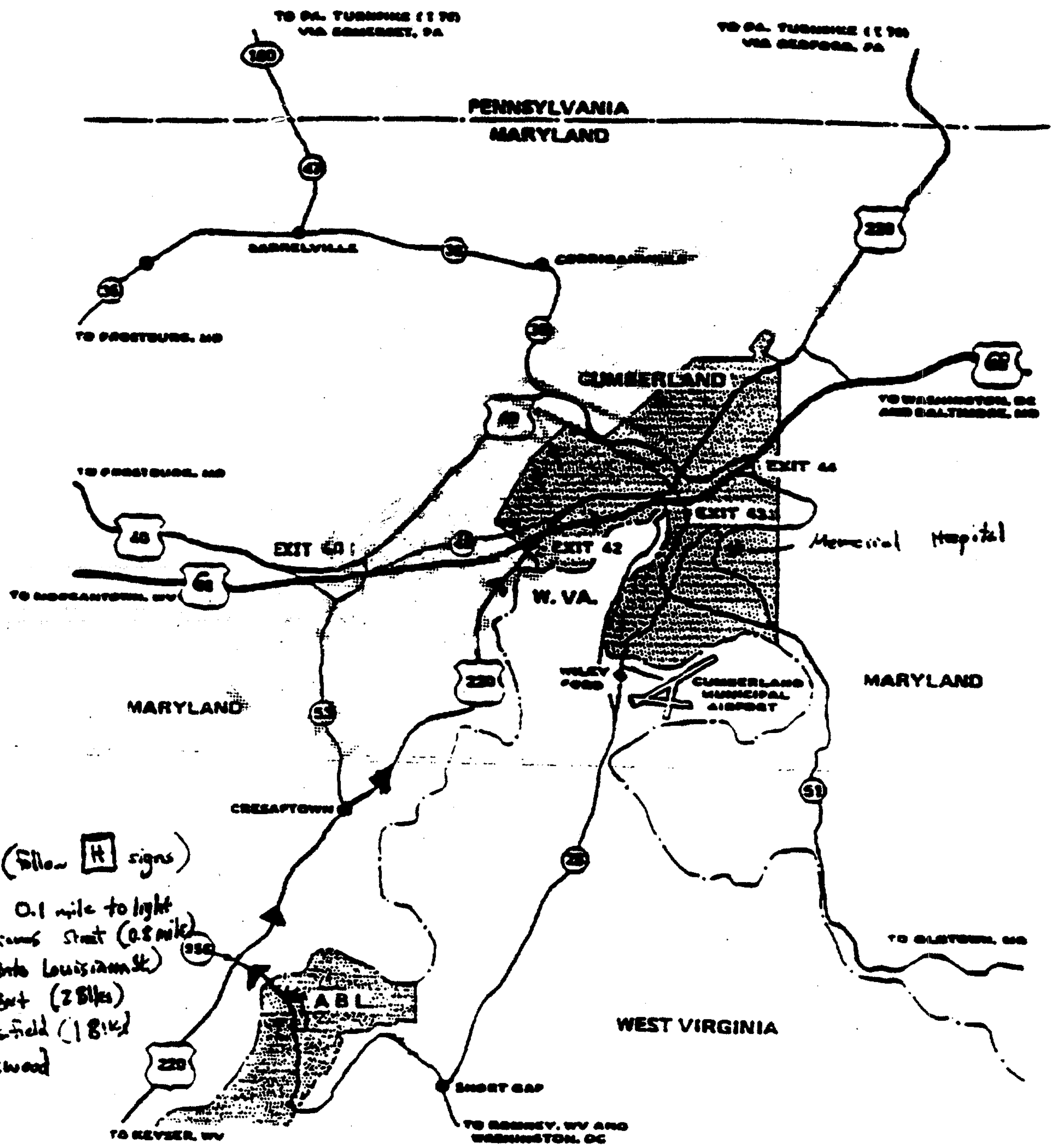
12.2 GOVERNMENT AGENCIES INVOLVED IN PROJECT

Federal Agency and Contact Name: Department of the Navy, Atlantic Division
Phone: (757) 322-4815 — Ms. Dawn Hayes, NTR

State Agency and Contact Name: WV DEP
Phone: 304-558-2745

State Agency and Contact Name: MD DOE
Phone: 410-631-3440

Contact the project manager. Generally, the project manager will contact relevant government agencies.



West 956
North 220
East I68
Exit 43D (follow [H] signs)
Maryland Ave 0.1 mile to light
left on Williams Street (0.8 mile)
(Williams turns into Louisiana St)
left on Kent (2 Blks)
left on Brookfield (1 Blk)
left on Ridgewood

Figure 12-1
MAP OF ROUTE TO HOSPITAL

13 EMERGENCY CONTACTS

If an injury occurs, notify the injured person's personnel office as soon as possible after obtaining medical attention for the injured person. Notification MUST be made within 24 hours of the injury.

CH2M HILL Medical Consultant

Dr. Elayne F. Theriault
Environmental Medical Resources, Inc.
Atlanta, Georgia
800/229-3674 OR 770/455-0818
(After-hours calls will be returned within 20 minutes.)

Occupational Physician (Regional or Local)

Dr. Laura Staton
46440 Benedict Drive, Suite 108
Sterling, Virginia 22170
(703) 444-5656

Corporate Director Health and Safety

Name: David Waite/SEA
Phone: 206/453-5005

Site Safety Coordinator (SSC)

Name: To be determined
Phone: (703) 471-1441

Medical and Training Administrator

Name: Susan Rineholt/COR
Phone: 303/771-0900

Regional Manager

Name: Dick Bedard
Phone: (617) 723-9036

Health and Safety Manager (HSM)

Name: John Longo
Phone: (201) 316-9300

Project Manager

Name: Brett Doerr
Phone: (703) 471-1441

Radiation Health Manager (RHM)

Name: Frank Petelka/ORO
Phone: 615/483-9032 (H)615/482-8667

Regional Human Resources Department

Name: Carol Barbary/DEN
Phone: (301) 771-0900

Client

Name: Dawn Hayes, NTR
Phone: (757) 322-4815

Corporate Human Resources Department

Name: Julie Zimmerman/COR
Phone: 303/771-0900

Federal Express Dangerous Goods Shipping
Phone: 800/238-5355

CH2M HILL Emergency Number for Shipping Dangerous Goods
Phone: 800/255-3924

Worker's Compensation and Auto Claims

GAB Business Services, Inc.
Phone: 800/747-7222 After hours 800/621-5410

Report fatalities AND report vehicular accidents involving pedestrians, motorcycles, or more than two cars.

14 APPROVAL

This site-specific health and safety plan has been written for use by CH2M HILL only. CH2M HILL claims no responsibility for its use by others unless that use has been specified and defined in project or contract documents. The plan is written for the specific site conditions, purposes, dates, and personnel specified and must be amended if those conditions change.

14.1 ORIGINAL PLAN

WRITTEN BY: Jack Robinson **DATE: 5-1-96**

APPROVED BY: **DATE:**

14.2 REVISIONS

REVISIONS MADE BY: Brett Doerr **DATE:** 05-04-98

REVISIONS TO PLAN: Name changes

REVISIONS APPROVED BY: **DATE:**

15 DISTRIBUTION

Name	Office	Responsibility	Number of Copies
Jerri McCauslin	COR	Senior Program Assistant	1
John Longo	NJO	Health and Safety Manager/Approver	1
Brett Doerr	WDC	Project Manager	1
Brett Doerr	WDC	Field Team Leader/Field Team	
Richard Doucette	WDC	Site Safety Coordinator	1
Client	NA	Client Project Manager	

16 ATTACHMENTS

Attachment 1: Employee Signoff
Attachment 2: Applicable Material Safety Data Sheets

Attachment 1
Employee Signoff

EMPLOYEE SIGNOFF

The employees listed below have been given a copy of this health and safety plan, have read and understood it, and agree to abide by its provisions.

EMPLOYEE NAME	EMPLOYEE SIGNATURE AND DATE

Attachment 2
Material Safety Data Sheets

Final

Investigation Derived Waste Management Plan Remedial Investigation and Feasibility Study of Site 11

for

Allegany Ballistics Laboratory
Rocket Center, West Virginia

Contract Task Order 0013

May 1998

Prepared for

Department of the Navy
Atlantic Division
Naval Facilities Engineering Command

Under the

LANTDIV CLEAN II Program
Contract N62470-95-D-6007

Prepared by

CH2MHILL

Herndon, Virginia

Contents

Tables

Section 1
Introduction

An Investigation Derived Waste Management Plan (IDWMP) has been developed to formulate the approach that will be taken at Allegany Ballistic Laboratory (ABL) for the handling and disposal of all investigation derived waste (IDW) generated during the Remedial Investigation/Feasibility Study (RI/FS) of ABL Site 11. The plan clearly details the logic used in determining the final disposition of all IDW.

Roles and Responsibilities

Atlantic Division Project Manager—No contractual provisions have been made for the contractor to analyze and dispose of any IDW off the site.

Contractor's Field Team Leader/Site Manager—The field team leader (FTL) is responsible for the onsite supervision of the waste handling procedures during the fieldwork. If site conditions change that effect the waste handling procedures, it is the FTL's responsibility to inform the contractor's project manager. The FTL also is responsible for ensuring that all other field personnel are familiar with and are properly implementing the procedures listed in the IDWMP.

Project Manager—It is the responsibility of the project manager (PM) to coordinate with Atlantic Division's PM and the facility representatives in the final disposition of IDW. The PM will relay the results of chemical analysis of the IDW and advise Atlantic Division's PM on the regulatory requirements and prudent measures appropriate to the disposition of the IDW. The PM is responsible for ensuring that field personnel involved in waste handling are familiar with the procedures to be implemented in the field, and that all documentation has been completed. In addition, it is the PM's responsibility to list all ARARs for the management of IDW and specifically discuss how they are applicable, and relevant and appropriate requirements.

ABL Facility Representative—It is the responsibility of the facility representative (FR) to prepare, record, and manifest IDW for offsite disposal. In addition, the FR should ensure that all containers are properly labeled and stored onsite in accordance with the IDWMP.

State Project Manager—The Navy views the state PMs from West Virginia and Maryland as being responsible for reviewing ARARs listed and identifying any additional ARARs associated with the management of the IDW.

Sources of Investigation Derived Waste

The IDW sources are site specific and/or activity specific. The following activities are planned for this field effort and will result in the generation of IDW. The first three activities generate IDW which is native to the site and the last two activities generate IDW which is transported from its place of origin. Both types of IDW will be containerized and disposed of as required by solid waste or hazardous waste regulations, and in accordance with CERCLA Section 121(d)(3) and the letter from the West Virginia Division of Environmental Protection, Office of Water Resources (WVDEP/OWR, December 1, 1995).

- Monitoring Well Installation
- Soil and Sediment Sampling
- Groundwater sampling
- Sampling equipment decontamination
- Personnel protective equipment

The IDW quantities estimated to be generated from the fieldwork at Sites 11 are listed below in Table 1-1.

Table 1-1
ESTIMATED IDW QUANTITIES GENERATED DURING VARIOUS SITE ACTIVITIES

Location	Activity	Media	Quantity
Site 11	Monitoring well installation and soil, sediment, and groundwater sampling	PPE and swabs	10 cubic yards
Site 11	Monitoring well installation and sampling	Groundwater	1900 gallons
Site 11	Soil, sediment, and groundwater sampling	Soil, sediment, and groundwater	20 cubic yards

Investigation Derived Waste Management

In developing the management options for the IDW, existing site conditions were taken into consideration. The underlying philosophy behind the proposed management option(s) is:

- Because free product has been detected in both the alluvium and bedrock during previous investigations, all IDW, both soil and groundwater, will be containerized, pending analysis. Disposal options will be evaluated once the IDW analytical results are received.

- The investigation should not contribute significantly to further environmental degradation, nor should an additional threat to public health or the environment be presented.

The IDW management for fieldwork performed in support of the RI/FS for Site 11 is located in Table 1-2.

Table 1-2

IDW MANAGEMENT FOR SITE 11

Media	Expected Quantity	Primary Contaminants of Concern	Concentration (µg/kg or µg/l)	Management Option
F-Well Groundwater	1,200 gallons	1,2-dichlorobenzene 1,4-dichlorobenzene 1,2,4- trichlorobenzene naphthalene chloromethane tetrachloroethene	0-510 0-58 0-122 0-11,000 0-68 0-910	Groundwater derived from bailing of product from the F-Well will be containerized for analysis.
F-Well Sediment	0.5 cubic yards	1,2-dichlorobenzene 1,4-dichlorobenzene 1,2,4- trichlorobenzene naphthalene chloromethane tetrachloroethene	0-510 0-58 0-122 0-11,000 0-68 0-910	Sediment remaining after sampling of sand at the bottom of the F-Well will be containerized and disposed of in a similar manner to F-Well groundwater.
Swabs	5 cubic yards	1,2-dichlorobenzene 1,4-dichlorobenzene 1,2,4- trichlorobenzene naphthalene chloromethane tetrachloroethene	0-510 0-58 0-122 0-11,000 0-68 0-910	Swabs will be containerized and disposed of in similar manner to F-Well groundwater.
Groundwater - Monitoring Well Installation and sampling	500 gallons	chlorobenzene trichloroethene tetrachloroethene vinyl chloride 1,4-dichlorobenzene	0-270 0-5 0-17 0-9 0-5	Purge water generated during sampling will be containerized pending IDW sample analysis
Soil, drill cuttings-Soil boring and monitoring well installation	20 cubic yards	Bis(2-ethylhexyl) phthalate Beryllium	0-300 1500	Soil and drill cuttings generated during soil boring ad monitoring well installation will be containerized pending IDW sample analysis
PPE	5 cubic yards	-------	-------	All PPE (tyvek, gloves, and other health and safety disposables) will be decontaminated following appropriate protocol, double bagged, and sent offsite for disposal in accordance with CERCLA Section 121(d)(3).
Decon fluids	200 gallons	Acetone rinse	-------	Since the quantity of fluid expected to be generated for decontamination is small, it will be containerized, tested, and sent offsite for proper disposal in accordance with CERCLA Section 121(d)(3).

Soil and Groundwater

Soil, cuttings, and groundwater generated during monitoring-well installation will be containerized pending analysis of the IDW samples. If sample analysis shows there are no contaminants present above risk-based concentrations, then it is proposed that the IDW be discharged to the ground surface proximate to its place of origin.

F-Well Product Recovery Wastes

Waste water, sediment, and expendables/PPE derived from the F-Well during the product-recovery phase of the investigation will be containerized in 55-gallon drums or a large-capacity container, such as a Baker tank. CH2M HILL estimates that eighteen 55-gallon drums will be required to handle the water, sediment, and expendables/PPE generated during the investigation.

At the conclusion of the product recovery event, the 55-gallon drums will be labeled and secured and left within the boundary of Site 11 at a location designated by Navy personnel. At the end of the Site 11 RI/FS field investigation activities, composited water and sediment samples will be collected from the drums or Baker tank. These samples will be submitted to the analytical laboratory for full TCLP analyses and disposed of accordingly.

Labeling

Where 55-gallon drums are used to containerize drill cuttings or purge water, the containers will be sequentially numbered and labeled by the field team during site activity. Container labels shall be legible and of an indelible medium (waterproof marker, paint stick, or similar means). Information shall be recorded both on the container lid and its side, and the contractor shall maintain a log of all drums left onsite. Container labels shall include, at a minimum:

- LANTDIV contract number and site number
- Project name
- Drum number
- Boring or well number
- Date
- Source
- Contents
- Sample ID

If laboratory analyses reveal that containerized IDW meets the requirements of classification as hazardous waste as defined by RCRA, additional labeling of containers may be necessary. The PM will assist the facility in additional labeling procedures, if necessary, after departure of the field team from the facility. These additional labeling procedures will be based on the identification of IDW present; EPA regulations applicable to labeling hazardous wastes are contained in 40 CFR Parts 261, 262.

Container Log

A container log shall be maintained in the site log book by the FTL. The container log shall contain the same information as the container label plus any additional remarks or information. Such additional information may include the identification number of a representative laboratory sample.

Container Storage

Containers of IDW shall be stored in a specially designated, secure area that is managed by ABL until final disposition is determined. The temporary storage area will be within Site 1, as designated by an ABL representative. All containers shall be placed on pallets and covered with plastic sheeting to provide protection from weather.

If laboratory analyses reveal that the containerized IDW satisfies the definition of a hazardous waste, additional storage security may be implemented. In the absence of the investigation team, additional security will be the responsibility of LANTDIV or the facility, as confirmed by the contingency discussions.

The contractor will assist LANTDIV in determining the storage requirements, which may include staging the drums on wooden pallets or other structures to prevent contact with the ground and to provide easy access. Weekly inspections by facility personnel of the temporary storage area also may be required. These inspections may assess the structural integrity of the containers and proper container labeling. Also, precipitation that may accumulate in the storage area may need to be removed. Results of the weekly inspections and any precipitation removal required shall be recorded in the site logbook.

Container Disposition

The disposition of containers holding IDW shall be determined by LANTDIV, with the assistance of the contractor, as necessary. Container disposition shall be based on quantity of materials, types of materials, and analytical results. If necessary, samples of specific IDW may be collected to further identify characteristics which may affect disposition. Typically, container disposition will not be addressed until after receipt of applicable analytical results; these results usually are not available until long after completion of the field investigation.

Disposal of Contaminated Materials

Actual disposal methods for contaminated materials disturbed during the site investigation are the same as for other hazardous substances: incineration, landfilling, treatment, and so forth. The responsibility for disposal must be determined and agreed upon by all involved parties during negotiations addressing this contingency.

The usual course will be to retain a contractor licensed for transportation and disposal. However, regardless of the mechanism used, all applicable federal, state, and local regulations shall be observed. EPA regulations applicable to generating, storing, and transporting hazardous wastes are contained in 40 CFR Part 262 and Part 263.

Another consideration in selecting the method of disposal of contaminated materials is whether the disposal can be incorporated into subsequent site cleanup activities. For example, if construction of a suitable onsite disposal or treatment structure is expected, contaminated materials generated during the site investigation may be stored at the site for treatment/disposal with other site materials. In this case, the initial containment (drums or other containers) shall be evaluated for use as long-term storage. Also, other site conditions such as drainage control, security, and soil types must be considered in order to provide proper storage.