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**Data Gap Investigation and
SVE Treatability Study Work Plan**

for

Operable Unit 2

at

Marine Corps Air Station
Cherry Point, North Carolina



Atlantic Division
Naval Facilities Engineering Command

Contract Number N62472-90-D-1298

Contract Task Order 0239

February 1997



Brown & Root Environmental

A Division of Halliburton NUS Corporation

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**DATA GAP INVESTIGATION AND
SVE TREATABILITY STUDY WORK PLAN
FOR
OPERABLE UNIT 2
AT
MARINE CORPS AIR STATION
CHERRY POINT, NORTH CAROLINA**

**COMPREHENSIVE LONG-TERM
ENVIRONMENTAL ACTION NAVY (CLEAN) CONTRACT**

**Submitted to:
Atlantic Division
Environmental Restoration Branch, Code 1823
Naval Facilities Engineering Command
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**CONTRACT NUMBER N62472-90-D-1298
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FEBRUARY 1997

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1.0 INTRODUCTION

The Northern Division of the Naval Facilities Engineering Command has issued Contract Task Order (CTO) 0239 to Brown & Root Environmental (B&R Environmental) under Comprehensive Long-Term Environmental Action Navy (CLEAN) Contract No. N62472-90-D-1298. Under CTO 239, B&R Environmental has prepared this Work Plan to design and operate a treatability study to quantify the operating parameters for soil vapor extraction (SVE) systems to treat soil "hot spot" contamination within the area known as Operable Unit 2 (OU2), Marine Corps Air Station Cherry Point (MCAS Cherry Point), North Carolina. This Work Plan will also provide information for conducting additional field investigations to fill data gaps in three areas within OU2.

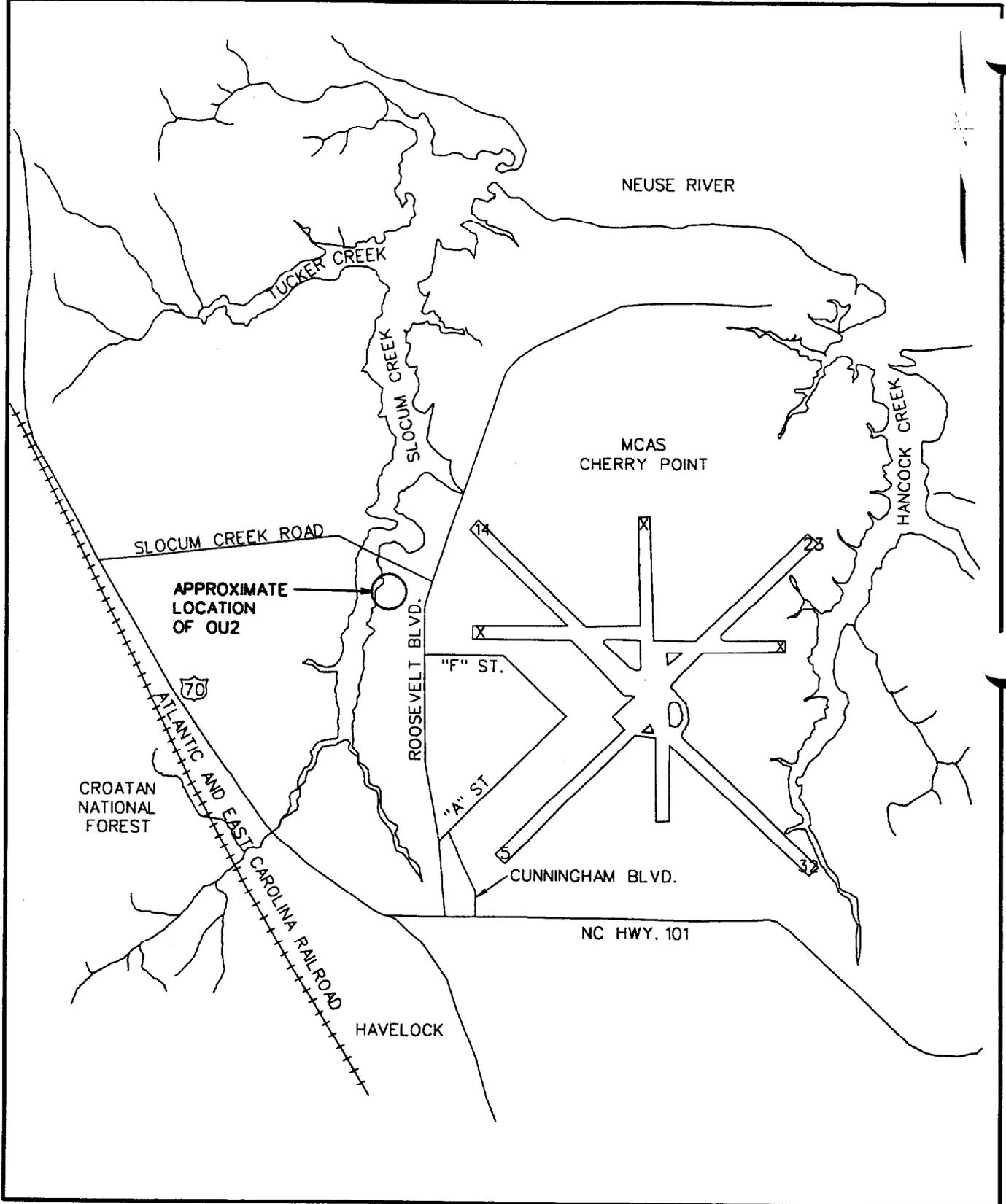
MCAS Cherry Point is located on a 11,485-acre tract of land north of Havelock, North Carolina. The mission of MCAS Cherry Point is to maintain and operate the support facilities and support services for the U.S. Marine Corps Aircraft Wing and other units and activities designated by higher authorities in coordination with the Chief of Naval Operations. In addition, MCAS Cherry Point provides training and support facilities for the Fleet Marine Force Atlantic Units and is a location for a Naval Aviation Depot.

1.1 OPERABLE UNIT 2

OU2 is located in the west/central portion of the Air Station, as shown on Figure 1-1. OU2 is bounded by the Sewage Treatment Plan (STP) to the north, Roosevelt Boulevard to the east, a residential area to the south, and Slocum Creek to the west. OU2 consists primarily of the Site 10 landfill. It also includes the polishing ponds (Site 46) north of the landfill, a former sludge application area (Site 44A formerly Site 45) located in the north-central portion of OU2, and the vehicle maintenance area (Hobby Shop) (Site 76) located southwest of the landfill. A general site location map of OU2 is shown on Figure 1-2. This figure also provides the location of the areas identified as soil hot spots and the areas requiring additional field investigation.

1.2 PHYSICAL CHARACTERISTICS

This section summarizes the pertinent information for surface features, geology, and hydrogeology. This information was obtained from the draft Remedial Investigation Report for OU2 (B&R Environmental, 1996).



SITE VICINITY
MCAS, CHERRY POINT, NORTH CAROLINA

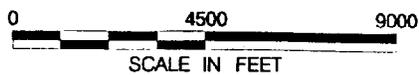
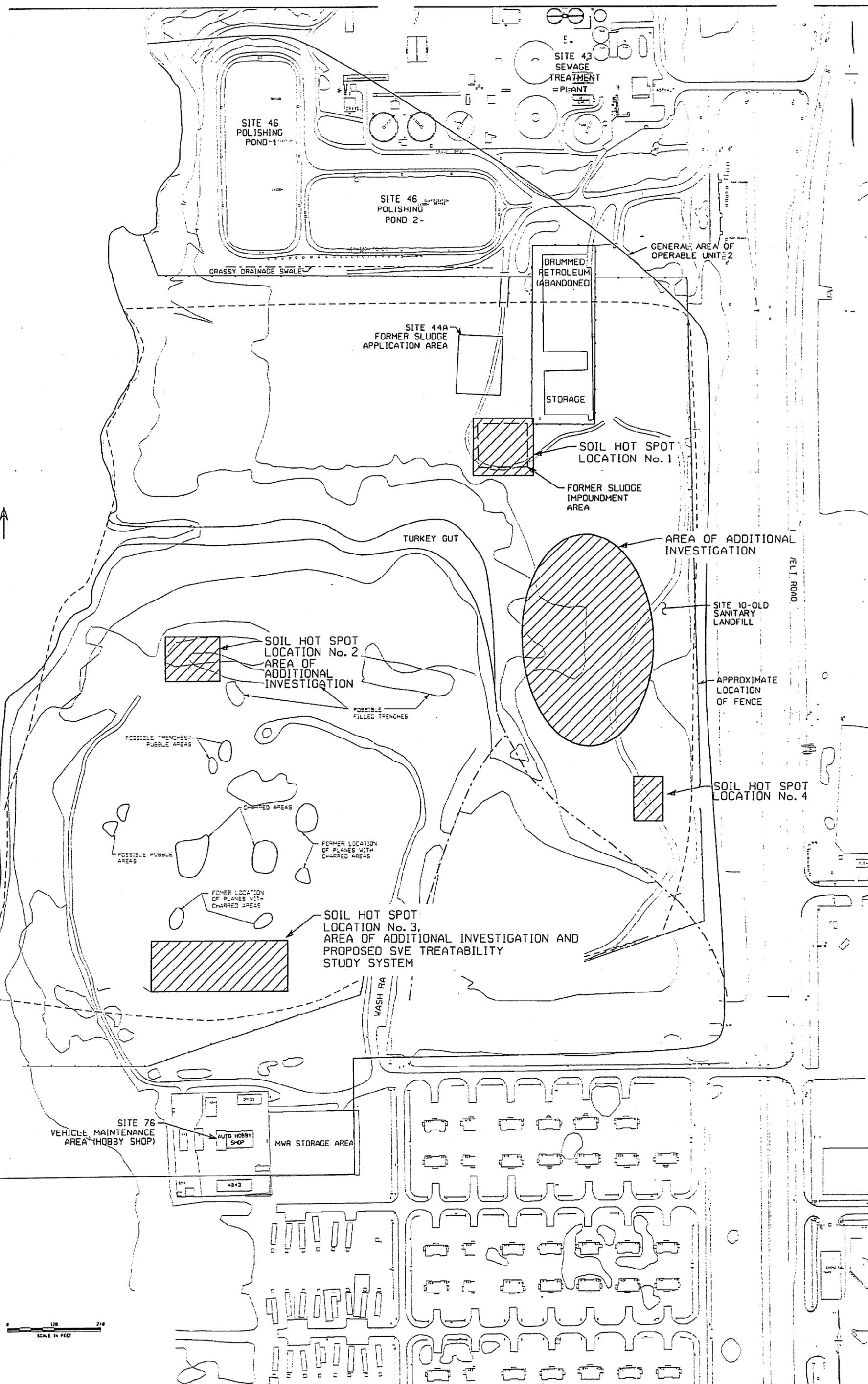


FIGURE 1-1



Brown & Root Environmental

SLOCUM CREEK ↑



SCALE IN FEET
0 120 240

1-3

DEPARTMENT OF THE NAVY ATLANTIC DIVISION NAVAL FACILITIES ENGINEERING COMMAND NORFOLK, VIRGINIA MARINE CORPS AIR STATION CHERRY POINT CHERRY POINT, NORTH CAROLINA OU2 GENERAL SITE LOCATION MAP		Brown & Root Environmental 1000 PLAZA AVE PITTSBURGH, PA 15222 APPROVED: _____ DATE: _____ ACTIVITY - SATISFACTORY TO _____ DATE: _____ REPORT FOR COMMAND USE ONLY		A/E: _____ DESIGN: _____ CHECK: _____ PROJECT NUMBER: _____ DATE: _____ PROJECT LOCATION: _____ QUALITY CONTROL: _____ DESIGN: _____ DESIGN DIRECTOR: _____		REVISIONS <table border="1"> <thead> <tr> <th>NO.</th> <th>DESCRIPTION</th> <th>DATE</th> <th>APPROVED</th> </tr> </thead> <tbody> <tr> <td> </td> <td> </td> <td> </td> <td> </td> </tr> <tr> <td> </td> <td> </td> <td> </td> <td> </td> </tr> </tbody> </table>		NO.	DESCRIPTION	DATE	APPROVED								
NO.	DESCRIPTION	DATE	APPROVED																

FIGURE 1-2

1.2.1 Surface Features

The ground surface elevation varies from approximately 30 feet mean sea level (MSL) in the central portions of the landfill to approximately 1.5 feet MSL at Slocum Creek. The ground surface is relatively flat in the central areas with relatively smaller areas of uneven terrain. The ground surface at the perimeter of the landfill adjacent to the floodplains of Slocum Creek and Turkey Gut generally forms moderate to steep slopes.

1.2.2 OU2 Geology

Four types of material were encountered during subsurface investigations at the OU2 area. These were identified as fill material, the undifferentiated Surficial Formation, the Yorktown Formation, and the upper portion of the Pungo River Formation.

Figure 1-3 identifies the location of cross-section B-B' which is provided in Figure 1-4. This cross-section is adjacent to the approximate area of the proposed treatability study system and identifies the various lithologic units encountered.

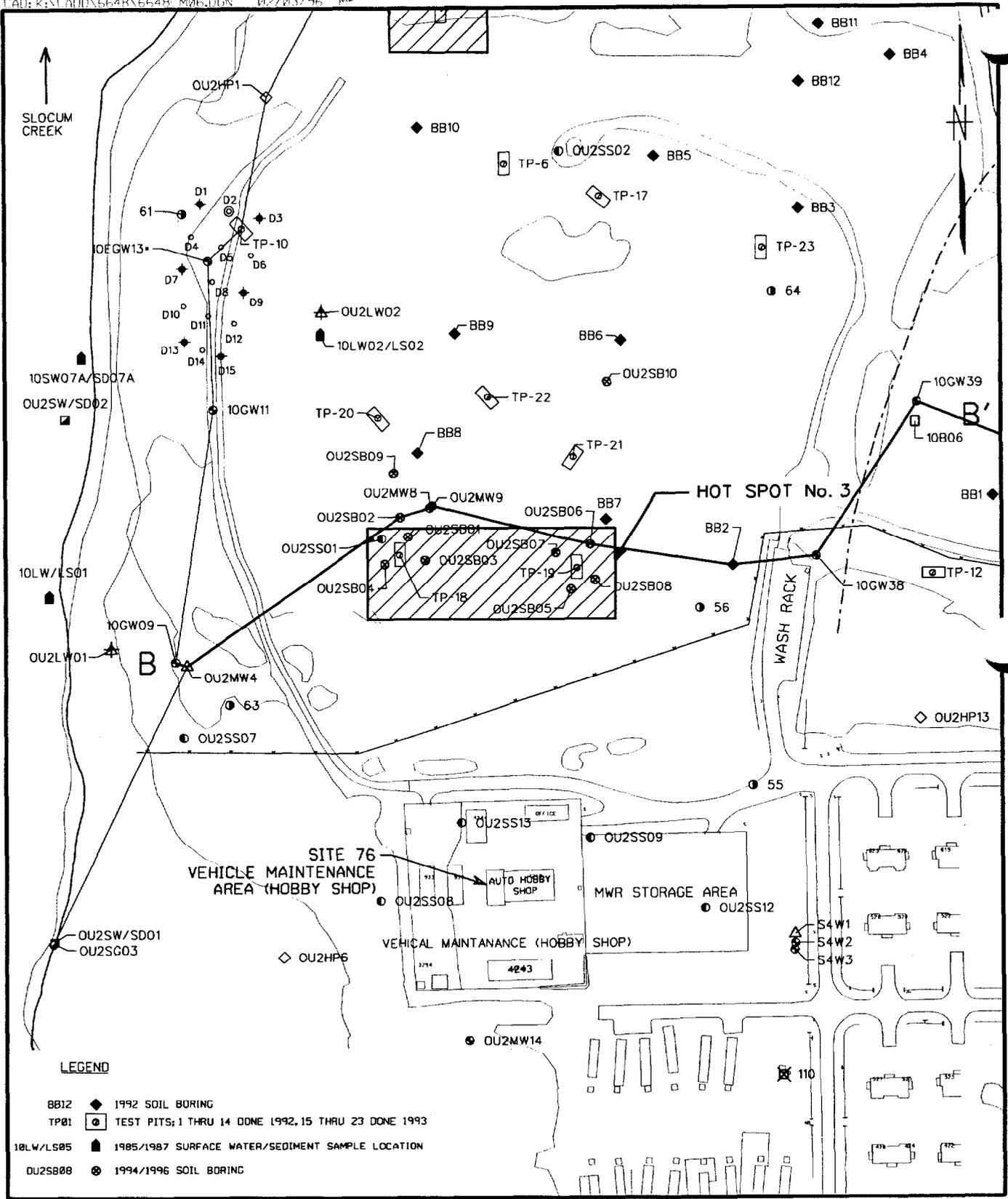
1.2.2.1 Fill Material

The fill material consists of sand, silt, and clay mixed with refuse consisting of domestic trash, wood, plastic, rubber, glass, asphalt, concrete, and metal fragments.

Generally, the fill material is at its maximum thickness in the center of the landfill area and thins gradually to the west and abruptly to the east. Refuse was encountered in several of the borings throughout the landfill and ranged in thickness from 10 to 26 feet. Fill material in the area of the proposed Treatability Study System ranges from 12 to 18 feet in thickness.

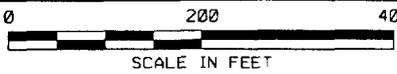
1.2.2.2 The Surficial Formation

The shallowest natural materials beneath OU2 consisted of orange, yellow, and brown silty sand with trace to some amounts of clay present in localized areas. This material is present at the ground surface where fill is nonexistent or underlies the fill. This material extends to a maximum depth of 52 feet below the ground surface in the southwest portion of OU2 and thins slightly to the north and northeast to approximately 38 and 40 feet below the ground surface, respectively. In the area of the proposed Treatability Study System, the thickness of this formation is approximately 35 feet.



**CROSS SECTION LOCATION MAP AND
PREVIOUS SAMPLE LOCATIONS
MCAS CHERRY POINT, NORTH CAROLINA**

FIGURE 1-3



1.2.2.3 The Yorktown Formation

Underlying the Surficial Formation is an olive green to grayish green, dense, fine sand with varying amounts of bivalve shell fragments, clay, and silt. It is believed that this layer correlates with the hydrogeologic Yorktown confining unit (formerly named the upper confining unit) that makes up the upper portion of the Yorktown Formation. It has an average thickness of 19 feet.

Seven Shelby tube samples were collected from the upper portion of the Yorktown Formation. The grain-size distribution curves indicate poorly sorted sands with little fines but with an average effective grain size of 0.029 mm diameter (silt).

Underlying the upper portion of the Yorktown Formation is a gray silty sand with varying amounts of bivalve shell fragments and correlates with the hydrogeologic unit named the Yorktown aquifer. The lower portion of the Yorktown Formation has an average thickness of approximately 35 feet in the eastern portion of the site and approximately 14 feet in the western portion of the site. In the area of the proposed Treatability System, the lower portion of the Yorktown Formation is approximately 15 feet thick.

1.2.2.4 The Pungo River Formation

A dark green, clayey silt and clayey sand was encountered in six of the OU2 Lower Yorktown wells at depths below ground surface varying from 69 to 100 feet. These materials are inferred to be the upper portion of the Pungo River Formation and correlate to the hydrogeologic unit named the Pungo River confining unit (formerly the lower confining unit). The top surface of the Pungo River Formation dips to the east at approximately 0.01 percent grade. The thickness of the Pungo River confining unit was not determined because the unit was not penetrated during the drilling activities.

One Shelby tube sample was collected from the upper portion of the Pungo River Formation. The grain-size distribution curve indicates poorly sorted sand with an effective grain size of 0.019 millimeter (mm) diameter (silt).

1.2.3 OU2 Hydrogeology

Four hydrogeologic units were encountered during the subsurface investigation at OU2. They are presented in order from top to bottom. The units are the surficial aquifer, the Yorktown confining unit (formerly the upper confining unit), the Yorktown aquifer, and the upper portion of the Pungo River confining unit (formerly the lower confining unit). Table 1-1 presents a summary of the monitoring well

TABLE 1-1

**MONITORING WELL CONSTRUCTION SUMMARY IN AREA OF TREATABILITY STUDY
OPERABLE UNIT 2
MCAS CHERRY POINT, NORTH CAROLINA**

Well Identification	Installation Date and Company	Ground Elevation (Feet MSL) ⁽¹⁾	Top of Riser Elevation (Feet MSL)	Total Well Depth (Feet BGS) ⁽²⁾	Monitored Interval (Feet BGS)	Monitored Aquifer	Depth to Water (Feet BGS) April 1996
10GW09	12-10-84 HNUS	21.68	22.87	25	10-25	Upper Surficial	15.26
10GW11	12-12-84 HNUS	25.13	26.26	25	10-25	Upper Surficial	18.83
10EGW13 (B-106)	12-2-81 Schnabel	24.62	24.66	20.00	15-20	Upper Surficial	18.75
10GW38	10-26-90 HNUS	21.85	22.95	45	10-25	Upper Surficial	10.90
10GW39	11-09-90 HNUS	20.30	23.00	20	3-18	Upper Surficial	5.15
OU2MW4	8-23-94 HNUS	22.20	24.14	84	66-76	Lower Yorktown	15.94
OU2MW5	8-11-94 HNUS	27.49	29.66	104	92.5-102.5	Lower Yorktown	20.25
OU2MW8	8-3-94 HNUS	30.01	32.11	28	18-28	Upper Surficial	21.68
OU2MW9	8-2-94 HNUS	29.82	31.51	57	45-55	Lower Surficial	22.81

- 1 MSL - Mean Sea Level
2 BGS - Below Ground Surface

construction data in the area of the proposed treatability study and includes various information including the depth to groundwater. Only the surficial aquifer is relevant to the activities proposed in this Work Plan.

The surficial aquifer is located approximately 7 to 22 feet below ground surface (BGS), and water-level elevations measured in April 1996 ranged from approximately 2.6 to 22 feet above MSL.

The saturated thickness of the surficial aquifer tends to increase toward the southern portion of the site. The average saturated thickness is 29 feet as measured at 9 well clusters across the site, ranging from approximately 22 feet at well cluster 10GW34 in the north, to approximately 37 feet at well cluster 10GW40 in the south. The saturated thickness in the area of the proposed Treatability Study System is approximately 35 feet thick.

1.3 NATURE AND EXTENT OF CONTAMINATION

The following is a summary of the nature and extent of contamination detected at OU2 in the area of the proposed Treatability Study. This report will only concentrate on contamination in the soils and groundwater. Surface water and sediment are not present in the areas being evaluated. Additional details on the various media in all areas of OU2 can be found in the RI Report.

1.3.1 Soil

The soil sampling program conducted at OU2 concentrated on areas that had a higher potential for contamination based on past experience and knowledge. Previous soil sampling programs were based on soil-gas and geophysical surveys, aerial photographs, and knowledge of existing groundwater contamination. When anomalous areas or areas of groundwater contamination were identified, soil borings and test pits were installed to collect subsurface soil samples. The 1994 and 1996 field activities were conducted to fill known data gaps from previous investigations.

The analytical results for soil identified a hot spot where the proposed Treatability Study System will be located. Volatile organic compounds (VOCs) were not detected frequently, but were detected at notable concentrations in a limited number of samples. Also, fuel-type constituents, including benzene, toluene, ethylbenzene, and xylenes (BTEX), were identified in a few of the subsurface soil samples.

Table 1-2 provides a summary of the analytical results for VOCs in soil which exceed the North Carolina S-3 Soil Target Concentrations for protection of groundwater. Four sample locations exceed these screening levels in the vicinity of Hot Spot 3. Samples from Test Pit 18 (10TP18) exceeded the soil levels

TABLE 1-2

SOIL VOC ANALYTICAL RESULTS EXCEEDING SCREENING CRITERIA (µg/kg)
 OPERABLE UNIT 2 TREATABILITY STUDY AREA
 MCAS CHERRY POINT, NORTH CAROLINA

Sample	Sample Date	Parameter	Result	NC S-3 Soil Target Concentration ⁽¹⁾
10TP18-0406	11/05/93	Ethylbenzene	14,000	343
10TP18-0910	11/06/93	Ethylbenzene	140,000	343
10TP18-0406	11/05/93	Methylene Chloride	63,000	21.9
10TP18-0910	11/06/93	Methylene Chloride	190,000	21.9
10TP18-0910	11/06/93	Toluene	27,000	8,111
OU2SB05-2224	7/30/94	Ethylbenzene	440	343
OU2SB07-2224	7/30/94	Ethylbenzene	20,000	343
OU2SB07-2224	7/30/94	Toluene	67,000	8,111
OU2SB08-2224	7/30/94	Benzene	280	5.6
OU2SB08-2224	7/30/94	Ethylbenzene	24,000	343
OU2SB08-2224	7/30/94	Toluene	31,000	8,111

1 Based on groundwater protection.

for protection of groundwater for ethylbenzene, methylene chloride, and toluene. The samples were collected in the range of 4 to 10 feet deep. Samples from soil borings OU2SB5, OU2SB07, and OU2SB08 also exhibited contamination above the screening levels. One sample from SB05 showed VOC contamination above the protection of groundwater screening levels for ethylbenzene at a depth of 22 to 24 feet. OU2SB07 showed VOC contamination above the protection of groundwater screening levels for ethylbenzene and toluene at a depth of 22 to 24 feet. SB08 showed VOC contamination above the protection of groundwater screening levels for benzene, ethylbenzene, and toluene at a depth of 22 to 24 feet.

1.3.2 Surficial Aquifer Groundwater

The most commonly detected contaminants in the surficial aquifer were VOCs including fuel-type constituents (BTEX); chlorinated solvents and breakdown products, such as tetrachloroethene, trichloroethene, dichloroethene, vinyl chloride, trichloroethylene, dichloroethanes, and chloroethane; and chlorinated monocyclic aromatics (chlorobenzene and dichlorobenzenes).

Samples from upper surficial aquifer wells 10GW09, 10GW11, and OU2MW8, which are located near the Treatability Study System, exceeded North Carolina Class GA groundwater standards for several VOCs. 10GW09 showed VOCs exceeding the state groundwater standard for benzene, ethyl benzene, and vinyl chloride. 10GW11 showed VOCs exceeding the state standard for benzene, chlorobenzene, ethylbenzene, and methylene chloride. OU2MW8 showed VOCs exceeding the state standard for benzene. Tables 1-3, 1-4, and 1-5 provide information on wells 10GW09, 10GW11, and OU2 MW8, respectively. Contaminant concentration trends in the area hydraulically downgradient of the proposed treatability study system are also provided in Tables 1-3 and 1-4.

To further evaluate the groundwater in the area of the SVE treatability study four upper surficial groundwater monitoring wells (OU2MW18, OU2MW19, OU2MW20, and OU2MW22) were installed on January 16 and 17, 1997 and sampled on January 19, 1997. The samples were submitted for full TCL/TAL analysis and the preliminary results of the TCL VOC analysis is provided in Appendix A.

1.4 TREATABILITY STUDY AND DATA GAP INVESTIGATION OBJECTIVES

This Work Plan includes a Data Gap Investigation and a Treatability Study. The objective of the Data Gap Investigation is to collect environmental samples to identify potential contamination in areas where insufficient analytical data exist. The objective of the Treatability Study is to construct and operate a soil vapor extraction Treatability Study system to generate data relevant to the remediation of VOC contamination in soil within OU2. Groundwater samples were also collected in the area of soil hotspot

TABLE 1-3

GROUNDWATER CONCENTRATION TRENDS - WELL 10GW09
POSITIVE DETECTIONS ONLY - µg/L
OPERABLE UNIT 2 - SURFICIAL AQUIFER
MCAS CHERRY POINT, NORTH CAROLINA

Analyte	NC Class GA Standard	10GW09				
		1/85	10/85	1987	1990	1994
Benzene*	1.0	130*	53*	160*	54*	230*
Chlorobenzene	50	5	ND	ND	17	26
Chloroethane	2800	12	27	ND	7	15
cis-1,2-Dichloroethene	70	ND	ND	ND	NA	1
1,4-Dichlorobenzene	75	NA	NA	16	NA	17
1,1-Dichloroethane	700	13	53	57	14	33
Ethylbenzene*	29	35	ND	ND	5 U	10
Toluene	1,000	67	25	92	5 U	2
trans-1,2-Dichloroethene	70	14	41	67	NA	1
Vinyl chloride*	0.015	35*	73*	ND	10 U	2*
Xylenes (total)	530	ND	40	79	3	14
Naphthalene	21	NA	ND	11	NA	NA
Aluminum	NS	NA	NA	NA	NA	42
Arsenic	50	NA	6	33	37.1	43.6
Barium	2,000	NA	NA	NA	NA	64
Calcium	NS	NA	NA	NA	NA	53,700
Iron*	300	NA	NA	NA	NA	64,100*
Lead	15	ND	ND	ND	2.2	1 U
Magnesium	NS	NA	NA	NA	NA	9,470
Manganese*	50	NA	NA	NA	NA	95*
Potassium	NS	NA	NA	NA	NA	8,140
Silver	18	ND	ND	ND	5.5	3 U
Sodium	NS	NA	NA	NA	NA	13,200
Zinc	2,100	10	10	20	15.7 U	7 U
TOC	NS	2,110	26,300	28,700	15,700	NA
TOX	NS	130	200	170	NA	NA

* Indicates that NC Class GA standard has been exceeded.

NS No standard

NA Not analyzed

ND Not detected

U Not detected at concentration presented

DL Detection limit

TABLE 1-4

GROUNDWATER CONCENTRATION TRENDS - WELL 10GW11
 POSITIVE DETECTIONS ONLY - µg/L
 OPERABLE UNIT 2 - SURFICIAL AQUIFER
 MCAS CHERRY POINT, NORTH CAROLINA

Analyte	NC Class GA Standard	10GW11				
		1/85	10/85	1987	1990 (Avg.)	1994
Benzene*	1.0	11*	5*	8*	11.5*	5*
Chlorobenzene*	50	9	12	28	185*	25
1,4-Dichlorobenzene	75	NA	NA	20	NA	18
Ethylbenzene*	29	37*	ND	ND	10 U	2 U
Methylene chloride*	5.0	ND	ND	ND	15.5*	4 U
Diethyl phthalate	5,000	NA	25	13	NA	NA
Arsenic*	50	NA	12	45	34.5	98*
Barium	2,000	NA	NA	NA	NA	51
Beryllium	NS	NA	ND	ND	2.2	1 U
Cadmium	5.0	ND	ND	ND	3.95	5 U
Calcium	NS	NA	NA	NA	NA	39,600
Chromium	50	ND	ND	ND	49.5	9 U
Copper	1,000	ND	ND	ND	10.05	2 U
Iron*	300	NA	NA	NA	NA	43,600*
Lead*	15	ND	ND	ND	23*	1 U
Magnesium	NS	NA	NA	NA	NA	17,100
Manganese	50	NA	NA	NA	NA	30
Nickel	100	ND	ND	ND	41.65	20 U
Potassium	NS	NA	NA	NA	NA	17,600
Silver*	18	ND	ND	ND	21.45*	3 U
Sodium	NS	NA	NA	NA	NA	39,700
Zinc	2,100	10	10	10	245.5	6 U
TOC	NS	1,940	33,000	31,100	NA	NA
TOX	NS	150	150	140	NA	NA

* Indicates that NC Class GA standard has been exceeded.

NS No standard

NA Not analyzed

ND Not detected

U Not detected at concentration presented

TABLE 1-5

**GROUNDWATER CONCENTRATIONS - WELL OU2MW8
POSITIVE DETECTIONS ONLY - µg/L
OPERABLE UNIT 2 - SURFICIAL AQUIFER
MCAS CHERRY POINT, NORTH CAROLINA**

Analyte	NC Class GA Standard	1994
1,2-Dichlorobenzene	620	3
1,4-Dichlorobenzene	75	11
Benzene*	1	7*
Chlorobenzene	50	11
Chloroethane	2,800 (interim)	1
Ethylbenzene	29	14
Xylenes, Total	530	10
2,4-Dimethylphenol*	DL	6*
Diethyl Phthalate	5000	9
Naphthalene	21	8
Endrin Aldehyde*	DL	0.057*
Aluminum	NS	35
Arsenic	50	32.7
Barium	2000	41
Calcium	NS	31,400
Iron*	300	50,800*
Magnesium	NS	9,050
Manganese	50	40
Potassium	NS	8710
Sodium	NS	21,800

* Indicates that NC Class GA standard has been exceeded.

NS No standard

NA Not analyzed

ND Not detected

U Not detected at concentration presented

DL Detection limit

No. 3 with the objective of determining if upper surficial groundwater VOC contamination plume exist in the area in order to determine if an air sparging system is appropriate in this area.

1.4.1 Data Gap Investigation

The goal of the Data Gap Investigation is to generate data for three specific areas identified within OU2 that require additional investigation. This data will be used to determine whether soil and/or groundwater contamination is present in these areas. The results of the Data Gap investigation will be presented in a technical letter report.

1.4.2 Treatability Study

The goal of the treatability study is to design and operate a soil vapor extraction (SVE) system at hotspot No. 3. In conjunction with the treatability study, four temporary wells were installed and four groundwater samples were collected and analyzed for 48 hour rush TCL VOC analysis plus standard turnaround on full TAL/TCL to determine if an air sparging system would be appropriate. A teleconference was held with the partnering team on January 29, 1997 to discuss the results of the groundwater sampling. The results of the VOC analysis indicated air sparging was not appropriate in this area and Brown & Root Environmental was directed not to install an air sparging system. The laboratory results and summary table are provided in Appendix A.

The data generated during this SVE treatability study will be used to identify the following performance parameters:

- The radius of influence for vacuum extraction wells for use in the hot spot SVE system design.
- The depths for the vacuum extraction wells in the hot spot SVE system.
- The operating vacuum pressures and air flow rates to be used in the hot spot SVE systems.
- An estimate of carbon consumption for operation of the hot spot SVE system.
- An estimate of the contaminant removal efficiency by the SVE systems.
- An estimate of the quantity of waste generated during installation and operation of the hot spot SVE systems.

- A determination if degradation of organic contamination from biological mechanisms is present; and if the degradation can be enhanced by the SVE systems.

The data from the short-term testing phase of the Treatability Study will be presented in the design basis document for the SVE systems to address the other hot spot areas. The final results of the treatability study will be presented in a technical letter report at the completion of the long-term evaluation.

1.5 WORK PLAN CONTENTS

Section 1.0, Introduction; provides information on the physical properties of OU2, the nature and extent of contamination in the treatability study area, and the objectives of this Work Plan. Section 2.0 details the scope of work to be conducted for the Data Gap Investigation and SVE Treatability Study. Section 3.0 provides guidance and procedures on conducting the field activities proposed in this Work Plan.

2.0 SCOPE OF WORK

The work associated with this Work Plan will be conducted under two main tasks, a Data Gap Investigation, and a SVE Treatability Study. The Data Gap Investigation is being conducted to evaluate three specific areas within OU2. The Site 10 east central area and Hot Spot areas numbers 2 and 3. The treatability study will be conducted in the Hot Spot No. 3 area to provide information required for the remedial design effort. In addition groundwater samples were collected to evaluate the need for an air sparging system in this area.

A summary of the sampling and analyses to be conducted for the Data Gap Investigation is provided in Table 2-1. A summary of the sampling and analyses to be conducted for the installation of the Treatability Study System is provided in Table 2-2. Information on sampling, analyses, and rationale to be conducted during the operation of the Treatability Study System is provided in Table 2-3.

2.1 DATA GAP INVESTIGATION

Additional field investigation will be conducted in three specific areas of OU2 to evaluate possible contamination in these areas. One of the areas is located in the east central area of OU2 (Site 10) in the vicinity of a previous soil gas survey. The other area is located in the area known as Hot Spot 3 and is the location of the proposed Treatability Study Soil Vapor Extraction (SVE) system. The area in Hot Spot 3 to be investigated is between test pit TP-18 and TP-19. Additional data is also required in the vicinity of Hot Spot No. 2 to fill geologic, hydrogeologic, and contamination data gaps in this area.

2.1.1 Site 10 East Central Area Investigation

A soil gas survey was conducted at Site 10 in 1989 to aid in locating monitoring wells. The soil gas maps are provided in Appendix B. Soil and/or groundwater samples were collected from most of the areas with elevated soil gas concentrations. However, no samples were collected to define the nature and extent of potential contamination in the area located approximately 300 feet due south of the drum storage (staging) area.

The field work in this area will include the drilling and installation of one permanent monitoring well (OU2MW17/OU2SB11) and the collection of two subsurface soil samples and one groundwater sampled from this well. In addition, four soil borings (OU2SB12 through OU2SB15) will be drilled for the collection of two subsurface soil samples from each soil boring. Two subsurface soil samples will also be collected from the OU2MW17/OU2SB11 monitoring well boring for a total of ten soil samples collected. The

TABLE 2-1

**PROPOSED SOIL AND GROUNDWATER SAMPLING RATIONALE
FOR DATA GAP INVESTIGATION
OPERABLE UNIT 2
MCAS CHERRY POINT, NORTH CAROLINA**

Number	Location	Sample Collection Depth and Analyses	Rationale
Groundwater Samples			
OU2MW17	East central area of Site 10 not fully characterized (1 monitoring well). Upper surficial aquifer to be sampled.	1 groundwater sample full TCL/TAL.	To determine if contamination is present in the upper surficial aquifer in the east central portion of Site 10.
Soil Samples			
OU2SB11 Through OU2SB15	East central area of Site 10 not fully characterized (5 soil borings).	2 soil samples will be collected from each soil boring at the 4 to 6 feet and at the vadose zone/water table interface (14 to 16 feet) or where highest PID reading detected. ⁽¹⁾ Full TCL/TAL analysis.	To determine if soil contamination is present in the east central portion of Site 10 where the soil gas study was conducted, and if present, an estimate of the lateral extent of contamination.
OU2SB16/ OU2EW08	Middle of Hot Spot Number 3.	2 soil samples will be collected from this soil boring at the 4 to 6 feet and at the vadose zone/water table interface (22 to 24 feet) or where highest PID reading detected. ⁽¹⁾ Full TCL/TAL analysis.	To determine if soil contamination is present in the central portion of Hot Spot Number 3.
OU2SB17/ OU2MW21	Middle of Hot Spot Number 2.	2 soil samples will be collected from this soil boring at the 4 to 6 feet and at the vadose zone/water table interface (22 to 24 feet) or where highest PID reading detected. ⁽¹⁾ Full TCL/TAL analysis. No groundwater sampling will be conducted during this field activity.	To further evaluate soil contamination and lithology at Hot Spot Number 2.

Full TCL/TAL includes TCL VOCs, SVOCs and Pesticides/PCBs, TAL metals and cyanide.

- 1 Soil samples will be continuously screened using field instrumentation such as a PID. The two soil samples with the greatest potential for the presence of contamination based on field screening and visible observation will be selected for laboratory analyses. If no indication of contamination is evident, the samples will be collected at the specified depths.

TABLE 2-2

**PROPOSED SOIL AND GROUNDWATER SAMPLING RATIONALE FOR
INSTALLATION OF TREATABILITY STUDY SYSTEM
OPERABLE UNIT 2
MCAS CHERRY POINT, NORTH CAROLINA
PAGE 1 OF 2**

Number	Location	Sample Collection Depth and Analysis	Rationale
Groundwater Samples			
OU2MW18	Well located downgradient of the treatability study area, soil Hot Spot No 3.	One groundwater sample shall be analyzed for full TCL/TAL ⁽¹⁾ .	This analysis shall be conducted to determine if air sparging is appropriate in this area.
OU2MW19	Well located within the treatability study system, at location of Test Pit Sample TP-18.	One groundwater sample shall be collected and analyzed for full TCL/TAL ⁽¹⁾ .	This analysis shall be conducted to determine if air sparging is appropriate in this area.
OU2MW22	Well located within the treatability study system at location of soil boring OU2SB07	One groundwater sample shall be collected and analyzed for full TCL/TAL ⁽¹⁾ .	This analysis shall be conducted to determine if air sparging is appropriate in this area and provide baseline data.
OU2/MW20	Well located upgradient of the treatability study area, soil Hot Spot No 3.	One groundwater sample shall be analyzed for full TCL/TAL ⁽¹⁾ .	This well will provide a localized background well of soil hot spot No. 3 and this analysis shall be conducted to determine if air sparging is appropriate in this area.
Soil Samples			
OU2EW12/OU2SB19	Western section of Hot Spot Number 3.	Two soil samples will be collected at 4 to 6 feet and at the vadose zone/water table interface (22 to 24 feet) or where PID reading or visible observation indicates highest contamination. Samples will be analyzed for total VOC and for total heterotrophic plate count including pseudomonas degrading bacteria.	Analysis shall provide baseline data for soil in the western portion of the treatability study. A baseline of biological degradation capability will be collected for this area.

TABLE 2-2

**PROPOSED SOIL AND GROUNDWATER SAMPLING RATIONALE FOR
INSTALLATION OF TREATABILITY STUDY SYSTEM
OPERABLE UNIT 2
MCAS CHERRY POINT, NORTH CAROLINA
PAGE 2 OF 2**

Number	Location	Sample Collection Depth and Analysis	Rationale
OU2EW03/OU2SB18	Eastern section of Hot Spot Number 3.	Two soil samples will be collected at 4 to 6 feet and at the vapoze zone/water tabel interface (22 to 24 feet) or where PID reading or visible observation indicates highest contamination. Samples will be analyzed for total VOC.	Analysis shall provide baseline data for soil in the eastern portion of the treatability study.
Additional Well Borings to be Sampled and Analyzed at Depths Determined in the Field	During the installation of the system, four soil samples that exhibit the highest PID reading or visible observation of contamination will be analyzed. If no sample is higher than any other, collect samples to provide adquate distribution across the entire study area.	Location to be determined in field and samples will be analyzed for total VOC.	Analysis shall provide baseline data in treatability study area. The samples will be collected in highest PID reading areas to provide data from most contaminated areas.

- 1 Full TCL/TAL includes TCL VOCs, SVOCs and Pesticides/PCBs, TAL metals and cyanide. TCL VOCs will be submitted for 48 hour quick turnaround analysis.

TABLE 2-3

**PROPOSED SOIL, AIR, AND GROUNDWATER SAMPLING RATIONALE FOR
OPERATION OF TREATABILITY STUDY SYSTEM
OPERABLE UNIT 2
MCAS CHERRY POINT, NORTH CAROLINA
PAGE 1 OF 2**

Task	Description of Activity	Sample Event	Analysis	Rationale
Soil Vapor Extraction System -	Collect one set of Drager tube samples and one fixed-base laboratory analysis air sample along the vapor extraction line entering the granular activated carbon (GAC) treatment system.	Immediately after turning on the vapor extraction system (Round 1, initial) and first week of short-term testing (Round 2, Week 1)	TCL VOC, O ₂ , and CO ₂ Drager tubes ^(a)	Analysis will provide data on initial levels of contamination at start-up of system and after the system has had a chance to stabilize (1 week).
Air Samples	Collect two sets of Drager tube samples and two fixed-base laboratory analyses air samples, one along the vapor extraction line entering the GAC treatment system and one exiting the first GAC unit.	After operating the vapor extraction system for two weeks (Week 2)	TCL VOC, O ₂ , and CO ₂ Drager tubes ^(a)	Analysis will provide data on progress of the system after two weeks of operation.
	Collect one set of Drager tube sample and one fixed-base laboratory analysis air sample along the air extraction lines entering the GAC treatment system.	At the end of short-term testing period (Week 4)	TCL VOC, O ₂ , and CO ₂ Drager tubes ^(a)	Data collected at the end of the short term tasking period will be used for the design at the hot spot remediation systems.
	Collect one set of Drager tube sample and fixed-base laboratory analysis air sample along the air extraction lines entering the GAC treatment system. (11 samples assumed)	Once every month over the duration of the long-term evaluation period.	TCL VOC, O ₂ , and CO ₂ Drager tubes ^(a)	Monthly sampling and analysis will be conducted to evaluate the progress of the system.
	Collect Drager tube samples along the vapor extraction line exiting the first GAC unit to determine if breakthrough has occurred. (11 samples assumed)	Once every month over the duration of the long-term evaluation period.	TCL VOC, O ₂ , and CO ₂ Drager tubes ^(a)	Monthly sampling will be conducted after the first month to determine if breakthrough of the first GAC unit has occurred.

TABLE 2-3

**PROPOSED SOIL, AIR, AND GROUNDWATER SAMPLING RATIONALE FOR
OPERATION OF TREATABILITY STUDY SYSTEM
OPERABLE UNIT 2
MCAS CHERRY POINT, NORTH CAROLINA
PAGE 2 OF 2**

Task	Description of Activity	Sample Event	Analysis	Rationale
Air Samples Continued	Collect fixed-base laboratory analysis air sample along the vapor extraction line exiting the first GAC treatment system unit to verify Drager tube analytical result. (To be determined)	As needed based on positive analytical result for Drager tube sample.	TCL VOC	If breakthrough is expected based on Drager tubes, fixed base laboratory analysis will be conducted to verify.
Soil Vapor Extraction System-Soil Samples	Collect eight soil samples next to the original eight sample location wells at the same depths to evaluate removal of VOC achieved.	At end of short-term testing period (week 4).	TCL VOC, Total heterotrophic Plate count including pseudomea grading bacteria.	Soil samples will be analyzed to evaluate amount of VOC contamination removed by comparing to base line results previously collected.
	Collect eight soil samples next to the original eight sample location wells at the same depths to evaluate removal of VOC achieved.	At end of long-term evaluation period.	TCL VOC, Total heterotrophic Plate count including pseudomea grading bacteria.	Soil samples will be analyzed to evaluate amount of VOC contamination removed and verify clean-up goals achieved.

NOTE: Short-term testing of the AS/SVE system will be conducted during the first month of the treatability study (Weeks 1, 2, 3, and 4). Long-term evaluation will begin at the end of the short-term testing and continue to the end of the treatability study (Week 4 - To Be Determined).

- (a) Draeger tube analyses will include: benzene, ethylbenzene, toluene, xylene, and methylene chloride. O₂ and CO₂ shall also be collected.
 (b) If sampling is required for longer than one year, it will be conducted under the long-term monitoring program for the intrinsic bioremediation design.

location of the proposed sampling are presented in Figure 2-1. Table 2-1 provides a summary of the sampling to be conducted, analytical requirements, and rationale for collecting the proposed samples.

2.1.2 Hot Spot 3 Area Investigation

Results of previous sampling indicate contamination in the south-west section of OU2 approximately 250 feet north of the vehicle maintenance area (hobby shop). Test Pit 18 and Soil Borings SB07 and SB08, east of Test Pit 18, were identified as localized hot spots. This area was selected for the Treatability Study SVE System. The area between Test Pit 18 and Soil Borings SB07 and SB08 needs to be evaluated further to determine whether contamination exists between the two areas.

The field work associated with this area will involve drilling one soil boring (OU2SB16/OU2EW08) and collecting two subsurface soil samples. The location of the proposed soil boring is provided in Figure 2-2. This soil boring will also be used for the installation of one of the treatability study vapor extraction well (OU2EW08) which will be discussed in Section 2.2. Table 2-1 provides a summary of the sampling, analyses, and rationale associated with this portion of the project.

2.1.3 Hot Spot 2 Area Investigation

Hot Spot No. 2 was identified in the west central area of OU2 approximately 250 feet from Slocum Creek in the area of Test Pit 15. Soil boring and monitoring well information is not available in this area, therefore limited data needs to be collected to provide information on the geology and hydrology which is required to conduct the remedial design effort in this area. Laboratory analysis will also be performed on samples collected to provide additional information on the contamination within Hot Spot No. 2.

The field work associated with this area will involve drilling one soil boring (OU2SB17/OU2MW21) to provide information on the lithology and depth to groundwater. Two subsurface soil samples will also be collected at depth which exhibit the highest level of contamination using field instrumentation. No groundwater sampling will be conducted during this field event, however the well will be used to evaluate surficial groundwater in this area at a later date. The location of the proposed soil boring is provided in Figure 2-2. Table 2-1 provides a summary of the sampling analyses, and rationale for collecting the proposed samples.

2.2 TREATABILITY STUDY

A soil vapor extraction (SVE) Treatability Study System will be installed to provide information on the in-situ-treatment of soils. The Treatability Study System shall be installed and operated in the southwestern

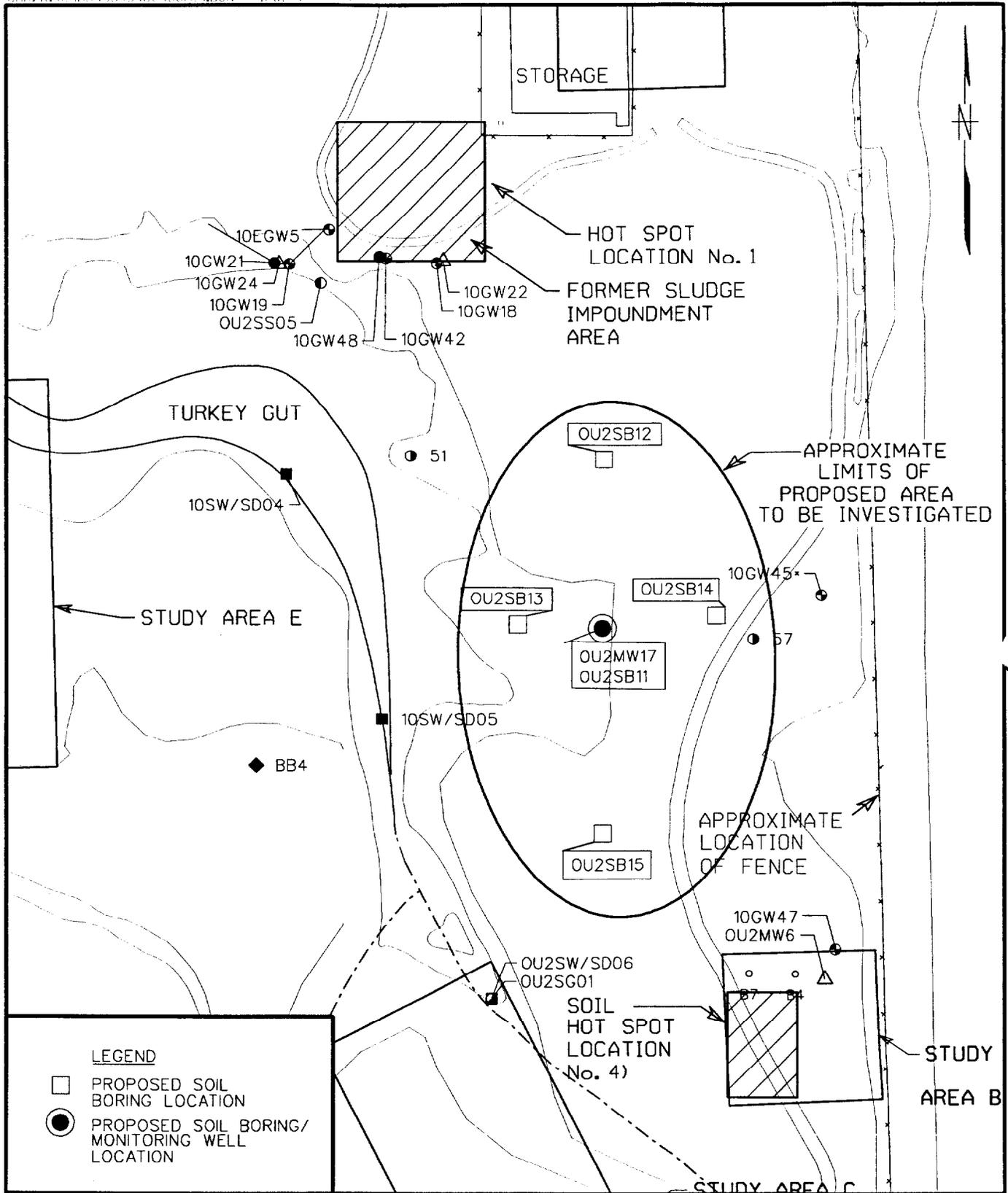


FIGURE 2-1

section of OU2 in the area identified as Hot Spot 3 where elevated levels of VOC contamination were detected in the soil. The B&R Environmental project team visited OU2 on November 12, 1996, and a Partnering meeting was held on November 15, 1996. Based on observations made during the site visit and the discussions at the meeting, the exact location of the system was selected. The area was marked in the field on a subsequent visit.

2.2.1 SVE Treatability Study System Installation and Sampling

The Treatability Study SVE System shall be located in the area north of the Vehicle Maintenance Area as shown in Figure 2-3. The overall site layout of the Treatability Study SVE System is presented in Figure 2-4. The plan view of the equipment layout of the soil vapor extraction system is as shown in Figure 2-5. The system is comprised of a soil vapor extraction blower unit connected to 14 vapor extraction wells (OU2EW01 through OU2EW14) that will extract vapor from the vadose zone. The extracted vapor will pass through a moisture separator and an in-line filter prior to entering the extraction blower. The discharge air will be routed through two in line carbon units prior to discharge to the atmosphere. Four air sparging groundwater monitoring wells (OU2MW18, OU2MW19, OU2MW20, and OU2MW22) were installed to collect groundwater samples to evaluate if an air sparging system is required. Evaluation of the groundwater sampling results was conducted and the partnering team decided an air sparging system is not appropriate. Twelve vapor extraction monitoring wells (arranged in four well clusters each containing three wells at varying depths) will be installed to evaluate the SVE system.

A vapor barrier will be placed over the eastern portion of the study area to evaluate the potential for increasing the soil vapor extraction capture zone area.

2.2.1.1 Sampling During System Installation

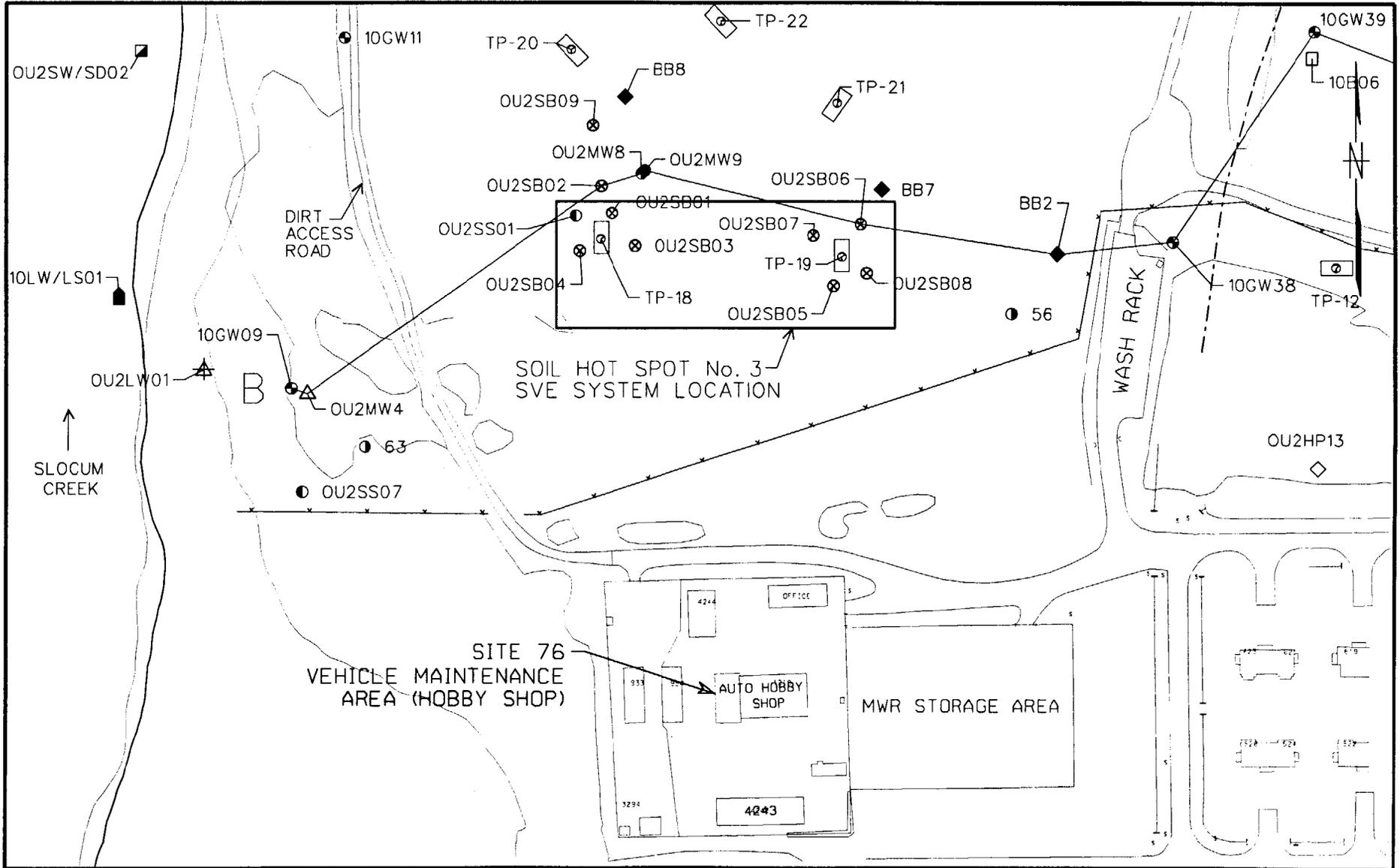
During the installation of the SVE Treatability Study system, groundwater and soil samples will be collected. Groundwater samples will be collected to evaluate if air sparging is appropriate and soil samples will be collected to provide a baseline. Table 2-2 identifies the sampling to be performed during the installation of the Treatability Study System and a summary of the soil borings and wells that will be sampled as part of the baseline data collection. This table also identifies the analysis that will be performed on the soil and groundwater samples and the rationale for collecting these samples.

2.2.2 Treatability Study System Operation and Sampling

Operation of the SVE Treatability Study System can be divided into two phases, the short-term testing and the long-term testing of the system. Short-term testing of the treatability study will be conducted over a

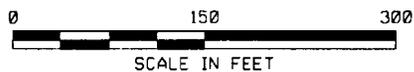
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2-11



**SOIL VAPOR EXTRACTION (SVE)
TREATABILITY STUDY - LOCATION MAP
MCAS, CHERRY POINT, NORTH CAROLINA**

FIGURE 2-3

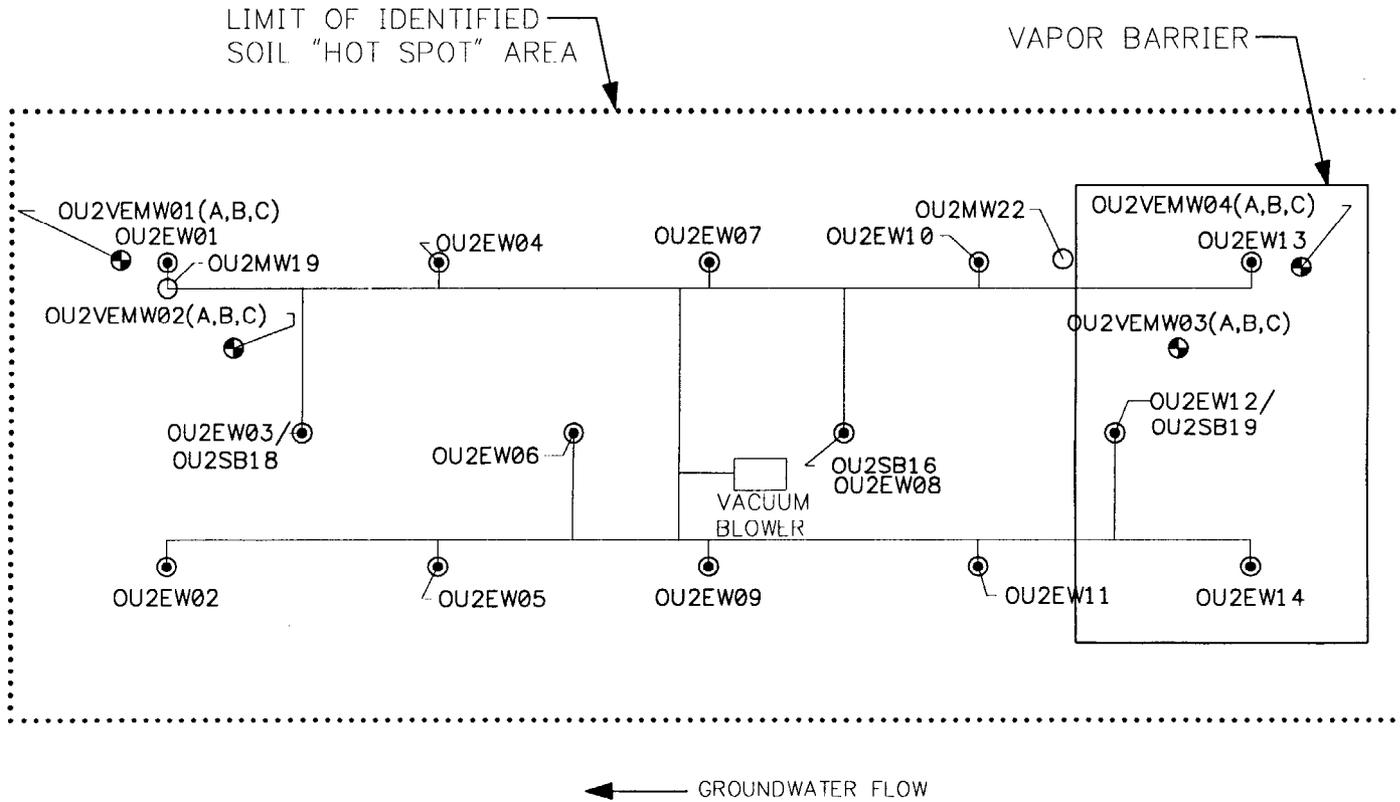


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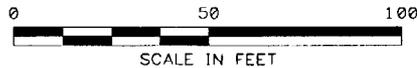
LEGEND

- ⊙ VAPOR EXTRACTION WELL (EW)
- ⊕ VAPOR EXTRACTION MONITORING WELL CLUSTER (VEMW)
- MONITORING WELL (MW)

NOTES: SOIL BORINGS OU2SB20 THROUGH OU2SB23 WILL BE LOCATED ADJACENT TO WHERE THE FOUR SAMPLES WHICH WERE SELECTED IN THE FIELD DURING THE INSTALLATION OF THIS SVE TREATABILITY STUDY SYSTEM.

**SOIL VAPOR EXTRACTION (SVE)
SYSTEM LAYOUT
MCAS, CHERRY POINT, NORTH CAROLINA**

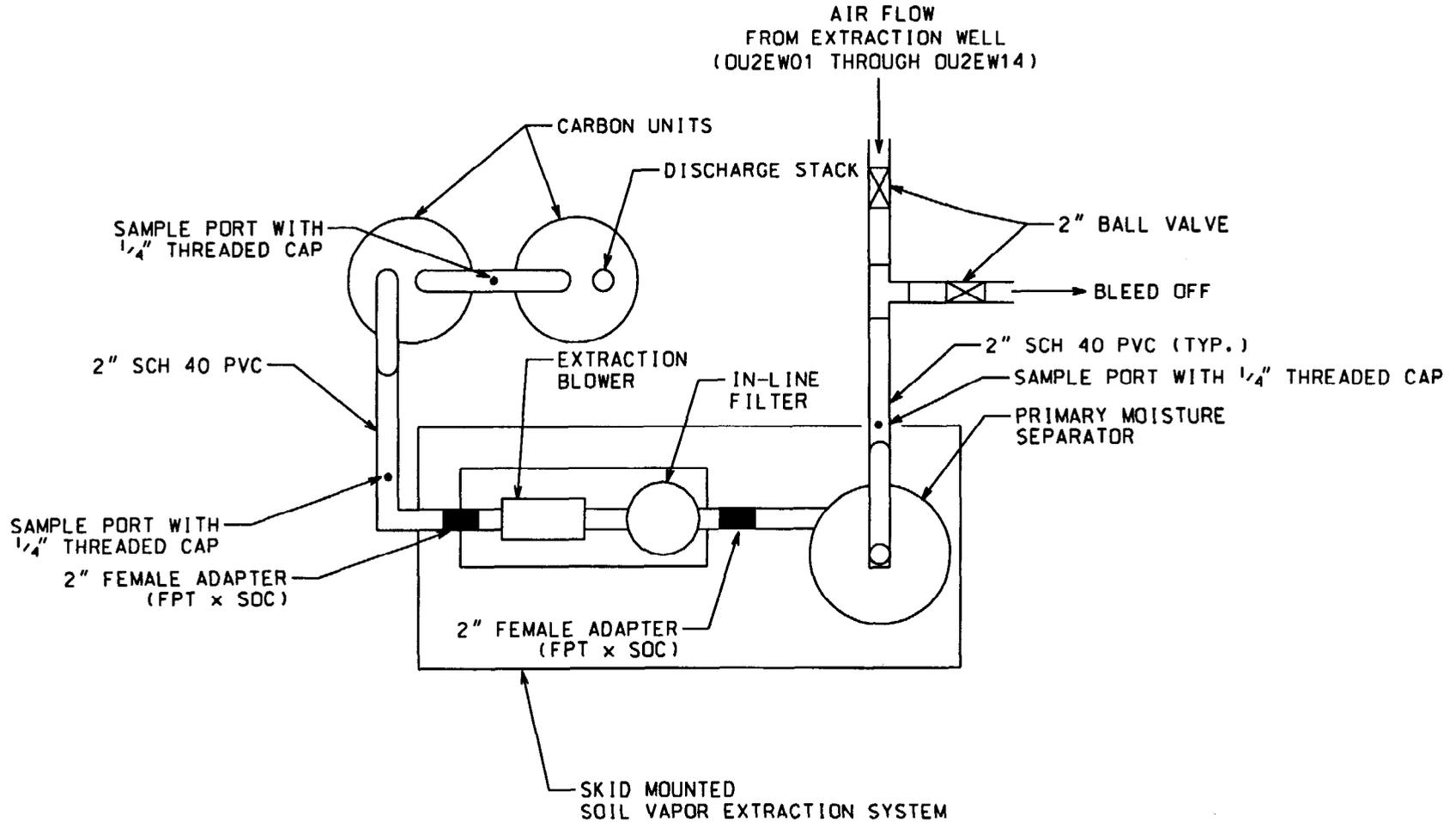
FIGURE 2-4



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2-13



SOIL VAPOR EXTRACTION SYSTEM
EQUIPMENT LAYOUT
MCAS, CHERRY POINT, NORTH CAROLINA

FIGURE 2-5

NOT TO SCALE

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one-month period. The SVE system will then be operated during the long term test until it has been determined that the system is no longer necessary or effective based on agreement between the Navy, State and EPA. Air and soil samples will also be collected during the treatability study operation. Table 2-3 identifies the sampling to be performed during the operation on the Treatability Study System.

2.2.1.1 Short-Term Testing

During the short-term testing phase of the treatability study, the SVE systems will be evaluated by operating various wells separately and in conjunction with the other wells. The radius of influence of the SVE systems will be determined by varying the air flow rates and monitoring pressure changes in the subsurface wells.

During these tests, vacuum and air flow measurements will be collected from the various monitoring wells located in the study area. In addition, flow measurements will be made at the discharge of the vapor extraction blower. Identical tests will be performed on both sides of the SVE system, the one side containing the vapor barrier and the other side without the vapor barrier, to determine the effects air short circuitry has on the system.

2.2.2.2 Long-Term Testing

During this phase of the treatability study, the system will be operated continuously. The system will be periodically inspected on a monthly basis, and the air flow in the various air transfer lines will be measured and balanced.

2.2.2.3 Air Sampling

Air quality of the SVE system will be measured by collecting air samples in tedlar bags for fixed base laboratory analysis and also by collecting field data using compound-specific Drager tubes. During the air sampling events, an air sample will be collected for laboratory analysis at the same time that Drager samples are collected so that a correlation between sample results may be developed for future use in evaluating system operation. Air sampling will be conducted at start-up of the system, after one week of operation, after two weeks, after four weeks (end of the short-term testing) of operation, and every month during the long-term evaluation period (1 year). Additional air samples for fixed base laboratory analysis will be collected at the exhaust of the Granular Activated Carbon (GAC) air treatment system when the Drager tube results indicate that contaminant breakthrough may be imminent.

2.2.2.4 Soil Samples

Soil samples will be collected during the system installation to provide baseline data as previously discussed. A second boring will be drilled (hand auger or conventional drilling) adjacent to the baseline sampling locations at the conclusion of the treatability study operation. A soil sample will be collected from the same soil interval as previously collected and will also be submitted for laboratory analyses as described in Table 2-3.

3.0 FIELD ACTIVITIES AND PROCEDURES

The field activities will include the following tasks:

- Mobilization/demobilization
- Drilling
 - Installation of soil borings
 - Installation of wells
- Well development
- Soil sampling
- Groundwater sampling
- Air sampling
- Treatability study system hookup and operation
- Investigation Derived Waste Disposal
- Decontamination
- QA/QC sampling
- Sample identification
- Sample handling
- Equipment calibration
- Record keeping

Sample blank forms are included in Appendix B. B&R Environmental Standard Operating Procedures (SOPs) and Region IV SOPs regarding field procedures are referenced in this Work Plan (see Appendix C for applicable B&R Environmental SOPs). Any exceptions to Region IV SOPs will be noted with a rationale for deviating from those recommended procedures.

3.1 MOBILIZATION/DEMOBILIZATION

B&R Environmental will prepare specifications and obtain subcontractors for the drilling, IDW disposal, surveying, and laboratory analyses. All field team members will review this Work Plan, the Heath and Safety Plan (HASP), and the HASP addendum. In addition, a field team orientation meeting will be held to familiarize personnel with the scope of the field activities.

A field meeting between MCAS Cherry Point Field Services and B&R Environmental took place on Monday, December 9, 1996 to identify any utilities in the area of proposed field activities. The Field

Services representative from MCAS Cherry Point stated that no underground utilities exist in the area of the proposed treatability studies nor in the area of the proposed Data Gap Investigation.

No permitting for off-gas emissions from groundwater and soil remediation systems is required in accordance with the North Carolina air permitting regulations. Air Strippers (air sparging systems) and soil vapor extraction systems qualify for permit exemption 15A NCAD 2Q.0102(b)(1)(H)(ix) - "no applicable requirements".

In the event the Air Station is required to obtain air toxic permitting for the construction/operation of some other emission source in the future, then it may be necessary to revisit air toxic compliance for these remedial systems. This situation is not expected to occur in the near future. Off-gas treatment will be performed; however, it is not required for permitting purposes.

3.2 DRILLING

Drilling will be accomplished using the hollow-stem auger method or mud rotary if necessary; however, hollow-stem auger is the preferred method. All borings will be drilled in accordance with EPA SOP E.2 and logged in accordance with B&R Environmental SOP GH-1.5 and EPA SOP/QAM Section 6.0. A boring log (Appendix B) will be completed for all borings drilled.

EPA SOP E.2.3.3 states that, "all drilling materials such as drilling muds, bentonite pellets, grouts, sand, etc., and the potable water to be used during drilling will be sampled and analyzed." Only the potable water will be sampled and analyzed. B&R Environmental believes that sampling and analyses of any other construction materials is not necessary for this field event on the basis that it is not standard practice and background wells that have been installed at MCAS Cherry Point in the past appear to have not detected any contamination due to leaching effects of well construction materials.

3.2.1 Installation of Soil Borings

Soil borings shall be installed using the hollow-stem auger drilling technique with the smallest auger diameter available. The auger flights will be advanced to the water table and, once the water table is encountered, the auger will be advanced an additional two feet to confirm that the water table is encountered. Split-barrel soil samples (in 2-foot increments) will be collected continuously over the drilled interval or as determined by the site geologist. Boring logging of auger cuttings will be appropriate as the activities progress provided that the lithology is adequately evaluated and the required soil samples are collected for analyses. However, all data gap investigation borings as well as treatability study borings for vapor extraction monitoring wells OU2VEMW02C and OU2VEMW03C will be continuously sampled for

lithology and laboratory analyses over the entire boring depth according to ASTM methods from the ground surface to the total depth of each boring and all soil samples will be screened with a PID. The soil samples will either be retained for lithologic description or submitted for laboratory analyses in accordance with Tables 2-1, 2-2 and 2-3.

Once the soil samples have been collected, the boring will be grouted by pumping or pouring a bentonite cement slurry (1 bag cement, 5 to 10 percent bentonite, 6.5 to 7 gallons water) through the center of the augers while the augers are being removed. This will continue until the grout level reaches the ground surface and all of the augers are removed from the boring. Grouting through the center of the augers will not be necessary if the borings do not collapse after the augers are removed. In this case, grout can be poured from the ground surface. All borings will be marked in the field with a wooden stake for subsequent surveying.

3.2.2 Well Installation

Several types of wells will be installed during the field activities including groundwater monitoring wells, air injection wells, air sparging monitoring wells, vapor extraction wells, and vapor extraction monitoring wells. The installation procedure common to all these wells is included in this section. Installation details specific to each well type are in following subsections.

Well borings will be advanced by the hollow-stem auger or mud rotary technique if necessary. Wells will be installed in accordance with B&R Environmental SOP GH-2.8 well installation procedures. A well construction log will be completed for each well installed as shown in Appendix B.

All well borings will be advanced using minimum 6-inch outside diameter hollow-stem augers with continuous split-spoon sampling (or as determined by the geologist) according to ASTM methods as described in Section 3.2.1.

Once the boring for the well has been completed, the well will be installed. The well will be constructed of Schedule 40, flush-joint, 2-inch-diameter National Science Foundation (NSF) PVC well screen and riser pipe. The well screens will have a slot size of 0.02 inches and be supplied with a PVC end cap. Once the screen and the riser pipe are in place, the annulus of the boring will be backfilled with clean silica sand (Nos. 20 and 30 U.S. Standard Sieve size or as determined by the site geologist) from the bottom of the boring to 1 to 3 feet above the top of the well screen. As the sandpack is being installed, sand will always be maintained several inches inside of the augers to insure an adequate sandpack around the well. A bentonite pellet seal (minimum 2-foot thickness) will then be installed and allowed to hydrate as per the

manufacturer's recommendations. The remainder of the annulus of the borehole (from the seal to the ground surface) will be grouted by pumping a cement/bentonite slurry (1 bag cement, 5 to 10 percent bentonite, 6.5 to 7 gallons water) through a tremie pipe until the grout level reaches the ground surface. The depths of the backfill materials will be constantly monitored during the installation of the monitoring well by using a weighted stainless steel or plastic tape.

The drilling subcontractor will prepare a separate written boring log and well completion log for each boring/well drilled and submit it to the B&R Environmental field geologist at the conclusion of the field activities. North Carolina Department of Natural Resources and Community Development GW-1 forms will be completed by the Drilling Subcontractor and provided to the B&R FOL per reviewer (an example of this form is provided in Appendix B) and forwarded to NREA/B&R Environmental for approval, signature and submittal to the North Carolina Department of Environment, Health, and Natural Resources, Division of Environmental Management (NCDEM).

3.2.2.1 Groundwater and Air Sparging Monitoring Wells

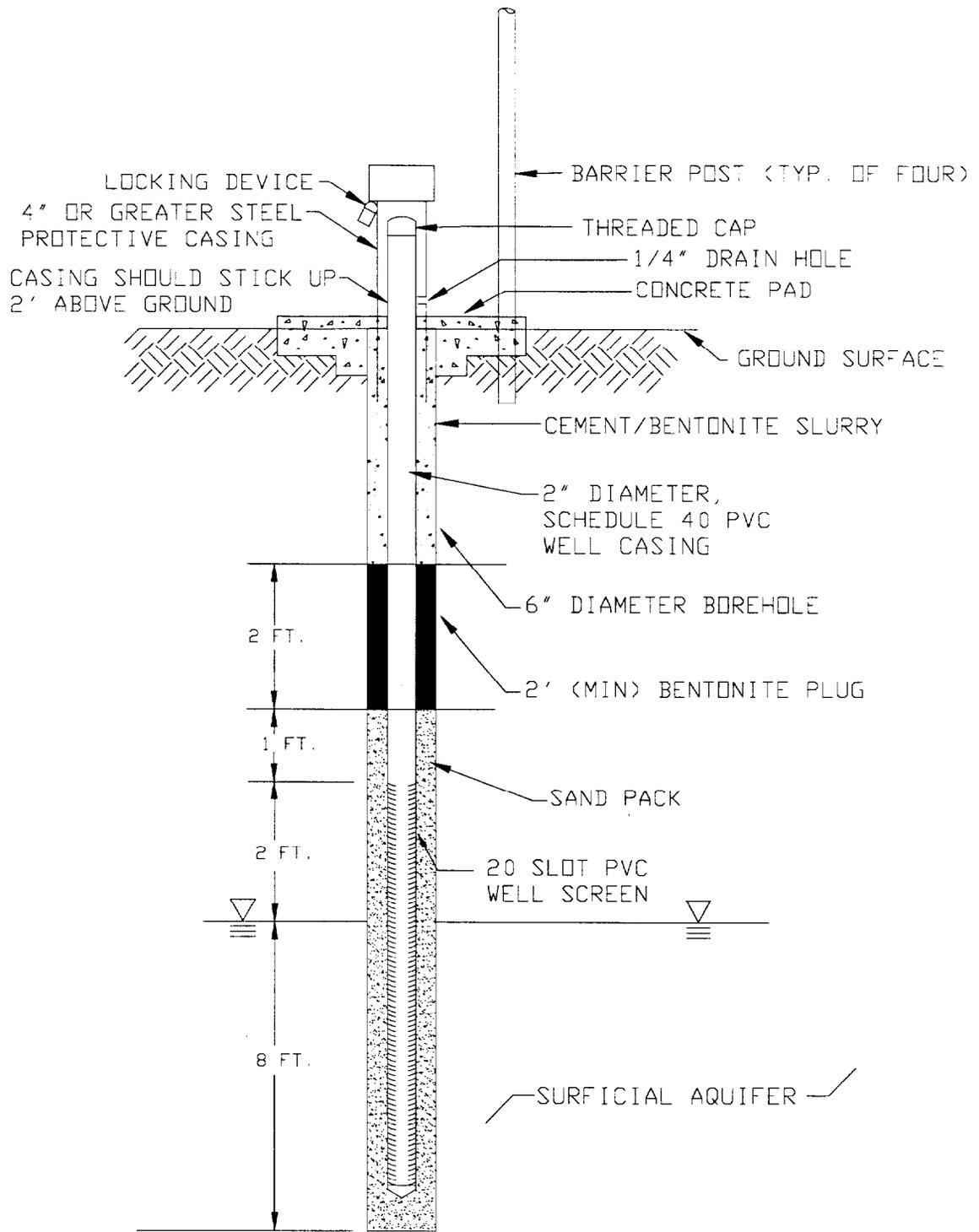
The groundwater monitoring wells (OU2MW17 and OU2MW21) and the groundwater monitoring wells installed to determine if air sparging is appropriate for the area (OU2MW18, OU2MW19, OU2MW20, and OU2MW22) will have 10 foot long screens positioned with the top of the well screen approximately 1 to 2 feet above the seasonally high water table. A steel protective casing with locking cap and four barrier posts will be cemented in place with concrete at each well. A typical groundwater monitoring well detail is shown in Figure 3-1.

3.2.2.2 Vapor Extraction Wells

Each vapor extraction well (OU2EW01 through OU2EW14) will be constructed of a 5-foot screen interval located immediately above the seasonally high water table. Each vapor extraction well will be capped using a tee with a threaded cap. A typical vapor extraction well is shown on Figure 3-2.

3.2.2.3 Vapor Extraction Monitoring Well Clusters

The SVE monitoring wells associated with the SVE system (OU2VEMW01A, B, C, through OU2VEMW04A, B, C) will be 3 well clusters constructed of 3-foot long screen intervals at depths of 3 to 6 feet, 11 to 14 feet, and 19 to 22 feet at each cluster location. These depths will be modified depending on the depth to groundwater and all wells will be screened in the vadose zone. Each well will be capped with a threaded cap and brass valve with 1/4" hose barb. A typical SVE monitoring well is shown in Figure 3-3.



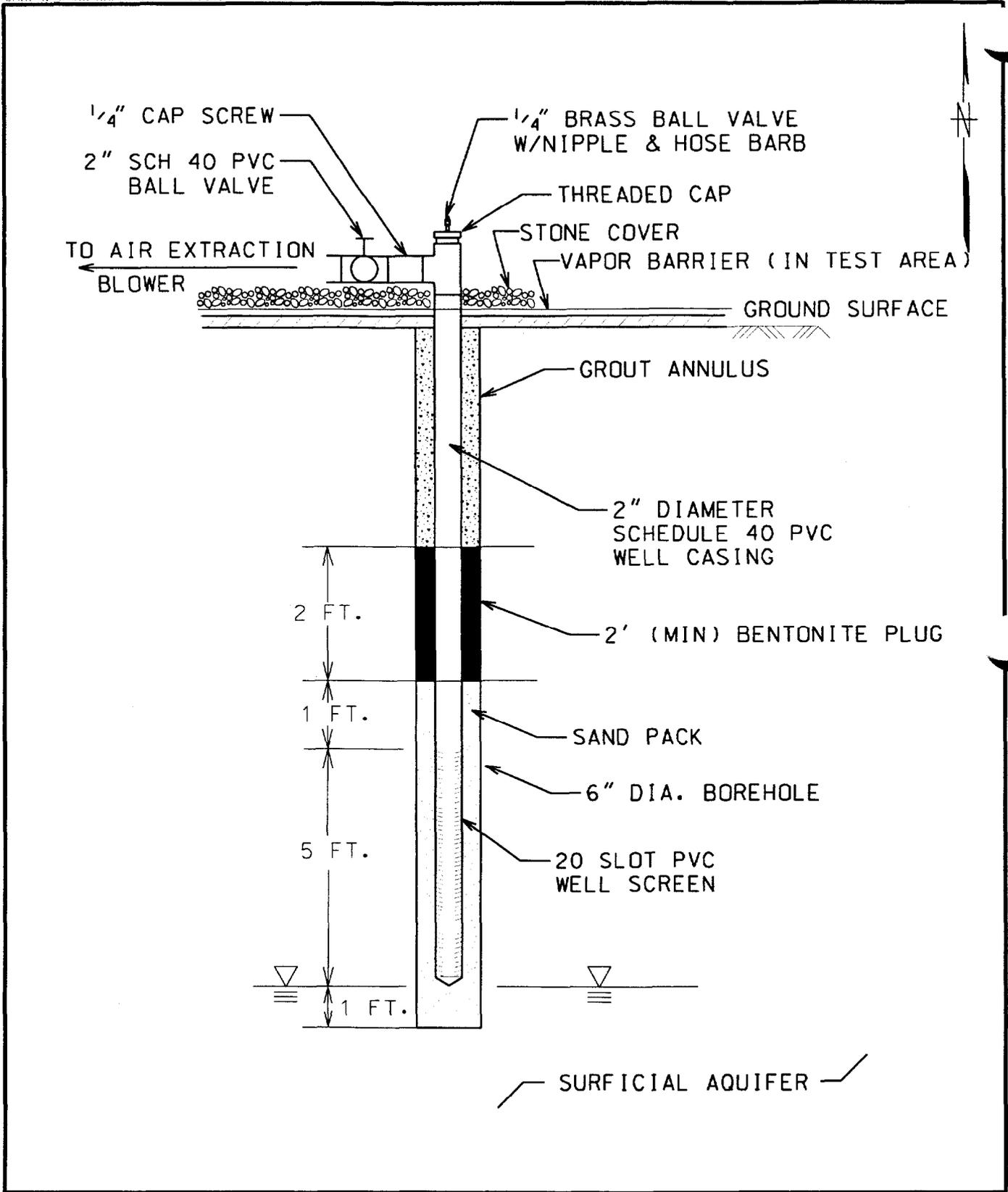
GROUNDWATER MONITORING WELL
WELL INSTALLATION DETAIL (TYPICAL)
MCAS, CHERRY POINT, NC

FIGURE 3-1

NOT TO SCALE



Brown & Root Environmental



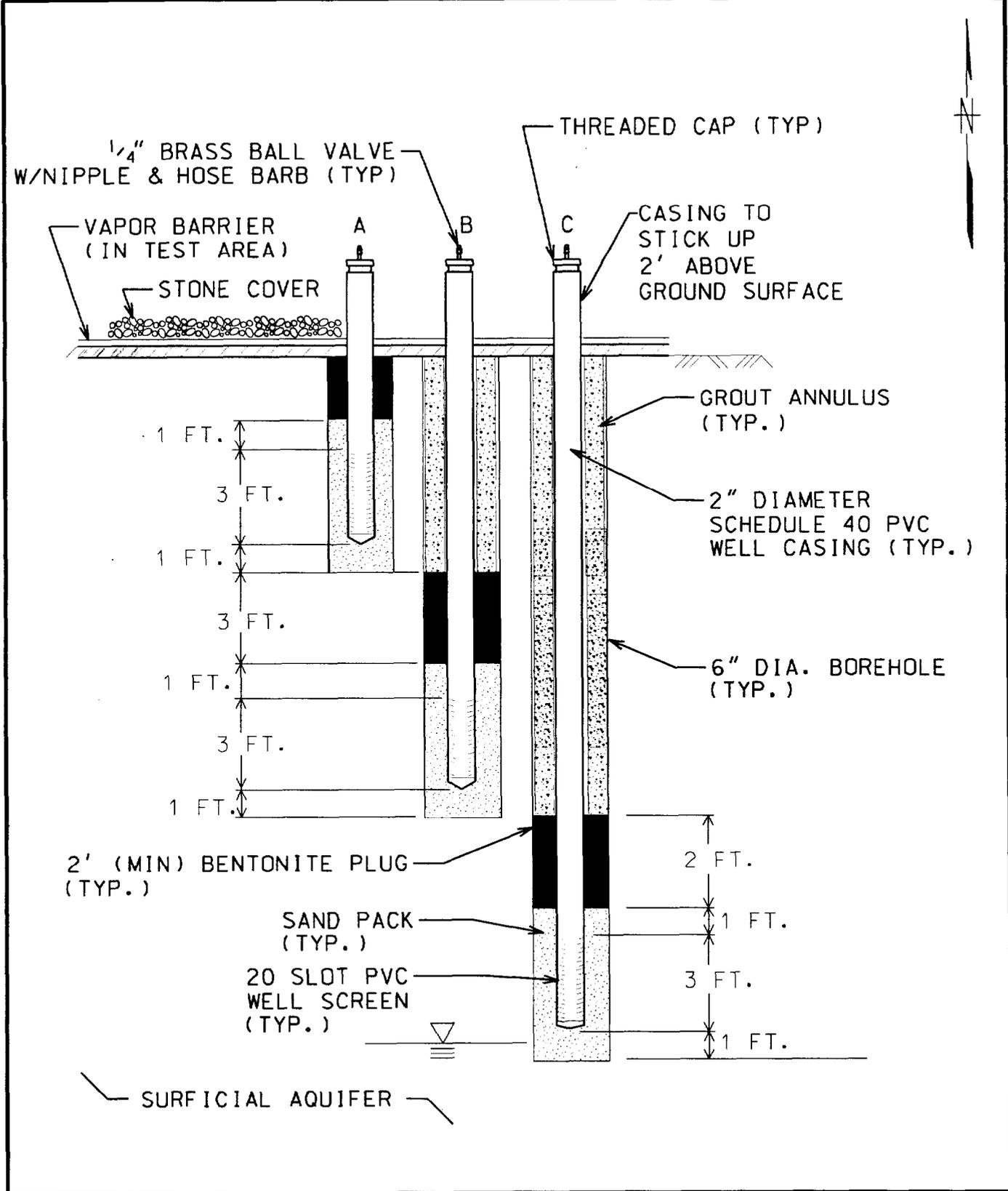
**VAPOR EXTRACTION WELL
WELL INSTALLATION DETAIL (TYPICAL)
MCAS, CHERRY POINT, NORTH CAROLINA**

NOT TO SCALE

FIGURE 3-2



Brown & Root Environmental



VAPOR EXTRACTION MONITORING WELL
WELL INSTALLATION DETAIL (TYPICAL)
MCAS, CHERRY POINT, NORTH CAROLINA

FIGURE 3-3

NOT TO SCALE



3.3 WELL DEVELOPMENT

All wells which contain water will be developed no sooner than 24 hours after installation to remove fine material from around the well screen. The well will be developed by vigorous airlift, bailing and surging, and/or by pumping with a peristaltic pump as determined by the field geologist. Measurements of pH, temperature, specific conductance, and turbidity will be collected after each well casing volume and recorded in the field logbook. The wells will be developed until two consecutive readings of pH, specific conductance, turbidity and temperature are similar (+/- 10 percent). EPA SOP/QAM Section 7.2 shall be referenced for additional guidance regarding well development.

3.4 SOIL SAMPLING

Soil samples will be collected from the specified well and soil borings. EPA SOP/QAM Section 12 and B&R Environmental SOP SA-1.3 contains guidance regarding soil sampling procedures.

All soil samples for laboratory analyses will be collected with split-spoon samplers. All samples will be screened with a PID and temporarily wrapped in aluminum foil while the remaining soil samples from a given boring are being collected.

The samples that have been selected for laboratory analyses will be mixed on the aluminum foil with plastic disposal trowel to homogenize the sample. The sample aliquot to be submitted for VOC analysis will be placed directly into the appropriate sample jar without being homogenized.

3.5 GROUNDWATER SAMPLING

Prior to obtaining the groundwater sample, the static water level and the depth of the well shall be measured with an electronic water level meter to determine the amount of water in one casing volume. The wells will then be purged at a rate of 0.3 liters per minute using a low-flow suction lift peristaltic pump and dedicated hose to minimize turbulence. Measurements of pH, specific conductance, temperature, oxidation reduction potential (Redox), and turbidity shall be recorded every 5 minutes during purging in accordance with B&R Environmental SOP SA-1.1, EPA SOP/QAM Section 7.0, and the manufacturer's instructions. If two consecutive readings of pH, specific conductance, temperature, ORP, and turbidity are similar (\pm 10 percent), then the well can be sampled. Purging will continue until stabilization is reached or a maximum of five casing volumes are purged, whichever comes first (as detailed in PULS et al, 1991 and 1992). One measurement of all purging parameters and dissolved oxygen shall also be taken prior to sample collection in accordance with B&R Environmental SOP SA-1.1, EPA SOP/QAM Section 7, and the manufacturer's instructions. If the well is purged dry before five casing volumes have been removed, the

water level will be allowed to recover and a groundwater sample will then be collected. In the event that recovery is too slow to adequately fill all sample containers, the sample shall be collected the following day.

The samples will be collected using the same peristaltic pump set at the same speed as used for purging the well. The samples, with the exception of the samples being collected for TCL VOCs, will be collected directly from the pump outlet. The sample containers for TCL VOCs will be filled by crimping the discharge end of the sample tubing when filled, removing the inlet end of the sample tubing from the well, suspending the inlet tubing above the vial, and allowing water to fill each vial by gravity flow.

3.6 AIR SAMPLING

3.6.1 Draeger Tube Sampling

Draeger tubes will be used to provide real time air sample results. Air samples will be collected between the vacuum blower and the GAC off gas treatment system and between the two GAC units. The sample is collected by installing a nipple in the 1/4 inch capped sample port and attaching a tedlar sample bag using a flexible hose. The tedlar bag will be purged with clean air three times prior to reuse. After the tedlar bag is attached the valve on the tedlar bag is opened and the pressure of the SVE system will fill the bag. Once the tedlar bag is full, the valve is closed and sampling using the Draeger tubes can be performed.

Draeger tube sampling will be conducted according to the instructions provided with the Draeger tubes paying close attention to the air flow direction and number of strokes required depending on the tube being used. The pump and tubes must be checked prior to use for evidence of damage. The pump is checked by inserting an unopened tube into the holder, squeezing the pump, and checking for signs of expansion. There shall be no evidence of expansion at the end of a 2 minute period. If there is expansion, then the pump should not be used.

When using Draeger tubes it is important that the total volume of air be drawn through the tube, therefore enough time must be allowed for each stroke of the pump to enable it to return its fully expanded position. It is also important the tedlar bag not be under a large pressure which would force air into the Draeger tube rather than being drawn through by the pump.

Once the number of strokes indicated on the tube and in the instructions have been performed, a measurement can be taken by reading the color change in relation to the printed scale on the tube. In many cases two scales are given which correspond to different number of strokes. If the lower number of

strokes does not provide an accurate reading because concentrations are too low, then the higher number of strokes will be conducted.

3.6.2 Fixed Base Laboratory Air Sampling

Suma canisters or tedlar bags can be used for the collection of air samples identified in the work plan. Air samples for fixed base laboratory analysis will be collected between the vacuum blower and the GAC off gas treatment system and between the two GAC units. The sample is collected by installing a nipple in the 1/4 inch capped sample port and attaching the Suma canister or tedlar bag via a flexible tubing and nipple connection. If a Suma canister is used, the valve on the Suma canister is opened for a few seconds allowing the vacuum in the canister and the pressure of the SVE system to fill the canister. The valve is then closed, the flexible tube removed, and securing cap replaced on the nozzle of the Suma canister prior to shipment. If tedlar bags are used then the valve is opened, the bag is allowed to fill using pressure from the system as an air pump. Once the bag is filled, the valve is closed and prepared for shipping.

3.7 PILOT-SCALE TREATABILITY STUDY INSTALLATION

The treatability study system will be installed after completion of all wells associated with the system. The installation process will consist of connecting the vapor extraction inlet line to the appropriate wells.

Connections will be made using threaded PVC or steel fittings or glue type PVC fittings, whenever appropriate. The system will be initially connected to a temporary portable electrical generator for the initial phases of operation, then transferred to a permanent electrical hookup once installed. All components of the Treatability Study systems will be installed by the B&R Environmental field team and an electrical subcontractor. The major components of the treatability study system are presented in the following sections.

3.7.1 Vapor Extraction Blower and Motor

The vapor extraction blower will be a skid-mounted, positive displacement blower capable of extracting 220 cfm of air at a pressure of 5 inches of mercury (Hg). The motor for the vapor extraction blower will be 10 horsepower and capable of operating on 3 phase, 480 volt electrical power. A motor starter, vacuum relief valve, and inlet filter will also be included with the vapor extraction blower.

3.7.2 Moisture Separator

A moisture separator will be attached in-line to the air extraction lines as part of the skid-mounted system. The moisture separator will be a high-efficiency, cyclonic-type separator capable of processing a 220 cfm air flow rate. The separator will have a minimum 20-gallon capacity and 2-inch-diameter inlet and outlet adapters. An air-pressure relief valve and condensate drain port will also be included on the moisture separator. An automatic shut-off switch will be connected between the moisture separator and the blower unit so that the blower will shut down in the event the moisture separator fills with condensate.

3.7.3 Electrical Wiring Design

The 3-phase, 480-volt power source available at the test sites will be connected to the Treatability Study systems according to the electrical wiring diagram illustrated on Figure 3-4 for the SVE system. The blower unit will operate using the 3-phase 480-volt circuit.

3.7.4 Vapor-Phase, Granular Activated Carbon, Air Treatment System

The extracted air from the SVE system will be treated using a vapor phase, granular activated carbon, air treatment system. B&R Environmental field personnel will attach two vapor phase granular activated carbon (GAC) air treatment units, in series, along the vapor extraction exhaust line. Each carbon unit will contain approximately 300 pounds of vapor phase GAC and be capable of treating the extraction exhaust air stream that has maximum temperature, pressure, and flow rate of 100° F, 4 psi, and 220 cfm, respectively.

3.7.5 Electric Supply

A three-phase, 480-volt electrical source will be supplied by a 25 kW portable generator, and all the necessary hook-ups and equipment will be supplied by B&R Environmental. Ultimately a permanent electrical source will replace the portable electrical source. The motors for the air injection and air extraction units used for the treatability study system will be capable of operating with this power supply.

3.7.6 Above Ground Air Transfer Lines

All air transfer piping between the blower unit and the vapor extraction wells will be installed above-ground by the B&R Environmental field team. All above-ground piping and fittings will be made of 2-inch-diameter Schedule 40 PVC.

3.7.7 Vapor Barrier

A vapor barrier will be installed in a test section of the treatability study SVE system. As shown on Figure 2-4, a vapor barrier will be installed over the ground surface at the treatability study location and covered with stone. This barrier will be installed to determine the effect of infiltration of surface air into the vapor extraction wells from the area immediately surrounding each well. It will also determine what effect system short-circuiting causes on the overall effectiveness of the system.

3.7.8 Air Flow Controls

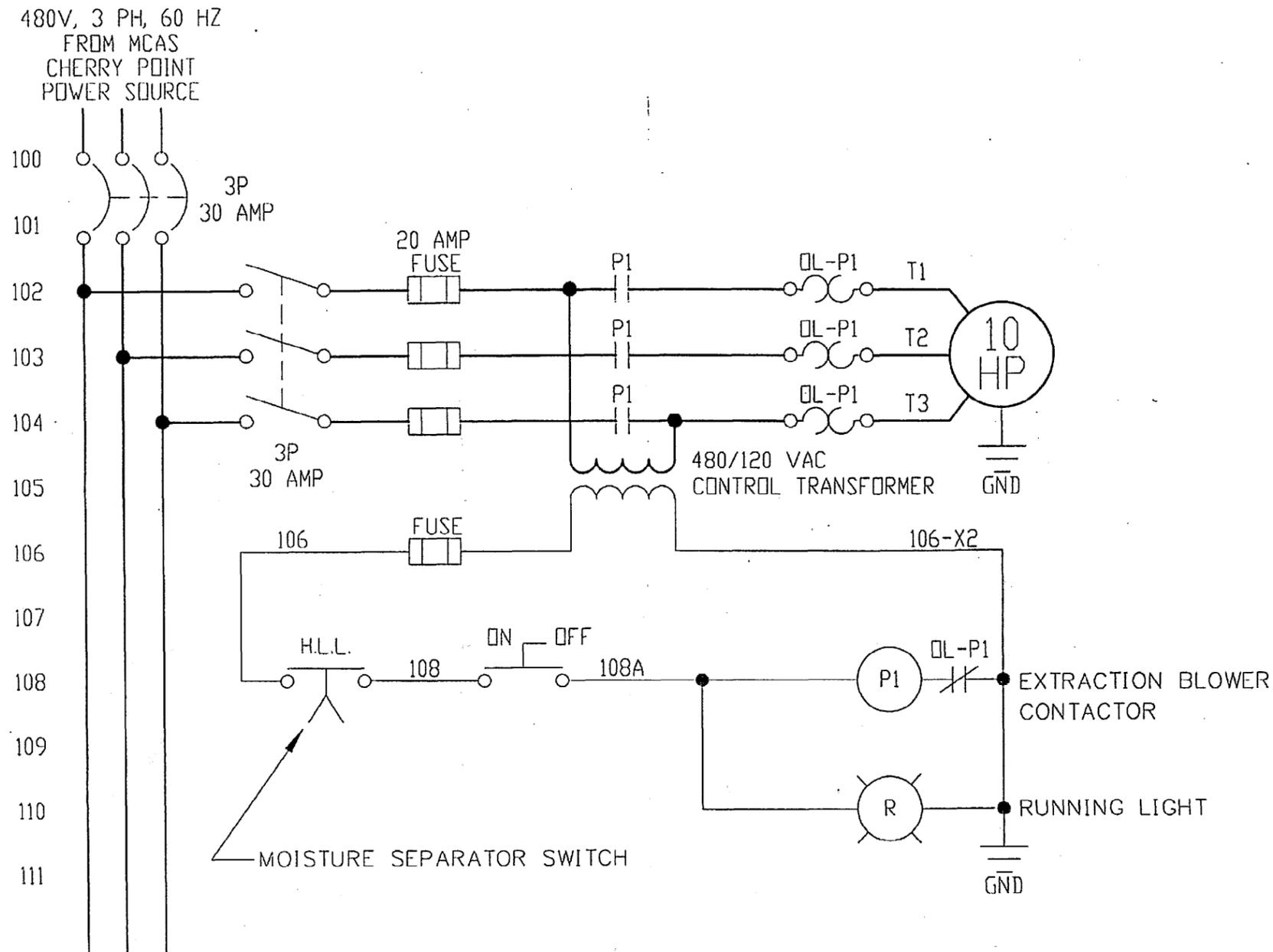
The rate of air flow into each of the vapor extraction wells will be controlled with 2-inch-diameter, Schedule-40 PVC ball valves at each well location. The system air flow will also be able to be adjusted by installing a ball valve on the main trunk line of SVE Systems.

3.8 INVESTIGATION-DERIVED WASTE DISPOSAL

Five types of potentially contaminated materials are expected to be generated during the field work. Personal protective equipment (PPE), drill rig decontamination fluids, sampling equipment decontamination fluids, drill cuttings, and purge water from well development and groundwater sampling will all be generated during the field investigation.

Based on the activities and types of contaminants present, none of these materials are expected to present a significant risk to human health or the environment if properly managed. Planned management of these materials is provided below. The recommended procedures were based on accepted procedures included in the EPA document "Management of Investigative Derived Wastes During Site Inspections," EPA/540/G-91/009, May 1991. Additional information is provided in B&R Environmental SOP SA-7.1.

- **Personal Protective Equipment.** PPE will be decontaminated and placed in the trash receptacles at the facility.
- **Drill Rig Decontamination Fluids.** Drill rig decontamination fluids will be allowed to accumulate in the sump located at the MCAS Cherry Point decontamination pad located at OU2 where decontamination operations will be conducted. An IDW disposal subcontractor will collect and dispose of these wastes at completion of the field activities.
- **Sample Equipment Decontamination Fluid.** These fluids will be handled with the drill rig decontamination fluids and placed in the sump for disposal by the IDW disposal subcontractor.

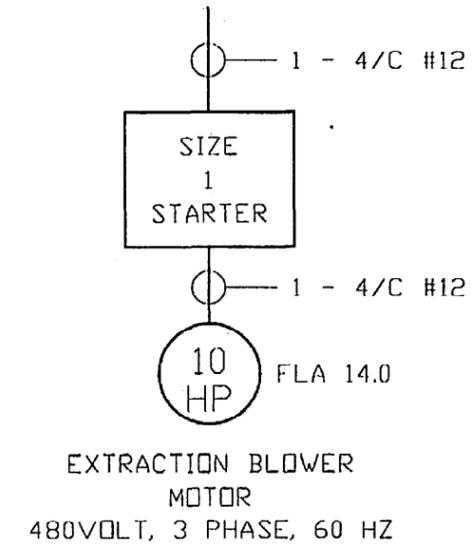


EXTRACTION BLOWER SCHEMATIC DIAGRAM

NOTES:

- 1.) ALL ELECTRICAL DEVICES AND WIRING SHALL BE FOR OUTDOOR USE. (NEMA 4)

FEED FROM MCAS CHERRY POINT POWER SOURCE
480V, 3 PHASE, 60 HERTZ



SINGLE LINE DIAGRAM

EXTRACTION BLOWER
ELECTRICAL SINGLE LINE
AND SCHEMATIC DIAGRAM
MCAS, CHERRY POINT, NORTH CAROLINA

FIGURE 3-4



- **Drill Cuttings.** Drill cuttings will be screened with a PID. The cuttings will be containerized in bulk containers and stored at a location to be determined by MCAS Cherry Point, until disposal by the IDW subcontractor. It is anticipated that, unless laboratory testing of the soil samples collected from the various soil boring indicate otherwise, sampling of the material in the containers and analyzing for the RCRA characteristics will not be required.
- **Purge Water.** Groundwater generated during monitoring well sampling will be containerized in bulk containers and stored at a location to be determined by MCAS Cherry Point or placed in the sump for disposal by the IDW disposal subcontractor.

3.9 DECONTAMINATION

The equipment involved in field sampling activities will be decontaminated in accordance with B&R Environmental SOP SA-7.1 prior to and during drilling and sampling activities. This equipment includes drilling rigs, downhole tools, augers, and all nondedicated reusable sampling equipment.

3.9.1 Major Equipment

All downhole drilling equipment and sampling tools shall be steam cleaned prior to beginning work, between soil borings, or wells or any time the drilling rig leaves the site prior to completing a boring, and at the completion of the drilling program.

Decontamination operations will consist of washing the equipment using a high-pressure steam wash. All decontamination activities will take place at the decontamination pad located at OU2. All water generated during drilling equipment decontamination will be allowed to collect in the sump at the decontamination pad.

3.9.2 Sampling Equipment

All nondedicated reusable sampling equipment used for collecting samples will be decontaminated both prior to beginning field sampling and between samples. That equipment includes the split-spoon samplers. The following decontamination steps will be taken:

- Potable water/laboratory-grade, phosphate-free detergent wash (scrub if necessary)
- Potable water rinse
- Deionized water rinse
- 10 percent nitric acid rinse

- Isopropanol
- Air dry

Field analytical equipment such as pH, conductivity, and temperature instrument probes will be rinsed first with analyte-free water, then with the sample liquid. Water level measurement devices will be rinsed with potable water.

3.10 QA/QC SAMPLES

In addition to regular calibration of field equipment and appropriate documentation, quality control (QC) samples will be collected during the data gap investigation sampling activities. QA/QC samples will not be required for sampling associated with monitoring the treatability study system. QC samples include field duplicates, field blanks, trip blanks, and equipment rinsate blanks. Each type of field QC sample is defined as follows. An analytical summary is included in Table 3-1.

3.10.1 Field Duplicates

Field duplicates are two samples collected: (1) independently at a sampling location in the case of groundwater or surface water, or (2) a single sample split into two portions in the case of soil. Duplicates are obtained during a single act of sampling and are used to assess the overall precision of the sampling and analysis program. Ten percent of all samples for each media shall be field duplicates. Duplicates shall be analyzed for the same parameters in the laboratory, as the corollary environmental samples.

3.10.2 Equipment Rinsate Blank

Equipment rinsate blanks are obtained under representative field conditions by running analyte-free water through sample collection equipment (split spoon) after decontamination and placing it in the appropriate sample containers for analysis. Equipment blanks will be used to assess the effectiveness of decontamination procedures. Equipment blanks will be collected for each type of non-dedicated sampling equipment used and will be submitted at a frequency of one per day per media. However, only equipment blanks obtained from every other day will be analyzed. Those not analyzed will be retained by the laboratory until completion of field activities. It will be the responsibility of the FOL to communicate to the laboratory whether an equipment blank is, or is not, to be analyzed as stated above.

TABLE 3-1
ANALYTICAL SUMMARY
OPERABLE UNIT 2
MCAS CHERRY POINT, NORTH CAROLINA
PAGE 1 OF 2

Matrix	Analysis	Methodology	Samples	Duplicates	Rinsate Blanks	Trip Blanks	Matrix Spike/Matrix Spike Duplicate	Total
Data Gap Investigation (January 13 through January 22, 1997)								
Groundwater	TAL Metals plus Cyanide	CLP SOW ILM03.0	1	1	TBD	NA	1	2
	TCL Volatile Organic Compounds	CLP Low Conc. SOW OLC02.0	1	1	TBD	1	1	2
	TCL Semivolatile Organic Compounds	CLP SOW OLM03.1	1	1	TBD	NA	1	2
	TLC Pesticides/PCBs	CLP SOW OLM03.1	1	1	TBD	NA	1	2
Soil	TAL Metals plus Cyanide	CLP SOW OLM03.0	14	1	TBD	NA	1	15
	TCL Volatile Organic Compounds	CLP SOW OLM03.1	14	1	TBD	1	1	15
	TCL Semivolatile Organic Compounds	CLP SOW OLM03.1	14	1	TBD	NA	1	15
	TCL Pesticides/PCBs	CLP SOW OLM03.1	14	1	TBD	NA	1	15
SVE Treatability Study Installation Investigation (January 13 through February 1997)								
Groundwater	TAL Metals plus Cyanide	CLP SOW OLM03.0	4	0	0	NA	0	4
	TCL Volatile Organic Compounds	CLP SOW DLM03.1(1)	4	0	0	0	0	4
	TCL Semivolatile Organic Compounds	CLP SOW OLM03.1	4	0	0	NA	0	4

TABLE 3-1
ANALYTICAL SUMMARY
OPERABLE UNIT 2
MCAS CHERRY POINT, NORTH CAROLINA
PAGE 2 OF 2

Matrix	Analysis	Methodology	Samples	Duplicates	Rinsate Blanks	Trip Blanks	Matrix Spike/Matrix Spike Duplicate	Total
Groundwater (Continued)	TCL Pesticides/PCBs	CLP SOW OLM03.1	4	0	0	NA	0	4
	Total Organic Carbon	EPA 415.1	1	0	0	NA	0	1
	Filtered Iron and Manganese	CLP SOW OLM03.0	1	0	0	NA	0	1
	Alkalinity	EPA 310	1	0	0	NA	0	1
Soil	TCL Volatile Organic Compounds	CLP SOW OLM03.1	8	0	0	NA	0	8
	Total heterotrophic plate count including pseudomonas bacteria	SM 907	1	0	0	NA	0	1

Treatability Study Operation (February 1997 through January 1998; start-up and monthly Air sampling for 11 months and soil confirmation sampling)

Soil	TCL Volatile Organic Compounds	CLP SOW OLM03.1	8	0	0	0	0	8
	Total heterotrophic plate count including pseudomonas bacteria	SM 907	2	0	0	NA	0	1
Air	TCL Volatile Organic Compounds	EPA 214	15	0	0	NA	0	15
	Oxygen and Carbon Dioxide	ASTM D1945	15	0	0	NA	0	15

(1) Total samples included does not include QA/QC samples.

3.10.3 Field Blanks

Field blanks are obtained by sampling the water(s) used for decontamination during the field investigation. Samples consist of the source water used in (1) steam cleaning of large equipment and (2) analyte-free water used for decontamination of sampling equipment. Field blanks will be used to confirm the effectiveness of decontamination procedures and to determine whether the analyte-free water or the potable water (used for steam cleaning) may be contributing to sample contamination. Field blanks will be collected for each type of water used for decontamination and will be submitted at a frequency of one per sampling event.

3.10.4 Trip Blanks

To determine whether contamination of samples has occurred during transit or storage, trip blanks will be used. Trip blanks consist of analyte-free water taken from the laboratory to the site, and returned. Trip blanks are taken at the rate of one per cooler of volatile organic samples and will be analyzed for Target Compound List (TCL) VOCs only.

3.10.5 Bottleware

Precleaned bottles will be used at MCAS Cherry Point.

3.11 SAMPLE IDENTIFICATION SYSTEM

Each sample submitted to a fixed base laboratory for chemical analysis will be assigned a unique sample tracking number. The sample tracking number will consist of a four-segment, alpha-numeric code that identifies the site, sample medium and location, and sample depth (in the case of soil samples). Quality assurance (QA) sample designations will be blind relative to sample duplicates. Any other pertinent information regarding sample identification will be recorded in the field log books and sample log sheets.

The alphanumeric coding to be used in the sample system is as follows:

Field Samples

(AAN) - (AA NN) - (NN)
(Site Name) (Sample Medium & Sample Location) (Sample Depth)

QA Samples

(AAN) - (AA) - (NN)
(Site Name) (QA Sample Designation) (Sample Number)

Character Type:

A - Alphabetic
N - Numeric

Site Name:

OU2 = Operable Unit 2

Sample Medium:

AS = Air Sample
MW = Groundwater Sample
SB = Soil Sample from a soil boring

Sample Location:

00 = Influent Line to GAC Unit
99 = Effluent Line exiting the first GAC Unit
01, 02, 03, etc. = Well Number or soil boring number

Sample Depth:

Soil = Depth from ground surface to soil sample
Air and Groundwater = Use none

QA Sample Designation:

TB = Trip Blank
FB = Field Blank
RB = Rinsate Blank

QA Sample Number:

The specific number in series of QA samples collected for a particular media.

3.12 SAMPLE HANDLING

Sample handling includes the field-related consideration regarding the selection of sample containers, preservatives, allowable holding times and requested analyses. Table 3-2 summarizes the sample handling considerations for this field activity. The EPA User's Guide to Contract Laboratory Program (EPA, 1988), and the Federal Register (EPA, 1984) address the topics of containers and sample preservations.

3.12.1 Sample Custody

Sample custody procedures are designed to provide documentation of preparation, handling, storage, and shipping of all samples collected. An example of the chain-of-custody form, which will be used during this investigation, is included in Appendix B.

Samples collected during the site investigation will be the responsibility of identified persons from the time they are collected until they are appropriately transferred. Stringent chain-of-custody procedures will be followed to document sample possession.

- The Field Operations Leader (FOL), or his or her designee, is responsible for the care and custody of the samples collected until they are delivered to the analytical laboratory or entrusted to a carrier.
- Sample logs or other records will always be signed and dated.
- Chain-of-custody sample forms will be completed to the fullest extent possible prior to sample shipment. They will include the following information: project name, sample number, time collected, source of sample and location, description of sample location, matrix, type of sample, grab or composite designation, preservative, number and size of bottle, analysis, and name of sampler.

These forms will be filled out in a legible manner, using waterproof ink, and will be signed by the sampler. Similar information will be provided on the sample label which will be securely attached to the sample bottle. The label will also include the general analyses to be conducted. In addition, sampling forms will be used to document collection, and preparation procedures.

TABLE 3-2

HOLDING TIME AND BOTTLEWARE REQUIREMENTS
 OPERABLE UNIT 2
 MCAS CHERRY POINT, NORTH CAROLINA
 PAGE 1 OF 2

Matrix	Analysis	Bottle Ware	Preservation	Holding Time
Air	Volatile Organic Compounds via EPA TO-214	Tedlar Bag or Suma Cylinder	None	3 days
	Oxygen and Carbon Dioxide ASTM D1945	Tedlar Bag or Suma Cylinder	None	3 days
Groundwater	TCL Volatile Organic Compounds CLP SOW OLM03.1 or CLP Low Conc. SOW OLC02.0	3, 40 mL volatile vials with Teflon-lined septum	Add hydrochloric acid to pH < 2 and cool to 4°C	14 days
	TCL Semivolatile Organic Compounds CLP SOW OLM03.1	1-1/2 gallon glass amber	Cool to 4°C	14 days to extraction 40 days to analysis
	TCL Pesticides/PCBs CLP SOW OLM03.1	1-1/2 gallon glass amber	Cool to 4°C	40 days
	Total Organic Carbon EPA 415.1	250 mL High Density Polyethylene	Add hydrochloric acid or sulfuric acid to pH < 2 and cool to 4°C	28 days
	TAL Metals + Cyanide CLP SOW ILM03.0	1 L High Density Polyethylene	Add nitric acid to pH < 2 and cool to 4°C	180 days (Hg 26 days)
	Filtered Iron and Manganese CLP SOW ILM03.0	1 L High Density Polyethylene	Add nitric acid to pH < 2 and cool to 4°C	180 days
	Alkalinity EPA 310	250 mL High Density Polyethylene	Cool to 4°C	14 days

TABLE 3-2

HOLDING TIME AND BOTTLEWARE REQUIREMENTS
 OPERABLE UNIT 2
 MCAS CHERRY POINT, NORTH CAROLINA
 PAGE 2 OF 2

Matrix	Analysis	Bottle Ware	Preservation	Holding Time
Soil	Heterotrophic Plate Count including pseudomonas degrading bacteria via SM 907	4 oz clear wide mouth jar with Teflon-lined closure	None	180 days
	TCL Volatile Organic Compound CLP SOW OLM03.1	100 g Glass jar	Cool to 4°C No Head Space	14 days
	TCL Semivolatile Organic Compounds CLP SOW OLM03.1	One 8 oz. clear glass wide mouth	Cool to 4°C	14 days to extraction 40 days to analysis
	TCL Pesticides/PCBs CLP SOW OLM03.1	One 8 oz. clear galss wide mouth	Cool to 4°C	14 days to extraction 40 days to analysis
	TAL Metals + Cyanide CLP SOW ILM03.0	100 g Glass jar	Cool to 4°C	180 days (Hg 26 days)

EPA - U.S. Environmental Protection Agency
 ASTM - American Society for Testing and Materials

- Samples will always be accompanied by a chain-of-custody record. When transferring samples, the individuals relinquishing and receiving them will sign, date, and note the time of the chain-of-custody record. This record documents the sample custody transfer from the sampler to the laboratory, often through another person or agency (common carrier). Upon arrival at the laboratory, internal sample custody procedures will be followed.
- Prior to shipment to the laboratory for analysis, samples will be properly packaged. Individual custody records will accompany each shipment. Shipping containers will then be sealed for shipment to the laboratory. The methods of shipment, courier name, and other pertinent information, will be entered in the remarks section of the custody record.
- All shipments will be accompanied by the chain-of-custody record identifying the contents. The original record will accompany the shipment; and a copy will be retained by the field sampler.
- Proper documentation will be maintained for shipments by common carrier.

3.12.2 Sample Shipment Procedures

Samples will be packaged and shipped in accordance with B&R Environmental SOP SA-6.1 (Appendix C).

- Samples requiring refrigeration will be promptly chilled with ice or Blue Ice to a temperature of 4°C and will be packaged in an insulated cooler for transport to the laboratory. Ice will be sealed in containers to prevent leakage of water. Samples will not be frozen.
- Only shipping containers that meet all applicable state and Federal standards for safe shipment will be used.
- Shipping containers will be sealed with nylon strapping tape, custody seals will be signed, dated, and affixed, in a manner that will allow the receiver to quickly identify any tampering that may have occurred during transport to the laboratory.
- Shipment will be made by overnight courier. After samples have been collected, they must be sent to the laboratory within 24 hours.

3.12.3 Field Documentation Responsibilities

It will be the responsibility of the Field Operations Leader (FOL) to secure all documents produced in the field (geologist's daily logs, lithologic and sampling logs, communications) at the end of each work day.

The possession of all records will be documented; however, only the project FOL or designee may remove field data from the site for reduction and evaluation.

The data generated by the laboratory will be sent to B&R Environmental and stored until completion of the pilot-scale AS/SVE project.

3.13 EQUIPMENT CALIBRATION

Field equipment used during this project will be calibrated and operated in accordance with the manufacturer's instructions and manuals. A log will be kept documenting the calibration results for each field instrument. The log will include the date, standards, personnel, and results of the calibration.

Calibration procedures for laboratory equipment used in the analysis of environmental samples will be performed in accordance with method-specific requirements.

3.14 RECORD KEEPING

In addition to chain-of-custody records, certain standard forms will be completed for sample description and documentation. These shall include sample log sheets (for soil and groundwater samples), boring logs, daily record of subsurface investigation reports, and logbooks.

A bound/weatherproof notebook shall be maintained by each sampling event leader. All information related to sampling or field activities will be recorded in the field notebook. This information will include, but is not limited to, sampling time, weather conditions, unusual events, field measurements, descriptions of photographs, etc.

A bound/weatherproof site logbook shall be maintained by the FOL. The requirements of the site logbook are outlined in B&R Environmental SOP SA-6.3, Sections 5 and 7 (Appendix C). This book will contain a summary of the day's activities and will reference the field notebooks when applicable.

The field team leader who is supervising a drilling subcontractor activity must complete a Daily Record of Subsurface Investigation Report. This report documents the activities and progress of the daily drilling

activities. The information contained within this report is used for billing verification and progress reports. The driller's signature is required at the end of each working day to verify work accomplished, hours worked, standby time, and materials used. A sample of the Daily Record is attached in Appendix B.

At the completion of field activities, the FOL shall submit to the Project Manager, all field records, data, field notebooks, logbooks, chain-of-custody receipts, sample log sheet, drilling logs, daily logs, etc.

REFERENCES

B&R Environmental (Brown & Root Environmental), June 1996. Draft Remedial Investigation and Feasibility Study Report for Operable Unit-2, Marine Corps Air Station, Cherry Point, NC,

EPA (U.S. Environmental Protection Agency), May 1996. Environmental Investigations Standard Operating Procedures and Quality Assurance Manual. Region IV, Athens, GA.

EPA (U.S. Environmental Protection Agency), 1988. EPA Users Guide to Contract Laboratory Program, Washington, DC.

EPA (U.S. Environmental Protection Agency), 1984. Federal Register, October 26, 1984: 40 CFR Part 136, Guidelines Establishing Test Procedures for the Analysis of Pollutants Under the Clean Water Act, EPA 600/ 4-82-057, Washington, DC.

ACGIH (American Conference of Governmental Industrial Hygienists) 1995-1996. Threshold Limit Values (TLVs) for Chemical Substances and Physical Agents and Biological Exposure Indices (BEIs), Cincinnati, OH.

APPENDIX A

**GROUNDWATER RESULTS FOR
EVALUATION OF AIR SPARGING SYSTEM**

GROUNDWATER CONCENTRATIONS - VOLATILE ORGANICS
 POSITIVE DETECTIONS ONLY - UG/L
 OPERABLE UNIT 2 - SURFICAL AQUIFER
 MCAS CHERRY POINT, NORTH CAROLINA

Analyte	NC Class GA Standard	Existing Monitoring Well		Newly Installed Monitoring Wells				Data Gap Investigation Well	
		OU2MW8 (1994 sample event)	OU2MW8 (recent sample event)	OU2MW18 (downgradient)	OU2MW19 ⁽¹⁾	OU2MW22 ⁽²⁾	OU2MW20 (upgradient)	OU2MW17	OU2DUP-01
Acetone	700	R	100 U	100 U	100 U	21	100 U	100 U	100 U
Benzene	1	7*	13*	7.8*	11*	36*	20*	5 U	5 U
Chlorobenzene	50	11	18	41	45	16	96*	5 U	5 U
Chloroethane	2,800 (interim)	1	10 U	4.3	10 U	28	14	10 U	10 U
Ethylbenzene	29	14	21	11	52*	50*	58*	1.9	1.7
Methylene chloride	5	2 U	5 U	5 U	5 U	25*	1.6	18*	27
Toluene	1000	1 U	5 U	2.5	5 U	110	34	12	13
Trichloroethene	2.8	1 U	5 U	5 U	5 U	40*	5 U	5 U	5 U
Vinyl chloride	0.015	1 U	10 U	10 U	10 U	6.9*	10 U	10 U	10 U
Xylenes (total)	530	10	5 U	8.8	6	44	97	6.4	6.1
1,2-Dichlorobenzene	620	3	NA	NA	NA	NA	NA	NA	NA
1,4-Dichlorobenzene	75	11	NA	NA	NA	NA	NA	NA	NA
1,1-Dichloroethane	700	1 U	5 U	5 U	5 U	8	10	1.7	2.1
1,2-Dichloroethene (total)	70	1 U	5 U	2	5 U	42	59	4.1	5.1
1,2-Dichloropropane	0.56	1 U	5 U	5 U	5 U	3.4*	5 U	5 U	5 U
2-Butanone	170	R	100 U	100 U	100 U	140	100 U	100 U	100 U
4-Methyl-2-pentanone	DL	5 U	50 U	50 U	50 U	180*	12*	50 U	50 U

Recent sampling results have not been validated

- * - Indicates that NC Class GA standard has been exceeded.
- U - Not detected at concentration indicated
- R - Result rejected during data validation
- DL - Any detection is considered an exceedance
- NA - Not Analyzed

- (1) Well installed at location of test pit TP-18
- (2) Well installed at location of soil boring OU2SB07

QUANTERRA INCORPORATED

PRELIMINARY DATA SUMMARY

 The results shown below may still require additional laboratory review and are subject to change. Actions taken based on these results are the responsibility of the data user.

PAGE 1

Lot #: C7A210116 Brown & Root Environmental Date Reported: 1/23/97
MCAS CHERRY POINT, NC
Project Number: CTO 0239

PARAMETER	RESULT	REPORTING LIMIT	UNITS	ANALYTICAL METHOD
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Client Sample ID: O02MW18

Sample #: 001 Date Sampled: 01/19/97 09:00 Date Received: 01/21/97 Matrix: WATER

Volatile Organics by GC/MS

Chloromethane	ND	10	ug/L	SW846 8260A	Reviewed
Bromomethane	ND	10	ug/L	SW846 8260A	
Vinyl chloride	ND	10	ug/L	SW846 8260A	
Chloroethane	4.3 J	10	ug/L	SW846 8260A	
Methylene chloride	ND	5.0	ug/L	SW846 8260A	
Acetone	ND	100	ug/L	SW846 8260A	
Carbon disulfide	ND	5.0	ug/L	SW846 8260A	
1,1-Dichloroethene	ND	5.0	ug/L	SW846 8260A	
1,1-Dichloroethane	ND	5.0	ug/L	SW846 8260A	
1,2-Dichloroethene	2.0 J	5.0	ug/L	SW846 8260A	
(total)					
Chloroform	ND	5.0	ug/L	SW846 8260A	
1,2-Dichloroethane	ND	5.0	ug/L	SW846 8260A	
2-Butanone	ND	100	ug/L	SW846 8260A	
1,1,1-Trichloroethane	ND	5.0	ug/L	SW846 8260A	
Carbon tetrachloride	ND	5.0	ug/L	SW846 8260A	
Bromodichloromethane	ND	5.0	ug/L	SW846 8260A	
1,2-Dichloropropane	ND	5.0	ug/L	SW846 8260A	
cis-1,3-Dichloropropene	ND	5.0	ug/L	SW846 8260A	
Trichloroethene	ND	5.0	ug/L	SW846 8260A	
Dibromochloromethane	ND	5.0	ug/L	SW846 8260A	
1,1,2-Trichloroethane	ND	5.0	ug/L	SW846 8260A	
Benzene	7.8	5.0	ug/L	SW846 8260A	
trans-1,3-Dichloropropene	ND	5.0	ug/L	SW846 8260A	
Bromoform	ND	5.0	ug/L	SW846 8260A	
4-Methyl-2-pentanone	ND	50	ug/L	SW846 8260A	
2-Hexanone	ND	50	ug/L	SW846 8260A	
Tetrachloroethene	ND	5.0	ug/L	SW846 8260A	
1,1,2,2-Tetrachloroethane	ND	5.0	ug/L	SW846 8260A	
Toluene	2.5 J	5.0	ug/L	SW846 8260A	
Chlorobenzene	41	5.0	ug/L	SW846 8260A	
Ethylbenzene	11	5.0	ug/L	SW846 8260A	
Styrene	ND	5.0	ug/L	SW846 8260A	
Xylenes (total)	8.8	5.0	ug/L	SW846 8260A	

J Estimated result. Result is less than RL.

(Continued on next page)

QUANTERRA INCORPORATED

PRELIMINARY DATA SUMMARY

 The results shown below may still require additional laboratory review and are subject to change. Actions taken based on these results are the responsibility of the data user.

Lot #: C7A210116 Brown & Root Environmental PAGE 2
MCAS CHERRY POINT, NC Date Reported: 1/23/97
Project Number: CTO 0239

PARAMETER	RESULT	REPORTING LIMIT	UNITS	ANALYTICAL METHOD
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Client Sample ID: OU2MW19

Sample #: 002 Date Sampled: 01/19/97 09:27 Date Received: 01/21/97 Matrix: WATER

Volatile Organics by GC/MS

Reviewed

Chloromethane	ND	10	ug/L	SW846 8260A
Bromomethane	ND	10	ug/L	SW846 8260A
Vinyl chloride	ND	10	ug/L	SW846 8260A
Chloroethane	ND	10	ug/L	SW846 8260A
Methylene chloride	ND	5.0	ug/L	SW846 8260A
Acetone	ND	100	ug/L	SW846 8260A
Carbon disulfide	ND	5.0	ug/L	SW846 8260A
1,1-Dichloroethene	ND	5.0	ug/L	SW846 8260A
1,1-Dichloroethane	ND	5.0	ug/L	SW846 8260A
1,2-Dichloroethene	ND	5.0	ug/L	SW846 8260A
(total)				
Chloroform	ND	5.0	ug/L	SW846 8260A
1,2-Dichloroethane	ND	5.0	ug/L	SW846 8260A
2-Butanone	ND	100	ug/L	SW846 8260A
1,1,1-Trichloroethane	ND	5.0	ug/L	SW846 8260A
Carbon tetrachloride	ND	5.0	ug/L	SW846 8260A
Bromodichloromethane	ND	5.0	ug/L	SW846 8260A
1,2-Dichloropropane	ND	5.0	ug/L	SW846 8260A
cis-1,3-Dichloropropene	ND	5.0	ug/L	SW846 8260A
Trichloroethene	ND	5.0	ug/L	SW846 8260A
Dibromochloromethane	ND	5.0	ug/L	SW846 8260A
1,1,2-Trichloroethane	ND	5.0	ug/L	SW846 8260A
Benzene	11	5.0	ug/L	SW846 8260A
trans-1,3-Dichloropropene	ND	5.0	ug/L	SW846 8260A
Bromoform	ND	5.0	ug/L	SW846 8260A
4-Methyl-2-pentanone	ND	50	ug/L	SW846 8260A
2-Hexanone	ND	50	ug/L	SW846 8260A
Tetrachloroethene	ND	5.0	ug/L	SW846 8260A
1,1,2,2-Tetrachloroethane	ND	5.0	ug/L	SW846 8260A
Toluene	ND	5.0	ug/L	SW846 8260A
Chlorobenzene	45	5.0	ug/L	SW846 8260A
Ethylbenzene	52	5.0	ug/L	SW846 8260A
Styrene	ND	5.0	ug/L	SW846 8260A
Xylenes (total)	6.0	5.0	ug/L	SW846 8260A

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QUANTERRA INCORPORATED
PRELIMINARY DATA SUMMARY

 The results shown below may still require additional laboratory review and are subject to change. Actions taken based on these results are the responsibility of the data user.

Brown & Root Environmental PAGE 3
 MCAS CHERRY POINT, NC Date Reported: 1/23/97
 Project Number: CTO 0239

Lot #: C7A210116

PARAMETER	RESULT	REPORTING LIMIT	UNITS	ANALYTICAL METHOD
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Client Sample ID: O02MW08

Sample #: 003 Date Sampled: 01/19/97 10:44 Date Received: 01/21/97 Matrix: WATER

Volatile Organics by GC/MS

Reviewed

Chloromethane	ND	10	ug/L	SW846 8260A
Bromomethane	ND	10	ug/L	SW846 8260A
Vinyl chloride	ND	10	ug/L	SW846 8260A
Chloroethane	ND	10	ug/L	SW846 8260A
Methylene chloride	ND	5.0	ug/L	SW846 8260A
Acetone	ND	100	ug/L	SW846 8260A
Carbon disulfide	ND	5.0	ug/L	SW846 8260A
1,1-Dichloroethene	ND	5.0	ug/L	SW846 8260A
1,1-Dichloroethane	ND	5.0	ug/L	SW846 8260A
1,2-Dichloroethene	ND	5.0	ug/L	SW846 8260A
(total)				
Chloroform	ND	5.0	ug/L	SW846 8260A
1,2-Dichloroethane	ND	5.0	ug/L	SW846 8260A
2-Butanone	ND	100	ug/L	SW846 8260A
1,1,1-Trichloroethane	ND	5.0	ug/L	SW846 8260A
Carbon tetrachloride	ND	5.0	ug/L	SW846 8260A
Bromodichloromethane	ND	5.0	ug/L	SW846 8260A
1,2-Dichloropropane	ND	5.0	ug/L	SW846 8260A
cis-1,3-Dichloropropene	ND	5.0	ug/L	SW846 8260A
Trichloroethene	ND	5.0	ug/L	SW846 8260A
Dibromochloromethane	ND	5.0	ug/L	SW846 8260A
1,1,2-Trichloroethane	ND	5.0	ug/L	SW846 8260A
Benzene	13	5.0	ug/L	SW846 8260A
trans-1,3-Dichloropropene	ND	5.0	ug/L	SW846 8260A
Bromoform	ND	5.0	ug/L	SW846 8260A
4-Methyl-2-pentanone	ND	50	ug/L	SW846 8260A
2-Hexanone	ND	50	ug/L	SW846 8260A
Tetrachloroethene	ND	5.0	ug/L	SW846 8260A
1,1,2,2-Tetrachloroethane	ND	5.0	ug/L	SW846 8260A
Toluene	ND	5.0	ug/L	SW846 8260A
Chlorobenzene	18	5.0	ug/L	SW846 8260A
xthylbenzene	21	5.0	ug/L	SW846 8260A
Styrene	ND	5.0	ug/L	SW846 8260A
Xylenes (total)	ND	5.0	ug/L	SW846 8260A

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QUANTERRA INCORPORATED
PRELIMINARY DATA SUMMARY

 The results shown below may still require additional laboratory review and are subject to change. Actions taken based on these results are the responsibility of the data user.

Lot #: C7A210116 Brown & Root Environmental PAGE 4
MCAS CHERRY POINT, NC Date Reported: 1/23/97
Project Number: CTO 0239

PARAMETER	RESULT	REPORTING LIMIT	UNITS	ANALYTICAL METHOD
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Client Sample ID: OU2MW22

Sample #: 004 Date Sampled: 01/19/97 11:40 Date Received: 01/21/97 Matrix: WATER

PARAMETER	RESULT	REPORTING LIMIT	UNITS	ANALYTICAL METHOD	Reviewed
Volatile Organics by GC/MS					Reviewed
Chloromethane	ND	10	ug/L	SW846 8260A	
Bromomethane	ND	10	ug/L	SW846 8260A	
Vinyl chloride	6.9 J	10	ug/L	SW846 8260A	
Chloroethane	28	10	ug/L	SW846 8260A	
Methylene chloride	25	5.0	ug/L	SW846 8260A	
Acetone	21 J	100	ug/L	SW846 8260A	
Carbon disulfide	ND	5.0	ug/L	SW846 8260A	
1,1-Dichloroethene	ND	5.0	ug/L	SW846 8260A	
1,1-Dichloroethane	8.0	5.0	ug/L	SW846 8260A	
1,2-Dichloroethene	42	5.0	ug/L	SW846 8260A	
(total)					
Chloroform	ND	5.0	ug/L	SW846 8260A	
1,2-Dichloroethane	ND	5.0	ug/L	SW846 8260A	
2-Butanone	140	100	ug/L	SW846 8260A	
1,1,1-Trichloroethane	ND	5.0	ug/L	SW846 8260A	
Carbon tetrachloride	ND	5.0	ug/L	SW846 8260A	
Bromodichloromethane	ND	5.0	ug/L	SW846 8260A	
1,2-Dichloropropane	3.4 J	5.0	ug/L	SW846 8260A	
cis-1,3-Dichloropropene	ND	5.0	ug/L	SW846 8260A	
Trichloroethene	40	5.0	ug/L	SW846 8260A	
Dibromochloromethane	ND	5.0	ug/L	SW846 8260A	
1,1,2-Trichloroethane	ND	5.0	ug/L	SW846 8260A	
Benzene	36	5.0	ug/L	SW846 8260A	
trans-1,3-Dichloropropene	ND	5.0	ug/L	SW846 8260A	
Bromoform	ND	5.0	ug/L	SW846 8260A	
4-Methyl-2-pentanone	180	50	ug/L	SW846 8260A	
2-Hexanone	ND	50	ug/L	SW846 8260A	
Tetrachloroethene	ND	5.0	ug/L	SW846 8260A	
1,1,2,2-Tetrachloroethane	ND	5.0	ug/L	SW846 8260A	
Toluene	110	5.0	ug/L	SW846 8260A	
Chlorobenzene	16	5.0	ug/L	SW846 8260A	
Ethylbenzene	50	5.0	ug/L	SW846 8260A	
Styrene	ND	5.0	ug/L	SW846 8260A	
Xylenes (total)	44	5.0	ug/L	SW846 8260A	

J Estimated result. Result is less than RL.

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QUANTERRA INCORPORATED

PRELIMINARY DATA SUMMARY

The results shown below may still require additional laboratory review and are subject to change. Actions taken based on these results are the responsibility of the data user.

Lot #: C7A210116 **Brown & Root Environmental** PAGE 5
MCAS CHERRY POINT, NC Date Reported: 1/23/97
Project Number: CTO 0239

PARAMETER	RESULT	REPORTING LIMIT	UNITS	ANALYTICAL METHOD
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Client Sample ID: OU2MW20

Sample #: 005 Date Sampled: 01/19/97 11:45 Date Received: 01/21/97 Matrix: WATER

Volatile Organics by GC/MS

Reviewed

Chloromethane	ND	10	ug/L	SW846 8260A
Bromomethane	ND	10	ug/L	SW846 8260A
Vinyl chloride	ND	10	ug/L	SW846 8260A
Chloroethane	14	10	ug/L	SW846 8260A
Methylene chloride	1.6 J	5.0	ug/L	SW846 8260A
Acetone	ND	100	ug/L	SW846 8260A
Carbon disulfide	ND	5.0	ug/L	SW846 8260A
1,1-Dichloroethene	ND	5.0	ug/L	SW846 8260A
1,1-Dichloroethane	10	5.0	ug/L	SW846 8260A
1,2-Dichloroethene	59	5.0	ug/L	SW846 8260A
(total)				
Chloroform	ND	5.0	ug/L	SW846 8260A
1,2-Dichloroethane	ND	5.0	ug/L	SW846 8260A
2-Butanone	ND	100	ug/L	SW846 8260A
1,1,1-Trichloroethane	ND	5.0	ug/L	SW846 8260A
Carbon tetrachloride	ND	5.0	ug/L	SW846 8260A
Bromodichloromethane	ND	5.0	ug/L	SW846 8260A
1,2-Dichloropropane	ND	5.0	ug/L	SW846 8260A
cis-1,3-Dichloropropene	ND	5.0	ug/L	SW846 8260A
Trichloroethene	ND	5.0	ug/L	SW846 8260A
Dibromochloromethane	ND	5.0	ug/L	SW846 8260A
1,1,2-Trichloroethane	ND	5.0	ug/L	SW846 8260A
Benzene	20	5.0	ug/L	SW846 8260A
trans-1,3-Dichloropropene	ND	5.0	ug/L	SW846 8260A
Bromoform	ND	5.0	ug/L	SW846 8260A
4-Methyl-2-pentanone	12 J	50	ug/L	SW846 8260A
2-Hexanone	ND	50	ug/L	SW846 8260A
Tetrachloroethene	ND	5.0	ug/L	SW846 8260A
1,1,2,2-Tetrachloroethane	ND	5.0	ug/L	SW846 8260A
Toluene	34	5.0	ug/L	SW846 8260A
Chlorobenzene	96	5.0	ug/L	SW846 8260A
Ethylbenzene	58	5.0	ug/L	SW846 8260A
Styrene	ND	5.0	ug/L	SW846 8260A
Xylenes (total)	97	5.0	ug/L	SW846 8260A

J Estimated result. Result is less than RL.

QUANTERRA INCORPORATED

PRELIMINARY DATA SUMMARY

 The results shown below may still require additional laboratory review and are subject to change. Actions taken based on these results are the responsibility of the data user.

Brown & Root Environmental PAGE 6

Lot #: C7A210116 MCAS CHERRY POINT, NC Date Reported: 1/23/97

Project Number: CTO 0239

PARAMETER	RESULT	REPORTING LIMIT	UNITS	ANALYTICAL METHOD
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Client Sample ID: OU2MW17

Sample #: 006 Date Sampled: 01/19/97 15:00 Date Received: 01/21/97 Matrix: WATER

Volatile Organics by GC/MS

Reviewed

Chloromethane	ND	10	ug/L	SW846 8260A
Bromomethane	ND	10	ug/L	SW846 8260A
Vinyl chloride	ND	10	ug/L	SW846 8260A
Chloroethane	ND	10	ug/L	SW846 8260A
Methylene chloride	18	5.0	ug/L	SW846 8260A
Acetone	ND	100	ug/L	SW846 8260A
Carbon disulfide	ND	5.0	ug/L	SW846 8260A
1,1-Dichloroethene	ND	5.0	ug/L	SW846 8260A
1,1-Dichloroethane	1.7 J	5.0	ug/L	SW846 8260A
1,2-Dichloroethene	4.1 J	5.0	ug/L	SW846 8260A
(total)				
Chloroform	ND	5.0	ug/L	SW846 8260A
1,2-Dichloroethane	ND	5.0	ug/L	SW846 8260A
2-Butanone	ND	100	ug/L	SW846 8260A
1,1,1-Trichloroethane	ND	5.0	ug/L	SW846 8260A
Carbon tetrachloride	ND	5.0	ug/L	SW846 8260A
Bromodichloromethane	ND	5.0	ug/L	SW846 8260A
1,2-Dichloropropane	ND	5.0	ug/L	SW846 8260A
cis-1,3-Dichloropropene	ND	5.0	ug/L	SW846 8260A
Trichloroethene	ND	5.0	ug/L	SW846 8260A
Dibromochloromethane	ND	5.0	ug/L	SW846 8260A
1,1,2-Trichloroethane	ND	5.0	ug/L	SW846 8260A
Benzene	ND	5.0	ug/L	SW846 8260A
trans-1,3-Dichloropropene	ND	5.0	ug/L	SW846 8260A
Bromoform	ND	5.0	ug/L	SW846 8260A
4-Methyl-2-pentanone	ND	50	ug/L	SW846 8260A
2-Hexanone	ND	50	ug/L	SW846 8260A
Tetrachloroethene	ND	5.0	ug/L	SW846 8260A
1,1,2,2-Tetrachloroethane	ND	5.0	ug/L	SW846 8260A
Toluene	12	5.0	ug/L	SW846 8260A
Chlorobenzene	ND	5.0	ug/L	SW846 8260A
Ethylbenzene	1.9 J	5.0	ug/L	SW846 8260A
Styrene	ND	5.0	ug/L	SW846 8260A
Xylenes (total)	6.4	5.0	ug/L	SW846 8260A

J Estimated result. Result is less than RL.

(Continued on next page)

QUANTERRA INCORPORATED

PRELIMINARY DATA SUMMARY

 The results shown below may still require additional laboratory review and are subject to change. Actions taken based on these results are the responsibility of the data user.

PAGE 7

Lot #: C7A210116 Brown & Root Environmental Date Reported: 1/23/97
MCAS CHERRY POINT, NC
Project Number: CTO 0239

PARAMETER	RESULT	REPORTING LIMIT	UNITS	ANALYTICAL METHOD
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Client Sample ID: O02DUP-01

Sample #: 007 Date Sampled: 01/19/97 15:00 Date Received: 01/21/97 Matrix: WATER

Volatile Organics by GC/MS

Reviewed

Chloromethane	ND	10	ug/L	SW846 8260A
Bromomethane	ND	10	ug/L	SW846 8260A
Vinyl chloride	ND	10	ug/L	SW846 8260A
Chloroethane	ND	10	ug/L	SW846 8260A
Methylene chloride	27	5.0	ug/L	SW846 8260A
Acetone	ND	100	ug/L	SW846 8260A
Carbon disulfide	ND	5.0	ug/L	SW846 8260A
1,1-Dichloroethene	ND	5.0	ug/L	SW846 8260A
1,1-Dichloroethane	2.1 J	5.0	ug/L	SW846 8260A
1,2-Dichloroethene	5.1	5.0	ug/L	SW846 8260A
(total)				
Chloroform	ND	5.0	ug/L	SW846 8260A
1,2-Dichloroethane	ND	5.0	ug/L	SW846 8260A
2-Butanone	ND	100	ug/L	SW846 8260A
1,1,1-Trichloroethane	ND	5.0	ug/L	SW846 8260A
Carbon tetrachloride	ND	5.0	ug/L	SW846 8260A
Bromodichloromethane	ND	5.0	ug/L	SW846 8260A
1,2-Dichloropropane	ND	5.0	ug/L	SW846 8260A
cis-1,3-Dichloropropene	ND	5.0	ug/L	SW846 8260A
Trichloroethene	ND	5.0	ug/L	SW846 8260A
Dibromochloromethane	ND	5.0	ug/L	SW846 8260A
1,1,2-Trichloroethane	ND	5.0	ug/L	SW846 8260A
Benzene	ND	5.0	ug/L	SW846 8260A
trans-1,3-Dichloropropene	ND	5.0	ug/L	SW846 8260A
Bromoform	ND	5.0	ug/L	SW846 8260A
4-Methyl-2-pentanone	ND	50	ug/L	SW846 8260A
2-Hexanone	ND	50	ug/L	SW846 8260A
Tetrachloroethene	ND	5.0	ug/L	SW846 8260A
1,1,2,2-Tetrachloroethane	ND	5.0	ug/L	SW846 8260A
Toluene	13	5.0	ug/L	SW846 8260A
Chlorobenzene	ND	5.0	ug/L	SW846 8260A
Ethylbenzene	1.7 J	5.0	ug/L	SW846 8260A
Styrene	ND	5.0	ug/L	SW846 8260A
Xylenes (total)	6.1	5.0	ug/L	SW846 8260A

J Estimated result. Result is less than RL.

QUANTERRA INCORPORATED

PRELIMINARY DATA SUMMARY

 The results shown below may still require additional laboratory review and are subject to change. Actions taken based on these results are the responsibility of the data user.

Brown & Root Environmental PAGE 8

Lot #: C7A210116 MCAS CHERRY POINT, NC Date Reported: 1/23/97

Project Number: CTO 0239

PARAMETER	RESULT	REPORTING LIMIT	UNITS	ANALYTICAL METHOD
-----------	--------	--------------------	-------	----------------------

Client Sample ID: TB011997-01

Sample #: 008 Date Sampled: 01/18/97 15:30 Date Received: 01/21/97 Matrix: WATER

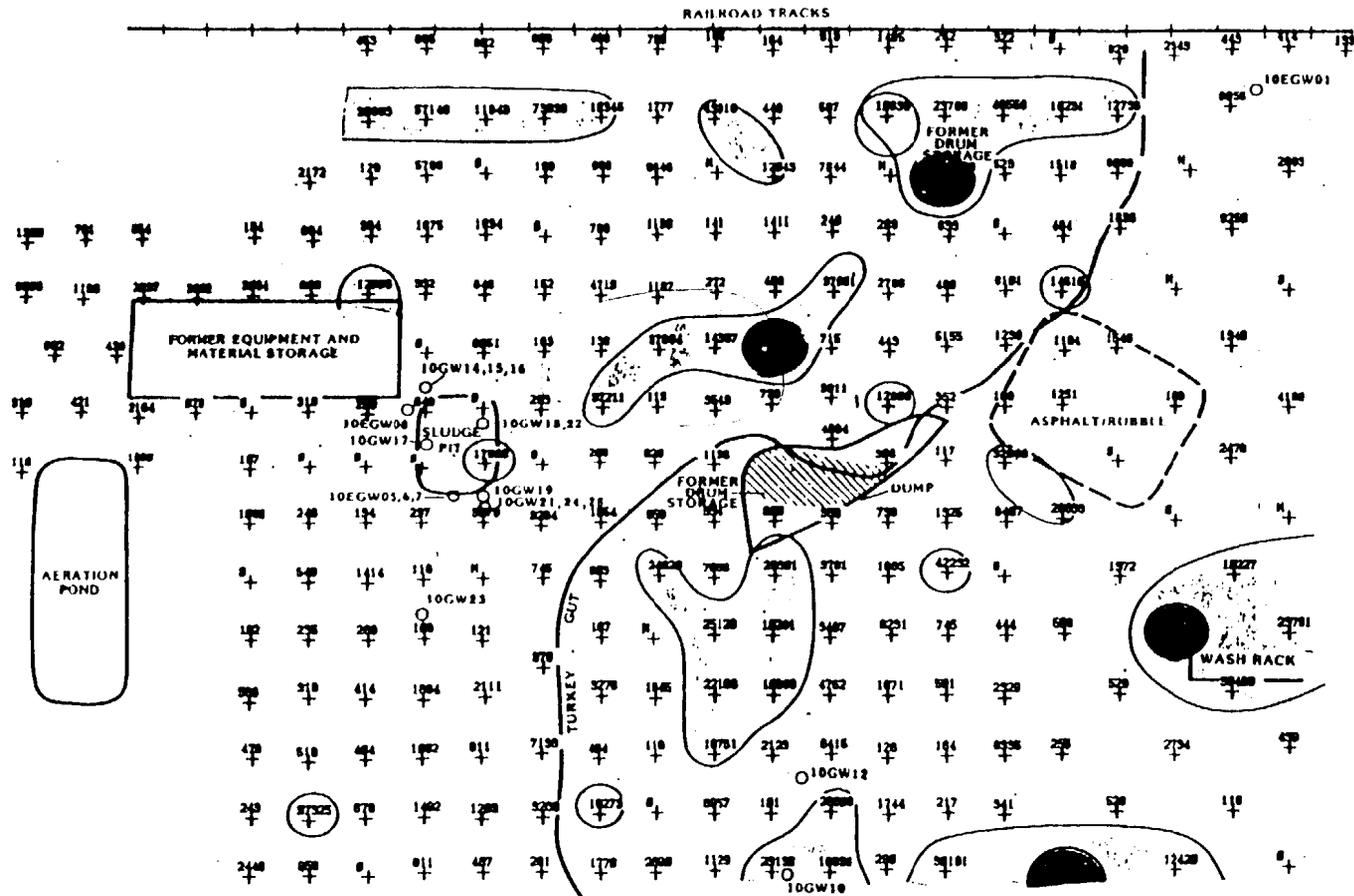
Volatile Organics by GC/MS

Reviewed

Chloromethane	ND	10	ug/L	SW846 8260A
Bromomethane	ND	10	ug/L	SW846 8260A
Vinyl chloride	ND	10	ug/L	SW846 8260A
Chloroethane	ND	10	ug/L	SW846 8260A
Methylene chloride	ND	5.0	ug/L	SW846 8260A
Acetone	ND	100	ug/L	SW846 8260A
Carbon disulfide	ND	5.0	ug/L	SW846 8260A
1,1-Dichloroethene	ND	5.0	ug/L	SW846 8260A
1,1-Dichloroethane	ND	5.0	ug/L	SW846 8260A
1,2-Dichloroethene	ND	5.0	ug/L	SW846 8260A
(total)				
Chloroform	ND	5.0	ug/L	SW846 8260A
1,2-Dichloroethane	ND	5.0	ug/L	SW846 8260A
2-Butanone	ND	100	ug/L	SW846 8260A
1,1,1-Trichloroethane	ND	5.0	ug/L	SW846 8260A
Carbon tetrachloride	ND	5.0	ug/L	SW846 8260A
Bromodichloromethane	ND	5.0	ug/L	SW846 8260A
1,2-Dichloropropane	ND	5.0	ug/L	SW846 8260A
cis-1,3-Dichloropropene	ND	5.0	ug/L	SW846 8260A
Trichloroethene	ND	5.0	ug/L	SW846 8260A
Dibromochloromethane	ND	5.0	ug/L	SW846 8260A
1,1,2-Trichloroethane	ND	5.0	ug/L	SW846 8260A
Benzene	ND	5.0	ug/L	SW846 8260A
trans-1,3-Dichloropropene	ND	5.0	ug/L	SW846 8260A
Bromoform	ND	5.0	ug/L	SW846 8260A
4-Methyl-2-pentanone	ND	50	ug/L	SW846 8260A
2-Hexanone	ND	50	ug/L	SW846 8260A
Tetrachloroethene	ND	5.0	ug/L	SW846 8260A
1,1,2,2-Tetrachloroethane	ND	5.0	ug/L	SW846 8260A
Toluene	ND	5.0	ug/L	SW846 8260A
Chlorobenzene	ND	5.0	ug/L	SW846 8260A
Ethylbenzene	ND	5.0	ug/L	SW846 8260A
Styrene	ND	5.0	ug/L	SW846 8260A
Xylenes (total)	ND	5.0	ug/L	SW846 8260A

APPENDIX B

SITE 10 SOIL GAS SURVEY MAPS



Legend:

Ion Counts:

■ ≥ 100,000

□ 10,000-99,999

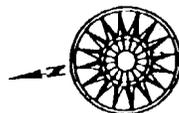
O = Monitoring Wells

+ = Petrex Collector

M = Missing Sample

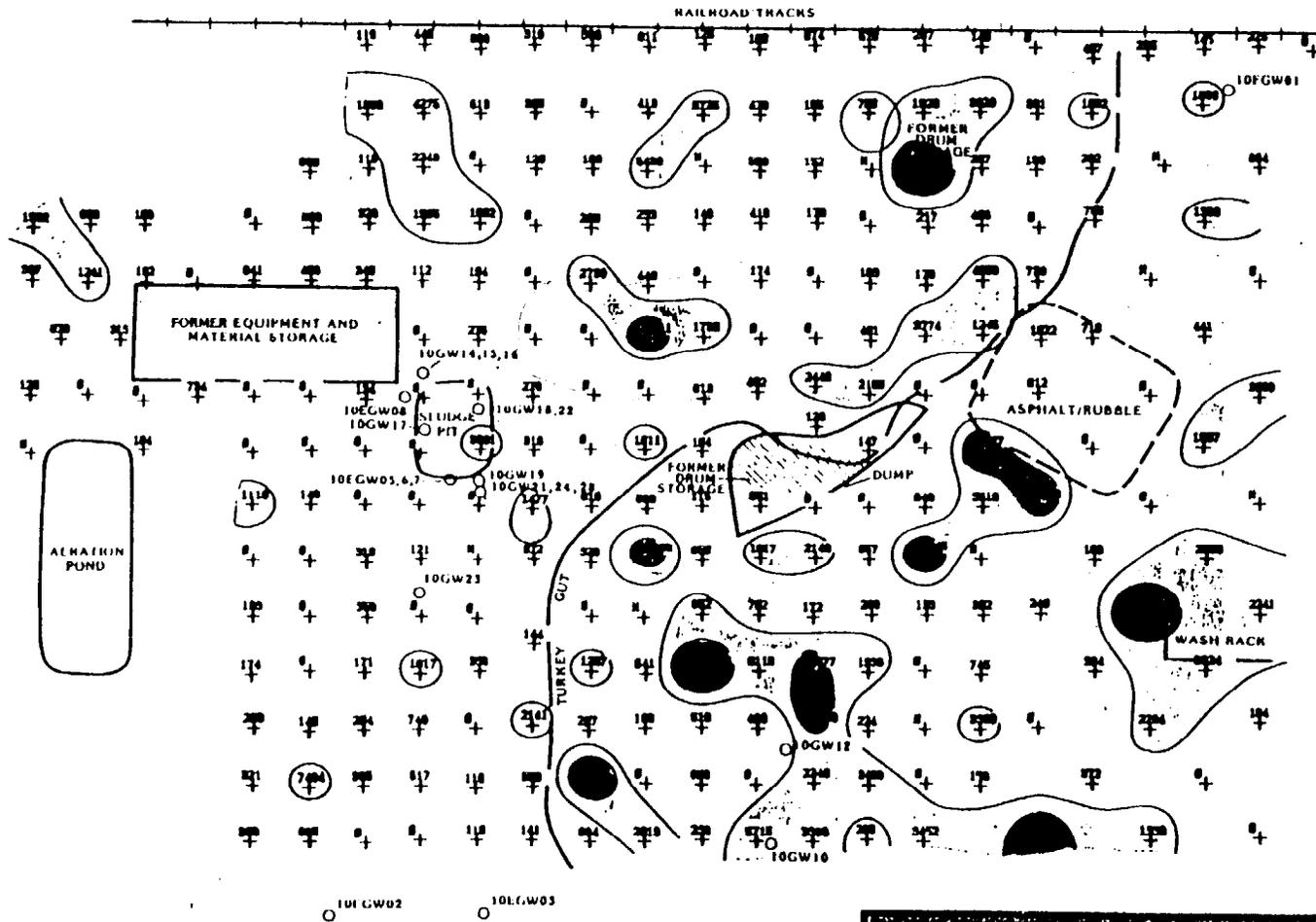
10EGW02

10EGW03



0 200
FEET

SITE 10
 CHENNY POINT, NORTH CAROLINA
 Relative Flux
 Trichloroethane and Freon II & 113
 April 9, 1990
 Figure: 8
 Scale: 1in. = 200ft.



Legend:

Ion Counts:

■ ≥ 100,000

■ 10,000 - 99,999

□ 1,000 - 9,999

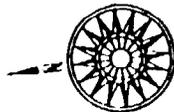
○ = Monitoring Wells

+ = Petrex Collector

M = Missing Sample

○ 10EGW02

○ 10EGW03



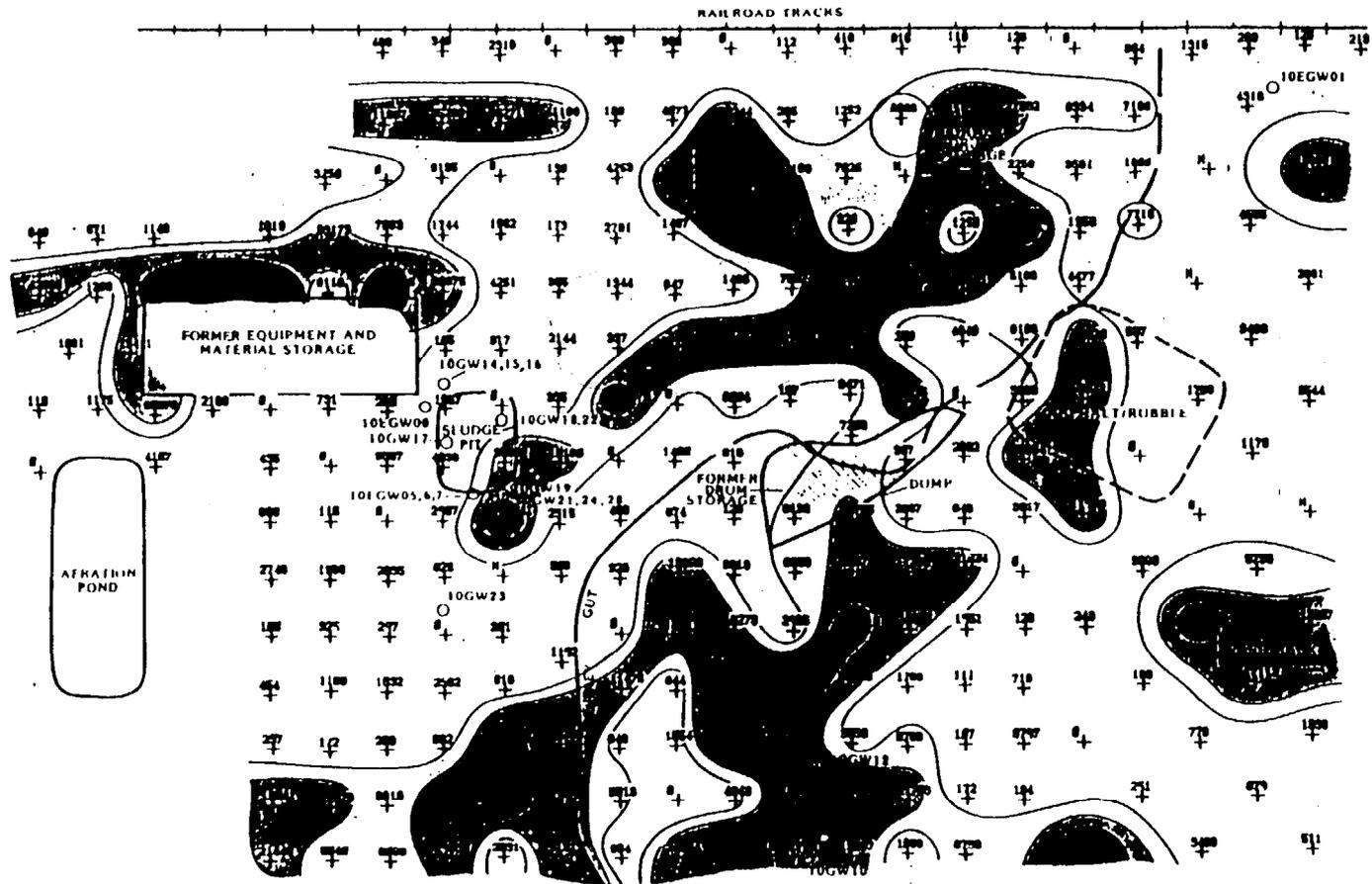
0 200
FEET

MAXIMIZER

SITE 10
CHERRY POINT, NORTH CAROLINA

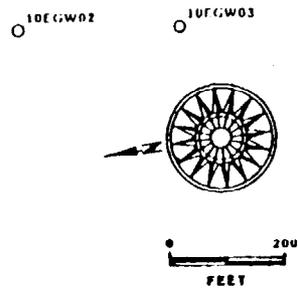
Relative Flux
Dichlorobenzene and Trichlorobenzene

April 9, 1990 Figure: 7 Scale: 1in. = 200ft



Legend:

- Ion Counts:
- ≥ 100,000
 - 10,000-99,999
 - 5,000-9,999
- = Monitoring Wells
 + = Petrex Collector
 M = Missing Sample

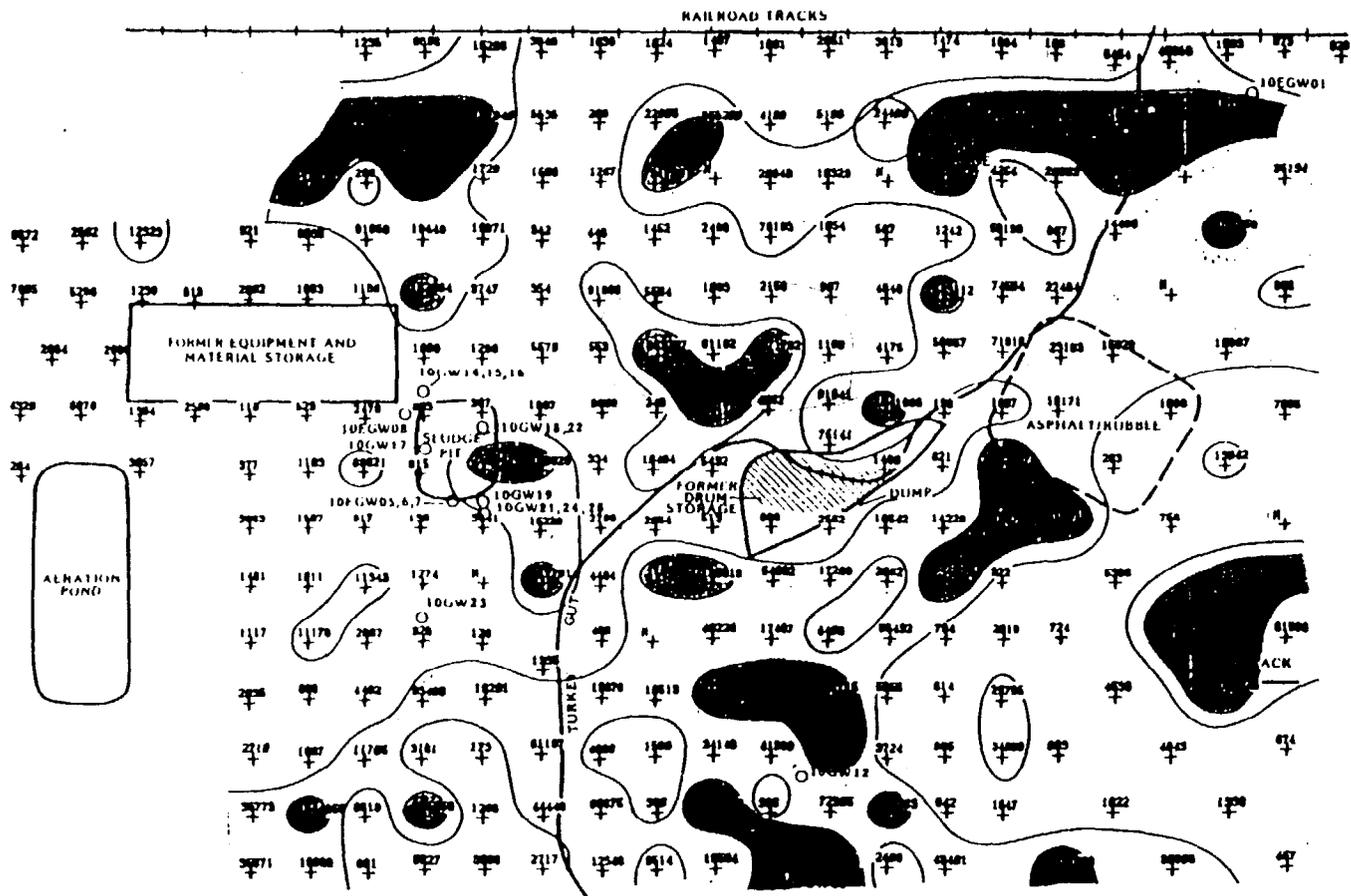


SITE 10

CHERRY POINT, NORTH CAROLINA

Relative Flux
Trichloroethylene and Tetrachloroethylene

April 9, 1990
Figure: 6
Scale: 1in. = 200ft.



Legend:

Ion Counts:

■ ≥ 100,000

□ 10,000 99,999

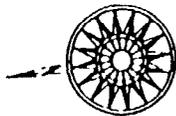
O = Monitoring Wells

+ = Petrex Collector

M = Missing Sample

10EGW02

10EGW03



0 200
FEET

ENVIRONMENTAL SCIENCE SERVICES, INC.

SITE 10
CHERRY POINT, NORTH CAROLINA

Relative Flux
Combined Hydrocarbons/Naphthalenes

April 9, 1990 Figure: 6 Scale: 1in.:200ft

APPENDIX C
SAMPLE FORMS



BORING NO.: _____

OVERBURDEN MONITORING WELL SHEET

PROJECT _____ LOCATION _____
 PROJECT NO. _____ BORING _____
 ELEVATION _____ DATE _____
 FIELD GEOLOGIST _____

DRILLER _____
 DRILLING METHOD _____
 DEVELOPMENT METHOD _____

GROUND ELEVATION _____

ELEVATION OF TOP OF SURFACE CASING: _____
 ELEVATION OF TOP OF RISER PIPE: _____

STICK - UP TOP OF SURFACE CASING _____
 STICK - UP RISER PIPE: _____

TYPE OF SURFACE SEAL: _____

I.D. OF SURFACE CASING: _____
 TYPE OF SURFACE CASING: _____

RISER PIPE I.D. _____
 TYPE OF RISER PIPE: _____

BOREHOLE DIAMETER: _____

TYPE OF BACKFILL: _____

ELEVATION / DEPTH TOP OF SEAL: _____ /

TYPE OF SEAL: _____

DEPTH TOP OF SAND PACK: _____

ELEVATION / DEPTH TOP OF SCREEN: _____ /

TYPE OF SCREEN: _____
 SLOT SIZE x LENGTH: _____
 I.D. OF SCREEN: _____

TYPE OF SAND PACK: _____

ELEVATION / DEPTH BOTTOM OF SCREEN: _____ /

ELEVATION / DEPTH BOTTOM OF SAND PACK: _____ /
 TYPE OF BACKFILL BELOW OBSERVATION WELL: _____

ELEVATION / DEPTH OF HOLE: _____ /



DAILY ACTIVITIES RECORD

PROJECT NAME: _____ **PROJECT NUMBER:** _____
CLIENT: _____ **LOCATION:** _____
DATE: _____ **ARRIVAL TIME:** _____
B&RE PERSONNEL: _____ **DEPARTURE TIME:** _____
CONTRACTOR: _____ **DRILLER:** _____

ITEM	QUANTITY ESTIMATE	QUANTITY TODAY	PREVIOUS TOTAL QUANTITY	CUMULATIVE QUANTITY TO DATE

COMMENTS: _____

APPROVED BY: _____

B&RE REPRESENTATIVE _____ **DRILLER** _____
DATE: _____



BORING NO.: _____

OVERBURDEN MONITORING WELL SHEET

PROJECT _____	LOCATION _____	DRILLER _____
PROJECT NO. _____	BORING _____	DRILLING _____
ELEVATION _____	DATE _____	METHOD _____
FIELD GEOLOGIST _____		DEVELOPMENT _____
		METHOD _____

GROUND ELEVATION		<p>ELEVATION OF TOP OF SURFACE CASING : _____</p> <p>ELEVATION OF TOP OF RISER PIPE : _____</p> <p>STICK - UP TOP OF SURFACE CASING : _____</p> <p>STICK - UP RISER PIPE : _____</p> <p>TYPE OF SURFACE SEAL: _____</p> <p>I.D. OF SURFACE CASING: _____</p> <p>TYPE OF SURFACE CASING: _____</p> <p>RISER PIPE I.D. _____</p> <p>TYPE OF RISER PIPE: _____</p> <p>BOREHOLE DIAMETER: _____</p> <p>TYPE OF BACKFILL: _____</p> <p>ELEVATION / DEPTH TOP OF SEAL: _____ /</p> <p>TYPE OF SEAL: _____</p> <p>DEPTH TOP OF SAND PACK: _____</p> <p>ELEVATION / DEPTH TOP OF SCREEN: _____ /</p> <p>TYPE OF SCREEN: _____</p> <p>SLOT SIZE x LENGTH: _____</p> <p>I.D. OF SCREEN: _____</p> <p>TYPE OF SAND PACK: _____</p> <p>ELEVATION / DEPTH BOTTOM OF SCREEN: _____ /</p> <p>ELEVATION / DEPTH BOTTOM OF SAND PACK: _____ /</p> <p>TYPE OF BACKFILL BELOW OBSERVATION WELL: _____</p> <p>ELEVATION / DEPTH OF HOLE: _____ /</p>
---------------------	--	--



WELL DEVELOPMENT SHEET

PROJECT SITE NAME: _____	SITE/LOCATION _____
PROJECT NUMBER: _____	WELL ID.: _____
WEATHER: _____	DATE: _____
STATIC WATER LEVEL: _____	PERSONNEL: _____
TOTAL WELL DEPTH: _____	WELL TYPE: [PVC], [S.S.], or _____
ONE CASING VOLUME: _____	OTHER _____
START TIME: _____	MEASURING DEVICE: _____
END TIME: _____	ADJUSTMENT FACTOR: _____

[] DOMESTIC WELL, [] MONITORING WELL, [] OTHER _____

METHOD & REMARKS _____

Approximate Volume	Time	Color	pH (S.U.)	Cond. (mS/cm)	Turbidity (NTU)	DO (mg/L)	Temp. (Celcius)	Salinity (%)

NOTE: All measurements to nearest 0.01 foot measured from top of well riser pipe unless otherwise noted.

ADDITIONAL COMMENTS: _____

SIGNATURE(s): _____

PAGE ___ OF ___

APPENDIX D

**BROWN & ROOT ENVIRONMENTAL
STANDARD OPERATING PROCEDURES**



BROWN & ROOT ENVIRONMENTAL

STANDARD OPERATING PROCEDURES

Number
GH-1.5

Page
1 of 21

Effective Date
03/01/96

Revision
0

Applicability
B&R Environmental, NE

Prepared
Earth Sciences Department

Subject
BOREHOLE AND SAMPLE LOGGING

Approved
D. Senovich *ds*

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1.0 PURPOSE

The purpose of this document is to establish standard procedures and technical guidance on borehole and sample logging.

2.0 SCOPE

These procedures provide descriptions of the standard techniques for borehole and sample logging. These techniques shall be used for each boring logged to provide consistent descriptions of subsurface lithology. While experience is the only method to develop confidence and accuracy in the description of soil and rock, the field geologist/engineer can do a good job of classification by careful, thoughtful observation and by being consistent throughout the classification procedure.

3.0 GLOSSARY

None.

4.0 RESPONSIBILITIES

Site Geologist. Responsible for supervising all boring activities and assuring that each borehole is completely logged. If more than one rig is being used on site, the Site Geologist must make sure that each field geologist is properly trained in logging procedures. A brief review or training session may be necessary prior to the start up of the field program and/or upon completion of the first boring.

5.0 PROCEDURES

The classification of soil and rocks is one of the most important jobs of the field geologist/engineer. To maintain a consistent flow of information, it is imperative that the field geologist/engineer understand and accurately use the field classification system described in this SOP. This identification is based on visual examination and manual tests.

5.1 Materials Needed

When logging soil and rock samples, the geologist or engineer may be equipped with the following:

- Rock hammer
- Knife
- Camera
- Dilute hydrochloric acid (HCl)
- Ruler (marked in tenths and hundredths of feet)
- Hand Lens

5.2 Classification of Soils

All data shall be written directly on the boring log (Figure 1) or in a field notebook if more space is needed. Details on filling out the boring log are discussed in Section 5.5.

5.2.1 USCS Classification

Soils are to be classified according to the Unified Soil Classification System (USCS). This method of classification is detailed in Figure 1 (Continued).

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This method of classification identifies soil types on the basis of grain size and cohesiveness.

Fine-grained soils, or fines, are smaller than the No. 200 sieve and are of two types: silt (M) and clay (C). Some classification systems define size ranges for these soil particles, but for field classification purposes, they are identified by their respective behaviors. Organic material (O) is a common component of soil but has no size range; it is recognized by its composition. The careful study of the USCS will aid in developing the competence and consistency necessary for the classification of soils.

Coarse-grained soils shall be divided into rock fragments, sand, or gravel. The terms sand and gravel not only refer to the size of the soil particles but also to their depositional history. To insure accuracy in description, the term rock fragments shall be used to indicate angular granular materials resulting from the breakup of rock. The sharp edges typically observed indicate little or no transport from their source area, and therefore the term provides additional information in reconstructing the depositional environment of the soils encountered. When the term "rock fragments" is used it shall be followed by a size designation such as "(1/4 inch Φ -1/2 inch Φ)" or "coarse-sand size" either immediately after the entry or in the remarks column. The USCS classification would not be affected by this variation in terms.

5.2.2 Color

Soil colors shall be described utilizing a single color descriptor preceded, when necessary, by a modifier to denote variations in shade or color mixtures. A soil could therefore be referred to as "gray" or "light gray" or "blue-gray." Since color can be utilized in correlating units between sampling locations, it is important for color descriptions to be consistent from one boring to another.

Colors must be described while the sample is still moist. Soil samples shall be broken or split vertically to describe colors. Samplers tend to smear the sample surface creating color variations between the sample interior and exterior.

The term "mottled" shall be used to indicate soils irregularly marked with spots of different colors. Mottling in soils usually indicates poor aeration and lack of good drainage.

Soil Color Charts shall not be used unless specified by the project manager.

5.2.3 Relative Density and Consistency

To classify the relative density and/or consistency of a soil, the geologist is to first identify the soil type. Granular soils contain predominantly sands and gravels. They are noncohesive (particles do not adhere well when compressed). Finer-grained soils (silts and clays) are cohesive (particles will adhere together when compressed).

The density of noncohesive, granular soils is classified according to standard penetration resistances obtained from split-barrel sampling performed according to the methods detailed in Standard Operating Procedures GH-1.3 and SA-1.3. Those designations are:

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Designation	Standard Penetration Resistance (Blows per Foot)
Very loose	0 to 4
Loose	5 to 10
Medium dense	11 to 30
Dense	31 to 50
Very dense	Over 50

Standard penetration resistance is the number of blows required to drive a split-barrel sampler with a 2-inch outside diameter 12 inches into the material using a 140-pound hammer falling freely through 30 inches. The sampler is driven through an 18-inch sample interval, and the number of blows is recorded for each 6-inch increment. The density designation of granular soils is obtained by adding the number of blows required to penetrate the last 12 inches of each sample interval. It is important to note that if gravel or rock fragments are broken by the sampler or if rock fragments are lodged in the tip, the resulting blow count will be erroneously high, reflecting a higher density than actually exists. This shall be noted on the log and referenced to the sample number. Granular soils are given the USCS classifications GW, GP, GM, SW, SP, SM, GC, or SC (see Figure 1).

The consistency of cohesive soils is determined by performing field tests and identifying the consistency as shown in Figure 2.

Cohesive soils are given the USCS classifications ML, MH, CL, CH, OL, or OH (see Figure 1).

The consistency of cohesive soils is determined either by blow counts, a pocket penetrometer (values listed in the table as Unconfined Compressive Strength), or by hand by determining the resistance to penetration by the thumb. The pocket penetrometer and thumb determination methods are conducted on a selected sample of the soil, preferably the lowest 0.5 foot of the sample in the split-barrel sampler. The sample shall be broken in half and the thumb or penetrometer pushed into the end of the sample to determine the consistency. Do not determine consistency by attempting to penetrate a rock fragment. If the sample is decomposed rock, it is classified as a soft decomposed rock rather than a hard soil. Consistency shall not be determined solely by blow counts. One of the other methods shall be used in conjunction with it. The designations used to describe the consistency of cohesive soils are shown in Figure 2.

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FIGURE 2

CONSISTENCY FOR COHESIVE SOILS

Consistency	Standard Penetration Resistance (Blows per Foot)	Unconfined Compressive Strength (Tons/Sq. Foot by pocket penetration)	Field Identification
Very soft	0 to 2	Less than 0.25	Easily penetrated several inches by fist
Soft	2 to 4	0.25 to 0.50	Easily penetrated several inches by thumb
Medium stiff	4 to 8	0.50 to 1.0	Can be penetrated several inches by thumb with moderate effort
Stiff	8 to 15	1.0 to 2.0	Readily indented by thumb but penetrated only with great effort
Very stiff	15 to 30	2.0 to 4.0	Readily indented by thumbnail
Hard	Over 30	More than 4.0	Indented with difficulty by thumbnail

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5.2.4 Weight Percentages

In nature, soils are comprised of particles of varying size and shape, and are combinations of the various grain types. The following terms are useful in the description of soil:

Terms of Identifying Proportion of the Component	Defining Range of Percentages by Weight
Trace	0 - 10 percent
Some	11 - 30 percent
Adjective form of the soil type (e.g., "sandy")	31 - 50 percent

Examples:

- Silty fine sand: 50 to 69 percent fine sand, 31 to 50 percent silt.
- Medium to coarse sand, some silt: 70 to 80 percent medium to coarse sand, 11 to 30 percent silt.
- Fine sandy silt, trace clay: 50 to 68 percent silt, 31 to 49 percent fine sand, 1 to 10 percent clay.
- Clayey silt, some coarse sand: 70 to 89 percent clayey silt, 11 to 30 percent coarse sand.

5.2.5 Moisture

Moisture content is estimated in the field according to four categories: dry, moist, wet, and saturated. In dry soil, there appears to be little or no water. Saturated samples obviously have all the water they can hold. Moist and wet classifications are somewhat subjective and often are determined by the individual's judgment. A suggested parameter for this would be calling a soil wet if rolling it in the hand or on a porous surface liberates water, i.e., dirties or muddies the surface. Whatever method is adopted for describing moisture, it is important that the method used by an individual remains consistent throughout an entire drilling job.

Laboratory tests for water content shall be performed if the natural water content is important.

5.2.6 Stratification

Stratification can only be determined after the sample barrel is opened. ~~The stratification or bedding thickness for soil and rock is depending on grain size and composition.~~ The classification to be used for stratification description is shown in Figure 3.

5.2.7 Texture/Fabric/Bedding

The texture/fabric/bedding of the soil shall be described. Texture is described as the relative angularity of the particles: rounded, subrounded, subangular, and angular. Fabric shall be noted as to whether the particles are flat or bulky and whether there is a particular relation between particles (i.e., all the flat particles are parallel or there is some cementation). The bedding or structure shall also be noted (e.g., stratified, lensed, nonstratified, heterogeneous varved).

FIGURE 3

BEDDING THICKNESS CLASSIFICATION

Thickness (metric)	Thickness (Approximate English Equivalent)	Classification
> 1.0 meter	> 3.3'	Massive
30 cm - 1 meter	1.0' - 3.3'	Thick Bedded
10 cm - 30 cm	4" - 1.0'	Medium Bedded
3 cm - 10 cm	1" - 4"	Thin Bedded
1 cm - 3 cm	2/5" - 1"	Very Thin Bedded
3 mm - 1 cm	1/8" - 2/5"	Laminated
1 mm - 3 mm	1/32" - 1/8"	Thinly Laminated
< 1 mm	< 1/32"	Micro Laminated

(Weir, 1973 and Ingram, 1954)

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5.2.8 Summary of Soil Classification

In summary, soils shall be classified in a similar manner by each geologist/engineer at a project site. The hierarchy of classification is as follows:

- Density and/or consistency
- Color
- Plasticity (Optional)
- Soil types
- Moisture content
- Stratification
- Texture, fabric, bedding
- Other distinguishing features

5.3 Classification of Rocks

Rocks are grouped into three main divisions: sedimentary, igneous and metamorphic. Sedimentary rocks are by far the predominant type exposed at the earth's surface. The following basic names are applied to the types of rocks found in sedimentary sequences:

- Sandstone - Made up predominantly of granular materials ranging between 1/16 to 2 mm in diameter.
- Siltstone - Made up of granular materials less than 1/16 to 1/256 mm in diameter. Fractures irregularly. Medium thick to thick bedded.
- Claystone - Very fine-grained rock made up of clay and silt-size materials. Fractures irregularly. Very smooth to touch. Generally has irregularly spaced pitting on surface of drilled cores.
- Shale - A fissile very fine-grained rock. Fractures along bedding planes.
- Limestone - Rock made up predominantly of calcite (CaCO_3). Effervesces strongly upon the application of dilute hydrochloric acid.
- Coal - Rock consisting mainly of organic remains.
- Others - Numerous other sedimentary rock types are present in lesser amounts in the stratigraphic record. The local abundance of any of these rock types is dependent upon the depositional history of the area. Conglomerate, halite, gypsum, dolomite, anhydrite, lignite, etc. are some of the rock types found in lesser amounts.

In classifying a sedimentary rock the following hierarchy shall be noted:

- Rock type
- Color
- Bedding thickness
- Hardness
- Fracturing
- Weathering
- Other characteristics

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5.3.1 Rock Type

As described above, there are numerous types of sedimentary rocks. In most cases, a rock will be a combination of several grain types, therefore, a modifier such as a sandy siltstone, or a silty sandstone can be used. The modifier indicates that a significant portion of the rock type is composed of the modifier. Other modifiers can include carbonaceous, calcareous, siliceous, etc.

Grain size is the basis for the classification of clastic sedimentary rocks. Figure 4 is the Udden-Wentworth classification that will be assigned to sedimentary rocks. The individual boundaries are slightly different than the USCS subdivision for soil classification. For field determination of grain sizes, a scale can be used for the coarse grained rocks. For example, the division between siltstone and claystone may not be measurable in the field. The boundary shall be determined by use of a hand lens. If the grains cannot be seen with the naked eye but are distinguishable with a hand lens, the rock is a siltstone. If the grains are not distinguishable with a hand lens, the rock is a claystone.

5.3.2 Color

The color of a rock can be determined in a similar manner as for soil samples. Rock core samples shall be classified while wet, when possible, and air cored samples shall be scraped clean of cuttings prior to color classifications.

Rock color charts shall not be used unless specified by the Project Manager.

5.3.3 Bedding Thickness

The bedding thickness designations applied to soil classification (see Figure 3) will also be used for rock classification.

5.3.4 Hardness

The hardness of a rock is a function of the compaction, cementation, and mineralogical composition of the rock. A relative scale for sedimentary rock hardness is as follows:

- Soft - Weathered, considerable erosion of core, easily gouged by screwdriver, scratched by fingernail. Soft rock crushes or deforms under pressure of a pressed hammer. This term is always used for the hardness of the saprolite (decomposed rock which occupies the zone between the lowest soil horizon and firm bedrock).
- Medium soft - Slight erosion of core, slightly gouged by screwdriver, or breaks with crumbly edges from single hammer blow.
- Medium hard - No core erosion, easily scratched by screwdriver, or breaks with sharp edges from single hammer blow.
- Hard - Requires several hammer blows to break and has sharp conchoidal breaks. Cannot be scratched with screwdriver.

Note the difference in usage here of the words "scratch" and "gouge." A scratch shall be considered a slight depression in the rock (do not mistake the scraping off of rock flour from drilling with a scratch in the rock itself), while a gouge is much deeper.

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FIGURE 4

GRAIN SIZE CLASSIFICATION FOR ROCKS

Particle Name	Grain Size Diameter
Cobbles	> 64 mm
Pebbles	4 - 64 mm
Granules	2 - 4 mm
Very Coarse Sand	1 - 2 mm
Coarse Sand	0.5 - 1 mm
Medium Sand	0.25 - 0.5 mm
Fine Sand	0.125 - 0.25 mm
Very Fine Sand	0.0625 - 0.125 mm
Silt	0.0039 - 0.0625 mm

After Wentworth, 1922

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5.3.5 Fracturing

The degree of fracturing or brokenness of a rock is described by measuring the fractures or joint spacing. After eliminating drilling breaks, the average spacing is calculated and the fracturing is described by the following terms:

- Very broken (V. BR.) - Less than 2-inch spacing between fractures
- Broken (BR.) - 2-inch to 1-foot spacing between fractures
- Blocky (BL.) - 1- to 3-foot spacing between fractures
- Massive (M.) - 3 to 10-foot spacing between fractures

The structural integrity of the rock can be approximated by calculating the Rock Quality Designation (RQD) of cores recovered. The RQD is determined by adding the total lengths of all pieces exceeding 4 inches and dividing by the total length of the coring run, to obtain a percentage.

Method of Calculating RQD
(After Deere, 1964)

$$RQD \% = r/l \times 100$$

r = Total length of all pieces of the lithologic unit being measured, which are greater than 4 inches length, and have resulted from natural breaks. Natural breaks include slickensides, joints, compaction slicks, bedding plane partings (not caused by drilling), friable zones, etc.

l = Total length of the coring run.

5.3.6 Weathering

The degree of weathering is a significant parameter that is important in determining weathering profiles and is also useful in engineering designs. The following terms can be applied to distinguish the degree of weathering:

- Fresh - Rock shows little or no weathering effect. Fractures or joints have little or no staining and rock has a bright appearance.
- Slight - Rock has some staining which may penetrate several centimeters into the rock. Clay filling of joints may occur. Feldspar grains may show some alteration.
- Moderate - Most of the rock, with exception of quartz grains, is stained. Rock is weakened due to weathering and can be easily broken with hammer.
- Severe - All rock including quartz grains is stained. Some of the rock is weathered to the extent of becoming a soil. Rock is very weak.

5.3.7 Other Characteristics

The following items shall be included in the rock description:

- Description of contact between two rock units. These can be sharp or gradational.
- Stratification (parallel, cross stratified).

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- Description of any filled cavities or vugs.
- Cementation (calcareous, siliceous, hematitic).
- Description of any joints or open fractures.
- Observation of the presence of fossils.
- Notation of joints with depth, approximate angle to horizontal, any mineral filling or coating, and degree of weathering.

All information shown on the boring logs shall be neat to the point where it can be reproduced on a copy machine for report presentation. The data shall be kept current to provide control of the drilling program and to indicate various areas requiring special consideration and sampling.

5.3.8 Additional Terms Used in the Description of Rock

The following terms are used to further identify rocks:

- Seam - Thin (12 inches or less), probably continuous layer.
- Some - Indicates significant (15 to 40 percent) amounts of the accessory material. For example, rock composed of seams of sandstone (70 percent) and shale (30 percent) would be "sandstone -- some shale seams."
- Few - Indicates insignificant (0 to 15 percent) amounts of the accessory material. For example, rock composed of seam of sandstone (90 percent) and shale (10 percent) would be "sandstone -- few shale seams."
- Interbedded - Used to indicate thin or very thin alternating seams of material occurring in approximately equal amounts. For example, rock composed of thin alternating seams of sandstone (50 percent) and shale (50 percent) would be "interbedded sandstone and shale."
- Interlayered - Used to indicate thick alternating seams of material occurring in approximately equal amounts.

The preceding sections describe the classification of sedimentary rocks. The following are some basic names that are applied to igneous rocks:

- Basalt - A fine-grained extrusive rock composed primarily of calcic plagioclase and pyroxene.
- Rhyolite - A fine-grained volcanic rock containing abundant quartz and orthoclase. The fine-grained equivalent of a granite.
- Granite - A coarse-grained plutonic rock consisting essentially of alkali feldspar and quartz.
- Diorite - A coarse-grained plutonic rock consisting essentially of sodic plagioclase and hornblende.
- Gabbro - A coarse-grained plutonic rock consisting of calcic plagioclase and clinopyroxene. Loosely used for any coarse-grained dark igneous rock.

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The following are some basic names that are applied to metamorphic rocks:

- Slate - A very fine-grained foliated rock possessing a well developed slaty cleavage. Contains predominantly chlorite, mica, quartz, and sericite.
- Phyllite - A fine-grained foliated rock that splits into thin flaky sheets with a silky sheen on cleavage surface.
- Schist - A medium to coarse-grained foliated rock with subparallel arrangement of the micaceous minerals which dominate its composition.
- Gneiss - A coarse-grained foliated rock with bands rich in granular and platy minerals.
- Quartzite - A fine- to coarse-grained nonfoliated rock breaking across grains, consisting essentially of quartz sand with silica cement.

5.4 Abbreviations

Abbreviations may be used in the description of a rock or soil. However, they shall be kept at a minimum. Following are some of the abbreviations that may be used:

C - Coarse	Lt - Light	Yl - Yellow
Med - Medium	BR - Broken	Or - Orange
F - Fine	BL - Blocky	SS - Sandstone
V - Very	M - Massive	Sh - Shale
Sl - Slight	Br - Brown	LS - Limestone
Occ - Occasional	Bl - Black	Fgr - Fine-grained
Tr - Trace		

5.5 Boring Logs and Documentation

This section describes in more detail the procedures to be used in completing boring logs in the field. Information obtained from the preceding sections shall be used to complete the logs. A sample boring log has been provided as Figure 5.

The field geologist/engineer shall use this example as a guide in completing each boring log. Each boring log shall be fully described by the geologist/engineer as the boring is being drilled. Every sheet contains space for 25 feet of log. Information regarding classification details is provided either on the back of the boring log or on a separate sheet, for field use.

**FIGURE 5
COMPLETED BORING LOG (EXAMPLE)**



BORING LOG

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PROJECT NAME: <u>NSB-SITE</u>	BORING NUMBER: <u>SB/MW1</u>
PROJECT NUMBER: <u>9594</u>	DATE: <u>3/8/96</u>
DRILLING COMPANY: <u>SOILTEST CO.</u>	GEOLOGIST: <u>SJ CONTI</u>
DRILLING RIG: <u>CME-55</u>	DRILLER: <u>R. ROCK</u>

Sample No. and Type or ROD	Depth (FL) or Run No.	Blows / 1" or ROD (%)	Sample Recovery / Sample Length	Lithology Change (Depth/FL) or Screened Interval	MATERIAL DESCRIPTION			U S C S	Remarks	PIOPID Reading (ppm)				
					Soil Density Consistency or Rock Hardness	Color	Material Classification			Sample	Sampler BZ	Borehole BZ	Driller BZ	
S-1 e	0.0	7 6	1.5/2.0	4.0	M DENSE	BRN	SILTY SAND - SOME	SM	MOIST SL. ODOR	5	0	0	0	
	0.800	9 10					TO BLK	Rock Fr. - TR BRICKS		ODOR				
	4.0							(FILL)		FILL TO 4'±				
S-2 e		5 7	3.9/2.0	7' ± 8.0	M DENSE	BRN	SILTY SAND - TR FINE	SM	MOIST - W ODOR	10	0	-	-	
	0.810	9 8						GRAVEL		NAT. MATL. TOOK SAMPLE SBOI-0406 FOR ANALYSIS				
	8.0													
S-3 e		6 8	1.9/2.0	12.0	DENSE	TAN BRN	FINE TO COARSE SAND	SW	WET	0	0	0	0	
	0.820	17 16						TR. F. GRAVEL		HIT WATER = 7'±				
	12.0													
S-4 e		7 6	1.6/2.0	15.0	STIFF	GRAY	SILTY CLAY	CL	MOIST → WET	0	.5	-	-	
	0.830	5 8												
	15.0									AUGER REF @ 15'				
				16 19'	M HARD	BRN	SILTSTONE	VER	WEATHERED					
										LO & JNTS @ 15.5				
95	①		4.0/5.0							WATER STAINS @ 16.5, 17.1, 17.5	0	0	0	0
	20.0			25	HARD	GRY	SANDSTONE - SOME	BR	DRILL H2O @ 17'±					
										LOSING SOME				
										SILTSTONE	SET TEMP 6" CAS TO 15.5			
49	②		5.0/5.0						SET 2"Ø PVC SCREEN 16-25	0	0	0	0	
	25.0								SAND 14-25					
									PELLETS 12-14					

* When rock coring, enter rock brokenness.
 ** include monitor reading in 6 foot intervals @ borehole. Increase reading frequency if elevated response read.

Remarks: CME-55 RIG, 4 1/4" ID HSA - 9" OD ± • 1-20Z Drilling Area
2" SPLIT SPOONS - 140 LB HAMMER - 30" DROP 1-80Z Background (ppm):
NX CORE IN BEDROCK RUN (1) = 25 min, RUN (2) = 15 min

Converted to Well: Yes No Well I.D. #: MW-1

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5.5.1 Soil Classification

- Identify site name, boring number, job number, etc. Elevations and water level data to be entered when surveyed data is available.
- Enter sample number (from SPT) under appropriate column. Enter depth sample was taken from (1 block = 1 foot). Fractional footages, i.e., change of lithology at 13.7 feet, shall be lined off at the proportional location between the 13- and 14-foot marks. Enter blow counts (Standard Penetration Resistance) diagonally (as shown). Standard penetration resistance is covered in Section 5.2.3.
- Determine sample recovery/sample length as shown. Measure the total length of sample recovered from the split-spoon sampler, including material in the drive shoe. Do not include cuttings or wash material that may be in the upper portion of the sample tube.
- Indicate any change in lithology by drawing a line at the appropriate depth. For example, if clayey silt was encountered from 0 to 5.5 feet and shale from 5.5 to 6.0 feet, a line shall be drawn at this increment. This information is helpful in the construction of cross-sections. As an alternative, symbols may be used to identify each change in lithology.
- The density of granular soils is obtained by adding the number of blows for the last two increments. Refer to Density of Granular Soils Chart on back of log sheet. For consistency of cohesive soils refer also to the back of log sheet - Consistency of Cohesive Soils. Enter this information under the appropriate column. Refer to Section 5.2.3.
- Enter color of the material in the appropriate column.
- Describe material using the USCS. Limit this column for sample description only. The predominate material is described last. If the primary soil is silt but has fines (clay) - use clayey silt. Limit soil descriptors to the following:
 - Trace: 0 - 10 percent
 - Some: 11 - 30 percent
 - And/Or: 31 - 50 percent
- Also indicate under Material Classification if the material is fill or natural soils. Indicate roots, organic material, etc.
- Enter USCS symbol - use chart on back of boring log as a guide. If the soils fall into one of two basic groups, a borderline symbol may be used with the two symbols separated by a slash. For example ML/CL or SM/SP.
- The following information shall be entered under the "Remarks" column and shall include, but is not limited by, the following:
 - Moisture - estimate moisture content using the following terms - dry, moist, wet and saturated. These terms are determined by the individual. Whatever method is used to determine moisture, be consistent throughout the log.

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- Angularity - describe angularity of coarse grained particles using the terms angular, subangular, subrounded, or rounded. Refer to ASTM D 2488 or Earth Manual for criteria for these terms.
 - Particle shape - flat, elongated, or flat and elongated.
 - Maximum particle size or dimension.
 - Water level observations.
 - Reaction with HCl - none, weak, or strong.
- Additional comments:
 - Indicate presence of mica, caving of hole, when water was encountered, difficulty in drilling, loss or gain of water.
 - Indicate odor and Photoionization Detector (PID) or Flame Ionization Detector (FID) reading if applicable.
 - Indicate any change in lithology by drawing a line through the lithology change column and indicate the depth. This will help when cross-sections are subsequently constructed.
 - At the bottom of the page indicate type of rig, drilling method, hammer size and drop, and any other useful information (i.e., borehole size, casing set, changes in drilling method).
 - Vertical lines shall be drawn (as shown in Figure 5) in columns 6 to 8 from the bottom of each sample to the top of the next sample to indicate consistency of material from sample to sample, if the material is consistent. Horizontal lines shall be drawn if there is a change in lithology, then vertical lines drawn to that point.
 - Indicate screened interval of well, as needed, in the lithology column. Show top and bottom of screen. Other details of well construction are provided on the well construction forms.

5.5.2 Rock Classification

- Indicate depth at which coring began by drawing a line at the appropriate depth. Indicate core run depths by drawing coring run lines (as shown) under the first and fourth columns on the log sheet. Indicate RQD, core run number, RQD percent, and core recovery under the appropriate columns.
- Indicate lithology change by drawing a line at the appropriate depth as explained in Section 5.5.1.
- Rock hardness is entered under designated column using terms as described on the back of the log or as explained earlier in this section.

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- Enter color as determined while the core sample is wet; if the sample is cored by air, the core shall be scraped clean prior to describing color.
- Enter rock type based on sedimentary, igneous or metamorphic. For sedimentary rocks use terms as described in Section 5.3. Again, be consistent in classification. Use modifiers and additional terms as needed. For igneous and metamorphic rock types use terms as described in Sections 5.3.8.
- Enter brokenness of rock or degree of fracturing under the appropriate column using symbols VBR, BR, BL, or M as explained in Section 5.3.5 and as noted on the back of the Boring Log.
- The following information shall be entered under the remarks column. Items shall include but are not limited to the following:
 - Indicate depths of joints, fractures and breaks and also approximate to horizontal angle (such as high, low), i.e., 70° angle from horizontal, high angle.
 - Indicate calcareous zones, description of any cavities or vugs.
 - Indicate any loss or gain of drill water.
 - Indicate drop of drill tools or change in color of drill water.
- Remarks at the bottom of Boring Log shall include:
 - Type and size of core obtained.
 - Depth casing was set.
 - Type of rig used.
- As a final check the boring log shall include the following:
 - Vertical lines shall be drawn as explained for soil classification to indicate consistency of bedrock material.
 - If applicable, indicate screened interval in the lithology column. Show top and bottom of screen. Other details of well construction are provided on the well construction forms.

5.5.3 Classification of Soil and Rock from Drill Cuttings

The previous sections describe procedures for classifying soil and rock samples when cores are obtained. However, some drilling methods (air/mud rotary) may require classification and borehole logging based on identifying drill cuttings removed from the borehole. Such cuttings provide only general information on subsurface lithology. Some procedures that shall be followed when logging cuttings are:

- Obtain cutting samples at approximately 5-foot intervals, sieve the cuttings (if mud rotary drilling) to obtain a cleaner sample, place the sample into a small sample bottle or "zip lock"

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bag for future reference, and label the jar or bag (i.e. hole number, depth, date, etc.). Cuttings shall be closely examined to determine general lithology.

- Note any change in color of drilling fluid or cuttings, to estimate changes in lithology.
- Note drop or chattering of drilling tools or a change in the rate of drilling, to determine fracture locations or lithologic changes.
- Observe loss or gain of drilling fluids or air (if air rotary methods are used), to identify potential fracture zones.
- Record this and any other useful information onto the boring log as provided in Figure 1.

This logging provides a general description of subsurface lithology and adequate information can be obtained through careful observation of the drilling process. It is recommended that split-barrel and rock core sampling methods be used at selected boring locations during the field investigation to provide detailed information to supplement the less detailed data generated through borings drilled using air/mud rotary methods.

5.6 Review

Upon completion of the borings logs, copies shall be made and reviewed. Items to be reviewed include:

- Checking for consistency of all logs.
- Checking for conformance to the guideline.
- Checking to see that all information is entered in their respective columns and spaces.

6.0 REFERENCES

Unified Soil Classification System (USCS).

ASTM D2488, 1985.

Earth Manual, U.S. Department of the Interior, 1974.

7.0 RECORDS

Originals of the boring logs shall be retained in the project files.



BROWN & ROOT ENVIRONMENTAL

STANDARD OPERATING PROCEDURES

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Applicability B&R Environmental, NE	
Prepared Earth Sciences Department	
Approved D. Senovich <i>DS</i>	

Subject
GROUNDWATER MONITORING POINT INSTALLATION

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1.0 PURPOSE

This procedure provides general guidance and information pertaining to proper monitoring well design, installation, and development.

2.0 SCOPE

This procedure is applicable to the construction of permanent monitoring wells. The methods described herein may be modified by project-specific requirements for monitoring well construction. In addition, many regulatory agencies have specific regulations pertaining to monitoring well construction and permitting. These requirements must be determined during the project planning phases of the investigation, and any required permits must be obtained before field work begins. Innovative monitoring well installation techniques, which typically are not used, will be discussed only generally in this procedure.

3.0 GLOSSARY

Monitoring Well - A well which is properly screened (if screening is necessary, e.g., open borehole), cased, and sealed which is capable of providing a groundwater level and groundwater sample representative of the zone being monitored.

Piezometer - A pipe or tube inserted into the water bearing zone, typically open to water flow at the bottom and to the atmosphere at the top, and used to measure water level elevations. Piezometers may range in size from 1/2-inch-diameter plastic tubes to well points or monitoring wells.

Potentiometric Surface - The surface representative of the level to which water will rise in a well cased to the screened aquifer.

Well Point (Drive Point) - A screened or perforated tube (Typically 1-1/4 or 2 inches in diameter) with a solid, conical, hardened point at one end, which is attached to a riser pipe and driven into the ground with a sledge hammer, drop weight, or mechanical vibrator. Well points may be used for groundwater injection and recovery, as piezometers (i.e., to measure water levels) or to provide groundwater samples for water quality data.

4.0 RESPONSIBILITIES

Driller - The driller provides adequate and operable equipment, sufficient quantities of materials, and an experienced and efficient labor force capable of performing all phases of proper monitoring well installation and construction. The driller may also be responsible for obtaining, in advance, any required permits for monitoring well installation and construction.

Rig Geologist - The rig geologist supervises and documents well installation and construction performed by the driller, and insures that well construction is adequate to provide representative groundwater data from the monitored interval. Geotechnical engineers, field technicians, or other suitable trained personnel may also serve in this capacity.

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5.0 PROCEDURES

5.1 Equipment/Items Needed

Below is a list of items that may be needed when installing a monitoring well:

- Health and safety equipment as required by the Site Safety Officer.
- Well drilling and installation equipment with associated materials (typically supplied by the driller).
- Hydrogeologic equipment (weighted engineer's tape, water level indicator, retractable engineers rule, electronic calculator, clipboard, mirror and flashlight - for observing downhole activities, paint and ink marker for marking monitoring wells, sample jars, well installation forms, and a field notebook).
- Drive point installations tools (sledge hammer, drop hammer, or mechanical vibrator; tripod, pipe wrenches, drive points, riser pipe, and end caps).

5.2 Well Design

The objectives for each monitoring well and its intended use must be clearly defined before the monitoring system is designed. Within the monitoring system, different monitoring wells may serve different purposes and, therefore, require different types of construction. During all phases of the well design, attention must be given to clearly documenting the basis for design decisions, the details of well construction, and the materials to be used. The objectives for installing the monitoring wells may include:

- Determining groundwater flow directions and velocities.
- Sampling or monitoring for trace contaminants.
- Determining aquifer characteristics (e.g., hydraulic conductivity).

Siting of monitoring wells shall be performed after a preliminary estimation of the groundwater flow direction. In most cases, groundwater flow and potential well locations can be determined through the review of geologic data and the site terrain. In addition, data from production wells or other monitoring wells in the area may be used to determine the groundwater flow direction. If these methods cannot be used, piezometers, which are relatively inexpensive to install, may have to be installed in a preliminary investigative phase to determine groundwater flow direction.

5.2.1 Well Depth, Diameter, and Monitored Interval

The well depth, diameter, and monitored interval must be tailored to the specific monitoring needs of each investigation. Specification of these items generally depends on the purpose of the monitoring system and the characteristics of the hydrogeologic system being monitored. Wells of different depth, diameter, and monitored interval can be employed in the same groundwater monitoring system. For instance, varying the monitored interval in several wells, at the same location (cluster wells) can help to determine the vertical gradient and the levels at which contaminants are present. Conversely, a fully penetrating well is usually not used to quantify or vertically locate a contaminant plume, since groundwater samples collected in wells that are screened over the full thickness of the water-bearing zone will be representative of average conditions across the entire monitored interval. However, fully penetrating wells can be used to establish the existence of contamination in the water-bearing zone. The

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well diameter desired depends upon the hydraulic characteristics of the water-bearing zone, sampling requirements, drilling method and cost.

The decision concerning the monitored interval and well depth is based on the following (and possibly other) information:

- The vertical location of the contaminant source in relation to the water-bearing zone.
- The depth, thickness and uniformity of the water-bearing zone.
- The anticipated depth, thickness, and characteristics (e.g., density relative to water) of the contaminant plume.
- Fluctuation in groundwater levels (due to pumping, tidal influences, or natural recharge/discharge events).
- The presence and location of contaminants encountered during drilling.
- Whether the purpose of the installation is for determining existence or non-existence of contamination or if a particular stratigraphic zone is being investigated.
- The analysis of borehole geophysical logs.

In most situations where groundwater flow lines are horizontal, depending on the purpose of the well and the site conditions, monitored intervals are 20 feet or less. Shorter screen lengths (1 to 2 feet) are usually required where flow lines are not horizontal, (i.e., if the wells are to be used for accurate measurement of the potentiometric head at a specific point).

Many factors influence the diameter of a monitoring well. The diameter of the monitoring well depends on the application. In determining well diameter, the following needs must be considered:

- Adequate water volume for sampling.
- Drilling methodology.
- Type of sampling device to be used.
- Costs.

Standard monitoring well diameters are 2, 4, 6, or 8 inches. However, drive points are typically 1-1/4 or 2 inches in diameter. For monitoring programs which require screened monitoring wells, either a 2-inch or 4-inch-diameter well is preferred. Typically, well diameters greater than 4 inches are used in monitoring programs in which open-hole monitoring wells are required. In the smaller diameter wells, the volume of stagnant water in the well is minimized, and well construction costs are reduced, however, the type of sampling devices that can be used are limited. In specifying well diameter, sampling requirements must be considered (up to a total of 4 gallons of water may be required for a single sample to account for full organic and inorganic analyses, and split samples). The volume of water in the monitoring well available for sampling is dependent on the well diameter as follows:

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Casing Inside Diameter (Inch)	Standing Water Depth to Obtain 1 Gallon Water (Feet)	Total Depth of Standing Water for 4 Gallons (Feet)
2	6.13	25
4	1.53	6
6	0.68	3

However, if a specific well recharges quickly after purging, then well diameter may not be an important factor regarding sample volume requirements.

Pumping tests for determining aquifer characteristics may require larger diameter wells; however, in small-diameter wells in-situ permeability tests can be performed during drilling or after well installation is completed.

5.2.2 Riser Pipe and Screen Materials

Well materials are specified by diameter, type of material, and thickness of pipe. Well screens require an additional specification of slot size. Thickness of pipe is referred to as "schedule" for polyvinyl chloride (PVC) casing and is usually Schedule 40 (thinner wall) or 80 (thicker wall). Steel pipe thickness is often referred to as "Strength" and Standard Strength is usually adequate for monitoring well purposes. With larger diameter pipe, the wall thickness must be greater to maintain adequate strength. The required thickness is also dependent on the method of installation; risers for drive points require greater strength than wells installed inside drilled borings.

The selection of well screen and riser materials depends on the method of drilling, the type of subsurface materials the well penetrates, the type of contamination expected, and natural water quality and depth. Cost and the level of accuracy required are also important. The materials generally available are Teflon, stainless steel, PVC galvanized steel, and carbon steel. Each has advantages and limitations (see Attachment A of this guideline for an extensive presentation on this topic). The two most commonly used materials are PVC and stainless steel for wells in which screens are installed. Properties of these two materials are compared in Attachment B. Stainless steel is preferred where trace metals or organic sampling is required; however, costs are high. Teflon materials are extremely expensive, but are relatively inert and provide the least opportunity for water contamination due to well materials. PVC has many advantages, including low cost, excellent availability, light weight, and ease of manipulation; however, there are also some questions about organic chemical sorption and leaching that are currently being researched (see Barcelona et al., 1983). Concern about the use of PVC can be minimized if PVC wells are used strictly for geohydrologic measurements and not for chemical sampling. The crushing strength of PVC may limit the depth of installation, but Schedule 80 materials normally used for wells greater than 50 feet deep may overcome some of the problems associated with depth. However, the smaller inside diameter of Schedule 80 pipe may be an important factor when considering the size of bailers or pumps required for sampling or testing. Due to this problem, the minimum well pipe size recommended for Schedule 80 wells is 4-inch I.D.

Screens and risers may have to be decontaminated before use because oil-based preservatives and oil used during thread cutting and screen manufacturing may contaminate samples. Metal pipe, may corrode and release metal ions or chemically react with organic constituents, but this is considered by some to be less of a problem than the problem associated with PVC material. Galvanized steel is not

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recommended where samples may be collected for metal analyses, as zinc and cadmium levels in groundwater samples may become elevated from leaching of the zinc coating.

Threaded, flush-joint casing is most often preferred for monitoring well applications. PVC, Teflon, and steel can all be obtained with threaded joints at slightly more costs. Welded-joint steel casing is also acceptable. Glued PVC may release organic contaminants into the well, and therefore, should not be used if the well is to be sampled for organic constituents.

When the water-bearing zone is in consolidated bedrock, such as limestone or fractured granite, a well screen is often not necessary (the well is simply an open hole in bedrock). Unconsolidated materials, such as sands, clay, and silts require a screen. A screen slot size of 0.010 or 0.020 inch is generally used when a screen is necessary and the screened interval is artificially packed with a fine sand. The slot size controls the quantity of water entering the well and prevents entry of natural materials or sand pack. The screen shall pass no more than 10 percent of the pack material, or in-situ aquifer material. The rig geologist shall specify the combination of screen slot size and sand pack which will be compatible with the water-bearing zone, to maximize groundwater inflow and minimize head losses and movement of fines into the wells. For example, as a standard procedure, a Morie No. 1 or No. 10 to No. 20 U.S. Standard Sieve size filter pack is typically appropriate for a 0.020-inch slot screen; however, a No. 20 to No. 40 U.S. Standard Sieve size filter pack is typically appropriate for a 0.010-inch slot screen.

5.2.3 Annular Materials

Materials placed in the annular space between the borehole and riser pipe and screen include a sand pack when necessary, a bentonite seal, and cement-bentonite grout. The sand pack is usually a fine-to medium-grained poorly graded, silica sand and should relate to the grain size of the aquifer sediments. The quantity of sand placed in the annular space is dependent upon the length of the screened interval, but should always extend at least 1 foot above the top of the screen. At least 1 to 3 feet of bentonite pellets or equivalent shall be placed above the sand pack. Cement-bentonite grout (or equivalent) is then placed to extent from the top of the bentonite pellets to the ground surface.

On occasion, and with the concurrence of the involved regulatory agencies, monitoring wells may be packed naturally (i.e., no artificial sand pack installed), and the natural formation material is allowed to collapse around the well screen after the well is installed. This method has been used where the formation material itself is a relatively uniform grain size, or when artificial sand packing is not possible due to borehole collapse.

Bentonite expands by absorbing water and provides a seal between the screened interval and the overlying portion of the annular space and formation. Cement-bentonite grout is placed on top of the bentonite pellets extending to the surface. The grout effectively seals the well and eliminates the possibility for surface infiltration reaching the screened interval. Grouting also replaces material removed during drilling and prevents hole collapse and subsidence around the well. A tremie pipe should be used to introduce grout from the bottom of the hole upward, to prevent bridging, and to provide a better seal. However, in shallow boreholes that don't collapse, it may be more practical to pour the grout from the surface without a tremie pipe.

Grout is a general term which has several different connotations. For all practical purposes within the monitoring well installation industry, grout refers to the solidified material which is installed and occupies the annular space above the bentonite pellet seal. Grout, most of the time, is made up of two assemblages of material, (e.g., cement-bentonite). A cement-bentonite grout normally is a mixture of cement, bentonite, and water at a ratio of one 90-pound bag of Portland Type I cement, plus

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3 to 5 pounds of granular or flake-type bentonite, and 6 gallons of water. A neat cement consists of one ninety-pound bag of Portland Type I cement and 6 gallons of water.

In certain cases, the borehole may be drilled to a depth greater than the anticipated well installation depth. For these cases, the well shall be backfilled to the desired depth with bentonite pellets or equivalent. A short (1- to 2-foot) section of capped riser pipe sump is sometimes installed immediately below the screen, as a silt reservoir, when significant post-development silting is anticipated. This will ensure that the entire screen surface remains unobstructed.

5.2.4 Protective Casing

When the well is completed and grouted to the surface, a protective steel casing is often placed over the top of the well. This casing generally has a hinged cap and can be locked to prevent vandalism. A vent hole shall be provided in the cap to allow venting of gases and maintain atmospheric pressure as water levels rise or fall in the well. The protective casing has a larger diameter than the well and is set into the wet cement grout over the well upon completion. In addition, one hole is drilled just above the cement collar through the protective casing which acts as a weep hole for the flow of water which may enter the annulus during well development, purging, or sampling.

A protective casing which is level with the ground surface is used in roadway or parking lot applications where the top of a monitoring well must be below the pavement. The top of the riser pipe is placed 4 to 5 inches below the pavement, and a locking protective casing is cemented in place to 3 inches below the pavement. A large diameter protective sleeve is set into the wet cement around the well with the top set level with the pavement. A manhole-type lid placed over the protective sleeve. The cement should be slightly mounded to direct pooled water away from the well head.

5.3 Monitoring Well Installation

Pertinent data regarding monitoring well installation shall be recorded on log sheets as depicted and discussed in SOP SA-6.3. Attachments to this referenced SOP illustrate terms and physical construction of various types of monitoring wells.

5.3.1 Monitoring Wells in Unconsolidated Sediments

After the borehole is drilled to the desired depth, well installation can begin. The procedure for well installation will partially be dictated by the stability of the formation in which the well is being placed. If the borehole collapses immediately after the drilling tools are withdrawn, then a temporary casing must be installed and well installation will proceed through the center of the temporary casing, and continue as the temporary casing is withdrawn from the borehole. In the case of hollow-stem auger drilling, the augers will act to stabilize the borehole during well installation.

Before the screen and riser pipe are lowered into the borehole, all pipe and screen sections should be measured with an engineer's rule to ensure proper placement. When measuring sections, the threads on one end of the pipe or screen must be excluded while measuring, since the pipe and screen sections are screwed flush together.

After the screen and riser pipe are lowered through the temporary casing, the sand pack can be installed. A weighted tape measure must be used during the installation procedure to carefully monitor installation progress. The sand is poured into the annulus between the riser pipe and temporary casing, as the casing is withdrawn. Sand should always be kept within the temporary casing during withdrawal in order to ensure an adequate sand pack. However, if too much sand is within the temporary casing (greater

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than 1 foot above the bottom of the casing) bridging between the temporary casing and riser pipe may occur.

After the sand pack is installed to the desired depth (at least 1 foot above the top of the screen), then the bentonite pellet seal (or equivalent), can be installed in the same manner as the sand pack. At least 1 to 3 feet of bentonite pellets should be installed above the sand pack.

The cement-bentonite grout is then mixed and either poured or tremied into the annulus as the temporary casing or augers are withdrawn. Finally, the protective casing can be installed as detailed in Section 5.2.4.

In stable formations where borehole collapse does not occur, the well can be installed as discussed above, and the use of a temporary casing is not needed. However, centralizers may have to be installed, one above and one below the screen, to assure enough annular space for sand pack placement.

~~5.3.2 Confining Layer Monitoring Wells~~

~~When drilling and installing a well in a confined aquifer, proper well installation techniques must be applied to avoid cross contamination between the unconfined and confined aquifer. Under most conditions, this can be accomplished by installing double-cased wells. This is accomplished by drilling a large-diameter boring through the upper aquifer, 1 to 3 feet into the underlying confining layer, and setting and pressure grouting or tremie grouting the outer casing into the confining layer. The grout material must fill the space between the native material and the outer casing. A smaller diameter boring is then continued through the confining layer for installation of the monitoring well as detailed for overburden monitoring wells (with the exception of not using a temporary casing during installation). Sufficient time (determined by the rig geologist), must be allowed for setting of the grout prior to drilling through the confined layer.~~

~~5.3.3 Bedrock Monitoring Wells~~

~~When installing bedrock monitoring wells, a large diameter boring is drilled through the overburden and approximately 5 feet into the bedrock. A casing (typically steel) is installed and either pressure grouted or tremie grouted in place. After the grout has cured, a smaller diameter boring is continued through the bedrock to the desired depth. If the boring does not collapse, the well can be left open, and a screen is not necessary. If the boring collapses, then a screen is required and can be installed as detailed for overburden monitoring wells. However, if a screen is to be used, then the casing which is installed through the overburden and into the bedrock does not require grouting and can be installed temporary until final well installation is completed.~~

~~5.3.4 Drive Points~~

~~Drive points can be installed with either a sledge hammer, drop hammer, or a mechanical vibrator. The screen is threaded and tightened onto the riser pipe with pipe wrenches. The drive point is simply pounded into the subsurface to the desired depth. If a heavy drop hammer is used, then a tripod and pulley setup is required to lift the hammer. Drive points typically cannot be driven to depths exceeding 10 feet.~~

~~5.3.5 Innovative Monitoring Well Installation Techniques~~

~~Certain innovative sampling devices have proven advantageous. These devices are essentially screened samplers installed in a borehole with only one or two small-diameter tubes extending to the surface.~~

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Manufacturers of these types of samplers claim that four samplers can be installed in a 3-inch-diameter borehole. This reduces drilling costs, decreases the volume of stagnant water, and provides a sampling system that minimizes cross-contamination from sampling equipment. These samplers also perform well when the water table is within 25 feet of the surface (the typical range of suction pumps). Two manufacturers of these samplers are Timco Manufacturing Company, Inc., of Prairie du Sac, Wisconsin, and BARCAD Systems, Inc., of Concord, Massachusetts. Each manufacturer offers various construction materials.

Two additional types of multilevel sampling systems have been developed. Both employ individual screened openings through a small-diameter casing. One of these systems (marketed by Westbay Instruments Ltd. of Vancouver, British Columbia, Canada) uses a screened port and a sampling probe to obtain samples and head measurements or perform permeability tests. This system allows sampling ports at intervals as close as 5 feet, if desired, in boreholes from 3 to 4.8 inches in diameter.

The second system, developed at the University of Waterloo at Waterloo, Ontario, Canada, requires field assembly of the individual sampling ports and tubes that actuate a simple piston pump and force the samples to the surface. Where the depth to ground water is less than 25 feet, the piston pumps are not required. The assembly is made of easily obtained materials; however, the cost of labor to assemble these monitoring systems may not be cost-effective.

5.4 Well Development Methods

The purpose of well development is to stabilize and increase the permeability of the gravel pack around the well screen, and to restore the permeability of the formation which may have been reduced by drilling operations. Wells are typically developed until all fine material and drilling water is removed from the well. Sequential measurements of pH, conductivity and temperature taken during development may yield information (stabilized values) that sufficient development is reached. The selection of the well development method shall be made by the rig geologist and is based on the drilling methods, well construction and installation details, and the characteristics of the formation that the well is screened in. The primary methods of well development are summarized below. A more detailed discussion may be found in Driscoll (1986).

5.4.1 Overpumping and Backwashing

Wells may be developed by alternatively drawing the water level down at a high rate (by pumping or bailing) and then reversing the flow direction (backwashing) so that water is passing from the well into the formation. This back and forth movement of water through the well screen and gravel pack serves to remove fines from the formation immediately adjacent to the well, while preventing bridging (wedging) of sand grains. Backwashing can be accomplished by several methods, including pouring water into the well and then bailing, starting and stopping a pump intermittently to change water levels, or forcing water into the well under pressure through a water-tight fitting ("rawhiding"). Care should be taken when backwashing not to apply too much pressure, which could damage or destroy the well screen.

5.4.2 Surging with a Surge Plunger

A surge plunger (also called a surge block) is approximately the same diameter as the well casing and is used to agitate the water, causing it to move in and out of the screens. This movement of water pulls fine materials into the well, where they may be removed by any of several methods, and prevents bridging of sand particles in the gravel pack. There are two basic types of surge plungers; solid and valved surge plungers. In formations with low yields, a valved surge plunger may be preferred, as solid

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plungers tend to force water out of the well at a greater rate than it will flow back in. Valved plungers are designed to produce a greater inflow than outflow of water during surging.

5.4.3 Compressed Air

Compressed air can be used to develop a well by either of two methods: backwashing or surging. Backwashing is done by forcing water out through the screens, using increasing air pressure inside a sealed well, then releasing the pressurized air to allow the water to flow back into the well. Care should be taken when using this method so that the water level does not drop below the top of the screen, thus reducing well yield. Surging, or the "open well" method, consists of alternately releasing large volumes of air suddenly into an open well below the water level to produce a strong surge by virtue of the resistance of water head, friction, and inertia. Pumping of the well is subsequently done using the air lift method.

5.4.4 High Velocity Jetting

In the high velocity jetting method, water is forced at high velocities from a plunger-type device and through the well screen to loosen fine particles from the sand pack and surrounding formation. The jetting tool is slowly rotated and raised and lowered along the length of the well screen to develop the entire screened area. Jetting using a hose lowered into the well may also be effective. The fines washed into the screen during this process can then be bailed or pumped from the well.

6.0 REFERENCES

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Driscoll, Fletcher G., 1986. Groundwater and Wells. Johnson Division, St. Paul, Minnesota, 1989.

7.0 RECORDS

A critical part of monitoring well installation is recording of significant details and events in the site logbook or field notebook. The geologist must record the exact depths of significant hydrogeological features screen placement, gravel pack placement, and bentonite placement.

A Monitoring Well Sheet (see Attachments to SOP SA-6.3) shall be completed thus ensuring the uniform recording of data for each installation and rapid identification of missing information. Well depth, length, materials of construction, length and openings of screen, length and type of riser, and depth and type of all backfill materials shall be recorded. Additional information shall include location, installation date, problems encountered, water levels before and after well installation, cross-reference to the geologic boring log, and methods used during the installation and development process. Documentation is very important to prevent problems involving questionable sample validity. Somewhat different information

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will need to be recorded. depending on whether the well is completed in overburden, in a confined layer, in bedrock with a cased well, or as an open hole in bedrock.

The quantities of sand, bentonite, and grout placed in the well are also important. The geologist shall calculate the annular space volume and have a general idea of the quantity of material needed to fill the annular space. Volumes of backfill significantly higher than the calculated volume may indicate a problem such as a large cavity, while a smaller backfill volume may indicate a cave-in. Any problems with rig operation or down-time shall be recorded and may affect the driller's final fee.

ATTACHMENT A

RELATIVE COMPATIBILITY OF RIGID WELL CASING MATERIAL (PERCENT)

Potentially-Deteriorating Substance	Type of Casing Material						
	PVC 1	Galvanized Steel	Carbon Steel	Lo-carbon Steel	Stainless Steel 304	Stainless Steel 316	Teflon*
Buffered Weak Acid	100	56	51	59	97	100	100
Weak Acid	98	59	43	47	96	100	100
Mineral Acid/ High Solids Content	100	48	57	60	80	82	100
Aqueous/Organic Mixtures	64	69	73	73	98	100	100
Percent Overall Rating	91	58	56	59	93	96	100

Preliminary Ranking of Rigid Materials:

- | | | | |
|---|---------------------|---|------------------|
| 1 | Teflon® | 5 | Lo-Carbon Steel |
| 2 | Stainless Steel 316 | 6 | Galvanized Steel |
| 3 | Stainless Steel 304 | 7 | Carbon Steel |
| 4 | PVC 1 | | |

* Trademark of DuPont

RELATIVE COMPATIBILITY OF SEMI-RIGID OR ELASTOMERIC MATERIALS (PERCENT)

Potentially-Deteriorating Substance	Type of Casing Material								
	PVC Flexible	PP	PE Conv.	PE Linear	PMM	Viton®*	Silicone	Neoprene	Teflon®*
Buffered Weak Acid	97	97	100	97	90	92	87	85	100
Weak Acid	92	90	94	96	78	78	75	75	100
Mineral Acid/ High Solids Content	100	100	100	100	95	100	78	82	100
Aqueous/Organic Mixtures	62	71	40	60	49	78	49	44	100
Percent Overall Rating	88	90	84	88	78	87	72	72	100

Preliminary Ranking of Semi-Rigid or Elastomeric Materials:

- | | | | |
|---|------------------------|---|------------------------|
| 1 | Teflon® | 5 | PE Conventional |
| 2 | Polypropylene (PP) | 6 | Plexiglas/Lucite (PMM) |
| 3 | PVC Flexible/PE Linear | 7 | Silicone/Neoprene |
| 4 | Viton® | | |

* Trademark of DuPont

Source: Barcelona et al., 1983

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ATTACHMENT B

COMPARISON OF STAINLESS STEEL AND PVC FOR MONITORING WELL CONSTRUCTION

Characteristic	Stainless Steel	PVC
Strength	Use in deep wells to prevent compression and closing of screen/riser.	Use when shear and compressive strength are not critical.
Weight	Relatively heavier.	Light-weight; floats in water.
Cost	Relatively expensive.	Relatively inexpensive.
Corrosivity	Deteriorates more rapidly in corrosive water.	Non-corrosive -- may deteriorate in presence of ketones, aromatics, alkyl sulfides, or some chlorinated hydrocarbons.
Ease of Use	Difficult to adjust size or length in the field.	Easy to handle and work with in the field.
Preparation for Use	Should be steam cleaned organics will be subsequently sampled.	Never use glue fittings -- pipes should be threaded or pressure fitted. Should be steam cleaned when used for monitoring wells.
Interaction with Contaminants*	May sorb organic or inorganic substances when oxidized.	May sorb or release organic substances.

* See also Attachment A.



BROWN & ROOT ENVIRONMENTAL

STANDARD OPERATING PROCEDURES

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Applicability
B&R Environmental, NE

Prepared
Earth Sciences Department

Subject

GROUNDWATER SAMPLE ACQUISITION AND ONSITE WATER
QUALITY TESTING

Approved
D. Senovich *[Signature]*

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1.0 PURPOSE

The purpose of this procedure is to provide general reference information regarding the sampling of groundwater wells.

2.0 SCOPE

This procedure provides information on proper sampling equipment, onsite water quality testing, and techniques for groundwater sampling. Review of the information contained herein will facilitate planning of the field sampling effort by describing standard sampling techniques. The techniques described shall be followed whenever applicable, noting that site-specific conditions or project-specific plans may require modifications to methodology.

3.0 GLOSSARY

Conductance - The conductance of a conductor 1 centimeter long and 1 square centimeter in cross-sectional area. For groundwater measurements, a volume of water contained in a 1 cm x 1 cm sample container (the water acts as the conductor). Conductivity and specific conductance are used synonymously.

Electrolytic Cell - An electrochemical cell in which electrical energy is supplied from an external source. This cell functions in much the same way as a galvanic cell, only the current flows in the opposite direction due to the external source of applied voltage. Electrolytic cells are used in dissolved oxygen measurement.

Galvanic Cell - A electrochemical cell in which chemical energy is spontaneously converted to electrical energy. The electrical energy produced is supplied to an external circuit. Galvanic cells are used in dissolved oxygen measurement.

Ohm - Standard unit of electrical resistance (R). Used in specific conductance measurement. A siemen (or umho) is the standard unit of electrical conductance, the inverse of the ohm.

Oxidation-Reduction Potential (ORP) - A measure of the activity ratio of oxidizing and reducing species as determined by the electromotive force developed by a noble metal electrode, immersed in water, as referenced against a standard hydrogen electrode.

pH - The negative logarithm (base 10) of the hydrogen ion activity. The hydrogen ion activity is related to the hydrogen ion concentration, and, in a relatively weak solution, the two are nearly equal. Thus, for all practical purposes, pH is a measure of the hydrogen ion concentration.

pH Paper - Indicator paper that turns different colors depending on the pH of the solution to which it is exposed. Comparison with color standards supplied by the manufacturer will then give an indication of the solution's pH.

Resistance - A measure of the solution's ability to oppose the passage of electrical current. For metals and solutions, resistance is defined by Ohm's Law, $E = IR$, where E is the potential difference, I is the current, and R is the resistance. Used in measurement of specific conductance.

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4.0 RESPONSIBILITIES

Project Hydrogeologist - Responsible for selecting and detailing the specific groundwater sampling techniques, onsite water quality testing (type, frequency, and location), and equipment to be used, and providing detailed input in this regard to the project plan documents. The project hydrogeologist is also responsible for properly briefing and overseeing the performance of the site sampling personnel.

Project Geologist - is primarily responsible for the proper acquisition of the groundwater samples. He/she is also responsible for the actual analyses of onsite water quality samples, as well as instrument calibration, care, and maintenance. When appropriate, such responsibilities may be performed by other qualified personnel (e.g., field technicians).

5.0 PROCEDURES

5.1 General

To be useful and accurate, a groundwater sample must be representative of the particular zone of the water being sampled. The physical, chemical, and bacteriological integrity of the sample must be maintained from the time of sampling to the time of analysis in order to keep any changes in water quality parameters to a minimum.

Methods for withdrawing samples from completed wells include the use of pumps, compressed air, bailers, and various types of samplers. The primary considerations in obtaining a representative sample of the groundwater are to avoid collection of stagnant (standing) water in the well and to avoid physical or chemical alteration of the water due to sampling techniques. In a non-pumping well, there will be little or no vertical mixing of water in the well pipe or casing, and stratification will occur. The well water in the screened section will mix with the groundwater due to normal flow patterns, but the well water above the screened section will remain isolated and become stagnant. To safeguard against collecting non-representative stagnant water in a sample, the following approach shall be followed prior to sample acquisition:

1. All monitoring wells shall be purged prior to obtaining a sample. Evacuation of three to five volumes is recommended prior to sampling. In a high-yielding groundwater formation and where there is no stagnant water in the well above the screened section, extensive evacuation prior to sample withdrawal is not as critical.
2. For wells that can be purged dry, the well shall be evacuated and allowed to recover prior to sample acquisition. If the recovery rate is fairly rapid, evacuation of more than one volume of water is required.
3. For high-yielding monitoring wells which cannot be evacuated to dryness, there is no absolute safeguard against contaminating the sample with stagnant water. One of the following techniques shall be used to minimize this possibility:
 - A submersible pump or the intake line of a surface pump or bailer shall be placed just below the water surface when removing the stagnant water and lowered as the water level drops. Three to five volumes of water shall be removed to provide reasonable assurance that all stagnant water has been evacuated. Once this is accomplished, a bailer or other approved device may be used to collect the sample for analysis.

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- The intake line of the sampling pump (or the submersible pump itself) shall be placed near the bottom of the screened section, and approximately one casing volume of water shall be pumped from the well at a low purge rate, equal to the well's recovery rate (low flow sampling).

Stratification of contaminants may exist in the aquifer. Concentration gradients as a result of mixing and dispersion processes, layers of variable permeability, and the presence of separate-phase product (i.e., floating hydrocarbons) may cause stratification. Excessive pumping or improper sampling methods can dilute or increase the contaminant concentrations in the recovered sample compared to what is representative of the integrated water column as it naturally occurs at that point, thus the result is the collection of a non-representative sample.

5.2 Sampling, Monitoring, and Evacuation Equipment

Sample containers shall conform with the guidelines expressed in SOP SA-6.1.

The following equipment shall be on hand when sampling ground water wells (reference SOPs SA-6.1 and SA-7.1):

- Sample packaging and shipping equipment - Coolers for sample shipping and cooling, chemical preservatives, appropriate sampling containers and filler, ice, labels and chain-of-custody documents.
- Field tools and instrumentation - Thermometer, pH paper/meter, camera and film (if appropriate), appropriate keys (for locked wells), engineer's rule, water level indicator, specific conductivity meter, and turbidity meter (as applicable).
- Pumps
 - Shallow-well pumps: Centrifugal, pitcher, suction, or peristaltic pumps with droplines, air-lift apparatus (compressor and tubing) where applicable.
 - Deep-well pumps: Submersible pump and electrical power-generating unit, or air-lift apparatus where applicable.
- Other sampling equipment - Bailers and inert line with tripod-pulley assembly (if necessary). Bailers or submersible centrifugal pumps shall be used to obtain samples for volatile organics from shallow and deep groundwater wells.
- Pails - Plastic, graduated.
- Decontamination solutions - Deionized water, laboratory detergents, 10% nitric acid solution (as required), and analytical-grade solvents (e.g., methanol, acetone, hexane), as required.

Ideally, sample withdrawal equipment shall be completely inert, economical, easily cleaned, cleaned prior to use, reusable, able to operate at remote sites in the absence of power sources, and capable of delivering variable rates for well flushing and sample collection.

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5.3 Calculations of Well Volume

To insure that the proper volume of water has been removed from the well prior to sampling it is first necessary to know the volume of standing water in the well pipe. This volume can be easily calculated by the following method. Calculations shall be entered in the site logbook or field notebook or on a sample log sheet form (see SOP SA-6.3):

- Obtain all available information on well construction (location, casing, screens, etc.).
- Determine well or casing diameter.
- Measure and record static water level (depth below ground level or top of casing reference point).
- Determine depth of well by sounding using a clean, decontaminated, weighted tape measure.
- Calculate number of linear feet of static water (total depth or length of well pipe minus the depth to static water level).
- Calculate one static well volume in gallons $V = (0.163)(T)(r^2)$

where:

V	=	Static volume of well in gallons.
T	=	Thickness of water table in the well measured in feet (i.e., linear feet of static water).
r	=	Inside radius of well casing in inches.
0.163	=	A constant conversion factor which compensates for the conversion of the casing radius from inches to feet, the conversion of cubic feet to gallons, and pi.

- Per evacuation volumes discussed above, determine the minimum amount to be evacuated before sampling.

5.4 Evacuation of Static Water (Purging)

5.4.1 General

The amount of purging a well shall receive prior to sample collection will depend on the intent of the monitoring program and the hydrogeologic conditions. Programs to determine overall quality of water resources may require long pumping periods to obtain a sample that is representative of a large volume of that aquifer. The pumped volume may be specified prior to sampling so that the sample can be a composite of a known volume of the aquifer. Alternately the well can be pumped until the parameters such as temperature, electrical conductance, pH, and turbidity (as applicable), have stabilized. Onsite measurements of these parameters shall be recorded in the site logbook, field notebook, or on standardized data sheets.

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5.4.2 Evacuation Devices

The following discussion is limited to those devices commonly used at hazardous waste sites. Attachment A provides guidance on the proper evacuation device to use for given sampling situations. Note that all of these techniques involve equipment which is portable and readily available.

Bailers

Bailers are the simplest evacuation devices used and have many advantages. They generally consist of a length of pipe with a sealed bottom (bucket-type bailer) or, as is more useful and favored, with a ball check-valve at the bottom. An inert line is used to lower the bailer and retrieve the sample.

Advantages of bailers include:

- Few limitations on size and materials used for bailers.
- No external power source needed.
- Bailers are inexpensive, and can be dedicated and hung in a well to reduce the chances of cross-contamination.
- There is minimal outgassing of volatile organics while the sample is in the bailer.
- Bailers are relatively easy to decontaminate.

Limitations on the use of bailers include the following:

- It is time consuming to remove stagnant water using a bailer.
- Transfer of sample may cause aeration.
- Use of bailers is physically demanding, especially in warm temperatures at protection levels above Level D.

Suction Pumps

There are many different types of inexpensive suction pumps including centrifugal, diaphragm, peristaltic, and pitcher pumps. Centrifugal and diaphragm pumps can be used for well evacuation at a fast pumping rate and for sampling at a low pumping rate. The peristaltic pump is a low volume pump that uses rollers to squeeze a flexible tubing, thereby creating suction. This tubing can be dedicated to a well to prevent cross contamination. The pitcher pump is a common farm hand-pump.

These pumps are all portable, inexpensive and readily available. However, because they are based on suction, their use is restricted to areas with water levels within 20 to 25 feet of the ground surface. A significant limitation is that the vacuum created by these pumps can cause significant loss of dissolved gases and volatile organics.

Air-Lift Samplers

This group of pump samplers uses gas pressure either in the annulus of the well or in a venturi to force the water up a sampling tube. These pumps are also relatively inexpensive. Air (or gas)-lift samplers are more suitable for well development than for sampling because the samples may be aerated, leading to pH changes and subsequent trace metal precipitation, or loss of volatile organics.

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Submersible Pumps

Submersible pumps take in water and push the sample up a sample tube to the surface. The power sources for these samplers may be compressed gas or electricity. The operation principles vary and the displacement of the sample can be by an inflatable bladder, sliding piston, gas bubble, or impeller. Pumps are available for 2-inch-diameter wells and larger. These pumps can lift water from considerable depths (several hundred feet).

Limitations of this class of pumps include:

- They may have low delivery rates.
- Many models of these pumps are expensive.
- Compressed gas or electric power is needed.
- Sediment in water may cause clogging of the valves or eroding the impellers with some of these pumps.
- Decontamination of internal components can be difficult and time-consuming.

5.5 Onsite Water Quality Testing

This section describes the procedures and equipment required to measure the following parameters of an aqueous sample in the field:

- pH
- Specific Conductance
- Temperature
- Dissolved Oxygen (DO) Concentration
- Oxidation Reduction Potential
- Certain Dissolved Constituents Using Specific Ion Elements
- Turbidity

This section is applicable for use in an onsite groundwater quality monitoring program to be conducted at a hazardous or nonhazardous site. The procedures and equipment described are applicable to groundwater samples and are not, in general, subject to solution interferences from color, turbidity, and colloidal material or suspended matter.

This section provides general information for measuring the parameters listed above with instruments and techniques in common use. Since instruments from different manufacturers may vary, review of the manufacturer's literature pertaining to the use of a specific instrument is required before use.

5.5.1 Measurement of pH

5.5.1.1 General

Measurement of pH is one of the most important and frequently used tests in water chemistry. Practically every phase of water supply and wastewater treatment such as acid-base neutralization, water softening, and corrosion control is pH dependent. Likewise, the pH of leachate can be correlated with other chemical analyses to determine the probable source of contamination. It is therefore important that reasonably accurate pH measurements be taken.

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Two methods are given for pH measurement: the pH meter and pH indicator paper. The indicator paper is used when only a rough estimate of the pH is required, and the pH meter when a more accurate measurement is needed. The response of a pH meter can be affected to a slight degree by high levels of colloidal or suspended solids, but the effect is usually small and generally of little significance. Consequently, specific methods to overcome this interference are not described. The response of pH paper is unaffected by solution interferences from color, turbidity, colloidal or suspended materials unless extremely high levels capable of coating or masking the paper are encountered. In such cases, use of a pH meter is recommended.

5.5.1.2 Principles of Equipment Operation

Use of pH papers for pH measurement relies on a chemical reaction caused by the acidity or basicity of the solution created by the addition of the water sample reacting with the indicator compound on the paper. Various types of pH papers are available, including litmus (for general acidity or basicity determination) and specific pH range hydrion paper.

Use of a pH meter relies on the same principle as other ion-specific electrodes. Measurement relies on establishment of a potential difference across a glass or other type of membrane in response to (in this instance, hydrogen) ion concentration across that membrane. The membrane is conductive to ionic species and, in combination with a standard or reference electrode, a potential difference proportional to the ion concentration is generated and measured.

5.5.1.3 Equipment

The following equipment is needed for taking pH measurements:

- Stand-alone 150 portable pH meter, or combination meter (e.g., Horiba U-10), or combination meter equipped with an in-line sample chamber.
- Combination electrode with polymer body to fit the above meter (alternately a pH electrode and a reference electrode can be used if the pH meter is equipped with suitable electrode inputs).
- Buffer solutions, as specified by the manufacturer.
- pH indicator paper, to cover the pH range 2 through 12.
- Manufacturer's operation manual.

5.5.1.4 Measurement Techniques for Field Determination of pH

pH Meter

The following procedure is used for measuring pH with a pH meter (meter standardization is according to manufacturer's instructions):

- Inspect the instrument and batteries prior to initiation of the field effort.
- Check the integrity of the buffer solutions used for field calibration. Buffer solutions need to be changed often as a result of degradation upon exposure to the atmosphere.

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- Immerse the tip of the electrodes in water overnight. If this is not possible due to field conditions, immerse the electrode tip in water for at least an hour before use. The electrode tip may be immersed in a rubber or plastic sack containing buffer solution for field transport or storage. This is not applicable for all electrodes as some must be stored dry.
- If applicable, make sure all electrolyte solutions within the electrode(s) are at their proper levels and that no air bubbles are present within the electrode(s).
- Calibrate on a daily use basis following manufacturer's instructions. Record calibration data on an equipment calibration log sheet.
- Immerse the electrode(s) in the unknown solution, slowly stirring the probe until the pH stabilizes. Stabilization may take several seconds to minutes. If the pH continues to drift, the sample temperature may not be stable, a physical reaction (e.g., degassing) may be taking place in the sample, or the meter or electrode may be malfunctioning. This must be clearly noted in the logbook.
- Read and record the pH of the solution. pH shall be recorded to the nearest 0.1 pH unit. Also record the sample temperature.
- Rinse the electrode(s) with deionized water.
- Store the electrode(s) in an appropriate manner when not in use.

Any visual observation of conditions which may interfere with pH measurement, such as oily materials, or turbidity, shall be noted.

pH Paper

Use of pH paper is very simple and requires no sample preparation, standardization, etc. pH paper is available in several ranges, including wide-range (indicating approximately pH 1 to 12), mid-range (approximately pH 0 to 6, 6 to 9, 8 to 14) and narrow-range (many available, with ranges as narrow as 1.5 pH units). The appropriate range of pH paper shall be selected. If the pH is unknown the investigation shall start with wide-range paper and proceed with successively narrower range paper until the sample pH is adequately determined.

5.5.2 Measurement of Specific Conductance

5.5.2.1 General

Conductance provides a measure of dissolved ionic species in water and can be used to identify the direction and extent of migration of contaminants in groundwater or surface water. It can also be used as a measure of subsurface biodegradation or to indicate alternate sources of groundwater contamination.

Conductivity is a numerical expression of the ability of a water sample to carry an electric current. This value depends on the total concentration of the ionized substances dissolved in the water and the temperature at which the measurement is made. The mobility of each of the various dissolved ions, their valences, and their actual and relative concentrations affect conductivity.

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It is important to obtain a specific conductance measurement soon after taking a sample, since temperature changes, precipitation reactions, and absorption of carbon dioxide from the air all affect the specific conductance.

5.5.2.2 Principles of Equipment Operation

An aqueous system containing ions will conduct an electric current. In a direct-current field, the positive ions migrate toward the negative electrode, while the negatively charged ions migrate toward the positive electrode. Most inorganic acids, bases and salts (such as hydrochloric acid, sodium carbonate, or sodium chloride, respectively) are relatively good conductors. Conversely, organic compounds such as sucrose or benzene, which do not disassociate in aqueous solution, conduct a current very poorly, if at all.

A conductance cell and a Wheatstone Bridge (for the measurement of potential difference) may be used for measurement of electrical resistance. The ratio of current applied to voltage across the cell may also be used as a measure of conductance. The core element of the apparatus is the conductivity cell containing the solution of interest. Depending on ionic strength of the aqueous solution to be tested, a potential difference is developed across the cell which can be converted directly or indirectly (depending on instrument type) to a measurement of specific conductance.

5.5.2.3 Equipment

The following equipment is needed for taking specific conductance (SC) measurements:

- Stand alone portable conductivity meter, or combination meter (e.g., Horiba U-10), or combination meter equipped with an in-line sample chamber.
- Calibration solution, as specified by the manufacturer.
- Manufacturer's operation manual.

A variety of conductivity meters are available which may also be used to monitor salinity and temperatures. Probe types and cable lengths vary, so equipment must be obtained to meet the specific requirement of the sampling program.

5.5.2.4 Measurement Techniques for Specific Conductance

The steps involved in taking specific conductance measurements are listed below (standardization is according to manufacturer's instructions):

- Check batteries and calibrate instrument before going into the field.
- Calibrate on a daily use basis, according to the manufacturer's instructions and record all pertinent information on an equipment calibration log sheet. Potassium chloride solutions with a SC closest to the values expected in the field shall be used for calibration. Attachment B provides guidance in this regard.
- Rinse the cell with one or more portions of the sample to be tested or with deionized water.

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- Immerse the electrode in the sample and measure the conductivity. Adjust the temperature setting to the sample temperature (if applicable).
- Read and record the results in a field logbook or sample log sheet.
- Rinse the electrode with deionized water.

If the specific conductance measurements become erratic, recalibrate the instrument and see the manufacturer's instructions for details.

5.5.3 Measurement of Temperature

5.5.3.1 General

In combination with other parameters, temperature can be a useful indicator of the likelihood of biological action in a water sample. It can also be used to trace the flow direction of contaminated groundwater. Temperature measurements shall be taken in-situ, or as quickly as possible in the field. Collected water samples may rapidly equilibrate with the temperature of their surroundings.

5.5.3.2 Equipment

Temperature measurements may be taken with alcohol-toluene, mercury filled or dial-type thermometers. In addition, various meters such as specific conductance or dissolved oxygen meters, which have temperature measurement capabilities, may also be used. Using such instrumentation along with suitable probes and cables, in-situ measurements of temperature at great depths can be performed.

5.5.3.3 Measurement Techniques for Water Temperature

If a thermometer is used to determine the temperature for a water sample:

- Immerse the thermometer in the sample until temperature equilibrium is obtained (1-3 minutes). To avoid the possibility of cross-contamination, the thermometer shall not be inserted into samples which will undergo subsequent chemical analysis.
- Record values in a field logbook or sample log sheet.

If a temperature meter or probe is used, the instrument shall be calibrated according to manufacturer's recommendations.

5.5.4 Measurement of Dissolved Oxygen Concentration

5.5.4.1 General

Dissolved oxygen (DO) levels in natural water and wastewater depend on the physical, chemical and biochemical activities in the water body. Conversely, the growth of many aquatic organisms as well as the rate of corrosivity, are dependent on the dissolved oxygen concentration. Thus, analysis for dissolved oxygen is a key test in water pollution and waste treatment process control. If at all possible, DO measurements shall be taken in-situ, since concentration may show a large change in a short time if the sample is not adequately preserved.

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The monitoring method discussed herein is limited to the use of dissolved oxygen meters only. Chemical methods of analysis (i.e., Winkler methods) are available, but require more equipment and greater sample manipulation. Furthermore, DO meters, using a membrane electrode, are suitable for highly polluted waters, because the probe is completely submersible, and is not susceptible to interference caused by color, turbidity, colloidal material or suspended matter.

5.5.4.2 Principles of Equipment Operation

Dissolved oxygen probes are normally electrochemical cells that have two solid metal electrodes of different nobility immersed in an electrolyte. The electrolyte is retained by an oxygen-permeable membrane. The metal of highest nobility (the cathode) is positioned at the membrane. When a suitable potential exists between the two metals, reduction of oxygen to hydroxide ion (OH⁻) occurs at the cathode surface. An electrical current is developed that is directly proportional to the rate of arrival of oxygen molecules at the cathode.

Since the current produced in the probe is directly proportional to the rate of arrival of oxygen at the cathode, it is important that a fresh supply of sample always be in contact with the membrane. Otherwise, the oxygen in the aqueous layer along the membrane is quickly depleted and false low readings are obtained. It is therefore necessary to stir the sample (or the probe) constantly to maintain fresh solution near the membrane interface. Stirring, however, shall not be so vigorous that additional oxygen is introduced through the air-water interface at the sample surface. To avoid this possibility, some probes are equipped with stirrers to agitate the solution near the probe, while leaving the surface of the solution undisturbed.

Dissolved oxygen probes are relatively unaffected by interferences. Interferences that can occur are reactions with oxidizing gases (such as chlorine) or with gases such as hydrogen sulfide, which are not easily depolarized from the indicating electrode. If a gaseous interference is suspected, it shall be noted in the field log book and checked if possible. Temperature variations can also cause interference because probes exhibit temperature sensitivity. Automatic temperature compensation is normally provided by the manufacturer.

5.5.4.3 Equipment

The following equipment is needed to measure dissolved oxygen concentration:

- Stand alone portable dissolved oxygen meter, or combination meter (e.g., Horiba U-10), or combination meter equipped with an in-line sample chamber.
- Sufficient cable to allow the probe to contact the sample.
- Manufacturer's operation manual.

5.5.4.4 Measurement Techniques for Dissolved Oxygen Determination

Probes differ as to specifics of use. Follow the manufacturer's instructions to obtain an accurate reading. The following general steps shall be used to measure the dissolved oxygen concentration:

- The equipment shall be calibrated and have its batteries checked in the warehouse before going to the field.

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- The probe shall be conditioned in a water sample for as long a period as practical before use in the field. Long periods of dry storage followed by short periods of use in the field may result in inaccurate readings.
- The instrument shall be calibrated in the field according to manufacturer's recommendations or in a freshly air-saturated water sample of known temperature. Dissolved oxygen values for air-saturated water can be determined by consulting a table listing oxygen solubilities as a function of temperature and salinity (see Attachment C).
- Record all pertinent information on an equipment calibration sheet.
- Rinse the probe with deionized water.
- Immerse the probe in the sample. Be sure to provide for sufficient flow past the membrane by stirring the sample. Probes without stirrers placed in wells can be moved up and down.
- Record the dissolved oxygen content and temperature of the sample in a field logbook or sample log sheet.
- Rinse the probe with deionized water.
- Recalibrate the probe when the membrane is replaced, or as needed. Follow the manufacturer's instructions.

Note that in-situ placement of the probe is preferable, since sample handling is not involved. This however, may not always be practical. Be sure to record whether the liquid was analyzed in-situ, or if a sample was taken.

Special care shall be taken during sample collection to avoid turbulence which can lead to increased oxygen solubilization and positive test interferences.

5.5.5 Measurement of Oxidation-Reduction Potential

5.5.5.1 General

The oxidation-reduction potential (ORP) provides a measure of the tendency of organic or inorganic compounds to exist in an oxidized state. The ORP parameter therefore provides evidence of the likelihood of anaerobic degradation of biodegradable organics or the ratio of activities of oxidized to reduced species in the sample.

5.5.5.2 Principles of Equipment Operation

When an inert metal electrode, such as platinum, is immersed in a solution, a potential is developed at that electrode depending on the ions present in the solution. If a reference electrode is placed in the same solution, an ORP electrode pair is established. This electrode pair allows the potential difference between the two electrodes to be measured and is dependent on the concentration of the ions in solution. By this measurement, the ability to oxidize or reduce species in solution may be determined. Supplemental measurements, such as dissolved oxygen, may be correlated with ORP to provide a knowledge of the quality of the solution, water, or wastewater.

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5.5.5.3 Equipment

The following equipment is needed for measuring the oxidation-reduction potential of a solution:

- Portable pH meter or equivalent, with a millivolt scale.
- Platinum electrode to fit above pH meter.
- Reference electrode such as a calomel, silver-silver chloride, or equivalent.
- Reference solution as specified by the manufacturer.
- Manufacturer's operation manual.

5.5.5.4 Measurement Techniques for Oxidation-Reduction Potential

The following procedure is used for measuring oxidation-reduction potential:

- The equipment shall be calibrated and have its batteries checked before going to the field.
- Check that the platinum probe is clean and that the platinum bond or tip is unoxidized. If dirty, polish with emery paper or, if necessary, clean the electrode using aqua regia, nitric acid, or chromic acid, in accordance with manufacturer's instructions.
- Thoroughly rinse the electrode with deionized water.
- Verify the sensitivity of the electrodes by noting the change in millivolt reading when the pH of the test solution is altered. The ORP will increase when the pH of the test solution decreases and the ORP will decrease if the test solution pH is increased. Place the sample in a clean container and agitate the sample. Insert the electrodes and note the ORP drops sharply when the caustic is added (i.e., pH is raised) thus indicating the electrodes are sensitive and operating properly. If the ORP increases sharply when the caustic is added, the polarity is reversed and must be corrected in accordance with the manufacturer's instructions. If the ORP does not respond as above when the caustic is added, the electrodes shall be cleaned and the above procedure repeated.
- After the assembly has been checked for sensitivity, wash the electrodes with three changes of water or by means of a flowing stream of deionized water from a wash bottle. Place the sample in a clean container and insert the electrodes. Set temperature compensator throughout the measurement period. Read the millivolt potential of the solution, allowing sufficient time for the system to stabilize and reach temperature equilibrium. Measure successive portions of the sample until readings on two successive portions differ by no more than 10 mV. A system that is very slow to stabilize properly will not yield a meaningful ORP. Record all results in a field logbook or sample logsheet, including ORP (to nearest 10 mV), sample temperature and pH at the time of measurement.

5.5.6 Measurement of Turbidity

5.5.6.1 General

Turbidity in water is caused by suspended matter, such as clay, silt, finely divided organic and inorganic matter, soluble colored organic compounds, and microscopic organisms, including plankton. Turbidity is an expression of the optical property that causes light to be scattered and absorbed rather than transmitted in a straight line through the sample.

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It is important to obtain a turbidity reading immediately after taking a sample, since irreversible changes in turbidity may occur if the sample is stored too long.

5.5.6.2 Principles of Equipment Operation

Turbidity is measured by the Nephelometric Method. This method is based on a comparison of the intensity of light scattered by the sample under defined conditions with the intensity of light scattered by a standard reference suspension under the same conditions. The higher the scattered light intensity, the higher the turbidity.

Formazin polymer is used as the reference turbidity standard suspension because of its ease of preparation combined with a higher reproducibility of its light-scattering properties than clay or turbid natural water. The turbidity of a specified concentration of formazin suspension is defined as 40 nephelometric units. This same suspension has an approximate turbidity of 40 Jackson units when measured on the candle turbidimeter. Therefore, nephelometric turbidity units (NTU) based on the formazin preparation will approximate units derived from the candle turbidimeter but will not be identical to them.

5.5.6.3 Equipment

The following equipment is needed for turbidity measurement:

- Stand alone portable turbidity meter, or combination meter (e.g., Horiba U-10), or combination meter equipped with an in-line sample chamber.
- Calibration solution, as specified by the manufacturer.
- Manufacturer's operation manual.

5.5.6.4 Measurements Techniques for Specific Conductance

The steps involved in taking turbidity measurements are listed below (standardization is according to manufacturer's instructions):

- Check batteries and calibrate instrument before going into the field.
- Check the expiration date (etc.) of the solutions used for field calibration.
- Calibrate on a daily use basis, according to the manufacturer's instructions and record all pertinent information on an equipment calibration log sheet.
- Rinse the cell with one or more portions of the sample to be tested or with deionized water.
- Immerse the probe in the sample and measure the turbidity. The reading must be taken immediately as suspended solids will settle over time resulting in a lower, inaccurate turbidity reading.

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- Read and record the results in a field logbook or sample log sheet. Include a physical description of the sample, including color, qualitative estimate of turbidity, etc.
- Rinse the electrode with deionized water.

5.6 Sampling

5.6.1 **Sampling Plan**

The sampling approach consisting of the following, shall be developed as part of the project plan documents which are approved prior to beginning work in the field:

- Background and objectives of sampling.
- Brief description of area and waste characterization.
- Identification of sampling locations, with map or sketch, and applicable well construction data (well size, depth, screened interval, reference elevation).
- Intended number, sequence volumes, and types of samples. If the relative degrees of contamination between wells is unknown or insignificant, a sampling sequence which facilitates sampling logistics may be followed. Where some wells are known or strongly suspected of being highly contaminated, these shall be sampled last to reduce the risk of cross-contamination between wells as a result of the sampling procedures.
- Sample preservation requirements.
- Work schedule.
- List of team members.
- List of observers and contacts.
- Other information, such as the necessity for a warrant or permission of entry, requirement for split samples, access problems, location of keys, etc.

5.6.2 **Sampling Methods**

The collection of a groundwater sample consists of the following steps:

1. The site Health & Safety Officer (or designee) will first open the well cap and use volatile organic detection equipment (PID or FID) on the escaping gases at the well head to determine the need for respiratory protection.
2. When proper respiratory protection has been donned, sound the well for total depth and water level (using clean equipment) and record these data on a groundwater sampling log sheet (see SOP SA-6.3); then calculate the fluid volume in the well pipe (as previously described in this SOP).
3. Calculate well volume to be removed as stated in Section 5.3.

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4. Select the appropriate purging equipment (see Attachment A). If an electric submersible pump with packer is chosen, go to Step 10.
5. Lower the purging equipment or intake into the well to a short distance below the water level and begin water removal. Collect the purged water and dispose of it in an acceptable manner (as applicable). Lower the purging device, as required, to maintain submergence.
6. Measure the rate of discharge frequently. A graduated bucket and stopwatch are most commonly used; other techniques include use of pipe trajectory methods, weir boxes or flow meters.
7. Observe the peristaltic pump intake for degassing "bubbles." If bubbles are abundant and the intake is fully submerged, this pump is not suitable for collecting samples for volatile organics. Never collect volatile organics samples using a vacuum pump.
8. Purge a minimum of three to five casing volumes before sampling. In low-permeability strata (i.e., if the well is pumped to dryness), one volume will suffice. Purged water shall be collected in a designated container and disposed in an acceptable manner.
9. If sampling using a pump, lower the pump intake to midscreen (or the middle of the open section in uncased wells) and collect the sample. If sampling with a bailer, lower the bailer to the sampling level before filling.
10. (For pump and packer assembly only). Lower the assembly into the well so that the packer is positioned just above the screen or open section. Inflate the packer. Purge a volume equal to at least twice the screened interval (or unscreened open section volume below the packer) before sampling. Packers shall always be tested in a casing section above ground to determine proper inflation pressures for good sealing.
11. In the event that recovery time of the well is very slow (e.g., 24 hours or greater), sample collection can be delayed until the following day. If the well has been purged early in the morning, sufficient water may be standing in the well by the day's end to permit sample collection. If the well is incapable of producing a sufficient volume of sample at any time, take the largest quantity available and record this occurrence in the site logbook.
12. Fill sample containers (preserve and label as described in SOP SA-6.1).
13. Replace the well cap and lock as appropriate. Make sure the well is readily identifiable as the source of the samples.
14. Process sample containers as described in SOP SA-6.1.
15. Decontaminate equipment as described in SOP SA-7.1.

5.7 Low Flow Purging and Sampling

5.7.1 Scope & Application

Low flow purging and sampling techniques are sometimes required for groundwater sampling activities. The purpose of low flow purging and sampling is to collect groundwater samples that contain

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"representative" amounts of mobile organic and inorganic constituents in the vicinity of the selected open well interval, at near natural flow conditions. The minimum stress procedure emphasizes negligible water level drawdown and low pumping rates in order to collect samples with minimal alterations in water chemistry. This procedure is designed primarily to be used in wells with a casing diameter of 2 inches or more and a saturated screen, or open interval, length of ten feet or less. Samples obtained are suitable for analyses of common types of groundwater contaminants (volatile and semi-volatile organic compounds, pesticides, PCBs, metals and other inorganic ions [cyanide, chloride, sulfate, etc.]). This procedure is not designed to collect non-aqueous phase liquids samples from wells containing light or dense non-aqueous phase liquids (LNAPLs or DNAPLs), using the low flow pumps.

The procedure is flexible for various well construction types and groundwater yields. The goal of the procedure is to obtain a turbidity level of less than 5 NTU and to achieve a water level drawdown of less than 0.3 feet during purging and sampling. If these goals cannot be achieved, sample collection can take place provided the remaining criteria in this procedure are met.

5.7.2 Equipment

The following equipment is required (as applicable) for low flow purging and sampling:

- Adjustable rate, submersible pump (e.g., centrifugal or bladder pump constructed of stainless steel or Teflon). Peristaltic pumps may be used only for inorganic sample collection.
- Disposable clear plastic bottom filling bailers may be used to check for and obtain samples of LNAPLs or DNAPLs.
- Tubing - Teflon, Teflon lined polyethylene, polyethylene, PVC, tygon steel tubing can be used to collect samples for analysis, depending on the analyses to be performed and regulatory requirements.
- Water level measuring device, 0.01 foot accuracy, (electronic devices are preferred for tracking water level drawdown during all pumping operations).
- Flow measurement supplies.
- Interface probe, if needed.
- Power source (generator, nitrogen tank, etc.). If a gasoline generator is used, it must be located downwind and at a safe distance from the well so that the exhaust fumes do not contaminate the samples.
- Indicator parameter monitoring instruments - pH, turbidity, specific conductance, and temperature. Use of a flow-through cell is recommended. Optional Indicators - eH and dissolved oxygen, flow-through cell is required. Standards to perform field calibration of instruments.
- Decontamination supplies.
- Logbook(s), and other forms (e.g., well purging forms).
- Sample Bottles.

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- Sample preservation supplies (as required by the analytical methods).
- Sample tags or labels.
- Well construction data, location map, field data from last sampling event.
- Field Sampling Plan.
- PID or FID instrument for measuring VOCs (volatile organic compounds).

5.7.3 Purging and Sampling Procedure

Use a submersible pump to purge and sample monitoring wells which have a 2.0 inch or greater well casing diameter.

Measure and record the water level immediately prior to placing the pump in the well.

Lower pump, safety cable, tubing and electrical lines slowly into the well so that the pump intake is located at the center of the saturated screen length of the well. If possible keep the pump intake at least two feet above the bottom of the well, to minimize mobilization of sediment that may be present in the bottom of the well. Collection of turbid free water samples may be difficult if there is three feet or less of standing water in the well.

When starting the pump, slowly increase the pump speed until a discharge occurs. Check water level. Adjust pump speed to maintain little or no water level drawdown. The target drawdown should be less than 0.3 feet and it should stabilize. If the target of less than 0.3 feet cannot be achieved or maintained, the sampling is acceptable if remaining criteria in the procedure are met. Subsequent sampling rounds will probably have intake settings and extraction rates that are comparable to those used in the initial sampling rounds.

Monitor water level and pumping rate every three to five minutes (or as appropriate) during purging. Record pumping rate adjustments and depths to water. Pumping rates should, as needed, be reduced to the minimum capabilities of the pump (e.g., 0.1-0.2 l/min) to ensure stabilization of indicator parameters. Adjustments are best made in the first fifteen minutes of pumping in order to help minimize purging time. During initial pump start-up, drawdown may exceed the 0.3 feet target and then recover as pump flow adjustments are made (minimum purge volume calculations should utilize stabilized drawdown values, not the initial drawdown). If the recharge rate of the well is less than minimum capability of the pump do not allow the water level to fall to the intake level (if the static water level is above the screen, avoid lowering the water level into the screen). Shut off the pump if either of the above is about to occur and allow the water level to recover. Repeat the process until field indicator parameters stabilize and the minimum purge volume is removed. The minimum purge volume with negligible drawdown (0.3 feet or less) is two saturated screen length volumes. In situations where the drawdown is greater than 0.3 feet and has stabilized, the minimum purge volume is two-times the saturated screen volume plus the stabilized drawdown volume. After the minimum purge volume is attained (and field parameters have stabilized) begin sampling. For low yields wells, commence sampling as soon as the well has recovered sufficiently to collect the appropriate volume for all anticipated samples.

During well purging, monitor field indicator parameters (turbidity, temperature, specific conductance, pH, etc.) every three to five minutes (or as appropriate). Purging is complete and sampling may begin when

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all field indicator parameters have stabilized (variations in values are within ten percent of each other, pH +/- 0.2 units, for three consecutive readings taken at three to five minute intervals). If the parameters have stabilized, but turbidity remains above 5 NTU goal, decrease pump flow rate, and continue measurement of parameters every three to five minutes. If pumping rate cannot be decreased any further and stabilized turbidity values remain above 5 NTU goal record this information. Measurements of field parameters should be obtained (as per Section 5.5) and recorded.

VOC samples are preferably collected first and directly into pre-preserved sample containers. Fill all sample containers by allowing the pump discharge to flow gently down the inside of the container with minimal turbulence.

If the water column in the pump tubing collapses (water does not completely fill the tubing) before exiting the tubing, use one of the following procedures to collect VOC samples: (1) Collect the non-VOCs samples first, then increase the flow rate incrementally until the water column completely fills the tubing, collect the sample and record the new flow rate; (2) reduce the diameter of the existing tubing until the water column fills the tubing either by adding a connector (Teflon or stainless steel), or clamp which should reduce the flow rate by constricting the end of the tubing; (3) insert a narrow diameter Teflon tube into the pump's tubing so that the end of the tubing is in the water column and the other end of the tubing protrudes beyond the pump's tubing, collect sample from the narrow diameter tubing.

Prepare samples for shipping as per SOP SA-6.1.

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ATTACHMENT A

PURGING EQUIPMENT SELECTION

Diameter Casing		Bailer	Peristaltic Pump	Vacuum Pump	Air-lift	Diaphragm "Trash" Pump	Submersible Diaphragm Pump	Submersible Electric Pump	Submersible Electric Pump w/Packer
1.25-Inch	Water level < 25 feet		X	X	X	X			
	Water Level > 25 feet				X				
2-Inch	Water level < 25 feet	X	X	X	X	X	X		
	Water Level > 25 feet	X			X		X		
4-Inch	Water level < 25 feet	X	X	X	X	X	X	X	X
	Water Level > 25 feet	X			X		X	X	X
6-Inch	Water level < 25 feet				X	X		X	X
	Water Level > 25 feet				X			X	X
8-Inch	Water level < 25 feet				X	X		X	X
	Water Level > 25 feet				X			X	X

**ATTACHMENT A
PURGING EQUIPMENT SELECTION
PAGE 2**

Manufacturer	Model Name/Number	Principle of Operation	Maximum Outside Diameter/Length (Inches)	Construction Materials (w/Lines and Tubing)	Lift Range (ft)	Delivery Rates or Volumes	1982 Price (Dollars)	Comments
BarCad Systems, Inc.	BarCad Sampler	Dedicated; gas drive (positive displacement)	1.5/16	PE, brass, nylon, aluminum oxide	0-150 with std. tubing	1 liter for each 10-15 feet of submergence	\$220-350	Requires compressed gas; custom sizes and materials available; acts as piezometer.
Cole-Parmer Inst. Co.	Master Flex 7570 Portable Sampling Pump	Portable; peristaltic (suction)	< 1.0/NA	(not submersible) Tygon [®] , silicone Viton [®]	0-30	670 mL/min with 7015-20 pump head	\$500-600	AC/DC; variable speed control available; other models may have different flow rates.
ECO Pump Corp.	SAMPLifier	Portable; venturi	< 1.5 or < 2.0/NA	PP, PE, PVC, SS, Teflon [®] , Tefzel [®]	0-100	0-500 mL/min depending on lift	\$400-700	AC, DC, or gasoline-driven motors available; must be primed.
Geltek Corp.	Bailer 219-4	Portable; grab (positive displacement)	1.66/38	Teflon [®]	No limit	1,075 mL	\$120-135	Other sizes available.
GeoEngineering, Inc.	GEO-MONITOR	Dedicated; gas drive (positive displacement)	1.5/16	PE, PP, PVC, Viton [®]	Probably 0-150	Approximately 1 liter for each 10 feet of submergence	\$185	Acts as piezometer; requires compressed gas.
Industrial and Environmental Analysts, Inc. (IEA)	Aquarius	Portable; bladder (positive displacement)	1.75/43	SS, Teflon [®] , Viton [®]	0-250	0-2,800 mL/min	\$1,500-3,000	Requires compressed gas; other models available; AC, DC, manual operation possible.
IEA	Syringe Sampler	Portable; grab (positive displacement)	1.75/43	SS, Teflon [®]	No limit	850 mL sample volume	\$1,100	Requires vacuum and/or pressure from hand pump.
Instrument Specialties Co. (ISCO)	Model 2600 Well Sampler	Portable; bladder (positive displacement)	1.75/50	PC, silicone, Teflon [®] , PP, PE, Dextrin [®] , acetal	0-150	0-7,500 mL/min	\$990	Requires compressed gas (40 psi minimum).
Keck Geophysical Instruments, Inc.	SP-81 Submersible Sampling Pump	Portable; helical rotor (positive displacement)	1.75/25	SS, Teflon [®] , PP, EPDM, Viton [®]	0-160	0-4,500 mL/min	\$3,500	DC operated.
Leonard Mold and Die Works, Inc.	GeoFilter Small Diameter Well Pump (#0500)	Portable; bladder (positive displacement)	1.75/38	SS, Teflon [®] , PC, Neoprene [®]	0-400	0-3,500 mL/min	\$1,400-1,500	Requires compressed gas (55 psi minimum); pneumatic or AC/DC control module.
Oil Recovery Systems, Inc.	Surface Sampler	Portable; grab (positive displacement)	1.75/12	acrylic, Dextrin [®]	No limit	Approximately 250 mL	\$125-160	Other materials and models available; for measuring thickness of "floating" contaminants.
Q.E.D. Environmental Systems, Inc.	Well Wizard [®] Monitoring System (P-100)	Dedicated; bladder (positive displacement)	1.66/36	PVC	0-230	0-2,000 mL/min	\$300-400	Requires compressed gas; piezometric level indicator; other materials available.

**ATTACHMENT A
PURGING EQUIPMENT SELECTION
PAGE 3**

Manufacturer	Model Name/Number	Principle of Operation	Maximum Outside Diameter/Length (Inches)	Construction Materials (w/Lines and Tubing)	Lift Range (ft)	Delivery Rates or Volumes	1982 Price (Dollars)	Comments
Randolph Austin Co.	Model 500 Vari-Flow Pump	Portable; peristaltic (suction)	<0.5/NA	(Not submersible) Rubber, Tygon®, or Neoprene®	0-30	See comments	\$1,200-1,300	Flow rate dependent on motor and tubing selected; AC operated; other models available.
Robert Bennett Co.	Model 180	Portable; piston (positive displacement)	1.8/22	SS, Teflon®, Delrin® PP, Viton®, acrylic, PE	0-500	0-1,800 mL/min	\$2,600-2,700	Requires compressed gas; water level indicator and flow meter; custom models available.
Slope Indicator Co. (SINCO)	Model 514124 Pneumatic Water Sampler	Portable; gas drive (positive displacement)	1.9/18	PVC, nylon	0-1,100	250 mL/flushing cycle	\$250-350	Requires compressed gas; SS available; piezometer model available; dedicated model available.
Solinst Canada Ltd.	5W Water Sampler	Portable; grab (positive displacement)	1.9/27	PVC, brass, nylon, Neoprene*	0-330	500 mL	\$1,300-1,800	Requires compressed gas; custom models available.
TIMCO Mfg. Co., Inc.	Std. Bailer	Portable; grab (positive displacement)	1.66/Custom	PVC, PP	No limit	250 mL/ft of bailer	\$20-60	Other sizes, materials, models available; optional bottom-emptying device available; no solvents used.
TIMCO	Air or Gas Lift Sampler	Portable; gas drive (positive displacement)	1.66/30	PVC, Tygon®, Teflon®	0-150	350 mL/flushing cycle	\$100-200	Requires compressed gas; other sizes, materials, models available; no solvents used.
Tole Devices Co.	Sampling Pump	Portable; bladder (positive displacement)	1.38/48	SS, silicone, Delrin®, Tygon®	0-125	0-4,000 mL/min	\$800-1,000	Compressed gas required; DC control module; custom built.

Construction Material Abbreviations:

PE Polyethylene
 PP Polypropylene
 PVC Polyvinyl chloride
 SS Stainless steel
 PC Polycarbonate
 EPDM Ethylene-propylene diene (synthetic rubber)

Other Abbreviations:

NA Not applicable
 AC Alternating current
 DC Direct current

NOTE: Other manufacturers market pumping devices which could be used for groundwater sampling, though not expressly designed for this purpose. The list is not meant to be all-inclusive and listing does not constitute endorsement for use. Information in the table is from sales literature and/or personal communication. No skimmer, scavenger-type, or high-capacity pumps are included.

Source: Barcelona et al., 1983.

**GROUNDWATER SAMPLE
ACQUISITION AND ONSITE WATER
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ATTACHMENT B

**SPECIFIC CONDUCTANCE OF 1 MOLAR KCl
AT VARIOUS TEMPERATURES¹**

Temperature (°C)	Specific Conductance (umhos/cm)
15	1,147
16	1,173
17	1,199
18	1,225
19	1,251
20	1,278
21	1,305
22	1,332
23	1,359
24	1,368
25	1,413
26	1,441
27	1,468
28	1,496
29	1,524
30	1,552

¹ Data derived from the International Critical Tables 1-3-8.

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ATTACHMENT C

**VARIATION OF DISSOLVED OXYGEN CONCENTRATION IN WATER
AS A FUNCTION OF TEMPERATURE AND SALINITY**

Temperature (°C)	Dissolved Oxygen (mg/L)					
	Chloride Concentration in Water					Difference/ 100 mg Chloride
	0	5,000	10,000	15,000	20,000	
0	14.6	13.8	13.0	12.1	11.3	0.017
1	14.2	13.4	12.6	11.8	11.0	0.016
2	13.8	13.1	12.3	11.5	10.8	0.015
3	13.5	12.7	12.0	11.2	10.5	0.015
4	13.1	12.4	11.7	11.0	10.3	0.014
5	12.8	12.1	11.4	10.7	10.0	0.014
6	12.5	11.8	11.1	10.5	9.8	0.014
7	12.2	11.5	10.9	10.2	9.6	0.013
8	11.9	11.2	10.6	10.0	9.4	0.013
9	11.6	11.0	10.4	9.8	9.2	0.012
10	11.3	10.7	10.1	9.6	9.0	0.012
11	11.1	10.5	9.9	9.4	8.8	0.011
12	10.8	10.3	9.7	9.2	8.6	0.011
13	10.6	10.1	9.5	9.0	8.5	0.011
14	10.4	9.9	9.3	8.8	8.3	0.010
15	10.2	9.7	9.1	8.6	8.1	0.010
16	10.0	9.5	9.0	8.5	8.0	0.010
17	9.7	9.3	8.8	8.3	7.8	0.010
18	9.5	9.1	8.6	8.2	7.7	0.009
19	9.4	8.9	8.5	8.0	7.6	0.009
20	9.2	8.7	8.3	7.9	7.4	0.009
21	9.0	8.6	8.1	7.7	7.3	0.009
22	8.8	8.4	8.0	7.6	7.1	0.008
23	8.7	8.3	7.9	7.4	7.0	0.008
24	8.5	8.1	7.7	7.3	6.9	0.008
25	8.4	8.0	7.6	7.2	6.7	0.008

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**ATTACHMENT C
 VARIATION OF DISSOLVED OXYGEN CONCENTRATION IN WATER
 AS A FUNCTION OF TEMPERATURE AND SALINITY
 PAGE TWO**

Temperature (°C)	Dissolved Oxygen (mg/L)						Difference/ 100 mg Chloride
	Chloride Concentration in Water						
	0	5,000	10,000	15,000	20,000		
26	8.2	7.8	7.4	7.0	6.6	0.008	
27	8.1	7.7	7.3	6.9	6.5	0.008	
28	7.9	7.5	7.1	6.8	6.4	0.008	
29	7.8	7.4	7.0	6.6	6.3	0.008	
30	7.6	7.3	6.9	6.5	6.1	0.008	
31	7.5						
32	7.4						
33	7.3						
34	7.2						
35	7.1						
36	7.0						
37	6.9						
38	6.8						
39	6.7						
40	6.6						
41	6.5						
42	6.4						
43	6.3						
44	6.2						
45	6.1						
46	6.0						
47	5.9						
48	5.8						
49	5.7						
50	5.6						

Note: In a chloride solution, conductivity can be roughly related to chloride concentration (and therefore, used to correct measured D.O. concentration) using Attachment B.



BROWN & ROOT ENVIRONMENTAL

STANDARD OPERATING PROCEDURES

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Applicability B&R Environmental, NE	
Prepared Earth Sciences Department	
Approved D. Senovich <i>[Signature]</i>	

Subject
SOIL SAMPLING

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1.0 PURPOSE

This procedure discusses the methods used to collect surface, near surface, and subsurface soil samples. Additionally, it describes the method for sampling of test pits and trenches to determine subsurface soil and rock conditions, and recover small-volume or bulk samples.

2.0 SCOPE

This procedure is applicable to the collection of surface, near surface and subsurface soils for laboratory testing, which are exposed through hand digging, hand augering, drilling, or machine excavating at hazardous substance sites.

3.0 GLOSSARY

Composite Sample - A composite sample exists as a combination of more than one sample at various locations and/or depths and times, which is homogenized and treated as one sample. This type of sample is usually collected when determination of an average waste concentration for a specific area is required. Composite samples are not to be collected for volatile organics analysis.

Grab Sample - One sample collected at one location and at one specific time.

Non-Volatile Sample - A non-volatile sample includes all other chemical parameters (e.g., semivolatiles, pesticides/PCBs, metals, etc.) and those engineering parameters that do not require undisturbed soil for their analysis.

Hand Auger - A sampling device used to extract soil from the ground in a relatively undisturbed form.

Thin-Walled Tube Sampler - A thin-walled metal tube (also called a Shelby tube) used to recover relatively undisturbed soil samples. These tubes are available in various sizes, ranging from 2 to 5 inches outside diameter (OD) and from 18 to 54 inches in length.

Split-Barrel Sampler - A steel tube, split in half lengthwise, with the halves held together by threaded collars at either end of the tube. Also called a split-spoon sampler, this device can be driven into resistant materials using a drive weight mounted in the drilling string. A standard split-barrel sampler is typically available in two common lengths, providing either 20-inch or 26-inch longitudinal clearance for obtaining 18-inch or 24-inch-long samples, respectively. These split-barrel samplers commonly range in size from 2-inch OD to 3-1/2 inch OD. The larger sizes are commonly used when a larger volume of sample material is required.

Test Pit and Trench - Open, shallow excavations, typically rectangular (if a test pit) or longitudinal (if a trench), excavated to determine the shallow subsurface conditions for engineering, geological, and soil chemistry exploration and/or sampling purposes. These pits are excavated manually or by machine (e.g., backhoe, clamshell, trencher excavator, or bulldozer).

4.0 RESPONSIBILITIES

Project Manager - The Project Manager is responsible for determining sampling objectives, as well as, the field procedures used in the collection of soil samples. Additionally, in consultation with other project personnel (geologist, hydrogeologist, etc.), the Project Manager establishes the need for test pits or trenches, and determines their approximate locations and dimensions.

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Site Safety Officer (SSO) - The SSO (or a qualified designee) is responsible for air quality monitoring during sampling, boring and excavation activities, to ensure that workers and offsite (downwind) individuals are not exposed to hazardous levels of airborne contaminants. The SSO/designee may also be required to advise the FOL on other safety-related matters regarding boring, excavation and sampling, such as mitigative measures to address potential hazards from unstable trench walls, puncturing of drums or other hazardous objects, etc.

Field Operations Leader (FOL) - The FOL is responsible for finalizing the location of surface, near surface, and subsurface (hand and machine borings, test pits/trenches) soil samples. He/she is ultimately responsible for the sampling and backfilling of boreholes, test pits and trenches, and for adherence to OSHA regulations during these operations.

Project Geologist/Sampler - The project geologist/sampler is responsible for the proper acquisition of soil samples and the completion of all required paperwork (i.e., sample log sheets, field notebook, boring logs, test pit logs, container labels, custody seals, and chain-of-custodies).

5.0 PROCEDURES

5.1 Overview

Soil sampling is an important adjunct to groundwater monitoring. Sampling of the soil horizons above the groundwater table can detect contaminants before they have migrated into the water table, and can establish the amount of contamination sorbed on aquifer solids that have the potential of contributing to groundwater contamination.

Soil types can vary considerably on a hazardous waste site. These variations, along with vegetation, can effect the rate of contaminant migration through the soil. It is important, therefore, that a detailed record be maintained during the sampling operations, particularly noting the location, depth, and such characteristics as grain size, color, and odor. Subsurface conditions are often stable on a daily basis and may demonstrate only slight seasonal variation especially with respect to temperature, available oxygen and light penetration. Changes in any of these conditions can radically alter the rate of chemical reactions or the associated microbiological community, thus further altering specific site conditions. As a result, samples must be kept at their at-depth temperature or lower, protected from direct light, sealed tightly in approved glass containers and be analyzed as soon as possible.

The physical properties of the soil, its grain size, cohesiveness, associated moisture, and such factors as depth to bedrock and water table, will limit the depth from which samples can be collected and the method required to collect them. Often this information on soil properties can be obtained from published soil surveys available through the U.S. Geological Surveys and other government or farm agencies. It is the intent of this procedure to present the most commonly employed soil sampling methods used at hazardous waste sites.

5.2 Soil Sample Collection

5.2.1 Procedure for Collecting Volatile Soil Samples

Volatile samples are only collected as grab samples and maintained and handled in as near an undisturbed state as possible. The sample is transferred directly into an approved glass container with a teflon lined cap. The sample must be packed down as much as possible to reduce air space within the sample container to an absolute minimum. Also, a properly filled volatile organics sample container will have no head space.

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5.2.2 Procedure for Collecting Non-Volatile Soil Samples

Non-volatile soil samples may be collected as either grab or composite samples. The non-volatile soil sample is thoroughly mixed in a stainless steel or disposable, inert plastic tray, using a stainless steel trowel or other approved tool, then transferred into the appropriate sample container(s). Head space is permitted in a non-volatile soil sample container to allow for sample expansion.

~~5.2.3 Procedure for Collecting Undisturbed Soil Samples (ASTM D1587-82)~~

~~When it is necessary to acquire undisturbed samples of soil for purposes of engineering parameter analysis (e.g., permeability), a thin-walled, seamless tube sampler (Shelby tube) will be employed. The following method will be used:~~

- ~~1. Remove all surface debris (e.g., vegetation, roots, twigs, etc.) from the specific sampling location and drill and clean out the borehole to the sampling depth, being careful to minimize the chance for disturbance of the material to be sampled. In saturated material, withdraw the drill bit slowly to prevent loosening of the soil around the borehole and to maintain the water level in the hole at or above groundwater level.~~
- ~~2. The use of bottom discharge bits or jetting through an open-tube sampler to clean out the borehole shall not be allowed. Use of any side-discharge bits is permitted.~~
- ~~3. A stationary piston-type sampler may be required to limit sample disturbance and aid in retaining the sample. Either the hydraulically operated or control rod activated-type of stationary piston sampler may be used. Prior to inserting the tube sampler into the borehole, check to ensure that the sampler head contains a check valve. The check valve is necessary to keep water in the rods from pushing the sample out the tube sampler during sample withdrawal and to maintain a suction within the tube to help retain the sample.~~
- ~~4. To minimize chemical reaction between the sample and the sampling tube, brass tubes may be required, especially if the tube is stored for an extended time prior to testing. While steel tubes coated with shellac are less expensive than brass, they're more reactive, and shall only be used when the sample will be tested within a few days after sampling or if chemical reaction is not anticipated. With the sampling tube resting on the bottom of the hole and the water level in the boring at groundwater level or above, push the tube into the soil by a continuous and rapid motion, without impacting or twisting. In no case shall the tube be pushed farther than the length provided for the soil sample. Allow about 3 inches in the tube for cuttings and sludge.~~
- ~~5. Upon removal of the sampling tube from the hole, measure the length of sample in the tube and also the length penetrated. Remove disturbed material in the upper end of the tube and measure the length of sample again. After removing at least an inch of soil from the lower end and after inserting an impervious disk, seal both ends of the tube with at least a 1/2-inch thickness of wax applied in a way that will prevent the wax from entering the sample. Clean filler must be placed in voids at either end of the tube prior to sealing with wax. Place plastic caps on the ends of the sample tube, tape the caps in place, and dip the ends in wax.~~
- ~~6. Affix label(s) to the tube as required and record sample number, depth, penetration, and recovery length on the label. Mark the "up" direction on the side of the tube with indelible ink, and mark the end of the sample. Complete Chain-of-Custody and other required forms (see SOP SA-5.3). Do not allow tubes to freeze, and store the samples vertically with the same orientation they had~~

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~~in the ground, (i.e., top of sample is up) in a cool place out of the sun at all times. Ship samples protected with suitable resilient packing material to reduce shock, vibration, and disturbance.~~

~~Thin-walled undisturbed tube samplers are restricted in their usage by the consistency of the soil to be sampled. Often, very loose and/or wet samples cannot be retrieved by the samplers, and soils with a consistency in excess of very stiff cannot be penetrated by the sampler. Devices such as Denison or Pitcher core samplers can be used to obtain undisturbed samples of stiff soils. Using these devices normally increases sampling costs, and therefore their use shall be weighed against the need for acquiring an undisturbed sample.~~

5.3 Surface Soil Sampling

The simplest, most direct method of collecting surface soil samples (most commonly collected to a depth of 6 inches) for subsequent analysis is by use of a stainless steel trowel.

In general, the following equipment is necessary for obtaining surface soil samples:

- Stainless steel trowel.
- Real-time air monitoring instrument (e.g., PID, FID, etc.).
- Latex gloves.
- Required Personal Protective Equipment (PPE).
- Required paperwork.
- Required decontamination equipment.
- Required sample container(s).
- Wooden stakes or pin flags.
- Sealable polyethylene bags (i.e., Ziploc baggies).
- Heavy duty cooler.
- Ice (if required) double-bagged in sealable polyethylene bags.
- Chain-of-custody records and custody seals.

When acquiring surface soil samples, the following procedure shall be used:

1. Carefully remove vegetation, roots, twigs, litter, etc., to expose an adequate soil surface area to accommodate sample volume requirements.
2. Using a decontaminated stainless steel trowel, follow the procedure cited in Section 5.2.1 for collecting a volatile soil sample.

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3. Thoroughly mix (in-situ) a sufficient amount of soil to fill the remaining sample containers and transfer the sample into those containers utilizing the same stainless steel trowel employed above. Cap and securely tighten all sample containers.
4. Affix a sample label to each container. Be sure to fill out each label carefully and clearly, addressing all the categories described in SOP SA-6.3.
5. Proceed with the handling and processing of each sample container as described in SOP SA-6.2.

5.4 Near-Surface Soil Sampling

Collection of samples from near the surface (depth of 6-18 inches) can be accomplished with tools such as shovels and stainless steel trowels.

The following equipment is necessary to collect near surface soil samples:

- Clean shovel.
- Plus the equipment listed under Section 5.3 of this procedure.

To obtain near-surface soil samples, the following protocol shall be observed:

1. With a clean shovel, make a series of vertical cuts to the depth required in the soil to form a square approximately 1 foot by 1 foot.
2. Lever out the formed plug and scrape the bottom of the freshly dug hole with a decontaminated stainless steel trowel to remove any loose soil.
3. Follow steps 2 through 10 listed under Section 5.3 of this procedure.

5.5 Subsurface Soil Sampling With a Hand Auger

A hand augering system generally consists of a variety of all stainless steel bucket bits (i.e., cylinders 6-1/2" long, and 2-3/4", 3-1/4", and 4" in diameter), a series of extension rods (available in 2', 3', 4' and 5' lengths), and a cross handle. A larger diameter bucket bit is commonly used to bore a hole to the desired sampling depth and then withdrawn. In turn, the larger diameter bit is replaced with a smaller diameter bit, lowered down the hole, and slowly turned into the soil at the completion depth (approximately 6"). The apparatus is then withdrawn and the soil sample collected.

The hand auger can be used in a wide variety of soil conditions. It can be used to sample soil both from the surface, or to depths in excess of 12 feet. However, the presence of rock layers and the collapse of the borehole normally contribute to its limiting factors.

To accomplish soil sampling using a hand augering system, the following equipment is required:

- Complete hand auger assembly (variety of bucket bit sizes).
- Stainless steel mixing bowls.
- Plus the equipment listed under Section 5.3 of this procedure.

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To obtain soil samples using a hand auger, the following procedure shall be followed:

1. Attach a properly decontaminated bucket bit to a clean extension rod and further attach the cross handle to the extension rod.
2. Clear the area to be sampled of any surface debris (vegetation, twigs, rocks, litter, etc.).
3. Begin augering (periodically removing accumulated soils from the bucket bit) and add additional rod extensions as necessary. Also, note (in a field notebook or on standardized data sheets) any changes in the color, texture or odor of the soil.
4. After reaching the desired depth, slowly and carefully withdraw the apparatus from the borehole.
5. Remove the soiled bucket bit from the rod extension and replace it with another properly decontaminated bucket bit. The bucket bit used for sampling is commonly smaller in diameter than the bucket bit employed to initiate the borehole.
6. Carefully lower the apparatus down the borehole. Care must be taken to avoid scraping the borehole sides.
7. Slowly turn the apparatus until the bucket bit is advanced approximately 6 inches.
8. Discard the top of the core (approximately 1"), which represents any loose material collected by the bucket bit before penetrating the sample material.
9. Fill volatile sample container(s), using a properly decontaminated stainless steel trowel, with sample material directly from the bucket bit. Refer to Section 5.2.1 of this procedure.
10. Utilizing the above trowel, remove the remaining sample material from the bucket bit and place into a properly decontaminated stainless steel mixing bowl and thoroughly homogenize the sample material prior to filling the remaining sample containers. Refer to Section 5.2.2 of this procedure.
11. Follow steps 4 through 10 listed under Section 5.3 of this procedure.

5.6 Subsurface Soil Sampling With a Split-Barrel Sampler (ASTM D1586-84)

Split-barrel (split-spoon) samplers consist of a heavy carbon steel or stainless steel sampling tube that can be split into two equal halves to reveal the soil sample (see Attachment A). A drive head is attached to the upper end of the tube and serves as a point of attachment for the drill rod. A removable tapered nosepiece/drive shoe attaches to the lower end of the tube and facilitates cutting. A basket-like sample retainer can be fitted to the lower end of the split tube to hold loose, dry soil samples in the tube when the sampler is removed from the drill hole. This split-barrel sampler is made to be attached to a drill rod and forced into the ground by means of a 140-lb. or larger casing driver.

Split-barrel samplers are used to collect soil samples from a wide variety of soil types and from depths greater than those attainable with other soil sampling equipment.

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The following equipment is used for obtaining split-barrel samples:

- Drilling equipment (provided by subcontractor).
- Split-barrel samplers (O.D. 2 inches, I.D. 1-3/8 inches, either 20 inches or 26 inches long); Larger O.D. samplers are available if a larger volume of sample is needed.
- Drive weight assembly, 140-lb. weight, driving head and guide permitting free fall of 30 inches.
- Stainless steel mixing bowls.
- Plus equipment listed under Section 5.3 of this procedure.

The following steps shall be followed to obtain split-barrel samples:

1. Remove the drive head and nosepiece, and open the sampler to reveal the soil sample. Immediately scan the sample core with a real-time air monitoring instrument (e.g., OVA, HNU, etc.). Carefully separate the soil core, with a decontaminated stainless steel knife or trowel, at about 6-inch intervals while scanning the center of the core for elevated readings. Also scan stained soil, soil lenses, and anomalies (if present), and record readings.
2. Collect the volatile sample from the center of the core where elevated readings occurred. If no elevated readings were encountered the sample material should still be collected from the core's center (this area represents the least disturbed area with minimal atmospheric contact). Refer to Section 5.2.1 of this procedure.
3. Using the same trowel, remove remaining sample material from the split-barrel sampler (except for the small portion of disturbed soil usually found at the top of the core sample) and place the soil into a decontaminated stainless steel mixing bowl. Thoroughly homogenize the sample material prior to filling the remaining sample containers. Refer to Section 5.2.2 of this procedure.
4. Follow steps 4 through 10 listed under Section 5.3.3 of this procedure.

~~5.7 Excavation and Sampling of Test Pits and Trenches~~

~~5.7.1 **Applicability**~~

~~This subsection presents routine test pit or trench excavation techniques and specialized techniques that are applicable under certain conditions.~~

~~During the excavation of trenches or pits at hazardous waste sites, several health and safety concerns arise which control the method of excavation. All excavations that are deeper than 4 feet must be stabilized (before entry into the excavation) by bracing the pit sides using wooden or steel support structures. Personnel entering the excavation may be exposed to toxic or explosive gases and oxygen-deficient environments. In these cases, substantial air monitoring is required before entry, and appropriate respiratory gear and protective clothing is mandatory. There must be at least two persons present at the immediate site before entry by one of the investigators. The reader shall refer to OSHA regulations 29 CFR 1926, 29 CFR 1910.120, and 29 CFR 1910.134.~~

Excavations are generally not practical where a depth of more than about 15 feet is desired, and they are usually limited to a few feet below the water table. In some cases, a pumping system may be required to control water levels within the pit, providing that pumped water can be adequately stored or disposed. If data on soils at depths greater than 15 feet are required, the data are usually obtained through test borings instead of test pits.

In addition, hazardous wastes may be brought to the surface by excavation equipment. This material, whether removed from the site or returned to the subsurface, must be properly handled according to any and all applicable federal, state, and local regulations.

5.7.2 Test Pit and Trench Excavation

These procedures describe the methods for excavating and logging test pits and trenches excavated to determine subsurface soil and rock conditions. Test pit operations shall be logged and documented as described in SOP SA-6.3.

Test pits and trenches may be excavated by hand or by power equipment to permit detailed description of the nature and contamination of the in-situ materials. The size of the excavation will depend primarily on the following:

- The purpose and extent of the exploration.
- The space required for efficient excavation.
- The chemicals of concern.
- The economics and efficiency of available equipment.

Test pits normally have a cross section that is 4 to 10 feet square; test trenches are usually 3 to 6 feet wide and may be extended for any length required to reveal conditions along a specific line. The following table, which is based on equipment efficiencies, gives a rough guide for design consideration:

Equipment	Typical Widths, in Feet
Trenching machine	2
Backhoe	2-6
Track dozer	10
Track loader	10
Excavator	10
Scraper	20

The lateral limits of excavation of trenches and the position of test pits shall be carefully marked on area base maps. If precise positioning is required to indicate the location of highly hazardous waste materials, nearby utilities, or dangerous conditions, the limits of the excavation shall be surveyed. Also, if precise determination of the depth of buried materials is needed for design or environmental assessment purposes, the elevation of the ground surface at the test pit or trench location shall also be determined by survey. If the test pit/trench will not be surveyed immediately, it shall be backfilled and its position identified with stakes placed in the ground at the margin of the excavation for later surveying.

The construction of test pits and trenches shall be planned and designed in advance as much as possible. However, field conditions may necessitate revisions to the initial plans. The final depth and construction method shall be determined by the field geologist. The actual layout of each test pit

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temporary staging area and spoils pile will be predicated based on site conditions and wind direction at the time the test pit is made. Prior to excavation, the area can be surveyed by magnetometer or metal detector to identify the presence of underground utilities or drums.

If the depth exceeds 4 feet and people will be entering the pit or trench, Occupational Safety and Health Administration (OSHA) requirements must be met (e.g., walls must be braced with wooden or steel braces, ladders must be in the hole at all times, and a temporary guardrail must be placed along the surface of the hole before entry. It is advisable to stay out of test pits as much as possible; if possible, the required data or samples shall be gathered without entering the pit. Samples of leachate, groundwater, or sidewall soils can be taken with telescoping poles, etc.

Dewatering may be required to assure the stability of the side walls, to prevent the bottom of the pit from heaving, and to keep the excavation dry. This is an important consideration for excavations in cohesionless material below the groundwater table. Liquids removed as a result of dewatering operations must be handled as potentially contaminated materials. Procedures for the collection and disposal of such materials should be discussed in the site-specific project plans.

5.7.3 Sampling in Test Pits and Trenches

5.7.3.1 General

Test pits and trenches are usually logged as they are excavated. Records of each test pit/trench will be made as described in SOP SA-6.3. These records include plan and profile sketches of the test pit/trench showing materials encountered, their depth and distribution in the pit/trench, and sample locations. These records also include safety and sample screening information.

Entry of test pits by personnel is extremely dangerous and shall be avoided unless absolutely necessary. Pits more than 4 feet deep must be shored prior to entry, the "buddy" system must be used, and all applicable Health and Safety and OSHA requirements must be followed.

The final depth and type of samples obtained from each test pit will be determined at the time the test pit is excavated. Sufficient samples are usually obtained and analyzed to quantify contaminant distribution as a function of depth for each test pit. Additional samples of each waste phase and any fluids encountered in each test pit may also be collected.

In some cases, samples of soil may be extracted from the test pit for reasons other than waste sampling and chemical analysis, for instance, to obtain geotechnical information. Such information would include soil types, stratigraphy, strength, etc., and could therefore entail the collection of disturbed (grab or bulk) or relatively undisturbed (hand-carved or pushed/driven) samples, which can be tested for geotechnical properties. The purposes of such explorations are very similar to those of shallow exploratory or test borings, but often test pits offer a faster, more cost-effective method of sampling than installing borings.

5.7.3.2 Sampling Equipment

The following equipment is needed for obtaining samples for chemical or geotechnical analysis from test pits and trenches:

- Backhoe or other excavating machinery.
- Shovels, picks and hand augers, stainless steel trowels.

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- Sample container - bucket with locking lid for large samples; appropriate bottleware for chemical or geotechnical analysis samples.
- Polyethylene bags for enclosing sample containers; buckets.
- Remote sampler consisting of 10-foot sections of steel conduit (1-inch-diameter), hose clamps and right angle adapter for conduit (see Attachment B).

5.7.3.3 Sampling Methods

The methods discussed in this section refer to test pit sampling from grade level. If test pit entry is required, see Section 5.7.3.4.

- Excavate trench or pit in several depth increments. After each increment, the operator will wait while the sampler inspects the test pit from grade level to decide if conditions are appropriate for sampling. (Monitoring of volatiles by the SSO will also be used to evaluate the need for sampling.) Practical depth increments range from 2 to 4 feet.

The backhoe operator, who will have the best view of the test pit, will immediately cease digging if:

- Any fluid phase or groundwater seepage is encountered in the test pit.
- Any drums, other potential waste containers, obstructions or utility lines are encountered.
- Distinct changes of material are encountered.

This action is necessary to permit proper sampling of the test pit and to prevent a breach of safety protocol. Depending upon the conditions encountered, it may be required to excavate more slowly and carefully with the backhoe.

For obtaining test pit samples from grade level, the following procedure shall be followed:

- Remove loose material to the greatest extent possible with backhoe.
- Secure walls of pit if necessary. (There is seldom any need to enter a pit or trench which would justify the expense of shoring the walls. All observations and samples can generally be taken from the ground surface.)
- Samples of the test pit material are to be obtained either directly from the backhoe bucket or from the material once it has been deposited on the ground. The sampler or Field Operations Leader directs the backhoe operator to remove material from the selected depth or location within the test pit/trench. The bucket is brought to the surface and moved away from the pit. The sampler and/or SSO then approaches the bucket and monitors its contents with a photoionization (HNU) or flame ionization (OVA) meter. The sample is collected from the center of the bucket or pile and placed in sample containers using a decontaminated stainless steel trowel or spatula.
- If a composite sample is desired, several depths or locations within the pit/trench are selected and a bucket is filled from each area. It is preferable to send individual sample bottles filled from each bucket to the laboratory for compositing under the more controlled laboratory conditions. However, if compositing in the field is required, each sample container

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shall be filled from materials that have been transferred into a mixing bucket and homogenized. Note that homogenization/compositing is not applicable for samples to be subjected to volatile organic analysis.

- Using the remote sampler shown in Attachment B, samples can be taken at the desired depth from the side wall or bottom of the pit. The face of the pit/trench shall first be scraped (using a long-handled shovel or hoe) to remove the smeared zone that has contacted the backhoe bucket. The sample shall then be collected directly into the sample jar, by scraping with the jar edge, eliminating the need to utilize samplers and minimizing the likelihood of cross-contamination. The sample jar is then capped, removed from the assembly, and packaged for shipment.
- Complete documentation as described in SOP SA-6.3.

5.7.3.4 In-Pit Sampling

Samples can also be obtained by personnel entering the test pit/trench. This is necessary when soil conditions preclude obtaining suitable samples from the backhoe bucket (e.g., excessive mixing of soils or wastes within the test pit/trench) or when samples from relatively small discrete zones within the test pit are required. This approach may also be necessary to sample any seepage occurring at discrete levels or zones in the test pit that are not accessible with remote samplers.

In general, personnel shall sample and log pits and trenches from the ground surface, except as provided for by the following criteria:

- The project will benefit significantly from the improved quality of the logging and sampling data obtained if personnel enter a pit or trench rather than conduct such operations from the ground surface.
- There is no practical alternative means of obtaining such data.
- The Site Safety Officer determines that such action can be accomplished without breaching site safety protocol. This determination will be based on actual monitoring of the pit/trench after it is dug (including, at a minimum, measurements of volatile organics, explosive gases and available oxygen).
- An experienced geotechnical professional determines that the pit/trench is stable or is made stable (by grading the sidewalls or using shoring) prior to entrance of any personnel. OSHA requirements (Reference 1) must be strictly implemented.

If these conditions are satisfied, one person will enter the pit/trench. On potentially hazardous waste sites, this individual will be dressed in safety gear as required by the conditions in the pit, usually Level B. He/she will be affixed to a safety rope and continuously monitored while in the pit.

A second individual will be fully dressed in protective clothing including a self-contained breathing device and on standby during all pit entry operations. The individual entering the pit will remain therein for as brief a period as practical, commensurate with performance of his/her work. After removing the smeared zone, samples shall be obtained with a decontaminated trowel or spoon. As an added precaution, it is advisable to keep the backhoe bucket in the test pit when personnel are working below grade. Such personnel can either stand in or near the bucket while performing sample operations. In the event of a

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cave-in they can either be lifted clear in the bucket, or at least climb up on the backhoe arm to reach safety.

5.7.3.5 Geotechnical Sampling

In addition to the equipment described in Section 5.7.3.2, the following equipment is needed for geotechnical sampling:

- Soil sampling equipment, similar to that used in shallow drilled boring (i.e., open tube samplers), which can be pushed or driven into the floor of the test pit.
- Suitable driving (i.e., a sledge hammer) or pushing (i.e., the backhoe bucket) equipment which is used to advance the sampler into the soil.
- Knives, spatulas, and other suitable devices for trimming hand-carved samples.
- Suitable containers (bags, jars, tubes, boxes, etc.), labels, wax, etc. for holding and safely transporting collected soil samples.
- Geotechnical equipment (pocket penetrometer, torvane, etc.) for field testing collected soil samples for classification and strength properties.

Disturbed grab or bulk geotechnical soil samples may be collected for most soils in the same manner as comparable soil samples for chemical analysis. These collected samples may be stored in jars or plastic-lined sacks (larger samples), which will preserve their moisture content. Smaller samples of this type are usually tested for their index properties to aid in soil identification and classification, while larger bulk samples are usually required to perform compaction tests.

Relatively undisturbed samples are usually extracted in cohesive soils using open tube samplers, and such samples are then tested in a geotechnical laboratory for their strength, permeability and/or compressibility. The techniques for extracting and preserving such samples are similar to those used in performing Shelby tube sampling in borings, except that the sampler is advanced by hand or backhoe, rather than by a drill rig. Also, the sampler may be extracted from the test pit by excavation around the sampler when it is difficult to pull it out of the ground. If this excavation requires entry of the test pit, the requirements described in Section 5.7.3.4 of this procedure must be followed. The open tube sampler shall be pushed or driven vertically into the floor or steps excavated in the test pit at the desired sampling elevations. Extracting tube samples horizontally from the walls of the test pit is not appropriate, because the sample will not have the correct orientation.

A sledge hammer or the backhoe may be used to drive or push the sampler or tube into the ground. Place a piece of wood over the top of the sampler or sampling tube to prevent damage during driving/pushing of the sample. Pushing the sampler with a constant thrust is always preferable to driving it with repeated blows, thus minimizing disturbance to the sample. If the sample cannot be extracted by rotating it at least two revolutions (to shear off the sample at the bottom), hand-excavate to remove the soil from around the sides of the sampler. If hand-excavation requires entry of the test pit, the requirements in Section 5.7.3.4 of this procedure must be followed. Prepare, label, pack and transport the sample in the required manner, as described in SOP SA-6.3.

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~~5.7.4 Backfilling of Trenches and Test Pits~~

~~Before backfilling, the onsite crew shall photograph all significant features exposed by the test pit and trench and shall include in the photograph a scale to show dimensions. Photographs of test pits shall be marked to include site number, test pit number, depth, description of feature, and date of photograph. In addition, a geologic description of each photograph shall be entered in the site logbook. All photographs shall be indexed and maintained as part of the project file for future reference.~~

~~After inspection, backfill material shall be returned to the pit under the direction of the FOL.~~

~~If a low permeability layer is penetrated (resulting in groundwater flow from an upper contaminated flow zone into a lower uncontaminated flow zone), backfill material must represent original conditions or be impermeable. Backfill could consist of a soil-bentonite mix prepared in a proportion specified by the FOL (representing a permeability equal to or less than original conditions). Backfill can be covered by "clean" soil and graded to the original land contour. Revegetation of the disturbed area may also be required.~~

5.8 Records

Either a single Sample Log Sheet (see Attachment C-1) or a multiple Sample Log Sheet (see Attachment C-2) must be completed by the site geologist/sampler. All soil sampling locations must be documented by tying in the location of two or more nearby permanent landmarks (building, telephone pole, fence, etc.) and shall be located on a single Sample Log Sheet, site map or field notebook. Surveying may also be necessary, depending on the project requirements. Composite samples must be recorded on the single Sample Log Sheet. Grab samples can be recorded on either the Single or Multiple Sample Log Sheets. However, if the Multiple Sample Log Sheet is used, a detailed map showing all soil sampling locations must be provided with the log sheet and must be referenced in the remarks section of the Multiple Sample Log Sheet.

Test pit logs shall contain a sketch of pit conditions (see Attachment D, Test Pit Log Form). In addition, at least one photograph with a scale for comparison shall be taken of each pit. Included in the photograph shall be a card showing the test pit number. Boreholes, test pits and trenches shall be logged by the field geologist in accordance with SOP GH-1.5. Other data to be recorded in the field logbook include the following:

- Name and location of job.
- Date of boring and excavation.
- Approximate surface elevation.
- Total depth of boring and excavation.
- Dimensions of pit.
- Method of sample acquisition.
- Type and size of samples.
- Soil and rock descriptions.
- Photographs.
- Groundwater levels.
- Organic gas or methane levels.
- Other pertinent information, such as waste material encountered.

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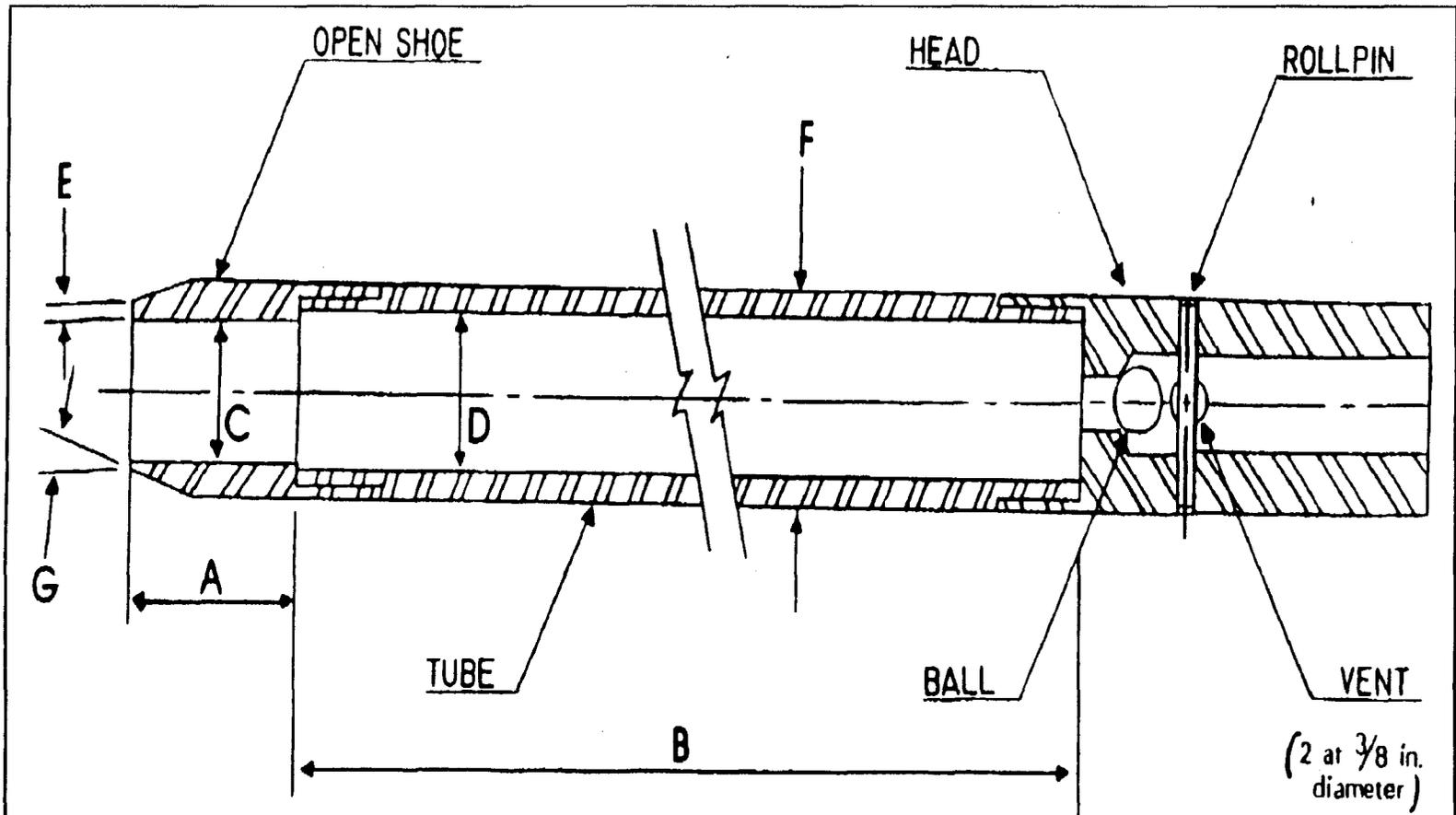
6.0 REFERENCES

American Society for Testing and Materials, 1987. ASTM Standards D1587-83 and D1586-84. ASTM Annual Book of Standards. ASTM. Philadelphia, Pennsylvania. Volume 4.08.

NUS Corporation, 1986. Hazardous Material Handling Training Manual.

NUS Corporation and CH2M Hill, August, 1987. Compendium of Field Operation Methods. Prepared for the U.S. EPA.

OSHA, 1979. Excavation, Trenching and Shoring 29 CFR 1926.650-653.



- 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 = $1.50 \pm 0.05 - 0.00$ in. ($38.1 \pm 1.3 - 0.0$ mm)
 E = 0.10 ± 0.02 in. (2.54 ± 0.25 mm)
 F = $2.00 \pm 0.05 - 0.00$ in. ($50.8 \pm 1.3 - 0.0$ 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.

ATTACHMENT A
SPLIT-SPOON SAMPLER

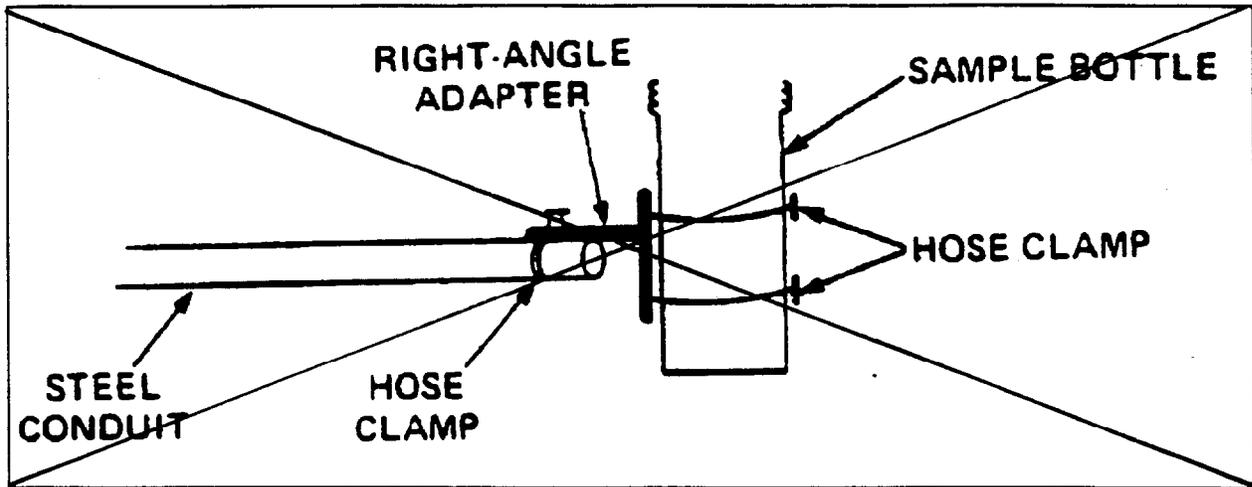
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**ATTACHMENT B
REMOTE SAMPLE HOLDER FOR TEST PIT/TRENCH SAMPLING**



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ATTACHMENT C-1
SINGLE SAMPLE LOG SHEET (SOIL)



SINGLE SAMPLE LOG SHEET

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Project Site Name: _____

Sample ID No.: _____

Project No.: _____

Sample Location: _____

- Surface Soil
- Subsurface Soil
- Sediment
- Other _____
- QA Sample Type: _____

Sampled By: _____

C.O.C. No.: _____

Sample Method:

Composite Sample Data

Sample	Time	Color/Description

Depth Sampled:

Sample Date and Time:

Type of Sample

- Grab
- Composite
- Grab-Composite
- High Concentration
- Low Concentration

Grab Sample Data

Color	Description: (Sand, Clay, Dry, Moist, Wet, etc.)

Analysis

Container Requirements

Collected (✓)

Map:

Observations/Notes:

Circle if Applicable:

Signature(s):

MS/MSD

Duplicate ID No:

**ATTACHMENT C-2
MULTIPLE SAMPLE LOG SHEET (SOIL)**

MULTIPLE SAMPLE LOG SHEET <input type="checkbox"/> SURFACE SOIL <input type="checkbox"/> LAGOON/POND <input type="checkbox"/> SUBSURFACE SOIL <input type="checkbox"/> OTHER <input type="checkbox"/> SEDIMENT		PAGE ___ OF ___ SAMPLER(S) SIGNATURE _____ AREA DESIGNATION _____
Brown & Root Environmental 		ANALYSES No. OF CONT. TOTAL SOIL DESCRIPTION
PROJECT NAME: _____ PROJECT NUMBER: _____	LAB: _____ CCC NO: _____	
Sample No. _____ SAMPLE METHOD _____ DEPTH (FT) _____ DATE _____ TIME _____ SAMPLED BY _____ CONCENTRATION (LOW (H)HIGH) _____ (G)GRAB (C)COMPOSITE _____	REMARKS: _____	ACAD. C:\100843\SAMPLOG.DWG 02/17/96 ID



BROWN & ROOT ENVIRONMENTAL

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Applicability B&R Environmental, NE	
Prepared Earth Sciences Department	
Approved D. Senovich	

Subject
AIR MONITORING AND SAMPLING

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1.0 PURPOSE

The objective of this Standard Operating Procedure is to specify the proper approach and methodologies to identify and quantify airborne chemical contamination levels through the use of direct reading instrumentation and air sample collection. The results of these activities provide vital information for site characterization and risk assessment considerations.

2.0 SCOPE

Applies to all Brown & Root Environmental site activities where the potential for personnel exposures to respiratory health hazards exists.

3.0 GLOSSARY

Direct Reading Instruments (DRIs) - Instrumentation operating on various detection principles such as flame ionization or photoionization providing real time readings of ambient contaminants in air.

Personal/Area Air Sampling - Personal/area air sampling is conducted utilizing an air sampling pump and a specific collection media to quantify airborne contaminants.

Meteorological Considerations - Meteorological information must be collected on site to properly determine air sampling results, as well as aid in the characterization of contaminant potential plume migration and intensity. This information will also be used to support the selection of sampling locations and determine which samples should be analyzed. The meteorological information will be used to estimate downwind concentration levels based on short-term field levels encountered at the source.

4.0 RESPONSIBILITIES

Project Manager (PM) - Responsible for all aspects of project implementation and direction. The project manager is responsible for providing the necessary resources in support of all air monitoring and sampling applications.

Field Operations Leader (FOL) - Responsible for implementing the air monitoring program as detailed in approved project plans for the specific site. Air monitoring requirements will be included in both the Field Sampling and Analysis Plan (FSAP) and the site-specific Health and Safety Plan (HASP).

Health and Safety Officer (HSO) - The health and safety officer provides technical assistance to the FOL concerning air monitoring and sampling applications, collection methodologies, data interpretations, and establishes action items based on results. This information is further used to assess atmospheric migration of airborne chemical contaminants.

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5.0 PROCEDURES

5.1 Introduction

Air monitoring is used to help establish criteria for worker safety, document potential exposures, and determine protective measures for the site personnel and the surrounding public. To accomplish this, it is necessary for an effective air surveillance program to be tailored to meet the conditions found at each work site.

During site operations, data are collected concerning air contaminants representative for site operations. Surveillance for vapors, gases, and particulates is performed using DRIs, air sampling systems, and meteorological considerations. DRIs can be used to detect many organics as well as a few inorganics and can provide approximate total concentrations through applications of relative response ratios of contaminants to reference standards. If specific chemicals (organics and inorganics) have been identified, then properly calibrated DRIs can be used for more accurate onsite assessments.

The most accurate method for evaluating any air contaminant is to collect samples and analyze them at a qualified laboratory. Although accurate, this method presents two disadvantages: (1) cost and (2) the time required to obtain results. Analyzing large numbers of laboratory samples can be expensive, especially if results are needed quickly. Onsite laboratories tend to reduce the turnaround time, but unless they can analyze other types of samples, they may also be costly. In emergencies, time is often not available for laboratory analysis of samples either on site or off site.

To obtain air monitoring data rapidly at the site, DRI utilizing flame ionization detectors (FIDs), photoionization detectors (PIDs), and other detection methodology can be used. Some of these may be used as survey instruments or operated as gas chromatographs. As gas chromatographs, these instruments can provide real-time, qualitative/quantitative data when calibrated with standards of known air contaminants. Combined with selective laboratory analysis of samples, they provide a tool for evaluating airborne organic hazards on a real-time basis and at a lower cost than analyzing samples in a laboratory.

5.2 Air Sampling

For more complete information about air contaminants, measurements obtained with DRIs can be supplemented by collecting and analyzing air samples. To assess air contaminants more thoroughly, air sampling devices equipped with appropriate collection media may be placed at various locations throughout the area and on persons within at-risk occupations. These samples provide air quality information for the period of time they are taken, and can indicate contaminant types and concentrations over the sampling period. As a result, careful selection of sampling types, numbers, and locations, by a qualified health and safety professional is essential to obtain representative information. As data is obtained (from the analysis of samples, DRIs, knowledge about materials involved, site operations, and the potential for airborne toxic hazards), adjustments can be in the types of samples, number of samples collected, frequency of sampling, and analysis required. In addition to air samplers, area monitoring stations may also include DRIs equipped with recorders and operated as continuous air monitors.

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Area air sampling locations may be located as required by project and site needs in various places including, but not limited to:

- Upwind - Because many hazardous incidents occur near industries or highways that generate air pollutants, samples may be taken upwind of the site to establish background levels.
- Support Zone (SZ) - Samples may be taken near the command post or other support facilities to ensure that they are, in fact, located in an unaffected area, and that the area remains clean throughout operations at the site.
- Contamination Reduction Zone (CRZ) - Air samples may be collected along the decontamination line to ensure that decontamination workers are properly protected and that onsite workers are not removing their respiratory protective gear in a contaminated area.
- Exclusion Zone (EZ) - The Exclusion Zone presents the greatest risk of release/generation of contaminants and requires the highest concern for air sampling. The location of sampling stations shall be based upon factors such as hot-spots detected by DRIs, types of substances present, and potential for airborne contaminants. The data from these stations, in conjunction with intermittent walk-around surveys with DRIs, are used to verify the selection of proper levels of worker protection and EZ boundaries as well as to provide a continual record of air contaminants.
- Downwind - One or more sampling stations may be located downwind from the site to indicate if any air contaminants are leaving the site. If there are indications of airborne hazards in populated areas, appropriate response action must be taken and additional samplers should be placed downwind. Downwind locations are further determined based on meteorological considerations concerning generation, air plume migration, and intensity.

5.3 Media for Collecting Air Samples

Hazardous material incidents and abandoned waste sites can involve thousands of potentially dangerous substances, such as gases, vapors, and particulates that could become airborne. A variety of media are used to collect these substances. Sampling systems typically include a calibrated air sampling pump, which draws air into selected collection media. It is essential that appropriate, approved air sampling methodologies (such as those published by NIOSH, OSHA, and EPA) be followed for the collection of each specific analyte. Some of the most common types of samples and the collection media used for them are described in the following information:

One of the most common types of collection media is activated carbon which is an excellent adsorbent for most organic vapors. However, other solid adsorbents (such as Tenax, silica gel, and Florisil) are routinely used to sample specific organic compounds or classes of compounds that do not adsorb or desorb well on activated carbon. To avoid stocking a large number of sorbents for all substances anticipated, a smaller number is generally chosen for collecting the widest range of materials or for substances known to be present. The vapors are collected using an industrial hygiene personal sampling pump with either one sampling port or a manifold capable of simultaneously collecting samples on several sorbent tubes (provided that sampling parameters such as flow rates and sample volumes are satisfied). For example, in a manifold with four sorbent tubes (or on individual pumps with varying flow rates), the tubes might contain:

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- Activated carbon to collect vapors of materials with a boiling point above zero degrees Centigrade. Common materials collected on activated carbon include organic vapors such as solvents, BTEX, and ketones.
- A porous polymer, such as Tenax or Chromosorb, to collect substances (such as high-molecular-weight hydrocarbons, organophosphorus compounds, and the vapors of certain pesticides) that adsorb poorly onto activated carbon. Some of these porous polymers also absorb organic materials at low ambient temperatures more efficiently than carbon.
- A polar sorbent, such as silica gel, to collect organic vapors (aromatic amines, for example) that exhibit a relatively high dipole moment.
- Another specialty absorbent selected for the specific site. For example, a Florisil tube could be used if polychlorinated biphenyls are expected.
- Liquid impingers - aldehydes, ketones, phosgene, phenols.
- Glass fiber filters, membrane filters, Teflon filters - Inorganics and other semivolatile compounds.
- Airborne particulates can be either solid or liquid. Examples of common particulate analytes include some metals, fibers such as asbestos, and condensed particulates such as welding fumes. Dusts, fumes, smoke, and fibers are dispersed solids; mists and fogs are dispersed liquids. For air sampling, most particulates are collected using glass fiber, mixed cellulose ester, or polyvinyl chloride filters, depending on the filter's ability to collect the subject material and its suitability for laboratory analysis. A cyclone is used to collect particles of respirable size. Atomic Absorption Spectrophotometry, Emission Spectroscopy, Phase Contrast Microscopy, and other techniques are used to analyze various types of particulates. Direct-reading monitors are also used to quantify particulate concentrations, and are usually based on the light-scattering properties of the particulate matter.

5.3.1 Other Methods

Colorimetric detector tubes can also be used with a sampling pump when monitoring for some specific compounds. Passive organic vapor monitors can be substituted for the active monitoring if they are available for the types of materials suspected to be present at a given site.

5.3.2 NIOSH Methods

The National Institute for Occupational Safety and Health's (NIOSH) Manual of Analytical Methods, 4th ed., contains acceptable methods for collecting and analyzing air samples for a variety of chemical substances. Consult these volumes for specific procedures.

5.4 Collection and Analysis

Collection and analysis of air samples is a multi-faceted task, and is part of the overall air surveillance program. The program is structured to cover the following air pathway analyses:

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5.4.1 Selecting Monitoring Constituents

Applications within this program are accomplished using two considerations:

- Air surveillance for specific constituents is based on quantity of the pollutant and the likelihood for vapor release or generation.
- Controlling toxicity - These substances, even when represented in limited quantities, present the greatest threat to the public or worker safety, and influence environmental impact.

5.4.2 Specifying Meteorological Considerations

The following factors will influence sample collection:

- Wind direction and speed
- Sigma theta (atmospheric stability)
- Temperature
- Barometric pressure
- Humidity

These factors will provide information essential to properly arrive at accurate air sampling concentration results. This information is also used to identify how airborne chemical contaminants will react for modeling and for monitoring purposes. The results will provide indicators of plume movement, intensity, and dilution.

5.4.3 Design of Monitoring Network

The air surveillance network is structured to consider:

- Source characteristics (physical state; vapor release and/or generation; emission rates; and disturbance of the source impacting these aspects)
- Receptor sites (receptor sites are monitored and tracked based on priority)
- Meteorological consideration
- Air modeling input
- Data quality objectives

5.4.4 Air Monitoring Documentation/Data Reduction

5.4.4.1 Air Monitoring Documentation

Elements of the air surveillance program are used to provide documentation valuable to safely performing/containing site activities.

Air monitoring results from DRIs must be recorded, such as on instrument results reporting forms, or in the field logbook. This information, where applicable, will be correlated to air sampling information if/when collected.

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Air sampling results for personnel and area measurement efforts must be validated, prior to notifying affected individuals. Personal air sampling results notification is accomplished through verbal or written communications.

Results of air monitoring/sampling activities can be identified on site maps. This information is used to structure operational zones and identify levels of protection.

5.4.4.2 Data Reduction

Data reduction combines and correlates the DRI results, air sampling results, and meteorological information to determine area and source airborne contaminant levels and movement.

All air sampling surveillance efforts must incorporate appropriate and approved NIOSH, OSHA, or EPA analytical methods. These procedures identify specific sample collection media, sampling methodologies, and analytical procedures. Sample analysis for health and safety considerations must be further supported by using American Industrial Hygiene Association accredited laboratories.

5.5 Personnel Monitoring

In addition to area atmospheric sampling, personnel monitoring -- both active and passive -- can be used to sample for air contaminants. Representative workers must be identified, and equipped with appropriate personal sampling systems to determine contaminants at specific locations or for specific work being performed. When sampling devices are placed on workers (generally within 1 foot of the mouth and nose) the results are used to indicate worker exposures.

5.6 Calibration

As a rule, the entire air sampling system shall be calibrated. Proper pre-and post-calibration activities are essential for correct operation and for accurate data. In some instances, additional calibration during the sampling period may be required. The overall frequency of calibration will depend upon the particular sampling event, including the general handling and use of a given sampling system. Pump mechanisms shall be calibrated after repair, when newly purchased, and following suspected abuse. All DRIs will be calibrated according to manufacturers instructions. All calibration activities for both air monitoring and sampling equipment must be properly documented, such as through the use of a calibration form. This form will be kept on site throughout the life of the project. The calibration log will be submitted as documentation that instrument calibration was performed on a regular basis.

5.7 Meteorological Considerations

Meteorological information is an integral part of an air surveillance program. Data concerning wind speed and direction, temperature, barometric pressure, and humidity (singularly or in combination) are needed for:

- Selecting air sampling locations
- Calculating accurate air sampling results
- Calculating air dispersion
- Calibrating instruments
- Determining population at risk or environmental exposure from airborne contaminants

Knowledge of wind speed and direction is necessary to effectively place air samplers. In source-oriented ambient air sampling, samplers need to be located downwind (at different distances) of the source and

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others need to be placed to collect background samples. Shifts in wind direction must be known. Consequently, the samplers must be relocated or corrections made for these shifts. In addition, atmospheric simulation models for predicting contaminant dispersion and concentration need windspeed and direction as inputs for predictive calculations. Information may be needed concerning the frequency and intensity that winds blow from certain directions (windrose data). Consequently, the wind direction must be continually monitored when use of this type of data is contemplated.

Air sampling systems need to be calibrated before use. This must include corrections in the calibration curves for actual temperatures and pressures during the sampling event. After sampling, collected air volumes are also mathematically corrected for temperature and pressure conditions.

Air sampling is sometimes designed to assess population exposure (and frequently potential worker exposure). Air samplers are generally located in population centers, irrespective of wind direction. Even in these instances, however, meteorological data is needed for air dispersion modeling. Models are then used to predict or verify population-oriented sampling results.

Proper data is collected by having meteorological stations on site or by obtaining the information from one or more of several government or private organizations, which routinely collect this data. The choice of how information is obtained depends on the availability of reliable data at the location desired, resources needed to obtain meteorological equipment, accuracy of information needed, and use of information.

The collection, handling, and analysis of air samples is an intricate, involved process. Appropriate methodologies, media, and equipment must be used to collect accurate data. Furthermore, selection of appropriate numbers, types, and locations of samples is essential if the data collected are to be used for personnel exposure criteria. For these reasons, air sampling activities must be coordinated and conducted by properly qualified and experienced industrial hygiene professionals. Air monitoring activities also need to be established and monitored carefully. However, as the proper use of these instruments is not as complicated as air sampling, it is commonly acceptable to cross-train capable environmental professionals to use DRIs, with adequate technical support provided by health and safety professionals.

6.0 REFERENCES

Standard Operating Safety Guides, EPA, November 1984.
NIOSH Manual of Analytical Methods, 4th Edition.

7.0 ATTACHMENTS

None.



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NON-RADIOLOGICAL SAMPLE HANDLING

Approved
D. Senovich *DS*

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1.0 PURPOSE

The purpose of this Standard Operating Procedure (SOP) is to provide information on sample preservation, packaging, and shipping procedures to be used in handling environmental samples submitted for chemical constituent, biological, or geotechnical analysis. Sample chain-of-custody procedures and other aspects of field documentation are addressed in SOP SA-6.3. Sample identification is addressed in SOP CT-04.

2.0 SCOPE

This procedure:

- Describes the appropriate containers to be used for samples depending on the analyses to be performed, and the steps necessary to preserve the samples when shipped off site for chemical analysis.
- Provides instruction for sample packaging and shipping in accordance with current U.S. Department of Transportation (DOT) regulations.

3.0 GLOSSARY

Hazardous Material - A substance or material which has been determined by the Secretary of Transportation to be capable of posing an unreasonable risk to health, safety, and property when transported in commerce, and which has been so designated. Under 49 CFR, the term includes hazardous substances, hazardous wastes, marine pollutants, and elevated temperature materials, as well as materials designated as hazardous under the provisions of §172.101 and §172.102 and materials that meet the defining criteria for hazard classes and divisions in Part 173.

Hazardous Waste - Any substance listed in 40 CFR, Subpart D (y261.30 et seq.), or otherwise characterized as ignitable, corrosive, reactive, or toxic (as defined by Toxicity Characteristic Leaching Procedure, TCLP, analysis) as specified under 40 CFR, Subpart C (y261.20 et seq.), that would be subject to manifest requirements specified in 40 CFR 262. Such substances are defined and regulated by EPA.

Marking - A descriptive name, identification number, instructions, cautions, weight, specification or UN marks, or combination thereof required on outer packaging of hazardous materials.

n.o.i - Not otherwise indicated (may be used interchangeably with n.o.s.).

n.o.s. - Not otherwise specified.

ORM - Other regulated material (see DOT 49 CFR 173.144).

Packaging - A receptacle and any other components or materials necessary for compliance with the minimum packaging requirements of 49 CFR 174, including containers (other than freight containers or overpacks), portable tanks, cargo tanks, tank cars, and multi-unit tank-car tanks to perform a containment function in conformance with the minimum packaging requirements of 49 CFR 173.24(a) & (b).

Placard - Color-coded, pictorial sign which depicts the hazard class symbol and name and which is placed on the side of a vehicle transporting certain hazardous materials.

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Common Preservatives:

- Hydrochloric Acid - HCl
- Sulfuric Acid - H₂SO₄
- Nitric Acid - HNO₃
- Sodium Hydroxide - NaOH

Other Preservatives

- Zinc Acetate
- Sodium Thiosulfate - Na₂S₂O₃

Normality (N) - Concentration of a solution expressed as equivalent per liter, an equivalent being the amount of a substance containing 1 gram-atom of replaceable hydrogen or its equivalent. Thus, a one-molar solution of HCl, containing 1 gram-atom of H, is "one normal," whereas a one-molar solution of H₂SO₄, containing 2 gram-atoms of H, is "two normal."

Reportable Quantity (RQ) - For the purposes of this SOP, means the quantity specified in column 3 of the Appendix to DOT 49 CFR §172.101 for any material identified in column 1 of the appendix. A spill greater than the amount specified must be reported to the National Response Center.

Sample - A sample is physical evidence collected from a facility or the environment, which is representative of conditions at the location and time of collection.

4.0 RESPONSIBILITIES

Field Operations Leader - Directly responsible for the bottling, preservation, labeling, packaging, shipping, and custody of samples up to and including release to the shipper.

Field Samplers - Responsible for initiating the Chain-of-Custody Record (per SOP SA-6.3), implementing the packaging and shipping requirements, and maintaining custody of samples until they are relinquished to another custodian or to the common carrier.

5.0 PROCEDURES

Sample identification, labeling, documentation, and chain-of-custody are addressed by SOP SA-6.3.

5.1 Sample Containers

Different types of chemicals react differently with sample containers made of various materials. For example, trace metals adsorb more strongly to glass than to plastic, whereas many organic chemicals may dissolve various types of plastic containers. Attachments A and B show proper containers (as well as other information) per 40 CFR 136. In general, the sample container shall allow approximately 5-10 percent air space ("ullage") to allow for expansion/vaporization if the sample warms during transport. However, for collection of volatile organic compounds, head space shall be omitted. The analytical laboratory will generally provide certified-clean containers for samples to be analyzed for chemical constituents. Shelby tubes or other sample containers are generally provided by the driller for samples requiring geotechnical analysis. Sufficient lead time shall be allowed for a delivery of bottle orders. Therefore, it is critical to use the correct container to maintain the integrity of the sample prior to analysis.

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Once opened, the container must be used at once for storage of a particular sample. Unused but opened containers are to be considered contaminated and must be discarded; because of the potential for introduction of contamination, they cannot be reclosed and saved for later use. Likewise, any unused containers which appear contaminated upon receipt, or which are found to have loose caps or a missing Teflon liner (if required for the container), shall be discarded.

5.2 Sample Preservation

Many water and soil samples are unstable and therefore require preservation to prevent changes in either the concentration or the physical condition of the constituent(s) requiring analysis. Although complete and irreversible preservation of samples is not possible, preservation does retard the chemical and biological changes that inevitably take place after the sample is collected. Preservation techniques are usually limited to pH control, chemical addition(s), and refrigeration/ freezing (certain biological samples only).

5.2.1 Overview

The preservation techniques to be used for various analytes are listed in Attachments A and B. Reagents required for sample preservation will either be added to the sample containers by the laboratory prior to their shipment to the field or be added in the field (in a clean environment). Only high purity reagents shall be used for preservation. In general, aqueous samples of low-concentration organics (or soil samples of low- or medium-concentration organics) are cooled to 4°C. Medium-concentration aqueous samples and high-hazard organics samples are typically not preserved. Low-concentration aqueous samples for metals are acidified with HNO₃, whereas medium-concentration and high-hazard aqueous metal samples are not preserved. Low- or medium-concentration soil samples for metals are cooled to 4°C, whereas high-hazard samples are not preserved.

The following subsections describe the procedures for preparing and adding chemical preservatives. Attachments A and B indicate the specific analytes which require these preservatives.

5.2.2 Preparation and Addition of Reagents

Addition of the following acids or bases may be specified for sample preservation; these reagents shall be analytical reagent (AR) grade or purer and shall be diluted to the required concentration with deionized water before field sampling commences. To avoid uncontrolled reactions, be sure to Add Acid to water (not vice versa). A dilutions guide is provided below.

Acid/Base	Dilution	Concentration	Estimated Amount Required for Preservation
Hydrochloric Acid (HCl)	1 part concentrated HCl: 1 part double-distilled, deionized water	6N	5-10 mL
Sulfuric Acid (H ₂ SO ₄)	1 part concentrated H ₂ SO ₄ : 1 part double-distilled, deionized water	18N	2 - 5 mL
Nitric Acid (HNO ₃)	Undiluted concentrated HNO ₃	16N	2 - 5 mL
Sodium Hydroxide (NaOH)	400 grams solid NaOH dissolved in 870 mL double-distilled, deionized water; yields 1 liter of solution	10N	2 mL

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The amounts required for preservation shown in the above table assumes proper preparation of the preservative and addition of the preservative to one liter of aqueous sample (assuming that the sample is initially at pH 7, is poorly buffered, and does not contain particulate matter; as these conditions vary, more preservative may be required). Consequently, the final sample pH must be checked using narrow-range pH paper, as described in the generalized procedure detailed below:

- Pour off 5-10 mL of sample into a dedicated, clean container. Use some of this sample to check the initial sample pH using wide range (0-14) pH paper. Never dip the pH paper into the sample; always apply a drop of sample to the pH paper using a clean stirring rod or pipette.
- Add about one-half of the estimated preservative required to the original sample bottle. Cap and invert gently several times to mix. Check pH (as described above) using medium range pH paper (pH 0-6 or pH 7.5-14, as applicable).
- Cap sample bottle and seal securely.

Additional considerations are discussed below:

- To test if ascorbic acid must be used to remove oxidizing agents present in the sample before it can be properly preserved, place a drop of sample on KI-starch paper. A blue color indicates the need for ascorbic acid addition.

If required, add a few crystals of ascorbic acid to the sample and retest with the KI-starch paper. Repeat until a drop of sample produces no color on the KI-starch paper. Then add an additional 0.6 grams of ascorbic acid per each liter of sample volume.

Continue with proper base preservation of the sample as described, generally, above.

- Samples for sulfide analysis must be treated by the addition of 4 drops (0.2 mL) of 2N zinc acetate solution per 100 ml of sample.

The 2N zinc acetate solution is made by dissolving 220 grams of zinc acetate in 870 mL of double-distilled, deionized water to make 1 liter of solution.

The sample pH is then raised to 9 using the NaOH preservative.

- To test of sodium thiosulfate must be added to remove residual chlorine from a sample, test the sample for residual chlorine using a field test kit especially made for this purpose.

If residual chlorine is present, add 0.08 grams of sodium thiosulfate per liter of sample to remove the residual chlorine.

Continue with proper acidification of the sample as described, generally, above.

For biological samples, 10% buffered formalin or isopropanol may also be required for preservation. Questions regarding preservation requirements should be resolved through communication with the laboratory before sampling begins.

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~~5.3 Field Filtration~~

~~At times, field-filtration may be required to provide for the analysis of dissolved chemical constituents. Field-filtration must be performed prior to the preservation of samples as described above. General procedures for field filtration are described below:~~

- ~~• The sample shall be filtered through a non-metallic, 0.45-micron membrane filter, immediately after collection. The filtration system shall consist of dedicated filter canister, dedicated silicon tubing, and a peristaltic pump with pressure or vacuum pumping squeeze action (since the sample is filtered by mechanical peristalsis, the sample travels only through the tubing).~~
- ~~• To perform filtration, thread the silicon tubing through the peristaltic pump head. Attach the filter canister to the discharge end of the silicon tubing (note flow direction arrow); attach the aqueous sample container to the intake end of the silicon tubing. Turn the peristaltic pump on and perform filtration.~~
- ~~• Continue by preserving the filtrate (contained in the filter canister), as applicable and generally described above.~~

5.4 Sample Packaging and Shipping

Samples collected for shipment from a site shall be classified as either environmental or hazardous material samples. Samples from drums containing materials other than Investigative Derived Waste (IDW) and samples obtained from waste piles or bulk storage tanks are generally shipped as hazardous materials. A distinction must be made between the two types of samples in order to:

- Determine appropriate procedures for transportation of samples (if there is any doubt, a sample shall be considered hazardous and shipped accordingly.)
- Protect the health and safety of transport and laboratory personnel receiving the samples (special precautions are used by the shipper and at laboratories when hazardous materials are received.)

Detailed procedures for packaging environmental and hazardous material samples are outlined in the remainder of this section.

5.4.1 Environmental Samples

Environmental samples are packaged as follows:

- Place sample container, properly identified and with lid securely fastened in a plastic bag (e.g. Ziploc baggie), and seal the bag.
- Place sample in a cooler constructed of sturdy material which has been lined with a large, plastic (e.g. "garbage" bag).
- Pack with enough noncombustible, absorbent, cushioning materials such as vermiculite (shoulders of bottles must be iced if required) to minimize the possibility of the container breaking.

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- If cooling is required (see Attachments A and B), double-bag ice in Ziploc baggies and place around container shoulders, and on top of absorbent packing material (minimum of 8 pounds of ice for a medium-size cooler).
- Seal (i.e., tape or tie top in knot) large liner bag.
- The original (top, signed copy) and extra carbonless copies of the COC form shall be placed inside a large Ziploc-type bag and taped inside the lid of the shipping cooler. If multiple coolers are sent but are included on one COC form, the COC form should be sent with the first cooler. The COC form should then state how many coolers are included with that shipment.
- Close and seal outside of cooler as described in SOP SA-6.3. Signed custody seals must be used.

Coolers must be marked as containing "Environmental Samples." The appropriate side of the container must be marked "This End Up" and arrows placed appropriately. No DOT marking or labeling is required; there are no DOT restrictions on mode of transportation.

5.4.2 Determination of Shipping Classification for Hazardous Material Samples

Samples not determined to be environmental samples, or samples known or expected to contain hazardous materials, must be considered hazardous material samples and transported according to the requirements listed below.

5.4.2.1 Known Substances

If the substance in the sample is known or can be identified, package, mark, label, and ship according to the specific instructions for that material (if it is listed) in the DOT Hazardous Materials Table, 49 CFR 172.101. (DOT Guide for shippers can be found in Attachment D of this document.)

To determine the proper shipping name, use the following steps to help locate the shipping name on the Hazardous Materials Table, DOT 49 CFR 172.101.

1. Look first for the chemical or technical name of the material, for example, ethyl alcohol. Note that many chemicals have more than one technical name, for example, perchloroethylene (not listed in 172.101) is listed as tetrachloroethylene (listed 172.101). It may be useful to consult a chemist for all possible technical names a material can have. If your material is not listed by its technical name, then . . .
2. Look for the chemical family name. For example, pentyl alcohol is not listed but the chemical family name is: alcohol, n.o.s. (not otherwise specified). If the chemical family name is not listed, then . . .
3. Look for a generic name based on end use. For example, Paint, n.o.s or Fireworks, n.o.s. If a generic name based on end use is not listed, then . . .
4. Look for a generic family name based on end use, for example, drugs, n.o.s. or cosmetics, n.o.s. Finally, if your material is not listed by a generic family name but you suspect or know the material is hazardous because it meets the definition of one or more hazardous classes, then . . .

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5. You will have to use the general hazard class for a proper shipping name. For example, Flammable Liquid, n.o.s. or Oxidizer, n.o.s.

5.4.2.2 Unknown Substances

For samples of hazardous substances of unknown content, select the appropriate transportation category according to the DOT hazardous materials classification of a material having more than one hazard. This procedure is outlined in DOT Regulation 49 CFR 173.2a. (This can be found in Attachment C of this SOP.)

The correct shipping classification for an unknown sample is selected through a process of elimination, as outlined in DOT Regulation 49 CFR 172.101(c)(11). By using the provisions in this paragraph, the proper shipping name and description will be determined. A step-by-step guide is provided by the Department of Transportation (DOT) and can be found in Attachment D of this SOP.

~~5.4.3 Packaging and Shipping of Samples Classified as Flammable Liquid (or Solid)~~

~~5.4.3.1 Packaging~~

~~Applying the word "flammable" to a sample does not imply that it is in fact flammable. The word prescribes the class of packaging according to DOT regulations.~~

- ~~1. Containerize sample as required (see Attachments A and B). To prevent leakage, fill container no more than 90 percent full. Seal lid with teflon tape or wire.~~
- ~~2. Complete sample label and attach securely to sample container.~~
- ~~3. Seal container and place in 2-mil-thick (or thicker) polyethylene bag (e.g., Ziploc baggie), one sample per bag. Position sample identification label so that it can be read through bag. Seal bag.~~
- ~~4. For soil jars, place sealed bag inside metal can (available from laboratory or laboratory supplier) and cushion it with enough noncombustible, absorbent material (for example, vermiculite or diatomaceous earth) between the bottom and sides of the can and bag to prevent breakage and absorb leakage. Pack one bag per can. Use clips, tape, or other positive means to hold can lid securely, tightly and permanently. Mark can as indicated in Paragraph 1 of Section 5.3.4.2 below. Single 1-gallon bottles do not need to be placed in metal cans.~~
- ~~5. Place one or more metal cans (or a single 1-gallon bottle) into a strong outside container, such as a metal picnic cooler or a DOT-approved fiberboard box. Surround cans (or bottle) with noncombustible, absorbent cushioning materials for stability during transport. The absorbent material should be able to absorb the entire contents of the container. Mark container as indicated in Paragraph 2 below.~~

~~5.4.3.2 Marking/Labeling~~

- ~~1. Use abbreviations only where specified. Place the following information, either hand-printed or in label form, on the metal can (or 1-gallon bottle):~~
 - ~~• Laboratory name and address.~~

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- Proper shipping name from the hazardous materials table (DOT Regulation CFR 49 172.101). Example: "Flammable Liquid, n.o.s. UN1993" or "Flammable Solid, n.o.s. UN1325." This will include packing group (see Section 5.3.4.2, No. 2.)

Not otherwise specified (n.o.s) is not used if the flammable liquid (or solid) is identified. If identified, the name of the specific material is listed before the category (for example, Acetone, Flammable Liquid), followed by its appropriate UN number found in the DOT Hazardous Materials table (49 CFR 172.101).

2. Determine packing group. The packing group is part of the proper shipping name and must be included on the shipping papers in the description section.

- I. Most Hazardous
- II. Medium Hazard
- III. Least Hazardous

The packing group will be listed in the hazardous materials table, column 5.

3. Place all information on outside shipping container as on can (or bottle), specifically:

- Proper shipping name
- UN or NA number
- Proper label(s)
- Addressee and sender

Place the following labels on the outside shipping container: "Cargo Aircraft Only" and DOT label such as: "Flammable Liquid" (or "Flammable Solid"). "Dangerous When Wet" label shall be used if the Flammable Solid has not been exposed to a wet environment. "Laboratory Samples" and "THIS SIDE UP" or "THIS END UP" shall also be marked on the top of the outside container, and upward-pointing arrows shall be placed on all four sides of the container.

5.4.3.3 Shipping Papers

1. Use abbreviations only where specified. Complete the carrier-provided bill of lading and sign certification statement. Provide the following information in the order listed (one form may be used for more than one exterior container):

- Proper shipping name. (Example: "Flammable Liquid, n.o.s. UN1993" or "Flammable Solid, n.o.s. UN1325 Packing Group I, II, III").
- "Limited Quantity" (or "Ltd. Qty."). (See No. 3, below.)
- "Cargo Aircraft Only."
- Net weight (wt) or net volume (vol), just before or just after "Flammable Liquid, n.o.s." or "Flammable Solid, n.o.s.," by item, if more than one metal can is inside an exterior container.
- "Laboratory Samples" (if applicable).

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2. Include Chain-of-Custody Record, properly executed in outside container; use custody seals.

3. "Limited Quantity" means the maximum amount of a hazardous material for which there is a specific labeling or packaging exception (DOT CFR 49 171.8). This may mean that packages are exempted from labeling requirements. To determine if your sample meets the Limited Quantity Exception, refer to DOT Regulation CFR 49 Subpart C 173.50 through 173.156. First, determine the proper classification and shipping name for the material; then refer to the exception requirements for that particular class of material beginning with 173.50.

Example: "Flammable Liquid n.o.s. UN1993 Packing Group 1." The outer package can weigh no more than 66 pounds gross weight. The inner package or container can weigh no more than 0.1 gallon net capacity for each container.

To determine whether the material can be shipped as a "Limited Quantity," you must check the specific requirement for that class of material.

5.4.3.4 Transportation

1. The majority of unknown hazardous substance samples will be classified as flammable liquids. The samples will be transported by rented or common carrier truck, railroad, or express overnight package services. Do not transport samples on any passenger-carrying air transport system, even if the system has cargo-only aircraft. DOT regulations permit regular airline cargo-only aircraft, but difficulties with most suggest avoiding them. Instead, ship by airline carriers that carry only cargo. If unsure of what mode of transportation to use, consult the FOL or Project Manager.
2. For transport by government-owned vehicle, including aircraft, DOT regulations do not apply. However, procedures described above, with the exception of execution of the bill of lading with certification, shall still be followed.
3. Use the hazardous materials shipping check list (Attachment E) as a guidance to ensure that all sample-handling requirements are satisfied.
4. In some cases, various materials may react if they break during shipment. To determine if you are shipping such materials, refer to the DOT compatibility chart in Attachment F.

5.5 Shipment of Lithium Batteries

Monitoring well data are analyzed using either the Hermit SE 1000 or the Hermit SE 2000 environmental data logger. These instruments are powered by lithium batteries. The Department of Transportation has determined that lithium batteries are a hazardous material and are to be shipped using the following information:

¹ Note: If you are unsure as how to ship the sample (hazardous or environmental sample), contact the FOL or Project Manager so that a decision can be made as to the proper shipping practices. The DOT penalties for improper shipment of a hazardous material are stringent and may include a prison term for intentional violations.

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- Product Designation
 - Hermit SE 1000
 - Hermit SE 2000
- DOT Proper Shipping Name
 - Lithium batteries, contained in equipment, UN3091
- Classification or Division
 - Class 9

Shipment of equipment containing lithium batteries must be accompanied by shipping papers completed as indicated in Attachment G. The instrument will be shipped by Federal Express as a Hazardous Material. Place the instrument in the same container in which it was received. This container or case is a DOT-approved shipping container. For Federal Express procedures to ship hazardous materials, call 1-800-238-5355, extension 922-1666. In most cases, the return shipping papers and DOT labels will be shipped to you from the company warehouse or the vendor. An example of the types of labels used for shipment and the wording are shown in Attachment G. These labels will be attached to the outside container with the following wording:

- Lithium Batteries Contained in Equipment
 - UN-3091
 - Shipped Under CA-9206009

6.0 REFERENCES

American Public Health Association, 1981. Standard Methods for the Examination of Water and Wastewater, 15th Edition. APHA, Washington, D.C.

U.S. Department of Transportation, 1993. Hazardous Materials Regulations, 49 CFR 171-177.

U.S. EPA, 1984. "Guidelines Establishing Test Procedures for the Analysis of Pollutants under Clean Water Act." Federal Register, Volume 49 (209), October 26, 1984, p. 43234.

U.S. EPA, 1979. Methods for Chemical Analysis of Water and Wastes. EPA-600/4-79-020, U.S. EPA-EMSL, Cincinnati, Ohio.

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ATTACHMENT A

GENERAL SAMPLE CONTAINER AND PRESERVATION REQUIREMENTS

Sample Type and Concentration	Container ⁽¹⁾	Sample Size	Preservation ⁽²⁾	Holding Time ⁽²⁾
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WATER

Organics (GC&GC/MS)	VOC	Low	Borosilicate glass	2 x 40 mL	Cool to 4°C HCl to ≤ 2	14 days ⁽⁸⁾
	Extractables SVOCs and pesticide/PCBs)	(Low	Amber glass	2x2 L or 4x1 L	Cool to 4°C	7 days to extraction; 40 days after extraction
	Extractables SVOCs and pesticide/PCBs)	(Medium	Amber glass	2x2 L or 4x1 L	None	7 days to extraction; 40 days after extraction
Inorganics	Metals	Low	High-density polyethylene	1 L	HNO ₃ to pH ≤ 2	6 months (Hg-28 days)
		Medium	Wide-mouth glass	16 oz.	None	6 months
	Cyanide	Low	High-density polyethylene	1 L	NaOH to pH > 12	14 days
	Cyanide	Medium	Wide-mouth glass	16 oz.	None	14 days
Organic/ Inorganic	High Hazard		Wide-mouth glass	8 oz.	None	14 days

SOIL

Organics (GC&GC/MS)	VOC		Wide-mouth glass with teflon liner	2 x 4 oz.	Cool to 4°C	14 days
	Extractables SVOCs and pesticides/PCBs)	(Low	Wide-mouth glass	8 oz.	Cool to 4°C	14 days to extraction; 40 days after extraction
	Extractables SVOCs and pesticides/PCBs)	(Medium	Wide-mouth glass	8 oz.	Cool to 4°C	14 days to extraction; 40 days after extraction
Inorganics	Low/Medium		Wide-mouth glass	8 oz.	Cool to 4°C	6 months (Hg - 28 days) Cyanide (14 days)
Organic/ Inorganic	High Hazard		Wide-mouth glass	8 oz.	None	NA
Dioxin/Furan	All		Wide-mouth glass	4 oz.	None	7 days until extraction; 40 days after extraction
TCLP	All		Wide-mouth glass	8 oz.	None	7 days until preparation; analysis as per fraction

AIR

Volatile Organics	Low/Medium	Charcoal tube - 7 cm long, 6 mm OD, 4 mm ID	100 L air	Cool to 4°C	5 days recommended
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⁽¹⁾ All glass containers should have Teflon cap liners or septa.

⁽²⁾ See Attachment E. Preservation and maximum holding time allowances per 40 CFR 136.

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ATTACHMENT B

**ADDITIONAL REQUIRED CONTAINERS, PRESERVATION TECHNIQUES,
AND HOLDING TIMES**

Parameter Number/Name	Container ⁽¹⁾	Preservation ⁽²⁾⁽³⁾	Maximum Holding Time ⁽⁴⁾
INORGANIC TESTS:			
Acidity	P, G	Cool, 4°C	14 days
Alkalinity	P, G	Cool, 4°C	14 days
Ammonia - Nitrogen	P, G	Cool, 4°C; H ₂ SO ₄ to pH 2	28 days
Biochemical Oxygen Demand (BOD)	P, G	Cool, 4°C	48 hours
Bromide	P, G	None required	28 days
Chemical Oxygen Demand (COD)	P, G	Cool, 4°C; H ₂ SO ₄ to pH 2	28 days
Chloride	P, G	None required	28 days
Chlorine, Total Residual	P, G	None required	Analyze immediately
Color	P, G	Cool, 4°C	48 hours
Cyanide, Total and Amenable to Chlorination	P, G	Cool, 4°C; NaOH to pH 12; 0.6 g ascorbic acid ⁽⁵⁾	14 days ⁽⁶⁾
Fluoride	P	None required	28 days
Hardness	P, G	HNO ₃ to pH 2; H ₂ SO ₄ to pH 2	6 months
Total Kjeldahl and Organic Nitrogen	P, G	Cool, 4°C; H ₂ SO ₄ to pH 2	28 days
Nitrate - Nitrogen	P, G	None required	48 hours
Nitrate-Nitrite - Nitrogen	P, G	Cool, 4°C; H ₂ SO ₄ to pH 2	28 days
Nitrite - Nitrogen	P, G	Cool, 4°C	48 hours
Oil & Grease	G	Cool, 4°C; H ₂ SO ₄ to pH 2	28 days
Total Organic Carbon (TOC)	P, G	Cool, 4°C; HCl or H ₂ SO ₄ to pH 2	28 days
Orthophosphate	P, G	Filter immediately; Cool, 4°C	48 hours
Oxygen, Dissolved-Probe	G Bottle & top	None required	Analyze immediately
Oxygen, Dissolved-Winkler	G Bottle & top	Fix on site and store in dark	8 hours
Phenols	G	Cool, 4°C; H ₂ SO ₄ to pH 2	28 days
Phosphorus, Total	P, G	Cool, 4°C; H ₂ SO ₄ to pH 2	28 days
Residue, Total	P, G	Cool, 4°C	7 days
Residue, Filterable (TDS)	P, G	Cool, 4°C	7 days
Residue, Nonfilterable (TSS)	P, G	Cool, 4°C	7 days
Residue, Settleable	P, G	Cool, 4°C	48 hours
Residue, Volatile (Ash Content)	P, G	Cool, 4°C	7 days
Silica	P	Cool, 4°C	28 days
Specific Conductance	P, G	Cool, 4°C	28 days
Sulfate	P, G	Cool, 4°C	28 days

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**ATTACHMENT B
ADDITIONAL REQUIRED CONTAINERS, PRESERVATION TECHNIQUES,
AND HOLDING TIMES
PAGE TWO**

Parameter Number/Name	Container ⁽¹⁾	Preservation ⁽²⁾⁽³⁾	Maximum Holding Time ⁽⁴⁾
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INORGANIC TESTS (Cont'd):

Sulfide	P, G	Cool, 4°C: add zinc acetate plus sodium hydroxide to pH 9	7 days
Sulfite	P, G	None required	Analyze immediately
Turbidity	P, G	Cool, 4°C	48 hours

METALS:⁽⁷⁾

Chromium VI (Hexachrome)	P, G	Cool, 4°C	24 hours
Mercury (Hg)	P, G	HNO ₃ to pH 2	28 days
Metals, except Chromium VI and Mercury	P, G	HNO ₃ to pH 2	6 months

ORGANIC TESTS:⁽⁸⁾

Purgeable Halocarbons	G. Teflon-lined septum	Cool, 4°C; 0.008% Na ₂ S ₂ O ₃ ⁽⁵⁾	14 days
Purgeable Aromatic Hydrocarbons	G. Teflon-lined septum	Cool, 4°C; 0.008% Na ₂ S ₂ O ₃ ⁽⁵⁾ HCl to pH 2 ⁽⁹⁾	14 days
Acrolein and Acrylonitrile	G. Teflon-lined septum	Cool, 4°C; 0.008% Na ₂ S ₂ O ₃ ⁽⁵⁾ adjust pH to 4-5 ⁽¹⁰⁾	14 days
Phenols ⁽¹¹⁾	G. Teflon-lined cap	Cool, 4°C; 0.008% Na ₂ S ₂ O ₃ ⁽⁵⁾	7 days until extraction; 40 days after extraction
Benzidines ^{(11), (12)}	G. Teflon-lined cap	Cool, 4°C; 0.008% Na ₂ S ₂ O ₃ ⁽⁵⁾	7 days until extraction ⁽¹³⁾
Phthalate esters ⁽¹¹⁾	G. Teflon-lined cap	Cool, 4°C	7 days until extraction; 40 days after extraction
Nitrosamines ^{(11), (14)}	G. Teflon-lined cap	Cool, 4°C; store in dark; 0.008% Na ₂ S ₂ O ₃ ⁽⁵⁾	7 days until extraction; 40 days after extraction
PCBs ⁽¹¹⁾	G. Teflon-lined cap	Cool, 4°C	7 days until extraction; 40 days after extraction
Nitroaromatics & Isophorone ⁽¹¹⁾	G. Teflon-lined cap	Cool, 4°C; 0.008% Na ₂ S ₂ O ₃ ⁽⁵⁾ ; store in dark	7 days until extraction; 40 days after extraction
Polynuclear Aromatic Hydrocarbons (PAHs) ^{(11), (14)}	G. Teflon-lined cap	Cool, 4°C; 0.008% Na ₂ S ₂ O ₃ ⁽⁵⁾ ; store in dark	7 days until extraction; 40 days after extraction
Haloethers ⁽¹¹⁾	G. Teflon-lined cap	Cool, 4°C; 0.008% Na ₂ S ₂ O ₃ ⁽⁵⁾	7 days until extraction; 40 days after extraction
Dioxin/Furan (TCDD/TCDF) ⁽¹¹⁾	G. Teflon-lined cap	Cool, 4°C; 0.008% Na ₂ S ₂ O ₃ ⁽⁵⁾	7 days until extraction; 40 days after extraction

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**ATTACHMENT B
ADDITIONAL REQUIRED CONTAINERS, PRESERVATION TECHNIQUES,
AND HOLDING TIMES
PAGE THREE**

Parameter Number/Name	Container ⁽¹⁾	Preservation ⁽²⁾⁽³⁾	Maximum Holding Time ⁽⁴⁾
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RADIOLOGICAL TESTS:

1-5 Alpha, beta and radium	P, G	HNO ₃ to pH 2	6 months
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- (1) Polyethylene (P): generally 500 ml or Glass (G): generally 1L.
- (2) Sample preservation should be performed immediately upon sample collection. For composite chemical samples each aliquot should be preserved at the time of collection. When use of an automated sampler makes it impossible to preserve each aliquot, then chemical samples may be preserved by maintaining at 4°C until compositing and sample splitting is completed.
- (3) When any sample is to be shipped by common carrier or sent through the United States Mail, it must comply with the Department of Transportation Hazardous Materials Regulations (49 CFR Part 172).
- (4) Samples should be analyzed as soon as possible after collection. The times listed are the maximum times that samples may be held before analysis and still be considered valid. Samples may be held for longer periods only if the permittee, or monitoring laboratory, has data on file to show that the specific types of samples under study are stable for the longer periods, and has received a variance from the Regional Administrator.
- (5) Should only be used in the presence of residual chlorine.
- (6) Maximum holding time is 24 hours when sulfide is present. Optionally, all samples may be tested with lead acetate paper before pH adjustments are made to determine if sulfide is present. If sulfide is present, it can be removed by the addition of cadmium nitrate powder until a negative spot test is obtained. The sample is filtered and then NaOH is added to pH 12.
- (7) Samples should be filtered immediately on site before adding preservative for dissolved metals.
- (8) Guidance applies to samples to be analyzed by GC, LC, or GC/MS for specific compounds.
- (9) Sample receiving no pH adjustment must be analyzed within 7 days of sampling.
- (10) The pH adjustment is not required if acrolein will not be measured. Samples for acrolein receiving no pH adjustment must be analyzed within 3 days of sampling.
- (11) When the extractable analytes of concern fall within a single chemical category, the specified preservative and maximum holding times should be observed for optimum safeguard of sample integrity. When the analytes of concern fall within two or more chemical categories, the sample may be preserved by cooling to 4°C, reducing residual chlorine with 0.008% sodium thiosulfate, storing in the dark, and adjusting the pH to 6-9; samples preserved in this manner may be held for 7 days before extraction and for 40 days after extraction. Exceptions to this optional preservation and holding time procedure are noted in footnote 5 (re: the requirement for thiosulfate reduction of residual chlorine) and footnotes 12, 13 (re: the analysis of benzidine).
- (12) If 1,2-diphenylhydrazine is likely to be present, adjust the pH of the sample to 4.0±0.2 to prevent rearrangement to benzidine.
- (13) Extracts may be stored up to 7 days before analysis if storage is conducted under an inert (oxidant-free) atmosphere.
- (14) For the analysis of diphenylnitrosamine, add 0.008% Na₂S₂O₃ and adjust pH to 7-10 with NaOH within 24 hours of sampling.
- (15) The pH adjustment may be performed upon receipt at the laboratory and may be omitted if the samples are extracted within 72 hours of collection. For the analysis of aldrin, add 0.008% Na₂S₂O₃.

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ATTACHMENT C

**DOT HAZARDOUS MATERIAL CLASSIFICATION
(49 CFR 173.2a)**

1. Radioactive material (except a limited quantity)
2. Division 2.3, Poisonous Gases
3. Division 2.1, Flammable Gas
4. Division 2.2, Nonflammable gas
5. Division 6.1, Poisonous Liquids, Packing Group 1 (poison by inhalation only)
6. Division 4.2, Pyrophoric Material
7. Division 4.1, Self-Reactive Material
8. Class 3, Flammable Liquids*
9. Class 8, Corrosive Material
10. Division 4.1, Flammable Solid*
11. Division 4.2, Spontaneously Combustible Materials*
12. Division 4.3, Dangerous When Wet Materials*
13. Division 5.1, Oxidizers*
14. Division 6.1, Poisonous Liquids or Solids (other than Packing Group 1)*
15. Combustible liquid
16. Class 9, Miscellaneous Hazardous Materials

* If a material has or meets the criteria for more than one hazard class, use the precedence of hazardous table on the following page for Classes 3 and 8 and Divisions 4.1, 4.2, 4.3, 5.1, and 6.1. The following table ranks those materials that meet the definition of Classes 3 and 8 and Divisions 4.1, 4.2, 4.3, 5.1, and 6.1.

ATTACHMENT C (Continued)

PRECEDENCE OF HAZARD TABLE
(Hazard Class and Packing Group)

Class	Packing Group	4.2	4.3	5.1 I ^(a)	5.1 II ^(a)	5.1 III ^(a)	6.1 I (Dermal)	6.1 I (Oral)	6.1 II	6.1 III	8 I (Liquid)	8 I (Solid)	8 II (Liquid)	8 II (Solid)	8 III (Liquid)	8 III (Solid)
3	I						3	3	3	3	3	(e)	3	(e)	3	(e)
3	II						3	3	3	3	8	(e)	3	(e)	3	(e)
3	III						6.1	6.1	6.1	3 ^(b)	8	(e)	8	(e)	3	(e)
4.1	II ^(b)	4.2	4.3	5.1	4.1	4.1	6.1	6.1	4.1	4.1	(e)	8	(e)	4.1	(e)	4.1
4.1	III ^(b)	4.2	4.3	5.1	4.1	4.1	6.1	6.1	6.1	4.1	(e)	8	(e)	8	(e)	4.1
4.2	II	4.3	4.3	5.1	4.2	4.2	6.1	6.1	4.2	4.2	(e)	8	(e)	4.2	(e)	4.2
4.2	III	4.3	4.3	5.1	4.2	4.2	6.1	6.1	6.1	4.2	(e)	8	(e)	8	(e)	4.2
4.3	I			5.1	4.3	4.3	6.1	4.3	4.3	4.3	4.3	4.3	4.3	4.3	4.3	4.3
4.3	II			5.1	4.3	4.3	6.1	4.3	4.3	4.3	8	8	8	4.3	4.3	4.3
4.3	III			5.1	4.3	4.3	6.1	6.1	6.1	4.3	8	8	8	8	4.3	4.3
5.1	I ^(c)						5.1	5.1	5.1	5.1	5.1	5.1	5.1	5.1	5.1	5.1
5.1	II ^(c)						6.1	5.1	5.1	5.1	8	8	8	5.1	5.1	5.1
5.1	III ^(c)						6.1	6.1	6.1	5.1	8	8	8	5.1	5.1	5.1
6.1	I, Dermal										8	6.1	6.1	6.1	6.1	6.1
6.1	I, Oral										8	6.1	6.1	6.1	6.1	6.1
6.1	II, Inhalation										8	6.1	6.1	6.1	6.1	6.1
6.1	II, Dermal										8	6.1	8	6.1	6.1	6.1
6.1	II, Oral										8	8	8	6.1	6.1	6.1
6.1	III										8	8	8	8	8	8

(e) There are at present no established criteria for determining Packing Groups for liquids in Division 5.1. At present, the degree of hazards is to be assessed by analogy with listed substances, allocating the substances to Packing Group I, Great; Group II, Medium; or Group III, Minor Danger.
 (b) Substances of Division 4.1 other than self-reactive substances.
 (c) Denotes an impossible combination.
 (d) For pesticides only, where a material has the hazards of Class 3, Packing Group III, and Division 6.1, Packing Group III, the primary hazard is Division 6.1, Packing Group III.

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ATTACHMENT D

GUIDE FOR HAZARDOUS MATERIALS SHIPPERS

USE OF GUIDE - This guide is presented as an aid to shippers of hazardous materials. It does not contain or refer to all of the DOT requirements for shipping hazardous materials. For specific details, refer to all of the DOT requirements for shipping hazardous materials, as provided in the Code of Federal Regulations (CFR), Title 49, Transportation, Parts 100-199.

The following is offered as a step-by-step procedure to aid in compliance with the applicable DOT regulations.

STEP 1 - DETERMINE THE PROPER SHIPPING NAME. The shipper must determine the proper shipping name of the materials as listed in the Hazardous Materials Table, 49 CFR 172.101, Column (2).

STEP 2 - DETERMINE THE HAZARD CLASS OR CLASSES.

- a. Refer to the Table, 49 CFR 172.101, Column (3), and locate the hazard class of the material.
- b. If more than one class is shown for the proper shipping name, determine the proper class by definition.
- c. If the materials have more than one hazard, classify the material based on the order of hazards in 49 CFR 173.2.

STEP 3 - SELECT THE PROPER IDENTIFICATION NUMBERS.

- a. Refer to the Table, 49 CFR 172.101, Column (3a), and select the Identification Number (ID) that corresponds to the proper shipping name and hazard class.
- b. Enter the ID number(s) on the shipping papers and display them, as required, on packagings, placards and/or orange panels.

STEP 4 - DETERMINE THE MODE(S) OF TRANSPORT TO ULTIMATE DESTINATION.

- a. As a shipper, you must assure yourself that the shipment complies with various modal requirements.
- b. The modal requirements may affect the following: (1) Packaging; (2) Quantity per Package; (3) Marking; (4) Labeling; (5) Shipping Papers; and (6) Certification.

STEP 5 - SELECT THE PROPER LABEL(S) AND APPLY AS REQUIRED.

- a. Refer to the Table, 49 CFR 172.101, Column (4) for required labels.
- b. For details on labeling refer to (1) Additional Labels, 49 CFR 172.402; (2) Placement of Labels, 49 CFR 172.406; (3) Packagings (Mixed or Consolidated), 49 CFR 172.404(a) and (h); (4) Packages Containing Samples, 49 CFR 172.402(h); (5) Radioactive Materials, 49 CFR 172.403; and (6) Authorized Label Modifications, 49 CFR 172.405.

STEP 6 - DETERMINE AND SELECT THE PROPER PACKAGES.

- a. Refer to the Table, 49 CFR 172.101, Column (5a) for exceptions and Column (5b) for specification packagings. Consider the following when selecting an authorized package: Quantity per Package; Cushioning Material, if required; Proper Closure and Reinforcement; Proper Pressure; Outage; etc., as required.
- b. If packaged by a prior shipper, make sure the packaging is correct and in proper condition for transportation.

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GUIDE FOR HAZARDOUS MATERIALS SHIPPERS**

STEP 7 - MARK THE PACKAGING (INCLUDING OVERPACKS).

- a. Apply the required markings (49 CFR 172.300); Proper shipping name and ID number when required (49 CFR 172.301); Name and address of Consignee or Consignor (49 CFR 172.306).
- b. For details and other required markings, see 49 CFR 172.300 through 172.338.

STEP 8 - PREPARE THE SHIPPING PAPERS.

- a. The basic requirements for preparing shipping papers include Proper Shipping Name; Hazard Class; ID Number; Total Quantity; Shipper's Certification; and Emergency Response Telephone Number.
- b. Make all entries on the shipping papers using the information required and in proper sequence (49 CFR 172.202).

STEP 9 - CERTIFICATION.

- a. Each shipper must certify by printing (manually or mechanically) on the shipping papers that the materials being offered for shipment are properly classified, described, packaged, marked and labeled, and in proper condition for transportation according to the applicable DOT Regulations (49 CFR 172.202).

STEP 10 - LOADING, BLOCKING, AND BRACING. When hazardous materials are loaded into the transport vehicle or freight container, each package must be loaded, blocked, and braced in accordance with the requirements for mode of transport.

- a. If the shipper loads the freight container or transport vehicle, the shipper is responsible for the proper loading, blocking, and bracing of the materials.
- b. If the carrier does the loading, the carrier is responsible.

STEP 11 - DETERMINE THE PROPER PLACARD(S). Each person who offers hazardous materials for transportation must determine that the placarding requirements have been met.

- a. For Highway, unless the vehicle is already correctly placarded, the shipper must provide the required placard(s) and required ID number(s) (49 CFR 172.506).
- b. For Rail, if loaded by the shipper, the shipper must placard the rail car if placards are required (49 CFR 172.508).
- c. For Air and Water shipments, the shipper has the responsibility to apply the proper placards.

STEP 12 - HAZARDOUS WASTE/HAZARDOUS SUBSTANCE.

- a. If the material is classed as a hazardous waste or hazardous substance, most of the above steps will be applicable.
- b. Pertinent Environmental Protection Agency regulations are found in the Code of Federal Regulations, Title 40, Part 262.

As a final check and before offering the shipment for transportation, visually inspect your shipment. The shipper should ensure that emergency response information is on the vehicle for transportation of hazardous materials.

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Revised March 1995.

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ATTACHMENT E

HAZARDOUS MATERIALS SHIPPING CHECK LIST

PACKAGING

1. Check DOT 173.24 for appropriate type of package for hazardous substance.
2. Check for container integrity, especially the closure.
3. Check for sufficient absorbent material in package.
4. Check for sample tags and log sheets for each sample and for chain-of-custody record.

SHIPPING PAPERS

1. Check that entries contain only approved DOT abbreviations.
2. Check that entries are in English.
3. Check that hazardous material entries are specially marked to differentiate them from any nonhazardous materials being sent using same shipping paper.
4. Be careful that all hazardous classes are shown for multiclass materials.
5. Check total amounts by weight, quantity, or other measures used.
6. Check that any limited-quantity exemptions are so designated on the shipping paper.
7. Check that certification is signed by shipper.
8. Make certain driver signs for shipment.

RCRA MANIFEST

1. Check that approved state/federal manifests are prepared.
2. Check that transporter has the following: valid EPA identification number, valid driver's license, valid vehicle registration, insurance protection, and proper DOT labels for materials being shipped.
3. Check that destination address is correct.
4. Check that driver knows where shipment is going.
5. Check that the driver is aware of emergency procedures for spills and accidents.
6. Make certain driver signs for shipment.
7. Make certain one copy of executed manifest and shipping document is retained by shipper.

ATTACHMENT F

DOT SEGREGATION AND SEPARATION CHART

Class or Division	Notes	1.1-1.2	1.3	1.4	1.5	1.6	2.1	2.2	2.3 gas Zone A*	2.3 gas Zone B*	3	4.1	4.2	4.3	5.1	5.2	6.1 liquids PG-I Zone A*	7	8 liquids only
Explosives 1.1 and 1.2	A	*	*	*	*	*	X	X	X	X	X	X	X	X	X	X	X	X	X
Explosives 1.3		*	*	*	*	*	X		X	X	X		X	X	X	X	X		X
Explosives 1.4		*	*	*	*	*	O		O	O	O		O				O		O
Very insensitive explosives 1.5	A	*	*	*	*	*	X	X	X	X	X	X	X	X	X	X	X	X	X
Extremely insensitive explosives 1.6		*	*	*	*	*													
Flammable gases 2.1		X	X	O	X				X	O							O	O	
Non-toxic, non-flammable gases 2.2		X			X														
Poisonous gas - Zone A** 2.3		X	X	O	X		X				X	X	X	X	X	X			X
Poisonous gas - Zone B** 2.3		X	X	O	X		O				O	O	O	O	O	O			O
Flammable liquids 3		X	X	O	X				X	O					O		X		
Flammable solids 4.1		X			X				X	O							X		O
Spontaneously combustible materials 4.2		X	X	O	X				X	O							X		X
Dangerous-when-wet materials 4.3		X	X		X				X	O							X		O
Oxidizers 5.1	A	X	X		X				X	O	O						X		O
Organic peroxides 5.2		X	X		X				X	O							X		O
Poisonous liquids PG I - Zone A** 6.1		X	X	O	X		O				X	X	X	X	X	X			X
Radioactive materials 7		X			X		O												
Corrosive liquids 8		X	X	O	X				X	O		O	X	O	O	O	X		

No entry means that the materials are compatible (have no restrictions).

X These materials may not be loaded, transported, or stored together in the same vehicle or facility.

O The materials may not be loaded, transported, or stored together in the same vehicle or facility unless they are separated for 4 feet on all sides.

* Check the explosives compatibility chart in 49 CFR 179.848(f).

A Ammonium nitrate fertilizers may be stored with Division 1.1 materials.

** Denotes inhalation hazardous for poisons; consult field team leader or project manager if you encounter a material in this class before shipment.

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3224637861

Two completed and signed copies of this Declaration must be handed to the operator.

WARNING

Failure to comply in all respects with the applicable Dangerous Goods Regulations may be in breach of the applicable law, subject to legal penalties. This Declaration must not, in any circumstances, be completed and/or signed by a consolidator, a forwarder or an IATA cargo agent.

TRANSPORT DETAILS	
This shipment is within the limitations prescribed for: (delete non applicable)	Airport of Departure
HERMIT SERIES DATALOGGER	CARGO AIRCRAFT ONLY
Airport of Destination: 19CYS	

Shipment type: (delete non-applicable)

NON-RADIOACTIVE RADIOACTIVE

NATURE AND QUANTITY OF DANGEROUS GOODS						
Dangerous Goods Identification						
Proper Shipping Name	Class or Division	UN or ID No.	Subsidiary Risk	Quantity and type of packing	Packing Inst.	Authorization
LITHIUM BATTERIES CONTAINED IN EQUIPMENT	9	UN3091		1 PLASTIC BOX X 55 GRAMS	912 II	PER CA-9206009

Additional Handling Information

1 HERMIT SERIES DATALOGGER X 55 GRAMS (11 GRAMS/CELL)

I hereby declare that the contents of this consignment are fully and accurately described above by proper shipping name and are classified, packed, marked, and labeled, and are in all respects in the proper condition for transport by air according to the applicable International and National Government Regulations.

Emergency Telephone Number (Required for US Origin or Destination Shipments)
800-535-8053

IF ACCEPTABLE FOR PASSENGER AIRCRAFT, THIS SHIPMENT CONTAINS RADIOACTIVE MATERIAL INTENDED FOR USE IN, OR INCIDENT TO, RESEARCH, MEDICAL DIAGNOSIS, OR TREATMENT.

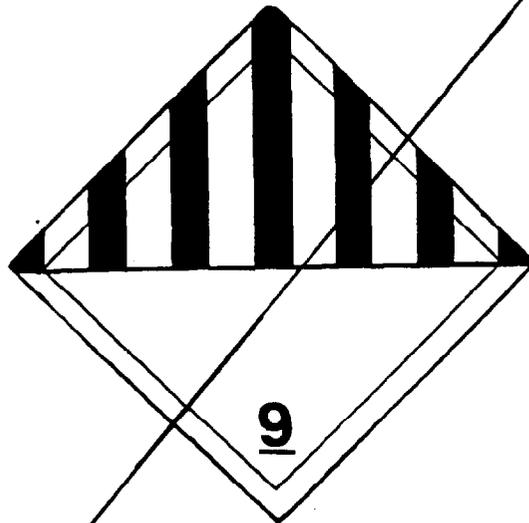
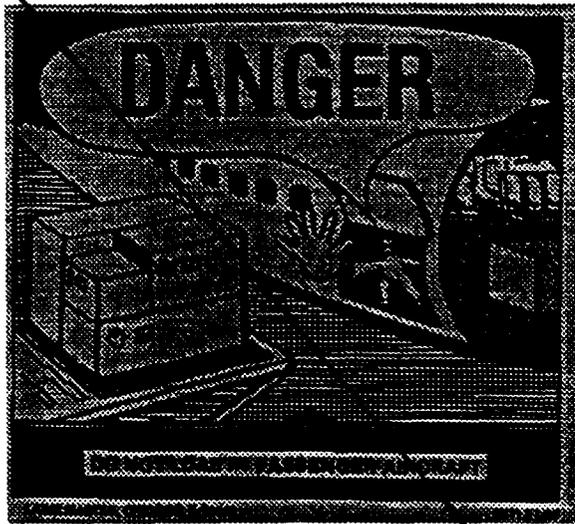
Name/Title of Signatory
Place and Date
Signature (see warning above)

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ATTACHMENT G
LITHIUM BATTERY SHIPPING PAPERS

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ATTACHMENT G (CONTINUED)
LITHIUM BATTERY SHIPPING PAPERS



**LITHIUM BATTERIES CONTAINED
IN EQUIPMENT.
UN-3091.
SHIPPED UNDER CA-9206009**



BROWN & ROOT ENVIRONMENTAL

STANDARD OPERATING PROCEDURES

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Applicability B&R Environmental, NE	
Prepared Earth Sciences Department	
Approved D. Senovich <i>ds</i>	

Subject FIELD DOCUMENTATION

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1.0 PURPOSE

The purpose of this Standard Operating Procedure (SOP) is to identify and designate the field data record forms, logs and reports generally initiated and maintained for documenting Brown & Root Environmental field activities.

2.0 SCOPE

Documents presented within this procedure (or equivalents) shall be used for all Brown & Root Environmental field activities, as applicable. Other or additional documents may be required by specific client contracts.

3.0 GLOSSARY

None

4.0 RESPONSIBILITIES

Project Manager - The Project Manager is responsible for obtaining hardbound, controlled-distribution logbooks (from the appropriate source), as needed. In addition, the Project Manager is responsible for placing all forms used in site activities (i.e., records, field reports, and upon the completion of field work, the site logbook) in the project's central file.

Field Operations Leader (FOL) - The Field Operations Leader is responsible for ensuring that the site logbook, notebooks, and all appropriate forms and field reports illustrated in this guideline (and any additional forms required by the contract) are correctly used, accurately filled out, and completed in the required time-frame.

5.0 PROCEDURES

5.1 Site Logbook

5.1.1 General

The site logbook is a hard-bound, paginated controlled-distribution record book in which all major onsite activities are documented. At a minimum, the following activities/events shall be recorded (daily) in the site logbook:

- All field personnel present
- Arrival/departure of site visitors
- Arrival/departure of equipment
- Start or completion of borehole/trench/monitoring well installation or sampling activities
- Daily onsite activities performed each day
- Sample pickup information
- Health and Safety issues (level of protection observed, etc.)
- Weather conditions

A site logbook shall be maintained for each project. The site logbook shall be initiated at the start of the first onsite activity (e.g., site visit or initial reconnaissance survey). Entries are to be made for every day that onsite activities take place which involve Brown & Root Environmental or subcontractor personnel. Upon completion of the fieldwork, the site logbook must become part of the project's central file.

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The following information must be recorded on the cover of each site logbook:

- Project name
- Brown & Root Environmental project number
- Sequential book number
- Start date
- End date

Information recorded daily in the site logbook need not be duplicated in other field notebooks (see Section 5.2), but must summarize the contents of these other notebooks and refer to specific page locations in these notebooks for detailed information (where applicable). An example of a typical site logbook entry is shown in Attachment A.

If measurements are made at any location, the measurements and equipment used must either be recorded in the site logbook or reference must be made to the site notebook in which the measurements are recorded (see Attachment A).

All logbook, notebook, and log sheet entries shall be made in indelible ink (black pen is preferred). No erasures are permitted. If an incorrect entry is made, the data shall be crossed out with a single strike mark, and initialed and dated. At the completion of entries by any individual, the logbook pages used must be signed and dated. The site logbook must also be signed by the Field Operations Leader at the end of each day.

5.1.2 Photographs

When movies, slides, or photographs are taken of a site or any monitoring location, they must be numbered sequentially to correspond to logbook entries. The name of the photographer, date, time, site location, site description, and weather conditions must be entered in the logbook as the photographs are taken. A series entry may be used for rapid-sequence photographs. The photographer is not required to record the aperture settings and shutter speeds for photographs taken within the normal automatic exposure range. However, special lenses, films, filters, and other image-enhancement techniques must be noted in the logbook. If possible, such techniques shall be avoided, since they can adversely affect the admissibility of photographs as evidence. Chain-of-custody procedures depend upon the subject matter, type of film, and the processing it requires. Film used for aerial photography, confidential information, or criminal investigation require chain-of-custody procedures. Adequate logbook notation and receipts must be compiled to account for routine film processing. Once processed, the slides or photographic prints shall be consecutively numbered and labeled according to the logbook descriptions. The site photographs and associated negatives must be docketed into the project's central file.

5.2 Site Notebooks

Key field team personnel may maintain a separate dedicated notebook to document the pertinent field activities conducted directly under their supervision. For example, on large projects with multiple investigative sites and varying operating conditions, the Health and Safety Officer may elect to maintain a separate site notebook. Where several drill rigs are in operation simultaneously, each site geologist assigned to oversee a rig must maintain a site notebook.

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5.3 Sample Forms

A summary of the forms illustrated in this procedure is shown as the listing of Attachments in the Table of Contents for this SOP. Forms may be altered or revised for project-specific needs contingent upon client approval. Care must be taken to ensure that all essential information can be documented. Guidelines for completing these forms can be found in the related sampling SOP.

5.3.1 Sample Collection, Labeling, Shipment and Request for Analysis

5.3.1.1 Sample Log Sheet

Sample Log Sheets are used to record specified types of data while sampling. Attachments B-1 to B-4 are examples of Sample Log Sheets. The data recorded on these sheets are useful in describing the waste source and sample as well as pointing out any problems encountered during sampling. A log sheet must be completed for each sample obtained, including field quality control (QC) samples.

5.3.1.2 Sample Label

A typical sample label is illustrated in Attachment B-5. Adhesive labels must be completed and applied to every sample container. Sample labels can usually be obtained from the appropriate Program source or are supplied from the laboratory subcontractor.

5.3.1.3 Chain-of-Custody Record Form

The Chain-of-Custody (COC) Record is a multi-part form that is initiated as samples are acquired and accompanies a sample (or group of samples) as they are transferred from person to person. This form must be used for any samples collected for chemical or geotechnical analysis whether the analyses are performed on site or off site. One part of the completed COC form is retained by the field crew while the other two or three portions are sent to the laboratory. The original (top, signed copy) and extra carbonless copies of the COC form shall be placed inside a large Ziploc-type bag and taped inside the lid of the shipping cooler. If multiple coolers are sent but are included on one COC form, the COC form should be sent with the first cooler. The COC form should then state how many coolers are included with that shipment. An example of a Chain-of-Custody Record form is provided as Attachment B-6. A supply of these forms are purchased and stocked by the field department of the various Brown & Root Environmental offices. Alternately, COC forms supplied by the laboratory may be used. Once the samples are received at the laboratory, the sample cooler and contents are checked and any problems are noted on the enclosed COC form (any discrepancies between the sample labels and COC form and any other problems that are noted are resolved through communication between the laboratory point-of-contact and the Brown & Root Environmental Project Manager). The COC form is signed and one of the remaining two parts are retained by the laboratory while the last part becomes part of the samples' corresponding analytical data package. Internal laboratory chain-of-custody procedures are documented in the Laboratory Quality Assurance Plan (LQAP).

5.3.1.4 Chain-of-Custody Seal

Attachment B-7 is an example of a custody seal. The Custody seal is also an adhesive-backed label. It is part of a chain-of-custody process and is used to prevent tampering with samples after they have been collected in the field and sealed in coolers for transit to the laboratory. The COC seals are signed and dated by the samplers and affixed across the opening edges of each cooler containing environmental samples. COC seals may be available from the laboratory; these seals may also be purchased from a supplier.

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5.3.2 Geohydrological and Geotechnical Forms

5.3.2.1 Groundwater Level Measurement Sheet

A groundwater level measurement sheet, shown in Attachment C-1 must be filled out for each round of water level measurements made at a site.

~~5.3.2.2 Data Sheet for Pumping Test~~

~~During the performance of a pumping test (or an in-situ hydraulic conductivity test), a large amount of data must be recorded, often within a short time period. The pumping test data sheet (Attachment C-2) facilitates this task by standardizing the data collection format, and allowing the time interval for collection to be laid out in advance.~~

~~5.3.2.3 Packer Test Report Form~~

~~A packer test report form shown in Attachment C-3 must be completed for each well upon which a packer test is conducted following well installation.~~

5.3.2.4 Summary Log of Boring

During the progress of each boring, a log of the materials encountered, operation and driving of casing, and location of samples must be kept. The Summary Log of Boring (Attachment C-4) is used for this purpose and must be completed for each soil boring performed. In addition, if volatile organics are monitored on cores, samples or cuttings from the borehole (using HNU or OVA detectors), these results must be entered on the boring log (under the "Remarks" column) at the appropriate depth. The "Remarks" column can also be used to subsequently enter the laboratory sample number and the concentration of a few key analytical results. This feature allows direct comparison of contaminant concentrations with soil characteristics.

5.3.2.5 Monitoring Well Construction Details Form

A Monitoring Well Construction Details Form must be completed for every monitoring well piezometer or temporary well point installed. This form contains specific information on length and type of well riser pipe and screen, backfill, filter pack, annular seal and grout characteristics, and surface seal characteristics. This information is important in evaluating the performance of the monitoring well, particularly in areas where water levels show temporal variation, or where there are multiple (immiscible) phases of contaminants. Depending on the type of monitoring well (in overburden or bedrock), different forms are used (see Attachments C-5 through C-9). Similar forms are used for flush-mount well completions. The Monitoring Well Construction Details Form is not a controlled document.

~~5.3.2.6 Test Pit Log~~

~~When a test pit or trench is constructed for investigative or sampling purposes, a Test Pit Log (Attachment C-10) must be filled out by the responsible field geologist or sampling technician.~~

5.3.3 Equipment Calibration and Maintenance Form

The calibration or standardization of monitoring, measuring or test equipment is necessary to assure the proper operation and response of the equipment, to document the accuracy, precision or sensitivity of the measurement, and determine if correction should be applied to the readings. Some items of

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equipment require frequent calibration, others infrequent. Some are calibrated by the manufacturer, others by the user.

Each instrument requiring calibration has its own Equipment Calibration Log (Attachment D) which documents that the manufacturer's instructions were followed for calibration of the equipment, including frequency and type of standard or calibration device. An Equipment Calibration Log must be maintained for each electronic measuring device used in the field; entries must be made for each day the equipment is used.

5.4 Field Reports

The primary means of recording onsite activities is the site logbook. Other field notebooks may also be maintained. These logbooks and notebooks (and supporting forms) contain detailed information required for data interpretation or documentation, but are not easily useful for tracking and reporting of progress. Furthermore, the field logbook/notebooks remain onsite for extended periods of time and are thus not accessible for timely review by project management.

5.4.1 Weekly Status Reports

To facilitate timely review by project management, Xeroxed copies of logbook/notebook entries may be made for internal use. To provide timely oversight of onsite contractors, Daily Activities Reports are completed and submitted as described below.

It should be noted that in addition to the summaries described herein, other summary reports may also be contractually required.

5.4.2 Daily Activities Report

5.4.2.1 Description

The Daily Activities Report (DAR) documents the activities and progress for each day's field work. This report must be filled out on a daily basis whenever there are drilling, test pitting, well construction, or other related activities occurring which involve subcontractor personnel. These sheets summarize the work performed and form the basis of payment to subcontractors (Attachment E is an example of a Daily Activities Report).

5.4.2.2 Responsibilities

It is the responsibility of the rig geologist to complete the DAR and obtain the driller's signature acknowledging that the times and quantities of material entered are correct.

5.4.2.3 Submittal and Approval

At the end of the shift, the rig geologist must submit the Daily Activities Report to the Field Operations Leader (FOL) for review and filing. The Daily Activities Report is not a formal report and thus requires no further approval. The DAR reports are retained by the FOL for use in preparing the site logbook and in preparing weekly status reports for submission to the Project Manager.

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6.0 ATTACHMENTS

Attachment A	TYPICAL SITE LOGBOOK ENTRY
Attachment B-1	EXAMPLE GROUNDWATER SAMPLE LOG SHEET
Attachment B-2	EXAMPLE SURFACE WATER SAMPLE LOG SHEET
Attachment B-3	EXAMPLE SOIL/SEDIMENT SAMPLE LOG SHEET
Attachment B-4	CONTAINER SAMPLE LOG SHEET FORM
Attachment B-5	SAMPLE LABEL
Attachment B-6	CHAIN-OF-CUSTODY RECORD FORM
Attachment B-7	CHAIN-OF-CUSTODY SEAL
Attachment C-1	EXAMPLE GROUNDWATER LEVEL MEASUREMENT SHEET
Attachment C-2	EXAMPLE PUMPING TEST DATA SHEET
Attachment C-3	PACKER TEST REPORT FORM
Attachment C-4	EXAMPLE BORING LOG
Attachment C-5	EXAMPLE OVERBURDEN MONITORING WELL SHEET
Attachment C-5A	EXAMPLE OVERBURDEN MONITORING WELL SHEET (FLUSHMOUNT)
Attachment C-6	EXAMPLE CONFINING LAYER MONITORING WELL SHEET
Attachment C-7	EXAMPLE BEDROCK MONITORING WELL SHEET - OPEN HOLE WELL
Attachment C-8	EXAMPLE BEDROCK MONITORING WELL SHEET - WELL INSTALLED IN BEDROCK
Attachment C-8A	EXAMPLE BEDROCK MONITORING WELL SHEET - WELL INSTALLED IN BEDROCK (FLUSHMOUNT)
Attachment C-9	EXAMPLE TEST PIT LOG
Attachment D	EXAMPLE EQUIPMENT CALIBRATION LOG
Attachment E	EXAMPLE DAILY ACTIVITIES RECORD
Attachment F	FIELD TRIP SUMMARY REPORT

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**ATTACHMENT A
TYPICAL SITE LOGBOOK ENTRY**

START TIME: _____ DATE: _____

SITE LEADER: _____

PERSONNEL:-

BROWN & ROOT ENV.	DRILLER	EPA
_____	_____	_____
_____	_____	_____
_____	_____	_____

WEATHER: Clear, 68°F, 2-5 mph wind from SE

ACTIVITIES:

1. Steam jenny and fire hoses were set up.
2. Drilling activities at well _____ resumes. Rig geologist was _____. See Geologist's Notebook, No. 1, page 29-30, for details of drilling activity. Sample No. 123-21-S4 collected; see sample logbook, page 42. Drilling activities completed at 11:50 and a 4-inch stainless steel well installed. See Geologist's Notebook, No. 1, page 31, and well construction details for well _____.
3. Drilling rig No. 2 steam-cleaned at decontamination pit. Then set up at location of well _____.
4. Well _____ drilled. Rig geologist was _____. See Geologist's Notebook, No. 2, page _____ for details of drilling activities. Sample numbers 123-22-S1, 123-22-S2, and 123-22-S3 collected; see sample logbook, pages 43, 44, and 45.
5. Well _____ was developed. Seven 55-gallon drums were filled in the flushing stage. The well was then pumped using the pitcher pump for 1 hour. At the end of the hour, water pumped from well was "sand free."
6. EPA remedial project manger arrives on site at 14:25 hours.
7. Large dump truck arrives at 14:45 and is steam-cleaned. Backhoe and dump truck set up over test pit _____.
8. Test pit _____ dug with cuttings placed in dump truck. Rig geologist was _____. See Geologist's Notebook, No. 1, page 32, for details of test pit activities. Test pit subsequently filled. No samples taken for chemical analysis. Due to shallow groundwater table, filling in of test pit _____ resulted in a very soft and wet area. A mound was developed and the area roped off.
9. Express carrier picked up samples (see Sample Logbook, pages 42 through 45) at 17:50 hours. Site activities terminated at 18:22 hours. All personnel off site, gate locked.

Field Operations Leader

**ATTACHMENT B-3
EXAMPLE SOIL/SEDIMENT SINGLE SAMPLE LOG SHEET**

			SOIL/SEDIMENT SINGLE SAMPLE LOG SHEET			Page ____ of ____		
Project Site Name: _____			Sample ID No.: _____					
Project No.: _____			Sample Location: _____					
<input type="checkbox"/> Surface Soil <input type="checkbox"/> Subsurface Soil <input type="checkbox"/> Sediment <input type="checkbox"/> Other _____ <input type="checkbox"/> QA Sample Type: _____			Sampled By: _____					
			C.O.C. No.: _____					
Sample Method:								
		Sample		Time		Color/Description		
Depth Sampled:								
Sample Date and Time:								
<u>Type of Sample</u> <input type="checkbox"/> Grab <input type="checkbox"/> Composite <input type="checkbox"/> Grab-Composite <input type="checkbox"/> High Concentration <input type="checkbox"/> Low Concentration								
		Color		Description: (Sand, Clay, Dry, Moist, Wet, etc.)				
Analysis		Container Type/Label		Collected by		Map:		
Observations/Notes:								
Circle if Applicable:						Signature(s):		
MS/MSD	Duplicate ID No:							

ATTACHMENT B-5

SAMPLE LABEL

	Brown & Root Environmental	PROJECT: _____
STATION LOCATION: _____		
DATE: ____/____/____	TIME: _____ hrs.	
MEDIA: WATER <input type="checkbox"/>	SOIL <input type="checkbox"/>	SEDIMENT <input type="checkbox"/>
CONCENTRATION: LOW <input type="checkbox"/>	MEDIUM <input type="checkbox"/>	HIGH <input type="checkbox"/>
TYPE: GRAB <input type="checkbox"/>	COMPOSITE <input type="checkbox"/>	
ANALYSIS		PRESERVATION
VOA <input type="checkbox"/>	BNAs <input type="checkbox"/>	Cool to 4°C <input type="checkbox"/>
PCBs <input type="checkbox"/>	PESTICIDES <input type="checkbox"/>	HNO ₃ to pH < 2 <input type="checkbox"/>
METALS: TOTAL <input type="checkbox"/>	DISSOLVED <input type="checkbox"/>	NaOH to pH > 12 <input type="checkbox"/>
CYANIDE <input type="checkbox"/>		<input type="checkbox"/>
Sampled by: _____		
Remarks: _____		

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ATTACHMENT B-7

CHAIN-OF-CUSTODY SEAL

Signature <hr/> Date <hr/> CUSTODY SEAL	CUSTODY SEAL <hr/> Date <hr/> Signature
--	--

LEGEND
SOIL TERMS

UNIFIED SOIL CLASSIFICATION (USCS)

COARSE-GRAINED SOILS More Than Half of Material is LARGER Than No. 200 Sieve Size					FINE-GRAINED SOILS More Than Half of Material is SMALLER Than No. 200 Sieve Size						
FIELD IDENTIFICATION PROCEDURES (Excluding Particles Larger Than 3 Inches and Basing Fractions on Estimated Weights)			GROUP SYMBOL	TYPICAL NAMES	FIELD IDENTIFICATION PROCEDURES (Excluding Particles Larger Than 3 Inches and Basing Fractions on Estimated Weights)			GROUP SYMBOL	TYPICAL NAMES		
					Identification Procedures on Fraction Smaller than No. 40 Sieve Size						
					DAY STRENGTH (Crushing Characteristics)	DILATANCY (Reaction to Shaking)	TOUGHNESS (Consistency Near Plastic Limit)				
GRAVELS (50%+) > 1/4"	CLEAN GRAVELS (Low % Fines)	Wide range in grain size and substantial amounts of all intermediate particle sizes.	GW	Well graded gravels, gravel-sand mixtures, little or no fines.	SILTS AND CLAYS Liquid Limit < 50	None to Slight	Quick to Slow	None	ML	Inorganic silts and very fine sands, rock flour, silty or clayey fine sands with slight plasticity.	
		Predominantly one size or a range of sizes with some intermediate sizes missing.	GP	Poorly graded gravels, gravel sand mixtures, little or no fines.		Medium to High	None to Very Slow	Medium	CL	Inorganic clays of low to medium plasticity, gravelly clays, sandy clays, silty clays, lean clays.	
	GRAVELS W/FINES (High % Fines)	Non-plastic fines (for identification procedures, see ML)	GM	Silty gravels, poorly graded gravel-sand-silt mixtures.		Slight to Medium	Slow	Slight	OL	Organic silts and organic silt-clays of low plasticity.	
		Plastic fines (for identification procedures, see CL)	GC	Clayey gravels, poorly graded gravel-sand-clay mixtures.		Slight to Medium	Slow to None	Slight to Medium	MH	Inorganic silts, micaceous or diatomaceous fine sandy or silty soils, plastic silts.	
SANDS 50%+) < 1/4"	CLEAN SANDS (Low % Fines)	Wide range in grain size and substantial amounts of all intermediate particle sizes.	SW	Well graded sand, gravelly sands, little or no fines.	SILTS AND CLAYS Liquid Limit > 50	High to Very High	None	High	CH	Inorganic clays of high plasticity, fat clays.	
		Predominantly one size or a range of sizes with some intermediate sizes missing.	SP	Poorly graded sands, gravelly sands, little or no fines.		Medium to High	None to Very Slow	Slight to Medium	OH	Organic clays of medium to high plasticity.	
	SANDS W/FINES (High % Fines)	Non-plastic fines (for identification procedures, see ML)	SM	Silty sands, poorly graded sand-silt mixtures.		LIGHT ORGANIC SOILS	Readily identified by color, odor, spongy feel and frequently by fibrous texture.			PT	Peat and other organic soils
		Plastic fines (for identification procedures, see CL)	SC	Clayey sands, poorly graded sand-clay mixtures.							

Boundary classifications: Soils possessing characteristics of two groups are designated by combining group symbols. For example, GW-GC, well graded gravel-sand mixture with clay binder. All sieve sizes on this chart are U.S. Standard.

DESIGNATION	STANDARD PENETRATION RESISTANCE-BLOWS/FOOT
Very Loose	0-4
Loose	5-10
Medium Loose	11-30
Dense	31-50
Very Dense	Over 50

CONSISTENCY	UNC. COMPRESSIVE STRENGTH (TONS/SQ. FT.)	STANDARD PENETRATION RESISTANCE-BLOWS/FOOT	FIELD IDENTIFICATION METHODS
Very Soft	Less than 0.25	0 to 2	Easily penetrated several inches by fist
Soft	0.25 to 0.50	2 to 4	Easily penetrated several inches by thumb.
Medium Stiff	0.50 to 1.0	4 to 8	Can be penetrated several inches by thumb.
Stiff	1.0 to 2.0	8 to 15	Readily indented by thumb.
Very Stiff	2.0 to 4.0	15 to 30	Readily indented by thumbnail.
Hard	More than 4.0	Over 30	Indented with difficulty by thumbnail.

ROCK TERMS

ROCK HARDNESS (FROM CORE SAMPLES)			ROCK BROKENESS		
Descriptive Term	Screwdriver or Knife Effects	Hammer Effects	Descriptive Terms	Abbreviation	Spacing
Soft	Easily gouged	Crushes when pressed with hammer	Very Broken	(V. Br.)	0'-2"
Medium Soft	Can be gouged	Breaks (one blow); crumbly edges	Broken	(Br.)	2" - 1'
Medium Hard	Can be scratched	Breaks (one blow); sharp edges	Blocky	(Bl.)	1' - 3"
Hard	Cannot be scratched	Breaks conchoidally (several blows); sharp edges	Massive	(M.)	3' - 10'

LEGEND:		ROCK SAMPLES - TYPES		WATER LEVELS	
5.2" Split Barrel Sample		X-MX (Conventional) Core (-2.1/8" O.D.)		12/18	W 12.6' Initial Level w/Date a Depth
ST-3" O.D. Undisturbed Sample		Q-MQ (Wireline) Core (-1.7/8" O.D.)		12/18	W 12.6' Stabilized Level w/Date a Depth
0 - Other Samples, Specify in Remarks		Z - Other Core Sizes, Specify in Remarks			

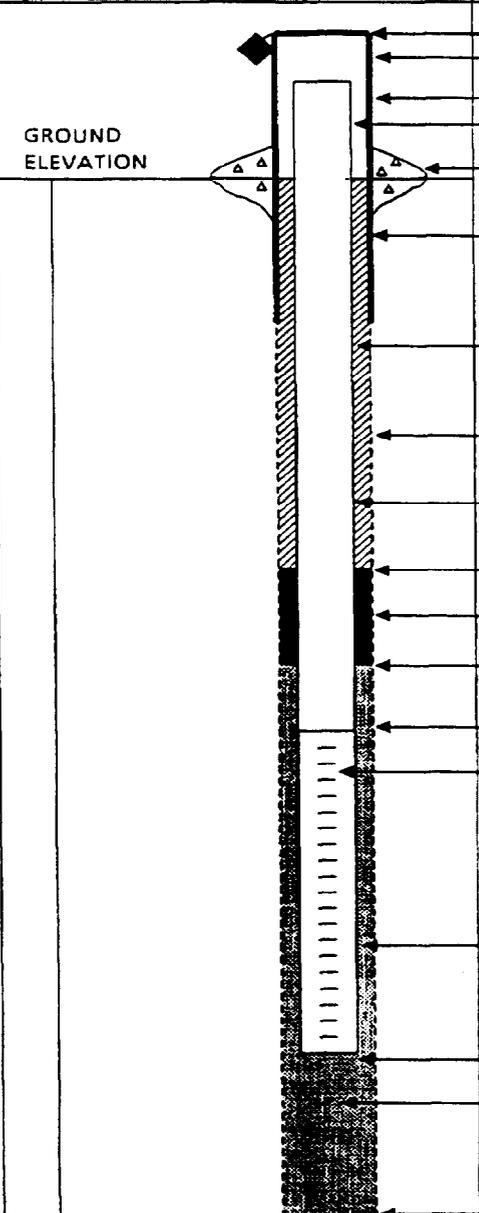
**ATTACHMENT C-5
EXAMPLE OVERBURDEN MONITORING WELL SHEET**



BORING NO.: _____

OVERBURDEN MONITORING WELL SHEET

PROJECT _____	LOCATION _____	DRILLER _____
PROJECT NO. _____	BORING _____	DRILLING METHOD _____
ELEVATION _____	DATE _____	DEVELOPMENT METHOD _____
FIELD GEOLOGIST _____		



	ELEVATION OF TOP OF SURFACE CASING : _____	
	ELEVATION OF TOP OF RISER PIPE : _____	
	STICK - UP TOP OF SURFACE CASING : _____	
	STICK - UP RISER PIPE : _____	
	TYPE OF SURFACE SEAL : _____	
	I.D. OF SURFACE CASING : _____	
	TYPE OF SURFACE CASING : _____	
	RISER PIPE I.D. : _____	
	TYPE OF RISER PIPE : _____	
	BOREHOLE DIAMETER : _____	
	TYPE OF BACKFILL : _____	
	ELEVATION / DEPTH TOP OF SEAL : _____	/
	TYPE OF SEAL : _____	
	DEPTH TOP OF SAND PACK : _____	
	ELEVATION / DEPTH TOP OF SCREEN : _____	/
	TYPE OF SCREEN : _____	
	SLOT SIZE x LENGTH : _____	
	I.D. OF SCREEN : _____	
	TYPE OF SAND PACK : _____	
	ELEVATION / DEPTH BOTTOM OF SCREEN : _____	/
	ELEVATION / DEPTH BOTTOM OF SAND PACK : _____	/
	TYPE OF BACKFILL BELOW OBSERVATION WELL : _____	
	ELEVATION / DEPTH OF HOLE : _____	/

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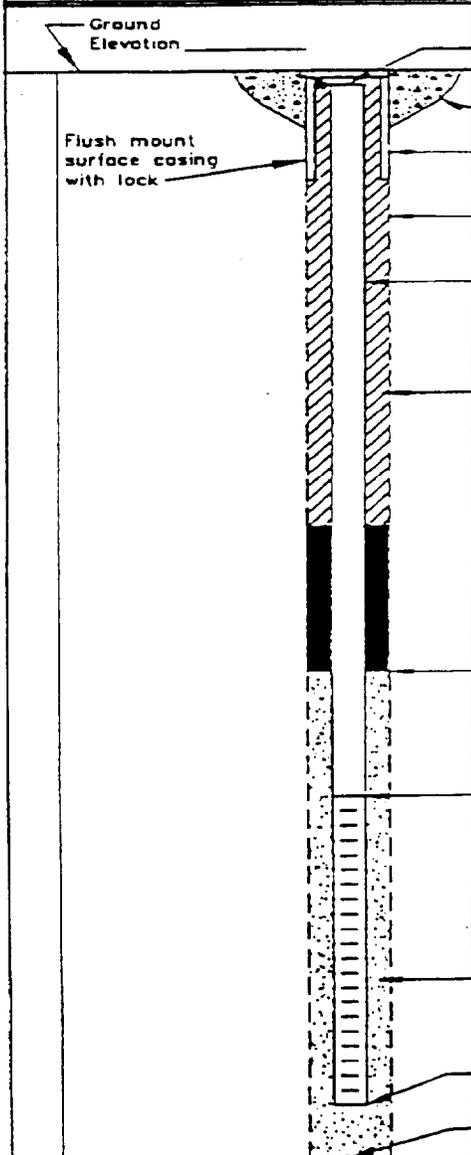
**ATTACHMENT C-5A
EXAMPLE OVERBURDEN MONITORING WELL SHEET (FLUSHMOUNT)**

BORING NO.: _____



MONITORING WELL SHEET

PROJECT _____	LOCATION _____	DRILLER _____
PROJECT NO. _____	BORING _____	DRILLING _____
ELEVATION _____	DATE _____	METHOD _____
FIELD GEOLOGIST _____		DEVELOPMENT _____
		METHOD _____



Ground Elevation _____

Flush mount surface casing with lock

ELEVATION TOP OF RISER: _____

TYPE OF SURFACE SEAL: _____

TYPE OF PROTECTIVE CASING: _____

I.D. OF PROTECTIVE CASING: _____

DIAMETER OF HOLE: _____

TYPE OF RISER PIPE: _____

RISER PIPE I.D.: _____

TYPE OF BACKFILL/SEAL: _____

DEPTH/ELEVATION TOP OF SAND: _____ /

DEPTH/ELEVATION TOP OF SCREEN: _____ /

TYPE OF SCREEN: _____

SLOT SIZE x LENGTH: _____

TYPE OF SAND PACK: _____

DIAMETER OF HOLE IN BEDROCK: _____

DEPTH/ELEVATION BOTTOM OF SCREEN: _____ /

DEPTH/ELEVATION BOTTOM OF SAND: _____ /

DEPTH/ELEVATION BOTTOM OF HOLE: _____ /

BACKFILL MATERIAL BELOW SAND: _____

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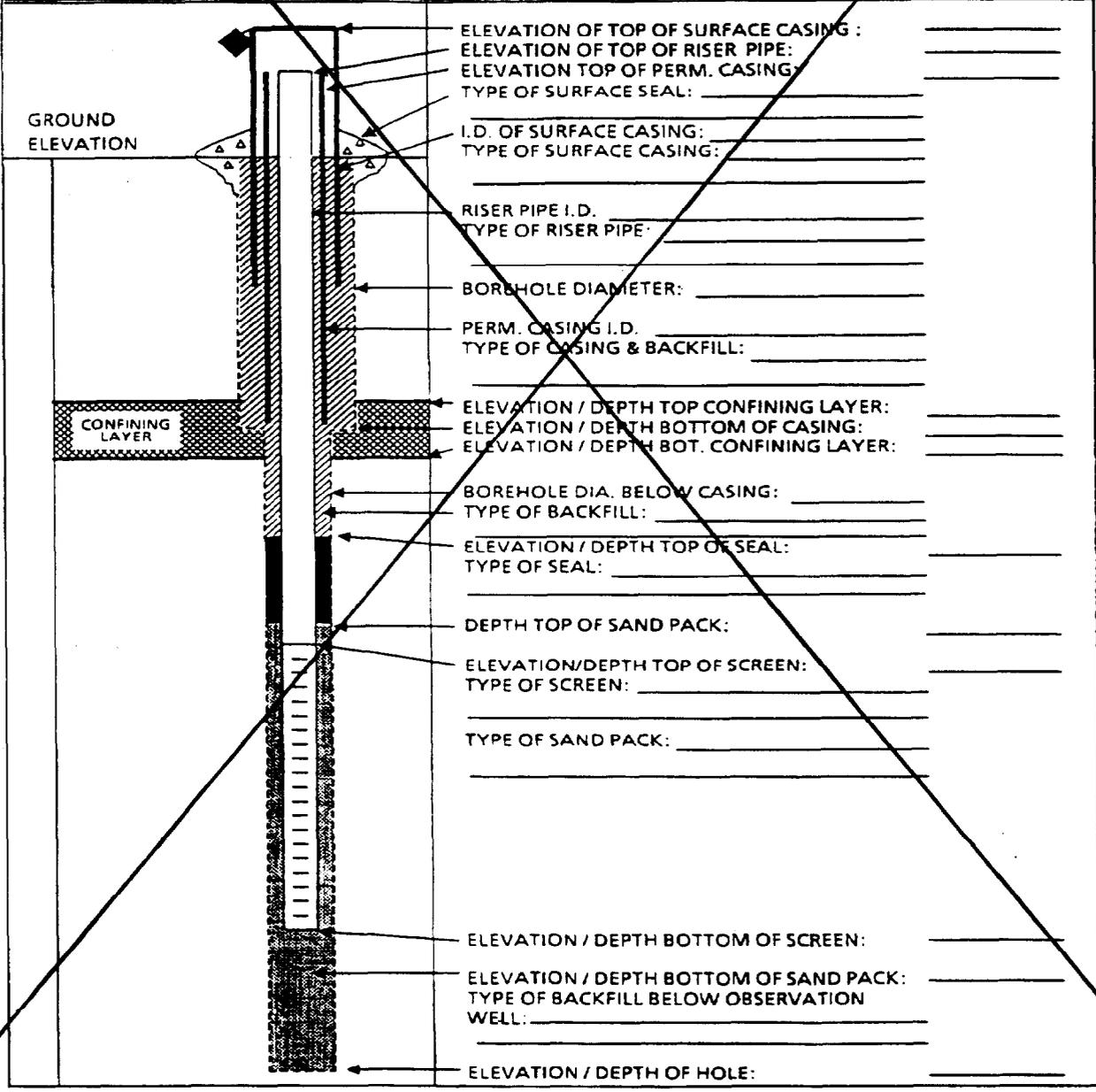
ATTACHMENT C-6
EXAMPLE CONFINING LAYER MONITORING WELL SHEET

BORING NO.: _____



CONFINING LAYER
MONITORING WELL SHEET

PROJECT _____	LOCATION _____	DRILLER _____
PROJECT NO. _____	BORING _____	DRILLING METHOD _____
ELEVATION _____	DATE _____	DEVELOPMENT METHOD _____
FIELD GEOLOGIST _____		



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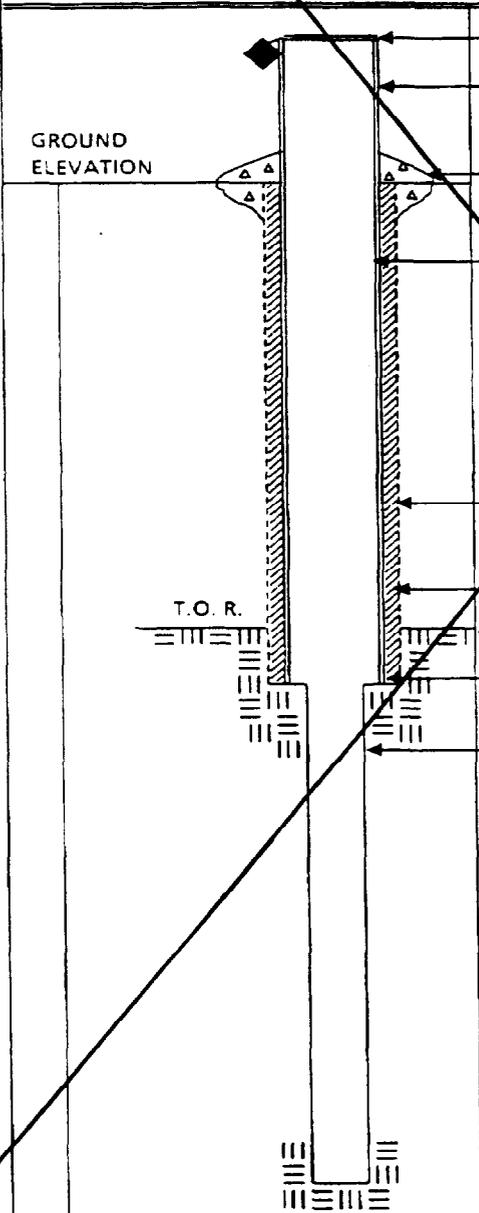
**ATTACHMENT C-7
EXAMPLE BEDROCK MONITORING WELL SHEET - OPEN HOLE WELL**

BORING NO.: _____



**BEDROCK
MONITORING WELL SHEET
OPEN HOLE WELL**

PROJECT _____	LOCATION _____	DRILLER _____
PROJECT NO. _____	BORING _____	DRILLING METHOD _____
ELEVATION _____	DATE _____	DEVELOPMENT METHOD _____
FIELD GEOLOGIST _____		



ELEVATION OF TOP OF CASING: _____

STICK UP OF CASING ABOVE GROUND SURFACE: _____

TYPE OF SURFACE SEAL: _____

I.D. OF CASING: _____

TYPE OF CASING: _____

TEMP. / PERM.: _____

DIAMETER OF HOLE: _____

TYPE OF CASING SEAL: _____

DEPTH TO TOP OF ROCK: _____

DEPTH TO BOTTOM CASING: _____

DIAMETER OF HOLE IN BEDROCK: _____

DESCRIBE IF CORE / REAMED WITH BIT:

DESCRIBE JOINTS IN BEDROCK AND DEPTH:

ELEVATION / DEPTH OF HOLE: _____

Subject

FIELD DOCUMENTATION

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ATTACHMENT C-8
EXAMPLE BEDROCK MONITORING WELL SHEET - WELL INSTALLED IN BEDROCK

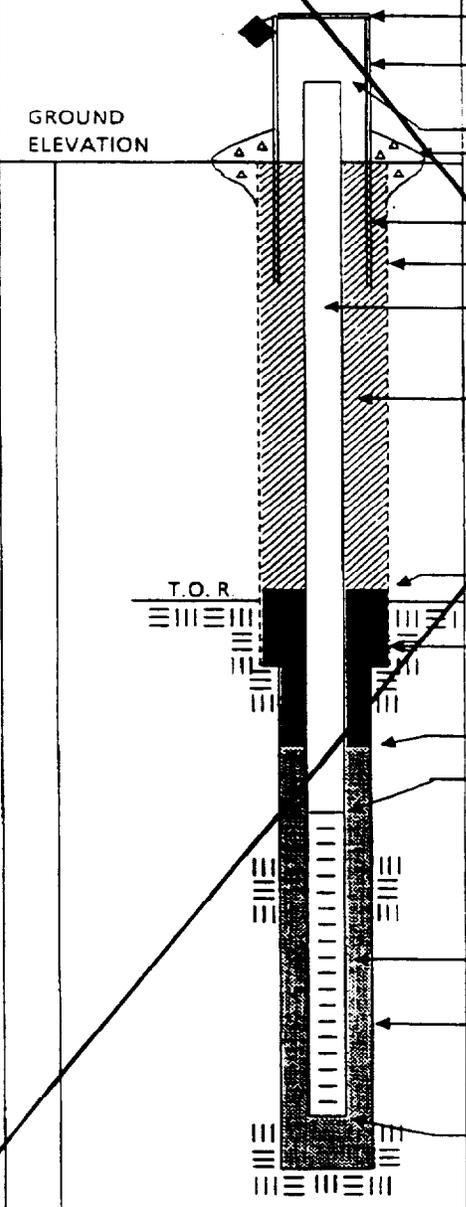
BORING NO.: _____



BEDROCK MONITORING WELL SHEET

WELL INSTALLED IN BEDROCK

PROJECT _____	LOCATION _____	DRILLER _____
PROJECT NO. _____	BORING _____	DRILLING _____
ELEVATION _____	DATE _____	METHOD _____
FIELD GEOLOGIST _____		DEVELOPMENT _____
		METHOD _____



ELEVATION OF TOP OF SURFACE CASING: _____
STICK UP OF CASING ABOVE GROUND SURFACE: _____
ELEVATION TOP OF RISER: _____
TYPE OF SURFACE SEAL: _____
I.D. OF SURFACE CASING: _____
DIAMETER OF HOLE: _____
RISER PIPE I.D.: _____
TYPE OF RISER PIPE: _____
TYPE OF BACKFILL: _____
ELEVATION / DEPTH TOP OF SEAL: _____
ELEVATION / DEPTH TOP OF BEDROCK: _____
TYPE OF SEAL: _____
ELEVATION / DEPTH TOP OF SAND: _____
ELEVATION / DEPTH TOP OF SCREEN: _____
TYPE OF SCREEN: _____
SLOT SIZE x LENGTH: _____
I.D. SCREEN: _____
TYPE OF SAND PACK: _____
DIAMETER OF HOLE IN BEDROCK: _____
CORE / REAM: _____
ELEVATION / DEPTH BOTTOM SCREEN: _____
ELEVATION / DEPTH BOTTOM OF HOLE: _____

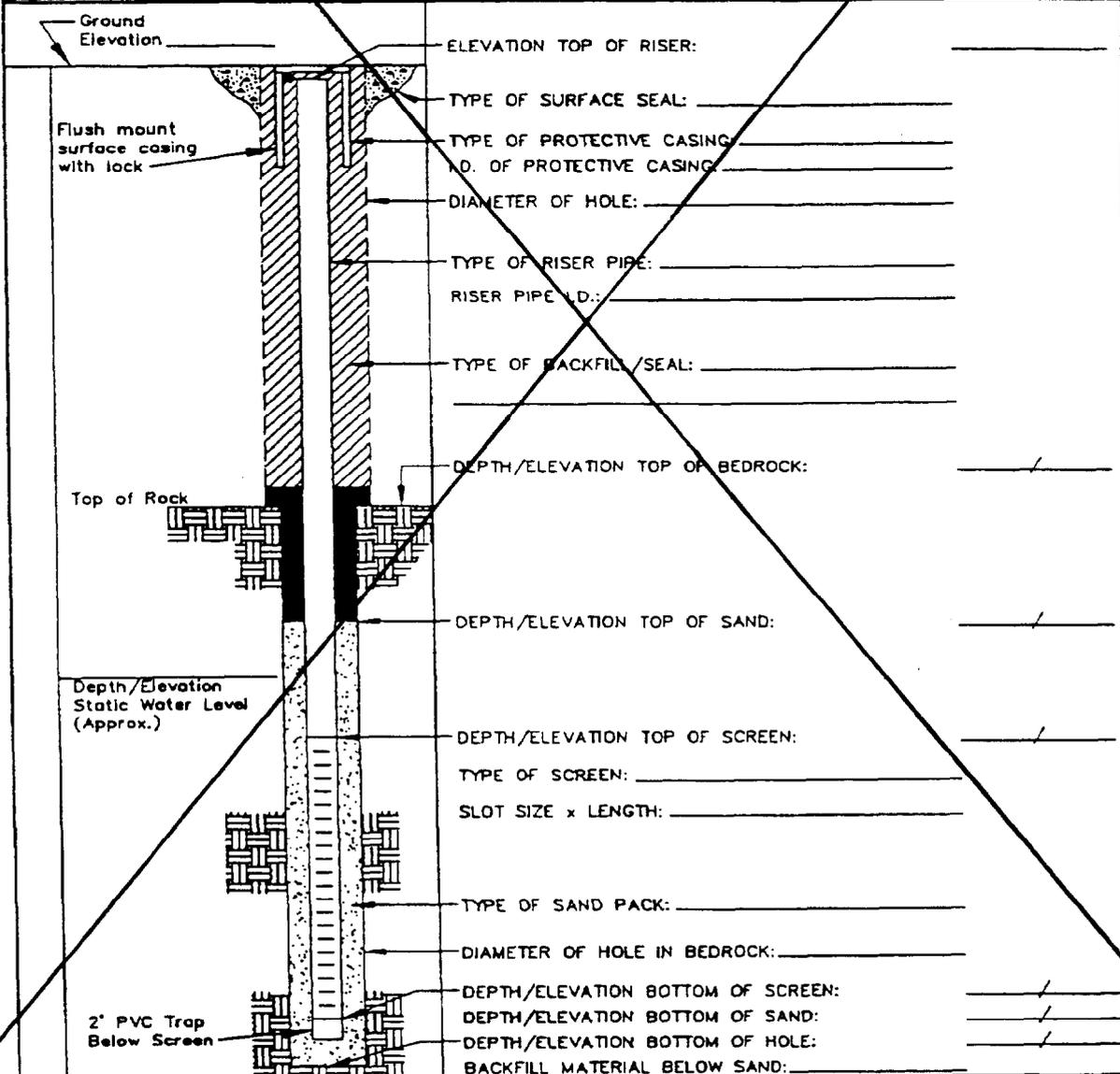
**ATTACHMENT C-8A
EXAMPLE BEDROCK MONITORING WELL SHEET
WELL INSTALLED IN BEDROCK (FLUSHMOUNT)**

BORING NO.: _____



**BEDROCK
MONITORING WELL SHEET
WELL INSTALLED IN BEDROCK**

PROJECT: _____	LOCATION: _____	DRILLER: _____
PROJECT NO.: _____	BORING: _____	DRILLING METHOD: _____
ELEVATION: _____	DATE: _____	DEVELOPMENT METHOD: _____
FIELD GEOLOGIST: _____		



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**ATTACHMENT F
FIELD TRIP SUMMARY REPORT
PAGE 1 OF 2**

SUNDAY

Date: _____ Personnel: _____

Weather: _____ Onsite: _____

Site Activities: _____

MONDAY

Date: _____ Personnel: _____

Weather: _____ Onsite: _____

Site Activities: _____

TUESDAY

Date: _____ Personnel: _____

Weather: _____ Onsite: _____

Site Activities: _____

WEDNESDAY

Date: _____ Personnel: _____

Weather: _____ Onsite: _____

Site Activities: _____

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**ATTACHMENT F
PAGE 2 OF 2
FIELD TRIP SUMMARY REPORT**

THURSDAY

Date: _____ Personnel: _____

Weather: _____ Onsite: _____

Site Activities: _____

FRIDAY

Date: _____ Personnel: _____

Weather: _____ Onsite: _____

Site Activities: _____

SATURDAY

Date: _____ Personnel: _____

Weather: _____ Onsite: _____

Site Activities: _____



BROWN & ROOT ENVIRONMENTAL

STANDARD OPERATING PROCEDURES

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Effective Date 03/01/96	Revision 0
Applicability B&R Environmental, NE	
Prepared Earth Sciences Department	
Approved D. Senovich <i>NS</i>	

Subject **DECONTAMINATION OF FIELD EQUIPMENT
AND WASTE HANDLING**

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1.0 PURPOSE

The purpose of this procedure is to provide guidelines regarding the appropriate procedures to be followed when decontaminating drilling equipment, monitoring well materials, chemical sampling equipment and field analytical equipment.

2.0 SCOPE

This procedure addresses drilling equipment and monitoring well materials decontamination, as well as chemical sampling and field analytical equipment decontamination. This procedure also provides general reference information on the control of contaminated materials.

3.0 GLOSSARY

None.

4.0 RESPONSIBILITIES

Project Manager - Responsible for ensuring that all field activities are conducted in accordance with approved project plan(s) requirements.

Field Operations Leader (FOL) - Responsible for the onsite verification that all field activities are performed in compliance with approved Standards Operating Procedures or as otherwise dictated by the approved project plan(s).

5.0 PROCEDURES

To ensure that analytical chemical results reflect actual contaminant concentrations present at sampling locations, the various drilling equipment and chemical sampling and analytical equipment used to acquire the environment sample must be properly decontaminated. Decontamination minimizes the potential for cross-contamination between sampling locations, and the transfer of contamination offsite.

5.1 Drilling Equipment

Prior to the initiation of a drilling program, all drilling equipment involved in field sampling activities shall be decontaminated by steam cleaning at a predetermined area. The steam cleaning procedure shall be performed using a high-pressure spray of heated potable water producing a pressurized stream of steam. This steam shall be sprayed directly onto all surfaces of the various equipment which might contact environmental samples. The decontamination procedure shall be performed until all equipment is free of all visible potential contamination (dirt, grease, oil, noticeable odors, etc.) In addition, this decontamination procedure shall be performed at the completion of each sampling and/or drilling location, including soil borings, installation of monitoring wells, test pits, etc. Such equipment shall include drilling rigs, backhoes, downhole tools, augers, well casings, and screens. Where the drilling rig is set to perform multiple borings at a single area of concern, the steam-cleaning of the drilling rig itself may be waived with proper approval. Downhole equipment, however, must always be steam-cleaned between borings. Where PVC well casings are to be installed, decontamination is not required if the manufacturer provides these casings in factory-sealed, protective, plastic sleeves (so long as the protective packaging is not compromised until immediately before use.

The steam cleaning area shall be designed to contain decontamination wastes and waste waters and can be a lined excavated pit or a bermed concrete or asphalt pad. For the latter, a floor drain must be

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provided which is connected to a holding facility. A shallow above-ground tank may be used or a pumping system with discharge to a waste tank may be installed.

In certain cases such an elaborate decontamination pad is not possible. In such cases, a plastic lined gravel bed pad with a collection system may serve as an adequate decontamination area. Alternately, a lined sloped pad with a collection pump installed at the lower end may be permissible. The location of the steam cleaning area shall be onsite in order to minimize potential impacts at certain sites.

Guidance to be used when decontaminating drilling equipment shall include:

- As a general rule, any part of the drilling rig which extends over the borehole, shall be steam cleaned.
- All drilling rods, augers, and any other equipment which will be introduced to the hole shall be steam cleaned.
- The drilling rig, all rods and augers, and any other potentially contaminated equipment shall be decontaminated between each well location to prevent cross contamination of potential hazardous substances.

Prior to leaving at the end of each work day and/or at the completion of the drilling program, drilling rigs and transport vehicles used onsite for personnel or equipment transfer shall be steam cleaned, as practicable. A drilling rig left at the drilling location does not need to be steam cleaned until it is finished drilling at that location.

5.2 Sampling Equipment

5.2.1 Bailers and Bailing Line

The potential for cross-contamination between sampling points through the use of a common bailer or its attached line is high unless strict procedures for decontamination are followed. For this reason, it is preferable to dedicate an individual bailer and its line to each sample point, although this does not eliminate the need for decontamination of dedicated bailers. For non-dedicated sampling equipment, the following conditions and/or decontamination procedures must be followed.

Before the initial sampling and after each successive sampling point, the bailer must be decontaminated. The following steps are to be performed when sampling for organic contaminants. Note: contract-specific requirements may permit alternative procedures.

- Potable water rinse
- Alconox or Liquinox detergent wash
- Scrubbing of the line and bailer with a scrub brush (may be required if the sample point is heavily contaminated with heavy or extremely viscous compounds)
- Potable water rinse
- Rinse with 10 percent nitric acid solution*
- Deionized water rinse

* Due to the leaching ability of nitric acid on stainless steel, this step is to be omitted if a stainless steel sampling device is being used and metals analysis is required with detection limits less than approximately 50 ppb.

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- Acetone or methanol rinse (in some EPA Regions, isopropanol is used instead)
- Hexane rinse**
- Copious distilled/Deionized water rinse
- Air dry

If sampling for volatile organic compounds (VOCs) only, the nitric acid, acetone, methanol, and hexane rinses may be omitted. Only reagent grade or purer solvents are to be used for decontamination. When isopropanol is used, the bailer must be thoroughly dry before using to acquire the next sample.

In general, specially purchased pre-cleaned disposable sampling equipment is not decontaminated (nor is an equipment rinsate blank collected) so long as the supplier has provided certification of cleanliness. If decontamination is performed on several bailers at once (i.e., in batches), bailers not immediately used may be completely wrapped in aluminum foil (shiny-side toward equipment) and stored for future use. When batch decontamination is performed, one equipment rinsate is generally collected from one of the bailers belonging to the batch before it is used for sampling.

It is recommended that clean, dedicated braided nylon or polypropylene line be employed with each bailer use.

5.2.2 Sampling Pumps

Most sampling pumps are low volume (less than 2 gpm) pumps. These include peristaltic, diaphragm, air-lift, pitcher and bladder pumps, to name a few. If these pumps are used for sampling from more than one sampling point, they must be decontaminated prior to initial use and after each use.

The procedures to be used for decontamination of sampling pumps compare to those used for a bailer except that the 10 percent nitric acid solution is omitted. Each of the liquid fractions is to be pumped through the system. The amount of pumping is dependent upon the size of the pump and the length of the intake and discharge hoses. Certain types of pumps are unacceptable for sampling purposes. For peristaltic pumps, the tubing is replaced rather than cleaned.

An additional problem is introduced when the pump relies on absorption of water via an inlet or outlet hose. For organic sampling, this hose should be Teflon. Other types of hoses leach organics (especially phthalate esters) into the water being sampled or adsorb organics from the sampled water. For all other sampling, the hose should be Viton, polyethylene, or polyvinyl chloride (listed in order of preference). Whenever possible, dedicated hoses should be used. It is preferable that these types of pumps not be used for sampling, only for purging.

~~5.2.3 Filtering Equipment~~

~~On occasion, the sampling plan may require acquisition of filtered groundwater samples. Field-filtering is addressed in SOP SA-6.1 and should be conducted as soon after sample acquisition as possible. To this end, three basic filtration systems are most commonly used: the in-line disposable Teflon filter, the inert gas over-pressure filtration system, and the vacuum filtration system.~~

~~For the in-line filter, decontamination is not required since the filter cartridge is disposable, however, the cartridge must be disposed of in an approved receptacle and the intake and discharge lines must still be decontaminated or replaced before each use.~~

** If sampling for pesticides, PCBs, or fuels.

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~~For the over-pressure and the vacuum filtration systems, the portions of the apparatus which come in contact with the sample must be decontaminated as outlined in the paragraphs describing the decontamination of bailers. (Note: Varieties of both of these systems come equipped from the manufacturer with Teflon lined surfaces for those that would come into contact with the sample. These filtration systems are preferred when decontamination procedures must be employed.)~~

5.2.4 Other Sampling Equipment

Field tools such as trowels and mixing bowls are to be decontaminated in the same manner as described above.

5.3 Field Analytical Equipment

5.3.1 Water Level Indicators

Water level indicators that come into contact with groundwater must be decontaminated using the following steps:

- Rinse with potable water
- Rinse with deionized water
- Acetone or methanol rinse (unless otherwise directed by manufacturer)
- Rinse with deionized water

Water level indicators that do not come in contact with the groundwater but may encounter incidental contact during installation or retrieval need only undergo the first and last steps stated above.

5.3.2 Probes

Probes (e.g., pH or specific-ion electrodes, geophysical probes, or thermometers) which would come in direct contact with the sample, will be decontaminated using the procedures specified above unless manufacturer's instructions indicate otherwise (e.g., dissolved oxygen probes). Probes that contact a volume of groundwater not used for laboratory analyses can be rinsed with deionized water. For probes which make no direct contact, (e.g., OVA equipment) the probe is self-cleaning when exposure to uncontaminated air is allowed and the housing can be wiped clean with paper-towels or cloth wetted with alcohol.

5.4 Waste Handling

For the purposes of these procedures, contaminated materials are defined as any byproducts of field activities that are suspected or known to be contaminated with hazardous substances. These byproducts include such materials as decontamination solutions, disposable equipment, drilling muds, well-development fluids, and spill-contaminated materials and Personal Protection Equipment (PPE).

The procedures for obtaining permits for investigations of sites containing hazardous substances are not clearly defined at present. In the absence of a clear directive to the contrary by the EPA and the states, it must be assumed that hazardous wastes generated during field activities will require compliance with Federal agency requirements for generation, storage, transportation, or disposal. In addition, there may be state regulations that govern the disposal action. This procedure exclusively describes the technical methods used to control contaminated materials.

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The plan documents for site activities must include a description of control procedures for contaminated materials. This planning strategy must assess the type of contamination, estimate the amounts that would be produced, describe containment equipment and procedures, and delineate storage or disposal methods. As a general policy, it is wise to select investigation methods that minimize the generation of contaminated spoils. Handling and disposing of potentially hazardous materials can be dangerous and expensive. Until sample analysis is complete, it is assumed that all produced materials are suspected of contamination from hazardous chemicals and require containment.

5.5 Sources of Contaminated Materials and Containment Methods

5.5.1 Decontamination Solutions

All waste decontamination solutions and rinses must be assumed to contain the hazardous chemicals associated with the site unless there are analytical or other data to the contrary. The waste solution volumes could vary from a few gallons to several hundred gallons in cases where large equipment required cleaning.

Containerized waste rinse solutions are best stored in 55-gallon drums (or equivalent containers) that can be sealed until ultimate disposal at an approved facility. Larger equipment such as backhoes and tractors must be decontaminated in an area provided with an impermeable liner and a liquid collection system. A decontamination area for large equipment could consist of a bermed concrete pad with a floor drain leading to a buried holding tank.

5.5.2 Disposable Equipment

Disposable equipment that could become contaminated during use typically includes PPE, rubber gloves, boots, broken sample containers, and cleaning-wipes. These items are small and can easily be contained in 55-gallon drums with lids. These containers should be closed at the end of each work day and upon project completion to provide secure containment until disposed.

5.5.3 Drilling Muds and Well-Development Fluids

Drilling muds and well-development fluids are materials that may be used in groundwater monitoring well installations. Their proper use could result in the surface accumulation of contaminated liquids and muds that require containment. The volumes of drilling muds and well-development fluids used depend on well diameter and depth, groundwater characteristics, and geologic formations. There are no simple mathematical formulas available for accurately predicting these volumes. It is best to rely on the experience of reputable well drillers familiar with local conditions and the well installation techniques selected. These individuals should be able to estimate the sizes (or number) of containment structures required. Since guesswork is involved, it is recommended that an slight excess of the estimated amount of containers required will be available.

Drilling muds are mixed and stored in what is commonly referred to as a mud pit. This mud pit consists of a suction section from which drilling mud is withdrawn and pumped through hoses, down the drill pipe to the bit, and back up the hole to the settling section of the mud pit. In the settling section, the mud's velocity is reduced by a screen and several flow-restriction devices, thereby allowing the well cuttings to settle out of the mud/fluid.

The mud pit may be either portable above-ground tanks commonly made of steel (which is preferred) or stationary in-ground pits as depicted in Attachment A. The above-ground tanks have a major advantage over the in-ground pits because the above-ground tanks isolate the natural soils from the

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contaminated fluids within the drilling system. These tanks are also portable and can usually be cleaned easily.

As the well is drilled, the cuttings that accumulate in the settling section must be removed. This is best done by shoveling them into drums or other similar containers. When the drilling is complete, the contents of the above-ground tank are likewise shoveled or pumped into drums, and the tank is cleaned and made available for its next use.

If in-ground pits are used, they should not extend into the natural water table. They should also be lined with a bentonite-cement mixture followed by a layer of flexible impermeable material such as plastic sheeting. Of course, to maintain its impermeable seal, the lining material used would have to be nonreactive with the wastes. An advantage of the in-ground pits is that well cuttings do not necessarily have to be removed periodically during drilling because the pit can be made deep enough to contain them. Depending on site conditions, the in-ground pit may have to be totally excavated and refilled with uncontaminated natural soils when the drilling operation is complete.

When the above-ground tank or the in-ground pit is used, a reserve tank or pit should be located at the site as a backup system for leaks, spills, and overflows. In either case, surface drainage should be such that any excess fluid could be controlled within the immediate area of the drill site.

The containment procedure for well-development fluids is similar to that for drilling muds. The volume and weight of contaminated fluid will be determined by the method used for development. When a new well is pumped or bailed to produce clear water, substantially less volume and weight of fluid result than when backwashing or high-velocity jetting is used.

5.5.4 Spill-Contaminated Materials

A spill is always possible when containers of liquids are opened or moved. Contaminated sorbents and soils resulting from spills must be contained. Small quantities of spill-contaminated materials are usually best contained in drums, while larger quantities can be placed in lined pits or in other impermeable structures. In some cases, onsite containment may not be feasible and immediate transport to an approved disposal site will be required.

5.6 Disposal of Contaminated Materials

Actual disposal techniques for contaminated materials are the same as those for any hazardous substance, that is, incineration, landfilling, treatment, and so on. The problem centers around the assignment of responsibility for disposal. The responsibility must be determined and agreed upon by all involved parties before the field work starts. If the site owner or manager was involved in activities that precipitated the investigation, it seems reasonable to encourage his acceptance of the disposal obligation. In instances where a responsible party cannot be identified, this responsibility may fall on the public agency or private organization investigating the site.

Another consideration in selecting disposal methods for contaminated materials is whether the disposal can be incorporated into subsequent site cleanup activities. For example, if construction of a suitable onsite disposal structure is expected, contaminated materials generated during the investigation should be stored at the site for disposal with other site materials. In this case, the initial containment structures should be evaluated for use as long-term storage structures. Also, other site conditions such as drainage control, security, and soil type must be considered so that proper storage is provided. If onsite storage is expected, then the containment structures should be specifically designed for that purpose.

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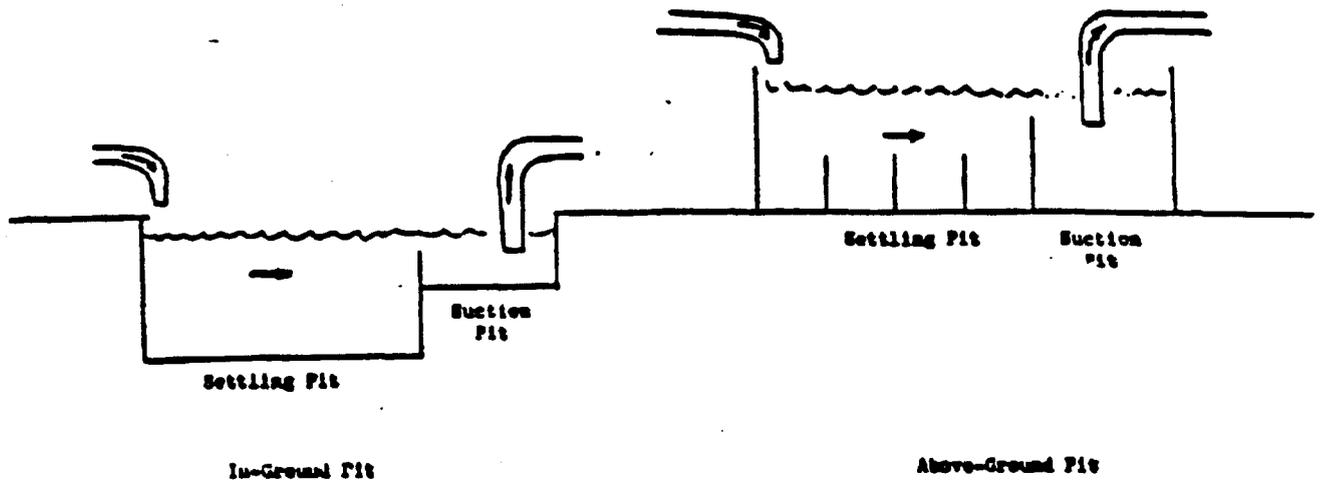
6.0 REFERENCES

Brown & Root Environmental: Standard Operating Procedure No. 4.33, Control of Contaminated Material.

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ATTACHMENT A

TWO TYPES OF MUD PITS USED IN WELL DRILLING



APPENDIX E

HEALTH AND SAFETY PLAN AND ADDENDUM

**HEALTH AND SAFETY PLAN ADDENDUM
FOR
MARINE CORPS AIR STATION
CHERRY POINT, NORTH CAROLINA**

**TREATABILITY STUDY AS AND SVE
TREATABILITY STUDY
AT 002**

Submitted to:

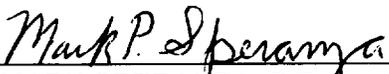
Northern Division
Environmental Branch, Code 18
Naval Facilities Engineering Command
10- Industrial Highway, Mail Stop #82
Lester, Pennsylvania 19113-2090

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Foster Plaza 7
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NOVEMBER 1996

APPROVED BY:


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PROJECT MANAGER
MANAGER

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MATTHEW M. SOLTIS, CIH, CSP
CLEAN HEALTH AND SAFETY

The following information represents modifications to the Health and Safety Plan (HASP) for the CERCLA RI/FS Project at Marine Corps Air Station (MCAS) Cherry Point, North Carolina. These modifications have been generated to address a change in work order of planned onsite activities, as presented in the Treatability Study Work Plan for the AS/SVE Operable Unit No. 2 (OU2). This document will be incorporated as an addendum to the aforementioned HASP. This addendum addresses additional activities that are to be conducted at the site. Activities associated with the Treatability Study Work Plan for the AS/SVE include the installation of eight air injection wells, fourteen vapor extraction wells, and seven performance monitoring wells, air sampling using tedlar bags, groundwater sampling and split spoon soil sampling. The hazards associated with these activities are also addressed in this addendum. Where potential hazards have been identified and associated with the planned activity, the necessary actions to be taken to mitigate these hazards have also been identified.

The following sections of the HASP dated June 1994 are to be amended to include the information identified within the text of this addendum. It is the Project Manager's (PM) responsibility to forward copies of this addendum to the field crew to be inserted into the field copies of the HASP. It is the Field Operation leader's (FOL) responsibility to ensure that all members of the field crew review the addendum. In addition to the review process, the final HASP (field copies) sections will be marked to indicate areas revised as a result of this addendum. All sections of the original HASP not modified by this addendum remain in effect. The FOL will ensure all field crew members indicate, by signing a field team review sheet in the back of this document, they have reviewed the elements of this addendum, understand its requirements, and any questions they may have had have been answered to their satisfaction.

Sections: 4.0 Scope of Work

 5.0 Hazard Assessment

 Table 13-1 Emergency Information

 15.0 Spill Containment Program

The following sections are added to the final HASP, as new sections to support his operation. These sections include:

Table 4-3 Site task and the associated hazards, air monitoring requirements, PPE, decontamination and control measures.

The modifications to the individual sections are presented in the remainder of this addendum.

4.0 SCOPE OF WORK

4.1 Site Activities at OU2

The following is a discussion of the site activities planned for OU2 at Cherry Point. Each site activity is briefly discussed below. For additional information, refer to the associated Treatability Study Work Plan for Pilot-Scale AS/SVE at Operable Unit Number Two.

4.1.1 Installation of Air Injection and Vapor Extraction Wells

Eight air injection wells and fourteen vapor extraction wells will be installed. These wells will be installed using conventional hollow-stem augering techniques. All air injection and vapor extraction wells will be constructed of 2-inch diameter, schedule 40 PVC piping.

4.1.2 Performance Monitoring Wells

All performance wells will be installed using conventional hollow-stem augering techniques. These wells will be located throughout the treatability study location in an effort to provide monitoring points at various distances from the air injection and vacuum extraction points to determine radii of influence.

4.1.3 Air Sampling

Air quality at the treatability study AS/SVE system will be measured by collecting grab air samples in Tedlar bags for fixed base laboratory analysis. Air samples will also be analyzed using compound specified Draeger tubes.

4.1.4 Groundwater and soil sampling

Groundwater samples will be collected from various performance monitoring wells to establish a baseline. One split spoon sample will be collected from selected wells during drilling. Another boring will be drilled (hand auger or conventional drilling) adjacent to the initial sampling points upon completion of the treatability study.

5.0 HAZARD ASSESSMENT

This section describes the chemical and physical hazards that are associated either directly or indirectly with the tasks and operations described in this addendum. Measures to control the hazards presented below can be found in Section 6.0 and Attachment 1 of this addendum and Sections 7.0, 8.0, and 11.0 for the HASP.

5.1 Primary Site contaminants at OU2

Previous analytical results for groundwater and subsurface samples collected at OU2 indicate the presence of volatile organics, semivolatiles, and metals.

5.1.1 Surficial Aquifer Groundwater

The most commonly detected contaminants in the surficial aquifer were monocyclic aromatic fuel constituents (BTEX), halogenated aliphatics (chlorinated solvents and breakdown products such as PCE, TCE, DCE, vinyl chloride, TCA, dichloroethanes (DCA), and chloroethane), and chlorinated monocyclic aromatics (chlorobenzene and dichlorobenzenes). Several items are of note in discussing the nature and extent of contamination in the surficial aquifer. First, there is widespread contamination of groundwater with organic chemicals. Those listed above are the most prevalent based on past and recent data. Second, the maximum detected concentrations of many compounds have declined over the years. Third, while no distinct plumes are visible based on the most recent sampling event, several areas of overall contamination can be outlined as general areas of concern. These areas of concern are where certain contaminants exceed state and/or federal groundwater or drinking water standards.

Benzene, TCE, and vinyl chloride were the compounds that exceeded the state groundwater quality standards most often. The concentration of benzene over almost the entire area exceeds the state standard of 1 microgram per liter ($\mu\text{g/L}$). Within this area of general benzene contamination, three areas of solvent contamination were identified. One area is located west (downgradient) of the former sludge impoundment area and extends to the south side of Turkey Gut (Study Area E). Another area is centered on Study Area B on the eastern edge of the landfill, and a third area is located in the southwest portion of OU2. This area may be associated with the fire training areas and potential use of solvents there or in the adjacent vehicle maintenance area (Site 76).

Several areas have chlorobenzene concentrations exceeding the state standard of 50 $\mu\text{g/L}$. These areas are as follows: (1) coincident with the solvent contamination area south of Turkey Gut (Study Area E), (2) an area in the upstream area of Turkey Gut (Study Area C), and (3) the areas surrounding OU2HP1, which is located southwest of Study Area E.

There is no significant difference in the analytical results for wells screened in the upper and lower portions of the surficial aquifer. This indicates there is little potential for nonaqueous-phase liquids at this site.

5.1.2 Subsurface Soil

The subsurface soil sampling program conducted at OU2 concentrated on areas that had a higher potential for contamination based on past experience and knowledge. Past soil sampling programs were based on soil-gas and geophysical surveys, aerial photographs, and knowledge of existing groundwater contamination. When anomalous areas or areas of groundwater contamination were identified, soil borings and test pits were installed to collect subsurface soil samples. The 1994 and 1996 field activities were conducted to fill known data gaps from previous investigations. The subsurface soil sampling results for volatile organics are summarized in Table 1-4. Table 1-5 provides subsurface soil data collected in the area of the prepared soil vapor extraction system.

The analytical results for subsurface soil show that volatile organic compounds were not detected frequently, but were detected at notable concentrations in a limited number of samples. In addition, only a limited number of samples were analyzed for semivolatile organic compounds and pesticides/PCBs. Fuel-type constituents, including benzene, toluene, ethylbenzene, and xylenes (BTEX), were identified in a number of subsurface soil samples. The vast majority of samples analyzed for BTEX did not contain these compounds at detectable levels. The primary detections were scattered throughout the site, with the highest concentrations reported in the areas used for fire training exercises in the southern portion of the landfill. The highest concentrations of BTEX (primarily, toluene, ethylbenzene, and xylenes, with lower concentrations of benzene) ranged from 155,280 to 617,000 µg/kg. The sample with the lower concentration was collected at the water table. All other sample intervals were above the water table.

Other areas with BTEX contamination were in the area of the former sludge impoundments (1,900 to 7,500 µg/kg); one boring in Study Area E, which is south of Turkey Gut (4,830 µg/kg); and in Study Area B, which is in the east-central portion of the site (2,174 to 10,993 µg/kg). All of the samples in these areas were collected from above the water table. The presence of these constituents in soil suggests potential source area(s) for BTEX in groundwater.

Another group of compounds potentially relating to observed groundwater contamination includes chlorinated solvents such as tetrachloroethene (PCE), trichloroethene (TCE), dichloroethenes (DCE), vinyl chloride, and 1,1,1-trichloroethane (TCA). While not widespread, their presence also appears to correlate with observed areas of these compounds in the surficial aquifer. There are a few areas with chlorinated solvents in the soil, such as in Study Area E (DCE at 6 to 4,700 µg/kg and vinyl chloride at 490 µg/kg), the area of the former sludge impoundments (PCE at 4,800 µg/kg, TCE at 800 to 880 µg/kg, and TCA at 2,500 µg/kg) and Study Area B (PCE at 38 µg/kg). All samples in these areas were collected above the water table.

5.2 Physical Hazards

Physical hazards which could be encountered in the execution of this scope of work include, but are not limited to the following items;

- Uneven or unstable terrain (slip, trip, and fall hazards)
- Lifting heavy objects
- Rotating or moving machinery such as drill rigs
- Contact with energized sources
- Ambient temperature extremes
- Noise in excess of 85 dBA
- Inclement weather
- Pinch/Compression points
- Natural hazards (e.g., snakes, ticks, mosquitoes, poisonous plants)

All of these physical hazards are discussed in detail in the HASP. These hazard are also addressed in the Attachment of this addendum.

Attachment 1 provides a table that discusses all of the tasks that are to be performed at the site. This table also provides information regarding the anticipated hazards associated with each task, the recommended control measures, air monitoring procedures, personal protective equipment requirements, and decontamination provisions. This table should be referenced for additional information.

TABLE 13-1
EMERGENCY INFORMATION

Police	On base	(919) 466-3615
Fire	On base	(919) 466-2351
Ambulance	On base	(919) 466-0152
Hospital	Craven RMC	(919) 633-8111
Hospital on Base	On Base	(919) 466-0256
Poison Control	Off base	1-800-848-6946
Base Contact	Renee Henderson	(919) 466-5391
Halliburton NUS Project Manager	Mark Speranza, P.E.	(412)921-8992
Halliburton NUS Health & Safety Officer	Donald J. Westerhoff, CSP	(412)921-7281
CLEAN Health and Safety Manager	Matthew M. Soltis, CIH, CSP	(412)921-8912

Directions to Craven RMC:

- Take Highway 70 West to New Bern.
- Take Glenburnie Road Exit (right turn).
- Glenburnie to Neuse Blvd. (turn right).
- Two miles, hospital is on the left.
- Cranen RMC, 2000 Neuse Blvd, New Bern.

Maps depicting directions from the site to the hospitals shall be obtained and attached to this Health and Safety plan prior to the commencement of site activities.

15.0 SPILL CONTAINMENT PROGRAM

This information is to be incorporated into the spill containment section of the HASP. This information pertains to Investigative Derived Wastes (IDW) that will be accumulated during the course of site activities.

Five types of potentially contaminated residues are expected to be generated during the proposed field activities. Worn Personal Protective Equipment (PPE), drill rig decontamination fluids, drill cuttings, purge water from well development and groundwater generated during the pumping tests all will be generated at some time during the field activities.

Based on the activities and the types of contaminants present, none of these residues are expected to represent a significant risk to human health or the environment if properly managed. Planned management of these residues is provided in the HASP and is discussed below. The recommended procedures below were based on accepted procedures included in the EPA document "Management of Investigative Derived Wastes During Site Inspections" EPA/540/G-91/009 May 1991.

PPE - Used PPE will be placed in trash receptacles at the facility. These receptacles will be labeled to indicate their contents.

Drill Rig Decontamination Fluids - Drill rig decontamination fluids will be allowed to accumulate in the sump located at the MCAS Cherry Point decontamination pad located at OU2 where decontamination operations will be conducted.

Drill Cuttings (drilling mud) - Drill cuttings will be screened with a PID. The cuttings will be containerized in bulk containers and stored at a location to be determined by MCAS Cherry Point, until the recommendations regarding additional sampling (if necessary) and ultimate disposal can be made. One composite sample will be collected from the material in the containers and analyzed for TCLP organics, TCLP inorganics, ignitability, corrosivity, and reactivity.

Purge Water - Groundwater generated during monitoring well development will be temporarily containerized in bulk containers by the drilling subcontractor in order to be transported and disposed of at the main inlet of the Industrial Wastewater Treatment plant (IWTP).

Pumping Test Water - Low turbid groundwater generated during the pumping test will be discharged to the IWTP drainage system.

ATTACHMENT 1

**TASKS/HAZARDS/CONTROL MEASURES COMPENDIUM FOR
TREATABILITY STUDY AS AND SVE TREATABILITY STUDY AT 002
CHERRY POINT, NORTH CAROLINA**

TASKS/HAZARDS/CONTROL MEASURES COMPENDIUM FOR
TREATABILITY STUDY AND AS AND SVE TREATABILITY STUDY AT OO2
CHERRY POINT, NORTH CAROLINA

Tasks/Operation	Anticipated Hazards	Recommended Control Measures	Air Monitoring	Personal Protective Equipment (items in italics are optional as directed by SSO)	Decontamination Procedures
<p>Soil boring activities associated with injection, vapor extraction, and monitoring well installations</p>	<p>Chemical hazards</p> <p>1) Contaminated media including groundwater, soils, and to a lesser extent air. Primary site contamination is associated with volatile organics present in groundwater. Specific contaminants of concern include chlorinated hydrocarbons such as trichloroethylene, tetrachloroethylene, 1,2-dichloroethene, 1,1,1-trichloroethane, and vinyl chloride. Other organic volatiles that are present include benzene, ethyl benzene, toluene, and xylene.</p> <p>Previous analytical results, indicated part per billion (ppb) concentrations of these contaminants in the groundwater.</p> <p>These chemicals were selected as the primary contaminants of concern given their volatility, low exposure limits, relative abundance in the groundwater, and higher concentrations observed from previous sample results.</p> <p>Other potential contaminants associated with the site, which are not considered to present a significant exposure potential, include some semivolatile compounds and metals such as aluminum, arsenic, barium, chromium, magnesium, manganese, and lead. These contaminants are not anticipated to present a significant exposure potential given the low concentrations observed from previous groundwater sample results and the limited routes of exposure due to limited volatility and the type of media in which they are present (groundwater).</p> <p>See Table 6-1 for more information regarding the contaminants of concern.</p> <p>2) Transfer of contaminants into clean areas or onto persons</p> <p>Physical hazards</p> <p>3) Rotating machinery (entanglement)</p> <p>4) Noise</p> <p>5) Energized systems</p> <p>6) Lifting</p> <p>7) Slips, trips, and falls</p> <p>8) Traffic hazards</p>	<p>Chemical hazards</p> <p>1) Use real-time monitoring instrumentation, action levels, personal sampling, and identified PPE to control exposures to potentially contaminated media (e.g. groundwater, soils, air).</p> <p>- Identify and physically barricade operational zones where potential contamination may exist to prevent incidental contact and transfer outside of the operational area.</p> <p>2) Decontaminate all equipment and supplies between drilling events and prior to leaving the site</p> <p>Physical hazards</p> <p>3) All equipment to be used will be</p> <p>- Inspected in accordance with Federal safety and transportation guidelines, OSHA (1926.600, .601, .602), and manufacturers design.</p> <p>- Operated by Certified operators, and knowledgeable ground crew.</p> <p>- Only manufacturer approved equipment may be used in conjunction with equipment repair procedures (i.e. pins for auger flights etc.).</p> <p>In addition to the equipment considerations, the following standard operating procedures will be employed:</p> <p>- All personnel not directly supporting the drilling operation will remain at least 25 feet from the point of operation.</p> <p>- Hand signals will be established prior to the commencement of drilling.</p> <p>- The driller and helper can simultaneously handle moving augers or flights only when there is a standby person to activate the emergency stop device.</p> <p>- The driller must never leave the controls while tools are rotating unless all personnel are clear of the rotating equipment.</p> <p>- A long handled shovel or equivalent shall be used to clear away drill cuttings from the hole and rotating equipment. Hands or feet shall not be used for this purpose.</p> <p>- A remote sampling device must be used to sample drill cuttings near rotating tools. The driller shall shutdown operations if the sampler is near the tools.</p> <p>- Never climb a drill mast while equipment is rotating.</p> <p>- Use ANSI approved fall protection (i.e. belts, lanyards and a fall protection slide rail) or portable ladders which meet OSHA's requirements when climbing drill masts.</p> <p>- Work areas will be kept clear of clutter.</p> <p>- All personnel will be instructed in the location and operations of the emergency shut off device(s). This device will be tested initially (and then periodically) to insure its operational status.</p> <p>- Areas will be inspected prior to the movement of drill rigs and support vehicle to eliminate any physical hazards. This will be the responsibility of the FOL and/or SSO.</p> <p>- Drill rigs and support vehicles will be moved no closer to banks, ditches, and other excavations than 3 feet unless the wall is supported.</p> <p>4) Excessive noise levels will be mitigated through the use of hearing protection. Any piece of equipment or operation that has the potential to generate excessive noise levels (You must raise your voice to speak to someone within two feet of where you are standing) will require hearing protection until sound level measurements and/or noise dosimetry may be conducted to quantify the associated noise levels.</p> <p>5) All utility clearances shall be obtained in writing prior to subsurface activities. The locations of all underground utilities will be identified and marked prior to all subsurface investigations. Where the clearance cannot be obtained in a reasonable period, or not located, drilling shall proceed with extreme caution using a magnetometer for periodic downhole surveys to at least 6 feet.</p> <p>- Drilling, drill masts or other projecting devices shall be at least 20 feet from overhead power lines and a minimum of 3 feet from identified underground locations.</p> <p>6) Employ machinery or multiple personnel for heavy lifts.</p> <p>- Use proper lifting techniques.</p> <p>7) Traffic and equipment considerations are to include the following:</p> <p>- Establish safe zones of approach (i.e. Boom + 3 feet).</p> <p>- Secure all loose articles to avoid possible entanglement.</p> <p>- All equipment shall be equipped with movement warning systems.</p> <p>- All personnel working in high equipment traffic areas are required to wear reflective vests for high visibility.</p> <p>- Employ safety belts and follow the site traffic rules.</p> <p>Traffic patterns will be dictated supporting on site activities. However, regulated patterns in and about the work zones and support thereof will be established to safely control</p>	<p>Direct reading monitoring instrumentation such as a photoionization detector or a flame ionization detector will be employed to detect the presence of any airborne concentrations of site contaminants.</p> <p>Potential source areas such as bore holes, will be monitored to determine the presence of site contaminants.</p> <p>Air monitoring activities will be performed using either photoionization detectors w/ 11.7 eV probes or flame ionization detectors.</p> <p>It should be noted that elevated airborne concentrations impacting the field crews or downwind receptors are not anticipated given the relative low concentrations (ppb range) observed from previous sample results for the two sites. The following information is provided as a contingency action only.</p> <p>1) Source monitoring will be conducted continuously during soil boring and well installation activities. Positive sustained results at a source location which may impact operations crew will require the following actions:</p> <p>- Monitor the breathing zone of high risk employees. Any sustained reading above background in the breathing zone of the at-risk employees requires the person (SSO/sampler, etc.) monitoring to suspend site activities and evacuate to an unaffected area until a determination of the source and identity of the contaminant can be made.</p> <p>Further investigation using colorimetric tubes will be employed to determine the identity of the particular contaminant causing the elevated readings in the breathing zone. The need to elevate the level of protection will be established based on the results of this investigation and the following procedures will be implemented:</p> <p>- Elevate the level of protection to Level C until the source of the readings may be identified and quantified.</p> <p>Sample-Colorimetric detector tube, vinyl chloride 0.5/a, which requires 10 strokes. Rxn: Blue gray to yellow - Benzene 0.5/c, requires 20 strokes. Rxn: White to brownish yellow</p> <p>- Any positive indication will require the use of Level C protection consisting of a full face air purifying respirator with combination organic vapor/HEPA cartridges. However, this level of protection may only be used for concentrations of vinyl chloride up to 10 ppm, or benzene up to 50 ppm.</p> <p>Negative indications of the presence of vinyl chloride will require the following action levels to be imposed:</p> <p>- Sustained direct reading instrument readings in worker breathing zones greater than established background levels will require the use of full face air purifying respirators with combination organic vapor/HEPA cartridges.</p> <p>- Any readings in worker breathing zones above 10 ppm will require the use of supplied air respiratory protection. However, readings of this magnitude are considered to be unlikely</p>	<p>All drilling operations are to be initiated in level D protection. Level D protection constitutes the following minimum protection</p> <p>- Standard field dress (Long pants Long Sleeve Shirts</p> <p>- Steel toe/shank safety shoes</p> <p>These following items will be incorporated during drilling operations:</p> <p>- Nitrile outer gloves,</p> <p>- Latex inner gloves</p> <p>- Hardhat, safety glasses, and earplugs or muffs.</p> <p>- Tyvek coveralls</p> <p>- Impermeable boot covers</p> <p>- <i>PVC or PE coated Tyvek will be incorporated if there is a potential for saturation of work attire.</i></p> <p>Level C protection upgrade will be done based on monitoring instrument results this will consist of Level D plus::</p> <p>- Air-Purifying Respirator (APR) with organic vapor/HEPA cartridges</p> <p>Level B protection will consist of Level D plus:</p> <p>Self-Contained Breathing Apparatus (SCBA), or airline respiratory protection will be used if sustained monitoring instrument readings in worker breathing zone areas exceed 10 ppm above established background levels</p> <p>Ascension to Level B protection requires immediate notification of the PM, and HSM.</p> <p>As site conditions may change the following equipment will be maintained during all on site activities</p> <p>- Fire Extinguishers (Strategically placed)</p> <p>- Basket stretcher, blankets, and first-aid kit</p>	<p>Personnel Decontamination - Will consist of a soap/water wash and rinse for outer protective equipment (e.g., boots, gloves, PVC splash suits, etc.). This function will take place at an area adjacent to the drilling operations bordering the support zone.</p> <p>This decontamination procedure for Level D protection will consist of</p> <p>- Equipment drop</p> <p>- Soap/water wash and rinse of outer gloves and outer boots as applicable</p> <p>- Remove outer gloves, dispose</p> <p>- Remove coveralls, dispose</p> <p>- Remove boot covers</p> <p>- Wash hands and face, leave contamination reduction zone</p> <p>For Levels C & B in addition to that described above, SCBA air tank or APR cartridge change out would take place at this point.</p> <p>- Respiratory (face mask) protection removal</p> <p>- Remove inner gloves, dispose</p> <p>- Wash hands and face, leave contamination reduction zone</p> <p>Equipment Decontamination - All equipment decontamination will take place at a centralized decontamination pad utilizing steam or pressure washers. Heavy equipment such as drill rigs, will have the wheels and tires cleaned along with any loose debris removed, prior to transporting to the central decontamination area. All site vehicles will be restricted access to exclusion zones, or also have their wheels/tires sprayed off as not to track mud onto the roadways servicing this installation. Roadways shall be cleared of any debris resulting from the on site activity.</p> <p>All equipment used in the exclusion zone will require a complete decontamination between locations and prior to removal from the site. The FOL or the SSO will be responsible for evaluating equipment arriving on site and that which is to leave the site. No equipment will be authorized access or exit without this authorization.</p> <p>Evaluation will consist of</p> <p>- Visual inspection</p> <p>- Scanning equipment with monitoring instruments</p>

Tasks/Operation	Anticipated Hazards	Recommended Control Measures	Air Monitoring	Personal Protective Equipment (items in italics are optional as directed by SSO)	Decontamination Procedures
<p>Multi-media sampling including groundwater, soils, and air from the AS/SVE system)</p>	<p>Chemical hazards:</p> <p>1) Contaminated media including groundwater, soils, and to a lesser extent air. Primary site contamination is associated with volatile organics present in groundwater. Specific contaminants of concern include chlorinated hydrocarbons such as trichloroethylene, tetrachloroethylene, 1,2-dichloroethane, 1,1,1-trichloroethane, and vinyl chloride. Other organic volatiles that are present include benzene, ethyl benzene, toluene, and xylene.</p> <p>Previous analytical results, indicated part per billion (ppb) concentrations of these contaminants in the groundwater.</p> <p>These chemicals were selected as the primary contaminants of concern given their volatility, low exposure limits, relative abundance in the groundwater, and higher concentrations observed from previous sample results.</p> <p>Other potential contaminants associated with the site, which are not considered to present a significant exposure potential, include some semivolatile compounds and metals such as aluminum, arsenic, barium, chromium, magnesium, manganese, and lead. These contaminants are not anticipated to present a significant exposure potential given the low concentrations observed from previous groundwater sample results and the limited routes of exposure due to limited volatility and the type of media in which they are present (groundwater).</p> <p>See Table 6-1 for more information regarding the contaminants of concern.</p> <p>2) Transfer of contaminants into clean areas or onto persons</p> <p>Physical hazards:</p> <p>3) Noise 4) Lifting (muscle strains and pulls) 5) Pinches and compressions 6) Slip, trips, and falls</p>	<p>Chemical hazards:</p> <p>1) Employ real-time monitoring instrumentation, action levels, personal sampling (if necessary), and identified PPE to identify, quantify, and control exposures to potentially contaminated media (e.g., groundwater, soils, and air).</p> <p>2) Restrict the cross use of equipment and supplies between sampling locations without first going through a suitable decontamination.</p> <p>Physical hazards:</p> <p>3) Due to operational and contributory activities in and about work areas (i.e., soil boring using a drill rig), generated noise levels may be excessive. Noise control will be facilitated through the use of hearing protection.</p> <p>As a general rule of thumb, anytime you must raise your voice to speak to someone to be heard within 2 feet of where you are standing the potential exists that sound pressure levels may be excessive. Therefore, personnel will be required to employ hearing protection in these situations until sound level measurements and/or noise dosimetry may be conducted to quantify the associated noise levels.</p> <p>4) Employ machinery or multiple personnel for heavy lifts. Use proper lifting techniques.</p> <p>5) Use pinch bars or other equipment to keep hands from the point of operation, when acquiring samples.</p> <p>6) Preview work locations for unstable/uneven terrain. Barricade all excavations (if applicable) deeper than 2 feet from access closer than 2 feet from the edge.</p>	<p>Direct reading monitoring instrumentation such as a photoionization detector or a flame ionization detector will be employed to detect the presence of any airborne concentrations of site contaminants.</p> <p>Potential source areas (bore holes, monitoring wells, injection wells, extraction wells, etc.) will be monitored to determine the presence of site contaminants. Wells to be sampled will be opened to allow venting and equilibration prior to sampling.</p> <p>Air monitoring activities will be performed using either photoionization detectors w/ 11.7 eV probes or flame ionization detectors.</p> <p>It should be noted that elevated airborne concentrations impacting the field crews or downwind receptors are not anticipated given the relative low concentrations (ppb range) observed from previous sample results for the two sites. The following information is provided as a contingency action only.</p> <p>1) Source monitoring will be conducted at regular intervals to be determined by the SSO. Positive sustained results at a source location which may impact operations crew will require the following actions:</p> <p>- Monitor the breathing zone of high risk employees. Any sustained reading above background in the breathing zone of the at-risk employees requires the person (SSO/sampler, etc.) monitoring to suspend site activities and evacuate to an unaffected area until a determination of the source and identity of the contaminant can be made.</p> <p>Further investigation using colorimetric tubes will be employed to determine the identity of the particular contaminant causing the elevated readings in the breathing zone. The need to elevate the level of protection will be established based on the results of this investigation.</p> <p>The procedures, action limits, and responses specified in the soil boring activities task will also be observed during sampling activities.</p>	<p>All sampling activities are anticipated to proceed in a modified Level D protection.</p> <p>Level D - (Minimum Requirements) For sampling activities:</p> <ul style="list-style-type: none"> - Standard field attire (Long sleeve shirt; long pants) - Safety shoes (Steel toe/shank) - Safety glasses - Hard hat (when overhead hazards exists, or identified as a operation requirement) - Reflective vest for high traffic areas - Hearing protection for high noise areas, or as directed on an operation by operation scenario. - Inner nitrile gloves - Nitrile outer gloves are required if extensive contact with potentially contaminated media (soils, mud, groundwater, etc.) is necessary. - Tyvek coverall will be used if contamination of work clothes exists. PVC or Saranex coveralls will be used if the potential for saturation of work clothes or Tyvek coveralls exists. <p>If an upgrade to Level C is required:</p> <ul style="list-style-type: none"> - Full face air purifying respirator with organic vapor/HEPA filters will be utilized for concentrations of volatile organics greater than established background. Full face air purifying respirators with organic vapor/HEPA filters must be used if the contaminant of concern is identified as vinyl chloride or benzene (through colorimetric tube analysis). If the concentration of either is greater than 10 ppm, level B protection must be used (supplied air respiratory protection). <p>Level C chemical protective clothing will consist of impermeable boot covers, layered (inner nitrile gloves) if necessary, Tyvek coveralls. Free phase product or splash potential will require the use of PVC or Saranex splash suit.</p>	<p>Decontaminate sample containers in accordance with the QA/QC Plan.</p> <p>Personnel decontamination:</p> <p>Observe decon sequence, presented in soil boring activities task. In summary, procedures involve:</p> <ul style="list-style-type: none"> - Wash and rinse outer protective garments - Remove outer protection garments and containerize for disposal - Wash hands and face, leave contamination reduction zone. <p>Equipment decontamination:</p> <p>All sampling equipment will undergo a soap/water wash and rinse utilizing a suitable potable water source until visibly clean. All downhole equipment and sampling tools will be steam cleaned prior to beginning work and between borings.</p> <p>All chemical decontamination will proceed in accordance with the other site documents such as QA/QC, the Sampling Analysis Plan, and EPA SOP B.</p>

Tasks/Operation	Anticipated Hazards	Recommended Control Measures	Air Monitoring	Personal Protective Equipment (Items in italics are optional as directed by SSO)	Decontamination Procedures
<p>Maintenance/Operation of the ASVE System. These tasks include both the pilot test and full scale operation.</p>	<p><i>Chemical Hazards</i></p> <p>1) Air/water borne contaminants including chlorinated hydrocarbons such as trichloroethylene, tetrachloroethylene, 1,2-dichloroethene, 1,1,1-trichloroethane, and vinyl chloride</p> <p><i>Physical Hazards</i></p> <p>2) Energized systems including pneumatic, electrical, hydraulic, kinetic, and compressed gas</p>	<p>1) use real-time monitoring instrumentation, action levels, and identified PPE to control exposures to potentially contaminated media (e.g. air, water, soils).</p> <p>2) Utilize accepted energy control methods as defined in 29 CFRR 1910.147 to control potential energy sources during maintenance operations.</p> <p>NOTE: Review entire process before and after construction, to the criteria protocol in 29 CFR 1910.119 "Process Safety Management". This is to prevent or minimize the consequences of a release through system failure, fire, or explosion. Although the contaminants in questions are not identified as applicable to this standard, this review process is recommended prior to initiation, then periodically once the operation is progress.</p>	<p>1) personal air sampling will be utilized to characterize potential exposures and appropriate PPE.</p>	<p>Selections for PPE should be made in accordance with the results of the personal sampling and the process safety review findings.</p> <p>At a minimum, Level D protection , as defined previously will be observed.</p>	<p>When personnel may encounter potential contaminants, PPE and decontamination procedures such as those described in the previous tasks will be utilized.</p>

ATTACHMENT 2
CONTAMINANTS OF CONCERN TABLE

CHEMICAL, PHYSICAL, AND TOXICOLOGICAL DATA

Substance	CAS No.	Air Monitoring/Sampling Information		Exposure Limits	Warning Property Rating	Physical Properties	Health Hazard Information
Benzene	71-43-2	PID: I.P. 9.24 eV, 100% response with PID and 10.2 eV lamp. FID: 150% relative response ratio with FID.	Air sample using charcoal tube; carbon disulfide desorption; Sampling and analytical protocol in accordance with OSHA 07 or NIOSH Method #1500.	OSHA: 1 ppm ACGIH: 10 ppm NIOSH: 0.1 ppm IDLH: 500 ppm	Inadequate - Odor threshold 34-199 ppm. The use of air-purifying respirators with organic vapor cartridge up to 10 ppm is acceptable despite the inadequate warning properties, providing cartridges are changed at the beginning of each shift. Recommended gloves: Butyl/neoprene blend - >8.00 hrs; Silver shield as a liner - >8.00 hrs; Viton - >8.00 hrs	Boiling Pt: 176°F; 80°C Melting Pt: 42°F; 5.5°C Solubility: 0.07% Flash Pt: 12°F; -11°C LEL/LFL: 1.3% UEL/UFL: 7.9% Vapor Density: 2.77 Vapor Pressure: 75 mmHg Specific Gravity: 0.88 Incompatibilities: Strong oxidizers, fluorides, perchlorates, and acids Appearance and Odor: Colorless to a light yellow liquid with an aromatic odor	Overexposure may result in irritation to the eyes, nose, throat, and respiratory system. CNS effects include giddiness, lightheadedness, headaches, staggered gait, fatigue, and lassitude and depression. Additional effects may include nausea. Long duration exposures may result in respiratory collapse. Regulated as an OSHA carcinogen. May cause damage to the blood forming organs and may cause a form of cancer called leukemia.
1,2-Dichloroethylene	540-59-0	PID: I.P. 9.65 eV, high response with PID and 10.2 eV lamp. FID: 50% response with FID.	Air sample using charcoal tube; and carbon disulfide desorption; Sampling and analytical protocol in accordance with OSHA Method #07, and NIOSH Method #1003	OSHA; NIOSH: ACGIH: 200 ppm IDLH: 1000 ppm	Adequate- odor threshold 0.085-17 ppm. Use organic vapor/acid gas cartridges for exceedances above the TWA up to 1,000 ppm. >1,000 ppm should use pressure-demand supplied air respirator above exposure limits. Recommended glove: nitrile - 0.12 hrs; viton - 0.95 hrs	Boiling Pt: 117°F; 47°C Melting Pt: 7°F; -13.8°C Solubility: 0.4% Flash Pt: 36°F; 2.2°C LEL/LFL: 5.6% UEL/UFL: 12.8% Vapor Density: 2.0 Vapor Pressure: 180-260 mmHg Specific Gravity: 1.27 @ 90°F; 32°C Incompatibilities: Strong oxidizers, alkalis, potassium hydroxide, and copper. When heated to decomposition temperatures will emit toxic fumes of phosgene. Appearance and Odor: Colorless liquid with an acid odor.	Overexposure may result in CNS depression with potential to cause sleepiness, hallucinations, distorted perceptions, and stupor (narcosis). Systemically, symptoms may result in nausea, vomiting, weakness, tremors, and cramps. May also irritate the eyes, skin, and mucous membranes. Chronic exposures may result in dermatitis, liver, kidney, and lung damage.
Ethylbenzene	100-41-4	PID: I.P. 8.76, High response with PID and 10.2 eV lamp. FID: 100% response with FID.	Air sample using charcoal tube; carbon disulfide desorption; GC/FID detection. Sampling and analytical protocol in accordance with OSHA Method #07 or NIOSH Method #1501 Aromatic Hydrocarbon.	ACGIH; NIOSH: 100 ppm; 125 ppm STEL OSHA: 100 ppm IDLH: 800 ppm	Adequate - Can use air-purifying respirator with organic vapor cartridge up to 800 ppm. Recommended gloves: Neoprene or nitrile w/ silver shield when potential for saturation; Teflon >3.00 hrs	Boiling Pt: 277°F; 136°C Melting Pt: -139°F; -95°C Solubility: 0.01% Flash Pt: 55°F; 13°C LEL/LFL: 1.0% UEL/UFL: 6.7% Vapor Density: 3.66 Vapor Pressure: 10 mmHg @ 79°F; 26°C Specific Gravity: 0.87 Incompatibilities: Strong oxidizers Appearance and odor: Colorless liquid with an aromatic odor. Odor Threshold of 0.092-0.60.	Regulated primarily because of its potential to irritate the eyes and respiratory system. In addition, effects of overexposure may include headaches, narcotic effects, CNS changes (i.e., coordination impairment, impaired reflexes, tremoring) difficulty in breathing, possible chemical pneumonia, and potentially respiratory failure or coma.

Substance	CAS No.	Air Monitoring/Sampling Information	Exposure Limits	Warning Property Rating	Physical Properties	Health Hazard Information	
Toluene	108-88-3	PID: 1.P 8.82 eV, High response with PID and 10.2 eV lamp. FID: 110% response with FID.	Air sample using charcoal tube; carbon disulfide desorption. Sampling and analytical protocol shall proceed in accordance with OSHA Method #07, or NIOSH Method #1500.	OSHA: 200 ppm 300 ppm (Ceiling) ACGIH: 50 ppm (skin) NIOSH: 100 ppm 150 ppm STEL IDLH: 500 ppm	Adequate - Odor threshold 1.6 ppm is considered good. Can use air-purifying respirator with organic vapor cartridge up to 1,000 ppm. Recommended gloves: Teflon >15.00 hrs; Viton >16.00 hrs; silver shield >6.00 hrs; supported nitrile (Useable time limit 0.5 hr, complete submersion for the nitrile selection); PV alcohol >25.00 hrs	Bolling Pt: 232°F; 111°C Melting Pt: -139°F; -95°C Solubility: 0.05% (61°F; 16°C) Flash Pt: 40°F; 4°C LEL/LFL: 1.2% UEL/UFL: 7.1% Vapor Density: 3.14 Vapor Pressure: 20 mmHg @ 65°F; 18°C Specific Gravity: 0.87 Incompatibilities: Strong oxidizers Appearance and odor: Colorless liquid with a sweet pungent aromatic odor.	Overexposure to this substance may result in mild to moderate irritation at all points of contact, and CNS changes including euphoria, confusion, nervousness, and possibly paresthesia characterized by an abnormal burning sensation, pricking, or numbness. At 200-500 ppm exposure has resulted in headaches, nausea, eye irritation, loss of appetite, bad taste, impair coordination, fatigue, and weariness. Chronically, toluene overexposure may result in dermatitis, liver, and kidney damage.
Trichloroethylene	79-01-6	PID: 1.P. 9.45 eV, High response with PID and 10.2 eV lamp. FID: 70% Response with FID.	Air sample using charcoal tube; carbon disulfide desorption; Sampling and analytical protocol shall proceed in accordance with OSHA Method #07, or NIOSH Method #1022 or #1003.	OSHA: 50 ppm; 200 ppm (Ceiling) ACGIH: 50 ppm; 100 ppm STEL NIOSH: 25 ppm IDLH: 1000 ppm	Inadequate - Odor threshold 82 ppm. APRs with organic vapor/acid gas cartridges may be used for escape purposes. Exceedances over the exposure limits require the use of positive pressure-demand supplied air respirator. Recommended gloves: PV Alcohol unsupported >16.00 hrs; Silver shield >6.00 hrs; Teflon >24.00 hrs; or Viton >24.00 hrs; Nitrile (Useable time limit 0.5 hr, complete submersion for the nitrile selection)	Bolling Pt: 188°F; 86.7°C Melting Pt: -99°F; -73°C Solubility: 0.1% @ 77°F; 25°C Flash Pt: 90°F; 32°C LEL/LFL: 8% @ 77°F; 25°C UEL/UFL: 10.5 @ 77°F; 25°C Vapor Density: 4.53 Vapor Pressure: 100 mmHg @ 90°F; 32°C Specific Gravity: 1.46 Incompatibilities: Strong caustics and alkalis, chemically active metals (barium, lithium, sodium, magnesium, titanium, and beryllium) Appearance and Odor: Colorless liquid with a chloroform type odor. Combustible liquid, however, burns with difficulty.	Central nervous system effects including euphoria, analgesia, anesthesia, paresthesia, headaches, tremors, vertigo, and somnolence. Damage to the liver, kidneys, heart, lungs, and skin have also been reported. Contact may result in irritation to the eyes, skin, and mucous membranes. Ingestion may result in GI disturbances including nausea, and vomiting NIOSH lists this substance a potential human carcinogen.
Vinyl chloride	75-01-4	PID: 1.P. 9.99 eV, High response with PID and 10.2 eV lamp. FID: 40% response with FID.	Air sample using charcoal or Anasorb CMS sorbent tube; carbon disulfide desorption; gas chromatography-flame ionization detection; Sampling and analytical protocol shall proceed in accordance with NIOSH Method #1007, or OSHA Method #75.	OSHA: 1.0 ppm; 5.0 ppm (Ceiling) ACGIH: 5 ppm NIOSH: Lowest Feasible Concentration	Inadequate - Odor threshold 10-20 ppm. Gas Mask with a vinyl chloride Type N canister may be employed for concentrations up to 25 ppm. Canisters employed must have a minimum service life of 4-hrs. Exceedances over 25 ppm, must use a positive pressure demand, open-circuit, self-contained breathing apparatus, pressure demand type, with full facepiece. Refer to 29 CFR 1910.1017(g) for specific requirements based on atmospheric concentrations of vinyl chloride. Recommended gloves: Silver shield >6.00 hrs; Nitrile 5.70 hrs; or Viton 4.4 hrs	Bolling Pt: 7°F; -13.9°C Melting Pt: -256°F; -160°C Solubility: 0.1% @ 77°F; 25°C Flash Pt: 18°F; -8°C LEL/LFL: 3.6% UEL/UFL: 33% Vapor Density: 2.21 Vapor Pressure: 3.3 atm Specific Gravity: N.A. Incompatibilities: Oxidizers, copper, aluminum, peroxides, iron, steel, Appearance and Odor: Colorless gas or liquid (below 7°F) with a pleasant odor at high concentrations.	A severe skin, eye, and mucous membrane irritant(Liquid: frostbite). Narcotic effect causing weakness, abdominal pains. GI bleeding, and pallor skin or cyanosis. Chronic exposure has been linked to the formation of malignant tumors originating from blood lymphatic vessels in the liver (associated enlargement of the liver), and kidneys (angiosarcoma and nephroblastoma). Listed as a carcinogen by NTP, IARC and ACGIH.

Substance	CAS No.	Air Monitoring/Sampling Information	Exposure Limits	Warning Property Rating	Physical Properties	Health Hazard Information	
Xylene All isomers o-, m-, p-	1330-20-7	PID: I.P. 8.56 eV, High response with PID and 10.2 eV lamp. FID: 110% response with FID.	Air sample using charcoal tube; carbon disulfide desorption; GC/FID detection. Sampling and analytical protocol shall proceed in accordance with OSHA 07, or NIOSH Method 1500.	ACGIH, & NIOSH: 100 ppm, 150 ppm STEL OSHA: 100 ppm IDLH: 900 ppm	Adequate - Odor thresholds for the following isomers: 0.6 m-; 5.4 p-; 20 o- ppm. Can use air-purifying respirator with organic vapor cartridge up to 1,000 ppm concentrations Recommended gloves: PV Alcohol >12.67 hrs; Viton >8.00 hrs; CPE >1.00 hr; Butyl 0.87 hrs; Nitrile is acceptable for limited operations and contact (>0.20 hrs)	Boiling Pt: 269-281°F; 132-138°C Melting Pt: -13o/-54m/56p°F; -25o/- 48m/13p °C Solubility: 0.02 % Flash Pt: 81-90°F; 27-32°C LEL/LFL: 0.9% UEL/UFL: 7.0% Vapor Density: 3.66 Vapor Pressure: 7-9 mmHg @ 70°F; 21° C Specific Gravity: 0.86-0.88 Incompatibilities: Strong oxidizers and strong acids Appearance and odor: Colorless liquid with an aromatic odor.	Effects may of overexposure include irritation at all points of contact, CNS changes (i.e. dizziness, excitement, drowsiness, incoherent, staggering gait), difficulty in breathing, pulmonary edema, and possibly respiratory failure. Chronic effects may include dermatitis and cornea vacuolization.
Tetrachloroethylene	127-18-4	PID: I.P. 9.32 eV, relative response ratio 200% with 10.6 eV lamp. FID: 70% relative response ratio with a FID	Air sample using charcoal tube; carbon disulfide desorption; GC/FID detection. Sampling and analytical protocol shall proceed in accordance with OSHA Method #07, or NIOSH Method #1003	ACGIH: 25 ppm 100 ppm STEL OSHA: 100 ppm 200 ppm Ceiling, 300 ppm 5- minute max peak in any 3-hr period. IDLH: 150 ppm	Odor threshold for this substance has been determined to be at airborne concentrations of approximately 47 ppm, which is considered adequate. APR with organic vapor/acid gas cartridges should be used for escape purposes only. Exceedances over the recommended exposure limits requires the use of airline or airline/APR combination units. Recommended glove: Viton, PV alcohol 5-16 hrs; silver shield >6.00 hrs; teflon 10-24 hrs; and Nitrile in that order. The breakthrough time for the nitrile glove ranges between 1.5 - 5.5 hrs. during complete immersion.	Boiling Pt: 250°F; 121°C Melting Pt: -2°F; 19°C Solubility: 0.02% Flash Pt: Not available LEL/LFL: Not available UEL/UFL: Not available Vapor Density: 5.83 Vapor Pressure: 14 mmHg @ 77°F; 25° C Specific Gravity: 1.62 @ 77°F; 25°C Incompatibilities: Strong oxidizers, alkalis, fuming sulfuric acid, and chemically active metals. When heated to decomposition temperatures will emit toxic fumes of chlorine. Appearance and Odor: Colorless liquid with a mild chloroform like odor.	Overexposure may result in irritation to eyes, nose, throat, and skin. Potential CNS effects including sleepiness, incoordination, headaches, hallucinations, distorted perceptions, and stupor (narcosis). Systemically, symptoms may result in nausea, vomiting, weakness, tremors, and cramps. Chronic exposures may result in dermatitis, enlarged tender liver, kidney, and lung damage. This material is considered a animal carcinogen (liver tumors), however, inadequate evidence exists concerning carcinogenic potential in humans.
Chlorobenzene	108-90-7	PID: I.P. 9.07 eV, High response with PID and 10.2 eV lamp. FID: Relative response ratio for FID detection is unknown, however, is considered to be detectable as this substance will burn.	Air sample using charcoal sorbent tube; carbon disulfide desorption with gas chromatography- flame ionization detector. Sampling and analytical protocol in accordance with NIOSH Method #1003.	OSHA: 75 ppm ACGIH: 10 ppm IDLH: 1000 ppm	Adequate - Odor threshold 1.3 ppm. Can use air-purifying respirator with organic vapor cartridge up to 500 ppm. Recommended glove: Viton - >8.00 hrs PV Alcohol >8.00 hrs	Boiling Pt: 268°F; 131°C Melting Pt: -49°F; -45°C Solubility: 0.05% Flash Pt: 82°F; 28°C LEL/LFL: 1.3% UEL/UFL: 9.6% Vapor Density: 3.88 Vapor Pressure: 10 mmHg @ 72°F; 22°C Specific Gravity: 1.11 Incompatibilities: Strong oxidizers Appearance and Odor: Colorless liquid with an almond-like odor.	Regulated primarily because of it potential to cause sleepiness and incoordination. Irritating to the eyes, nose, and skin. Chronic exposure may cause liver, kidney, and lung damage.

Substance	CAS No.	Air Monitoring/Sampling Information	Exposure Limits	Warning Property Rating	Physical Properties	Health Hazard Information	
Dichlorobenzene	o-95-50-1 p-106-46-7	PID: I.P. 9.06 eV, p-I P. 8.98 High response with PID and 10.2 eV lamp FID: 50% relative response ratio with FID.	Air sample using charcoal sorbent tube; and carbon disulfide desorption with gas chromatography- flame ionization detector; Sampling and analytical protocol in accordance with OSHA Method #07, and NIOSH Method #1003.	ACGIH: o- 25 ppm; 50 ppm STEL p- 10 ppm OSHA: o- 50 ppm Ceiling p- 75 ppm IDLH: 150 ppm	Adequate - Odor threshold o- 0.70 ppm (pleasant aromatic odor); p- 0.12 ppm (mothball odor). Can use air-purifying respirator with organic vapor cartridge/dusts and mists for concentrations up to 1000 ppm. Recommended glove: Viton - >4.00 hrs; Nitrile - 0.35 hrs	Boiling Pt: 345-357°F; 174-181°C Melting Pt: o- 2°F; -17°C; p- 128°F; 53°C Solubility: 0.008-0.01% Flash Pt: 150°F; 66°C LEL/LFL: 2.2% UEL/UFL: 9.2% Vapor Density: 3.88 Vapor Pressure: 1 mmHg @ 72°F; 22°C Specific Gravity: o- 1.3; p- 1.25 Incompatibilities: Strong oxidizers, halogens, acids, and acid fumes Appearance and Odor: o- Colorless to pale yellow liquid with a pleasant aromatic odor. p- Colorless to white crystalline solid with a mothball like odor.	Overexposure to either of these isomers may cause irritation to the eyes, nose, throat, and respiratory tract. Symptoms associated with the o- dichlorobenzene may also include skin blisters. Prolonged or repeated exposures may result in chronic effects including damage to the liver and kidneys. Additionally, overexposure to p- Dichlorobenzene may result in headache, nausea, vomiting, swelling of the area around the eyes, and profuse runny nose. Chronically symptoms may include anorexia, jaundice, cirrhosis of the liver. This substance has demonstrated kidney and liver cancer causing capabilities.
1,1,2- Trichloroethane	79-00-5	PID: I.P. 11.0 eV, relative response ratio unknown. FID: 85% response with FID.	Air sample using charcoal sorbent tube and carbon disulfide desorption with gas chromatography- flame ionization detector; Sampling and analytical protocol in accordance with OSHA Method #07, or NIOSH Method #1003 Halogenated Hydrocarbons.	OSHA; NIOSH; ACGIH: 10 ppm (skin) IDLH: 100 ppm	No information was found concerning odor threshold limits. The use of air- purifying respirator with organic vapor cartridge for <100 ppm for escape purposes is permitted. Exceedances above 100 ppm will require the use of airline or SCBA combination units. Recommended glove: Butyl rubber, solvent dipped, unsupported - >5.78 hrs; PV alcohol - >8.00 hrs; Teflon - >24.00 hrs; Viton - <24.00 hrs	Boiling Pt: 237°F; 114°C Melting Pt: -31°F-35°C Solubility: 0.6% Flash Pt: Not available LEL/LFL: 6% UEL/UFL: 15.5% Vapor Density: Not available Vapor Pressure: 19 mmHg @ 68°F; 20°C Specific Gravity: 1.44 Incompatibilities: Acids, acid fumes, oxidizers, caustics, and chemically active metals such as aluminum, magnesium, sodium, potassium, etc. Appearance and Odor: Colorless liquid with a sweet chloroform- like odor.	Overexposure to this substance may cause irritation to the eyes, skin, and mucous membranes of the respiratory and gastrointestinal tract. CNS effects may include sleepiness, incoordination, depression similar to a narcotic. Chronic exposure may cause liver, kidney and lung damage. This substance has demonstrated carcinogenic potential in laboratory animals. Repeated or prolonged exposure may cause dermatitis.
1,2-Dichloroethane see also Ethylene Dichloride	107-06-2	PID: I.P. 11.05 eV, 140% relative response ratio. FID: 80% response with FID.	Air sample using charcoal sorbent tube and carbon disulfide desorption with gas chromatography- flame ionization detector; Sample and analytical protocol in accordance with NIOSH Method #1003	OSHA: 50 ppm, 100 ppm (Ceiling) ACGIH: 10 ppm NIOSH: 1 ppm IDLH: 50 ppm	Inadequate - This compound has poor warning properties (odor threshold 26 ppm) OSHA allows the use of organic vapor cartridges in certain circumstances. Recommended glove: Polyvinyl alcohol >8.00 hrs; Viton 6.90 hrs; Teflon >24.00 hrs; Silver Shield >6.00 hrs	Boiling Pt: 182°F; 83°C Melting Pt: -31°F; -35°C Solubility: 0.9% Flash Pt: 56°F; 13°C LEL/LFL: 6.2% UEL/UFL: 16% Vapor Density: Not available Vapor Pressure: 64 mmHg @ 68°F; 20°C Specific Gravity: 1.24 Incompatibilities: Strong oxidizers and caustics, chemically active metals such as aluminum or magnesium powder, sodium and potassium. Appearance and Odor: Colorless liquid with a pleasant, chloroform-like odor.	Exposure to this substance may cause CNS depression, nausea, vomiting, dermatitis, and irritation of the eyes. Chronic overexposure may result in damage to the kidneys, liver, eyes (cornea opacity), skin and CNS.

SITE-SPECIFIC HEALTH AND SAFETY PLAN

**Site-Specific
Health and Safety Plan**
for
Marine Corps Air Station
Cherry Point, North Carolina



Northern Division
Naval Facilities Engineering Command
Contract Number N62472-90-D-1298
Contract Task Order 0161

June 1994

HEALTH AND SAFETY PLAN

CERCLA RI/FS PROJECT
FOR
MARINE CORPS AIR STATION (MCAS)
CHERRY POINT, NORTH CAROLINA

Submitted to:
Northern Division
Environmental Branch, Code 18
Naval Facilities Engineering Command
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and

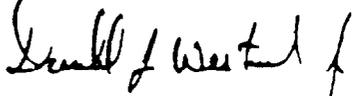
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Contract Task Order No. 0161

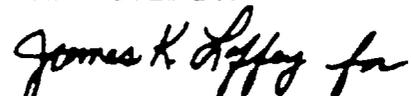
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PART C: HEALTH AND SAFETY PLAN

1.0 PURPOSE

The purpose of this plan is to assign responsibilities, establish personnel protection standards and mandatory safety practices and procedures, and provide for contingencies that may arise while operations are being conducted at the site.

2.0 APPLICABILITY

The provisions of the plan are mandatory for all onsite employees engaged in hazardous material management activities including, but not limited to, initial site reconnaissance, installation of Hydropunches, soil borings, and monitoring wells, collection of groundwater and soil samples, collection of sediment and surface water samples, performance of soil gas survey, the installation of staff gages, survey activities, and demobilization. This plan has been developed under U.S. Environmental Protection Agency (EPA) guidelines and complies with all regulations including OSHA 29 CFR 1910, and specifically 1910.120 HAZWOPER, 1926 OSHA Construction Industry standards, and State and local regulations as applicable. This plan is based on available information regarding possible contaminants and physical hazards that may exist at the site. If more information concerning the nature and/or concentrations of contaminants becomes available, this HASP will be modified accordingly. It will be the Halliburton NUS Project Manager's responsibility to communicate any such information to the Project Site Safety Officer (SSO) who will, in turn, determine the need for modifying the HASP.

2.1 AUTHORITY

The Northern Division of the Naval Facilities Engineering Command issued Contract Task Order (CTO) 0161, under the Comprehensive Long-term Environmental Action Navy (CLEAN) Contract No. N62477-90-D-1298 to HALLIBURTON NUS Environmental Corporation (HALLIBURTON NUS). The CTO is an assignment to perform field activities which will support the preparation of CERCLA RI/FS Project Plans for waste sites (Operable Units 1 through 4 and Operable Unit 13) at the Marine Corps Air Station (MCAS), Cherry Point, North Carolina.

This Health and Safety Plan (HASP) for the MCAS, Cherry Point, North Carolina facility has been prepared by HALLIBURTON NUS under Contract N62477-90-D-1298, Contract Task Order 0161.

Reviewed:

HALLIBURTON NUS

Project Manager: Gregory L. Zimmerman, P.E.

Follow Up Report:

Responsible Person: TBA (Must fill out Follow-Up Report)

3.0 SITE BACKGROUND INFORMATION

3.1 FACILITY LOCATION

The Marine Corps Air Station (MCAS), Cherry Point, is part of a military installation located in southeastern Craven County, North Carolina, just north of Havelock (see Figure 2-1). The site is located on a 11,485-acre tract of land bounded on the north by the Neuse River estuary, the east by Hancock Creek, and the south by North Carolina Highway 101 (see Figure 2-2). The irregular western boundary line lies approximately 3/4 mile west of the Slocum Creek. The entire area is located on a peninsula with Core and Bogue Sounds to the south.

3.2 FACILITY DESCRIPTION

The Marine Corps Air Station (MCAS) mission is to maintain and operate support facilities, services, and material of a Marine Aircraft Wing, or units thereof, and other activities and units as designated by the Commandant of the Marine Corps in coordination with the Chief of Naval Operations (CNO). Occupants include the Second Marine Aircraft Wing (2nd MAW), the Naval Aviation Depot (NADEP), the Combat Service Support Detachment 21 Second Force Service Support Group (2nd FSSG), the Naval Hospital, the Dental Clinic, the Naval Air Maintenance Training Group Detachment, and the Defense Reutilization and Marketing office (DRMO). The station provides facilities for training and support of the Fleet Marine Force (FMF) Atlantic aviation units. It is also designated as a primary aviation supply point.

A brief summary of the facility history is presented in Table 2-1, including a general history of waste disposal operations. The air station was commissioned in 1942. Continuing construction in 1943 included addition of a massive aircraft assembly and repair shop, which later became the Naval Aviation Depot (NADEP) (originally NAVAIREWORKFAC). A building boom during the 1950s and 1960s resulted in land acquisitions increasing the MCAS acreage at Cherry Point from 7,582 acres to more than 11,000 acres (not including the bombing ranges and the two outlying Atlantic and Bogue fields). During the 1970s, a great deal of commercial and residential development occurred around the station particularly in the City of Havelock. In 1980, Havelock annexed Cherry Point.

4.0 SCOPE OF WORK

This section outlines the work to be performed at the sites by Halliburton NUS personnel and subcontractors and, therefore defines the work covered by this Health and Safety Plan (HASP). If site work other than that listed below must be performed, Halliburton NUS will revise this HASP accordingly.

4.1 SCOPE AND OBJECTIVES

MCAS Cherry Point is currently under a Resource Conservation and Recovery Act (RCRA) Consent Order to investigate sites identified as Solid Waste Management Units (SWMUs). Representatives of MCAS Cherry Point, LANTDIV, EPA, the state of North Carolina, and Halliburton NUS have organized the SWMUs at the air station into Operable Units. Table 4-1 provides a listing of the SWMUs included in Operable Units 1 through 4 and Operable Unit 13.

The specific objective of the Preliminary Field Event is to further characterize the nature and extent of contamination at various Operable Units at MCAS, Cherry Point. To accomplish this objective, work performed in conjunction with this Health and Safety Plan will include the installation of hydropunches and soil borings; the installation of new groundwater monitoring wells; collecting soil and groundwater samples from hydropunches, soil borings, new monitoring wells, and existing monitoring wells; collecting surface water and sediment samples; performance of a soil-gas survey; the installation of staff gages; surveying activities; and Industrial Wastewater Treatment Plant influent sampling. The extent to which these activities will be performed is dependent upon the individual SWMU associated with each Operable Unit. Not all of these tasks will be performed at each Operable Unit. Table 4-2 provides a list of tasks associated with each of the Operable Units.

General information pertaining to each of the preliminary field event tasks are described below. Detailed information can be referenced in the Work Plan and Sampling and Analysis Plan.

TABLE 4-1

OPERABLE UNITS 1 THROUGH 4, 13
MCAS, CHERRY POINT, NORTH CAROLINA

Operable Unit 1	Operable Unit 2	Operable Unit 3	Operable Unit 4	Operable Unit 13
Industrial Area and Landfill at Sandy Branch	Old Sanitary Landfill and Related Sources	Fly Ash Ponds and Incinerator	Borrow Pit/Landfill North of Runway 14	Borrow Pit/Landfill at the South End of Runway 32
<p>Site 15 - Area and Ditch behind NADEP</p> <p>Site 18 - Landfill at Sandy Branch (Asbestos Area)</p> <p>Site 40 - Former NADEP Drum Storage Area</p> <p>Site 42 - Industrial Wastewater Treatment Plant</p> <p>Site 47 - Industrial Sewer System</p> <p>Site 51 - Former Plating Shop Building 137</p> <p>Site 52 - Former Plating Shop Building 133</p>	<p>Site 10 - Old Sanitary Landfill</p> <p>Site 44 - A Former Sludge Application Area</p> <p>Site 46 - Polishing Ponds #1 and #2</p>	<p>Site 6 - Fly Ash Ponds</p> <p>Site 7 - Incinerator</p>	<p>Site 4 - Borrow Pit/Landfill North of Runway 14</p>	<p>Site 21 - Borrow Pit/Landfill at the South End of Runway 32</p> <p>Site 44B - Former Sludge Application Area</p>

TABLE 4-2

ASSOCIATED TASKS
WITH EACH OPERABLE UNIT
MCAS, CHERRY POINT, NORTH CAROLINA

Operable Unit 1	Operable Unit 2	Operable Unit 3	Operable Unit 4	Operable Unit 13
Installation of Hydropunches, Soil Borings, and Permanent Monitoring Wells	Installation of Hydropunches, Soil Borings, and Permanent Monitoring Wells	Installation of Hydropunches, Soil Borings, and Permanent Monitoring Wells	Install Monitoring Wells	Installation of Hydropunches, Soil Borings, and Permanent Monitoring Wells
Groundwater sampling	Groundwater sampling	Ground water sampling	Surface soil sampling	Soil sampling
Soil sampling	Soil sampling	Soil sampling	Groundwater sampling	Groundwater sampling
Soil gas survey - Site 16	Surface water and sediment sampling	Surface water and sediment sampling	Surface water and sediment sampling	Surface water and sediment sampling
Surface water and sediment sampling			Soil gas survey	Soil gas survey
Installation of Staff gages				Installation of Staff gages
Industrial Waste Treatment Plant (IWT) influent samples				

4.1.1 Installation of Hydropunches, Soil Borings, and Permanent Monitoring Wells

Hydropunches (temporary monitoring wells) will be installed at Operable Units 1 and 2, soil borings are proposed at Operable Units 1, 3, and 13, and permanent monitoring wells are to be installed at all five Operable Units. In addition, pond sediments will be cored at Operable Units 2 and 3. Several different techniques (i.e. "Geoprobe" hydraulics, hollow stem augers) will be used to install the hydropunches and soil borings. The selection of which technique that will be used will depend on site conditions, the type of samples to be collected, and the depth of the proposed hydropunch/soil boring. Pond sediments at Operable Units 2 and 3 will be cored using equipment mounted on a pontoon boat.

It has been reported that areas of Landfill 16 (Site 16) contain piping which is insulated with asbestos and asbestos containing material. This piping is not to be disturbed and every attempt shall be made to distance site activities from this area. Installation of Hydropunches, soil borings, and monitoring wells, surface soil sampling, and any other operations in the asbestos area of Landfill 16 will be performed in Level C (air purifying respirators with High Efficiency Air Purifying - HEPA filters) since soil may contain friable asbestos and asbestos containing material.

4.1.2 Soil Sampling

As the soil borings are being installed, continuous split-spoon samples will be collected. In addition, continuous split-spoon samples will also be collected from selected hydropunch locations. The soil samples will be screened in the field using a Photo-ionization Detector (PID) for high organic content.

In addition to subsurface soil samples that will be collected from the hydropunches, soil borings, and monitoring wells, four surface soil samples are proposed for the asbestos pile located at Landfill 16 in Operable Unit 1 and 10 surface soil samples are proposed at Operable Unit 4. The same personnel protective equipment requirements (for Site 16) will be required for these sampling activities as those prescribed in this Health and Safety Plan.

4.1.3 Groundwater Sampling

Groundwater samples will be collected from the hydropunches and the new permanent monitoring wells. In addition to these groundwater samples, groundwater samples will be collected from selected existing monitoring wells at all five Operable Units.

4.1.4 Surface Water/Sediment Sampling

Surface water and sediment samples will be collected at each Operable Unit (refer to Table 3-5 of the Project Plans for Number of surface water and sediment samples at each Operable Unit). It is anticipated that ten additional surface water and sediment samples will be collected at locations throughout the study area to be determined during the field screening. Surface water and sediment samples obtained from Stocum Creek will be collected from a boat.

4.1.5 Soil Gas Survey

A soil gas survey will be conducted at Operable Units 1, 4 and 13 using a portable gas chromatograph (GC). The survey at Operable Unit 1 will be confined to the Site 16 Landfill area and will consist of approximately 240 points at 100-foot centers. The survey at Operable Unit 4 will also consist of 240 points at 100-foot centers and will be confined to previously disturbed areas. Like the survey at Operable Unit 4, the survey at Operable Unit 13 will also be confined to previously disturbed areas of the Operable Unit. The survey of Operable Unit 13, however, will consist of only 100 points at 100-foot centers.

It is anticipated that the soil gas survey will monitor the soil gas only to a depth of 5 feet. The soil gas survey will be conducted using "Geoprobe" hydraulics to push a sample rod into the ground. A flexible

tube will then be placed inside of the sample rod and a sample will be pulled through the flexible tubing and collected. Once collected, the soil gas sample will be analyzed with the portable GC/MS.

4.1.6 Staff Gages

Permanent staff gauges are to be installed in the surface water bodies adjacent to Operable Units 1, 4 and 13. Six locations are proposed for Operable Unit 1, three locations are proposed for Operable Unit 4, and five locations are proposed for Operable Unit 13. It is anticipated that the Staff Gauges will be installed during the surface water/sediment sampling by the same field crew.

4.1.7 Survey

Once the sampling activities have been completed, all sample locations will be surveyed in relation to two permanent fixed points. It is anticipated that a local surveyor familiar with MCAS Cherry Point will be subcontracted to perform the survey. It may be necessary to survey some of the locations as the drilling activities are being performed so that the locations can be surveyed before the hydropunch of soil boring has been abandoned.

4.1.8 Industrial Wastewater Treatment Plant Sampling

Two samples of the influent to the Industrial Wastewater Treatment Plant (IWTP) will be collected at separate times to characterize the material that flows through the sewer system and into the IWTP.

5.0 HAZARD ASSESSMENT

This section describes the chemical and physical hazards that are associated either directly or indirectly with the tasks and operations described in Section 4.0 of this HASP. Measures to control the hazards presented below can be found in Sections 6.0, 7.0, 8.0, and 11.0 of this plan.

5.1 PRIMARY SITE CONTAMINANTS

Based upon the nature and extent of contamination associated with the site, the potential exists for workers engaged in intrusive activities (i.e. sampling, installation of hydropunches, monitoring wells, soil borings, and staff gauges, and soil gas surveys) to be exposed to site contaminants which include various volatile organics and metals. In addition, workers performing sampling and test pit activities in Area 16 of Operable Unit 1 have the potential to be exposed to asbestos and asbestos containing materials in the form of pipe insulation. Table 5-1 provides a detailed list of the chemicals of concern and information regarding toxicological, physical properties, and exposure limits pertaining to these contaminants. Exposure potentials to site contaminants vary depending upon the area in which work is being performed and the activity that is to be performed. However, with few exceptions all of the chemicals provided in Table 5-1 are present at each of the Operable Units in varying concentrations. Air monitoring and personal protective requirements in sections 6.0 and 7.0 respectively, take into consideration the concentrations and activities that are to be performed.

Total Petroleum Hydrocarbons

In addition to the site contaminants listed in Table 5-1, workers have the potential to be exposed to petroleum based hydrocarbons such as oil, lubricating oils, hydraulic fluids and greases. When high concentrations of petroleum vapor are inhaled, symptoms of intoxicification may result. These symptoms, ranging from dizziness to excitement or unconsciousness, are similar to those produced by alcohol. If such effects occur, the victim should be removed to an area with fresh air which should result in complete recovery. Prolonged or repeated exposure to some petroleum products, specifically those containing benzene soluble polycyclic aromatic hydrocarbons may cause cancer. However, exposures of this magnitude and duration are not anticipated in the performance of the planned site activities. In addition, previous sampling efforts have indicated the presence of benzene in very few locations at extremely low concentrations. Repeated or prolonged skin contact with petroleum products may cause skin rashes and pimples. Exposure to TPHs will most likely result from contact with contaminated soils and sediments. However, inhalation and ingestion may result from releases of volatile substances, or if excessive dusty conditions are experienced and are not controlled.

TABLE 5-1

**CHEMICAL, PHYSICAL, AND TOXICOLOGICAL DATA
MARINE CORPS AIR STATION (MCAS)
CHERRY POINT, NORTH CAROLINA**

Substance	CAS No.	Air Monitoring/Sampling Information			Exposure Limits	Warning Property Rating	Physical Properties	Health Hazard Information
Chlorobenzene	108-90-7	I.P. 9.07 eV, High response with PID and 10.2 eV lamp	200% response with FID	Air sample using charcoal sorbent tube and carbon disulfide desorption with gas chromatography-flame ionization detector, OSHA 07, NIOSH 1003	75 ppm TWA, OSHA, NIOSH 10 ppm TWA, ACGIH	Adequate - Can use air-purifying respirator with organic vapor cartridge up to 500 ppm Recommended glove: nitrile	Boiling Pt: 131°C Melting Pt: -45°C Solubility: 0.05% Flash Pt: 29°C LEL/LFL: 1.3% UEL/UFL: 9.8% Vapor Density: 3.68 Vapor Pressure: 10 mm @ 22°C Specific Gravity: 1.11 Incompatibilities: Strong oxidizers Appearance and Odor: Colorless liquid with an almond-like odor.	Regulated primarily because of its potential to cause sleepiness and incoordination. Irritating to the eyes, nose, and skin. May cause liver, kidney, and lung damage.
1,2-Dichloroethylene	540-59-0	I.P. 9.65 eV, High response with PID and 10.2 eV lamp	50% response with FID	Air sample using charcoal tube and carbon disulfide, OSHA 07	200 ppm TWA, OSHA, ACGIH, and NIOSH	Limited data available. Should use pressure-demand supplied air respirator above exposure limits. Recommended glove: nitrile	Boiling Pt: 47°C Melting Pt: -13.8°C Solubility: 0.4% Flash Pt: 2.2°C LEL/LFL: 5.6% UEL/UFL: 12.6% Vapor Density: 2.0 Vapor Pressure: 180-260 mm Specific Gravity: 1.27 @ 32°C Incompatibilities: Strong oxidizers, alkalis, potassium hydroxide, and copper. When heated to decomposition temperatures will emit toxic fumes of phosgene. Appearance and Odor: Colorless liquid with an acrid odor.	Overexposure may result in CNS depression potential to cause sleepiness, hallucinations, distorted perceptions, and stupor (narcosis). Systemically, symptoms may result in nausea, vomiting, weakness, tremors, and cramps. May also irritate the eyes, skin, and mucous membranes. Chronic exposures may result in dermatitis, liver, kidney, and lung damage.

**TABLE 5-1
CHEMICAL, PHYSICAL, AND TOXICOLOGICAL DATA
MARINE CORPS AIR STATION (MCAS), CHERRY POINT, NC**

Substance	CAS No.	Air Monitoring/Sampling Information		Exposure Limits	Warning Property Rating	Physical Properties	Health Hazard Information	
1,1,2,2-Tetrachloroethane	79-34-5	IP 11.1 eV	100% response with FID	Air sample using charcoal tube and carbon disulfide desorption, OSHA 07, or NIOSH method 1003	1 ppm TWA OSHA, ACGIH, and NIOSH Overall exposure to this substance may be contributed through skin absorption IDLH -150 ppm	Odor threshold for this substance has been determined to be at airborne concentrations of approximately 1.5 ppm, which is considered adequate. Recommended glove: Nitrile	Boiling Pt: 47°C Melting Pt: -36 to -43.8°C Solubility: 0.3% Flash Pt: N/A LEL/LFL: N/A UEL/UFL: N/A Vapor Density: Not available Vapor Pressure: 9mm @ 86°F Specific Gravity: 1.59 @ 25°C Incompatibilities: Strong oxidizers, alkalis, fuming sulfuric acid, and chemically active metals. When heated to decomposition temperatures will emit toxic fumes of chlorine. Appearance and Odor: Colorless to pale yellow liquid with a pungent chloroform like odor.	Overexposure may result in CNS depression potential to cause sleepiness, hallucinations, distorted perceptions, and stupor (narcosis). Systemically, symptoms may result in nausea, vomiting, weakness, tremors, and cramps. May also irritate the eyes, skin, and mucous membranes. Chronic exposures may result in dermatitis, enlarged tender liver, kidney, and lung damage.
Ethylbenzene	100-41-4	IP 8.76, High response with PID and 10.2 eV lamp	100% response with FID	Air sample using charcoal tube and carbon disulfide desorption, OSHA 07	100 ppm TWA 125 ppm STEL OSHA, ACGIH, & NIOSH	Adequate - Can use air-purifying respirator with organic vapor cartridge up to 1,000 ppm Recommended gloves: Neoprene or nitrile w/ silver shield when potential for saturation	Boiling Pt: 277°F Melting Pt: -139°F Solubility: 0.01% Flash Pt: 85°F LEL/LFL: 1.0% UEL/UFL: 6.7% Vapor Density: 3.66 Vapor Pressure: 10 mmhg @ 79°F Specific Gravity: 0.87 Incompatibilities: Strong oxidizers Appearance and odor: Colorless liquid with an aromatic odor. Odor Threshold of 0.092-0.60	Regulated primarily because of its potential to irritate the eyes and respiratory system. In addition, effects of overexposure may include headaches, narcotic effects, CNS changes (i.e. coordination impairment, impaired reflexes, tremoring) difficulty in breathing, possible chemical pneumonia, and potentially respiratory failure.

TABLE 5-1
 CHEMICAL, PHYSICAL, AND TOXICOLOGICAL DATA
 MARINE CORPS AIR STATION (MCAS), CHERRY POINT, NC

Substance	CAS No.	Air Monitoring/Sampling Information			Exposure Limits	Warning Property Rating	Physical Properties	Health Hazard Information
Methylene chloride	75-09-2	IP: 11.32 eV, High response with PID and 11.7 eV lamp	100% response with FID	Air sample using charcoal or Anasorb CMS sorbent tube and carbon disulfide desorption with gas chromatography-flame ionization detector, OSHA 50 or 80, NIOSH 1005	500 ppm TWA, OSHA 1,000 ppm ceiling, OSHA 50 ppm TWA, ACGIH Lowest feasible concentration, NIOSH	Inadequate - Must use a supplied air respirator (airline respirator with emergency escape cylinder or a Self-Contained Breathing Apparatus - SCBA) Recommended gloves: Butyl rubber or nitrile	Boiling Pt: 39.8°C Melting Pt: -96°C Solubility: 2% Flash Pt: N.A. LEL/LFL: 15.5% UEL/UFL: 68.4% Vapor Density: 2.93 Vapor Pressure: 380 mm @ 22°C Specific Gravity: 1.33 Incompatibilities: Strong oxidizers, caustics, metals (i.e. aluminum, magnesium, potassium, sodium, lithium), and concentrated acids Appearance and Odor: Colorless liquid with a chloroform-like odor. (Note: A gas above 104°F). Odor Threshold of 160 ppm.	Regulated primarily because of its ability to cause sleepiness, fatigue, weakness, lightheadedness, numbness of the limbs, altered cardiac rate and incoordination. These signs and symptoms may be accompanied by nausea, gastric and pulmonary irritation leading possibly to pulmonary edema. In addition to the narcosis long term effects may include liver injury. Listed as possessing carcinogenic properties by NTP, IARC, and ACGIH.
Toluene	108-88-3	IP: 8.82 eV, High response with PID and 10.2 eV lamp	110% response with FID	Air sample using charcoal tube and carbon disulfide desorption, OSHA 07	100 ppm TWA, OSHA 150 ppm STEL, OSHA 50 ppm TWA, ACGIH	Adequate - Can use air-purifying respirator with organic vapor cartridge up to 500 ppm Recommended gloves: Butyl rubber, Viton, neoprene or nitrile	Boiling Pt: 232°F Melting Pt: -139°F Solubility: 0.05% (61°F) Flash Pt: 40°F LEL/LFL: 1.2% UEL/UFL: 7.1% Vapor Density: 3.14 Vapor Pressure: 20 mmHg @ 65°F Specific Gravity: 0.87 Incompatibilities: Strong oxidizers Appearance and odor: Colorless liquid with a sweet pungent aromatic odor. Odor Threshold of 0.16-37 ppm.	Overexposure to this substance may result in mild to moderate irritation at all points of contact, CNS changes. At 200-500 ppm exposure has resulted in headaches, nausea, eye irritation, loss of appetite, bad taste, impair coordination, fatigue, and weariness.

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 CHEMICAL, PHYSICAL, AND TOXICOLOGICAL DATA
 MARINE CORPS AIR STATION (MCAS), CHERRY POINT, NC

Substance	CAS No.	Air Monitoring/Sampling Information		Exposure Limits	Warning Property Rating	Physical Properties	Health Hazard Information	
Trichloroethylene	79-01-6	IP 9.45 eV, High response with PID and 10.2 eV lamp	100% Response with FID	Air sample using charcoal tube and carbon disulfide desorption, OSHA 07	50 ppm OSHA TWA 200 ppm OSHA STEL 50 ppm ACGIH TWA 25 ppm NIOSH TWA	Inadequate - Should use pressure-demand supplied air respirator above exposure limits Recommended gloves: Viton or nitrile	Boiling Pt: 86.7°C Melting Pt: -73°C Solubility: 0.1% @ 25°C Flash Pt: 32°C LEL/LFL: 12.5% UEL/UFL: 90% Vapor Density: 4.53 Vapor Pressure: 100 mm @ 32°C Specific Gravity: 1.46 Incompatibilities: Strong caustics and alkalis, chemically active metals (barium, lithium, sodium, magnesium, titanium, and beryllium) Appearance and Odor: Colorless liquid with a chloroform type odor.	Central nervous system effects (euphoria, analgesia, anesthesia, paresthesia, headaches, tremors, vertigo, and somnolence) are the limiting factors in decreasing the exposures. Damage to the liver, kidneys, heart, lungs, and skin have also been reported. Contact may result in irritation to the eyes, skin, and mucous membranes. Ingestion may result in GI disturbances including nausea, and vomiting. NIOSH lists this substance a potential human carcinogen.
Vinyl chloride	75-01-4	IP 9.99 eV, High response with PID and 10.2 eV lamp	40% response with FID	Air sample using charcoal or Anasorb CMS sorbent tube and carbon disulfide desorption with gas chromatography-flame ionization detector; NIOSH 1007, OSHA 75	1.0 ppm TWA, OSHA 5.0 ppm Ceiling, OSHA 5 ppm TWA, ACGIH Lowest Feasible Concentration; NIOSH	Inadequate - Must use an open-circuit, self-contained breathing apparatus, pressure demand type, with full facepiece. Refer to 29 CFR 1910.1017(g) for specific requirements based on atmospheric concentrations of vinyl chloride. Recommended gloves: Silver shield, nitrile, or Viton	Boiling Pt: -13.9°C Melting Pt: -160°C Solubility: slight Flash Pt: -8°C LEL/LFL: 4% UEL/UFL: 22% Vapor Density: 2.15 Vapor Pressure: 2600 mm @ 25°C Specific Gravity: N.A. Incompatibilities: Oxidizers, copper, aluminum, peroxides, iron, steel. Appearance and Odor: Colorless gas or liquid (below 56°F) with a pleasant odor at high concentrations. Odor Threshold of 10-20 ppm	A severe skin, eye, and mucous membrane irritant. Narcotic effect causing weakness, abdominal pains, GI bleeding, and pallor skin or cyanosis. Regulated primarily because of its depressant effects on the CNS and its association with the formation of malignant tumors originating from blood lymphatic vessels in the liver and kidneys (angiosarcoma and nephroblastoma). Listed as a carcinogen by NTP, IARC and ACGIH

TABLE 5-1
 CHEMICAL, PHYSICAL, AND TOXICOLOGICAL DATA
 MARINE CORPS AIR STATION (MCAS), CHERRY POINT, NC

Substance	CAS No.	Air Monitoring/Sampling Information			Exposure Limits	Warning Property Rating	Physical Properties	Health Hazard Information
Xylene All isomers o-, m-, p-	1330-20-7	IP: 8.58 eV, High response with PID and 10.2 eV lamp	110% response with FID	Air sample using charcoal tube and carbon disulfide desorption, OSHA 07	100 ppm TWA 150 ppm STEL OSHA, ACGIH, & NIOSH	Adequate - Can use air-purifying respirator with organic vapor cartridge up to 1,000 ppm Recommended gloves: Viton, Silver shield, nitrile, or neoprene	Boiling Pt: 269-281°F Melting Pt: -13/-54/56°F Solubility: Insoluble Flash Pt: 63-81°F LEL/UFL: 1.0% UEL/UFL: 7.0% Vapor Density: 3.66 Vapor Pressure: 7-9 mmHg @ 70°F Specific Gravity: 0.86-0.88 Incompatibilities: Strong oxidizers Appearance and odor: Colorless liquid with an aromatic odor. Odor Threshold of 20 ppm.	Regulated primarily because of its potential to irritate the eyes and respiratory system. In addition, effects may include CNS changes (i.e. dizziness, excitement, drowsiness, incoherent, staggering gait), difficulty in breathing, pulmonary edema, and possibly respiratory failure.
Acetone	67-84-1	IP: 9.89 eV, High response with PID and 10.2 eV lamp	60 % Relative Response with FID	Air sample using a charcoal tube and carbon disulfide desorption, OSHA 89, 07 / NIOSH 1300	1000 ppm, OSHA; 750 ppm ACGIH with 1000 ppm STEL; 250 ppm, NIOSH	Adequate - Can use air purifying respirator with organic vapor cartridge up to 5000 ppm Recommended glove: Natural rubber	Boiling Pt: 133°F Melting Pt: NA Solubility: Miscible Flash Pt: 0°F LEL/UFL: 2.5% UEL/UFL: 13% Vapor Density: NA Vapor Pressure: 180 mm Specific Gravity: 0.79 Incompatibilities: Oxidizers, acids Appearance and odor: Colorless liquid with a fragrant mlr-like odor.	Exposure to this chemical may result in irritation to the eyes, nose, throat. Overexposure may cause headache, dizziness. Contact with the skin may cause dermatitis. Target organs are listed as the respiratory system (lungs) and skin.

TABLE 5-1
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 MARINE CORPS AIR STATION (MCAS), CHERRY POINT, NC

Substance	CAS No.	Air Monitoring/Sampling Information			Exposure Limits	Warning Property Rating	Physical Properties	Health Hazard Information
Methyl ethyl ketone (2-Butanone)	78-93-3	IP: 9.54 eV High response with PID and 10.2 eV lamp	80% Relative Response with FID	Air sample using Ambersorb tube and carbon disulfide desorption, OSHA 16, 64 / NIOSH 2500	OSHA, NIOSH and ACGIH: 200 ppm NIOSH and ACGIH have established STEL of 300 ppm	Adequate - Can use air purifying respirator with organic vapor cartridges up to 2000 ppm Recommended glove: Poly vinyl alcohol or natural rubber	Boiling Pt: 175°F Melting Pt: NA Solubility: 28% Flash Pt: 18°F LEL/LFL: 1.4% UEL/UFL: 11.4% Vapor Density: NA Vapor Pressure: 71 mm Specific Gravity: 0.81 Incompatibilities: Strong oxidizers, amines, ammonia, inorganic acids, caustics, copper, isocyanates, pyridines Appearance and odor: Colorless liquid with a moderately sharp, fragrant mint- or acetone like odor	Exposure may result in irritation to the eyes and nose Overexposure may cause headache, dizziness, and vomiting. Target organs are the Central Nervous System and lungs
1,1-Dichloroethane	75-34-3	IP: 11.06 eV	80% Relative Response with FID	Air sample using charcoal tube and carbon disulfide desorption, OSHA 07-B / NIOSH 1003	OSHA, NIOSH and ACGIH have established a TWA of 100 ppm	Questionable warning properties. Recommended use of supplied air respirator Recommended glove: Poly vinyl alcohol	Boiling Pt: 135°F Melting Pt: NA Solubility: 0.6% Flash Pt: 22°F LEL/LFL: 5.6% UEL/UFL: ? Vapor Density: NA Vapor Pressure: 230 mm Specific Gravity: 1.18 Incompatibilities: Strong oxidizers, strong caustics Appearance and odor: Colorless, oily liquid with a chloroform-like odor.	Overexposure may result in CNS depression, skin irritation, and damage to the liver and kidneys. Target organs are listed as the kidneys, liver, and skin

TABLE 5-1
 CHEMICAL, PHYSICAL, AND TOXICOLOGICAL DATA
 MARINE CORPS AIR STATION (MCAS), CHERRY POINT, NC

Substance	CAS No.	Air Monitoring/Sampling Information		Exposure Limits	Warning Property Rating	Physical Properties	Health Hazard Information	
Naphthalene	91-20-3	IP 8 12eV	No information was found as to the relative response for FID	Air sample using charcoal tube and carbon disulfide desorption, OSHA 35 / NIOSH 1501	OSHA, NIOSH AND ACGIH establish a TWA of 10 ppm; NIOSH and ACGIH have established a STEL of 15 ppm	Adequate - Can use an air purifying respirator for organic vapors and dust/mists Recommended glove: Nitrile	Boiling Pt: 424°F Melting Pt: 178°F Solubility: 0.003% Flash Pt: 174°F LEL/LFL: 0.9% UEL/UFL: 5.9% Vapor Density: NA Vapor Pressure: 1mm Specific Gravity: 1.06 Incompatibilities: Strong oxidizers, chromic anhydride Appearance and odor: Colorless to brown solid with and odor of mothballs	Overexposure may result in irritation to the eyes, headache, confusion, excitement, nausea, vomiting, abdominal pain, irritation of the bladder, profuse sweating, jaundice, blood in the urine, renal (kidney shutdown), and dermatitis [Target organs are listed as eyes, blood, liver, kidneys, skin, red blood cells, and central nervous system
Asbestos	1332-21-4	Particulate / fibrous form - unable to be detected by PID/FID	Not detectable by FID	Air sample using particulate filter; analyze using Phase Contrast Microscopy (PCM); NIOSH 7400	0.1 fiber per cubic centimeter - OSHA and NIOSH TWA; ACGIH Exposure limits are dependant upon the type of asbestos; range from 0.2 to 2.0 fiber/cc	Unable to be perceived by senses. Requires use of full face air purifying respirator with dual High Efficiency Air Particulate (HEPA) filter in accordance with OSHA standards 29 CFR 1910.1001 and 1926.58	Boiling Pt: Decomposes Melting Pt: 1112°F Solubility: Insoluble Flash Pt: NA LEL/LFL: NA UEL/UFL: NA Vapor Density: NA Vapor Pressure: NA Specific Gravity: NA Incompatibilities: None Reported Appearance and odor: White or greenish (chrysotile), blue (crocidolite), or gray-green (amosite) fibrous, odorless, solids	Exposure may result in difficulty breathing, scarring of the lungs, restricted pulmonary function, and finger clubbing. Asbestos is listed as a carcinogen. Target organ is listed as the lungs.

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 MARINE CORPS AIR STATION (MCAS), CHERRY POINT, NC

Substance	CAS No.	Air Monitoring/Sampling Information			Exposure Limits	Warning Property Rating	Physical Properties	Health Hazard Information
		Unable to be detected by PID	Unable to be detected by FID	Air sample using filter, analyze using specific ion electrode				
Cyanides (as CN)	varies depending of compound	Unable to be detected by PID	Unable to be detected by FID	Air sample using filter, analyze using specific ion electrode	OSHA and ACGIH 5 mg/m ³ ; NIOSH 4.7 mg/m ³	Inadequate warning properties; recommend the use of supplied air respirators	Boiling Pt: 2725°F Melting Pt: 1047°F Solubility: 58% Flash Pt: NA LEL/LFL: NA UEL/UFL: NA Vapor Density: NA Vapor Pressure: 0mm (approx) Specific Gravity: 1.6 Incompatibilities: Strong oxidizers, such as acids, acid salts, chlorates, and nitrates Appearance and odor: KCN and NaCN are white granular or crystalline solids with a faint almond-like odor	Overexposure may result in asphyxiation or death. Symptoms of exposure include weakness, headache, confusion, nausea, vomiting, increased respiratory rate, slow gasping respirations, irritation of the eyes and skin. Target organs are listed as cardiovascular system, central nervous system, liver, kidneys, and skin
Dioxane	123-91-1	9.13 eV, High response with 10.2 eV lamp	30% Relative Response with FID	Air sample using charcoal tube and carbon disulfide desorption; NIOSH 1602	100 ppm OSHA 1 ppm NIOSH 25 ppm ACGIH	Questionable warning properties. Recommend the use of a supplied air respirator. However the irritating effects should provide sufficient warning	Boiling Pt: 214°F Melting Pt: NA Solubility: Miscible Flash Pt: 55°F LEL/LFL: 2.0% UEL/UFL: 22% Vapor Density: NA Vapor Pressure: 29 mm Specific Gravity: 1.03 Incompatibilities: Strong oxidizers, decaborane, triethylaluminum Appearance and odor: Colorless liquid or solid (below 53°F) with a mild ether-like odor. Odor Threshold of 0.8-172 ppm.	Exposure may result in drowsiness, headache, vomiting, irritation of the eyes, nose, throat, and skin. Overexposure may cause damage to the liver and kidney failure. Target organs are listed as liver, kidneys, skin and eyes

TABLE 5-1
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Substance	CAS No.	Air Monitoring/Sampling Information			Exposure Limits	Warning Property Rating	Physical Properties	Health Hazard Information
Aluminum	7429-90-5	Particulate form - unable to be detected by PID/FID	Not detectable	NIOSH Method 7013 and 7300	<p>OSHA 15 mg/m³ Total dust 5 mg/m³ Respirable fraction</p> <p>NIOSH 10 mg/m³ Total dust 5 mg/m³ Respirable fraction</p> <p>ACGIH 10 mg/m³</p>	<p>Particulate form - No identifiable warning properties to indicate presence and thereby detection</p> <p>Recommended APR Cartridge: Suitable for dusts, mists, and fumes. Recommended gloves: this is in the particulate form. Therefore any glove suitable to prevent skin contact (Nitrile has been the one most widely used for the other substances).</p>	<p>Boiling Pt: 2450°C Melting Pt: 660°C Solubility: Insoluble Flash Pt: Nonflammable LEL/LFL: Nonflammable UEL/UFL: Nonflammable</p> <p>It should be noted that finely divided powders or dust when airborne becomes moderately flammable/explosive when exposed to heat, flame, or powerful oxidizers Vapor Density: Not available Vapor Pressure: 1mm @ 1284°C Specific Gravity: 2.702 @ 25°C</p> <p>Incompatible: Acids, alkalis, oxidizers, halogens and halocarbons, alcohols Appearance and odor: silvery gray ductile, lustrous metal</p>	<p>Inhalation of finely divided powders or dusts may result in difficulty in breathing, coughing, and has been reported to cause pulmonary fibrosis. This malady known as "Shavers disease" is a form of benign pneumoconiosis.</p>

TABLE 5-1
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 MARINE CORPS AIR STATION (MCAS), CHERRY POINT, NC

Substance	CAS No.	Air Monitoring/Sampling Information			Exposure Limits	Warning Property Rating	Physical Properties	Health Hazard Information
Antimony	7440-36-0	Particulate form - unable to be detected by PID/FID	Not detectable	Air sample using a mixed cellulose-ester filter, analyze by Atomic absorption or inductively coupled plasma/atomic emission spectroscopy, OSHA 121 or 125, NIOSH 2 (s2) of 4(261)	OSHA NIOSH ACGIH 0.5 mg/m ³	Metallic taste resulting from exposure Recommended Air Purifying Cartridges: with dusts/mists cartridges or HEPA filters Recommended gloves: this is in the particulate form. Therefore any glove suitable to prevent skin contact (Nitrile has been the one most widely used for the other substances).	Boiling Pt: 1635°C Melting Pt: 630°C Solubility: Insoluble Flash Pt: Nonflammable LEL/LFL: Nonflammable UEL/UFL: Nonflammable Vapor Density: N.A. Vapor Pressure: 1mm @ 686°C Specific Gravity: 6.684 @ 25°C Incompatible: Acids, oxidizers, halogens Appearance and odor: silvery gray, lustrous metal	This substance is considered a poison by ingestion, irritating to the skin and mucous membranes causing inflammation to the nose, mouth, and throat. Chronic exposure may result in some forms of dermatitis Ingestion may result in a metallic taste, vomiting, colic, and diarrhea. Chronic exposure may result in addition to those stated above indigestion, loss of appetite and weight, and diarrhea. Sores in the mouth along with a sore throat help distinguish this form of poisoning from other forms of metallic poisoning such as lead and arsenic. Inhalation at excessive concentrations may result in difficulty in breathing, headaches and a bloody discharge from the nose, and chemical pneumonitis.

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Substance	CAS No.	Air Monitoring/Sampling Information			Exposure Limits	Warning Property Rating	Physical Properties	Health Hazard Information
Arsenic	7440-38-2	Particulate form - This substance is unable to be detected by PID/FID	Particulate form - This substance is unable to be detected by PID/FID	NIOSH Method #7900 or Method #7300	OSHA Organic compounds 0.5 mg/m ³ Inorganic compounds 0.01 mg/m ³ NIOSH ceiling 0.002 mg/m ³ ACGIH 0.2 mg/m ³	No identifiable warning properties to indicate presence and thereby detection Recommended APR Cartridge: Suitable for dust and fume. Organic vapor acid gases with HEPA filter. This substance may be presented as a pesticide, therefore a cartridge suitable for pesticides (MSA-GMP) Recommended Gloves: This is in the particulate form. Therefore any glove suitable to prevent skin contact (Nitrile has been the one most widely used for the other substances).	Boiling Pt: sublimation @ 612°C Melting Pt: 814°C @ 36 atm Solubility: Insoluble in water, soluble in nitric acid Flash Pt: Nonflammable, however, airborne in the form of a dust this substance will support combustion LEL/LFL: Nonflammable UEL/UFL: Nonflammable Vapor Density: N.A. Vapor Pressure: 1 mm @ 372°C (sublimes) Specific Gravity: 5.73 Incompatibilities: Oxidizers, halogens, zinc, lithium, azides, and acetylides Appearance and odor: Gray to black, brittle, crystalline, amorphous, odorless.	Overexposure to this substance through inhalation or ingestion may result in ulceration of the nasal septum, GI disturbances resulting in violent purging and vomiting, hoarse voice, sore throat, excessive salivation, peripheral neuropathy (numbness and burning sensations beginning at the extremities followed by motor weakness), respiratory irritation leading to possible pulmonary edema. Skin or eye contact may result in irritation, conjunctiva, dermatitis, and hyperpigmentation (darkening of the areas exposed) of the skin. This substance has been judged to be a Human carcinogen by NTP, and IARC.

TABLE 5-1
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 MARINE CORPS AIR STATION (MCAS), CHERRY POINT, NC

Substance	CAS No.	Air Monitoring/Sampling Information		Exposure Limits	Warning Property Rating	Physical Properties	Health Hazard Information	
Barium	7440-39-3 as Ba 10022-31-8 as Ba (NO ₃), 10381-37-2 as Ba Cl ₂	Particulate form - This substance is unable to be detected by PID/FID	Particulate form - This substance is unable to be detected by PID/FID	NIOSH Method # 7056	OSHA NIOSH ACGIH 0.5 mg/m ³	No identifiable warning properties to indicate presence and thereby detection Recommended APR Cartridge: Suitable for dust and fume. Organic vapor acid gases with HEPA filter. Recommended gloves: This is in the particulate form. Therefore any glove suitable to prevent skin contact (Nitrile has been the one most widely used for the other substances).	Boiling Pt: 1640°C (decomposes) Melting Pt: 725°C Solubility: Varies between compounds 9/38% Flash Pt: N.A. (Airborne dust may burn or explode when exposed to heat, flame, or incompatible chemicals) LEL/LFL: N.A. UEL/UFL: N.A. Vapor Density: N.A. Vapor Pressure: 10 mm @ 1049°C Specific Gravity: 3.5 Incompatibilities: Acids, oxidizers Appearance and odor: Silver to white, odorless	Overexposure to this substance results in the solubilization in the water or stomach acids Symptoms include vomiting, colic, diarrhea (watery sometimes bloody), slow to irregular pulse, transient hypertension, convulsive tremors, and muscular paralysis resulting in stiffness. Immobility, leg cramps, twitching, and impairment of speech and swallowing. Overexposure to some compounds via inhalation may result in respiratory distress, dyspnea, and baritosis (a benign pneumoconiosis). Direct contact to the skin or eyes may result in irritation.
Beryllium	7440-41-7 as Be	Particulate form - This substance is unable to be detected by PID/FID	Particulate form - This substance is unable to be detected by PID/FID	NIOSH Method #7102 and Method # 7300	OSHA 0.002 mg/m ³ ; ceiling 0.005 mg/m ³ NIOSH 0.0005 mg/m ³ ACGIH 0.002 mg/m ³	No identifiable warning properties to indicate presence and thereby detection Recommended APR Cartridge: Suitable for dust and fume. Organic vapor acid gases with HEPA filter. Recommended gloves: This is in the particulate form. Therefore any glove suitable to prevent skin contact (Nitrile has been the one most widely used for the other substances).	Boiling Pt: 2970°C Melting Pt: 1278°C Solubility: Insoluble Flash Pt: N.A. (Airborne dust may burn or explode when exposed to heat, flame, or incompatible chemicals) LEL/LFL: N.A. UEL/UFL: N.A. Vapor Density: N.A. Vapor Pressure: 0 mm Specific Gravity: 1.85 Incompatibilities: Halocarbons, strong oxidizers, acids and caustics Appearance and odor: gray to white hard light metal, brittle	Overexposure to this substance may result in respiratory symptoms including difficulty in breathing, coughing, rales, chest pain, possibly pulmonary edema, weakness, fatigue, headache, weight loss. Direct contact may result in irritant action on the skin (dermatitis), eyes (conjunctivae), and mucous membranes. This substance has been identified as a potential human carcinogen

TABLE 5-1
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 MARINE CORPS AIR STATION (MCAS), CHERRY POINT, NC

Substance	CAS No.	Air Monitoring/Sampling Information		Exposure Limits	Warning Property Rating	Physical Properties	Health Hazard Information	
Cadmium	7440-43-9	Substance is not volatile. Unable to be easily detected by PID or FID.	Not detected by FID.	Air sample using a mixed cellulose-ester filter / acid desorption and analysis by atomic absorption-flame; NIOSH 7300 or 7048	5 µg/m ³ (0.05 mg/m ³) TWA; OSHA 0.01 mg/m ³ TWA (total particulate); ACGIH 0.002 mg/m ³ (respirable particulate); ACGIH	The use of an air purifying, full face-piece respirator with a high efficiency particulate air filter.	Boiling Pt: 767°C Melting Pt: 320.9°C Solubility: Insoluble Flash Pt: Not applicable (Airborne dust may burn or explode when exposed to heat, flame, or incompatible chemicals) LEL/LFL: Not applicable UEL/UFL: Not applicable Vapor Density: N.A. Vapor Pressure: 1 mm @ 394°C Specific Gravity: 8.65 @ 32°C Incompatibilities: Strong oxidizers, elemental sulfur, selenium, tellurium, zinc, nitric acid, and hydrazoic acid Appearance and Odor: Metal: Silver-white, blue-tinted lustrous, odorless solid Fume: yellow-brown, finely divided particulate dispersed in air.	Overexposure to this substance may result in irritation to the respiratory tract, dyspnea, tightness in the chest, coughing, possibly pulmonary edema. Overexposure to fumes causes symptoms characteristic of the flu (headaches, chills, muscle aches, nausea, vomiting, diarrhea). Chronic exposure may result in damage to the lungs, kidneys and liver. This substance has been identified as a confirmed animal, potential human carcinogen by IARC and NTP.

TABLE 5-1
 CHEMICAL, PHYSICAL, AND TOXICOLOGICAL DATA
 MARINE CORPS AIR STATION (MCAS), CHERRY POINT, NC

Substance	CAS No.	Air Monitoring/Sampling Information			Exposure Limits	Warning Property Rating	Physical Properties	Health Hazard Information
Chromium Compounds	7440-47-3 (Element)	Properties vary depending upon the specific compounds. Not detectable by PID.	Not detectable by FID	Air sample using mixed cellulose - ester filter / acid desorption and analysis by atomic absorption, NIOSH 7024	0.5 mg/m ³ TWA OSHA & NIOSH. 0.05 mg/m ³ TLV; ACGIH.	The use of a air purifying, full face-piece respirator with a high efficiency particulate filter.	Boiling Pt: 2642°C Melting Pt: 1900°C Solubility: Insoluble Flash Pt: Not applicable (Airborne dust may burn or explode when exposed to heat, flame, or incompatible chemicals) LEL/LFL: Not applicable UEL/UFL: Not applicable Vapor Density: N.A. Vapor Pressure: 0 mm Specific Gravity: 7.14 Incompatibilities: Strong oxidizers, peroxides, and alkalis Appearance and Odor: Appearance and odor vary depending upon the specific compound.	Health hazards are characterized normally through chronic exposure manifesting as histologic fibrosis of the lungs and ulceration of the nasal septum and skin. IARC, NTP and ACGIH list various chromium compounds as possessing carcinogenic properties
Cobalt	7440-48-4 as Co	Particulate form - This substance is unable to be detected by PID/FID	Particulate form - This substance is unable to be detected by PID/FID	NIOSH Method # 7027 and Method # 7300	OSHA NIOSH ACGIH 0.05 mg/m ³	No identifiable warning properties to indicate presence and thereby detection Recommended APR Cartridge: Suitable for dust and fume. Organic vapor acid gases with HEPA filter. Recommended gloves: This is in the particulate form. Therefore any glove suitable to prevent skin contact (Nitrile has been the one most widely used for the other substances).	Boiling Pt: 3100°C Melting Pt: 1493°C Solubility: Insoluble in water; soluble in nitric acid Flash Pt: N.A. (Airborne dust may burn or explode when exposed to heat, flame, or incompatible chemicals) LEL/LFL: N.A. UEL/UFL: N.A. Vapor Density: N.A. Vapor Pressure: 0 mm Specific Gravity: 8.92 Incompatibilities: Strong oxidizers, and ammonium nitrate Appearance and odor: Silver-gray to black solid, odorless	Overexposure to this substance through ingestion may result in symptoms of nausea, and vomiting. Symptoms manifested through inhalation may include wheezing, coughing, dyspnea, increased by reduced pulmonary volume by nodular fibrosis. Direct contact may result in irritation leading to dermatitis of the skin. Irritation to the eyes may result largely from mechanical damage

TABLE 5-1
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 MARINE CORPS AIR STATION (MCAS), CHERRY POINT, NC

Substance	CAS No.	Air Monitoring/Sampling Information		Exposure Limits	Warning Property Rating	Physical Properties	Health Hazard Information	
Copper	7440-50-8 (Cu) 1317-38-0 (CuO)	Substance is not volatile Unable to be detected by PID or FID.	Not detected by FID	Air sample using a mixed cellulose ester filter / inductively coupled plasma/atomic emission spectroscopy; NIOSH 7300.	0.10 mg/m ³ TWA; OSHA and NIOSH. 0.2 mg/m ³ TWA; ACGIH.	The use of an air-purifying full-face respirator with a high efficiency particulate air filter. Recommended gloves: This is in the particulate form. Therefore any glove suitable to prevent skin contact (Nitrile has been the one most widely used for the other substances).	Boiling Pt: 2324°C Melting Pt: 1083°C Solubility: Insoluble Flash Pt: Not applicable (Airborne dust may burn or explode when exposed to heat, flame, or incompatible chemicals) LEL/FL: Not applicable UEL/UFL: Not applicable Vapor Density: N.A. Vapor Pressure: 1 mm @ 1828°C Specific Gravity: 8.94 Incompatibilities: Oxidizers, alkalis, sodium azide, acetylene, bromates, chlorates, iodates, and acids. Appearance and Odor: Metal: Reddish, lustrous malleable, odorless solid. Fume: Finely divided black particulate dispersed in air.	Irritation to the nose, throat, and respiratory tract. Metallic taste. Discoloration of skin (potential dermatitis) and hair. Chronic exposure may result in dermatitis and damage to the liver and kidneys. Overexposure to fumes causes symptoms characteristic of the flu (headaches, chills, muscle aches, nausea, vomiting, diarrhea). Ingestion may cause burning in the mouth, throat, and stomach. Metallic taste with colicky abdominal pain. Individuals with Wilson's disease are at greater risk of chronic exposure as a result of the body's tendency to absorb and retain copper.
Lead	7439-92-1	Substance is not volatile Unable to be detected by either PID or FID	Unable to be detected by FID.	Air sample using a mixed cellulose ester filter / HNO ₃ or H ₂ O ₂ desorption / Atomic absorption; NIOSH 7082 or 7300	0.05mg/m ³ TWA; OSHA 0.15mg/m ³ TWA; ACGIH 0.10mg/m ³ TWA; NIOSH	The use of a air purifying, full-face respirator with high efficiency particulate air filter. Recommended gloves: This is in the particulate form. Therefore any glove suitable to prevent skin contact (Nitrile has been the one most widely used for the other substances).	Boiling Pt: 1740°C Melting Pt: 327°C Solubility: Insoluble Flash Pt: Not applicable (Airborne dust may burn or explode when exposed to heat, flame, or incompatible chemicals) LEL/FL: Not applicable UEL/UFL: Not applicable Vapor Density: N.A. Vapor Pressure: 0 mm Specific Gravity: 11.34 Incompatibilities: Strong oxidizers, peroxides, sodium acetylide, zirconium, and acids Appearance and Odor: Metal A heavy ductile, soft gray solid.	Overexposure to this substance via ingestion or inhalation may result in metallic taste in the mouth, dry throat, thirst, Gastrointestinal disorders (burning stomach pain, nausea, vomiting, possible diarrhea sometimes bloody or black, accompanied by severe bouts of colic), CNS effects (muscular weakness, pain, cramps, headaches, insomnia, depression, partial paralysis possibly coma and death. Extended exposure may result in damage to the kidneys, brain, and blood

**TABLE 5-1
CHEMICAL, PHYSICAL, AND TOXICOLOGICAL DATA
MARINE CORPS AIR STATION (MCAS), CHERRY POINT, NC**

Substance	CAS No.	Air Monitoring/Sampling Information		Exposure Limits	Warning Property Rating	Physical Properties	Health Hazard Information	
Manganese	7439-96-5 as Mn	Particulate form - This substance is unable to be detected by PID/FID	Particulate form - This substance is unable to be detected by PID/FID	NIOSH Method # 173 and Method # 7300	OSHA Ceiling 5 mg/m ³ as a fume 1 mg/m ³ NIOSH 1 mg/m ³ for dust and fume 3 mg/m ³ as a STEL ACGIH 5 mg/m ³ for dust 1 mg/m ³ for fume	No identifiable warning properties to indicate presence and thereby detection Recommended APR Cartridge: Suitable for dust and fume. Organic vapor acid gases with HEPA filter. Recommended gloves: This is in the particulate form. Therefore any glove suitable to prevent skin contact (Nitrile has been the one most widely used for the other substances)	Boiling Pt: 1900°C Melting Pt: 1280°C Solubility: Insoluble Flash Pt: N.A. (Airborne dust may burn or explode when exposed to heat, flame, or incompatible chemicals. This substance is considered a combustible solid.) LEL/LFL: N.A. UEL/UFL: N.A. Vapor Density: N.A. Vapor Pressure: 1 mm @ 1282°C Specific Gravity: 7.20 Incompatibilities: Strong oxidizers, halogens, and nitrates. Will react with water to produce hydrogen gas Appearance and odor: Silvery solid or reddish-gray, odorless	Overexposure to this product may result in Central Nervous System and pulmonary effects by inhalation. Symptoms may include disturbances in gait and speech, sleepiness, mental confusion, stolid, masklike face, muscular twitching varying from tremors to coarse rhythmical movements of the extremities accompanied by cramps. Symptoms are described as postencephalitic Parkinsonism Additionally dry throat, tightness in the chest, dyspnea, rales, flu- like symptoms low back pain, and vomiting
Mercury	7439-97-6	Jerome Mercury Vapor Analyzer	Particulate form - This substance is unable to be detected by PID/FID	NIOSH Method # 6009	OSHA NIOSH ACGIH as alkyl compounds 0.01 mg/m ³ ; STEL 0.03 mg/m ³	No identifiable warning properties to indicate presence and thereby detection Recommended APR Cartridge: Suitable for Metallic mercury with HEPA filter. Preferably, with an end-of-service life indicator. Recommended gloves: This is in the liquid form. Therefore any glove suitable to prevent skin contact (Nitrile has been the one most widely used for the other substances).	Boiling Pt: 356.9°C Melting Pt: -38.89°C Solubility: Insoluble Flash Pt: N.A. LEL/LFL: N.A. UEL/UFL: N.A. Vapor Density: N.A. Vapor Pressure: 0.0012 mm @ 25°C Specific Gravity: 13.6 Incompatibilities: Acetylene, ammonia, chlorine dioxide, azides, calcium, sodium carbide, lithium, rubidium, and copper Appearance and odor: Silvery-white heavy mobile liquid, odorless	This substance is corrosive to all points of contact. Systemic symptoms include irritability, wakefulness, muscle weakness and tremors, increased reflexes, gingivitis, anorexia, headache, tinnitus, hypermotility, GI disturbances (nausea, vomiting), diarrhea (sometimes bloody), liver changes, dermatitis, and fever. Symptoms experienced via inhalation include to those above coughing, chest pain, dyspnea, bronchial pneumonitis, and excessive salivation

TABLE 5-1
 CHEMICAL, PHYSICAL, AND TOXICOLOGICAL DATA
 MARINE CORPS AIR STATION (MCAS), CHERRY POINT, NC

Substance	CAS No.	Air Monitoring/Sampling Information			Exposure Limits	Warning Property Rating	Physical Properties	Health Hazard Information
		Particulate form - This substance is unable to be detected by PID/FID	Particulate form - This substance is unable to be detected by PID/FID	NIOSH Method # 173 and Method # 7300				
Nickel	7440-02-0	Particulate form - This substance is unable to be detected by PID/FID	Particulate form - This substance is unable to be detected by PID/FID	NIOSH Method # 173 and Method # 7300	OSHA as Ni metal and insoluble compounds 1 mg/m ³ NIOSH 0.015 mg/m ³ ACGIH 0.05 mg/m ³	No identifiable warning properties to indicate presence and thereby detection Recommended APR Cartridge: Suitable for dust and fume. Organic vapor acid gases with HEPA filter. Recommended gloves: This is in the particulate form. Therefore any glove suitable to prevent skin contact (Nitrile has been the one most widely used for the other substances).	Boiling Pt: 2730°C Melting Pt: 1455°C Solubility: Insoluble acid Flash Pt: N.A. (Airborne dust may burn or explode when exposed to heat, flame, or incompatible chemicals) LEL/LFL: N.A. UEL/UFL: N.A. Vapor Density: N.A. Vapor Pressure: 1 mm @ 1810°C Specific Gravity: 8.90 Incompatibilities: Strong acids, halogens, sulfur, wood and other combustibles, nickel nitrate, and oxidizers Appearance and odor: Silvery white, hard, malleable ductile metal, odorless	Symptoms of overexposure to this product may include headaches, vertigo, delirium, extreme weakness, GI disturbance and pain including nausea vomiting and diarrhea, coughing, hyperpnea, cyanosis, weakness, allergic dermatitis, nickel itch, pulmonary asthma, chest pains tightness, dyspnea, dry cough, and conjunctivitis. This substance has been identified as a Human carcinogen by NTP and IARC.
Silver	7440-22-4	Substance is not volatile and thus is unable to be detected by PID or FID	Unable to be detected by FID	Air sample using a mixed cellulose ester filter / Atomic absorption or plasma emission spectroscopy, NIOSH 5(s182), OSHA ID121.	0.01mg/m ³ TWA, OSHA, ACGIH and NIOSH	The use of a air purifying, full-face respirator with a high efficiency particulate air filter. Recommended gloves: This is in the particulate form. Therefore any glove suitable to prevent skin contact (Nitrile has been the one most widely used for the other substances).	Boiling Pt: 2212°C Melting Pt: 962°C Solubility: Insoluble Flash Pt: Not applicable (Airborne dust may burn or explode when exposed to heat, flame, or incompatible chemicals) LEL/LFL: Not applicable UEL/UFL: Not applicable Vapor Density: N.A. Vapor Pressure: 0 mm Specific Gravity: 10.49 Incompatibilities: Acetylene, acetylene compounds, ammonia, peroxides, bromoazide, chlorine, trifluoride, ethylene imine, oxalic acid, nitric acid, and tartaric acid Appearance and Odor: Metal white lustrous solid	Overexposure to this substance may result in gastrointestinal, upper respiratory, and skin irritation. Discoloration of the eyes, skin and hair

TABLE 5-1
 CHEMICAL, PHYSICAL, AND TOXICOLOGICAL DATA
 MARINE CORPS AIR STATION (MCAS), CHERRY POINT, NC

Substance	CAS No.	Air Monitoring/Sampling Information			Exposure Limits	Warning Property Rating	Physical Properties	Health Hazard Information
		Particulate form - This substance is unable to be detected by PID/FID	Particulate form - This substance is unable to be detected by PID/FID	NIOSH Method # 173 and Method # 7300				
Vanadium	7440-82-2 as V metal 1314-82-1 as vanadium pentoxide	Particulate form - This substance is unable to be detected by PID/FID	Particulate form - This substance is unable to be detected by PID/FID	NIOSH Method # 173 and Method # 7300	OSHA ACGIH 0.05 mg/m ³ NIOSH Ceiling 0.05 mg/m ³	No identifiable warning properties to indicate presence and thereby detection Recommended APR Cartridge: Suitable for dust and fume. Organic vapor acid gases with HEPA filter. Recommended gloves: This is in the particulate form. Therefore any glove suitable to prevent skin contact (Nitrile has been the one most widely used for the other substances).	Boiling Pt: 3000°C Melting Pt: 1917°C Solubility: Insoluble Flash Pt: N.A. (Airborne dust may burn or explode when exposed to heat, flame, or incompatible chemicals) LEL/FL: N.A. UEL/UFL: N.A. Vapor Density: N.A. Vapor Pressure: 0 mm Specific Gravity: 6.11 Incompatibilities: Strong acids, halogens, sulfur, wood and other combustibles, lithium, oxidizers, nitril fluoride Appearance and odor: Bright white, soft, malleable ductile metal, odorless	Symptoms of overexposure to this substance may include conjunctivitis, rhinitis, irritation to the respiratory tract, coughing, rales, dyspnea, bronchitis, bronchospasm, with asthma-like diseases in more severe cases, anemia, loss of skin pallor, and GI disturbances
Zinc	7440-86-6	Nondetectable (particulate)	Nondetectable (particulate)	NIOSH method 7030 or 7300	OSHA 10 mg/m ³ Total dust 5 mg/m ³ Respirable fraction NIOSH 5 mg/m ³ 15 mg/m ³ as a TWA ceiling ACGIH 10 mg/m ³ These TWAs are based on zinc oxide dust	No identifiable warning properties to indicate presence and thereby detection Recommended APR Cartridge: Suitable for dust and fume. Organic vapor acid gases with HEPA filter. Recommended gloves: This is in the particulate form. Therefore any glove suitable to prevent skin contact (Nitrile has been the one most widely used for the other substances).	Boiling Pt: 908°C Melting Pt: 419.6°C Solubility: Insoluble Flash Pt: N.A. (Airborne dust may burn or explode when exposed to heat, flame, or incompatible chemicals) LEL/FL: N.A. UEL/UFL: N.A. Vapor Density: N.A. Vapor Pressure: 0 mm Specific Gravity: 7.14 Incompatibilities: Strong acids, halogens, catalytic metals, combustibles, oxidizers, nitril fluoride Appearance and odor: Bluish-white, lustrous metal, odorless	Inhalation of fumes may result in metal fume fever. This condition is characterized by metallic taste, dryness of the throat, coughing with generalized aching and flu-like symptoms. Effects through ingestion may include coughing, difficulty in breathing, and sweating. A human skin irritant. Irritation to the eyes may result from mechanical action.

TABLE 5-1
 CHEMICAL, PHYSICAL, AND TOXICOLOGICAL DATA
 MARINE CORPS AIR STATION (MCAS), CHERRY POINT, NC

Substance	CAS No.	Air Monitoring/Sampling Information			Exposure Limits	Warning Property Rating	Physical Properties	Health Hazard Information
Bis(2 ethylhexyl) phthalate	117-81-7	No information found	This is a combustible liquid therefore the FID should detect it however the relative response ratio is unknown	NIOSH Method # 5020	OSHA NIOSH ACGIH 5 mg/m ³ STEL 10 mg/m ³	Irritating, tingling sensation Recommended APR Cartridge: Suitable for dust and fume. Organic vapor acid gases with HEPA filter. Recommended gloves: Nitrile has been the one most widely used for the other substances and is acceptable for this substance. Other options include butyl rubber or neoprene	Boiling Pt: 386°C Melting Pt: freezes -14°C Solubility: Insoluble Flash Pt: 215°C LEL/FL: 0.3% @ 245°C UEL/UL: N.A. Vapor Density: N.A. Vapor Pressure: <0.01 mm Specific Gravity: 0.99 Incompatibilities: Nitrates, strong oxidizers, acids, and caustics. Appearance and odor: Colorless, oily liquid, odorless	This substance is a mild skin, eye, mucous membrane irritant, and mild gastric disturbance.
Creosote / cresol (Fluoranthene, pyrene)	8001-58-9 1319-77-3 (206-44-0)	Creosol, a major constituent of creosote has I P of 8.97 eV	Response factor unknown but given the substances flammability detection by FID can be anticipated	Air sampling for cresol (a major constituent of creosote) by silica gel or xad-7 sorbent tube. Acetone desorption and analysis by gas chromatography - flame ionization detector or high-pressure liquid chromatography. NIOSH 2001, OSHA 32	5 ppm TWA, OSHA, ACGIH 2.3 ppm TWA, NIOSH	Adequate - use a full-face air-purifying respirator with organic vapor / dust/mist cartridge up to 250 ppm. Odor Threshold of cresol is 0.00005-0.0079 ppm Recommended gloves: Viton, butyl rubber, neoprene, or nitrile	Boiling Pt: 181-203°C Melting Pt: 10.9-35.5°C Solubility: Insoluble Flash Pt: 81°C LEL/FL: N.A. UEL/UL: N.A. Vapor Density: 3.72 Vapor Pressure: 1 mm @ 38-53°C Specific Gravity: 1.030-1.038 Incompatibilities: Nitric acid, oleum, chlorosulfonic acid, oxidizers Appearance and Odor: Yellowish or colorless, flammable, oily liquid (often brownish because of impurities or oxidation)	Regulated based on effects on central nervous system, and respiratory system. Acute exposures may result in difficulty breathing, respiratory failure and skin and eye burns. Chronic exposure may damage the liver, kidneys, lungs and skin.

5.2 PHYSICAL HAZARDS

Physical hazards which could be involved in the execution of this scope of work include, but are not limited to, the following items:

- Uneven or unstable terrain (Slip/trip hazards)
- Lifting heavy objects
- Pinch/Compression points
- Inclement weather
- The potential for a worker to be struck by or entangled in heavy machinery
- Contact with energized sources
- Ambient temperature extremes
- Noise in excess of 85 dBA
- Water hazards
- Natural Hazards (e.g. snakes, ticks, mosquitos, poisonous plants, etc.)

Control efforts for these potential hazards will encompass and possibly combine use of proper equipment maintenance, guarding, and operation. Additionally, adherence to proper standard work practices (Section 12.0) and standard operating procedures will aid in the elimination of these hazards. Each of the above mentioned items are further detailed below.

5.2.1 Uneven/Unstable Terrain

Planned activities described in the scope of work for sampling activities will bring field personnel into areas where this potential hazard exists (e.g. river banks, test pits, loose and shifting ground cover of landfill areas, etc.).

As it has been determined this hazard may exist in various locations, it will be the Field Team Leader's responsibility (in accordance with Standard Operating Procedures and Safe Work Practices) to inspect and document the areas prior to placing heavy equipment or personnel at risk. As the operation moves from one area to another this hazard and others associated with that area will be discussed as part of the safety briefing prior to the commencement of activities in that area.

5.2.2 Lifting heavy objects

The potential exists for workers to be injured while lifting or maneuvering heavy objects during the performance of various tasks. During the soil boring activity workers have the potential to over-exert themselves while maneuvering the angering device and during sample extraction. In addition, various tasks may require lifting heavy pieces of equipment. If objects are improperly lifted, debilitating back strain and/or other injuries can result. Workers should obtain help from others, employ proper lifting techniques, and use machinery, where possible, to assist when handling heavy objects.

5.2.3 Pinch/Compression Points

Pinch and Compression Points of drilling or sampling equipment may result in injury. All equipment must be maintained in proper working order, with machine guarding devices in place. Any equipment found to be lacking in these areas shall be removed from service.

5.2.4 Inclement Weather

As all work will be conducted outdoors, inclement weather may be encountered. As conditions may vary, it will be at the discretion of the Field Team Leader and the Site Safety Officer representative to temporarily suspend or terminate activities as conditions dictate. All activities will be terminated in the advent of electrical storms.

5.2.5 Heavy Machinery

The performance of soil borings will be accomplished through drilling operations which will require the use of a drilling rig. The most predominant physical hazard associated with this type of work is entanglement of safety equipment or clothing.

into the rotating augers. To address this hazard, a thorough inspection of all equipment will be performed to remove potential snag points and to ensure emergency stop devices operate properly and all members of the field team know the location and operation of these devices. Persons working in close proximity of the drill rig will be required to secure all loose clothing or protective equipment to avoid possible entanglement. The use of a long-handled shovel or the equivalent will be used to remove drill cuttings away from the hole and from rotating tools. In addition, pins that protrude from augers shall not be allowed.

All mechanized equipment brought onsite to complete this scope of work will be inspected initially prior to the commencement of onsite activities and then periodically thereafter. These inspections will be performed by the SSO and will include that the following are ensured:

- All safety guards are in place
- All safety-restraints (i.e. seatbelts) are in place and functioning properly as required by Federal regulations
- All mobile equipment is equipped with a backup alarm and emergency stop device
- All operators are qualified to do so. All drivers will be required to have their Commercial Drivers License
- Traffic Control Measure Routes and regulations will be established and adherence required.
- All maintenance performed on the equipment will employ manufacturers recommended parts, and be inspected prior to returning to services by the SSO.

In addition to the requirements established by this HASP all heavy equipment and/or the movement of may also be bound to meet local or site-specific regulations. Control measures for these hazards are presented in Section 12.0 "Standard Work Practices".

5.2.6 Contact with Energized Sources

One of the hazards associated with the execution of this scope of work is the potential for encountering energized sources (i.e. pressurized lines, water lines, telephone lines, buried utility lines), primarily while engaged in drilling activities. Due to the obvious ramifications associated with this hazard, extreme caution and strict adherence to procedures to detect, identify, and take evasive action shall be followed during the completion of the scope of work. Efforts will be made through local contacts, as built drawings (where available) along with geophysical surveys to identify potential locations. Positive readings will require the relocation of a soil boring point. To further avoid hazards of this type, no drilling mast, boom, or any other such projecting items shall be permitted within a 20-foot radius of any energized source. Also, any areas targeted for subsurface activities shall first be investigated to determine the presence of underground utilities. Any such utilities identified shall be physically marked and avoided.

5.2.7 Ambient Temperature Extremes

Ambient temperature extremes (hot or cold working environments) may occur during performance of this work depending on the project schedule. Work performed when ambient air temperatures are below 50°F may result in varying levels of cold stress (frost nip, frost bite, and/or hypothermia) depending on environmental factors such as temperature, wind speed, and humidity; physiological factors such as metabolic rate and moisture content of the skin; and other factors such as work load and the protective clothing being worn. Work performed when ambient temperatures exceed 70°F may result in varying levels of heat stress (heat rash, heat cramps, heat exhaustion, and/or heat stroke) depending on factors similar to those presented above for cold stress.

In either case, these conditions can be debilitating and, when extreme, they can be fatal. An understanding of the importance in preventing heat/cold stress, coupled with the worker's awareness of the signs and symptoms of overexposure, can significantly reduce the potential for adverse health effects. This awareness is typically a part of each employees' 40-hour hazardous waste operations training. If this hazard is present during site operations, each worker will be provided with information necessary to protect themselves and site management will be instructed to permit frequent breaks in mild temperature rest areas having hot/cold fluids available for consumption. In extreme cases, biological monitoring may be performed and data compared to the most recent recommendations of the American Conference of Governmental Industrial Hygienists. Additional information regarding heat/cold stress is provided in Appendix A.

5.2.8 Noise in Excess of 85 dBA

Noise exposures exceeding the OSHA Permissible Exposure Limit could be encountered during certain phases of the drilling operation. Personnel who are repeatedly overexposed could experience a permanent reduction in their ability hear normal conversation. Appropriate hearing protectors will be worn when in close proximity to drilling operations, as determined by the SSO. It shall also be the responsibility of the SSO to ensure the application, use, and maintenance of occupational noise protective measures shall be determined and proceed in accordance with 29 CFR 1910.95

5.2.9 Water Hazards

As stated in the scope of work, sampling and drilling activities will take place near waters edge or from boats. To avoid potential hazards associated with working on or over water (drowning) the field team shall employ lifelines, safety harnesses, and U.S. Coast Guard approved personal flotation devices when working within four feet of the waters edge. Due to the obvious hazards associated with working on or near waters edge during inclement weather, all field activities may be temporarily suspended or terminated at the discretion and direction of the Field Team Leader, or Site Safety Officer representative.

5.2.10 Natural Hazards

Natural hazards such as poisonous plants, bites from poisonous or disease carrying animals or insects (e.g. snakes, ticks, mosquitos) cannot be avoided in this type of environment. However, in an effort to offset the impact of this hazard, field personnel will have access to commercially available snake bite kits and insect repellents. Potential nesting areas in and about work areas shall be avoided to the greatest extent possible. Lastly, within recent years a marked increase in Lyme's Disease has been reported. Ticks have been shown to be the primary vector in the transmission of this disease. In an effort to control this hazard, close attention will be given during operations and decontamination with regard to personal hygiene to detect and remove any ticks from personnel. The information provided in Appendix B will be reviewed with site personnel to aid in the recognition and control of this threat.

6.0 AIR MONITORING

This section presents requirements for the use of real-time air monitoring instruments during site activities involving potential for exposure to site contaminants. It establishes the types of instruments to be used, the frequency of which they are to be used, techniques for their use, action levels for upgrading/downgrading levels of protection, and methods for instrument maintenance and calibration.

6.1 INSTRUMENTS AND USE

6.1.1 HNu-PI101 Photoionization Detector

A HNu PI-101 photoionization detector (PID) with a 11.7 eV lamp will be used to monitor potential source areas and to screen the breathing zones of employees during soil boring, sampling, or any intrusive activities. The PID has been selected because it is capable of detecting organic gases and vapors and some inorganic gases and vapors. Detection is based on the contaminants ionization potential in comparison to the lamp energy, which has to be equal to or greater than the ionization potential of the contaminant. When calibrated with isobutylene, the PID has a one-to-one correspondence with benzene.

Prior to the commencement of any field activities, the background levels of the site must be determined and noted. Daily background readings must be taken away from areas of potential contamination to obtain accurate results. These readings, any influencing conditions (i.e., weather, temperature, humidity) and location will also be documented in the Health and Safety Logbook as a matter of reference.

Any positive instrument responses observed above background levels will be considered to indicate contaminant release. As such the following actions will be taken:

- Monitor work areas continuously, concentrating on worker breathing zones (BZ) areas (head and face regions) when positive source results are reported. If readings are observed at these areas to be at background levels, continue monitoring and work efforts.
- If sustained or repeated intermittent readings in the workers BZ are above background, workers are to retreat to an unaffected area and remain until further determinations regarding the contaminant are made or until further direction from the FOL. Additional analysis (colormetric tubes) will be used to confirm that the contaminant is not vinyl chloride or methylene chloride. Further actions will be dependant upon results of colormetric tube analysis and levels of contaminant concentration as indicated by the HNu (refer to Section 6.3 for action levels).

6.1.2 OVA-Model 128 Flameionization Detector

The use of an Organic Vapor Analyzer (OVA) (Flame Ionization Detector) may also be utilized to screen potential source emissions and the breathing zones of employees during the execution of the scope of work or during any intrusive activities which may release airborne emissions. The OVA has been selected because it may detect the presence of long chain hydrocarbons more efficiently than a photoionization detector (PID). The relative response for BTEX compounds range from 100-150%. Both instruments are suitable for use, and are offered here as alternative devices, based on the field technicians' knowledge and level of comfort using these instruments.

If positive readings are indicated by either the HNu PI-01 or the OVA, colormetric tube (Dräger tubes) will be used to determine if vinyl chloride and/or methylene chloride is the contaminant that is detected. Exposure to vinyl chloride and methylene chloride is unlikely given the low concentrations detected in previous samples the low probability of free product being present at the sites. These devices are used as primary screening tools to detect contaminants which are readily released into the environment and that may pose an increased threat to site workers.

NOTE: It should be realized that many of the contaminants of concern are nondetectable using these types of screening instruments, therefore primary emphasis will be given to visual observation as these contaminants may present themselves as particulates or bound to particulates.

6.1.3 Dräger (Colormetric) Tubes

The Dräger tubes shall be employed in conjunction with the HNu, and OVA, whichever is selected for use, in this part of the air monitoring program supporting site activities. This action is taken in order to meet the requirements of 29 CFR 1910.120 (h), which is to identify and quantify potential site contaminants. The use of the HNu, and OVA by their nature in the survey mode will not identify airborne substances, only detect them at very low levels. However, using the Dräger tubes in conjunction with these instruments permits a semi-quantitative result with positive identification within the restrictions of the limitations of the instrument.

Of primary concern is the exposure to vinyl chloride and methylene chloride vapors. The use of air-purifying respirators are insufficient for protection against inhalation of methylene chloride vapors due to its inherent poor warning properties (high odor threshold, and inability to be easily perceived via irritation to eyes, nose or respiratory passages). Air-purifying respirators can be used for protection against vinyl chloride vapors at low concentrations. However, the presence of vinyl chloride must be determined prior to the initiation of work activities due to the very low permissible exposure levels for vinyl chloride as established by OSHA. As a result, colormetric tube analysis with Dräger tubes must be instituted to determine the presence or absence of vapors of these two chemical contaminants. OSHA has established an 8-hour Time Weighted Average (TWA) Permissible Exposure Level (PEL) of 500 ppm for methylene chloride. In addition, an acceptable ceiling concentration of 1,000 ppm has been assigned to methylene chloride. Vinyl chloride has an 8-hour TWA PEL of 1 ppm.

Air monitoring with Dräger tubes (Vinyl chloride 1/a tube 67 28 031 and Methylene chloride 100/a tube 6724601) will be performed if elevated readings above established background levels are detected in workers' breathing zones. These tubes will be used due to the previously detected presence of vinyl chloride and methylene chloride in groundwater, soil, and sediment samples. With regard to methylene chloride, an action level of any color change from white to brownish green on the tubes indicating layer will indicate methylene chlorides' presence. The measuring range for this tube begins at 100 ppm. It should be noted however, that this particular tube has a cross sensitivity to other halogenated hydrocarbons as well as carbon monoxide and petroleum hydrocarbons. As a result, false positive indications of methylene chloride may be observed. However, any positive result will be assumed to be methylene chloride, and will result in workers to retreat to an unaffected area until readings on the PID or OVA subside. Otherwise, work may be continued only in Level B (supplied-air respirators)

With regard to vinyl chloride, a color change from light gray to yellow/orange on the tubes' indicating layer will indicate the presence of vinyl chloride. These tubes have measuring ranges of 1 to 10 ppm and 5 to 50 ppm. If results of air monitoring with Dräger tubes indicate that vinyl chloride is present (at concentrations below 10 ppm), personnel will don air-purifying respirators equipped with organic vapor cartridges. Filters on air purifying respirators must be changed every 4 hours of use or at the beginning of each shift, whichever comes first. If results indicate concentrations of vinyl chloride greater than 10 ppm, personnel will don pressure-demand supplied air respirators.

If colormetric sampling results confirm that neither vinyl chloride nor methylene chloride are present in the workers' breathing zone, the following actions levels may be imposed:

- The presence of elevated readings (<50 ppm above established background levels) in the worker's breathing zone requires that workers don a full face air-purifying respirators equipped with organic vapor cartridges.
- Readings above 50 ppm in the worker's breathing zone requires that workers don pressure demand supplied air respirators (either air-line respirators with emergency escape cylinder or Self Contained Breathing Apparatus - SCBA)

6.2 AIR MONITORING REQUIREMENTS - HNu and OVA

Air monitoring with the HNu PI-101 and OVA will be initiated at potential sources of vapor emissions. The following potential sources are anticipated.

- All intrusive activities (i.e. installation of hydropunches, soil boring, monitoring wells, drill cuttings, test pits, sampling, etc.)
- Decontamination procedures
- Any time chemical odors are perceived
- All potential sources of exposure

6.2.1 Air Monitoring Frequency

All site readings (including indications of no positive readings) must be recorded on the direct reading instrument response sheet provided in Table 6-2. Site readings may instead be recorded in the Health and Safety Logbook provided that the same information is recorded as in Table 6-1.

The following schedule used in conjunction with Table 4-2 will be followed, but not limited to, for air monitoring activities as specified for each activity:

**TABLE 6-1
AIR MONITORING TYPE AND FREQUENCY**

TASK(S)	ATMOSPHERIC HAZARD(S)	MONITORING TYPE & FREQUENCY
Installation of hydropunches, soil borings, and monitoring wells Soil gas surveys Installation of Staff gages	Flammable/Explosive Toxic Particulates Asbestos fibers (Site 16 of OU-1 only)	PID/OVA - potential sources continuously, Breathing zone based on positive results at potential source areas. Visual Observation - for dusty conditions since contaminants may be present in particulate form or bound to particulates Dräger tubes - as conditions and results dictate (refer to section 6.1.3)
Sampling Surface water Ground water Subsurface soil Surface soil Sediment Industrial Waste Treatment Plant (IWTP) sampling	This is a task driven specification. Each site has varying potentials for exposure. However, all sites may contain the following atmospheric hazards: Flammable/Explosive Toxic Particulates Asbestos fibers (Site 16 of OU-1 only)	As this is an intrusive activity, monitoring may be used to detect hot spots and respective airborne concentrations PID/OVA - during the initial opening of the well casing or area of surface water, then periodically if conditions so dictate Dräger tubes - as conditions and results dictate

6.3 ACTION LEVELS

The following action levels will apply to this project:

INSTRUMENT	ACTION LEVEL	RESULTANT ACTION
<p>HNu PHOTOIONIZATION DETECTOR</p>	<p>Any sustained readings above established background levels in workers' breathing zones up to 10 ppm.</p>	<p>Retreat to an unaffected area and remain until readings subside or until further determinations are made via colorimetric tube analysis. Perform colorimetric (detector tube) analysis to confirm that readings are not associated with methylene chloride or vinyl chloride exposure. If colorimetric tube analysis indicates that the contaminant is not methylene chloride or vinyl chloride, continue work in Level D Protection, continue monitoring.</p> <p>If colorimetric analysis indicates that the contaminant is methylene chloride, work can only continue in supplied air respiratory protection (Level B Protection). If colorimetric tube analysis indicates the contaminant is vinyl chloride (<10 ppm), work will continue only in full-face air-purifying respirators equipped with organic vapor cartridges (Level C Protection).</p> <p>If excessive dusty conditions are observed, use in conjunction with a High Efficiency Particulate Air filter (HEPA). If colorimetric tube analysis indicates vapor concentration of vinyl chloride greater than 10 ppm, work may only be continued in Level B Protection.</p>
	<p>10 ppm - 50 ppm</p>	<p>Continue work using an air-purifying respirator equipped with organic vapor cartridges and observe workers for symptoms of overexposure. If colorimetric tube analysis indicates that methylene chloride and/or vinyl chloride is present, discontinue work and proceed to an unaffected area, contact the Project HSO. Refer to resultant action listed above.</p>
	<p>Greater than 50 ppm</p>	<p>Continue only in supplied air respiratory protection.</p>
<p>OVA Detector</p>	<p>Any sustained reading greater than background</p>	<p>Same resultant actions are to be performed as described with the HNu Photoionization detector discussed above.</p>
	<p>10 ppm - 50 ppm</p>	<p>Same resultant actions are to be performed as described with the HNu Photoionization detector discussed above.</p>
	<p>Greater than 50 ppm</p>	<p>Same resultant actions are to be performed as described with the HNu Photoionization detector discussed above.</p>
<p>Dräger Colorimetric Tubes</p>	<p>HNu or OVA positive result in the breathing zone</p>	<p>Identify and quantify the level of methylene chloride and/or vinyl chloride or any other compounds of concern. Don air-purifying respirator equipped with organic vapor cartridges (if excessive dusty conditions are observed, utilize in conjunction with High Efficiency Particulate Air filter (HEPA)).</p>

INSTRUMENT	ACTION LEVEL	RESULTANT ACTION
	Positive results greater than 50 ppm	If colorimetric analysis indicates the presence of methylene chloride, workers can only continue work with the use of supplied-air respiratory protection. If concentrations \leq 10 ppm of vinyl chloride are present, the use of full-face air-purifying respirators with organic vapor cartridges must be implemented. If vinyl chloride vapor concentrations are indicated by colorimetric tube analysis to be greater than 10 ppm, the use of supplied air respirators must be implemented.

6.4 VISUAL OBSERVATION

Based on the hazard assessment, the potential exists for contaminants to be present in the form of a particulate. Of particular concern is activities conducted near the asbestos area of Landfill 10. Site activities are not anticipated to be performed directly in the piles of insulated piping. However, the potential exists for friable components of asbestos to be present in the surrounding soil. Any observations of airborne dusts or particulates should be noted and attempts shall be made to minimize generation of dust emissions. Controlling particulate generation and dispersal is accomplished through work practices such as wetting down areas of potential dust generation.

6.5 INSTRUMENT MAINTENANCE AND CALIBRATION

Air monitoring instruments will be maintained and pre-field calibrated by the equipment supplier. Field calibration will be performed daily prior to the initiation of work. An additional calibration will be performed at the end of the day to determine any significant instrument drift. All calibration efforts will be documented to include the following:

- Dates calibration was performed
- Individual calibrating the instrument
- Instrument name, model, and serial number
- Any relevant readings (before and after) calibration
- Identification of the calibration standard (lot no., source concentration, supplier)
- Any relevant comments or remarks

Field maintenance will consist of daily cleaning of the instruments using a damp towel or rag to wipe off the instrument's outer casing and overnight battery recharging.

6.6 RECORDKEEPING

All instrument readings above and including background levels must be recorded in the field book. This should indicate the date, instrument operator's name, instrument used (type, model number, I.D. No.), location of the reading (eg. borehole, breathing zone, etc.), reading(s) observed, workers potentially affected, and actions taken to reduce exposures. In addition, results of any colorimetric analysis must be recorded in the log book. The absence of instrument responses (excursions above background levels) must also be recorded, at least on a daily basis. Lastly, information concerning influencing factors (i.e. weather, activities, interferences) which may have had an impact on the results should also be recorded.

7.0 PERSONAL PROTECTIVE EQUIPMENT (PPE)

This section presents requirements for the use of personal protective equipment for each of the activities being conducted as defined in Section 4.0 of this HASP. This section includes anticipated levels of protection for each of the activities, the criteria used for selecting various levels of protection, and criteria for modifying levels of protection based on monitoring instrument readings and personal observations.

7.1 ANTICIPATED LEVELS OF PROTECTION

Most work associated with this project is anticipated to be performed in a Level D Protection, as defined in Appendix B of OSHA Standard 29 CFR 1910.120 - "Hazardous Waste Operations and Emergency Response." Many sampling activities will require the use of chemical resistant coveralls, gloves, and boot covers as presented in the task breakdown which follows. Where activities overlap, the more protective requirements will be applied. Site activities (sampling, installation of hydropunches, soil borings, and monitoring wells, etc.) at or near the asbestos area of Site 16 of Operable Unit 1 are anticipated to be performed in Level C protection (air-purifying respirators with High Efficiency Air Particulate - HEPA filters). If air monitoring results in this area exceed action levels as discussed in section 6.3, this respiratory protection may be used in conjunction with organic vapor cartridges. Additionally, it is possible that work in other areas will be upgraded to Level C protection (air-purifying respirators equipped with organic vapor cartridges in possible conjunction with HEPA filters if excessive dusty conditions are observed) depending on the results of air monitoring as discussed in Section 6.0 of this HASP. Overpacking of drums will be performed in Level B Protection (supplied air respirators) either in the form of Self Contained Breathing Apparatus (SCBA) or airline respirators with escape SCBA. Additionally, based on information obtained from the monitoring instruments, it is possible that other operations concerning some tasks may go to level B protection (Supplied Air Respirators). This is based on the detection of certain site contaminants which because of their nature (i.e. warning properties, chemical and physical properties, selection criteria for use of an APR) would not permit the use of APRs. Lastly, in certain scenarios, upgrading the level of protection for Halliburton NUS personnel will be reserved to the discretion of the FTL and SSO based on extenuating circumstances in addition to monitoring results and information, activities, and site conditions.

7.1.1 Minimum Requirements (All Tasks)

Minimum requirements include steel-toe and steel shank work boots, chemical resistant boot covers, with standard field dress consisting of long pants and long-sleeved shirts. Hard hats and safety glasses will be worn when overhead or eye hazards exist based on the task or if working in and around machinery. It will be at the discretion of the FTL or the SSO based on tasks, site conditions, and other influencing factors for the use of optional equipment. This is of course providing action levels or the requirements of this plan are not compromised when additional elements of personal protection are required.

7.1.2 Mobilization/Demobilization and Site Reconnaissance

As mobilization and demobilization activities present limited potentials for contacting the suspected hazardous materials associated with some tasks, the minimum requirements will be adhered to for this task. Disposable boot covers will be worn when onsite as much of the contaminants may exist on the surface.

7.1.3 Installation of Hydropunches, Soil Borings, and Monitoring Wells (EXCLUDING THE ASBESTOS AREA AT SITE 16 OF OU-1)

Minimum requirements include steel-toe, steel shank work boots, chemical resistant boot covers, Tyvek coveralls, and nitrile outer gloves over cotton work gloves. In addition, hard hat and safety glasses will be worn when working in close proximity to machinery, equipment, or when the potential for eye or overhead hazards exist. If the potential for saturation of work cloths exists, the use of PVC or PE-coated Tyvek can substituted in place of Tyvek. Additional personal protective items may include hearing protection during the operation of mechanized equipment as specified in section 5.2.8.

7.1.4 Groundwater and Soil Sampling (EXCLUDING THE ASBESTOS AREA AT SITE 16 OF OU-1)

Hard hats, when necessary, safety glasses, steel-toe, steel shank work boots, disposable boot covers, Tyvek coveralls with taped ankle and wrist seams, nitrile inner gloves (layered as necessary), and nitrile outer gloves (as necessary). Since soil within the borings has the potential to be saturated with water, the use of PVC, or PE-coated Tyvek coveralls are to be worn whenever there is a potential for saturation of work clothes.

7.1.5 Surface Water/Sediment Sampling

Hard hats, when necessary, safety glasses, steel-toe, steel shank work boots, disposable boot covers, Tyvek coveralls with taped ankle and wrist seams, nitrile inner gloves (layered as necessary), and nitrile outer gloves (as necessary). Since sampling surface water and sediment has the potential to saturate work cloth the use of PVC, or PE-coated Tyvek coveralls are to be worn whenever there this potential exists. In addition, the field team shall employ lifelines, safety harnesses, and U.S. Coast Guard approved personal flotation devices when working within four feet of the waters edge or on boats.

7.1.6 Soil Gas Survey (EXCLUDING THE ASBESTOS AREA AT SITE 16 OF OU-1)

Minimum requirements include steel-toe, steel shank work boots, chemical resistant boot covers, Tyvek coveralls (as necessary), and nitrile outer gloves over cotton work gloves. In addition, hard hat and safety glasses will be worn when working in close proximity to machinery, equipment, or when the potential for eye or overhead hazards exist. If the potential for saturation of work cloths exists the use of PVC or PE-coated Tyvek can substituted in place of Tyvek. Additional personal protective items may include hearing protection during the operation of mechanized equipment as specified in section 5.2.8.

7.1.7 Installation of Staff Gauges (EXCLUDING THE ASBESTOS AREA AT SITE 16 OF OU-1)

Since it is anticipated that Staff Gages will be installed during the surface water/sediment sampling by the same crew, the same personal protective measures will be applied for this task.

Hard hats, when necessary, safety glasses, steel-toe, steel shank work boots, disposable boot covers, Tyvek coveralls with taped ankle and wrist seams, nitrile inner gloves (layered as necessary), and nitrile outer gloves (as necessary). Since sampling surface water and sediment has the potential to saturate work cloth the use of PVC, or PE-coated Tyvek coveralls are to be worn whenever there this potential exists. In addition, the field team shall employ lifelines, safety harnesses, and U.S. Coast Guard approved personal flotation devices when working within four feet of the waters edge or on boats.

7.1.8 Industrial Waste Treatment Plant (IWTP) Influent Sampling

Hard hats, when necessary, safety glasses, steel-toe, steel shank work boots, disposable boot covers, Tyvek coveralls with taped ankle and wrist seams, nitrile inner gloves (layered as necessary), and nitrile outer gloves (as necessary). Since sampling surface water and sediment has the potential to saturate work clothes, the use of PVC, or PE-coated Tyvek coveralls are to be worn whenever this potential exists. In addition, the field team shall employ lifelines, safety harnesses and U.S. Coast Guard approved personal flotation devices when working within four feet of the waters edge or on boat.

7.1.9 All Activities at the asbestos pile area at Site 16 of OU-1

All site activities (Installation of hydropunches, soil borings, and monitoring wells, soil, groundwater, surface water and sediment sampling, at the asbestos pile area at Site 16 of OU-1 will require, in addition to those personal protective requirements prescribed for representative tasks, the use of full-face air purifying respirators equipped with High Efficiency Air Particulate (HEPA) filters. This requirement is based on the observation that the site contains piping that is insulated with asbestos and asbestos containing material. At the time that this HASP was prepared the condition of the insulation was unknown. However, it is anticipated that the asbestos may be friable and pose a potential exposure hazard to workers performing activities in this area.

7.1.10 Decontamination Activities

The PPE requirements for decontamination activities will include the minimum requirements for all tasks (See Section 7.1.1) and the use of PE-coated Tyvek or PVC with nitrile outer and inner gloves when the potential for saturation of work clothing exists, and splash shield as necessary or as directed by the FOL or SSO. This will be the required level of protection when performing large scale decontamination activities such as cleaning augers and drill flights. The general rule of thumb for respiratory protection will be to require the same level as, or one below, that of the field personnel who were using the equipment.

7.2 PPE SELECTION CRITERIA

Based on the relative low volatility, low concentrations anticipated to be encountered (based on previous sample results), and dispersion of potential vapors via natural ventilation (i.e. wind currents), vapor concentrations in worker breathing zones are not anticipated to be at levels which would warrant respiratory protection for most tasks. However, the potential exists for dust emissions containing site contaminants to be generated. These dust emissions can be inhaled or ingested and result in exposure. If dust emissions are observed and cannot be controlled (i.e. via area wetting techniques), the use of full-face air-purifying respirators equipped with a combination High Efficiency Particulate Air (HEPA) filter and Organic Vapor mist cartridge will be implemented. Initiation of this action will be determined by either the FTL or SSO. Air purifying respirators with HEPA filters were selected for site activities at Site 16 (Landfill) of Operable Unit 1 to provide protection against inhalation and ingestion of friable asbestos fibers and asbestos containing material. Supplied air respirators (SCBA/airline respirators) were selected for overpacking drum operations to protect personnel against exposure to unidentified contents of the drums.

Nitrile gloves were selected to provide protection against the potential site contaminants that could be encountered and to help reduce the amount of contaminants ingested as a result of incidental hand to mouth contact. Again, this has been determined to be an adequate barrier material based on the low concentrations assumed to be directly contacted. Hard hats, safety glasses, and work boots were selected to provide protection against some of the physical hazards associated with the proposed operations and disposable boot covers were selected to help minimize the spread of contamination. Tyvek coveralls were selected to minimize the potential for contamination of street clothes and PVC or PE coated Tyvek coveralls were selected for use in the event that sampling activities have the potential to result in the saturation of work clothes.

7.3 PPE MODIFICATION CRITERIA

This section presents criteria for upgrading and downgrading chemical protective clothing and/or respiratory protection. Where uncertainties arise, the more protective requirement will apply.

7.3.1 Chemical Protective Clothing Modification Criteria

Tyvek coveralls and boot covers must be worn anytime there is a reasonable potential for contamination of street clothes. Polyvinyl chloride (PVC) or PE-coated Tyvek coveralls must be worn anytime there is a reasonable potential for saturation of work clothes. Nitrile gloves must be worn anytime there is a reasonable potential for contact with site contaminants.

7.3.2 Respiratory Protection Modification Criteria

Full-face air-purifying respirators equipped with high-efficiency particulate air (HEPA) filters must be worn anytime dusty conditions are observed and these emissions cannot be suppressed with water spray. In addition, full-face air-purifying respirators with organic vapor cartridges or supplied air respirators will be utilized anytime action levels specified in Section 6.3 are exceeded.

8.0 DECONTAMINATION

Decontamination is the procedure to be employed to remove and/or neutralize site contaminants encountered through the execution of the scope of work. This procedure will be employed for the purpose of preventing cross contamination, protecting onsite personnel, and protecting the individuals outside this operation from the spread of contamination.

8.1 STANDARD PROCEDURES

1. As part of each site's mobilization activity the SSO and FTL will establish a personnel decontamination station (PADS) suitable to handle the activities, type and the amount of anticipated contamination, and the level of protection to be used. This area will be located adjacent to the exclusion zone or work area, and will consist of the stations described in section 8.2.
2. Upon leaving the contamination area (exclusion zone), all personnel shall proceed through the appropriate contamination reduction sequence.
3. All protective gear should be left onsite during any lunch break following decontamination procedures.
4. Also as part of mobilization, a central decontamination area for heavy equipment will be established. The equipment upon completing the task at hand will require that at least the wheels and tires to be cleaned prior to moving to the decontamination area. This area should be accessible to resources and emergency services.
5. All equipment will be inspected by the FTL or SSO and approved prior to leaving the decontamination area within the contamination reduction corridor.
6. All discarded materials (i.e. drill cuttings, decontamination fluids) will be drummed, labeled, and staged to await sample analyses.

8.2 PERSONNEL DECONTAMINATION REQUIREMENTS

The decontamination of personnel and their protective clothing shall be performed in sequential stages. These stages shall include:

- Removing contamination from protective clothing and equipment with a detergent/water solution and soft bristle scrub brushes.
- Removal of protective clothing (disposable items shall be discarded into a container conspicuously marked "Potentially Contaminated Clothing").
- Workers washing hands and face with potable water and soap whenever they remove PPE and leave the exclusion zone.

The maximum decontamination layout is described in the following table. Within this format the **bolded** sections represent the minimum requirements for all tasks conducted in an established exclusion zone. Should the task or scope require use of the material identified as optional, those sections will become mandatory (at the discretion of the onsite safety representative).

Maximum/Minimum Measures for Decontamination

Station 1:	Segregated Equipment Drop	Deposit equipment used onsite (tools, sampling devices and containers, monitoring instruments, radios, clipboards, etc.) on plastic drop cloths or in different plastic-lined containers. Segregation at the drop reduces the probability of cross contamination.
Station 2:	Boot Cover and Glove Wash	Scrub outer boot covers and gloves with detergent and water.
Station 3:	Boot Cover and Glove Rinse	Rinse off from Station 2 using as much water as necessary.
Station 4:	Suit and Safety Boot Wash. As applicable as not all operations will require the use of protective suits.	Wash splash suit, gloves, and safety boots. Scrub with long-handled scrub brush and decon solution. If disposable suits are worn (i.e. Tyvek) skip to station 6.
Station 5:	Suit and Safety Boot Rinse	Rinse off decon solution using water. Rinse Repeat as many times as necessary.
Station 6:	Tape Removal	Remove tape around boots and gloves and deposit them in the plastic-lined container.
Station 7:	Boot Cover Removal	Remove boot covers and deposit them in the plastic-lined container for decontamination and reuse.
Station 8:	Outer Glove Removal	Remove outer gloves and deposit them in a plastic-lined container for disposal.
Station 9:	Cartridge or Mask Change (Level C usage). As applicable not all operations will require respiratory protection.	If worker leaves exclusion zone to change cartridges (or mask), this is the last step in the decontamination procedure. Worker's cartridges exchanged, new outer gloves and boot covers donned, and joints taped. Worker returns to duty.
Station 10:	Splash Suit Removal	With the helper's assistance, remove splash suit. Deposit it in the plastic-lined container.
Station 11:	Respirator Removal (if worn) ¹	Remove face piece. Deposit it in a plastic-lined container. Avoid touching face with fingers.
Station 12:	Inner Glove Removal	Remove inner gloves and deposit them in the plastic-lined container.
Station 13:	Field Wash	Wash hands and face with potable water.
Station 14:	Heat stress evaluation/Break Heat stress monitoring will be conducted on a as needed basis.	If heat stress monitoring procedures are engaged, they should be performed at the very beginning of the break periods. Break areas should consist of a shaded area with the ability to provide drinking fluids to personnel, if necessary.

(1) Respirators (if worn) will be cleaned and sanitized at a latter time following the conclusion of personnel decontamination, and are therefore not considered a part of this sequence.

8.3 MINIMAL DECONTAMINATION

Less extensive procedures for decontamination can be established when Level D protection is utilized, when the type and degree of contamination are known, or when the potential for transfer is judged to be minimal by the Site Safety Officer. These procedures generally may involve one or two washdowns only, and/or progressive removal (and disposal, as appropriate) of items of PPE.

8.4 EQUIPMENT DECONTAMINATION

The drill rig, all drilling tools, and hand augers will be steam cleaned between boreholes. All downhole tools, samplers, and other downhole equipment will be steam cleaned between boreholes. Under muddy conditions, the back end of the drill rig and wheels will also be steam cleaned, as needed, between boreholes. A decontamination pad at Site 10 will be used for steam cleaning and decontamination operations.

8.5 DECONTAMINATION OF SAMPLING TOOLS

All sampling equipment will be cleaned between sample acquisitions in accordance with the requirements established in the sampling plan. In addition, all sampling equipment that will be leaving the site will require a thorough decontamination, and approval by the FTL or SSO to verify it has been properly decontaminated, prior to leaving the site. This can be accomplished either by steam cleaning or by a detergent wash and potable water rinse until tools are visibly clean.

8.6 CLOSURE OF THE PERSONNEL DECONTAMINATION STATION

Decontamination-generated liquid wastes, all disposable clothing and plastic sheeting used during the operation will be containerized, labeled, and staged onsite to await disposal. The disposal method used will be based upon available information regarding the characteristics of the site, sample analysis, and contaminant levels. Reusable protective equipment will be cleaned, dried, and prepared for future use. (If gross contamination has occurred, the item will be properly disposed of.)

All wash tubs, pail containers, etc., will be thoroughly washed, rinsed, and dried prior to removal from the site. The Site Safety Officer will be responsible for inspecting and clearing equipment to leave the site.

8.7 PPE REQUIREMENTS FOR DECONTAMINATION OPERATIONS

All equipment decontamination efforts will require the use of chemical protective clothing as described below:

- PVC or PE coated Tyvek coveralls
 - Nitrile outer gloves
 - Latex or nitrile inner gloves (surgeons)
 - Rubber boots (or rubber boot covers)
 - Splash shield (if respirator not worn)
 - Respiratory protection (if needed*)
- * The same level of respiratory protection worn for the work assignment, will be worn when decontaminating the equipment used for that assignment. This requirement is further described in section 6.0.

8.8 EMERGENCY DECONTAMINATION PROCEDURES

In addition to routine decontamination procedures, emergency procedures will establish the protocol to be followed in the event of a medical emergency. This procedure will be established and conducted based on the severity of the injury including procedures for potential loss of life, and injury requiring first-aid. (NOTE: An emergency first aid instruction poster has been attached to this HASP. This shall be posted at the site at a convenient location.)

Potential loss of life:

- Delay decontamination (if necessary), or modify it to perform as much decontamination of the injured person possible.
- Stabilize victim
- Wrap the victim in blankets, or plastic sheeting to reduce the potential of contamination to medical personnel.
- All medical support will be informed of the suspected hazards associated with the task. All receiving facilities however must be alerted to the potential hazards. Clearance from the hospital for accepting potentially contaminated personnel will be obtained by the SSO prior to the commencement of onsite activities.

Injury:

In situations where the contamination is extremely toxic or corrosive

- Implement immediate decontamination procedures
- Administer First-Aid (if qualified to do so)
- For heat related disorders, remove all protective clothing, wash as appropriate, treat for heat stress. Extremely toxic or corrosive contamination is not expected to be encountered based upon known site characteristics.

8.9 DECONTAMINATION EVALUATION

The decontamination process effectiveness will be judged in the following manner.

- Visual observation - Discoloration, stains, visible dirt, and alterations of the fabric due to chemical contact will be the primary method used to determine effectiveness.

The following methods may be used if gross contamination is encountered:

- Monitoring Instrumentation - Instruments used to detect site contaminants may be employed to scan garments and equipment for the presence of site contaminants after decontamination procedures have been employed.
- Decontamination Solution Analyses - An analyses of the solution (final rinse) and the presence of contaminants may suggest additional cleaning is required. This information may be useful in the ultimate disposal of the fluids generated.
- Sample Analyses - sample analyses may indicate the level of contamination and therefore the potential for contamination. Once again this information may be useful in the ultimate disposal.

It is suggested that a combination of methods be used to determine the effectiveness of the decontamination of the process used.

9.0 TRAINING REQUIREMENTS

This section describes the minimum requirements for initial, refresher, and site-specific training.

9.1 INTRODUCTORY AND REFRESHER TRAINING

9.1.1 Requirements for HALLIBURTON NUS Personnel

All Halliburton NUS personnel must complete 40 hours of introductory hazardous waste site training prior to performing work at MCAS, Cherry Point, North Carolina. Additionally, HALLIBURTON NUS personnel who have had introductory training more than 12 months prior to site work must have completed 8 hours of refresher training within the past 12 months before being cleared for site work.

All Halliburton NUS personnel functioning in the supervisory capacity will have had Management and Supervisory training as required by 29 CFR 1910.120 (e)(4). No field personnel will function independently from a supervisor, unless they also satisfy this requirement.

Documentation of Halliburton NUS introductory, supervisory, and refresher training will be maintained at the project. Copies of certificates or other official documentation will be used to fulfill this requirement.

9.1.2 Requirements for Subcontractors

All Halliburton NUS subcontractor personnel must have completed introductory hazardous waste site training or equivalent work experience as defined in OSHA Standard 29 CFR 1910.120(e) and 8 hours of refresher training meeting the requirements of 29 CFR 1910.120(e)(8) prior to performing field work at the sites. All subcontractor personnel serving in the supervisory capacity will have had Management and Supervisory training as required by 29 CFR 1910.120 (e) (4). Halliburton NUS subcontractors must certify that each employee has had such training by sending Halliburton NUS a letter, on company letterhead, containing the information in the example letter provided as Figure 9-2. Accompanying that letter (or submitted separately prior to the initiation of any on-site activities), copies of training certificates will be provided for all subcontractor personnel. Figures 9-2 and 10-2 can be combined into one letter.

9.1.3 Subcontractor Exceptions

Subcontractors such as surveying teams who will not perform any activities in the exclusion zone during sampling tasks or where there is no potential for exposure, will be excluded from the requirements stipulated in Section 9.1.2.

9.2 SITE-SPECIFIC TRAINING

Halliburton NUS will provide site-specific training to all Halliburton NUS employees and subcontractor personnel who will perform work on this project. Site-specific training will include:

- Names of personnel and alternates responsible for site safety and health
- Safety, health and other hazards present on site
- Use of personal protective equipment
- Work practices to minimize risks from hazards
- Safe use of engineering controls and equipment
- Medical surveillance requirements
- Signs and symptoms of overexposure
- The contents of the health and safety plan and addendum
- Emergency response procedures (evacuation and assembly points)
- Review the contents of relevant Material Safety Data Sheets

FIGURE 9-2

OSHA TRAINING CERTIFICATION

The following statements must be typed on company letterhead and signed by an officer of the company:

LOGO

XYZ CORPORATION

555 E. 5th Street

Nowheresville, Kansas 55555

Month, day, year

Mr. Gregory L. Zimmerman, P.E.

Project Manager

Halliburton NUS Environmental Corp.

Foster Plaza VII 661 Andersen Drive

Pittsburgh, Pennsylvania 15220

Subject: Hazardous Waste Site Training - MCAS, Cherry Point, North Carolina

Dear Mr. Zimmerman,

The employees listed below have had introductory hazardous waste site training or equivalent work experience as required by 29 CFR 1910.120(e). In addition, those employees listed below who have received their introductory training more than 12 months ago have also received 8 hours of refresher training in accordance with 29 CFR 1910.120 (e)(8) within the past 12 months.

LIST FULL NAMES OF EMPLOYEES AND THEIR SOCIAL SECURITY NUMBERS HERE

Should you have any questions, please contact me at (555) 555-5555.

Sincerely,

(Name of Company Officer)

10.0 MEDICAL SURVEILLANCE

10.1 REQUIREMENTS FOR HALLIBURTON NUS PERSONNEL

All Halliburton NUS personnel participating in project field activities will have had a physical examination meeting the requirements of Halliburton NUS' medical surveillance program and will be medically qualified to perform hazardous waste site work using respiratory protection.

Documentation for medical clearances will be maintained in the Halliburton NUS Pittsburgh office and made available as necessary.

10.2 REQUIREMENTS FOR SUBCONTRACTORS

Subcontractors are required to obtain a certificate of their ability to perform hazardous waste site work and to wear respiratory protection. The "Subcontractor Medical Approval Form" (Figure 10-1) can be used to satisfy this requirement providing it is properly completed and signed by a licensed physician.

Subcontractors who have a company medical surveillance program meeting the requirements of paragraph (f) of OSHA 29 CFR 1910.120 can substitute Figure 10-1 with a letter, on company letterhead, containing all of the information in the example letter presented as Figure 10-2. Figures 9-2 and 10-2 can be combined into one letter.

10.3 REQUIREMENTS FOR ALL FIELD PERSONNEL

Each field team member (including subcontractors) shall be required to complete and submit a copy of Medical Data Sheet. These will be handed out and collected as part of the site-specific training. This shall be provided to the SSO prior to participating in site activities.

FIGURE 10-1

SUBCONTRACTOR MEDICAL APPROVAL FORM

For employees of _____
Company Name

Participant Name: _____ Date of Exam: _____

Part A

The above-named individual has:

1. Undergone a physical examination in accordance with OSHA Standard 29 CFR 1910.120, paragraph (f) and found to be medically -

- () qualified to perform work at the MCAS, Cherry Point, North Carolina work site
- (-) not qualified to perform work at the MCAS, Cherry Point, North Carolina work site

and,

2. Undergone a physical examination as per OSHA 29 CFR 1910.134(b)(10) and found to be medically -

- () qualified to wear respiratory protection
- () not qualified to wear respiratory protection

My evaluation has been based on the following information, as provided to me by the employer.

- () A copy of OSHA Standard 29 CFR 1910.120 and appendices.
- () A description of the employee's duties as they relate to the employee's exposures.
- () A list of known/suspected contaminants and their concentrations (if known).
- () A description of any personal protective equipment used or to be used.
- () Information from previous medical examinations of the employee which is not readily available to the examining physician.

Part B

I, _____, have examined _____
Physician's Name (print) Participant's Name (print)

and have determined the following information:

FIGURE 10-1
SUBCONTRACTOR MEDICAL APPROVAL FORM
PAGE TWO

1. Results of the medical examination and tests (excluding finding or diagnoses unrelated to occupational exposure)

2. Any detected medical conditions which would place the employee at increased risk of material impairment of the employee's health:

3. Recommended limitations upon the employee's assigned work:

I have informed this participant of the results of this medical examination and any medical conditions which require further examination or treatment.

Based on the information provided to me, and in view of the activities and hazard potentials involved at the MCAS, Cherry Point, North Carolina work site, this participant

- may
- may not

perform his/her assigned task.

Physician's Signature _____

Address _____

Phone Number _____

NOTE: Copies of test results are maintained and available at:

Address

FIGURE 10-2

MEDICAL SURVEILLANCE LETTER

The following statements must be typed on company letterhead and signed by an officer of the company:

LOGO
XYZ CORPORATION
555 E. 5th Street
Nowheresville, Kansas 55555

Month, day, year

Mr. Gregory I. Zimmerman, P.E.
Project Manager
Halliburton NUS Environmental Corp.
Foster Plaza VII 661 Andersen Drive
Pittsburgh, Pennsylvania 15220

Subject: Medical Surveillance - MCAS, Cherry Point, North Carolina

Dear Mr. Zimmerman,

As an officer of XYZ Corporation, I hereby state that the persons listed below participate in a medical surveillance program meeting the requirements contained in paragraph (f) of Title 29 of the Code of Federal Regulations (CFR), Part 1910.120 entitled "Hazardous Waste Operations and Emergency Response: Final Rule." I further state that the persons listed below have had physical examinations under this program within the past 12 months and that they have been cleared, by a licensed physician, to perform hazardous waste site work and to wear positive and negative pressure respiratory protection. I also state that, to my knowledge, no person listed below has any medical restriction that would preclude him/her from working at MCAS, Cherry Point, North Carolina.

LIST FULL NAMES OF EMPLOYEES AND THEIR SOCIAL SECURITY NUMBERS HERE

Should you have any questions, please contact me at (555) 555-5555.

Sincerely,

(Name of Company Officer)

11.0 SITE CONTROL

This section outlines the means by which Halliburton NUS will delineate work zones and use these work zones in conjunction with decontamination procedures to prevent the spread of contaminants into previously unaffected areas of the site. It is anticipated that a three zone approach will be used during work at this site; exclusion zone, contamination reduction zone, and support zone.

11.1 EXCLUSION ZONE

The exclusion zone will be considered those areas of the site of known or suspected contamination. However, significant amounts of surface contamination may not be encountered in the proposed work areas of this site until/unless contaminants are brought to the surface by soil boring activities. Furthermore, once such activities have been completed and surface contamination has been removed, the potential for exposure is again diminished and the area can then be reclassified as part of the contamination reduction zone. Therefore, the exclusion zones for this project will be limited to those areas of the site where active work is being performed and/or anywhere there is believed to be the potential for inhalation and/or ingestion exposure to site contaminants.

11.2 CONTAMINATION REDUCTION ZONE

The contamination reduction zone (CRZ) will be a buffer area between the exclusion zone and any area of the site where contamination is not suspected. The personnel and equipment decontamination area established for this project will take place in the CRZ. This area will serve as a focal point in supporting exclusion zone activities. In addition, this area will serve as the access and control points to the exclusion zone.

11.3 SUPPORT ZONE

The support zone for this project will include a staging area where site vehicles will be parked, equipment will be unloaded, and where food and drink containers will be maintained. In all cases, the support zones will be established at areas of the site where exposure to site contaminants would not be expected during normal working conditions or foreseeable emergencies.

11.4 SITE MAP

Once the areas of contamination, access routes, topography, dispersion routes are determined a site map will be generated and adjusted as site conditions change. These maps will be posted to illustrate up to date collection of contaminants and adjustment of zones and access points.

11.5 BUDDY SYSTEM

Personnel engaged in onsite activities will practice the "buddy system" to insure the safety of all personnel involved in this operation.

11.6 MATERIALS SAFETY DATA SHEET (MSDS) REQUIREMENTS

Halliburton NUS personnel will provide MSDS's for all chemicals brought on site. The contents of these documents will be reviewed by the Health and Safety officer with the user(s) of the chemical substances prior to any actual use or application of the substances on site. The MSDS's will then be maintained in a central location (i.e. temporary office) and will be available for anyone to review upon request. The SSO will create and maintain an inventory of those substances, and perform other functions necessary to comply with OSHA 1910.1200 Hazard Communication requirements.

11.7 COMMUNICATION

As personnel will not always be working in close proximity to one another during field activities, a supported means of communication may be necessary. For this purpose 2-way radio communication will be used. All means of communication will have the MCAS approval.

External communication will be done so utilizing the telephones at predetermined and approved locations where work is being conducted. External communication will primarily be used for the purpose of resource and emergency response communications. Prior to the commencement of site activities the FTL and Base contact will determine and arrange for telephone communications.

12.0 STANDARD WORK PRACTICES

The following Standard Work Practices are to be applied in addition to the Health and Safety Standard Operating procedures:

- Eating, drinking, chewing gum or tobacco, taking medication, and smoking are prohibited in the exclusion or decontamination zones, or any location where there is a possibility for contact with site contaminants exists.
- Upon leaving the exclusion zone, hands and face must be thoroughly washed with soap and potable water. Any protective outer clothing is to be decontaminated and removed as specified in this HASP, and left at a designated area prior to entering the clean area.
- Contact with potentially-contaminated substances must be avoided. Contact with the ground or with contaminated equipment must also be avoided.
- No facial hair, which interferes with a satisfactory fit of the mask-to-face seal, is permitted on personnel required to wear respiratory protective equipment.
- All personnel must satisfy all training requirements (40-hr Introductory, 8-hr Refresher, Site-specific training, Emergency response training, and Supervisory as applicable) prior to commencing site activities.
- All personnel must have a working knowledge of this HASP. Including being aware of the action levels for upgrading/downgrading levels of protective equipment, and emergency procedures.
- All personnel must satisfy medical monitoring procedures.
- All personnel must complete a medical data sheet, to be maintained on site.
- All personnel working on-site must utilize the buddy system.
- When lifting or moving equipment or material, use proper lifting techniques, the proper number of personnel, or equipment to move heavy loads.
- All work areas must be kept free of ground clutter.
- No flames or open fires will be permitted on site.
- Site personnel must immediately notify Halliburton NUS Health Sciences of all incidents for OSHA recordkeeping purposes.
- If personnel note any warning properties of chemicals (irritation, odors, symptoms, etc.) or even remotely suspect the occurrence of exposure, they must immediately notify the SSO for further direction.
- Site personnel are not to undertake any activity which would be considered a confined-space entry.
- A full-sized copy of the OSHA poster included as part of this HASP shall be conspicuously posted on site.
- Any new information relative to potential hazards or exposures must be promptly conveyed to the Project SSO and the Field Team Leader
- All compressed gas cylinders used (empty or full) must be stored, secured, and used properly to protect from damage

- All field team members shall employ the use of lifelines, safety harnesses, and U.S. Coast Guard approved personal floatation devices when working within four feet of the water edge.
- All field activities, particularly those associated with working on or near waters edge, will be suspended (at the discretion and direction of the Field Team Leader, or Site Safety Officer) in the event of inclement weather.

DRILLING OPERATIONS

- No drilling or any other operation which will bring a drill mast or any other projecting device within 20 feet in any direction of overhead power lines will be permitted. Prior to any subsurface investigations by the FTL shall ensure the locations of all underground utilities will be identified and marked prior to initiating any subsurface activity.
- Hand signals with the driller will be established prior to the commencement of drilling activities.
- All drill rigs and other machinery with exposed moving parts must be equipped with an operational emergency stop device. All personnel working in a close proximity must be aware of the location of this emergency stop device and its operation. This device will be tested initially (and then periodically) to insure its operational status. The driller and helper shall not simultaneously handle moving augers or flights unless there is a standby person able to activate the emergency stop device.
- The driller must never leave the controls while tools are rotating unless all personnel are clear of the rotating equipment.
- A long handled shovel or the equivalent shall be used to clear away drill cuttings from the hole and rotating equipment. Hands or feet shall not be used for this purpose.
- A remote sampling device must be used to sample drill cuttings near rotating tools. The driller shall shut down operations if the sampler must go near the tools to obtain samples.
- All personnel working in the vicinity of the drill rig while its operating shall secure all loose clothing.
- Only manufacturer-approved equipment may be used in conjunction with site equipment (i.e. pins for auger flights etc.). Pins or other protruding items from rotating equipment shall not be permitted.
- No person shall climb a drill mast while equipment is rotating.
- No person shall climb a drill mast without use of ANSI approved fall protection (i.e. belts, lanyards and a fall protection slide rail) or portable ladders which meet OSHA's requirements.

13.0 EMERGENCY RESPONSE

In the event of an emergency, all site personnel will be evacuated to a predetermined location away from the work place. Emergency Response Planning will follow in accordance with 29 CFR 1910.38(a). Contractor shall utilize Base Fire Protection and Emergency Services in order to avoid potential emergencies.

13.1 PRE-PLANNING

Upon initial arrival at the base, the Halliburton NUS FTL/SSO will meet with the Base Fire Protection Department and Emergency Services to notify coordinators of the activities to be undertaken and where. All site personnel will be required to follow base emergency procedures and will rely on base services to handle emergency situations if encountered.

13.2 EMERGENCY ESCAPE PROCEDURES AND ASSIGNMENTS

Upon notification of a site emergency requiring evacuation, all site personnel will proceed to predetermined locations based on emergency location and wind directions. If personnel cannot reach those locations without endangering life or health, they shall report to the selected alternate meeting place. Personnel shall be trained to remain at the refuge location until directed to resume work, or leave the site.

13.3 PROCEDURE TO ACCOUNT FOR SITE PERSONNEL

The site work force will be small enough so that accounting for personnel will not be a problem. Accounting for personnel will be the FTL's responsibility. This will be accomplished by taking a roll call using the site log book.

13.4 RESCUE AND MEDICAL DUTIES

A physician approved first aid kit ANSI approved eye wash station and a Class ABC fire extinguisher will be readily available on site. Site personnel shall not be authorized to participate in emergency rescue operations. Only personnel with appropriate first aid training (which is current) are authorized to assist in emergency first aid functions.

13.5 ACTIVATION OF EMERGENCY RESPONSE PROCEDURES

Should any emergency occur which requires the support of outside services, the appropriate contacts shall be made by the FTL/SSO. A list of the appropriate contacts can be found in Table 13-1.

Examples requiring outside services are as follows:

- Any field crew member involved in an accident or experiencing signs and symptoms of exposure.
- A condition discovered which suggests the activity is more hazardous than anticipated.
- Emergency conditions in the nearby areas which directly impact operations.

Persons who observe an emergency situation must notify Base contacts, Base Services and Office Contacts.

TABLE 13-1

EMERGENCY INFORMATION

Police	On base	(919) 466-3615
Fire	On base	(919) 466-3333
Ambulance	On base	(919) 466-4419
Hospital	Craven RMC	(919) 633-8111
Hospital on Base	On Base	(919) 466-5751
Poison Control	Off base	1-800-672-1697
Base Contact	Renee Henderson	(919) 466-5391
ton NUS Project Manager	Gregory L. Zimmerman, P.E.	(412)921-8992
burton NUS Health & Safety Officer	Donald J. Westerhoff	(412)921-7281
CLEAN Health and Safety Manager	Matthew M. Soltis, CSP	(412)921-8912

Directions to Craven RMC:

- Take Highway 70 West to New Bern.
- Take Glenburnie Road Exit (right turn).
- Glenburnie to Neuse Blvd. (turn right).
- Two miles, hospital is on the left.
- Craven RMC, 2000 Neuse Blvd, New Bern.

Maps depicting directions from the site to the hospitals shall be obtained and attached to this Health and Safety plan prior to the commencement of site activities.

13.6 INCIDENT FOLLOW-UP

On receiving a report of an incident (or near incident) occurrence the FT/SSO shall immediately investigate and make the appropriate recommendations to prevent reoccurrence. The CLEAN HSM shall be immediately notified by telephone on occurrence of an incident. At his discretion he may wish to participate in the investigation. Details of the incident shall be documented on an Incident Report within 24 hours of the occurrence and distributed to the Project Manager and CLEAN HSM.

14.0 CONFINED SPACE

No Confined Space Operations are anticipated to be involved in the planned scope of work. Therefore, specific procedures for such efforts are not applicable and not addressed in this Health and Safety Plan. Should any confined space situations arise, the site health and safety officer should be notified immediately before any action is taken.

15.0 SPILL CONTAINMENT PROGRAM

15.1 SCOPE AND APPLICATION

It is not anticipated that bulk hazardous materials (over 55-gallons) will be handled at a given time as part of this scope of work. It is also not anticipated that such spillage would constitute a danger to human health or the environment. However, as the job progresses the potential for accumulating decontamination fluids in the central staging area exists. Once characterized these fluids can be removed from this area and disposed of. As these fluids, while in the staging area remain uncharacterized, a spill containment program will be developed and instituted as part of this HASP.

15.2 POTENTIAL SPILL AREAS

In an ongoing attempt to prevent and control further potential contamination of the environment, efforts will be taken to minimize the potential for spill releases. Based on planned activities and available information, there are limited areas and operations where this potential threat can be reasonably expected. One of these is the area intended to be used for central staging area for potentially contaminated soils and decontamination fluids. Additionally, the handling, loading and unloading areas present limited potential for leaks or spills. At the time of the preparation of this Health and Safety Plan, it is anticipated all investigation derived waste (such as decontamination fluids) generated, as a result of this scope of work, will be containerized, labeled, and staged to await sampling and analysis for the determination of proper disposal procedures. The results of these analysis will determine whether these substances will be disposed of in the Industrial Waste Treatment Plant (IWTP) as nonhazardous wastes, or will have to be transported as hazardous materials to an off-site treatment facility. Until the ultimate fate of these substances can be determined, there exists a possibility to accumulate multiple drums of waste materials.

15.2.1 55-GALLON DRUMS

All drums containing liquids will be staged within a polyethylene lined berm capable of holding a maximum of 10 drums. The capacity of the bermed area should contain the contents of the drums plus volumes reduced caused by displacement of the drums, approximately 110% of the total capacity. Rainwater captured inside the lined area will be allowed to evaporate. However, if rainwater accumulations should reach 1% of the total capacity of the bermed area, those accumulations will be removed, placed in labeled drums, and placed in this area.

15.3 LEAK AND SPILL DETECTION

To establish an early detection of potential spills or leaks, a daily walk around by personnel staging or disposing of drums will be conducted during working hours to visually determine that containers are not leaking. If a leak is detected the drum contents will be transferred using a hand pump into a new 55-gallon drum. The leak will be collected and contained using absorbents such as Oil-dry, vermiculite, or sand, stored at the staging area in a drum conspicuously marked. This material too, will be containerized for disposal pending analyses. All inspections will be documented in the Project logbook.

15.4 PERSONNEL TRAINING AND SPILL PREVENTION

All personnel will be instructed on the procedures for spill prevention, containment, and collection of hazardous materials in the site specific training. The FTL and the SSO will serve as the Spill Response Coordinators for this operation should the need arise.

15.5 SPILL PREVENTION AND CONTAINMENT EQUIPMENT

The following represents the minimum equipment which will be maintained at the staging area at all times for the purpose of supporting this Spill Prevention/Containment Program.

- Sand, clean fill, vermiculite, or other noncombustible absorbent (oil-dry);
- Drums (55-gallon U.S. DOT 17-E or 17-H)
- Shovels, rakes, and brooms
- Hand operated drum pump with hose
- Labels
- Drum Patch kit

15.6 SPILL CONTROL PLAN

This section describes the procedures the Halliburton NUS field crew members will employ upon the detection of a spill or leak.

- 1) Notify the SSO or FOL immediately upon the detection of a leak or spill.
- 2) Employ the personnel protective equipment stored at the staging area, take immediate actions to stop the leak or spill by plugging or patching the drum or raising the leak to the highest point. Spread the sorbent material in the area of the spill covering completely.
- 3) Transfer the material to a new drum, collect and containerize the absorbent material. Label the new drum appropriately. Await analyses for treatment or disposal options.
- 4) Solid spills will be recontainerized with 2-inches of top cover, and await for test results for treatment or disposal options.

It is not anticipated that a spill will occur in which the field crews cannot handle. Should this occur notification of a Hazardous Material Response Team will be carried out by the FOL or SSO.

16.0 DOCUMENTATION AND EQUIPMENT

This section summarizes documentation and equipment required for the support of this Health and Safety Plan (HASP). Its purpose is a final checklist to help ensure all of the necessary resources are available to carry out the requirements of this HASP.

16.1 DOCUMENTATION

- Health and Safety Log Book
- Instrument Log Sheets
- HASP (Signed Copy)
- OSHA Poster 11 x 14
- MSDS's (if applicable)
- Medical Data Sheets
- Employee Training Certificates
- Medical Surveillance Documentation
- Incident Reports
- Fit Test Records

16.2 HEALTH AND SAFETY EQUIPMENT

- First Aid Kit (Physician's Approved)
- ANSI Approved Eye Wash
- Class ABC Fire Extinguishers
- Nitrile Gloves
- Inner Gloves
- Tyvek
- Chemical Resistant Tyvek
- Barricade Tape
- Boot Covers
- Duct Tape
- Decon Kit (Alconox tube, brush, sorbants, step stool)
- Hard Hats safety Glasses
- Splash Shield
- Steel Toe/Shank Boots

ATTACHMENT A HEAT/COLD STRESS

Heat Stress

The SSO shall visually monitor personnel to note for signs of heat stress. Field personnel will also be instructed to observe for symptoms of heat stress and methods on how to control it. One or more of the following control measures can be used to help control heat stress:

- Provide adequate liquids to replace lost body fluids. Personnel must replace water and salt lost from sweating. Personnel must be encouraged to drink more than the amount required to satisfy thirst. Thirst satisfaction is not an accurate indicator of adequate salt and fluid replacement.
- Replacement fluids can be commercial mixes such as Gatorade®.
- Establish a work regime that will provide adequate rest periods for cooling down. This may require additional shifts of workers.
- Cooling devices such as vortex tubes or cooling vests can be worn beneath protective garments.
- Breaks are to be taken in a cool rest area (77°F is best).
- Personnel shall remove impermeable protective garments during rest periods.
- Personnel shall not be assigned other tasks during rest periods.
- Personnel shall be informed of the importance of adequate rest, acclimation, and proper diet in the prevention of heat stress.

The heat stress of personnel on-site may be monitored utilizing biological monitoring or the Wet Bulb Globe Temperature Index (WBGT) technique when workers are not wearing protective coveralls (i.e. Tyvek®). This method will require the use of a heat stress monitoring device.

One of the following biological monitoring procedures shall be followed when the workplace temperature is 70°F or above.

- Heart rate (HR) shall be measured by the 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. If the HR is higher, the next work period should be shortened by 10 minutes (or 33 percent), while the length of rest period stays the same. If the pulse rate is 100 beats/minute at the beginning of the next rest period, the following work cycle should be shortened by 33 percent. The length of the initial work period will be determined by using the table below.

Since prolonged exposure to cold air, or to immersion in cold water, at temperatures well above freezing can lead to dangerous hypothermia, whole body protection must be provided.

1. Adequate insulating dry clothing to maintain core temperatures above 36°C (96.8°F) must be provided to workers if work is performed in air temperatures below 4°C (40°F). Wind chill cooling rate and the cooling power of air are critical factors. [Wind chill cooling rate is defined as heat loss from a body expressed in watts per meter squared which is a function of the air temperature and wind velocity upon the exposed body.] The higher the wind speed and the lower the temperature in the work area, the greater the insulation value of the protective clothing required. An equivalent chill temperature chart relating the actual dry bulb air temperature and the wind velocity is presented in Table 2. The equivalent chill temperature should be used when estimating the combined cooling effect of wind and low air temperatures on exposed skin or when determining clothing insulation requirements to maintain the deep body core temperature.
2. Unless there are unusual or extenuating circumstances, cold injury to other than hands, feet, and head is not likely to occur without the development of the initial signs of hypothermia. Older workers or workers with circulatory problems require special precautionary protection against cold injury. The use of extra insulating clothing and/or a reduction in the duration of the exposure period are among the special precautions which should be considered. The precautionary actions to be taken will depend upon the physical condition of the worker and should be determined with the advice of a physician with knowledge of the cold stress factors and the medical condition of the worker.

PERMISSIBLE HEAT EXPOSURE THRESHOLD LIMIT VALUES

<u>Work-Rest Regimen</u>	<u>Work Load</u>		
	<u>Light</u>	<u>Moderate</u>	<u>Heavy</u>
Continuous	80.0°F	80.0°F	77.0°F
75% Work - 25% Rest, Each Hour	87.0°F	82.4°F	78.6°F
50% Work - 50% Rest, Each Hour	88.5°F	85.0°F	82.2°F
25% Work - 75% Rest, Each Hour	90.0°F	88.0°F	86.0°F

- Body temperature shall be measured orally with a clinical thermometer as early as possible in the resting period. Oral temperature at the beginning of the rest period should not exceed 99°F. If it does, the next work period should be shortened by 10 minutes (or 33 percent), while the length of the rest period stays the same. However, if the oral temperature exceeds 99.7°F at the beginning of the next rest period, the following work cycle shall be further shortened by 33 percent. OT should be measured at the end of the rest period to make sure that it has dropped below 99°F. At no time shall work begin with the oral temperature above 99°F.

NOTE: External temperatures in excess of those stated above shall be regarded as inclement weather. Work continuation, termination, or alteration of the work schedule will be at the discretion of the FTL and on site health and safety representative. The heat and cold stress related sections of this are applicable to the season when work will be completed.

Cold Stress

Cold stress TLVs are intended to protect workers from the severest effects of cold stress (hypothermia) and cold injury. They describe exposures to cold working conditions under which it is believed that nearly all workers can be repeatedly exposed without adverse health effects. The TLV objective is to prevent the deep body temperature from falling below 36°C (96.8°F) and to prevent cold injury to body extremities (deep body temperature is the core temperature of the body determined by conventional methods for rectal temperature measurements). For a single, occasional exposure to a cold environment, a drop in core temperature to no lower than 35°C (95°F) should be permitted. In addition to provisions for total body protection, the TLV objective is to protect all parts of the body with emphasis on hands, feet, and head from cold injury.

Introduction

Fatal exposures to cold among workers have almost always resulted from accidental exposures involving failure to escape from low environmental air temperatures or from immersion in low temperature water. The single most important aspect of life-threatening hypothermia is the fall in the deep core temperature of the body. The clinical presentations of victims of hypothermia are shown in Table 1. Workers should be protected from exposure to cold so that the deep core temperature does not fall below 36°C (96.8°F); lower body temperatures will very likely result in reduced mental alertness, reduction in rational decision making, or loss of consciousness with the threat of fatal consequences.

Pain in the extremities may be the first early warning of danger to cold stress. During exposure to cold, maximum severe shivering depends when the body temperature has fallen to 35°C (95°F). This must be taken as a sign of danger to all workers and exposure to cold should be immediately terminated for any workers when severe shivering becomes evident. Useful physical or mental work is limited when severe shivering occurs.

Evaluation and Control

For exposed skin, continuous exposure should not be permitted when the air speed and temperature results in an equivalent chill temperature of -32°C (-25.6°F). Superficial or deep local tissue freezing will occur only at temperatures below -1°C (30.2°F) regardless of wind speed.

At air temperatures of 2°C (35.6°F) or less, it is imperative that workers who become immersed in water or whose clothing becomes wet be immediately provided a change of clothing and be treated for hypothermia.

TLVs recommended for properly clothed workers for periods of work at temperatures below freezing are shown in Table 3.

Special protection of the hands is required to maintain manual dexterity for the prevention of accidents:

1. If fine work is to be performed with bare hands for more than 10-20 minutes in an environment below 16°C (60.8°F), special provisions should be established for keeping the workers' hands warm. For this purpose, warm air jets, radiant heaters (fuel burner or electric radiator), or contact warm plates may be utilized. Metal handles of tools and control bars should be covered by thermal insulating material at temperatures below -1°C (30.2°F).
2. If the air temperature falls below 16°C (60.8°F) for sedentary, 4°C (39.2°F) for light, -7°C (19.4°F) for moderate work and fine manual dexterity is not required, then gloves should be used by the workers.

To prevent contact frostbite, the workers should wear anti-contact gloves.

1. When cold surfaces below -7°C (19.4°F) are within reach, a warning should be given to each worker by the supervisor to prevent inadvertent contact by bare skin.
2. If the air temperature is -17.5°C (0°F) or less, the hands should be protected by mittens. Machine controls and tools for use in cold conditions should be designed so that they can be handled without removing the mittens.

Provisions for additional total body protection are required if work is performed in an environment at or below 4°C (39.2°F). The workers should wear cold protective clothing appropriate for the level of cold and physical activity:

1. If the air velocity at the job site is increased by wind, draft, or artificial ventilating equipment, the cooling effect of the wind should be reduced by shielding the work area or by wearing an easily removable windbreak garment.
2. If only light work is involved and if the clothing on the worker may become wet on the job site, the outer layer of the clothing in use may be of a type impermeable to water. With more severe work under such conditions, the outer layer should be water repellent, and the outerwear should be changed as it becomes wetted. The outer garments should include provisions for easy ventilation in order to prevent wetting of inner layers of sweat. If work is done at normal temperatures or in a hot environment before entering the cold area, the employee should make sure that clothing is not wet as a consequence of sweating. If clothing is wet, the employee should change into dry clothes before entering the cold area. The workers should change socks and any removable felt insoles at regular daily intervals or use vapor barrier boots. The optimal frequency of change should be determined empirically and will vary individually and according to the type of shoe worn and how much the individual's feet sweat.
3. If exposed areas of the body cannot be protected sufficiently to prevent sensation of excessive cold or frostbite, protective items should be supplied in auxiliary heated versions.
4. If the available clothing does not give adequate protection to prevent hypothermia or frostbite, work should be modified or suspended until adequate clothing is made available or until weather conditions improve.
5. Workers handling evaporative liquid (gasoline, alcohol, or cleaning fluids) at air temperatures below 4°C (39.2°F) should take special precautions to avoid soaking of clothing or gloves with the liquids because of the added danger of cold injury due to evaporative cooling. Special note should be taken of the particularly acute effects of splashes of "cryogenic fluids" or those liquids with a boiling point that is just above ambient temperature.

TABLE 1
PROGRESSIVE CLINICAL PRESENTATIONS OF HYPOTHERMIA*

Core Temperature		Clinical Signs
°C	°F	
37.6	99.6	"Normal" rectal temperature
37	98.6	"Normal" oral temperature
36	96.8	Metabolic rate increases in an attempt to compensate for heat loss
35	95.0	Maximum shivering
34	93.2	Victim conscious and responsive, with normal blood pressure
33	91.4	Severe hypothermia below this temperature
32	86.0	Consciousness clouded; blood pressure becomes difficult to obtain; pupils dilated but react to light; shivering ceases
31	87.8	
30	86.0	Progressive loss of consciousness; muscular rigidity increases; pulse and blood pressure difficult to obtain; respiratory rate decreases
29	84.2	
28	82.4	Ventricular fibrillation possible with myocardial irritability
27	80.6	Voluntary motion ceases; pupils nonreactive to light; deep tendon and superficial reflexes absent
26	78.8	Victim seldom conscious
25	77.0	Ventricular fibrillation may occur spontaneously
24	75.2	Pulmonary edema
22	71.6	Maximum risk of ventricular fibrillation
21	69.8	
20	68.0	Cardiac standstill
18	64.4	Lowest accidental hypothermia victim to recover
17	62.6	Isoelectric electroencephalogram
9	48.2	Lowest artificially cooled hypothermia patient to recover

* Presentations approximately related to core temperature. Reprinted from the January 1982 issue of American Family Physician, published by the American Academy of Family Physicians.

TABLE 3
THRESHOLD LIMIT VALUES WORK/WARM-UP SCHEDULE FOR FOUR-HOUR SHIFT*

Air Temperature - Sunny Sky		No Noticeable Wind		5 mph Wind		10 mph Wind		15 mph Wind		20 mph Wind	
°C (approx)	°F (approx)	Max. Work Period	No. of Breaks								
-26° to -28°	-15° to -19°	(Norm Breaks) 1		(Norm Breaks) 1		75 min	2	55 min	3	40 min	4
-29° to -31°	-20° to -24°	(Norm Breaks) 1		75 min	2	55 min	3	40 min	4	30 min	5
-32° to -34°	-25° to -29°	75 min	2	55 min	3	40 min	4	30 min	5	Non-emergency work should cease	
-35° to -37°	-30° to -34°	55 min	3	40 min	2	30 min	5	Non-emergency work should cease		Non-emergency work should cease	
-38° to -39°	-35° to -39°	40 min	4	30 min	1	Non-emergency work should cease		Non-emergency work should cease		Non-emergency work should cease	
-40° to -42°	-40° to -44°	30 min	5	Non-emergency work should cease							
-43° & below	-45° & below	Non-emergency work should cease									

NOTES:

- Schedule applies to moderate to heavy work activity with warm-up breaks of ten (10) minutes in a warm location. For Light-to-Moderate Work (limited physical movement): apply the schedule one step lower. For example, at -35°C (-30°F) with no noticeable wind (Step 4), a worker at a job with little physical movement should have a maximum work period of 40 minutes with 4 breaks in a 4-hour period (Step 5).
- The following is suggested as a guide for estimating wind velocity if accurate information is not available: 5 mph: light flag moves; 10 mph: light flag fully extended; 15 mph: raises newspaper sheet; 20 mph: blowing and drifting snow.
- If only the wind chill cooling rate is available, a rough rule of thumb for applying it rather than the temperature and wind velocity factors given above would be: 1) special warm-up breaks should be initiated at a wind chill cooling rate of about 1750 W/M²; 2) all non-emergency work should have ceased at or before a wind chill of 2250 W/m². In general, the warm-up schedule provided above slightly under-compensates for the wind at the warmer temperatures, assuming acclimatization and clothing

TABLE 2
COOLING POWER OF WIND ON EXPOSED FLESH EXPRESSED AS EQUIVALENT TEMPERATURE
(under calm conditions)*

Estimated Wind Speed (in mph)	Actual Temperature Reading (°F)											
	50	40	30	20	10	0	-10	-20	-30	-40	-50	-60
	Equivalent Temperature (°F)											
Calm	50	40	30	20	10	0	-10	-20	-30	-40	-50	-60
5	48	37	27	16	6	-5	-15	-26	-36	-47	-57	-68
10	40	28	16	4	-9	-24	-33	-46	-58	-70	-83	-95
15	36	22	9	-5	-18	-32	-45	-58	-72	-85	-99	-112
20	32	18	4	-10	-25	-39	-53	-67	-82	-96	-110	-121
25	30	16	0	-15	-29	-44	-59	-74	-88	-104	-118	-133
30	28	13	-2	-18	-33	-48	-63	-79	-94	-109	-125	-140
35	27	11	-4	-20	-35	-51	-67	-82	-98	-113	-129	-145
40	26	10	-6	-21	-37	-53	-69	-85	-100	-116	-132	-148

(Wind speeds greater than 40 mph have little additional effect)	LITTLE DANGER In < hr with dry skin. Maximum danger of false sense of security	INCREASING DANGER Danger from freezing of exposed flesh within one minute.	GREAT DANGER Flesh may freeze within 30 seconds.
	Trenchfoot and immersion foot may occur at any point on this chart.		

* Developed by U.S. Army Research Institute of Environmental Medicine, Natick MA.

Work - Warming Regimen

If work is performed continuously in the cold at an equivalent chill temperature (ECT) or below -7°C (19.4°F), heated warming shelters (tents, cabins, rest rooms, etc.) should be made available nearby. The workers should be encouraged to use these shelters at regular intervals, the frequency depending on the severity of the environmental exposure. The onset of heavy shivering, frostnip, the feeling of excessive fatigue, drowsiness, irritability, or euphoria are indications for immediate return to the shelter. When entering the heated shelter, the outer layer of clothing should be removed and the remainder of the clothing loosened to permit sweat evaporation or a change of dry work clothing provided. A change of dry work clothing should be provided as necessary to prevent workers from returning to work with wet clothing. Dehydration, or the loss of body fluids, occurs insidiously in the cold environment and may increase the susceptibility of the worker to cold injury due to a significant change in blood flow to the extremities. Warm sweet drinks and soups should be provided at the work site to provide caloric intake and fluid volume. The intake of coffee should be limited because of the diuretic and circulatory effects.

For work practices at or below -12°C (10.4°F) ECT, the following should apply:

1. The worker should be under constant protective observation (buddy system or supervision).
2. The work rate should not be so high as to cause heavy sweating that will result in wet clothing; if heavy work must be done, rest periods should be taken in heated shelters and opportunity for changing into dry clothing should be provided.
3. New employees should not be required to work full time in the cold during the first days of employment until they become accustomed to the working conditions and required protective clothing.
4. The weight and bulkiness of clothing should be included in estimating the required work performance and weights to be lifted by the worker.
5. The work should be arranged in such a way that sitting still or standing still for long periods is minimized. Unprotected metal chair seats should not be used. The worker should be protected from drafts to the greatest extent possible.
6. The workers should be instructed in safety and health procedures. The training program should include as a minimum instruction in:
 - a. Proper rewarming procedures and appropriate first aid treatment.
 - b. Proper clothing practices.
 - c. Proper eating and drinking habits.
 - d. Recognition of impending frostbite.
 - e. Recognition of signs and symptoms of impending hypothermia or excessive cooling of the body even when shivering does not occur.
 - f. Safe work practices.

Special Workplace Recommendations

Special design requirements for refrigerator rooms include:

1. In refrigerator rooms, the air velocity should be minimized as much as possible and should not exceed 1 meter/sec (200 fpm) at the job site. This can be achieved by properly designed air distribution systems.
2. Special wind protective clothing should be provided based upon existing air velocities to which workers are exposed.

Special caution should be exercised when working with toxic substances and when workers are exposed to vibration. Cold exposure may require reduced exposure limits.

Eye protection for workers employed out-of-doors in a snow and/or ice-covered terrain should be supplied. Special safety goggles to protect against ultraviolet light and glare (which can produce temporary conjunctivitis and/or temperature loss

appropriate for winter work. On the other hand, the chart slightly over-compensates for the actual temperatures in the colder ranges, since windy conditions rarely prevail at extremely low temperatures.

4. TLVs apply only for workers in dry clothing.

* Adapted from Occupational Health & Safety Division, Saskatchewan Department of Labor.

**ATTACHMENT B
TICK CONTROL
AND
LYME DISEASE**

of vision) and blowing ice crystals should be required when there is an expanse of snow coverage causing a potential exposure hazard.

Workplace monitoring is required as follows:

1. Suitable thermometry should be arranged at any workplace where the environmental temperature is below 16°C (60.8°F) so that overall compliance with the requirements of the TLV can be maintained.
2. Whenever the air temperature at a workplace falls below -1°C (30.2°F), the dry bulb temperature should be measured and recorded at least every 4 hours.
3. In indoor workplaces, the wind speed should also be recorded at least every 4 hours whenever the rate of air movement exceeds 2 meters per second (5 mph).
4. In outdoor work situations, the wind speed should be measured and recorded together with the air temperature whenever the air temperature is below -1°C (30.2°F)
5. Equivalent chill temperature should be obtained from Table 2 in all cases where air movement measurements are made; it should be recorded with the other data whenever the equivalent chill temperature is below -7°C (19.4°F)

Employees should be excluded from work in cold at -1°C (30.2°F) or below if they are suffering from diseases or taking medication which interferes with normal body temperature regulation or reduces tolerance to work in cold environments. Workers who are routinely exposed to temperatures below -24°C (-11.2°F) with wind speeds less than five miles per hour, or air temperatures below -18°C (0°F) with wind speeds above five miles per hour, should be medically certified as suitable for such exposures.

Trauma sustained in freezing or subzero conditions requires special attention because an injured worker is predisposed to cold injury. Special provisions should be made to prevent hypothermia and freezing of damaged tissues in addition to providing for first aid treatment.

Note: This information has been adopted from the 1992-1993 "Threshold Limit Values for Chemical Substances and Physical Agents and Biological Indices" by the American Conference of Governmental Industrial Hygienists (ACGIH).

TICK CONTROL AND LYME DISEASE

The occurrence of Lyme disease has become a worldwide problem since its identification in 1976. This disease is characteristically recognized as being transmitted by ticks, which may be encountered by field personnel while working at this site. As a result, this discussion has been included with this Health and Safety Plan to provide for adequate recognition, evaluation, and control efforts to minimize the occurrence and effects of this potential hazard.

The discovery of Lyme disease is credited to Dr. Allen Steere of Yale University Medical School, and is named after the community where it was (reportedly) first encountered, Lyme, Connecticut. This disease can be transmitted to man through the bite of ticks that are infected with a cork screw-shaped microbe (spirochete). The spread of this disease has been so rapid that in 1984 it surpassed Rocky Mountain Spotted fever as the most common tick-borne disease in the United States. In this country, most of the incidents of this disease have been recorded in the Northeast, and the tick species most commonly attributed with its spread is the deer tick.

Recognition

This hazard potential exists primarily in the spring and summer months, as these are the seasons that tick populations and activity flourish. In fact, 90 percent of the reported cases have occurred from early June through September. Also, this concern exists primarily in heavily vegetated areas. Therefore, recognition of these factors can aid in the awareness and control of this threat.

To aid in the recognition and identification of these insects, an example illustration of the tick species common to the region where this site is located has been included with this discussion. This species (the American Dog tick) is common in the eastern half of the United States, and typically exists in areas covered with grass or underbrush. These insects will attach themselves to animals (including man) that pass through the area and rub against them. After finding a host, the tick inserts its mouthparts and sucks blood until it is fully engorged. This requires a time period of three to twelve days, then the tick will drop off. In addition to Lyme disease concerns, this tick has also been identified as a transmitter of Rocky Mountain Spotted Fever, and the organisms of tularemia and possibly relapsing fever. The wounds left by tick bites can be painful, and can also have a paralyzing effect commonly referred to as tick paralysis.

The earliest symptom of the onset of this disease is the occurrence of an unusual red skin rash. This is commonly the first indication since it has been evidenced that many persons who have contracted this disease were, in fact, unaware that they had been bitten. This rash can appear at the site of the bite anywhere from several days to a few weeks after the bite. It typically starts as a small red spot, and then expands as the spirochetes expand from the bite location. Rash sizes can vary, but have been most commonly associated in a 2 to 3 inch diameter size range. This rash will fade (with or without treatment) after a few weeks. Close inspection is necessary to detect this symptom as the rashes are easy to miss because they're often very faint. Body sites where rashes frequently occur include the thigh areas, groin, and armpits. Also, it is not uncommon for a rash to develop in more than one place.

Other early symptoms include profound fatigue, a stiff neck, and flu-like symptoms such as headache, chills, fever, and muscle aches. Recognition of the onset of any of these symptoms is important since tick bites do not always produce a rash. If left untreated, the disease will progress to its second stage within weeks or months after the infection. This stage involves affects to the heart and nervous system. A common second stage symptom is a paralysis on one or both sides of the face. Others include severe headache, encephalitis, or meningitis. The third and final stage involves the development of chronic inflammatory arthritis, which can occur up to a year or more after the bite.

Evaluation

Evaluation of this hazard potential principally involves field personnel performing close self-inspections for the presence of ticks each time they leave the site. This should involve careful examination, especially of the individuals' heads. Personnel should be aware that when a tick attaches itself to its host, it inserts its entire head under the surface of the skin.

Control

Control of this threat involves several components. First, field personnel must be aware of the climate and area conditions which are commonly associated with being conducive to tick infestation. Second, when working in or walking through potential infested areas, personnel must ensure that they do not have exposed body parts (i.e. at least long sleeved shirts and long pants, particularly when protective coveralls are not worn). In heavily vegetated areas where infestation is likely, Tyvek coveralls will be required to minimize this hazard potential. Also, several commercial products have been demonstrated as being effective in repelling ticks. Examples include Permanone, Off!, and Cutter. These types of repellents will be used at the direction and discretion of the Brown & Root Environmental Health and Safety Officer, and only in accordance and observation of manufacturer's recommendations. In most instances, however, such repellents are typically applied to the outside surfaces of clothing (and not directly onto the skin), and should be applied also to shoe tops, socks, pants cuffs, and other areas most susceptible to ticks.

Tick Removal

In the event that a tick is discovered to be attached to a member of the field team, timely removal of the insect is critical to reducing the potential for contracting the disease. According to available information and research, there is apparently a grace period of at least a few hours from the time of the bite before the tick transmits the microbe (the spirochetes are not present in the mouth parts of the tick). However, the incident of a tick bite is frequently unnoticed, and the discovery of the tick may not occur until after this suspected grace period has already elapsed. Therefore, timely removal is very important. The preferred method of tick removal is to pull it out using tweezers or small forceps. In this method, the tick should be grasped as close to the mouth as possible, and then pulled steadily upward. Care must be exercised so as not to pull in a jerking motion as this can result in the head becoming detached. After the tick has been removed, disinfect the bite with rubbing alcohol or povidone iodine (Betadine). The tick must not be handled as the microbes can enter the body through any breaks in intact skin. The bite should be checked occasionally for at least a two-week period to see if a rash forms. If it does, medical attention must be promptly sought.

In order to provide for proper and timely response to the occurrence of a tick bite, the Health and Safety Officer will ensure that the site First Aid kit is properly equipped with medical forceps and rubbing alcohol, in addition to the standard kit contents. Also, an adequate supply of commercial insect (tick) repellents will be maintained onsite, and all personnel will be trained in its proper application and will be required to use it, at the direction of the Health and Safety Officer.