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Pilot-Scale Air Sparging/Soil Vapor Extraction System Work Plan

for

Naval Weapons Industrial Reserve Plant

Bethpage, New York

DEPARTMENT OF THE NAVY
UNITED STATES OF AMERICA

Northern Division
Naval Facilities Engineering Command
Contract Number N62472-90-D-1298
Contract Task Order 0213

March 1997

C F BRAUN ENGINEERING CORPORATION

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FOR
NAVAL WEAPONS INDUSTRIAL RESERVE PLANT
BETHPAGE, NEW YORK

COMPREHENSIVE LONG-TERM
ENVIRONMENTAL ACTION NAVY (CLEAN) CONTRACT

Submitted to:
Northern Division
Environmental Branch Code 18
Naval Facilities Engineering Command
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Lester, Pennsylvania 19113-2090

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1.0 PROJECT DESCRIPTION

1.1 AUTHORIZATION

The Northern Division of the Naval Facilities Engineering Command has issued Contract Task Order (CTO) 0213 to C F Braun Engineering Corporation under a master agreement with Halliburton NUS Corporation under Comprehensive Long-Term Environmental Action Navy (CLEAN) Contract N62472-90-D-1298. Under CTO 213, C F Braun shall prepare a Work Plan for a Pilot Scale Air Sparging/Soil Vapor Extraction System (AS/SVE) as part of the Remedial Design, Phase II, for Site 1 at the Naval Weapons Industrial Reserve Plant (NWIRP) located in Bethpage, New York.

1.2 BACKGROUND INFORMATION

1.2.1 The Naval Weapons Industrial Reserve Plant

The Naval Weapons Industrial Reserve Plant (NWIRP) Bethpage is located in Nassau County on Long Island, New York, approximately 30 miles east of New York City. This 108 acre site is bordered on the north, west, and south by the Grumman facilities which covers approximately 605 acres, and by a residential neighborhood to the east. The NWIRP is a Government-Owned Contractor Operated (GOCO) facility operated by Northrop-Grumman Corporation. The NWIRP was established in 1933 and is still active. Since its inception, the primary mission for the facility has been the research proto-typing, testing, design engineering, fabrication, and primary assembly of military aircraft.

The facilities at NWIRP include four plants (Nos. 3, 5, and 20, used for assembly and prototype testing; and No. 10, which contains a group of quality control laboratories), two warehouse complexes (north and south), a salvage storage area, water recharge basins, an industrial wastewater treatment plant (WWTP) and several smaller support buildings.

The field activities discussed in this work plan will be performed in the area of Site 1. A brief description of Site 1 is presented below.

1.2.2 Site 1 - Former Drum Marshaling Area

Site 1 is located in the middle third of the NWIRP facility and east of Plant 3 as shown in Figure 1-1.

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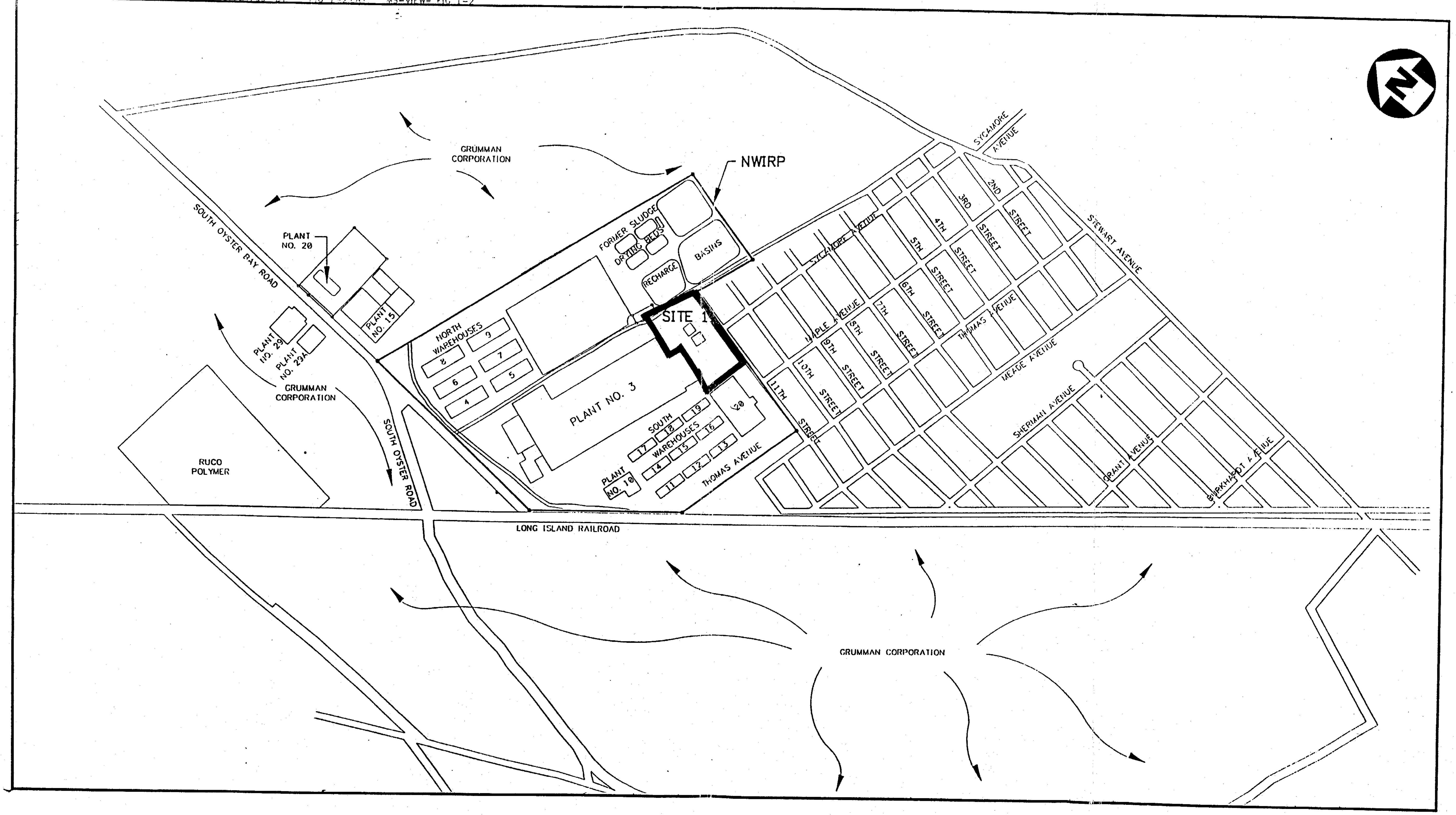

SITE LOCATION MAP
NWIRP, BETHPAGE, NEW YORK

0 700 1400
SCALE IN FEET

FIGURE 1-1

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ENGINEERING CORP.

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CTO 213

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Site 1 occupies an area of approximately 4 acres. It is surrounded on three sides by a fence and on the fourth side by Plant No. 3. The site is relatively flat, with the eastern portion covered with bare sandy soils, gravel, grass, and one concrete pad. The western portion of the site is predominantly covered with concrete. A vegetated wind row (pine) and fence are present along the eastern edge of the site to reduce community visibility.

1.2.3 Previous Investigations

The original basis for the work conducted at the Navy's Site 1 resulted from pubic water supply wells being impacted by VOC contamination. In response to this impact, a regional groundwater quality study was conducted in the 1980s. The results of this study indicated that the Navy's Site 1 to be one of several potential sources of a relatively large groundwater VOC plume originating near this area and extending for several thousand feet to the south (hydraulic downgradient direction).

The Navy conducted a Remedial Investigation in the early 1990s to investigate potential sources of the VOC contamination, (Halliburton NUS, May 1992 and Halliburton NUS July, 1993). Based on this investigation, the source of the groundwater contamination at Site 1 was determined to originate near the former drum marshaling areas. All shallow groundwater samples collected south of the Former Cinder Drum Marshaling Pad, and a few shallow groundwater samples collected north of the pad, exhibited VOC contamination. However, this area of groundwater contamination also coincides with the location of cesspools at the site. The cesspools could also be a source of the VOC contamination.

Soil testing during the Remedial Investigation determined that Site 1 soils contained VOC, PCB, and arsenic contamination. Subsequent soil testing at the site confirmed the presence of PCB and VOC contamination; however, the arsenic contamination could not be confirmed. In addition, testing of the cesspool contents revealed even higher concentrations of VOCs and PCBs in the cesspools then in the surrounding soils, as well as the presence of cadmium contamination.

During pre-design testing under this CTO, sampling was again conducted to confirm an appropriate location for the pilot-scale AS/SVE system. Samples results from soil borings DSB10, DSB11, DSB12, and DSB13 all exceeded the site specific action levels for VOCs. The VOC concentrations in DSB14 did not exceed site-specific action levels.

The most current estimate of VOC- and PCB-contaminated soils and cesspool content is presented in Figure 1-2. Also presented is the estimated extent of groundwater contamination at Site 1.

1.3 PURPOSE

The purpose of this Work Plan is as follows.

- Prepare design plans and installation specifications for a pilot-scale AS/SVE system at Site 1.
- Generate a Field Sampling Plan to monitor AS/SVE operating parameters and VOC concentrations in the soil and groundwater, over the duration of the pilot-scale study.

The objective of the pilot study is as follows.

- Determine the physical parameters required for a full scale system design (well spacing, extraction/injection rates, and well depths).
- Evaluate the effectiveness of air sparging/soil vapor extraction in removing VOCs from site soils, cesspools, and shallow groundwater.
- Estimate the time required for cleanup of soils, groundwater, and cesspool contents.
- Determine the requirements for offgas treatment.

1.4 SCOPE OF WORK

Field samples collected during a previous site investigations established the nature and extent of the soil, cesspool, and groundwater contamination at the Site 1. The system installation specifications and Field Sampling Plan contained in this Work Plan will be used to install and monitor a pilot-scale AS/SVE system for remediation of concentrations of VOCs contained in the soil, cesspools, and shallow groundwater. The estimated period of operation of the pilot-scale AS/SVE system at Site 1 is approximately 3 months.

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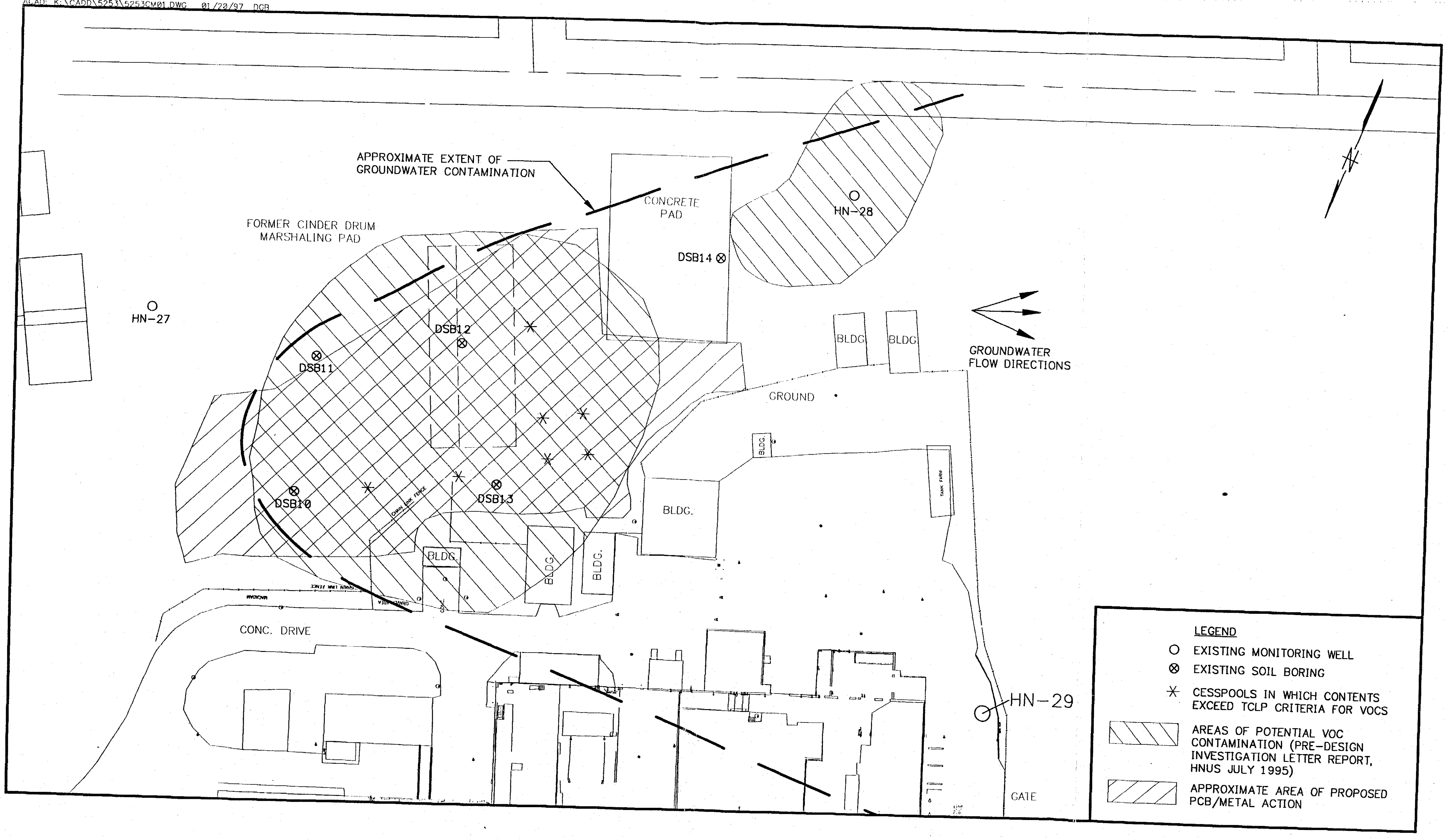

SITE 1
POTENTIAL AREAS OF CONTAMINATION (REVISED JANUARY 1997)
NWIRP, BETHPAGE, NEW YORK

0 60 120
SCALE IN FEET

FIGURE 1-2

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1.5 SAMPLE MATRICES, PARAMETERS, AND FREQUENCY OF COLLECTION

Soil, groundwater, and air samples will be collected at specific times over the duration of the project. A detailed description of sample locations, collection frequencies and analytical methods to be applied to the collected samples is presented in the Field Activities Section 4.0 of this document.

1.6 REGULATORY REQUIREMENTS

No permitting is required for the operation of the pilot-scale AS/SVE System as stated by the New York State Department of Environmental Conservation provided in Appendix A.

1.7 REPORT FORMAT

This Work Plan presents the operating procedures and performance standards required to perform the work identified in this report. Section 1.0 identifies the facility and work required. Section 2.0 provides a description of the key personnel and their responsibility on this project. Section 3.0 identifies the Quality Assurance procedures for the data generated during the implementation of the work. Section 4.0 provides a detailed description of the field work to be performed. Section 5.0 provides the chain-of-custody procedures. Section 6.0 identifies calibration procedures. Section 7.0 provides sample preparation and analytical procedures. Section 8.0 provides information of the procedures for presenting data. Section 9.0 identifies quality control checks. Section 10.0 identifies system audit procedures. Section 11.0 identifies preventive maintenance. Section 12.0 identifies data assessment procedures. Section 13.0 identifies the corrective action procedures and Section 14.0 identifies the procedures for providing Quality Assurance Reports to management. Supplemental information identified in these sections is provided in Appendices A through F.

2.0 PROJECT ORGANIZATION AND RESPONSIBILITY

C F Braun will be responsible for the overall management of the project, including the field inspection and conduct of all drilling, excavation, and sampling activities. Personnel from the Navy will be actively involved in the investigation and will coordinate with personnel from C F Braun in a number of areas.

2.1 PROJECT ORGANIZATION

The key firms and personnel involved in the investigation, as well as the chain-of-communication and responsibility of the project personnel are as follows. The Navy Remedial Project Manager is responsible for the overall management of the IR Program for the NWIRP Bethpage.

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David Brayack
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Fred Ramser
Field Operations Leader

Matthew Soltis
Health and Safety Manager

The Project Manager has the primary responsibility for project and technical management of this project. He is responsible for the coordination of all onsite personnel, and for providing technical assistance for all activities that are directly related to the determination of the environmental quality of the site. If quality assurance problems or deficiencies requiring specific action are identified, the project and QA/QC managers will identify the appropriate corrective action.

2.2 FIELD ORGANIZATION

The C F Braun field investigation team will be organized according to the activity planned. For onsite sampling, the sampling team members will be selected based upon the type and extent of effort required. The team will consist of a combination of the following personnel.

- Field Operation Leader (FOL)
- Field Geologist
- Quality Assurance/Quality Control (QA/QC) Advisor

The FOL will be responsible for the coordination of all onsite personnel and for providing technical assistance when required. The FOL, or designee, will coordinate and be present during all sampling activities and will assure the availability and maintenance of all sampling materials and equipment. The FOL will be responsible for completing all sampling and chain-of-custody documentation, state custody of all samples, and ensuring that the samples are properly handled and shipped. The FOL will also be responsible for providing technical supervision of the drilling subcontractor and for maintaining a geologic log of all borings drilled. Copies of the forms to be used in this investigation are provided in Appendix B.

One field team member will be assigned QA/QC Advisor responsibilities. The QA/QC Advisor will assure that all QA/QC guidelines defined in this Work Plan are followed during installation and operation of this pilot-scale AS/SVE system and interface with the QA/QC Manager as needed. Strict adherence to these procedures is critical to the collection of acceptable and representative data.

One designated field team member will function as the Site Health and Safety Specialist. The Site Health and Safety Specialist will be responsible for assuring that all team members adhere to the site health and safety requirements. Additional responsibilities of the Site Health and Safety Specialist are as follows:

- Updating equipment or procedures based upon new information gathered during the site operation.

- Modifying the levels of protection based upon site observations.

- Determining and posting locations and routes to medical facilities, including poison control centers, and arranging for emergency transportation to medical facilities.

- Notifying local public emergency officers, including police and fire departments, of the nature or the team's operations and for posting these department's telephone numbers.

- Examining work-party members for symptoms of exposure of stress.

- Providing emergency medical care and first aid as necessary on site. The site health and safety manager also has the responsibility to stop any field operation that threatens the health or safety of the team or the surrounding populace.

- Interfacing with the Health and Safety Manager as necessary.

3.0 QUALITY ASSURANCE OBJECTIVES FOR DATA MANAGEMENT

The overall QA objective is to develop and implement procedures for field sampling, chain-of-custody, laboratory analysis, and reporting that will provide environmental monitoring data of known and acceptable quality. Specific procedures to be used for sampling, chain-of-custody, calibration of field instruments, laboratory analysis, reporting, internal quality control, audits, preventative maintenance, and corrective actions are described in later sections of this Work Plan. The purpose of this section is to address the data quality objectives in terms of the (PARCC) parameters, quantitation and detection limits, field duplicates, field blanks, trip blanks, rinsate blanks, and bottleware cleanliness.

3.1 DATA QUALITY OBJECTIVES

Data Quality Objectives (DQOs) are qualitative and/or quantitative statements regarding the quality of data needed to support the Work Plan activities. The sampling rationale provided in Section 4.0 explains the choice of sample locations and media which will supply information needed for installation and operation of the pilot-scale AS/SVE system. The data to be collected will be used to evaluate changes in soil, waste, groundwater, and air VOC concentrations during the course of the pilot study.

The site is known to be contaminated with several specific VOCs. If other VOCs are detected (from cross contamination), the relevance of the other VOCs would be evaluated based on previous site data, and non-site related data may be eliminated. Each of these media are expected to be contaminated with VOCs at concentrations of one or more orders of magnitude greater than the chemical-specific MDLs. Therefore, trace concentrations of unexpected compounds (from cross contamination), could also be evaluated for relevance. Also, during the pilot study, a VOC reduction of approximately 90% will be targeted for the soils and groundwater. Overall, based on this use of the data, a reduced QA/QC sample effort will be conducted.

3.2 QUANTITATION AND DETECTION LIMITS

The analytical laboratory will report sample values as Practical Quantitation Limits (PQLs), with allowances for dilutions and dry weight conversions. PQLs are an expression of an analytical methods capability, with consideration given to the matrix characteristics of the samples analyzed. PQLs levels for each analytical method are defined within the method. The laboratory also reports Method Detection Limits (MDLs - for organics) and Instrument Detection Limits (IDLs - for inorganics). These limits, by contract, must be equal to or less than the PQLs.

3.3 PARCC PARAMETERS

The quality of the data set is measured by certain characteristics of the data, namely the PARCC (precision, accuracy, representativeness, comparability, and completeness) parameters. Some of the parameters are expressed quantitatively, while others are expressed qualitatively. The objectives of this project and the intended use of the data define the PARCC goals.

3.3.1 Precision

Precision characterizes the amount of variability and bias inherent in a data set. Precision describes the reproducibility of measurements of the same parameter for a sample under the same or similar conditions. Precision is expressed as a range (the difference between two measurements of the same parameter) or as a relative percent difference (the range relative to the mean, expressed as a percent). Range and Relative Percent Difference (RPD) values are calculated as follows:

$$\text{Range} = \text{OR} - \text{DR}$$

$$\text{RPD} = (\text{OR} - \text{DR})/[(1/2)(\text{OR} + \text{DR})] \times 100\%$$

where: OR = original sample result

DR = duplicate sample result

The internal laboratory control limits for precision are three times the standard deviation of a series of RPD or range values. RPD values may be calculated for both laboratory and field duplicates, and can be compared to the control limits as a QA check. Because of the relatively high reduction targeted (90%) and the use of replicate samples for groundwater and air, laboratory only limited field duplicates will be analyzed during this program.

3.3.2 Accuracy

Accuracy is the comparison between experimental and known or calculated values expressed as a percent recovery (%R). Percent recoveries are derived from analysis of standards spiked into deionized water (blank spike recovery) or into actual samples (matrix spike or surrogate spike recovery). Recovery is calculated as follows:

$$\%R = E/T \times 100\%$$

where: E = experimental result
T = true value (theoretical result)

and

T = [(sample aliq.)(sample conc.) + (spike aliq.)(spike conc.)]/(sample aliq. + spike aliq)

Control limits for accuracy are set at the mean plus or minus three times the standard deviation of a series or %R values. Organic control limits are set at the mean plus or minus two times the standard deviation of a series of %R values. Because of the projected use of the data, accuracy estimates for aqueous and solid samples will not be evaluated during this program.

3.3.3 Representativeness

All data obtained should be representative of actual conditions at the sampling location. The Work Plan is designed so that the samples taken will present an accurate representation of actual site conditions, by providing for use of standardized sampling and analysis protocols. All sampling activities will conform to the protocols described in Section 4.0 of this Work Plan. The use of EPA-approved analytical protocols and data deliverables will ensure that analytical results and deliverables are representative, and both consistently performed and reported.

3.3.4 Comparability

Use of standardized sampling and analysis methods and data reporting format will also ensure comparability of the data obtained. These measures will also maximize the comparability of this new data to previous data. Additionally, consideration will be given to seasonal conditions and other environmental conditions that could influence analytical results.

3.3.5 Completeness

Completeness is a measure of the amount of valid data obtained from the measurement program, compared to the total amount collected. For relatively clean, homogeneous matrices, 100-percent completeness is expected. However, as matrix complexity and heterogeneous increase, completeness may decrease. Where analysis is precluded or where DQOs are compromised, effects on the overall investigation must be considered. Whether any particular sample is critical to the investigation will be evaluated in terms of the sample location, the parameter in question, the intended data use, and the risk associated with the error.

Critical data points may not be evaluated until all the analytical results are evaluated. If in the evaluation of results it becomes apparent that the data for a specific medium are of insufficient quality (95 percent), either with respect to the number of samples or an individual analysis, re-sampling of the deficient data points may be necessary.

3.4 VALIDATION SAMPLES

Validation samples typically include Field Duplicates, Field Blanks, Trip Blanks, and Rinsate Blanks. As identified in Section 8.0 - Data Reduction, Validation, and Reporting; Field Duplicates and Trip Blanks will be collected, but field blanks and rinsate blanks will not be collected during this field activity.

3.4.1 Field Duplicates

Field duplicates are two samples typically collected either: (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 or sediment. Duplicates are obtained during a single act of sampling and are used to assess the overall precision of the sampling and analysis program. Duplicates will be collected at a rate of approximately one in ten for soils and groundwater samples.

3.4.2 Field Blanks

Field blanks consist of the source waters used in decontamination processes (steam cleaning and field equipment decontamination). Field blanks are typically obtained at the rate of one per source per sampling event, and are analyzed to determine if these source waters could be introducing contaminants to the collected samples. Field blanks are analyzed for all parameters investigated to support project goals. Field blanks will not be collected during this program.

3.4.3 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 for groundwater samples and will be analyzed for TCL VOCs only.

3.4.4 Rinsate Blanks

An equipment rinsate blank consists of the final analyte-free water rinse from equipment decontamination procedures. Typically, one rinsate blank is collected each day per each type of sampling device, however, only rinsate blanks from every other day are analyzed. Rinsate blanks are analyzed for the same parameters as the associated samples. Rinsate samples will not be collected during this field program.

3.5 BOTTLEWARE

The NEESA guidelines require specific bottleware. Bottles will be provided by the laboratory. The required certification will be provided. Table 3-1 provides a summary of the analysis, bottle requirements, presentation requirements and associated holding times for the samples to be collected.

TABLE 3-1

SUMMARY OF ANALYSIS, BOTTLE REQUIREMENTS, PRESERVATION REQUIREMENTS AND HOLDING TIMES
SUBSURFACE SOIL AND GROUNDWATER SAMPLES
SITE 1
NWIRP, BETHPAGE, NEW YORK

Analysis Parameter	Analytical Method	Total No. of Samples	No. of Containers per Sample	Container Type	Preservation Requirements	Holding Times
SOIL						
Soil Classification	ASTM-2487	3	1	32 oz. clear, wide-mouth jars	None required	None required
Volatile Organic Compounds	SW-846-8240	20	1	4 oz. clear, wide-mouth jar, full and packed.	Cool to 4°C, dark	14 days (10 days within receipt by laboratory)
GROUNDWATER						
Volatile Organic Compounds	SW-846-8240	28	2	60 ml, VOC vial	HCL to pH <2, Cool to 4°C, dark	14 days (10 days within receipt by laboratory
AIR						
VOC	TO-14	8	1	Tedlar Bag	None	3 days

4.0 FIELD ACTIVITIES

4.1 STATEMENT OF WORK

A pilot-scale Air Sparging/Soil Vapor Extraction (AS/SVE) system will be installed at the NWIRP, Bethpage, New York. The system will inject air into the ground via an injection well and extract soil vapor via extraction wells to remove the volatile organic compounds (VOCs) trapped in the soil and groundwater. The VOCs will be removed from the vapor stream by passing the vapor through a carbon adsorption off-gas treatment system before release into the atmosphere. The spent carbon in the off-gas treatment system can be reactivated for later use. The pilot-scale system to be installed for this project and associated sampling and analysis activities are intended to provide information regarding removal and treatment of chlorinated volatile organic compounds (chlorinated VOCs) identified at Site 1.

The results of the pilot-scale test will be used to determine final design parameters for a full scale system including effective radii of influence, off-gas treatment requirements, subsurface soil conditions, well location and depth requirements, flow rate requirements, vacuum and injection pressures, and removal efficiencies.

The air sparging and soil vapor extraction design includes consideration of the cover soil texture, soil permeability, structure, and for relatively tight soils (clays and silts), moisture content. Since air leakage through the cover soils ultimately provides the net air requirement for a vapor extraction system, the cover soil texture directly affects the radius of influence for an individual well. Low permeable cover soils would decrease air leakage into the nearby soils and thereby increase the radius of influence. As a result, low permeability covers are often placed over a site to increase the area affected by each well. Even though the surface soils at this site are relatively permeable, because the relatively deep unsaturated zone (approximately 60 feet) and associated placement of the screens, surface covering was not considered for the pilot study. If the pilot study results indicate that excessive surface leakage is occurring, then the full scale design would include provisions for adding a surface cover.

The coarse native sands at the site should provide a relatively good soil texture and permeability for this technology. For typical fine sands, at moderate pressures, common individual well air injection and extraction rates for this technology are 8 to 12 CFM and 6 to 10 CFM, respectively. For tight, clayey and silty soils, relatively high vacuums or pressures may be required to obtain these rates; or these rates may not be obtainable. Whereas for coarse sandy soils such as those present at the site, these rates may be obtainable with relatively low vacuums and pressures. In addition, at higher vacuums or pressures, much higher air injection and extraction rates can be considered.

Based on the pilot testing conducted at NWIRP Calverton, which has a similar soil type, individual well air injection rates of 13 CFM were achieved at a pressure within 0.5 psi of the pressure needed to displace the water column. Similarly, for individual extraction wells, flow rates of 12 CFM could be achieved with a vacuum pressure of only 0.12 inches of mercury. Based on the relatively low pressure and vacuum requirements experienced during the Calverton pilot study, higher air injection and extraction rates can be considered during the NWIRP Bethpage pilot study.

One potential concern at the NWIRP Bethpage, and in particular for the testing within a cesspool, is that oil contamination at select locations and thin silt lenses could affect the system performance. The data collected during the pilot study can be used to evaluate these affects. Because the site materials are primarily sand, soil moisture is not a primary concern at this site.

4.2 INSTALLATION OF PILOT SCALE SYSTEM

The pilot scale system consists of an air injection system, a soil vapor extraction system, and soil vapor/groundwater monitoring points. Prior to, during, and after the pilot study operation, samples of soil, groundwater, and/or soil gas will be collected and analyzed. The planned location for the major components are presented in Figure 4-1. Details on the installation of the air injection system and soil vapor extraction system are presented in Appendix C and are summarized below. Planned testing and sampling activities are detailed in this section.

Air Injection System - Summary

The air injection system consists of a positive displacement blower and an air injection well (IW01). The blower will be rated for 35 to 60 cubic feet per minute (CFM) at a pressure of 6 pounds per square inch (PSI). The air will be injected at 8 to 10 feet below the water table, (approximate total depth of 70 feet below ground surface (bgs)). The injection well will be located 60 feet east-northeast of Cesspool 79. Sample taps will be installed to allow measurement of pressure and flowrate.

Air Extraction System - Summary

The air extraction system consists of five air extraction wells, a positive displacement soil vapor extraction blower, and vapor phase carbon. The blower will be rated for 100 to 150 CFM at a vacuum of 5 inches of mercury column. The soil vapor extraction wells will be screened at the following depths.

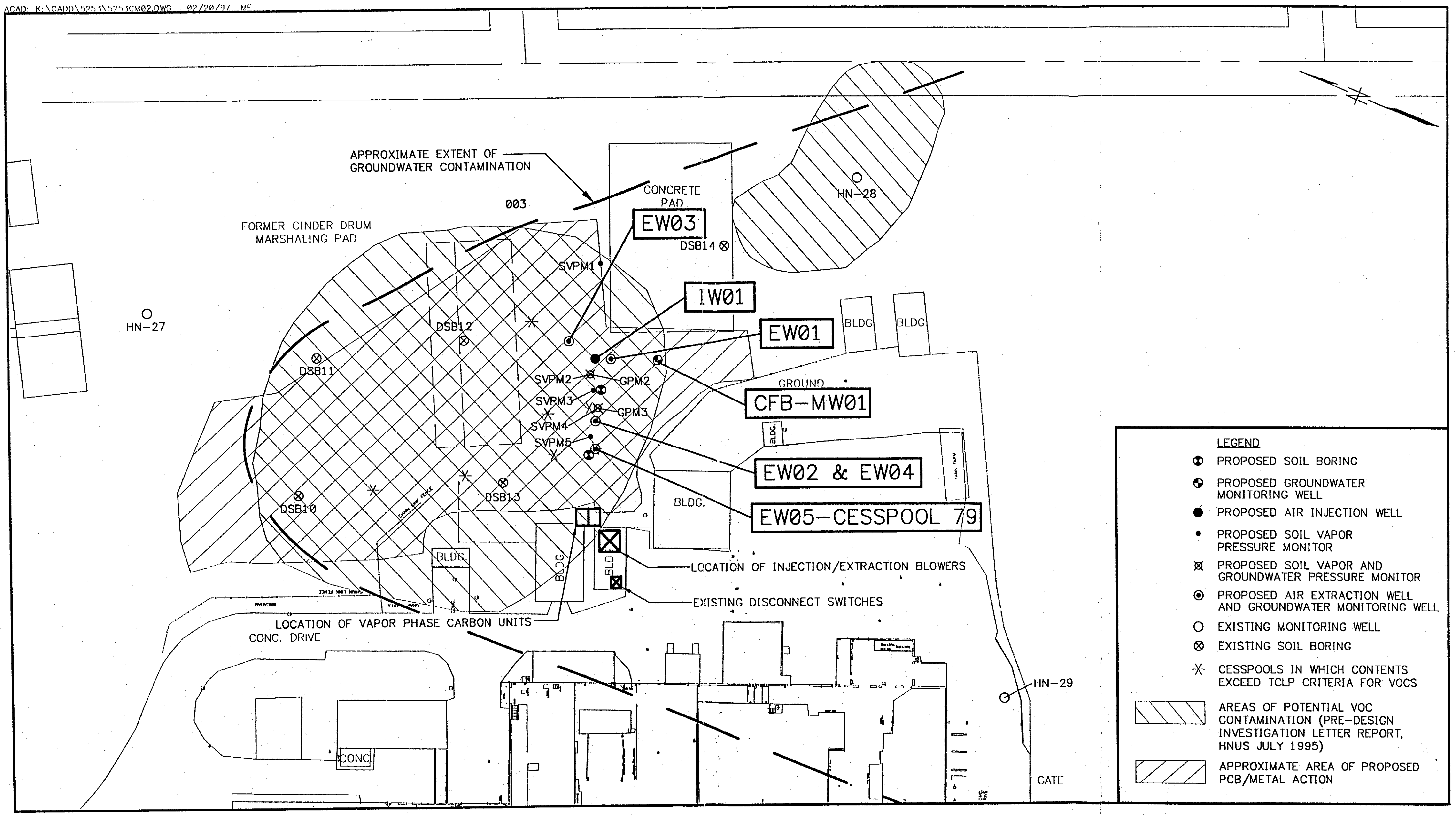

FIGURE 4-1

0 60 120
SCALE IN FEET

SITE 1
PROPOSED LAYOUT – AIR SPARGING/SOIL VAPOR EXTRACTION PILOT STUDY
NWIRP, BETHPAGE, NEW YORK

C.F. BRAUN

0090A03Z

Extraction Well	Screened Interval	Location
EW01	10 feet above water table to 5 feet below water table (approximately 55 to 70 feet bgs).	Well to be located 10 feet south-southwest of IW01.
EW02	10 feet above water table to 5 feet below water table (approximately 55 to 70 feet bgs).	Well to be located 40 feet west-northwest of IW01, in line with Cesspool 79. Well to be nested with EW04.
EW03	10 feet above water table to 5 feet below water table (approximately 55 to 70 feet bgs).	Well to be located 20 feet north-northeast of IW01.
EW04	20 to 30 feet bgs.	Well to be nested with EW02.
EW05	15 to 20 feet bgs.	Well to located in the center of Cesspool 79.

Two 2000-pound vapor phase carbon units will be used to treat the offgas during the course of the pilot study. Sample taps will be provided on the vacuum header and each individual extraction line to measure flowrate, vacuum, and allow the collection of soil gas samples. Sample taps will be provided prior to, between, and after the carbon units to measure flowrate and allow collection of soil gas.

Monitoring Points - Summary

Monitoring points will be used to determine effective radius of influence distances for the extraction and injection system. These monitor points consist of both dedicated soil vapor, water table, and groundwater monitoring points, as well as the extraction wells.

Four dedicated soil vapor points will be located on the line between the air injection well (IW01) and extraction well EW05. A fifth soil vapor point will be located east of the injection well to confirm that all injected air is being captured. Four of the soil vapor points (SVPM 1, 2, 3, and 4) will be installed with a screened depth of 25 to 30 feet below ground surface. Soil vapor point SVPM 5 will be installed with a screened depth of 15 to 20 feet below ground surface. These points will be installed using the same procedure as the soil vapor extraction wells, (see Appendix C).

A dedicated water table monitoring well (CFB-MW01) will be installed 30 feet downgradient of the air injection well (IW01). The well will be installed across the water table, with 2 feet of screen above the water table and 8 feet of screen below the water table. This well, in conjunction with the air extraction wells, will be used to evaluate groundwater remediation time requirements. Installation techniques will be the same as the air injection well, and include a bentonite seal, (see Appendix C).

Two dedicated groundwater pressure monitors (GPM-2 and GPM-3) will be installed with a screened depth of 4 to 6 feet below the water table. Installation techniques will be the same as for the air injection well and will include a bentonite seal, (see Appendix C).

4.3 FIELD SAMPLING OBJECTIVES

The objectives to be achieved by these field sampling activities are as follows.

- Determine pre-, interim-, and/or post-treatment concentrations of the identified parameters in subsurface soil, groundwater, and extracted soil gas at select points within the proposed area of operation of the AS/SVE system to evaluate the effectiveness of the technology.
- Measure the effective radius-of-influence for the soil vapor extraction wells and air injection well to serve as the basis for a full scale system.

4.4 FIELD SAMPLING ACTIVITIES

The following types of field samples will be collected for fixed-base analytical testing at specified times during installation and operation of the pilot-scale AS/SVE system:

- Soil samples.
- Groundwater samples collected from a permanent groundwater monitoring well, an injection well, and extraction wells.
- Air samples collected from pre- and post-air treatment locations along the vapor-phase air treatment system. Note that addition air samples will be collected for field analysis (Draeger tube and PID analysis).

Each of these sample types are discussed below. The collection frequency and analysis methods are listed in Table 4-1. A schedule for collecting these samples is presented Figure 4-2. A daily/weekly checklist for recording the operation of the pilot study is provided in Figure 4-3.

TABLE 4-1

FIELD SAMPLING ACTIVITIES
PILOT-SCALE AS/SVE SYSTEM - SITE 1
NWIRP, BETHPAGE, NEW YORK

Task	Description of Activities	Sample Event	Sample Depth	Number of Samples	Analysis
Subsurface Soil Boring	Collect soil samples from borings prior to, and after operation of pilot study.	Prior to AS/SVE operation	2 to 3 depths per boring, locations to be determined.	6 to 9, plus one duplicate	VOCs
				3	Geotechnical parameters(1)
		End of AS/SVE operation	Locations to correspond to pre-study locations.	6 to 9, plus one duplicate	VOCs
Groundwater Sample	Collect water samples from air injection well, vapor extraction wells, and new groundwater monitoring wells.	Prior to AS/SVE operation	Water Table	5, plus trip blank and duplicate	VOCs
		End of first and second month of operation	Water Table	10, plus trip blanks and duplicates	VOCs
		End of AS/SVE operation	Water Table	5, plus trip blank and duplicate	VOCs
Air Samples	Collect air samples from pre- and post-air treatment locations on the vapor-phase treatment system.	One week after AS/SVE start-up	Water Table	2	VOCs
		Following each month of operation	Water Table	4	VOCs
		End of AS/SVE operation	Water Table	2	VOCs

VOC = Volatile organic compounds

(1) Geotechnical Parameters to be taken at three boring locations.

FIGURE 4-2

PROPOSED ANALYTICAL TESTING DURING OPERATION AIR SPARGING/SOIL VAPOR EXTRACTION PILOT STUDY NWIRP BETHPAGE, NEW YORK

Activity	Pretrial	Week 1 (04/21/97)	Week 2	Week 3	Week 4	Weeks 5 - 7	Week 8	Week 9 - 11	Week 12
Overview	Collect pre-trial samples	Allow system to stablize	Conduct ROI Testing	Conplete ROI Testing	Normal operation	Normal Operation	Normal Operation	Normal Operation	Last week of operation.
Soil Testing	6 - 9 VOCs 3 Geotech.								6 to 9 VOCs
Groundwater Testing	5 samples - VOCs				5 samples - VOCs				5 samples - VOCs
Stratification Testing	3 wells, 3 depths		If necessary						
Soil Vapor - PID[1]		3 rounds, 8 points-VOCs	3 rounds, 8 points-VOCs	8 points-VOCs	8 points - total VOCs	8 points - total VOCs	8 points - total VOCs	8 points - total VOCs	8 points - total VOCs
Soil Vapor - Draeger Tubes,[1,2]		3 rounds, 8 points	3 rounds, 8 points	8 points	8 points	8 points	8 points	8 points	8 points - VOCs
Soil Vapor - Fixed Base[3]	2 samples VOCs	2 samples - VOCs			2 samples - VOCs		2 samples - VOCs		2 samples - VOCs
Radius of Influence - Vapor Extraction			EW01, EW05, EW02, EW04						1 -2 extraction rates
Radius of Influence - Air Sparge				IW01					1 - 2 injection rates
Blower Maintenance					Change oil and filter, grease		Change oil and filter, grease		Change oil and filter, grease

1) Sample points are: each extraction well (5); pre-carbon unit header; between carbon units; and after carbon units.
2) Initial draeger tubes will consist of carbon dioxide, trichloroethane, trichloroethene, and vinyl chloride. Draeger tube testing may be modified in the field based on initial results.
3) Samples to be collected pre- and post-carbon units.

FIGURE 4-3

CHECK LIST - NORMAL OPERATION
AIR SPARGING/SOIL VAPOR EXTRACTION PILOT STUDY
NWIRP CALVERTON, NEW YORK

1. Extraction Wells

Well	Vacuum inch water	Water Level	PID Reading	Flowrate (ft/min)	TCA	TCE	CO2	Vinyl chloride
EW01								
EW02								
EW03								
EW04		-						
EW05		-						

2. Injection Wells

Well	Pressure (PSI)	Flowrate (ft/min)
IW01		

4.1 Carbon System

Location	Pressure	Flowrate	PID
Pre-carbon			
Between Carbon			
Post Carbon			

3. Monitoring Points

Well	Pressure/Vacuum (inches of water)	Water Level
SVPM1		
SVPM2		
SVPM3		
SVPM4		
SVPM5		
GPM 2		
GPM 3		
CFB-MW01		
HN-29S		

Drilling and Sampling Procedures

Drilling and sampling will be performed in accordance with Halliburton NUS SOPs GH-1.3 and GH-1.5 provided in Appendix D. Requirements of the drilling subcontractor are outlined in Solicitation No. 1298-95-279 procurement of drilling services for CTO 213.

Subsurface soil borings will be drilled to the specified depth depending on the type of well to be installed using hollow stem auger drilling techniques. During drilling operations, Standard Penetration Tests and split-spoon sampling for lithologic description will be performed every 10 feet continuously to the bottom of each soil boring. All split-spoon samples will be screened with an Organic Vapor Analyzer (OVA) or Photoionization Detector (PID) and visually inspected for lithologic description. Split spoon samplers will have a minimum outside diameter of 2 inches and be at least 2 feet long to fulfill the sample volume requirements for chemical analysis. The use of drilling fluids is prohibited during soil boring activities. Drill cuttings will be containerized onsite in 55-gallon drums provided by the drilling subcontractor.

A complete log of each boring will be maintained by the field geologist. Appendix B contains an example of the boring log form and other field forms necessary for recording field activities. At a minimum, the boring log will contain the following information, when applicable, for each overburden boring:

- Sample numbers and types
- Sample depths
- Standard Penetration Test data
- Sample recovery/sample interval
- Soil density or cohesiveness
- Soil color
- Unified Soil Classification System (USCS) material description and symbol

In addition, depths of changes in lithology, sample moisture observations, depth to water, OVA readings, drilling method, and total depth of each borehole should be included on each boring log, as well as any other pertinent observations.

Soil Samples

Subsurface soil testing at the site will consist of preliminary screening of the soils, chemical testing of the soils prior to the start of the pilot study, and chemical testing of the soils at the end of the pilot study. The pilot-scale system includes the installation of one injection well, five soil vapor extraction wells, several monitoring wells, and soil borings. During the installation of each of the wells, split spoon samples will be collected to define lithology, as well as to better define potential VOC contamination of the soils via PID field screening. The PID data will be used to select locations and depths for subsequent soil boring samples and fixed-base VOC analysis.

Based on this data, CF Braun will select three soil boring locations to conduct pre- and post-trial soil testing. These locations will in general represent the three high VOC concentrations detected during the field screening. However, at least one of these soil borings will be within Cesspool 79. The other two soil borings will be within an area affected by the pilot study.

For each soil boring, two or three samples will be collected for chemical analysis (6 to 9 samples) and submitted to a fixed-base laboratory for Volatile Organics Compound (VOC) analysis. Exact sample intervals will be based on the results of the preliminary screening. However, once a location is selected, the same location and depth will be used for both the initial and final sample events. One field duplicate will collected during each sample event. Since all of the soil samples will be collected in areas of known and environmentally significant concentrations of VOCs (greater than the action levels) and the potential for cross contamination is minimal, other QA/QC samples will not be collected during the soil sampling program.

Samples for chemical analysis will be collected by splitting the split spoon open longitudinally and extracting soil from the entire length of the interior of the split spoon. Portions of the sample submitted for volatile organic analysis will be placed directly into the required containers. A stainless steel or dedicated plastic trowel will be used to place the sample into the required containers. The analytical methods to be used for each collected sample is provided in Tables 3-1. Decontamination of drilling and sampling equipment will be performed as described in Section 4-11.

In addition, one soil sample will be collected during the installation of the injection well and two samples will be collected during the installation of two of the extraction well soil borings for geotechnical parameters (Soil Classification - ASTM D2487). The borings to be sampled for geotechnical parameters will be determined in the field, but as a minimum, will be located so as to provide representative data throughout the site.

The pilot-scale system is currently scheduled to operate for a total of 3 months. At the end of the of system operation borings will be placed directly next to the borings sampled during the installation of the pilot-scale system. The same sample collection and procedures will be followed for this round of sampling except Lithology and Geotechnical samples do not need to be collected or submitted for analysis. These samples will be analyzed according to the matrix outlined in Table 4-1.

Groundwater Samples Collected from the Air Injection Well, Vapor Extraction Wells, and Groundwater Monitoring Well

The location of the air injection well, vapor extraction wells, and groundwater monitoring well for groundwater sampling are identified in Figure 4-1. Each of these wells will be sampled prior to start up of the pilot-scale system; after each month of operation (two events), and immediately following the close of operations of the pilot-scale system. A field duplicate and trip blank will be collected during each sample event. No other QA/QC samples are planned. Sampling of the wells shall be performed in accordance with SOP SA-1.1 provided in Appendix D. The analytical methods to be used for each sampling event are listed in Table 3-1. The number of samples to be collected, schedule for the sample events, and analysis to be performed are provided in Table 4-1 and Figure 4-2.

Fixed Base - VOC Air Monitoring Samples

Air samples will be collected from two (2) locations along the exhaust line from the air extraction blower for fixed base chemical testing. One air sample will be collected from the air line that enters the vapor-phase GAC air treatment system, and one air sample will be collected from the air line that exits the GAC treatment system. Air samples for laboratory analysis will be collected from the two locations at the end of the first week of operation, at end of the first and second months of operation, and finally at the end of the pilot-scale study (approximately 3 months after start up). These samples will be used to monitor the overall quality of extracted and treated air discharge and will be used in conjunction with additional field PID readings to calibrate PID results from individual well results and results from between the carbon units . QA/QC samples will not be collected. The analytical methods to be used for each sampling event are listed in Table 3-1. The following procedure will be followed to collect air samples for laboratory analysis:

1. Attach one end of an unused section of Tygon tubing to the hose barb on the vacuum port of the portable vacuum sampling pump. Attach the other end of the tubing to the in-line sample port.

2. Attach one end of another unused section of Tygon tubing to the hose barb on the pressure port of the vacuum sample pump.

3. Turn on the pump and purge the pump and lines for approximately 2 minutes.

4. After the purge is complete, attach the sample pump pressure port line to the tedlar bag, open the fill valve, and allow the sample bag to fill. Once the bag has been inflated to approximately two-thirds of its full capacity (e.g., fully inflated), close the fill valve and the ball valve, and then remove the tubing from the fill valve.

5. While keeping the sample bag under pressure, open the fill valve and deflate the sample bag.

6. Reconnect the fill valve to the teflon tubing.

7. Allow the bag to fill twice by repeating Steps 1 through 6, deflating the bag after each fill to purge the sample bag.

8. After repeating the sample purge procedure, follow Steps 1 through 6 to fill the bag once again to collect the sample, making sure the fill valve is securely closed once the bag is filled.

9. Prepare the air sample for shipping to the lab.

10. Field measurements of VOCs will also be collected by inserting the sample tip of the PID into a separate Tedlar bag fill tube and opening the fill valve.

Soil Gas Stratification Testing

Prior to the start of the test, at a minimum one week after the extraction wells have been installed, soil gas stratification test will be conducted. This test will evaluate the potential for VOCs to stratify within an extraction well and adjacent monitoring well prior to, and during soil vapor extraction. Discrete samples will be collected within the screen zone of the three deep extraction wells (EW01, EW02, and EW03). A personal diaphragm air pump will be used to collect the samples. A length-calibrated suction hose will be placed within the well at depths corresponding to the top of the well screen, the mid-point of the well screen, and just above water table. PID readings will be obtained from the pump discharge.

The testing will be conducted first at the top of the well screen, then at the mid point, and finally at the water table. The time required for each test will be based on sample tube purge times, (determined in the field). At the time equivalent to three suction tube purge volumes, a tedlar sample will be collected as described for the fixed-base VOC air monitoring samples. For each depth, two consecutive air samples will be collected to evaluate variability.

If soil gas stratification is noted in the extraction wells prior to the operation of the soil vapor extraction wells, then additional soil gas stratification tests will be conducted during the operation of the trial. In particular, during the radius of influence testing described below, the stratification testing would be conducted to determine under which soil vapor extraction conditions stratification occurs and what steps can be taken to minimize it.

Field VOC Analysis/Real Time Monitoring

The performance of the AS/SVE system will be monitored in the field using an PID to measure VOC concentrations at each of the extraction wells, prior to the carbon units, between the carbon units, and after the carbon units. At a minimum, each extraction well will be tested during each fixed-base soil vapor sample event. The same tedlar bag may be used at more than one location, with a preference for moving from less contaminated to more contaminated locations. Ambient air will be used to purge the bag in between samples and the PID will be used to document displacement of residual VOCs. The standard to be applied to document adequate purging is less than 1 ppm or less than 10 percent of the following location to be sampled. In the event that this standard is exceeded, then the sample must be collected again.

4.5 RADIUS OF INFLUENCE TESTING

In order to allow the system wells to stabilize, radius of influence testing will be conducted one week after system startup. The testing will consist of operating only one extraction or injection well at a time. Variable extraction and injection rates will be tested. The soil vapor extraction rates will be evaluated over a range of 5 to 80 CFM (if achievable). The injection well will be evaluated over a range of 10 to 60 SCM (if achievable). During the course of the tests, the soil vapor pressures will be allow to stabilize at each flow rate. The soil vapor pressures will be considered stable, when the readings change less then 10% over three consecutive readings. During the tests, Figure 4-4 will be completed for each well tested. The wells and flow rates to be tested (in order) are as follows.

EW01:	5, 10, 20, 40, and 80 CFM.
EW05:	5, 10, 20, 40, and 80 CFM.
EW02:	5, 10, 20, 40, and 80 CFM.
EW04:	5, 10, 20, 40, and 80 CFM.
IW01:	10, 20, 30, 45, and 60 CFM.
IW01/EW02:	Injection rate to be fixed based on previous testing. Extraction rate to vary from 1.0, 1.5, 2.0, and 3.0 times the injection rate.

FIGURE 4-4
RADIUS OF INFLUENCE TESTING - SCHEDULE
AIR SPARGING/SOIL VAPOR EXTRACTION PILOT STUDY
NWIRP BETHPAGE, NEW YORK

Test:__________________________
Start Time:_______________________
Target Flow rate:__________________
Initial Header Pressure/Vacuum:_____________

Date:__________________
Well (s) Operating:________

Time (hrs)	Flow Rate	SVPM 1	SVPM 2	SVPM 3	SVPM 4	SVPM 5	EW01 Press	EW01 Level	EW02 Press	EW02 Level	EW03 Press	EW03 Level	EW04 Press	EW05 Press	GPM2 Level	GPM3 Level	HN29 Level
0.0																	
0.5																	
1.0																	
2.0																	
4.0																	
6.0																	
8.0																	

Time 0.0 hours is recorded prior to the start of the test.
The criteria for completing the test is to have three consecutive readings with less than a 10% difference for each of the wells.

The test for each well is expected to require one to two days to perform. When switching the test from one well to another, the extraction system must be shutdown and the soil vapor pressures allowed to return to normal prior to testing the next well.

4.6 HEALTH AND SAFETY

Work conducted in conjunction with this field effort shall be performed in a manner which follows the guidelines provided in the site-specific Health and Safety Plan provided in Appendix E.

4.7 SURVEYING

The horizontal and vertical locations of each well and boring will be surveyed following complete installation of the pilot-scale system. Existing survey monuments located near Site 1 at the NWIRP, Bethpage facility will be used as reference points. Horizontal locations will be referenced to the New York state Plane Coordinate System. The horizontal locations of all surveyed points shall be completed to the nearest 0.10 foot. The vertical locations of all surveyed points shall be completed to the nearest 0.01 foot.

4.8 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 number, and sample identification. Any other pertinent information regarding sample identification will be recorded in the field log books and sample log sheets.

The alpha-numeric coding to be used in the sample system is explained below.

Field Samples

(AA)	-	(AANNN)	-	(NN)
(Site name)		(Sample Medium & Number)		(Sample identifier)

Character Type:

A = Alpha
N = Numeric

Project name:

PS =Pilot-scale

Sample Medium:

GW = Groundwater from the pressure monitoring well (PS-MW-01)
IW = Groundwater from an air injection well
EW = Groundwater from an air extraction well
SB = Subsurface soil from a soil boring
AS = Air sample from the air exhaust system

Sample Number:

A running total of samples collected - Independent of medium

Sample Identifier:

Permanent Monitoring Well = Sample identifier not used
Air Injection Well = Sample identifier not used
Subsurface Soil = Start depth of interval at which sample is collected.
Air = 01 Pre-carbon treatment sample
02 Post-carbon treatment sample

For example, a subsurface soil sample which was the fifth sample collected during this field event was collected from the soil boring to install air injection well at a depth of 10 to 12 feet would be:

PS-SB01-10

4.9 SAMPLING EQUIPMENT AND PROTOCOLS

The protocols to be used during field sampling at Site 1 are presented in Appendix D of this Work Plan and consist of Halliburton NUS Standard Operating Procedures (SOPs).

4.10 SAMPLE HANDLING

Sample handling includes the field-related considerations regarding the selection of sample containers, preservatives, allowable holding times and analyses requested. The EPA User's Guide to the Contract Laboratory Program (EPA, December 1988), and the Federal Register (EPA, October 26, 1984) address the topics of containers and sample preservations.

4.10.1 Sample Packaging and Shipping

Samples will be packaged and shipped in accordance with Halliburton NUS SOP SA-6.2 provided in Appendix D. The FOL will be responsible for completion of the following forms:

- Sample Labels
- Chain-of-Custody Forms
- Appropriate labels applied to shipping coolers
- Chain-of-Custody Labels
- Federal Express Air Bills

4.10.2 Sample Custody

Custody of samples must be maintained and documented at all times. Chain-of-custody begins with the collection of the samples in the field. Section 5.3 of Halliburton NUS SOP SA-6.1 provided in Appendix D provides a description of the chain-of-custody procedures to be followed. A sample chain-of-custody form is attached in Appendix C.

4.11 EQUIPMENT DECONTAMINATION

The equipment involved in field sampling activities will be decontaminated prior to and during drilling and sampling activities. This equipment includes drilling rigs, downhole tools, augers, well casing and screens, and all sampling equipment.

4.11.1 Major Equipment

Downhole drilling and sampling tools shall be steam cleaned prior to beginning work, between well borings, any time the drilling rig leaves the site prior to completing a boring, and at the completion of the drilling program.

These decontamination operations will consist of washing the equipment using a high-pressure steam wash. All decontamination activities will take place on a decontamination pad at a location determined during mobilization. It is assumed that the facility will provide a suitable location for decontamination operations along with potable water and electricity. Additional requirements for drilling equipment decontamination can be found in Halliburton NUS SOP SA-7.1 provided in Appendix D.

4.11.2 Sampling Equipment

All sampling equipment used for collecting samples will be decontaminated both prior to beginning field sampling and between samples. The following decontamination steps will be taken:

- Potable water rinse
- Alconox or liquinox detergent wash
- Potable water rinse
- Methanol rinse
- Hexane rinse (pesticide grade) (only necessary for equipment used on pesticide/PCB samples)
- Steam distilled water rinse
- Air dry
- Wrap in aluminum foil for transport.

4.12 RESIDUE MANAGEMENT

Five types of potentially contaminated residues are expected to be generated during this field investigation, namely Personal Protection Equipment (PPE), drill rig decontamination fluids, sampling equipment decontamination fluids, auger soil cuttings, and purge waters. Based on the activities and 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 each of these residues is provided below.

PPE - PPE will be placed in the trash receptacles at the facility.

Drill Rig Decontamination Fluids - Drill rig decontamination fluids will be containerized in a 55 gallon drums and stored at the site for disposal at the WWTP.

Sampling Equipment Decontamination Fluids - Equipment decontamination fluids will be containerized in 55 gallon drums and handled with the drill rig decontamination fluids.

Auger Soil Cuttings - With the exception of soil cuttings from the upper 30 feet in the PCB hotspot area (EW-02 and EW-04), auger soil cuttings will be spread neatly around the borings at Site 1 to fill in existing dips in the topography. Based on previous testing, the deeper soils at each of these locations are less contaminated than in the surface soils. The upper 30 feet of auger cuttings from EW-02 and EW-04 will be containerized and labeled for ultimate disposal during the full scale, Site 1, PCB remediation.

Purge Water - Groundwater generated during the initial purging of the wells and subsequent sampling of these wells will be screened with an OVA (or PID). Fluids with elevated OVA readings (greater than 1 ppm) will be containerized with the drill rig decontamination fluids. Fluids without elevated OVA readings will be discharged to the ground surface at the site. Runoff will not be allowed.

5.0 DOCUMENTATION AND CHAIN-OF-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.

5.1 FIELD CUSTODY

- The 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, filtration, and preparation procedures. Copies of all field documentation forms are provided in Appendix B.

5.2 TRANSFER OF CUSTODY AND SHIPMENT

The following procedures will be used when transferring custody of samples:

- 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.

5.3 SAMPLE SHIPMENT PROCEDURES

The following procedures will be followed when shipping samples for laboratory analysis:

- 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 taken, they must be sent to the laboratory within 24 hours.

5.4 FIELD DOCUMENTATION RESPONSIBILITIES

It will be the responsibility of the 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 C F Braun and stored by C F Braun until completion of the pilot-scale AS/SVE project.

6.0 CALIBRATION PROCEDURES

Field equipment such as the Photoionization Detector (PID) and any geophysical 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.

7.0 SAMPLE PREPARATION AND ANALYTICAL PROCEDURES

Environmental samples collected during the field investigation for chemical analyses will be analyzed using the appropriate analytical procedures as outlined in Table 4-1 of this work plan. All methods to be used are EPA-approved or other guidance..

8.0 DATA REDUCTION, VALIDATION, AND REPORTING

Data validation is the stringent review of an analytical chemical data package with respect to sample receipt and handling, analytical methods, data reporting and deliverables, and document control. To complete a data validation, the full range of QA/QA samples are required. Typically, data validation is used to support potential litigation and is normally conducted during the Remedial Investigation to confirm the presence of contamination and during the Remedial Action to confirm the extent of contamination and final compliance with objectives. Data validation can sometimes be performed during the Feasibility Study and Remedial Design phases. However, it use is limited to cases where relatively small uncertainties in the data can affect the conclusions of the work.

The goal of this sampling event is to determine the effectiveness of the pilot-scale remediation system in support of the design efforts. The area is already identified as contaminated, and VOC reductions in excess of 90% are targeted. Since no additional human or ecological risk assessments will be performed and no litigation involving this work is anticipated, data validation will not be performed for the data generated under this RD task order. Furthermore, information establishing the extent and levels of contamination were already established in the Remedial Investigation.

9.0 EXTERNAL/INTERNAL QUALITY CONTROL CHECKS

There are two types of quality assurance mechanisms used to ensure the production of analytical data of known and documented quality. The internal laboratory quality control procedures for the analytical services are specified in the analytical methodology. These specifications include the types of control samples required (sample spikes, surrogate spikes, controls, and blanks), the frequency of each control, the compounds to be used for sample spikes and surrogate spikes, and the quality control acceptance criteria. It will be the laboratory's responsibility to document, in each data package, that both initial and on-going instrument and analytical QC criteria are met. Only limited external quality control samples (i.e., trip blanks and field duplicates) will be generated by C F Braun.

Analytical results will also be compared to acceptance criteria, and documentation will be performed showing that criteria have been met. Any samples in nonconformance with the QC criteria will be identified and reanalyzed by the laboratory, as required. The following procedures will be employed for the processing of NWIRP Bethpage samples:

- Proper storage of samples.
- Use of qualified and/or certified technicians.
- Use of calibrated equipment.
- Use of standardized test procedures.

10.0 PERFORMANCE AND SYSTEM AUDITS

The following measures have been established to assure that the work is being implemented in accordance with the approved project SOPs and in an overall satisfactory manner:

- The FOL will supervise and check on a daily basis that the soil borings are installed correctly, field measurements are made accurately, equipment is thoroughly decontaminated, samples are collected and handled properly, and the field work is accurately and neatly documented.
- The project manager will oversee the FOL, and check that management of the acquired data proceeds in an organized and expeditious manner.
- System audits for the laboratory are performed on a regular basis.

A formal audit of the field sampling procedures may be conducted in addition to the auditing that is an inherent part of the daily project activities. If so conducted, the auditors will check that sample collection, sample handling, decontamination protocols, and instrument calibration and use are in accordance with the approved project SOPs. The auditors will also check that the field documentation logs and chain-of-custody forms are being filled out properly.

11.0 PREVENTATIVE MAINTENANCE

C F Braun has established a program for the maintenance of field equipment to ensure the availability of equipment in good working order when and where it is needed. This program consists of the following elements:

- The equipment manager keeps an inventory of the equipment in terms of items (model and serial number) quantity and condition. Each item of equipment is signed out when in use, and its operating condition and cleanliness checked upon return.
- The equipment manager conducts routine checks on the status of equipment and is responsible for the stocking of spare parts and equipment readiness.
- The equipment manager maintains the equipment manual library and trains field personnel in the proper use and care of equipment.
- The FOL is responsible for working with the equipment manager to make sure that the equipment is tested, cleaned, charged, and calibrated in accordance with the manufacturer's instructions before being taken to the job site.

The laboratory follows a well-defined program to prevent the failure of laboratory equipment and instrumentation. This preventative program, includes the periodic inspection, lubrication, cleaning, and replacement of parts of the equipment, and is detailed in the laboratory quality assurance plan.

12.0 DATA ASSESSMENT PROCEDURES

12.1 REPRESENTATIVENESS, ACCURACY, AND PRECISION

All data generated in the investigation will be assessed for its representativeness, accuracy, and precision, as feasible. The completeness of the data will also be assessed by comparing the valid acquired data to the project objectives to see that these objectives are being addressed and met. The specific procedures used to determine data precision, accuracy, and completeness will be provided in the analytical reports.

The representativeness of the data will be assessed by determining if the data are consistent with known or anticipated hydrogeologic or chemical conditions and accepted principles. Field measurements will be checked for completeness of procedures and documentation of procedures and results.

Precision and accuracy will be evaluated using replicate and duplicate samples and trip blank samples, respectively. The specific procedures for determining PARCC parameters are outlined in Section 3.0.

12.2 VALIDATION

As discussed in Section 8.0, data validation is not being performed for this RD project, because the information observed is for basic design purposes only and does not require validation. However, a data review will be conducted. This review will compare the results obtained with previous data sets and expected trends, (e.g. decrease in concentration with treatment).

13.0 CORRECTIVE ACTIONS

The Brown & Root Environmental QA program will enable problems to be identified, controlled, and corrected. Potential problems may involve nonconformance with the SOPs and/or analytical procedures established for the project or other unforeseen difficulties. Any person identifying an unacceptable condition will notify the project manager. The project manager, with the assistance of the project QA/QC advisor, will be responsible for developing and initiating appropriate corrective action and verifying that the correction action has been effective. Corrective actions may include the following: resampling and/or reanalysis of sample, amending or adjusting project procedures. If warranted by the severity of the problem (for example, if a change in the approved work plan is required), the Navy will be notified in writing and their approval will be obtained prior to implementing any change. Additional work that is dependent on a nonconforming activity will not be performed until the problem has been eliminated.

The laboratory maintains an internal closed-loop corrective action system that operates under the direction of the laboratory QA coordinator.

14.0 QUALITY ASSURANCE REPORTS TO MANAGEMENT

The QA/QC manager will review all aspects of the implementation of the FSAP on a regular basis and with the use of designated support personnel, will prepare a summary report. Reviews will be performed at the completion of each field activity and reports will be completed at this time. These reports will include an assessment of data quality and the results of system and/or performance audits. Any significant QA deficiencies will be reported and identified, and corrective action possibilities discussed. The laboratory will issue monthly progress reports.

REFERENCES

ASTM, March 1988. Annual Book of Standards - Soil and Rock, Building Stones; Geotextiles. Section 4, Volume 04.08.

Halliburton NUS, May 1992. Final Remedial Investigation Report, Naval Weapons Industrial Reserve Plant.

Halliburton NUS, July 1993. Phase 2 Remedial Investigation Report for Naval Weapons Industrial Reserve Plant.

Halliburton NUS, March 1994. Feasibility Study Report for Naval Weapons Industrial Reserve Plant.

Naval Energy and Environmental Support Activity (NEESA), June 1988. Sampling and Chemical Analysis Quality Assurance Requirements for the Navy Installation Restoration Program. NEESA, Port Hueneme, CA. NEESA 20.2-047B.

NYSDEC (New York State Department of Environmental Conservation), 1989. NYSDEC Analytical Services Protocols (ASP). NYSDEC Division of Water, Bureau of Technical Services and Research, September.

NYSDEC, 1991. RCRA Quality Assurance Project Plan Guidance, NYSDEC Division of Hazardous Substances Regulation, March.

U.S. EPA, 1986. Test Methods for Evaluating Solid Waste - SW846.

U.S. EPA, September 1986, Test Methods for Evaluating of Solid Waste - Physical/Chemical Methods SW846.

U.S. EPA, February 1988, Laboratory Data Validation Functional Guidelines for Evaluating Organic Analyses.

U.S. EPA, July 1988, Laboratory Data Validation Functional Guidelines for Evaluating Inorganic Analyses.

APPENDIX A

AIR PERMIT WAIVER LETTER

New York State Department of Environmental Conservation
50 Wolf Road, Albany, New York 12233-7010

Michael D. Zagata
Commissioner

April 5, 1995

Mr. David Brayack, P.E.
Halliburton NUS Environmental Corporation
661 Anderson Drive
Pittsburgh, PA 11501-4250

RE: NWIRP-Bethpage
Calverton-NWIRP
Site Numbers: 130003B 152136

Dear Mr. Brayack:

Enclosed please find three (3) copies of the permit form for a Process, Exhaust or Ventilation System along with a copy of the instruction manual.

A permit application need not be submitted for the soil vapor extraction pilot test programs at the above-referenced sites as long as there is a treatment system in place (such as a vapor phase granular activated carbon system) at each site. A permit application will be required for each site as part of the design reports for the full-scale soil vapor extraction systems.

If you have any questions regarding this matter, please feel free to contact me at (518) 457-3395 or Jeff McCullough at (518) 457-3976.

Very truly yours,

John D. Barnes, P.E.
Environmental Engineer 2
Bureau of Eastern Remedial Action
Div. of Hazardous Waste Remediation

cc: S. Ervolina
S. McCormick
M. Chen
J. McCullough
J. Colter (Navy)

APPENDIX B

FIELD FORMS

BORING LOG

Brown & Root Environmental

PROJECT: ______________________ BORING NO.: ____________

PROJECT NO.: ____________ DATE: ____________ DRILLER: ____________

ELEVATION: ____________ FIELD GEOLOGIST: ____________

WATER LEVEL DATA: ______________________

(Date, Time & Conditions) ______________________

SAMPLE NO. & TYPE	DEPTH (Ft.) OR RUN NO.	BLOWS 6" OR RQD (%)	SAMPLE RECOVERY / SAMPLE LENGTH	LITHOLOGY CHANGE (Depth, Ft.)	MATERIAL DESCRIPTION*			ROCK BK. or USCS	REMARKS
					SOIL DENSITY CONSISTENCY OR ROCK HARDNESS	COLOR	MATERIAL CLASSIFICATION		

REMARKS ______________________

____

____

BORING ____________

PAGE ____ OF ____

* See Legend on Back

SOIL TERMS

UNIFIED SOIL CLASSIFICATION (USCS)

COARSE GRAINED SOILS

More than half of material is LARGER than No. 200 sieve size

FIELD IDENTIFICATION PROCEDURES (Excluding particles larger than 3" & basing fractions on estimated weights)			GROUP SYMBOL	TYPICAL NAMES
GRAVELS 50%(+)> ¼"Ø	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
		Predominantly one size or a range of sizes with some intermediate sizes missing	GP	Poorly graded gravels, gravel-sand mixtures, little or no fines
	GRAVELS W/FINES (High % fines)	Non plastic fines (for identification procedures see ML)	GM	Silty gravels, poorly graded gravel sand silt mixtures.
		Plastic fines (for identification procedures see CL)	GC	Clayey gravels, poorly graded gravel sand clay mixtures
SANDS 50%(+)< ¼"Ø	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
		Predominantly one size or a range of sizes with some intermediate sizes missing	SP	Poorly graded sands, gravelly sands, little or no fines
	SANDS W/FINES (High % fines)	Non plastic fines (for identification procedures see ML)	SM	Silty sands, poorly graded sand silt mixtures
		Plastic fines (for identification procedures see CL)	SC	Clayey sands, poorly graded sand clay mixtures.

FINE GRAINED SOILS

More than half of material is SMALLER than No. 200 sieve size

FIELD IDENTIFICATION PROCEDURES (Excluding particles larger than 3" & basing fractions on estimated weights)				GROUP SYMBOL	TYPICAL NAMES
Identification procedures on fraction smaller than No. 40 sieve size					
	DRY STRENGTH (Crushing Characteristics)	DILATANCY (Reaction to Shaking)	TOUGHNESS (Consistency Near Plastic Limit)		
SILTS & 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
	Medium to high	None to very slow	Medium	CL	Inorganic clays of low to medium plasticity, gravelly clays, sandy clays, silty clays, lean clays
	Slight to medium	Slow	Slight	OL	Organic silts and organic silt clays of low plasticity
SILTS & CLAYS Liquid limit > 50	Slight to medium	Slow to none	Slight to medium	MH	Inorganic silts, micaceous or diatomaceous fine sandy or silty soils, elastic silts
	High to very high	None	High	CH	Inorganic clays of high plasticity, fat clays
	Medium to high	None to very slow	Slight to medium	OH	Organic clays of medium to high plasticity
HIGHLY ORGANIC SOILS	Readily identified by color, odor, spongy feel and frequently by fibrous texture.			Pt	Peat and other organic soils

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.

LEGEND

SOIL SAMPLES - TYPES

S - 2" O.D. Split Barrel Sample
ST - 3" O.D. Undisturbed Sample
O - Other Samples, Specify in Remarks

ROCK SAMPLES - TYPES

X - NX (Conventional) Core (~2-1/8" O.D.
Q - NQ (Wireline) Core (~1-7/8" O.D.)
Z - Other Core Sizes, Specify in Remarks

WATER LEVELS

12/18
▼ 12.6' Initial Level w/Date & Depth

12/18
▼ 12.6' Stabilized Level w/Date & Dept

DENSITY OF GRANULAR SOILS

DESIGNATION	STANDARD PENETRATION RESISTANCE - BLOWS/FOOT
Very loose	0-4
Loose	5-10
Medium dense	11-30
Dense	31-50
Very dense	Over 50

CONSISTENCY OF COHESIVE SOILS

CONSISTENCY	UNC. COMPRESSIVE STR. 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)

DESCRIPTIVE TERMS	SCREWDRIVER OR KNIFE EFFECTS	HAMMER EFFECTS
Soft	Easily gouged	Crushes when pressed with hammer
Medium soft	Can be gouged	Breaks (one blow) Crumbly edges
Medium hard	Can be scratched	Breaks (one blow) Sharp edges
Hard	Cannot be scratched	Breaks conchoidally (several blows) Sharp edges

ROCK BROKENNESS

DESCRIPTIVE TERMS	ABBREVIATION	SPACING
Very broken	(V. Br.)	0 - 2"
Broken	(Br.)	2" - 1'
Blocky	(Bl.)	1' - 3'
Massive	(M.)	3' - 10'

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SAMPLE LOG SHEET

PAGE____OF____

☐ SURFACE SOIL
☐ SUBSURFACE SOIL
☐ SEDIMENT

☐ LAGOON/POND
☐ OTHER

SAMPLERS SIGNATURE____________________

SITE NAME____

SITE NUMBER____

SAMPLE No.	SAMPLE METHOD	DEPTH (FT)	DATE	TIME	SAMPLED BY	CONCENTRATION (L)LOW (H)HIGH	(G)GRAB (C)COMPOSITE	ANALYSES							No. OF CONT TOTAL	SOIL DESCRIPTION

REMARKS:

LAB:

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SAMPLE LOG SHEET

☐ Monitoring Well Data
☐ Domestic Well Data
☐ Other ____________

Page _____ of _____
Case # ____________
By ____________

Project Site Name ______________________________ Project Site Number ____________________
NUS Source No. ______________________________ Source Location ____________________

Total Well Depth:	Purge Data						
Well Casing Size & Depth:	Volume	pH	S.C.	Temp. (°C)	TURB	DO	SAL
Static Water Level:							
One Casing Volume:							
Start Purge (hrs.):							
End Purge (hrs.):							
Total Purge Time (min.):							
Total Amount Purged (gal.):							
Monitor Reading:							
Purge Method:							
Sample Method:							
Depth Sampled:							

Sample Date & Time:	Sample Data					
	pH	S.C.	Temp. (°C)	TURB	DO	SAL
Sampled By:						

Signature(s):	Observations / Notes:

Type of Sample

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

Analysis:	Preservative				

BORING NO. ______

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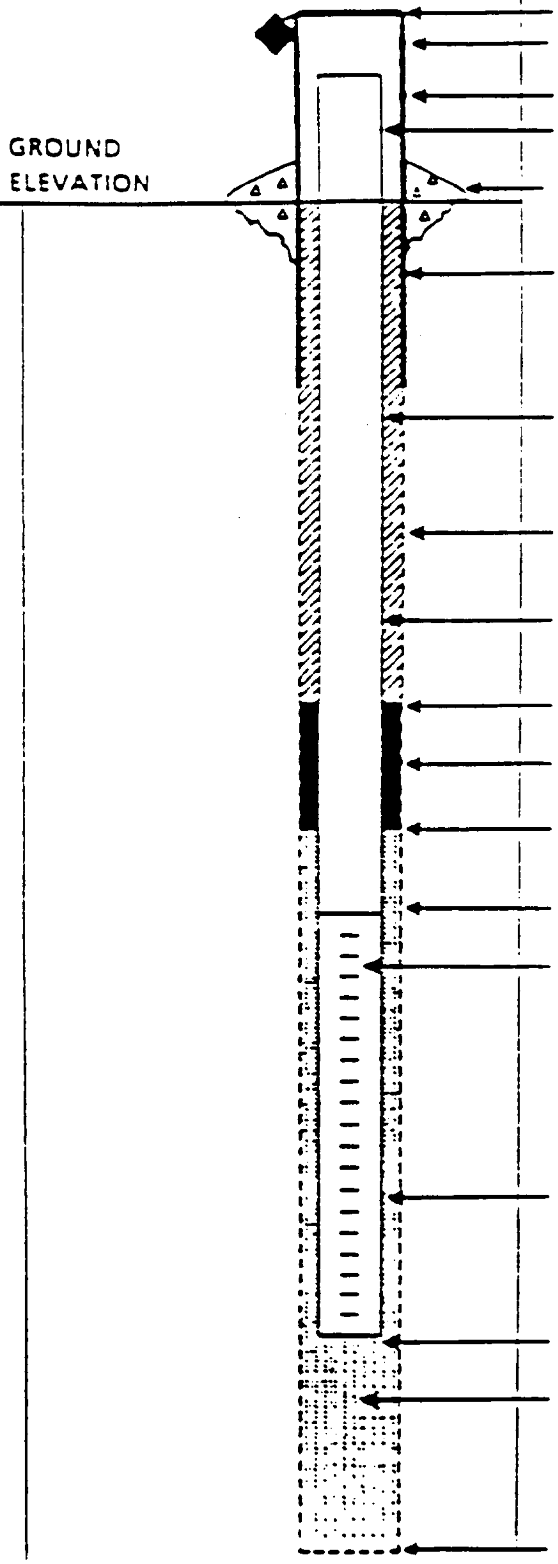
MONITORING WELL SHEET

PROJECT ______
PROJECT NO. ______
ELEVATION ______
FIELD GEOLOGIST ______

LOCATION ______
BORING ______
DATE ______

DRILLER ______
DRILLING METHOD ______
DEVELOPMENT METHOD ______



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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WELL NO.: ____________

MONITORING WELL SHEET

PROJECT: ____________ LOCATION: ____________

PROJECT NO.: ____________ BORING: ____________

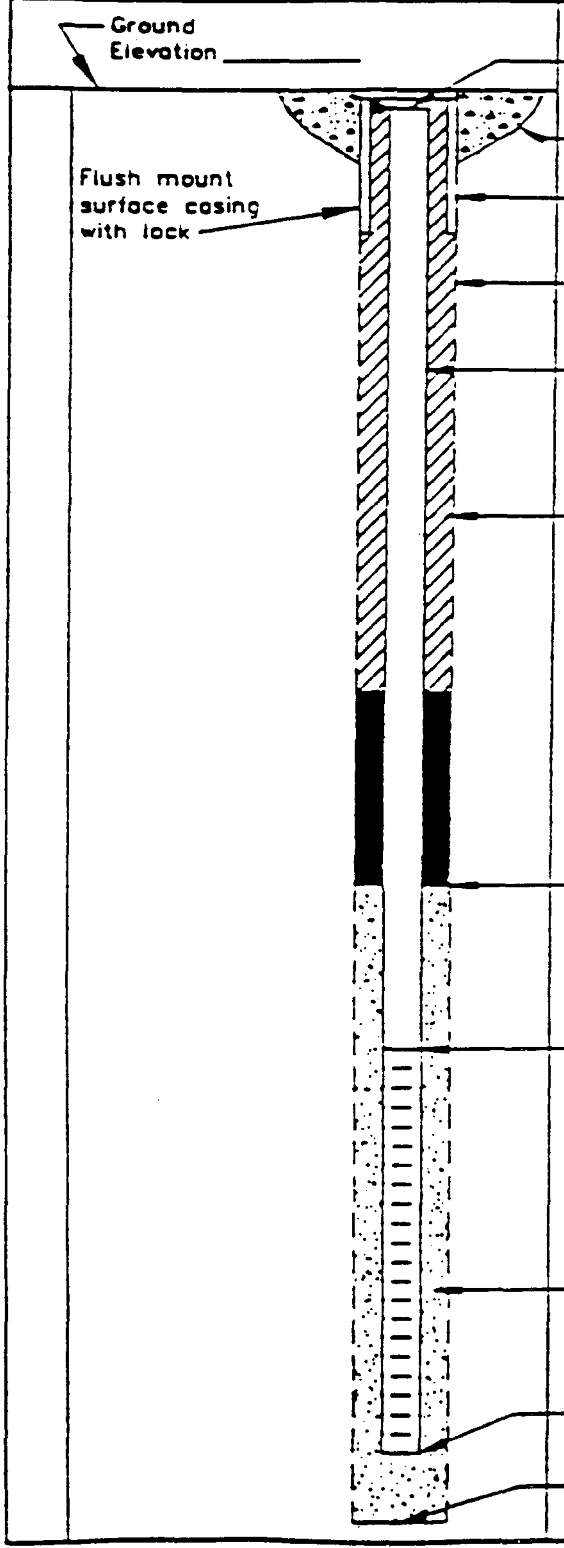
ELEVATION: ____________ DATE: ____________

FIELD GEOLOGIST: ____________

DRILLER: ____________

DRILLING METHOD: ____________

DEVELOPMENT METHOD: ____________



ELEVATION TOP OF RISER: ____________

TYPE OF SURFACE SEAL: ____________

TYPE OF PROTECTIVE CASING. ____________

I.D. OF PROTECTIVE CASING: ____________

BOREHOLE DIAMETER: ____________

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: ____________

DEPTH/ELEVATION BOTTOM OF SCREEN: ______ / ______

DEPTH/ELEVATION BOTTOM OF SAND: ______ / ______

DEPTH/ELEVATION BOTTOM OF HOLE: ______ / ______

BACKFILL MATERIAL BELOW SAND: ____________

ACFILE: L670\GEOL\[illegible]

Brown & Root Environmental

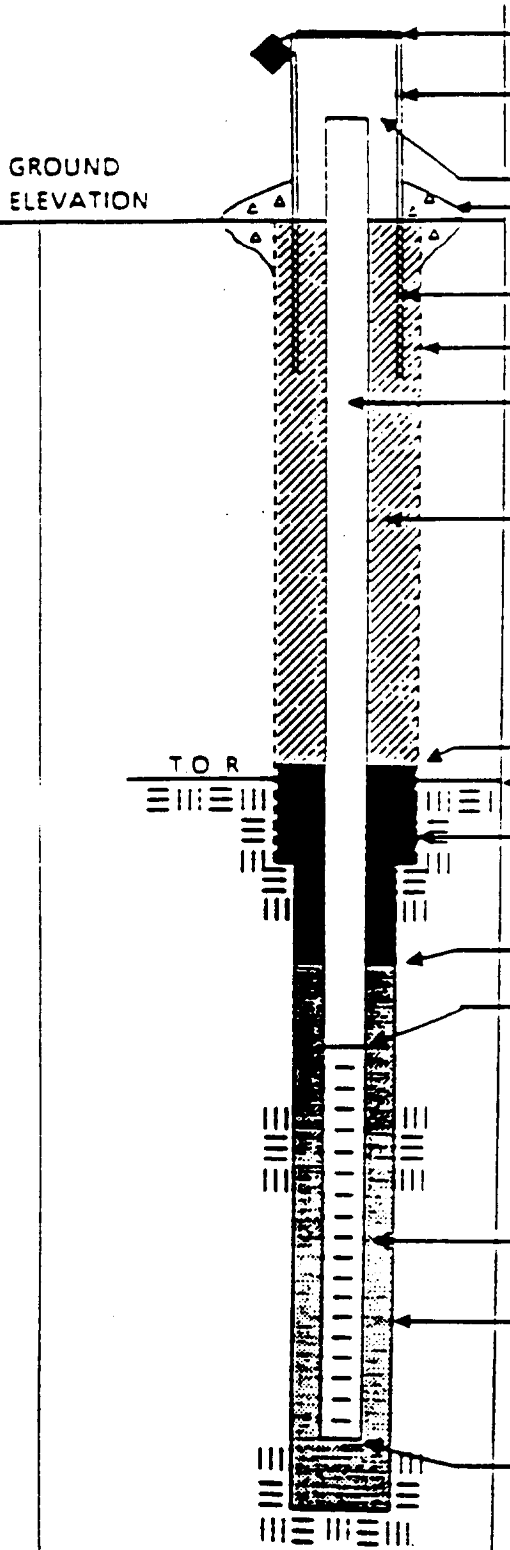
BORING NO : ____

BEDROCK
MONITORING WELL SHEET
WELL INSTALLED IN BEDROCK

PROJECT ____
PROJECT NO. ____
ELEVATION ____
FIELD GEOLOGIST ____

LOCATION ____
BORING ____
DATE ____

DRILLER ____
DRILLING METHOD ____
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 ____

Brown & Root Environmental

WELL NO.:

BEDROCK

MONITORING WELL SHEET

WELL INSTALLED IN BEDROCK

PROJECT:

PROJECT NO.:

ELEVATION:

FIELD GEOLOGIST:

LOCATION:

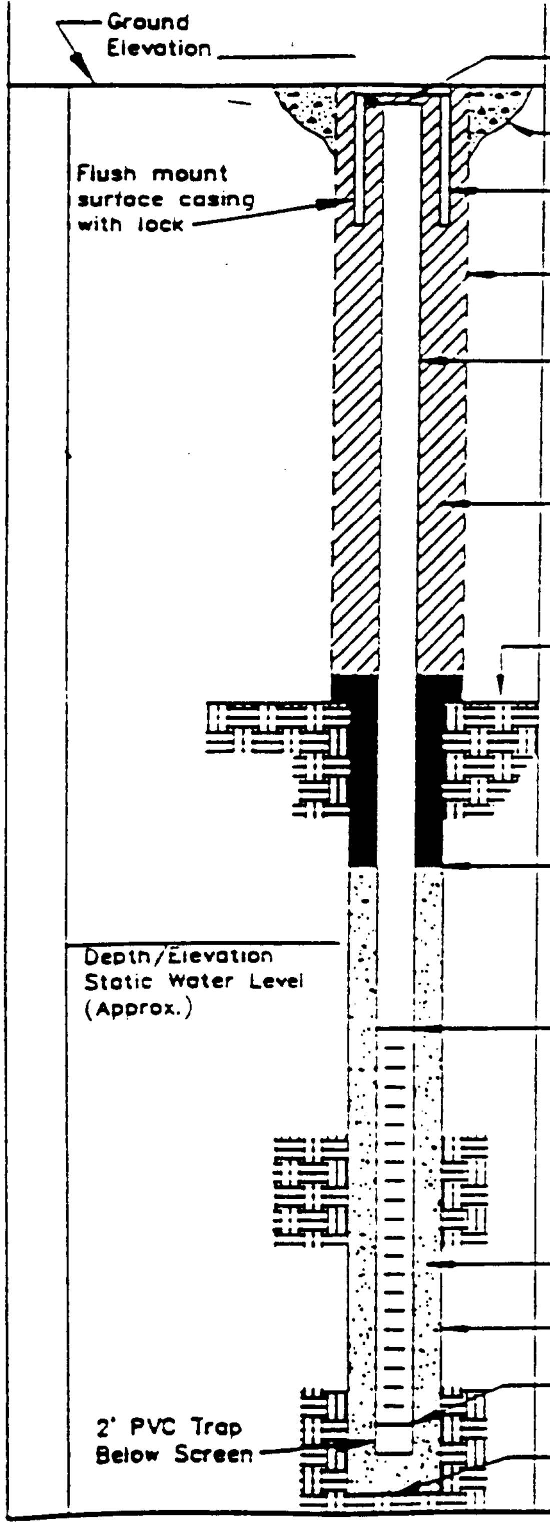
BORING:

DATE:

DRILLER:

DRILLING METHOD:

DEVELOPMENT METHOD:



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 BEDROCK: /

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:

[illegible]

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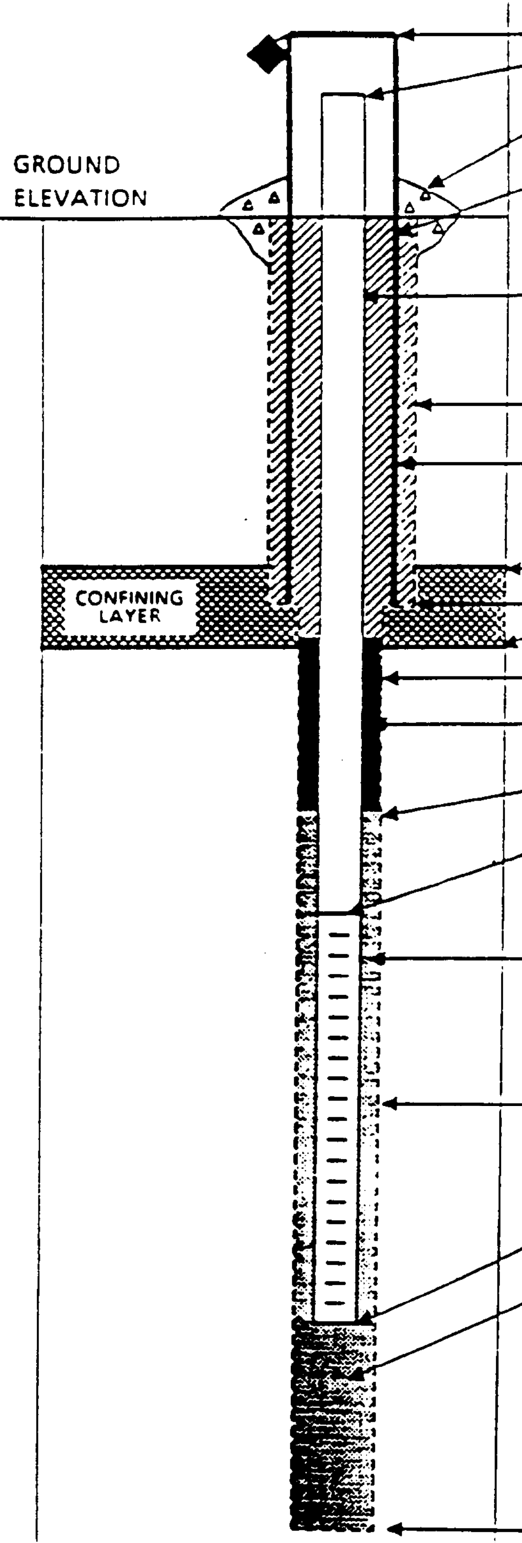
BORING NO ____________

CONFINING LAYER
MONITORING WELL SHEET

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



ELEVATION OF TOP OF PERM. CASING: ____________
ELEVATION OF TOP OF RISER PIPE: ____________
TYPE OF SURFACE SEAL: ____________
I.D. OF PERM. CASING: ____________
TYPE OF SURFACE CASING: ____________
RISER PIPE I.D. ____________
TYPE OF RISER PIPE: ____________
BOREHOLE DIAMETER: ____________
PERM. CASING I.D ____________
TYPE OF CASING & BACKFILL: ____________
ELEVATION / DEPTH TOP CONFINING LAYER: ____________
ELEVATION / DEPTH BOTTOM OF CASING: ____________
ELEVATION / DEPTH BOT. CONFINING LAYER: ____________
ELEVATION / DEPTH TOP OF SEAL: ____________
TYPE OF SEAL: ____________
DEPTH TOP OF SAND PACK: ____________
ELEVATION/DEPTH TOP OF SCREEN: ____________
TYPE OF SCREEN: ____________
TYPE OF SAND PACK: ____________
BOREHOLE DIA. BELOW CASING: ____________
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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DAILY ACTIVITIES RECORD

PROJECT ______________________ LOCATION ______________________

CLIENT ______________________ ARRIVAL TIME ________ JOB NO. __________

DATE ______________________ DEPARTURE TIME ____________

CONTRACTOR ______________________ DRILLER ______________________

BORING NO. ______________________ HNUS REPRESENTATIVE ______________

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

COMMENTS: ____

APPROVED BY:

HNUS FIELD REPRESENTATIVE

DRILLER OR REPRESENTATIVE

Brown & Root Environmental

EQUIPMENT CALIBRATION LOG

Instrument (Name/Model No./Serial No.): ______________________

Manufacturer ______________________ Date Purchased ______________

Calibration Date	Initial Settings	Standard/Gas Used	Procedure	Adjustments Made	Final Settings	Signature	Comments

TECHNICAL SPECIFICATION FOR CONSTRUCTION OF PILOT SCALE REMEDIATION SYSTEM

NAVAL WEAPONS INDUSTRIAL RESERVE PLANT
BETHPAGE, NEW YORK
CONTRACT NUMBER N62472-90-D-1298, CTO-0213

1.0 INTRODUCTION

A pilot-scale remediation system will be installed at the NWIRP, Bethpage, New York. The remediation system will consist of an air sparging/vapor soil extraction system (AS/SVE) in which air is injected into the ground via an injection well and extracted through contaminated soil via extraction wells to remove the volatile organic compound (VOC) trapped in the soil and groundwater. The VOCs are removed from the vapor in a carbon adsorption off-gas treatment system before release into the atmosphere. The spent carbon in the off-gas treatment system can then be reactivated for later use. The pilot-scale system to be installed for this project is intended to provide information regarding removal and treatment of chlorinated volatile organic compounds (chlorinated VOCs).

The work required to install the pilot-scale system includes placement of injection, extraction, and monitoring wells, blowers, piping, electrical hookup and emissions control equipment. All wells will be installed by a drilling subcontractor procured by C F Braun.

The purpose of the pilot-scale system is to determine final design parameters including effective radii of influence, off-gas treatment requirements, subsurface soil conditions, well location and depth requirements, flow rate requirements, vacuum and injection pressures, and removal efficiencies.

2.0 SCOPE OF WORK

The scope of work for the installation of the pilot-scale AS/SVE system is defined as follows:

- Mobilization/demobilization.
- Installation of injection, extraction, and monitoring wells.
- Procurement and installation of blowers, piping, and vapor phase carbon units.
- Collection of soil, groundwater, and air samples prior to, during, and/or after system operation.
- An existing building located at Site 1 will be used to house the unit.

2.1 MOBILIZATION/DEMOBILIZATION

Mobilization/demobilization includes the following:

- Mobilization to the site.
- Securing any necessary permits.
- Initial Health and Safety meeting of approximately 2 hours (presented by C F Braun).
- All decontamination of excavation and transportation equipment, including hauling of potable water for high-pressure water cleaning and decontamination purposes.
- Miscellaneous supplies (crew PPE, air monitoring equipment, hand tools, etc.)
- Incidental site clearing and site access.
- General site clean-up.
- Demobilization from the site.

Decontamination operations will consist of washing large equipment (excavation buckets, tires, etc.) using a high pressure potable wash prior to demobilizing equipment from the site. All decontamination water will be collected and transported to the Industrial Wastewater Treatment plant located near the Navy's recharge basin.

2.2 AIR INJECTION SYSTEM

The air injection system will consist of a positive displacement air injection blower, conveyance piping, and one injection well. A piping schematic is provided as Attachment C-1. The air injection well will be located approximately 60 feet from the center of Cesspool 79, see Figure 4-1.

The positive displacement air injection blower will be a rotary lobe-type blower, rated for 35 CFM and 60 CFM at 6 psi. Multiple sheaves will be used to provide this range of flowrates. The blower will be equipped with a high temperature cutoff switch and a pressure switch interlock to the vapor extraction system piping, where a lack of vacuum on the extraction system will cause the injection blower to shut down. The blower will be equipped with inlet and outlet air silencers to reduce noise levels and an inlet air filter to remove ambient dust. The blower and associated control panel will be pre-assembled and mounted on a skid. This skid will be placed within an existing building at Site 1. The skid will be anchored to the existing concrete slab via four 3/4-inch cinch bolts. A 5 to 7.5 HP (based on blower efficiency), three-phase, 480 volt motor will be used.

The conveyance piping will consist of 10 feet of 2-inch carbon steel pipe immediately adjacent to the blower to dissipate heat, a flexible rubber coupling for vibration control, 2-inch schedule 40 PVC pipe, two 2-inch ball valves to control air flow to the sparge well and provide a pressure bleed off, and a 4-inch noise suppresser on the pressure bleed off. Expansion joints will be installed on each straight run of pipe greater than 100 feet. Sample taps and plugs will be installed on the injection line to allow measurement of air velocity and line pressure. Line size calculations are provided as Appendix F.

The air injection well (IW01) will consist of a 2-inch PVC riser pipe, with a 2-foot long 0.020 inch slot size well screen located 10 feet below the water table. Total depth of well will be approximately 70 feet below ground surface. The well will be installed using a 4-inch diameter hollow stem auger. During installation of the well, split spoon samples will be collected every 10 feet. These samples will be classified in the field for lithology. In addition, PID readings will be taken from the split spoon head space.

Well construction details are as follows.

- Auger to 10 feet below the water table.
- Collect split spoons sample every 10 feet during augering. The last split spoon sample will be collected at 8 to 10 feet below the water table (screened interval).
- Place the injection well at depth.
- Install No. 1 Sand around the well screen to a height of two feet above the well screen.
- Install a 2 foot thick bentonite seal.
- Complete the well with a cement/bentonite grout.
- The well will be developed by pumping and/or surging methods to obtain a final water turbidity of 50 NTUs.

2.3 VAPOR EXTRACTION SYSTEM

The vapor extraction system will consist of a positive displacement soil vapor extraction blower, moisture separator, conveyance piping, five vapor extraction wells, and two vapor phase carbon units. A piping schematic is provided as Attachment C-2. The locations of the extraction wells are presented in Figure 4-1. Extraction Wells EW01 to EW04 are to located based on IW01 as a reference point. EW05 is to be located in Cesspool 79.

The positive displacement vapor extraction blower will be rated for 100 cfm and 150 cfm at +1 psi/-5 inches of mercury. Multiple sheaves will be used to provide this range of flowrates. The blower will be equipped with a high temperature and high water level (moisture separator) cut off switch. In addition, an inlet air filter will be used to remove potential dust and sand in the extraction system. The blower, moisture separator, and associated control panel will be pre-assembled on a skid. The skid will be placed within an existing building at Site 1. The skid will be anchored to the existing concrete slab via 3/4-inch cinch bolts. A 5 to 7.5 HP (based on blower efficiency), three-phase 480 volt motor will be used.

The moisture separator will consist of a 55-gallon tank, complete with a high water level switch and drain tap. The moisture separator will mounted on the blower skid.

The conveyance system will consist of a vacuum component to the extraction wells and a pressure component to the vapor phase carbon. The vacuum piping will consist of a flexible rubber coupling for vibration control, a 4-inch PVC header, five 2-inch schedule 40 PVC lines, (one to each well), and five 2-inch ball valves to control air flow to each extraction well, plus one vacuum bleed valve. Expansion joints will be installed on each straight run of pipe greater than 100 feet. Sample taps will be installed in the header, and on each extraction well line to allow measurement of flow rate and pressure, as well as to allow samples of the soil vapor to be collected. A manual and automatic vacuum relief valve will be provided on the vacuum piping to prevent excessive line vacuums.

The pressure piping will consist of 10 feet of 3-inch carbon steel at the blower outlet to dissipate heat, a rubber coupling for vibration control, and 4-inch PVC pipe leading to, between, and after the carbon units. Sample taps will be installed on this line prior to, between, and after the carbon unit to allow measurement of flow rate and pressure, as well as to allow soil vapor samples to be collected. Line size calculations are provided as Appendix F.

The soil vapor extraction wells will be five 2-inch PVC riser pipes, with screened intervals at location-specific depths. Three of the extraction wells (EW01, EW02, and EW03) will be installed to a depth of 5 feet below the water table (approximately 65 feet) and include a 15 foot long screen with a 0.020 slot size. The fourth extraction well (EW04) will be installed to a depth of 30 feet below ground surface and include a 10 foot long screen, with a 0.020 slot size. The fifth extraction well (EW05) will be located within an existing cesspool (Cesspool 79) to a depth of 20 feet and include a 5 foot long well screen, with a 0.020 slot size. This well will be installed through an existing opening in the cesspool.

The wells will be installed using a 4-inch hollow stem auger. During installation of the well, split spoon samples will be collected every 10 feet. In addition, one split spoon sample will be collected in the middle of each screened interval. These samples will be classified in the field for lithology. In addition, PID readings will be taken from the split spoon head space.

Well construction details are as follows.

- Auger to the depth of each well, collecting a split spoon sample every 10 feet. In addition, collect one split spoon sample in the middle of the screened interval.
- Place the extraction well at depth.
- Install No. 1 Sand around the well screen to a height of one foot above the well screen.
- Install a 2 foot thick bentonite seal.
- Complete the well with a cement/bentonite grout.
- The wells which are installed below the water table will be developed by pumping and/or surging methods to obtain a final water turbidity of 50 NTUs.

The moisture knockout drum will be a 55-gallon tank, with a high moisture level switch and drain. This tank will be mounted on the same skid as the blower.

Two 2000-pound vapor phase activated carbon units will be used to treat the extracted air prior to discharge. The vapor phase carbon units will be used in series. The carbon units will be located outside the blower building.

2.4 SOIL VAPOR PRESSURE MONITORS

Four soil vapor pressure monitors (SVPM 1 to 4) will be located at a distance of 10, 20, 30, and 60 feet from the air injection well, as shown in Figure 4-1. The screened depth of each monitor will be 25 to 30 feet below ground surface. A fifth monitor (SVPM 5) will be located at a distance of 10 feet from the center of Cesspool - CP79 and have a screened depth of 15 to 20 feet below ground surface. The fifth monitor should also be located at a distance of approximately 40 feet from the air injection well. The location of these four soil vapor pressure monitors coincides with distances of approximately 10, 20, 30, 40, 50, 60, 80, 100, and 120 feet from one or more air extraction wells.

The soil vapor monitors are to be installed as described for the soil vapor extraction wells.

Also, air extraction wells will be used to supplement these soil vapor pressure monitors during the air injection and extraction system testing. As previously indicated, three of the air extraction wells will be screened at the water table (60 to 70 feet below ground surface), one well will be screened at 20 to 30 feet below ground surface, and one well will be screened at 15 to 20 feet below ground surface.

2.5 GROUNDWATER PRESSURE MONITORS AND MONITORING WELL

Two 2-inch groundwater pressure monitors (GPM 2 and GPM 3) will be located a distance of 10 and 30 feet from the air injection well. These wells will be used to assess groundwater flow at these depths and distances. The screened interval on these monitors will be 4 to 6 feet below the water table. Total depth of the two monitors is approximately 66 feet below ground surface.

One new groundwater monitoring well (CFB-01) will be located 30 feet south (hydraulically downgradient) of the air injection well. The screened interval on this monitoring well will be from 2 feet above the water table to 8 feet below the water table.

In addition to the groundwater pressure monitors and monitoring well, the three air extraction wells located into the water table, will be used to monitor groundwater table elevation fluctuations during the trial. Groundwater table monitors will be available at distances of 10, 20, 30, and 40 feet from the air injection wells.

2.6 POWER SUPPLY

Two existing 440 volt, 30 amp, three-phase disconnect switches, located in the proposed blower building, will be used to supply power to the two blowers. Two existing, but unused building heaters will be temporary disconnected. A certified New York State electrician will be subcontracted to perform the work.

2.7 UTILITY CLEARANCE

Each of the soil boring and well locations will be cleared for utilities prior to construction by reviewing facility drawings, interviewing local personnel, toning by the local phone company, and confirming in the field with a pipe and cable locator. In addition, over 100 abandoned cesspools are present at the site. Cesspools are reportedly 8 feet in diameter and are located on 30 foot centers. Except for EW05 and associated soil borings, these cesspools should be avoided. Reportedly, each cesspool is covered with a several inch-thick concrete cap at a depth of 1 to 3 feet below ground surface. If encountered during drilling, the drilling location should be moved north or south to avoid them.

CALCULATION WORKSHEET

Order No. 19110 (01-91)

CLIENT Navy CTO 212

JOB NUMBER

SUBJECT Extraction System P3ID

BASED ON

DRAWING NUMBER

BY DAC

CHECKED BY

APPROVED BY

DATE 2/18/97

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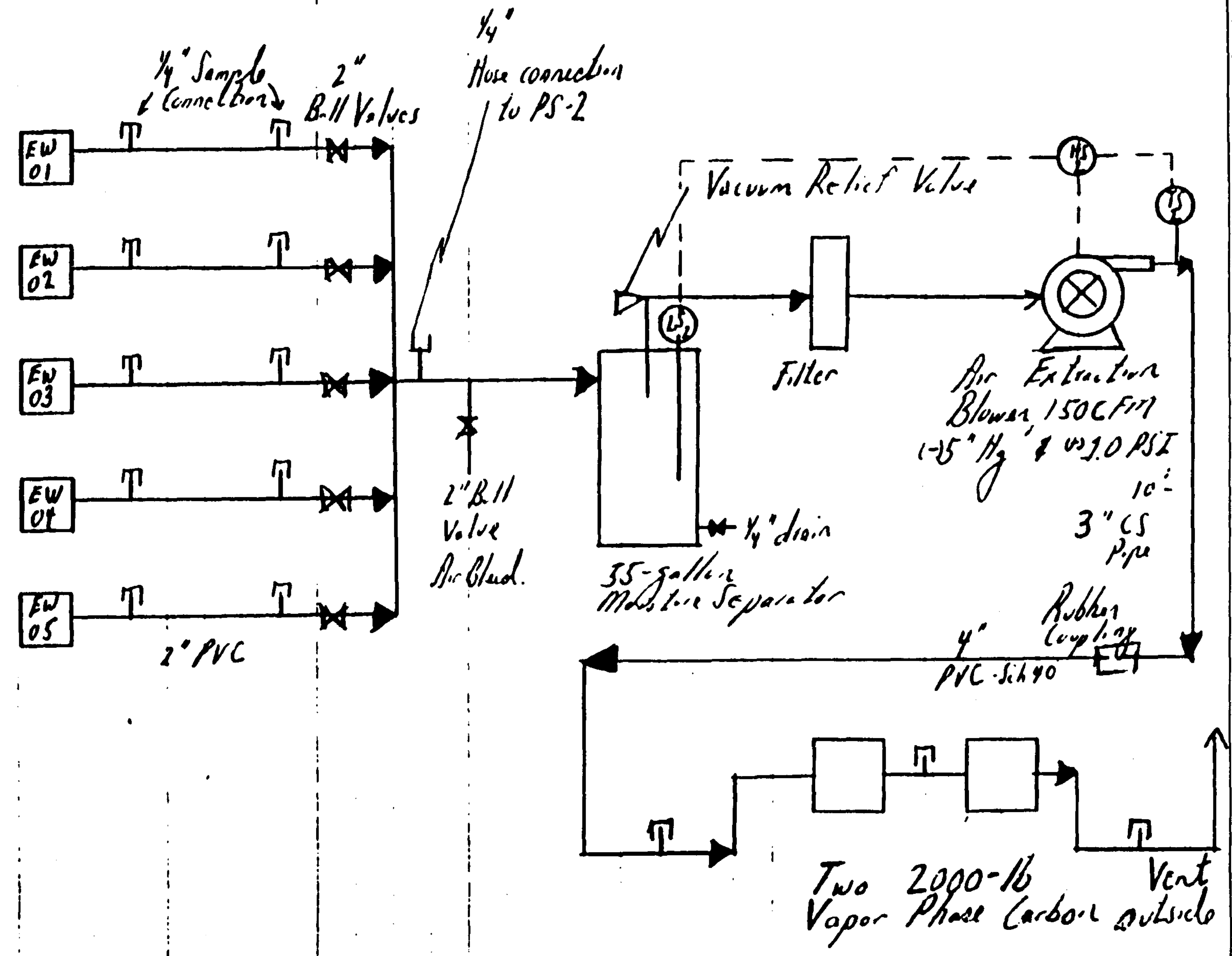

CALCULATION WORKSHEET

Order No. 19116 (01-01)

CLIENT: Navy CTO 213

JOB NUMBER:

SUBJECT: Injection System, NTC

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BASED ON:

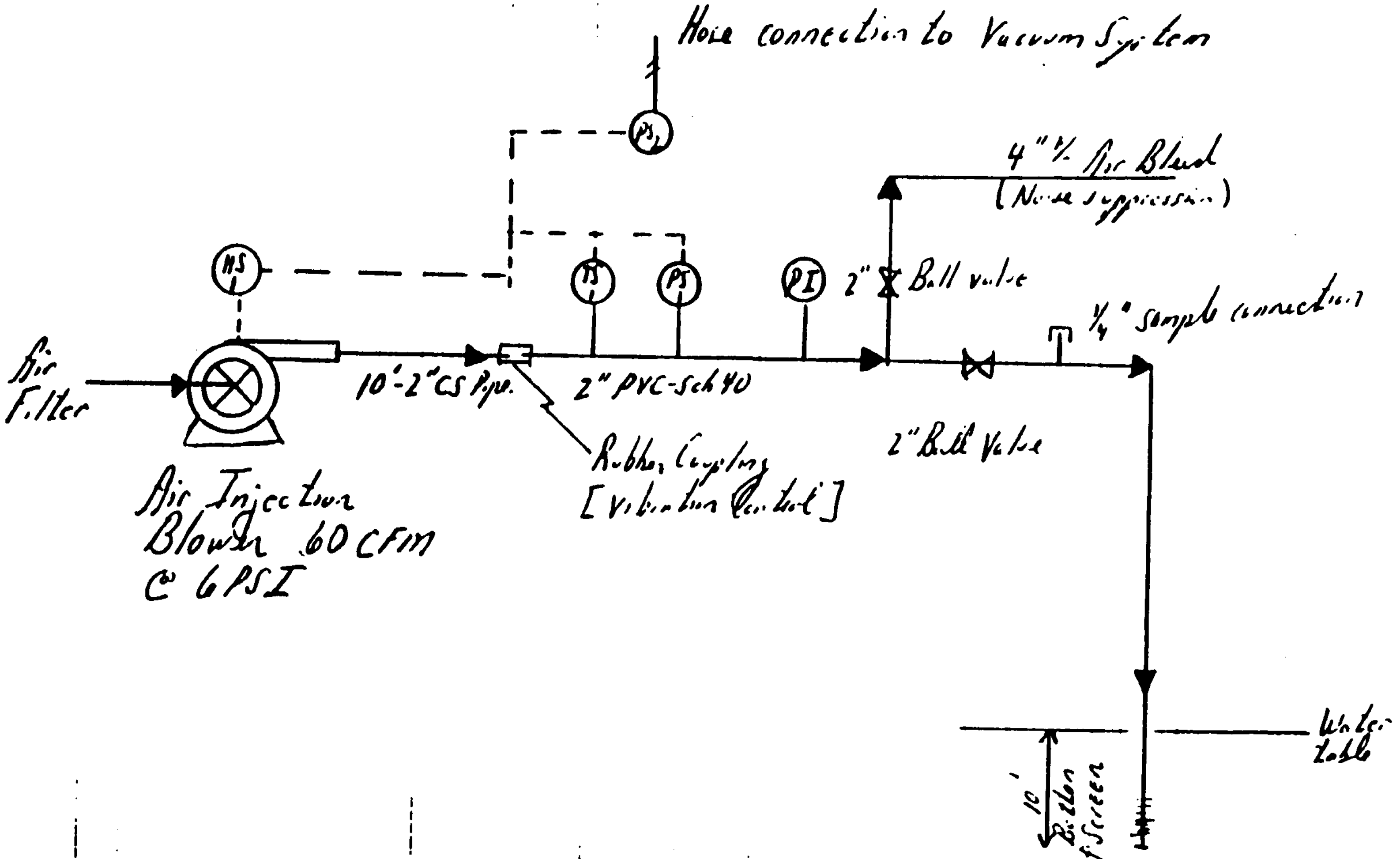
DRAWING NUMBER:

BY: JWK

CHECKED BY:

APPROVED BY:

DATE: 2/16/92



APPENDIX D

STANDARD OPERATING PROCEDURES

SA-1.1	Groundwater Sample Acquisition and Onsite Water Quality Testing
SA-2.2	Air Monitoring and Sampling
SA-6.1	Non-Radiological Sample Handling
SA-7.1	Decontamination of Field Equipment and Waste Handling
GH-1.3	Soil and Rock Drilling Methods
GH-1.5	Borehole and Sample Logging
GH-2.8	Groundwater Monitoring Point Installation

BROWN & ROOT ENVIRONMENTAL

STANDARD OPERATING PROCEDURES

Number SA-1.1	Page 1 of 27
Effective Date 03/01/96	Revision 3
Applicability B&R Environmental, NE	
Prepared Earth Sciences Department	
Approved D. Senovich	

Subject
GROUNDWATER SAMPLE ACQUISITION AND ONSITE WATER QUALITY TESTING

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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.

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.

- 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.

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.

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.

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.

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.

- 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.

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.

- 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.

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.

- 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.

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.

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 turbidmeter. 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.

- 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 groundwarer 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.

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 "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.

- 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 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.

6.0 REFERENCES

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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

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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, Detrin®, 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, Detrin®	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
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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.

ATTACHMENT B

SPECIFIC CONDUCTANCE OF 1 MOLAR KCl AT VARIOUS TEMPERATURES[1]

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.

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

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

Temperature (°C)	Dissolved Oxygen (mg/L)					
	Chloride Concentration in Water					Difference/ 100 mg Chloride
	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.

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		Effective Date 03/01/96	Revision 0
		Applicability B&R Environmental, NE	
		Prepared Earth Sciences Department	
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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.

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.

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:

- 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:

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.

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 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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		Effective Date 03/01/96	Revision 0
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		Prepared Earth Sciences Department	
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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 (§261.30 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 (§261.20 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.

Common Preservatives:

- Hydrochloric Acid - HCl
- Sulfuric Acid - H_2SO_4
- Nitric Acid - HNO_3
- Sodium Hydroxide - NaOH

Other Preservatives

- Zinc Acetate
- Sodium Thiosulfate - $Na_2S_2O_3$

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 H_2SO_4, 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.

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 HNO_3, 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_2SO_4)	1 part concentrated H_2SO_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

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 <u>before</u> sampling begins.

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.

- 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 . . .

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.

- 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).

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.[1]

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:

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[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.

- 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.

ATTACHMENT A

GENERAL SAMPLE CONTAINER AND PRESERVATION REQUIREMENTS

Sample Type and Concentration		Container[1]	Sample Size	Preservation[2]	Holding Time[2]
WATER					
Organics (GC&GC/MS)	VOC Low	Borosilicate glass	2 x 40 mL	Cool to 4°C HCl to ≤ 2	14 days[2]
	Extractables (Low SVOCs and pesticide/PCBs)	Amber glass	2x2 L or 4x1 L	Cool to 4°C	7 days to extraction; 40 days after extraction
	Extractables (Medium SVOCs and pesticide/PCBs)	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 (Low SVOCs and pesticides/PCBs)	Wide-mouth glass	8 oz.	Cool to 4°C	14 days to extraction; 40 days after extraction
	Extractables (Medium SVOCs and pesticides/PCBs)	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.

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_2SO_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_2SO_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_2SO_4 to pH 2	6 months
Total Kjeldahl and Organic Nitrogen	P, G	Cool, 4°C; H_2SO_4 to pH 2	28 days
Nitrate - Nitrogen	P, G	None required	48 hours
Nitrate-Nitrite - Nitrogen	P, G	Cool, 4°C: H_2SO_4 to pH 2	28 days
Nitrite - Nitrogen	P, G	Cool, 4°C	48 hours
Oil & Grease	G	Cool, 4°C; H_2SO_4 to pH 2	28 days
Total Organic Carbon (TOC)	P, G	Cool, 4°C; HCl or H_2SO_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_2SO_4 to pH 2	28 days
Phosphorus, Total	P, G	Cool, 4°C; H_2SO_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

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

Parameter Number/Name	Container(1)	Preservation(2)(3)	Maximum Holding Time(4)
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% $Na_2S_2O_3$(5)	14 days
Purgeable Aromatic Hydrocarbons	G, Teflon-lined septum	Cool, 4°C; 0.008% $Na_2S_2O_3$(5) HCl to pH 2 (9)	14 days
Acrolein and Acrylonitrile	G, Teflon-lined septum	Cool, 4°C; 0.008% $Na_2S_2O_3$(5) adjust pH to 4-5 (10)	14 days
Phenols(11)	G, Teflon-lined cap	Cool, 4°C; 0.008% $Na_2S_2O_3$(5)	7 days until extraction; 40 days after extraction
Benzidines(11), (12)	G, Teflon-lined cap	Cool, 4°C; 0.008% $Na_2S_2O_3$(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% $Na_2S_2O_3$(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% $Na_2S_2O_3$(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% $Na_2S_2O_3$(5); store in dark	7 days until extraction; 40 days after extraction
Haloethers(11)	G, Teflon-lined cap	Cool, 4°C; 0.008% $Na_2S_2O_3$(5)	7 days until extraction; 40 days after extraction
Dioxin/Furan (TCDD/TCDF)(11)	G, Teflon-lined cap	Cool, 4°C; 0.008% $Na_2S_2O_3$(5)	7 days until extraction; 40 days after extraction

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

Parameter Number/Name	Container[1]	Preservation[2][3]	Maximum Holding Time[4]
RADIOLOGICAL TESTS:			
1-5 Alpha, beta and radium	P, G	HNO_3 to pH 2	6 months

(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-diphenylthydrazine 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% $Na_2S_2O_3$ 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% $Na_2S_2O_3$.

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	[c]	3	[c]	3	[c]
3	II						3	3	3	3	8	[c]	3	[c]	3	[c]
3	III						6.1	6.1	6.1	3[d]	8	[c]	8	[c]	3	[c]
4.1	II[b]	4.2	4.3	5.1	4.1	4.1	6.1	6.1	4.1	4.1	[c]	8	[c]	4.1	[c]	4.1
4.1	III[b]	4.2	4.3	5.1	4.1	4.1	6.1	6.1	6.1	4.1	[c]	8	[c]	8	[c]	4.1
4.2	II		4.3	5.1	4.2	4.2	6.1	6.1	4.2	4.2	[c]	8	[c]	4.2	[c]	4.2
4.2	III		4.3	5.1	4.2	4.2	6.1	6.1	6.1	4.2	[c]	8	[c]	8	[c]	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[a]						5.1	5.1	5.1	5.1	5.1	5.1	5.1	5.1	5.1	5.1
5.1	II[a]						6.1	5.1	5.1	5.1	8	8	8	5.1	5.1	5.1
5.1	III[a]						6.1	6.1	6.1	5.1	8	8	8	8	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

[a] There are at present no established criteria for determining Packing Groups for liquids in Division 5.1. At present, the degree of hazard 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.

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.

ATTACHMENT D (Continued)
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.

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.

ATTACHMENT G
LITHIUM BATTERY SHIPPING PAPERS

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)

[illegible]	CARGO AIRCRAFT ONLY

Airport of Departure

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.

Name/Title of Signatory

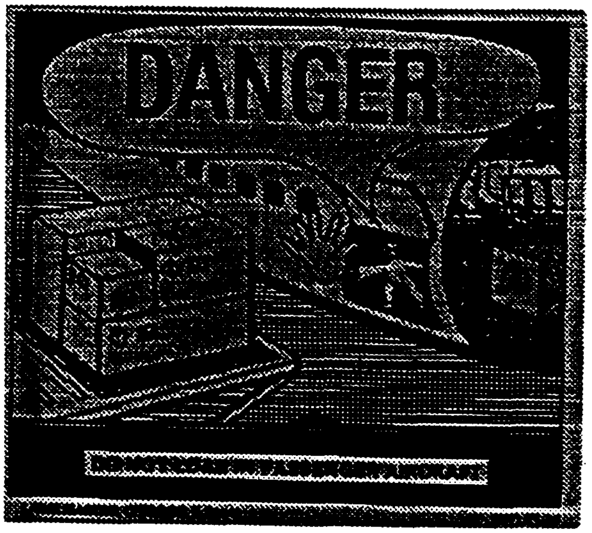
Place and Date

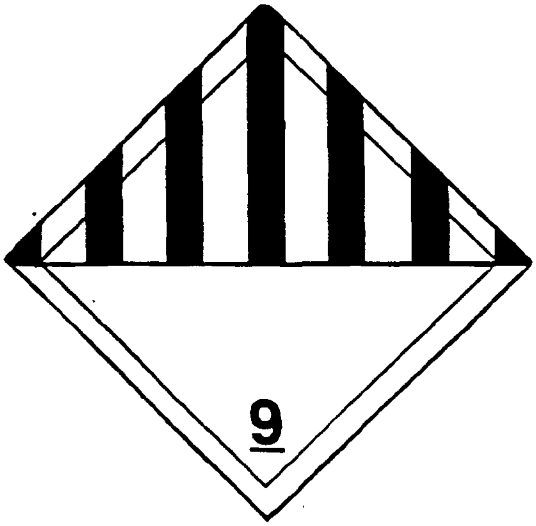
Signature
(see warning above)

Emergency Telephone Number (Required for US Origin or Destination Shipments)
800-535-5053

IF ACCEPTABLE FOR PASSENGER AIRCRAFT, THIS SHIPMENT CONTAINS RADIOACTIVE MATERIAL INTENDED FOR USE IN, OR INCIDENT TO, RESEARCH, MEDICAL DIAGNOSIS, OR TREATMENT.

ATTACHMENT G (CONTINUED)
LITHIUM BATTERY SHIPPING PAPERS





LITHIUM BATTERIES CONTAINED IN EQUIPMENT.
UN-3091.
SHIPPED UNDER CA-9206009

BROWN & ROOT ENVIRONMENTAL	**STANDARD OPERATING PROCEDURES**	Number SA-7.1	Page 1 of 9
		Effective Date 01/21/97	Revision 1
		Applicability B&R Environmental, NE	
		Prepared Earth Sciences Department	
Subject	DECONTAMINATION OF FIELD EQUIPMENT AND WASTE HANDLING	Approved D. Senovich	

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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

Acid - For decontamination of equipment when sampling for trace levels of inorganics, a 10% solution of nitric acid in deionized water should be used. Due to the leaching ability of nitric acid, it should not be used on stainless steel.

Alconox/Liquinox - A brand of phosphate-free laboratory-grade detergent.

Deionized Water - Deionized (analyte free) water is tap water that has been treated by passing through a standard deionizing resin column. Deionized water should contain no detectable heavy metals or other inorganic compounds at or above the analytical detection limits for the project.

Potable Water - Tap water used from any municipal water treatment system. Use of an untreated potable water supply is not an acceptable substitute for tap water.

Solvent - The solvent of choice is pesticide-grade Isopropanol. Use of other solvents (methanol, acetone, pesticide-grade hexane, or petroleum ether) may be required for particular projects or for a particular purpose (e.g. for the removal of concentrated waste) and must be justified in the project planning documents. As an example, it may be necessary to use hexane when analyzing for trace levels of pesticides, PCBs, or fuels. In addition, because many of these solvents are not miscible in water, the equipment should be air dried prior to use. Solvents should not be used on PVC equipment or well construction materials.

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 off site.

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 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
- Pesticide-grade isopropanol (unless otherwise required)
- Pesticide-grade hexane rinse[**]
- Copious distilled/Deionized water rinse
- Air dry

If sampling for volatile organic compounds (VOCs) only, the nitric acid, isopropanol, and hexane rinses may be omitted. Only reagent grade or purer solvents are to be used for decontamination. When solvents are 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 factions 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.

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[*] 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.

[**] If sampling for pesticides, PCBs, or fuels.

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.

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
- Pesticide-grade isopropanol (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.

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 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.

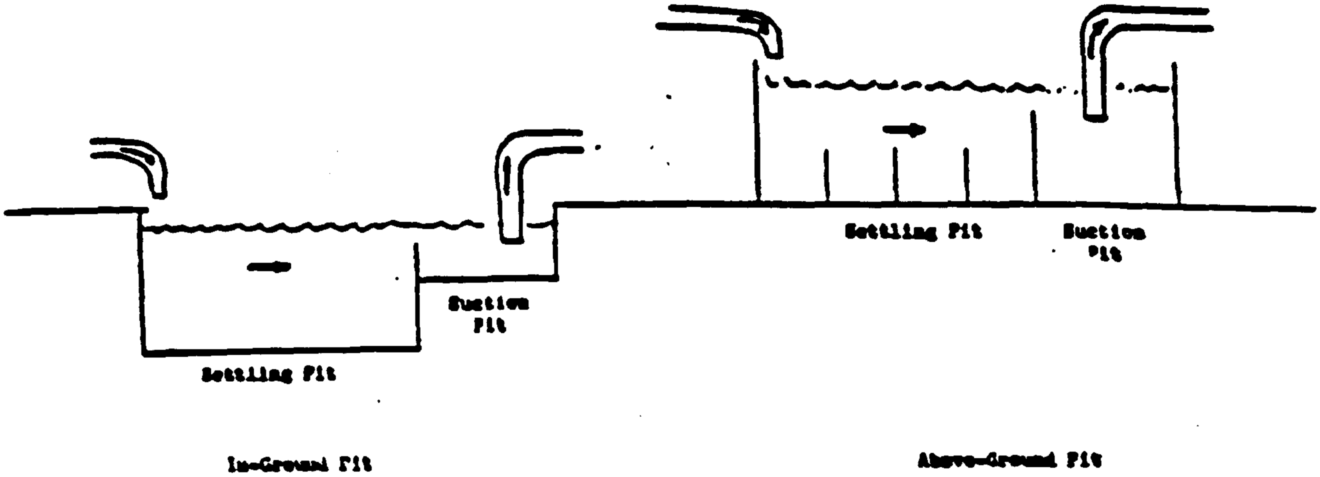
Another consideration in selecting disposal methods for contaminated materials is whether the disposal can be incorporated into subsequent site cleanup activities. For example, if construction of a suitable onsite disposal structure is expected, contaminated materials generated during the investigation 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.

6.0 REFERENCES

Brown & Root Environmental: Standard Operating Procedure No. 4.33, Control of Contaminated Material.

ATTACHMENT A

TWO TYPES OF MUD PITS USED IN WELL DRILLING



BROWN & ROOT ENVIRONMENTAL

STANDARD OPERATING PROCEDURES

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1.0 PURPOSE

The purpose of this procedure is to describe the methods and equipment necessary to perform soil and rock borings and identify the equipment, sequence of events, and appropriate methods necessary to obtain soil, both surface and subsurface, and rock samples during field sampling activities.

2.0 SCOPE

This guideline addresses most of the accepted and standard drilling techniques, their benefits, and drawbacks. It should be used generally to determine what type of drilling techniques would be most successful depending on site-specific geologic conditions and the type of sampling required.

The sampling methods described within this procedure are applicable to collecting surface and subsurface soil samples, and obtaining rock core samples for lithologic and hydrogeologic evaluation, excavation/foundation design and related civil engineering purposes.

3.0 GLOSSARY

Rock Coring - A method in which a continuous solid cylindrical sample of rock or compact rock-like soil is obtained by the use of a double tube core barrel that is equipped with an appropriate diamond-studded drill bit which is advanced with a hydraulic rotary drilling machine.

Wire-Line Coring - As an alternative to conventional coring, this technique is valuable in deep hole drilling, since this method eliminates trips in and out of the hole with the coring equipment. With this technique, the core barrel becomes an integral part of the drill rod string. The drill rod serves as both a coring device and casing.

4.0 RESPONSIBILITIES

Project Manager - In consultation with the project geologist, the Project Manager is responsible for evaluating the drilling requirements for the site and specifying drilling techniques that will be successful given the study objectives and geologic conditions at the site. The Project Manager also determines the disposal methods for products generated by drilling, such as drill cuttings and well development water, as well as any specialized supplies or logistical support required for the drilling operations.

Field Operations Leader (FOL) - The FOL is responsible for the overall supervision and scheduling of drilling activities, and is strongly supported by the project geologist.

Project Geologist - The project geologist is responsible for ensuring that standard and approved drilling procedures are followed. The geologist will generate a detailed boring log for each test hole. This log shall include a description of materials, samples, method of sampling, blow counts, and other pertinent drilling and testing information that may be obtained during drilling (see SOPs SA-6.3 and GH-1.5). Often this position for inspecting the drilling operations may be filled by other geotechnical personnel, such as soils and foundation engineers, civil engineers, etc.

Determination of the exact location for borings is the responsibility of the site geologist. The final location for drilling must be properly documented on the boring log. The general area in which the borings are to be located will be shown on a site map included in the Work Plan and/or Sampling and Analysis Plan.

Drilling Subcontractor - Operates under the supervision of the FOL. Responsible for obtaining all drilling permits and clearances, and supplying all services (including labor), equipment and material required to perform the drilling, testing, and well installation program, as well as maintenance and quality control of such required equipment except as stated in signed and approved subcontracts.

The driller must report any major technical or analytical problems encountered in the field to the FOL within 24 hours of determination, and must provide advance written notification of any changes in field procedures, describing and justifying such changes. No such changes shall be made unless requested and authorized in writing by the FOL (with the concurrence of the Project Manager).

The drilling subcontractor is responsible for following decontamination procedures specified in the project plan documents. Upon completion of the work, the driller is responsible for demobilizing all equipment, cleaning up any materials deposited on site during drilling operations, and properly backfilling any open borings.

5.0 PROCEDURES

5.1 General

The purpose of drilling boreholes is:

- To determine the type, thickness, and certain physical and chemical properties of the soil, water and rock strata which underlie the site.
- To install monitoring wells or piezometers.

All drilling and sampling equipment will be cleaned between samples and borings using appropriate decontamination procedures as outlined in SOP SA-7.1. Unless otherwise specified, it is generally advisable to drill borings at "clean" locations first, and at the most contaminated locations last, to reduce the risk of spreading contamination between locations. All borings must be logged by the rig geologist as they proceed (see SOPs SA-6.3 and GH-1.5). Situations where logging would not be required would include installation of multiple well points within a small area, or a "second attempt" boring adjacent to a boring that could not be continued through resistant material. In the latter case, the boring log can be resumed 5 feet above the depth at which the initial boring was abandoned, although the rig geologist should still confirm that the stratigraphy at the redrilled location conforms essentially with that encountered at the original location. If significant differences are seen, each hole should be logged separately.

5.2 Drilling Methods

The selected drilling methods described below apply to drilling in subsurface materials, including, but not limited to, sand, gravel, clay, silt, cobbles, boulders, rock and man-made fill. Drilling methods should be selected after studying the site geology and terrain, the waste conditions at the site, and reviewing the purpose of drilling and the overall subsurface investigation program proposed for the site. The full range of different drilling methods applicable to the proposed program should be identified with final selection based on relative cost, availability, time constraints, and how well each method meets the sampling and testing requirements of the individual drilling program.

5.2.1 Continuous-Flight Hollow-Stem Auger Drilling

This method of drilling consists of rotating augers with a hollow stem into the ground. Cuttings are brought to the surface by the rotating action of the auger. This method is relatively quick and inexpensive. Advantages of this type of drilling include:

- Samples can be obtained without pulling the augers out of the hole. However, this is a poor method for obtaining grab samples from thin, discrete formations because of mixing of soils which occurs as the material is brought to the surface. Sampling of such formations requires the use of split-barrel or thin-wall tube samplers advanced through the hollow core of the auger.

- No drilling fluids are required.

- A well can be installed inside the auger stem and backfilled as the augers are withdrawn.

Disadvantages and limitations of this method of drilling include:

- Augering can only be done in unconsolidated materials.

- The inside diameter of hollow stem augers used for well installation should be at least 4 inches greater than the well casing. Use of such large-diameter hollow-stem augers is more expensive than the use of small-diameter augers in boreholes not used for well installation. Furthermore, the density of unconsolidated materials and depths become more of a limiting factor. More friction is produced with the larger diameter auger and subsequently greater torque is needed to advance the boring.

- The maximum effective depth for drilling is 150 feet or less, depending on site conditions and the size of augers used.

- In augering through clean sand formations below the water table, the sand will tend to flow into the hollow stem when the plug is removed for soil sampling or well installation. If the condition of "running" or "flowing" sands is persistent at a site, an alternative method of drilling is recommended, in particular for wells or boreholes deeper than 25 feet.

- Hollow-stem auger drilling is the preferred method of drilling. Most alternative methods require the introduction of water or mud downhole (air rotary is the exception) to maintain the open borehole. With these other methods, great care must be taken to ensure that the method does not interfere with the collection of a representative sample (which is the objective of the borehole construction. With this in mind, the preferred order of choice of drilling method after hollow-stem augering (HSA) is:

    - Cable tool
    - Casing drive (air)
    - Air rotary
    - Mud rotary
    - Rotosonic
    - Drive and wash
    - Jetting

However, the use of any method will also depend on efficiency and cost-effectiveness. In many cases, mud rotary is the only feasible alternative to hollow-stem augering. Thus, mud rotary drilling is generally acceptable as a first substitute for HSA.

The procedures for sampling soils through holes drilled by hollow-stem auger shall conform with the applicable ASTM Standards: D1587-83 and D1586-84. The guidelines established in SOP SA-1.3 shall also be followed. The hollow-stem auger may be advanced by any power-operated drilling machine having sufficient torque and ram range to rotate and force the auger to the desired depth. The machine must, however, be equipped with the accessory equipment needed to perform required sampling, or rock coring.

The hollow-stem auger may be used without the plug when boring for geotechnical examination or for well installation. However, when drilling below the water table, specially designed plugs which allow passage of formation water but not solid material shall be used (see Reference 1 of this guideline). This drilling configuration method also prevents blow back and plugging of the auger when the plug is removed for sampling.

Alternately, it may be necessary to keep the hollow stem full of water, at least to the level of the water table, to prevent blowback and plugging of the auger. If water is added to the hole, it must be sampled and analyzed to determine if it is free from contaminants prior to use. In addition, the amount of water introduced, the amount recovered upon attainment of depth, and the amount of water extracted during well development must be carefully logged in order to ensure that a representative sample of the formation water can be obtained. Well development should occur as soon after well completion as practicable (see SOP GH-2.8 for well development procedures). If gravelly or hard material is encountered which prevents advancing the auger to the desired depth, augering should be halted and either driven casing or hydraulic rotary methods should be attempted. If the depth to the bedrock/soil interface and bedrock lithology must be determined, then a 5-foot confirmatory core run should be conducted (see Section 5.2.9).

At the option of the Field Operations Leader (in communication with the Project Manager), when resistant materials prevent the advancement of the auger, a new boring can be attempted. The original boring must be properly backfilled and the new boring started a short distance away at a location determined by the site geologist. If multiple water bearing strata were encountered, the original boring must be grouted. In some formations, it may be prudent to also grout borings which penetrate only the water table aquifer, since loose soil backfill in the boring may still provide a preferred pathway for surface liquids to reach the water table.

5.2.2 Continuous-Flight Solid-Stem Auger Drilling

This drilling method is similar to hollow-stem augering. Practical application of this method is severely restricted compared to use of hollow-stem augers. Split-barrel (split-spoon) sampling cannot be performed without pulling the augers out, which may allow the hole to collapse. The continuous-flight solid-stem auger drilling method is therefore very time consuming and is not cost effective. Also, augers would have to be withdrawn before installing a monitoring well, which again, may allow the hole to collapse. Furthermore, geologic logging by examining the soils brought to the surface is unreliable, and depth to water may be difficult to determine while drilling.

There would be very few situations where use of a solid-stem auger would be preferable to other drilling methods. The only practical applications of this method would be to drill boreholes for well installation where no lithologic information is desired and the soils are such that the borehole can be expected to remain open after the augers are withdrawn. Alternatively, this technique can be used to find depth to bedrock in an area when no other information is required from drilling.

5.2.3 Rotary Drilling

Direct rotary drilling includes air-rotary and fluid-rotary drilling. For air or fluid-rotary drilling, the rotary drill may be advanced to the desired depth by any power-operated drilling machine having sufficient torque and ram range to rotate and force the bit to the desired depth. The drilling machine must, however, be equipped with any accessory equipment needed to perform required sampling, or coring. Prior to sampling, any settled drill cuttings in the borehole must be removed.

Air-rotary drilling is a method of drilling where the drill rig simultaneously turns and exerts a downward pressure on the drilling rods and bit while circulating compressed air down the inside of the drill rods, around the bit, and out the annulus of the borehole. Air circulation serves to both cool the bit and remove the cuttings from the borehole. Advantages of this method include:

- The drilling rate is high (even in rock).
- The cost per foot of drilling is relatively low.
- Air-rotary rigs are common in most areas.
- No drilling fluid is required (except when water is injected to keep down dust).
- The borehole diameter is large, to allow room for proper well installation procedures.

Disadvantages to using this method include:

- Formations must be logged from the cuttings that are blown to the surface and thus the depths of materials logged are approximate.

- Air blown into the formation during drilling may "bind" the formation and impede well development and natural groundwater flow.

- In-situ samples cannot be taken, unless the hole is cased.

- Casing must generally be used in unconsolidated materials.

- Air-rotary drill rigs are large and heavy.

A variation of the typical air-rotary drill bit is a down hole hammer which hammers the drill bit down as it drills. This makes drilling in hard rock faster. Air-rotary drills can also be adapted to use for rock coring although they are generally slower than other types of core drills. A major application of the air-rotary drilling method would be to drill holes in rock for well installation.

Fluid-Rotary drilling operates in a similar manner to air-rotary drilling except that a drilling fluid ("mud") or clean water is used in place of air to cool the drill bit and remove cuttings. There are a variety of fluids that can be used with this drilling method, including bentonite slurry and synthetic slurries. If a drilling fluid other than water/cuttings is used, it must be a natural clay (i.e., bentonite) and a "background" sample of the fluid should be taken for analysis of possible organic or inorganic contaminants.

Advantages to the fluid-rotary drilling method include:

- The ability to drill in many types of formations.
- Relatively quick and inexpensive.
- Split-barrel (split-spoon) or thin-wall (Shelby) tube samples can be obtained without removing drill rods if the appropriate size drill rods and bits (i.e., fish-tail or drag bit) are used.
- In some borings temporary casing may not be needed as the drilling fluids may keep the borehole open.
- Drill rigs are readily available in most areas.

Disadvantages to this method include:

- Formation logging is not as accurate as with hollow-stem auger method if split-barrel (split-spoon) samples are not taken (i.e., the depths of materials logged from cuttings delivered to the surface are approximate).
- Drilling fluids reduce permeability of the formation adjacent to the boring to some degree, and require more extensive well development than "dry" techniques (augering, air-rotary).
- No information on depth to water is obtainable while drilling.
- Fluids are needed for drilling, and there is some question about the effects of the drilling fluids on subsequent water samples obtained. For this reason as well, extensive well development may be required.
- In very porous materials (i.e., rubble fill, boulders, coarse gravel) drilling fluids may be continuously lost into the formation. This requires either constant replenishment of the drilling fluid, or the use of casing through this formation.
- Drill rigs are large and heavy, and must be supported with supplied water.
- Groundwater samples can be potentially diluted with drilling fluid.

The procedures for performing direct rotary soil investigations and sampling shall conform with the applicable ASTM standards: D2113-83, D1587-83, and D1586-84.

Soil samples shall be taken as specified by project plan documents, or more frequently, if requested by the project geologist. Any required sampling shall be performed by rotation, pressing, or driving in accordance with the standard or approved method governing use of the particular sampling tool.

When field conditions prevent the advancement of the hole to the desired depth, a new boring may be drilled at the request of the Field Operations Leader. The original boring shall be backfilled using methods and materials appropriate for the given site and a new boring started a short distance away at a location determined by the project geologist.

5.2.4 Rotosonic Drilling

The Rotosonic drilling method employs a high frequency vibrational and low speed rotational motion coupled with down pressure to advance the cutting edge of a drill string. This produces a uniform borehole while providing a continuous, undisturbed core sample of both unconsolidated and most bedrock formations. Rotosonic drilling advances a 4-inch diameter to 12-inch diameter core barrel for sampling and can advance up to a 12-inch diameter outer casing for the construcito of standard and telescoped monitoring wells. During drilling, the core barrel is advanced ahead of the outer barrel in increments as determined by the site geologist and depending upon type of material, degree of subsurface contamination and sampling objectives.

The outer casing can be advanced at the same time as the inner drill string and core barrel, or advanced down over the inner drill rods and core barrel, or after the core barrel has moved ahead to collect the undisturbed sample and has been pulled out of the borehole. The outer casing can be advanced dry in most cases, or can be advanced with water or air depending upon the formations being drilled, the depth and diameter of the hole, or requirements of the project.

Advantages of this method include:

- Sampling and well installation are faster as compared to other drilling methods.
- Continuous sampling, with larger sample volume as compared to split-spoon sampling.
- The ability to drill through difficult formations such as cobbles or boulders, hard till and bedrock.
- Reduction of IDW by an average of 70 to 80 percent.
- Well installations are quick and controlled by elimination of potential bridging of annular materials during well installation, due to the ability to vibrate the outer casing during removal.

Disadvantages include:

- The cost for Rotosonic drilling as compared to other methods are generally higher. However, the net result can be a significant savings considering reduced IDW and shortened project duration.
- Rotosonic drill rigs are large and need ample room to drill, however, Rotosonic units can be placed on the ground or placed on an ATV.
- There are a limited number of Rotosonic drilling contractors at the present time.

5.2.5 Reverse Circulation Rotary Drilling

The common reverse-circulation rig is a water or mud-rotary rig with a large-diameter drill pipe which circulates the drilling water down the annulus and up the inside of the drill pipe (reverse flow direction from direct mud-rotary). This type of rig is used for the construction of large-capacity production water wells and is not suited for small, water quality sampling wells because of the use of drilling muds and the large-diameter hole which is created. A few special reverse-circulation rotary rigs are made with double-wall drill pipe. The drilling water or air is circulated down the annulus between the drill pipes and up inside the inner pipe.

Advantages of the latter method include:

- The formation water is not contaminated by the drilling water.
- Formation samples can be obtained, from known depths.
- When drilling with air, immediate information is available regarding the water-bearing properties of formations penetrated.
- Collapsing of the hole in unconsolidated formations is not as great a problem as when drilling with the normal air-rotary rig.

Disadvantages include:

- Double-wall, reverse-circulation drill rigs are very rare and expensive to operate.
- Placing cement grout around the outside of the well casing above a well screen often is difficult, especially when the screen and casing are placed down through the inner drill pipe before the drill pipe is pulled out.

5.2.6 Drill-through Casing Driver

The driven-casing method consists of alternately driving casing (fitted with a sharp, hardened casing shoe) into the ground using a hammer lifted and dropped by the drill rig (or an air-hammer) and cleaning out the casing using a rotary chopping bit and air or water to flush out the materials. The casing is driven down in stages (usually 5 feet per stage); a continuous record is kept of the blows per foot in driving the casing (see SOP GH-1.5). The casing is normally advanced by a 300-pound hammer falling freely through a height of 30 inches. Simultaneous washing and driving of the casing is not recommended. If this procedure is used, the elevations within which wash water is used and in which the casing is driven must be clearly recorded.

The driven casing method is used in unconsolidated formations only. When the boring is to be used for later well installation, the driven casing used should be at least 4 inches larger in diameter than the well casing to be installed. Advantages to this method of drilling include:

- Split-barrel (split-spoon) sampling can be conducted while drilling.
- Well installation is easily accomplished.
- Drill rigs used are relatively small and mobile.
- The use of casing minimizes flow into the hole from upper water-bearing layers; therefore, multiple aquifers can be penetrated and sampled for rough field determinations of some water quality parameters.

Some of the disadvantages include:

- This method can only be used in unconsolidated formations.
- The method is slower than other methods (average drilling progress is 30 to 50 feet per day).

- Maximum depth of the borehole varies with the size of the drill rig and casing diameter used. and the nature of the formations drilled.

- The cost per hour or per foot of drilling may be substantially higher than other drilling methods.

- It is difficult and time consuming to pull back the casing if it has been driven very deep (deeper than 50 feet in many formations).

5.2.7 Cable Tool Drilling

A cable tool rig uses a heavy, solid-steel, chisel-type drill bit ("tool") suspended on a steel cable, which when raised and dropped, chisels or pounds a hole through the soils and rock. Drilling progress may be expedited by the use of "slip-jars" which serve as a cable-activated down hole percussion device to hammer the bit ahead.

When drilling through the unsaturated zone, some water must be added to the hole. The cuttings are suspended in the water and then bailed out periodically. Below the water table, after sufficient ground water enters the borehole to replace the water removed by bailing, no further water needs to be added.

When soft caving formations are encountered, it is usually necessary to drive casing as the hole is advanced to prevent collapse of the hole. Often the drilling can be only a few feet below the bottom of the casing. Because the drill bit is lowered through the casing, the hole created by the bit is smaller than the casing. Therefore, the casing (with a sharp, hardened casing shoe on the bottom) must be driven into the hole (see Section 5.2.5 of this guideline).

Advantages of the cable-tool method include the following:

- Information regarding water-bearing zones is readily available during the drilling. Even relative permeabilities and rough water quality data from different zones penetrated can be obtained by skilled operators.

- The cable-tool rig can operate satisfactorily in all formations, but is best suited for caving, boulder, cable or coarse gravel type formations (e.g., glacial till) or formations with large cavities above the water table (such as limestones).

- When casing is used, the casing seals formation water out of the hole, preventing down hole contamination and allowing sampling of deeper aquifers for field-measurable water quality parameters.

- Split-barrel (split-spoon) or thin-wall (Shelby) tube samples can be collected through the casing.

Disadvantages include:

- Drilling is slow compared with rotary rigs.

- The necessity of driving the casing in unconsolidated formations requires that the casing be pulled back if exposure of selected water-bearing zones is desired. This process complicates the well completion process and often increases costs. There is also a chance that the casing may become stuck in the hole.

- The relatively large diameters required (minimum of 4-inch casing) plus the cost of steel casing result in higher costs compared to rotary drilling methods where casing is not required (e.g., such use of a hollow-stem auger).
- Cable-tool rigs have largely been replaced by rotary rigs. In some parts of the U.S., availability may be difficult.

5.2.8 Jet Drilling (Washing)

Jet drilling, which should be used only for piezometer or vadose zone sampler installation, consists of pumping water or drilling mud down through a small diameter (1/2- to 2-inch) standard pipe (steel or PVC). The pipe may be fitted with a chisel bit or a special jetting screen. Formation materials dislodged by the bit and jetting action of the water are brought to the surface through the annulus around the pipe. As the pipe is jetted deeper, additional lengths of pipe may be added at the surface.

Jet percussion is a variation of the jetting method, in which the casing is driven with a drive weight. Normally, this method is used to place 2-inch-diameter casing in shallow, unconsolidated sand formations, but this method has also been used to install 3- to 4-inch-diameter casings to a depth of 200 feet.

Jetting is acceptable in very soft formations, usually for shallow sampling, and when introduction of drilling water to the formation is acceptable. Such conditions would occur during rough stratigraphic investigation or installation of piezometers for water level measurement. Advantages of this method include:

- Jetting is fast and inexpensive.
- Because of the small amount of equipment required, jetting can be accomplished in locations where access by a normal drilling rig would be very difficult. For example, it would be possible to jet down a well point in the center of a lagoon at a fraction of the cost of using a drill rig.
- Jetting numerous well points just into a shallow water table is an inexpensive method for determining the water table contours, hence flow direction.

Disadvantages include the following:

- A large amount of foreign water or drilling mud is introduced above and into the formation to be sampled.
- Jetting is usually done in very soft formations which are subject to caving. Because of this caving, it is often not possible to place a grout seal above the screen to assure that water in the well is only from the screened interval.
- The diameter of the casing is usually limited to 2 inches; therefore, samples must be obtained by methods applicable to small diameter casings.
- Jetting is only possible in very soft formations that do not contain boulders or coarse gravel, and the depth limitation is shallow (about 30 feet without jet percussion equipment).
- Large quantities of water are often needed.

5.2.9 Drilling with a Hand Auger

This method is applicable wherever the formation, total depth of sampling, and the site and groundwater conditions are such as to allow hand auger drilling. Hand augering can also be considered at locations where drill rig access is not possible. All hand auger borings will be performed according to ASTM D1452-80.

Samples should be taken continuously unless otherwise specified by the project plan documents. Any required sampling is performed by rotation, pressing, or driving in accordance with the standard or approved method governing use of the particular sampling tool. Typical equipment used for sampling and advancing shallow "hand auger" holes are Iwan samplers (which are rotated) or post hole diggers (which are operated like tongs). These techniques are slow but effective where larger pieces of equipment do not have access, and where very shallow holes are desired (less than 15 feet). Surficial soils must be composed of relatively soft and non-cemented formations to allow penetration by the auger.

5.2.10 Rock Drilling and Coring

When soil borings cannot be continued using augers or rotary methods due to the hardness of the soil or when rock or large boulders are encountered, drilling and sampling can be performed using a diamond bit corer in accordance with ASTM D2113.

Drilling is done by rotating and applying downward pressure to the drill rods and drill bit. The drill bit is a circular, hollow, diamond-studded bit attached to the outer core barrel in a double-tube core barrel. The use of single-tube core barrels is not recommended, as the rotation of the barrel erodes the sample and limits its use for detailed geological evaluation. Water or air is circulated down through the drill rods and annular space between the core barrel tubes to cool the bit and remove the cuttings. The bit cuts a core out of the rock which rises into an inner barrel mounted inside the outer barrel. The inner core barrel and rock core are removed by lowering a wire line with a coupling into the drill rods, latching onto the inner barrel and withdrawing the inner barrel. A less efficient variation of this method utilizes a core barrel that cannot be removed without pulling all of the drill rods. This variation is practical only if less than 50 feet of core is required.

Core borings are made through the casing used for the soil borings. The casing must be driven and sealed into the rock formation to prevent seepage from the overburden into the hole to be cored (see Section 5.3 of this guideline). A double-tube core barrel with a diamond bit and reaming shell or equivalent should be used to recover rock cores of a size specified in the project plans. The most common core barrel diameters are listed in Attachment A.

Soft or decomposed rock should be sampled with a driven split-barrel whenever possible or cored with a Denison or Pitcher sampler.

When coring rock, including shale and claystone, the speed of the drill and the drilling pressure, amount and pressure of water, and length of run can be varied to give the maximum recovery from the rock being drilled. Should any rock formation be so soft or broken that the pieces continually fall into the hole causing unsatisfactory coring, the hole should be reamed and a flush-joint casing installed to a point below the broken formation. The size of the flush-joint casing must permit securing the core size specified. When soft or broken rock is anticipated, the length of core runs should be reduced to less than 5 feet to avoid core loss and minimize core disturbance.

Advantages of core drilling include:

- Undisturbed rock cores can be recovered for examination and/or testing.
- In formations in which the cored hole will remain open without casing, water from the rock fractures may be recovered from the well without the installation of a well screen and gravel pack.
- Formation logging is extremely accurate.
- Drill rigs are relatively small and mobile.

Disadvantages include:

- Water or air is needed for drilling.
- Coring is slower than rotary drilling (and more expensive).
- Depth to water cannot accurately be determined if water is used for drilling.
- The size of the borehole is limited.

This drilling method is useful if accurate determinations of rock lithology are desired or if open wells are to be installed into bedrock. To install larger diameter wells in coreholes, the hole must be reamed out to the proper size after boring, using air or mud rotary drilling methods.

5.2.11 Drilling & Support Vehicles

In addition to the drilling method required to accomplish the objectives of the field program, the type of vehicle carrying the drill rig and/or support equipment and its suitability for the site terrain, will often be an additional deciding factor in planning the drilling program. The types of vehicles available are extensive, and depend upon the particular drilling subcontractor's fleet. Most large drilling subcontractors will have a wide variety of vehicle and drill types suited for most drilling assignments in their particular region, while smaller drilling subcontractors will usually have a fleet of much more limited diversity. The weight, size, and means of locomotion (tires, tracks, etc.) of the drill rig must be selected to be compatible with the site terrain to assure adequate mobility between borehole locations. Such considerations also apply to necessary support vehicles used to transport water and/or drilling materials to the drill rigs at the borehole locations. When the drill rigs or support vehicles do not have adequate mobility to easily traverse the site, provisions must be made for assisting equipment, such as bulldozers, winches, timber planking, etc., to maintain adequate progress during the drilling program.

Some of the typical vehicles which are usually available for drill rigs and support equipment are:

- Totally portable drilling/sampling equipment, where all necessary components (tripods, samplers, hammers, catheads, etc.) may be hand carried to the borehole site. Drilling/sampling methods used with such equipment include:
    - Hand augers and lightweight motorized augers.
    - Retractable plug samplers--driven by hand (hammer).

  - Motorized cathead - a lightweight aluminum tripod with a small gas-engine cathead mounted on one leg, used to install small-diameter cased borings. This rig is sometimes called a "monkey on a stick."

- Skid-mounted drilling equipment containing a rotary drill or engine-driven cathead (to lift hammers and drill string), a pump, and a dismounted tripod. The skid is pushed, dragged, or winched (using the cathead drum) between boring locations.

- Small truck-mounted drilling equipment using a jeep, stake body or other light truck (4 to 6 wheels), upon which are mounted the drill and/or a cathead, a pump, and a tripod or small drilling derrick. On some rigs, the drill and/or a cathead are driven by a power take-off from the truck, instead of by a separate engine.

- Track-mounted drilling equipment is similar to truck-mounted rigs, except that the vehicle used has wide bulldozer tracks for traversing soft ground. Sometimes a continuous-track "all terrain vehicle" is also modified for this purpose. Some types of tracked drill rigs are called "bombardier" or "weasel" rigs.

- Heavy truck-mounted drilling equipment is mounted on tandem or dual tandem trucks to transport the drill, derrick, winches, and pumps or compressors. The drill may be provided with a separate engine or may use a power take-off from the truck engine. Large augers, hydraulic rotary and reverse circulation rotary drilling equipment are usually mounted on such heavy duty trucks. For soft-ground sites, the drilling equipment is sometimes mounted on and off the road vehicle having low pressure, very wide diameter tires and capable of floating; these vehicles are called "swamp buggy" rigs.

- Marine drilling equipment is mounted on various floating equipment for drilling borings in lakes, estuaries and other bodies of water. The floating equipment varies, and is often manufactured or customized by the drilling subcontractor to suit specific drilling requirements. Typically, the range of flotation vehicles include:

  - Barrel-float rigs - a drill rig mounted on a timber platform buoyed by empty 55-gallon drums or similar flotation units.

  - Barge-mounted drill rigs.

  - Jack-up platforms - drilling equipment mounted on a floating platform having retractable legs to support the unit on the sea or lake bed when the platform is jacked up out of the water.

  - Drill ships - for deep ocean drilling.

In addition to the mobility for the drilling equipment, similar consideration must be given for equipment to support the drilling operations. Such vehicles or floating equipment are needed to transport drill water, drilling supplies and equipment, samples, drilling personnel, etc. to and/or from various boring locations.

5.2.12 Equipment Sizes

In planning subsurface exploration programs, care must be taken in specifying the various drilling components, so that they will fit properly in the boring or well.

For drilling open boreholes using rotary drilling equipment, tri-cone drill bits are employed with air, water or drilling mud to remove cuttings and cool the bit. Tri-cone bits are slightly smaller than the holes they drill (i.e., 5-7/8-inch or 7-7/8-inch bits will nominally drill 6-inch and 8-inch holes, respectively).

For obtaining split-barrel samples of a formation, samplers are commonly manufactured in sizes ranging from 2 inches to 3-1/2 inches in outside diameter. However, the most commonly used size is the 2-inch O.D., 1-3/8-inch I.D. split-barrel sampler. When this sampler is used and driven by a 140-pound (± 2-pound) hammer dropping 30 inches (± 1 inch), the procedure is called a Standard Penetration Test, and the blows per foot required to advance the sampler into the formation can be correlated to the formation's density or strength.

In planning the drilling of boreholes using hollow-stem augers or casing, in which thin-wall tube samples or diamond core drilling will be performed, refer to the various sizes and clearances provided in Attachment A of this guideline. Sizes selected must be stated in the project plan documents.

5.2.13 Estimated Drilling Progress

To estimate the anticipated rates of drilling progress for a site, the following must be considered:

- The speed of the drilling method employed.
- Applicable site conditions (e.g., terrain, mobility between borings, difficult drilling conditions in bouldery soils, rubble fill or broken rock, etc.).
- Project-imposed restrictions (e.g., drilling while wearing personal protective equipment, decontamination of drilling equipment, etc.).

Based on recent experience in drilling average soil conditions (no boulders) and taking samples at 5-foot intervals, for moderate depth (30 feet to 50 feet) boreholes (not including installation or development of wells), the following daily rates of total drilling progress may be anticipated for the following drilling methods:

Drilling Method	Average Daily Progress (linear feet)
Hollow-stem augers	75'
Solid-stem augers	50'
Mud-Rotary Drilling	100' (cuttings samples)
Rotosonic Drilling	100'-160' (continuous core)
Reverse-Circulation Rotary	100' (cuttings samples)
Skid-Rig with driven casing	30'
Rotary with driven casing	50'
Cable Tool	30'
Hand Auger	Varies
Continuous Rock Coring	50'

5.3 Prevention of Cross-Contamination

A telescoping or multiple casing technique minimizes the potential for the migration of contaminated groundwater to lower strata below a confining layer. The telescoping technique consists of drilling to a confining layer utilizing a spun casing method with a diamond cutting or augering shoe (a method similar to the rock coring method described in Section 5.2.10, except that larger casing is used) or by using a driven-casing method (see Section 5.2.6 of this guideline) and installing a specified diameter steel well casing. The operation consists of three separate steps. Initially, a drilling casing (usually of 8-inch diameter) is installed followed by installation of the well casing (6-inch-diameter is common for 2-inch wells). This well casing is driven into the confining layer to ensure a tight seal at the bottom of the hole. The well casing is sealed at the bottom with a bentonite-cement slurry. The remaining depth of the boring is drilled utilizing a narrower diameter spun or driven casing technique within the outer well casing. A smaller diameter well casing with an appropriate length of slotted screen on the lower end, is installed to the surface.

Clean sand is placed in the annulus around and to a point of about 2 feet above the screen prior to withdrawal of the drilling casing. The annular space above the screen and to a point 2 feet above the bottom of the outer well casing is sealed with a tremied cement-bentonite slurry which is pressure-grouted or displacement-grouted into the hole. The remaining casing annulus is backfilled with clean material and grouted at the surface, or it is grouted all the way to the surface.

5.4 Cleanout of Casing Prior to Sampling

The boring hole must be completely cleaned of disturbed soil, segregated coarse material and clay adhering to the inside walls of the casing. The cleaning must extend to the bottom edge of the casing and, if possible, a short distance further (1 or 2 inches) to bypass disturbed soil resulting from the advancement of the casing. Loss of wash water during cleaning should be recorded.

For disturbed samples both above and below the water table and where introduction of relatively large volumes of wash water is permissible, the cleaning operation is usually performed by washing the material out of the casing with water; however, the cleaning should never be accomplished with a strong, downward-directed jet which will disturb the underlying soil. When clean out has reached the bottom of the casing or slightly below (as specified above), the string of tools should be lifted one foot off the bottom with the water still flowing, until the wash water coming out of the casing is clear of granular soil particles. In formations where the cuttings contain gravel and other larger particles, it is often useful to repeatedly raise and lower the drill rods and wash bit while washing out the hole, to surge these large particles upward out of the hole. As a time saver, the drilling contractor may be permitted to use a split-barrel (split-spoon) sampler with the ball check valve removed as the clean-out tool, provided the material below the spoon is not disturbed and the shoe of the spoon is not damaged. However, because the ball check valve has been removed, in some formations it may be necessary to install a flap valve or spring sample retainer in the split-spoon bit, to prevent the sample from falling out as the sampler is withdrawn from the hole. The use of jet-type chopping bits is discouraged except where large boulders and cobbles or hard-cemented soils are encountered. If water markedly softens the soils above the water table, clean out should be performed dry with an auger.

For undisturbed samples below the water table, or where wash water must be minimized, clean out is usually accomplished with an appropriate diameter clean out auger. This auger has cutting blades at the bottom to carry loose material up into the auger, and up-turned water jets just above the cutting blades to carry the removed soil to the surface. In this manner, there is a minimum of disturbance at the top of the material to be sampled. If any gravel material washes down into the casing and cannot be removed by the clean out auger, a split-barrel sample can be taken to remove it; bailers and sandpumps should not be used. For undisturbed samples above the groundwater table, all operations must be performed in a dry manner.

If all of the cuttings created by drilling through the overlying formations are not cleaned from the borehole prior to sampling, some of the problems which may be encountered during sampling include:

- When sampling is attempted through the cuttings remaining in the borehole, all or part of the sampler may become filled with the cuttings. This limits the amount of sample from the underlying formation which can enter and be retained in the sampler, and also raises questions as to the validity of the sample.
- If the cuttings remaining in the borehole contain coarse gravel and/or other large particles, these may block the bit of the sampler and prevent any materials from the underlying formation from entering the sampler when the sampler is advanced.
- In cased borings, should sampling be attempted through cuttings which remain in the lower portion of the casing, these cuttings could cause the sampler to become bound into the casing, such that it becomes very difficult to either advance or retract the sampler.
- When sampler blow counts are used to estimate the density or strength of the formation being sampled, the presence of cuttings in the borehole will usually give erroneously high sample blow counts.

To confirm that all cuttings have been removed from the borehole prior to attempting sampling, it is important that the rig geologist measure the "stickup" of the drill string. This is accomplished by measuring the assembled length of all drill rods and bits or samplers (the drill string) as they are lowered to the bottom of the hole, below some convenient reference point of the drill string, then measuring the height of this reference point above the ground surface. The difference of these measurements is the depth of the drill string (lower end of the bit or sampler) below the ground surface, which must then be compared with the depth of sampling required (installed depth of casing or depth of borehole drilled). If the length of drill string below grade is more than the drilled or casing depth, the borehole has been cleaned too deeply, and this deeper depth of sampling must be recorded on the log. If the length of drill string below grade is less than the drilled or casing depth, the difference represents the thickness of cuttings which remain in the borehole. In most cases, an inch or two of cuttings may be left in the borehole with little or no problem. However, if more than a few inches of cuttings are encountered, the borehole must be recleaned prior to attempting sampling.

5.5 Materials of Construction

The effects of monitoring well construction materials on specific chemical analytical parameters are described and/or referenced in SOP GH-2.8. However, there are several materials used during drilling, particularly drilling fluids and lubricants, which must be used with care to avoid compromising the representativeness of soil and ground water samples.

The use of synthetic or organic polymer slurries is not permitted at any location where soil samples for chemical analysis are to be collected. These slurry materials could be used for installation of long-term monitoring wells, but the early time data in time series collection of ground water data may then be suspect. If synthetic or organic polymer muds are proposed for use at a given site, a complete written justification including methods and procedures for their use must be provided by the site geologist and approved by the Project Manager. The specific slurry composition and the concentration of suspected contaminants for each site must be known.

For many drilling operations, potable water is an adequate lubricant for drill stem and drilling tool connections. However, there are instances, such as drilling in tight clayey formations or in loose gravels, when threaded couplings must be lubricated to avoid binding. In these instances, to be determined in the field by the judgment of the site geologist and noted in the site logbook, and only after approval by the Project Manager, a vegetable oil or silicone-based lubricant should be used. Petroleum based greases, etc. will not be permitted. Samples of lubricants used must be provided and analyzed for chemical parameters appropriate to the given site.

5.6 Subsurface Soil Samples

Subsurface soil samples are used to characterize subsurface stratigraphy. This characterization can indicate the potential for migration of chemical contaminants in the subsurface. In addition, definition of the actual migration of contaminants can be obtained through chemical analysis of the soil samples. Where the remedial activities may include in-situ treatment or excavation and removal of the contaminated soil, the depth and areal extent of contamination must be known as accurately as possible.

Engineering and physical properties of soil may also be of interest should site construction activities be planned. Soil types, grain size distribution, shear strength, compressibility, permeability, plasticity, unit weight, and moisture content are some of the physical characteristics that may be determined for soil samples.

Penetration tests are also described in this procedure. The tests can be used to estimate various physical and engineering parameters such as relative density, unconfined compressive strength, and consolidation characteristics of soils.

Surface protocols for various soil sampling techniques are discussed in SOP SA-1.3. Continuous-core soil sampling and rock coring are discussed below. The procedures described here are representative of a larger number of possible drilling and sampling techniques. The choice of techniques is based on a large number of variables such as cost, local geology, etc. The final choice of methods must be made with the assistance of drilling subcontractors familiar with the local geologic conditions. Alternative techniques must be based upon the underlying principles of quality assurance implicit in the following procedures.

The CME continuous sample tube system provides a method of sampling soil continuously during hollow-stem augering. The 5-foot sample barrel fits within the lead auger of a hollow-auger column. The sampling system can be used with a wide range of I.D. hollow-stem augers (from 3-1/4-inch to 8-1/4-inch I.D.). This method has been used to sample many different materials such as glacial drift, hard clays and shales, mine tailings, etc. This method is particularly used when SPT samples are not required and a large volume of material is needed. Also, this method is useful when a visual description of the subsurface lithology is required. Rotosonic drilling methods also provide a continuous soil sample.

5.7 Rock Sampling (Coring) (ASTM D2113-83)

Rock coring enables a detailed assessment of borehole conditions to be made, showing precisely all lithologic changes and characteristics. Because coring is an expensive drilling method, it is commonly used for shallow studies of 500 feet or less, or for specific intervals in the drill hole that require detailed logging and/or analyzing. Rock coring can, however, proceed for thousands of feet continuously, depending on the size of the drill rig, and yields better quality data than air-rotary drilling, although at a substantially reduced drilling rate. Rate of drilling varies widely, depending on the characteristics of lithologies encountered, drilling methods, depth of drilling, and condition of drilling equipment. Average output in a 10-hour day ranges from 40 to over 200 feet. Down hole geophysical logging or television camera monitoring is sometimes used to complement the data generated by coring.

Borehole diameter can be drilled to various sizes, depending on the information needed. Standard sizes of core barrels (showing core diameter) and casing are shown in Figure 1.

Core drilling is used when formations are too hard to be sampled by soil sampling methods and a continuous solid sample is desired. Usually, soil samples are used for overburden, and coring begins in sound bedrock. Casing is set into bedrock before coring begins to prevent loose material from entering the borehole, to prevent loss of drilling fluid, and to prevent cross-contamination of aquifers.

Drilling through bedrock is initiated by using a diamond-tipped core bit threaded to a drill rod (outer core barrel) with a rate of drilling determined by the downward pressure, rotation speed of drill rods, drilling fluid pressure in the borehole, and the characteristics of the rock (mineralogy, cementation, weathering).

5.7.1 Diamond Core Drilling

A penetration of typically less than 6 inches per 50 blows using a 140-lb. hammer dropping 30 inches with a 2-inch split-barrel sampler shall be considered an indication that soil sampling methods may not be applicable and that coring may be necessary to obtain samples.

When formations are encountered that are too hard to be sampled by soil sampling methods, the following diamond core drilling procedure may be used:

- Firmly seat a casing into the bedrock or the hard material to prevent loose materials from entering the hole and to prevent the loss of drilling fluid return. Level the surface of the rock or hard material when necessary by the use of a fishtail or other bits. If the drill hole can be retained open without the casing and if cross-contamination of aquifers in the unconsolidated materials is unlikely, leveling may be omitted.

- Begin the core drilling using a double-tube swivel-core barrel of the desired size. After drilling no more than 10 feet (3 m), remove the core barrel from the hole and take out the core. If the core blocks the flow of the drilling fluid during drilling, remove the core barrel immediately. In soft materials, a large starting size may be specified for the coring tools; where local experience indicates satisfactory core recovery or where hard, sound materials are anticipated, a smaller size or the single-tube type may be specified and longer runs may be drilled. NX/NW size coring equipment is the most commonly used size.

- When soft materials are encountered that produce less than 50 percent recovery, stop the core drilling. If soil samples are desired, secure such samples in accordance with the procedures described in ASTM Method D 1586 (Split-barrel Sampling) or in Method D 1587 (Thin-Walled Tube Sampling); sample soils per SOP SA-1.3. Resume diamond core drilling when refusal materials are again encountered.

- Since rock structures and the occurrence of seams, fissures, cavities, and broken areas are among the most important items to be detected and described, take special care to obtain and record these features. If such broken zones or cavities prevent further advance of the boring, one of the following three steps shall be taken: (1) cement the hole; (2) ream and case; or (3) case and advance with the next smaller size core barrel, as conditions warrant.

FIGURE 1

STANDARD SIZES OF CORE BARRELS AND CASING

Coring Bit Size	Nominal*		Set Size*	
	O.D.	I.D.	O.D.	I.D.
RWT	1 5/32	3/4	1.160	0.735
EWT	1 1/2	29/32	1.470	0.905
EX, EXL, EWG, EWM	1 1/2	13/16	1.470	0.845
AWT	1 7/8	1 9/32	1.875	1.281
AX, AXL, AWG, AWM	1 7/8	1 3/16	1.875	1.185
BWT	2 3/8	1 3/4	2.345	1.750
BX, BXL, BWG, BWM	2 3/8	1 5/8	2.345	1.655
NWT	3	2 5/16	2.965	2.313
NX, NXL, NWG, NWM	3	2 1/8	2.965	2.155
HWT	3 29/32	3 3/16	3.889	3.187
HWG	3 29/32	3	3.889	3.000
2 3/4 x 3 7/8	3 7/8	2 3/4	3.840	2.690
4 x 5 1/2	5 1/2	4	5.435	3.970
6 x 7 3/4	7 3/4	6	7.655	5.970
AX Wire line ___|___/	1 7/8	1	1.875	1.000
BX Wire line ___|___/	2 3/8	1 7/16	2.345	1.437
NX Wire line ___|___/	3	1 15/16	2.965	1.937

* All dimensions are in inches; to convert to millimeters, multiply by 254.
___|___/ Wire line dimensions and designations may vary according to manufacturer.

FIGURE 1
STANDARD SIZES OF CORE BARRELS AND CASING
PAGE TWO

Size Designations		Casing O.D., Inches	Casing Coupling		Casing bit O.D., Inches	Core barrel bit O.D., Inches*	Drill rod O.D., Inches	Approximate Core Diameter	
Casing; Casing coupling; Casing bits; Core barrel bits	Rod; rod couplings		O.D., Inches	I.D., Inches				Normal, Inches	Thinwall, Inches
RX	RW	1.437	1.437	1.188	1.485	1.160	1.094	—	0.735
EX	E	1.812	1.812	1.500	1.875	1.470	1.313	0.845	0.905
AX	A	2.250	2.250	1.906	2.345	1.875	1.625	1.185	1.281
BX	B	2.875	2.875	2.375	2.965	2.345	1.906	1.655	1.750
NX	N	3.500	3.500	3.000	3.615	2.965	2.375	2.155	2.313
HX	HW	4.500	4.500	3.938	4.625	3.890	3.500	3.000	3.187
RW	RW	1.437	Flush Joint	No Coupling	1.485	1.160	1.094	—	0.735
EW	EW	1.812			1.875	1.470	1.375	0.845	0.905
AW	AW	2.250			2.345	1.875	1.750	1.185	1.281
BW	BW	2.875			2.965	2.345	2.125	1.655	1.750
NW	NW	3.500			3.615	2.965	2.625	2.155	2.313
HW	HW	4.500			4.625	3.890	3.500	3.000	3.187
PW	—	5.500			5.650	—	—	—	—
SW	—	6.625			6.790	—	—	—	—
UW	—	7.625			7.800	—	—	—	—
ZW	—	8.625			8.810	—	—	—	—
—	AX __|__\	—	—	—	—	1.875	1.750	1.000	—
—	BX __|__\	—	—	—	—	2.345	2.250	1.437	—
—	NX __|__\	—	—	—	—	2.965	2.813	1.937	—

* All dimensions are in inches; to convert to millimeters, multiply by 254.

___|___/ Wire line dimensions and designations may vary according to manufacturer.

NOMINAL DIMENSIONS FOR DRILL CASINGS AND ACCESSORIES. (DIAMOND CORE DRILL MANUFACTURERS ASSOCIATION). 288-D-2889

- In soft, seamy, or otherwise unsound rock, where core recovery may be difficult, M-design core barrels may be used. In hard, sound rock where a high percentage of core recovery is anticipated, the single-tube core barrel may be employed.

5.7.2 Rock Sample Preparation and Documentation

Once the rock coring has been completed and the core recovered, the rock core shall be carefully removed from the barrel, placed in a core tray (previously labeled "top" and "bottom" to avoid confusion), classified, and measured for percentage of recovery as well as the rock quality designation (RQD). Each core shall be described, classified, and logged using a uniform system as presented in SOP GH-1.5. If moisture content will be determined or if it is desirable to prevent drying (e.g., to prevent shrinkage of clay formations) or oxidation of the core, the core shall be wrapped in plastic sleeves immediately after logging. Each plastic sleeve shall be labeled with indelible ink. The boring number, run number, and the footage represented in each sleeve shall be included, as well as designating the top and bottom of the core run.

After sampling, rock cores shall be placed in the sequence of recovery in well-constructed wooden boxes provided by the drilling contractor. Rock cores from two different borings shall not be placed in the same core box unless accepted by the Project Geologist. The core boxes shall be constructed to accommodate at least 20 linear feet of core in rows of approximately 5 feet each and shall be constructed with hinged tops secured with screws, and a latch (usually a hook and eye) to keep the top securely fastened down. Wood partitions shall be placed at the end of each core run and between rows.

The depth from the surface of the boring to the top and bottom of the drill run and run number shall be marked on the wooden partitions with indelible ink. A wooden partition (wooden block) shall be placed at the end of each run with the depth of the bottom of the run written on the block. These blocks will serve to separate successive core runs and indicate depth intervals for each run. The order of placing cores shall be the same in all core boxes. Rock core shall be placed in the box so that, when the box is open, with the inside of the lid facing the observer, the top of the cored interval contained within the box is in the upper left corner of the box, and the bottom of the cored interval is in the lower right corner of the box. The top and bottom of each core obtained and its true depth shall be clearly and permanently marked on each box. The width of each row must be compatible with the core diameter to prevent lateral movement of the core in the box. Similarly, an empty space in a row shall be filled with an appropriate filler material or spacers to prevent longitudinal movement of the core in the box.
The inside and outside of the core-box lid shall be marked by indelible ink to show all pertinent data on the box's contents. At a minimum, the following information shall be included:

- Project name.
- Project number.
- Boring number.
- Run numbers.
- Footage (depths).
- Recovery.
- RQD (%).
- Box number and total number of boxes for that boring (Example: Box 5 of 7).

For easy retrieval when core boxes are stacked, the sides and ends of the box shall also be labeled and include project number, boring number, top and bottom depths of core and box number.

Prior to final closing of the core box, a photograph of the recovered core and the labeling on the inside cover shall be taken. If moisture content is not critical, the core shall be wetted and wiped clean for the photograph. (This will help to show true colors and bedding features in the cores).

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ATTACHMENT A

DRILLING EQUIPMENT SIZES

Drilling Component	Designation or Hole Size (Inches)	O.D. (Inches)	I.D. (Inches)	Coupling I.D. (Inches)
Hollow-stem augers (Ref. 7)	6 1/4	5	2 1/4	
	6 3/4	5 3/4	2 3/4	—
	7 1/4	6 1/4	3 1/4	—
	13 1/4	12	6	—
Thin Wall Tube Samplers (Ref. 7)	—	2	1 7/8	—
	—	2 1/2	2 3/8	—
	—	3	2 7/8	—
	—	3 1/2	3 3/8	—
	—	4 1/2	4 3/8	—
	—	5	4 3/4	—
Drill Rods (Ref. 7)	RW	1 3/32	23/32	13/32
	EW	1 3/8	15/16	7/16
	AW	1 3/4	1 1/4	5/8
	BW	2 1/8	1 3/4	3/4
	NW	2 5/8	2 1/4	1 3/8
	HW	3 1/2	3 1/16	2 3/8
	E	1 5/16	7/8	7/16
	A	1 5/8	1 1/8	9/16
	B	1 7/8	1 1/4	5/8
	N	2 3/8	2	1
				Wall Thickness (Inches)
Driven External Coupled Extra Strong Steel* Casing (Ref. 8)	2 1/2	2.875	2.323	0.276
	3	3.5	2.9	0.300
	3 1/2	4.0	3.364	0.318
	4	4.5	3.826	0.337
	5	5.63	4.813	0.375
	6	6.625	5.761	0.432
	8	8.625	7.625	0.500
	10	10.750	9.750	0.500
	12	12.750	11.750	0.500

* Add twice the casing wall thickness to casing O.D. to obtain the approximate O.D. of the external pipe couplings.

ATTACHMENT A
DRILLING EQUIPMENT SIZES
PAGE TWO

Drilling Component	Designation or Hole Size (Inches)	O.D. (Inches)	I.D. (Inches)	Coupling I.D. (Inches)
Flush Coupled Casing (Ref. 7)	RX	1 7/16	1 3/16	1 3/16
	EX	1 13/16	1 5/8	1 1/2
	AX	2 1/4	2	1 29/32
	BX	2 7/8	2 9/16	2 3/8
	NX	3 1/2	3 3/16	3
	HX	4 1/2	4 1/8	3 15/16
Flush Joint Casing (Ref. 7)	RW	1 7/16	1 3/16	
	EW	1 13/16	1 1/2	
	AW	2 1/4	1 29/32	
	BW	2 7/8	2 3/8	
	NW	3 1/2	3	
	HW	4 1/2	4	
	PW	5 1/2	5	
	SW	6 5/8	6	
	UW	7 5/8	7	
	ZW	8 5/8	8	
Diamond Core Barrels (Ref. 7)	EWM	1 1/2	7/8**	
	AWM	1 7/8	1 1/8**	
	BWM	2 3/8	1 5/8**	
	NWM	3	2 1/8	
	HWG	3 7/8	3	
	2 3/4 x 3 7/8	3 7/8	2 11/16	
	4 x 5 1/2	5 1/2	3 15/16	
	6 x 7 3/4	7 3/4	5 15/16	
	AQ (wireline)	1 57/64	1 1/16**	
	BQ (wireline)	2 23/64	1 7/16**	
	NQ (wireline)	2 63/64	1 7/8	
	HQ (wireline)	3 25/32	2 1/2	

** Because of the fragile nature of the core and the difficulty to identify rock details, use of small-diameter core (1 3/8") is not recommended.

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		Effective Date 03/01/96	Revision 0
		Applicability B&R Environmental, NE	
		Prepared Earth Sciences Department	
Subject BOREHOLE AND SAMPLE LOGGING		Approved D. Senovich	

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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).

FIGURE 1

BORING LOG (EXAMPLE)

BORING LOG

Page ___ of ___

PROJECT NAME: ______________________
PROJECT NUMBER: ______________________
DRILLING COMPANY: ______________________
DRILLING RIG: ______________________

BORING NUMBER: ______________________
DATE: ______________________
GEOLOGIST: ______________________
DRILLER: ______________________

Sample No. and Type or RQD	Depth (Ft.) or Run No.	Blows / 6" or RQD (%)	Sample Recovery / Sample Length	Lithology Change (Depth/Ft.) or Screened Interval	MATERIAL DESCRIPTION			U S C S *	Remarks	PID/FID Reading (ppm)			
					Soil Density/ Consistency or Rock Hardness	Color	Material Classification			Sample	Sampler BZ	Borehole**	Driller BZ

* When rock coring, enter rock brokeness.

** Include monitor reading in 6 foot intervals @ borehole. Increase reading frequency if elevated response read.

Remarks: ______________________

Drilling Area Background (ppm): ☐

Converted to Well: Yes ______ No ______ Well I.D. #: ______________

FIGURE 1 (CONTINUED)

SOIL TERMS

UNIFIED SOIL CLASSIFICATION (USCS)

COARSE-GRAINED SOILS
More Than Half of Material is LARGER Than No. 200 Sieve Size

FIELD IDENTIFICATION PROCEDURES (Excluding Particles Larger Than 3 Inches and Basing Fractions on Estimated Weights)			GROUP SYMBOL	TYPICAL NAMES
GRAVELS (50%(+)>1/4"Ø	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.
		Predominantly one size or a range of sizes with some intermediate sizes missing.	GP	Poorly graded gravels, gravel-sand mixtures, little or no fines.
	GRAVELS W/FINES (High % Fines)	Non-plastic fines (for identification procedures, see ML)	GM	Silty gravels, poorly graded gravel-sand-silt mixtures.
		Plastic fines (for identification procedures, see CL)	GC	Clayey gravels, poorly graded gravel sand-clay mixtures.
SANDS 50%(+)<1/4"Ø	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.
		Predominantly one size or a range of sizes with some intermediate sizes missing.	SP	Poorly graded sands, gravelly sands, little or no fines.
	SANDS W/FINES (High % Fines)	Non-plastic fines (for identification procedures, see MCL)	SM	Silty sands, poorly graded sand-silt mixtures.
		Plastic fines (for identification procedures, see CL)	SC	Clayey sands, poorly graded sand clay mixtures.

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
	Identification Procedures on Fraction Smaller than No. 40 Sieve Size				
	DRY STRENGTH (Crushing Characteristics)	DILATANCY (Reaction to Shaking)	TOUGHNESS (Consistency Near Plastic Limit)		
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.
	Medium to High	None to Very Slow	Medium	CL	Inorganic clays of low to medium plasticity, gravelly clays, sandy clays, silty clays, lean clays.
	Slight to Medium	Slow	Slight	OL	Organic silts and organic silt-clays of low plasticity.
SILTS AND CLAYS Liquid Limit >50	Slight to Medium	Slow to None	Slight to Medium	MH	Inorganic silts, micaceous or diatomaceous fine sandy or silty soils, elastic silts.
	High to Very High	None	High	CH	Inorganic clays of high plasticity, fat clays.
	Medium to High	None to Very Slow	Slight to Medium	OH	Organic clays of medium to high plasticity.
HIGHLY ORGANIC SOILS	Readily identified by color, odor, spongy feel and frequently by fibrous texture.			Pt	Peat and other organic soils

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.

DENSITY OF GRANULAR SOILS

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 OF COHESIVE SOILS

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 BROKENNESS		
Descriptive Terms	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:

SOIL SAMPLES - TYPES
S-2" Split-Barrel Sample
ST-3" O.D. Undisturbed Sample
O - Other Samples, Specify in Remarks

ROCK SAMPLES - TYPES
X-NX (Conventional) Core (-2-1/8" O.D.)
Q-NQ (Wireline) Core (-1-7/8" O.D.)
Z - Other Core Sizes, Specify in Remarks

WATER LEVELS
12/10
▼ 12.6' Initial Level w/Date & Depth
12/10
▼ 12.6' Stabilized Level w/Date & Depth

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 inchΦ-1/2 inchΦ)" 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:

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.

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

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)

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

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 works "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.

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

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).

- 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.

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

Page 1 of 1

PROJECT NAME: NSB - SITE
PROJECT NUMBER: 9594
DRILLING COMPANY: SOILTEST CO.
DRILLING RIG: CME-55
BORING NUMBER: SB/MW 1
DATE: 3/8/96
GEOLOGIST: SJ CONTI
DRILLER: R. ROCK

Sample No. and Type or RQD	Depth (Ft.) or Run No.	Blows / 6" or RQD (%)	Sample Recovery / Sample Length	Lithology Change (Depth/Ft.) or Screened Interval	MATERIAL DESCRIPTION: Soil Density/ Consistency or Rock Hardness	Color	Material Classification	U S C S *	Remarks	PID/FID Reading (ppm): Sample	Sampler BZ	Borehole**	Driller BZ**
S-1	0.0	7/6	1.5/2.0		M DENSE	BRN	SILTY SAND - SOME	SM	MOIST SL. ORG.	5	0	0	0
@ 0800	2.0	9/10				TO BLK	ROCK FR. - TR BRICKS		ODOR				
							(FILL)		FILL TO 4'±				
	4.0			4.0	↓	↓	↓						
S-2 @		5/7	2.0/2.0		M DENSE	BRN	SILTY SAND - TR FINE	SM	MOIST - W ODOR	10	0	-	-
0810	6.0	9/8					GRAVEL		NAT. MATL. TOOK SAMPLE				
	●			7' ▽ ±					SB01-0406 FOR ANALYSIS				
	8.0			8.0	↓	↓	↓						
S-3 @		6/8	1.9/2.0		DENSE	TAN BRN	FINE TO COARSE SAND	SW	WET	0	0	0	0
0820	10.0	17/16					TR. F. GRAVEL		HIT WATER ≈ 7'±				
	12.0			12.0	↓	↓	↓						
S-4 @		7/6	1.6/2.0		STIFF	GRAY	SILTY CLAY	CL	MOIST → WET	0	.5	-	-
0830	14.0	5/8											
	15.0			15.0	↓	↓	↓		AUGER REF @ 15'				
▼			▼	[illegible]	M HARD	BRN	SILTSTONE	WBR	WEATHERED				
				16					LO & JNTS @ 15.5				
9/5	①		4.0/5.0						WATER STAINS @ 16.5, 17.1, 17.5	0	0	0	0
				19'	↓	↓	↓	↓	LOSING SOME				
⊕	20.0		⊕		HARD	GRAY	SANDSTONE - SOME	BR	DRILL H2O @ 17'±				
							SILTSTONE		SET TEMP 6" CAS TO 15.5				
4.0/5.0	②		5.0/5.0						SET 2" Ø PVC SCREEN 16-25	0	0	0	0
									SAND 14-25				
▲	25.0		▲	25	↓	↓	↓	↓	PELLETS 12-14				

* When rock coring, enter rock brokeness.

** Include monitor reading in 6 foot intervals @ borehole. Increase reading frequency if elevated response read.

● 1-20Z
1-80Z

Drilling Area Background (ppm): 0

Remarks: CME-55 RIG, 4 1/4" ID HSA - 9" OD ±
2" SPLIT SPOONS - 140 LB HAMMER - 30" DROP
NX CORE IN BEDROCK RUN ① = 25 min. RUN ② = 15 min

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

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.

  - 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.

- 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" 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.

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		Applicability B&R Environmental, NE	
		Prepared Earth Sciences Department	
Subject GROUNDWATER MONITORING POINT INSTALLATION		Approved D. Senovich	

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ATTACHMENTS

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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.

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 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:

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 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

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 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.

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 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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Barcelona, M. J., P. P. Gibb and R. A. Miller, 1983. A Guide to the selection of Materials for Monitoring Well Construction and Groundwater Sampling. ISWS Contract Report 327, Illinois State Water Survey, Champaign, Illinois.

U.S. EPA, 1980. Procedures Manual for Groundwater Monitoring of Solid Waste Disposal Facilities. Publication SW-611, Office of Solid Waste, U.S. EPA, Washington, D.C.

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

* 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®
2 Polypropylene (PP)
3. PVC Flexible/PE Linear
4 Viton®
5 PE Conventional
6 Plexiglas/Lucite (PMM)
7 Silicone/Neoprene

* Trademark of DuPont

Source: Barcelona et al., 1983

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.

APPENDIX E

SITE SPECIFIC HEALTH & SAFETY PLAN

AIR SPARGING/SOIL VAPOR EXTRACTION PILOT STUDY

Naval Weapons Industrial Reserve Plant

Bethpage, New York

DEPARTMENT OF THE NAVY • UNITED STATES OF AMERICA

Northern Division
Naval Facilities Engineering Command
Contract Number N62472-90-D-1298
Contract Task Order 0215

February 1997

C F BRAUN ENGINEERING CORPORATION

AIR SPARGING / SOIL VAPOR EXTRACTION PILOT STUDY FOR NAVAL WEAPONS INDUSTRIAL RESERVE PLANT BETHPAGE, NEW YORK

COMPREHENSIVE LONG-TERM ENVIRONMENTAL ACTION NAVY (CLEAN) CONTRACT

Submitted to:
Northern Division
Environmental Branch Code 18
Naval Facilities Engineering Command
10 Industrial Highway, Mail Stop #82
Lester, Pennsylvania 19113-2090

Submitted by:
CF Braun Engineering Corporation
993 Old Eagle School Road, Suite 415
Wayne, Pennsylvania 19087-1710

CONTRACT NUMBER N62472-90-D-1298
CONTRACT TASK ORDER 0215

FEBRUARY 1997

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1.0 INTRODUCTION

This Health and Safety Plan (HASP) has been specifically written for Naval Weapons Industrial Reserve Plant (NWIRP), Bethpage, New York. This HASP provides the minimum health and safety practices required for CF Braun Engineering Corporation and subcontractor personnel involved in the pre-pilot site characterization and Pilot-scale Remediation System installation. The latest available information regarding known or suspected chemical contaminants and potential physical hazards is included in this document. This plan must be used in conjunction with the Brown & Root Environmental Health and Safety Guidance Manual which contains detailed information on the policies and procedures listed within this HASP. This plan may be modified as new information becomes available. Requests for modifications to this plan will be directed to the SSO who will in turn, determine and make the necessary changes. The SSO will notify the Project Manager (PM) who will notify all affected personnel of all changes. A Site Safety Follow Up Report will document all changes to this plan. This HASP has been written and is intended to be in compliance with the requirements established by OSHA 29 CFR 1910.120 "Hazardous Waste Operations and Emergency Response" (HAZWOPER) and applicable sections of 29 CFR 1926 "Safety and Health Regulations For Construction." The information contained in this plan and policies on conducting on site operations were obtained from the Brown & Root Environmental Health and Safety Program and Bethpage NWIRP policies and procedures.

1.1 KEY PROJECT PERSONNEL AND ORGANIZATION

This section defines responsibility for site safety and health for CF Braun Engineering Corporation and subcontractor employees engaged in on site activities. Personnel assigned to these positions will exercise the primary responsibility for all on site health and safety. These persons will be the primary point of contact for any questions regarding the safety and health procedures and the selected control measures.

- The CF Braun Engineering Corporation Project Manager (PM) is responsible for the overall direction and implementation of health and safety for this project.

- The CF Braun Engineering Corporation Field Operations Leader (FOL) is responsible for implementation of this HASP with the assistance of an appointed Site Safety Officer (SSO). The FOL duties may include:

    - Managing field activities.
    - Execution of the work plan.

    - Enforcement safety procedures, as applicable to the work plan.
    - Implementation of activities deemed necessary by the SSO.

- The SSO supports site activities by advising the FOL on all aspects of health and safety on site. These duties may include:

    - Coordinates all health and safety activities with the FOL
    - Selects, applies, inspects, and maintains personal protective equipment
    - Establishes work zones and control points
    - Implements air monitoring program for onsite activities
    - Verifies training and medical of onsite personnel status in relation to site activities
    - Implements hazard communication and respiratory protection programs
    - Coordinates emergency services.

- Compliance to these requirements is monitored by the SSO and coordinated through the CLEAN HSM.

1.2 SITE INFORMATION AND PERSONNEL ASSIGNMENTS

Site Name:	NWIRP Bethpage	Client Contact:	Al Taormina (ROICC)
Address:	Nassau County, New York	Phone Number:	(516) 525-2121
Effective Date:	February 1997	Alternate Contact:	None identified

Purpose of Site Visit: This activity will be divided into a multi-task operation including pre-pilot site characterization and the installation of a pilot scale Air Sparging / Vapor Extraction (ASVE) Remedial System to be operated for 3 month period. Detail information concerning these tasks may be found in the scope of work.

Proposed Dates of Work: Spring 1997

CF Braun Engineering Corporation Personnel:	**Discipline/Tasks Assigned:**
David D. Brayack, P.E.	Project Manager (PM)
Matthew M. Soltis, CIH, CSP	CLEAN Health and Safety Manager (HSM)
TBD	Field Operations Leader (FOL)
TBD	Field Engineers
Donald J. Westerhoff, CSP	Project Health and Safety Officer/Site Safety Officer (SSO)
Non-CF Braun Engineering Corporation Personnel:	Affiliation/Discipline/Tasks Assigned:
TBD	TBD
TBD	TBD

Prepared by: Donald J. Westerhoff, CSP

Reviewed and Approved by:

David D. Brayack, P.E.
Project Manager

Matthew M. Soltis CIH, CSP
CLEAN Health & Safety Manager

2.0 EMERGENCY ACTION PLAN

2.1 INTRODUCTION

In the event of onsite emergencies, site personnel will be evacuated to a safe place of refuge. The appropriate emergency response agencies will be notified. The emergency response agencies listed in this plan are capable of providing the most effective response. These agencies are located within a reasonable distance from the area of operations. This ensures adequate emergency response time. CF Braun Engineering Corporation and subcontractor personnel will not provide emergency response support. This is due to the types of emergencies most likely to be encountered during performance of this work, and limitations of the field crew concerning the types of equipment necessary to support this type of operation. This emergency action plan conforms to the requirements of OSHA Standard 29 CFR 1910.38(a), as defined in OSHA 29 CFR 1910.120(l)(1)(ii).

2.2 PRE-EMERGENCY PLANNING

Pre-emergency planning activities associated with this project include the following:

- The SSO and/or the FOL are responsible for coordinating with Bethpage NWIRP Emergency Services personnel to ensure that CF Braun Engineering Corporation emergency action activities are compatible with existing facility emergency response procedures.

- The CF Braun Engineering Corporation FOL will be responsible for establishing and maintaining information at the project staging area (support zone) for easy access in the event of an emergency. This information will include the following:

    - Chemical Inventory (used on site), with Material Safety Data Sheets.
    - On-site personnel medical records (medical data sheets).
    - A logbook identifying personnel on site, and activities which are being conducted each day.

- The FOL and the SSO will periodically evaluate ongoing operation in an effort to identify and/or minimize potential hazards and foreseeable emergencies. This activity will be documented within the logbook. Preliminary evaluations of the planned activities indicate that the only foreseeable emergencies in this case is the potential for injury or illness.

- Identifying a chain of command for emergency action. For on site activities at NWIRP the FOL will serve as the primary point of contact for CF Braun Engineering Corporation and subcontractor personnel. The FOL will be supported in this effort by the SSO who will serve as an alternate.

2.3 EMERGENCY RECOGNITION AND PREVENTION

2.3.1 Recognition

Generally, potential emergency situations are recognizable by visual observation. An injury or illness will be considered an emergency, if it requires treatment other than self administered first-aid (i.e. requires treatment by a medical professional).

2.3.2 Prevention

CF Braun Engineering Corporation will attempt to minimize or prevent emergencies by ensuring compliance with this site-specific HASP, and regular monitoring of the work areas and field crews.

2.4 SAFE DISTANCES AND PLACES OF REFUGE

In the event that the site must be evacuated, all personnel will immediately stop activities and report to the telephone communications point for that area (office area). Upon reporting to the refuge location, personnel will remain there until directed otherwise by the CF Braun Engineering Corporation FOL. The FOL or the SSO will take a head count at this location, using the logbook, to confirm the location of all site personnel.

2.5 EVACUATION ROUTES AND PROCEDURES

An evacuation will be initiated whenever; a fire or explosion occurs, readings on monitoring instrumentation indicate levels of contamination greater than instituted action levels, or personnel show signs or symptoms of overexposure to potential site contaminants. In the event of an evacuation, personnel will proceed immediately to the support zone (office area), unless doing so would further jeopardize the welfare of workers. Should access to the primary assembly point be denied, personnel will proceed to an alternate location until instructed otherwise by the CF Braun Engineering Corporation FOL. Alternate locations will be selected by the FOL or the SSO and communicated to the field crews, prior to the initiation of any work relative to the area of operation for that day. These locations for that day will be documented in the logbook for each area of operation.

Emergency alerting and evacuation procedures will be drilled at a time selected by the FOL and SSO to determine its effectiveness.

2.6 DECONTAMINATION PROCEDURES/EMERGENCY MEDICAL TREATMENT

Decontamination procedures will be performed only if doing so does not further jeopardize the welfare of site workers. Decontamination will not be performed, if the action which initiates an evacuation would further endanger the lives of workers, if workers were to perform decontamination procedures. However, it is unlikely that such an event could occur at this site that would require workers to evacuate the site without first performing decontamination procedures.

2.7 EMERGENCY ALERTING AND ACTION/RESPONSE PROCEDURES

Since CF Braun Engineering Corporation personnel will be working in close proximity to each other, hand signals and voice commands, and 2-way radio will be sufficient to alert site personnel of an emergency.

If an accident occurs on Base, the following procedures are to be initiated:

> Call **575-3895** (Guard Headquarters) and report the emergency. All personnel initiating emergency notification procedures shall provide the following information

- Give the emergency operator
    - Your name;
    - The location of the emergency;
    - Brief description of what has occurred;
    - The number of personnel involved;
    - The types of injuries, or assistance needed.
- Follow the instructions given by the operator. Emergency services will be notified by the guards, who will in turn, direct them to your location upon their arrival.

All emergency notification shall be directed through the Guard Headquarters. Failure to do so may result in the emergency services arriving at the gate being denied access.

2.8 PPE AND EMERGENCY EQUIPMENT

A first-aid kit, fire extinguishers (strategically placed), portable eyewash, and fire blanket will be maintained on site and immediately available for use in the event of an emergency.

2.9 EMERGENCY CONTACTS

Prior to performing work at any of the sites, all personnel will be thoroughly briefed on the emergency procedures to be followed in the event of an accident. A phone shall be available on site at the office area within Plant 03. The numerical designation beside the reference designation establishes the notification sequence.

EMERGENCY REFERENCE

Bethpage NWIRP - Nassau County, New York

AGENCY	TELEPHONE
EMERGENCY: Ambulance Police Fire Department	**575-3895** Guard Headquarters
David D. Brayack, PE Project Manager	(412) 921-8916
Al Taormina, NWIRP Base Contact	(516) 525-2121
Donald J. Westerhoff, CSP Project HSO/SSO	(412) 921-7281
Matthew M. Soltis, CIH, CSP CLEAN Health & Safety Manager (HSM)	(412) 921-8912
Syossett Hospital	575-3895 Guard Headquarters
National Response Center	(800) 424-8802

FOL: Post emergency numbers at the telephone communications locations.

2.10 EMERGENCY ROUTE TO HOSPITAL

The Guard Headquarters will make all arrangements for transportation in the event of a medical emergency. The Guard Headquaters will be contacted as per instruction provided in Section 2.7, Emergency Alerting and Action Response Procedures.

3.0 SITE BACKGROUND

The NWIRP is a government-owned contractor-operated (GOCO) facility. The NWIRP is situated on approximately 108 acres in Nassau County in the Hamlet of Bethpage, Town of Oyster Bay, New York. The NWIRP is bordered on the north, west, and south by a Grumman Corporation-owned facility which covers approximately 605 acres. There is also a residential neighborhood which borders the NWIRP to the east. An Occidental Chemical/RUCO Polymer Corporation facility (Hooker/RUCO) which is a Federal Superfund site is located adjacent to the western boundary of the Grumman facility.

The NWIRP was divided into three sites for the purpose of conducting Remedial Investigations. These three sites encompass most of the 108 acres. Activities planned for Phase II Remedial Design and Pilot-scale Remediation System installation will be confined to Site 1. A brief description of Site 1 is presented below.

- <u>Site 1 - Former Drum Marshaling Area</u>. This site is located in the middle third of the NWIRP facility and east of Plant 3. It consists of two concrete drum storage pads (no longer active) and an abandoned cesspool leach field. No drums are anticipated to be present in the areas of proposed site activities. The Former Drum Marshaling Area has been used as a storage area for various types of equipment and heavy materials, including transformers.

4.0 SCOPE OF WORK

This CF Braun Engineering Corporation project is a multi-task operation including a pre-characterization of Site 1 to verify the extent of contamination, soil properties, and types and quantities of contamination at Site 1 to provide adequate information for the location of the pilot-scale system and for the design of the full-scale remediation system. This investigation will be performed prior to installation of the pilot system to verify that the location of the pilot system is within an area of contamination. Soil borings will be installed to the water table at the locations identified in Figure 4-1. Additional soil borings will be drilled at the end of the 2 month operation period of the pilot remediation system to determine any impact on the contaminant plume. Soil samples will be collected from each boring. One sample will be collected from the top, one from the middle, and one from the bottom portion of each boring. In addition, split-spoon samples will be collected at 5-foot intervals during installation of the boring for purposes of determining lithology.

The installation of the Air Sparging/Vapor Extraction (ASVE) remedial systems within predetermined locations at Site 1 are pending the initial characterization. This operation will include the following items:

- Installation of recovery and injection wells.
- Installation of a complete ASVE Remedial System including blowers, piping, extraction nests, separators, valves, gages, etc.
- ASVE Pilot Test, and the operation of the ASVE system for a 3 month period.
- Multi media sampling including air, water (ground and surface), soils, decontamination, and purge waters. Personal samples will be collected on personnel representing at-risk job classifications during this action.

The above listing is only a summary of the identified tasks as they apply to the scope and application of this HASP. For a more detailed description of the associated tasks see the Sampling and Analyses Plan (SAP) (Halliburton NUS, April 1995) and the Pilot-scale Work Plan (forth coming).

Other tasks will occur under this contract order, however, they do not apply to the scope and application of this HASP and will not be addressed in this plan.

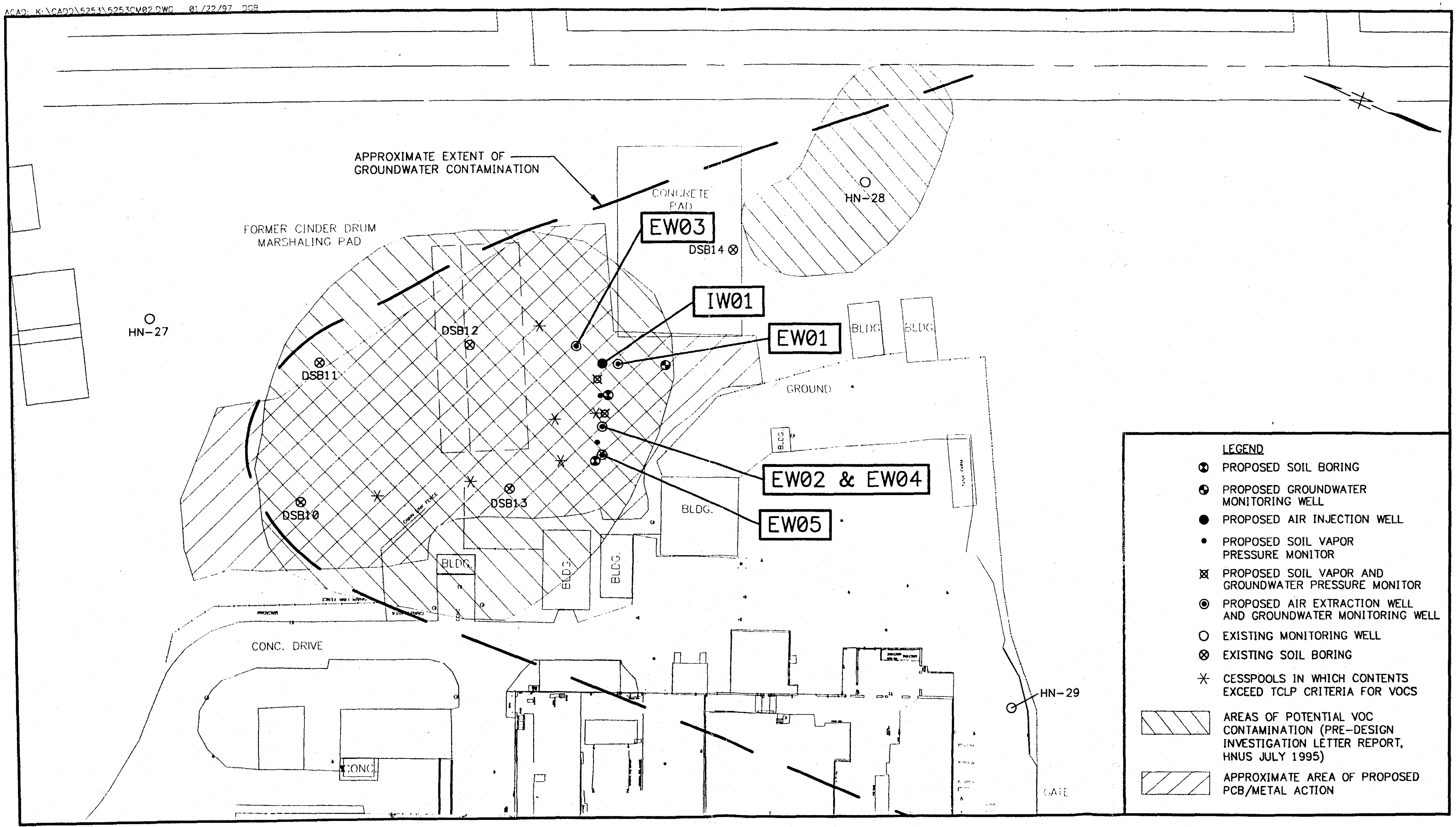


FIGURE 4-1

0 60 120
SCALE IN FEET

SITE 1
PROPOSED LAYOUT – AIR SPARGING/SOIL VAPOR EXTRACTION PILOT STUDY
NWIRP, BETHPAGE, NEW YORK

C.F. BRAUN

0090A04Z

5.0 TASKS/HAZARDS/ASSOCIATED CONTROL MEASURES SUMMARIZATION

The following table identifies the tasks to be performed as stated in Section 4.0, "Scope of Work". Based on these tasks, the anticipated hazards, recommended control measures, air monitoring recommendations, recommended PPE, and decontamination measures that were selected are identified. Should the scope, or other conditions change, this table and control measures will require modification.

Accompanying this site-specific HASP is the Health and Safety Guidance Manual. This manual is designed to further explain supporting elements for any site-specific operations as required by 29 CFR 1910.120.

TASKS/HAZARDS/CONTROL MEASURES COMPENDIUM
BETHPAGE NWIRP ASVE REMEDIATION PROJECT

Tasks/Operation/ Locations	Anticipated Hazards	Recommended Control Measures	Air Monitoring Type/Action Levels	Personal Protective Equipment	Decontamination Procedures
Mobilization Demobilization	Physical hazards including 1) Lifting (muscle strains and pulls) 2) Pinches and compressions 3) Slip, trips, and falls 4) Moving machinery 5) Biological hazards (Insect/animal bites and stings) 6) Vehicular and foot traffic 7) Ambient temperature extremes (particularly cold stress concerns) These hazards may also be associated with the other operations identified in this HASP however they will not be repeated.	1) Employ machinery or multiple personnel for heavy lifts. Use proper lifting techniques. 2) Use tools or other equipment to keep hands out of moving machine areas. 3) Preview work locations for unstable/uneven terrain. 4) All equipment to be employed will be - Inspected in accordance with OSHA, and manufacturers design. - Operated by Certified operators, and knowledgeable ground crew, as applicable. - Establish safe zones of approach (i.e. Boom + 3 feet). - Secure all loose articles to avoid possible entanglement. 5) Avoid nesting areas, employ repellents (Do NOT use repellents during sampling activities). Report potential hazards to the SSO. Frequently inspect clothing and persons during and after activities in wooded areas. 6) Identify all access/egress routes and locations, hours of clearance, and base contacts, in addition to the badge clearance and associated requirements for base clearance. 7) Wear appropriate clothing for weather conditions. Institute work/rest regimens in accordance with ACGIH guidelines. Provide acceptable shelter and liquids for field crews. Additional information regarding cold/heat stress concerns is provided in module 4 of the Brown & Root Environmental Health and Safety Guidance Manual.	Air monitoring activities will not be required for this task since contact with potentially contaminated media should be minimal. However, since surface contamination is likely to be present at the former drum marshaling area (particularly PCB contamination), workers must minimize the generation of dusts as a result of mobilization or demobilization activities. Any observations of airborne dusts will require the use of area wetting methods since contaminants may be bound to particulates (soils). If airborne dusts cannot be controlled by area wetting methods, air monitoring procedures using a direct reading dust monitor or industrial hygiene sampling methods will be required. This determination will be made by the SSO and FOL.	Level D - (Minimum Requirements) - Standard field attire (long sleeve shirt; long pants) - Safety shoes (steel toe/shank) - Safety glasses - Hardhat (when overhead hazards exists, or identified as an operation requirement) - Reflective vest for high traffic areas - Hearing protection for high noise areas, or as directed on an operation by operation scenario. The use of upgraded levels of protection (modified level D consisting of the minimum requirments discussed above plus Tyvek coveralls, disposable boot covers, and nitrile gloves) will be required if this activity is performed in the presence of airborne dusts that cannot be controlled by area wetting methods.	**Personnel Decontamination** will consist of a soap/water wash and rinse for outer protective equipment (e.g. boots, gloves, etc.). This function will take place at an area adjacent to the remedial activities. This procedure will consist of - Equipment drop - Soap/water wash and rinse of outer boots and gloves **Equipment Decontamination** - All equipment decontamination will take place at a centralized decontamination pad utilizing steam or pressure washers. Heavy equipment will have the wheels and tires cleaned of any loose debris removed prior to transporting to the central area. All site vehicles will be restricted or also have their wheels/tires sprayed off as not to track mud onto the roadways servicing the base. Roadways shall be monitored to pick up any debris resulting from the on site activity. 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 onsite and that which is to leave the site. No equipment will be authorized access or exit without this authorization.
Maintenance/ Operation of the ASVE System	Chemical hazards 1) Air, particulate, and water borne contaminants - primarily chlorinated hydrocarbons and hydrocarbons. Metals and PCBs are also associated with the site and are present in surface and subsurface soils. 2) Physical hazards - Energized Systems	1) Use real-time monitoring instruments, action levels, personal sampling, and identified PPE to control potential exposures. 2) Utilize accepted energy control measures as defined in OSHA 29 CFR 1910.147 to control potential energy sources during maintenance. **NOTE:** Process review in accordance with protocol established in OSHA 29 CPR 1910.119 process safety management is recommended. Although the contaminants of question are not identified as applicable to this standard, this action will aid in minimizing potential hazards and releases through systems failure, fire, or explosion.	A photoionization detector (PID) w/ an 11.7 eV UV lamp source or a flame ionization detector (FID) will be used to monitor ASVE emissions. This instrument will also be used to monitor the following: 1) Source areas where potential vapors and gases from the ASVE system could be emitted. These locations will be monitored at regular intervals to be determined by the SSO. Positive sustained results at a source location which may impact field crew members will require the actions discussed below. It is anticipated that potential contaminant concentrations at source areas will be dispersed via natural wind currents and dilution prior to reaching worker breathing zones. As a result, hazardous concentrations of site contaminants are not anticipated to be present in worker breathing zones. a) Monitor the breathing zone of at risk employees. Any sustained readings above background in the breathing zone will require site activities to be suspended until readings return to background levels, or the contaminant of concern is identified through additional air monitoring activities. The procedures and levels of protection that are to be used when collecting additional air monitoring information are discussed in Section 6.2 of the HASP. Significant dust emissions are not anticipated to be generated as a result of this task. However, if such dusts are observed, area wetting methods must be employed.	At a minimum, the Level D protection as defined in the mobilization/demobilization section will be observed for maintenance activities.	Anytime the maintenance personnel or operator of the system may encounter potential contaminants, PPE and decontamination procedures such as those described in the ASVE installation task will be utilized.

TASKS/HAZARDS/CONTROL MEASURES COMPENDIUM
BETHPAGE NWIRP ASVE REMEDIATION PROJECT

Tasks/Operation/ Locations	Anticipated Hazards	Recommended Control Measures	Air Monitoring Type/Action Levels	Personal Protective Equipment	Decontamination Procedures
Installation of complete ASVE Remedial System including blowers, piping, nests, separators, valves, and gauges.	1) Air/particulate borne contaminant primarily chlorinated hydrocarbons (e.g., TCE, PCE) hydrocarbons, metals, and PCBs. (see Table 6-1) PVC pipe cleaner, cement, and other products will be used during the installation of the system. Refer to manufacturer MSDSs for the hazards and associated protective clothing, control measures, and first-aid procedures to use when handling these products. 2) Cross contamination **Physical hazards** 3) Moving machinery 4) Heavy lifting 5) Energized systems 6) Noise 7) Pinch points, sharp objects, flying projectiles	1) Employ real-time monitoring instrumentation, action levels, personal sampling, and identified PPE to control exposures to potentially contaminated medias (e.g. air, water, soils). 2) Restrict the cross use of equipment and supplies from performing remedial activities, to handling clean fill, and construction services without first going through a suitable decontamination. 3) All equipment to be employed will be - Inspected in accordance with Federal safety and transportation guidelines, OSHA (1926.600,.601,.602), and manufacturer's design. - Operated by Certified operators, and knowledgeable ground crew, as applicable. - Establish safe zones of approach (i.e. Boom + 3 feet). - Secure all loose articles to avoid possible entanglement. - All equipment shall be equipped with movement warning systems. - All personnel working near equipment traffic are required to wear reflective vests for high visibility 4) Employ proper lifting techniques (using your legs not your back) and obtain help when lifting heavy loads. Whenever possible, handle loads using available equipment onsite. 5) All utility clearances shall be obtained prior to any site activities. Where the clearance can not be obtained in a reasonable period, or not located, subsurface activities shall proceed with extreme caution and proceed using cable and piping locators. Permit only trained/licensed electricians to perform wiring and electrical hook-ups. 6) Excessive noise levels will be mitigated through the use of hearing protection. Anticipated excessive noise level operations include the following: • Heavy equipment operation • Portable hand tools (circular saws), 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 can be conducted to quantify the associated noise levels. 7) Employ safe work practices when handling equipment and machinery that have the potential to cause injury. Ensure proper guarding is in place and utilize PPE such as leather gloves when handling sharp objects.	A photoionization detector (PID) w/ an 11.7 eV UV lamp source or flame ionization detector (FID) will be used to monitor potential source areas. 1) Source areas such as ground surfaces, and general work locations will be monitored at regular intervals to be determined by the SSO. Positive sustained results at a source location which may impact field crew members will require the actions discussed below. It is anticipated that potential contaminant concentrations at source areas will be dispersed via natural wind currents and dilution prior to reaching worker breathing zones. As a result, airborne concentrations of site contaminants are not anticipated to be present in worker breathing zones. a) Monitor the breathing zone of at risk employees. Any sustained readings above background in the breathing zone will require site activities to be suspended until readings return to background levels or the contaminant of concern is identified through additional air monitoring activities. The procedures and levels of protection that are to be used when collecting additional air monitoring information are discussed in Section 6.2 of the HASP. Significant dust emissions are not anticipated to be generated as a result of this task. However, if such dusts are observed, area wetting methods will be employed. .	Level D - (Minimum Requirements) - Standard field attire (long sleeve shirt; long pants) - Safety shoes (Steel toe/shank) - Safety glasses - Hardhat (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. Tyvek coveralls, disposable boots, and nitrile glvoes will be required if workers performing this task have the potential to contact site contaminants. If necessary, leather gloves with surgical style inner gloves can be substituted for nitrile gloves. MSDS for PVC pipe cleaners and adhesives will be referenced to determine any additional PPE needs. Level C protection consisting will be required whenever : - unidentified (contaminant unknown) PID / FID readings <10 ppm above background in the workers breathing zone. - positive indications of benzene, vinyl chloride, or methylene chloride at concentrations <10 ppm in worker breathing zones. - identified (contaminant known) PID/FID readings in worker breathing zones >10 ppm above background. - airborne dusts cannot be controlled with area wetting methods. Level C protection consists of the following PPE in addition to Level D requirements discussed above - Air-Purifying Respirator (APR) with combination GMC-H - Impermeable boot covers - Tyvek coveralls (unless free phase product is encountered). Free phase product or splash potential will require the use of PVC splash suit - Nitrile outer gloves with surgical style inner gloves Level B protection consisting of Self-Contained Breathing Apparatus (SCBA), or airline respiratory protection will be required in the following situations - unidentified PID/FID readings in worker breathing zones at concentrations > 10 ppm. - if additional monitoring activities determine excessive concentrations or the presence of airborne contaminants which cannot be adequately removed by APRs (i.e., benzene, vinyl chloride, methylene chloride at concentrations > 10 ppm). - identified PID/FID readings in worker breathing zones > 50 ppm - IDLH concentrations of the indicator compounds - O_2 readings <19.5; >23.5 Ascension to Level B protection requires immediate notification of the PM, and Manager of Health Sciences (Pgh. Office) As contaminant concentrations and conditions may change radically the following emergency equipment will be maintained during all on site activities • Fire Extinguishers (Strategically placed) • Basket stretcher, blankets, and first-aid kit • SCBA, lifelines	**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 remedial activities. This procedure will consist of - Equipment drop - Soap/water wash and rinse of outer boots and gloves **Note:** For PPE Levels B or C tank or cartridge change out would take place at this point, if necessary. - Soap/water wash and rinse of the outer splash suit, as applicable - Outer suit, boot covers, outer glove removal - Respiratory (face mask) protection removal - Wash hands and face, leave contamination reduction zone **Equipment Decontamination** - All equipment decontamination will take place at a centralized decontamination pad utilizing steam or pressure washers. Heavy equipment will have the wheels and tires cleaned of any loose debris removed prior to transporting to the central area. All site vehicles will be restricted or also have their wheels/tires sprayed off as not to track mud onto the roadways servicing the base. Roadways shall be monitored to pick up any debris resulting from the on site activity. 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 onsite and that which is to leave the site. No equipment will be authorized access or exit without this authorization.

TASKS/HAZARDS/CONTROL MEASURES COMPENDIUM
BETHPAGE NWIRP ASVE REMEDIATION PROJECT

Tasks/Operation/ Locations	Anticipated Hazards	Recommended Control Measures	Air Monitoring Type/Action Levels	Personal Protective Equipment	Decontamination Procedures
Drilling/Well Installation of injection and recovery wells using hollow stem augering techniques.	1) Air/particulate borne contaminant - chlorinated hydrocarbons (e.g., TCE, PCE), hydrocarbons, metals, and PCBs (See Table 6-1). 2) Cross contamination Physical hazards 3) Rotating machinery 4) Noise 5) Energized systems	1) Employ real-time monitoring instrumentation, action levels, personal sampling, and identified PPE to control exposures to potentially contaminated medias (e.g. air, water, soils, etc.). 2) Dispersion fans may be employed to control the accumulation of exhaust emissions from equipment operated within buildings. Whenever possible, windows and doors of the building should be opened to provide some ventilation. 3) Restrict the cross use of equipment and supplies between drilling events without first going through the designated decontamination process. 4) All equipment to be employed will be - Inspected in accordance with Federal safety and transportation guidelines, OSHA (1926.600,.601,.602), and manufacturers design. - Operated by Certified operators, and knowledgeable ground crew, as applicable. - Establish safe zones and routes of approach to the operation (personnel should remain cognizant that this is a multi-task operation with many active simultaneously). - Restrictions at the operation (All personnel not directly supporting the drilling operation will remain at least 25 feet from the point of operation). - 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. - Hand signals between the driller and other crew personnel will be established prior to the commencement of field activities. - The driller and the helper shall not simultaneously handle moving augers of flights unless there is a standby person 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 all drill cuttings from the hole and rotating equipment. Hands and 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 shutdown operations if the sampler must get near the tools to obtain samples. - Only manufacturer approved equipment may be used in conjunction with site equipment (i.e., pins or rauger flights). Pins or other protruding equipment shall not be permitted. - No person shall climb the drill mast while equipment is operating. - No person shall climb the drill mast without the use of ANSI approved fall protection (i.e., belts, lanyards, and a fall protection slide rail or ladders) 5) Hearing protection will be employed during any operation (drilling) in which excessive noise levels are produced. 6) All utility clearances will be obtained prior to any site activities. Where the clearances can not be obtained in a reasonable period, or not located, subsurface activities shall proceed with extreme caution and proceed using cable and piping locators. Any procjecting objects (drill rig masts, backhoe booms, etc.) will be restricted from within 20 feet of any overhead energy sources.	A photoionization detector (PID) w/ an 11.7 eV UV lamp source or flame ionization detector (FID) will be used to monitor potential source areas. Source areas such as boreholes and general work locations will be monitored at regular intervals to be determined by the SSO. Positive sustained results at a source location which may impact field crew members will require the actions discussed below. It is anticipated that potential contaminant concentrations at source areas will be dispersed via natural wind currents and dilution prior to reaching worker breathing zones. As a result, airborne concentrations of site contaminants are not anticipated to be present in worker breathing zones. Monitor the breathing zone of at risk employees. Any sustained readings above background in the breathing zone of the at risk employee requires site activities to be suspended until readings return to background levels or if the contaminant of concern is identified through additional air monitoring activities. The procedures and levels of protection that are to be used when collecting additional air monitoring information are discussed in Section 6.2 of the HASP. The potential exists for dust emissions to be generated during the course of this task. Generation of dusts should be minimized to the greatest extent possible. If dust emissions are observed, area wetting methods will be employed.	Level D - (Minimum Requirements) - Standard field attire (Long sleeve shirt; long pants) - Tyvek coveralls and disposable boot covers if surface contamination is present. - Nitrile gloves or leather gloves with surgical sytle inner gloves - Safety shoes (Steel toe/shank) - Safety glasses - Hardhat - Reflective vest for high traffic areas - Hearing protection for high noise areas, as directed by the SSO. Level C protection consisting will be required whenever : - unidentified (contaminant unknown) PID / FID readings <10 ppm above background in the workers breathing zone. - positive indications of benzene, vinyl chloride, or methylene chloride at concentrations <10 ppm in worker breathing zones. - identified (contaminant known) PID/FID readings in worker breathing zones >10 ppm. - airborne dusts cannot be controlled with area wetting methods. Level C protection consists of the following PPE in addition to Level D requirements discussed above - Air-Purifying Respirator (APR) with combination GMC-H - Free phase product or splash potential will require the use of PVC splash suit Level B protection consisting of Self-Contained Breathing Apparatus (SCBA), or airline respiratory protection will be required in the following situations - unidentified PID/FID readings in worker breathing zones at concentrations > 10 ppm. - if additional monitoring activities determine excessive concentrations or the presence of airborne contaminants which cannot be adequately removed by APRs (i.e., benzene, vinyl chloride, methylene chloride at concentrations > 10 ppm). - identified PID/FID readings in worker breathing zones > 50 ppm - IDLH concentrations of the indicator compounds - O_2 readings <19.5; >23.5 Ascension to Level B protection requires immediate notification of the PM, and Manager of Health Sciences (Pgh. Office) As contaminant concentrations and conditions may change radically the following equipment will be maintained during all on site activities • Fire Extinguishers (Strategically placed) • Basket stretcher, blankets, and first-aid kit • SCBA, lifelines	**Personnel Decontamination** - 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. This decontamination procedure will consist of - Equipment drop - Soap/water wash and rinse of outer boots and gloves - Soap/water wash and rinse of the outer splash suit, as applicable **Note:** For PPE Levels B or C tank or cartridge change out would take place at this point, if necessary. - Outer suit, boot covers, outer glove removal - Respiratory (face mask) protection removal - Wash hands and face, leave contamination reduction zone **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 the base. Roadways shall be monitored to pick up any debris resulting from the onsite activity. 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 onsite and that which is to leave the site. No equipment will be authorized access or exit without this authorization.

TASKS/HAZARDS/CONTROL MEASURES COMPENDIUM
BETHPAGE NWIRP ASVE REMEDIATION PROJECT

Tasks/Operation/ Locations	Anticipated Hazards	Recommended Control Measures	Air Monitoring Type/Action Levels	Personal Protective Equipment	Decontamination Procedures
Multi-media sampling including soils (surface and subsurface); sediments; water (surface and subsurface); air (personal and area)	1) Air/particulate borne contaminant - chlorinated hydrocarbons (e.g., TCE, PCE), hydrocarbons, metals, and PCBs (See Table 6-1) 2) Cross contamination Physical hazards 3) Noise 4) Lifting (muscle strains and pulls) 5) Pinches and compressions 6) Slip, trips, and falls 7) Biological hazards (Insect/animal bites and stings)	1) Employ real-time monitoring instrumentation, action levels, personal sampling, and identified PPE to control exposures to potentially contaminated medias (e.g. air, water, soils). 2) Restrict the cross use of equipment and supplies from location to location without first going through a suitable decontamination. 3) Hearing protection will be required if surrounding operations create excessive noise levels. As a general rule, if a person two feet away must raise his/her voice to be heard noise levels are excessive. 4) Employ machinery or multiple personnel for heavy lifts. Use proper lifting techniques. 5) Use tools or other equipment to keep hands away from moving machine parts. 6) Preview work locations for unstable/uneven terrain. Barricade all excavations deeper than two feet from access closer than two feet from the edge. 7) Avoid potential nesting areas, employ repellents (Do NOT use repellents during sampling activities). Report potential hazards to the SSO. Identify all access/egress routes and locations, hours of clearance, and base contacts, in addition to the badge clearance and associated requirements for base clearance.	Monitoring instrumentation will be employed as specified in the Sampling and analyses plan to bias samples. Wells to be sampled will require opening to allow venting and equilibration prior to sampling. A photoionization detector (PID) w/ an 11.7 eV UV lamp source or flame ionization detector (FID) will be used to monitor potential source areas. Source areas such as boreholes and general work locations will be monitored at regular intervals to be determined by the SSO. Positive sustained results at a source location which may impact field crew members will require the actions discussed below. It is anticipated that potential contaminant concentrations at source areas will be dispersed via natural wind currents and dilution prior to reaching worker breathing zones. As a result, airborne concentrations of site contaminants are not anticipated to be present in worker breathing zones. Monitor the breathing zone of at risk employees. Any sustained readings above background in the breathing zone of the at risk employee requires site activities to be suspended until readings return to background levels or if the contaminant of concern is identified through additional air monitoring activities. The procedures and levels of protection that are to be used when collecting additional air monitoring information are discussed in Section 6.2 of the HASP. Significant dust emissions are not anticipated to be generated as a result of this task. However, if such dusts are observed, area wetting methods must be employed.	Level D - (Minimum Requirements) - Standard field attire (long sleeve shirt; long pants) - Tyvek coveralls and disposable boot covers if surface contamination is present - Nitrile gloves with surgical style inner gloves - Safety shoes (steel toe/shank) - Safety glasses - Hardhat (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. Level C protection consisting will be required whenever : - unidentified (contaminant unknown) PID / FID readings <10 ppm above background in the workers breathing zone. - positive indications of benzene, vinyl chloride, or methylene chloride at concentrations <10 ppm in worker breathing zones. - identified (contaminant known) PID/FID readings in worker breathing zones >10 ppm. - airborne dusts cannot be controlled with area wetting methods. Level C protection consists of the following PPE in addition to Level D requirements discussed above - Air-Purifying Respirator (APR) with combination GMC-H - Free phase product or splash potential will require the use of PVC splash suit - Impermeable boot covers Level B protection consisting of Self-Contained Breathing Apparatus (SCBA), or airline respiratory protection will be required in the following situations - unidentified PID/FID readings in worker breathing zones at concentrations > 10 ppm. - if additional monitoring activities determine excessive concentrations or the presence of airborne contaminants which cannot be adequately removed by APRs (i.e., benzene, vinyl chloride, methylene chloride at concentrations > 10 ppm). - identified PID/FID readings in worker breathing zones > 50 ppm - IDLH concentrations of the indicator compounds - O_2 readings <19.5; >23.5 Ascension to Level B protection requires immediate notification of the PM, and Manager of Health Sciences (Pgh. Office) As contaminant concentrations and conditions may change radically the following equipment will be maintained during all on site activities • Fire Extinguishers (Strategically placed) • Basket stretcher, blankets, and first-aid kit • SCBA, lifelines	**Personnel Decontamination** - 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. This decontamination procedure will consist of - Equipment drop - Soap/water wash and rinse of outer boots and gloves - Soap/water wash and rinse of the outer splash suit, as applicable **Note:** For PPE Levels B or C tank or cartridge change out would take place at this point, if necessary. - Outer suit, boot covers, outer glove removal - Respiratory (face mask) protection removal - Wash hands and face, leave contamination reduction zone **Equipment Decontamination -** Sampling equipment will be decontaminated as per the requirements in the Sampling and Analysis Plan MSDS for any decon solutions (Alconox, methanol, isopropanol, hexane, etc.) will be obtained and used to determine proper handling and disposal methods. 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 onsite and that which is to leave the site. No equipment will be authorized access or exit without this authorization.

6.0 CHEMICAL, PHYSICAL, AND TOXICOLOGICAL DATA

The following table represents potential chemical contaminants which may be encountered during the onsite activities, as defined in Section 4.0 "Scope of Work".

In addition to the potential chemical contaminants, this table provides air monitoring/sampling information, exposure limits, warning properties, physical properties, and health hazard information. This table is included to educate onsite personnel of the potential chemical hazards, which may be encountered.

6.1 SITE CONTAMINANTS

Site contaminants primarily consist of chlorinated hydrocarbons such as trichloroethane (TCE) and perchloroethene (PCE). Other site contaminants include hydrocarbons, metals and poly chlorinated biphenyls (PCBs).

Various chlorinated hydrocarbons have been widely used as chemical intermediates and solvents. The predominant physiological response to exposure to many chlorinated hydrocarbons results in central nervous system (CNS) depression. General symptoms of exposure include dizziness, visual disturbances, mental confusion, fatigue, nausea, vomiting, and headache. Studies have shown repeated or prolonged exposure to chlorinated hydrocarbons may result in damage to the liver and kidneys. Some chlorinated hydrocarbons have been identified as having carcinogenic properties. However, carcinogenicity is dependent upon the specific chlorinated hydrocarbon of concern. A discussion of two of the most predominant chlorinated hydrocarbons is provided below. Additional information regarding these and other chlorinated hydrocarbons is provided in Table 6-1 of this HASP.

6.1.1 Trichloroethylene (TCE)

TCE has been widely used as an industrial solvent, particularly in metal degreasing and extraction processes. TCE is a clear, colorless (sometimes dyed blue) mobile liquid with a sweet chloroform odor. CNS depression is the predominant acute response to TCE. Other acute response in humans include visual disturbances, metal confusion, fatigue, and sometimes nausea and vomiting. TCE vapors are irritating to the eyes, nose, and respiratory tract. Contact with TCE is irritating to the skin and may lead to dermatitis by defatting the skin. A condition known as "degreaser's flush" has been noted in some cases in which alcohol has been consumed shortly before or after exposure to TCE. This condition is characterized by extreme reddening of the skin on the face and arms. Primary routes of exposure include inhalation, skin and eye contact, and in rare instances ingestion. Chronic effects of long term exposure may include digestive disturbances, irritability, headache, double vision, loss or impairment of sense of smell, peripheral nervous system function impairment including persistent neuritis. Repeated or prolonged exposure to TCE may cause damage to the liver, kidneys, respiratory system, and peripheral & central nervous, and cardiovascular systems. The International Agency for Research on Cancer (IARC) has assigned TCE as a Class 3 carcinogen (limited animal evidence and insufficient human data).

6.1.2 Perchloroethylene (PCE)

PCE has been used in dry cleaning and textile processing; metal degreasing; production of adhesives, aerosols, paints, and coatings; and as a chemical intermediate. PCE is a colorless liquid with a ether-like odor. PCE exerts the majority of it toxicity on the CNS causing symptoms ranging from lightheadedness, and slight inebriation to unconsciousness. Liver damage is possible after severe acute of minor long-term exposure. Primary routes of entry include inhalation and contact with the skin and eyes. Prolonged exposure may cause impaired memory, extremity weakness, impaired vision, muscle cramps, liver damage (fatty degeneration, necrosis, yellow jaundice, and dark urine), and kidney damage. PCE is listed as a carcinogen by the IARC (Group 2B, animal sufficient evidence, human inadequate data), and National Toxicological Program (NTP) Class 2 (reasonably anticipated as a carcinogen, with limited human evidence and sufficient animal evidence).

6.2 AIR MONITORING

Air monitoring activities are discussed in Table 5-1 of this HASP. Initial air monitoring shall consist of source monitoring with a PID or FID. These instruments will also be utilized to bias samples and to collect air data once the ASVE system is operating. Any positive readings at source areas will require the breathing zones of at risk personnel to be monitored to determine their potential for exposure to site contaminants. It should be noted that sustained airborne concentrations in worker breathing zones are not anticipated to be present during site activities. This observation is based on the fact that site activities will be performed outside and potential vapors and gases should be dispersed and diluted via natural wind currents. The following procedures will be initiated in the event that sustained positive results (above background) in the worker breathing zone are detected.

Suspend site activities and report to an unaffected area of the site. Site activities may continue in Level D protection only when breathing zone readings return to background levels.

Any additional air sampling activities and site tasks performed in the presence of breathing zone readings above background levels will require the use of upgraded levels of protection. The level of protection will be based on the concentrations observed during breathing zone sampling with the PID or FID. If breathing zone readings were < 10ppm above background levels, site activities will proceed using Level C protection (full-face air-purifying respirators with GMC-H filters). If breathing zone readings were >10 ppm above background levels, site activities will proceed in Level B protection (supplied breathing air consisting of self-contained breathing apparatus or air line respirators). Site personnel must notify the CLEAN Health and Safety Manager prior to initiating Level B work. These increased levels of protection are necessary since some contaminants associated with the site (benzene, vinyl chloride, trichloroethylene, 1,2-dichloroethane, etc.) have poor warning properties and/or low exposure limits. An initial action level of 10 ppm has been established based on the GMC-H filters ability to adequately remove contaminants of concern at low concentrations.

If sustained airborne concentrations are observed in worker breathing zones, the CLEAN Health and Safety Manager will be notified and additional air monitoring activities will be performed to qualitatively and quantitatively evaluate airborne concentrations of potential site contaminants. These additional air monitoring activities will consist of sorbent tube sampling and analysis in accordance with applicable NIOSH and OSHA sampling methods and/or the collection of tedlar bag "grab" samples. By determining the actual concentration of a specific contaminant of concern, action levels can be adjusted and the level protection can be appropriately established.

TABLE 6-1
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.
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.
Chloroform	67-66-3	PID: I.P. 11.42 eV, relative response ratio unknown. FID: 100% 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 (ceiling) NIOSH: STEL 2 ppm ACGIH: 10 ppm IDLH: 500 ppm	Inadequate - Odor threshold 133 - 276 ppm. Chloroform has poor warning properties but will adhere to organic vapor cartridges. Supplied air respirators are recommended. **Recommended glove:** Polyvinyl Alcohol >8.00 hrs; Viton 9.50 hrs; Teflon >3.60 hrs	**Boiling Pt:** 143°F; 62°C **Melting Pt:** -81°F; -62°C **Solubility:** 0.5% **Flash Pt:** Not available **LEL/LFL:** Not available **UEL/UFL:** Not available **Vapor Density:** Not available **Vapor Pressure:** 160 mmHg @ 68°F; 20° C **Specific Gravity:** 1.48 **Incompatibilities:** Strong caustics, chemically active metals such as aluminum or magnesium powder, sodium and potassium, strong oxidizers **Appearance and Odor:** Colorless liquid with a sweet pleasant odor.	Overexposure to this substance may cause dizziness, mental dullness, nausea, headache, fatigue, anaesthesia, and irritation of the skin and eyes. Chronic overexposure may result in damage to the liver, kidneys, heart, eyes and skin.

TABLE 6-1
CHEMICAL, PHYSICAL, AND TOXICOLOGICAL DATA
BETHPAGE, NWIRP, NEW YORK

Substance	CAS No.	Air Monitoring/Sampling Information		Exposure Limits	Warning Property Rating	Physical Properties	Health Hazard Information
1,1-Dichloroethane	75-34-3	PID: I.P. 11.06 eV, relative response ratio unknown. FID: 80% relative response ratio with FID.	Air sample using charcoal tube; carbon disulfide desorption; GC/FID detection. Sampling and analytical protocol shall proceed in accordance with OSHA Method #07-B or NIOSH Method #1003	OSHA; NIOSH; ACGIH: 100 ppm IDLH: 4000 ppm	Questionable warning properties - Odor threshold 49 - 1359 ppm APRs may be employed for escape only. Exceedances over the exposure limits are recommended to use airline or airline/APR combination type respirator. **Recommended glove:** Butyl; Polyvinyl alcohol; Viton	**Boiling Pt:** 135°F; 57°C **Melting Pt:** -143°F;-97°C **Solubility:** 0.6% **Flash Pt:** 2°F; -17°C **LEL/LFL:** 5.6% **UEL/UFL:** 11.4% Vapor Density: 3.42 **Vapor Pressure:** 182 mmHg **Specific Gravity:** 1.18 **Incompatibilities:** Strong oxidizers, strong causfics **Appearance and odor:** Colorless, oily liquid with a chloroform-like odor.	Overexposure may result in CNS depression, skin and eye irritation, and damage to the liver, kidneys, and lungs
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.
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 acrid 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.

TABLE 6-1
CHEMICAL, PHYSICAL, AND TOXICOLOGICAL DATA
BETHPAGE, NWIRP, NEW YORK

Substance	***CAS No.***	***Air Monitoring/Sampling Information***		***Exposure Limits***	***Warning Property Rating***	***Physical Properties***	***Health Hazard Information***
Diesel Fuel No.2-D	Mixture	Components of this substance will be detected readily however no documentation exists as to the relative response ratio of either PID or FID.	Air sample using charcoal tube as a collection media; carbon disulfide desorption; GC/FID detection. Sampling and analytical protocol in accordance with NIOSH Method *#1550.*	OSHA; NIOSH; ACGIH: 5 mg/m^3 as mineral oil mist. In addition NIOSH and ACGIH establish 10 mg/m^3 as a STEL.	Kerosene odor **Recommended Air Purifying cartridges:** Organic vapor **Recommended gloves:** Nitrile	**Boiling Pt:** <170-400°F; 77-204°C **Melting Pt:** Not available **Solubility: Negligible** **Flash Pt:** 125°F; 52°C **LEL/LFL: 0.6%** **UEL/UFL:** 7.5% **Vapor Density:** >5 **Vapor Pressure:** <1 mmHg @ 70°F; 21°C **Specific Gravity:** 0.86 **Incompatibilities:** strong oxidizers, halogens, and hypochlorites **Appearance and odor:** Colorless to amber with a kerosene odor	Prolonged or repeated exposures to this product may cause skin and eye irritation. Due to the defatting capabilities this exposure may lead to a dermatitis condition. High vapor concentrations are irritating to the eyes and respiratory tract. Exposure to high airborne concentrations may result in narcotic effects including dizziness, headaches, and anesthetic to unconsciousness. High concentrations in a confined space may adequately displace oxygen thereby resulting in suffocation.
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.

TABLE 6-1
CHEMICAL, PHYSICAL, AND TOXICOLOGICAL DATA
BETHPAGE, NWIRP, NEW YORK

Substance	CAS No.	Air Monitoring/Sampling Information		Exposure Limits	Warning Property Rating	Physical Properties	Health Hazard Information
Methylene chloride	75-09-2	PID: I.P. 11.32 eV, High response with PID and 11.7 eV lamp. FID: 100% response with FID.	Air sample using charcoal or Anasorb CMS sorbent tube; carbon disulfide desorption; gas chromatography-flame ionization detector; Sampling and analytical protocol shall proceed in accordance with OSHA Method #59, 80, or NIOSH Method #1005.	OSHA: 50 ppm, 100 ppm (Ceiling) ACGIH: 50 ppm NIOSH: Lowest feasible concentration IDLH: 2300 ppm	Inadequate - Odor threshold 160 ppm. Use a gas mask with a Type N canister for concentrations up to 25 ppm. In excess of 25 ppm, use a supplied air respirator (airline respirator with emergency escape cylinder or a Self-Contained Breathing Apparatus - (SCBA). **Recommended gloves:** Nitrile rubber latex glove 3.00 hrs (vendor specific); supported Polyvinyl alcohol glove, unsupported 1-8 hrs; Silver shield 1.90 hrs	**Boiling Pt:** 104°F; 39.8°C **Melting Pt:** -141°F; -96°C **Solubility:** 2% **Flash Pt:** Not available **LEL/LFL:** 13% **UEL/UFL:** 12% **Vapor Density:** 2.93 **Vapor Pressure:** 380 mmHg @ 72°F; 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; 40°C).	Effects of overexposure may include CNS effects - 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.
Sulfuric Acid	7664-93-9	This substance is unable to be detected by PID/FID.	Sampling and analytical protocol shall be in accordance with NIOSH Method #7903.	OSHA; NIOSH: 1 mg/m³ ACGIH: 1 mg/m³, 3 mg/m³ (Ceiling) NIOSH: 1 mg/m³ IDLH: 15 mg/m³	Adequate - Irritating, tingling sensation. Odor threshold 0.15 ppm. Suitable for acid gases and dusts and mists for concentrations less than 15 mg/m³. **Recommended gloves:** Nitrile 6.00 hrs has been the one most widely used for the other substances and is acceptable for this substance. Other options include butyl rubber >8.00 hrs; silver shield 6.00 hrs; neoprene 1-3 hrs; and Viton >8.00 hrs.	**Boiling Pt:** 554°F; 290°C **Melting Pt:** 51°F; 10°C **Solubility:** Miscible **Flash Pt:** Not available **LEL/LFL:** Not available **UEL/UFL:** Not available **Vapor Density:** Not available **Vapor Pressure:** 1 mmHg @ 295°F; 146° C **Specific Gravity:** 1.84 **Incompatibilities:** Organic materials, chlorates, carbides, fulminates, water, and powdered metals. Liberates excessive heat when mixed with water. **Appearance and odor:** Colorless, oily liquid, odorless	This substance is corrosive at all points of contact. Severe exposure may result in burns, chemical pneumonitis, conjunctivitis, stomatitis, and erosion of the teeth. Depending on the severity, shock and collapse may result.
Tetrachloroethylene See also Perchloroethylene PERK PCE	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

TABLE 6-1
CHEMICAL, PHYSICAL, AND TOXICOLOGICAL DATA
BETHPAGE, NWIRP, NEW YORK

Substance	CAS No.	Air Monitoring/Sampling Information		Exposure Limits	Warning Property Rating	Physical Properties	Health Hazard Information
Toluene	108-88-3	PID: I.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	**Boiling 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.
1,1,2- Trichloroethane	79-00-5	I.P. 11.0 eV, 85% response with FID	Air sample using charcoal sorbent tube and carbon disulfide desorption with gas chromatography-flame ionization detector; OSHA 07, NIOSH 1003	OSHA, NIOSH, ACGIH 10 ppm TWA Exposure contribution may also occur through skin absorption. IDLH ~100 ppm	No information was found concerning odor threshold limits. The use of air-purifying respirator with organic vapor cartridge for <500 ppm for escape purposes is permitted. Exceedances above the exposure limits will require the use of airline or airline/APR combination units. Recommended glove: Butyl rubber,solvent dipped, unsupported; PV alcohol; Teflon; Viton	Boiling Pt: 237°F; 114°C Melting Pt: -31°F-35°C Solubility: 0.6% Flash Pt: N/A 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.
Trichloroethylene	79-01-6	PID: I.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)	**Boiling 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.

TABLE 6-1
CHEMICAL, PHYSICAL, AND TOXICOLOGICAL DATA
BETHPAGE, NWIRP, NEW YORK

Substance	CAS No.	Air Monitoring/Sampling Information		Exposure Limits	Warning Property Rating	Physical Properties	Health Hazard Information
Vinyl chloride	75-01-4	PID: I.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	**Boiling 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.
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.

TABLE 6-1
CHEMICAL, PHYSICAL, AND TOXICOLOGICAL DATA
BETHPAGE, NWIRP, NEW YORK

Substance	CAS No.	Air Monitoring/Sampling Information		Exposure Limits	Warning Property Rating	Physical Properties	Health Hazard Information
Cadmium	7440-43-9	Particulate Form - Unable to be easily detected by PID or FID.	Air sample using a mixed cellulose-ester filter / acid desorption and analysis by atomic absorption-flame. Sampling and analytical protocol shall proceed in accordance with NIOSH Method #7300 or #7048.	OSHA: 2 µg/m^3 (0.002 mg/m^3) ACGIH: 0.01 mg/m^3 (total particulate); 0.002 mg/m^3 (respirable particulate) IDLH: 9 mg/m3 (as cd)	The use of an air purifying, full face-piece respirator with a high efficiency particulate air filter for concentrations up to 0.25 mg/m^3. **Recommended Gloves:** This is in particulate form. Therefore any glove suitable to prevent skin contact.	**Boiling Pt:** 1412°F; 767°C **Melting Pt:** 610°F; 321°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:** Not available **Vapor Pressure:** 1 mmHg @ 741°F; 394° C **Specific Gravity:** 8.65 @ 90°F; 32°C **Incompatibilities:** Strong oxidizers, elemental sulfur, selenium, tellurium, zinc, nitric acid, and hydrazoic acid **Appearance and Odor:** Metal: Silver-white, blue-tinged 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.
Chromium Compounds	7440-47-3 (Element)	Not detectable by PID. Not detectable by FID.	Air sample using mixed cellulose -ester filter; acid desorption and analysis by atomic absorption. Sampling and analytical protocol shall proceed in accordance with NIOSH Method #7024.	OSHA & NIOSH: (Chromium II, III) 0.5 mg/m^3 (Chromium VI) 0.1 mg/m^3 (Ceiling) ACGIH: 0.5 mg/m^3 (Chromium II, III compounds), 0.05 mg/m^3 (Chromium VI compounds) IDLH: 30 mg/m^3 (Chromium VI compounds)	The use of a air purifying, full face-piece respirator with a high efficiency particulate filter for concentrations up to 0.1 mg/m^3. **Recommended Gloves:** This is in particulate form. Therefore any glove suitable to prevent skin contact.	**Boiling Pt:** 4788°F; 2642°C **Melting Pt:** 3452°F; 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:** Not available **Vapor Pressure:** 0 mmHg **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.

TABLE 6-1
CHEMICAL, PHYSICAL, AND TOXICOLOGICAL DATA
BETHPAGE, NWIRP, NEW YORK

Substance	CAS No.	Air Monitoring/Sampling Information		Exposure Limits	Warning Property Rating	Physical Properties	Health Hazard Information
Lead	7439-92-1	Particulate form - Unable to be detected by either PID or FID.	Air sample using a mixed cellulose ester filter; or HNO_3 or H_2O_2 desorption; or Atomic absorption detection. Sampling and analytical protocol shall proceed in accordance with NIOSH Method #7082 or #7300.	OSHA: 0.05 mg/m³ ACGIH: 0.15 mg/m³ NIOSH: 0.10 mg/m³ IDLH: 100 mg/m³ as lead	The use of a air purifying, full-face respirator with high efficiency particulate air filter for up to 2.5 mg/m³. **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:** 3164°F; 1740°C **Melting Pt:** 621°F; 327°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:** Not available **Vapor Pressure:** 0 mmHg **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, gingival lead line, brain, and anemia.
Aroclor-1260 (Polychlorinated Biphenyl, PCB) It should be noted that this substance is representative of the more common isomers Aroclor - 1242, 1254, which may be encountered.	11096-82-5 53469-21-9 (42%) 11097-69-1 (54%)	Substance is not volatile (VP=0.00006 mmHg), I.P. is unknown however is anticipated to be elevated, therefore, PID is not anticipated to detect this substance. Substance is non combustible and as a result will not be detected by FID.	Air sample using a particulate filter, Florisil sorbent tube with glass fiber filter; hexane desorption; gas chromatography-electron capture detector. Sampling and analytical protocol shall proceed in accordance with NIOSH Method #5503 (PCBs).	OSHA; ACGIH: 0.5 mg/m³ (skin) NIOSH: 0.001 mg/m³ IDLH: 5 mg/m³	Inadequate - However due to the low volatility it is assumed unless agitated this substance does not present a volatile vapor or gas respiratory threat. For dusty conditions where this material may cling to particulates, use a HEPA filter. APRs are approved for escape only when concentrations exceed the exposure limits. Concentrations greater than the exposure limits require PAPR or supplied air respirators. **Recommended glove:** Butyl rubber >24 hrs; Neoprene rubber >24.00 hrs; Silver shield or Viton (for pure product).	**Boiling Pt:** distillation range 689- 734°F; 365-390°C **Melting Pt:** -2 to 50°F; -19 to 10°C **Solubility:** Insoluble **Flash Pt:** Not applicable **LEL/LFL:** Not applicable **UEL/UFL:** Not applicable Nonflammable liquid, however, exposure to fire results in black soot containing PCBs, dibenzofurans, & chlorinated dibenzo-p-dioxins **Vapor Density:** Not available **Vapor Pressure:** 0.00006 - 0.001 mmHg **Specific Gravity:** 1.566 @ 60°F; 15.5°C **Incompatibilities:** Strong oxidizers **Appearance and Odor:** Colorless to pale yellow, viscous liquid or solid (Aroclor 54 below 50°F) with a mild, hydrocarbon odor	This substance is irritating to the eyes and skin. Chronic effects of overexposure may include potential to cause liver damage, chloracne, and reproductive effects. Recognized as possessing carcinogenic properties by NIOSH, and NTP.
Waste Oils All information is based on mineral oil	N.E. 8012-95-1 for mineral oil	Varies between fractions however waste oils tend to be less volatile. The FID tends to handle the longer chained aliphatic hydrocarbons more efficiently than its PID counterpart and would be selected as the instrument of choice.	Sampling and analytical protocol shall be in accordance with NIOSH Method #5026 is the recommended method for mineral oil mist.	ACGIH; NIOSH: 5 mg/m³ (Oil mists); 10 mg/m³ STEL OSHA: 5 mg/m³ (Oil mists)	Non-volatile substance, therefore no respiratory protection is required. In an aerosol form dust and mist respirator would be considered acceptable for up to 500 mg/m³. **Recommended gloves:** Any glove suitable to prevent skin contact (Nitrile has been the one most widely used for the other substances, and will be acceptable).	**Boiling Pt:** 680°F; 360°C **Melting Pt:** Not available **Solubility:** Insoluble **Flash Pt:** 275-500°F; 135-260°C depends on the distillation fraction **LEL/LFL:** Not available **UEL/UFL:** Not available **Vapor Density:** Not available **Vapor Pressure:** <0.5 mmHg **Specific Gravity:** 0.90 **Incompatibilities:** None reported **Appearance and odor:** Colorless, oily, with an odor of burned lubricating oil	Minor irritation to the eyes, skin, and respiratory system.

TABLE 6-1
CHEMICAL, PHYSICAL, AND TOXICOLOGICAL DATA
BETHPAGE, NWIRP, NEW YORK

Substance	CAS No.	Air Monitoring/Sampling Information		Exposure Limits	Warning Property Rating	Physical Properties	Health Hazard Information
Cyanides (as CN)	varies depending of compound	No information found.	Air sample using filter; analyze using specific ion electrode. Sampling and analytical protocol in accordance with established methodology.	OSHA; ACGIH; NIOSH: 5 mg/m³ (Ceiling) IDLH: 50 mg/m³	Inadequate warning properties; recommend the use of supplied air respirators. **Recommended Gloves:** Butyl 1.00 hr.	**Boiling Pt:** 2725°F; 1496°C **Melting Pt:** 1047°F; 564°C **Solubility:** 58% **Flash Pt:** Not available **LEL/LFL:** Not available **UEL/UFL:** Not available **Vapor Density:** Not available **Vapor Pressure:** 0 mmHg **Specific Gravity:** 1.6 **Incompatibilities:** Strong oxidizers, 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 chemical asphyxiation and 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.

7.0 TRAINING/MEDICAL SURVEILLANCE REQUIREMENTS

7.1 INTRODUCTORY/REFRESHER/SUPERVISORY TRAINING

7.1.1 Requirements for CF Braun Engineering Corporation Personnel

All CF Braun Engineering Corporation personnel must complete 40 hours of introductory hazardous waste site training in accordance with OSHA 29 CFR 1910.120(e) prior to performing work at Bethpage NWIRP. Additionally, CF Braun Engineering Corporation 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. 8-hour Supervisory Training in accordance with OSHA 29 CFR 1910.120(e)(4) will be required for site supervisory personnel charged with the responsibility of directing others engaged in hazardous waste operations.

Documentation of CF Braun Engineering Corporation Health and Safety Training will be maintained at the project site. Copies of certificates or other official documentation will be used to fulfill this requirement.

7.1.2 Requirements for Subcontractors

All CF Braun Engineering Corporation 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, as applicable, meeting the requirements of 29 CFR 1910.120(e)(8) prior to performing field work at Bethpage NWIRP. CF Braun Engineering Corporation subcontractors must certify that each employee has had such training by sending CF Braun Engineering_Corporation copies of training certificates for all potential site workers. Additionally, a letter, on company letterhead, containing the information in the example letter provided in the Health and Safety Guidance Manual will be sent to **CF Braun Engineering Corporation**.

7.2 SITE-SPECIFIC TRAINING

CF Braun Engineering Corporation will provide site-specific training to all CF Braun Engineering Corporation 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 site-specific health and safety plan
- Emergency response procedures (evacuation and assembly points)
- Review the contents of relevant Material Safety Data Sheets

7.3 MEDICAL SURVEILLANCE

7.3.1 Medical Surveillance Requirements For CF Braun Engineering Corporation Personnel

All CF Braun Engineering Corporation personnel participating in project field activities will have had a physical examination meeting the requirements of CF Braun Engineering Corporation's 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 CF Braun Engineering Corporation Pittsburgh office and made available as necessary.

7.3.2 Medical Surveillance 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" located in the Health and Safety Guidance Manual 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 (f) can substitute "Subcontractor Medical Approval Form" with a letter, on company letterhead, containing all of the information in the example letter presented in the Brown & Root Environmental Health and Safety Guidance Manual.

7.3.3 Requirements For All Field Personnel

Each field team member (including subcontractors) shall be required to complete and submit a copy of the Medical Data Sheet found in the Brown & Root Environmental Health and Safety Guidance Manual. This shall be provided to the SSO prior to participating in site activities.

7.4 SUBCONTRACTOR EXCEPTION

Subcontractors who will not enter the exclusion zone during operation, and whose activities involve no potential for exposure to site contaminants, will not be required to meet the requirements for training/medical surveillance, other than site-specific training as stipulated in Section 7-1.

FIGURE 7-1

TRAINING/MEDICAL SURVEILLANCE DOCUMENTATION

My signature below indicates that I am aware of the potential hazardous nature of performing remedial action/construction activities at Bethpage NWIRP, New York, and that I have received site-specific training which included the elements presented below:

- 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 site-specific health and safety plan
- Emergency response procedures (evacuation and assembly points)
- Review contents of relevant Material Safety Data Sheets

I further state that I have been given the opportunity to ask questions and that all of my questions have been answered to my satisfaction.

I further state by the presence of my signature below the dates of my training (introductory, refresher, and supervisory, as applicable), and my medical surveillance requirements are accurate and correct to the best of my knowledge.

Name	40-Hour General Site Worker Training (Date)	8-Hour Refresher Training (Date)	8-Hour Supervisory Training (Date)	Medical Surveillance (Date)	Signature

FOL: Post this page for purposes of tracking site clearance status.

8.0 SPILL CONTAINMENT PROGRAM

8.1 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. As the job progresses the potential for accumulating decontamination fluids, soil cuttings, etc. in the central staging area exists. However, it is currently planned that drill cuttings will be spread on the surfaces of potential VOC/PCB contaminated areas. These areas are to be remediated in the future. If drill cuttings and other investigative derived wastes are collected and stored they will need to be characterized to determine appropriate disposal methods. Since these fluids and soils remain uncharacterized while in the staging area, this spill containment program has be developed and instituted as part of the HASP.

8.2 POTENTIAL SPILL AREAS

Potential spill areas will be monitored in an ongoing attempt to prevent and control further potential contamination of the environment. Currently, there is limited areas vulnerable to this hazard including the area used for the central staging and decontamination for potentially contaminated soils and decontamination fluids. Additionally, the handling, loading and unloading areas present limited potential for leak or spill. It is anticipated decontamination fluids generated as a result of this scope of work will be containerized, labeled, and staged to await chemical analyses. The results of these analyses will determine whether the fluids will be disposed of in the Industrial Waste Water Treatment Facility (IWWTF) as nonhazardous, or must go offsite as hazardous to a treatment facility. During the turn- around for the chemical analyses there exists a possibility to accumulate multiple drums of fluid.

8.2.1 55-Gallon Drums

All drums containing liquids will be staged within a centralized area.

8.3 LEAK AND SPILL DETECTION

To establish an early detection of potential spills or leaks, a periodic 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.

8.4 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 FOL and the SSO will serve as the Spill Response Coordinator for this operation should the need arise.

8.5 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

8.6 SPILL CONTROL PLAN

This section describes the procedures the CF Braun Engineering Corporation 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 absorbent 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 (spills on earthen materials), 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 Hazardous Materials Teams will be contacted through the Guard Headquarters.

9.0 SITE CONTROL

This section outlines the means by which CF Braun Engineering Corporation 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. It is also anticipated that this control measure will be used to control access to site work areas. Use of such controls will restrict the general public, minimize potentials for the spread of contaminants, and protect individuals who are not cleared to enter work areas.

9.1 EXCLUSION ZONE

The exclusion zone will be considered those areas of the site of known or suspected contamination. It is not anticipated that significant amounts of surface contamination are in the proposed work areas of this site. It is anticipated that this will remain so until/unless contaminants are brought to the surface by intrusive activities such as drilling. Furthermore, once intrusive 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 plus a designated area surrounding the point of operation (see Table 5-1 for specific operation). The exclusion zone for this activity will be fragmented to represent the areas where the soils are disturbed through drilling, sampling, or ASVE installation activities. All exclusion zones will be delineated using barrier tape, cones and/or drive poles, and postings to inform and direct facility personnel.

9.1.1 Exclusion Zone Clearance

A pre-startup site visit will be conducted by members of the identified field team in an effort to identify proposed subsurface investigation locations, obtain utility clearances, and provide upfront notices concerning scheduled activities within the facility. Access to the identified work areas of the facility will be coordinated through the site contact. Utility clearances will incorporate the combined efforts of One Call Utility location services and the site contact.

In all cases, no subsurface activities will proceed without utility clearance. In the event that a utility is struck during a subsurface investigative activity, the emergency numbers provided in Section 2.9 will be notified.

When personnel are in the proximity of this investigation, they will be moved or their operation temporarily discontinued to remove them from potential hazards associated with this operation.

9.2 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. Personnel and equipment decontamination will take place in this area. This area will also serve as a focal point in supporting exclusion zone activities. This area will be delineated using barrier tape, cones and/or drive poles, and postings to inform and direct facility personnel.

9.3 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.

9.4 SAFE WORK PERMITS

All exclusion zone work conducted in support of this project will be done using Safe Work Permits to guide and direct field crews on a task by task basis. An example of the Safe Work Permit to be used is illustrated in Figure 9-1. These work permits will be further supported by the daily meetings conducted during their generation. This effort will ensure all site-specific considerations and changing conditions are incorporated into the planning effort. All permits will require the signature of the FOL, the SSO, and if possible a NWIRP onsite representative. All personnel engaged in onsite activities will be aware of the elements indicating levels of protection and precautionary measures to be used.

The use of these permits will establish and provide for reviewing protective measures and hazards associated with each operation. This HASP will be used as the primary reference for selecting levels of protection and control measures. The work permit will take precedence over the HASP when more conservative measures are required based on specific site conditions.

FIGURE 9-1
SAFE WORK PERMIT

Permit No. ____________ Date: ____________________ Time: From ______ to ______

SECTION I: General Job Scope (To be filled in by person performing work)

I. Work limited to the following (description, area, equipment used): ____________________

II. Names: ____________________

III. Onsite Inspection conducted ☐ Yes ☐ No Initials of Inspector ____________ ____________
CF Braun Eng. Corp NWIRP

SECTION II: General Safety Requirements (To be filled in by permit issuer)

IV. Protective equipment required
Level D ☐ Level B ☐
Level C ☐ Level A ☐
Detailed on Reverse

Respiratory equipment required
Full face APR ☐
Half face APR ☐
SKA-PAC SAR ☐
Skid Rig ☐
Escape Pack ☐
SCBA ☐
Bottle Trailer ☐
None ☐

Modifications/Exceptions: ____________________

V. Chemicals of Concern	Action Level(s)	Response Measure

VI. Additional Safety Equipment/Procedures
Chemical goggles ☐ Yes ☐ No
Hearing Protection ☐ Yes ☐ No
Safety belt/harness ☐ Yes ☐ No
Radio ☐ Yes ☐ No
Barricades ☐ Yes ☐ No
Work/rest regimen ☐ Yes ☐ No
Modifications/Exceptions: ____________________

VII. Procedure review with permit acceptors

	Yes	NA
Safety shower/eyewash (Location & Use)	☐	☐
Procedure for safe job completion	☐	☐
Contractor tools/equipment inspected	☐	☐
Emergency alarms	☐	☐
Evacuation routes	☐	☐
Assembly points	☐	☐

VIII. Equipment Preparation

	Yes	NA
Equipment drained/depressured	☐	☐
Equipment purged/cleaned	☐	☐
Isolation checklist completed	☐	☐
Electrical lockout required/field switch tested	☐	☐
Blinds/misalignments/blocks & bleeds in place	☐	☐
Hazardous materials on walls/behind liners considered	☐	☐

IX. Additional Permits required (Hot work, enclosed entry, excavation etc.). ☐ Yes ☐ No
If yes, contact the Health Sciences Department.

X. Special instructions, precautions: ____________________

Permit Issued by: ____________________ Permit Accepted by: ____________________
Job Completed by: ____________________ Date: ____________________

9.5 SITE VISITORS

Site visitors for the purpose of this document are identified as representing the following groups of individuals:

- Personnel invited to observe or participate in operations by CF Braun Engineering Corporation
- Regulatory personnel (i.e., DOD, EPA, OSHA)
- Northern Division Navy Personnel
- Other authorized visitors

All non-DOD personnel working on this project are required to gain initial access to the facility by coordinating with the CF Braun Engineering Corporation FOL or designee and following established facility access procedures.

Once access to the facility is obtained, all personnel who require site access (areas of ongoing operations) will be required to obtain permission from the FOL. Upon gaining access to the site, all site visitors wishing to observe operations in progress from the exclusion zone will be escorted by a CF Braun Engineering Corporation representative and shall be required to meet the minimum requirements discussed below:

- All site visitors will be routed to the FOL, who will sign them into the field logbook. Information to be recorded in the logbook will include the individuals name (proper identification required), who they represent, and the purpose of the visit.

- All site visitors will be required to produce the necessary information supporting clearance to the site. This include information attesting to applicable training (40-hours of HAZWOPER training required for all Northern Division Navy personnel), and medical surveillance as stipulated in Section 7.0 of this document. In addition, to enter the site operational zones during planned activities, all visitors will be required to first go through site-specific training covering the topics stipulated in Section 7.2, of this HASP.

Once the site visitors have completed the above items they will be permitted to enter the operational zone. All visitors are required to observe the protective equipment and site restrictions in effect at the site of their visit. Any and all visitors not meeting the requirements as stipulated in this plan for site clearance will not be permitted to enter the site operational zones during planned activities. Any incidence of unauthorized site visitation will cause all onsite activities to be terminated until the unauthorized visitor is removed from the premises. Removal of unauthorized visitors will be accomplished with support from the facility. If necessary, the facility contact will be notified of any unauthorized visitors.

9.6 WORK SITE SECURITY

CF Braun Engineering Corporation will retain complete control over active operational zones (immediate areas in which site activities discussed in the scope of work are being performed). As this activity takes place at a Navy facility, the first line of security will be performed by Navy personnel at the base gate restricting the general public. The second line of security will be performed by CF Braun Engineering Corporation and will take place at immediate ares where site work is being performed. Any visitors wishing to observed site activities will be referred to the FOL. These visitor will be escorted by CF Braun Engineering Corporation personnel at all times.

9.7 SITE MAP

Once the areas of contamination, access routes, topography, and 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. A site map to the hospital will also be provided as part of this HASP.

9.8 BUDDY SYSTEM

Personnel engaged in onsite activities will practice the "buddy system" to ensure the safety of all personnel involved in this operation.

9.9 MATERIAL SAFETY DATA SHEET (MSDS) REQUIREMENTS

CF Braun Engineering Corporation personnel will provide MSDSs for all chemicals brought on site. The contents of these documents will be reviewed by the SSO with the user(s) of the chemical substances prior to any actual use or application of the substances on site. A chemical inventory of all chemicals used on site will be developed using the Brown & Root Environmental Health and Safety Guidance Manual. The MSDSs will then be maintained in a central location (i.e., temporary office) and will be available for anyone to review upon request.

9.10 COMMUNICATION

If site ersonnel are not working in proximity to one another during field activities, a supported means of communication between field crews will be used as necessary. Two-way radio communication devices will be submitted for approval by NWIRP for use while at the facility.

External communication will be accomplished by using the telephones at predetermined and approved locations or through cellular phones. External communication will primarily be used for the purpose of resource and emergency resource communications. Prior to the commencement of activities at the NWIRP, the FOL will determine and arrange for telephone communications, if it is determined a cellular means will not be used.

10.0 CONFINED SPACE ENTRY

Personnel under the provisions of this HASP are not allowed. under any circumstances, to enter confined spaces. Confined spaces or Permit-Required Confined Spaces are not anticipated as part of this task order and have not been identified within the scope of work. Personnel should understand a confined space is defined as an area which has one or more of the following characteristics:

- Is large enough and so configured that an employee can bodily enter and perform assigned work.
- Has limited or restricted means for entry or exit (for example, tanks, vessels, silos, storage bins, hoppers, vaults, and pits are spaces that may have limited means of entry).
- Is not designed for continuous employee occupancy.

Additionally, a Permit-Required Confined Space may also have one or more of the following characteristics:

- Contains or has a potential to contain a hazardous atmosphere.
- Contains a material that has the potential to engulf an entrant.
- Has an internal configuration such that an entrant could be trapped or asphyxiated by inwardly converging walls or by a floor which slopes downward and tapers to a smaller cross-section.
- Contains any other recognized, serious, safety or health hazard.

For further information on confined space consult the Health and Safety Guidance Manual or call the Manager, Health Sciences.

11.0 MATERIALS AND DOCUMENTS

The CF Braun Engineering Corporation FOL shall ensure the following materials/documents are taken to the project site and utilized as required.

- Incident Reports
- Medical Data Sheets
- Material Safety Data Sheets for decon solutions and other substances brought to the site
- Follow-Up Reports (to be completed by the FOL)
- OSHA Job Safety and Health Poster (posted in site trailer)
- Training/Medical Surveillance Documentation Form (Blank)
- First Aid Supply Usage Form
- Emergency Reference Form (Section 2.0, extra copy for posting)
- Health and Safety Guidance Manual

12.0 GLOSSARY

ACGIH	American Conference of Governmental Industrial Hygienists
APR	Air Purifying Respirators
ASVE	Air Sparging Vapor Extraction
CFR	Code of Federal Regulations
CNS	Central Nervous System
CQP	Construction Quality Plan
eV	electron Volts
FID	Flame Ionization Detector
FOL	Field Operations Leader
HASP	Health and Safety Plan
HAZWOPER	Hazardous Waste Operations and Emergency Response
HEPA	High Efficiency Particulate Air
HSM	Health and Safety Manager
IWWTF	Industrial Waste Water Treatment Facility
N/A	Not Available
NIOSH	National Institute Occupational Safety and Health
NWIRP	Naval Weapons Industrial Reserve Plant
OSHA	Occupational Safety and Health Administration (U.S. Department of Labor)
PEL	Permissible Exposure Limit
PID	Photo Ionization Detector
PM	Project Manager
PPE	Personal Protective Equipment
PVC	Poly Vinyl Chloride
SAP	Sampling and Analyses Plan
SCBA	Self Contained Breathing Apparatus
SSO	Site Safety Officer
STEL	Short Term Exposure Limit
TWA	Time Weighted Average
UV	Ultra Violet
WP	Work Plan

APPENDIX F

SUPPORT CALCULATION FOR AS/SVE SYSTEM

Appendix F - Calculations

North Div - Navy, CTO 213 **DDB, 03/20/1997** DDB 3/20/97

Maximum Pressure Drop Calculations for the Injection and Extraction System and Consideration of Potential VOC Stratification

1.0 Estimate pressure drop through extraction piping system

Use the furtherest well at the highest flowrate.

Piping material:	2" PVC
Estimated piping run - horizontal:	180 LF (EW03 - maximum)
Estimated piping run - vertical:	60 LF
Equivalent length of pipe for fittings:	
- valves:1	23 LF (wide open)
- elbows:8	60 LF
Total piping length - equivalent	323 LF
Maximum flow from one extraction well:	80 CFM
which equals:	4800 CFHr

Pressure drop, see attached Pipe Flow Computer. Properties would be the same as for air.

Result: 45 inches water gauge

Convert result to inches Hg.

45/13.5= 3.33 inches HG, SG of Hg is 13.5

Approximate pressure drop for blower and separator: 1 inch HG

Measured soil resistance data from Calverton Pilot Study:

For a 4 foot well screen, the data is as follows and includes pressure drop from approximately 6 feet of pipe and well screen.

CFM	Header Vacuum (inches water) - X
4	0.6
5	0.95
8	1
10	1.6
12	1.6

Perform a linear regression of the data.

Regression Output:	
Constant	-0.41429
Std Err of Y Est	1.355764
R Squared	0.876913
No. of Observations	5
Degrees of Freedom	3

DSB 3/2/97
2

X Coefficient(s)	7.142857
Std Err of Coef.	1.545036

Calculate the vacuum required for 80 CFM:

Formula is y = mx + b

For y equal to 80 CFM, x = 11.3 inches of water

Next evaluate data using a log plot, (typical for pressure drop calculations)

Log (CFM)	Log (vacuum)
0.60206	-0.22185
0.69897	-0.02228
0.90309	0
1	0.20412
1.079181	0.20412

Next perform a regression on the log-log data.

Regression Output:

Constant	0.822033
Std Err of Y Est	0.081293
R Squared	0.877549
No. of Observations	5
Degrees of Freedom	3

X Coefficient(s)	1.054981
Std Err of Coef.	0.227526

Note that the R coefficients are very similar, probably because the x coefficient is close to 1.0. This similarity likely results from only a small range of flow rates being evaluated.

Calculate vacuum required at 80 CFM, using log-log regression.

Formula is y' = mx' + b, where y' and x' are the log of y and x, respectively

For y equal to 80 CFM, y' = 1.90309 (log of 80)

From the formula, y' = mx' + b, x' = 1.024717
x = 10.6 inches of water

In both cases, the estimated vacuum based on Calverton Work is approximately 0.8 "Hg.

The total calculated pressure drop would be: 3.3+0.8+1.0 = 5.1 inches Hg.

Note that because of a longer well screen will be used, (10 feet), lower pressure drops around the well screen would be expected. However, there will be approximately 50 feet of soil overlaying the well screen.

Assuming a conservative linear drop across the depth of the vadose zone, (60 at Bethpage,versus 6 feet at Calverton), the vacuum could increase by a factor of approximately 10, i.e. 110 inches of water, or 8" Hg.

DDG 3/2/97
3

110 inches of water column vacuum could cause the the water table to rise approximately 9 feet.

This concern will have to be monitored during the trial to ensure that the water level does not block off the soil vapor flow and or cause system vacuums to exceed the rating of the blower. Note that vacuum measurements are planned at each well, and that excessive vacuum could become a limiting design criteria.

However, as long as the vacuum is maintained at less than approximately 60 inches of water column, there should not be a problem with water rise impacting well opertion.

2.0 Evaluate the impact that PCE may have on the soil vapor density.

PCE, with a molecular weight of 166, is heavier than air by a factor of approximately 166/29 = 5.7

Typical maximum VOC concentrations measured in the soil gas were 1000 ppm. At this concentration, air is 99.9% and VOCs are 0.1%

The specific gravity of this mixture is as follows.

0.999*29 + 0.001*166/29 1.005

This density difference should not impact the ability to extract air. However, based on the density difference, one conclusion is that PCE (and similar compounds) would be expected to sink to a confining layer (groundwater). Conversely, diffusion and atmospheric disturbances would be expected to cause the PCE (and similar compounds) to rise and escape to the atmosphere.

The implication being that for a soil vapor extraction system without air sparging, it is possible that contaminated soil vapors could stratify, and therefore would not be effectively collected by an extraction system. However, with an air sparging system, this concern would not be expected to be as significant since the air flow direction would then be opposite of the stratification effects.

For the pilot study, CF Braun recommends that some tests be conducted to evaluate the potential for stratification.

These tests would be as follows.

1. At an extraction well prior to operation, measure total VOC concentration at depths of 1, 2, 5 and 10 feet above the water table. A calibrated suction tube and air pump would be used.

2. Measure the total VOC concentration at the same depths during operation of this well to determine if stratification is present.

3. At an adjacent monitoring well, conduct the same tests prior to and during operation.

4. If stratification is detected, conduct the same tests after the air sparging well is in operation.

DDB 3/20/[illegible]
4

3.0 Estimate pressure drop through injection piping system

Piping material:	2" PVC
Estimated piping run - horizontal:	150 LF
Estimated piping run - vertical:	69 LF
Equivalent length of pipe for fittings:	
- valves:1	23 LF (wide open)
- elbows:8	60 LF
Total piping length - equivalent	302 LF
Maximum flow to one extraction well:	60 CFM
which equals:	3600 CFHr

Pressure drop, see attached Pipe Flow Computer. Properties would be the same as for air.

Result:	16 inches water gauge

Convert result to psi

16/(12*2.3)	0.6 psi	2.3 feet of water equals one psi

Static head loss.

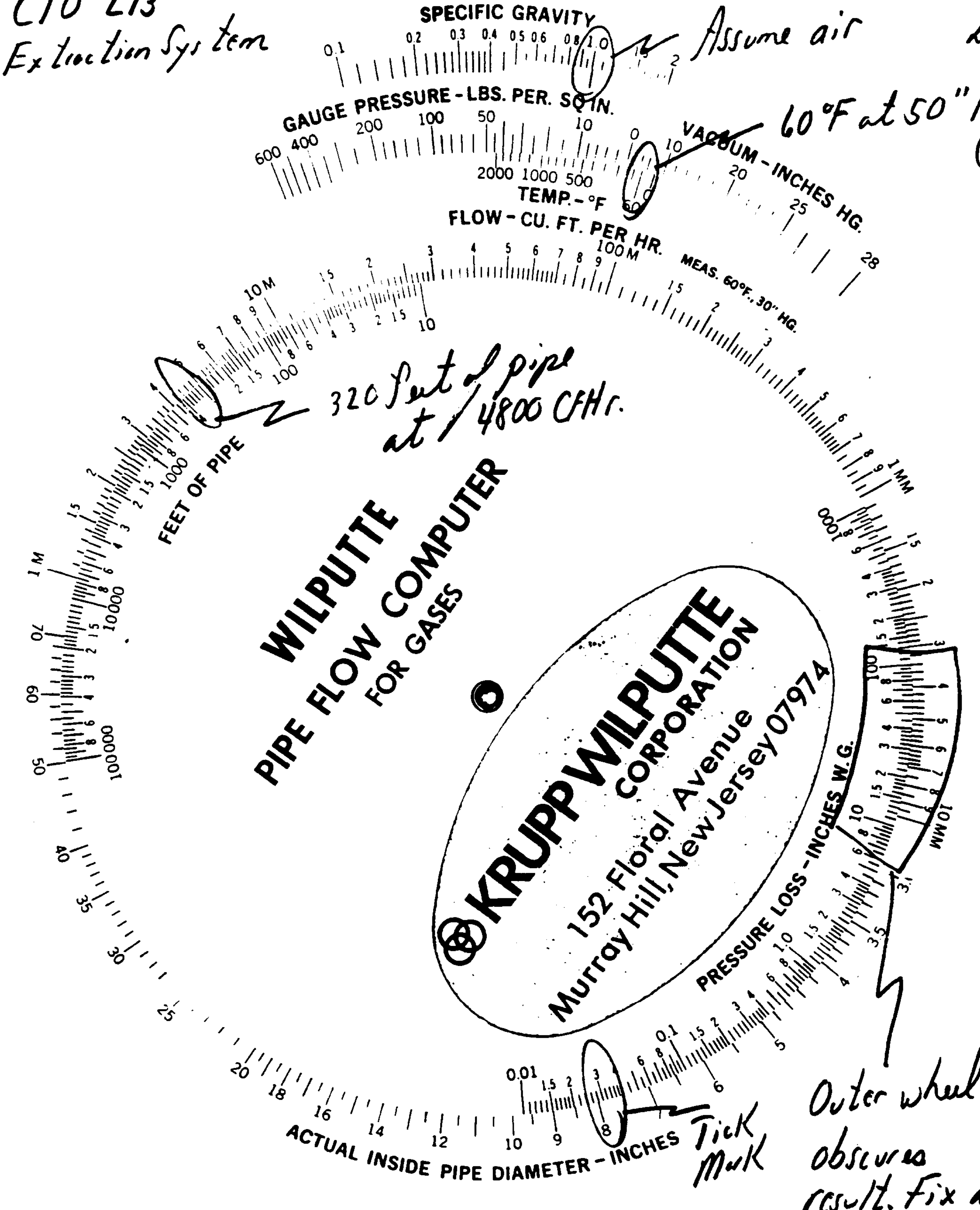
Minimum is 8 feet:	8/2.3	3.5 psi
Maximum is 10 feet	10/2.3	4.3 psi

Total pressure drop: 4.9 psi

One psi of pressure will be available to push air into aquifer.

CTO 213
Extraction System

5
DDB 2/1/91



Assume air

60°F at 50" Hg

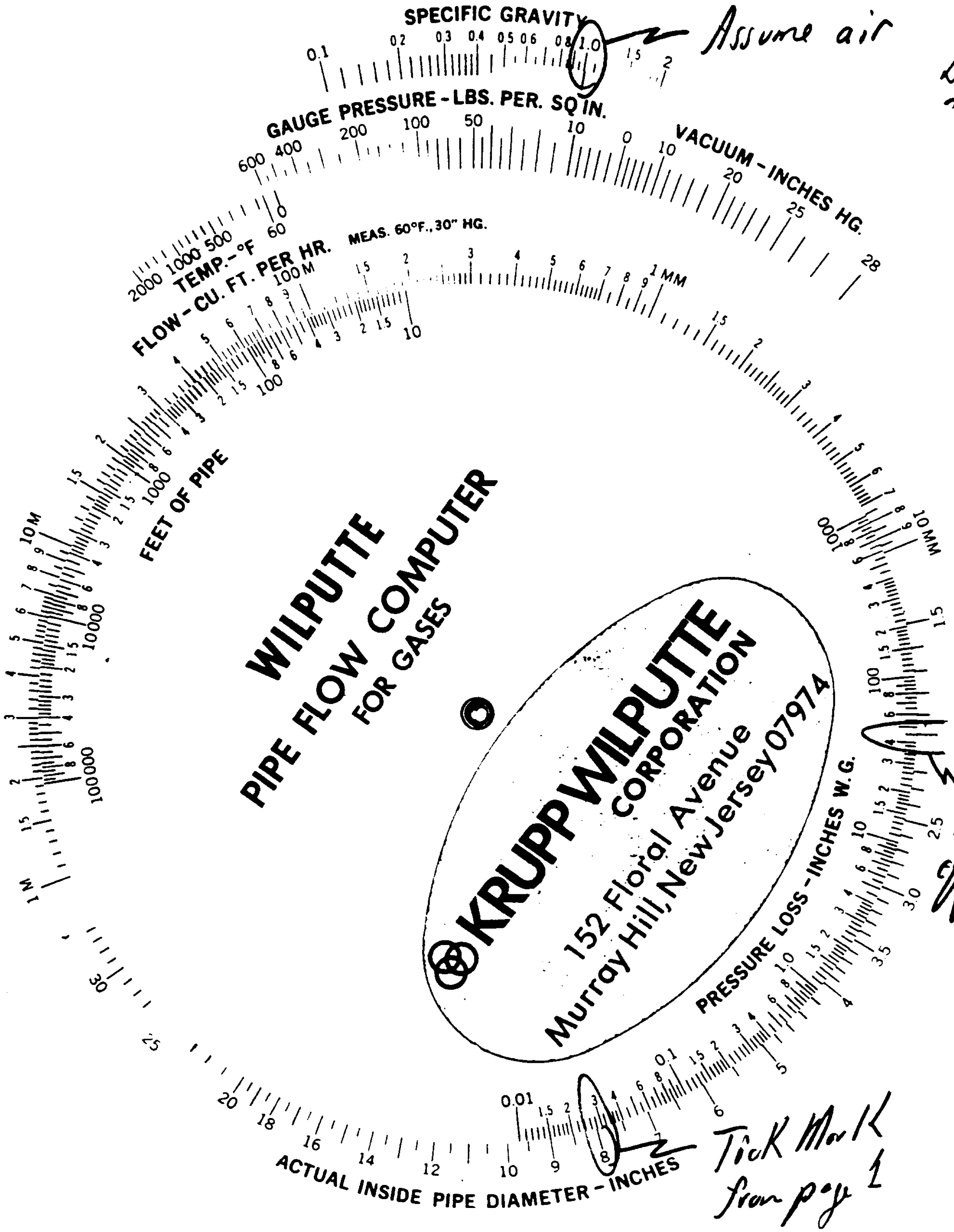
320 feet of pipe at 4800 CFHr.

Tick Mark

Outer wheel obscures result. Fix a tick mark & rotate out of way. see Page 6

The Computer is based on the flow of gas which leaves no deposit in the pipe. For reasonably clean lines multiply the computed pressure losses by the following factors which allow for normal deposits:

Natural gas	1.00
Air	1.00
Clean blast furnace gas	1.10
Coke oven gas	1.30
Carburetted water gas	1.30



Assume air

Tick Mark from pag 1

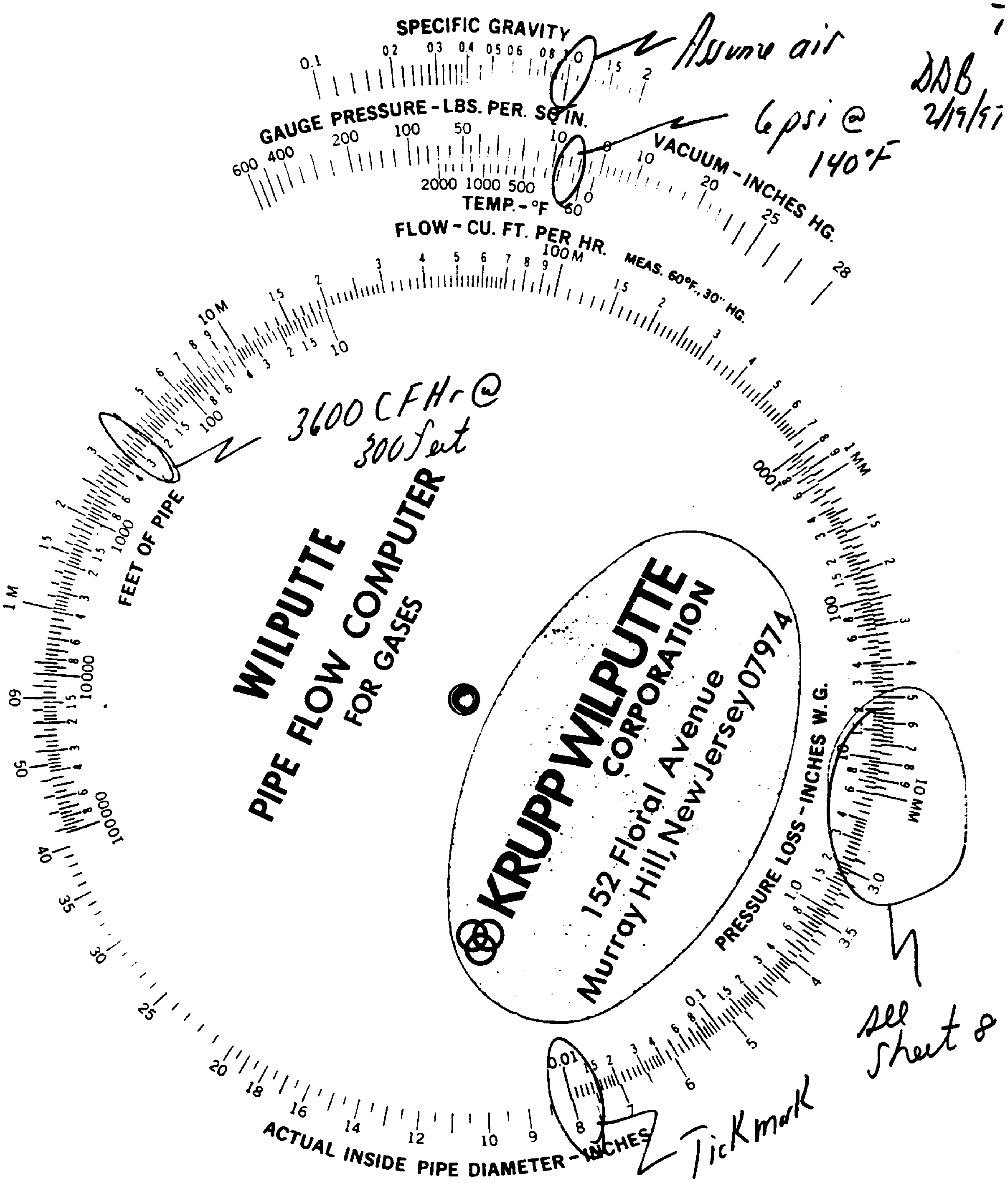
2

equals

W.

The Computer is based on the flow of gas which leaves no deposit in the pipe. For reasonably clean lines multiply the computed pressure losses by the following factors which allow for normal deposits:

Natural gas	1.00
Air	1.00
Clean blast furnace gas	1.10
Coke oven gas	1.30
Carburetted water gas	1.30



Assume air

6 psi @ 140°F

DDB
2/19/97

3600 CFHr @
300 feet

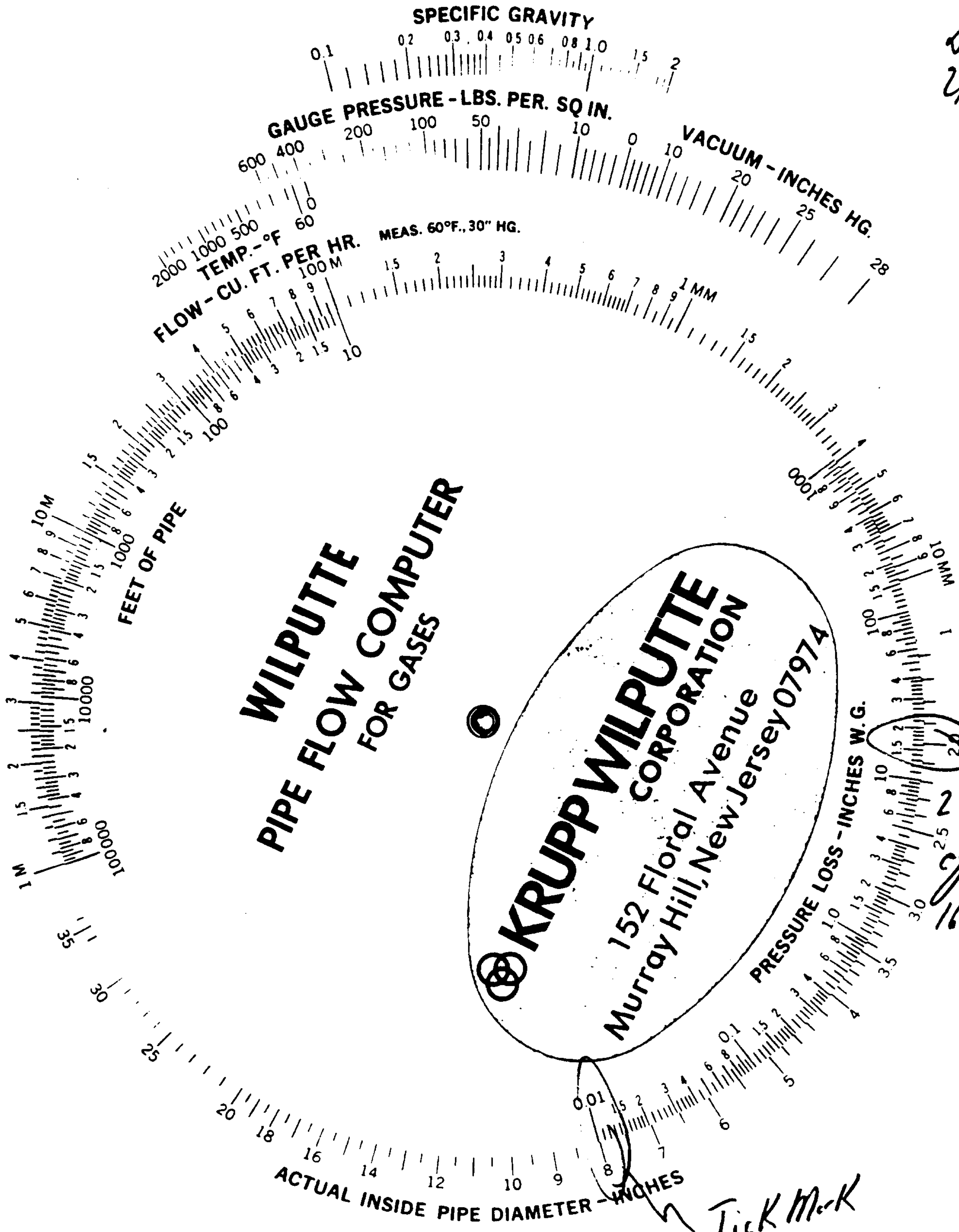
See
Sheet 8

Tickmark

The Computer is based on the flow of gas which leaves no deposit in the pipe. For reasonably clean lines multiply the computed pressure losses by the following factors which allow for normal deposits:

Natural gas	1.00
Air	1.00
Clean blast furnace gas	1.10
Coke oven gas	1.30
Carburetted water gas	1.30

DDB
2/19/97



2" pipe equals 16" wc

Tick Mark

The Computer is based on the flow of gas which leaves no deposit in the pipe. For reasonably clean lines multiply the computed pressure losses by the following factors which allow for normal deposits:

Natural gas	1.00
Air	1.00
Clean blast furnace gas	1.10
Coke oven gas	1.30
Carburetted water gas	1.30

Injection Blower

C70 213

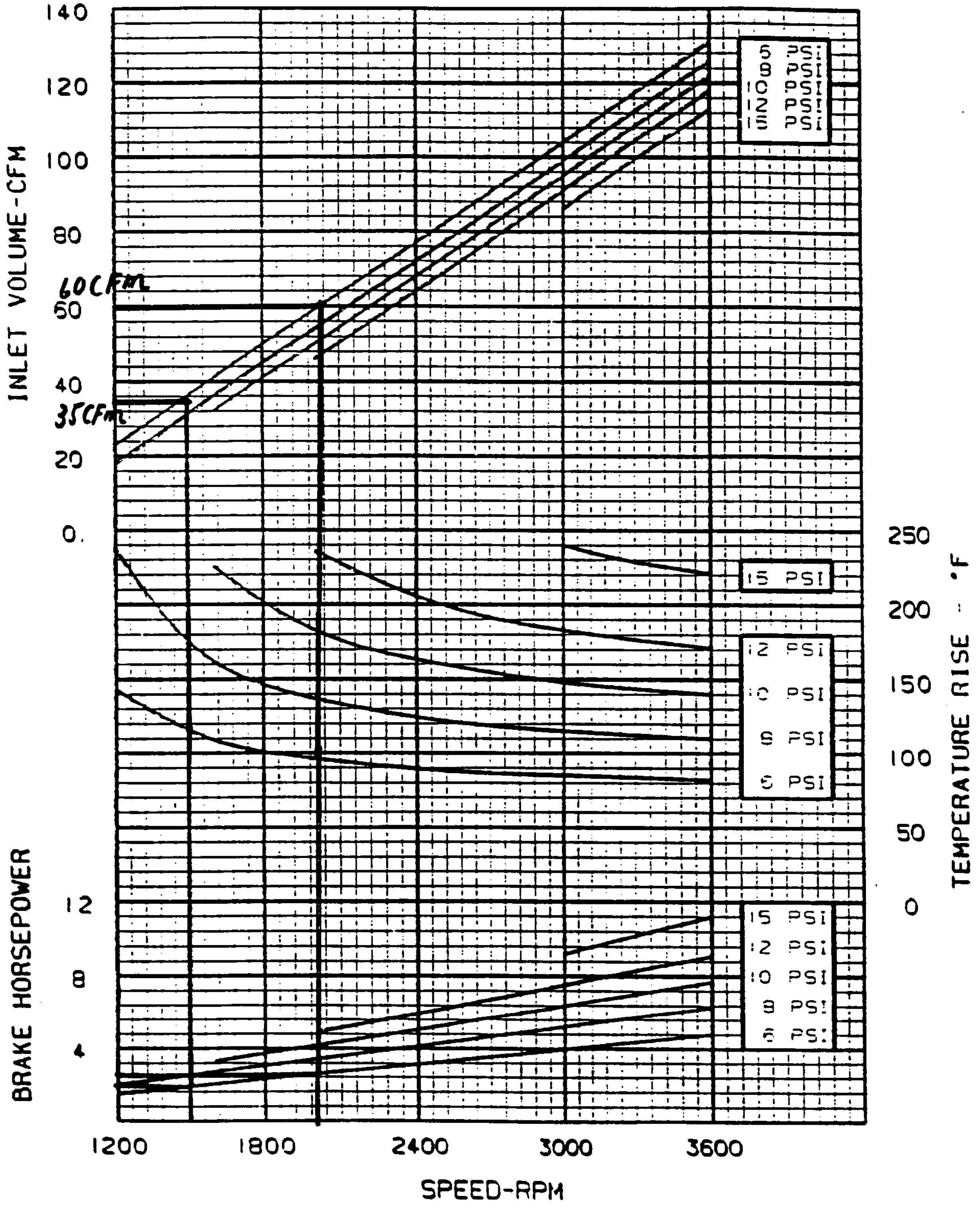
9

DDB
2/9/57

DRESSER INDUSTRIES, INC.
ROOTS DIVISION
900 WEST MOUNT STREET
CONNERSVILLE, INDIANA 47331
PRINTED IN U.S.A.

PERFORMANCE BASED ON
INLET AIR AT 14.7 PSIA & 68°F
JULY, 1984

PRESSURE PERFORMANCE
FRAME 32 UNIVERSAL RAI BLOWER
MAXIMUM PRESSURE RISE=15 PSI
MAXIMUM SPEED=3600 RPM



PART32 CRVE

Extraction Blower

CTO 213

DDB 2/1/95,

DRESSER INDUSTRIES, INC.
ROOTS DIVISION
900 WEST MOUNT STREET
CONNERSVILLE, INDIANA 47331
PRINTED IN U.S.A.

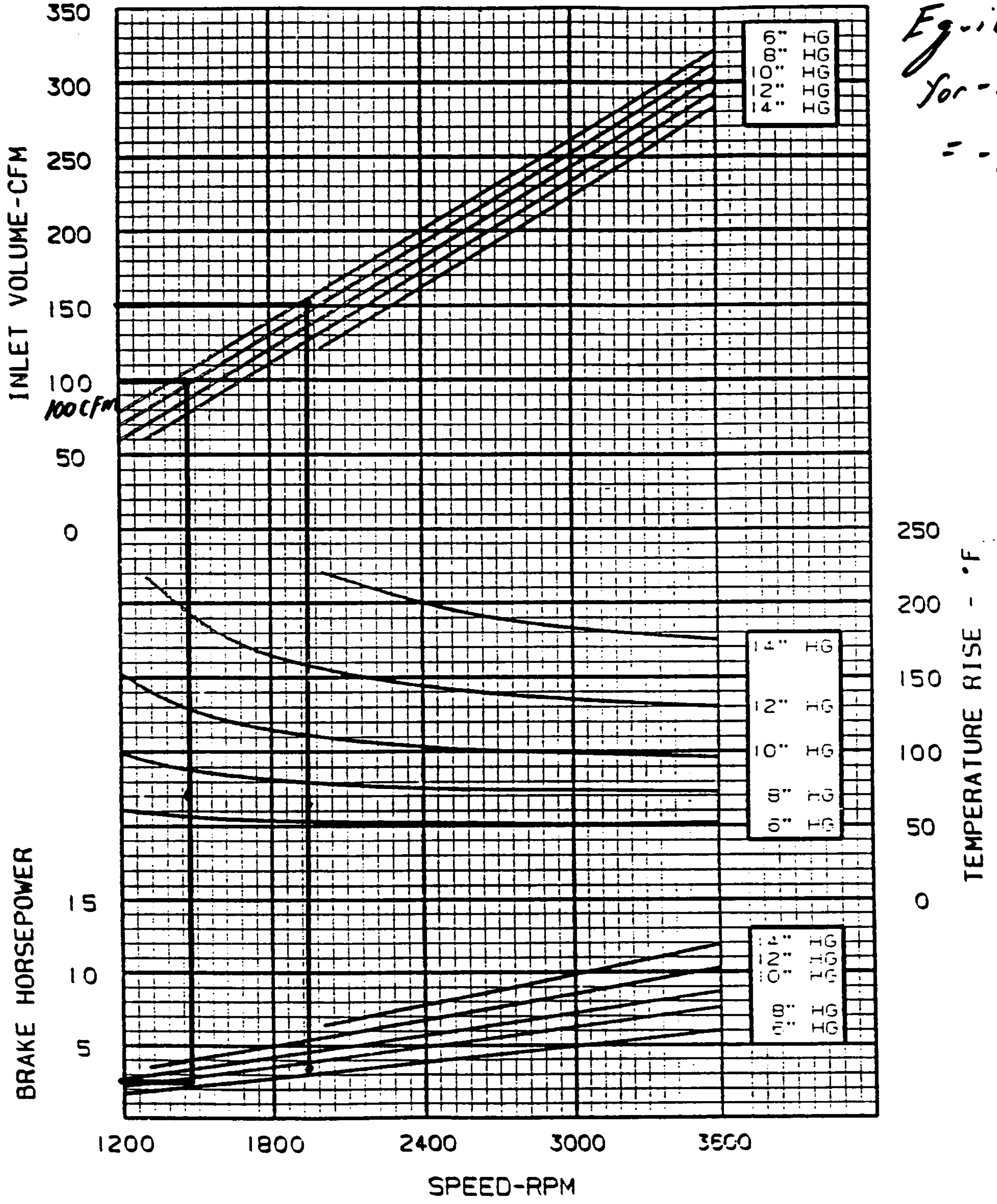
PERFORMANCE BASED ON
INLET AIR = 68°F
DISCHARGE PRESSURE = 30" HG ABS.
JULY, 1994

VACUUM PERFORMANCE
FRAME 36 UNIVERSAL RAI BLOWER
MAXIMUM VACUUM=15 IN. HG
MAXIMUM SPEED=3600 RPM

1.0 PSI (discharge) = 2" Hg

Equivalent for -5" Hg / +1.0

= -7" Hg



C70213

```
Roots - Blower Selection  Dist 2.9c      Tuesday  February 18, 1997  9:45 am
 ——Copyright (c) Dresser Industries Inc 1995.  All rights reserved.——

                                  Selected Unit

                     Model: 24   URAI                    Summary: <list>
      Inlet Volume (ACFM): 60        SCFM: 55                 Gas: AIR
    Inlet Pressure (PSIA): 14.18                          K-Value: 1.395
        Inlet Temp(Deg.F): 100                   Specific Gravity: 1.000
Discharge Pressure (PSIA): 20.68                 Molecular Weight: 28.966
Differential Press. (PSI): 6.50      92%           Elevation/Feet: 600
  Ambient Pressure (PSIA): 14.38              Relative Humidity: 0%
              Speed (RPM): 2957      56%     Amb/Jet Temperature: 100
         Brake Horsepower: 2.8                         Motor Type: TEFC
Temperature Rise (Deg. F): 97        46%

        Discharge Temperature (Deg. F):     197
             Discharge Volume (ACFM):        48
               Gear Tip Speed (FPM):       1937
     Estimated B10 Bearing Life (HRS):   144000
Estimated Noise Level at 1 Meter (DBA):    80.9

     <Esc> Print Proposal,  <F7> Cancel,  <F10> Next,  <F8> Previous
```

```
Roots - Blower Selection  Dist 2.9c      Tuesday  February 18, 1997  9:50 am
 ——Copyright (c) Dresser Industries Inc 1995.  All rights reserved.——

                                  Selected Unit

                     Model: 32   URAI                    Summary: <list>
      Inlet Volume (ACFM): 60        SCFM: 55                 Gas: AIR
    Inlet Pressure (PSIA): 14.18                          K-Value: 1.395
        Inlet Temp(Deg.F): 100                   Specific Gravity: 1.000
Discharge Pressure (PSIA): 20.68                 Molecular Weight: 28.966
Differential Press. (PSI): 6.50      43%           Elevation/Feet: 600
  Ambient Pressure (PSIA): 14.38              Relative Humidity: 0%
              Speed (RPM): 2082      57%     Amb/Jet Temperature: 100
         Brake Horsepower: 2.9                         Motor Type: TEFC
Temperature Rise (Deg. F): 104       46%

        Discharge Temperature (Deg. F):     204
             Discharge Volume (ACFM):        48
               Gear Tip Speed (FPM):       1909
     Estimated B10 Bearing Life (HRS):  1412000
Estimated Noise Level at 1 Meter (DBA):    83.1

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C70213

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Roots - Blower Selection  Dist 2.9c       Tuesday  February 18, 1997  9:53 am
      Copyright (c) Dresser Industries Inc 1995.  All rights reserved.

                              Selected Unit

                    Model: 36    URAI                     Summary: <list>
     Inlet Volume (ACFM): 100       SCFM: 79                   Gas: AIR
   Inlet Pressure (PSIA): 11.52                           K-Value: 1.395
       Inlet Temp(Deg.F): 68                     Specific Gravity: 1.000
Discharge Pressure (PSIA): 14.70                 Molecular Weight: 28.966
       Inlet Vacuum (HG): 6.50      43%            Elevation/Feet: 0
  Ambient Pressure (PSIA): 14.70                Relative Humidity: 0%
            Speed (RPM): 1439      39%       Amb/Jet Temperature: 100
        Brake Horsepower: 2.2                          Motor Type: TEFC
Temperature Rise (Deg. F): 57       25%

      Discharge Temperature (Deg. F):      125
            Discharge Volume (ACFM):       86
               Gear Tip Speed (FPM):     1320
     Estimated B10 Bearing Life (HRS): 1654000
Estimated Noise Level at 1 Meter (DBA):     73.1

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```
Roots - Blower Selection  Dist 2.9c       Tuesday  February 18, 1997  9:54 am
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                              Selected Unit

                    Model: 36    URAI                     Summary: <list>
     Inlet Volume (ACFM): 200       SCFM: 158                  Gas: AIR
   Inlet Pressure (PSIA): 11.52                           K-Value: 1.395
       Inlet Temp(Deg.F): 68                     Specific Gravity: 1.000
Discharge Pressure (PSIA): 14.70                 Molecular Weight: 28.966
       Inlet Vacuum (HG): 6.50      43%            Elevation/Feet: 0
  Ambient Pressure (PSIA): 14.70                Relative Humidity: 0%
            Speed (RPM): 2419      67%       Amb/Jet Temperature: 100
        Brake Horsepower: 4.0                          Motor Type: TEFC
Temperature Rise (Deg. F): 51       22%

      Discharge Temperature (Deg. F):      119
            Discharge Volume (ACFM):      171
               Gear Tip Speed (FPM):     2219
     Estimated B10 Bearing Life (HRS):  984000
Estimated Noise Level at 1 Meter (DBA):     79.9

     <Esc> Print Proposal,  <F7> Cancel,  <F10> Next,  <F8> Previous
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Should be 150

Should be 15.7

C70 213

13

```
Roots - Blower Selection  Dist 2.9c      Tuesday  February 18. 1997  9:42 am
  ——Copyright (c) Dresser Industries Inc 1995.  All rights reserved.——

                              Selected Unit

                    Model: 24   URAI                       Summary: <list>
       Inlet Volume (ACFM): 35         SCFM: 32                Gas: AIR
     Inlet Pressure (PSIA): 14.18                          K-Value: 1.395
         Inlet Temp(Deg.F): 100                   Specific Gravity: 1.000
 Discharge Pressure (PSIA): 20.68                Molecular Weight: 28.966
 Differential Press. (PSI): 6.50     92%           Elevation/Feet: 600
   Ambient Pressure (PSIA): 14.38               Relative Humidity: 0%
               Speed (RPM): 2176     41%     Amb/Jet Temperature: 100
          Brake Horsepower: 2.1                        Motor Type: TEFC
 Temperature Rise (Deg. F): 121      57%

        Discharge Temperature (Deg. F):     221
              Discharge Volume (ACFM):      29
                 Gear Tip Speed (FPM):    1425
       Estimated B10 Bearing Life (HRS):  195000
 Estimated Noise Level at 1 Meter (DBA):    76.8

    <Esc> Print Proposal,  <F7> Cancel,  <F10> Next,  <F8> Previous
```

```
Roots - Blower Selection  Dist 2.9c      Tuesday  February 18, 1997  9:44 am
   ——Copyright (c) Dresser Industries Inc 1995.  All rights reserved.——

                              Selected Unit

                    Model: 32   URAI                       Summary: <list>
       Inlet Volume (ACFM): 35         SCFM: 32                Gas: AIR
     Inlet Pressure (PSIA): 14.18                          K-Value: 1.395
         Inlet Temp(Deg.F): 100                   Specific Gravity: 1.000
 Discharge Pressure (PSIA): 20.68                Molecular Weight: 28.966
 Differential Press. (PSI): 6.50     43%           Elevation/Feet: 600
   Ambient Pressure (PSIA): 14.38               Relative Humidity: 0%
               Speed (RPM): 1526     42%     Amb/Jet Temperature: 100
          Brake Horsepower: 2.1                        Motor Type: TEFC
 Temperature Rise (Deg. F): 128      56%

        Discharge Temperature (Deg. F):     228
              Discharge Volume (ACFM):      29
                 Gear Tip Speed (FPM):    1399
       Estimated B10 Bearing Life (HRS): 1926000
 Estimated Noise Level at 1 Meter (DBA):    78.8

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```
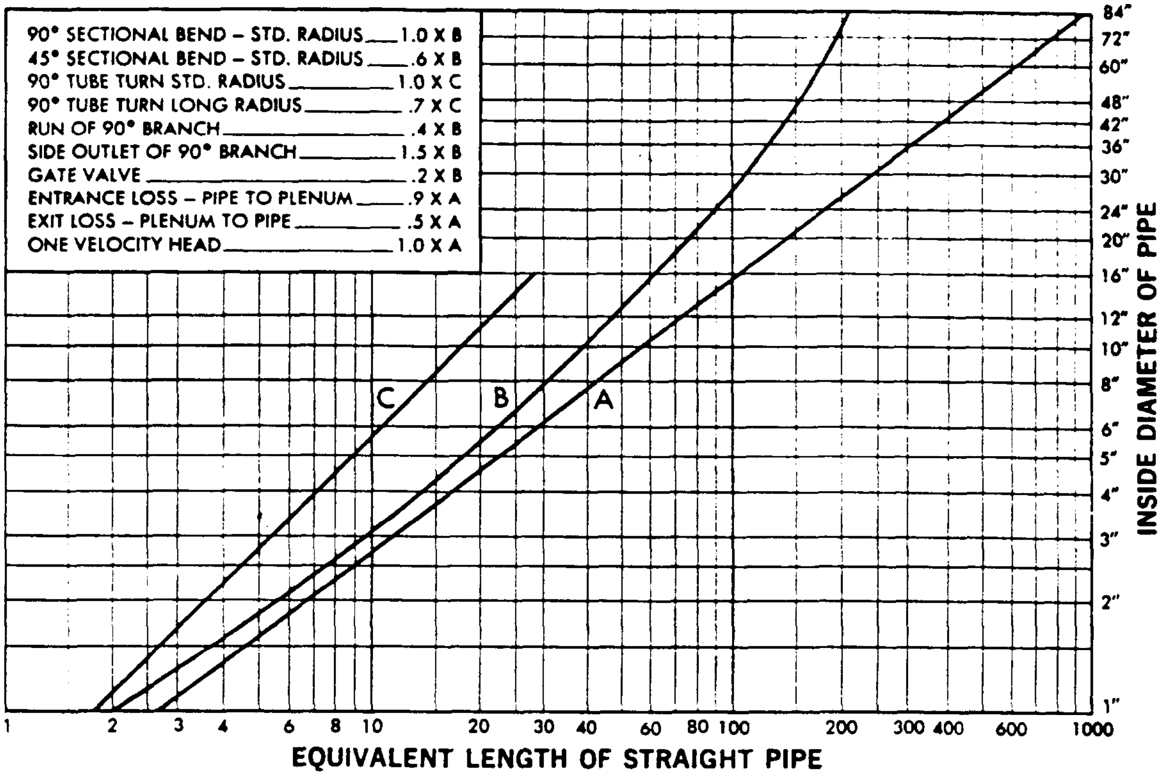

FACTORS FOR LOSS THROUGH FITTINGS



90° SECTIONAL BEND – STD. RADIUS	1.0 X B
45° SECTIONAL BEND – STD. RADIUS	.6 X B
90° TUBE TURN STD. RADIUS	1.0 X C
90° TUBE TURN LONG RADIUS	.7 X C
RUN OF 90° BRANCH	.4 X B
SIDE OUTLET OF 90° BRANCH	1.5 X B
GATE VALVE	.2 X B
ENTRANCE LOSS – PIPE TO PLENUM	.9 X A
EXIT LOSS – PLENUM TO PIPE	.5 X A
ONE VELOCITY HEAD	1.0 X A

Examples of Use of Computer

Example 1

Gas saturated at 60°F, 30" Hg., other conditions as follows:

Specific gravity	.40
Average pressure	10 lbs. per sq. in. gauge
Average temperature	150°F
Flow	100,000 CFH (measured @ 60°F, 30" Hg)

Length of pipe—1000' (including straight pipe plus the equivalent length for valves, fittings, entrance and exit losses, as determined from above curves.)

Actual inside diameter of pipe	8.0"
Pressure loss	9.8" W.G.

Example 2

Length of line 20,000', initial pressure 10 lbs. per sq. in. gauge, other conditions (except average pressure) same as for example 1.

Setting up the values on the computer with average pressure tentatively *assumed* as say 8 lbs. per sq. in. a *trial* pressure loss is found to be 220" W.G. (=8 lbs. per sq. in.). With the initial pressure of 10, and a loss of 8, the terminal pressure would be 2 and the average line pressure 6. Resetting the computer to 6 lbs. per sq. in. pressure, pressure loss is found to be 240" W.G.

Example 3

The Computer is based on flow of gas saturated at 60°F, 30" Hg. If the gas contains an appreciably greater amount of water vapor, the pressure loss, computed as in Example 1, must be multiplied by a correction factor. Correction factors for water vapor for various conditions are given in the following table:

CORRECTION FACTORS FOR WATER VAPOR						
Specific Gravity	Dewpoint at 30" Hg absolute pressure					
	80°F	100°F	120°F	140°F	150°F	160°F
0.40	1.05	1.13	1.30	1.64	1.96	2.43
0.60	1.04	1.10	1.24	1.50	1.74	2.11
0.80	1.03	1.09	1.20	1.43	1.63	1.95
1.00	1.03	1.08	1.19	1.39	1.58	1.86