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Work Plan
For Source Removal Evaluation

Old Fire Fighting Training Area
Naval Education and Training Center
Newport, Rhode Island

Northern Division
Naval Facilities Engineering Command

Contract Number N62472-90-D-1298
Contract Task Order 288

May 1997

Brown & Root Environmental
A Division of Halliburt n NUS Corporation

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WORK PLAN
FOR SOURCE REMOVAL EVALUATION

OLD FIRE FIGHTING TRAINING AREA
NAVAL EDUCATION AND TRAINING CENTER
NEWPORT, RHODE ISLAND

COMPREHENSIVE LONG-TERM
ENVIRONMENTAL ACTION NAVY (CLEAN) CONTRACT

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Northern Division, Code 18
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1.0 INTRODUCTION

This Work Plan has been prepared under the Comprehensive Long-Term Environmental Action Navy (CLEAN) Contract Task Order (CTO) 0288 dated January 28, 1997. The statement of work requires Brown & Root (B&R) Environmental to provide a Work Plan to assess whether a removal action of potential sources is warranted at the Old Fire Fighting Training Area (Site 09) located at the Naval Education & Training Center (NETC) on Coasters Harbor Island, in Newport, Rhode Island (Figure 1-1).

The 5.5-acre Old Fire Fighting Training Area (OFFTA) was used to train Navy personnel in fighting fires on ships during the period from approximately World War II until 1972. Site 09 historical information presented in the Draft Final Phase II Remedial Investigation report, prepared by TRC Environmental Corporation (TRC) in July 1994, indicated that fuels, oils, and spent solvents had been used at Site 09 to set the fires for training purposes. TRC surmised from pre-construction drawings (c. 1943) and a 1944 aerial photograph that approximately 69,000 square feet of the site was used for actual fire fighting practices. The OFFTA site location relative to other NETC sites is depicted in Figure 1-2. Figure 1-3 is a base map that presents the boundaries of Site 09 and major current features.

1.1 PROJECT OBJECTIVES

The objective of this source removal evaluation is to determine whether site-specific conditions present at Site 09 are comparable to one or more of the eight conditions, as presented in the National Oil and Hazardous Substances Contingency Plan (Title 40, Code of Federal Regulations, Section 300.415), which may result in the need for a removal action to protect public health or welfare, or the environment.

Previous investigation results presented in the Draft Final Remedial Investigation Report (TRC, August 1994) will be used to preliminary identify targets under this source removal evaluation. Review of the RI data indicates that potential chemical sources may still be present on site in the subsurface. The potential sources may include: defunct underground oil and fuel storage tanks and piping, subsurface drains, asphaltic materials eroding along the shoreline that may enter Narragansett Bay, and free product (petroleum hydrocarbons).

Field investigations will be performed to assess the presence of these potential chemical sources. The site-specific conditions, and field and analytical data will be evaluated and compared with the conditions presented in 40 CFR 300.415 to assess whether immediate or actual threats exist to public health or welfare, or the environment.

Should conditions be identified that warrant a source removal action, then a determination will be made whether a time-critical or a non-time-critical removal action (NTCRA) is warranted. If a time-critical removal action is determined to be necessary, then the action will be implemented to mitigate potential or actual releases. If a NTCRA is needed, where a planning period exceeding 6

months is necessary, then an Engineering Evaluation/Cost Analysis (EE/CA) document will be prepared. An EE/CA provides technical and cost information that will be used to select appropriate removal action(s) that fulfills the goals and objectives for a proposed NTCRA for the OFFTA. After issuance of the EE/CA, a 30-day comment period will be initiated to solicit questions and concerns from the public. After the close of the comment period, an Action Memorandum will be prepared that provides a concise, written record of the decision to select an appropriate removal action, and a responsiveness summary will be prepared that addresses the public comments.

1.2 PROJECT ORGANIZATION AND RESPONSIBILITIES

The B&R Environmental team will be responsible for managing and performing the field investigation activities and developing the letter report and EE/CA document presented in this Work Plan. Figure 1-4 presents the proposed staff organization with the names of key personnel.

Naval Facilities Engineering Command, Northern Division (NAVFAC, NORTHDIV) personnel will be responsible for administrative and technical oversight of the program, and project management and coordination between state or federal regulatory agencies. The NETC on-site representative will be responsible for on-site coordination with B&R Environmental.

Key Navy personnel managing and supporting this project are as follows:

Jim X. Shafer, Remedial Project Manager
Naval Facilities Engineering Command, Northern Division
Lester, PA

Brad Wheeler, Installation Restoration Manager
Kevin Coyle (Primary Contact)
Environmental Branch, Public Works Department
NETC Newport, RI

Key B&R Environmental personnel supporting this project are as follows:

Liyang Chu
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The B&R Environmental Project Manager (PM) will have the primary responsibility for implementing and managing the source removal evaluation. The B&R Environmental PM will also be responsible for notifying Navy and the regulatory agencies of field activities or schedule modifications. The Field Team Leader (FTL) and lead technical staff will support the PM in planning and implementing the field program, evaluating the results, and developing the necessary documents.

The Quality Assurance Manager is responsible for the QA/QC requirements for the B&R Environmental CLEAN program. The QA manager ensures that data and deliverable document reviews, and system audits are performed to meet contract QA/QC goals.

The B&R Environmental CLEAN Health and Safety Manager is responsible for reviewing health and safety plans for all CLEAN operations, and performing site audits to ensure compliance with site health and safety requirements.

The Lead Chemist will coordinate the sample analytical and data validation efforts. The Lead Chemist will advise the PM on technical requirements of the data and sample collection. The Lead Chemist will assume a secondary role as the site QA/QC officer, and provide the QA/QC reviews of the analytical data and project deliverables.

The Field Team Leader (FTL) will be responsible for directing on-site field investigation activities and will report directly to the PM. The FTL will coordinate efforts of the field sampling staff, the subcontractors, and the lead technical staff. The FTL will be responsible for identifying problem areas and bringing them to the attention of the PM for resolution.

The Lead Geologist will direct technical work relating to the geologic and hydrogeologic investigations. The Lead Geologist will advise the PM on technical requirements relating to these tasks. Direction of certain subcontractors (excavation, drilling) may be delegated from the FTL to the Lead Geologist. This individual will also coordinate the efforts of the field geologists with the FTL and the PM to ensure the objectives of the tasks are met.

The Site Safety Officer (SSO) is a field team member that will be selected for this project and will coordinate with the PM on implementing site-specific health and safety requirements.

The Lead Engineer will direct the data review, assess whether potential sources are present, develop the letter report, and develop and evaluate response actions for the EE/CA document.

In addition to the above personnel, B&R Environmental program personnel will provide overall support in subcontracting, cost tracking, reporting progress, and directing the PM. The program personnel include the following:

John Trepanowski, P.E.
Program Manager

Michael Turco, P.E.
Deputy Program Manager

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1.3 PROJECT DELIVERABLES

Project deliverables to be submitted during this project will include a letter report and an Engineering Evaluation/Cost Analysis document, if necessary. Details of these two documents are presented in Section 5.0.

1.4 WORK PLAN ORGANIZATION

Section 2.0 of this Work Plan describes the history of Site 09 and some of the findings of previous investigations. In particular, the findings of the Draft Final RI Report (TRC, August 1994) are summarized.

Section 3.0 presents the field work required for this investigation. Sample collection procedures and analytical parameters are also described in Section 3.0.

Section 4.0 presents the Quality Assurance Plan for this source removal evaluation. This plan describes the QA/QC sample collection procedures and frequencies, data quality protocols, and analytical data validation requirements.

Section 5.0 presents a general outline of the EE/CA document to be prepared following completion of all the field work described in Section 3.0.

A site-specific Health and Safety Plan is attached as Appendix A. Appendix B presents B&R Environmental's Standard Operating Procedures (SOPs) for the field investigation work. Appendix C contains examples of forms to be used for documentation during this investigation. Appendix D

presents copies of 1953 NETC Public Works Department plans of the major features that were present at OFFTA.

1.5 CHANGES TO THE WORK PLAN

During the field investigation, the plan for collecting of data may need to be modified; if so, the work plan may be amended through use of a Request for Field Modification. This form will be prepared by the B&R Environmental FTL and forwarded to the B&R Environmental PM. The PM will make a recommendation to the Navy RPM, who if necessary, will forward it to the regulatory oversight RPMs. Time limits on acceptance of or comment on the field modification requests will be stated. An example of this form is presented in Appendix C.

1.6 SCHEDULE

A tentative schedule for the field investigations is included with this Work Plan and is presented in Figure 1-5. Based on discussion between the Navy RPM and the regulatory agencies, it was determined that the Work Plan will be provided to U. S. Environmental Protection Agency (EPA) and the Rhode Island Department of Environmental Management (RIDEM) for informational purposes and that no formal review was anticipated. In addition, there was agreement that document reviews and revisions will be limited to a two-week duration to accelerate the site evaluation and development of the EE/CA document and Action Memorandum. Because the site is currently used for recreational activities, modifications to this schedule may be necessary to minimize disruption of those activities. This tentative schedule will be updated as necessary to inform oversight personnel when different tasks and activities will take place such that they can plan accordingly. B&R Environmental will attempt to notify the EPA and RIDEM about schedule modifications at least 7 calendar days in advance.

2.0 SITE DESCRIPTION AND POTENTIAL SOURCES

The information provided in this section has been adapted from the Draft Final Remedial Investigation report for OFFTA (TRC, August 1994). Section 2.4 identifies potential sources that may remain at the OFFTA that could warrant a removal action to prevent or mitigate releases of hazardous substances posing possible threats to the public health and welfare, or to the environment.

2.1 SITE LOCATION AND DESCRIPTION

The Old Fire Fighting Training Area site is located in the southern portion of NETC, at the northern end of Coasters Harbor Island (Figure 1-2). Site 09 is an irregularly shaped semi-circular area of approximately 5.5 acres and is bordered by Taylor Drive to the south and Narragansett Bay (Coasters Harbor) to the east, north, and west. This parcel currently contains a picnic area with an open-air pavilion, a playground, a baseball field, and a two-story brick building (Building 144). This area is actively used for recreational activities (picnics, etc.) by NETC facility personnel. Building 144 occupies approximately 5,000 square feet of Site 09 and was formerly used to house an NETC child day-care facility, which ceased operations in January 1994. The building is currently vacant. Access to the site is unrestricted except for Building 144, which is kept locked. The former child care facility outdoor play area, abutting the north wall of Building 144, is enclosed with a chain-link fence. Access to the site is provided from Taylor Drive, an asphalt roadway located south of the site. An overhead electrical supply, and public water and sewer service are available along Taylor Drive.

With the exception of two mounds, topography at Site 09 is generally flat with surface elevations ranging from approximately 8 to 12 feet above Mean Low Water (MLW). The eastern most of the two soil mounds occupies approximately 18,000 square feet and rises to an elevation of 30 feet above MLW. The western soil mound occupies 7,200 square feet and rises to an elevation of 16 feet above MLW. The entire site is vegetated with grass with the exception of the baseball infield and areas occupied by asphalt paving and buildings. Observations by previous investigators indicate that the area is well kept, with the grass mowed and trees and shrubs trimmed in keeping with the recreational nature of site use.

Approximately 1,300 feet of the northern edge of the site abuts Coasters Harbor, a narrow inlet that forms the northern and eastern waterway around Coasters Harbor Island. This area of Coasters Harbor is reported to have a maximum depth of 9 feet below MLW, with the majority of the harbor area north of the site approximately 4 to 6 feet deep (feet below MLW). The width of Coasters Harbor directly north of the site varies from approximately 1,000 to 1,700 feet.

Shoreline conditions along the harborside of the site are varied. In general, the portion of the site shoreline immediately north of the large (eastern) soil mound is relatively uniformly sloped and composed of concrete slabs, cobble and larger-sized shale fragments, mortared brick, pea-size gravel, and degraded asphalt fragments. Further west of this portion of the shoreline, concrete and brick debris-like material are less evident and a higher percentage of shale bedrock is visible. In addition, the intertidal zone shrinks as shoreline conditions become steeper along the western portion of the site shoreline. A 24-inch diameter storm drain discharge is located along the mid-point of the shoreline of the site. A site plan, which shows topography and significant current site features is provided as Figure 1-3.

2.2 SITE HISTORY

Available information indicates that Site 09 was used by the Navy as a fire fighting training area from World War II to 1972. This information is consistent with historic aerial photographs and a 1943 pre-construction drawing for the OFFTA. The RI report determined that information provided on the 1943 drawing indicates that approximately 69,000 square feet of the site was occupied by a fire fighting training area. A 1944 aerial photograph of the site is provided as Figure 2-1. As illustrated on this photograph, the fire fighting training area included an administrative building along the eastern end of Taylor Drive and a long rectangular concrete pad and an area that appears to be covered with asphalt paving. Available data suggest that two buildings (143 and 144) labeled "Carrier Compartment" on the 1943 drawing served as injection points for distribution of oil/water mixtures that were subsequently set on fire for fire fighting practice. Runoff from the concrete pad and pavement areas was reportedly routed to a series of surface drains that were connected to an on-site oil-water separator. In addition to the 1943 plan, several Public Works Department plans from 1953 are available that depict the location of surface drains, USTs, and subsurface piping. After 1972, data on site use is limited. Aerial photographs taken in 1975 show significant changes from conditions shown on the 1943 site plan. Changes that are evident by 1975 include the removal of all structures and facilities associated with the fire fighting training area, except the "hose house" and Building 144. 1987 aerial photographic coverage

indicates site conditions consistent with those observed in 1994, with soil mounds present on-site and the open air pavilion present on the eastern portion of the site.

Available site data are generally consistent with the hypothesis that the two soil mounds were created from fire fighter training building and pavement demolition material and covered with topsoil to provide topographic high points for this recreational area at NETC.

In November 1989, the entire NETC, including the Old Fire Fighting Training Area was listed on the U.S. EPA's National Priorities List (NPL) of abandoned or uncontrolled hazardous waste sites. A Federal Facilities Interagency Agreement (FFA) was signed by the Navy, the State of Rhode Island, and the EPA on March 23, 1992. The FFA outlines response action requirements under the Department of Defense Installation Restoration Program at the NETC. The FFA was developed, in part, to ensure that environmental impacts associated with past and present activities at NETC are thoroughly investigated and remediated, as necessary. The Old Fire Fighting Training Area was listed in the FFA.

An initial Assessment Study (IAS) was completed in 1983. The discovery of oily subsurface soils in 1987 as part of a geotechnical investigation coupled with the documented former use of the site for fire fighting training resulted in the performance of a Phase I Remedial Investigation in 1992 by TRC. During Phase I, site soils and groundwater were collected and analyzed, and a human health risk assessment was completed. A Phase II Remedial Investigation was conducted in 1993 and 1994 to further delineate the horizontal and vertical extent of contamination. Under Phase II, an ecological risk assessment and a human health risk assessment were also prepared.

2.3 REMEDIAL INVESTIGATION FINDINGS

A summary of the Phase I and II RI findings is presented in this section. A detailed presentation of analytical results and interpretations is presented in the Draft Final Remedial Investigation Report for the Old Fire Fighting Training Area (TRC, August 1994).

Surface Soils

Surface soils collected at Site 09, at a depth interval ranging from 0 to 1 feet, contained only low **volatile organic compound (VOCs)** concentrations, ranging from 1 to 17 ug/kg. All detected VOCs are well below the state's residential direct exposure criteria. **Polynuclear aromatic hydr carbons**

(PAHs) were detected in 95 percent of the surface soil samples. **PAHs** ranged from 44 to 27,010 ug/kg. Most of the detected semi-volatile organic compounds (SVOCs) were detected at below the state residential direct exposure criteria.

Pesticides were detected in almost all samples, probably the result of cultivating the vegetative cover at the site for recreational use at levels well below the state's residential direct exposure criteria. **Polychlorinated biphenyls (PCBs)** were detected at one location, at a maximum of 530 ug/kg [0.53 mg/kg], well below the state residential soil direct exposure criterion of 10 mg/kg.

A number of metals were detected and were compared to off-site background locations. Metals exceeding the background range were detected primarily along the shoreline locations. Three samples were found to exceed the state's 150 mg/kg lead residential direct exposure criterion; only one exceeded the state's industrial/commercial direct exposure criterion (500 mg/kg).

Dioxins (as 2,3,7,8-TCDD equivalents) were detected at up to 0.025 ng/g (ug/kg), below the EPA residential action level of 1 ng/g. There is no established state direct exposure criterion for dioxins.

Overall, the RI surmised that the most contaminated surface soils were located along the shoreline in the northern portion of the site, while the highest subsurface soils contamination was observed in the central to western portions of the site.

The review of he RI results did not identify any site surficial soil conditions that represent a release or threat that will need to be abated in the short term.

<u>Subsurface Soils</u>

VOCs detected in the samples included: **chloroethane, methylene chloride, carbon disulfide, 2-butanone, tetrachloroethene, toluene, ethylbenzene, and xylenes**. However, presence of some of the VOCs (methylene chloride, carbon disulfide, 2-butanone) in laboratory, field, and trip blanks indicated possible laboratory contamination. Analytical results indicated VOCs in subsurface soils were present in the central to north central portions of the site (near MW-2, MW-3, B-3, and B-6) and primarily at the water table. The VOCs in the subsurface soils may be associated with the contaminated groundwater. Detected VOCs were present at levels below the state's residential direct exposure criteria.

PAHs constituted the majority of SVOCs detected in the subsurface soils and ranged from 40 to 25,080 ug/kg. PAHs were detected in almost all the Site 09 subsurface soil samples. Some PAHs were present at levels higher than the residential criteria, but all were well below the commercial/industrial direct exposure criteria. Highest PAH concentrations were detected below the asphalt layer and just above the water table. Based on observations during the soil boring and test pit excavation programs, the RI indicated that soil contaminated by petroleum was observed typically at or below the water table. Petroleum odors were also noted during a number of the test pit excavations and soil borings.

Pesticides were detected in subsurface soil samples collected from throughout Site 09; all were below the state's residential direct exposure criteria. PCBs were only detected in two samples at 39 and 190 ug/kg, well below the state's 10 mg/kg direct exposure criterion.

A variety of metals were detected in the subsurface soil samples. The analytical results were compared with site-specific, off-site location samples; several samples were identified as having metal levels higher than background. In particular, sample locations just at or below the water table (TP3-1, M02-01, and M02-02) and just above the water table (B-16-2, M07-2, and M11-2 had greater than background levels). Petroleum staining and odors accompanied these locations. Lead in 10 samples exceeded the state's 150 mg/kg direct exposure criterion.

During the Phase II RI test pit excavation program investigators encountered a buried clay pipe located near a buried building foundation footing that contained an oily sludge at location TP-1. After a sample was collected for subsequent analysis, the pipe was plugged with absorbent pads and reburied to prevent potential releases. The oily sludge contained SVOCs (PAHs and bis(2-ethylhexyl)phthalate (BEHP) and some pesticides.

A general observation made in the RI report was that the soils with the highest SVOC and metal levels were accompanied by the presence of petroleum-like odors and/or staining of the soils, and were generally detected in samples obtained near, at, or just below the water table.

Groundwater

Only two VOCs, **chloroform and carbon disulfide,** were detected during the RI at low concentrations (2 ug/L or less), and are likely laboratory contaminants. Groundwater from several of the shallow monitoring wells had "noticeable petroleum-like odor". The RI report surmised that aged or degraded petroleum-related VOCs were present, based on the detection of tentatively identified compounds (TICs) during laboratory analyses.

PAHs and **phthalate esters** were detected in four shallow monitoring wells. The highest total PAH levels (less than 28 ug/L) were detected at MW-2S and MW-11S (both in the northern portion of the site), and a petroleum odor and a sheen were present on the water surface. Phthalate esters were detected in shallow and deep monitoring wells.

Only one pesticide (endrin at 0.05 J ug/L) was detected in site groundwater. No PCBs were detected.

Both unfiltered and filtered metal samples were collected during the Phases I and II RI. The unfiltered samples results exceeded either the federal Maximum Contaminant Levels (MCL)s or the state groundwater quality standards and included: **antimony, arsenic, beryllium, cadmium, chromium, lead, and nickel.** Filtered aqueous samples indicated that elevated metals presence was likely the result of high silt content. Background aqueous metals also contained elevated metals presence.

Because the aquifer underlying the OFFTA is classified as GB, there are no state groundwater objectives for any of these organic compounds or metals.

The RI concluded that past site activities probably have affected the underlying groundwater. Petroleum odors were noted in groundwater purged from several monitoring wells (MW-2S, MW-3S, and MW-11S) located in the central to northern portions of the site. The RI report also concluded that the elevated metals presence may be attributable to the high turbidity in the wells, i.e., high suspended solids content.

Storm Water

Low concentrations of **bis(2-ethylhexyl)phthalate (BEHP)** (3 ug/L) and **PAHs** (10 ug/L) were detected in two samples. PAHs were only detected at the outfall, suggesting that sea water may have entrained sediments or asphalt bits and carried them into the storm drain. Trace levels of pesticides were also detected.

Metals detected include: **aluminum, barium, calcium, copper, iron, lead, magnesium, manganese, potassium, sodium, and zinc.**

Sediments and Bivalves

Sediment and bivalve samples were collected from both the near-shore and off-shore locations. **PAHs, PCBs**, and **metals** were present in samples from both sets of locations. The detected PAHs were primarily combustion-related (pyrogenic) and/or of creosote/coal tar (petrogenic) origin. The **pyrogenic PAHs** dominate the majority of PAHs detected. The shellfish samples were generally consistent with the sediment results, with higher contaminant concentrations observed in the near-shore samples. Near-shore shellfish samples contained a greater proportion of pyrogenic PAHs to petrogenic PAHs, while the converse was the case for the off-shore samples. The PAH levels were higher than those typically reported for Narragansett Bay.

PCBs were detected in both near- and off-shore sediment samples (4.51 to 54.2 ug/kg); the highest were detected in the near-shore location NS-1/2. Sediment PCB levels are comparable to those detected at reference stations or within Narragansett Bay.

Butyltins were detected in two of three mussel samples. **Tributyltin** levels were below those reported for Narragansett Bay mussels.

The highest sediment metal concentrations were detected in the off-shore sampling locations.

2.4 POTENTIAL SOURCES OF CONCERN

An effort was initiated by the Navy in late 1996 to determine whether discrete contamination sources existed that could be addressed under a removal action to prevent or minimize releases that will be detrimental to public health and welfare, or the environment.

A review of the RI data and identification of subsurface features on NETC Public Works Department plans indicates that several sources may remain at the site that could mobilize and cause further soil, groundwater, or sediment impacts. This source removal evaluation is meant to ascertain whether the potential sources are present, or whether contaminant presence in the environment may be attributed to the sources. These potential sources will be the targets investigated under the field program.

Underground Storage Tanks and Associated Piping

During the Phase II RI implemented by TRC in 1993 and 1994, the only readily available plan depicting site features of the fire fighting school was a 1943 Public Works Department (PWD)drawing (No. 7146-78). The plan depicted several features including the mock carrier compartments, oil-water separator, the concrete pad with open-topped above ground tanks and "christmas tree" structures, and the asphalt pavement (see Appendix D, Figure D-1).

Since the completion of the Phase II RI investigations, a more extensive search of archived records and drawings were performed by NETC and B&R Environmental personnel in October 1996. Three drawings (dated 1953) from the Public Works Department were discovered that identified additional features associated with the former fire fighting use of Site 09 including: underground storage tanks (USTs) for oil and gasoline; piping leading from the USTs to the open-topped above ground tanks and "christmas tree" structures; piping leading to the mock carrier compartments (labeled buildings 132 and 133); three structures (buildings 134, 135, and 136) that may have been used for training because of their proximity to the other on-site fire fighting training features; and sanitary and storm drains that channeled runoff from the above ground tanks and "christmas trees", and from buildings 132 and 133 to the oil-water separator. Portions of the three drawings have been photocopied and are included in Appendix D. B&R Environmental believes that the drawings were prepared during the design and may not represent of "as-built" conditions.

During the Phase II RI, geophysical investigations identified several anomalies in the subsurface. Subsequent test pit excavations encountered a portion of a building foundation and a section of clay pipe that contained an oily sludge residue. Analytical results indicated the presence of PAHs, which is consistent with the presence of weathered oils and gasoline.

Based on the Phase II RI findings of subsurface soils contamination by SVOCs (PAHs) and a buried section of piping bearing oily sludge, and the features depicted in the 1953 PWD drawings, it is possible that USTs and subsurface piping, oil-water separator, and drains may remain on site long after the OFFTA was used as an active training facility. The USTs and associated piping, and the oil-water separator may have been abandoned in place and may contain oily residues that could be released and result in additional soils and groundwater contamination. These potentials sources will be assessed in this source removal evaluation.

Metals and PAHs in Groundwater

The RI report identified elevated levels (higher than at representative upgradient locations) of metals and PAHs, and concluded that past site activities may have affected the underlying groundwater. The concern associated with the metals and PAHs presence in groundwater is their continuing migration with groundwater and discharge to Narragansett Bay. However, review of the RI data and descriptions indicates that the elevated metals and PAHs presence may be attributable to high suspended solids content (turbidity) in the monitoring wells. Bailers were used during the RI to collect the groundwater samples, which resulted in the collection of both dissolved chemicals and those adsorbed to the suspended solids. The use of low stress sampling methods will be appropriate to assess what portion of the observed metals and PAHs are likely to be mobile and may pose potential threats to bay sediments and biota, rather than the fraction adsorbed to fines (silts and clays) that are unlikely to be mobile.

Therefore, additional groundwater sampling using low stress methods will be needed to provide a more accurate assessment of whether the metals and PAHs detected during the Phase II RI are potential sources of contamination to the Narragansett Bay sediments and biota.

Potential Non-Aqueous Phase Liquids

The Phase II RI identified the presence of petroleum odors at a number of test pits and soil borings, and SVOCs in the subsurface soils throughout Site 09. While non-aqueous phase liquids

(NAPLs) were not found, it is possible that light NAPL (gasoline, oil) may be present. If NAPL is present, then it will probably be a continuing source of SVOCs and PAHs to groundwater. This potential source needs to be assessed under the source removal evaluation.

Shoreline Asphalt Debris

As presented in Section 2.1, the northern shoreline is strewn with construction debris and fill, and chunks of weathered asphalt. The asphalt materials appear to be present in sizes ranging from large sections embedded in the face of the fill materials to smaller chunks and bits in the intertidal zone marine sediments. The exposed face of the fill materials appears to be eroding and asphalt chunks and bits are continually being released into the intertidal zone. It is likely that wave action and seasonal storms gradually reduce the asphalt bits to smaller sizes and may transport them into the bay where they will mingle with the off-shore marine sediments. The RI has identified the presence of PAHs in both the near-shore and off-shore sediments at levels that exceed typical Narragansett Bay levels. The asphalt in the shoreline and the open face of the fill materials appear to be continuing sources of PAHs to the marine sediments, which poses risks for the marine biota and possibly to humans that harvest and eat the shellfish taken from those areas. The source removal evaluation will assess whether the eroded fill materials need to be addressed to mitigate or prevent further asphalt and PAH loading to Narragansett Bay sediments.

Storm Sewer Outfall

The RI identified the presence of PAHs in the outfall of the storm drain and hypothesized that asphalt bits or sediments with entrained PAHs may have been carried into the outfall by tidal action. Therefore, the source removal evaluation will attempt to corroborate the Phase II RI's findings. Once available, current results will be compared with past sampling results to ascertain the potential source of the previously detected PAHs: the storm sewer or tidal action in Coasters Harbor.

3.0 FIELD INVESTIGATION AND SAMPLING PLAN

This section provides a detailed description of field investigation activities to develop data that would evaluate the need for potential removal of contaminant sources. The data collected during the field investigation will be used assess the need for a removal action, to prepare a letter report and, as necessary subsequently, an Engineering Evaluation/Cost Analysis (EE/CA) Report.

3.1 OBJECTIVES

The objective of the Field Sampling Plan (FSP) is to obtain adequate data to determine the need for a removal action to address discrete contaminant sources that may still be present at the Old Fire Fighting Training Area. If a time critical removal action is deemed necessary, then the Navy will coordinate with the EPA and RIDEM on the removal action implementation. If a NTCRA is deemed necessary, then an EE/CA will be prepared to support the selection of an appropriate response action, and an Action Memorandum will be prepared.

In conjunction with data that has been provided in the Remedial Investigation Report (TRC, August 1994), the data collected during these investigations, must be capable of supporting an EE/CA, if determined to be necessary. The content of the EE/CA report is described in Section 5.0 of this Work Plan.

The Field Sampling Plan is organized by the following chronological tasks:

Task 1: Site Visit
Task 2: Location of Potential Buried Piping and Structures
Task 3: Field Investigation of Potential Sources
Task 4: NA
Task 5: Investigation-Derived Waste Handling and Disposal

Field forms for the above tasks are presented in Appendix C.

3.2 TASK 1: SITE VISIT

A site reconnaissance was performed by B&R Environmental personnel on April 7, 1997. Although the site use has changed from a fire fighting training area to a recreational area, several of the subsurface features associated with the past training activities appear to remain in place. The site visit helped evaluate whether visible traces of the training area are evident that will indicate potential source areas such as the USTs access ports, storm sewer manholes, structural foundations, fire staging area concrete slab, oil-water separators, drainage inlets and outlets, fill pipes, and evidence of underground piping indicators. In addition, the site visit was useful in determining accessibility for the future field investigation work, such as test pits, soil borings, and monitoring well installation. Other observations made included the current topography, the location of demolition debris along the shoreline, the condition of the existing recreational facility, shoreline erosion impacts, and any unusual site features that will influence a field investigation. Results of the site visit were used to plan and implement the remaining tasks outlined in this field sampling plan (FSP).

During the site visit, the following observations were made:

- The recreational area appeared to be well maintained. Subsequent discussion with NETC personnel confirmed that the recreational areas are actively used in the spring and summer months, especially on weekends.

- Two closely spaced UST access ports embedded in concrete were located northeast of the northeastern corner of Building 144. These ports appear to correspond approximately to the location of one of the gasoline USTs depicted in Public Works Department (PWD) drawing no. 637871.

- One UST access port was located within the fenced play area that abuts the northern wall of Building 144. This port corresponds to the approximate location of an underground oil tank identified in PWD drawing no. 637871.

- A section of concrete was encountered in the approximate location of the oil-water separator depicted on PWD drawing no. 637871.

- Several storm drain covers were located, as was the storm water outfall that discharges to Coasters Harbor Island.

- The beach head was heavily eroded, and the face of the fill material is exposed.

- Some of the fence posts located near the outfield of the baseball diamond do not appear to be stable since the underlying materials have been eroded by wave action.

3.3 TASK 2: LOCATION OF POTENTIAL BURIED PIPING AND STRUCTURES

The objectives of this task are to identify and clear underground utilities, and to locate potential subsurface structures such as piping and USTs. The information obtained through the use of metal and cable detectors will be used, in conjunction with available site data and piping and utilities plans, to select test pit locations, as part of Task 3.

Aerial photographs taken during the operation of the OFFTA (1940s and 1950s) show evidence of oil and staining in the vicinity of underground utility inlets and outlets. As outlined in the RI report, many of the subsurface utilities were at one time used to store or transport oil and other flammable liquids. The approximate locations of the subsurface structures, according to PWD plans provided by NETC, are shown on Figure 3-1. However, due to the transformation of the OFFTA to a recreational facility, the existence and location of these subsurface utilities are unknown. Current subsurface features known to be located at Site 09 include two storm sewer pipes and surface water discharge outfalls along the shoreline.

This task will involve clearing underground utilities, in preparation for intrusive activities described in later sections of this FSP. Clearing underground utilities will consist of reviewing available site plans and contacting the Rhode Island Dig Safe and the NETC Dig Safe prior to initiating any field investigations.

Following clearing of underground utilities by Rhode Island Dig Safe and the NETC Dig Safe, B&R Environmental personnel will conduct a metal and piping detection survey using a utility tracking device. The metal detection survey for Site 09 encompasses evaluating suspected and known underground utilities and subsurface structures, USTs, piping, oil/water separator, etc. Metal detection survey procedures are described in the B&R Environmental SOP GH-3.2, Magnetic and Metal Detection Surveys, as presented in Appendix B. The southern edge of Site 09, adjacent to the street, will be surveyed first because this area will be where underground utilities or piping are expected to enter the site. Based on site plans and a visual inspection, probable locations of subsurface contaminant sources will be surveyed to further define the existence and locations of potential buried piping and USTs associated with former OFFTA activities. The locations of these potential contaminant source areas are shown in Figure 3-1. Based on site plans, it is assumed that five potential UST locations (three oil and two gas) need to be investigated. A fourth oil tank site may still be present in the vicinity of Building 130,

where two diesel sea water pumps were formerly housed. The presence of underground piping running from the UST north of Building 144 to Buildings 132 and 133 will also be evaluated. The locations of the oil/water separators also need to be evaluated.

3.4 TASK 3: FIELD INVESTIGATION OF POTENTIAL SOURCES

The primary objective of the field investigation is to identify potential discrete contaminant sources that may still be present at Site 09. The following tasks will be performed to investigate potential contaminant sources that may be present at OFFTA.

Table 3-1 presents a summary of field sampling and analyses. Table 3-2 presents a summary of sample container, preservative, and holding time requirements. Table 3-3 presents a summary of field quality control samples. Section 4.0 of this Work Plan describes analytical methodologies and quality control requirements.

3.4.1 Subtask 0310: Test Pit Excavation Program

The objective of this subtask is to evaluate the potential presence of subsurface features such as underground piping, USTs, etc. and to perform a limited assessment of the materials that constitute the on-site "mound", located near Building 144. This subtask will involve collecting soil samples for screening and laboratory analysis.

Five days of test pit excavation will be conducted by an excavation subcontractor to B&R Environmental, operating under the B&R Environmental Health and Safety Plan, and supervised by B&R Environmental personnel. The intent is to excavate approximately ten test pits, based on the Navy's statement of work requirements and a review of available historical information. The actual locations of the test pits will be determined after a review of the metal detection survey results. A summary of the probable test pit locations is presented below:

- One test pit will be excavated at each of the five suspected UST locations (two gas and three oil).
- Associated piping from each identified UST may be evaluated with test pits, or if the metal detection survey indicates possible piping presence.

- One test pit each will be excavated at each of the approximate former locations of Buildings 132 and 133.

- One test pit will be excavated in the approximate location of the oil/water separator.

- One test pit will be excavated at the "mound" to further evaluate the nature of the buried/interior materials.

- One test pit will be excavated at the approximate former location of Buildings 134, 135, and 136.

Other potential test pit locations may be selected depending on a detailed review of RI report information or the findings of the other test pits as they are excavated.

Because some of the test pit activities are proximal to the shoreline, these activities may fall under the Rhode Island Coastal Resources Management Council (CRMC) jurisdiction. The CRMC will be notified of the work to be performed, and their concerns will be addressed prior to initiation of this work.

Test Pit Excavation Sequence

The test pits will be excavated in 6- to 8-inch lifts. The 1-foot top layer, considered to be uncontaminated (based on comparison of RI data with state direct exposure criteria), will be removed and stockpiled separately. The underlying materials will be excavated and placed on plastic sheeting. Large pieces of metal that can be readily removed from the excavated material will be decontaminated, if necessary, and placed in an industrial dumpster for off-site disposal, by a subcontractor to B&R Environmental. If very large pieces of metal or buried equipment are encountered, the test pit will be extended so that excavation can continue without removing the metal pieces or equipment. No source removal is anticipated under this task.

Test pits will be excavated to the depth of the suspected underground piping or USTs, as determined from the metal detection assessment. The actual depth of each test pit will be determined by the conditions encountered. Test pits will not be excavated into natural soils, as determined by field observations. If at any time a test pit is judged to be unstable, i.e. the sides become undermined due to collapse, then the test pit will be backfilled and an adjacent location will be selected if site conditions permit.

The test pits will be backfilled with excavated material at the completion of soil sampling. The types of soils and materials encountered will be documented through photographing and video taping the test pit and excavated materials, and recording the observations and dimensions on test pit logs and logbook notes.

The test pits will not be left open longer than necessary to complete the sampling and documentation activities. The site currently has unrestricted access and is used for recreation activities such as baseball and picnics and related activities.

Test Pit Backfilling

The deep soils will be placed in the completed test pit first and compacted with the backhoe bucket during test pit backfilling. The top 15 inches of the test pits will be backfilled with clean soil (loam) suitable for planting grass. An estimated 120 cubic yards of loam will be provided by the excavation subcontractor and stockpiled on site for backfilling. The actual quantity of loam will be determined by the type and thickness of soil encountered during the test pit program.

The excavation contractor will provide all equipment and personnel to excavate and backfill the test pits. These tasks will include laborers for placing, grading, and seeding the top soil. At the completion of the test pit use, the work area will be restored to its original grade and as close to its original condition as practical.

It is assumed that investigation-derived water and soils generated during decontamination of the backhoe bucket will be contained in drums to be supplied by the subcontractor and stored at a location at OFFTA designated by the Navy.

Test Pit Sample Collection

Soil samples will be collected for fixed laboratory analyses from the portion of the test pits that are expected to have the highest potential for contaminants, based on visual observations and identification of subsurface features (USTs, piping, etc.), oily sludges or residues, or obvious releases, and head space field screening with a flame ionization detector (FID). Field screening procedures are described in the Analytical Procedure for Headspace Screening, as presented in Appendix B. If no target features (USTs, piping, etc.) are encountered, and there are no visual observations of field contaminants are present, and as field screening results indicate the potential for contaminants, then a test pit excavation soil sample

may not be collected. Head space screening and visual observations will also be used to select soil samples for total petroleum hydrocarbon (TPH) analysis. No groundwater samples will be collected from test pits.

Test pit sampling procedures are described in the B&R Environmental SOP SA-1.3, Soil Sampling, as presented in Appendix B. The samples will be collected after the excavation has been completed. Soil samples from test pit operations will be collected such that the sample will represent the location within the test pit adjacent to an identified feature, to a release from of an identified subsurface feature, or from the location with the highest observed presence of oily sludges, NAPL, or FID screening level. Soils will be collected from the center of the backhoe bucket using a scoop, and placed in a stainless steel bowl. Except for VOC samples, which will be collected directly from the bucket into the sample jar, all soil samples will be homogenized in the bowl prior to splitting for analyses.

At locations where concrete or asphalt cover is present on the ground surface, the 0-1 foot interval will begin at the bottom of this cover material. If asphalt is in contact with the surface soils, the upper 4 inches of the soil will be excluded from the sample to minimize interference of PAH compounds from the asphalt in the soil sample. As a result, the test pit log will show the ground surface as the bottom of the asphalt layer, but overlying materials will be described in detail on the log as positive distances *above* the ground surface. The field geologist/engineer evaluating the samples will determine the presence and thickness of the asphalt layer and proceed with the sample collection accordingly.

Laboratory samples will be analyzed for TCL VOCs, total TAL metals, total petroleum hydrocarbons (TPH), TCL semivolatile organic compounds (SVOCs), and TCL pesticides and PCB compounds. It is anticipated that TCLP analyses will be optional under this investigation program. Instead, the total waste (organics and inorganics) analyses may be used to estimate the TCLP concentrations, based on the procedure provided through the EPA/RCRA Hotline (Appendix B-4).

3.4.2 Subtask 0320: Shoreline Sediment Sampling

Five sediment samples will be collected adjacent to the shoreline to evaluate semivolatile organic compound (SVOC or PAH) contamination as a result of weathered asphalt, which is part of the eroded face along the northern shoreline of Coasters Harbor Island. Previous analytical data from near-shore sampling detected PAHs, PCBs, and metals. The detected PAHs were primarily combustion related (pyrogenic) and/or of creosote/coal tar origins (petrogenic). The objective of this subtask is to determine whether the weathered asphalt debris located at the shoreline is the source of the PAH contamination

detected in the near-shore sediment samples. The sediment analytical data will be used to supplement RI sediment data and to assess the contribution to PAH analytical results by eroded asphalt along the weathered shoreline face.

Sediment sampling techniques are described in the B&R Environmental SOP SA-1.2, Surface Water and Sediment Sampling, as presented in Appendix B. The sediment samples will be collected on the northern shoreline using a stainless-steel trowel or disposable scoopula. One sample will be collected along the western/northwestern edge of Coasters Harbor Island to represent an area devoid of fill materials. A second sample comprising only asphalt will be collected from a large section of asphalt to be obtained from the open face of the fill materials present along much of the shoreline. Three samples, representing a mix of asphalt and natural shoreline materials, will be collected along the shoreline.

The sediment samples will be analyzed for TCL SVOC at a contracted analytical laboratory.

3.4.3 Subtask 0330: Soil Boring and Monitoring Well Installation

This subtask will include advancing one soil boring, installing one monitoring well, and developing the well for subsequent groundwater sample collection. In addition, field screening of soils samples will be performed with a FID to identify soil samples to be shipped to the off-site laboratory, and to identify well screen interval. B&R Environmental will provide oversight of a drilling subcontractor, and collect and analyze soil samples. The objective of the soil borings sampling and analysis is to provide data to supplement the available Site 09 Remedial Investigation results to ascertain the presence of contaminant sources. The monitoring wells will be installed to supplement the existing well network to better evaluate current groundwater chemical conditions, groundwater elevations, and assess the potential presence of non-aqueous phase liquids One monitoring well will be located downgradient of an identified source (UST, piping, etc.).

During well development, potable water may be added to wells that do not produce enough water to allow for proper well development through pumping and surging. The solid PVC riser section of the well will then be backfilled with bentonite slurry or a suitable alternate, if site conditions indicate the need. The well installation will be finished with a flush mount road box set at a height selected to minimize impacts to current site uses. The flush mount protective casing will be grouted in place using cement grout.

Well development water will be containerized in drums to be supplied by the drilling subcontractor and stored at one Site 09 location, as designated by the Navy.

Advancement of Borings

General procedures for soil and rock boring advancement are described in the B&R Environmental SOP GH-1.3, Soil and Rock Drilling Methods, as presented in Appendix B. One soil boring will be advanced at the site to an estimated depth of 20 feet or to refusal, using 4-inch nominal inside diameter flush joint steel casing and standard drive-and-wash drilling methods. The soil samples will be collected continuously using a 24-inch long split-barrel sampler with a nominal inside diameter of 3 inches. This method has been successful at other sites in the installation of monitoring wells that can be developed and sampled in fine-grained formations that have a high water table. The location of this boring/well will be determined after evaluating available groundwater data (from the Site 09 RI report), field observations, and results of the test pit excavation program.

The boring to be advanced during this activity will be labeled as MW##, reflecting the number of the monitoring well that will be installed at that location. The borings will be advanced through the overburden to the top of bedrock or refusal. Continuous samples will be collected during boring advancement. The boring will then be backfilled to an appropriate depth for the well screen installation. Depth of the well screen installation will be determined after reviewing visual observations, locations of identified sources, the FID screening data, and consideration of previous RI data. Field screening procedures are described in the Analytical Procedure for Headspace Screening, as presented in Appendix B-2. In general, the saturated zone exhibiting the highest observed visually presence or concentrations of contaminants based on field screening analysis will be targeted for the well screen interval. However, alterations may be made based on other conditions noted in the field including: vertical zones that are more or less permeable to water than others, depth to water, depth to bedrock, soil types present, and the presence of multiple horizons of contaminants.

Continuous standard penetration tests will be conducted during advancement of each boring. Soils will be described according to the Unified Soil Classification System, and logged to provide a complete lithologic record of the subsurface materials. As each split-spoon is opened, the soils will be monitored for organic vapors using a FID. The borehole itself will be periodically monitored for organic vapors, in accordance with the Health and Safety Plan (Appendix A).

A log of the borehole will be maintained by the field geologist to describe lithologies encountered, depth of geologic contacts, water levels, sample depths, bedrock characteristics, and any other pertinent observations made during drilling. Boring logs will also include information on sample number, type, and depth; sample interval and recovery; and data from Standard Penetration Tests. An example boring log is included in Appendix C of this Work Plan. Borehole and sample logging procedures are described in the B&R Environmental SOP GH-1.5, Borehole and Sample Logging, as presented in Appendix B.

Under this source evaluation program, no boring is anticipated to be advanced into the bedrock zone because all USTs and piping are anticipated to have been installed in the overburden materials. Should a boring be advanced into bedrock, it will be backfilled with bentonite chips and sand prior to the overburden well construction.

Drill cuttings will be containerized and sampled for waste characterization, as described in Section 3.5. Decontamination of sampling equipment and drilling apparatus will be performed as described in Section 3.6.

Drilling fluids will be changed after reaching bedrock, to eliminate the potential for cross contamination of aquifers.

Soil Sampling

Soil samples will be collected and field screened using a FID. One sample from the boring will be selected and sent to an off-site contract laboratory for analysis based on the presence of an identified target, visual observations of oily residues or contaminants, and field screening results. General soil sampling techniques are described in the B&R Environmental SOP SA-1.3, Soil Sampling, as presented in Appendix B.

Soil samples will be collected at 2-foot intervals continuously from the ground surface at all boring locations so that the stratigraphy may be logged. At locations where concrete or asphalt pavement is present on the ground surface, the 0 to 1 foot interval will begin at the bottom of this pavement material. If asphalt is in contact with the surface soils, the upper 4 inches of the soil cover will be excluded from the sample to minimize interference of PAH compounds from the asphalt in the soil sample. As a result, the boring log will show the ground surface as the bottom of the asphalt layer, but overlying materials will be described in detail on the boring log as positive distances above the ground surface. The field geologist/engineer evaluating the split-barrel samples will determine the presence and thickness of asphalt in the sample, and proceed with the sample collection.

The sample from each 2-foot each interval will be treated as a separate sample, and placed into a decontaminated stainless steel bowl. A portion of the soil will first be removed and containerized for standard FID headspace screening. Aliquots of the material will then be removed and containerized for VOCs analysis; the remaining material will be homogenized with a decontaminated stainless steel Scoopula or similar device. After mixing to homogenize the sample, aliquots will be removed for each analyte described in Table 3-1.

The selected soil sample will be sent off site for laboratory analysis of TCL VOCs, TCL SVOCs, TCL Pesticides/PCBs, total TAL metals, and TPH. It is anticipated that TCLP analyses will be optional under this investigation program. Instead the total waste (organics and inorganics) analyses may be used to estimate the TCLP concentrations based on information provided by the EPA/RCRA Hotline (Appendix B-4).

Samples will be designated as the well designation (MW##), and depth intervals will be expressed in feet: Sample OFF-A-MW05-0204 indicates a sample from the boring for MW05, 2 feet to 4 feet below ground surface. Details of sample designations are presented in Section 4.0 of this Work Plan.

Bedrock Coring (If Determined to be Necessary)

If additional bedrock samples are determined to be necessary, then bedrock cores will be acquired and used to provide an initial characterization of the nature of bedrock fracturing and potential contaminant transport in the bedrock. Rock coring will be performed with standard NX double-wall core barrels that will provide a nominal 2-inch core and a 3-inch diameter borehole Bedrock coring will commence only after securely seating the drilling casing into the top of the rock to isolate the bedrock aquifer from the overburden aquifer. The bedrock cores will be logged by the rig geologist at the completion of each core run. Bedrock cores will be described using standard rock description methods. Where applicable, features such as grain size, color, hardness, sedimentary structures, and degree of cementation will be recorded. Planar features including fractures, joints, bedding planes, and other lithologic contacts will be recorded. Rock Quality Designation (RQD) will be calculated

Groundwater Monitoring Well Installation

At the completion of each boring, a monitoring well will be constructed that consists of a 2-inch inside diameter PVC well screen and solid riser The monitoring wells will be designed and installed to determine if LNAPLs is present. A sand pack will be placed around the well screen to stabilize the formation materials. The sand pack will be designed to allow groundwater to freely enter the well but limit the migration of fine-grained aquifer material from entering the well. Following installation, the monitoring wells will be developed to remove aquifer materials disturbed during the drilling. Well development methods will include surging and pumping the well to remove disturbed aquifer material. Groundwater monitoring well installation techniques are described in the B&R Environmental SOP GH-2.8, Groundwater Monitoring Point Installation, as presented in Appendix B.

Well screens and sandpacks used for monitoring well installations will be sized in accordance with the geologic formation at each boring location and state regulations. The State of Rhode Island Groundwater Quality Regulations specify that the well screen slot size shall retain at least 90 percent of the grain size of the filter pack. Soil boring results presented in the RI indicate silty soils at Site 09. As such, a No. 10 (0.01 inch) screen slot size and No. 1 sand were chosen for monitoring well construction to minimize siltation of the well. A uniform No. 1 sand has an effective grain size (D10 = 10 percent passing or 90 percent retained) of approximately 0.035 inches. The No. 10 screen size retains at least 90 percent of the grain size of a uniform No. 1 filter sand pack. Should field conditions be present that indicate the need for a different screen size and filter pack, the Navy RPM will be notified.

The well screens will be installed in the saturated zones, if possible, across the interval that shows the highest level of contamination and the observed water table. The well screens need to cross the water table zone in order to detect the possible presence of LNAPL. Well screens will not be screened across stratigraphic units, i.e. through silty sand and bedrock. No well will be installed across the overburden/bedrock contact in order to prevent potential vertical migration of contaminants. If conditions exist that warrant bedrock cores, then the Navy will be notified. Figures 3-2 and 3-3 present typical well construction details.

Overburden aquifer wells will be installed according to the following protocol: clean silica sand of uniform grain size will be carefully placed in the annular space between the well screen and casing, to a minimum of 0.5 foot above the top of the screen. A bentonite pellet seal with an approximate thickness of 1.5 feet will then be installed immediately above the silica sand backfill. If, due to the shallowness of the water table, a bentonite pellet seal is not possible, then the well will be sealed using bentonite grout. The remainder of the borehole will be backfilled with a bentonite grout to a depth of approximately 2 feet below ground surface. If possible, a layer of clean silica sand (such as that used for the sand pack) will be added to serve as a drainage layer beneath the protective casing. This minimizes the possibility of water collecting in the annular space between the casing and the riser. During winter weather, water collecting in this annular space can freeze, resulting in binding the protective casing to the riser Subsequent frost heaving of the installation can damage the well that has frozen to the casing. The monitoring well will be finished with a cement grout seal and a flush-mounted roadway box

Because of the shallowness of bedrock within Site 09, it is possible that the water table for one of the three borings will be within bedrock stratigraphy. If a bedrock well screen is required, then the screen will be set and held in place with stainless steel centralizers and the annular space will be backfilled with sand (at least 90 percent retained) to at least 0.5 feet above the top of the well screen. The area around the remaining riser will be backfilled with a bentonite grout.

During the well installation process, the depths of all backfill materials will be continually monitored with a weighted tape. Wells will be completed at the ground surface using flush-mounted road boxes or protective guard pipes. Wells located within paved areas will be finished with concrete grout to match the existing grade of the surrounding paved surfaces. Bentonite grout will be allowed to set for a minimum of one day prior to developing the well. Development will be conducted by bailing, or pumping and surging, to remove residual drill cuttings and fines from around the well screens.

The horizontal and vertical locations of the wells will be surveyed following the completion of well construction. A notch will be cut into the tops of the PVC well riser that will be used as a permanent reference point. The survey operations are described in detail in Section 3.4.6 of this Work Plan. Well purge water will be containerized in accordance with Section 3.5 of this Work Plan.

Well Development

Once the newly installed well has stabilized, a full round of groundwater level measurements will be performed. The Groundwater level in the well will be measured to a reference point, onsisting of a notch cut at the top of the PVC well riser. If LNAPL is present, its thickness will be measured using an oil/water interface probe, and the subsequent water level will be corrected for the presence of LNAPL. Groundwater level measurement techniques are described in the B&R Environmental SOP GH-1.2, Evaluation of Existing Monitoring Wells and Water Level Measurement, as presented in Appendix B.

The well will be developed by bailing and/or surging and pumping, as determined by the field geologist. Fine-grained material around the well screen will be drawn into the well and removed by agitating the well water with a surge block and simultaneously pumping water from the well at a low discharge rate. A pump outfitted with ASTM drinking water grade polyethylene tubing will be used to remove the water from the well. To prevent potential cross contamination the surge block will be decontaminated prior to use with non-phosphate detergent and tap water, rinsed with tap water, rinsed with methanol, air dried, and rinsed with deionized water. The polyethylene tubing will also be replaced between each well. The dedicated new tubing will be rinsed with deionized water prior to its use. Water produced during well development will be containerized in 55-gallon drums (DOT Specification 17E), as described in Section 3.4 of this Work Plan.

Based on field conditions, should the use of the surge block and pumping technique be deemed inappropriate by the B&R Environmental field team, an alternative method will be used to develop the well. A suitable pumping device, e.g., submersible pump, Waterra™ pump, will instead be placed in the well and used for its development.

The volume of groundwater extracted from each monitoring well during development will be monitored and water quality parameters (pH, temperature, salinity, specific conductance, and turbidity will be determined every 15 minutes. Development will continue until pH, temperature, and specific conductance have stabilized and turbidity is equal to or less than 10 nephelometric turbidity units (NTUs). The well will be stable when consecutive readings differ less than 10 percent. If the NTU criteria is not achievable, the parties will determine if a turbidity standard of plus or minus 10 percent of successive well volumes is appropriate on a case-by-case basis.

If a well is not completely developed after 3 hours, the field geologist will notify the B&R Environmental PM for authorization to continue well development or to stop.

3.4.4 Subtask 0340: Groundwater Sampling

Groundwater samples will be collected and analyzed to assess current groundwater contaminant conditions and to assess the potential presence of LNAPLs. One round of static water level measurements and groundwater sample collection will be conducted from fourteen existing on-site wells and the one new monitoring well, installed as part of Subtask 0330.

Prior to the initiation of groundwater sampling, a full round of groundwater level measurements will be performed. Groundwater levels in all wells will be measured to a reference point, consisting of a notch cut at the top of the PVC well riser. If LNAPL is present in any of the wells, its thickness will be measured using an oil/water interface probe, and subsequently, the water levels will be corrected for the presence of LNAPL. Groundwater level measurement techniques are described in the B&R Environmental SOP GH-1.2, Evaluation of Existing Monitoring Wells and Water Level Measurement, as presented in Appendix B

Because the groundwater samples will be collected from monitoring wells that are situated close to Narragansett Bay and will likely be subject to saltwater intrusion, B&R Environmental will conduct the sampling to avoid potential matrix interferences of high salinity samples to be analyzed for metals by Inductively Coupled Plasma (ICP) spectrophotometry. To evaluate the potential for interferences due to high concentrations of sodium and magnesium, the contracted laboratory will be required to analyze a set of ICP interference standards containing the interferent metals at the same concentration found in the field samples. Corrective factors will be applied to the sample results during data validation. In addition, ICP serial dilution analysis will be performed for all samples with metal concentrations above the calibration range of the instrument.

Samples will be collected from the newly installed monitoring well and the 14 wells previously installed by TRC, including applicable field QA/QC samples (blanks and duplicates), using low stress pumping methods. The locations of the 14 existing wells are shown on Figure 3-4. Groundwater from four selected monitoring wells will also be sampled using standard bailing techniques, and filtered and preserved in the field prior to sample shipment for dissolved metals analysis; the samples will supplement the low stress sampling specimens. All groundwater samples will be analyzed at a Navy-approved contracted laboratory.

Groundwater samples collected using low stress sampling will be analyzed for TCL VOCs, total TAL metals, TCL SVOCs, TCL pesticides and PCB compounds, and TPH. Filtered groundwater samples collected using standard bailing techniques will be analyzed for TAL metals (filtered).

Work elements for this task include:

- Noting, measuring, and if possible, sampling non-aqueous phase liquids (both LNAPL and DNAPL)
- Measuring water levels in wells prior to purging
- Purging wells using low stress methodology
- Measuring pH, temperature, specific conductance, dissolved oxygen, salinity, and turbidity periodically during the extraction of water from the well
- Collecting samples using low stress methodology
- Documenting, packing, and shipping samples for analysis
- After the completing of low stress sampling, sampling four wells using standard bailing methods

Groundwater Sampling Procedure

For each well to be sampled, the overall low stress sampling procedures to be followed are described in the B&R Environmental SOP SA-1.1, Groundwater Sample Acquisition and Onsite Water Quality Testing, as presented in Appendix B. Low-flow sampling requires an initial purge volume and subsequent stabilization of the groundwater quality parameters prior to sample collection. Groundwater sampling will be consistent with the U.S. EPA Region I SOP for low stress sample collection (SOP GW-001, July 30, 1996), as presented in Appendix B. RIDEM has provided a recommended approach for low flow sample collection that differs slightly from the approach described in this work plan, and is also presented in Appendix B. If the EPA method is unsuccessful in collection of a sample, then the RIDEM method will be followed.

The project-specific low stress sample collection procedures to be followed are summarized below.

1. The presence of floating product (NAPL) in the wells will be determined with the use of an ORS interface probe (or equivalent). The presence of product will be noted, and if appropriate, the thickness measured. If possible, a sample of the NAPL will be acquired for laboratory analysis. The depth to water in the well will be measured and recorded to the nearest 0.01 feet.

2. The required length of tubing will be calculated and measured for attachment to either the submersible or the peristaltic pump, such that the intake (submersible pump, or tubing intake if peristaltic used) is placed at the midpoint of the saturated screened interval. Note that the tubing will be measured to allow a minimum distance between the well head and the discharge point (field testing equipment), to minimize temperature changes in the groundwater discharged from the well. Teflon-lined tubing will be used and dedicated of to each well after sampling is complete.

3. The pump and/or tubing will be slowly and smoothly lowered to the required depth to minimize the amount of mixing in the well. The pump cable and/or discharge tubing will be secured to the well casing (or PVC stick-up) to minimize movement.

4. The field testing equipment (and peristaltic pump head, if used) will be assembled, and placed as close as possible to the well head/discharge tubing. For the peristaltic pump, the discharge tubing will be connected to the pump head with a minimum length of pharmaceutical grade silicone tubing.

5. The pump will be connected to the power supply (generator or other power source) and the power supply turned on (without starting the pump).

6. The depth to water with the pump and/or tubing in the well will be re-measured and compared with the initial reading; if the readings vary by more than 0.05 feet, field personnel will wait for 5 minutes, remeasure the water, and begin pumping.

7. The pump will be started at the lowest flow setting. The pump start time will be recorded and the flow rate will be measured and recorded using a graduated measuring device and stopwatch. (Note that during the initial period of pumping, an estimated initial 5 to 10 minutes, the depth to water in the well should be measured frequently (at an estimated frequency of approximately once per minute), to enable timely pump flow adjustments to attempt to minimize significant drawdown in the well).

8. The initial groundwater sample discharged from the tubing will be collected, and the time and field parameters (pH, temperature, conductivity, turbidity, salinity, and dissolved oxygen) will be measured and recorded.

9. These field parameters (pH, temperature, conductivity, turbidity, salinity, and dissolved oxygen) and the depth to water in the well (using the M-scope or ORS probe) will be measured at 3 to 5-minute intervals (initially the water level will be measured more frequently, as discussed in step 7 above). The data and the associated time will be recorded on the low stress sampling data sheet. Attempts will be made to maintain the drawdown in the well during pumping to 0.3 feet or less, by adjusting the pump flow rate. Drawdown for each well will vary depending on the recharge capacity of the well.

10. Groundwater samples will be collected following stabilization of measured field parameters"Stabilization" of readings will be readings within plus or minus ten percent for three consecutive 3 to 5-minute readings. Turbidity values are expected to be 10 NTUs or less at stabilization, however, the location of the well with respect to the contaminant source may result in turbidity readings that are "naturally" above 10 NTUs.

Following purging procedures, samples will be collected directly through the tubing into appropriate sample bottles. Samples will be preserved according to requirements described in Section 4.0. All non-disposable sampling equipment will be decontaminated prior to each use, as described in Section 3 6. All pertinent sampling data will be recorded on appropriate sample log sheets and in the site logbook

Purge water from the wells will be containerized for waste characterization, as described in Section 3 5 of this Work Plan.

3.4.5 Subtask 0350: Storm Sewer Outfall Sampling

The presence of two storm sewer lines have been identified based on available plans provided by NETC and discussions with Navy personnel. Sampling of the outfall of one pipe, conducted during the RI, indicated the presence of SVOCs. The objective of this subtask is to assess the current status of discharge of PAH constituents detected during the RI for one of the storm sewers. The data from the storm sewer outfall sampling will be compared to data collected during the RI.

Outfall and drainage feature sampling procedures are described in the B&R Environmental SOP SA-1.2, Surface Water and Sediment Sampling. One aqueous sample will be collected as a direct fill sample from each outfall pipe during a period of outflow (low tide). The aqueous samples will be analyzed at a contracted analytical laboratory.

To address the potential for matrix interference during laboratory analysis that may be caused by high salinity, the procedures presented in Section 3.4.4 for groundwater samples will be applied.

All samples will be shipped to contract laboratories for analysis of TCL VOCs, TCL SVOCs, TCL pesticides and PCBs, and total TAL metals. Details of sample designations are presented in Section 4.0 of this Work Plan. Sampling equipment decontamination will be performed, as described in Section 3.5.

3.4.6 Subtask 0360: Location Survey

After completing field investigation activities, a surveying subcontractor will locate all sampling locations, test pit excavations, the new monitoring well location and elevation, and other pertinent site features. The objective of this subtask is to provide a base map with the most current site features that pertain to the former OFFTA facility. The information provided by the location survey will be used for future work at the site, and for the development of an EE/CA, if deemed necessary. It is anticipated that the location survey will be conducted during the period when groundwater sampling is ongoing so that B&R Environmental personnel will be available to provide surveying oversight.

The location survey will provide:

- Elevations (to the nearest 0.01 foot) of new and existing monitoring well riser pipes and protective casings

- Horizontal locations (to the nearest 0.1 foot) of all sampling stations, monitoring wells, and up to 50 pertinent surface features at the site, including building corners, catch

basins, outfalls, manholes, etc. These features will be identified by B&R Environmental at the time of the survey.

This task will be subcontracted to a land surveyor licensed in the State of Rhode Island. A surface topographical survey will not be performed for the area. The survey will be conducted to establish relative locations of sample points. Survey control will be maintained by tying into either the State of Rhode Island or USGS grid systems. Horizontal and vertical measurements will be made relative to existing wells or on-site control points.

B&R Environmental assumes that a digitized base map of the OFFTA area will be made available by the Navy so that the to-be-acquired survey information can be added. If a digitized base map is unavailable from the Navy, then B&R Environmental will have the surveyor digitize an existing hard copy map for use as the base map. Surveyed points will be mapped with Autocad V12.0 or a compatible system. The survey subcontractor will provide hard-copy prints and disk versions of the survey information for each survey operation. Survey points for each task will be set on different "layers" of the Autocad data such that printouts of sample collection points can be made specific to each task or any group of tasks.

3.5 INVESTIGATION-DERIVED WASTE (IDW)

As a result of site activities associated with this field effort, it is anticipated that investigation- derived wastes (IDW) including drill cuttings, drill/purge water, test pit soils, decontamination fluids, personal protective equipment (PPE), disposable sampling equipment, and solid debris (metal debris) will be generated and disposed of off site. Contaminated soils, water, metal, or assorted solid debris will be disposed of as part of this task. This work will be performed by subcontracted personnel, as required, and a B&R Environmental staff member will oversee the subcontractor when present on site to load, sample, or transport waste. Waste handling procedures are described in the B&R Environmental SOP SA-7.1, Decontamination of Field Equipment and Waste Handling.

B&R Environmental will engage the appropriate subcontractors who will remove and dispose of all investigative waste materials (well purge water, soil cuttings, and PPE) following completion of the field investigation program. This waste disposal program will be conducted at the end of the investigation program.

Containers of IDW will be labeled as to their point of origin, and date collected. Samples of these materials will be labeled with the information clearly denoted on the containers. Containers of IDW that are found to be hazardous will be characterized and disposed of within 90 days.

Solid Wastes

Personal protective equipment (gloves, tyvek, and disposable boots) will be decontaminated, double bagged, and disposed of in an on-site industrial dumpster. A dumpster will be available for the disposal of metal debris removed from the site as part of excavation activities.

Soil Wastes

Excess drill cuttings, discarded sample material, and other soil wastes will be containerized in 30-cubic yard rolloffs.

The screening results from sample collection will be used as the first step of segregating the wastes into groups, based on the level of contamination present. This effort will require collecting samples to determine disposal characteristics from each containerized source and the analysis, transportation and off-site disposal (if required) of the contents. Laboratory analysis of samples collected during the investigation program will be used to further characterize the materials, as required by state and federal disposal requirements. Additional samples for other parameters may also be required. Typical disposal parameters are listed below:

- TCLP organics and metals
- Volatile organic compounds
- Pesticide/PCB compounds
- Flash point, reactivity, corrosivity
- Free liquid

Analysis of representative samples of waste materials for disposal parameters will be the responsibility of an outside disposal subcontractor. Samples of the waste material for disposal parameters will be collected by the subcontractor, and split for possible later analyses by B&R Environmental. All soil wastes will be shipped off site by this same subcontractor.

Aqueous Wastes

Decontamination fluids, well development and purge water, and drilling fluids will be initially contained in 55-gallon drums. The drums will be supplied by the drilling subcontractor and stored in a central or secured area of Site 09, as designated by Navy. This material will be combined at the conclusion of the project and shipped off site for disposal in accordance with RIDEM, USEPA, and DOT Regulations.

3.6 DECONTAMINATION PROCEDURES

Equipment will be decontaminated in accordance with the methods described in the B&R Environmental SOP SA-7.1, Decontamination of Field Equipment and Waste Handling. Decontamination procedures are summarized below:

Monitoring Equipment

All monitoring equipment will, to the extent possible, be wrapped and sealed in plastic with only the controls, readouts, and intake and exhaust ports open to the atmosphere. If monitoring equipment decontamination is required the following procedure will be utilized:

- remove gross contamination with potable water
- scrub with potable water/liquinox
- rinse lightly with potable water
- remove plastic covering
- wipe dry immediately with disposable towels

Drilling, Excavation, and Other Heavy Equipment

Drill rigs and excavation equipment will be decontaminated by steam cleaning following their arrival on site and prior to beginning work at each location.

Drilling casing, rods, and augers, as well as the affected portions of the drilling rigs, will be decontaminated before beginning each borehole. Excavation equipment used for test pit investigations will be decontaminated before operating at each location. Excavation equipment used to clean catch basins will be decontaminated between each location.

Heavy equipment decontamination will be performed at a temporary, centrally located decontamination pad constructed specifically for this purpose. The decontamination pad will be large enough to capture all wash water and channel it into a sump. The fluids in the sump will be containerized after each use.

Sampling Equipment

All non-disposable sampling equipment that comes in contact with the sample medium will be decontaminated to prevent cross contamination between sampling points. This includes equipment such

as soil sampling spatulas, split spoons, and hand auger buckets, etc. The following decontamination sequence will be employed:

- remove gross contamination by scrubbing with potable water
- scrub with potable water/liquinox
- rinse with potable water
- rinse with methanol
- rinse with deionized water
- air dry on steel screens
- wrap with aluminum foil, dull side toward equipment.

Submersible Pump

The following decontamination sequence will be employed for submersible pumps (the electrical wires must be rinsed with the decontaminating solutions as well):

- Upon removal of the pump from the well following sample collection, submerse the pump in a bucket containing potable water and scrub the exterior surface. At least 1 to 2 gallons of water will be pumped through (start pump at a low stress rate, as in sampling, and increase to a high speed).

- Submerse the pump in a bucket containing a potable water and detergent (Alconox or Liquinox) solution. At least 1 to 2 gallons of detergent will be pumped through (start pump at a low stress rate, as in sampling, and increase to a high speed).

- Remove the pump, and rinse or spray with potable water to minimize transfer of soap to the rinse bucket.

- Submerse the pump in a bucket of a potable water rinse and pump at least 1 to 2 gallons through (start pump at a low stress rate, as in sampling, and increase to a high speed).

- Submerse the pump in a bucket of a deionized/distilled water rinse and pump at least 1 to 2 gallons through (start pump at a low stress rate, as in sampling, and increase to a high speed).

- Submerse the pump in a bucket of isopropyl alcohol rinse and pump least 1 to 2 gallons through.

- Submerse the pump in a bucket of a deionized/distilled water rinse and pump least 1 to 2 gallons through (start pump at a low stress rate, as in sampling, and increase to a high speed).

- Air dry and wrap the pump in aluminum foil (dull side toward pump).

4.0 QUALITY ASSURANCE/QUALITY CONTROL

This section provides technical guidelines and procedures for conducting the field work. This document references the B&R Environmental Standard Operating Procedures (SOPs) and other procedures for specific protocols discussed in Section 3.0.

Pertinent B&R Environmental SOPs are included in this Work Plan as Appendix B-1. These SOPs include, but are not limited to:

SOP	DESCRIPTION
GH-3.2	Magnetic and Metal Detection Surveys
SA-1.2	Surface Water and Sediment Sampling
SA-1.3	Soil Sampling
GH-1 3	Soil and Rock Drilling Methods
GH-1.5	Borehole and Sample Logging
GH-2.8	Groundwater Monitoring Point Installation
GH-1.2	Evaluation of Existing Monitoring Wells and Water Level Measurement
SA-1.1	Groundwater Sample Acquisition and Onsite Water Quality Testing
SA-7.1	Decontamination of Field Equipment and Waste Handling
ME-15	Photovac MicroFID Handheld Flame Ionization Detector

Technical procedures for low-flow sampling are presented in Appendix B-2 and include:

EPA-GW-001	Low Stress Purging and Sampling Procedure for the Collection of Groundwater Samples from Monitoring Wells
RIDEM	Rules and Regulations for Groundwater Quality

The Analytical Procedure for Headspace Screening is presented in Appendix B-3.

The estimation of the equivalent TCLP concentration based on total waste analyses is presented in Appendix B-4.

4.1 QUALITY ASSURANCE OBJECTIVES

The objectives of the environmental sampling are to provide sufficient data, when evaluated with existing RI data, to assess whether a removal action of potential contaminant sources is warranted for the OFFTA. Samples would be collected for analysis at fixed-base laboratories. Samples would be analyzed for TCL organics and TAL metals, as well as TPH. The equivalent TCLP concentration for soils would be estimated to help assess potential off-site disposal options.

Achieving these objectives requires that the data collected from the field conform to an appropriate level of quality. The quality of a data set is measured by certain characteristics of the data, namely the precision and accuracy, representativeness, completeness, and comparability (PARCC) parameters. Some of the parameters are expressed quantitatively, while others are expressed qualitatively. The PARCC goals for a particular project are determined by the intended use of the data, usually referred to as Data Quality Objectives (DQOs). DQOs are discussed in Section 4.1.1; the PARCC parameters are discussed in Section 4.1.2.

4.1.1 Data Quality Objectives

The intended use of the data resulting from a field investigation is a determining factor in defining the DQO for that data. As described by the Naval Energy and Environmental Support Activity (NEESA) guidance entitled "Navy Installation Restoration Laboratory Quality Assurance Guide" (NEESA, February 1996), investigation-specific DQOs would be developed in accordance with the EPA document "Data Quality Objectives for Remedial Response Activities Development Process" (EPA/540/G-87/003, 1994)

Two types of analytical data will be generated as part of this field investigation. The intended uses of the analytical data are 1) the screening data shall be used to target samples for laboratory analyses and to identify "hot spots" in the soils, and 2) laboratory analytical data will be used, in conjunction with the previous RI data, to assess whether a source removal is warranted at Site 09

4.1.2 PARCC Parameters

The precision and accuracy, representativeness, completeness, and comparability (PARCC) goals for the work covered by this quality assurance plan are discussed in the following sections

4.1.2.1 Precision and Accuracy

Field and laboratory precision and accuracy performance can affect the attainment of project objectives, particularly when compliance with established criteria is based on laboratory analysis of environmental samples.

Analytical precision and accuracy will be evaluated upon receipt of the laboratory analytical data. Analytical precision will be measured as the relative percent difference from duplicate measurements and relative standard deviation from three or more replicates. Analytical accuracy measures the bias as the percent recovery from matrix spike and matrix spike duplicate samples. The samples will be analyzed using NEESA-approved laboratories and analytical data will be evaluated using NEESA guidelines.

Field sampling precision and accuracy are not easily measured. Field contamination, sample preservation, and sample handling will affect precision and accuracy. By following the appropriate B&R Environmental Standard Operating Procedures, precision and accuracy errors associated with field activities can be minimized. Field duplicates and blanks (field, trip, and rinsate) will be used to estimate field sampling precision and accuracy for soil samples submitted for laboratory analysis.

Field duplicate and field quality control blank analyses results will be used to review the laboratory-analyzed results and determine the usability of the data with respect to its intended use. In general, results that are rejected by the data review process will be disqualified from application to the intended use. Qualified data will be used to the greatest extent practicable.

4.1.2.2 Representativeness

Representativeness describes the degree to which analytical data accurately and precisely define the population being measured Several elements of the sampling and sample handling process must be controlled to maximize the representativeness of the analytical data (appropriate number of samples collected, physical state of the samples, site-specific factors, sampling equipment, containers, sample preservation and storage, holding times, sample identity and chain of custody will be defined to ensure that the samples analyzed represent the population being measured). The sampling program is designed to provide analytical data that is representative of the existing contaminant levels.

On-site field FID headspace screening will be used to identify the presence of VOCs in soil, and to compare relative amounts between one location or another. FID headspace screening analysis will be used to evaluate the presence of these contaminants in soils during soil sample collection as part of test pit excavation activities and soil boring activities.

Representativeness of data may also be affected by sampling techniques. The sample collection methods for field screening and laboratory analysis are the same. Errors or cross contamination during the sampling could affect either field screening or analytical laboratory results. However, every effort will be made during sample collection to minimize the introduction of errors or cross contamination by following the sampling techniques, described in Section 3.0, which are the B&R Environmental Standard Operating Procedures included in Appendix B-1.

The type and concentration of the contaminants in the samples screened on site depend on the type of contaminants present in the soil samples and their concentration. The VOCs in the headspace represent the soil VOCs in the container. The sample with the highest concentration of soil VOCs will deliver the highest concentration of VOCs to the headspace container.

Field FID headspace screening data will be used to help assess the potential presence of VOC sources and the nature and extent of contamination. The screening data will be used to determine hot spots of contamination to target laboratory split samples.

4.1.2.3 Completeness

Completeness describes the amount of data generated that meets the objectives for precision, accuracy, and representativeness versus the amount of data expected to be obtained. For relatively clean, homogeneous matrices, 100 percent completeness is expected. However, as matrix complexity and heterogeneity increase, completeness may decrease. Where analysis is precluded or where data quality objectives are compromised, effects on the overall investigation must be considered. Whether or not 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.

The sampling and analysis program for the site is sufficiently broad in scope to prevent a single data point or parameter from jeopardizing attainment of the monitoring objectives. Each medium is critical to the assessment of contaminant migration. Consequently, there exists some critical data requirement below which the objectives of the monitoring program will be compromised.

Critical data points may not be evaluated until all the analytical results are evaluated. Additionally, several sampling points, in aggregate, may be considered to be critical either by location or by analysis. A subsequent sampling event may be necessary if it becomes apparent that the data for a specific medium are of insufficient quality, either with respect to the number of samples or based on an individual analysis.

For the purposes of this effort, 90 percent is established as the minimum acceptable level of completeness. A data point will be determined to contribute to the completeness of the data set if the information provided is meaningful, useful, and contributes to the project objectives.

4.1.2.4 Comparability

One of the objectives of the sampling effort is to provide analytical data that is characterized by a level of quality that is comparable between sampling points. By specifying the use of standard analytical procedures (as well as standardizing field sampling procedures by employing B&R Environmental and others' SOPs), the potential for variables to affect the final data quality will be effectively minimized. Analytical methods for this work are shown in Table 3-1, and SOPs appear in Appendix B.

4.1.3 Quality Control Samples

QC samples to be collected during the sampling effort are identified below, and include field duplicates or replicates, laboratory duplicates or replicates, rinsate blanks, trip blanks, and field blanks. Each type of field quality control sample defined below will undergo the same preservation, holding times, etc., as the field samples. Table 3-3 presents a summary of these QC samples to be collected during this field sampling event.

4.1.3.1 Field Duplicates

Field duplicates will be submitted at the rate of one for every 10 samples per matrix, or one duplicate if less than 10 are shipped to the laboratory on any given day. Field personnel will note on the sample summary form and in the logbook which samples are field duplicates. Duplicate samples will be shipped blind to the laboratories, and shipping paperwork will be completed accordingly.

Field personnel will note in the remarks block on the chain-of-custody form which of the samples is to be used for internal laboratory matrix spike/matrix spike duplicate analysis. Field duplicates and multiple sample aliquots are collected by mixing a double portion of the required volume of sample and dividing it into two sample containers. Aliquots for VOC analysis are always removed prior to homogenization to minimize volatilization of contaminants. Field duplicates provide precision information regarding homogeneity, handling, shipping, storing, preparation, and analysis.

4.1.3.2 Rinsate Blanks

Rinsate blanks are obtained under representative field conditions by running analyte-free deionized water through sample collection equipment after decontamination, immediately before sampling and placing it in the appropriate sample containers for analysis. These samples are used to assess the effectiveness of decontamination procedures. Rinsate blanks will be prepared at the rate of one per day and will be analyzed for the same parameters as the related samples. All rinsate samples will be sent to the laboratory.

4.1.3.3 Field Blanks

Field blanks will consist of the source water used in decontamination (includes analyte-free deionized water, potable water from each source, and other waters used in decontamination operations). Field blanks will be prepared at the rate of one per source of water per sampling event.

4.1.3.4 Trip Blanks

Trip blanks consist of aqueous VOCs-free samples prepared by the laboratories. One trip blank sample will accompany each shipment of VOC samples to the laboratories. If more than ten VOC samples are in one shipment, one trip blank sample will be provided for each ten field samples If less than ten VOC samples are in one shipment, one trip blank will be provided. If there are multiple sampling crews out at one time, trip blanks will accompany each sampling team. If the samples are "pooled" in a single cooler for shipment, then the trip blanks accompanying each respective sampling team will be submitted for VOC analysis.

4.1.3.5 Matrix Spike/Matrix Spike Duplicates

A matrix spike sample will be identified by field teams at a frequency of one in 20 field samples collected. Samples for matrix spike analyses and laboratory duplicate analysis are collected in triplicate volumes for aqueous organics (three containers for each analyte group), and duplicate volumes for aqueous metals (two containers). Soil matrix spikes will be collected in double volumes.

4.2 SAMPLING PROCEDURES

Field sampling will be conducted in accordance with Section 3.0 of this document and the B&R Environmental SOPs presented in Appendix B-1, and EPA and RIDEM low-stress sampling procedures in Appendix B-2. Allowable sample holding times and preservation requirements are shown in Table 3-2.

4.3 SAMPLE DESIGNATION AND CUSTODY

Samples collected will be tracked by sample number and date collected. The sample number will be the basis for maintaining chain of custody. These procedures are described below.

4.3.1 Sample Numbering

Samples will be labeled as soon as they are collected. Sample numbers will reflect the source, medium, and location. An alpha numeric numbering system will be used to describe this information. This system is detailed below:

AAA	-	A	-	AANN	-	NNNN
(Site Identifier)		(Medium)		(Sample Location)		(Depth)

The site identifier for OFFTA - Site 09 is OFF. Medium indicates solids (S) or Aqueous (A). Sample locations will be noted as TP (soil from test pit excavations- Task 3, Subtask 0310), MW (groundwater and soil from borings/groundwater monitoring well locations- Task 3, Subtask 0330), SS (shoreline sediment- Task 3, Subtask 0320) or SW (storm sewer outfall- Task 3, Subtask 0350).

For example, a soil sample collected from 2 to 4 feet below ground surface from the well MW15 location will be identified as OFF-S-MW15-0204. The first groundwater sample collected from this well will be identified as OFF-A-MW15-01.

Blind duplicate samples will be designated such that the location designation will be replaced with a chronological number:

Duplicates: OFF-A-DUPL#

Field blanks will be designated such that they can clearly be identified as field blanks. The designation must be able to be referenced to the source using the field paperwork.

Field Blanks: OFF-A-HYD1-FB

Rinsate blanks will be identified using the code for the sample for which the tool was last used, the identifier (RB), and its chronological number.

Rinsate Blanks: OFF-A-MW12-0204-RB#

Trip blanks will be designated so that they can clearly be identified as aqueous trip blanks using an identifier (TB) and its chronological number.

Trip Blanks: OFF-A-TB#

Matrix spike samples are simply marked as such on the sample containers and on the Chain-of-Custody Record.

4.3.2 Sample Chain of Custody

Custody of samples must be maintained and documented at all times. To ensure the integrity of a sample from collection through analysis, an accurate written record is necessary to trace the possession and handling of the sample. This documentation is referred to as the "chain of custody". Chain of custody begins when samples are collected in the field, and is maintained by storing the samples in secure areas until custody can be passed on. All samples will be accompanied by a chain-of-custody form that will describe the analytical parameters, and the persons who are responsible for its integrity.

Samples will be placed on ice and attended by B&R Environmental personnel or placed in locked vehicles or designated storage areas until analysis or shipment to an off-site laboratory. Chain-of-custody procedures are described in further detail in the SOPs presented in Appendix B of this Work Plan.

4.4 CALIBRATION PROCEDURES

Field equipment normally requiring calibration will be calibrated and operated in accordance with the manufacturer's instructions and manuals. A log will be kept on site, documenting the periodic calibration results for each field instrument.

Calibration procedures for laboratory equipment used in the analysis of environmental samples will be performed in accordance with NEESA requirements, i.e., CLP requirements.

4.5 ANALYTICAL PROCEDURES

Samples collected will be analyzed for various parameters described in previous sections and on Table 3-1.

4.5.1 Laboratory Analysis

Those environmental samples collected for laboratory analysis during the field investigation will be analyzed by a laboratory previously approved by NEESA. In general, standard EPA analytical procedures will be employed, as depicted in Table 3-1. Tier III data validation will be conducted in accordance with EPA guidance.

4.5.2 Field Screening

Soil samples collected for field headspace screening will be analyzed in the field using a Photovac MicroFID Handheld Flame Ionization Detector (or equivalent) for VOCs. The field FID headspace screening method will be in accordance with the procedure presented in Appendix B-3.

4.6 DATA REDUCTION, REVIEW, AND REPORTING

Analytical data will be reviewed by qualified B&R Environmental technical staff. Laboratory data will undergo data validation consistent with EPA Tier III protocols. Data validation memoranda will be prepared and submitted to the PM as a part of that activity. Data validation procedures are described in Section 4.10.2 of this Work Plan.

4.7 INTERNAL QUALITY CONTROL

Section 4.1.3 discussed the types and frequency of quality control samples that will be prepared during the field investigation activities for those samples that undergo laboratory analysis. The quantities of the various types of the QC samples are shown in Table 3-3. Laboratory analysis will follow the QC criteria described in the EPA-approved procedures.

Quality control criteria for field FID headspace screening consists of daily calibration of the FID, according to manufacturer's instrument guidance. Calibration information would be kept on a calibration field form.

4.8 PERFORMANCE AND SYSTEM AUDITS

System audits will be performed as appropriate to ensure that the work is being implemented in accordance with the approved project SOPs and in an overall satisfactory manner

- The FTL will supervise and on a daily basis check to ensure that the equipment is thoroughly decontaminated, samples are collected and handled properly, and the field work is accurately and neatly documented

- The data reviewer(s) will review the data and will check that the data was obtained through the approved methodology, and that the appropriate level of QC effort and reporting were conducted. The data validation effort will be supervised by the B&R Environmental CLEAN Quality Assurance Manager or designee.

- The PM will oversee the FTL and data reviewer, and check that management of the acquired data proceeds in an organized and expeditious manner.

4.9 PREVENTIVE MAINTENANCE

B&R Environmental has established a field equipment maintenance program 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 maintains an inventory of the equipment by model and serial number, quantity, and condition. Each item of equipment is signed out when in use, and its operating condition and cleanliness is checked upon return.

- The equipment manager conducts routine checks on the status of equipment and is responsible for stocking 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 FTL 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.

- While the equipment is in the field, the FTL takes responsibility for the equipment, maintains calibration records, and performs maintenance operations and checks.

4.10 DATA ASSESSMENT PROCEDURES

The following paragraphs describe the procedures used to evaluate data prior to inclusion and description in the deliverable reports described elsewhere in this work plan.

4.10.1 Representativeness, Accuracy, and Precision

All laboratory data generated in the investigation will be assessed for representativeness, accuracy, and precision, as described in Section 4.1.2. The completeness of the data will also be assessed by comparing the acquired data to the project objectives to see that these objectives are being addressed and met. The specific information used to determine data precision, accuracy, and completeness will be provided in the laboratory data packages.

The PARCC parameter assessment will be conducted by qualified B&R Environmental personnel. The representativeness of the data will be assessed by determining if the data are consistent with known or anticipated 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 determined using replicate samples and blank and spiked samples, respectively. PARCC parameters are addressed in more detail in Section 4.1.2.

4.10.2 Data Validation

Samples will be analyzed for parameters described on Table 3-1 of this Work Plan. Results will undergo a Tier III validation using the "National Functional Guidelines for Organic/Inorganic Data Review" (U.S. EPA December 1990, revised February 1994 [organic] and February 1993 [inorganic]). Use of these validation protocols is in accordance with the Navy Installation Restoration Laboratory Quality Assurance Guide, Interim Document (revised February 1996), and the NEESA 20.2047B; June 1988 guidelines.

4.10.3 Data Evaluation

The evaluation of the data collected during the field investigation will include comparison of analytical laboratory data (from this field investigation) to previous RI analytical laboratory data. Further evaluation of the data will be performed in conjunction with the preparation of the letter report and EE/CA report.

4.11 CORRECTIVE ACTION

The QA program will enable problems to be identified, controlled, and corrected. Potential problems may involve non-conformance with the SOPs and/or analytical procedures established for the project, or other unforeseen difficulties. Any person identifying an unacceptable condition will notify the FTL and the PM. The PM, with the assistance of the Quality Assurance Manager and the project QA/QC officer, will be responsible for developing and initiating appropriate corrective action and verifying that the corrective action has been effective.

Corrective actions may include re-sampling and/or re-analysis of samples or modifying 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 source of the problem has been addressed.

4.12 QUALITY ASSURANCE REPORTS/DOCUMENTS

A bound/weatherproof field logbook will be maintained by the FTL. The FTL or designee will record all information related to sampling or field activities. This information may include sampling time, weather conditions, unusual events, field measurements, description of photographs, etc. The site logbook maintained by the FTL will contain a summary of the day's activities and will reference the other field logbooks when applicable.

In addition, the following information will be maintained on a daily basis:

- field headspace screening results
- health and safety concerns, incidents, PPE used, and instruments used to determine PPE levels
- site sign-in log
- copies of all chain of custody samples collected

At the completion of field activities, the FTL will submit all field records, data, field notebooks, logbooks, chain-of-custody receipts, sample log sheets, etc. to the PM. The PM will ensure that these materials are entered into the project file

Changes in project operating procedures may be necessary as a result of changed field conditions or unanticipated events. A summary of the sequence of events associated with field changes is as follows:

- The FTL notifies the PM of the need for the change.

- If necessary, the PM will discuss the change with the pertinent individuals, e.g., Navy personnel, B&R Environmental Navy CLEAN Quality Assurance Manager, and will provide a verbal approval or denial to the FTL for the proposed change.

- The FTL will document the change on a Request for Field Modification and forward the form to the PM at the earliest convenient time (end of the workday).

- The PM will sign the form and distribute copies to the Program Manager, Quality Assurance Manager, FTL, and the project file. If necessary, the PM will submit the form to the Navy RPM for delivery to the regulatory oversight parties.

- A copy of the completed Request for Field Modification will also be attached to the field copy of the affected document, Work Plan/Field Sampling Plan.

5.0 REPORTING

Following the completion of the field investigation and laboratory analyses described in Section 3, the results will be compiled and evaluated to assess whether conditions exist at Site 09 that may warrant a removal action. If it is determined that a NTCRA is warranted, then an EE/CA report would be prepared. If a time critical removal action is determined to be necessary, then Navy will notify EPA and RIDEM about proposed response actions.

5.1 LETTER REPORT

The field investigation data and analytical results will be evaluated to assess whether a NTCRA for potential contaminant sources is needed. Site-specific conditions will be evaluated against the National Contingency Plan (40 CFR 300.415) to determine whether one or more of the eight conditions exist that may result in the need for a removal action to protect public health or welfare or the environment. If conditions exist that may warrant a response action, then an EE/CA document will be prepared that provides the necessary technical and cost information to select the most appropriate removal action(s) that fulfills the goals and objectives for a proposed non-time-critical removal action for the OFFTA.

A letter report would be prepared and provided to the Navy, EPA, and RIDEM for discussion purposes. A brief letter report would be prepared that:

- summarizes the field investigation findings,
- identifies whether conditions exist that may warrant a NTCRA,
- identifies potential contaminant sources,
- presents estimates of contaminant volumes and types,
- provides a candidate list of removal actions to address identified sources (USTs, piping, etc.), contaminated sediments, NAPL, or contaminated groundwater.

It is assumed that a three-page summary would be prepared with three supporting maps (soil PAHs, soil metals, and groundwater contaminants) that depict the approximate locations and estimated contaminant extent that may require a removal action.

Supporting documentation to be provided may include:

- maps depicting: sampling locations; key site features; surveyed locations of test pits, borings, and monitoring wells; and other significant features.
- results of laboratory chemical analyses.
- boring logs and well installation logs.

5.2 ENGINEERING EVALUATION/COST ANALYSIS DOCUMENT

Draft EE/CA Preparation

After Navy concurrence with the technical approach presented in the letter report, has been obtained B&R Environmental will prepare a draft EE/CA report that is consistent with the EPA's Guidance on Conducting Non-Time-Critical Removal Actions Under CERCLA, EPA/540-R-93-057 (Publication 9360.0-32), August 1993. The following items would be presented in the EE/CA:

- a summary of site background information
- a brief description of field investigation activities
- an identification of potential sources, if determined to be present
- a summary and interpretation of chemical data
- estimates of contaminant volumes and types
- a limited human health risk evaluation
- a list NTCRA objectives
- an identification and summary of ARARs and TBCs
- an identification and summary of potential response technologies and alternatives
- descriptions of response alternatives
- conceptual calculations and cost estimates
- an evaluation of effectiveness, implementability, and cost
- a list of recommendations

The EE/CA document will present one map with the field investigation sampling locations, one map depicting soil total petroleum hydrocarbon levels (TPH), one map depicting SVOC and metals, and one map depicting groundwater where detected chemicals exceed the appropriate

groundwater quality criteria. In addition, the EE/CA will provide summary tables of detected organic compounds and metals.

B&R Environmental anticipates evaluating up to five removal action alternatives (including a no action option as a baseline) that would achieve the NTCRA objectives. Available presumptive remedies would also be considered during the formulation of alternatives step. Each alternative shall be described in sufficient detail to facilitate the detailed evaluation process. As appropriate, recommendations for removal will be included in the EE/CA report.

Response to Comments

It is assumed that EPA and RIDEM comments will be provided to the Navy and B&R Environmental within 14 days after their receipt of the draft EE/CA documents (based on an assumed regulatory review duration). B&R Environmental will prepare responses to these comments within one week of receipt and distribute them as necessary. A response to comments letter would be provided (to EPA and to RIDEM) that presents the regulatory agency's comment followed by the written response that addresses the concern or issue. It is anticipated that either a meeting or a conference call would be conducted to resolve concerns or issues.

Final EE/CA Report

The final EE/CA report will be prepared by incorporating responses to comments as agreed at a meeting (or conference call) or by general acceptance by the regulatory agencies. The final EE/CA report will be published and distributed within 14 days following the distribution of accepted responses to comments.

REFERENCES

REFERENCES

Naval Energy and Environmental Support Activity, February 1996. "Navy Installation Restoration Quality Assurance Guide."

State of Rhode Island and Providence Plantations, Department of Environmental Management, 1956, and Amendments 1988. "Water Quality Regulations for Water Pollution Control." Division of Water Resources, Providence, Rhode Island.

State of Rhode Island and Providence Plantations, Department of Environmental Management, Division of Site Remediation, August 1993. "Rules and Regulations for the Investigation and Remediation of Hazardous Material Releases", DEM-DSR-01-93.

TRC Environmental Corporation, August 1994. "Volume I, Old Fire Fighting Training Area Remedial Investigation Report: Technical Report". Draft Final. Naval Education Training Center, Newport, Rhode Island.

U.S. Environmental Protection Agency, 1994. "Data Quality Objectives for Remedial Response Activities Development Process". EPA/540/G-87/003.

U.S. Environmental Protection Agency, Region I, July 30, 1996. "Low Stress (low flow) Purging and Sampling Procedure for the Collection of Ground Water Samples From Monitoring Wells". SOP No. GW 0001, Revision No. 2.

TABLES

TABLE 3-1
SUMMARY OF SAMPLING AND ANALYSES
SOURCE REMOVAL EVALUATION WORK PLAN
SITE 09: OLD FIRE FIGHTING TRAINING AREA (OFFTA)
NETC - NEWPORT, RHODE ISLAND

SAMPLE EVENT	ESTIMATED NUMBER OF SAMPLES	SAMPLE ANALYSES	ANALYTICAL METHOD
Test Pit Subsurface Soil Sampling	18	TCL VOCs	CLP SOW OLM03.0, w/rev.
	14	TCL SVOCs	CLP SOW OLM03.0, w/rev.
	14	TCL Pesticides/PCBs	CLP SOW OLM03.0, w/rev.
	14	Total TAL Metals	CLP SOW ILM03.0, w/rev.
	10	TPH	EPA 418.1
	4	TCLP SVOCs (If required)	TCLP: SW-846 - 1311/SVOCs: CLP SOW OLM03.0, w/rev.
	4	TCLP Metals (If required)	TCLP: SW-846 - 1311/metals: CLP SOW ILM03.0, w/rev.
Soil Boring Subsurface Soil Sampling	5	TCL VOCs	CLP SOW OLM03.0, w/rev.
	4	TCL SVOCs	CLP SOW OLM03.0, w/rev.
	4	TCL Pesticides/PCBs	CLP SOW OLM03.0, w/rev.
	4	Total TAL Metals	CLP SOW ILM03.0, w/rev.
	1	TPH	EPA 418.1
	1	TCLP SVOCs (If required)	TCLP: SW-846 - 1311/SVOCs: CLP SOW OLM03.0, w/rev.
	1	TCLP Metals (If required)	TCLP: SW-846 - 1311/metals: CLP SOW ILM03.0, w/rev.
Groundwater Sampling	23	TCL VOCs	CLP SOW OLM03.0, w/rev.
	18	TCL SVOCs	CLP SOW OLM03.0, w/rev.
	18	TCL Pesticides/PCBs	CLP SOW OLM03.0, w/rev.
	18	Total TAL Metals	CLP SOW ILM03.0, w/rev.
	6	TAL Metals (Filtered)	CLP SOW ILM03.0, w/rev.
	17	TPH	EPA 418.1

TABLE 3-1
SUMMARY OF SAMPLING AND ANALYSES
SOURCE REMOVAL IMPLEMENTATION PLAN
SITE 09: OLD FIRE FIGHTING TRAINING AREA (OFFTA)
NETC, NEWPORT, RHODE ISLAND

SAMPLE EVENT	ESTIMATED NUMBER OF SAMPLES	SAMPLE ANALYSES	ANALYTICAL METHOD
Sediment Sampling	7	TCL SVOCs	CLP SOW ILMO3.0, w/rev.
Outfall Pipe Sampling	4	TCL VOCs	CLP SOW OLMO3.0, w/rev.
	3	TCL SVOCs	CLP SOW OLMO3.0, w/rev.
	3	TCL Pesticides/PCBs	CLP SOW OLMO3.0, w/rev.
	3	Total TAL Metals	CLP SOW ILMO3.0, w/rev.
	3	TPH	EPA 418.1

Notes:
Number of samples includes field QA/QC samples.

CLP - Contract Laboratory Program
ILM - Inorganic Low/Medium
OLM - Organic Low/Medium
PCBs - Polychlorinated biphenyls
SOW - Statement of Work
SVOCs - Semi-Volatile Organic Compounds
TAL - Target Analyte List
TCL - Target Compound List
TCLP - Toxicity Characteristic Leaching Procedure
TPH - Total Petroleum Hydrocarbon
VOCs - Volatile Organic Compounds

TABLE 3-2
SAMPLE CONTAINER, PRESERVATIVE, AND HOLDING TIME REQUIREMENTS
SOURCE REMOVAL EVALUATION WORK PLAN
SITE 09: OLD FIRE FIGHTING TRAINING AREA (OFFTA)
NETC - NEWPORT, RHODE ISLAND

SAMPLE MEDIUM	SAMPLE ANALYSIS	SAMPLE CONTAINER	MINIMUM VOLUME	PRESERVATIVE	HOLDING TIME[1]
Test Pit Subsurface Soil	TCL VOCs	1 - 4 oz VOC jar	1 - 4 oz jar	Cool to 4° C	14 Days
	TCL SVOCs	1 - 8 oz jar	1 - 8 oz jar	Cool to 4° C	7 Days/40 Days [2]
	TCL Pesticide/PCBs	1 - 8 oz jar	1 - 8 oz jar	Cool to 4° C	7 Days/40 Days [2]
	Total TAL Metals	1 - 8 oz jar	1 - 4 oz jar	Cool to 4° C	6 Months/28 Days [3]
	TPH	1 - 8 oz jar	50 grams	Cool to 4° C	14 Days
	TCLP SVOCs (If required)	2 - 8 oz jar	200 grams	Cool to 4° C	14/7/40 Days [4]
	TCLP Metals (If required)	2 - 8 oz jar	200 grams	Cool to 4° C	180/180 Days [5]
Soil Boring Subsurface Soil	TCL VOCs	1 - 2 oz VOC jar	1 - 2 oz jar	Cool to 4° C	14 Days
	TCL SVOCs	1 - 8 oz jar	1 - 8 oz jar	Cool to 4° C	7 Days/40 Days [2]
	TCL Pesticide/PCBs	1 - 8 oz jar	1 - 8 oz jar	Cool to 4° C	7 Days/40 Days [2]
	Total TAL Metals	1 - 8 oz jar	1 - 4 oz jar	Cool to 4° C	6 Months/28 Days [3]
	TPH	1 - 8 oz jar	1 - 8 oz jar	Cool to 4° C	14 Days
	TCLP SVOCs (If required)	2 - 8 oz jar	200 grams	Cool to 4° C	14/7/40 Days [4]
	TCLP Metals (If required)	2 - 8 oz jar	200 grams	Cool to 4° C	180/180 Days [5]
Groundwater	TCL VOCs	2 - 40 ml VOC vials	1 - 40 ml VOC vial	HCL to pH < 2	14 Days
	TCL SVOCs	1 - 1 lit. amber bottle	1 - 1 lit. amber bottle	Cool to 4° C	7 Days/40 Days [2]
	TCL Pesticide/PCBs	1 - 1 lit. amber bottle	1 - 1 lit. amber bottle	Cool to 4° C	7 Days/40 Days [2]
	Total TAL Metals	1 - 500 ml plastic bottle	300 ml	HNO_3 to pH < 2	6 Months/28 Days [3]
	Dissolved TAL Metals (filtered)	1 - 1 lit. plastic bottle	500 ml	HNO_3 to pH < 2	6 Months/28 Days [3]
	TPH	1 - 250 ml plastic bottle	50 ml	H_2SO_4 to pH < 2	28 Days

TABLE 3-2
SAMPLE CONTAINER, PRESERVATIVE, AND HOLDING TIME REQUIREMENTS
SOURCE REMOVAL EVALUATION WORK PLAN
SITE 09: OLD FIRE FIGHTING TRAINING AREA (OFFTA)
NETC - NEWPORT, RHODE ISLAND

SAMPLE MEDIUM	SAMPLE ANALYSIS	SAMPLE CONTAINER	MINIMUM VOLUME	PRESERVATIVE	HOLDING TIME (1)
Outfall Pipe/ Surface Water	TCL VOCs	2 - 40 ml VOC vials	1 - 40 ml VOC vial	HCL to pH < 2	14 Days
	TCL SVOCs	1 - 1 lit. amber bottle	1 - 1 lit. amber bottle	Cool to 4° C	7 Days/40 Days (2)
	TCL Pesticide/PCBs	1 - 1 lit. amber bottle	1 - 1 lit. amber bottle	Cool to 4° C	7 Days/40 Days (2)
	Total TAL Metals	1 - 500 ml plastic bottle	300 ml	HNO_3 to pH < 2	6 Months/28 Days (3)
	TPH	1 - 250 ml plastic bottle	50 ml	H_2SO_4 to pH < 2	28 Days
Sediment Shoreline	TCL SVOCs	1 - 8 oz jar	1- 8 oz jar	Cool to 4°C	7 Days/40 Days (2)

Notes:

(1) Holding times are maximum allowable durations from date of collection until analyses, unless otherwise specified.
(2) TCL Semivolatile Compounds and Pesticides/PCBs extractions are to be completed within 7 days of time of collection; analyses to be completed within 40 days after extraction.
(3) Analyses for all metals, except mercury, to be completed within 6 months; for mercury, analyses to be completed within 28 days.
(4) For TCLP SVOCs: TCLP extraction completed within 14 days, SVOCs extraction completed within 7 days after TCLP extraction, SVOCs analyses completed within 40 days after SVOCs extraction.
(5) For TCLP Metals (except mercury): TCLP extraction completed within 180 days, TAL Metals analyses completed within 180 days after TCLP extraction. For mercury: TCLP extraction completed within 28 days, TAL Metals analyses completed within 28 days after TCLP extraction.

TCL - Target Compound List
VOCs - Volatile Organic Compounds
SVOCs - Semi-Volatile Organic Compounds
PCBs - Polychlorinated biphenyls
TAL - Target Analyte List
TPH - Total Petroleum Hydrocarbons
TCLP - Toxicity Characteristic Leaching Procedure

VOC - Volatile Organic Compounds
HCL - Hydrochloric Acid
HNO_3 - Nitric Acid
H_2SO_4 - Sulfuric Acid

TABLE 3-3
FIELD QUALITY CONTROL SAMPLE SUMMARY
SOURCE REMOVAL EVALUATION WORK PLAN
SITE 09: OLD FIRE FIGHTING TRAINING AREA (OFFTA) CTO 0288
NETC - NEWPORT, RHODE ISLAND

SAMPLE EVENT	SAMPLE ANALYSES	ESTIMATED NO. OF SAMPLES	FIELD DUPLICATES (1)	SOURCE BLANKS(2)	RINSATE BLANKS(3)	TRIP BLANKS(4)	TOTAL QC SAMPLES
Test Pit Subsurface Soil Sampling	TCL VOCs	10	1	1	2	4	8
	TCL SVOCs	10	1	1	2	--	4
	TCL Pesticide/PCBs	10	1	1	2	--	4
	Total TAL Metals	10	1	1	2	--	4
	TPH	10	--	--	--	--	--
	TCLP Extraction/SVOCs(TBD)	4	--	--	--	--	--
	TCLP Extraction/Metals (TBD)	4	--	--	--	--	--
Soil Boring Subsurface Soil Sampling	TCL VOCs	1	1	1	1	3	4
	TCL SVOCs	1	1	1	1	--	3
	TCL Pesticide/PCBs	1	1	1	1	--	3
	Total TAL Metals	1	1	1	1	--	3
	TPH	1	--	--	--	--	--
	TCLP Extraction/SVOCs(TBD)	1	--	--	--	--	--
	TCLP Extraction/Metals (TBD)	1	--	--	--	--	--
Groundwater Sampling	TCL VOCs	15	2	--	1	6	8
	TCL SVOCs	15	2	--	1	--	3
	TCL Pesticide/PCBs	15	2	--	1	--	3
	Total TAL Metals (Low Flow)	15	2	--	1	--	3
	TAL Metals (Filtered)	4	1	--	1	--	2
	TPH	15	2	--	--	--	2

TABLE 3-3
FIELD QUALITY CONTROL SAMPLE SUMMARY
SOURCE REMOVAL EVALUATION IMPLEMENTATION PLAN
SITE 09: OLD FIRE FIGHTING TRAINING AREA (OFFTA) CTO 0288
NETC - NEWPORT, RHODE ISLAND

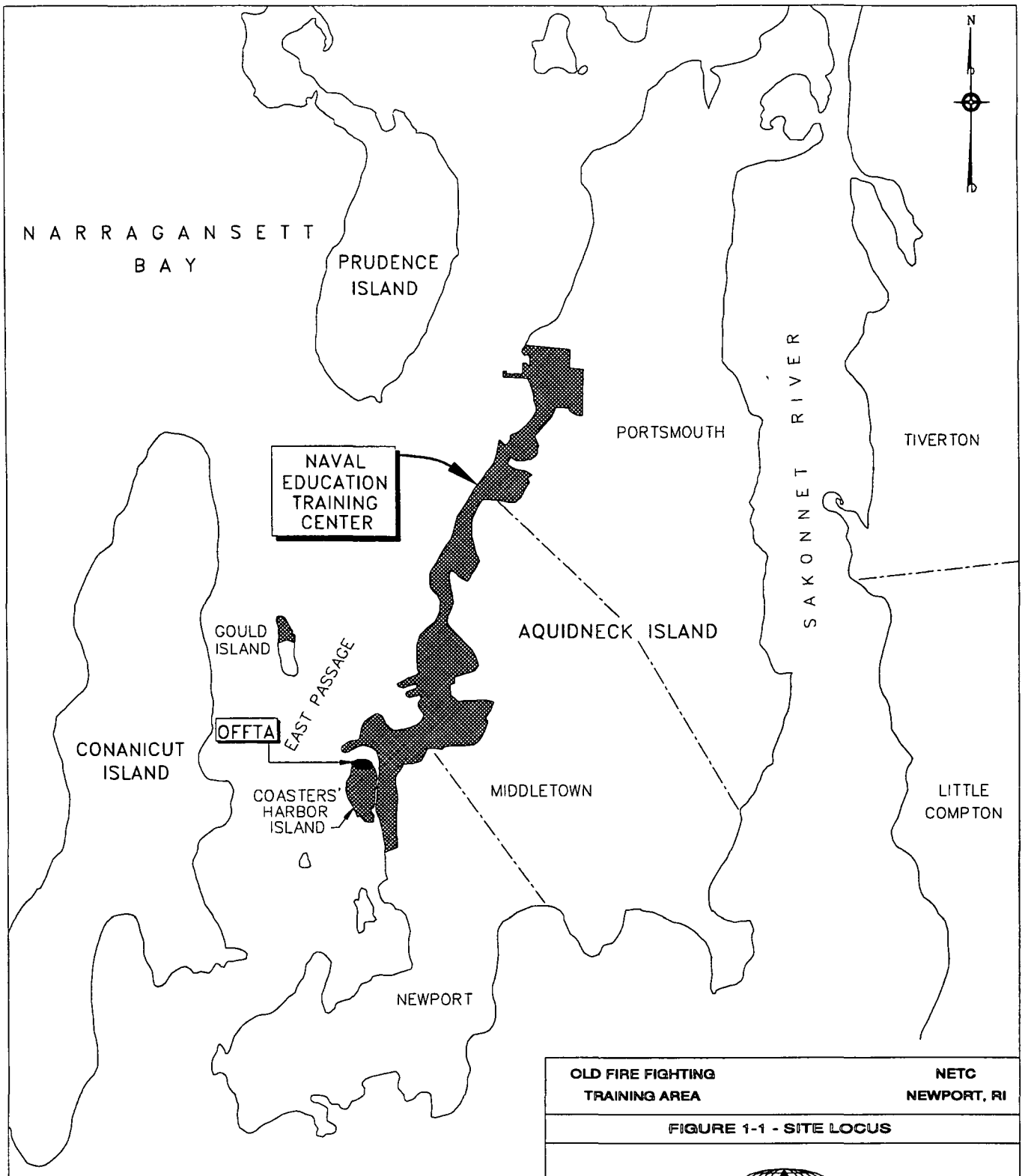
SAMPLE EVENT	SAMPLE ANALYSES	ESTIMATED NO. OF SAMPLES	FIELD DUPLICATES (1)	SOURCE BLANKS (2)	RINSATE BLANKS (3)	TRIP BLANKS (4)	TOTAL QC SAMPLES
Outfall Sampling/ Surface Water	TCL VOCs	2	1	--	--	1	2
	TCL SVOCs	2	1	--	--	--	1
	TCL Pesticide/PCBs	2	1	--	--	--	1
	Total TAL Metals	2	1	--	--	--	1
	TPH	2	1	--	--	--	1
Sediment Sampling	TCL SVOCs	5	1	--	1	--	2

Notes:

(1) Field Duplicates are to be collected at 10% frequency.
(2) Source Blanks consist of water used for decontamination and steam cleaning (1 per water source per sampling event).
(3) One Rinsate Blank will be collected per day per matrix for nondisposable equipment.
(4) One Trip Blank will accompany each cooler containing samples to be analyzed for VOCs.

TCL - Target Compound List
VOCs - Volatile Organic Compounds
SVOCs - Semi-Volatile Organic Compounds
PCBs - Polychlorinated biphenyls
TAL - Target Analyte List
TPH - Total Petroleum Hydrocarbons
TCLP - Toxicity Characteristic Leaching Procedure
TBD - To Be Determined

FIGURES



SCALE

0 2 MILES

SOURCES DRAFT FINAL REMEDIAL INVESTIGATION REPORT
TRC ENVIRONMENTAL CORPORATION - AUGUST 1994

ACAD NAME. F \CADD\FIREFITE\FIG1-1 DWG

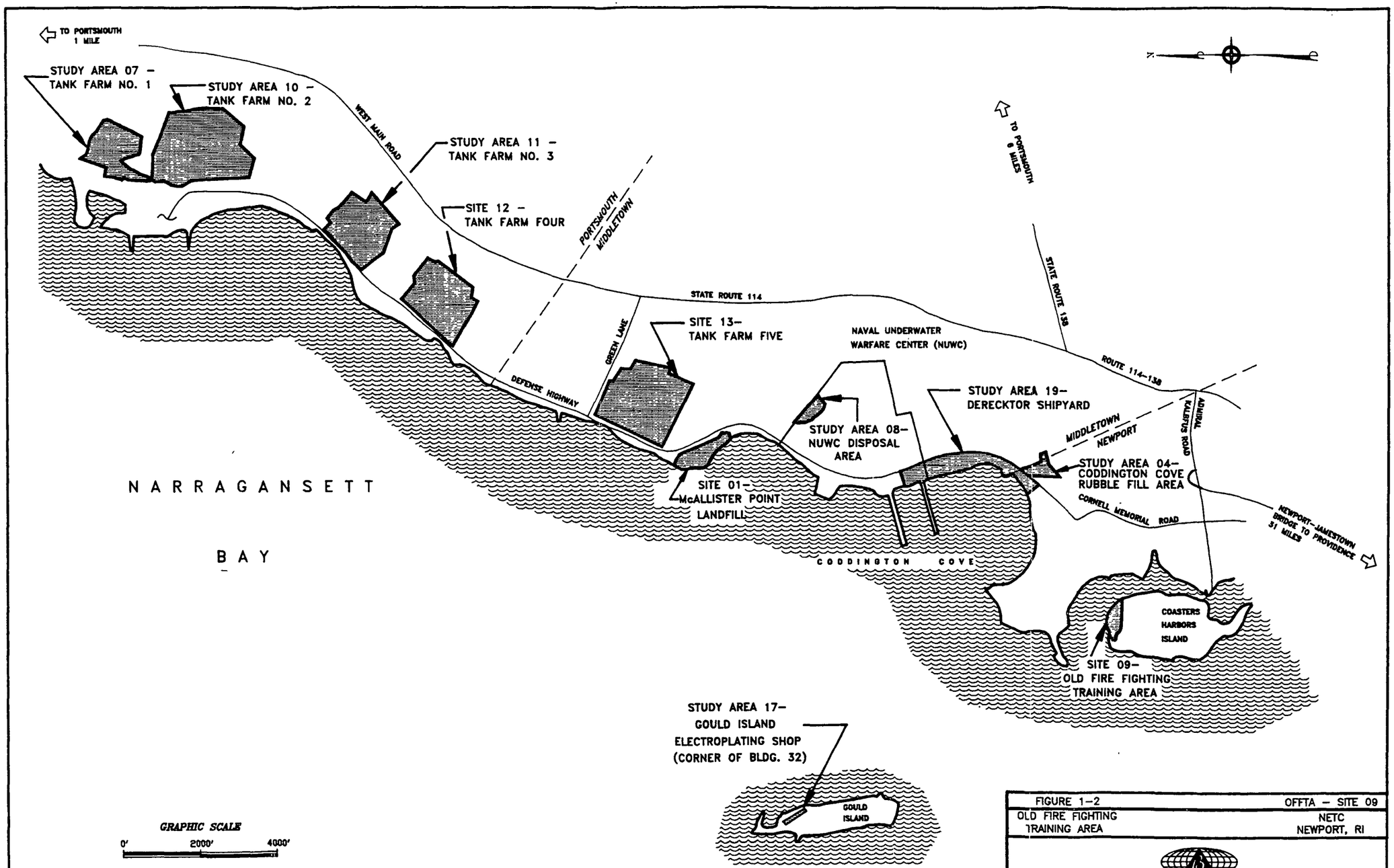
OLD FIRE FIGHTING TRAINING AREA	NETC NEWPORT, RI

FIGURE 1-1 - SITE LOCUS

Brown & Root Environmental

A Division of Halliburton NUS Corporation

55 JONSPIN ROAD
WILMINGTON, MASSACHUSETTS 01887
(508)658-7899



SOURCE: DRAFT FINAL REMEDIAL INVESTIGATION REPORT
TRC ENVIRONMENTAL CORPORATION - AUGUST 1994

FIGURE 1–2 OFFTA – SITE 09
OLD FIRE FIGHTING TRAINING AREA
NETC NEWPORT, RI

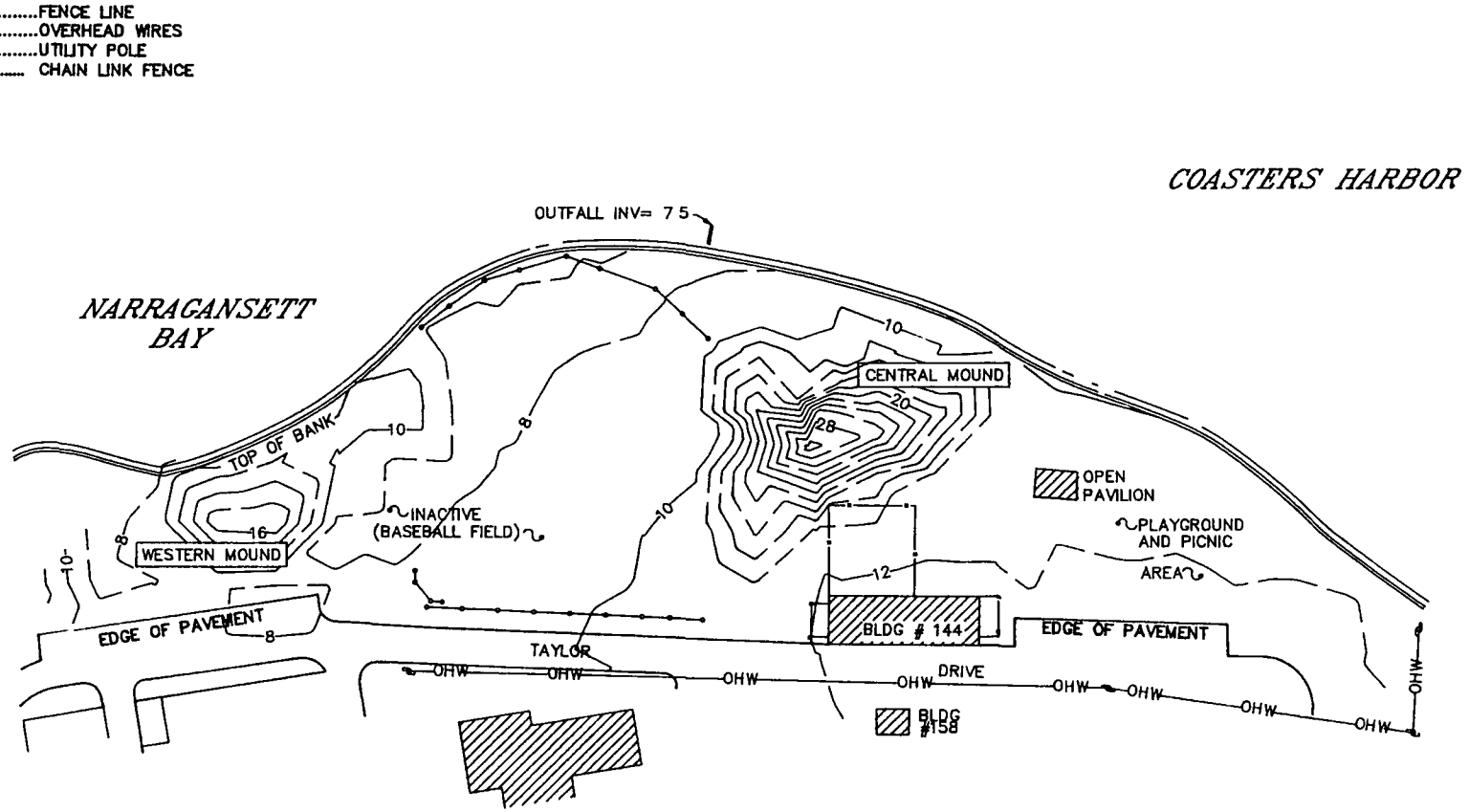
Brown & Root Environmental

A Division of Halliburton NUS Corporation

55 JONSPIN ROAD
WILMINGTON, MASSACHUSETTS 01887
(508)658–7899

LEGEND

- FENCE LINE
- OVERHEAD WIRES
- UTILITY POLE
- CHAIN LINK FENCE



SOURCE: DRAFT FINAL REMEDIAL INVESTIGATION REPORT
TRC ENVIRONMENTAL CORPORATION - AUGUST 1994

GRAPHIC SCALE
0' 150'
1 INCH = 150 FEET

ACAD NAME: DWG\NETC\FIREFITE\FIG1-3.DWG

CURRENT SITE FEATURES			FIGURE 1-3
SITE 09 – OLD FIRE FIGHTING AREA			
NAVAL EDUCATION AND TRAINING CENTER – NEWPORT, RI			
DRAWN BY:	D.W. MACDOUGALL	REV: 0	
CHECKED BY:	L. CHU	DATE: MAY 1997	
SCALE:	1" = 150'	FILE NO.: F:\CADD\FIREFITE\FIG1-3F.DWG	

Brown & Root Environmental
A Division of Halliburton NUS Corporation
55 Jonspin Road Wilmington, MA 01887
(508)658-7899

FIGURE 1-4
STAFF ORGANIZATION
OLD FIRE FIGHTING TRAINING AREA - SITE 09
SOURCE REMOVAL EVALUATION
NETC, NEWPORT, RHODE ISLAND

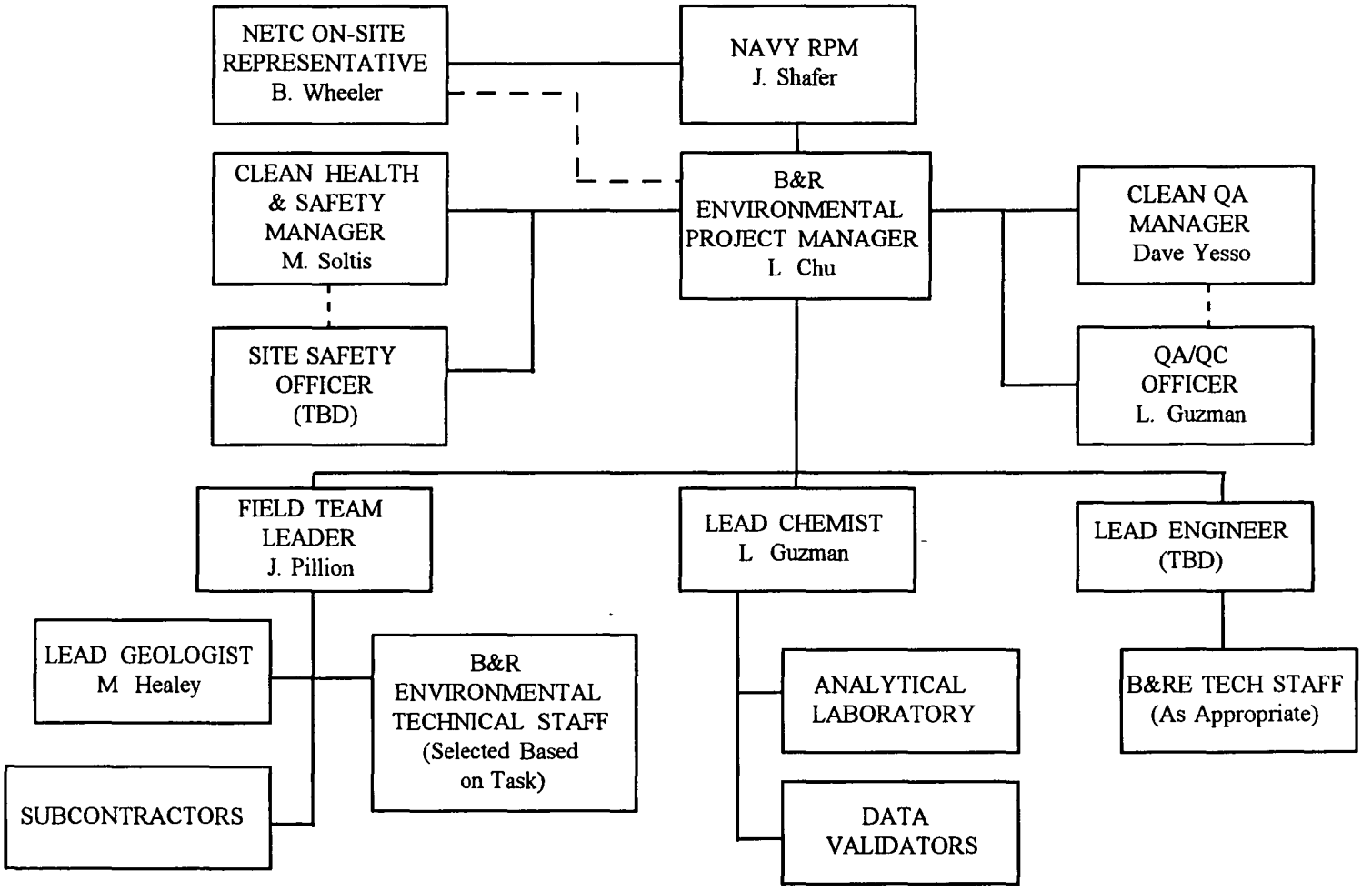


FIGURE 1 - 5
SOURCE REMOVAL EVALUATION TENTATIVE SCHEDULE
OFFTA - SITE 09

ID	Task Name	Duration	Start	Finish
1	**TASK 1 - SITE VISIT**	1d	Mon 4/7/97	Mon 4/7/97
2				
3	**WORK PLAN PREPARATION**	26d	Mon 4/7/97	Fri 5/2/97
4	-	26d	Mon 4/7/97	Fri 5/2/97
10	***DR. WORK PLAN SUBMITTAL TO EPA/RIDEM***	***0d***	***Fri 5/2/97***	***Fri 5/2/97***
11	- EPA/RIDEM review	14d	Sat 5/3/97	Fri 5/16/97
12	- Final Work Plan Prep.	10d	Sat 5/17/97	Mon 5/26/97
13	***FINAL WORK PLAN SUBMITTAL***	***1d***	***Mon 5/26/97***	***Mon 5/26/97***
14				
15	Subcontractor Procurement	53d	Mon 4/7/97	Thu 5/29/97
20				
21	**TASK 2 - LOC. OF BURIED PIPING/STRUCT.**	1d	Tue 5/27/97	Tue 5/27/97
22				
23	**TASK 3 - FIELD INVESTIGATION**	13d	Mon 6/2/97	Sat 6/14/97
24	0310 - Test Pit Excavation	5d	Mon 6/2/97	Fri 6/6/97
25	0320 - Shoreline Sediment Sampling	1d	Tue 6/10/97	Tue 6/10/97
26	0330 - Soil Borings & Monit Wells Install.	3d	Tue 6/3/97	Thu 6/5/97
27	0340 - Groundwater Sampling	6d	Mon 6/9/97	Sat 6/14/97
28	0350 - Storm Sewer Outfall Sampling	1d	Wed 6/11/97	Wed 6/11/97
29	0360 - Location Survey	1d	Mon 6/9/97	Mon 6/9/97
30				
31	**IDW HANDLING & DISPOSAL**	40d	Fri 6/6/97	Tue 7/15/97

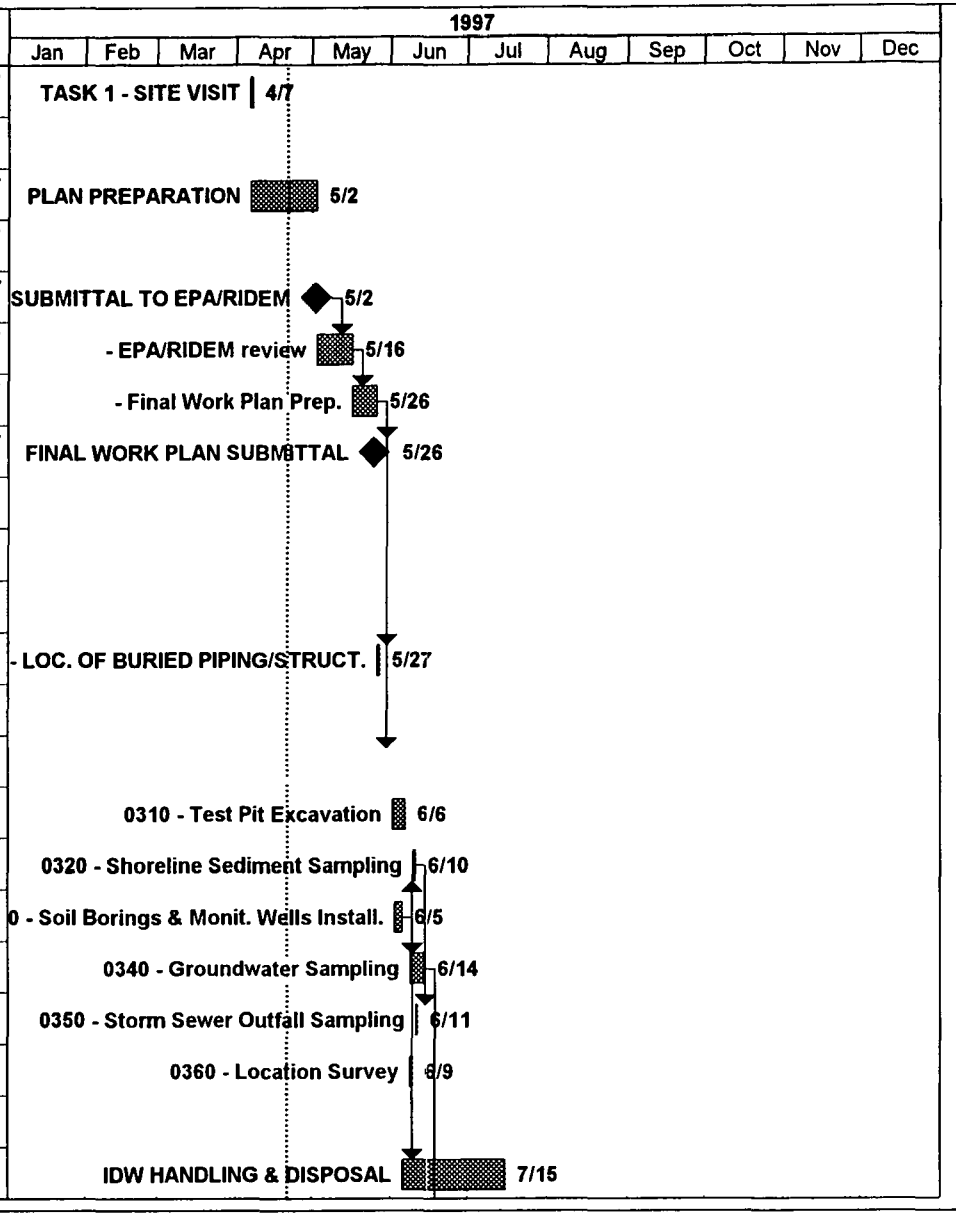


FIGURE 1 - 5
SOURCE REMOVAL EVALUATION TENTATIVE SCHEDULE
OFFTA - SITE 09

ID	Task Name	Duration	Start	Finish
32				
33	**LABORATORY ANALYSES**	21d	Mon 6/16/97	Sun 7/6/97
34				
35	**DATA VALIDATION**	19d	Mon 7/7/97	Fri 7/25/97
36	- Data Validation	19d	Mon 7/7/97	Fri 7/25/97
37				
38	**DATA EVALUATION**	14d	Sat 7/26/97	Fri 8/8/97
39	- prelim draft letter report to Navy	***0d***	***Sat 7/26/97***	***Sat 7/26/97***
40	- Navy review/comments	5d	Mon 7/28/97	Fri 8/1/97
41	- revise letter report	7d	Sat 8/2/97	Fri 8/8/97
42				
43	***ISSUE LETTER REPORT TO EPA & RIDEM***	***0d***	***Fri 8/8/97***	***Fri 8/8/97***
44				
45	**MEETING TO DISCUSS RESULTS (actual date**	1d	Wed 8/13/97	Wed 8/13/97
46				
47	**INTERNAL DR EE/CA PREP. (based on meeting**	20d	Wed 8/13/97	Mon 9/1/97
48	- prep & issue int EE/CA report to Navy	20d	Wed 8/13/97	Mon 9/1/97
49				
50	***ISSUE DRAFT EE/CA to EPA/RIDEM***	***0d***	***Mon 9/1/97***	***Mon 9/1/97***
51	- EPA/RIDEM comments	14d	Tue 9/2/97	Mon 9/15/97
52	- response to comments	7d	Tue 9/16/97	Mon 9/22/97
53	- issue final EE/CA	14d	Tue 9/23/97	Mon 10/6/97

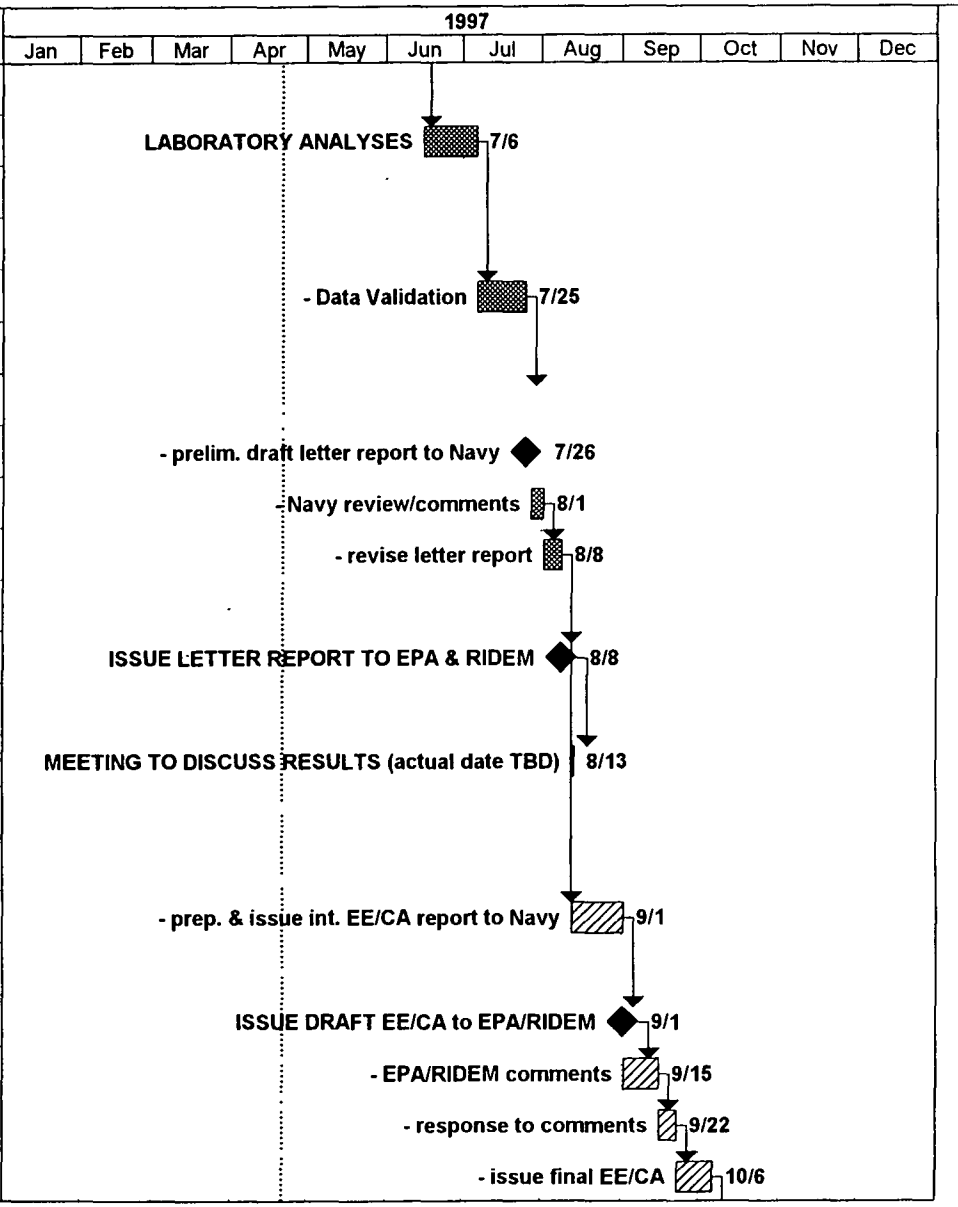
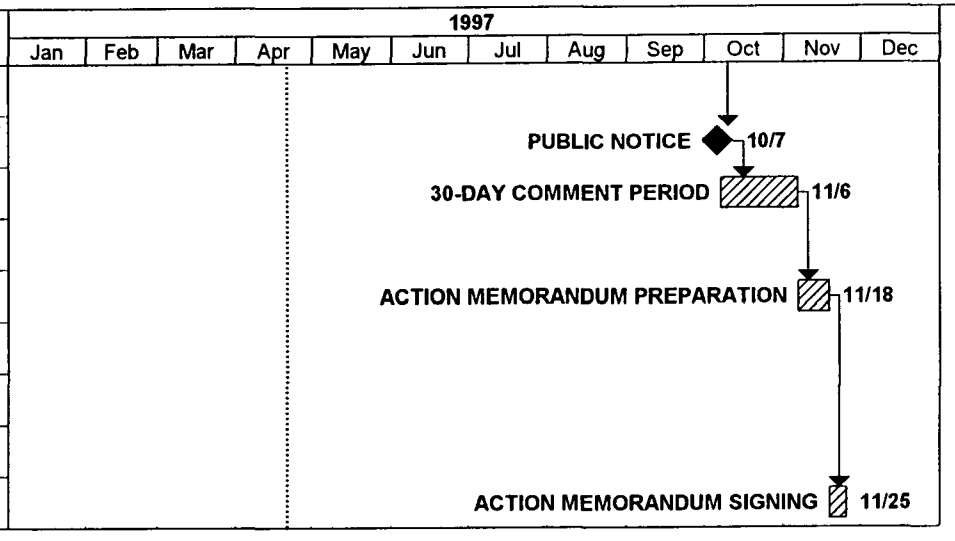
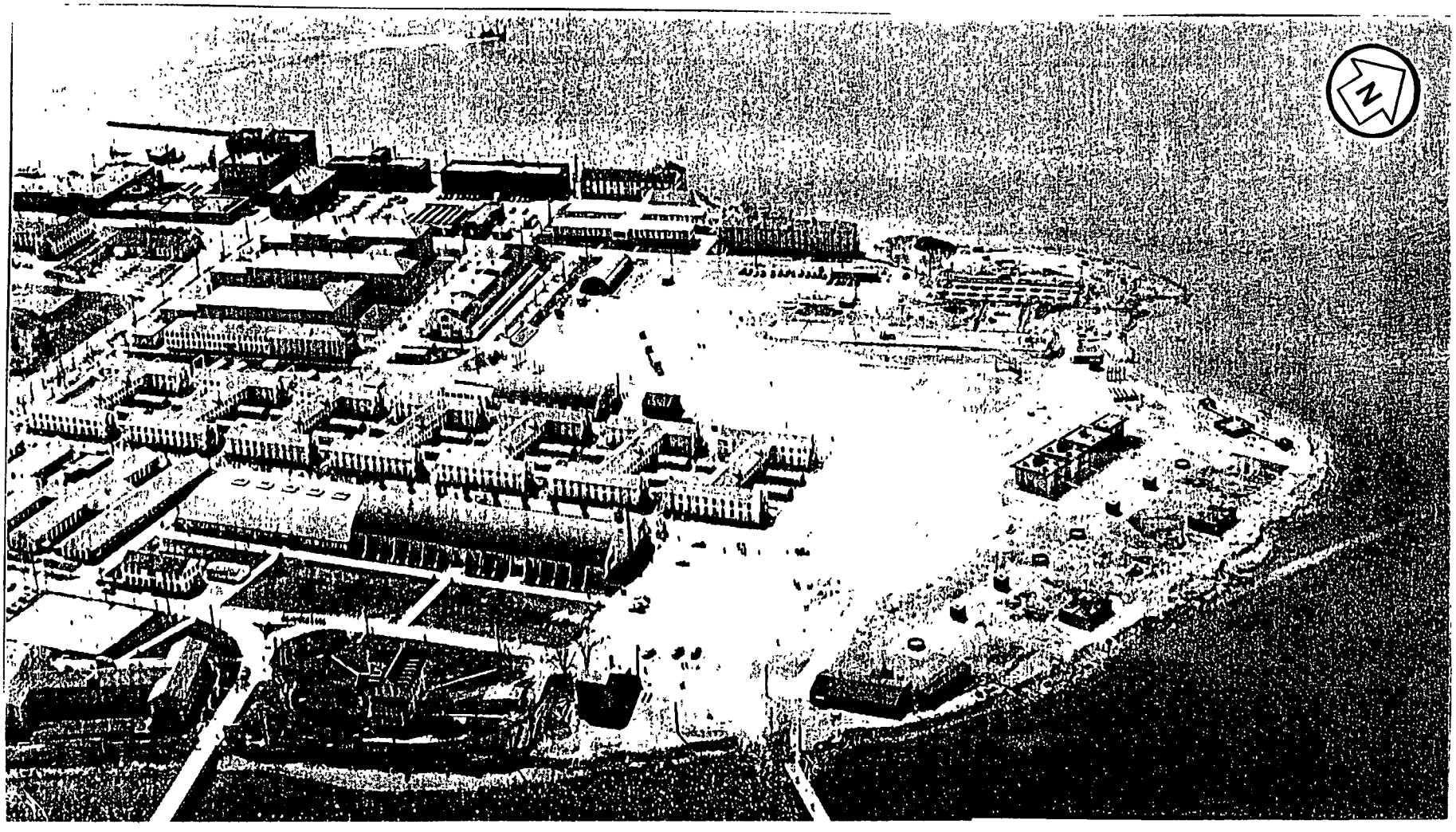


FIGURE 1 - 5
SOURCE REMOVAL EVALUATION TENTATIVE SCHEDULE
OFFTA - SITE 09

ID	Task Name	Duration	Start	Finish
54				
55	***PUBLIC NOTICE***	***1d***	***Tue 10/7/97***	***Tue 10/7/97***
56	***30-DAY COMMENT PERIOD***	30d	Wed 10/8/97	Thu 11/6/97
57				
58	**ACTION MEMORANDUM PREPARATION**	12d	Fri 11/7/97	Tue 11/18/97
59				
60	**MEETINGS**	196d	Sat 5/3/97	Fri 11/14/97
64				
65	***ACTION MEMORANDUM SIGNING***	7d	Wed 11/19/97	Tue 11/25/97



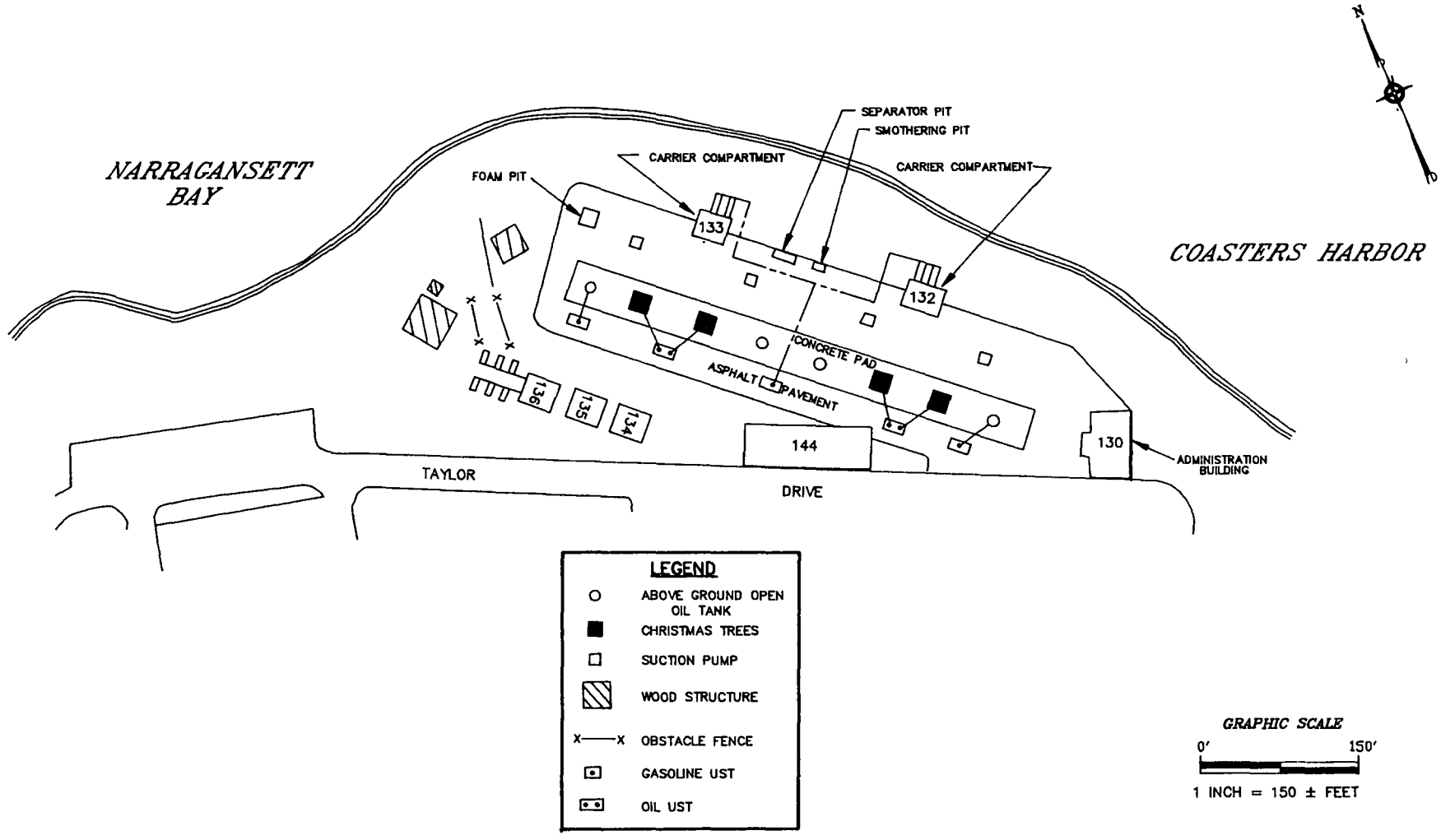


SOURCE: DRAFT FINAL REMEDIAL INVESTIGATION REPORT
TRC ENVIRONMENTAL CORPORATION - AUGUST 1994

LOCAL NEG. NO. QUON.X. 5980,
ALTITUDE = 800', LENS = 10'

COASTERS HARBOR ISLAND – MAY 1, 1944 AERIAL PHOTGRAPH			FIGURE 2–1
SITE 09 – OLD FIRE FIGHTING TRAINING AREA			
NAVAL EDUCATION AND TRAINING CENTER – NEWPORT, RHODE ISLAND			
DRAWN BY:	D.W. MACDOUGALL	REV..	0
CHECKED BY:	LC	DATE:	APRIL 1997
SCALE		FILE NO.:	F:\CADD\FIREFITE\FIG2–1.DWG

Brown & Root Environmental
A Division of Halliburton NUS Corporation
55 Jonspin Road Wilmington, MA 01887
(508)658–7899



SOURCES: DRAFT FINAL REMEDIAL INVESTIGATION REPORT
TRC ENVIRONMENTAL CORPORATION - AUGUST 1994

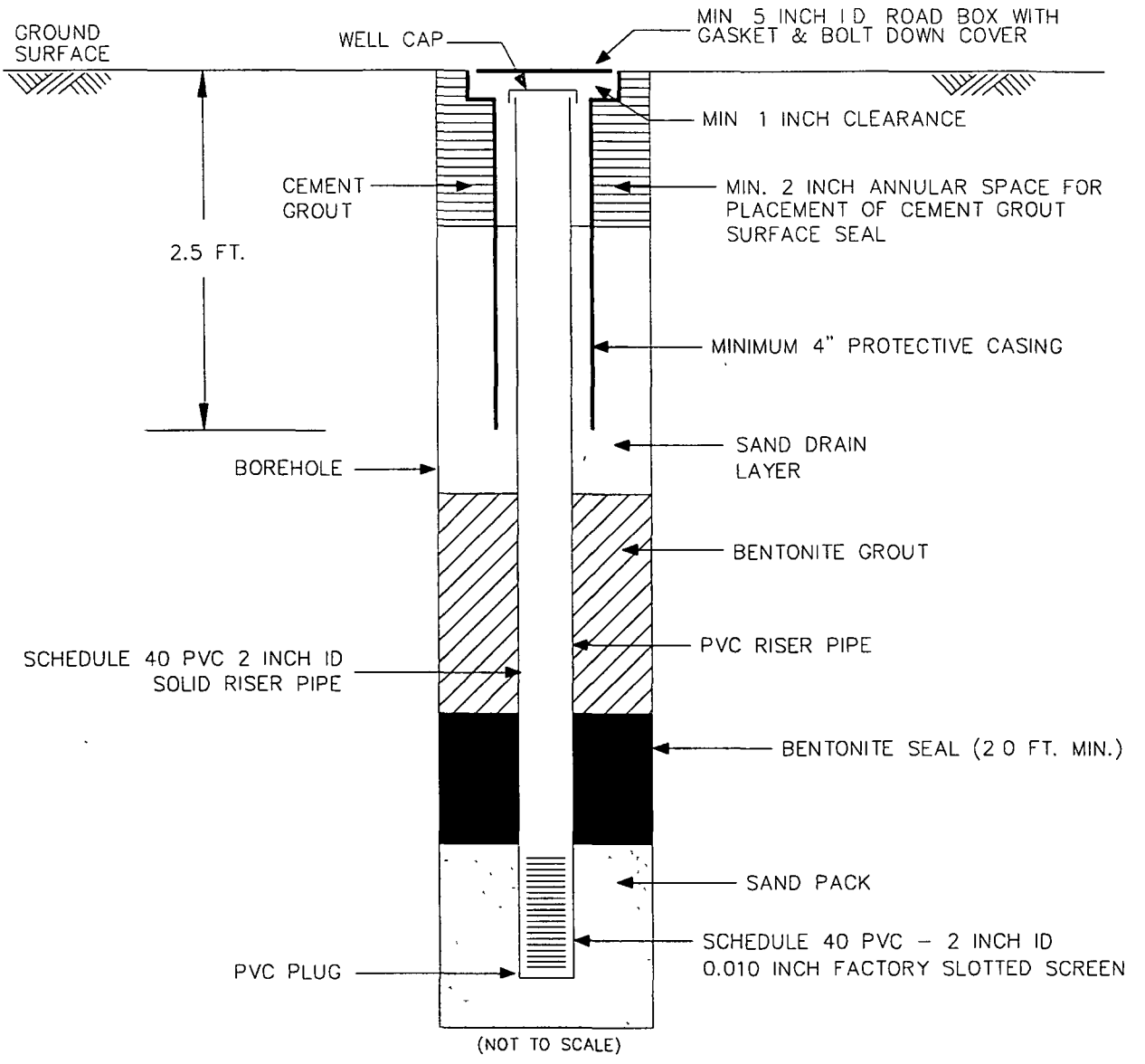
STEAM & RETURN FUEL OIL, DRAWING NO. 637871

NOTES:

1. ALL LOCATIONS ARE APPROXIMATIONS BASED ON AVAILABLE PLANS.

FORMER SITE FEATURES AT OFFTA – SITE 09			FIGURE 3-1
SITE 09 – OLD FIRE FIGHTING AREA			
NAVAL EDUCATION AND TRAINING CENTER – NEWPORT, RI			
DRAWN BY:	R.G. DEWSNAP	REV.:	0
CHECKED BY:	L. CHU	DATE:	MAY 1997
SCALE:	1" = 150'	FILE NO.:	DWG\NETC\FIREFITE\FIG3-1.DWG

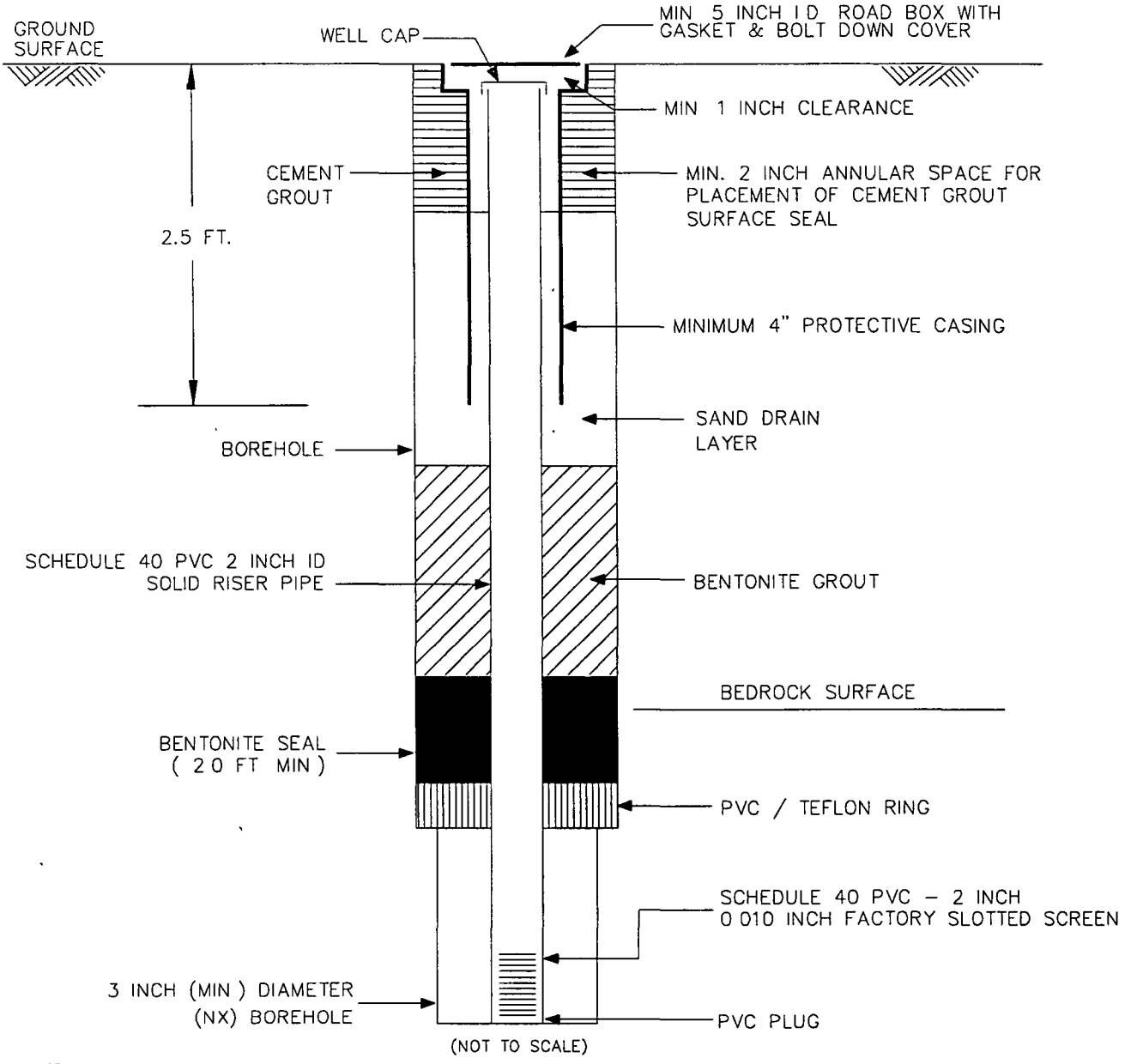
Brown & Root Environmental
A Division of Halliburton NUS Corporation
55 Jonspin Road Wilmington, MA 01887
(508)658-7899



NOTE:

The diameter of the Protective Road Box shall allow for the uniform placement of a minimum of 2 0 inches of cement grout around the casing
The inside diameter shall be of sufficient size to allow easy removal of the PVC cap This may require that the upper five feet of some borings have a diameter larger than the specified minimum

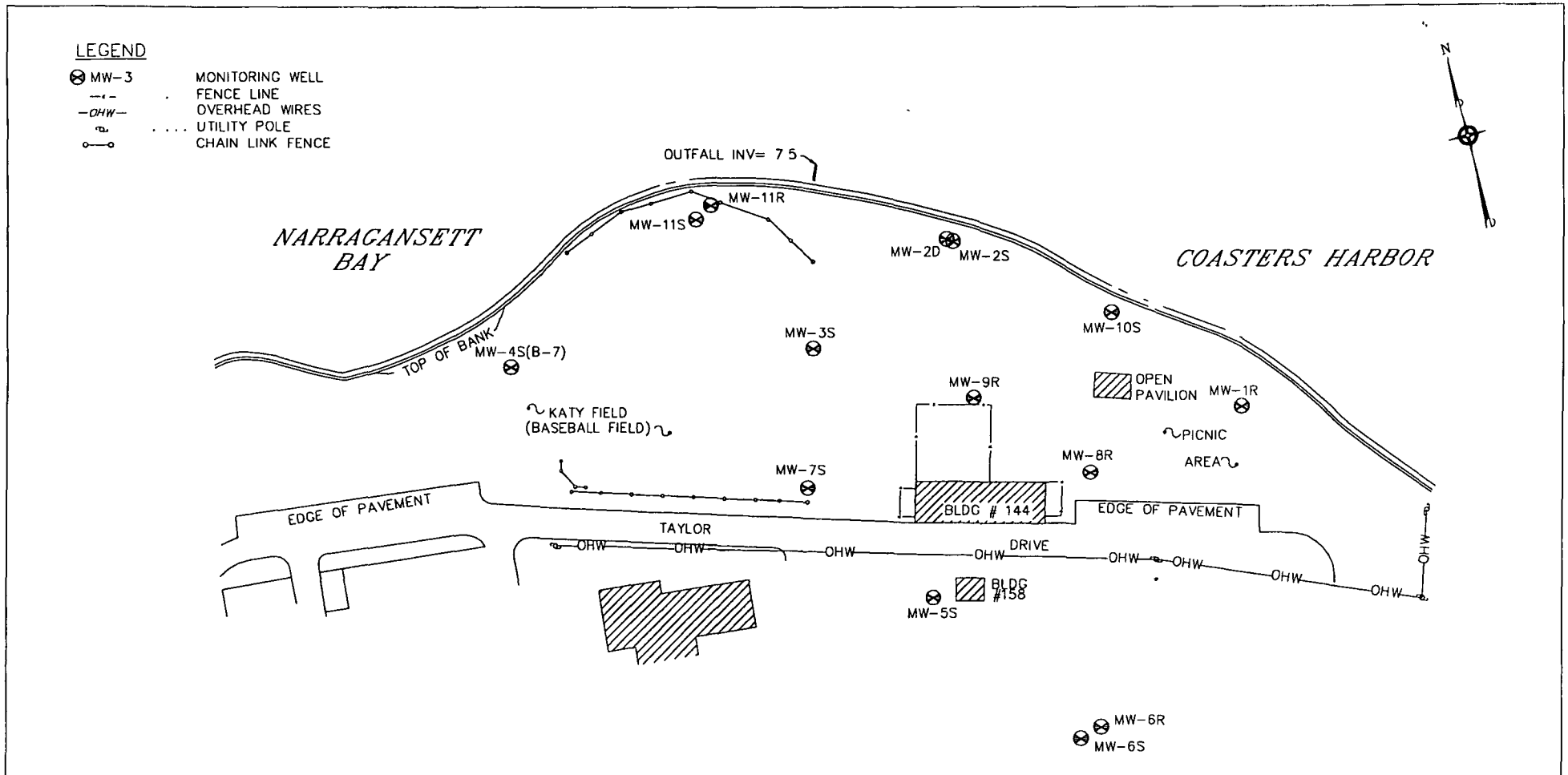
OVERBURDEN WELL CONSTRUCTION DETAILS			FIGURE 3–2
OLD FIRE FIGHTING AREA			Brown & Root Environmental
NAVAL EDUCATION AND TRAINING CENTER – NEWPORT, RHODE ISLAND			A Division of Halliburton NUS Corporation
DRAWN BY	D W MACDOUGALL	REV 0	55 Jonspin Road Wilmington, MA 01887
CHECKED BY	L CHU	DATE 01 MAY 97	(508)658–7899
SCALE	NONE	ACAD NAME: F \CADD\FIREFITE\FIG3–2 DWG	



NOTE:

The diameter of the Protective Road Box shall allow for the uniform placement of a minimum of 2.0 inches of cement grout around the casing
The inside diameter shall be of sufficient size to allow easy removal of the PVC cap This may require that the upper five feet of some borings have a diameter larger than the specified minimum

BEDROCK WELL CONSTRUCTION DETAILS			FIGURE 3–3
OLD FIRE FIGHTING TRAINING AREA			Brown & Root Environmental A Division of Halliburton NUS Corporation 55 Jonspin Road Wilmington, MA 01887 (508)658–7899
NAVAL EDUCATION AND TRAINING CENTER – NEWPORT, RHODE ISLAND			
DRAWN BY	D W MACDOUGALL	REV 0	
CHECKED BY	L CHU	DATE 01 MAY 97	
SCALE	NONE	ACAD NAME F \CADD\FIREFITE\FIG3-3 DWG	



SOURCE DRAFT FINAL REMEDIAL INVESTIGATION REPORT
TRC ENVIRONMENTAL CORPORATION - AUGUST 1994

GRAPHIC SCALE
0' 150'
1 INCH = 150 FEET

CURRENT MONITORING WELL LOCATIONS			FIGURE 3-4
SITE 09 - OLD FIRE FIGHTING AREA			
NAVAL EDUCATION AND TRAINING CENTER - NEWPORT, RI			Brown & Root Environmental
DRAWN BY	D W MACDOUGALL	REV 0	A Division of Halliburton NUS Corporation
CHECKED BY	L CHU	DATE MAY 1997	55 Jonspin Road Wilmington, MA 01887
SCALE	1" = 150'	FILE NO. F \CADD\FIREFITE\FIG3-4 DWG	(508)658-7899

Health and Safety Plan

Old Fire Fighting Training Area
Source Removal Evaluation For Site 09
Newport, Rhode Island

Northern Division
Naval Facilities Engineering Command
Contract Number N62472-90-D-1298
Contract Task Order 0288

May 1997

W5297147D

HEALTH AND SAFETY PLAN

SOURCE REMOVAL EVALUATION FOR SITE 09
OLD FIRE FIGHTING TRAINING AREA
NEWPORT, RHODE ISLAND

COMPREHENSIVE LONG-TERM
ENVIRONMENTAL ACTION NAVY (CLEAN) CONTRACT

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

Submitted by:
Brown & Root Environmental
600 Clark Avenue, Suite 3
King of Prussia, Pennsylvania 19406

Contract No. N62472-90-D-1298
Contract Task Order No. 0288

May 1997

SUBMITTED BY:

JANET A. PILLION
HEALTH AND SAFETY OFFICER

APPROVED BY:

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PROJECT MANAGER
BROWN & ROOT ENVIRONMENTAL
WILMINGTON, MASSACHUSETTS

MATTHEW SOLTIS, CSP, CIH
HEALTH AND SAFETY MANAGER
BROWN & ROOT ENVIRONMENTAL
KING OF PRUSSIA, PENNSYLVANIA

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NEWPORT, RHODE ISLAND

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1.0 INTRODUCTION

This Health and Safety Plan (HASP) was prepared to provide safe procedures and practices for Brown & Root (B&R) Environmental and subcontractor personnel engaged in Source Removal Evaluation for Site 09, the Old Fire Fighting Training Area, located at the U.S. Naval Education and Training Center (NETC) in Newport, Rhode Island.

This plan has been developed to conform to the requirements of 29 CFR OSHA Standard 1910.120 (Hazardous Waste Operations and Emergency Response), and guidance set forth in the CLEAN Health and Safety Management Plan (HSMP) developed by B&R Environmental and is based on the available information concerning possible contaminants and physical hazards that may exist on the site.

As more data concerning the nature and/or concentrations of contaminants becomes available, the HASP will be modified accordingly. Modifications will be determined by the Health and Safety Officer (HSO). They will be communicated via task specific health and safety plans obtained by field personnel prior to each new site visit.

All activities covered by this HASP must be conducted in complete compliance with this HASP and with all applicable federal, state, and local health and safety regulations.

Subcontractors performing work onsite will be required to comply with the minimum requirements of this plan. Each subcontractor employee performing work at the site must complete a copy of the HASP review form (Attachment A) indicating that the individual has read, understands, and will comply with the HASP.

1.1 KEY PERSONNEL/RESPONSIBILITIES

The B&R Environmental Project Manager (PM) is responsible for the overall direction and implementation of the project tasks and is, therefore, ultimately responsible for the implementation of this HASP. Specifically, the PM is responsible for collecting the training and medical documentation and HASP review form(s) from the B&R Environmental field team and subcontractors and forwarding these documents to the HSO or CHSM.

The CLEAN Health and Safety Manager (CHSM) and the HSO are responsible for oversight of health and safety issues in conjunction with this project. The CHSM must approve any modifications to this HASP after finalization.

On-site health and safety issues will be delegated to the Site Safety Officer (SSO). This individual will be responsible for day to day implementation of the HASP and its requirements. As a part of this role, the SSO is responsible for assisting the CHSM and HSO in ensuring compliance with the Health and Safety requirements and guidelines and to provide technical expertise for this project. The SSO has the authority to stop all work where imminent danger is perceived and is responsible for initiating emergency response and coordinating site evacuation when necessary.

The B&R Environmental Field Operations Leader (FOL) is responsible for the day to day operations at the site, and shall support the SSO in implementation of this HASP.

Any personnel performing work at the Site must be approved by the B&R Environmental PM and the CHSM or the HSO prior to the commencement of field activities.

Site Name:	Site 09 - Old Fire Fighting Training Area
Address:	Northern End of Coasters Harbor Island, NETC-Newport, RI
Site C ntact:	Brad Wheeler
	Department of Defense, United States Navy
Phone No.:	(401) 841-3735 or 6375
Purpose of Fieldwork:	To determine the need and establish the basis for a removal action of contaminant sources at the site.
Prop sed Date of Work:	May 1997 - July 1997

PERSONNEL ASSIGNMENTS

B&R Environmental Personnel	Assignment
John Trepanowski	CLEAN Program Manager
Liyang Chu	Project Manager
Matthew Soltis	CLEAN HSM
TBD	Field Operations Leader (FOL)
Janet Pillion	Health & Safety Officer (HSO)
TBD	SSO/Tech. Staff

Non-B&R Environmental Personnel	Purpose
TBD	Drilling Subcontractor
TBD	Excavation Subcontractor
TBD	Surveying Subcontractor

MODIFICATION OF THIS HASP IN THE FIELD MUST BE APPROVED BY THE CHSM OR THE HSO

2.0 SITE BACKGROUND

Site 09 is located in the southern portion of NETC Newport, at the northern end of Coasters Harbor Island (Figure 2-1). Reportedly, this 5.5 acre site was used from approximately World War II until 1972 as a fire fighting training area. From pre-construction drawings (c. 1943) and a 1944 aerial photograph, approximately 69,000 sq ft of the site was used for actual fire fighting practices. The 1943 plan indicated locations of surface drains and subsurface piping. It is possible that two buildings, labeled "Carrier Compartment" served as injection points of oil/water mixtures onto a long concrete pad, and the mixtures were set on fire for fire fighting practice purposes. Runoff of the oil/water mixtures were reportedly routed to the surface drains and into the an oil-water separator. During previous test pitting activities, the presence of some of the underground piping was confirmed.

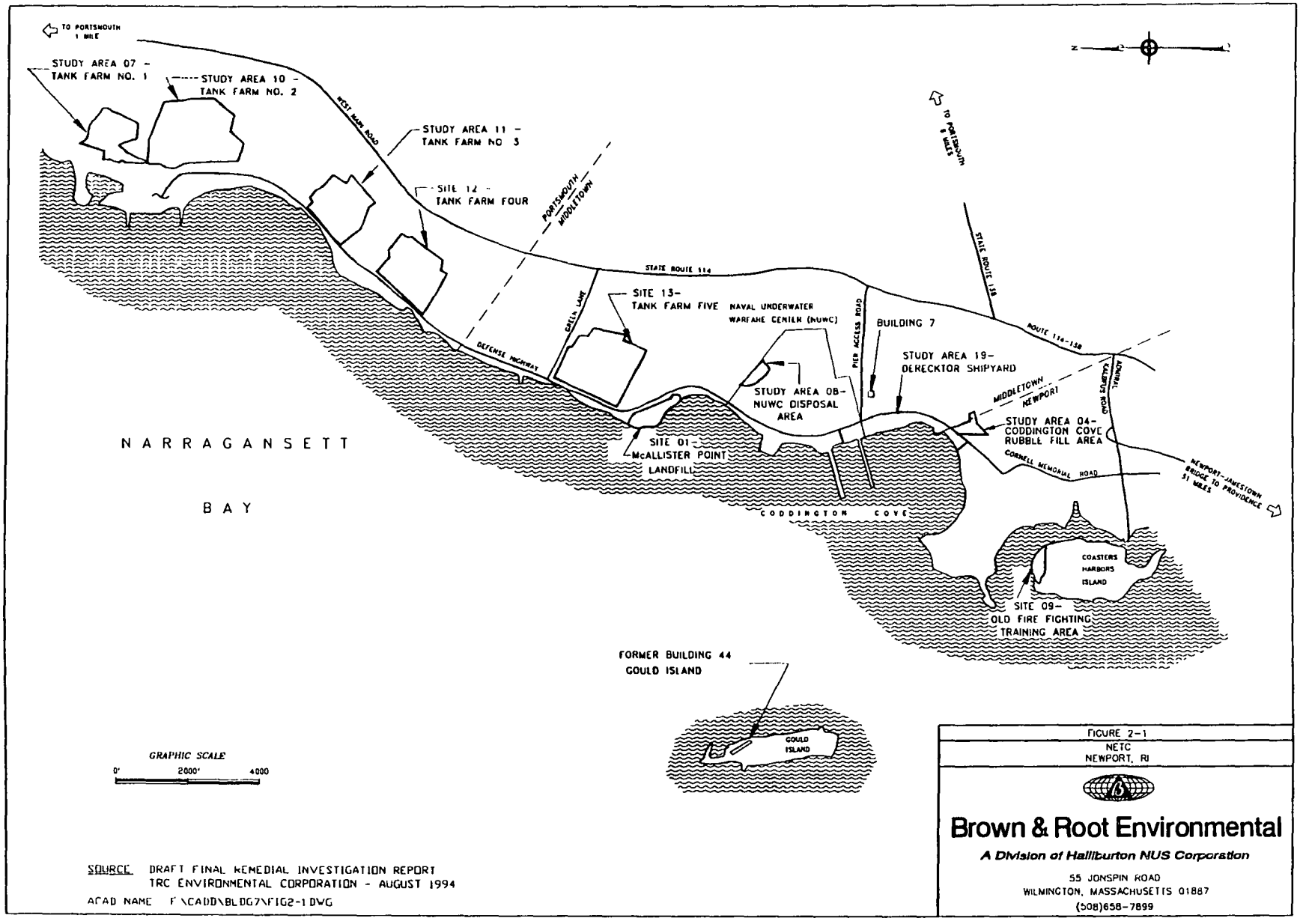
Based on review of a 1975 aerial photograph, most of the structures and facilities associated with fire fighting (except Building 144 and the "hose house") had been removed at that time.

Approximately 1,300 lineal feet of the northern edge of Site 09 abuts Coasters Harbor. The shoreline varies from east to west. The eastern shoreline consists of concrete slabs, cobble- and larger-sized shale fragments, brick debris, pea-sized gravel, and degraded asphalt fragments. Towards the western portion, concrete and brick-like debris are less evident. A 24-in diameter storm drain is located at the mid-point of Site 9's shoreline.

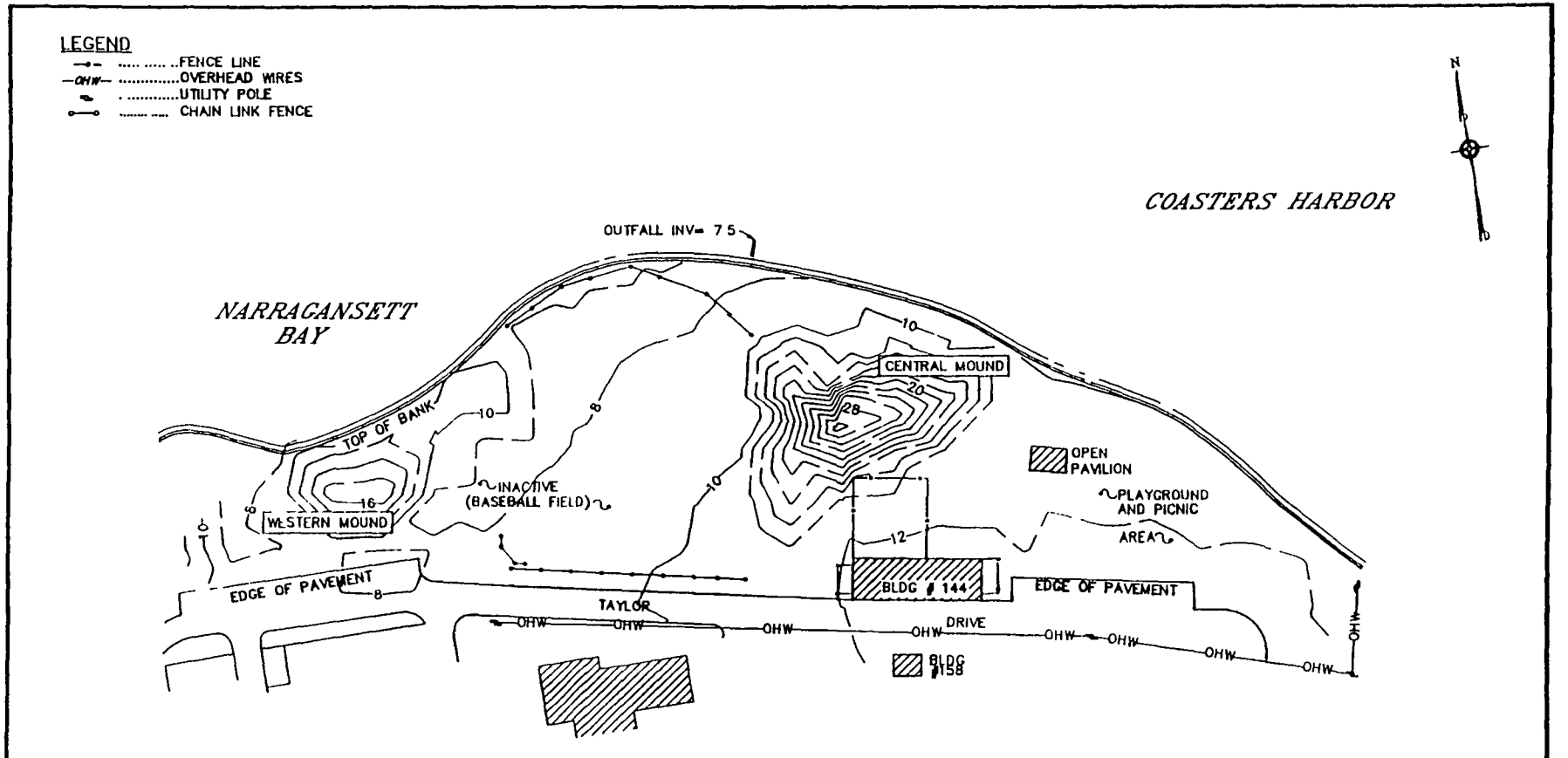
Currently, Site 09, the Old Fire Fighting Training Area (OFFTA) is primarily used for recreational activities and contains: a picnic area with an open-air pavilion, a playground, a baseball field, and Building 144 (locked and unused). The site is vegetated with grass, with the exception of the baseball field, asphalt paved areas, and Building 144. The general topographic relief of Site 09 is relatively flat, with ground surface ranging from 8 - 12 feet above Mean Low Water. Two mounds situated onsite were apparently created from the debris generated by the demolition of a training building and some asphalt pavement. The mounds were covered with top soil and provide topographic high points in the current recreational area. Figure 2-2 depicts the current OFFTA features.

A 1983 report concluded that further site investigations were not warranted since waste oils used for training were no longer present, that the site had been extensively excavated, and that there were no reports of environmental problems resulting from past operations. In 1987, oily subsurface soils were encountered during a geotechnical program related to the expansion of building 144. To date, a two-phase Remedial Investigation has been completed for Site 9 and a draft Feasibility Study has been prepared.

For more information, refer to the B&R Environmental Field Sampling Plan, dated May, 1997.


TO PORTSMOUTH 1 MILE
STUDY AREA 07 - TANK FARM NO. 1
STUDY AREA 10 - TANK FARM NO. 2
WEST MAIN ROAD
STUDY AREA 11 - TANK FARM NO 3
SITE 12 - TANK FARM FOUR
PORTSMOUTH
MIDDLETOWN
STATE ROUTE 114
TO PORTSMOUTH 8 MILES
STATE ROUTE 138
ROUTE 114-138
SITE 13- TANK FARM FIVE
NAVAL UNDERWATER WARFARE CENTER (NUWC)
PIER ACCESS ROAD
BUILDING 7
STUDY AREA 19- DERECKTOR SHIPYARD
DEFENSE HIGHWAY
STUDY AREA 08- NUWC DISPOSAL AREA
MIDDLETOWN
NEWPORT
STUDY AREA 04- CODDINGTON COVE RUBBLE FILL AREA
ADMIRAL KALBFUS ROAD
CORNELL MEMORIAL ROAD
NEWPORT-JAMESTOWN BRIDGE TO PROVIDENCE 51 MILES
SITE 01- McALLISTER POINT LANDFILL
NARRAGANSETT
BAY
CODDINGTON COVE
COASTERS HARBORS ISLAND
SITE 09- OLD FIRE FIGHTING TRAINING AREA
FORMER BUILDING 44 GOULD ISLAND
GOULD ISLAND
GRAPHIC SCALE
0' 2000' 4000
SOURCE DRAFT FINAL REMEDIAL INVESTIGATION REPORT
TRC ENVIRONMENTAL CORPORATION - AUGUST 1994
ACAD NAME F:\CADD\BLDG7\FIG2-1.DWG
FIGURE 2-1
NETC
NEWPORT, RI
Brown & Root Environmental
A Division of Halliburton NUS Corporation
55 JONSPIN ROAD
WILMINGTON, MASSACHUSETTS 01887
(508)658-7899

DRAFT



SOURCE: DRAFT FINAL REMEDIAL INVESTIGATION REPORT
TRC ENVIRONMENTAL CORPORATION - AUGUST 1994

GRAPHIC SCALE
0' 150'
1 INCH = 150 FEET

ACAD NAME: DWG\NETC\FIREFITE\FIG1-3.DWG

CURRENT SITE FEATURES			FIGURE 2-2
SITE 09 – OLD FIRE FIGHTING AREA			
NAVAL EDUCATION AND TRAINING CENTER – NEWPORT, RI			
DRAWN BY:	D.W. MACDOUGALL	REV.: 0	
CHECKED BY:	L. CHU	DATE: MAY 1997	
SCALE	1" = 150'	FILE NO.: F:\CADD\FIREFITE\FIG1-3F.DWG	

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(508)658-7899

DRAFT

3.0 SCOPE OF WORK

The objective is to determine the need and establish the basis for a removal action of contaminant sources at the OFFTA. Based on previous studies of Site 09, Navy believes that a source removal may be warranted in one or more locations. These sources may include petroleum hydrocarbon-contaminated soils, defunct underground piping or tanks, buried debris, asphaltic materials along the shoreline, and light non-aqueous phase liquids (petroleum hydrocarbons).

For more information refer to the Brown & Root Environmental Field Sampling Plan, dated May 1997.

Field activities will include:

- location of potential buried piping and structures using magnetic line detector,
- test pit excavation,
- subsurface soil sampling,
- drilling and installation of monitoring wells,
- measuring water levels and sampling groundwater,
- storm sewer outfall sampling,
- sediment sampling,
- surveying.

4.0 HAZARD ASSESSMENT

This section presents information regarding known and suspected chemical and physical hazards associated with the activities at the Site. Only those activities anticipated in this HASP are considered in this evaluation. Any additional activities must be communicated to the CHSM/HSO for inclusion into this plan. This evaluation is based solely on the currently available information. As new data comes available, this HASP may need to be modified accordingly.

The types and degree of potential hazards that may be presented to site personnel vary depending on factors such as the task to be performed, the location involved, climatic conditions, etc. The site tasks scheduled to take place in this project can generally be segregated into two categories: intrusive and nonintrusive. The types and degrees of risks recognized in this project are more significant in regard to the intrusive activities (i.e. drilling and excavations) rather than the nonintrusive operations (i.e. site walkovers and surveys).

4.1 CHEMICAL HAZARDS

4.1.1 Product Historically Used Onsite/Stored in the Former USTs:

Gasoline

OSHA PEL:	Not Established
ACGIH TLV:	300 ppm
STEL:	500 ppm
Odor Threshold:	Approximately 0.25 ppm

Gasoline is a clear, mobile liquid with a characteristic odor which can be recognized at approximately 0.25 ppm in air. The 8-hour time weighted average (TWA) for gasoline is 300 ppm. Inhalation causes intense burning of the mucous membranes, throat and respiratory tract; overexposure to vapors can lead to bronchopneumonia. Inhalation of high concentrations can cause fatal pulmonary edema. Repeated or prolonged skin exposure causes dermatitis. It can cause blistering of skin due to its defatting properties. Exposure to eyes can cause hyperemia of the conjunctiva. Ingestion or excessive vapors can cause inebriation, drowsiness, blurred vision, vertigo, confusion, vomiting and cyanosis (2,000 ppm produces mild anesthesia in 30 minutes, higher concentrations are intoxicating in less time).

Fuel Oils

Previous site activities and observations indicate the potential for fuel oil contamination to be present on-site. Fuel oils are considered to be of moderate to low toxicity and are not considered to be carcinogenic by NTP, OSHA, or IARC. Potential routes of entry are inhalation and skin/dermal contact. Fuel oil health hazard data sheets present dermal exposure as the primary route of concern. Federal or recommended airborne exposure limits have not been established for fuel oil vapors; however, the toxic and hazardous ingredients of petroleum hydrocarbons include: benzene, cyclohexane, heptane, methyl cyclohexane, toluene, octane, xylenes, nonane, and hexane. Permissible concentrations include naphtha (100 ppm), Stoddard Solvent (100 ppm), and benzene (1 ppm). Benzene is an OSHA regulated carcinogen. Effects of short-term (acute) overexposure may be indicated by symptoms such as headache, dizziness, blurred vision, drowsiness, dermatitis, difficulty in breathing, irritations of the eyes, nose and throat, and at extremely high concentrations death may occur. Chronic effects of overexposure include: hydrocarbons - nausea, headache, dry, cracked skin, irritation of nose, eye, respiratory system, nausea, lassitude. Effects of long-term (chronic) skin exposure typically result in the development of chronic dermatitis.

Because of the very low vapor pressure of fuel oils and work being conducted in an outdoor environment, overexposure to these vapors is not expected to occur. Dusts from soils that are contaminated with fuel oils may be generated during subsurface activities. Dermal contact is the most likely route of exposure.

Material Safety Data Sheets (MSDS') state that no special respiratory protection is required when working with fuel oils under normal conditions of use and with adequate ventilation. For skin protection, impervious gloves (i.e. viton, nitrile) or clothing is recommended when continuous exposure is expected to prevent repeated or prolonged skin contact.

4.1.2 Summary of Environmental Media Contamination (compiled from previous onsite investigations)

The following is a summary of compounds and elements that have been detected onsite. These contaminants were detected at low concentrations and are not at levels that present a health effect to onsite workers.

Surface Soils

Only very low concentrations of VOCs have been detected at the site.

PAHs were detected in 95% of the surface soil samples. **PAHs** ranged from 44 to 27,010 ug/kg. **Carcinogenic PAHs (CPAHs)** ranged from ND to 14,050 ug/kg. Pesticides were detected in all but one sample.

PCBs were detected at a maximum of 530 ug/kg, well below the RIDEM soil guidance level of 10 mg/kg.

A number of metals were detected and were compared to off-site background locations. Metals exceeding the background range were detected primarily along the shoreline locations. Three samples exceeded the RIDEM's 150 mg/kg lead guidance level (EPA guidance level of 400 mg/kg for residential land use).

Dioxins (as 2,3,7,8-TCDD equivalents) were detected at up to 0.025 ng/g (ug/kg), below the EPA residential action level of 1 ng/g.

Subsurface Soils

VOCs detected included: **chloroethane, methylene chloride, carbon disulfide, 2-butan ne, tetrachloroethene, toluene, ethylbenzene, and xylenes**.

PAHs constituted the "significant" contaminants detected, and ranged from 40 to 25,080 ug/kg. Highest PAH concentrations detected below asphalt layer, and just above the water table. The Remedial Investigation (RI) indicated that soil contamination by petroleum was observed typically at or below the water table based on observations during the soil boring and test pit excavation programs.

Pesticides were detected in subsurface soil samples collected throughout Site 9.

PCBs were only detected in 2 samples: 39 and 190 ug/kg, well below the RIDEM 10 mg/kg action level or the EPA 400 mg/kg guidance value.

Lead in 10 samples exceeded the RIDEM 150 mg/kg guidance level.

Overall, the RI surmised that the most contaminated surface soils were located along the shoreline in the northern portion of the site, while the highest subsurface soils contamination were observed in the central to western portion of the site. A general observation made by the RI was that the soils with the highest SVOC and metal levels were accompanied by the presence of petroleum-like odors and/or staining of the soils.

Groundwater

Two VOCs, **chloroform and carbon disulfide**, detected at less then 2 ug/L, are probably laboratory contaminants.

PAHs and **phthalate esters** were detected in 4 shallow monitoring wells. The highest PAH levels detected at MW-2S and MW-11S (both in northern portion of the site), and had petroleum odor and sheen on the water surface. Phthalates were detected in shallow and deep monitoring wells

Metals from unfiltered samples exceeded either the federal MCLs or the state groundwater quality standards and included: **antimony, arsenic, beryllium, cadmium, chromium, lead and nickel**. Filtered aqueous samples indicated that elevated metals presence was likely the result of high silt content. Background aqueous metals indicate elevated metals presence also.

The RI concluded that past site activities have affected underlying groundwater. Petroleum odors were noted in groundwater purged from several monitoring wells (MW-2S, MW-3S, and MW-11S) located in the central to northern portions of the site.

Storm Water

Low concentrations of **bis(2-ethylhexyl)phthalate (BEHP)** (3 ug/L) and **PAHs** (10 ug/L) were detected in two samples. PAHs were only detected at the outfall, suggesting that sea water may have entrained sediments or asphalt bits and carried these into the storm drain. Trace levels of pesticides were also detected.

Metals detected include: **aluminum, barium, calcium, copper, iron, lead, magnesium, manganese, potassium, sodium, and zinc.**

During sampling, a petroleum sheen and odor was noted at station ST-1, the catch basin to the south of Site 9, but was not noted in the outfall which is subject to tidal influence.

No additional information provided in the RI as to other possible sources that discharge to the pipe, which conveys the storm water (and some contaminants) into Coasters Harbor.

Hazards associated with this investigation include the potential for exposure to site contaminants via inhalation of toxic vapors and/or airborne particulates, dermal contact, and (to a much lesser extent) ingestion.

4.1.3 Other Chemicals

MSDS for decontamination solutions or other chemicals that the field crew may use during the investigation will be available onsite. All containers will be properly labeled in accordance with OSHA's Hazard Communication Standard, 29 CFR 1910.1200 and 1926.59.

The most likely route of exposure for these chemicals is through dermal exposure, although ingestion and eye contact via a potential splash hazard exists.

4.1.4 Chemical Hazard Evaluation of Each Site Task

The tasks presented in the Scope of Work have been grouped as appropriate according to potential hazards associated with them and a hazard evaluation for these work activities is as follows:

Drilling/Soil Sampling/Test Pit Excavation

Drilling, soil sampling, and test pit excavation activities present the highest exposure potentials of this investigation. Exposure concerns include inhalation of contaminant-laden dust and/or volatile organic emissions caused by soil or waste disturbance, and direct skin contact with contaminants. The physical hazards associated with these tasks are addressed in Section 4.2 of this HASP.

Exposure potentials could vary significantly depending on where the drilling or test pit excavation activities are taking place; activities in the petroleum-impacted soils pose the greatest risk of worker exposure. Drillers and other workers in the vicinity of the drill rig are especially at risk to exposure due to their work position proximity to the boreholes, soils, or other potentially contaminated material or media (VOCs & particulates), or during handling of potentially contaminated augers or soil sampling of contaminated media (dermal contact).

Groundwater Sampling/Static Water Level Measurements/Storm Sewer Outfall Sampling/Sediment Sampling

This task presents a moderate to low exposure potential. The primary concern for these tasks is inhalation of volatile organic compounds while obtaining water levels or sampling potentially contaminated waters and dermal contact with contaminated water. These hazards will also vary depending on the sample locations. It is likely that the drilling operations will provide some data regarding the concentrations of contaminants in each well.

Mobilization/Demobilization/Site Walkovers/Magnetic and Topographic Survey

These tasks present a low exposure potential due to the non-intrusive nature of the activity and the fact that site contamination is limited to subsurface soils and groundwater. It is not anticipated that an exposure to contaminant-laden particulates or volatile organic compounds would occur during these tasks. If information collected during site activities indicates the potential for exposure then these tasks will be reevaluated.

4.1.5 Control of Chemical Hazards

Exposure to site contaminants will be controlled through the use of the following elements:

- Personal Protective Equipment (PPE) - PPE consisting of protective clothing, and respiratory protection, as necessary, to reduce/eliminate exposure to contaminants. For specific PPE requirements, refer to Section 6.0.

- Air Monitoring - Work area monitoring will be performed with a flame ionization detector (FID) or a photoionization detector (PID) calibrated to respond to the compounds identified previously in this section. The readings detected on the air monitoring instruments will be used to determine the need for respiratory protection during work at the site (refer to Sections 5.0 and 6.0 of this HASP).

- Decontamination Procedures - Personal and equipment decontamination procedures were established to reduce/eliminate personnel exposure to site contaminants and to control the migration of contamination from dirty to clean areas. Specific decontamination requirements are outlined in Section 8.0.

- Safe Work Practices - Safe work practices, such as those found in Section 4.2.1 and 7.2, will be followed to aid in the efforts to reduce exposure or injuries.

4.2 PHYSICAL HAZARDS

Physical hazards are also a serious concern to site personnel involved with field activities. These may be intrinsic to the nature of the operation being performed, or the result of factors such as the work location or schedule. These potential risks include the following:

- Excavating/Test Pitting
- Rotating tools/augers of the drill rig
- Contact with overhead energized sources
- Contact with subsurface/energized utilities during subsurface operations.
- Exposure to moving machinery - struck by/caught between hazards (e.g. point of operation areas, nip points, etc.).
- Noise in excess of 85 dBA.
- Uneven or unstable terrain - could cause slip/trip/fall type hazards.
- Hazards associated with working around heavy equipment/vehicles
- Strain or muscle pulls from manual lifting.
- Heat/Cold stress.
- Inclement weather
- Natural hazards (e.g. snakes, ticks, mosquitoes, poisonous plants, etc.).
- Overhead/eye hazards

4.2.1 Control of Physical Hazards

Control efforts for these physical hazards include the following:

Excavations/Test Pitting - Excavations pose a physical hazard to workers. Fatalities resulting from poor trenching/excavating practices occur regularly in the work place. All excavation work will comply with the requirements given in 29 CFR 1926 Subpart P

- No entry into excavations will be permitted unless adequately protected as specified in 29 CFR 1926 Subpart P.
- No entry into excavations that are a permit-required confined space (as defined in 29 CFR 1910.146) will be conducted.
- Excavations greater than 4 feet will be securely shored or the walls will be bench-cut or sloped at an angle well below the angle of repose of the surrounding soils but not less than one and one-half horizontal to one vertical (34° measured from the horizontal).
- Personnel may not approach a test pit closer than 2 feet from the edge and spoils will be stored at least 2 feet from the edge of an excavation. Unstable pits must be sloped at the side to prevent cave-in.
- The SSO shall frequently inspect test pits for slide or cave-in potential.
- Personnel must not lean over excavations.
- Open pits must be staffed by site personnel at all times. No open excavation will be left unattended unless properly barricaded.
- Restrict the excavation work area to authorized personnel only.
- Water will not be allowed to accumulate in an excavation.
- Vibration sources or heavy objects will not be situated on the edge of an excavation unless measures are taken to ensure the stability of the wall.

- All personnel must stand upwind of the test pits and away from the reach of the backhoe, tires, and outriggers.

- The backhoe operator must be instructed not to undermine the excavation.

- All work areas must be kept free of ground clutter.

Rotating Tools/Augers - Entanglement within the rotating tools/augers of the drill rig can occur anytime a worker or their clothing contacts the moving machinery. This hazard can result in a worker being fatally crushed and/or dismembered. To address this hazard, a thorough inspection of all equipment will be performed to remove or guard potential snag points. Also, efforts will be taken to ensure that emergency stop devices operate properly, and that all members of the field team know the location and operation of these devices. Persons working in close proximity to or in the operation of the drill rig, shall be required to secure all loose clothing or protective equipment to avoid possible entanglement.

Overhead Energized Sources - Overhead utility wires (i.e. electrical and telephone) can be hazardous when any projecting items extend to a height within close proximity of overhead lines.

- Overhead utilities should be considered "live" until determined otherwise.

- No projecting items shall be erected within 20 feet of an overhead/electrical line until the line is deenergized, grounded, or shielded and an electrician has certified that arcing cannot occur.

Contact with Subsurface Utilities/Energized Sources

A DIGSAFE permit number shall be obtained prior to any subsurface work, additionally Base Digsafe must also be contacted prior to intrusive site work. Any areas targeted for subsurface activities shall first be investigated to determine the presence of underground utilities and such utilities identified shall be physically marked and avoided. Efforts will be made through local contacts, as-built drawings (where available) along with geophysical surveys to identify potential locations. Positive readings will require the relocation of a borehole.

Exposure to Pinch/Compression Points

Personnel are to be advised of struck by/caught between type hazards related to hand/clothing contact with moving machinery. Protective gear must fit properly and be taped, when applicable, not only to control

chemical exposure, but also to avoid contact with moving machinery. Additionally, equipment shall be shut down and locked out before maintenance functions are performed. All mechanized equipment brought on-site (e.g. drill rigs) to complete this scope of work will be inspected initially prior to the commencement of on-site activities and then periodically thereafter. These inspections will be performed by the SSO and include the following:

- All safety guards are in place
- All safety-restraints (i.e. seatbelts) are in place and functioning properly as required by Federal regulations
- All mobile equipment is equipped with a backup alarm and emergency stop device
- All operators are qualified to do so. All drivers will be required to have their Commercial Drivers License as applicable
- All maintenance performed on the equipment will employ manufacturers recommended parts and be inspected prior to returning to services by the SSO

Heavy Equipment/Vehicles - Operation of, and proximity to, heavy equipment, pose a threat of serious injury to operators and workers; operators of heavy equipment and vehicles typically have decreased visibility and hearing.

- Motor vehicles and material handling equipment shall be in compliance with the OSHA Construction Industry Standards 29 CFR 1926.
- Only qualified/licensed people are to operate heavy equipment.
- Never walk directly in back of, or to the side of, heavy equipment without the operators' knowledge.
- Steel-toe/shank workboots and hardhats shall be worn when working around, or with, heavy equipment.
- Heavy equipment vehicles will have back-up alarms or will only back-up when assisted by a flag person.

- Pedestrians and lighter vehicles will yield to heavy equipment/ vehicles.
- All chains, lines, cables, etc. should be inspected daily for weak spots, frays, etc.
- All high pressure lines should be checked prior to and during use.
- If dusty conditions exist, wet methods will be used to suppress dust. Wetting methods (water truck, etc.) will be used if there are visible dust emissions.

Manual Lifting - Back strain may occur as a result of lifting or handling heavy equipment.

- Back strain may be prevented by employing proper lifting techniques.
- During any manual handling tasks, personnel are to lift with the force of the load supported by their legs and not their backs. The correct number of personnel must be used to lift or handle heavy equipment.

Heat/Cold Stress

Worker overexposure to heat is a recognized potential hazard due to possible ambient temperatures combined with the use of personal protective equipment which can contribute to this threat. Based on the current project schedule, heat stress is not anticipated, however, it will be the responsibility of the FOL, with assistance from the SSO, to determine the need to employ heat stress monitoring techniques and control measures based on observations of site conditions and personnel. Generally, consideration for these efforts are to commence if/when ambient weather conditions involve temperatures in excess of 70 degrees Fahrenheit. Additionally, cold stress is also a recognized potential hazard posed to workers. Refer to Attachment D for recognition, evaluation, and control of these potential hazards.

Buddy System/Site Communication

The activities conducted and equipment utilized during the site work demand competency, coordination, and concentration. To prevent accidents and injuries occurring on-site, and in order to provide rapid assistance to employees in the event of an emergency, implementing the "buddy system" or organizing employees to support "line-of-sight" is required.

The buddy system will be implemented in all work areas where there exists the potential for chemical exposure and work areas proximal to vehicle traffic, heavy equipment and other machinery or equipment that poses a threat of serious injury to on-site workers. Line-of-site or a communication system can be via visual, voice, or regular radio contact and must be maintained at all times.

Natural Hazards

Natural hazards such as poisonous plants, bites from poisonous or disease carrying animals or insects (e.g. snakes, ticks, mosquitoes) cannot be avoided in this type of environment. Within recent years a marked increase in Lyme's Disease has been reported. Ticks have been shown to be the primary vector in the transmission of this disease. In an effort to control this hazard, close attention will be given during operations and decontamination with regard to personal hygiene to detect and remove any ticks from personnel.

Overhead/Eye Hazards

Head protection (hard hats) will be required whenever and wherever potential overhead hazards are recognized, including when in the vicinity of any operating heavy machinery. Eye protection will be required wherever potential eye hazards are identified.

Inclement Weather

Incidents of inclement weather will be evaluated by the FOL, with input from the SSO, in regard to limiting or interrupting site operations. At a minimum, however, site operations will be interrupted in the event of electrical storms and other severe conditions (e.g. torrential rain, high wind, etc.).

Noise Exposure

Elevated sound levels may be generated as a result of activities onsite which may cause hearing damage and/or be a hindrance to communication.

- Hearing protection must be used if noise levels exceed the 8-hour time-weighted average OSHA action level of 85 dBA. As a general rule-of-thumb, hearing protection will be required if personnel standing approximately 2 feet apart cannot converse without raising their voices to be heard.

- The use of hearing protection, either ear muffs or ear plugs, will be used during all noisy field activities (i.e. drilling) to effectively reduce noise levels.

Slip/Trip/Fall/Puncture Hazards - Due to wet, slick, uneven or steep terrain, or cumbersome protective equipment, injury (strained muscles, sprained ligaments, cuts, and/or abrasions) or exposure could result due to a fall or puncture.

- Slipping on wet surfaces can be prevented by wearing boots with good treads and being alert in areas where personnel are walking to decrease the chance of slipping.

- Tripping caused by wearing disposable footwear can be reduced when properly sized disposable boots are selected.

- To reduce potential puncture hazards, steel-toe/shank work boots must be worn.

- All work areas must be kept free of ground clutter.

In General:

- Hardhats shall be worn at all times when working around a drilling and any other heavy equipment, or when the potential for overhead hazards exist.

- Loose clothing and straps shall be secured when working around heavy or high hazard equipment.

- Electrical cords or extension cords shall be protected or guarded from damage (i.e. cuts from other machinery) and be maintained in good condition.

- Eye protection shall be worn where the potential for injury from objects or exposure from chemicals or contaminated media may occur.

- Inclement weather (i.e. lightning, heavy rain) shall be evaluated as a condition to stop work.

4.2.2 Confined Space Entry Operations

Site activities that may require personnel entry into structures, containers or excavations that could be considered to be permit-required confined spaces, as defined by OSHA Standard 1910.146, are not authorized under this HASP. The CHSM must be notified prior to any potential confined space entry operations. An addendum to this HASP will need to be prepared prior to any entry into a permit-required confined space.

5.0 AIR MONITORING

This section presents requirements for the use of real-time air monitoring instruments during site activities involving potential for exposure to site contaminants. It establishes the types of instruments to be used, the frequency of which they are to be used, techniques for their use, action levels for upgrading/downgrading levels of protection, and methods for instrument maintenance and calibration.

5.1 INSTRUMENTS AND USE

Air monitoring using a photoionization detector (PID) or a flame ionization detector (FID) will be conducted onsite in the breathing zone of high risk workers during subsurface explorations and during any other activity deemed necessary to determine the presence or absence of ionizable volatile organic compounds.

The MiniRAE PGM-75 (or equivalent), a PID, equipped with a 10.6 eV lamp, respectively, or the Photovac MicroFID (or equivalent), an FID, will be used to detect the presence or absence of airborne ionizable chemical gases and vapors. The PID/FID will be calibrated and operated as outlined in the B&R Environmental Standard Operating Procedures (SOPs).

In summary, the following air monitoring instruments will be utilized during the following tasks as specified above and in accordance with the action levels specified in Section 5.3:

- Mobilization/Demobilization/Site Walkover/Magnetometry and Topographic Survey - None.
- Test Pit Excavation/Drilling/Well Installation/Soil Sampling - PID/FID monitor.*
- Static Water Level Measurements/Groundwater Sampling/Storm Sewer Outfall Sampling/Sediment Sampling - PID/FID monitor.*

* - Monitoring frequency shall be conducted at the initiation of the activity and periodically every 30 minutes or more frequently if needed as determined by the SSO.

NOTE: It should be realized that contaminated particulates and possibly other contaminants of concern are nondetectable using these types of screening instruments. Therefore, in addition to the use of these screening instruments, emphasis will also be given to visual observations, as these contaminants may present themselves as particulates (or may be bound to particulates). It is also the logic used in selecting respiratory protection as presented in Section 6.0.

5.2 MODIFICATION OF AIR MONITORING REQUIREMENTS

The air monitoring requirements presented in Section 5.1 are based upon the tasks presented in Section 4.1.6 and the assumption that the contaminants presented in Section 4.1 are the only contaminants which pose a reasonable health risk to site workers covered by this HASP. In the event that this assumption is found to be invalid, the requirements will be subject to change.

5.3 ACTION LEVELS

The following action levels will apply to this project:

PID/FID Monitor

0.0 ppm to 5 ppm	Level D*
5 ppm to 25 ppm	Level C*
Greater than 25 ppm	Stop work and contact HSO or CHSM

These action levels are based upon above background concentrations detected in the breathing zone and the assumption that volatile organic compounds typical of petroleum products will be the only air contaminants which pose a reasonable health risk to site workers. In the event that this assumption is suspected to be invalid, the action levels will be modified as appropriate.

* These respiratory protection levels do not downgrade the respiratory protection requirements as presented in Section 6.0.

5.4 INSTRUMENT MAINTENANCE AND CALIBRATION

Air monitoring instruments will be maintained and pre-field calibrated. Field calibration and operational checks will be conducted in accordance with the B&R Environmental SOPs. Field maintenance will consist of daily cleaning of the instruments using a damp towel or rag to wipe off the instrument's outer casing and overnight battery recharging.

5.5 RECORD KEEPING

Instrument calibration notes and readings will be recorded in the respective instrument log. Instrument readings observed during site monitoring activities will be recorded in the field logbook. PID/FID readings above background in the breathing zone must be recorded in the field logbook. This should indicate the date, reading(s) observed, duration of readings, workers potentially affected, and actions taken to reduce exposures.

6.0 PERSONAL PROTECTIVE EQUIPMENT (PPE)

This section presents requirements for the use of personal protective equipment for each of the activities being conducted as defined in Section 3.0 and 4.1 6 of this HASP. This section includes anticipated levels of protection for each of the activities, the criteria used for selecting various levels of protection, and criteria for modifying levels of protection based on personal observations.

6.1 ANTICIPATED LEVELS OF PROTECTION

All work is anticipated to be performed in Level D Protection, as defined in Appendix B of OSHA Standard 29 CFR 1910.120 - "Hazardous Waste Operations and Emergency Response." Where activities overlap, the more protective requirements will be applied.

6.1.1 Mobilization/Demobilization/Site Walkover/Magnetometry and Topographic Survey

Level D Respiratory Protection - (No respiratory protection).

Minimum requirements during these activities include steel-toe/shank work boots, safety glasses, and a hardhat. Leather or cotton work gloves will be worn, as needed, to prevent cuts and abrasions when handling equipment.

6.1.2 Test Pit Excavation/Drilling/Soil Sampling/Well Installation

Level D Respiratory Protection - (No respiratory protection).

Minimum requirements during these activities include hard hat, steel-toe/shank work boots, Tyvek coveralls, disposable boot covers, nitrile, viton, or silvershield gloves over latex/nitrile inner gloves, and hearing protection (to be worn when the potential for noise exposure exists). All loose clothing will be secured. If activities present the potential for Tyvek to become saturated, PVC coveralls will be substituted.

6.1.3 Measuring Static Water Levels/Groundwater Sampling/Storm Sewer Outfall Sampling/Sediment Sampling

Level D Respiratory Protection - (No respiratory protection)

Minimum requirements during these activities include steel-toe/shank work boots, Tyvek coveralls, disposable boot covers, and disposable nitrile gloves, and eye protection/splash goggles. If activities present the potential for Tyvek to become saturated, PVC coveralls will be substituted.

6.2 PPE SELECTION CRITERIA

Respiratory protection (Level C) was not selected for use during intrusive activities as the site contamination is known to be degraded petroleum fuels and other low level contaminant concentrations, and based on the work being performed outdoors. Nitrile/Latex gloves were selected to provide protection against potential contamination that could be encountered and to help reduce dermal absorption and ingestion as a result of incidental hand to mouth contact. Hard hats and work boots were selected to provide protection against some of the physical hazards associated with heavy equipment and disposable boot covers were selected to help minimize the spread of contamination. Tyvek coveralls were selected to minimize the potential for contamination of street clothes and PVC coveralls were selected for use in the event that site activities have the potential to result in the saturation of work clothes and dermal contact. Hearing protection was selected to protect against hearing loss due to working with heavy equipment.

6.3 PPE MODIFICATION CRITERIA

This section presents criteria for upgrading and downgrading chemical protective clothing (CPC) and/or respiratory protection. Where uncertainties arise, the more protective requirement will apply.

6.3.1 CPC Modification Criteria

Tyvek coveralls and boot covers must be worn anytime there is a reasonable potential for contamination of street clothes. Polyvinyl chloride (PVC) coveralls must be worn if there is a reasonable potential for saturation of work clothes.

Nitrile, viton, or silvershield gloves must be worn anytime there is a reasonable potential for contact with site contamination.

6.3.2 Respiratory Protection Modification Criteria

Due to the potential for exposure to possible toxic concentrations, respiratory protection is required for work at the site if monitoring instrument readings indicate the presence of volatile organic compounds in the breathing zones of the workers.

Respiratory protection will be modified, based on the following guidelines utilizing the most stringent guideline applicable. Monitoring instrument readings will be initiated at the source of potential emissions (e.g. borehole or well head) and then to the workers breathing zone if readings are detected at the source.

Level D protection (no respiratory protection) with appropriate dermal protection will be adequate under the following conditions:

- No odors present, no source PID/FID readings above 5 ppm, and no signs/symptoms of overexposure.
- Odors detected, but no source PID/FID readings detected above 5 ppm and no signs/symptoms of overexposure.
- Source PID/FID readings above background but no breathing zone FID readings above 5 ppm.

Level C protection consisting of full face, air-purifying respirators (APR) equipped with GMC-H cartridges (or equivalent) along with appropriate dermal protection will be acceptable under the following conditions:

- Sustained readings above 5 ppm but less than 25 ppm in the breathing zone.
- Greater than 19.5% O_2 content in air but less than 23.5% O_2.

7.0 SITE CONTROL MEASURES

Various site control measures are required to prevent accidental injury due to physical and chemical hazards presented by the work performed. These control measures are described in the following subsections.

7.1 WORK ZONES

Various activities will be undertaken in each of the separate work areas. Each location will involve a separate site set-up. The exclusion zone will be designated as the specific excavation, staged waste or other such work location. During work activities, areas will be designated by the use of ropes, flagging, or cones to control pedestrian traffic and the entrance of unauthorized personnel. Each work location will also contain a personnel decontamination station, as part of the Contamination Reduction Corridor (CRC)

The Support Zone, where the administrative, communications, and other support services are based, will be in a controlled area spatially removed from site contamination.

7.2 SAFE WORKING PROCEDURES

The following minimum safe working procedure must be complied with during the performance of work at the Site:

- Eating, drinking, chewing gum or tobacco, taking medication, and smoking are prohibited where the possibility for the transfer of contamination exists.

- Upon leaving the exclusion zone, hands and face must be thoroughly washed. Any protective outer clothing is to be removed and left at a designated area prior to entering the clean area.

- Contact with potentially contaminated substances must be avoided. Equipment must not be placed on potentially contaminated surfaces.

- All personnel and equipment must be thoroughly decontaminated prior to leaving the site.

- All personnel must review and understand the site-specific Health and Safety Plan prior to commencing work on site.

- All personnel must satisfy training requirements and medical monitoring procedures as specified by OSHA regulations referenced in 29 CFR 1910.120.

- No flames or open fires will be permitted on site.

- All underground utilities must be positively identified and marked prior to subsurface activities.

- Personnel must develop hand signals with the heavy equipment operator.

- A copy of the attached OSHA Job Safety poster must be prominently posted at each work site.

8.0 DECONTAMINATION

All personnel and re-usable equipment which comes into contact with potentially contaminated materials must be decontaminated prior to removal from the site. These decontamination procedures are described in the following subsections.

8.1 PERSONNEL DECONTAMINATION REQUIREMENTS

Exclusion Zone Crew: Prior to leaving the exclusion zone, personnel will briefly remove gross contamination from external clothing using decontamination equipment on hand. These individuals may then return to the contamination reduction zone and a thorough decontamination will be performed.

Support Crew: The support personnel will first assist the exclusion zone personnel through decontamination. The support personnel will then move through similar decontamination steps.

The decontamination of personnel and their protective clothing shall be performed in three stages:

Stage 1 includes removing contamination from reusable protective clothing with a detergent/water solution and soft bristle scrub brushes.

Stage 2 shall include removal of disposable protective clothing and double bagging for disposal. Rubber boots or other PPE that is not disposable will be decontaminated using a detergent/water scrub followed by a water rinse prior to exiting the contamination reduction zone.

Stage 3 shall consist of workers washing hands and face with potable water and soap each time they leave the exclusion zone.

8.2 EQUIPMENT DECONTAMINATION

Monitoring Equipment:

All monitoring equipment may, to the extent possible, be wrapped and sealed in plastic with only the controls, readouts, and intake and exhaust ports open to the atmosphere. The monitoring equipment must be wiped down with a damp rag if they become soiled.

Heavy Equipment

Drilling and excavation equipment and other heavy equipment will be decontaminated by steam cleaning prior to departing the site.

Sampling Equipment

All devices or implements (augers, trowels, bowls, etc.) which actually contact the samples collected for laboratory analysis will be decontaminated after each use in accordance with the following procedure:

- remove gross contamination with potable water
- potable water/liquinox scrub
- rinse with potable water
- rinse with methanol*
- rinse with deionized water, air dry
- wrap with aluminum foil (dull side toward equipment)

* = Use of methanol:
- Must be restricted to well-ventilated areas, such as outdoors - Not in Trailers
- Have MSDS on-hand and all users familiar with the contents
- Butyl rubber (methanol) gloves are recommended
- Requires use of eye/splash protection.

9.0 MEDICAL SURVEILLANCE/TRAINING REQUIREMENTS

9.1 MEDICAL SURVEILLANCE REQUIREMENTS FOR B&R ENVIRONMENTAL PERSONNEL

All B&R Environmental personnel participating in project field activities will have had a physical examination meeting the requirements of B&R Environmental's medical surveillance program and will be medically qualified to perform hazardous waste site work using respiratory protection.

Documentation for medical clearances can be obtained from the B&R Environmental HSO.

9.2 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" (Figure 9-1) must be used to satisfy this requirement providing it is properly completed and signed by a licensed physician.

9.3 TRAINING

9.3.1 Introductory and Refresher Training

Requirements for B&R Environmental Personnel

All B&R Environmental personnel must complete 40 hours of introductory hazardous waste site training prior to performing work at the site. Additionally, B&R Environmental 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. Supervisory training is required of any onsite personnel directly responsible for, or who supervise, employees working onsite.

Documentation of B&R Environmental introductory, refresher and supervisory training can be obtained through the HSO. Copies of certificates or other official documentation will be used to fulfill this requirement.

Requirements for Subcontractors

All B&R Environmental subcontractor personnel must have completed introductory hazardous waste site training or equivalent work experience as defined in OSHA Standard 29 CFR 1910.120(e) and 8 hours of refresher training meeting the requirements of 29 CFR 1910.120(e)(8) prior to performing work at the site. Additionally, supervisory training is required of any onsite personnel directly responsible for, or who supervise, employees working onsite. B&R Environmental subcontractors must certify that each employee has had such training by sending B&R Environmental a letter, on company letterhead, containing the information in the example letter provided as Figure 9-2. Copies of training certificates must also be provided as supporting documentation and will be maintained onsite.

9.3.2 Site-Specific Training

B&R Environmental will provide site-specific training to all B&R Environmental employees and subcontractor personnel who will perform work at this project. This training will only be provided once and personnel who do not attend will not be permitted to perform work at the work area. Site-specific training will include:

- Names of personnel and alternates responsible for site safety and health
- Safety, health and other hazards present on-site
- Use of personal protective equipment
- Work practices to minimize risks from hazards
- Safe use of engineering controls and equipment
- Medical surveillance requirements
- Signs and symptoms of overexposure
- The contents of the health and safety plan, and addendums, if any.
- Review of relevant MSDSs

9.3.3 Site-Specific Training Documentation

B&R Environmental and subcontractor personnel will be required to sign a statement indicating receipt of site-specific training and understanding of site hazards and control measures. Refer to Attachment A for the site-specific training document.

FIGURE 9-1
SUBCONTRACTOR MEDICAL APPROVAL FORM

For employees of

_____
Company Name

Participant Name: _____

Date of Exam: _____

Part A

The above-named individual has:

1. Undergone a physical examination in accordance with OSHA Standard 29 CFR 1910.120, paragraph (f) and found to be medically -

   ( ) qualified to perform work at OFFTA work site
   ( ) not qualified to perform work at OFFTA work site

   and,

2. Undergone a physical examination as per OSHA 29 CFR 1910.134(b)(10) and found to be medically -

   ( ) qualified to wear respiratory protection
   ( ) not qualified to wear respiratory protection

My evaluation has been based on the following information, as provided to me by the employer.

( ) A copy of OSHA Standard 29 CFR 1910.120 and appendices.
( ) A description of the employee's duties as they relate to the employee's exposures.
( ) A list of known/suspected contaminants and their concentrations (if known).
( ) A description of any personal protective equipment used or to be used.
( ) Information from previous medical examinations of the employee which is not readily available to the examining physician.

Part B

I, _____, have examined _____
Physician's Name (print) Participant's Name (print)

and have determined the following information:

FIGURE 9-1
SUBCONTRACTOR MEDICAL APPROVAL FORM
PAGE TWO

1. Results of the medical examination and tests as they pertain to site work (excluding finding or diagnoses unrelated to occupational exposure):

_____
_____
_____
_____
_____

2. Any detected medical conditions which would place the employee at increased risk:

_____
_____
_____
_____
_____

3. Recommended limitations upon the employee's assigned work:

_____
_____
_____
_____
_____

I have informed this participant of the results of this medical examination and any medical conditions which require further examination of treatment.

Based on the information provided to me, and in view of the activities and hazard potentials involved at OFFTA work site, this participant

( ) may ( ) may not

perform his/her assigned task.

FIGURE 9-1
SUBCONTRACTOR MEDICAL APPROVAL FORM
PAGE THREE

Physician's Signature _____

Address _____

Phone Number _____

NOTE: Copies of test results are maintained and available at:

_____

_____
Address

FIGURE 9-2
OSHA TRAINING CERTIFICATION

The following statements must be typed on company letterhead and signed by an officer of the company:

LOGO
XYZ CORPORATION
555 E. 5th Street
Nowheresville, Kansas 55555

Month, day, year

Mr. Liyang Chu
Project Manager
Brown & Root Environmental
55 Jonspin Road
Wilmington, MA 01887

Subject: Hazardous Waste Site Training

Dear Mr. Chu:

The employees listed below have had introductory hazardous waste site training or equivalent work experience as required by 29 CFR 1910.120(e) and those employees listed below who have received their introductory training more than 12 months ago have also received 8 hours of refresher training in accordance with 29 CFR 1910.120 (e)(8). In addition, supervisory training is required of any onsite personnel directly responsible for, or who supervise, employees working onsite.

LIST FULL NAMES OF EMPLOYEES

Should you have any questions, please contact me at (555) 555-5555.

Sincerely,

(Name of Company Officer)

10.0 EMERGENCY RESPONSE PLAN

This emergency response plan has been prepared to accommodate requirements presented in 29 CFR 1910.120. A copy of this Emergency Response Plan must remain on site at all times when work is in progress.

10.1 ANTICIPATED SITE EMERGENCIES

Compliance with this HASP can assist in the prevention of anticipated site emergencies. There are several emergencies which can reasonably be anticipated during the activities at the Site, to include:

- Personal Injury/Illness
- Incipient Stage, non-structural fires
- Unwanted chemical releases/exposures

These emergency situations can easily be recognized by visual observations, worker complaints or through the use of monitoring instruments. A chemical release shall be considered an emergency when it is sufficient to affect unprotected personnel, including site workers and the public.

10.2 PERSONNEL ROLES AND LINES OF AUTHORITY

The SSO or alternate is responsible for initiating and coordinating emergency response actions during emergencies.

The FOL or alternate is responsible for assisting the SSO in notifying the appropriate outside emergency assistance, as needed, in accordance with Figure 10-1. Figure 10-2 depicts directions to the local hospital.

10.3 SAFE DISTANCES AND EVACUATION ROUTES

All support personnel will remain a minimum of 100 feet upwind of all work and sample locations. All approaches to the sampling crews will be made from the upwind direction. The SSO shall continuously monitor prevailing wind direction and advise support or response crews accordingly.

Safe distances for unprotected personnel are to be determined by the FOL/SSO on an emergency specific basis. Considerations shall include wind direction and site topography. The FOL shall post evacuation routes and meeting points, for each work area, at the site command post.

10.4 SITE SECURITY AND CONTROL

All crews will maintain observation of the area where work is being undertaken to assure that no inadvertent exposure to unauthorized and untrained personnel will occur. The contamination reduction and exclusion zones will be clearly marked to exclude unauthorized and unprotected persons from these areas.

A daily visitors log will be maintained to assure that all workers are accounted for during emergency response actions.

10.5 RESPONSE PROCEDURES

The information provided in this subsection is presented as a guideline to assist the FOL and SSO in safe and effective response to anticipated site emergencies. This information is in no way designed to take the place of reasonable decisions based on incident-specific information.

First Priority

Prevent further injury or illness by:

- Protecting response personnel
- Isolating the scene to authorized personnel only
- Rescuing the injured parties
- Notifying Outside Emergency Assistance

Second Priority

Provide first-aid to those persons with life threatening injuries or illnesses.

Third Priority

Alleviate the immediate hazards by:

- Extinguishing incipient stage fires
- Reducing chemical releases

Fourth Priority

Provide first-aid to those persons with non-life threatening injuries or illnesses and further efforts to alleviate the hazard.

Last Priority

Complete an incident report, critique the response and prevent recurrence. All persons with known or suspected chemically related injuries or illnesses shall be immediately examined by a licensed physician. The examining physician may choose to consult with the B&R Environmental medical consultant for additional expertise on occupational injury/illness.

10.6 EMERGENCY EQUIPMENT

This section provides guidelines for maintaining and selecting the appropriate PPE and emergency equipment for response to anticipated site emergencies.

Incipient Stage, Non-structural Fires (Class A or B)

- Class A,B,C Fire Extinguisher.
- Approach from up-wind side.
- No special PPE required unless fire has moved out of its incipient stage to an uncontrolled burn or if upwind approach is not possible. In either of these cases, do not attempt to extinguish the flames.

Personal Injury or Illness

- First-aid kit, eyewash station

10.7 EMERGENCY REPORTING

Emergency reporting functions shall be the responsibility of the FOL. The FOL will become thoroughly familiar with this plan prior to the initiation of any site work activities.

In the event that an emergency incident occurs and offsite response assistance is necessary, the FOL shall contact the appropriate agency(s) presented in Figure 10-1.

FIGURE 10-1

EMERGENCY REFERENCE INFORMATION

AMBULANCE	911
POLICE	911
FIRE DEPARTMENT	911
NEAREST PHONE	Cellular Phone (508) 397-7640 or 7642
*PROJECT MANAGER	Liyang Chu (508) 658-7899
*HSO	Janet Pillion (508) 658-7899
SSO	TBD

EMERGENCY CONTACTS (Medical & Health)

B&R Environmental Consulting Physician:	Health Resources
Office:	(617) 935-8581
CLEAN Health & Safety Manager:	Matthew Soltis, CSP, CIH
Office:	(412) 921-8912

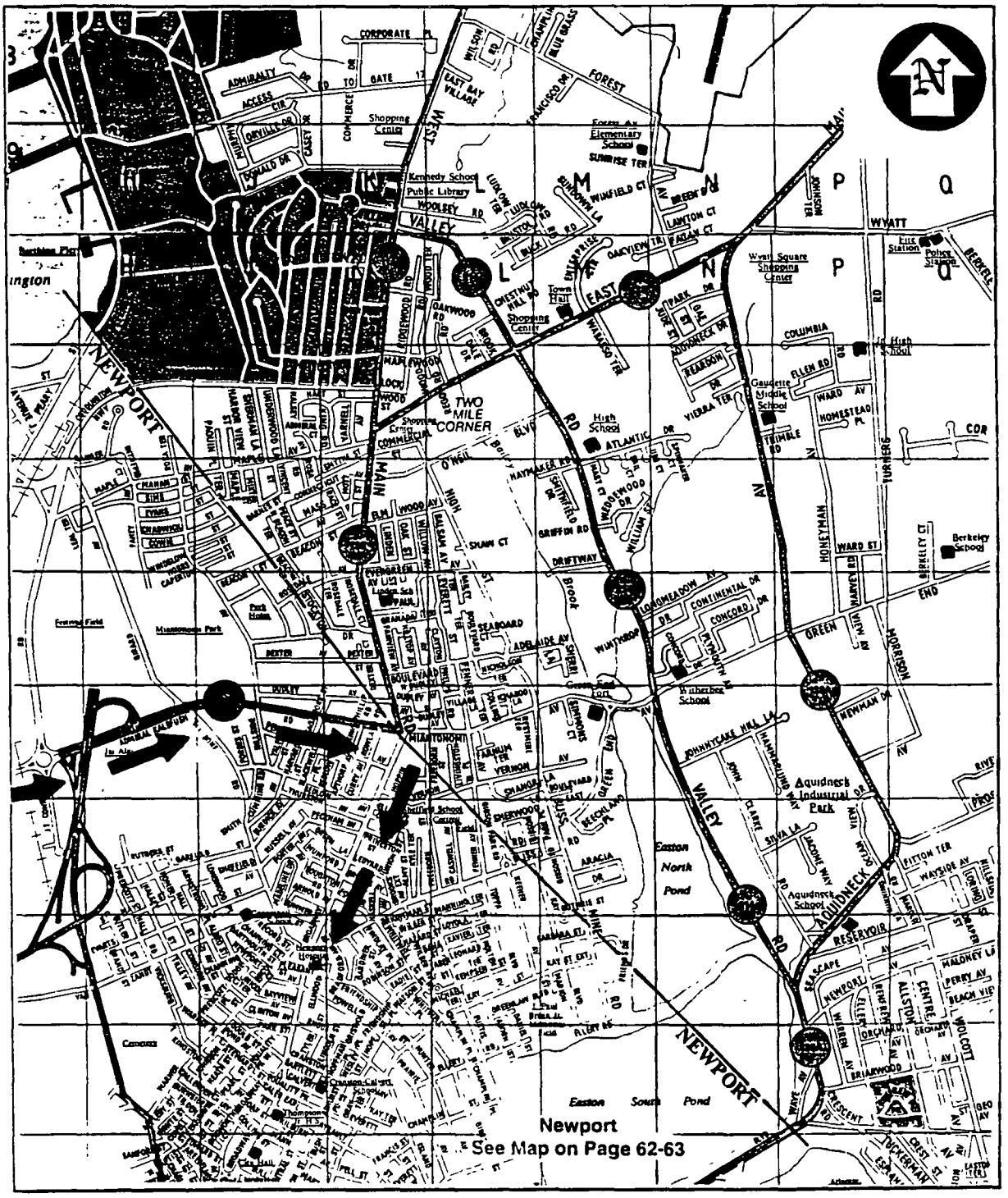
National Response Center (for Environmental Emergency Only): 1-800-424-8802
B&R Environmental Wilmington, MA Office: (508) 658-7899

Directions to Hospital: Newport Hospital
Friendship Street
Newport, RI
(401) 846-6400

From the site take a right onto Admiral Kalbfus Road.

Take a right onto Route 114/138 (South).

The Newport Hospital will be on your left.



NEWPORT HOSPITAL ROUTE MAP

OLD FIRE FIGHTING TRAINING AREA - NETC

NEWPORT, RHODE ISLAND

FIGURE 10-2

Brown & Root Environmental
A Division of Halliburton NUS Corporation
55 Jonspin Road Wilmington, MA 01887
(508)658-7899

11.0 SPILL CONTAINMENT PROCEDURES

It is possible that during handling of the decontamination fluids or other investigative derived wastes, a spill could occur. The fluids will be stored in DOT approved 55-gallon drums during site activities and will remain onsite for disposal by the Navy. The Navy or their contractor will be responsible for spills or leaks during removal and transport.

The procedures defined in this section comprise the spill containment program in place for B&R Environmental activities at the site.

11.1 SPILL CONTROL

- Drums and containers used during site activities shall meet the appropriate DOT, OSHA, and EPA regulations for the wastes that they contain.

- Drums and containers shall be inspected and their integrity assured prior to being moved. Drums or containers that cannot be inspected before being moved because of storage conditions (i.e. buried, stacked behind other drums or several tiers high, etc.) shall be moved to an accessible location and inspected prior to further handling.

- Site operations shall be organized to minimize the amount of drum or container movement.

- Prior to movement of the drums or containers, all employees involved shall be warned of the potential associated hazards.

- Where spills, leaks, or ruptures may occur, adequate quantities of spill containment equipment (absorbent, pillows, etc.) will be stationed in the immediate area. The spill containment program must be sufficient to contain and isolate the entire volume of hazardous substances being handled.

- Drums or containers that cannot be moved due to their integrity, shall be emptied into a sound container.

- Fire extinguishing equipment meeting 29 CFR part 1910, subpart L, shall be on hand and ready if needed.

12.0 OTHER MISCELLANEOUS REQUIREMENTS

Materials and Document

The B&R Environmental FOL shall ensure the following materials/documents are taken to the project site and utilized as required.

- Incident Reports
- Material Safety Data Sheets for decontamination solutions and other substances brought to the site
- Follow-Up Reports (to be completed by the SSO)
- OSHA Job Safety and Health Poster (posted in site trailer)
- Site-specific Training Documentation Form
- First Aid Supply Usage Form
- Emergency Reference Posting

HASP ATTACHMENT A

HASP REVIEW FORM

HASP REVIEW FORM

My signature below indicates that I am aware of the potential hazardous nature of performing activities at OFFTA located in NETC-Newport, RI and that I have reviewed the Health and Safety Plan prepared for the Removal Action/Disposal activities. I have also received site-specific training which included the items presented below:

- Names of Personnel and alternates responsible for site safety and health
- Hazards presented by working at the site
- Use of personal protective equipment
- Work practices to minimize risks from hazards
- Safe use of equipment
- Medical surveillance requirements
- Signs and symptoms of overexposure
- The contents of the Health and Safety Plan and Attachments

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.

Name	Signature	Date

HASP ATTACHMENT B

MATERIAL SAFETY DATA SHEETS

The Field Copy binder of MSDSs will be assigned to the field team and brought into the field.

HASP ATTACHMENT C

OSHA POSTER

JOB SAFETY & HEALTH PROTECTION

The Occupational Safety and Health Act of 1970 provides job safety and health protection for workers by promoting safe and healthful working conditions throughout the Nation. Provisions of the Act include the following:

Employers

All employers must furnish to employees employment and a place of employment free from recognized hazards that are causing or are likely to cause death or serious harm to employees. Employers must comply with occupational safety and health standards issued under the Act.

Employees

Employees must comply with all occupational safety and health standards, rules, regulations and orders issued under the Act that apply to their own actions and conduct on the job.

The Occupational Safety and Health Administration (OSHA) of the U.S. Department of Labor has the primary responsibility for administering the Act. OSHA issues occupational safety and health standards, and its Compliance Safety and Health Officers conduct jobsite inspections to help ensure compliance with the Act.

Inspection

The Act requires that a representative of the employer and a representative authorized by the employees be given an opportunity to accompany the OSHA inspector for the purpose of aiding the inspection.

Where there is no authorized employee representative, the OSHA Compliance Officer must consult with a reasonable number of employees concerning safety and health conditions in the workplace.

Complaint

Employees or their representatives have the right to file a complaint with the nearest OSHA office requesting an inspection if they believe unsafe or unhealthful conditions exist in their workplace. OSHA will withhold, on request, names of employees complaining.

The Act provides that employees may not be discharged or discriminated against in any way for filing safety and health complaints or for otherwise exercising their rights under the Act.

Employees who believe they have been discriminated against may file a complaint with their nearest OSHA office within 30 days of the alleged discriminatory action.

Citation

If upon inspection OSHA believes an employer has violated the Act, a citation alleging such violations will be issued to the employer. Each citation will specify a time period within which the alleged violation must be corrected.

The OSHA citation must be prominently displayed at or near the place of alleged violation for three days, or until it is corrected, whichever is later, to warn employees of dangers that may exist there.

Proposed Penalty

The Act provides for mandatory civil penalties against employers of up to $7,000 for each serious violation and for optional penalties of up to $7,000 for each nonserious violation. Penalties of up to $7,000 per day may be proposed for failure to correct violations within the proposed time period and for each day the violation continues beyond the prescribed abatement date. Also, any employer who willfully or repeatedly violates the Act may be assessed penalties of up to $70,000 for each such violation. A minimum penalty of $5,000 may be imposed for each willful violation. A violation of posting requirements can bring a penalty of up to $7,000.

There are also provisions for criminal penalties. Any willful violation resulting in the death of any employee, upon conviction, is punishable by a fine of up to $250,000 (or $500,000 if the employer is a corporation), or by imprisonment for up to six months, or both. A second conviction of an employer doubles the possible term of imprisonment. Falsifying records, reports, or applications is punishable by a fine of $10,000 or up to six months in jail or both.

Voluntary Activity

While providing penalties for violations, the Act also encourages efforts by labor and management, before an OSHA inspection, to reduce workplace hazards voluntarily and to develop and improve safety and health programs in all workplaces and industries. OSHA's Voluntary Protection Programs recognize outstanding efforts of this nature.

OSHA has published Safety and Health Program Management Guidelines to assist employers in establishing or perfecting programs to prevent or control employee exposure to workplace hazards. There are many public and private organizations that can provide information and assistance in this effort, if requested. Also, your local OSHA office can provide considerable help and advice on solving safety and health problems or can refer you to other sources for help such as training.

Consultation

Free assistance in identifying and correcting hazards and in improving safety and health management is available to employers, without citation or penalty, through OSHA-supported programs in each State. These programs are usually administered by the State Labor or Health department or a State university.

Posting Instructions

Employers in States operating OSHA approved State Plans should obtain and post the State's equivalent poster.

Under provisions of Title 29, Code of Federal Regulations, Part 1903.2(a)(1) employers must post this notice (or facsimile) in a conspicuous place where notices to employees are customarily posted.

More Information

Additional information and copies of the Act, specific OSHA safety and health standards, and other applicable regulations may be obtained from your employer or from the nearest OSHA Regional Office in the following locations:

Atlanta, GA	(404) 347-3573
Boston, MA	(617) 565-7164
Chicago, IL	(312) 353-2220
Dallas, TX	(214) 767-4731
Denver, CO	(303) 844-3061
Kansas City, MO	(816) 426-5861
New York, NY	(212) 337-2378
Philadelphia, PA	(215) 596-1201
San Francisco, CA	(415) 744-6670
Seattle, WA	(206) 442-5930

Lynn Martin

Lynn Martin, Secretary of Labor

U.S. Department of Labor

Occupational Safety and Health Administration

Washington, DC
1991 (Reprinted)
OSHA 2203

To report suspected fire hazards, imminent danger safety and health hazards in the workplace, or other job safety and health emergencies, such as toxic waste in the workplace, call OSHA's 24-hour hotline: 1-800-321-OSHA.

HASP ATTACHMENT D

HEAT/COLD STRESS MONITORING

HEAT/COLD STRESS MONITORING

HEAT STRESS MONITORING

The heat stress monitoring program will be managed on-site by the SSO. Monitoring will based on heat stress monitoring.

Heat Stress Symptoms

Heat stroke is always life-threatening. The person's temperature control system that causes sweating stops working correctly. The body temperature rises so high that brain damage and death will result if the person is not cooled quickly. The main signs of heat stroke are red or flushed skin; hot, dry skin, although the person may have been sweating earlier; and extremely high body temperature, often to 41°C (106°F). There may be dizziness, nausea, headache, rapid pulse and unconsciousness.

Heat exhaustion is much less dangerous than heat stroke. The major signs of heat exhaustion are pale, clammy skin, profuse perspiration, and extreme tiredness or weakness. The body temperature is approximately normal. The person may have a headache and may vomit.

Cool a victim of heat stroke quickly. If the body temperature is not brought down fast, permanent brain damage or death may result. Soak the person in cool but not cold water, sponge the body with rubbing alcohol or cool water, or pour water on the body to reduce the temperature to a safe level, about 39°C (102°F). Then stop cooling and observe the victim for 10 minutes. Call an ambulance as soon as possible. If the temperature starts to rise again, cool the victim again. Do not give coffee, tea, or alcoholic beverages.

For mild heat exhaustion, stop work, remove the protective coveralls and get out of the sun. Give the person water, juice, or Gatorade. Medical care is needed for severe heat exhaustion.

Of particular importance is heat stress resulting when protective clothing decreases natural body ventilation. One or more of the following will help reduce heat stress:

1. Drinking water shall be made available to the workers in such a way that they are stimulated to frequently drink small amounts, i.e., one cup, every 15-20 minutes (about 150 ml or 1/2 pint).

   The water shall be kept reasonably cool (55-60°F) and shall be placed close to the workplace so that the worker can reach it without abandoning the work area. However, where contaminants are known/suspected to exist that pose an ingestion toxicity hazard potential, workers shall not be permitted to consume any fluids without first being decontaminated and going to a noncontaminated area.

2. Long cotton underwear acts as a wick to help absorb moisture and protect the skin from direct contact with heat-absorbing protective clothing. It should be the minimum undergarment worn.

3. When necessary/applicable, install mobile showers and/or hose-down facilities to reduce body temperature and cool protective clothing.

4. In the extremely hot weather, conduct non-emergency response operations in the early morning or evening.

5. In hot weather, rotate shifts of workers wearing impervious clothing.

6. Good hygienic standards must be maintained by frequent changes of clothing and daily showering. Clothing should be permitted to dry during rest periods. Persons who notice skin problems should immediately consult medical personnel.

7. Acclimatization to heat involves a series of physiological and psychological adjustments that occur in an individual during their first week of exposure to hot environmental conditions. The work-rest regimen in this procedure is valid for acclimated workers who are physically fit. Extra caution must be employed when unacclimated or physically unfit workers must be exposed to heat stress conditions.

8. Provide a shaded rest area.

Heat Stress Monitoring

In the event that heat stress/heat exhaustion is observed during work activities, the on-site B&R Environmental representative determines that the type of work may require careful monitoring, or environmental conditions dictate careful monitoring (e.g., respirators, plastic tyvek, and heavy workload) the following procedures could be implemented.

Work-Rest Regimen

Establishment of a proper work-rest regimen may be used in conjunction with the work load required to perform each task. Light work examples include sitting or standing to control machines or performing light hand or arm work. Moderate work includes walking about with moderate lifting and pushing or use of coated coveralls and respirators. Heavy work corresponds to pick and shovel-type work or the use of full body protective clothing. It must be assumed that any activity involving this type of clothing will be considered heavy work.

The work-rest regimen selected will be utilized as a baseline. The actual or adjusted period of work will be determined based on the biological monitoring outlined in the biological monitoring section.

Biological Monitoring

One of the following procedures shall be followed when the work-place temperature is 70°F or above, and/or upon this site HSO's discretion, in order to make sure the work/rest regime is providing proper personal protection and to document exposure.

1. Heart rate (HR) shall be measured by the pulse for 30 seconds as early as possible in the resting period. The HR at the beginning of the rest period should not exceed 110 beats/min. If the HR is higher, the next work period should be shortened by 10 minutes (or 33 percent), while the length of rest period stays the same. If the pulse rate is 100 beats/min at the beginning of the next rest period, the following work cycle should be shortened by 33 percent.

2. Body temperature shall be measured orally with a clinical thermometer as early as possible in the resting period. Oral temperature (OT) at the beginning of the rest period should not exceed 99°F. If it does, the next work period should be shortened by 10 minutes (or 33 percent), while the length of the rest period stays the same. However, if the OT exceeds 99.7°F at the beginning of the next rest period, the following work cycle should be further shortened by 33 percent. The worker's OT should be measured at the end of the rest period to make sure that it has dropped below 99°F. At no time shall work begin with OT above 99°F.

HEAT STRESS PREVENTION WORK-REST REGIMENT GUIDELINES
(Values Are Given in 0°F WBGT)

Work Rest Regimen	Work Load		
	Light	Moderate	Heavy
Continuous Work	86.0	80.0	77.0
75% Work - 25% Rest Each Hour	87.0	82.0	78.6
50% Work - 50% Rest Each Hour	89.0	85.0	82.0
25% Work - 75% Rest Each Hour	90.0	88.0	86.0

COLD STRESS MONITORING

Persons working outdoors in temperatures at or below freezing may experience frostbite. Extreme cold for a short time may cause severe injury to the surface of the body. Areas of the body that have a high surface area to volume ratio, such as fingers, toes, and ears, are the most susceptible.

Two factors influence the development of a cold injury: ambient temperature and the velocity of the wind. Wind chill (Table 1, Attachment A) is used to describe the chilling effect of moving air in combination with low temperature. For instance, 10°F with a wind of 15 mph is equivalent in chilling effect to still air at - 18°F.

As a general rule, the greatest incremental increase in wind chill occurs when a wind of 5 mph increases to 10 mph. Additionally, water conducts heat 240 times faster than air. Thus, the body cools suddenly when chemical-protective equipment is removed, if the clothing underneath is soaked with perspiration.

Frostbite

Local injury resulting from cold is included in the generic term frostbite. There are several degrees of damage. Frostbite of the extremities can be categorized into:

1. Frost nip or incident frostbite - the conditions are characterized by sudden blanching or whitening of skin.

2. Superficial frostbite - skin has a waxy or white appearance and is firm to the touch, but tissue beneath is resilient.

3. Deep frostbite - tissues are cold, pale, and solid; extremely serious injury.

Hypothermia

Authorities agree that there are degrees of hypothermia which are characterized as "moderate" and "severe". A victim of moderate hypothermia, who may exhibit the first seven signs listed below, is still conscious but often confused. Severe hypothermia is determined by extreme skin coldness; loss of consciousness; faint pulse; and shallow, infrequent, or apparently absent respiration. Death is the ultimate result.

Practically, the onset of severe shivering signals danger to personnel. Exposure to cold shall be immediately terminated for any severely shivering worker.

Signs of Hypothermia

1. Severe shivering
2. Abnormal behavior
3. Slowing
4. Stumbling
5. Weakness
6. Repeated falling
7. Inability to walk
8. Collapse
9. Stupor
10. Unconsciousness

Cold Stress Emergency Action

1 Remove the victim from the hypothermia-/frostbite-producing environment.

2. Seek expert medical help immediately.

3. Reduce handling to a minimum. Do not rub or massage the victim.

4. Prevent further body heat loss by covering the victim lightly with blankets. Plastic may be used for further insulation. Do not cover the victim's face.

5. If the victim is still conscious, administer hot drinks. Encourage activity, such as walking while wrapped in a blanket. Do not administer any form of sedative, tranquilizer, or analgesic (pain reliever), because these may facilitate further heat loss and convert moderate hypothermia into a severe case.

Cold Stress Work-Place Monitoring

Work-place monitoring is required as follows:

1. A thermometer accurate to 1°F shall be assigned at any workplace where the environmental temperature is known or expected to be below 60°F to enable overall compliance with the requirements of this procedure.

2. Whenever the air temperature at a work place falls to 30°F or below, the dry-bulb temperature and wind speed shall be measured and recorded at least every 4 work-hours.

3. The equivalent chill temperature shall be obtained (in all cases where air movement measurements are required) and shall be recorded with the other data in the site log, together with a record of the length of time spent working and resting.

Personal Protective Equipment Requirements for Cold Environments

Since prolonged exposure to cold air can lead to dangerous hypothermia, whole body protection must be provided as follows:

Adequate insulating clothing, to maintain core temperatures above 97°F, must be provided to workers if work is performed in air temperatures below 40°F. Wind chill or the cooling power of the air is a critical factor.

As wind speed increases and work area temperature decreases, the insulation values of the workers' protective clothing must increase. The equivalent chill temperature must be used when estimating the combined cooling effects of wind and low air temperatures on exposed skin or when determining clothing insulation requirements to maintain the deep body core temperature.

APPENDIX B

B-1 STANDARD OPERATING PROCEDURES

B-2 EPA SOP GW 0001

B-3 RIDEM SUGGESTED LOW STRESS SAMPLING APPROACH

B-4 PROCEDURE TO ESTIMATE TCLP CONCENTRATIONS

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1.0 PURPOSE

The purpose of this guideline is to provide a general description of, and technical management guidance on, the use of Magnetic and Metal Detection Surveys for site investigations.

2.0 SCOPE

This guideline provides a description of the principles of operation, instrumentation, applicability and implementability of standard geophysical methods used during site investigations to determine site features related to magnetic anomalies and buried metal. The document is intended to be used by the site manager (SM), RI leader, field operations leader, or site geologist to develop an understanding of each method sufficient to permit work planning and scheduling, resource planning, subcontractor procurement and evaluation, and manipulation and use of the technical data during remedial investigations and feasibility studies. This guidance is not intended to provide a detailed description of methodology and operation. The highly specialized nature of the subject geophysical methods requires inclusion of project-specific, site-specific, and subcontractor-specific information prior to development of detailed operating procedures, during both planning and execution.

The description focuses on methods and equipment that are readily available and typically applied; it is not intended to provide a complete discussion of the state of the art.

3.0 GLOSSARY

Magnetic Susceptibility -- Property of a material corresponding to its ability to distort an applied magnetic field.

Magnetometer -- A device used for precise and sensitive measurements of magnetic fields.

Magnetic Survey -- A geophysical survey method that depends on detection of magnetic anomalies caused by the presence of buried ferromagnetic objects.

Metal detection -- A geophysical survey method that is based on electromagnetic coupling caused by underground conductive objects.

Magnetometry -- The science of measuring variations in the earth's magnetic field.

Vertical Gradiometer -- A magnetometer equipped with two sensors that are vertically separated a fixed distance apart. It is best suited to map near surface features and is less susceptible to deep geologic features.

4.0 RESPONSIBILITIES

Site Manager -- responsible for scoping the magnetic or metal detection surveys during development of the Work Plan with the help of the RI leader, site geologist, and site geophysicist.

Site Geophysicist -- central role in determining the technique used for providing necessary data. Field work for these surveys is supervised by the site geophysicist, with support from geophysical technical specialists and other personnel as needed. Data reduction and interpretation are performed by the site geophysicist or technical specialists.

5.0 PROCEDURES

5.1 Description of Methods

5.1.1 Theory and Principles of Operation

5.1.1.1 Magnetometry

Materials subject to a magnetic field will develop an induced magnetization, proportional to the applied magnetic field and the magnetic susceptibility of the material.

Induced magnetization in an object produces a local magnetic field which either reinforces (positive magnetic susceptibility) or reduces (negative susceptibility) the external applied field. The variations in an otherwise homogenous field caused by the presence of the object is called a magnetic anomaly, and observations of such anomalies can be used to infer the presence of magnetic objects.

Because there are numerous factors that affect magnetic fields there is no unique interpretation of a set of magnetometry data. Conversely, there is no unique magnetic anomaly produced by a particular kind of buried object. Factors that influence the response of a magnetometer to buried objects include the size, shape, depth, orientation, and magnetic susceptibility of the buried material, and permanent magnetometers such that many objects of interest at hazardous waste sites (particularly buried ferromagnetic materials such as drums, tanks, pipes and iron scrap) are detectable. While the location of ferromagnetic material can be detected to the precision of the survey, difficulties may be encountered in interpreting and attempting to identify the source of magnetic anomalies.

5.1.1.2 Metal Detection

When a radio frequency electromagnetic field generated by a transmitter coil encounters a highly conductive object such as metal (not necessarily ferromagnetic), alternating currents are induced in the object that, in turn, generate alternating secondary magnetic fields that are detected as alternating voltages by a receiver coil. The presence of the metal object effectively "couples" the transmitter and receiver coils, which otherwise are oriented so that little or no coupling exists. The principles of metal detector operation are very similar to those associated with electromagnetic induction instruments.

A number of factors influence the response of a metal detector. The receiver response increases with the size and surface area, and decreases with the depth of a buried object. Factors such as soil properties and object shape complicate detectability and interpretation. Certain shapes, such as elongated metal rods, are difficult to detect. Iron minerals and conductive fluids will affect the detector response in much the same manner as a target of interest. Generally, metal detectors show greater response to smaller nearby targets than to larger targets at greater depth, and the presence of widespread metallic debris at a site can interfere with attempts to detect buried drums and other objects.

5.1.2 General Applicability

5.1.2.1 Magnetic Surveys (Magnetometry)

Magnetometer and gradiometer surveys are useful in environmental and engineering projects that require a technique for mapping buried vertically oriented metallic pipe (e.g., locating a buried water well casing), or mapping stratigraphy or geologic structure in an igneous settings. Magnetometers are also a useful tool for mapping buried metallic debris, metallic utilities or metallic containers. However, electromagnetic (EM) equipment is generally better suited for mapping and delineating these targets.

Magnetic surveys can more readily detect metallic masses than identify or characterize targets. Calculations of the mass or size of detected objects generally yield only approximate results.

Magnetic surveys may be impractical in areas where metal pipes, fences, railroad tracks, metal buildings, and other ferrous metal artifacts are abundant. However, proper selection of equipment and survey techniques can often alleviate some of these problems.

5.1.2.2 Metal Detectors

Metal detectors (MDs) can be used for locating buried metallic containers of various sizes; defining the boundaries of trenches containing metallic containers; locating buried metallic storage tanks; locating buried metallic pipes; avoiding buried utilities when drilling or trenching; or locating utility trenches which may provide a permeable pathway for contaminants.

The detection range of a MD is relatively short. Its sensitive areas are focused directly above and below the coil providing good definition of object location. Quart-sized metal objects can be detected at a distance of about 1 meter; objects the size of a 55 gallon drum can be detected up to 3 meters; and massive piles of metals can be detected at depths of 3 to 6 meters. Deeper objects are difficult to detect with an MD. Although most MDs are operated on foot, some can be vehicle-mounted if desired.

5.1.3 Instrumentation

5.1.3.1 Magnetometers

Three types of magnetometers, the fluxgate, proton precession, and the cesium vapor magnetometers, are commonly used at hazardous waste sites. The fluxgate magnetometer uses an iron core of high magnetic susceptibility as a sensor. The amount of coiled electrical current necessary to induce magnetic saturation of the rod is directly dependent upon, and thus measures, the strength of the ambient magnetic field. In a proton precession magnetometer a strong magnetic field is applied to a sensor filled with proton-rich fluid (e.g., kerosene) that realigns the protons. The field is then turned off and the frequency of the signal generated by the protons as they realign themselves ("precess") to the earth's magnetic field is dependent upon and measures the strength of the field at that point. The third common type of magnetometer is the cesium vapor (alkali-vapor) magnetometer. The cesium vapor magnetometer is capable of obtaining an order of magnitude greater sensitivity than the proton precession magnetometer. The cesium vapor magnetometer operates via a beam of polarized light from a cesium vapor lamp that is passed through a cell of cesium vapor. The atoms of the vapor become excited as they absorb greater amounts of the polarized light. The vapor in the cell eventually reaches an energy state that can no longer absorb the light and renders the cell transparent. A radio-frequency magnetic field causes the atoms of the vapor to shift back to an energy state that allows the vapor to again absorb the polarized light. The frequency required to return the vapor to an energy state that allows the cell to absorb light is a function of the ambient magnetic field. Some magnetometers, such as the fluxgate, are extremely sensitive to orientation during measurement. In order to alleviate this problem, two sensors are connected by a rigid pole to form a "gradiometer" that measures only a certain directional component of the earth's magnetic field. These gradiometers are commonly used at hazardous waste sites.

The type of magnetometer best suited for a particular site investigation depends upon characteristics of that site and should be chosen by a person familiar with the different instruments available. Proton precession magnetometers, while very useful in many situations, will cease to function in an area with high magnetic gradients such as a junkyard or near a steel bridge.

Different instruments have different levels of sensitivity. Whereas in some cases, high sensitivity may be desired to detect deeply buried objects, in other instances, a low sensitivity instrument may be desired to reduce the effects of "noise" from nearby fences or cars. Furthermore, the size of the survey area and the resolution required will determine whether the magnetometer used is hand-held for stationary measurements or a vehicle-mounted continuous sensor model.

5.1.3.2 Metal Detectors (MDs)

Three general classes of metal detectors are commonly used in hazardous waste site studies: pipeline/cable locators, conventional "treasure hunter" detectors and specialized detectors. The pipeline/cable detectors are commonly used by EPA field investigation teams. They do not respond to small objects like soda cans. Although most of the "treasure hunter" type detectors are used for locating coin-sized objects, some can be fitted with larger sensor coils suitable for detection of larger objects at greater depths. Some of these models also can operate with adverse soil conditions such as high iron content. Specialized detectors are also available to operate to greater depths, over a wide sweep area, operate continuously, cope with special field problems, or operate while vehicle-mounted. These special MDs require an experienced operator and are not commonly available.

5.2 Data Acquisition

5.2.1 Field Procedures

5.2.1.1 Magnetics

Magnetic measurements are generally made in a cross-grid pattern, or if a continuous sensor is used, in a series of parallel lines across the survey area. The desired resolution (reconnaissance or high density) and the size and depth of the objects sought, determines the spacing of measurement stations or survey lines. Because of the phenomenon of temporal magnetic drift, a magnetic survey must include a base station where magnetic measurements are made at regular intervals. A separate base station magnetometer is used to monitor fluctuations in the earth's magnetic field. The base station magnetometer is time synchronized with the mobile magnetometer and placed in an area of the site believed to be free of metals or other anthropogenic features. The base station magnetometer is configured to record one data point at a set time interval (e.g., every 5 seconds). At the completion of the survey, the base station magnetometer is interfaced with the mobile magnetometer and the total field magnetic data are automatically corrected for any observed diurnal drift.

Special care must be taken with handling of the magnetometer during use. The operator must not take measurements with the sensor near ferromagnetic objects such as belt buckles or steel-toed boots. The orientation of the magnetometer and its height from the ground must also be carefully controlled during operation. Recorded data must be annotated with station locations to allow construction of a site magnetic map.

5.2.1.2 Metal Detector

Surveys with metal detectors are similar in planning to those with magnetometers. A grid pattern of evenly spaced parallel lines is used. Desired resolution and the size of objects determine spacing. In some cases, elevating the MD a few feet off the ground may help to eliminate noise from small surface objects. An experienced operator is recommended. Recorded data must be annotated with station locations to allow construction of a site metal detection map.

5.2.2 Data Format

5.2.2.1 Magnetics

Most magnetometers are equipped with a solid stated data logger that records the total field magnetic and/or the vertical gradient values, the survey line location, the survey station location and the time of the reading. The common units (SI) for total field magnetic data are Teslas (T). Magnetometers data record total field data in units of nanoTeslas (nT). However, older texts may also refer to magnetic values as gammas (one gamma equals one nanoTesla). Vertical gradient data are commonly recorded in units of nanoTeslas per meter (nT/M).

5.2.2.2 Metal Detection

The data provided by a metal detector is less quantitative than that of a magnetometer. The MD signal strength may vary (depending on the instrument) with object depth, size and shape, but this signal does not translate into a quantity such as field strength. It merely indicates the presence of a metal object. This on/off type of signal is useful because it can indicate the boundaries of a metal-bearing zone more clearly than some quantitative data such as magnetometer recordings.

5.3 Data Interpretation

5.3.1 Magnetics

5.3.1.1 Correction of Diurnal Variations

Diurnal drift is automatically corrected for by interfacing the mobile magnetometer with the base station magnetometer. However, all of the diurnal corrections should be checked to verify the values and insure against instrument malfunction.

5.3.1.2 Depth Estimates from Total Field

The width of a magnetic anomaly is proportional to the depth (or distance) of the source from the magnetometer sensor; the deeper the source, the broader the anomaly. This relationship is of primary importance in interpreting the results of a magnetic survey. The proportion between the width of an anomaly and the depth of the source is a function of the fall-off rate, or the variation of anomaly amplitude with distance(d). For a dipole, the total-field anomaly amplitude varies as $1/d^3$, and for a monopole as $1/d^2$. In actual practice, source orientation and other factors may result in fall-off rates from $1/d$ to $1/d^3$. The shape of the magnetic profile of an anomaly and knowledge of the source object help in selecting the proper fall-off rate for depth estimation. A range of depths determined from several fall-off rates may be the most appropriate way to present depth estimates.

In general the anomaly width is on the order of one to three times the depth of the source. Thus, for an anomaly with a width of 100 feet, the source probably lies between 30 and 100 feet deep (or distant). Several methods, including the half-width rule and the slope technique, can be used to estimate source depths from total field profiles.

5.3.1.3 Half-Width Rule

The half-width ($x_{1/2}$) of an anomaly on a total field profile is the horizontal distance between the principal maximum (or minimum) of the anomaly (assumed to be over the center of the source) and the point where the total field value is exactly one-half of the principal maximum (Figure 3 2-1) A profile that is used for

depth estimation by using the half-width rule should be oriented perpendicular to the long axis of the anomaly to give the narrowest profile. This rule is valid only for forms such as spheres, cylinders, and other simple shapes. For example, a single upright 55-gallon steel drum can be approximated as a vertical cylinder (monopole) and the depth (d) = 1 3 $x_{1/2}$. A buried trench filled with drums can be approximated by a horizontal cylinder, where d = 2 $x_{1/2}$.

5.3.1.4 Slope Techniques

Depth of the source can be estimated using the slope of the anomaly at the inflection points of the profile. The horizontal extent (X_z) of the "straight" portion of the slope is determined as shown in Figure 3 2-1. The depth is then estimated by the equation,

$$d = KX_z \text{ where } 0.5 < K < 1.5$$

5.3.2 Metal Detection

Very little interpretation is necessary for Metal Detection surveys performed to provide qualitative data on the presence of metallic objects in the survey area, as a precursor to more detailed subsequent geophysical surveys. For these cases, the positive audible responses or meter deflections are recorded on site grid maps and no further processing or interpretation is made. More detailed metal detection surveys using strip-chart or magnetic tape recording are possible. Typically, data is plotted on site grid maps following computer processing. Corrections for nonlinearities and smoothing of the data to eliminate small-target responses can be accomplished.

5.4 Applications Management

5.4.1 Prerequisites

As described in Section 5.1.2, appropriate planning of magnetic and metal detection surveys requires at least a basic understanding of general site features and geohydrologic characteristics, as well as the probable variability in conditions. The Work Plan should describe, in as much detail as possible, the known site conditions which may affect the measurements, and the objectives of proposed survey efforts. The type and degree of data interpretation and the desired format for data presentation should be specified if possible.

5.4.2 Work Planning and Scheduling

Magnetic and metal detection surveys may be performed concurrently with field geotechnical investigations, in which case on-site interpretation of data may provide real-time guidance for well drilling activities. Ideally, however, these geophysical surveys should be conducted in advance, allowing sufficient time for data interpretation and use of the results in planning other field exercises.

The time and effort required by these geophysical surveys vary greatly depending on the site-specific objectives and site conditions. Typically, 2 to 10 acres of metal detection can be performed by one person per day. Additionally, 2 to 3 linear miles of magnetometer data can be collected by 1 person per day. Data reduction and interpretation will require at least an equivalent amount of time to the field work. Weather onditions, terrain, and obstructive site features cause considerable variability in these estimates.

5.5 Calibration

5.5.1 Magnetic Survey

Magnetometer readings should be compared regularly to readings of a reference base station magnetometer; this procedure is necessary if corrections are to be made for changes in the earth's magnetic field over time.

5.5.1.1 Daily Quality Control

All data sets should be accompanied by quality control data that indicates the level of quality of each individual data point. Periodically, replicate measurements should be made so that measurement precision can be established. This procedure also requires corrections for variations in the earth's magnetic field with time. Each data set should be referenced to the most recent calibrations. All data obtained prior to a calibration requiring significant changes in instrument controls is suspect, and the measurements should be repeated or otherwise validated. Data should be preliminarily reduced and plotted during the field program to determine the overall quality of the data and whether the survey results are consistent with the site conceptualization. Data points representing discontinuities in the curves should be validated by repetition and, if necessary, a fine grid of measurements made to determine whether the anomaly represents a site feature of interest, a spurious reading, or an obstructive interference.

The earth's magnetic field varies constantly due, primarily, to solar activity. These natural fluctuations must be accounted for and removed from the survey data. A second magnetometer will be used as a base station to measure and record these fluctuations. These data will subsequently be used to drift correct the survey magnetometer data. In addition, the U.S. Space Environmental Agency should be contacted daily to obtain the latest solar activity forecasts. Data acquisition will cease in the event of a magnetic storm. The phone number for the U.S. Space environmental Agency is (303) 497-3171.

5.5.2 Metal Detection

5.5.2.1 Calibration

Metal detectors normally are not calibrated, and only relative response is of interest. Periodically, the sensitivity should be checked by nulling the instrument at a fixed location known to be free of metal, and adjusting the gain to provide a proper response over a known target.

5.5.2.2 Daily Quality Control

Metal detector data should be accompanied by sufficient quality control data to verify that the instrument was operating properly. Occasional repetitive measurements and a log of the sensitivity adjustments usually suffice for this purpose.

5.6 LIMITATIONS

Magnetometer data may be adversely affected by the presence of anthropogenic surface features such as buildings, fences, power lines, vehicles, and reinforced concrete. The magnetic response from these surface features can be much larger than that due to a single buried steel drum, and thus can mask the response of a drum. Magnetometer surveys should not be conducted in urban areas or areas where surface anthropogenic features are prevalent.

Data interpretation is not always straight forward with magnetic data. Metallic drums that are buried at the same depth but at different orientations can yield very dissimilar instrument responses. Data that are collected along survey lines oriented east-west can appear very different than data that are collected along survey lines oriented north-south (the preferred survey orientation).

6.0 REFERENCES

Good discussions of various geophysical survey techniques and applications are found in the following references:

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McKown, G. L., G. A. Sandness and G. W. Dawson, 1980. Detection and Identification of Buried Waste and Munitions, Proceedings of the 11th American Defense Preparedness Association Environmental Systems Symposium, Arlington, Virginia, 1980.

Ward, Stanley, H. 1990. Geotechnical and Environmental Geophysics, Society of Exploration Geophysicists. Tulsa, Oklahoma.

7.0 RECORDS

None.

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5.2 Defining the Sampling Program

Many factors must be considered in developing a sampling program for surface water or sediments including study objectives, accessibility, site topography, physical characteristics of the water body (such as flow and mixing), point and diffuse sources of contamination, and personnel and equipment available to conduct the study. For waterborne constituents, dispersion depends on the vertical and lateral mixing within the body of water. For sediments, dispersion depends on bottom current or flow characteristics, sediment characteristics (density, size) and geochemical properties (which affect adsorption/desorption). The hydrogeologist developing the sampling plan must therefore know not only the mixing characteristics of streams and lakes, but also must understand the role of fluvial-sediment transport, deposition, and chemical sorption.

5.2.1 Sampling Program Objectives

The objective of surface water sampling is to determine the surface water quality entering, leaving or remaining within the site. The scope of the sampling program must consider the sources and potential pathways for transport of contamination to or within a surface water body. Sources may include point sources (leaky tanks, outfalls, etc.) or nonpoint sources (e.g., spills). The major pathways for surface water contamination (not including airborne deposition) are overland runoff, leachate influx to the waterbody, direct waste disposal (solid or liquid) into the water body; and groundwater flow influx from upgradient. The relative importance of these pathways, and therefore the design of the sampling program, is controlled by the physiographic and hydrologic features of the site, the drainage basin(s) which encompass the site, and the history of site activities.

Physiographic and hydrologic features to be considered include slopes and runoff direction, areas of temporary flooding or pooling, tidal effects, artificial surface runoff controls such as berms or drainage ditches (and when they were constructed relative to site operation), and locations of springs, seeps, marshes, etc. In addition, the obvious considerations such as the location of man-made discharge points to the nearest stream (intermittent or flowing), pond, lake, estuary, etc., shall be considered.

A more subtle consideration in designing the sampling program is the potential for dispersion of dissolved or sediment-associated contaminants away from the source. The dispersion could lead to a more homogeneous distribution of contamination at low or possibly non-detectable concentrations. Such dispersion does not, however, always readily occur. For example, obtaining a representative sample of contamination from a main stream immediately below an outfall or a tributary is difficult because the inflow frequently follows a stream bank with little lateral mixing for some distance. Sampling alternatives to overcome this situation are: (1) move the site far enough downstream to allow for adequate mixing, or (2) collect integrated samples in a cross section. Also, nonhomogeneous distribution is a particular problem with regard to sediment-associated contaminants, which may accumulate in low-energy environments (coves, river bends, deep spots, or even behind boulders) near or distant from the source while higher-energy areas (main stream channels) near the source may show no contaminant accumulation.

The distribution of particulates within a sample itself is an important consideration. Many organic compounds are only slightly water soluble and tend to adsorb onto particulate matter. Nitrogen, phosphorus, and the heavy metals may also be transported by particulates Samples must be collected with a representative amount of suspended material; transfer from the sampling device shall include transferring a proportionate amount of the suspended material.

5.3 Surface Water Sample Collection

5.3.1 Streams, Rivers, Outfalls and Drainage Features (Ditches, Culverts)

Methods for sampling streams, rivers, outfalls and drainage features at a single point vary from the simplest of hand-sampling procedures to the more sophisticated multi-point sampling techniques known as the equal-width-increment (EWI) method or the equal-discharge-increment (EDI) methods (see below).

Samples from different depths or cross-sectional locations in the watercourse taken during the same sampling episode, shall be composited. However, samples collected along the length of the watercourse or at different times may reflect differing inputs or dilutions and therefore shall not be composited. Generally, the number and type of samples to be taken depend on the river's width, depth, discharge and on the suspended sediment the stream or river transports. The greater the number of individual points that are sampled, the more likely that the composite sample will truly represent the overall characteristics of the water.

In small streams less than about 20 feet wide, a sampling site can generally be found where the water is well mixed. In such cases, a single grab sample taken at mid-depth in the center of the channel is adequate to represent the entire cross section.

For larger streams, at least one vertical composite shall be taken with one sample each from just below the surface, at mid-depth, and just above the bottom. The measurement of DO, pH, temperature, conductivity, etc., shall be made on each aliquot of the vertical composite and on the composite itself. For rivers, several vertical composites shall be collected, as directed in the project plan documents.

5.3.2 Lakes, Ponds and Reservoirs

Lakes, ponds, and reservoirs have a much greater tendency to stratify than rivers and streams. The relative lack of mixing requires that more samples be obtained.

The number of water sampling sites on a lake, pond, or impoundment will vary with the size and shape of the basin. In ponds and small lakes, a single vertical composite at the deepest point may be sufficient. Similarly, the measurement of DO, pH, temperature, etc., is to be conducted on each aliquot of the vertical composite and on the composite itself. In naturally-formed ponds, the deepest point may have to be determined empirically; in impoundments, the deepest point is usually near the dam.

In lakes and larger reservoirs, several vertical composites shall be composited to form a single sample. These verticals are often taken along a transect or grid. In some cases, it may be of interest to form separate composites of epilimnetic and hypolimnetic zones. In a stratified lake, the epilimnion is the thermocline which is exposed to the atmosphere. The hypolimnion is the lower, "confined" layer which is only mixed with the epilimnion and vented to the atmosphere during seasonal "overturn" (when density stratification disappears). These two zones may thus have very different concentrations of contaminants if input is only to one zone, if the contaminants are volatile (and therefore vented from the epilimnion but not the hypolimnion), or if the epilimnion only is involved in short-term flushing (i.e., inflow from or outflow to shallow streams). Normally, however, a composite consists of several verticals with samples collected at various depths.

In lakes with irregular shape and with bays and coves that are protected from the wind, separate composite samples may be needed to adequately represent water quality since it is likely that only poor mixing will occur. Similarly, additional samples are recommended where discharges, tributaries, land use characteristics, and other such factors are suspected of influencing water quality.

The criteria for selecting a sampler include:

- Disposability and/or easy decontamination.
- Inexpensive cost (if the item is to be disposed).
- Ease of operation.
- Nonreactive/noncontaminating properties - Teflon-coated, glass, stainless-steel or PVC sample chambers are preferred (in that order).

As specified in the project plan document plan documents, each sample (grab or each aliquot collected for compositing) shall be measured for:

- Specific conductance.
- Temperature.
- pH.
- Dissolved oxygen (optional).

Sample measurements shall be conducted as soon as the sample is acquired. Measurement techniques described in SOP SA-1.1 shall be followed. All pertinent data and results shall be recorded in a field notebook or on sample logsheets (see SOP SA-6.3). These analyses will provide information on water mixing/stratification and potential contamination.

Dip Sampling

Water is often sampled by filling a container either attached to a pole or held directly, from just beneath the surface of the water (a dip or grab sample). Constituents measured in grab samples are only indicative of conditions near the surface of the water and may not be a true representation of the total concentration that is distributed throughout the water column and in the cross section. Therefore, whenever possible, it is recommended to augment dip samples with samples that represent both dissolved and suspended constituents and both vertical and horizontal distributions.

Weighted Bottle Sampling

A grab sample can also be taken using a weighted holder that allows a bottle to be lowered to any desired depth, opened for filling, closed, and returned to the surface. This allows discrete sampling with depth. Several of these samples can be combined to provide a vertical composite. Alternatively, an open bottle can be lowered to the bottom and raised to the surface at a uniform rate so that the bottle collects sample throughout the total depth and is just filled on reaching the surface. The resulting sample using either method will roughly approach what is known as a depth-integrated sample.

A closed weighted bottle sampler consists of a stopped glass or plastic bottle, a weight and/or holding device, and lines to open the stopper and lower or raise the bottle. The procedure for sampling with this device is:

- Gently lower the sampler to the desired depth so as not to remove the stopper prematurely (watch for bubbles).
- Pull out the stopper with a sharp jerk of the sampling line.
- Allow the bottle to fill completely, as evidenced by the absence of air bubbles.

5.4 Onsite Water Quality Testing

Onsite water quality testing shall be conducted as described in SOP SA-1.1

5.5 Sediment Sampling

5.5.1 General

Sediment samples are usually collected at the same verticals at which water samples were collected. If only one sediment sample is to be collected, the sampling location shall be approximately at the center of the water body.

Generally, the coarser grained sediments are deposited near the headwaters of the reservoir. Bed sediments near the center of a water body will be composed of fine-grained materials which may, because of their lower porosity and greater surface area available for adsorption, contain greater concentrations of contaminants. The shape, flow pattern, bathometry (i.e., depth distribution), and water circulation patterns must all be considered when selecting sediment sampling sites. In streams, areas likely to have sediment accumulation (e.g., bends, behind islands or boulders, quiet shallow areas or very deep, low-velocity areas) shall be sampled while areas likely to show net erosion (i.e., high-velocity, turbulent areas) and suspension of fine solid materials, shall be avoided.

Chemical constituents associated with bottom material may reflect an integration of chemical and biological processes. Bottom samples reflect the historical input to streams, lakes, and estuaries with respect to time, application of chemicals, and land use. Bottom sediments (especially fine-grained material) may act as a sink or reservoir for adsorbed heavy metals and organic contaminants (even if water column concentrations are below detection limits). Therefore, it is important to minimize the loss of low-density "fines" during any sampling process.

All relevant information pertaining to sediment sampling shall be documented as applicably described in SOP SA-6.3.

5.5.2 Sampling Equipment and Techniques

A bottom-material sample may consist of a single scoop or core, or may be a composite of several individual samples in the cross section. Sediment samples may be obtained using onshore or offshore techniques.

When boats are used for sampling, life preservers must be provided and two individuals must undertake the sampling. An additional person shall remain onshore in visual contact at all times.

The following samplers may be used to collect bottom materials:

- Scoop sampler.
- Dredge samplers.

Each type of sampler is discussed subsequently

U.S. Geological Survey, 1977. National Handbook of Recommended Methods for Water-Data Acquisition. Office of Water Data Coordination, USGS, Reston, Virginia.

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1.0 PURPOSE

This section provides an overview of current techniques used to rapidly determine the presence or absence of various target organic compounds at hazardous waste sites. This section also describes the functions and capabilities of available instrumentation and provides suggestions of adapted methods suitable to the use and constraints of mobile laboratories. The purpose of this section is not to establish standardized analytical procedures, but to describe the concepts employed in field screening analyses. The purpose also is to provide guidance in the application of the best methodology practicable, based upon site-specific requirements, with consideration given to native interferences, specific data quality objectives, and variances in available instrumentation.

2.0 SCOPE

Field screening techniques provide for the semi-quantitative analysis of specified compounds by use of portable or transportable instruments based at, or near, a sampling site. Field screening generates Level II data. As such, field screening provides unique information, and it is therefore important to understand the usability of the data generated. Because of the sophistication of the instruments used and the ability to identify specific compounds, field screening analysis should not be confused with non-specific techniques (for example, the process of obtaining total organic readings from portable meters). However, because field screening results are not confirmed (i.e., are generated by non-confirmatory columns and detectors) and are supported by only moderate control criteria, field screening data are not suitable for assessing risk.

The main asset of field screening lies in quick turn-around time and specific (though not confirmed) data, which are suitable for support in field decisions involving, for example, the best placement of well screens, the optimal positioning of monitoring wells, the focusing of sample submissions to fixed-base laboratories (i.e., the selection of samples that will yield the most important information), the delineation of contaminant plumes, the evaluation of unexpected exposures to the field crew, and fundamental regulatory/remedial support. In this manner, field screening allows for decisions to be made on a real-time basis while the field team is mobilized, thus avoiding the several week lag time which occurs when waiting for fixed-base laboratory results.

Field screening techniques are applicable to the analysis of air, soil gas, water and solid matrices for various volatile, semi-volatile, pesticide and PCB compounds. For correlative and quality control purposes, field screening is usually performed in conjunction with a previously established percentage of sample submissions sent to a fixed-base laboratory as split-sample analyses.

3.0 GLOSSARY

Affinity - Molecular attraction

Inert Gas - Non-reactive gas, such as nitrogen or helium, which are both commonly used as purge/carrier gas

Isothermal - At constant temperature.

Neat - Undiluted.

Suspect - Estimated; of questionable accuracy

Target Compound - Of the host of plausible compounds (i.e., compounds that would be recognized by the methodology used), the few compounds chosen for analysis that are felt to be representative of site contamination. Typically, a few compounds are selected and monitored, thus facilitating the analytical effort.

4.0 RESPONSIBILITIES

Field screening generally consists of two phases:

- An initial survey (pre-screening) using instruments such as OVA meters or HNU detectors to analyze the ambient conditions on site or to conduct limited analyses of samples. Pre-screening generates Level I data. Pre-screening activities may be forfeited if sufficient site historical data exist.

- Mobile laboratory analysis to quickly process a larger number of samples, and to provide specific qualitative and quantitative Level II data.

Personnel and assigned duties essential to the accomplishment of the above two tasks are outlined below:

- Site Manager - Responsible for developing, in consultation with other project personnel (e.g., geologists, chemists, engineers, toxicologists, client), a comprehensive work plan in which pre-screening and screening activities are defined.

- Field Operation Leader - Responsible for the procurement of all necessary equipment and the direct supervision of site activities.

- Sampler - Responsible for conducting pre-screening, if applicable, sampling for submission to the mobile laboratory and fixed-base laboratory, packaging and shipment of samples to the fixed-base laboratory, and the preparation of all necessary paper work associated with sampling and shipment.

- Site Chemist - Responsible for the receipt and analysis of samples submitted to the mobile laboratory for targeted analysis. Responsible for giving guidance in conjunction with the interpretation and appropriate use of the field screening data generated. Responsible for the oversight of analytical QA/QC.

- Health and Safety Officer - Responsible for the development of an appropriate health and safety plan prior to the commencement of site activities. Responsible for the observance of all site operations, for providing assistance and modifying the health and safety plan as necessary to ensure worker protection.

5.0 PROCEDURES

The following subsections discuss methodologies that have been applied successfully in the field screening of environmental samples obtained from hazardous waste sites. These methodologies are not stand-alone protocols and are not intended to serve as standardized analytical procedures. These methodologies are presented as formats within which analytical approaches, based on the referenced established methods, may be developed to fit site specific needs and data quality objectives. It is necessary for the site chemist and the project manager to address the specific modifications to the

procedures that will be employed and to obtain the necessary approval prior to the commencement of site activities.

5.1 Field Screening of Target Purgeable Volatile Organic Compounds (Aqueous Matrix)

5.1.1 Overview

The following methodology describes a modification of EPA 600 series purge and trap gas chromatographic procedures suitable for the determination of volatile organic contaminants in aqueous matrix samples.[1] Via this methodology, a portion of neat sample or dilution is placed into a glass sparging vessel which is sealed onto a purging device. The contained sample aliquot is subjected to a stream of inert gas which is allowed to bubble through the matrix. This mechanical bubbling action effectively strips the contaminants (now volatilized) from the aqueous matrix and sweeps them onto a packed sorbent tube (i.e., trap), where they are subsequently desorbed (by the action of heat and reverse gas flow) onto a suitable column housed in a pre-programmed gas chromatograph (GC). The contaminants become separated and resolved as they travel through the GC column. Eventually, the contaminants elute through an appropriate detector. The detector signals are processed and interpreted via a previously programmed integrator. Figure 1 provides a list of Potential Volatile Target Compounds.

5.1.2 Summary of Methods

Low Level Analysis - Use of 20 mL neat sample aliquot is suggested in order to achieve reportable detection limits of approximately 5 μg/L. Sample aliquots should be introduced into the sparger using a 10 mL GC syringe. Sample aliquots should not be pipetted, as the action of pipetting may compromise sample integrity due to mechanical stripping.

Medium Level Analysis - Proportioned dilutions may be achieved by using a reduced sample aliquot plus a complementary portion of organic-free water for sparging. For example, a four-fold dilution can be simulated by injecting 5 mL of neat sample plus 15 mL of organic-free water. Similarly, extremely high concentration samples may be analyzed by spiking μL aliquots of neat sample in 19+ mL of organic-free water.

5.1.3 Interferences

Interferences can result from many sources, considering the environmental settings of most hazardous waste sites. However, most interfering impurities are artifacts originating from organic compounds within the specialty gases and the plumbing within the purging mechanism. Interferences in the analytical system are monitored by the analysis of method blanks. Method blanks are analyzed under the same conditions and at the same time as standards and samples, to establish an average background response.

Samples can become contaminated by the diffusion of high concentration contaminants to lower concentrated samples through container seals during shipping and storage. If opted as part of the analysis plan, organic-free trip blanks may be developed and carried by the sampling team together with field samples to assess the existence and the magnitude of this phenomenon

[1] (EPA Methods 601, 602, 612, and 624).

FIGURE 1

SUMMARY OF POTENTIAL TARGET COMPOUNDS

(Volatile Organics Analysis)
Acetone
Benzene
Bromoform
Carbon Tetrachloride
Chlorobenzene
Chloroform
Ethylbenzene
Methylene chloride
1,1-Dichloroethene
total 1,2-Dichloroethenes
1,1-Dichloroethane
1,2-Dichloroethane
1,1,1-Trichloroethane
Tetrachloroethene
Toluene
Trichloroethene
Total Dichlorobenzenes
Total Xylenes
2-Butanone (MEK)
4-Methyl-2-pentanone (MIBK)

Artifacts, which manifest themselves as carryover in the next analytical run, can also occur within the analytical apparatus whenever a highly contaminated sample is introduced. To preclude this from occurring, the sample line and sparge vessel are thoroughly rinsed with organic-free water prior to the bake cycle of each highly contaminated sample run.

5.1.4 Major Apparatus and Materials

Purge and Trap Device - Tekmar Company Model LSC-2 or equivalent complete with a 25 mL glass sparge vessel and a 1/8-inch-O.D. x 25-cm-long stainless steel trap. The trap may be packed solely with Tenax. Alternately, trap packing may consist of 1 0 cm of 3 percent OV-1, 15 cm of Tenax and 8 cm of silica gel. Appropriate trap selection is contingent upon the target compounds being analyzed.

Gas Chromatograph (GC) - Hewlett Packard 5890 or equivalent. The analytical system should be equipped for temperature programming, packed and/or capillary column analysis, and direct-column injection.

Detector - PID/FID or PID/HECD in series; FID only. Optimum detector selection should be based upon the sensitivities of the target compounds being analyzed.

Analytical Column - Glass or stainless steel column packed with 1 percent SP-1000 on 60/80 mesh Carbopack B. Alternatively a suitable capillary column may be used.

Syringes - Assorted: 5 μL, 25 μL, 100 μL, 1 mL, 10 mL

Volumetric Flasks - 10 mL, 25 mL, 100 mL

Analytical Balance - Capable of accurately weighing 0.0001 g.

Oven - Constant temperature for the regeneration of contaminated apparatus.

Refrigerators - One dedicated refrigerator each for separate sample and standard storage. Each should be capable of maintaining a stable temperature of 4°C.

5.1.5 Reagents

Methanol - Pesticide grade or equivalent.

Organic-Free Water - Supplied by laboratory or purchased.

Neat Solvents - 96 percent purity, or better, for each compound of interest.

5.1.6 Calibration

Standards - Calibration standards containing the compounds of interest are prepared in methanol by either diluting commercially purchased stock standard mixes or by creating in-house standards from pure solvents. In-house calibration standards are prepared gravimetrically, in that an appropriate μL aliquot of each target compound is introduced into a known volume of methanol. The appropriate μL aliquot of compound is based upon the compound's density and response to the selected detector. Calibration standards are created at a level such that a 2-5 μL spike of standard into 20 mL of organic-free water is suitable for continuing calibration purposes.

Peak Identification. Compound identities may be substantiated by the analysis of each individual component, thereby documenting compound retention time.

Initial Linearity. An initial three-point calibration curve is generated by the analysis of multiple-aliquot injections of calibration standard. For example, if the calibration standard is created such that a 2 μL spike into organic-free water yields results at the level of the reported detection limits, a three-point calibration curve may be achieved by the analysis of 2 μL, 5 μL, and 10 μL aliquot spikes. The linearity study for field screening is conducted in such a way as to substantiate the performance of the detector at the level of the reportable limits. It is not performed to demonstrate the entire range of detector capability. The primary objective of field screening is the determination of "clean" versus "dirty" and all results are therefore, considered to be semi-quantitative.

Integration. Calibration of the analytical system is achieved via the external standard method in which response factors (RF) for each compound are obtained by the analysis of a standard mix of known concentration. Following the analysis of this known standard mix, an electronic file is created establishing each peak's identity, retention time, RF, and known concentration. The RF for each target compound is determined by dividing the known concentration by the associated peak response (area or height units). For initial calibration, each compound's average response factor is determined by averaging the peak response results generated for the initial linearity study. These average response factors are programmed into the integrator to allow for direct concentration reading of contaminants found in subsequent sample analyses.

Continuing Calibration. Calibration of the analytical system should be updated three times daily, using the mid-concentration standard: (1) preceding the daily analysis, (2) mid-day and (3) after the daily analyses.

5.1.7 Gas Chromatography

Preconcentration of sample contaminants is achieved through the purge-and-trap process in which stripped volatile contaminants are adsorbed onto a sorbent trap. The affinity the volatilized organic contaminants have for the special packing inside the sorbent tube cause them to be retained within the tube (i e., adsorbed onto the packing), while other inert components pass through the tube. The purge and trap process consists of a prepurge cycle (optional), a purge cycle (during which contaminants are stripped away from the sample matrix and are trapped within the sorbent tube), a dry purge cycle (optional), a desorb cycle (in which the contaminants are backflushed off the sorbent tube and onto the GC column), and a bake cycle in which the sorbent tube (trap) is heated (with flow) to a high temperature, regenerating of the trap. The selection of the appropriate temperature, options, and duration of the purge and trap processes are contingent upon the target compounds being analyzed. Generally, the following range of conditions apply:

Cycle	Temperature	Duration
Purge	Ambient	8 - 10 minutes
Desorb	180°C	2 - 4 minutes
Bake	215°C	7 - 10 minutes

Desorption of the adsorbed contents of the sorbent trap onto the head of a previously conditioned GC analytical column allows for subsequent analysis by temperature-programmed gas chromatography. The desorbed contaminants are first held at constant temperature (usually in the range of 45-55°C) at the

head of the analytical column for a period of 3 to 5 minutes. After this initial time period, the GC oven temperature is raised at a constant rate (usually 8-15°C/minute) until a final temperature of 200-225°C is reached. The final temperature is customarily held for a period of 3 to 10 minutes.

The affinity of the volatile contaminants to either the analytical column's mobile or stationary phase, the effect of elevated temperature, and the action of the carrier gas flow through the column cause the volatile contaminants to become separated and resolved, allowing them to elute in bands through the selected detector. As long as the analytical conditions remain constant, each type of volatile component will elute at a characteristic retention time (RT). In this manner, sample contaminants are identified and quantified by comparison to a run of a standard mix containing known compounds concentrations.

Quantitation of volatile contaminants in aqueous matrix samples is calculated based upon the following formula:

$$\text{Concentration sample } (\mu g/L) = \text{target peak response (sample)} \times RF \times DF$$

$$\text{where: } RF \text{ (Response Factor)} = \frac{\text{Target Concentration Std. } (\mu g/L)}{\text{Target Peak Response Std.}}$$

DF (Dilution Factor) is used when applicable

5.2 Field Screening of Target Purgeable Volatile Organic Compounds (Solid Matrix)

5.2.1 Overview

The following methodology describes a modification of SW846 analytical procedures suitable for th determination of volatile organic contaminants in solid matrix samples.[2] Via this methodology a portion of sample matrix, or extract, is placed into a glass sparging vessel along with 5-10 mL of organic-free water. The sparge vessel is then sealed onto a purging device. The contained sample (or extract) aliquot is heated while a stream of inert gas is bubbled through the slurry. The mechanical bubbling action effectively strips the contaminants (now volatilized) from the matrix slurry and sweeps them onto a packed sorbent tube (i e., trap) where they are subsequently desorbed (by action of heat and revers gas flow) onto a suitable column housed by a pre-programmed gas chromatograph (GC). The volatile contaminants become separated and resolved as they travel through the GC column. Eventually the contaminants elute through an appropriate detector. The detector signals are processed and interpreted by a previously programmed integrator (see Figure 1 for a list of Potential Volatile Target Compounds).

5.2.2 Summary of Methods

Low Level Analysis. Use of a 5 gram sample is suggested to achieve reportable detection limits of approximately 5 μg/kg. The solid matrix (free of obvious pebbles and unrepresentative organic matter) should be quickly measured directly into a tared sparge vessel. After the exact weight of sample is recorded, 5 mL of organic-free water is introduced into the sparger. A heated purge is required.

[2] (SW846 Methods 5030, 8010, 8015, 8020, 8120, 8240, and 3580).

Medium Level Analysis. Simple dilutions may be achieved by using a reduced portion of the solid matrix (i e., 1-<5 grams) and a complementary portion of 9 to 5 mL organic-free water. For example, a 2.5X dilution can be simulated by adding 8 mL of organic-free water to 2 grams of weighed matrix. Moderate to high concentration samples are prepared by extracting a 5 gram portion of solid matrix with 10 mL methanol. A suitable aliquot of the methanol extract (usually 10 μL to 200 μL) is then spiked into a sparge vessel containing 10 mL organic-free water. Note that the 1:2 ratio of sample to solvent has introduced a two-fold dilution. The additional dilution factor based upon the μL injection used must also be taken into consideration.

5.2.3 Interferences

The analysis of volatile organic contaminants in solid matrix samples is susceptible to the same interferences discussed in Subsection 5.1.3. Additionally, some chromatographic artifacts may occur due to impurities present in the methanol used to extract medium/high concentration samples.

5.2.4 Major Apparatus and Materials

In addition to the equipment listed in Subsection 5.1.4, the following devices and materials are required:

Sparge Heater - Tekmar Model 4100 or equivalent. Must be capable of maintaining constant temperature during the purge process.

Pipettes - Assorted glass disposable: 1 mL, 5 mL, 10 mL

Vials - 15 mL septum-seal for storage of sample extracts.

Vials - 40 mL septum-seal for use in extracting contaminants from sample matrix.

Glass Marking Pen - For labeling vials.

Laboratory Timer - To use during the extraction process

Aluminum Weighing Pans - For use in determining moisture content of the sample matrix.

5.2.5 Reagents

Methanol - Pesticide grade or equivalent.

Organic-Free Water - Supplied by laboratory or purchased.

Neat Solvents - 96 percent purity or better for each compound of interest.

5.2.6 Calibration

Standard preparation, peak identification, initial linearity integration, and continuing calibration are accomplished as outlined in Subsection 5.1 6.

5.2.7 Sample Preparation

Medium to high concentration samples are extracted in methanol prior to chromatographic analysis. The following extraction protocol is suggested:

- Weigh and tare a 40 mL septum-seal vial using an analytical balance.
- Add 5.0 grams of sample matrix to the vial: record weight.
- Pipet a 10 mL volume of methanol into the vial. Assuming 100 percent transference of contaminants from matrix to methanol, note that a 2X dilution factor has been introduced.
- Remove the vial from the analytical balance, cap and shake vigorously for 2 full minutes (alternatively, vial contents may be sonicated).
- Set the vial aside and allow the contents to settle for 5 minutes.
- Pipet off the supernatant extract into a labeled 15 mL vial.
- Perform a gas chromatographic analysis by spiking 10 μL-200 μL of the methanol extract into approximately 10 mL organic-free water. Calculate total dilution (deviation) from the original 5 gram sample base.

5.2.8 Gas Chromatography

The same chromatographic theory and GC run conditions outlined in Subsection 5.1.7 are applicable to the volatile organic analysis of solid matrix samples with the following additions:

Prepurge and dry-purge options of the purge and trap process are recommended; a heated purge is required. Sample prepurge enhances subsequent chromatography by allowing air molecules present in the sparge vessel to be replaced by inert purge gas molecules prior to the actual purge cycle. The dry-purge option follows the purge cycle. Dry-purge removes water vapor from the trap tube prior to the desorb cycle. The selection of appropriate purge and trap conditions are contingent upon the target compounds being analyzed. Generally, the following range of conditions apply:

Cycle	Temperature	Duration
Prepurge/Preheat	Ambient/to 40°C	2 minutes/1 minute
Purge	40°C	8 - 10 minutes
Dry-Purge	40°C	2 minutes
Desorb	180°C	3 - 5 minutes
Bake	215°C	7 - 10 minutes

Due to the extraction process and the need to correct the final value for moisture content, the quantitation of volatile contaminants in solid matrix samples is calculated based upon the following formula:

Concentration (µg/kg) = Sample Peak Response (Area or Height) x RF x 1/wt. of sample extract(g) x final volume (mL) x 1% solids

$$\text{where: } RF\ (\text{Response Factor}) = \frac{\text{Target Conc. Std. } (\mu g/L)}{\text{Target Peak Response Std.}}$$

$$\%\ solids = 100 - \%\ moisture$$

$$\%\ moisture = \frac{\text{Wet wt.} - \text{Dry wt.}}{\text{Wet wt.}} \times 100$$

The protocol for determining percent moisture is presented in Subsection 5.12.

5.3 Field Screening of Target Semivolatile Organic Compounds (Aqueous Matrix)

5.3.1 Overview

The following methodology describes a modification of SW846 preparative and EPA 600 series analytical gas chromatographic procedures suitable for the determination of semi-volatile contaminants in aqueous matrix samples.[3] Via this methodology, a portion of neat sample is extracted using rapid field techniques. An aliquot of sample extract is then directly injected onto an analytical column housed by a previously calibrated gas chromatograph (GC). The semi-volatile compounds are resolved by temperature-programmed gas chromatography and are detected by an FID (Flame Ionization Detector). The detector signals are processed and interpreted via a previously programmed integrator. Figure 2 provides a list of Potential Target Compounds).

5.3.2 Summary of Method

Low Level Analysis - Use of 25 mL neat sample aliquot is suggested. Detection limits vary per each compound sensitivity to the detector. Detection limits of approximately 100 µg/L to 800 µg/L are achievable.

Medium Level Analysis - Proportioned dilutions may be achieved by using a reduced sample aliquot. For example, a five-fold dilution can be simulated by extracting only 5 mL neat sample while retaining the same volume of extraction solvent.

[3] (SW846 Methods 3550 and 3580; EPA Methods 604, 605, 610, 611, and 625).

FIGURE 2

SUMMARY OF POTENTIAL TARGET COMPOUNDS

(Semivolatile Organics Analysis)	
Acenaphthene	Hexachloroethane
Acenaphthylene	Naphthalene
Anthracene	2-Chloronaphthalene
Benzo(a)anthracene	2-Methylnaphthalene
Benzo(a)pyrene	Phenanthrene
total Benzofluoranthenes	Pyrene
Butyl benzyl phthalate	1,2,4-Trichlorobenzene
Chrysene	total Dichlorobenzenes
Diethyl phthalate	Phenol
Dimethyl phthalate	2-Chlorophenol
Di-n-butyl phthalate	2,4-Dichlorophenol
Di-n-octyl phthalate	2,4,5-Trichlorophenol
Fluoranthene	2,4,6-Trichlorophenol
Fluorene	2-Methylphenol
Hexachlorobenzene	4-Methylphenol
Hexachlorobutadiene	2,4-Dimethylphenol
Hexachlorocyclopentadiene	4-Chloro-3-methylphenol

5.3.3 Interferences

Interferences inherent to this procedure stem from four major sources: (1) impurities present in the solvents used for extraction, (2) system artifacts caused by insufficient column conditioning (3) residual contamination remaining on improperly cleaned glassware and (4) matrix interferences caused by co-extracted organic matter.

Interferences in the analytical system are monitored by the analysis of method blanks. Method blanks are analyzed under the same conditions and at the same time as standards and samples, in order to establish average background response.

Artifacts, which manifest themselves as carryover in the next analytical run, can also occur within the analytical apparatus whenever a highly contaminated sample is introduced. To preclude this from occurring, injection syringes are repeatedly flushed with solvent and the analytical column is baked for a short period of time following each direct injection analysis.

5.3.4 Major Apparatus and Materials

Gas Chromatograph - Hewlett Packard 5890 or equivalent. The analytical system should be equipped for packed or capillary column analysis with a temperature programmable oven and on-column injection capabilities.

Detector - Flame Ionization Detector (FID).

Analytical Column - Better resolution is achieved through use of a capillary column (such a DB-5 or equivalent). However, a packed column, such as 3 percent SP-2250 on 100/120 mesh Supelcoport, is more practical for field use.

Syringes - Assorted: 5 µL, 25 µL, 100 µL, 1 mL.

Analytical Balance - Capable of accurately weighing 0.0001 g.

Vials - 40 mL septum-seal for extraction.

Vials - 2 dram septum-seal for extract storage.

Pipets - Assorted: 1 mL, 5 mL, 10 mL; disposable glass.

Refrigerator - Separate for sample and standard storage. Capable of maintaining a stable temperature of 4°C.

Glass Marking Pen - For labeling vials.

Laboratory Timer - To use during the extraction process.

Hydrion Paper - To measure pH.

5.3.5 Reagents

Methanol - Pesticide grade or equivalent.

Methylene Chloride - Pesticide grade or equivalent.

Sulfuric Acid - 1N, reagent grade.

Neat Standards - 96 percent purity or better for each compound of interest.

5.3.6 Calibration

Standards. Calibration standards containing the compounds of interest are prepared from commercially purchased standard mixes or pure compound. All standards are made and/or diluted using a 1:1 mixture of methylene chloride: methanol and are created for use via a 2 μL direct injection.

Peak Identification. Compound identities may be substantiated by the analysis of each individual component thereby documenting compound retention time.

Initial Linearity. An initial three point calibration curve is generated by the analysis of multiple-aliquot injections of calibration standard. For example, if the calibration standard is created such that a 2 μL spike yields results at the level of the reported detection limits, a three-point calibration curve may be achieved by the analysis of 2 μL, 5 μL and 10 μL aliquot spikes.

Calibration. Calibration of the analytical system is achieved via the external standard method, in which response factors (RF) for each compound are obtained by the analysis of a standard mix of known concentration. Following the analysis of this known standard mix, an electronic file is created establishing each peak's identity, retention time, RF and known concentration. The RF for each peak is determined by dividing the known concentration by the peak response (area or height units) of the associated peak. For initial calibration, each compound's average response factor is determined by averaging the peak response results generated for the initial linearity study. These average response factors are programmed into the integrator to allow for direct concentration reading of contaminants found in subsequent sample analyses.

Continuing Calibration. Calibration of the analytical system should be updated three times daily: (1) preceding the daily analyses, (2) mid-day and (3) after the daily analyses. Continuing calibration should be conducted at a concentration level equal to the reported detection limits.

5.3.7 Sample Preparation

All samples must be extracted prior to chromatographic analysis. A suggested protocol follows:

- Pipet 25 mL of aqueous sample matrix each into two 40 mL septum-seal vials: discard pipet.
- Add exactly 2 5 mL of methylene chloride to one of the vial's contents.
- Adjust the pH of the other vial's contents to pH<2 using sulfuric acid.

  Add exactly 2.5 mL methylene chloride to the adjusted contents of the second vial.

- Cap the vials and shake vigorously for 2 full minutes.
- Set the vials aside and allow the contents to settle for 5 minutes.
- Combine the extracts by pipetting exactly 1 5 mL each of the supernatant extracts into a 2 dram septum-seal vial.
- Gas chromatographic analysis is performed by directly injecting 2-5 μL of combined sample extract onto the GC's analytical column.

5.3.8 Gas Chromatography

Sample contaminants are first stripped from the matrix by means of methylene chloride extraction (see Subsection 5 3.7). A 2-5 μL aliquot of the sample extract is introduced onto the head of a previously conditioned analytical column by means of direct injection technique. The semi-volatile contaminants are then resolved by temperature-programmed gas chromatography in which the action of carrier gas flow, elevated temperatures and the affinity each semi-volatile compound has for the phases of the column packing cause the contaminants to separate into bands. As the bands of contaminants elute from the column, they are recognized by an FID (Flame Ionization Detector). Detector signals are then processed by a previously programmed integrator. As long as analytical conditions remain constant, each semivolatile compound will elute at a characteristic retention time (RT). In this manner, sample contaminants are identified and quantified by comparison to a run of standard mix of known concentration.

Under the following run conditions, most compounds of interest will elute within 32 minutes:

Run Parameter	Setting
Initial Column Temperature	100°C
Initial Hold Time	1 minute
Rate	10°C/minute
Final Column Temperature	300°C
Carrier Gas Flow	20 mL/minute

These conditions will need to be adjusted as necessary in order to optimize the resolution of the specific compounds of interest.

Appropriate quantitation of sample contaminants is based upon the following formula:

$$\text{Concentration } (\mu g/L) = \text{Target peak response (sample)} \times RF \times DF$$

$$\text{where: } RF \text{ (Response Factor)} = \frac{\text{Target Concentration Std. } (\mu g/L)}{\text{Target Peak Response}}$$

DF (Dilution Factor) is used when applicable

5.4 Field Screening of Target Semivolatile Organic Compounds (Solid Matrix)

5.4.1 Overview

The following methodology describes a modification of SW846 analytical gas chromatographic procedures suitable for the determination of semi-volatile organic contaminants in solid matrix samples.[4] Via this methodology, a 2 gram portion of a solid sample is extracted using rapid field techniques. An aliquot of the sample extract is then directly injected onto an analytical column for analyses by temperature-programmed gas chromatography. The semi-volatile contaminants are subsequently analyzed by a flame ionization detector (FID). The detector signals are processed by a previously programmed integrator (see Figure 2 for a list of Potential Target Compounds).

5.4.2 Summary of Methods

Low Level Analysis - The extraction of a 2 gram sample portion is suggested to achieve analytical results comparable to approximately 50 mg/kg reportable detection limits.

Medium Level Analysis - Sample dilutions are achieved by diluting a portion of the sample extract (as above) in an appropriate volume of methylene chloride.

5.4.3 Interferences

The analysis of semi-volatile contaminants in solid matrix samples is susceptible to the same interferences discussed in Subsection 5.3.3.

5.4.4 Major Apparatus and Materials

In addition to the equipment listed in Subsection 5 3.4 the following device is required.

Oven - Constant temperature: for use in the determination of moisture content.

[4] (SW864 Methods 3550 and 3580; 8040; 8060; 8100; 8270; and 8310).

5.4.5 Reagents

Methanol - Pesticide grade or equivalent.

Methylene Chloride - Pesticide grade or equivalent.

Sulfuric Acid - 1N, reagent grade.

Neat Standards - 96 percent purity or better for each compound of interest.

Anhydrous Sodium Sulfate - Used to remove moisture from the sample matrix.

5.4.6 Calibration

Standard preparation, peak identification, initial linearity, integration and continuing calibration are accomplished as outlined in Subsection 5 3.6.

5.4.7 Sample Preparation

All samples must be extracted prior to chromatographic analysis. A suggested protocol follows:

- Weigh and tare two 40 mL septum-seal vials using an analytical balance.
- Add 2.0 grams of sample matrix (each) to the two vials. Record both sample weights.
- Add approximately 2 grams of anhydrous sodium sulfate to each vial. Mix the vial contents thoroughly using a clean spatula.
- Add exactly 10 mL of methylene chloride to each vial.
- Invert one vial several times to mix. Adjust the pH of this vial's contents to pH<2 using sulfuric acid.
- Cap the vial and shake vigorously for 2 full minutes (alternately, vial contents may be sonicated).
- Set the vials aside and allow the contents to settle for 5 minutes.
- Combine the extracts by pipetting off exactly 1 5 mL each of the supernatant extracts into a labeled 2-dram septum-seal vial.
- Gas chromatographic analysis is performed by directly injecting a 2-5 μL aliquot of the combined sample extract onto the GC's analytical column.

5.4.8 Gas Chromatography

The same chromatographic theory and GC run conditions outlined in Subsection 5.3.8 are applicable to the semivolatile analysis of solid matrix samples, with one addition:

Due to the extraction process and the need to correct the final value for moisture content, the quantitation of semi-volatile contaminants in solid matrix samples is calculated based upon the following formula:

Concentration (µg/kg) = Sample Peak Response (Area or Height) x RF x 1/wt. of sample extract(g) x final volume (mL) x 1% solids

$$\text{where: } RF\ (\text{Response Factor}) = \frac{\text{Target Conc. Std. } (\mu g/L)}{\text{Target Peak Response Std.}}$$

$$\%\ solids = 100 - \%\ moisture$$

$$\%\ moisture = \frac{\text{Wet wt.} - \text{Dry wt.}}{\text{Wet wt.}} \times 100$$

The protocol for determining percent moisture is presented in Subsection 5.12.

5.5 Field Screening of Organochlorine Pesticides (Aqueous Matrix)

5.5.1 Overview

The following methodology describes a modification of EPA Method 608. This methodology is suitable for the determination of organochlorine pesticide contaminants in aqueous matrix samples. Via this methodology, a portion of neat sample is extracted using rapid field techniques. An aliquot of sample extract is then directly injected onto an analytical column housed in a previously calibrated gas chromatograph (GC). The pesticide contaminants are resolved isothermally and are detected by an electron capture detector (ECD). Detector signals are processed and interpreted via a previously programmed integrator. Figure 3 provides a list of Potential Target Compounds.

5.5.2 Summary of Methods

Low Level Analysis. A 20 mL neat sample aliquot is suggested to achieve method detection limits of approximately 0 5 µg/L.

Medium Level Analysis. Proportioned dilutions may be achieved by using a reduced sample aliquot. For example, a five-fold dilution can be simulated by extracting only 4 mL neat sample while retaining the same volume of extraction solvent.

5.5.3 Interferences

Interferences inherent to this procedure stem from four major sources: (1) impurities present in the solvents used for extraction, (2) system artifacts caused by insufficient column conditioning (3) residual contamination remaining on improperly cleaned glassware and (4) matrix interferences caused by co-extracted organic matter.

Interferences in the analytical system are monitored by the analysis of method blanks. Method blanks are analyzed under the same conditions and at the same time as standards and samples, in order to establish average background response.

FIGURE 3

SUMMARY OF POTENTIAL TARGET COMPOUNDS

(Organochlorine Pesticide Analysis)
Alpha-BHC
Beta-BHC
Delta-BHC
Gamma-BHC (Lindane)
Aldrin
Chlordane
Dieldrin
Endosulfan I
Endosulfan II
Endosulfan sulfate
Endrin
Heptachlor
Heptachlor epoxide
4,4-DDD
4,4-DDE
4,4-DDT

Artifacts, which manifest themselves as carryover in the next analytical run, can also occur within the analytical apparatus whenever a highly contaminated sample is introduced. To preclude this, injection syringes are repeatedly flushed with solvent and the analytical column is baked for a short period of time following each direct injection analysis.

5.5.4 Major Apparatus and Materials

Gas Chromatograph - Hewlett Packard 5890 or equivalent. The analytical system should be equipped for packed or capillary column analysis with isothermal oven and on-column injection capabilities.

Detector - Electron Capture Detector (ECD)

Analytical Column - Glass or stainless steel packed with 1.5 percent SP-2250/1.95 percent SP-2401 on 100/120 mesh Supelcoport. Alternately, a 3 percent OV-1 on 80/100 mesh Supelcoport packed column or a suitable capillary column may be used.

Syringes - Assorted: 5 μL, 25 μL, 100 μL, 1 mL

Analytical Balance - Capable of accurately weighing 0.0001 g.

Vials - 40 mL septum-seal for extraction.

Vials - 2 dram septum-seal for extract storage.

Glass Marking Pen - For labeling vials.

Laboratory Timer - To use during the extraction process.

Pipets - Assorted: 1 mL, 5 mL, 10 mL; disposable glass.

Refrigerator - Separate for sample and standard storage. Capable of maintaining a stable temperature of 4°C.

5.5.5 Reagents

Hexane - Pesticide grade or equivalent.

Iso-octane - Distilled in glass.

Neat Standards - 96 percent purity or better for each compound of interest.

Zero-Grade Nitrogen - As carrier gas for the gas chromatograph (GC).

5.5.6 Calibration

Standards. Calibration standards containing the compounds of interest are prepared from commercially purchased standard mixes or pure compound. All standards are made and/or diluted using iso-octane and are created for use via a 2 μL injection. An example of a working calibration standard within a practical concentration range follows:

Compound	Concentration
Lindane	0.0125 ng/μL
Aldrin	0.0250 ng/μL
4,4'-DDT	0.0625 ng/μL

Peak Identification. Compound identities may be substantiated by the analysis of each individual component thereby documenting compound retention time.

Initial Linearity. An initial three-point calibration curve is generated by the analysis of multiple-aliquot injections of calibration standard. For example, if the calibration standard is created such that a 2 μL spike yields results at the level of the reported detection limits, a three-point calibration curve may be achieved by the analysis of 2 μL, 5 μL, and 10 μL aliquot spikes.

Calibration. Calibration of the analytical system is achieved via the external standard method in which response factors (RF) for each compound are obtained by the analysis of a standard mix of known concentration. Following the analysis of this known standard mix, an electronic file is created establishing each peak's identity, retention time, RF, and known concentration. The RF for each peak is determined by dividing the known concentration by the peak response (area or height units) of the associated peak. For initial calibration, each compound's average response factor is determined by averaging the peak response results generated for the initial linearity study These average response factors are programmed into the integrator to allow for direct concentration reading of contaminants found in subsequent sample analyses.

Continuing Calibration. Calibration of the analytical system should be updated three times daily: (1) preceding the daily analysis, (2) mid-day, and (3) after the daily analysis. Continuing calibration should be conducted at a concentration level equal to the reported detection limits.

5.5.7 Sample Preparation

All samples must be extracted prior to chromatographic analysis. Samples are extracted in hexane according to the following suggested protocol:

- Pipet 20 mL aqueous sample matrix into a 40 mL septum-seal vial: discard pipet.
- Add exactly 2.0 mL hexane to the measured matrix aliquot.
- Cap the vial and shake vigorously for 2 full minutes.
- Set the vial aside and allow the contents to settle for 5 minutes.

- Pipet off the supernatant extract into a labeled 2 dram septum-seal vial.
- Gas chromatographic analysis is performed by directly injecting 2-5 μL of sample extract onto the GC's analytical column.

5.5.8 Gas Chromatography

Sample contaminants are first stripped from the matrix by means of hexane extraction (see Subsection 5.5.7). A 2-5 μL aliquot of the sample extract is introduced onto the head of a previously conditioned analytical column by means of direct injection technique. The organochlorine pesticide compounds are resolved isothermally due to the affinity each compound has for the phases of the column packing as they migrate (under flow) through the analytical column. As the contaminants elute from the column, they are recognized by an electron capture detector (ECD). Detector signals are then processed by a previously programmed integrator As long as analytical conditions remain constant, each type of organochlorine compound will elute at a characteristic retention time (RT) In this manner, sample contaminants are identified and quantified by comparison to a run of standard mix of known concentration.

Under the following run conditions all commonly targeted organochlorine pesticides will elute within 15 minutes:

Injection Port Temperature	300°C
Isothermal Oven Temperature	215°C
Detector Temperature	350°C
Carrier Gas Flow	70 mL/minute

Appropriate quantitation of sample contaminants is based upon the following formula:

$$\textit{Concentration } (\mu g/L) = \textit{Target Peak Response (Sample)} \times RF \times DF$$

$$\textit{where: } RF \textit{ (Response Factor)} = \frac{\textit{Target Concentration Std. } (\mu g/L)}{\textit{Target Peak Response Std.}}$$

DF (Dilution Factor) is used when applicable

5.6 Field Screening of Organochlorine Pesticides (Solid Matrix)

5.6.1 Overview

The following methodology describes a modification of SW846 analytical gas chromatographic procedures suitable for the determination of organochlorine pesticide contaminants in solid matrix samples.[5] Via this methodology, a 5 gram portion of solid sample is extracted using rapid field

[5] (SW8465 Methods 3550, 3580, and 8080).

techniques. A 2-5 μL aliquot of sample extract is then directly injected onto an analytical column for the isothermal resolution of target compounds. The organochlorine pesticide contaminants are detected by an electron capture detector (ECD). Detector signals are processed and interpreted via a previously programmed integrator.

5.6.2 Summary of Method

Low Level Analysis - Use of a 5 gram portion of sample is suggested to achieve method detection limits of approximately 25 μg/kg.

Medium Level Analysis - Sample dilutions are achieved by diluting a portion of the sample extract (as above) in an appropriate volume of iso-octane.

5.6.3 Interferences

The analysis of organochlorine pesticide contaminants in solid matrix samples is susceptible to the same interferences discussed in Subsection 5.5.3.

5.6.4 Major Apparatus and Materials

In addition to the equipment listed in Subsection 5.5.4, the following device is required:

Oven - Constant temperature; for use in the determination of moisture content.

5.6.5 Reagents

Hexane - Pesticide grade or equivalent.

Iso-Octane - Distilled in glass.

Neat Standards - 96 percent purity or better for each compound of interest.

Zero-Grade Nitrogen - As carrier gas for the gas chromatograph (GC).

Anhydrous Sodium Sulfate - Used to remove moisture from the portion of soil prior to extraction.

5.6.6 Calibration

Standard preparation, peak identification, initial linearity, integration and continuing calibration are accomplished as outlined in Subsection 5.5.6.

5.6.7 Sample Preparation

All samples must be extracted prior to chromatographic analysis. A suggested extraction protocol follows:

- Weigh and tare a 40 mL septum-seal vial using an analytical balance.

  Add 5.0 grams of sample matrix to the vial; record weight.

- Add approximately 3 grams of anhydrous sodium sulfate; mix thoroughly using a clean spatula.
- Pipet exactly 8.0 mL of hexane into the vial.
- Cap the vial and shake vigorously for 2 full minutes (alternately, vial contents may be sonicated).
- Set the vial aside and allow the contents to settle for 5 minutes.
- Pipet off the supernatant extract into a labeled 2 dram septum-seal vial.
- Gas chromatographic analysis is performed by directly injecting 2-5 μL of sample extract onto the GC's analytical column.

5.6.8 Gas Chromatography

The same chromatographic theory and GC run conditions outlined in Subsection 5.5.8 are applicable to the pesticide analysis of solid matrix samples, with one modification:

Due to the need to correct the final value for moisture content, the quantitation of pesticide contaminants in solid matrix samples is calculated based upon the following formula:

Concentration (μg/kg) = *Sample Peak Response (Area or Height) x RF x 1/wt. of sample extract(g) x final volume (mL) x 1% solids*

$$\text{where: } RF \text{ (Response Factor)} = \frac{\text{Target Conc. Std. } (\mu g/L)}{\text{Target Peak Response Std.}}$$

$$\%\ solids = 100 - \%\ moisture$$

$$\%\ moisture = \frac{\text{Wet wt} - \text{Dry wt.}}{\text{Wet wt.}} \times 100$$

The protocol for determining percent moisture is presented in Subsection 5.12.

5.7 Field Screening of Polychlorinated Biphenyl (PCB) Compounds (Aqueous Matrix)

5.7.1 Overview

The following methodology describes a modification of EPA Methods 608 and 625. This methodology is suitable for the determination of polychlorinated biphenyl (PCB) contaminants in aqueous matrix samples. Via this methodology, a portion of neat sample is extracted using rapid field techniques. An aliquot of sample extract is then directly injected onto an analytical column housed by a previously calibrated gas chromatograph (GC) The PCB contaminants are resolved isothermally and are detected by an electron capture detector (ECD). Detector signals are processed and interpreted via a previously programmed integrator (see Figure 4 for a list of Potential Target Compounds).

FIGURE 4

SUMMARY OF POTENTIAL TARGET COMPOUNDS

(PCB Analysis)
Aroclor-1016
Aroclor-1221
Aroclor-1242
Aroclor-1248
Aroclor-1254
Aroclor-1260

5.7.2 Summary of Method

Low Level Analysis - A 20 mL neat sample aliquot is suggested to achieve method detection limits of approximately 15 μg/L.

Medium Level Analysis - Proportioned dilutions may be achieved by using a reduced sample aliquot. For example, a five-fold dilution can be simulated by extracting only 4 mL neat sample while retaining the same volume of extraction solvent.

5.7.3 Interferences

Interferences inherent to this procedure stem from four major sources: (1) impurities present in the solvents used for extraction, (2) system artifacts caused by insufficient column conditioning (3) residual contamination remaining on improperly cleaned glassware and (4) matrix interferences caused by co-extracted organic matter.

Interferences in the analytical system are monitored by the analyses of method blanks. Method blanks are analyzed under the same conditions and at the same time as standards and samples, in order to establish average background response.

Artifacts (which manifest themselves as carryover in the next analytical run) can also occur within the analytical apparatus whenever a highly contaminated sample is introduced. To preclude this, injection syringes are repeatedly flushed with solvent and the analytical column is baked for a short period of time following each direct injection analysis.

5.7.4 Major Apparatus and Materials

Gas Chromatograph - Hewlett Packard 5890 or equivalent. The analytical system should be equipped for packed or capillary column analysis with isothermal oven and on-column injection capabilities.

Detector - Electron Capture Detector (ECD).

Analytical Column - Glass or stainless steel packed with 1 5 percent SP-2250/1 95 percent SP-2401 on 100/120 mesh Supelcoport or equivalent. Alternately, a suitable capillary column may be used

Syringes - Assorted: 5 μL, 25 μL, 100 μL, 1 ml

Analytical Balance - Capable of accurately weighing 0 0001 g.

Vials - 40 mL septum-seal for sample extraction.

Glass Marking Pen - For labeling vials.

Laboratory Timer - For use during the extraction process

Vials - 2 dram septum-seal for extract storage.

Pipets - Assorted: 1 mL, 5 mL, 10 mL; disposable glass.

Refrigerator - Separate for sample and standard storage. Capable of maintaining a stable temperature of 4°C.

5.7.5 Reagents

Hexane - Pesticide grade or equivalent.

Neat Standards - 96 percent purity or better for each compound of interest.

Zero-Grade Nitrogen - As carrier gas for the gas chromatograph (GC).

5.7.6 Calibration

Standards. A singular calibration standard for each PCB compound is prepared from commercially purchased standards or pure compound. All standards are made and/or diluted using hexane and are created for use via a 2 μL injection. A working calibration standard concentration of 0.375 ng/μL for each arochlor is usually practical.

Peak Identification. Each PCB compound is identified by its unique pattern (fingerprint). The identity of each target arochlor is substantiated by the singular analysis of each individual arochlor.

Calibration. Calibration of the analytical system is achieved via the external standard method in which response factors (RF) for each individual arochlor are obtained by the analysis of a standard of known concentration. For each arochlor analyzed, the responses of several peaks characteristic to that particular arochlor are summated. Following the analysis of this known standard, a file is created noting each arochlor's pattern (i.e., the retention times of each characteristic peak), the appropriate RF and known concentration. The RF for each arochlor is determined by dividing the arochlor's known concentration by the summated peak responses (area or height units) which were taken from the associated pattern. The concentration of PCB contaminants in samples is usually hand calculated by manually summating the responses of the characteristic peaks and comparing them to the analogous summated peaks designated in the arochlor standard.

Continuing Calibration - Calibration of the analytical system is performed three times daily: (1) preceding the daily analyses, (2) mid-day and (3) after the daily analyses. Continuing calibration should be conducted at a concentration level equal to the reported detection limits.

5.7.7 Sample Preparation

All samples must be extracted prior to chromatographic analysis. A suggested protocol for hexane extraction follows:

- Pipet 20 mL aqueous sample matrix into a 40 mL septum-seal vial; discard pipet.
- Add exactly 2.0 mL hexane to the measured matrix aliquot.
- Cap the vial and shake vigorously for 2 full minutes.
- Set the vial aside and allow the contents to settle for 5 minutes.
- Pipet off the supernatant extract into a labeled 2-dram septum-seal vial.
- Gas chromatographic analysis is performed by directly injecting 2-5 μL of sample extract onto the GC's analytical column

5.7.8 Gas Chromatography

Sample contaminants are first stripped from the matrix by means of hexane extraction (see Subsection 5.7.7). A 2-5 μL aliquot of the sample extract is introduced onto the head of a previously conditioned analytical column by means of direct injection technique. The PCB compounds are resolved

isothermally due to the affinity the PCB components have for the phases of the column's packing as they migrate (under flow) through the analytical column. As the contaminants elute from the column, they are recognized by an electron capture detector (ECD). Detector signals are then processed by an integrator. As long as analytical conditions remain constant, each PCB pattern will elute at characteristic retention times (RT). In this manner, sample contaminants are identified and quantified by comparison to a run of standards of known concentration.

The following run conditions have been found to be practical for the analysis of PCB compounds analyzed by field screening techniques:

Run Parameter	Setting
Injection Port Temperature	280°C
Isothermal Oven Temperature	215°C
Detector Temperature	300°C
Carrier Gas Flow	30 mL/minute

Under these conditions, arochlor-1260 will elute within 35 minutes.

Appropriate quantitation of sample contaminants is based upon the following formula:

$$\text{Concentration } (\mu g/L) = \Sigma \text{ designated peak responses (sample)} \times RF \times DF$$

$$\text{where: } RF \text{ (Response Factor)} = \frac{\text{Concentration standard}}{\Sigma \text{ designated peak responses std.}}$$

DF (Dilution Factor) is used when applicable

5.8 Field Screening of Polychlorinated Biphenyl (PCB) Compounds (Solid Matrix)

5.8.1 Overview

The following methodology describes a modification of SW846 Methods suitable for the determination of polychlorinated biphenyl (PCB) contaminants in solid matrix samples.[6] Via this methodology, a 5 gram portion of solid sample is extracted using rapid field techniques. A μL aliquot of sample extract is then directly injected onto an analytical column for the isothermal resolution of target components. The PCB pattern is recognized by an electron capture detector (ECD) with detector signals processed by a previously programmed integrator (see Figure 4 for a list of Potential Target Compounds).

5.8.2 Summary of Methods

Low Level Analysis - Use of a 5 gram portion of sample matrix is suggested to achieve method detection limits of approximately 100 μg/kg.

[6] (SW846 Methods 3550, 3580, and 8080).

Medium Level Analysis - Sample dilutions are achieved by diluting a portion of the sample extract (as above) in an appropriate volume of hexane.

5.8.3 Interferences

Interferences inherent to this procedure stem from four major sources: (1) impurities present in the solvents used for extraction, (2) system artifacts caused by insufficient column conditioning (3) residual contamination remaining on improperly cleaned glassware and (4) matrix interferences caused by co-extracted organic matter.

Interferences in the analytical system are monitored by the analysis of method blanks. Method blanks are analyzed under the same conditions and at the same time as standards and samples, in order to establish average background response.

Artifacts (which manifest themselves as carryover in the next analytical run) can also occur within the analytical apparatus whenever a highly contaminated sample is introduced. To preclude this, injection syringes are repeatedly flushed with solvent and the analytical column is baked for a short period of time following each direct injection analysis.

5.8.4 Major Apparatus and Materials

In addition to the equipment listed in Subsection 5.7.4, the following device is required:

Oven - Constant temperature for use in the determination of moisture content.

5.8.5 Reagents

Methanol - Pesticide grade or equivalent.

Hexane - Pesticide grade or equivalent

Neat Compounds - 96 percent purity or better for each arochlor of interest.

Organic-Free Water - Laboratory supplied or purchased.

Zero-grade Nitrogen - As carrier gas for the gas chromatograph (GC)

5.8.6 Calibration

Standard preparation, compound identification, integration and continuing calibration are accomplished as outlined in Subsection 5.7 6.

5.8.7 Sample Preparation

All samples must be extracted prior to chromatographic analysis A suggested protocol for hexane extraction follows

- Weigh and tare a 40 mL septum-seal vial using an analytical balance.
- Add 5.0 grams of sample matrix to the vial; record weight.

- Pipet approximately 1.5 mL of organic-free water into the vial. (The water serves as a wetting agent thus facilitating the transference of the PCB compounds from the soil matrix into the methanol.)
- Pipet approximately 2 mL of methanol into the vial.
- Pipet exactly 2.5 mL of hexane into the vial. (By preference, the PCB compounds almost exclusively partition into the hexane.)
- Cap the vial and shake vigorously for 2 full minutes (alternately, vial contents may be sonicated).
- Pipet off the supernatant extract into a labeled 2 dram septum-seal vial.
- Gas chromatographic analysis is performed by directly injecting 2-5 μL of sample extract onto the GC's analytical column.

5.8.8 Gas Chromatography

The same chromatographic theory and GC run conditions outlined in Subsection 5.7 8 are applicable to the PCB analysis of solid matrix samples, with one modification.

Due to the need to correct the final value for moisture content, the quantitation of PCB contaminants in solid matrix samples is calculated based upon the following formula:

$$\text{Concentration } (\mu g/kg) = \Sigma \text{ designated peak responses (sample)} \times RF \times 1/\text{wt. of sample extract}(g) \times \text{final volume } (mL) \times 1\% \text{ solids}$$

$$\text{where: } RF \text{ (Response Factor)} = \frac{\text{Concentration Standard}}{\Sigma \text{ designated peak responses std.}}$$

$$\%\ solids = 100 - \%\ moisture$$

$$\%\ moisture = \frac{\text{Wet wt.} - \text{Dry wt.}}{\text{Wet wt.}} \times 100$$

The protocol for determining percent moisture is presented in Subsection 5 12.

5.9 Field Screening Analysis of Ambient Air

5.9.1 Overview

The following methodology describes a modification of EPA Compendium methods suitable for the determination of volatile organic contaminants in ambient air.[7] Via this methodology, an aliquot of gaseous sample is routed through a packed sorbent tube. Volatile contaminants present in the gaseous sample are adsorbed onto the packing within the sorbent tube. The contents of the sorbent tube are

[7] (EPA Compendium Methods TO-1, TO-2, TO-3, and TO-12).

subsequently desorbed (by action of heat and reverse gas flow) onto a suitable column housed by a pre-programmed gas chromatograph (GC). The contaminants become separated and resolved as they travel through the GC's column. Eventually, the contaminants elute through an appropriate detector. Detector signals are processed and interpreted via a previously programmed integrator (see Figure 1 for a list of Potential Target Compounds).

5.9.2 Summary of Method

The procedure described here is based upon the analysis of whole air samples collected in canisters or Tedlar bags. However, this procedure can easily be adapted for the analysis of samples collected directly on sorbent tubes or for source sample analysis using aliquot introduction into the GC via direct gaseous injection or an appropriate size commercial sample loop.

5.9.3 Interferences

Interferences can result from many sources, considering the environmental settings of most hazardous waste sites. However, most interfering impurities are artifacts originating from organic compounds within the specialty gases and the plumbing within the trapping/desorption device. Interferences in the analytical system are monitored by the analysis of inert gas method blanks. Method blanks are analyzed under the same conditions and at the same time as standards and samples, to establish an average background response.

5.9.4 Major Apparatus and Materials

Purge and Trap Device - Tekmar Company Model LSC-2 or Model 5000. Traps may be packed solely with Tenax or alternately, trap packing may consist of 1 0 cm of 3 percent OV-1, 15 cm of Tenax and 8 cm of silica gel. Appropriate trap selection is contingent upon the target compounds being analyzed.

Gas Chromatograph - Hewlett Packard 5890 or equivalent. The analytical system should be equipped for temperature programming, packed and/or capillary column analysis and on-column injection.

Detector - PID/FID or PID/HECD in series: FID only Optimum detector selection should be based upon the sensitivities of the target compounds being analyzed.

Analytical Column - Glass or stainless steel packed with 1 percent SP-1000 on 60/80 mesh Carbopack B. Alternately a suitable capillary column may be used.

Syringes - Assorted. 5 μL, 25 μL, 100 μL, 1 mL, 10 mL.

Volumetric Flasks - 10 mL, 25 mL, 100 mL.

Tedlar Bag - For making gaseous standards.

Flow Meter - For use in measuring the exact volume of gas introduced to the Tedlar

Analytical Balance - Capable of accurately weighing 0.0001 g

Vacuum Pump - Low draw positive seal.

Refrigerator - Separate for sample and standard storage. Capable of maintaining a stable temperature of 4°C.

5.9.5 Reagents

Methanol - Pesticide grade or equivalent.

Organic-Free Water - Supplied by laboratory or purchased.

Neat Solvents - 96 percent purity or better for each compound of interest.

Ultra-high Purity Nitrogen - For use in generating standards and method blanks.

5.9.6 Calibration

Standards. Calibration standards containing the compounds of interest are prepared in methanol by either diluting commercially purchased stock standard mixes or by creating in-house standards from pure solvents. In-house calibration standards are prepared gravimetrically, in that an appropriate μL aliquot of each target compound is introduced into a known volume of methanol. The appropriate μL aliquot of compound is based upon the compound's density and response to the selected detector. The calibration standards should be created at such a level that a 5-10 μL spike into a 1 liter Tedlar bag filled with nitrogen yields a concentration of 10 μg/L based upon the analysis of a 500 mL aliquot. Aliquots are evacuated onto a clean trap. Alternately, commercially prepared stock calibration gases may be used.

Peak Identification. Compound identities may be substantiated by the analysis of each individual component thereby documenting compound retention time.

Initial Linearity. An initial three-point calibration curve is generated by the trapping and analysis multiple aliquots of calibration standard. For example, if the calibration standard is created such that analysis of a 500 mL aliquot of standard yields results at the level of the reported detection limits, a three-point calibration curve may be achieved by the analysis of 500, 700 and 1,000 mL aliquots.

Integration Calibration of the analytical system is achieved via the external standard method in which response factors (RF) for each compound are obtained by the analysis of a standard mix of known concentration. Following the analysis of this known standard mix, an electronic file is created establishing each peak's identity, retention time, RF, and known concentration. The RF for each target compound is determined by dividing the known concentration by the associated peak response (area or height units). For initial calibration, each compound's average response factor is determined by averaging the peak response results generated for the initial linearity study. These average response factors are programmed into the integrator to allow for direct concentration reading of contaminants found in subsequent sample analyses.

Continuing Calibration. Calibration of the analytical system should be updated three times daily: (1) preceding the daily analysis, (2) mid-day and (3) after the daily analyses. Continuing calibration should be conducted at a concentration level equal to the reported detection limits.

5.9.7 Gas Chromatography

Preconcentration of sample contaminants is achieved through the trapping process in which the volatile contaminants are adsorbed on to a sorbent trap. The affinity that the volatilized organic contaminants have for the special packing inside the sorbent tube cause them to be retained within the tube (i.e., adsorbed onto the packing) while other components of the gaseous aliquot pass through the tube.

Desorption of the adsorbed contents of the sorbent trap onto the head of a previously conditioned GC analytical column, allows for subsequent analysis by temperature-programmed gas chromatography. The desorbed contaminants are first held at constant temperature (usually in the range of 45-55°C) at the head of the analytical column for a period of 3-5 minutes. After this initial time period, the GC oven temperature is raised at a constant rate (usually 8-15°C/minute) until a final temperature of 200-225°C is reached. The final temperature is customarily held for a period of 3-10 minutes.

The preferential affinity of the volatile contaminants to either the analytical column's mobile or stationary phase, the effect of elevated temperature and the action of carrier gas flow through the column cause the volatile contaminants to become separated and resolved allowing them to elute in bands through the selected detector. As long as analytical conditions remain constant, each type of volatile component will elute at a characteristic retention time (RT). In this manner, sample contaminants are identified and quantified by comparison to a run of standard of known concentration.

The quantitation of volatile contaminants is calculated based upon the following formula:

$$\textit{Concentration sample } (\mu g/L) = \textit{Target peak response (sample)} \times RF \times DF$$

$$\textit{where: } RF \textit{ (Response Factor)} = \frac{\textit{Target concentration standard } (\mu g/L)}{\textit{Target peak response std.}}$$

DF (Dilution Factor) is used when applicable

5.10 Field Screening Analysis of Volatile Contaminants in Soil Gas Matrix

5.10.1 Overview

The following methodology describes a modification of SW846 and EPA Compendium methods as applied to the determination of volatile organic contaminants in soil gas.[8] Via this methodology, a sorbent tube containing previously trapped volatile organic contaminants obtained via the sampling of soil gas matrix, is subsequently desorbed (by action of heat and reverse gas flow) onto a suitable analytical column housed by a pre-programmed gas chromatograph (GC). The volatile organic contaminants become separated and resolved as they travel through the GC's column. Eventually, the contaminants elute through an appropriate detector. Detector signals are processed and interpreted via a previously programmed integrator Figure 1 provides a list of Potential Target Compounds.

5.10.2 Interferences

Interferences can result from many sources, considering the environmental settings of most hazardous waste sites However, most interfering impurities are artifacts originating from organic compounds within the specialty gases and the plumbing within the trapping/desorption device. The presence of air molecules and excessive water vapor and/or the degradation of the trap packing can also account for many artifacts

[8] (SW846 Method 5040; EPA Compendium Methods TO-1, TO-2, TO-3, and TO-12).

Interferences in the analytical system are monitored by the analysis of inert gas method blanks. Method blanks are analyzed under the same conditions and at the same time as standards and samples, to establish an average background response.

5.10.3 Major Apparatus and Materials

Purge and Trap Device - Tekmar Company Model LSC-2 or Model 5000. Traps may be packed solely with Tenax or, alternately, trap packing may consist of 10 cm of 3 percent OV-1, 15 cm of Tenax and 8 cm of silica gel. Appropriate trap selection is contingent upon the target compounds being analyzed.

Gas Chromatograph - Hewlett Packard 5890 or equivalent. The analytical system should be equipped for temperature programming, packed and/or capillary column analysis, and on-column injection.

Detector. PID/FID or PID/HECD in series; FID only. Optimum detector selection should be based upon the sensitivity to the detector for the target compounds being analyzed.

Analytical Column. Glass or stainless steel packed with 1 percent SP-1000 on 60/80 mesh Carbopack B. Alternately a suitable capillary column may be used.

Syringes - Assorted gas tight 5 μL, 25 μL, 100 μL, 1 mL, 10 mL

Volumetric Flasks - 10 mL, 25 mL, 100 mL

Tedlar Bags - For making gaseous standards.

Flow Meter - For use in measuring the exact volume of gas introduced to the Tedlar bag.

Analytical Balance - Capable of accurately weighting 0.0001 g.

Vacuum Pump - Low draw, positive seal.

Refrigerator - Separate for sample and standard storage. Capable of maintaining a stable temperature of 4°C.

5.10.4 Reagents

Methanol - Pesticide grade or equivalent

Organic-Free Water - Supplied by laboratory or purchased.

Neat Solvents - 96 percent purity or better for each compound of interest.

Ultra-high Purity Nitrogen - For use in generating standards and method blanks.

5.10.5 Calibration

Standard Calibration standards containing the compounds of interest are prepared in methanol by either diluting commercially purchased stock standard mixes or pure solvents. In-house calibration standards are prepared gravimetrically in that a μL aliquot of each target compound is introduced into a known volume of methanol. The appropriate μL aliquot of compound is based upon the compounds density and response to the selected detector. The calibration standards should be created at such a level that

a 5-10 μL spike into a 1-liter Tedlar bag filled with nitrogen yields a concentration of 10 μg/L based upon the analysis of a 500 mL aliquot. Aliquots are evacuated onto a clean trap . Alternately, commercially prepared stock calibration gases may be used.

Peak Identification. Compound identities may be substantiated by the analysis of each individual component thereby documenting compound retention time.

Initial Linearity An initial three-point calibration curve is generated by the trapping and analysis of multiple aliquots of calibration standard. For example, if the calibration standard is created such that analysis of a 500 mL aliquot of standard yields results at the level of the reported detection limits, a three-point calibration curve may be achieved by the analysis of 500, 700 and 1,000 mL aliquots.

Integration. Calibration of the analytical system is achieved via the external standard method in which response factors (RF) for each compound are obtained by the analysis of a standard mix of known concentration. Following the analysis of this known standard mix, an electronic file is created establishing each peak's identity, retention time, RF, and known concentration. The RF for each target compound is determined by dividing the known concentration by the associated peak response (area or height units). For initial calibration, each compound's average response factor is determined by averaging the peak response results generated for the initial linearity study. These average response factors are programmed into the integrator to allow for direct concentration reading of contaminants found in subsequent sample analyses.

Continuing Calibration. Calibration of the analytical system should be updated three times daily: (1) preceding the daily analysis, (2) mid-day and (3) after the daily analyses. Continuing calibration should be conducted at a concentration level equal to the reported detection limits.

5.10.6 Sample Preparation

Prior to the desorption and analysis of previously trapped soil gas contaminant tubes, the introduction of a surrogate spike compound via a short purge is recommended. In addition to enhancing quality assurance, this short purge cycle allows inert gas molecules to replace potentially destructive air molecules still entrained within the trap tube. The surrogate spike compound should be introduced to the trap via the following procedure:

- Program the Tekmar LSC-2 device for a 3 minute purge, 3 minute desorb and 8 minute bake cycle.
- Insert a previously trapped soil gas contaminant tube.
- Spike 2 μL of an appropriate surrogate spike solution (such as 1 μg/μL 2-bromo-1-chloropropane) into a glass sparge vessel containing 20 mL organic-free water.
- Purge the surrogate spike onto the trap Desorb and analyze

5.10.7 Gas Chromatography

Preconcentration of soil gas matrix contaminants is achieved through the sampling process in which the volatile contaminants are adsorbed onto the sorbent trap. The affinity that the volatile organic contaminants have for the special packing inside the sorbent tube cause them to be retained within the tube (i.e., adsorbed onto the packing) while other components of the gaseous matrix pass through the tube.

Following the addition of a surrogate spike compound, the adsorbed contents of the sorbent trap are desorbed (by action of heat and reverse gas flow) onto the head of a previously conditioned GC analytical column. The desorbed contaminants are first held at constant temperature (usually between 45-55°C) for an initial time period of 3-5 minutes. The desorbed contaminants are subsequently analyzed by temperature-programmed gas chromatography in which, following the initial hold, the GC oven temperature is raised at a constant rate (usually 8-15°C/minute) until a final temperature of 200-225°C is reached. The final temperature is customarily held for a period of 3-10 minutes.

The preferential affinity of the volatile contaminants to either the analytical column's mobile or stationary phase, the effect of elevated temperature and the action of carrier gas flow through the column cause the volatile contaminants to become separated and resolved allowing them to elute in bands through the selected detector. As long as analytical conditions remain constant, each type of volatile component will elute at a characteristic retention time (RT). In this manner, sample contaminants are identified and quantified by comparison to a run of standard of known concentration.

The quantitation of volatile contaminants is calculated based upon the following formula:

$$\text{Concentration sample } (\mu g/L) = \text{Target peak response (sample)} \times RF \times DF$$

$$\text{where: } RF \text{ (Response Factor)} = \frac{\text{Target concentration standard } (\mu g/L)}{\text{Target peak response std.}}$$

DF (Dilution Factor) is used when applicable

5.11 Quality Assurance/Quality Control (QA/QC)

5.11.1 Overview

Field screening generates Level II data. As Level II data, the concurrent analysis of laboratory duplicates and matrix spike analyses and the use of surrogate spike compounds is not required. However, beyond the maintenance of practical Standard Operating Procedures (SOPs), certain elements of quality control (if opted) can greatly enhance the interpretation of and the confidence in the data generated. These traditional elements of quality control are discussed here as to how they are adapted to meet the demands of a successfully applied field screening QA/QC program.

The primary purposes of an appropriate QA/QC program are to: (1) substantiate system performance and give credence to the accuracy of the results generated, (2) to define aberrations and give guidance to the interpretation of data, and (3) to achieve these goals through realistic efforts that do not impede the forward progress of the analytical set

The discussion presented here deals with only direct analytical quality control. Additional elements of QA/QC, such as field duplicate sample submissions, blind spike analysis and external audits are not discussed. Also not discussed are elements of QA/QC that are inherent to good chromatographic technique. Examples of these accepted laboratory practices include (but are not limited to) the following:

- The proper conditioning of analytical columns and traps.
- Use of the solvent flush technique for the creation of standards and for direct injections.
- The appropriate maintenance of selected detectors.

Details regarding these accepted practices are given in the referenced methodologies.

5.11.2 Holding Times

The primary purpose of field screening is to provide cost-effective, specific data on a near- to real-time turn-around basis. For this reason, samples submitted to the mobile laboratory should be analyzed as soon as possible. Samples awaiting analysis are stored at 4°C in a dedicated refrigerator. If, because of loading, it is not possible to analyze all samples taken daily, the following holding times are suggested:

Type of Sample	Holding Time
VOA (aqueous matrix)	Seven days prior to analysis
VOX (soil matrix)	Ten days prior to analysis
SEMI, PEST, and PCB (aqueous matrix)	Five days prior to extraction; analysis within 30 days
SEMI, PEST, and PCB (soil matrix)	Five days prior to extraction; analysis within 30 days

5.11.3 Sample Sets

Analyses should be conducted in sets of ten, whenever possible, with one laboratory duplicate spike analysis run per set. Each set of sample analyses should be bracketed by the analysis of a standard, with a method blank analysis following each standard run.

The number of analyses per sample set and the associated QA/QC varies per contract. The project work plan should be consulted to verify that all contractual obligations were met.

5.11.4 Continuing Calibration

Standards run for continuing calibration purposes should be analyzed at a level equal to the reported detection limits. Continuing calibration response factors for each parameter should fall within 25 percent D of the average response factor calculated for that particular compound during the initial linearity study (see Figure 5). Data associated with individual parameter not meeting the 25 percent D criteria should be flagged as suspect.

5.11.5 Laboratory Duplicates

One laboratory duplicate should be analyzed per sample set. Laboratory duplicate analyses should generate results within 30 percent RPD (see Figure 5)

5.11.6 Matrix Spike Analyses

Matrix spikes should be conducted at a level of 1-4X the concentration of the reported detection limits. One matrix spike analysis should be run per every 20 samples. Advised recovery ranges vary with respect to the compound being analyzed. Recoveries of 35-150 percent are generally acceptable (see Figure 5).

FIGURE 5

QC COMPUTATIONS

$$\%\ RSD\ (Relative\ Standard\ Deviation) = \frac{SD}{X} \times 100$$

where: $SD = \sum_{i=1}^{N} \frac{(x_i - x)^2}{N - 1}$

X = mean of initial four response factors (per compound)

$$\%\ RPD\ (Relative\ Percent\ Difference) = \frac{D_1 - D_2}{(D_1 + D_2) / 2} \times 100$$

where: D_1 = First Sample Value

D_2 = Second Sample Value

$$\%\ D\ (Percent\ Difference) = \frac{X_1 - X_2}{X_1} \times 100$$

where: X_1 = RF (Response Factor) of first result

X_2 = RF of Second Result

$$\%\ R\ (Percent\ Recovery) = \frac{SSR - SR}{S} \times 100$$

where: SSR = Spike Sample Results

SR = Sample Result

S = Amount of Spike Added

5.11.7 Surrogate Spikes

The use of at least one surrogate spike compound is highly recommended. The identity, concentration and addition of the appropriate surrogate spike varies with the procedure being used. Each associated referenced methodology should be consulted for guidance. Surrogate spike recoveries should fall within ±30 percent (see Figure 5). Sample analyses yielding recoveries outside this 30 percent window should be reanalyzed or the associated data should be flagged as suspect.

5.11.8 Initial Linearity

An initial linearity study is performed as described in each adapted methodology. The associated response factors should all fall within <20 percent RSD (see Figure 5). Standard runs yielding data that does not meet the <20 percent RSD criteria should be reanalyzed.

5.11.9 Method Blanks

Method blanks are prepared and analyzed in exactly the same manner as sample matrices. A method blank analysis should follow every standard run and sample of high concentration. Ideally, method blank results should yield no interferences to the chromatographic analysis and interpretation of target compounds. If interferences are present, associated data should be qualified as suspect and/or target detection limits should be adjusted accordingly.

5.11.10 Detection Limits

The appropriate method detection limit (MDL) for an adapted methodology may be statistically calculated using results generated for the initial linearity study and continuing calibrations, or, method detection limits may be substantiated by the analysis of a low standard at the level of the anticipated MDL.

5.12 Supplemental Protocol: Percent Moisture Determination

A moisture correction factor (MCF) is used to adjust the value generated for the amount of contaminant present in a solid matrix sample, so that the value reflects the true (dry weight) concentration of contaminant. Moisture content is determined gravimetrically The following protocol is suggested for determining percent moisture:

- Mark and weigh an aluminum weighing pan using an analytical balance. Record weight; tare balance.
- Place 5-10 grams of matrix (free from unrepresentative pebbles and organic matter) into the pan; record weight.
- Place the pan and its contents into a drying oven heated to 103°C
- Dry the matrix for a period of 4-6 hours (or until weight is constant)
- Remove the pan from the oven and allow to cool to room temperature.
- Weigh the pan and record the weight.
- Calculate percent moisture and the MCF

5.13 Supplemental Protocol: Field Screening Validation

The validation process serves as an independent check thus ensuring the proper performance of all QA/QC measures. Figures 6 and 7 illustrate a validation protocol that is suitable for the evaluation of field screening data.

6.0 REFERENCES

"Methods for Organic Chemical Analysis of Municipal and Industrial Wastewater," EPA-600/4-82-057. (EPA 600 Series methods):

Method	Title
601	Purgeable Halocarbons
601	Purgeable Aromatics
604	Phenols
606	Phthalate esters
608	Pesticides and PCBs
610	Polynuclear Aromatic Hydrocarbons
612	Chlorinated Hydrocarbons
624	Purgeables
625	Base/Neutrals, Acids, and Pesticides

"Test Methods for the Evaluation of Solid Waste." SW-846, EPA Publication No. 955-001-00000-1 (SW846 preparative methods).

Method	Title
5030	Purge and Trap Technique (Methanol Extraction)
5040	Protocol for Analysis of Sorbent Cartridges
3580	Waste Dilution

FIGURE 6

BROWN & ROOT ENVIRONMENTAL/FIELD SCREENING

VALIDATION PROTOCOL

1. Verify that samples were handled in sets of ten or less.

2. Verify that at least one laboratory duplicate was run once every ten samples.

3. Verify that one matrix spike analysis was performed once every 20 samples.

4. Ensure that at least one surrogate spike compound was used.

5. Substantiate daily initial calibration table.

6. Determine if at least one standard was run every 8 hours and that a calibration standard was run after every set of 10 samples (plus QC runs).

7. Check standard tracking form to ensure that parameter response factors fall within 25 percent of the initial calibration. If parameters exceed 25 percent value, check to see how problem was corrected and verify all reported results for that parameter were flagged as suspect.

8. Check that method blanks were run after every calibration and every sample of high concentration. Verify that any system artifacts were tracked and reported.

9. Verify that reported detection levels have been properly substantiated.

10. Evaluate chromatograms of target compound peaks for proper identification. (Check peak shapes and shoulders.)

11 Check quantitations of approximately 20 percent of samples.

12. Verify if statistics have been calculated for the data package.

13. Verify retention time window.

14 Determine if each chromatogram reports the following information:

   a. Sample name/number
   b Date/time of analysis
   c Laboratory duplicate designation (if applicable)
   d Matrix spike designation (if applicable)
   e. Concentration/dilution value recorded (if applicable)
   f Retention time reported at apex of each peak
   g. Chromatographic report generated includes peak name retention time, peak area or peak height.

FIGURE 6
BROWN & ROOT ENVIRONMENTAL/FIELD SCREENING
VALIDATION PROTOCOL
PAGE TWO

15. Verify that package Operations Record contains the following information:

    a. Purge, desorb, and bake time of sample concentrator

    b. GC flow rate, attenuation, range, initial temperature, initial time, ramp, final temperature, final time; injection temperature and detector temperature.

16. Verify that chain of custody was maintained.

17. Verify that package narrative relates all pertinent information necessary to properly interpret results.

FIGURE 7

BROWN & ROOT ENVIRONMENTAL/FIELD SCREENING

VALIDATION RECORD

Project Name/Number: _____ Sample Matrix: _____

Dates Samples Received: _____ Data Reviewer: _____

Dates Samples Analyzed: _____ Data Reviewed: _____

Evaluation Checklist:

____ Data Completeness

____ Calibration Records

____ Method Blank Analyses

____ Surrogate Spike Results

____ Duplicate Analyses Results

____ Matrix Spike Recoveries

____ Compound Identification

____ Detection Limits Achieved

Reviewier's Evaluation	Volatiles	Acids	Base/Neutrals	PCBs/Pesticides
Acceptable				
Acceptable with Exception(s)				
Questionable				
Unacceptable				

Validator's Comments:

"Test Methods for the Evaluation of Solid Waste," SW846, EPA Publication No. 955-001-00000-1. (SW846 analytical methods):

Method	Title
8010	Halogenated Volatile Organics
8015	Non-halogenated Volatile Organics
8020	Aromatic Volatile Organics
8040	Phenols
8060	Phthalate Esters
8080	Organochlorine Pesticides and PCBs
8100	Polynuclear Aromatic Hydrocarbons
8120	Chlorinated Hydrocarbons
8240	GC/MS for Volatile Organics
8250	GC/MS for Semi-volatile Organics (Packed Column)
8270	GC/MS for Semi-volatile Organics (Capillary Column)
8310	Polynuclear Aromatic Hydrocarbons

"Compendium of Methods for the Determination of Toxic Organic Compounds in Ambient Air," EPA-600/4-84-041.

Method	Title
TO-1	Tenax GC Adsorption
TO-2	Carbon Molecular Sieve Adsorption
TO-3	Cryogenic Trapping
TO-12	NMOC in Ambient Air Using Preconcentration and FID

"Field Measurement of PCBs in Soil and Sediment Using a Portable Gas Chromatograph," Spittler, Dr Thomas. U.S. EPA Region I

"Comparability of Field Screening Data to Fixed-base Laboratory Results," Scheib, Debra A., Dr. H Roffman and C. Kieda. NUS Corporation.

"Manual of Field Analytical Technique," Scheib, Debra A NUS Corporation.

7.0 RECORDS

A formalized system for tracking and reporting information is essential to appropriately document the specific analytical approach used to support the investigation of a hazardous waste site. Sound record keeping practices serve to:

- Document the QA/QC measures performed.
- Substantiate sample integrity.
- Present data in a usable form.
- Organize and record the occurrences pertinent to the interpretation of the data generated.
- Function as the historical record leading to the development of new methodologies and for the improvement of existing methods.

In light of the advances in laboratory automation and computer technology, record keeping can take the form of either electronic file or bench data sheets. Regardless of the method of record keeping employed while in the field, the submission (to the Project Manager) of a formalized, hard-copy data package upon conclusion of the field screening activity is strongly recommended. Examples of useful bench data sheets not already presented in this text follow as Figures 8 through 20. A suggested Table of Contents (Figure 21) and data package Cover Sheet (Figure 22) are also presented.

Mobile laboratory facilities vary greatly in design. Consequently, in addition to the maintenance of pertinent records, a trailer-specific S.O.P. (Standard Operating Procedure) should be developed to provide the following:

- Specific information regarding the operation and maintenance of the particular affiliated instrumentation.
- Guidance regarding the hook-up of power and telephone service.
- Procedures addressing the disposal of laboratory waste.
- Materials and supply resources
- Towing and transport considerations
- Housekeeping requirements

FIGURE 8

BROWN & ROOT ENVIRONMENTAL/FIELD SCREENING
PROJECT SUMMARY REPORT

Compound	Target Detection Limits	Sample Number						
DILUTION								
DATE SAMPLED								
DATE ANALYZED								
REPORT NUMBER								
COMMENTS								

FIGURE 9

BROWN & ROOT ENVIRONMENTAL/FIELD SCREENING

DATA QUALIFIERS

B - found in blank

DL - detection limit

DNI - peak "did not integrate;" quantitation is not possible

J - estimated quantity

u - compound analyzed for but value generated is below reported DL

↑ - GC peak over range. Peak exceeds linear range of detector and is not quantifiable

( ) - compound present, but detected at levels below the reported DL

CHROMATOGRAM NOTATIONS

ART - artifact; peak produced by chromatographic system, not caused by sample content

au - area units

D - laboratory duplicate

hu - height units

MB - method blank

MS - matrix spike

NEAT - sample is not diluted

FD - field duplicate

FIGURE 10

BROWN & ROOT ENVIRONMENTAL/FIELD SCREENING OPERATIONS RECORD

General Information:

Date(s)	_____	Task Name	_____	Std Used	_____
Site Name	_____	Task No.	_____	Analyst	_____
Site No.	_____	Matrix	_____		

Chromatographic Programming:

Flow	_____	In. Temp.	_____	Inj. Temp.	_____
Attn	_____	In. Time	_____	Det. Temp.	_____
Range	_____	Rate	_____	Other	_____
Col.	_____	Fin. Temp.	_____		_____
Detector	_____	Fin. Time	_____		_____

Integration System:

File	_____	Speed	_____	Other	
Attn	_____	Zero/Slope	_____		_____
Range	_____	Min. Area	_____		_____
Method	_____	Stop Time	_____		_____
Format	_____		_____		_____

Purge/Desorption System:

Purge Time	_____	SP-2	_____	Prepurge	_____
Desorb	_____	SP-3	_____	Preheat	_____
Bake Time	_____	SP-4	_____	Purge Temp.	_____
SP-1	_____	SP-5	_____	Line Temp.	_____

Comments:

_____

_____

_____

FIGURE 11

BROWN & ROOT ENVIRONMENTAL/FIELD SCREENING ANALYTICAL STANDARDS LOG

Target Compound	Desired Final Concentration*	Matrix Amount	Required Dose	Desired Standard Injection	Required Standard Concentration	Volume of Standard	Compound Density	Calculation	Amount Neat Compound
Example· Trichloroethene	3 ppb	20 mL	0 06 µg/L	2 µL	0 03 µg/µL	50,000 µL	1,465 µg/µL	µL = {0.03 µg/µL x 50,000 µL} + 1,465 µg/µL	1 02

*Example $\frac{3\ \mu g}{L} \div \frac{3\ \mu g}{1{,}000\ mL} = 0\ 06\ \mu g$ per 20 mL

Therefore, 0 06 µg per 2 µL injection of standard
Therefore, standard concentration must equal 0 03 µg/µL.

Formula Neat Solvent (µL) = $\frac{\text{Required Std Concentration } (\mu g/L) \times \text{Volume of Std } (\mu L)}{\text{Compound Density } (\mu g/\mu L)}$

Check $1\ 02\ (\mu L) \times \frac{1{,}494\ \mu g}{\mu L} = \frac{1{,}494\ \mu g}{5{,}000\ \mu L} \times 2\ \mu L = \frac{0\ 0598\ \mu g}{20\ mL} \times \frac{1{,}000\ mL}{L} = 2\ 99$ ppb

FIGURE 12

BROWN & ROOT ENVIRONMENTAL/FIELD SCREENING

<u>3-POINT INITIAL CALIBRATION</u>

DATE: ____________________ **INSTRUMENT:** ____________________

ANALYST: ____________________ **COLUMN:** ____________________

Compound	Standard I D Number	Standard Concentration	Response	Response Factor	x_{RF}	s_{RF}	%RSD

FIGURE 13

BROWN & ROOT ENVIRONMENTAL/FIELD SCREENING

CONTINUING CALIBRATION SUMMARY
VOLATILES

Retention Time	Parameter	Concentration of Standard Injection	Analysis Date											
			Analysis Time											
			Average RF (Initial Calib)	%D		%D		%D		%D		%D		

Response Factor (RF) tracking where RF = $\frac{\text{Concentration}}{\text{Peak response}}$ - Quality Control Criteria:

%D between average initial RF and continuing calibration RF must not exceed ±25%, where %D = $\frac{\text{initial average RF - continuing calibration RF}}{\text{initial average RF}} \times 100$

FIGURE 14

BROWN & ROOT ENVIRONMENTAL/FIELD SCREENING

CONTINUING CALIBRATION SUMMARY
VOLATILES

Retention Time	Parameter	Concentration of Standard Injection	Analysis Date											
			Analysis Time											
			Average RF (Initial Calib.)	%D		%D		%D		%D		%D		

Response Factor (RF) tracking where $RF = \frac{\text{Concentration}}{\text{Peak response}}$ - Quality Control Criteria.

%D between average initial RF and continuing calibration RF must not exceed ±25% where $\%D = \frac{\text{initial average RF - continuing calibration RF}}{\text{initial average RF}} \times 100$

FIGURE 15
BROWN & ROOT ENVIRONMENTAL/FIELD SCREENING

METHOD BLANK SUMMARY (OVERVIEW)

By definition, method blanks consist of an equal aliquot of like matrix + surrogate spike. For quality control/troubleshooting purposes, it sometimes becomes necessary to exclude the surrogate spike or run variations of the matrix. In order to avoid confusion, distinctions of various types of blanks are clarified here:

Trip Blank - previously prepared VOA vials filled with organic-free water, sealed and transported with sample containers. These sealed vials are not opened until analysis; their purpose is to ensure no cross contamination (migration of contaminants through the container's seal) has occurred during transit.

Field Blank - sometimes referred to as "Decon Rinsate." A containerized aliquot of bailer or sampler washwater. Ensures appropriate cleaning and rinsing of the sampling equipment.

Prepared Soil Matrix Blank - laboratory soil matrix is prepared by obtaining an amount of earth and baking it in the drying oven overnight at 105°C to drive off volatile organic compounds. An aliquot of prepared matrix is run without surrogate spike to ensure the matrix is free of contaminants.

Aqueous Method Blank - an aliquot of organic-free water + surrogate spike.

Solid Method Blank - an aliquot of prepared soil matrix + surrogate spike.

Water Purge (System Blank) - an aliquot of organic-free water only; no surrogate spike.

Repurge - repurging, trapping and analysis of material run previously in sparging apparatus.

Desorption/Redesorption - desorb and analysis of trap without any additional purging

GC Column Only - analysis of GC column response without any prior desorption onto the GC

Comments regarding the various blank analyses performed for this site appear on the following summary sheets:

FIGURE 16
BROWN & ROOT ENVIRONMENTAL/FIELD SCREENING

METHOD BLANK SUMMARY

FRACTION: _____ **MATRIX:** _____

DATE ANALYZED: _____ **BY:** _____

INSTRUMENT: _____

Compounds Found	Concentrations	Detection Limit

Comments: _____

FIGURE 17
BROWN & ROOT ENVIRONMENTAL/FIELD SCREENING

LABORATORY DUPLICATE SUMMARY

Sample Number: _____

Matrix: _____

Chromatogram Number: _____

Compound	Original Result	Duplicate Result	Percent Difference

$$\text{Percent Difference} = \frac{\text{Original} - \text{Duplicate}}{1/2\ \text{Original} + \text{Duplicate}} \times 100\%$$

FIGURE 18

HALLIBURTON NUS/FIELD SCREENING

MATRIX SPIKE SUMMARY

Fraction: _____ **Sample Number:** _____

MS Chromatogram Number: _____

Matrix Spike Compounds	Original Result	Aliquot	Spike Added	Theoretical[1] Result	Matrix Spike	
					Result	MSR%[2]

(1) Theoretical Result = $\frac{(\text{Original Result} \times \text{Aliquot}) + \text{Spike Added}}{\text{Aliquot}}$

(2) Matrix Spike Recovery = $\frac{\text{Matrix Spike Result}}{\text{Theoretical Result}}$

FIGURE 19
HALLIBURTON NUS/FIELD SCREENING

SAMPLE LOG/RUN ROSTER

Date Received	Project Number	Matrix	Submitted by	Sample Information	Sample Description	Date Analysis	Time Analysis	Analysis Number	Run Number	C/D	Chrom. Number	Analysis Comments

*All analyses performed by _____ Page _____ of _____

FIGURE 20
BROWN & ROOT ENVIRONMENTAL/FIELD SCREENING

SURROGATE RECOVERIES

Chromatogram Number	Sample Designation	Peak Area or Height	%	Chromatogram Number	Sample Designation	Peak Area or Height	%

Surrogate peak response of daily method blank analysis = 100%

$$\text{Sample recovery (\%)} = \frac{\text{sample surrogate response}}{\text{method blank surrogate response}} \times 100$$

FIGURE 21
BROWN & ROOT ENVIRONMENTAL/FIELD SCREENING

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FIGURE 22

COVER SHEET

BROWN & ROOT ENVIRONMENTAL/FIELD SCREENING

Project Number/Name: _____

Analysis/Matrix: _____

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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 (av rage 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 sit geologist and approved by th 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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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: _____ BORING NUMBER: _____
PROJECT NUMBER: _____ DATE: _____
DRILLING COMPANY: _____ GEOLOGIST: _____
DRILLING RIG: _____ 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: Soil Density/ Consistency or Rock Hardness	Color*	Material Classification	USCS*	Remarks	PID/FID Reading (ppm): 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

Drilling Area Background (ppm): _____

Remarks: _____

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 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 Inches and Basing Fractions on Estimated Weights)	Identification Procedures on Fraction Smaller Than No. 40 Sieve Size: DRY STRENGTH (Crushing Characteristics)	DILATANCY (Reaction to Shaking)	TOUGHNESS (Consistency Near Plastic Limit)	GROUP SYMBOL	TYPICAL NAMES
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)

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'

LEGEND:

SOIL SAMPLES TYPES
- S-2 Split Barrel Sample
- SI-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 & 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 -- <u>some</u> 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 -- <u>few</u> 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 "<u>interbedded</u> 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	USCS*	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
C 0800	2.0	9/10				TO BLK	ROCK FR. - TR BRICKS		ODOR				
							(FILL)		FILL TO 4'±				
	4.0			4.0									
S-2 C		5/7	2.9/2.0		M DENSE	BRN	SILTY SAND - TR FINE	SM	MOIST - W ODOR	10	0	-	-
0810	6.0	9/8					GRAVEL		NAT. MATL.				
	•			7'± ▽					TOOK SAMPLE				
									SB01-0406 FOR				
	8.0			8.0					ANALYSIS				
S-3 C		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 C		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'				
				11 GIVE 16	M HARD	BRN	SILTSTONE	VBR	WEATHERED				
									LO ∡ JNTS @ 15.5				
9/5	①		4.0/5.0						WATER STAINS @ 16.5, 17, 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				
4.9/5.0	②		5.0/5.0						SET 2" 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 R16, 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.

BROWN & ROOT ENVIRONMENTAL	STANDARD OPERATING PROCEDURES	Number SA-1.3	Page 1 of 20
		Effective Date 03/01/96	Revision 3
		Applicability B&R Environmental, NE	
		Prepared Earth Sciences Department	
Subject SOIL SAMPLING		Approved D. Senovich	

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

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

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

5.0 PROCEDURES

5.1 Overview

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

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

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

5.2 Soil Sample Collection

5.2.1 Procedure for Collecting Volatile Soil Samples

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

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

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

5.3 Surface Soil Sampling

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

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

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

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

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

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

1. Attach a properly decontaminated bucket bit to a clean extension rod and further attach the cross handle to the extension rod.

2. Clear the area to be sampled of any surface debris (vegetation, twigs, rocks, litter, etc.).

3. Begin augering (periodically removing accumulated soils from the bucket bit) and add additional rod extensions as necessary. Also, note (in a field notebook or on standardized data sheets) any changes in the color, texture or odor of the soil.

4. After reaching the desired depth, slowly and carefully withdraw the apparatus from the borehole.

5. Remove the soiled bucket bit from the rod extension and replace it with another properly decontaminated bucket bit. The bucket bit used for sampling is commonly smaller in diameter than the bucket bit employed to initiate the borehole.

6. Carefully lower the apparatus down the borehole. Care must be taken to avoid scraping the borehole sides.

7. Slowly turn the apparatus until the bucket bit is advanced approximately 6 inches.

8. Discard the top of the core (approximately 1"), which represents any loose material collected by the bucket bit before penetrating the sample material.

9. Fill volatile sample container(s), using a properly decontaminated stainless steel trowel, with sample material directly from the bucket bit. Refer to Section 5.2.1 of this procedure.

10. Utilizing the above trowel, remove the remaining sample material from the bucket bit and place into a properly decontaminated stainless steel mixing bowl and thoroughly homogenize the sample material prior to filling the remaining sample containers. Refer to Section 5.2.2 of this procedure.

11. Follow steps 4 through 10 listed under Section 5.3 of this procedure.

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

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

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

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

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

5.7.2 Test Pit and Trench Excavation

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

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

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

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

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

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

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

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

5.7.3.3 Sampling Methods

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

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

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

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

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

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

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

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

5.7.3.5 Geotechnical Sampling

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

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

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

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

A sledge hammer or the backhoe may be used to drive or push the sampler or tube into the ground. Place a piece of wood over the top of the sampler or sampling tube to prevent damage during driving/pushing of the sample. Pushing the sampler with a constant thrust is always preferable to driving it with repeated blows, thus minimizing disturbance to the sample. If the sample cannot be extracted by rotating it at least two revolutions (to shear off the sample at the bottom), hand-excavate to remove the soil from around the sides of the sampler. If hand-excavation requires entry of the test pit, the requirements in Section 5.7.3.4 of this procedure must be followed. Prepare, label, pack and transport the sample in the required manner, as described in SOP SA-6 3.

6.0 REFERENCES

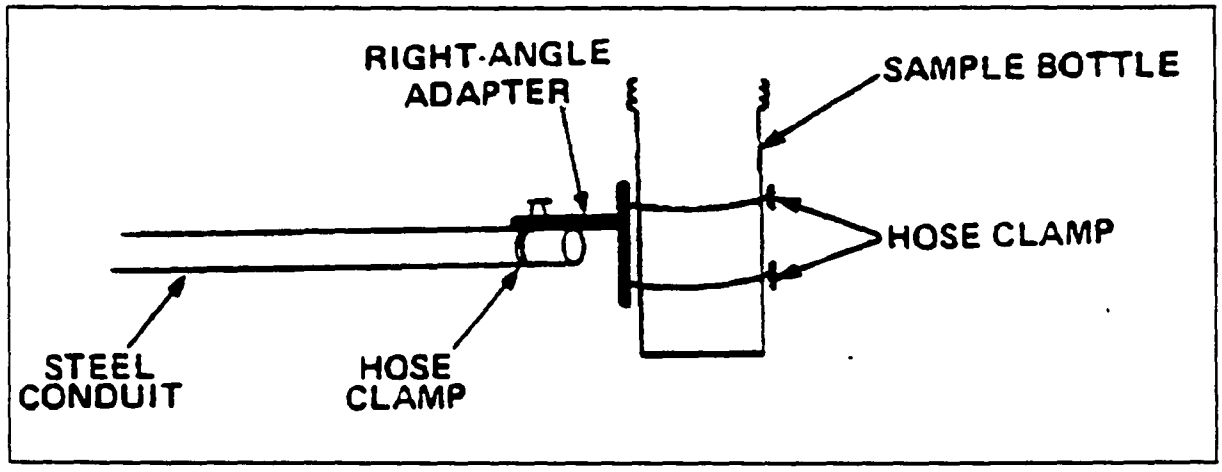
American Society for Testing and Materials, 1987. ASTM Standards D1587-83 and D1586-84. ASTM Annual Book of Standards. ASTM. Philadelphia, Pennsylvania. Volume 4.08.

NUS Corporation, 1986. Hazardous Material Handling Training Manual.

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

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

ATTACHMENT B
REMOTE SAMPLE HOLDER FOR TEST PIT/TRENCH SAMPLING



ATTACHMENT C-2
MULTIPLE SAMPLE LOG SHEET (SOIL)

Brown & Root Environmental

MULTIPLE SAMPLE LOG SHEET

☐ SURFACE SOIL ☐ LAGOON/POND
☐ SUBSURFACE SOIL ☐ OTHER
☐ SEDIMENT

PAGE ___ OF ___

SAMPLER(S) SIGNATURE _____

PROJECT NAME. _____

PROJECT NUMBER _____

AREA DESIGNATION _____

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

COC NO:

ACAD: C:\FORMS\SAMPLOG.DWG 02/07/93 TD

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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 méthods: 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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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.

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1.0 PURPOSE

The purpose of this procedure is to provide reference information regarding the proper methods for evaluating existing monitoring wells, and determining water level measurements.

2.0 SCOPE

The procedures described herein are applicable to all existing monitoring wells and, for the most part, are independent of construction materials and methods.

3.0 GLOSSARY

Hydraulic Head - The height to which water will rise in a well.

Water Table - A surface in an unconfined aquifer where groundwater pressure is equal to atmospheric pressure (i.e., the pressure head is zero).

4.0 RESPONSIBILITIES

Site Geologist/Hydrogeologist - Has overall responsibility for obtaining water level measurements and developing groundwater contour maps. The site geologist/hydrogeologist (in concurrence with the Project Manager) shall specify the reference point from which water levels are measured (usually a specific point on the upper edge of the inner well casing), the number of data points needed and which wells shall be used for a contour map, and how many complete sets of water levels are required to adequately define groundwater flow directions (e.g., if there are seasonal variations).

Field Personnel - Must have a basic familiarity with the equipment and procedures involved in obtaining water levels, and must be aware of any project-specific requirements.

5.0 PROCEDURES

Accurate, valid and useful groundwater monitoring requires that four important conditions be met:

Proper characterization of site hydrogeology.

- Proper design of the groundwater monitoring program, including adequate numbers of wells installed at appropriate locations and depths.

Satisfactory methods of groundwater sampling and analysis to meet the data quality objectives (DQOs).

- The assurance that specific monitoring well samples are representative of water quality conditions in the monitored interval

To insure that these conditions are met, adequate descriptions of subsurface geology, well construction methods and well testing results must be available. The following steps will help to insure that the required data are available to permit an evaluation of the utility of existing monitoring wells for collecting additional samples.

5.1 Preliminary Evaluation

A necessary first step in evaluating existing monitoring well data is the study and review of the original work plan for monitoring well installation (if available). This helps to familiarize the site geologist/hydrogeologist with site-specific conditions, and will promote an understanding of the original purpose of the monitoring wells.

The next step of the evaluation should involve a review of all available information concerning borehole drilling and well construction. This will allow interpretation of groundwater flow conditions and area geology, and will help to establish consistency between hydraulic properties of the well and physical features of the well or formation. The physical features which should be identified and detailed, if available, include:

- The well identification number, permit number and location by referenced coordinates, the distance from prominent site features, or the location of the well on a map.
- The installation dates, drilling methods, well development methods, and contractors.
- The depth to bedrock -- where rock cores were not taken, auger refusal, drive casing refusal or penetration test results (blow counts for split-barrel sampling) may be used to estimate bedrock interface.
- The soil profile and stratigraphy.
- The borehole depth and diameter.
- The elevation of the top of the protective casing, the top of the well riser, and the ground surface.
- The total depth of the well.
- The type of well materials, screen type, slot size, and length, and the elevation/depths of the screen, interval, and/or monitored interval.
- The elevation/depths of the tops and bottom of the filter pack and well seals and the type and size.

5.2 Field Inspection

During the onsite inspection of existing monitoring wells, features to be noted include:

- The condition of the protective casing, cap and lock.
- The condition of the cement seal surrounding the protective casing.
- The presence of depressions or standing water around the casing.
- The presence of any electrical cable and its connections.

If the protective casing, cap and lock have been damaged or the cement collar appears deteriorated, or if there are any depressions around the well casing capable of holding water, surface water may have

infiltrated into the well. This may invalidate previous sampling results since the time when leakage started is unknown.

The routine physical inspection must be followed by a more detailed investigation to identify other potential routes of contamination or sampling equipment malfunction. Any of these occurrences may invalidate previously-collected water quality data. If the monitoring well is to be used in the future, considerations shown in the steps described above should be rectified to rehabilitate the well. After disconnecting any wires, cables or electrical sources, remove the lock and open the cap. Check for the presence of organic vapors with a photoionization detector (PID) or flame-ionization detector (FID) and combustible gas meter to determine the appropriate worker safety level. The following information should be noted:

Cap function.

Physical characteristics and composition of the inner casing or riser, including inner diameter and annular space.

Presence of grout between the riser and outer protective casing and the existence of drain holes in the protective casing.

Presence of a riser cap, method of attachment to casing, and venting of the riser.

Presence of dedicated sampling equipment; if possible, remove such equipment and inspect size, materials of construction and condition.

The final step of the field inspection is to confirm previous hydraulic or physical property data and to obtain data not previously available. This includes the determination of static water levels, total well depth and well obstruction. This may be accomplished using a weighted tape measure which can also be used to check for sediment (the weight will advance slowly if sediment is present, and the presence of sediment on the weight upon removal should be noted). If sediment is present, the well be should be redeveloped before sampling.

Lastly, as a final step, the location, condition and expected water quality of the wells should be reviewed in light of their usefulness for the intended purpose of the investigation.

5.3 Water Level (Hydraulic Head) Measurements

5.3.1 General

Groundwater level measurements can be made in monitoring wells, private or public water wells, piezometers, open boreholes, or test pits (after stabilization). Groundwater measurements should generally not be made in boreholes with drilling rods or auger flights present. If groundwater sampling activities are to occur, groundwater level measurements shall take place prior to well evacuation or sampling.

All groundwater level measurements shall be made to the nearest 0.01 foot, and recorded in the site geologist/hydrogeologist's field notebook or on the Groundwater Level Measurement Sheet (Attachment A), along with the date and time of the reading. The total depth of the well shall be measured and recorded, if not already known. Weather changes that occur over the period of time during which water levels are being taken, such as precipitation and barometric pressure changes, should be noted.

In measuring groundwater levels, there shall be a clearly-established reference point of known elevation, which is normally identified by a mark on the upper edge of the inner well casing. The reference point shall be noted in the field notebook. To be useful, the reference point should be tied in with an established USGS benchmark or other properly surveyed elevation datum. An arbitrary datum could be used for an isolated group of wells, if necessary.

Cascading water within a borehole or steel well casings can cause false readings with some types of sounding devices (chalked line, electrical). Oil layers may also cause problems in determining the true water level in a well. Special devices (interface probes) are available for measuring the thickness of oil layers and true depth to groundwater, if required.

Water level readings shall be taken regularly, as required by the site geologist/hydrogeologist. Monitoring wells or open-cased boreholes that are subject to tidal fluctuations should be read in conjunction with a tidal chart (or preferably in conjunction with readings of a tide staff or tide level recorder installed in the adjacent water body); the frequency of such readings shall be established by the site hydrogeologist. All water level measurements at a site used to develop a groundwater contour map shall be made in the shortest practical time to minimize affects due weather changes, and at least during the same day.

5.3.2 Water Level Measuring Techniques

There are several methods for determining standing or changing water levels in boreholes and monitoring wells. Certain methods have particular advantages and disadvantages depending upon well conditions. A general description of these methods is presented, along with a listing of various advantages and disadvantages of each technique. An effective technique shall be selected for the particular site conditions by the site geologist/hydrogeologist.

In most instances, preparation of accurate potentiometric surface maps require that static water level measurements be obtained to a precision of 0.01 feet. To obtain such measurements in individual accessible wells, chalked tape or electrical water level indicator methods have been found best, and thus are the most often utilized. Other, less precise methods, such as the popper or bell sound, or bailer line methods, may be appropriate for developing preliminary estimates of hydraulic conditions. When a large number of (or continuous) readings are required, time-consuming individual readings are not usually feasible. In such cases, it is best to use the float recorder or pressure transducer methods. When conditions in the well limit readings (i.e., turbulence in the water surface or limited access through small diameter tubing), less precise, but appropriate methods such as the air line or capillary tubing methods can be used (see subsequent SOP section for discussion of these devices).

5.3.3 Methods

Water levels can be measured by several different techniques, but the same steps shall be followed in each case. The proper sequence is as follows:

1 Check operation of recording equipment above ground. Prior to opening the well, don personal protective equipment, as required.

2. Record all information specified below in the geologist/hydrogeologist's field notebook or on the Groundwater Level Measurement Sheet (Attachment A):

- Well number.

- Water level (to the nearest 0.01 foot; 0.3 cm). Water levels shall be taken from the surveyed reference mark on the top edge of the inner well casing.

- Time and day of the measurement.

Water level measuring devices with permanently marked intervals shall be used when possible. If water level measuring devices marked by metal or plastic bands clamped at intervals along the measuring line are used, the spacing and accuracy of these bands shall be checked frequently as they may loosen and slide up or down the line, resulting in inaccurate reference points.

5.3.4 Water Level Measuring Devices

Chalked Steel Tape

The water level is measured by chalking a weighted steel tape and lowering it a known distance (to any convenient whole foot mark) into the well or borehole. The water level is determined by subtracting the wetted chalked mark from the total length lowered into the hole.

The tape shall be withdrawn quickly from the well because water has a tendency to rise up the chalk due to capillary action. A water finding paste may be used in place of chalk. The paste is spread on the tape the same way as the chalk, and turns red upon contacting water.

Disadvantages to this method include the following: depths are limited by the inconvenience of using heavier weights to properly tension longer tape lengths; ineffective if borehole/well wall is wet or inflow is occurring above the static water level; chalking the tape is time-consuming; difficult to use during periods of precipitation.

Electric Water Level Indicators

These devices consist of a spool of small-diameter cable and a weighted probe attached to the end. When the probe comes in contact with the water, an electrical circuit is closed and a meter, light, and/or buzzer attached to the spool will signal the contact.

There are a number of commercial electric sounders available, none of which is entirely reliable under all conditions likely to occur in a contaminated monitoring well. In conditions where there is oil on the water, groundwater with high specific conductance, water cascading into the well, steel well casing, or a turbulent water surface in the well, measuring with an electric sounder may be difficult.

For accurate readings, the probe shall be lowered slowly into the well. The electric tape is marked at the measuring point where contact with the water surface was indicated. The distance from the mark to the nearest tape band is measured using an engineer's folding ruler or steel tape, and added to the band reading to obtain the depth to water. If the band is not a permanent marking band, spacing shall be checked periodically as described in Section 5 3.6.

Popper or Bell Sounder

A bell- or cup-shaped weight that is hollow on the bottom is attached to a measuring tape and lowered into the well. A "plopping" or "popping" sound is made when the weight strikes the surface of the water. An accurate reading can be determined by lifting and lowering the weight in short strokes, and reading the tape when the weight strikes the water. This method is not sufficiently accurate to obtain water levels to 0.01 feet, and thus is more appropriate for obtaining only approximate water levels quickly.

Float Recorder

A float or an electromechanically actuated water-seeking probe may be used to detect vertical changes of the water surface in the hole. A paper-covered recording chart drum is rotated by the up and down motion of the float via a pulley and reduction gear mechanism, while a clock drive moves a recording pen horizontally across the chart. To ensure continuous records, the recorder shall be inspected, maintained, and adjusted periodically. This type of device is useful for continuously measuring periodic water level fluctuations, such as tidal fluctuations or influences of pumping wells.

Air Line

An air line is especially useful in pumped wells where water turbulence may preclude the use of other devices. A small-diameter weighted tube of known length is installed from the surface to a depth below the lowest water level expected. Compressed air (from a compressor, bottled air, or air pump) is used to purge the water from the tube, until air begins to escape the lower end of the tube, and is seen (or heard) to be bubbling up through the water in the well. The pressure needed to purge the water from the air line multiplied by 2.307 (feet of water for 1 psi) equals the length in feet of submerged air line. The depth to water below the center of the pressure gauge can be calculated by subtracting the length of air line below the water surface from the total length of the air line.

The disadvantages to this method include the need for an air supply and lower level of accuracy (unless a very accurate air pressure gauge is used. this method cannot be used to obtain water level readings to the nearest 0.01 ft).

Capillary Tubing

In small diameter piezometer tubing, water levels are determined by using a capillary tube. Colored or clear water is placed in a small "U"-shaped loop in one end of the tube (the rest of the tube contains air). The other end of the capillary tube is lowered down the piezometer tubing until the water in the loop moves. indicating that the water level has been reached. The point is then measured from the bottom of the capillary tube or recorded if the capillary tube is calibrated. This is the best method for very small diameter tubing monitoring systems such as Barcad and other multilevel systems. Unless the capillary tube is calibrated, two people may be required to measure the length of capillary tubing used to reach the groundwater. Since the piezometer tubing and capillary tubing usually are somewhat coiled when installed, it is difficult to accurately measure absolute water level elevations using this method. However, the method is useful in accurately measuring differences or changes in water levels (i.e., during pumping tests)

Pressure Transducer

Pressure transducers can be lowered into a well or borehole to measure the pressure of water and therefore the water elevation above the transducer. The transducer is wired into a recorder at the surface to record changes in water level with time. The recorder digitizes the information and can provide a printout or transfer the information to a computer for evaluation (using a well drawdown/recovery model). The pressure transducer should be initially calibrated with another water level measurement technique to ensure accuracy. This technique is very useful for hydraulic conductivity testing in highly permeable material where repeated, accurate water level measurements are required in a very short period of time. A sensitive transducer element is required to measure water levels to 0.01 foot accuracy.

B rehole Geophysics

Approximate water levels can be determined during geophysical logging of the borehole (although this is not the primary purpose for geophysical logging and such logging is not cost effective if used only for this purpose). Several logging techniques will indicate water level. Commonly-used logs which will indicate saturated/unsaturated conditions include the spontaneous potential (SP) log and the neutron log.

5.3.5 Data Recording

Water level measurements, time, data, and weather conditions shall be recorded in the geologist/hydrogeologist's field notebook or on the Groundwater Level Measurement Sheet. All water level measurements shall be measured from a known reference point. The reference point is generally a marked point on the upper edge of the inner well casing that has been surveyed for an elevation. The exact reference point shall be marked with permanent ink on the casing since the top of the casing may not be entirely level. It is important to note changes in weather conditions because changes in the barometric pressure may affect the water level within the well.

5.3.6 Specific Quality Control Procedures for Water Level Measuring Devices

All groundwater level measurement devices must be cleaned before and after each use to prevent cross contamination of wells. Manufacturer's instructions for cleaning the device shall be strictly followed. Some devices used to measure groundwater levels may need to be calibrated. These devices shall be calibrated to 0.01 foot accuracy and any adjustments/corrections shall be recorded in the field logbook/notebook. After the corrections/adjustments are made to the measuring device and entered in the field logbook/notebook, the corrected readings shall be entered onto the Groundwater Level Measurement Sheet (Attachment A). Elevations will be entered on the sheet when they become available.

5.4 Health and Safety Considerations

Groundwater contaminated by volatile organic compounds may release toxic vapors into the air space inside the well pipe. The release of this air when the well is initially opened is a health/safety hazard which must be considered. Initial monitoring of the well headspace and breathing zone concentrations using a PID (e.g., HNu) or FID (e.g., OVA) and combustible gas meters shall be performed to determine required levels of protection.

6.0 RECORDS

A record of all field procedures, tests and observations must be recorded in the site logbook or designated field notebook. Entries in the log/notebook should include the individuals participating in the field effort, and the date and time. The use of annotated sketches may help to supplement the evaluation

ATTACHMENT A
EXAMPLE GROUNDWATER LEVEL MEASUREMENT SHEET

GROUNDWATER LEVEL MEASUREMENT SHEET

Page ___ of ___

PROJECT NAME: _____ LOCATION: _____
PROJECT NUMBER: _____ MEASURING DEVICE: _____
PERSONNEL: _____ ADJUSTMENT FACTOR: _____
DATE: _____ REMARKS: _____
WEATHER CONDITIONS: _____

Well or Piezometer Number	Time	Elevation of Reference Point (Feet)*	Water Level Indicator Reading (Feet)*	Groundwater Elevation (Feet)*	Comments

*Measurements to nearest 0.01 foot.

Signature(s): _____

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		Effective Date 03/01/96	Revision 3
		Applicability B&R Environmental, NE	
		Prepared Earth Sciences Department	
Subject GROUNDWATER SAMPLE ACQUISITION AND ONSITE WATER QUALITY TESTING		Approved D. Senovich	

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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.

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ATTACHMENT A

PURGING EQUIPMENT SELECTION

Diameter Casing		Bailer	Peristaltic Pump	Vacuum Pump	Air-lift	Diaphragm "Trash" Pump	Submersible Diaphragm Pump	Submersible Electric Pump	Submersible Electric Pump w/Packer
1 25-inch	Water level <25 feet		X	X	X	X			
	Water Level >25 feet				X				
2-inch	Water level <25 feet	X	X	X	X	X	X		
	Water Level >25 feet	X			X		X		
4-inch	Water level <25 feet	X	X	X	X	X	X	X	X
	Water Level >25 feet	X			X		X	X	X
6-inch	Water level <25 feet				X	X		X	X
	Water Level >25 feet				X			X	X
8-inch	Water level <25 feet				X	X		X	X
	Water Level >25 feet				X			X	X

ATTACHMENT A
PURGING EQUIPMENT SELECTION
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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 volum e	$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
PURGING EQUIPMENT SELECTION
PAGE 3

Manufacturer	Model Name/Number	Principle of Operation	Maximum Outside Diameter/ Length (Inches)	Construction Materials (w/Lines and Tubing)	Lift Range (ft)	Delivery Rates or Volumes	1982 Price (Dollars)	Comments
Randolph Austin Co.	Model 500 Vari-Flow Pump	Portable; peristaltic (suction)	<0 5/NA	(Not submersible) Rubber, Tygon®, or Neoprene®	0-30	See comments	$1,200-1,300	Flow rate dependent on motor and tubing selected; AC operated; other models available.
Robert Bennett Co.	Model 180	Portable, piston (positive displacement)	1 8/22	SS, Teflon®, Delrin® PP, Viton®, acrylic, PE	0-500	0-1,800 mL/min	$2,600-2,700	Requires compressed gas; water level indicator and flow meter; custom models available
Slope Indicator Co. (SINCO)	Model 514124 Pneumatic Water Sampler	Portable; gas drive (positive displacement)	1.9/18	PVC, nylon	0-1,100	250 mL/ flushing cycle	$250-350	Requires compressed gas, SS available, piezometer model available; dedicated model available.
Solinst Canada Ltd.	5W Water Sampler	Portable; grab (positive displacement)	1 9/27	PVC, brass, nylon, Neoprene®	0-330	500 mL	$1,300-1,800	Requires compressed gas, custom models available
TIMCO Mfg Co., Inc.	Std Bailer	Portable; grab (positive displacement)	1.66/Custom	PVC, PP	No limit	250 mL/ft of bailer	$20-60	Other sizes, materials, models available, optional bottom-emptying device available; no solvents used.
TIMCO	Air or Gas Lift Sampler	Portable; gas drive (positive displacement)	1.66/30	PVC, Tygon®, Teflon®	0-150	350 mL/ flushing cycle	$100-200	Requires compressed gas, other sizes, materials, models available, no solvents used
Tole Devices Co	Sampling Pump	Portable; bladder (positive displacement)	1 38/48	SS, silicone, Delrin®, Tygon®	0-125	0-4,000 mL/min	$800-1,000	Compressed gas required, DC control module, custom built

Construction Material Abbreviations

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

Other Abbreviations:

NA	Not applicable
AC	Alternating current
DC	Direct current

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

Source. Barcelona et al , 1983

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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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.

Dei nized 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.

S lvent - 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

Pr ject 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.

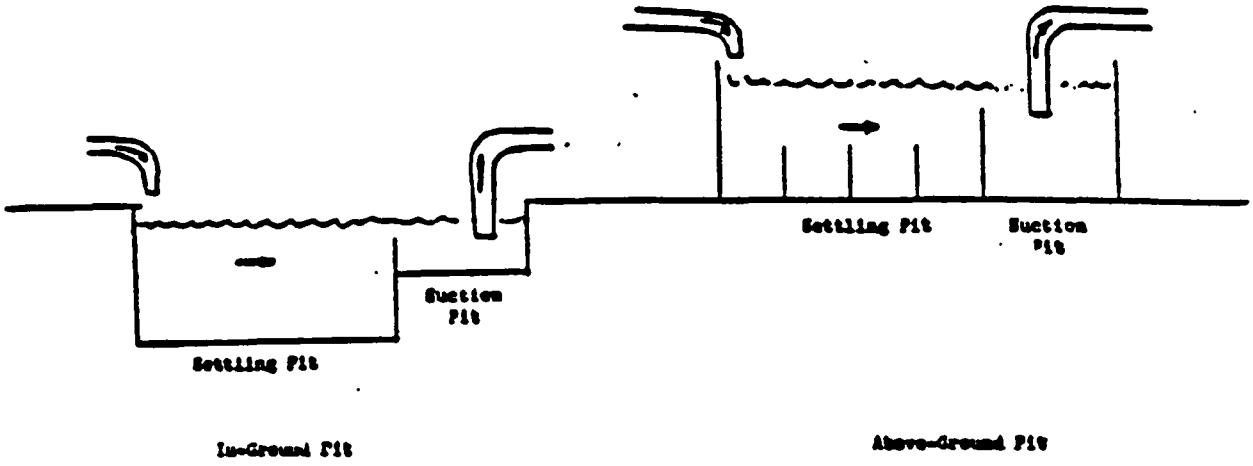
Another consideration in selecting disposal methods for contaminated materials is whether the disposal can be incorporated into subsequent site cleanup activities. For example, if construction of a suitable onsite disposal structure is expected, contaminated materials generated during the investigation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



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1.0 PURPOSE

To establish procedures for the use, calibration, maintenance, troubleshooting, and shipment of the Photovac MicroFID handheld flame ionization detector.

2.0 SCOPE

Applies to all Brown & Root Environmental personnel who operate the MicroFID instrument during the performance of their work.

3.0 GLOSSARY

None.

4.0 RESPONSIBILITIES

Health and Safety Manager (HSM) - The HSM shall ensure that the user has been appropriately trained and certified in the usage of the Photovac 2020 instrument.

Equipment Manager - The Equipment Manager shall ensure that all air monitoring instrumentation slated for field activities has been operationally checked out, fully charged, and calibrated prior to issuance for field service. Maintenance deficiencies identified by the Equipment Manager will require those instruments to be pulled from service until repairs can be facilitated.

Field Operations Leader (FOL)/Field Team Leader (FTL) - The FOL/FTL shall ensure all field team members using monitoring instruments as part of their assigned duties are adequately trained in their proper operation and limitations. The FOL/FTL shall ensure that the air monitoring instruments are employed as directed by site guidance documents (i.e., Work Plan, Health and Safety Plan, etc.). Additionally, the FOL/FTL shall ensure that the appropriate documentation and recordkeeping requirements are fulfilled including Documentation of Calibration and Direct Reading Instrument Response Data Sheets for air monitoring activities.

Health and Safety Officer (HSO) - The HSO is responsible for determining air monitoring requirements for the site activities, and providing direction for air monitoring during specific site activities. This identification of types of air monitoring and direction for use are indicated within the Site-Specific Health and Safety Plan (HASP).

Site Safety Officer (SSO) - The SSO shall ensure the instruments identified are employed in the manner directed by the HSO and action levels employed as contingencies marks for the application of engineering controls, personal protective equipment (PPE) use, and administrative controls are employed as directed. Additionally, he/she shall ensure the instruments are properly maintained and calibrated prior to use in the field. The SSO during specific air monitoring applications including STEL and TWA mode measurements will be responsible for operation and application of this specialty air monitoring employment duty.

5.0 PROCEDURES

5.1 Principles of Operation

The MicroFID is a flame ionization detector used for the measurement of combustible organic compounds in air at parts per million levels. Permanent air gases (argon, carbon dioxide, nitrogen, oxygen, water vapor, etc.) are not ionized by the flame.

When the MicroFID is turned on, the display prompts you to turn on the hydrogen. The internal pump draws air in through MicroFID's inlet. This sample air provides the oxygen necessary for combustion in the hydrogen-fueled flame. When the proper ratio of hydrogen to air is present in the combustion chamber, the flame is automatically started with a glow plug. A thermocouple is used to monitor the status of the flame. When the sample passes through the flame the combustible organic compounds in the sample will be ionized. After the compounds have been ionized, they are subjected to a continuous electric field between the repeller electrode at the jet and the collector electrode. The ions in the electric field generate a current which is proportional to the concentration of the ionized molecules in the ionization chamber. An electrometer circuit converts the current to a voltage that is then fed to the microprocessor which interprets the current in units of ppm. After the sample passes through the flame and has become ionized, it is vented from the detector through a flame arrestor. The flame arrestor prevents the flame from igniting any flammable gases present in the working atmosphere.

MicroFID is strictly an organic compound detector. It does not respond to inorganic compounds. MicroFID's sensitivity is highly dependent on chemical structure and bonding characteristics. The combustion efficiency of a compound determines its sensitivity. Simple saturated hydrocarbons (methane, ethane, etc.) posses high combustion efficiencies and are among the compounds that produce the highest MicroFID response. Organic fuels (acetylene, refined petroleum products), burn easily and are also extremely well detected.

The presence of substituted functional groups (amino, hydroxyl, halogens) on a simple hydrocarbon reduces its combustion efficiency and the MicroFID's sensitivity to the compound. For example, methanol and chloromethane are detectable with MicroFID, but not at the same sensitivity as methane. The number of carbon atoms can also affect the instrument's sensitivity due to substitution. For example, MicroFID is more sensitive to n-butanol than it is to methanol. For additional information regarding response factors of the MicroFID, consult Appendix 8.5 of the User's Manual.

Beginning Operation

You can operate MicroFID without the flame to print or review logged data. In this way you can conserve the hydrogen fuel.

If you choose to start the flame, MicroFID will attempt to ignite the flame once you have turned on the flow of hydrogen gas. If the MicroFID has not been used for a while, it is possible that the gas supply lines are filled with air. If the flame cannot be started, MicroFID will begin a 30 second purge cycle. During the purge cycle it will flush the gas supply lines with hydrogen. After the purge cycle, it will attempt to light the flame again. If it fails again, another purge cycle will be performed and MicroFID will try a third time to ignite the flame. The following steps summarize proper start-up procedures.

1. Turn the instrument on by pressing the front of the On/Off switch. When the instrument is powered up, the version number and creation date of the instrument software are displayed. Press ENTER.

2. You will be prompted to start the flame If you do not want to start the flame, use the ARROW keys to select "No Flame Needed" and press ENTER. To start the flame, use the ARROW keys to select Start Flame and press ENTER.

3. If you selected "Start Flame," MicroFID will prompt you to turn on the hydrogen. Turn the shut-off valve counterclockwise to start the flow of hydrogen and press ENTER.

4. The pump will start and MicroFID will then ignite the flame. You will hear a small pop when the flame has been ignited. Once the flame has been started the message "Detector flame has been started OK" will be displayed followed by the default display.

The default display provides the following information: instrument status, current detected concentration, event name (if the datalogger is on), time, and date. If an event name is longer than three characters, the bottom line of the display will scroll through the information.

The instrument status appears at the left of the upper line of the display and on the Print and Graph outputs. Each status has a priority assigned to it. If more than one status is in effect, then the status with the highest priority is displayed until the condition is corrected or until the option is turned off.

5.2 Calibration

The calibration (CAL) key is used to calibrate MicroFID. Before beginning calibration, ensure that you have a reliable source of both zero air and calibration gas. To document calibration efforts, field personnel will record information on Figure 1-1. A brief description of the functions under the CAL key are as follows:

1. When you press the CAL key you will first be prompted to select a Cal Memory. Each Cal Memory stores a unique zero point, sensitivity setting, response factor and alarm level.

2. You will then be prompted to enter a response factor. Refer to Appendix 8.5 of the User's Manual for a list of response factors. If the compound is not in that reference, or if you are measuring gas mixtures, enter a value of 1.00. The concentration detected by MicroFID will be multiplied by the response factor before it is displayed and logged.

3. Next select Low Range or High Range operation. Use Low Range if you are sampling concentrations between 0.5 and 2000 ppm (methane equivalents). Use High Range if you are sampling concentrations between 10 and 50,000 ppm (methane equivalents).

4 You will now be prompted to connect a supply of zero air. You can use ambient air or, for best results, use a clean sampling bag filled with zero grade air. In most cases, ambient air will be used provided calibration is performed in an area in which airborne concentrations of contaminants are not present. If using ambient air, press <ENTER> to being zeroing.

5. If you are using a charcoal filter to clean ambient air, connect the filter by loading the Teflon ferrules into the nut (the ferrules and the nut are supplied with the filter). Connect the nut to MicroFID's inlet. Do not tighten the nut. Remove the charcoal filter from its plastic bag and insert it into the nut. Finger tighten the nut onto the inlet. If the filter is not secure, ensure you have inserted the tube far enough into the nut. Do not over-tighten the fitting. Press <ENTER> and the MicroFID will set its zero point. NOTE: The charcoal filter does not filter methane or ethane. If these compounds are present, use a gas bag with a supply of commercial zero air.

6 If you are using a gas bag with zero air, connect the gas bag to the inlet. Open the bag and press <ENTER>. MicroFID will set its zero point.

7. After MicroFID has set its zero point, you can then enter the concentration of the calibration gas (span gas), and then connect the gas bag adapter to the inlet. Open the bag and press <ENTER>. MicroFID sets its sensitivity. Note: You must have a supply of calibration gas ready before calibrating MicroFID. When calibrating MicroFID, ensure the instrument is level. If MicroFID is tilted from side to side, gravity will affect the flame height and cause erroneous readings.

FIGURE 1-1

DOCUMENTATION OF FIELD CALIBRATION

SITE NAME. _____ PROJECT NO.: _____

Date of Calibration	Instrument Name and Model	B & R Environmental Instrument I.D. Number	Person Performing Calibration	Instrument Settings/Readings		Calibration Standard (Lot Number)	Remarks/ Comments
				Pre-Calibration	Post-Calibration		

8. When MicroFID's display reverts to normal, it is calibrated and ready to use. Remove the span gas bag from the inlet.

9. Press the ALARM key and enter the alarm level for the selected CAL memory.

5.3 Routine Maintenance

5.3.1 Battery Charging

A fully charged battery will power the MicroFID for approximately 15 hours. If the instrument is to be used for more than 15 hours, carry a spare battery pack. Battery life is reduced if the instrument is turned off and then on again repeatedly.

When the instrument status displays "LoBat," the battery pack requires changing. When the "LoBat" status is displayed, you have a few minutes of operation left. MicroFID will turn itself off before the battery pack becomes critically low.

To remove the battery pack:

1. Stop the flow of hydrogen gas by turning the hydrogen shut-off valve fully clockwise. Turn the instrument off by pressing the On/Off switch twice.

2. Use the MicroFID multi-tool to loosen the two captive screws in the bottom of the battery pack.

3. A retainer at the rear of the instrument helps secure the battery pack to the instrument. Free the battery pack from the instrument.

4. Connect the charged battery pack to the retainer at the rear of the instrument.

5. Retighten the two captive screws and the bottom of the battery pack.

To charge the battery pack:

1. Ensure the correct plug is installed on the line cord of the battery charger.

2. Plug the charger into the jack located on the front of the battery pack.

3. Plug the charger into an AC outlet. The LED, on the battery pack indicates the charge state. Red indicates the battery is being charged. Green indicates the battery is fully charged and ready for use. It is normal for a fully charged battery to indicate it is charging (red light) when first plugged in. The LED will turn green as the battery charges.

4. When the battery pack is charged remove the charger, first from the wall outlet then from the battery pack.

Charging a fully discharged battery pack will take approximately 8 hours. Leaving the charger connected to a charged battery pack will not harm the battery or the charger in any way. If a battery pack is to be left indefinitely, leave it connected to the charger so that it will be fully charged and ready for operation.

5.3.2 Emptying the Hydrogen Cylinder

When you transport the MicroFID, you should empty the internal hydrogen cylinder and then refill it when you arrive at your destination.

To empty the cylinder:

1. Turn the MicroFID off and open the hydrogen shut-off valve.
2. Remove the battery pack as described above.
3. Locate the purge outlet. It is located on the underside of the instrument.
4. Use the MicroFID multi-tool to turn the screws counterclockwise. Loosen the screw but do not remove it.
5. Leave the instrument so that the purge outlet is facing up. If the purge outlet is facing down, hydrogen will vent into MicroFID's case.
6. If the cylinder is full, it will take approximately 15 minutes to empty.
7. Watch the Contents gauge. When the cylinder is empty, close the purge outlet. Use the MicroFID multi-tool to turn the screw clockwise.
8. Replace the battery pack as discussed above.

5.3.3 Replacing the Sample Inlet Filter

MicroFID is equipped with a combined dust and water filter to reduce detector contamination. As the filter collects dust, MicroFID's inlet flow rate and sensitivity decrease. The filter will not allow water to pass through, but the filter will not stop all solvents.

Replace the filter on a weekly basis, or more frequently if MicroFID is used in a dusty or wet environment. You must replace the filter if MicroFID has been exposed to liquid water. The pump will sound labored when the filter requires replacement.

1. Turn off the instrument and unscrew the filter housing from the detector housing. Be careful not to lose the o-ring seal.
2. Remove the Teflon/Polypropylene filter and install the new filter. Place the filter in the filter housing with the Teflon side facing down into the filter housing and the mesh side facing the MicroFID. Handle the filter disk only by the edges. The mesh may be damaged or contaminated by excessive handling. Use forceps if possible.
3. Replace the filter housing.
4. Calibrate the CAL Memories that you are using before continuing operation.

5.4 Troubleshooting

This section provides guidance for troubleshooting the MicroFID. If problems are not corrected through these troubleshooting methods, contact the Photovac Service Department.

5.4.1 MicroFID Fault Messages

When the "Check" status is displayed, MicroFID's operation is compromised. Press the <TUTOR> key for a two-line description of the fault. One exception is the flame out fault. When a flame out fault occurs, the instrument status changes to "NoFlm."

Fault: **Detector flame has gone out.**

Cause: The hydrogen gas has run out.

Action: Ensure the shut-off valve is open. Check the hydrogen contents gauge on the side of the instrument and refill the hydrogen cylinder if necessary. Ensure the cylinder purge outlet has been closed.

Cause: Oxygen supply is deficient.

Action: Ensure there is an adequate supply of oxygen. If you are sampling very high concentrations it is possible you are sampling above the flame out concentration. The flame out concentration for methane is approximately 52,000 ppm (5.2 percent methane in air).

A minimum of 17 percent oxygen is required to start the hydrogen flame. The oxygen is supplied from the sample as it is drawn in by the pump. A minimum of 10 percent oxygen is required to maintain the hydrogen flame.

Flame out also may occur when sampling enclosed or confined spaces where vapors and gases cannot escape. Watch for indications of increased flame height such as erratic readings or sudden high concentrations followed by a flame out fault.

If you will be using the MicroFID in a highly contaminated area where it is possible that the oxygen content is below 10 percent, watch for indication of reduced flame height such as lowered detection limits or a flame out fault.

Cause: High concentrations of flammable gases (gases within their flammable range) are present. High concentrations of flammable gases can act as an additional fuel source. When this happens, the flame height may increase beyond the confines of the combustion chamber. The hydrogen supply will then be cut-off and the flame will go out.

Action: Move to a location where there is an adequate supply of air and restart the flame. See the information above. Watch for indications of increased flame height such as erratic readings or sudden height concentrations followed by a flame out fault.

Cause: Exhaust port is blocked.

Action: At low temperatures, water vapor, a by-product of the hydrogen flame, may condense at the exhaust port. At sub-zero temperatures the water will freeze and obstruct the exhaust port. If the exhaust port becomes obstructed, pump operation will be inhibited. Flame out may also result. Operate the MicroFID within the operating temperature range 41 to 105 degrees Fahrenheit. In the event that the flame arrestor becomes clogged, contact the Photovac Service Department.

Cause: Sample line is blocked.

Action: Ensure the sample line is not obstructed in any way. If you are using the long sample probe, ensure flow is maintained through the entire length of tubing.

Cause: Inlet filter is plugged.

Action: Replace the inlet filter.

Fault: **Signal form zero gas is too high.**

Cause: Contamination of sample line or fittings before the detector.

Action: Clean or replace the sample line of the inlet filter.

Cause: Span gas is used instead of zero gas.

Action: Ensure clean gas is used to zero the MicroFID. Mark the calibration and zero gas bags clearly.

Cause: Ambient air is contaminated.

Action: If you are unsure about the quality of the ambient air, use a charcoal filter or a supply of commercial zero grade air.

Cause: Hydrogen supply is contaminated.

Action: Hydrogen may react with the carbon element of the steel tank to produce methane. This will only occur if the cylinder is in poor condition and if the hydrogen has a high moisture content. Replace the hydrogen tank. Empty and refill the MicroFID internal cylinder with fresh hydrogen.

Fault: **Signal form the span gas is too small**

Cause: Span gas and zero air are switched.

Action: Ensure calibration is used to calibrate MicroFID. Mark the calibration and zero gas bags clearly. Ensure the span gas is of a reliable concentration.

Fault: **Detector field voltage is low.**

Cause: Internal fault in electronics.

Action: Contact the Photovac Service Department.

Problem: **No instrument response detected, yet compounds are known to be present.**

Cause: MicroFID has not been calibrated properly.

Action: Ensure calibration gas is of a reliable concentration and then calibrate the instrument. After the instrument has been calibrated, sample the bag of calibration gas. A reading equivalent to the calibration gas should be displayed. If not, contact the Photovac Service Department.

Action: When calibrating the MicroFID, ensure the instrument is level. If the MicroFID is tilted side to side, gravity will affect the flame height and cause erroneous readings. If the sampling location is difficult to reach without tilting the instrument, use the long sample probe.

Cause: Background contamination from the hydrogen.

Action: It is possible that the hydrogen has become contaminated and is contributing a high background signal. If the hydrogen supply tank is more than 6 months old it should be replaced with a new cylinder. When ordering hydrogen, specify ultra-high purity (99.999 percent pure). Empty the MicroFID hydrogen cylinder and then refill with hydrogen from the new cylinder.

Problem: **Date and time settings are not retained.**

Cause: MicroFID has not been used for 3 months or more and the internal battery (not the external battery pack) has been discharged.

Action: Turn MicroFID on and allow it to run until a "LoBat" status appears. This will take approximately 15 hours. Remove the battery pack and recharge it overnight. Repeat this procedure for 3 or 4 days. While MicroFID is running the internal battery is charging.

Problem: **Cannot bill the internal hydrogen cylinder to 1800 psig.**

Cause: Supply tank has less than 1800 psig of pressure. You can only fill the internal cylinder to a pressure of less than or equal to the tank pressure.

Action: Fill the internal cylinder to the pressure of the tank or replace the tank with a full one.

Cause: The hydrogen purge outlet is open.

Action: Close the outlet and fill the cylinder.

Cause: There is a problem with the refill adapter.

Action: Contact the Photovac Service Department

Problem: Instrument status shows "Over."

Cause: Rapid change in signal level. The detector electronics have been momentarily saturated.

Action: Wait a few seconds for the status to return to "Ready."

Cause: The detector has become saturated.

Action: Move the MicroFID to a location where it can sample clean air. Sample zero air until the reading stabilizes around "0." If you were using Low Range, switch to High Range. Calibrate the CAL Memory you were using when the "Over" status appeared.

Pr blem: Display contrast bars are on or display is blank.

Cause: Battery pack is critically low.

Action: Recharge the battery pack or connect the MicroFID to the battery charger.

Cause: The battery pack is not connected to the instrument properly.

Action: Ensure the battery pack has been aligned correctly. Ensure the battery pack is secured by the retainer at the rear of the instrument.

Pr blem: Sample flow rate varies from 600 ml/min. +/-10 percent.

Cause: Inlet filter has not been installed.

Action: Install an inlet filter.

Cause: Inlet filter has not been tightened onto the detector cap.

Action: Finger-tighten the filter cap.

Cause: Inlet filter is plugged.

Action: Replace the inlet filter.

Cause: Pump has been damaged.

Action: Contact the Photovac Service Department

Cause: Exhaust port is blocked.

Action: At low temperatures, water vapor (a by-product of the hydrogen flame) may condense at the exhaust port. At sub-zero temperatures the water will freeze and obstruct the exhaust port. If the exhaust port becomes obstructed, pump operation will be inhibited. Flame out may also result. Operate the MicroFID within the operating temperature range 41 to 105 degrees Fahrenheit. In the event that the flame arrestor becomes clogged, contact the Photovac Service Department.

Problem: Flame will not ignite.

Cause: The hydrogen gas has run out.

Action: Ensure the shut-off valve is open. Check the hydrogen contents gauge on the side of the instrument and refill the hydrogen cylinder if necessary. Ensure the hydrogen purge outlet is closed.

Cause: Oxygen supply is deficient.

Action: Ensure there is an adequate supply of oxygen. Do not attempt to ignite the flame in a location where there is greater than 10,000 ppm methane or the equivalent concentration of a flammable gas. Move to a location where there are lower concentrations, start the flame and then begin sampling higher concentrations. If the flame goes out while you are sampling very high concentrations, it is possible you are sampling above the flame out concentration. The flame out concentration of methane is approximately 52,000 ppm (5.2 percent methane in air). A minimum of 17 percent oxygen is required to start the hydrogen flame. Oxygen is supplied from the sample as it is drawn in by the pump. A minimum or 10 percent oxygen is required to maintain the hydrogen flame.

Cause: Exhaust port is blocked.

Action: At low temperatures, water vapor (a by-product of the hydrogen flame) may condense at the exhaust port. At sub-zero temperatures the water will freeze and obstruct the exhaust port. If the exhaust port becomes obstructed, pump operation will be inhibited. Flame out may also result. Operate the MicroFID within the operating temperature range 41 to 105 degrees Fahrenheit. In the event that the flame arrestor becomes clogged, contact the Photovac Service Department.

Cause: Hydrogen supply lines are full of air.

Action: If MicroFID has not been operated for some time, it is possible that the hydrogen supply lines contain air. Fill the hydrogen cylinder and then open the hydrogen shut-off valve. Allow the hydrogen to purge the system for about 5 minutes and then turn MicroFID on and start the flame.

Cause: Hydrogen lines are blocked.

Action: Contact the Photovac Service Department.

Problem: Liquid has been aspirated.

Cause: MicroFID has been exposed to a solvent that can pass through the Teflon/Polypropylene filter.

Action: Contact the Photovac Service Department.

5.5 Transporting MicroFID

When you transport MicroFID, you should empty the internal hydrogen cylinder and then refill it when you arrive at your destination. If you are traveling by passenger aircraft, you must empty the hydrogen cylinder. You cannot transport MicroFID by passenger aircraft with hydrogen in the cylinder.

The MicroFID can be shipped to sites. However, if shipment is to be performed while the cylinder still contains hydrogen, a hazardous materials airbill must be filled out. Examples of various completed forms are provided as Figures 6-1 and 6-2.

6.0 SHIPPING

The Photovac may be shipped as cargo or carried on as luggage providing there is no hydrogen fuel source or calibration gas cylinder accompanying the kit. If shipping or transporting the hydrogen fuel source, a Hazardous Airbill (such as the example in Figure 6-1) must be completed. When shipping or transporting the calibration gas, a separate Hazardous Airbill such as the one illustrated in Figure 6-2 must be prepared.

7.0 REFERENCES

MicroFID Handheld Flame Ionization Detector User's Manual, 1995.

FIGURE 6-1

EXAMPLE OF A HAZARDOUS AIRBILL FOR HYDROGEN

SHIPPER'S DECLARATION FOR DANGEROUS GOODS (Provide at least two copies to the airline)

Shipper
BROWN & ROOT ENVIRONMENTAL
SPRING RUN ROAD EXTENTION
CORAOPOLIS, PA 15108

Consignee

FedEx. Federal Express

Two completed and signed copies of this Declaration must be handed to the operator.

TRANSPORT DETAILS

This shipment is within the limitations prescribed for: (delete non-applicable)

[redacted] | CARGO AIRCRAFT ONLY

Airport of Departure

Airport of Destination:

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.

Shipment type: (delete non-applicable)

NON-RADIOACTIVE | [redacted]

NATURE AND QUANTITY OF DANGEROUS GOODS

Dangerous Goods Identification							
Proper Shipping Name	Class or Division	UN or ID No.	Packing Group	Subsidiary Risk	Quantity and type of packaging	Packing Inst.	Authorization
HYDROGEN, COMPRESSED	2.1	UN 1049			1 PLASTIC BOX X KG	200	

Additional Handling Information

(412) 262-4583

Emergency Telephone Number

I hereby declare that the contents of this consignment are fully and accurately described above by the proper shipping name, and are classified, packaged, marked and labelled/placarded, and are in all respects in proper condition for transport according to applicable International and National Governmental Regulations.

Name/Title of Signatory
TOM PATTON, EQUIPMENT MGR.

Place and Date
PITTSBURGH, PA

Signature
(see warning above)

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

FedEx 10-1431 10/91 LOGOS® 2041780848

FIGURE 6-2

EXAMPLE OF A HAZARDOUS AIRBILL FOR METHANE IN AIR

SHIPPER'S DECLARATION FOR DANGEROUS GOODS (Provide at least two copies to the airline)

Shipper: BROWN & ROOT ENVIRONMENTAL
SPRING RUN RD, EXT.
CORAOPOLIS, PA 15108

Page 1 of 1 Pages

Consignee

FedEx. Federal Express

Two completed and signed copies of this Declaration must be handed to the operator.

TRANSPORT DETAILS

This shipment is within the limitations prescribed for: (delete non-applicable)

PASSENGER AND CARGO AIRCRAFT | ~~CARGO AIRCRAFT ONLY~~

Airport of Departure

Airport of Destination:

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.

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.	Packing Group	Additional Description	Quantity and type of packaging	Packing Inst.	Authorization
COMPRESSED GAS N.O.S. (METHANE IN AIR)	2.2	UN 1956			1 FIBERBOARD BOX X ____ KG	200	

Additional Handling Information

Emergency Telephone Number (412) 262-4583

I hereby declare that the contents of this consignment are fully and accurately described above by the proper shipping name, and are classified, packaged, marked and labelled/placarded, and are in all respects in proper condition for transport according to applicable International and National Governmental Regulations.

Name/Title of Signatory: TOM PATTON, Equip Mgr.

Place and Date: Pittsburgh, PA

Signature (see warning above)

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

U.S. ENVIRONMENTAL PROTECTION AGENCY
REGION I

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

July 30, 1996
Revision 2

U.S. ENVIRONMENTAL PROTECTION AGENCY
REGION I

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

I. SCOPE & APPLICATION

This standard operating procedure (SOP) provides a general framework for collecting ground water samples that are indicative of mobile organic and inorganic loads at ambient flow conditions (both the dissolved fraction and the fraction associated with mobile particulates). The SOP emphasizes the need to minimize stress by low water-level drawdowns, and low pumping rates (usually less than 1 liter/min) in order to collect samples with minimal alterations to water chemistry. This SOP is aimed primarily at sampling monitoring wells that can accept a submersible pump and have a screen, or open interval length of 10 feet or less (this is the most common situation). However, this procedure is flexible and can be used in a variety of well construction and ground-water yield situations. Samples thus obtained are suitable for analyses of ground water contaminants (volatile and semi-volatile organic analytes, pesticides, PCBs, metals and other inorganics), or other naturally occurring analytes.

This procedure does not address the collection of samples from wells containing light or dense non-aqueous phase liquids (LNAPLs and DNAPLs). For this the reader may wish to check: Cohen, R.M. and J.W. Mercer, 1993, DNAPL Site Evaluation; C.K. Smoley (CRC Press), Boca Raton, Florida and U.S. Environmental Protection Agency, 1992, RCRA Ground-Water Monitoring: Draft Technical Guidance; Washington, DC (EPA/530-R-93-001).

The screen, or open interval of the monitoring well should be optimally located (both laterally and vertically) to intercept existing contaminant plume(s) or along flowpaths of potential contaminant releases. It is presumed that the analytes of interest move (or potentially move) primarily through the more permeable zones within the screen, or open interval.

Use of trademark names does not imply endorsement by U.S.EPA but is intended only to assist in identification of a specific type of device.

II. EQUIPMENT

A. Extraction device

Adjustable rate, submersible pumps are preferred (for example, centrifugal or bladder pump constructed of stainless steel or Teflon).

Adjustable rate, peristaltic pumps (suction) may be used with caution. Note that EPA guidance states: "Suction pumps are not recommended because they may cause degassing, pH modification, and loss of volatile compounds" (EPA/540/P-87/001, 1987, page 8.5-11).

The use of inertial pumps is discouraged. These devices frequently cause greater disturbance during purging and sampling and are less easily controlled than the pumps listed above. This can lead to sampling results that are adversely affected by purging and sampling operations, and a higher degree of data variability.

B. Tubing

Teflon or Teflon lined polyethylene tubing are preferred when sampling is to include VOCs, SVOCs, pesticides, PCBs and inorganics.

PVC, polypropylene or polyethylene tubing may be used when collecting samples for inorganics analyses. However, these materials should be used with caution when sampling for organics. If these materials are used, the equipment blank (which includes the tubing) data must show that these materials do not add contaminants to the sample.

Stainless steel tubing may be used when sampling for VOCs, SVOCs, pesticides, and PCBs. However, it should be used with caution when sampling for metals.

The use of 1/4 inch or 3/8 inch (inner diameter) tubing is preferred. This will help ensure the tubing remains liquid filled when operating at very low pumping rates.

Pharmaceutical grade (Pharmed) tubing should be used for the section around the rotor head of a peristaltic pump, to minimize gaseous diffusion.

C. Water level measuring device(s), capable of measuring to 0.01 foot accuracy (electronic "tape", pressure transducer). Recording pressure transducers, mounted above the pump, are especially helpful in tracking water levels during pumping operations, but their use

III. PRELIMINARY SITE ACTIVITIES

Check well for security damage or evidence of tampering, record pertinent observations.

Lay out sheet of clean polyethylene for monitoring and sampling equipment.

Remove well cap and immediately measure VOCs at the rim of the well with a PID or FID instrument and record the reading in the field logbook.

If the well casing does not have a reference point (usually a V-cut or indelible mark in the well casing), make one. Describe its location and record the date of the mark in the logbook.

A synoptic water level measurement round should be performed (in the shortest possible time) before any purging and sampling activities begin. It is recommended that water level depth (to 0.01 ft.) and total well depth (to 0.1 ft.) be measured the day before, in order to allow for re-settlement of any particulates in the water column. If measurement of total well depth is not made the day before, it should not be measured until after sampling of the well is complete. All measurements must be taken from the established referenced point. Care should be taken to minimize water column disturbance.

Check newly constructed wells for the presence of LNAPLs or DNAPLs before the initial sampling round. If none are encountered, subsequent check measurements with an interface probe are usually not needed unless analytical data or field head space information signal a worsening situation. Note: procedures for collection of LNAPL and DNAPL samples are not addressed in this SOP.

IV. PURGING AND SAMPLING PROCEDURE

Sampling wells in order of increasing chemical concentrations (known or anticipated) is preferred.

1. Install Pump

Lower pump, safety cable, tubing and electrical lines slowly (to minimize disturbance) into the well to the midpoint of the zone to be sampled. The Sampling and Analysis Plan should specify the sampling depth, or provide criteria for selection of intake depth for each well (see Section I). If possible keep the pump intake at least two

3b. Subsequent Low Stress Sampling Events

After synoptic water level measurement round, check intake depth and drawdown information from previous sampling event(s) for each well. Duplicate, to the extent practicable, the intake depth and extraction rate (use final pump dial setting information) from previous event(s). Perform purging operations as above.

4. Monitor Indicator Field Parameters

During well purging, monitor indicator field parameters (turbidity, temperature, specific conductance, pH, Eh, DO) every three to five minutes (or less frequently, if appropriate). Note: during the early phase of purging emphasis should be put on minimizing and stabilizing pumping stress, and recording those adjustments. Purging is considered complete and sampling may begin when all the above indicator field parameters have stabilized. Stabilization is considered to be achieved when three consecutive readings, taken at three (3) to five (5) minute intervals, are within the following limits:

turbidity (10% for values greater than 1 NTU),
DO (10%),
specific conductance (3%),
temperature (3%),
pH (± 0.1 unit),
ORP/Eh (± 10 millivolts).

All measurements, except turbidity, must be obtained using a flow-through-cell. Transparent flow-through-cells are preferred, because they allow field personnel to watch for particulate build-up within the cell. This build-up may affect indicator field parameter values measured within the cell and may also cause an underestimation of turbidity values measured after the cell. If the cell needs to be cleaned during purging operations, continue pumping and disconnect cell for cleaning, then reconnect after cleaning and continue monitoring activities.

The flow-through-cell must be designed in a way that prevents air bubble entrapment in the cell. When the pump is turned off or cycling on/off (when using a bladder pump), water in the cell must not drain out. Monitoring probes must be submerged in water at all times. If two flow-through-cells are used in series, the one containing the dissolved oxygen probe should come first (this parameter is most susceptible to error if air leaks into the system).

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

6. Post Sampling Activities

If recording pressure transducer is used, remeasure water level with tape.

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

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

Secure the well.

V.DECONTAMINATION

Decontaminate sampling equipment prior to use in the first well and following sampling of each subsequent well. Pumps will not be removed between purging and sampling operations. The pump and tubing (including support cable and electrical wires which are in contact with the well) will be decontaminated by one of the procedures listed below.

<u>Procedure 1</u>

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

Flush the equipment/pump with potable water.

Flush with non-phosphate detergent solution. If the solution is

may not exceed 20 samples). Trip blanks are required for the VOC samples at a frequency of one set per VOC sample cooler.

Field duplicate.

Matrix spike.

Matrix spike duplicate.

Equipment blank.

Trip blank (VOCs).

Temperature blank (one per sample cooler).

Equipment blank shall include the pump and the pump's tubing. If tubing is dedicated to the well, the equipment blank will only include the pump in subsequent sampling rounds.

Collect samples in order from wells with lowest contaminant concentration to highest concentration. Collect equipment blanks after sampling from contaminated wells and not after background wells.

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

If split samples are to be collected, collect split for each analyte group in consecutive order (VOC original, VOC split, etc.). Split sample should be as identical as possible to original sample.

All monitoring instrumentation shall be operated in accordance with EPA analytical methods and manufacturer's operating instructions. EPA analytical methods are listed in 40 CFR 136, 40 CFR 141, and SW-846 with exception of Eh, for which the manufacturer's instructions are to be followed. Instruments shall be calibrated at the beginning of each day. If a measurement falls outside the calibration range, the instrument should be re-calibrated so that all measurements fall within the calibration range. At the end of each day, check calibration to verify that instruments remained in calibration. Temperature measuring equipment, thermometers and thermistors, need not be calibrated to the above frequency. They should be checked for accuracy prior to field use according to EPA Methods and the manufacturer's instructions.

EXAMPLE (Minimum Requirements) Page____of____

Well PURGING-FIELD WATER QUALITY MEASUREMENTS FORM

Location (Site/Facility Name)_____ Depth to _____/_____ of screen
Well Number_____ Date_____ (below MP) top bottom
Field Personnel_____ Pump Intake at (ft. below MP)_____
Sampling Organization_____ Purging Device; (pump type)_____
Identify MP_____

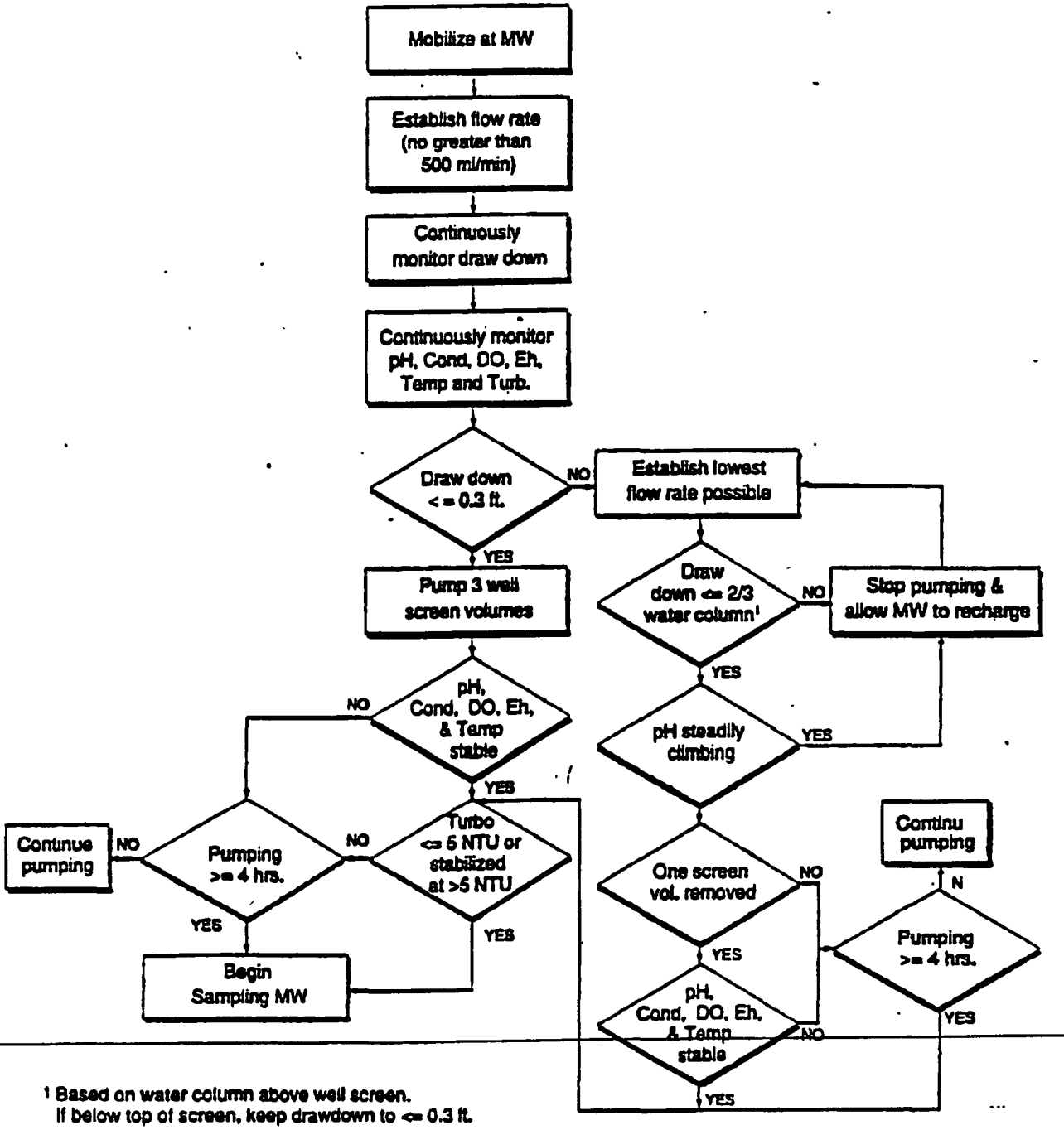
Clock Time 24 HR	Water Depth below MP ft	Pump Dial[1]	Purge Rate ml/min	Cum. Volume Purged liters	Temp. °C	Spec. Cond.[2] µS/cm	pH	ORP/ Eh[3] mv	DO mg/L	Turb-idity NTU	Comments

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

Decision Tree

Rhode Island Department of Environmental Management
Recommended Low-Flow Groundwater Sample Collection

Source: Metcalf & Eddy



[1] Based on water column above well screen.
If below top of screen, keep drawdown to <= 0.3 ft.

HOTLINE QUESTIONS AND ANSWERS

RCRA

1. Use of Total Waste Analysis in Toxicity Characteristic Determinations

A generator suspects that his waste may exhibit the toxicity characteristic and thus be subject to regulation as a RCRA hazardous waste. Since he is unsure of the types and concentrations of hazardous contaminants present in the waste, he performs a total waste analysis. Can he use the results of the total waste analysis to make a toxicity characteristic determination, or must he perform Method 1311, the toxicity characteristic leaching procedure (TCLP), to determine the waste's regulatory status?

While a toxicity characteristic determination under §261.24 typically involves application of the TCLP followed by analysis of the TCLP extract, a generator may be able to use total waste analysis to demonstrate that a waste does not exhibit the toxicity characteristic. Section 1.2 of the TCLP states, "If a total analysis of the waste demonstrates that individual analytes are not present in the waste, or that they are present but at such low concentrations that the appropriate regulatory levels could not possibly be exceeded, the TCLP need not be run." This analysis can provide the generator with a convenient and cost-effective means of determining if he needs to run the TCLP in order to definitively characterize a waste.

The means for using total waste analysis results to make a toxicity characteristic determination reflect TCLP methodology and therefore vary depending on whether the waste is defined as a liquid, a solid, or a dual-phase waste. Under the TCLP, liquid wastes (i.e., those wastes that contain less than 0.5% dry solids) do not require extraction. The waste, after filtration, is defined as the TCLP extract (Part 261, Appendix II, §2.1). A generator can therefore characterize a liquid waste by filtering the waste, measuring total constituent concentrations in the resulting filtrate, and comparing these concentrations to the appropriate regulatory limits under §261.24.

Wastes which are either 100% solid (i.e., wastes that contain no filterable liquid (Part 261, Appendix II, §7.1.1.1)) or which contain both a liquid and a solid component require conversion of total waste analysis data to estimates of constituent concentrations in the TCLP extract, or maximum theoretical leachate concentrations. For instance, to evaluate the regulatory status of a 100% solid, a generator can simply divide each total constituent concentration by 20 and then compare the resulting maximum theoretical leachate concentration to the appropriate regulatory limit (the division factor reflects the 20-to-1 ratio of extraction fluid to solid used in the TCLP). If no maximum theoretical leachate concentration equals or exceeds the appropriate regulatory limit, the solid cannot exhibit the toxicity characteristic and the TCLP need not be run.

The generator of a dual-phase waste (i.e., a waste which has both a solid and a filterable liquid component) can perform a total waste analysis on the liquid and solid portions and calculate maximum theoretical leachate

concentrations for the waste as a whole by combining results mathematically through use of the following formula:

$$\frac{[A \times B] + [C \times D]}{B + [20\ L/kg \times D]} = M$$

where:

A= concentration of the analyte in the liquid portion of the sample (mg/L)

B= volume of the liquid portion of the sample (L)

C= concentration of the analyte in the solid portion of the sample (mg/kg)

D= weight of the solid portion of the sample (kg)

M= maximum theoretical leachate concentration (mg/L)

For example:

A generator who receives the results of a total waste analysis wishes to determine if his waste exhibits the toxicity characteristic for lead. Since he knows the lead concentration in each phase of the waste (0.023 mg/L in the liquid phase, 85 mg/kg in the solid phase), the volume of the liquid phase (0.025 L), and the weight of the solid phase (0.075 kg), he can calculate the waste's maximum theoretical leachate concentration:

$$\frac{[A \times B] + [C \times D]}{B + [20\ L/kg \times D]} =$$

$$\frac{[0.023\ mg/L \times 0.025\ L] + [85\ mg/kg \times 0.075\ kg]}{0.025\ L + [20\ L/kg \times 0.075\ kg]}$$

$$= 4.18\ mg/L$$

Because the 4.18 mg/L maximum theoretical leachate concentration is below the 5.0 mg/L regulatory limit, the generator determines that the waste cannot exhibit the toxicity characteristic for lead.

If maximum theoretical leachate concentrations are less than the applicable limits under §261.24, the waste does not exhibit the toxicity characteristic and the TCLP need not be run. If, on the other hand, total waste analysis data yield a maximum theoretical leachate concentration that equals or exceeds the toxicity characteristic threshold, the data cannot be used to conclusively demonstrate that the waste does not exhibit the toxicity characteristic. The generator may have to conduct further testing to make a definitive toxicity characteristic determination.

EPCRA

2. Recycle/Reuse of Toxic Chemicals in Closed-Loop Refrigeration Systems under EPCRA §313

Many facilities maintain recycle/reuse operations such as closed-loop refrigeration systems. If a facility utilizes 15,000 pounds of ammonia as a coolant in a closed-loop refrigeration system, this amount of the toxic chemical is considered otherwise used under EPCRA §313 because the ammonia is not incorporated into the final product. According to Directive #7 of Toxic Chemical Release Inventory Questions and Answers, Revised 1990 Version, only the amount of a toxic chemical added to a refrigeration system during the reporting year must be included in the threshold calculation. If the facility replaces its refrigeration system but uses the same ammonia to maintain the new system,

APPENDIX C

FIELD FORMS

Brown & Root Environmental

SITE ENTRY LOG

Site Name: _____ Date: _____

Location: _____ Project Number: _____

NAME	REPRESENTING	TIME IN (HOURS)	TIME OUT (HOURS	INITIALS

B&R FORM 0002

BEDROCK MONITORING WELL CONSTRUCTION LOG

BROWN & ROOT ENVIRONMENTAL

PROJECT NAME _____ PROJECT NO _____

PROJECT LOCATION _____ WELL NO _____

CLIENT _____ BORING NO _____

CONTRACTOR _____ DRILLER _____ BORING LOCATION _____

LOGGED BY _____ DATE _____

CHECKED BY _____ DATE _____

ELEVATION TOP OF PROTECTIVE CASING _____

ELEVATION TOP OF RISER PIPE _____

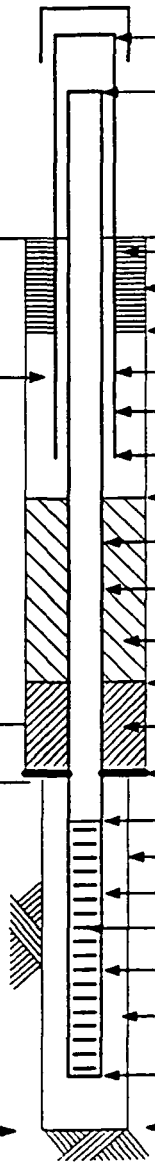
GROUND ELEVATION _____

SAND DRAIN LAYER

DEPTH TO BEDROCK (Ft) _____

DEPTH TO RING (Ft.) _____

END OF BORING @ _____ Ft



LENGTH OF PROTECTIVE CASING ABOVE GROUND SURFACE (Ft) _____

LENGTH OF RISER PIPE ABOVE GROUND SURFACE (Ft) _____

TYPE OF SURFACE SEAL _____

DIA. SURFACE SEAL BGS (In) _____

DEPTH TO BOTTOM OF SURFACE SEAL (Ft) _____

I D OF PROTECTIVE CASING (In) _____

TYPE OF PROTECTIVE CASING _____

DEPTH BOTTOM OF PROTECTIVE CASING (Ft) _____

DEPTH BOTTOM OF DRAIN LAYER (Ft) _____

RISER PIPE (In.) I.D.: _____ O.D.. _____

TYPE OF RISER PIPE _____

TYPE OF BACKFILL AROUND RISER PIPE _____

DEPTH TOP OF SEAL (Ft) _____

TYPE OF SEAL _____

DEPTH BOTTOM OF SEAL (Ft) _____

DEPTH TOP OF PERVIOUS SECTION (Ft) _____

DIAMETER OF BOREHOLE (In) _____

TYPE OF PERVIOUS SECTION _____

TYPE OF OPENINGS _____

PERVIOUS SECTION (In) I D.. _____ O D: _____

TYPE OF FILTER PACK AROUND PERVIOUS SECTION _____

DEPTH BOTTOM OF PERVIOUS SECTION (Ft) _____

DEPTH BOTTOM OF FILTER PACK (Ft) _____

GENERAL NOTE

1 Entry of 0.00 for Ground Elevation, Elev Top of Riser Pipe & Elev Top of Protective Casing Indicates that Surveyed Ground Elevation Not Available

FLUSH MOUNT MONITORING WELL CONSTRUCTION LOG — BROWN & ROOT ENVIRONMENTAL

PROJECT NAME: _____ PROJECT NO: _____

PROJECT LOCATION: _____ WELL NO: _____

CLIENT: _____ BORING NO: _____

CONTRACTOR: _____ DRILLER: _____ BORING LOCATION: _____

LOGGED BY: _____ DATE: _____

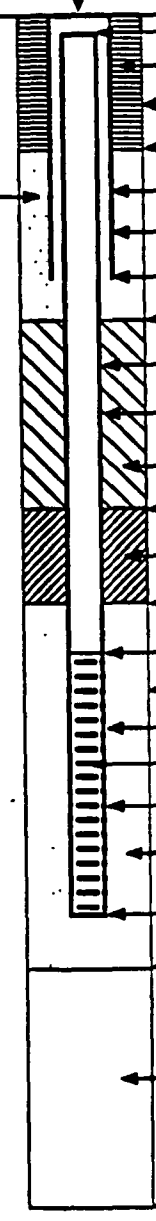
CHECKED BY: _____ DATE: _____

PAGE: 1 OF 1

ELEVATION TOP OF PROTECTIVE CASING _____

ELEVATION TOP OF RISER PIPE _____

GROUND ELEVATION _____



FLUSH MOUNT PROTECTIVE CASING

SAND DRAIN LAYER

LENGTH RISER PIPE BELOW GRD. SURF.(Ft.) _____

TYPE OF SURFACE SEAL _____

DIA. SURFACE SEAL BGS (In.) _____

DEPTH TO BOTTOM OF SURFACE SEAL (Ft.) _____

I.D. OF PROTECTIVE CASING (In.) _____

TYPE OF PROTECTIVE CASING _____

DEPTH BOTTOM OF PROTECTIVE CASING (Ft.) _____

DEPTH BOTTOM OF DRAIN LAYER (Ft.) _____

RISER PIPE (In.) I.D.: _____ O.D.: _____

TYPE OF RISER PIPE _____

TYPE OF BACKFILL AROUND RISER PIPE _____

DEPTH TOP OF SEAL (Ft.) _____

TYPE OF SEAL _____

DEPTH BOTTOM OF SEAL (Ft.) _____

DEPTH TOP OF PERVIOUS SECTION (Ft.) _____

DIAMETER OF BOREHOLE (In.) _____

TYPE OF PERVIOUS SECTION _____

TYPE OF OPENINGS _____

PERVIOUS SECTION (In.) I.D.: _____ O.D.: _____

TYPE OF FILTER PACK AROUND PERVIOUS SECTION _____

DEPTH BOTTOM OF PERVIOUS SECTION (Ft.) _____

DEPTH BOTTOM OF FILTER PACK (Ft.) _____

TYPE OF BACKFILL (GROUT) BELOW FILTER PACK _____

END OF BORING _____

NOTE:

- 2 Centralizers
- Boring Advanced w/ D & W

GENERAL NOTE:

1. Entry of 0.00 for Ground Elevation, Elev. Top of Riser Pipe & Elev. Top of Protective Casing Indicates that Surveyed Ground Elevation Not Available.

Brown & Root Environmental

SAMPLE COLLECTION SUMMARY RECORD

PROJECT NAME: _____ B&R JOB NO./PMS: _____

SAMPLING EVENT: _____ CASE NO.: _____ DAS NO.: _____

DATE	TIME	SAMPLE LOCATION	FIELD QC							COMMENTS

B&R FORM 0012

Brown & Root Environmental

HORIBA U-10 WATER QUALITY CHECKER

Serial No . _____ Model No.: _____ Decal No.: _____

Site Name: _____ Job No.: _____ Buffer Lot No : _____

Instrument is calibrated in accordance with Manufacturer's Instructions

Calibration Date	Initial Readings						Final Readings						Signature	Comments
	pH = 4 0	Cond. m/cm	Turbidity NTUs	D.O. mg/l	Temp. (°C)	Salinity	pH = 4 0	Cond. m/cm	Turbidity NTUs	D.O. mg/l	Temp. (°C)	Salinity		

B&RE FORM 0027

BROWN & ROOT ENVIRONMENTAL

CHAIN OF CUSTODY RECORD

Pag ___ of ___

PROJECT NO	PROJECT NAME/SAMPLING EVENT	NO OF CON-TAINERS							
SAMPLERS (Signature)									
DATE	TIME	COMP	GRAB	SAMPLE LOCATION					

RELINQUISHED BY. (Signature)	DATE/TIME	RECEIVED BY (Signature)	RELINQUISHED BY: (Signature)	DATE/TIME	RECEIVED BY: (Signature)
RELINQUISHED BY (Signature)	DATE/TIME	RECEIVED FOR LABORATORY BY: (Signature)	DATE/TIME	REMARKS	

HNUS ARCS I FORM 0067

Brown & Root Environmental

GROUNDWATER LEVEL MEASUREMENT SHEET

SITE INFORMATION

Site Name: _____

Project Number: _____

Personnel: _____

Date: _____

Municipality: _____

County: _____

State: _____

Street or Map Location: _____

(If Off-Site) _____

WEATHER CONDITIONS AND EQUIPMENT

Temperature Range: _____

Precipitation: _____

Barometric Pressure: _____

Tidally-Influenced [ ] Yes [ ] No

Equipment No.: _____

Equipment Number: _____

Latest Calibration Date: _____

Well or Piezometer Number	Date/Time	Elevation of Reference Point (Feet)*	Water Level Indicator Reading (Feet)*	Adjusted Depth (Feet)*	Groundwater Elevation (Feet)*

B&R FORM 0010

Brown & Root Environmental

WELL INSPECTION AND GROUNDWATER LEVEL MEASUREMENT SHEET

WELL NUMBER: _____ PROJECT NAME: _____

DATE/TIME _____ PROJECT NUMBER: _____

INSPECTED BY: _____

_____

VENT WELL

MONITORING INSTRUMENT READING _____

LEL/O2 READING _____

WELL INSPECTION/GROUNDWATER LEVEL MEASUREMENT

WELL DEPTH (FEET FROM TOP OF PVC) _____

WATER LEVEL DEPTH (FEET FROM TOP OF PVC) _____

WELL STICK-UP _____

CASING STICK-UP (FEET) _____

WELL DIAMETER (INCHES) _____

WELL CONSTRUCTION (PVC, STEEL, ETC.) _____

LOCKED UPON ARRIVAL?	YES	NO	
LOCK REPLACED?	YES	NO	
OBSTRUCTIONS?	YES	NO	
WELL RELABELED?	YES	NO	
SLUG TEST CONDUCTED?	YES	NO	(If YES, refer to "Hydraulic Conductivity Testing Data Sheet")

GENERAL CONDITION/COMMENTS: _____

_____

_____

_____

_____

_____

HNUS ARCS I FORM 0011

BORING LOG FOR: _____ BORING NO. : _____
PROJECT NO: _____ START DATE: _____
LOGGED BY: _____ TRANSCRIBED BY: _____ COMPLETION DATE: _____
DRILLED BY (Company/Driller): _____ MON. WELL NO.: _____
GRD. SURFACE ELEVATION: ELEVATION FROM: CHECKED BY :

DEPTH (FEET)	BLOWS PER 6"	SAMP REC. / SAMP LENG.	SAMPLING TIME & SAMPLE NO. (QA/QC STATUS)	DEPTH MAT'L CHG./ WELL PROF'L	SOIL DENSITY/ CONSIS. or ROCK HARD.	CLR	MATERIAL CLASSIFICATION	USCS or ROCK BRKN	REMARKS (moisture condition; odors, geological classification; rock weathering; etc.)	FIELD SCREENING DATA METHOD = [ ]

TYPE OF DRILLING RIG.

METHOD OF ADVANCING BORING.
METHOD OF SOI L SAMPLING:
METHOD OF ROCK CORING:

GROUNDWATER LEVELS:
OTHER OBSERVATIONS:

Brown & Root Environmental

BORING NO.:_____

PAGE: ____ f____

Brown & Root Environmental

SAMPLE LOG SHEET - LIQUID PHASE

Site Name: _____ HNUS Job No./PMS _____

Sample ID: _____ QC Information: _____ (if applicable)

Sample Method/Device: _____

Depth Sampled: _____ feet Total Depth _____ feet (SW Only)

Sample Date & Time: ___/___/___ _____ hours

Sampler(s): _____

Data Recorded By: _____
Signature

TYPE OF SAMPLE: (Check all that apply)

___ Groundwater
___ Surface Water
___ Residential Supply
___ Grab
___ Composite
___ Trip Blank*
___ Rinsate Blank*
___ Field Duplicate Collected
___ Other (Specify): _____

* include sample source & lot no.

WELL PURGE DATA:

Well Depth	feet	Purge Start	hrs
Inside Diameter	inches	Purge Stop Time	hrs
Water Level	feet	Total Gallons Purged	
Well Volume	gal.	Purge Method	

Color: _____ Turbidity: CLR / SL CLDY / CLDY / OPAQ

MicroTip/OVA Monitor Reading: ppm

Sampling/Purge Data:

Vol. #	Temp °c	pH	Spec. Cond. mill-mhos/cm	DO mg/L
0				
1				
2				
3				
4				

ANALYSIS	BOTTLE LOT NUMBER	TRAFFIC REPORT NO.		COMMENTS
		ORGANIC	INORGANIC	

Brown & Root Environmental

SAMPLE LOG SHEET - SOLID PHASE

Site Name: _____ B&R Job No./PMS _____

Sample ID: _____ Replicate/Duplicate No.: _____ (if applicable)

Sample Method: _____

Depth Sampled: _____ feet

Sample Date & Time: ___/___/___ _____ hours Dup _____ hours

Sampler(s): _____

Data Recorded By: _____
Signature

TYPE OF SAMPLE: (Check all that apply)

___ Soil
___ Sediment
___ Lagoon/Pond
___ Grab
___ Trip Blank*
___ Rinsate Blank*
___ Field Duplicate collected
___ Other (Specify): _____
(Include sample source & lot no.)

Description: (Sand, Clay, Muck, Peat, Dry, Moist, Wet, Etc.)

SAMPLE DATA/REMARKS:

ANALYSIS	BOTTLE LOT NO.	TEMP (oC)	SPECIFIC CONDUCTIVITY (mmhos/cm)	pH STANDARD UNITS	TURBIDITY NTU	DISSOLVED OXYGEN (mg/L)	SALINITY

B&R FORM 0005

Brown & Root Environmental

SAMPLE LOG SHEET - "LOW-FLOW" GROUNDWATER

Site Name: _____

Sample ID: _____

HNUS Job No./PMS _____

QC: _____ (if applicable)

TIME (HOURS)	WL (FEET)	TEMP (°C)	SP. COND. mmhos/cm	pH	TURBIDITY NTu	DISSOLVED OXYGEN (mg/L)	FLOW RATE ml/min		

Brown & Root Environmental

SAMPLE LOG SHEET - "LOW-FLOW" GROUNDWATER

Site Name: _____

Sample ID: _____

HNUS Job No./PMS _____

QC: _____ (if applicable)

Sample Method: _____

Depth Sampled: _____ feet Screened Interval Depth _____ feet

Sample Date & Time: ___/___/___ _____ hours _____ /Dup

Sampler(s): _____

Data Recorded By: _____ Signature: _____

Notes:

H&S Survey Meter _____ PPM Field Instrument Group A/B/C

Pre-pump insertion WL _____ ft Post-pump insertion WL _____ ft

MicroTip Reading: _____

TIME (HOURS)	WL (FEET)	TEMP (°C)	SP. COND. mmhos/cm	pH	TURBIDITY NTu	DISSOLVED OXYGEN (mg/L)	FLOW RATE ml/min	ANALYSIS	BOTTLE LOT NUMBER

Brown & Root Environmental

FIELD INSTRUMENT CALIBRATION LOG

INSTRUMENT NAME _____ MODEL NO.: _____

SERIAL NO : _____ DECAL NO.: _____ B&R JOB NO./PMS _____

CALIBRATION DATE	INITIAL READING	PROCEDURE	FINAL READING	SIGNATURE	COMMENTS

B&R FORM 0007

Brown & Root Environmental

JAR HEADSPACE ANALYSIS LOG

SITE NAME: _____

SITE LOCATION: _____

PROJECT NO./CTO NO.: _____

SAMPLE LOCATION: _____

INSTRUMENT: _____

SERIAL NO.: _____

MODEL NO.: _____

SAMPLE PREP METHOD[1] _____

HEADSPACE ANALYST: _____

DATE: _____

SAMPLE TYPE[2]/NUMBER	SAMPLE DEPTH (FEET)	READING (ppm)	COMMENTS

B&R FORM 0008

1) (a) ambient temp
(h) heated (air)
(w) hot water bath

2) Type of Sample
SB Soil Boring
SD Sediment Sample
SS Surface Soil Sample
GWGroundwater Sample
TP Test Pit Sample

Brown & Root Environmental

TEST PIT LOG

Site Name: _____ Test Pit No.: _____

Project Number: _____ Date: _____

Location: _____ Field Geologist: _____

DEPTH (feet)	LITHOLOGY CHANGE (Depth, feet)	MATERIAL DESCRIPTION (Soil Density/Consistency, Color)	USCS	REMARKS

Test Pit Cross Section and/or Plan View

REMARKS: _____

PHOTO LOG: _____

TEST PIT: _____

PAGE _____ OF _____

B&R FORM 0010

Brown & Root Environmental

FIELD MODIFICATION REQUEST

Site Name: _____ Location: _____

CTO Number: _____ Project Number: _____

To: _____ Location: _____ Date: _____

Description: _____

_____

_____

_____

Reason for Change: _____

_____

_____

Field Team Leader Signature: _____ Date: _____

Recommended Action: _____

_____

_____

_____

Navy RPM Signature: _____ Date: _____

Action: _____

_____

_____

_____

Distribution:

		Others as Required:
Program Manager:	_____	
Project Manager:	_____	_____
Quality Assurance Officer:	_____	_____
Field Team Leader:	_____	_____
Project File:	_____	_____

B&R FORM 0003

Brown & Root Environmental

YSI pH/Conductivity/Temperature Meter Field Calibration Log

SERIAL NO _____ MODEL NO.: _____ EPA DECAL NO. _____

SITE NAME. _____ JOB NO.: _____

CALIBRATION DATE	INITIAL READINGS				PROCEDURES	FINAL READINGS		SIGNATURE	COMMENTS
	pH = 4.0 (Buffer Lot #)	pH = 7.0 (Buffer Lot #)	Conductivity m /cm (Lot #)	Temperature (°C)		pH = 4.0	pH = 7.0		
					MANUFACTURERS INSTRUCTIONS				
					MANUFACTURERS INSTRUCTIONS				
					MANUFACTURERS INSTRUCTIONS				
					MANUFACTURERS INSTRUCTIONS				
					MANUFACTURERS INSTRUCTIONS				
					MANUFACTURERS INSTRUCTIONS				
					MANUFACTURERS INSTRUCTIONS				
					MANUFACTURERS INSTRUCTIONS				

NUS ARCS I FORM 0029 Rev. 1

Brown & Root Environmental

YSI Dissolved Oxygen Meter Field Calibration Log

SERIAL NO _____ MODEL NO _____ EPA DECAL NO _____

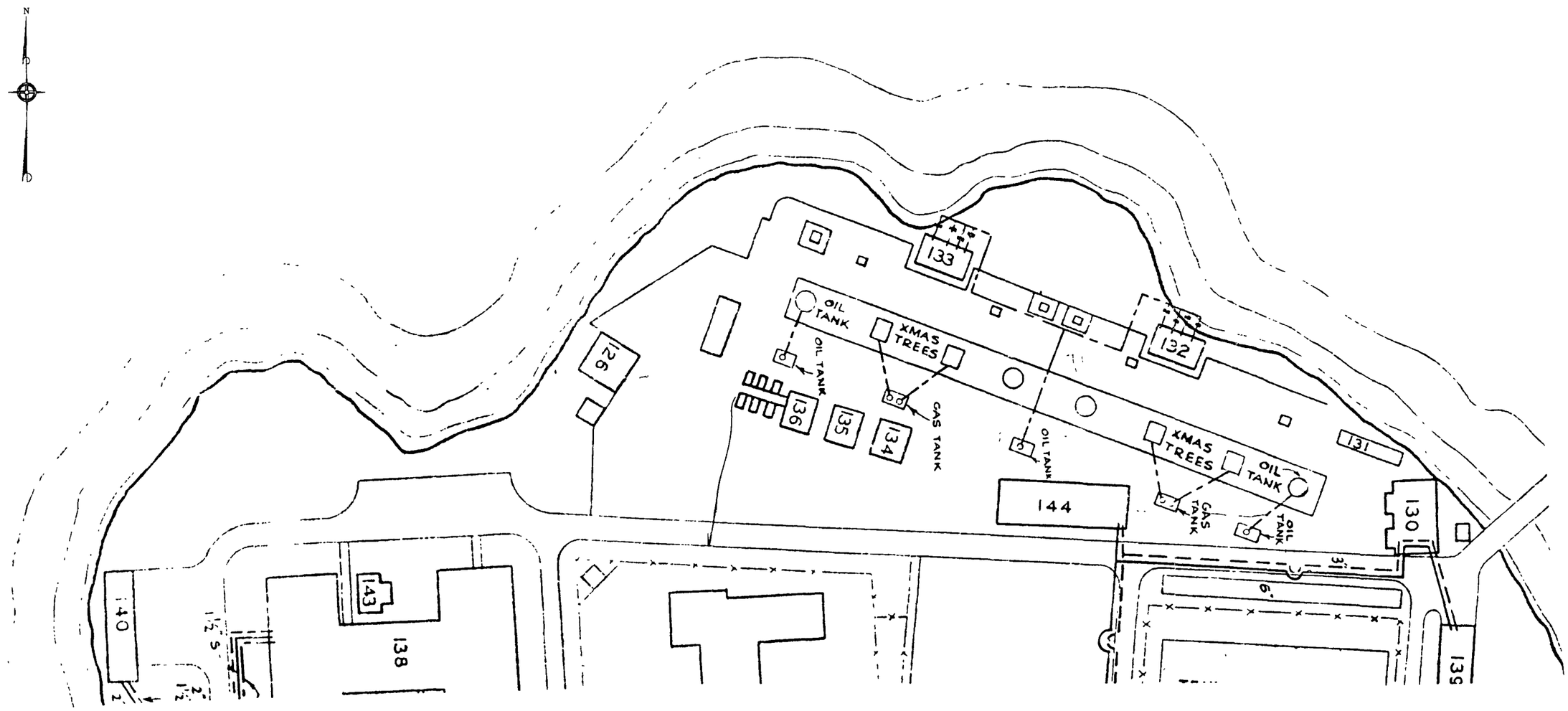
SITE NAME _____ JOB NO _____

CALIBRATION DATE	INITIAL READINGS		PROCEDURE	FINAL SETTINGS		SIGNATURE	COMMENTS
	Dissolved Oxygen (mg/L)	Temperature (°C)		Dissolved Oxygen (mg/L)	Temperature (°C)		
			Air Calibration				
			Air Calibration				
			Air Calibration				
			Air Calibration				
			Air Calibration				
			Air Calibration				
			Air Calibration				
			Air Calibration				
			Air Calibration				
			Air Calibration				

NUS ARCS I FORM 0030 Rev. 1

APPENDIX D

D-1 EXCERPT OF STEAM AND RETURN FUEL OIL PIPING
D-2 EXCERPT OF FRESH AND SALT WATER PIPING
D-3 EXCERPT OF SANITARY AND STORM SEWER LINES



Note: This figure was excerpted from Drawing No. 637871, entitled: Master Shore Station Development Plan, Part IV, Section 6, Steam & Return Fuel Oil, dated December 7, 1953

GRAPHIC SCALE

0' 100' 200'

1 INCH = 100 FEET

STEAM AND RETURN FUEL OIL PIPING			FIGURE D-1
1953 NETC PWD PLAN 637871			
NAVAL EDUCATION AND TRAINING CENTER – NEWPORT, RI			
DRAWN BY	D W MACDOUGALL	REV	0
CHECKED BY	L CHU	DATE.	MAY 1997
SCALE	1" = 100'	FILE NO ·	F \CADD\FIREFITE\FIGD-1 DWG

Brown & Root Environmental
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55 Jonspin Road Wilmington, MA 01887
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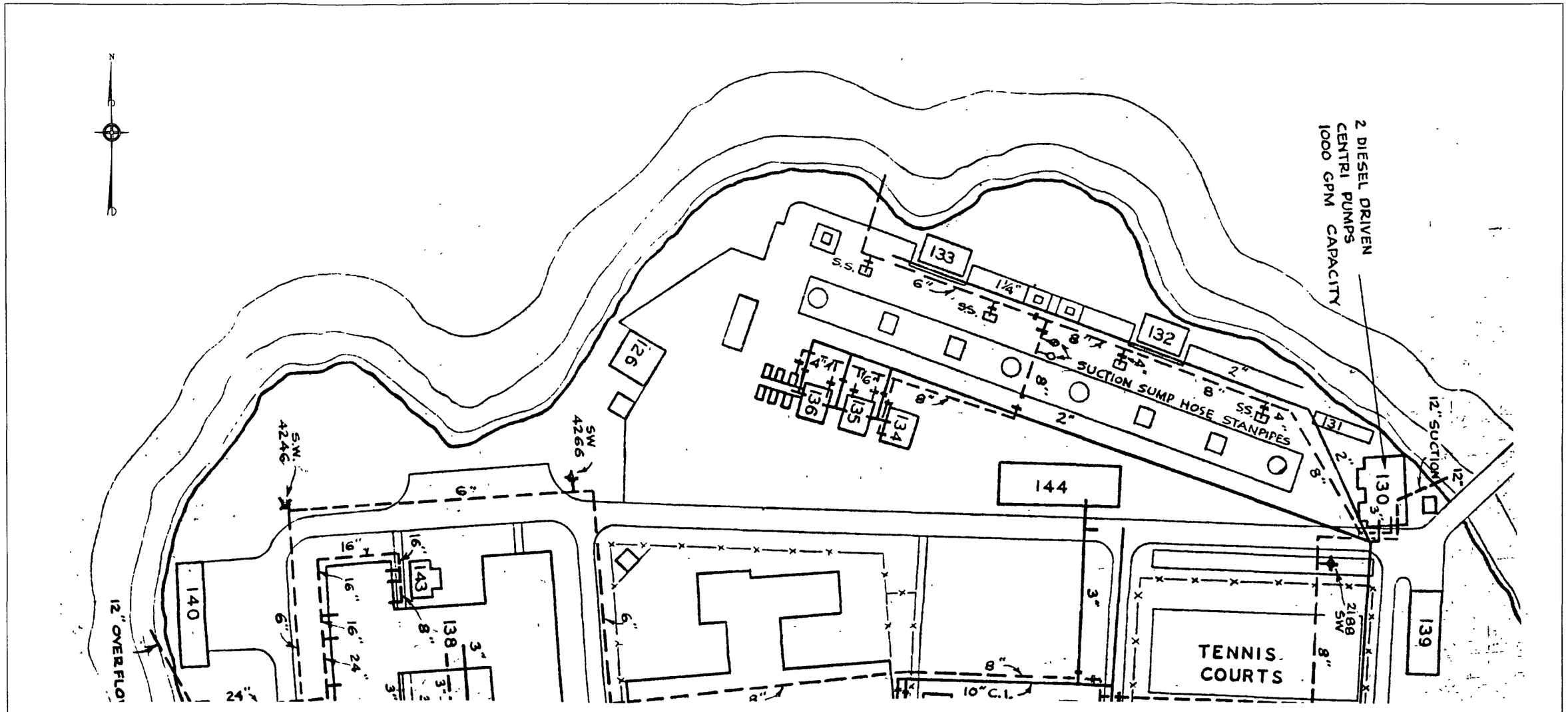

Note: This figure was excerpted from Drawing No. 637867, entitled: Master Shore Station Development Plan, Part IV, Section 6, Fresh & Salt Water, dated December 9, 1953

GRAPHIC SCALE

0' 100' 200'

1 INCH = 100 FEET

FRESH AND SALT WATER PIPING			FIGURE D-2
1953 NETC PWD PLAN 637867			
NAVAL EDUCATION AND TRAINING CENTER – NEWPORT, RI			
DRAWN BY:	D W MACDOUGALL	REV.: 0	
CHECKED BY	L. CHU	DATE: MAY 1997	
SCALE	1" = 100'	FILE NO.: F \CADD\FIREFITE\FIGD-2 DWG	

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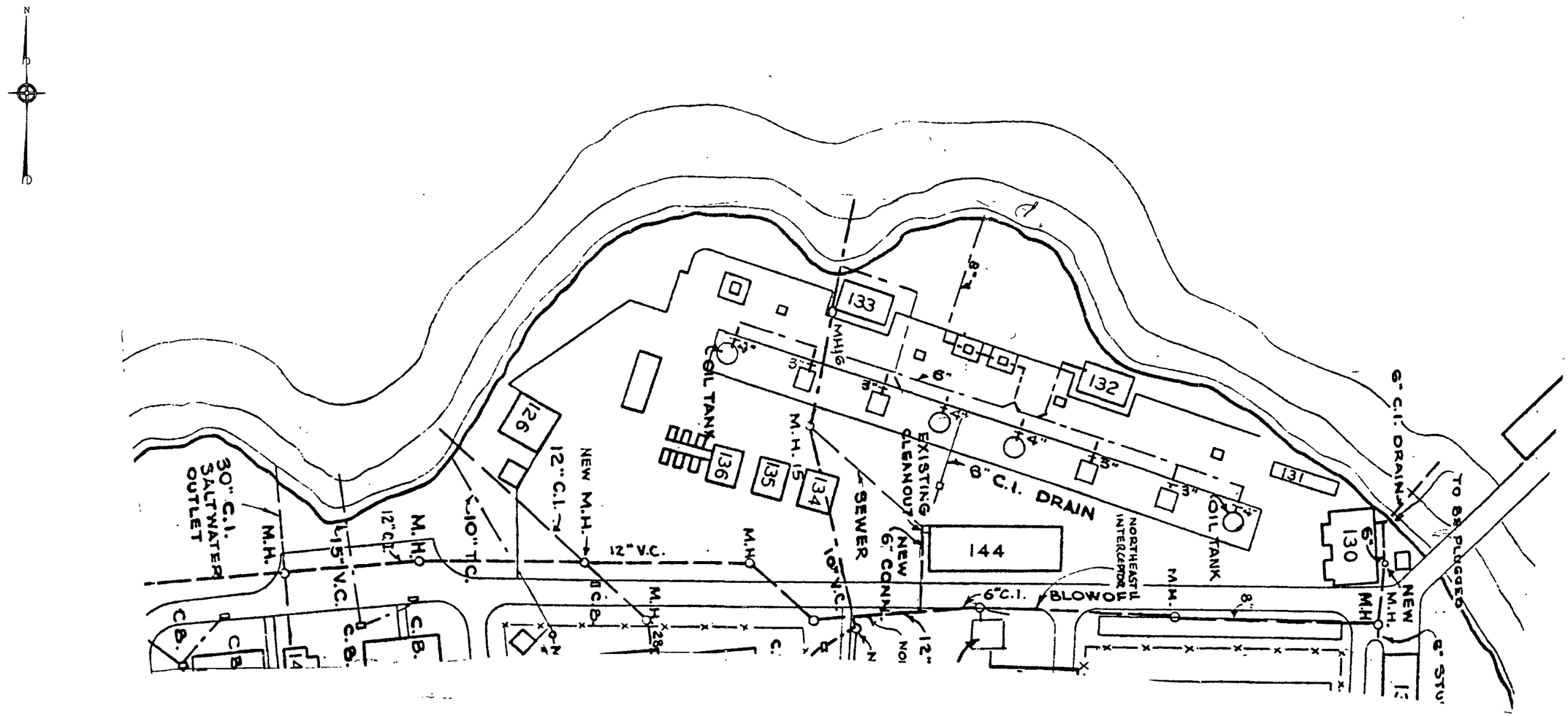

Note: This figure was excerpted from Drawing No. 637869, entitled: Master Shore Station Development Plan, Part IV, Section 6, Sanitary & Storm Sewers, dated December 9, 1953

GRAPHIC SCALE

0' 100' 200'

1 INCH = 100 FEET

SANITARY AND STORM SEWER LINES			FIGURE D-3
1953 NETC PWD PLAN 637869			
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SCALE	1" = 100'	FILE NO	F \CADD\FIREFITE\FIGD-3 DWG

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