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Work Plan
Preliminary Closure Assessments of Tank Farms 4 and 5

Naval Education and Training Center
Newport, Rhode Island

Northern Division
Naval Facilities Engineering Command

Contract Number N62472-90-D-1298
Contract Task Order 143

September 1994

Halliburton NUS
CORPORATION

W5293024F

WORK PLAN
PRELIMINARY CLOSURE ASSESSMENTS
OF
TANK FARMS 4 AND 5

NAVAL EDUCATION AND TRAINING CENTER
NEWPORT, RHODE ISLAND

COMPREHENSIVE LONG-TERM
ENVIRONMENTAL ACTION NAVY (CLEAN) CONTRACT

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

Submitted by:
Halliburton NUS Corporation
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Wayne, Pennsylvania 19087

CONTRACT NUMBER N62472-90-D-1298
"CLEAN" Contract Task Order No. 143

September 1994

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1.0 INTRODUCTION

This Work Plan was prepared to support field sampling activities associated with the Preliminary Closure Assessment (the Assessment) of Tank Farms 4 and 5 located at the Naval Education and Training Center (NETC), Newport, Rhode Island (Figure 1-1). The Assessment will include an investigation of soil and groundwater in areas adjacent to tanks within Tank Farms 4 and 5 (Figure 1-2). This plan addresses work requested by the Naval Facilities Engineering Command (NAVFAC) under Contract Task Order (CTO) #143, Contract Number N62472-90-D-1298 (CLEAN).

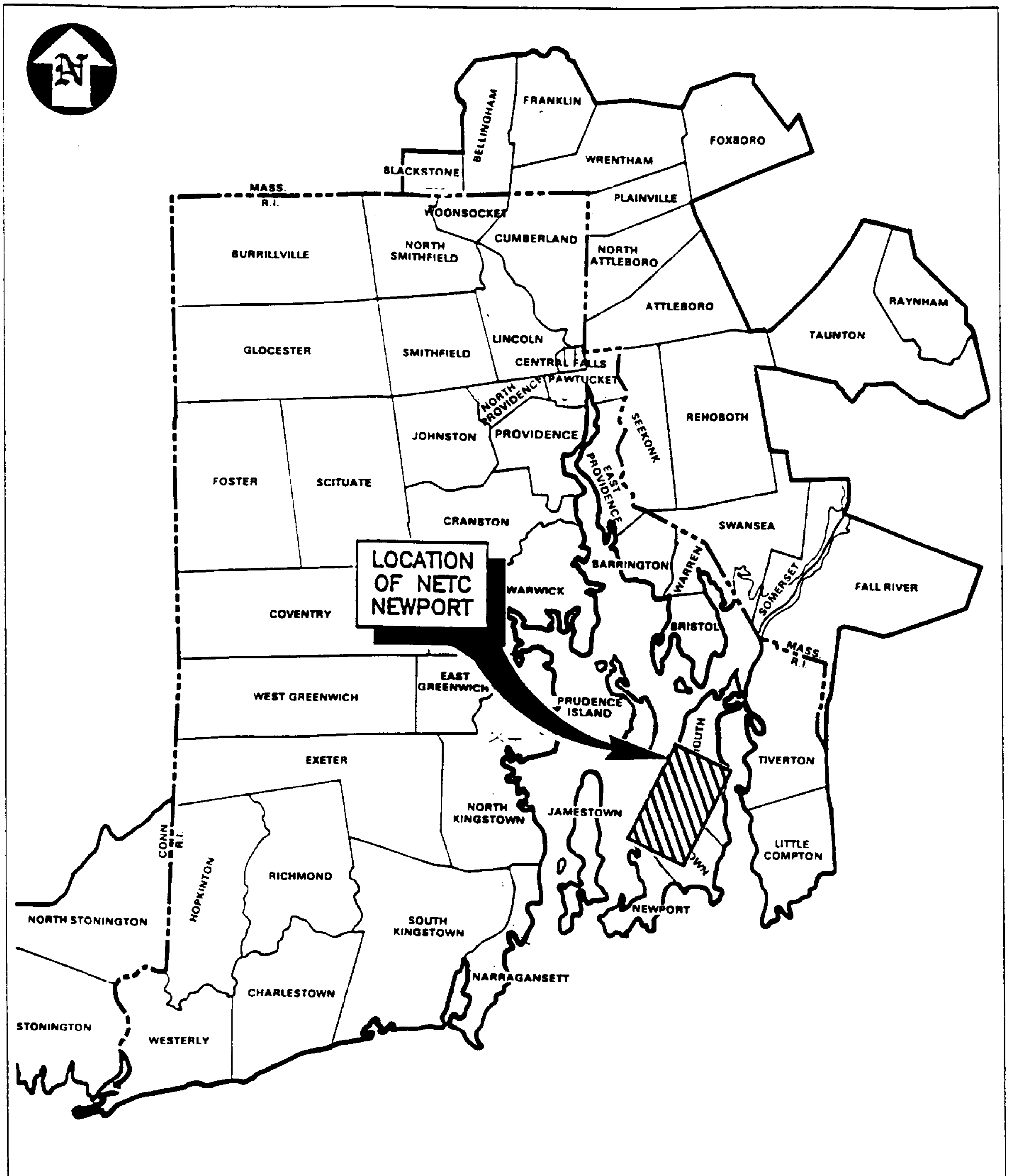
Tank Farms 4 and 5 at NETC Newport contain 23 - 2.5 million gallon concrete underground storage tanks (USTs) that were previously used to store heavy fuel oils. The tanks were abandoned in the 1970's; however, two tanks were used for a brief period during 1974-1975 to store waste oil. These two tanks were cleaned and are being closed under Rhode Island UST regulations.

Rhode Island regulations enacted in 1992 removed the exemption for USTs storing heavy oils, making the tanks subject to closure requirements. A request for extension of temporary closure of the remaining 21 USTs under the regulations was granted in July 1993. Due to the complexity and expense of closing the tanks, additional extensions will be needed. The Preliminary Closure Assessments conducted under this CTO will provide the Navy with information needed to request additional extensions.

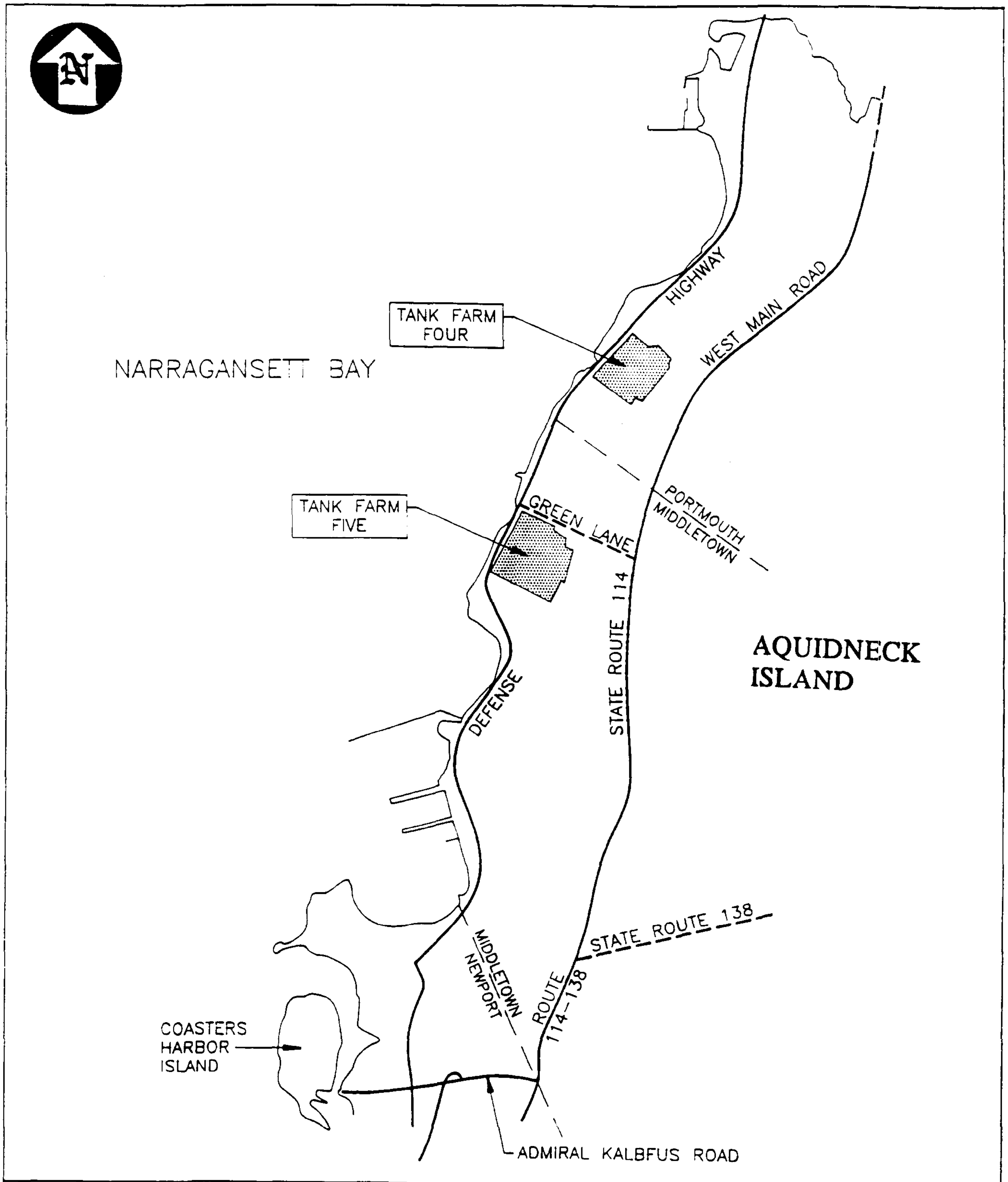
This document, with the Quality Assurance and Quality Control (QA/QC) Plan, provides technical guidelines and procedures to be followed by the field personnel for conducting field activities.

The Health and Safety Plan (HASP) is included in this document. The HASP is intended to protect Halliburton NUS Corporation (HNUS) personnel during the conduct of the field activities discussed in this document.

This Work Plan is divided into four major sections: Section 1.0 is this Introduction; Section 2.0, Site Management Plan (SMP); Section 3.0, Field Sampling Plan (FSP); Section 4.0, Quality Assurance and Quality Control Plan. The Health and Safety Plan is included in Appendix A.



NETC LOCATION PLAN				FIGURE 1-1
NETC – NEWPORT, RI				Halliburton NUS CORPORATION
WORK PLAN				
DRAWN BY:	R. SARGENT	REV.:	0	
CHECKED BY:	W. MARTIN	DATE:	11 NOV 93	
SCALE:		PROJECT NO.:	2288 CTO #143	187 Ballardvale St. Wilmington, MA 01887 (508)658-7899



SITE MAP				FIGURE 1-2
NETC – NEWPORT, RI				Halliburton NUS CORPORATION
WORK PLAN				
DRAWN BY:	R. SARGENT	REV.:	0	
CHECKED BY:	W. MARTIN	DATE:	11 NOV 93	
SCALE:	APPROXIMATELY 1"=4800'	PROJECT NO.:	0288 CTO #143:	187 Ballardvale St. Wilmington, MA 01887 (508)658-7899

2.0 SITE MANAGEMENT PLAN

The Site Management Plan (SMP) outlines the overall project organization for the field investigation, and identifies of key personnel and their responsibilities. The SMP also details site access, security, and control to be exercised during the field investigation. A tentative schedule for the startup and termination of individual activities is presented later in this section.

2.1 SITE CONTROL

The following sections summarize the procedures to be implemented during the field activities.

2.1.1 Site Access

Access to the sites may be gained via Defense Highway. Access to the Tank Farms is essentially uncontrolled. Tank Farm 4 is enclosed by an unsecured fence, while Tank Farm 5 has no perimeter security.

Prior to commencing field activities, the Project Manager shall notify the Navy Northern Division Environmental Branch Point of Contact (POC), Mr. Brian Helland (telephone 215-595-0567) and the Newport Naval Education And Training Center (NETC) Base Coordinator, Mr. David Dorocz (telephone 401-841-3735).

No Halliburton NUS personnel shall perform work at the site until: (1) written or verbal authorization is received from the Project Manager, (2) notice is given to the POC, (3) at least 24-hour notice is given to the NETC Base Coordinator, and (4) each field team member has personal identification in the form of a driver's license, a Halliburton NUS identification card, or a suitable substitute approved by the Field Operations Leader (FOL).

2.1.2 Site Security/Control

As discussed above, access to the Tank Farms is essentially unrestricted. Persons unconnected with this project can enter either site unnoticed by on-site personnel. A minimal degree of security can be achieved at Tank Farm 4 by closing the unsecured access road gate. The field team will conduct activities from a lockable vehicle as discussed in the following section. Although the sampling points cannot be protected, all sampling equipment and supplies (e.g., bottles, trowels, augers, decontamination supplies, etc.) shall be maintained in the vehicle, and the field team shall secure all supplies and equipment in the vehicle prior to each departure from the site. Additionally, the field team shall conduct the work, to the extent possible, that all samples from a sampling point are collected during a single day.

2.1.3 Field Office

Due to the brief field time anticipated for this project, a van-type vehicle will serve as a command post through the duration of this scope of field work, providing shelter, office space, and space for equipment storage and sample handling. A cellular transportable telephone will be used for communications. Offsite sanitary facilities will be identified and utilized.

2.2 PROJECT ORGANIZATION AND RESPONSIBILITIES

Halliburton NUS will be responsible for the overall management and conduct of the activities covered by this Plan. The sections that follow present the names and organizations of the key personnel connected with the work. Navy personnel will be actively involved in the investigation and will coordinate between the regulatory agencies and Halliburton NUS.

2.2.1 Organization

The key personnel connected with this project, their respective organizations and the chain of communications follow.

- Northern Division
  Naval Facilities Engineering Command
  10 Industrial Highway
  Mail Stop 82, Code 1812
  Lester, PA 19113
  Telephone: (215) 595-0567
  Fax: (215) 595-0555

  Brian Helland
  Point of Contact - Engineer in Charge (EIC)

- Halliburton NUS Environmental Corporation
  187 Ballardvale Street
  Suite A-100
  Wilmington, Massachusetts 01887
  Telephone: (508) 658-7899
  Fax: (508) 658-7870

  Walter Martin, Project Manager
  Point of Contact

  Kayleen Jalkut
  Field Operations Leader

  Debra Scheib
  Pittsburgh, PA
  Quality Assurance/Quality Control Manager

  Matt Soltis
  Pittsburgh, PA
  Health and Safety Manager

The Project Manager serves as the Halliburton NUS POC and has the primary responsibility for the management and conduct of the work. He is responsible for the coordination of all onsite personnel and for providing technical guidance for all activities that are directly related to the scope of work associated with this CTO. The review of all environmental data will be conducted by the Project Manager or his designee. If quality assurance issues requiring special action are identified, the Project Manager and the Project QA/QC Advisor will identify the appropriate corrective action.

All field work will be performed by a team composed of a Field Operations Leader (FOL) and Field Technicians, one of whom will also serve as the Site Safety Officer (SSO). The FOL will direct and participate in all field activities, and will report directly to the Project Manager. The SSO will report to the Health and Safety Officer (HSO) in connection with his SSO functions.

An organizational chart illustrating lines of communication is shown in Figure 2-1.

2.2.2 Responsibilities

Responsibilities of field operations personnel reporting to the Project Manager are discussed below.

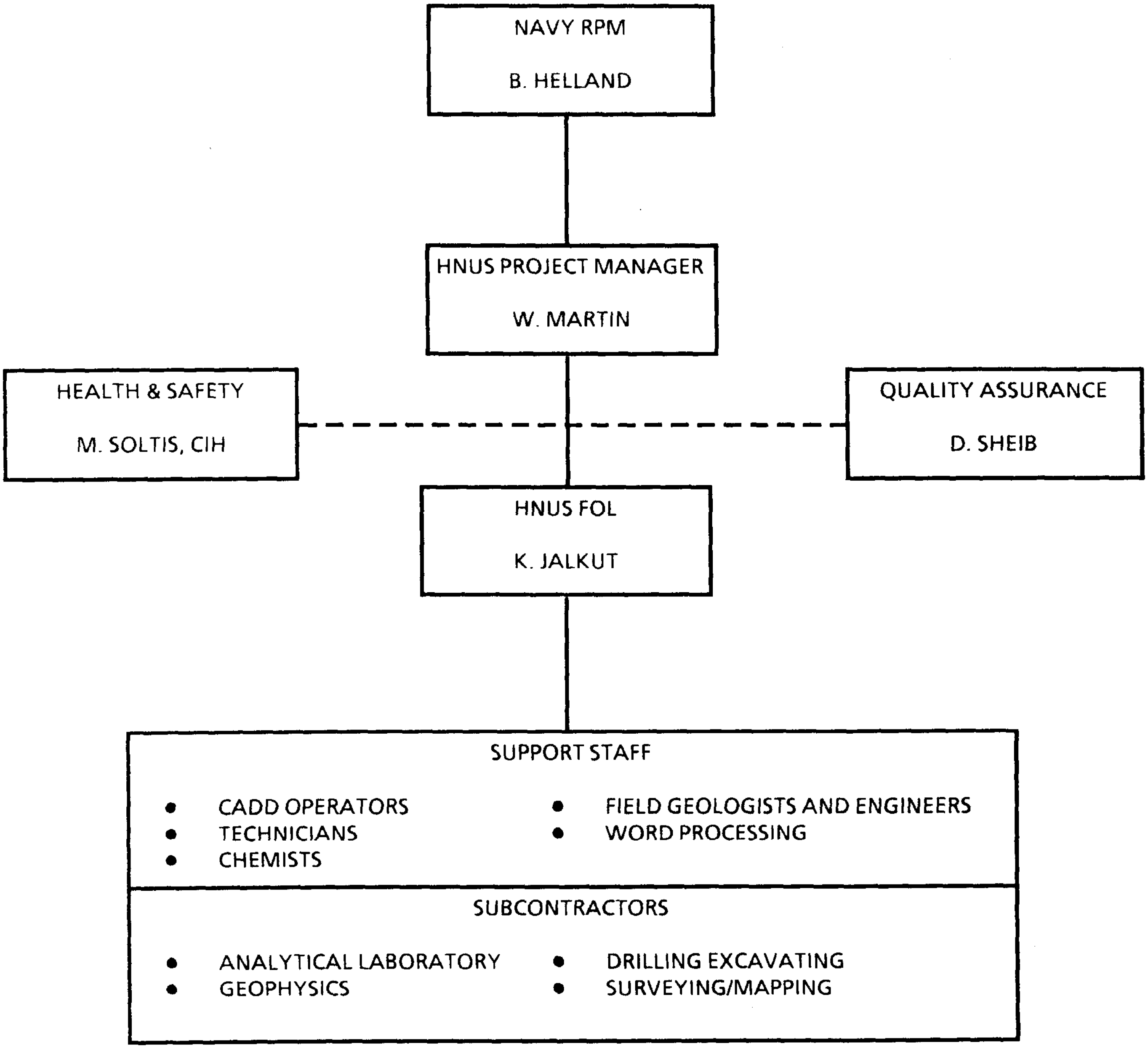
Field Operations Leader (FOL). The FOL is responsible for all day-to-day aspects of the field work. The responsibilities of the FOL include:

- Assuring that all field team members are familiar with this document; ultimate responsibility for field operations, quality control, and documentation.
- Providing team members with daily assignments.
- Assuring that all field team members have completed health and safety training.
- Reporting to the Project Manager on a daily basis regarding the status of all field work and any problems encountered.
- Completing the site logbook on a daily basis.
- Completing Field Modification Records (FMRs), as necessary, for approval by the Project Manager.
- Assuring that team members comply with the procedures outlined in the FSP, particularly documenting the sampling and groundwater level measuring activities.
- Assuring sample shipping schedules are met.

Site Safety Officer (SSO). The SSO reports to the Program Health and Safety Officer (HSO) and indirectly to the FOL and Project Manager. Details of the SSOs responsibilities are presented in the HASP and include:

- Controlling specific health and safety-related field operations such as personnel decontamination, monitoring of worker heat or cold stress, distribution of safety equipment,etc.
- Assuring that field team personnel comply with all procedures established by the HASP.
- Identifying Assistant SSOs or SSO designees in his absence.
- Terminating work if an imminent safety hazard, emergency situation, or other potentially dangerous situation is encountered.

FIGURE 2-1
PROJECT ORGANIZATION



- Assuring the availability and the condition of health and safety monitoring equipment.
- Assuring the proper Health and Safety monitoring equipment calibration methods and schedule is maintained and documented.

2.3 SCHEDULE

The target dates connected with the site investigation field activities follow.

09/30/93	Halliburton NUS notified of authorization to proceed
11/12/93	Submit Draft Work Plan
12/24/93	HNUS Receives Government Comments
09/12/94	Submit Final Work Plan
09/19/94	Initiate Subcontractor Procurements
10/03/94	Complete Subcontractor Procurements
10/17/94	Mobilize Field Crew
11/11/94	Demobilize Field Crew
01/09/95	Submit Draft Report
02/21/95	HNUS Receives Government Comments
03/12/95	Submit Final Report

3.0 FIELD SAMPLING PLAN

This section provides the field sampling team with the direction necessary to meet the objectives of the sampling program. General field procedures and the activity sequence are discussed below.

3.1 SAMPLING OBJECTIVE AND GENERAL PLAN

The objective of this project is to implement a field sampling task to evaluate the presence of soil and groundwater contamination resulting from possible releases of petroleum products from USTs at NETC-Newport, Tank Farms 4 and 5. The data collected during this field task will be used to; evaluate the presence of petroleum related components in soil and groundwater adjacent to subject tanks; and to request additional closure extensions at the sites. Tank numbers 37 through 52, 54 and 55, and 57 through 59 will be investigated by installing and sampling a groundwater monitoring well within each tank ring drain. In addition, piping connecting tanks with the Piping Loop at Tank Farm 4 will be investigated by advancing probes in the vicinity of the piping using a Geoprobe or similar technology to collect soil samples. A round of groundwater samples will be collected from seven wells previously installed by other contractors at tank 53; no new wells will be installed at tank 53.

The investigation will include the installation of a groundwater monitoring well in the ring drain of each UST included in this investigation. The wells will be installed with an appropriately sized drill rig using standard hollow stem auger methods at a hydraulically downgradient location at each tank. The ring drain is a reported four foot thick layer of crushed stone which underlies each tank. The drains reportedly protrude from the edge of the USTs a distance of approximately three feet. A collector pipe is located within this portion of the ring drain. This feature is not well documented on construction documents; and the distance could be significantly more or less than three feet, making the placement of the monitoring well critical.

The exact location of tanks and piping is not available on construction drawings or documents provided to HNUS. As soil samples and wells must be located in close proximity to the target structure, a geophysical survey will be conducted to determine the location of piping and the edges of tanks. A geophysical survey will be conducted to provide this information. This survey will be followed-up by excavating selected features to confirm the effectiveness of the geophysical survey.

The ring drain directly overlies bedrock, which was blasted and excavated during construction of the Tank Farms. The ring drain serves the function of a collector for groundwater; an associated sump pump removes groundwater from the drain to prevent the tank from becoming buoyant when empty. A release of petroleum product from the tank is likely to accumulate in the ring drain. A groundwater monitoring well installed in the ring drain will therefore serve as a monitoring point for a release of product from the tank.

A Geoprobe or equivalent technology will be used to collect soil samples to evaluate possible releases of product from piping (shunt lines) which connects the individual USTs to the Piping Loop feeding the main base fuel supply pipeline. Approximately 40 probes will be advanced in the vicinity of the shunt lines at Tank Farm 4. Ancillary piping is also located adjacent to the fuel Loop and shunt lines. Among this piping is the Bottom Sediment and Water Line (BS&W). The BS&W line from the Piping Loop to the oil-water separator at Tank Farm 4 will also be investigated with the Geoprobe. The Navy will remove piping associated with tanks at Tank Farm 5, therefore, investigation of the lines will not be included at Tank Farm 5. The BS&W lines are shown on the Site figures only where the lines are not coincident with fuel supply lines. Soil samples will also be collected with the Geoprobe in the vicinity of the oil/water separators located at each Tank Farm. Up to 5 probes will be made at each oil and water separator and the BS&W line at Tank Farm 4.

Soil samples will also be collected in conjunction with the Geoprobe investigation and the well installation. Groundwater samples will be collected from all newly installed wells. This sampling will investigate the presence of petroleum components in soils and groundwater in areas adjacent to the Tanks and associated piping.

An Ensys Petro Risc immunoassay field screening kit will be utilized to semi-quantitatively determine the presence of petroleum hydrocarbons in soils. Samples containing the highest concentrations of petroleum hydrocarbons in each Geoprobe boring will be submitted to an analytical laboratory for analysis of Total Petroleum Hydrocarbons (TPH). Soil samples collected from well borings will be analyzed for volatile and semi-volatile organic compounds (VOCs and SVOCs), Total Petroleum Hydrocarbons (TPH), and the 8 RCRA metals. Groundwater collected from newly installed wells will be analyzed for the same parameters.

Groundwater samples collected from wells adjacent to Tank 53 will be analyzed by an analytical laboratory for full VOCs, SVOCs, Pesticides/PCBs, 8 RCRA metals, and TPH.

Ceimic Laboratories was selected to conduct analytical work under this CTO. Ceimic is an approved NEESA laboratory with which HNUS has a Basic Ordering Agreement (BOA) in place.

Following sampling activities, a subcontracted survey crew will conduct a land survey to establish horizontal and vertical control and locate all newly installed wells. The survey subcontractor will provide maps of Tank Farms 4 and 5 which will be used as base maps for subsequent reporting to the Navy.

3.1.1 Research - Task 0110

Research was conducted as part of the preparation of this document to locate records concerning the locations of active and inactive underground utilities at the sites that could provide migration pathways or otherwise impact remedial activities. This information was compiled from site drawings provided by NETC-Newport and is presented in Figures 3-1 and 3-2 (see map pockets at the end of this section). These drawings are not to replace "Digsafe", which will be consulted, along with other appropriate base offices, prior to conducting any intrusive work at the sites.

No attempt was made to research construction documents to evaluate the potential for each utility line to act as a preferential contaminant pathway. However, it is assumed that backfill around any of the utilities can act as a preferential contaminant pathway. Further research and evaluation will be considered based on results of this investigation.

One significant discrepancy was noted during a review of tank construction documents. An outside tank diameter of 68'8" is indicated by the specification of a 34'8" radius for bending and forming reinforcement bands installed on the circumference of each tank. The diameter of the tanks was originally reported to be approximately 119 feet. The investigation includes a survey to more precisely locate the edges of the USTs, and this discrepancy will be addressed during this phase of the work.

Available construction documents and excerpts from a tank report describing installation of tanks at Tank Farm 3 and 5 are included in Appendix D. Document research will continue during field operations.

3.2 MOBILIZATION/DEMOBILIZATION - INCLUDED IN TASK 0220

All field team members will review the FSP, and the Health and Safety Plan (HASP) which is included in Appendix A. In addition, a field team orientation meeting will be held to familiarize personnel with the scope of the field work. It is estimated that the field work will take approximately four weeks to complete. A survey crew will be subcontracted to provide topographical and site survey services at the completion of sampling activities. Demobilization will occur after all activities have been completed.

3.3 GEOPHYSICAL SURVEY - TASK 0210

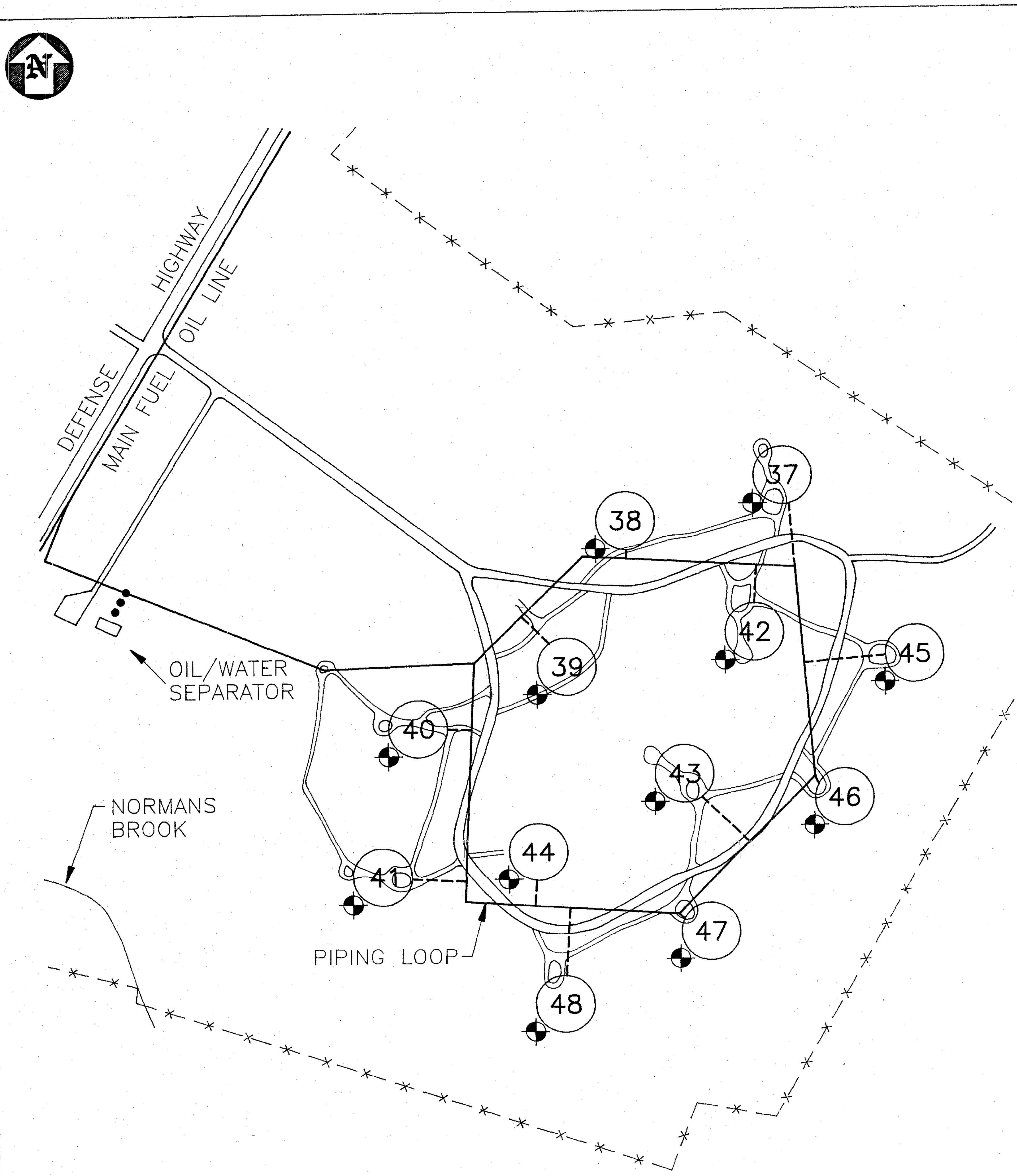
A GPR survey and/or magnetic utility locator survey will be conducted at each of the 21 tanks addressed in this investigation to determine the location of the edge of each tank in the vicinity of the proposed well (Figure 3-3 and 3-4); and the location and approximate depth of the associated piping to be investigated by Geoprobe borings. The information will be used to accurately locate boreholes in proximity to tanks and piping.

GPR systems transmit an electromagnetic pulse into the ground and electrical contrasts in the subsurface cause some of the pulse to be reflected back to the receiver. This returned pulse is recorded as a function of the velocity and depth of penetration of the pulse. The density of materials affects the velocity of the wave in the subsurface; therefore more dense materials (concrete) can be distinguished from less dense materials (unsaturated sands). Anomalies are the result of a large percentage of the signal being reflected back to the receiver from a discrete GPR "reflector". Generally, good conductors, such as metal drums and steel reinforced concrete, reflect most or all of the electromagnetic pulse, resulting in an anomaly.

Utility locators measure the changes in magnetic field across a target area. Increases in magnetic intensity indicate the presence of a buried magnetic body, in this case the steel reinforcing pan present in the concrete tank walls. Utility locators are capable of precisely locating magnetic objects and will be tested at the Tank Farms.

Interpretation of the geophysical record can locate subsurface structures, with sufficient accuracy for the purposes of this investigation provided the target is within the effective depth of penetration. It is assumed for the purposes of this investigation that the geophysical targets, the tanks and piping, are within the effective operating depth of the geophysical systems operating at standard configurations, although, definitive documentation showing the depth to the piping is not presently available. The effective depth of penetration for GPR under these field conditions, and considering a target of a concrete reinforced pipe, is approximately 10 to 15 feet. Frequencies ranging from 300 to 600 megahertz will be tested and field checked by excavation to determine the most effective survey frequency. Magnetic Utility Locators are effective to a depth of 15 to 20 feet.

The geophysical methods will be field tested by conducting two to three profiles in the vicinity of the downgradient edge of one tank. The resulting anomaly, the interpreted edge of the tank, will be excavated with an excavator (backhoe) to confirm the source and accuracy of the anomaly. Further geophysical surveying will be reevaluated and the survey redesigned, if necessary, based on these initial results. Geophysical services will be terminated if the tank edge cannot be interpreted from the geophysical records to within two feet of actual locations, based on visual observation of the target after excavation. The excavator may be retained to continue to locate tanks, and the best available data will be utilized to locate piping runs.



LEGEND

- (48) UNDERGROUND STORAGE TANK
- PROPOSED TANK RING WELL LOCATION
- —x— FENCE
- – – – PIPING
- ●●● BOTTOM SEDIMENT AND WATER LINE

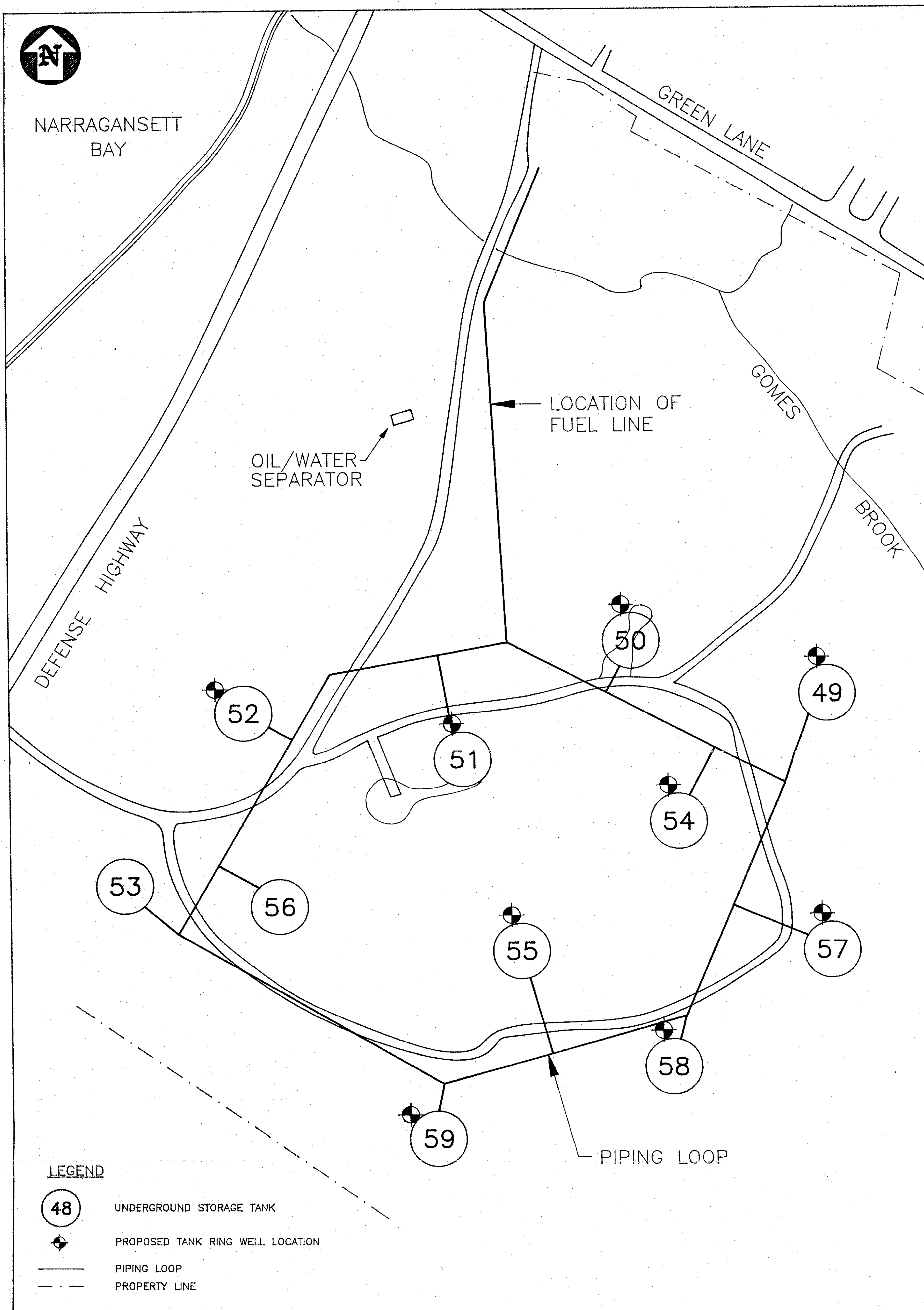
SCALE: 0 — 200 — 400 FEET

PROPOSED TANK WELL LOCATIONS – TANK FARM 4			
NETC – NEWPORT, RI			
WORK PLAN			
DRAWN BY:	R. SARGENT	REV.:	0
CHECKED BY:	W. MARTIN	DATE:	27 DEC 93
SCALE:	1" = 200'	PROJECT NO.:	0288 CTO #143:

FIGURE 3–3

Halliburton NUS CORPORATION

187 Ballardvale St. Wilmington, MA 01887 (508)658-7899



SCALE

0 200 400 FEET

PROPOSED TANK WELL LOCATIONS – TANK FARM 5				FIGURE 3–4
NETC – NEWPORT, RI				Halliburton NUS CORPORATION
WORK PLAN				
DRAWN BY:	R. SARGENT	REV.:	0	
CHECKED BY:	W. MARTIN	DATE:	27 DEC 93	
SCALE:	1" = 200'	PROJECT NO.:	0288 CTO #143:	187 Ballardvale St. Wilmington, MA 01887 (508)658-7899

Geophysical methods will also be tested over the piping runs. Anomalies resulting from cylindrical steel reinforced targets are distinctive and, if present are easily interpreted. Because anomalies are expected to be distinctive, they will not be excavated to avoid damage to piping. The geophysical survey will be terminated after the field test if distinctive anomalies are not generated and the best available data will be utilized to locate piping. If the field test demonstrates geophysics will be useful in locating the piping two to three profiles will be conducted over each piping run.

3.4 SUBSURFACE INVESTIGATION - TASK 0220

The subsurface investigation will be conducted in two phases; a groundwater well installation phase and a Geoprobe soil sampling phase. Monitoring well and probe locations will be selected based on results of the GPR survey described in Section 3.3. Twenty-one (21) groundwater monitoring wells will be installed.

Subcontractors will be procured to conduct the intrusive work.

3.4.1 Soil Borings for Monitoring Well Installations

Borings will be advanced within several feet of operating tank ring drain collector pipes. There is a possibility of damaging a pipe while advancing a boring. Precautions will be taken during the advancement of the borings to minimize the possibility of damage. Neither HNUS, nor its subcontractors, will be responsible for damages to ring drain installations.

The wells will be installed in boreholes advanced with hollow stem auger drilling methods. Minimum 6 1/4 inch inside diameter by nominal ten (10) inch outside diameter hollow stem augers will be used to advance the borings. No drill fluids will be used, except for the use of potable water to control running sands.

3.4.2 Soil Sampling in Monitoring Well Borings

Soil sampling will be conducted in each borehole beginning below the water table, which is present at the site at approximately 15 feet below ground surface. Releases from tanks occurring above the water table will migrate vertically downward to the water table where evidence of the release will be detected in soils and possibly groundwater. Continuous split-barrel sampling will be conducted in each boring from 20 feet below the ground surface to the estimated end of the boring, 45 feet. Two or three inch diameter split spoons will be used. Standard penetration tests may not comply with requirements of ASTM-D-1586-84, as this data is not significant to this investigation. Soil samples will be described and documented by a HNUS on site geologist or engineer according to the Unified Soil Classification System. Soil descriptions, and other significant information, will be included on boring logs which will be included in the final report. Soil samples will be stored by HNUS only until the completion of field work. The Navy will be consulted concerning the disposition of the soil samples prior to the completion of field work.

Soil samples collected from deeper than 20 feet below ground surface will be screened using the Ensys Petro Risc field screening kit to determine the concentration of petroleum components in these soils. Soil samples will be collected at five foot intervals, below 20 feet deep, to the estimated end of boring, 45 feet, for field screening with the Ensys kit. One soil sample containing the highest concentration of petroleum components as determined by the Ensys kit will be selected from each boring and submitted to Ceimic Laboratories for analyses. If no positive detects of TPH are noted, the soil interval corresponding with the ring drain will be shipped to the lab for analysis.

3.4.3 Monitoring Well Installation

Groundwater monitoring wells will be installed in borings advanced at the downgradient location of each UST included in this investigation. Well screens will be five feet long and installed within the ring drain materials or adjacent to the ring drain materials. If the borehole does not intersect the ring drain materials, the well screen will be set at a depth corresponding to the depth of the ring drain. The RPM will be notified if this condition is encountered. In no case will borings be advanced into bedrock. Auger refusal at a depth corresponding to the anticipated bottom of the ring drain materials will be interpreted as the bedrock surface. If subsurface conditions or the presence of contaminants is noted in zones other than the ring drain, the Navy RPM will be contacted to discuss an alternative well screen location.

The proposed well construction details are shown in Figure 3-5. General construction methods and well materials will be standardized for this project.

Monitoring wells will be constructed through the hollow stem augers. The augers will be withdrawn from the boring in increments during the placement of well materials to avoid caving of the borehole wall. Monitoring wells will be constructed of nominal four inch inside diameter, flush joint, threaded Schedule 40 PVC pipe and factory-slotted nominal 0.010 inch well screens. The bottom of the screen will be plugged with a threaded well cap and the top of the riser will be equipped with a loose fitting cap to allow venting.

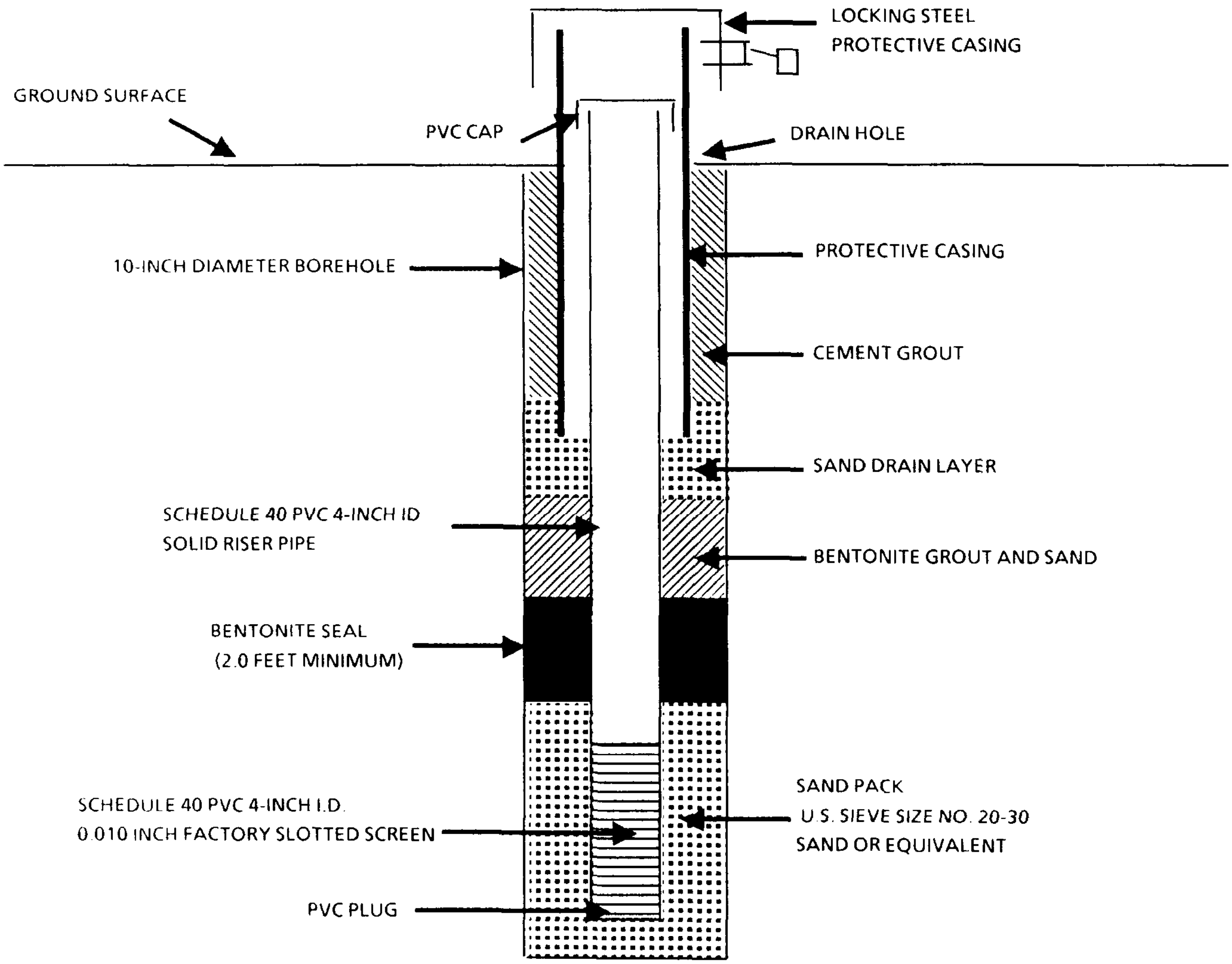
The geologic unit will be visually evaluated for grain size distribution and sand pack will be appropriately sized for the existing geologic conditions. The sand pack will be placed around the well screen to at least two feet above the five foot long screen. A bentonite pellet seal at least two feet thick will be placed immediately above the sand pack. The interval above the bentonite pellet seal to approximately four feet below the ground surface will be backfilled with a mixture of bentonite grout and sand. A one foot thick layer of clean quartz sand (such as that used for the filter 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 the winter weather, water collecting in this annular space can freeze, resulting in binding the protective casing to the riser. Subsequently, frost heaving of the installation can damage the well which has frozen to the casing.

A five foot long, minimum six inch inside diameter locking steel casing will be installed over the PVC well pipe. A weep hole will be drilled in the protective casing at the ground surface. Cement grout with vertical sides will be installed around the outside of the protective casing and the well number inscribed in the concrete. The vertical sided cement grout seal will minimize frost heaving of the casing.

Monitoring wells will be developed a minimum of one day after installation. Development will be conducted using a combination of pumping and surging. The wells will be pumped until the formation water is relatively free of fines. The standard well development criteria of stabilizing the pH may not be feasible at this site, as a large volume of concrete is present below the water table and may affect the pH of the groundwater system. The pH, however, will be monitored. Temperature, specific conductivity and turbidity will be monitored during the development process. Wells will be purged until these parameters stabilize or for a maximum time of four hours each.

Parameters to be analyzed include VOCs, method 8240; SVOCs, method 8270; TPH, method 8015; and the 8 RCRA metals. Additional information pertaining to sample handling, analytical methods and QA/QC requirements are provided in Section 4.0.

OVERBURDEN WELL



(Not to Scale)

PROPOSED OVERBURDEN WELL DETAILS
PRELIMINARY CLOSURE ASSESSMENTS
NAVAL EDUCATION AND TRAINING CENTER
NEWPORT, RHODE ISLAND

Halliburton NUS CORPORATION

FIGURE 3-5

3.4.4 Geoprobe Investigation

This task is scoped to use the Geoprobe system (or equivalent) to advance probes in order to collect soil samples in the proximity of the piping runs connecting individual USTs to the Piping Loop. This work will be conducted by a subcontractor, and therefore, costing will be requested from vendors capable of providing a variety of technologies. For this reason, specific equipment operations will not be discussed in this section.

Geoprobe investigations will be conducted in proximity of shunt lines at Tank Farm 4, in the vicinity of the oil/water separators at Tank Farms 4 and 5, and in the vicinity of bottom sediment and water lines in proximity to the oil/water separators. Piping Loops will not be investigated.

The probe locations will be selected using the data provided by the geophysical survey described in Section 3.3 and will be advanced using standard operating techniques of the system utilized. As is practical, probes will be located in the downgradient direction from each piping run. Probes will be advanced below ground surface to a depth of three feet (as interpreted from the geophysical data, or best available data) beneath the piping. If the interpreted depth to the piping is beyond the capabilities of the contracted system, this task will be reevaluated.

The objective of this task is to provide soil samples to evaluate the presence of petroleum components in the soils in the vicinity of the piping and oil/water separators. Continuous soil samples will be collected at the same depth below ground surface as the piping is installed, to a depth of three feet below the piping installation. These samples will be field screened with an Ensys Petro Risc kit for the presence of petroleum hydrocarbon components. This procedure is discussed in a following section. One soil sample from each boring, the sample containing the highest concentration of petroleum hydrocarbon components as determined by the Petro Risc kit, will be analyzed by Ceimic Laboratories for TPH using EPA method 8015. If no positive detects of TPH are noted, a sample from a lower elevation than the piping will be shipped to the lab for analysis.

A total of 60 probings are anticipated, distributed among all the piping runs and oil/water separators. Approximately 60 soil samples, one from each probing, will be analyzed by Ceimic Laboratories using method 8015.

3.5 GROUNDWATER SAMPLE COLLECTION - TASK 0230

Sampling and analysis of groundwater will be conducted in the 21 newly installed wells and in seven (7) existing wells in the vicinity of Tank 53. Table 4-1 provides applicable analytical parameters to be sampled. Section 4.0 provides additional detail concerning the groundwater sample handling, preservation, and analytical procedures.

Work elements for this task include:

- Noting and measuring floating product, if present
- Measuring water levels in wells prior to purging
- Documenting pH, temperature, specific conductance and turbidity
- Purging wells with a pump or bailer
- Collecting groundwater samples
- Documenting, packing and shipping samples for analysis

Prior to collection of groundwater samples, the presence of floating product in the wells will be determined with the use of a ORS probe (or equivalent). The presence of product will be noted, and if appropriate, the thickness measured.

The wells will then be purged using PVC bailers or chemically resistant pumps. Three to five well volumes of water will be purged from each well before sampling. If the wells are purged dry with less than three well volumes removed, the water level in the well will be allowed to recover to at least 70 percent prior to collecting a sample. In the event that sampling is slow, samples will be collected the following day. However, a period of no longer than 24 hours after purging will be allowed for sampling. Temperature measurements will be collected during purging to determine stabilization of water chemistry prior to sampling. The wells will be sampled when temperature, specific conductance, and turbidity have stabilized.

Samples will be poured directly from the sampling device to the sample bottles, preserved according to the requirements discussed in Section 4.0 and submitted for analysis. Appropriate field data will be recorded and chain-of-custody procedures will be followed.

3.6 SURVEY - TASK 0240

A location survey will be conducted to establish relative locations and elevations of wells installed under Task 0220. A subcontractor will conduct this task. The survey will be tied 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. Measurements will be established to within +/-0.1 foot horizontally, and +/-0.01 foot vertically.

HNUS will provide full time field oversight for the survey subcontractor.

3.7 GENERAL FIELD PROCEDURES

3.7.1 Sample Designation System

Field samples collected from both sites, Tank Farms 4 and 5, will be assigned a unique field sample tracking number. Sample numbers will be keyed to specific tanks in each tank farm. The sample tracking number will consist of a five-segment alphanumeric code that identifies the sample matrix, the site and sample location, sample depth, and the quality control (QC) identifier. Other pertinent information regarding sample identification will be recorded in the field logbook or on sample log sheets.

The alphanumeric coding to be used in the sample numbering system is explained in the following diagram and the subsequent definitions:

AA	= (Matrix)
TFN-AA-NN	= (Sample location, site identifier - borehole/probe - number)
NN	= (Sample depth)
A	= (QC identifier)

Character type: A = Alpha
N = Numeric

Matrix: SO = Soil
GW = Groundwater

Sample location: Sample locations will be identified by specific tank farm and borehole or groundwater monitoring well number. Two alpha characters will indicate the specific tank farm; a pair of numeric characters will be assigned to correspond with individual tank numbers so that location is identifiable from all other locations of a similar type.

TF-4 = Tank Farm 4
TF-5 = Tank Farm 5
B = Borehole (subsequent monitoring well installation)
P = Probe

Sample identifier: Depth in feet below ground surface representing the top of the interval sample was collected.

QC Identifier: The QC identifier will be assigned only when applicable. The following identifiers will be utilized.

D = Field Duplicate
R = Equipment Rinsate Blank
F = Field Blank
T = Trip Blank

Example: A soil sample collected from 2 to 4 feet below ground surface from a boring located in Tank Farm 4, adjacent to tank number 39 will be numbered:

SO-TF4-B-39-02

3.7.2 TPH Field Screening

An Ensys Petro Risc petroleum field screening immunoassay kit will be used to preliminarily characterize soils at Tank Farms 4 and 5. Soil samples from both monitoring well borings and probes in the vicinity of piping will be screened using this method. Field technicians trained in the process will conduct the field screening according to established industry and manufacturer recommended procedures. The manufacturer's operating manual is included in Appendix B.

3.7.3 Decontamination Procedures

All non-disposable sampling equipment which comes in contact with the sample medium will be decontaminated before each sample to prevent cross contamination between sampling points. For sampling equipment that will come in contact with the sample such as trowels and split spoons, the following decontamination sequence will be followed:

- Potable water and detergent (Alconox or Liquidnox) wash (scrub equipment with brush)
- Potable water rinse
- Methanol rinse
- Distilled/deionized water rinse
- Air dry (temperature permitting)
- Wrap sampling device in clean aluminum foil (dull side towards equipment

The methanol rinse will not be conducted on sample equipment while collecting soils analyzed for TPH. Residual methanol on sample tool may be entrained in the soil sample and result in false positive TPH detects.

A glove wash station will be utilized to decontaminate gloves between soil sample locations.

3.7.4 Investigative Derived Waste (IDW) Disposal

Disposable items such as Personal Protective Equipment (PPE) materials, and plastic sheeting will be decontaminated and containerized for off-site disposal. Decontaminated PPE will be disposed in an industrial dumpster by HNUS.

Soil cuttings generated by augering will be temporarily stored on plastic sheeting, labeled, and covered. If no positive detects of TPH are noted in the field screening, the soils will be disposed on the ground surface. If a positive detect of TPH is noted, the soils will be containerized within 24 hours in DOT approved drums for further evaluation by the Navy.

Well development and purge water will be visually inspected for the presence of sheens or floating product. If none are observed, the water will be disposed on the ground surface near the point of origin. If sheens are observed, the water will be containerized in DOT approved drums for further evaluation by the Navy.

If sheens are noted on decontamination fluids, the fluids will be containerized for further evaluation by the Navy. All IDW requiring containerization will be stored on-site in DOT approved drums and remain the responsibility of the Navy.

3.7.5 Field Custody Procedures for Samples

The Field Operations Leader (FOL) is responsible for the care and custody of the samples collected until they are either delivered to the analyzing laboratory or are entrusted to a carrier for shipment to the laboratory. Sample logs and other field records shall always be signed and dated.

Chain-of-custody sample forms shall be completed to the fullest extent possible prior to sample shipment. The forms shall include the following information:

- Project Name
- Sample Number
- Location of the sample collection point
- Description of the sample location
- Type of sample (grab, composite, etc)
- Name of the person collecting the sample
- Number of containers
- Type of sample container
- Remarks

The chain-of-custody form will be completed legibly using waterproof ink and will be signed by the sampler. Similar information will be provided on the sample label which will be securely attached to the sample bottle. The label will also include a description of the analyses to be conducted on the sample.

3.7.6 Transfer of Custody and Shipment Procedures

When shipped, samples will be accompanied by a chain-of-custody record. Sample chain-of-custody will be maintained by HNUS personnel until relinquished to a courier. The original of the record will be retained by HNUS field personnel.

3.7.7 Sample Shipping Procedures

Samples will be shipped in containers that meet all applicable state and Federal standards for safe shipment. Samples requiring refrigeration will be stored on ice. Ice will be sealed in containers to prevent leakage of water. The field chain-of-custody forms will be placed inside the shipping container.

GRAPHIC SCALE

100 0 50 100 200 400

(IN FEET)
1 inch = 100 feet

APPROXIMATE UNDERGROUND UTILITY LOCATIONS (TANK FARM 5)			
NETC – NEWPORT, RI			
WORK PLAN			
DRAWN BY:	R. SARGENT	REV.:	0
CHECKED BY:	W. MARTIN	DATE:	17 NOV 93
SCALE:	1" = 100'	PROJECT NO.:	0288 CTO #143:

FIGURE 3–2

Halliburton NUS CORPORATION

187 Ballardvale St. Wilmington, MA 01887 (508)658–7899

000462 F01X

4.0 QUALITY ASSURANCE/QUALITY CONTROL

This section provides technical guidelines and procedures for conducting the site assessment at the Fuel Farm site. This document references the Halliburton NUS Standard Operating Procedures (SOPs) for specific protocols pertaining to individual procedures discussed in Sections 3.0 and 4.0.

4.1 PROJECT DESCRIPTION

A description of the project covered by this document is provided in Section 1.0.

4.2 PROJECT ORGANIZATION AND RESPONSIBILITY

The project organization is discussed under Section 2.2.1 of this document. Personnel responsibilities are discussed under Section 2.2.2.

4.3 QUALITY ASSURANCE OBJECTIVES

This document covers investigatory sampling at two tank farms, "Tank Farm 4" and "Tank Farm 5". The objectives of this sampling are to provide sufficient data to determine the presence of petroleum hydrocarbon contamination in these areas and to provide preliminary waste characterization data for future site evaluation. To accomplish these objectives, two types of samples are to be collected:

- Field-screening samples for petroleum hydrocarbon contamination (soils)
- Laboratory-analyzed samples for petroleum hydrocarbon contamination (soils and waters)

Achieving the above described 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 PARCC parameters, precision and accuracy, representativeness, completeness, and comparability. 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 4.3.1; the PARCC parameters are discussed in Section 4.3.2.

4.3.1 Data Quality Objectives

The intended use of the data resulting from a field investigation is a determining factor in defining the Data Quality Objective (DQO) for that data. As described by the Naval Energy and Environmental Support Activity (NEESA), in the guidance document entitled "Sampling and Chemical Analysis Quality Assurance Requirements for the Navy Installation Restoration Program" (NEESA, June 1988), the Navy has adopted three analytical quality levels (C, D, and E) corresponding to EPA quality levels III, IV, and V, respectively as described in the EPA document "Data Quality Objectives for Remedial Response Activities Development Process" (EPA/540/G-87/003, March 1987). The analytical data reports to be generated for those samples which undergo laboratory analysis will conform with NEESA data quality Level C requirements.

4.3.2 PARCC Parameters

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

4.3.2.1 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 are evaluated based upon the laboratory data. Analytical precision is measured as the relative percent difference of the data from the laboratory (internal) duplicates. Analytical accuracy measures the bias as the percent recovery from matrix spike and matrix spike duplicate samples. The samples will be analyzed using SW-846 protocols.

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 Halliburton NUS Standard Operating Procedures, precision and accuracy errors associated with field activities can be minimized. Field duplicates and blanks (field and rinsate) will be used to estimate field sampling precision and accuracy for soil and water samples submitted for laboratory analysis of petroleum hydrocarbons.

No project resources will be expended to develop precision and accuracy data for method (field or analytical) validation except those commonly applied for collection of routine QA/QC data. Routine QA/QC data will include analyses of field duplicates and field quality control blanks based on the existing NEESA guidance that specifies the type and frequency of QA/QC sampling and analysis. QA/QC samples will not be collected for field-screening samples.

Field duplicate and field and laboratory quality control blank analyses results will be used to review the laboratory-analyzed petroleum hydrocarbon results and determine the useability 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.

4.3.2.2 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 (e.g., 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 assure 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.

Representativeness of data is also affected by sampling techniques. Sampling techniques are described in Section 3 and in the Halliburton NUS Standard Operating Procedures included in Appendix C.

4.3.2.3 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. If in the evaluation of laboratory results it becomes apparent that the data for a specific medium are of insufficient quality, either with respect to the number of samples or an individual analysis, a subsequent sampling event may be necessary.

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

4.3.2.4 Comparability

One of the objectives of this document 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 in addition to standardizing field sampling procedures by employing Halliburton NUS SOPs, the potential for variables to affect the final data quality will have been effectively minimized. Analytical methods for this work are shown in Table 4-1, and Halliburton NUS SOPs appear in Appendix C.

4.3.3 Quality Control Samples

Field quality control (QC) samples will be collected only for the soil and water samples which are to undergo laboratory analysis. Field QC samples will not be collected for field-screening soil samples. QC samples to be collected during the sampling effort are identified below, and include field duplicates, source water field blanks, equipment rinsate blanks, and trip blanks. Each type of field quality control sample defined below will undergo the same preservation, holding times, etc., as the field samples. Table 4-1 presents a summary of these QC samples to be collected during this field sampling event.

4.3.3.1 Field Duplicates

Field Duplicates will be submitted at the rate of one for every 10 samples, per matrix (one for every 20 for TPH). Field personnel will note on the Sample Log Sheet and in the Logbook which samples are field duplicates. However, the field duplicates will be sent "blind" to the laboratory, therefore, no designation for duplicate samples will be noted on the sample labels or the Chain-of-Custody Forms.

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. Soil field duplicates are collected by splitting split-spoon samples lengthwise and transferring each half into separate containers. Groundwater field duplicates are collected by filling all of the bottles for one sample then filling all of the bottles for the other sample. Field duplicates provide precision information regarding homogeneity, handling, shipping, storing, preparation, and analysis.

TABLE 4-1
FIELD QUALITY CONTROL SAMPLE SUMMARY
CTO 143
NAVAL EDUCATION AND TRAINING CENTER
NEWPORT, RHODE ISLAND

SAMPLE TYPE	MATRIX	ANALYSIS	FIELD SAMPLES*	FIELD DUPLICATES	EQUIPMENT RINSATE BLANKS	FIELD BLANKS	TRIP BLANKS	TOTAL QUANTITY
Newly Installed Ring Drain Wells	Soil	VOC SW/8240	21	2	**	**		23
		SVOC SW/8270	21	2				23
		RCRA Metals	21	2				23
	Water	VOC SW/8240	21	2	4	2	4	33
		SVOC SW/8270	21	2	3	2		28
		RCRA Metals	21	2	2	2		27
Existing Wells (Tank 53)	Water	VOC SW/8240	7	1	1		2	11
		SVOC SW/8270	7	1	1			9
		RCRA Metals	7	1	1			9
		Pest/PCB SW/8080	7	1	1			9
		TPH SW/8015	7	1	1			9
Geoprobe	Soil	TPH SW/8015	60	3				63
	Water	TPH SW/8015	0	0	3		0	3
Total Number of Analyses			221	20	17	6	6	270

* One field sample shall be collected in triple volume for the laboratory matrix spike/matrix spike duplicate (MS/MSD) sample at the rate of one per twenty field samples, per matrix, per analysis. This sample should be designated "MS/MSD" in the "Remarks" section of the Chain-of-Custody Form.

** Equipment rinsate and field blanks collected during soil sampling are aqueous samples and are included under the "Water" category.

4.3.3.2 Field Blanks

Field Blanks will consist of the source water used in steam cleaning drilling tools and analyte-free deionized water used to decontaminate hand tools. Field blanks will be prepared at the rate of one per source of water per sampling event.

4.3.3.3 Rinsate Blanks

Rinsate blanks are obtained under representative field conditions by running analyte-free deionized water through sample collection equipment after decontamination, 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 per 20 samples per matrix.

4.3.3.4 Trip Blanks

Trip blanks are used to detect potential contamination by volatile organic compounds (VOCs) during sample shipping and handling. Trip blanks consist of 40-ml volatile organic analysis (VOA) vials filled with water that is known to be free of VOCs. The vials are transported to the sampling site, and returned to the laboratory with the VOA samples. Each trip blank is stored and analyzed with associated samples at the laboratory. Trip blanks are only analyzed for VOCs. Trip blanks must be sent with both water and soil samples; however, they are always analyzed and reported as water samples.

4.4 SAMPLING PROCEDURES

Field sampling will be conducted in accordance with Section 3.0 of this document and the Halliburton NUS SOPs presented in Appendix C. Allowable sample holding times and preservation requirements are shown in Table 4-2.

4.5 SAMPLE CUSTODY

The custody of field samples will be maintained, recorded and tracked in accordance with Section 3.0 of this document and the Halliburton NUS SOPs given in Appendix C.

4.6 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 documenting the 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 for NEESA level C, and the laboratory's quality assurance plan).

TABLE 4-2
MAXIMUM SAMPLE HOLDING TIMES AND PRESERVATION
CTO 143
NAVAL EDUCATION AND TRAINING CENTER
NEWPORT, RHODE ISLAND

ANALYTE	MAXIMUM HOLDING TIME(1)	PRESERVATIVE	MATRIX	GENERAL SAMPLE (2) CONTAINER REQUIREMENTS
Volatile Organic Compounds (VOCs)	14 days	Cool to 4°C	Soil	2 4-oz clear glass/teflon septum
	7 days	Cool to 4°C	Water	2 40-ml clear glass/teflon septum
	14 days	Cool to 4°C and HCl to pH ≤ 2		
Semivolatile Organic Compounds (SVOCs) Pesticide/PCBs (Pest/PCB)	7 days to extraction, 40 days from extraction to analysis	Cool to 4°C	Soil	1 8-oz amber glass/teflon lined lid
			Water	2 80-oz amber glass/teflon lined cap
RCRA Metals	6 months	Cool to 4°C	Soil	1 8-oz amber glass/teflon lined lid
		Cool to 4°C and HNO_3 to pH ≤ 2	Water	1 1-liter polyethylene bottle/ plastic cap
Total Petroleum Hydrocarbons (TPH)	14 days	Cool to 4°C	Soil	1 8-oz amber glass/teflon lined lid
			Water	2 80-oz amber glass/teflon lined cap

(1) Maximum holding times from date of sample collection to date of sample extraction or analysis for preserved samples.
(2) Actual sample containers provided by the laboratory may vary from those listed. Requirements listed here are EPA-based and incorporate NEESA criteria.

4.7 ANALYTICAL PROCEDURES

The environmental samples collected for laboratory analysis during the field investigation covered by this document will be analyzed by a laboratory previously approved by NEESA. The analytical procedures will conform to NEESA quality level C as described in Section 4.3.1. Table 4-1 shows the analytical methods that are to be employed. Formal data validation will not be conducted. Also note that field QC samples will not be collected for field-screening samples.

The soil samples collected for field-screening will be tested using an enzyme immunoassay procedure developed by Ensys. The analytical method and QC requirements for those samples which are to undergo field-screening for petroleum hydrocarbons will be in accordance with the method specified by the manufacturer.

4.8 DATA REDUCTION, REVIEW, AND REPORTING

Data reduction, review, and reporting will be conducted, however, full data validation is not required for the analytical data since contaminant delineation is the intended data use. Halliburton NUS will perform data review based on blank contamination and field duplicate precision. Data will be summarized in spread-sheets and the same data qualifiers recommended by EPA Region I will be used. The data review does not include assessment of the raw data and no validation report will be generated.

4.9 INTERNAL QUALITY CONTROL

Section 4.3.3 discusses the types and frequency of quality control samples that will be prepared during the field investigation activities for those samples to undergo laboratory analysis. The quantities of the various types of the QC samples are shown in Table 4-1.

Laboratory analyses will be conducted in accordance with SW846 protocols.

4.10 PERFORMANCE AND SYSTEM AUDITS

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

- The FOL will supervise and check on a daily basis that the 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 was conducted.

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

4.11 PREVENTATIVE MAINTENANCE

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

- The equipment manager keeps an inventory of the equipment in terms of items (model and serial number) quantity and condition. Each item of equipment is signed out when in use, and its operating condition and cleanliness checked upon return.

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

- The equipment manager maintains the equipment manual library and trains field personnel in the proper use and care of equipment.

- The FOL is responsible for working with the equipment manager to make sure that the equipment is tested, cleaned, charged, and calibrated in accordance with the manufacturer's instructions before being taken to the job site.

4.12 DATA ASSESSMENT PROCEDURES

4.12.1 Precision, Representativeness, Comparability, and Completeness

All environmental data generated as a consequence of this field activity will be used for purposes of contaminant plume delineation. No formal validation of the data will be conducted. The data will, however, be reviewed as described in Section 4.8. The PARCC parameters will be evaluated to the fullest extent practicable.

Precision will be assessed through the evaluation of field duplicate results. The representativeness and comparability of the data will be assessed by determining if the data are consistent with known or anticipated chemical conditions and accepted principals. The completeness of the data will be assessed by comparing the acquired data to the project objectives to examine if these objectives are being effectively addressed.

The PARCC parameter assessment will be conducted by qualified personnel.

4.12.2 Data Validation

Formal data validation will not be conducted, however, data review as described in Section 4.8 will be conducted.

4.12.3 Data Evaluation

The evaluation of the data collected during the field investigation will include a comparison of closure goals and chemical concentrations in soil samples collected from the field. Evidence of the presence of contamination at concentrations greater than the closure goals will indicate the need for additional site evaluation.

4.13 CORRECTIVE ACTION

The QA program will enable problems to be identified, controlled, and corrected. Potential problems may involve nonconformance with the SOPs and/or analytical procedures established for the project, or other unforeseen difficulties. Any person identifying an unacceptable condition will notify the Project Manager. The project manager, with the assistance of the Quality Assurance Manager and the project QA/QC officer, will be responsible for developing and initiating appropriate corrective action and verifying that the correction action has been effective. Corrective actions may include resampling and/or reanalysis of samples taken 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.

4.14 QUALITY ASSURANCE REPORTS/DOCUMENTS

A bound/weatherproof field notebook shall be maintained by the SSO, and by the FOL. The FOL or designee shall 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 FOL will contain a summary of the day's activities and will reference the field notebooks when applicable.

Custody of samples must be maintained and documented at all times. Chain-of-custody begins with the collection of the samples in the field; Section 3.0 addresses the topic of chain-of-custody.

At the completion of field activities, the FOL shall submit to the Project Manager all field records, data, field notebooks, logbooks, chain-of-custody receipts, sample log sheets, etc. The Project Manager shall 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 FOL notifies the Project Manager of the need for the change.
- If necessary, the Project Manager will discuss the change with the pertinent individuals (e.g., Navy personnel, CLEAN Quality Assurance Manager) and will provide a verbal approval or denial to the FOL for the proposed change.
- The FOL will document the change on a Field Modification Record and forward the form to the Project Manager at the earliest convenient time (e.g., end of the workweek).
- The Project Manager will sign the form and distribute copies to the Program Manager, Quality Assurance Manager, Field Operations Leader, and the project file.
- A copy of the completed Field Modification Record form will also be attached to the field copy of the affected document (i.e., Work Plan and Sampling and Analysis Plan).

APPENDIX A

HEALTH AND SAFETY PLAN

W5293026F

FINAL HEALTH AND SAFETY PLAN
PRELIMINARY CLOSURE ASSESSMENTS
OF
TANK FARMS 4 AND 5

NAVAL EDUCATION AND TRAINING CENTER
NEWPORT, RHODE ISLAND

COMPREHENSIVE LONG-TERM
ENVIRONMENTAL ACTION NAVY (CLEAN) CONTRACT

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

Submitted by:
Halliburton NUS Corporation
993 Old Eagle School Road, Suite 415
Wayne, Pennsylvania 19087

CONTRACT NUMBER N62472-90-D-1298
"CLEAN" Contract Task Order No. 143

September 1994

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1.0 INTRODUCTION

This Health and Safety Plan (HASP) is designed to provide practices and procedures for HALLIBURTON NUS Environmental Corporation (HNUS) personnel and subcontractor personnel engaged in the Preliminary Closure Assessments of Tank Farms 4 and 5 at the Naval Education and Training Center (NETC) in Newport, Rhode Island. This plan has been developed to conform to the requirements of OSHA Standard 29 CFR 1910.120 - Hazardous Waste Operations and Emergency Response and is based on available information regarding possible contaminants and physical hazards that may exist on the site. If more information concerning the nature and/or concentrations of contaminants becomes available, this HASP will be modified accordingly. It will be the HALLIBURTON NUS Project Manager's responsibility to communicate any such information to the CLEAN Health and Safety Manager (CHSM) (Matthew M. Soltis) who will, in turn, determine the need for modifying the HASP.

1.1 KEY PROJECT PERSONNEL AND ORGANIZATION

The table below presents Key Project Personnel and Responsibilities and establishes responsibility for site safety and health. The HALLIBURTON NUS Project Manager (PM) is responsible for the overall direction and implementation of health and safety for this project. The HALLIBURTON NUS Field Team Leader (FTL) is responsible for implementation of this HASP with the assistance of an appointed Site Safety Officer (SSO). The activities of the SSO are monitored by the CLEAN Health and Safety Manager (CHSM) for compliance with this HASP and the CLEAN Health and Safety Management Plan.

NAME	RESPONSIBILITY
Walter Martin	HNUS Project Manager
TBA	Field Team Leader
TBA	Site Safety Officer
Janet Pillion	HNUS Health & Safety Officer
Matthew M. Soltis	CLEAN Health & Safety Manager

1.2 SITE/PROJECT BACKGROUND

The NETC is located within the Newport Naval Base which encompasses approximately six miles of the western shore of Aquidneck Island, Newport County, Rhode Island. Aquidneck Island is comprised of three towns: Newport, Middletown, and Portsmouth. The NETC serves as a training facility and provides logistic support for the Newport Naval Base. The NETC occupies approximately 1,063 acres of land. The locations of Tank Farms 4 and 5 are within the Newport Naval Base property.

Tank Farms 4 and 5 are located on the east side of the Defense Highway and Tank Farm 4 is approximately 4,500 feet north of Tank Farm 5. Tank Farms 4 and 5 contain 23, 2.5 million gallon concrete underground storage tanks that were used to store heavy fuel oils from World War II to 1974. The tanks are approximately 116 feet in diameter, 33 feet deep, and are covered by approximately four feet of soil. Each tank is surrounded by a ring drain which consists of a 12-inch reinforced concrete drain pipe located within a permeable backfill approximately four feet wide. The drain is connected to a sump pump to remove groundwater from the backfill area. The tanks were abandoned in the 1970's. Two of the tanks (53 and 56 at Tank Farm 5) were also used to store waste oils. These tanks have been cleaned and are being closed under Rhode Island hazardous waste regulations.

Other facilities located adjacent to Tank Farm 5 include the Fire Fighting Training Area, a small metal building which was used as an electrical substation, and a concrete structure formerly used as an oil-water separator on Tank Farms 4 and 5.

1.3 SCOPE OF WORK

The objective of the work is to perform an Underground Storage Tank (UST) Preliminary Closure Assessments at Tank Farms 4 and 5. Additional data regarding groundwater quality in the vicinity of Tank 53 will also be gathered. The following field activities are planned:

- Drilling (Monitoring well installation, Split Spoon Sampling) - Installation of 4 inch diameter monitoring wells within each tank ring drain on the downgradient side of the tank (not to include Tanks 53 and 56);
- A survey of each monitoring well;
- A Geoprobe investigation of piping connecting the tanks to the piping loop (not to include piping loops);
- Groundwater Sampling (sampling will include some existing wells around Tank 53).

For additional information or detail, refer to the Field Sampling Plan.

2.0 HAZARD ASSESSMENT

This section presents information regarding known and suspected chemical and physical hazards associated with the work areas, tasks and operations described in Section 1.3 of this HASP. Any additional activities must be communicated to the CHSM 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. Measures to control the hazards presented below can be found in Sections 3.0, 4.0, and 5.0 of this plan.

The onsite work areas will be limited to Tank Farms 4 and 5 on the NETC property. The greatest potential for worker exposure exists during drilling activities at the downgradient locations of the fuel tanks.

2.1 CHEMICAL HAZARDS

The degree of hazard potential(s) posed to onsite personnel depends not only on where work will be conducted but also upon the task or tasks being performed. The tasks scheduled to take place generally can be grouped into two categories: non-intrusive and intrusive activities. Potential health risks posed to onsite workers will be of greater concern during intrusive activities such as drilling monitoring wells, and split spoon sampling. Non-intrusive activities, such as groundwater sampling and surveying activities will be of lesser concern to worker health.

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

2.1.1 Fuel Oils

Previous site activities and observations indicate the potential for fuel oil contamination to be present at the well installation locations.

Fuel oils are considered to be of moderate to low toxicity and are not considered to be carcinogenic by NTP, OSHA, or IARC. Potential route(s) 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, 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. Effects of long-term (chronic) overexposure typically result in the development of chronic dermatitis.

Because of the very low vapor pressure of fuel oils, and the work being conducted in an outdoor environment, overexposure to their 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.

2.1.2 Waste Oils

In 1975, the Navy began using Tanks 53 and 56 for used oil storage. Volatile organic compounds (VOC's), base neutral/acid extractable (BNA) compounds, and inorganics were present in the groundwater samples collected from wells located near Tanks 53 and 56.

Low VOC levels in downgradient well MW-4 have been detected and inorganic concentrations have exceeded groundwater action levels in all wells, including the background well.

Because of the low concentrations previously detected, the nature of the matrix (groundwater) being sampled, and the work being conducted in an outdoor environment, an overexposure to site contaminants is not expected to occur.

2.1.3 Hazard Evaluation of Each Site Task

A hazard evaluation for the work activities is as follows:

Well Installation/Geoprobe Investigation/Subsurface Soil Sampling

Drilling activities and other soil-disturbing subsurface investigation 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 disturbance, and direct skin contact with contaminants. The physical hazards associated with these tasks are addressed in following sections.

Exposure potentials could vary depending on where the drilling is taking place; drilling near the underground tanks poses the greatest risk of worker exposure. Drillers and laborers are especially at risk to exposure due to their work position directly over the boreholes and their handling of potentially contaminated augers/rods when pulling the augers/rods out of the ground (inhalation and dermal contact). Additionally, the exposure potential may be the greatest when drilling activities intersect the groundwater table. Heavy fuel oils are not miscible with water and there may exist a floating product layer on the water table.

Groundwater Sampling

This task presents a low to moderate exposure potential. The primary concern for this task is dermal contact with contaminated water. When sampling groundwater from monitoring wells, however, inhalation exposure could occur when removing the well cap. To reduce this potential hazard, the wellhead should be opened while standing upwind and allowed to vent before sampling activities commence. Additionally, there exists the potential for a floating product layer on the water table.

Land Surveying

This task has low to no exposure potential. This task is limited to surveying the locations and elevations of the monitoring wells. There is no known surficial contamination onsite, therefore, there is no exposure potential anticipated during this activity.

2.2 PHYSICAL HAZARDS

In addition to the chemical hazards presented above, certain physical hazards may also be encountered. The most significant of these hazards include:

- The potential for a worker to become entangled in the rotating tools of the drill rig
- Contact with overhead energized sources
- Exposure to moving and heavy machinery/vehicles (drill rigs, Geoprobe, trucks) - stuck by/caught between hazards and nip points
- Manual lifting
- Noise exposure
- Fire/Explosion potential
- Buried/Underground Utilities
- Slip/Trip/Fall/Puncture hazards
- Uneven or unstable terrain
- Heat/Cold stress
- Confined Spaces
- Insects/Rodents
- Lightning/Inclement Weather Conditions

2.2.1 Hazard Description & Hazard Prevention

Rotating Tools - Entanglement within the rotating tools 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.

Overhead Energized Sources - Overhead utility wires, i.e. electrical and telephone, can be hazardous when the drill rig boom/mast or any other such projecting items are in the upright position.

- Overhead utilities should be considered "live" until determined otherwise.
- No drilling boom/mast or any other such 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.
- To avoid contact with any overhead lines, the drill rig boom should be lowered prior to moving the rig.

Heavy Equipment/Vehicles - Operation of, and proximity to, Geoprobe, drill rigs/heavy equipment pose a threat of serious injury to operators and workers; operators of the Geoprobe, drill rigs/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 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.

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

- Back strain may be prevented by employing proper lifting and **bailing** 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.

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

- Noise levels are not to exceed the 8-hour time-weighted average OSHA PEL of 90 dBA without the use of hearing protection. As a general rule-of-thumb, hearing protection is 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 worn to effectively reduce noise levels.

Buried/Underground Utilities - Excavation work or any intrusive earthwork presents the possibility of contacting or puncturing an underground line or utility.

- A thorough underground utilities search must be conducted before the commencement of any intrusive earthwork. The Base "Dig Safe", the National Dig Safe, and the base Engineering and Defense Fuel Support departments must be contacted and clear all drilling and Geoprobe locations prior to any ground penetrating work.

- No subsurface activities will commence until the work area has been positively cleared of utilities or underground lines.

- Any utilities confirmed or suspected will have their location marked and these areas will be avoided.

- Known buried utilities include electric, phone, diesel, steam, water, wastewater, and oil.

Heat/Cold Stress - Heat/Cold stress shall be monitored and controlled in accordance with the guidelines presented in Attachment B.

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 be alert 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-shank work boots should be worn.

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

<u>In General:</u>

- Hardhats shall be worn at all times when working around a drill rig or when the potential for overhead hazards exist.

- Loose clothing and straps should be secured when working around a drill rig or any other heavy or high hazard equipment.

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

- Eye protection should 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) should be evaluated as a condition to stop work.

- Be sure that any compressed gas cylinders are secured properly to heavy mobile equipment.

2.3 BUDDY SYSTEM/SITE COMMUNICATIONS

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 a significant 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.

In order to control these hazards, the measures previously discussed and the Standard Work Practices specified in Section 5.0 of this HASP (as well as the other requirements stated in this document) will be implemented and enforced throughout site operations.

2.4 CONFINED SPACE ENTRY

Confined space entries are not anticipated during this site investigation and, therefore, are not authorized and will not be discussed in this HASP. If confined space entry becomes necessary for any reason, the project manager and the CHSM must modify this HASP prior to authorizing entry. This includes entry to building housing tank manholes (some of these are open).

3.0 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.

Heavy fuel oil is the primary site contaminant. The physical properties of this compound include a very low vapor pressure and high boiling point. The onsite activities will be conducted in an outdoor environment where it is unlikely that vapor emissions will exist or be of sufficient quantity to cause adverse health effects. However, air monitoring using direct reading instrumentation will be conducted to assure that vapor concentrations do not exceed acceptable levels.

3.1 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 organic compounds.

The Photovac MicroTip, a PID, equipped with a 10.6 eV lamp, or the OVA Model 128 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 HNUS Standard Operating Procedures. These SOP's will be maintained onsite. The OVA 128 does detect methane (and the PID does not); if there are any sustained readings in the breathing zone using the OVA 128, the methane screening technique will be used to determine if there are other VOCs present, or a PID will be used in tandem with the OVA to determine if the readings are due to methane. Respiratory protection upgrade need not occur if the readings are determined to be from methane and are less than 10% of the Lower Explosive Limit (LEL) reading.

A combustible gas (lower explosive limit (LEL) and oxygen (O_2) alarm meter will be used to monitor levels of combustible gas and oxygen deficient atmospheres during subsurface activities. The LEL/O_2 meter will be calibrated using pentane (0.75 percent by volume in air) and operated as outlined in the HNUS Standard Operating Procedures. If airborne concentrations of flammable vapors exceed 10 percent or greater of the LEL, no work will take place until the source of the emission has been identified and control measures instituted or until vapor concentrations subside. Monitoring with the LEL/O_2 meter will only be necessary if there are sustained readings detected using the PID/FID air monitoring instrument.

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 3.3:

- Site Walkovers - None.
- Drilling/Geoprobe Investigation/Soil Borings/Split Spoon Sampling - PID/FID monitor; LEL/O_2 monitor.
- Groundwater Sampling - PID/FID monitor.
- Surveying - None.

3.2 MODIFICATION OF AIR MONITORING REQUIREMENTS

The air monitoring requirements presented in Section 3.2 are based upon the tasks presented in Section 1.3 and the assumption that the contaminants presented in Section 2.1 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.

3.3 ACTION LEVELS

The following action levels represent background readings in the breathing zone and will apply to this project:

PID/FID Monitor	Greater than 0.0 ppm	To be evaluated using CTD[1]
	0.0 ppm to 50 ppm	Level D
	50 ppm to 100 ppm	Level C
	Greater than 100 ppm	Level B
	Less than 19.5% O_2	Level B
	Greater than 200 ppm	Stop work and contact CLEAN Health & Safety Manager

These action levels are based upon 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 found to be invalid, the action levels will be modified as appropriate.

(1) - A Colorimetric Detector Tube (0.5/c Draeger tube) for benzene will be used initially when there are any PID/FID readings in the breathing zone. If it is determined that benzene is an airborne contaminant then the following action levels will be used:

Level C	1 - 50 ppm
Level B	50 - 100 ppm

3.4 INSTRUMENT MAINTENANCE AND CALIBRATION

Air monitoring instruments will be maintained and pre-field calibrated. Field calibration will be conducted in accordance with the HNUS Standard Operating Procedures. 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.

3.5 RECORDKEEPING

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, including the absence of readings, must be recorded in the field logbook. Exceedances above background levels in the workers breathing zone must be recorded specifying the date, reading(s) observed, workers potentially affected, operators name, duration of reading, and the location of the reading, and actions taken to reduce exposures.

4.0 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 1.3 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.

4.1 ANTICIPATED LEVELS OF PROTECTION

All work is anticipated to be performed in a Level D Protection, as defined in Appendix B of OSHA Standard 29 CFR 1910.120 - "Hazardous Waste Operations and Emergency Response: Final Rule." Many activities will require the use of chemical resistant coveralls, gloves, and boot covers as presented in the task breakdown which follows. Where activities overlap, the more protective requirements will be applied. Additionally, it is possible that work will be upgraded to Level C protection (air-purifying respirators equipped with GMC-H filters) depending on site conditions and observations as discussed in Section 4.3.2 of this HASP.

4.1.1 Mobilization/Demobilization/Site Walkovers/Surveying

Minimum requirements include steel-toe/shank work boots. Leather or cotton work gloves will be worn, as needed, to prevent cuts and abrasions when handling drilling or Geoprobe equipment.

4.1.2 Drilling Operations

Minimum requirements include hard hat, safety glasses, steel-toe/shank work boots, Tyvek coveralls, disposable boot covers, and nitrile or neoprene gloves over latex inner gloves. All ankle and wrist seams will be taped and all loose clothing will be secured. If activities present the potential for tyvek to become saturated, PVC coveralls will be substituted.

4.1.3 Groundwater Sampling

Minimum requirements include steel-toe/shank work boots, Tyvek coveralls, disposable boot covers, and nitrile or neoprene gloves over latex inner gloves, and eye protection/splash goggles. All ankle and wrist seams will be taped. If activities present the potential for tyvek to become saturated, PVC coveralls will be substituted.

4.2 PPE SELECTION CRITERIA

Respiratory protection was not selected for use during initial stages of work as it is unlikely that exposures will exceed OSHA permissible exposure limits or of sufficient concentration to cause adverse health effects. Nitrile and/or neoprene gloves were selected to provide protection against potential contamination that could be encountered and to help reduce ingestion as a result of incidental hand to mouth contact. Hard hats, safety glasses, and work boots were selected to provide protection against some of the physical hazards associated with heavy equipment and drilling operations and disposable boot covers were selected to help minimize the spread of contamination. Tyvek coveralls were selected to minimize the potential for contamination of street clothes and PVC coveralls were selected for use in the event that drilling and/or sampling operations have the potential to result in the saturation of work clothes and dermal contact.

4.3 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.

4.3.1 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 gross heavy fuel oil contamination of groundwater and/or soils encountered or anytime there is a reasonable potential for saturation of work clothes.

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

4.3.2 Respiratory Protection Modification Criteria

Level C respiratory protection consisting of full/half-face, air-purifying respirators, equipped with GMC-H filters must be worn if gross contamination of heavy fuel oil is encountered which emit vapors that exceed the action limits presented in section 3.3. The SSO will evaluate and determine the need for upgrading respiratory protection. Additionally, at any time during intrusive activities onsite, workers may elect to don Level C respiratory protection.

5.0 STANDARD WORK PRACTICES

The following standard work practices will apply to all HALLIBURTON NUS and subcontractor personnel as applicable to the work being performed at this site.

5.1 GENERAL REQUIREMENTS (ALL TASKS)

- Work areas shall be physically cordoned off (using items such as caution tape, hazard cones, etc.) to clearly identify the work area, and to aid in restricting access of unauthorized persons.

- Objects that cannot be manually handled comfortably shall either be handled by more than one person or with mechanical lifting devices.

- Eating, drinking, chewing gum or tobacco, taking medication, and smoking are prohibited in the exclusion or decontamination zones, or any location where there is a possibility for contact with site contamination exists.

- Upon leaving the exclusion zone, hands and face must be thoroughly washed with soap and potable water. Any protective outer clothing is to be decontaminated and removed as specified in this HASP, and left at a designated area prior to entering the clean area.

- Contact with potentially-contaminated substances must be avoided. Contact with the ground or with contaminated equipment must also be avoided.

- No facial hair, which interferes with a satisfactory fit of the mask-to-face seal, is permitted on personnel required to wear respiratory protective equipment.

- All personnel must procure a site-specific Health and Safety Plan from the project Health and Safety Officer prior to commencing work on site. All site personnel must read and understand all components of this HASP.

- All personnel must satisfy medical monitoring procedures.

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

- Areas must be designated for chemical storage. Acids, bases and flammable shall all be stored separately. Storage areas must be labeled as to the contents within the storage area.

- All compressed gas cylinders must be stored and used in an upright position, properly secured and protected from damage, segregated, and labelled as empty or full.

- Site personnel must immediately notify the HALLIBURTON NUS Health and Safety Officer of all incidents for OSHA recordkeeping purposes.

- If personnel note any warning properties of chemicals (irritation, odors, symptoms, etc.) or even remotely suspect the occurrence of exposure, they must immediately notify the CLEAN Health and Safety Manager for further direction.

- Site personnel are not to undertake any activity which would be considered a confined-space entry without first being trained in the proper procedures as required by the CLEAN Health and Safety Manager, and without first obtaining a Confined Space/Limited Egress Permit.

5.2 DRILLING AND GEOPROBE OPERATIONS

- The location of all underground and overhead utilities must be confirmed and visibly identified prior to initiating ground penetrating activities. The mast of the drill rig shall be positioned so as not to contact live conductors, raceways, conduit, or piping.

- All drill rigs must be equipped with an operational emergency stop device or on/off switch. Drillers and geologists must be aware of the location of this device. This device must be tested prior to job initiation, and periodically thereafter. No one shall handle rotating augers unless absolutely necessary and unless there is a standby person in the ready position to activate the emergency stop.

- The driller must never leave the controls while the tools are rotating unless all personnel are clear of the rotating equipment.

- A long-handled shovel or equivalent must be used to clear drill cuttings away from the hole and from rotating tools. Hands and/or feet are not to be used for this purpose.

- A remote sampling device must be used to sample drill cuttings if the tools are rotating. Samplers must not reach into or near the rotating equipment. If personnel must work near any tools which could rotate, the driller must shut down the rig prior to initiating such work.

- Drillers, helpers, and samplers must secure all loose clothing when in the vicinity of the drilling operations.
- Only equipment which has been approved by the manufacturer may be used in conjunction with site equipment and specifically to attach sections of drilling tools together. Pins that excessively protrude from augers shall not be allowed.
- No persons shall climb the drill mast while tools are rotating.
- No person shall climb the drill mast without the use of ANSI approved fall protection (i.e. approved belts, lanyards, and a fall protection slide rail) or portable ladder which meets the requirements of OSHA standards.
- Hearing protection shall be worn while the drill rig is in operation unless it can be demonstrated that noise exposures will not exceed 85 dBA as an 8-hour time-weighted average.

6.0 DECONTAMINATION

This section describes the steps site personnel will follow to prevent the spread of site contaminants into areas that may affect unprotected, unsuspecting site personnel or the public. It includes requirements for decontamination of personnel, sampling equipment, and drilling equipment.

6.1 PERSONNEL DECONTAMINATION

The decontamination of personnel and their protective clothing will be performed in three stages.

- Stage 1 includes removing contamination from reusable protective clothing and/or disposable clothing. These efforts will involve washing and rinsing these items in a sequence that begins at the highest level to the lowest level (i.e.: from the head down towards the feet).

- Stage 2 will include removal of protective clothing, discarding disposable clothing into a drum conspicuously marked "Contaminated Clothing" and/or storing reusable protective clothing in the contamination reduction zone. Stage 2 efforts involve a structured, segregated process carefully removing PPE items beginning with the outermost item and progressing inward.

- Stage 3 will consist of workers washing their hands and face with potable water and soap each time they leave the exclusion zone, before performing any type of hand-to-mouth activity.

All decontamination fluids generated will be contained as described in the site work plan. The decontamination area will be physically identified with rope or flagging and well equipped to be conducive for completion of proper decontamination activities.

6.2 SAMPLING EQUIPMENT DECONTAMINATION

Decontamination of sampling tools may involve the use of deionized water, detergents (Alconox), and/or methanol. Requirements for decontaminating sampling equipment are presented in the site work plan. Methanol will only be used in well ventilated areas and personnel will avoid breathing vapor and/or mist. Material Safety Data Sheets for the decontamination solutions will be presented during site specific training and maintained on site for reference upon request.

6.3 HEAVY EQUIPMENT DECONTAMINATION

Decontamination of drilling tools and other heavy equipment will be accomplished through the use of a high pressure steam system. The HALLIBURTON NUS representative or Field Team Leader (FTL), or designee, will inspect all heavy equipment prior to being released from the site. All decontamination fluids generated will be contained and disposed of as described in the site work plan.

7.0 TRAINING

7.1 INTRODUCTORY AND REFRESHER TRAINING

7.1.1 Requirements for HALLIBURTON NUS Personnel

All HALLIBURTON NUS personnel must complete 40 hours of introductory hazardous waste site training prior to performing work at the NETC-Newport. Additionally, HALLIBURTON NUS personnel who have had introductory training more than 12 months prior to site work must have completed 8 hours of refresher training within the past 12 months before being cleared for site work. Supervisory training is required of any onsite personnel directly responsible for, or who supervise, employees working onsite.

Documentation of HALLIBURTON NUS introductory, refresher and supervisory training can be obtained through the Health and Safety Officer. Copies of certificates or other official documentation will be used to fulfill this requirement.

7.1.2 Requirements for Subcontractors

All HALLIBURTON NUS subcontractor personnel must have completed introductory hazardous waste site training or equivalent work experience as defined in OSHA Standard 29 CFR 1910.120(e) and 8 hours of refresher training meeting the requirements of 29 CFR 1910.120(e)(8) prior to performing work at the NETC-Newport. Additionally, supervisory training is required of any onsite personnel directly responsible for, or who supervise, employees working onsite. HALLIBURTON NUS subcontractors must certify that each employee has had such training by sending HALLIBURTON NUS a letter, on company letterhead, containing the information in the example letter provided as Figure 7-1. Copies of training certificates will not be accepted as a substitute for the official letter but may be provided as supporting documentation.

7.2 SITE-SPECIFIC TRAINING

HALLIBURTON NUS will provide site-specific training to all HALLIBURTON NUS 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 NETC-Newport. Site-specific training will include:

- Names of personnel and alternates responsible for site safety and health
- Safety, health and other hazards present on site
- Use of personal protective equipment
- Work practices to minimize risks from hazards
- Safe use of engineering controls and equipment

- Medical surveillance requirements
- Signs and symptoms of overexposure
- The contents of the health and safety plan and addendum
- Review of relevant MSDSs

7.2.1 Site-Specific Training Documentation

HALLIBURTON NUS and subcontractor personnel will be required to sign a statement indicating receipt of site-specific training and understanding of site hazards and control measures. Figure 7-2 will be used to document site-specific training.

FIGURE 7-1
OSHA TRAINING CERTIFICATION

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

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

Month, day, year

Mr. Walter Martin
Project Manager
HALLIBURTON NUS Corporation
187 Ballardvale St. Suite A-100
Wilmington, MA 01887

Subject: Hazardous Waste Site Training - NETC-Newport

Dear Mr. Martin:

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)

FIGURE 7-2
SITE-SPECIFIC TRAINING DOCUMENTATION

My signature below indicates that I am aware of the potential hazardous nature of working at the NETC-Newport site and that I have received site-specific training which included the elements presented below:

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

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 (PRINT CLEARLY)	SIGNATURE	DATE

Training Conducted By: ______________________________

Date: ______________

8.0 MEDICAL SURVEILLANCE

8.1 REQUIREMENTS FOR HALLIBURTON NUS PERSONNEL

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

Documentation for medical clearances can be obtained from the HALLIBURTON NUS Health and Safety Officer.

8.2 REQUIREMENTS FOR SUBCONTRACTORS

Subcontractors are required to obtain a certificate of their ability to perform hazardous waste site work and to wear respiratory protection. The "Subcontractor Medical Approval Form" (Figure 8-1) must be used to satisfy this requirement providing it is properly completed and signed by a licensed physician.

FIGURE 8-1
SUBCONTRACTOR MEDICAL APPROVAL FORM

For employees of ____
Company Name

Participant Name: ___________________________ Date of Exam: _______________

Part A

The above-named individual has:

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

   ( ) qualified to perform work at the **NETC-Newport** work site
   ( ) not qualified to perform work at the **NETC-Newport** 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 8-1
SUBCONTRACTOR MEDICAL APPROVAL FORM
PAGE TWO

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

____

____

____

2. Any detected medical conditions which would place the employee at increased risk of material impairment of the employee's health:

____

____

____

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

____

____

____

____

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

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

( ) may
( ) may not

perform his/her assigned task.

FIGURE 8-1
SUBCONTRACTOR MEDICAL APPROVAL FORM
PAGE THREE

Physician's Signature ______________________

Address ______________________

Phone Number ______________________

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

____
Address

9.0 SITE CONTROL

This section outlines the means by which HALLIBURTON NUS will delineate work zones and use these work zones in conjunction with decontamination procedures to prevent the spread of contaminants into previously unaffected areas of the site. In general, a three zone approach will be used during work at this site; exclusion zone, contamination reduction zone, and support zone.

9.1 EXCLUSION ZONE

The exclusion zone will be considered those areas of the site where subsurface activities or groundwater sampling activities are being conducted. Significant amounts of surface contamination will not be encountered in the proposed work areas of this site until/unless contaminants are brought to the surface by drilling or other subsurface exploration activities. Furthermore, once such activities have been completed and surface contamination has been removed, the potential for exposure is again diminished and the area can then be reclassified as part of the contamination reduction zone. Therefore, the exclusion zones for this project will be limited to those areas of the site where active work is being performed and/or anywhere there is believed to be the potential for inhalation exposure to site contaminants. During subsurface explorations, a 25-foot exclusion zone around the operating equipment will be demarcated using caution tape, signs, safety cones, or barricades.

9.2 CONTAMINATION REDUCTION ZONE

The contamination reduction zone (CRZ) will be a buffer area between the exclusion zone and any area of the site where contamination is not suspected. For purposes of this project, the CRZ will be considered the areas abutting the exclusion zone/work areas. In addition, the equipment decontamination area established for this project will be considered as a separate CRZ.

9.3 SUPPORT ZONE

The support zone for this project will be located in areas designated outside of the exclusion and contamination reduction zone. This area will include a staging area where site vehicles will be parked, equipment will be unloaded, and where food and drink containers will be maintained. In all cases, the support zones will be established at areas of the site where exposure to site contaminants would not be expected during normal working conditions or foreseeable emergencies.

10.0 OTHER MISCELLANEOUS REQUIREMENTS

10.1 SPILL CONTAINMENT PROGRAM

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

10.1.1 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.
- Unlabeled drums and containers shall be considered to contain hazardous substances and handled accordingly until the contents are positively identified and labeled.
- 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.

It is not anticipated that bulk hazardous materials will be handled as part of this scope of work such that spillage would constitute a danger to human health or the environment.

10.2 MATERIALS AND DOCUMENTS

The HALLIBURTON NUS Field Team Leader shall ensure the following materials/documents are taken to the project site and utilized as required.

- Incident Reports
- Material Safety Data Sheets for decon solutions and other substances brought to the site
- Follow-Up Reports (to be completed by the Field Team Leader)
- OSHA Job Safety and Health Poster (posted in site trailer)
- Site-specific Training Documentation Form
- First Aid Supply Usage Form
- Emergency Reference Posting (Figure 11-1)

11.0 EMERGENCY RESPONSE PLAN

11.1 INTRODUCTION

In the event of any on-site emergencies, site personnel will be immediately evacuated to a safe place of refuge and the appropriate off-site response agencies will be notified. HALLIBURTON NUS and subcontractor personnel will not provide emergency response support. This approach has been selected based on the types of emergencies most likely to be encountered during performance of this work and the fact that off-site emergency response organizations will provide the most effective repose to these emergencies. Specifically, fire/explosion or personal injury/illness, resulting from exposure to physical hazards are the emergencies most likely to be encountered. The local fire department and ambulance service will be best suited for handling these emergencies and are located within a reasonable distance from the site to ensure adequate response time. In light of this approach, this emergency response plan has been prepared to conform to the requirements of OSHA Standard 29 CFR 1910.38(a), as permitted by OSHA 29 CFR 1910.120(l)(1)(ii).

11.2 PRE-EMERGENCY PLANNING

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

- Coordinating with NETC base personnel to ensure that HALLIBURTON NUS emergency response activities are compatible with existing facility emergency response procedures.

- Establishing and maintaining information at the project staging area (support zone) for easy access in the event of an emergency. This information will include the following and it will be the responsibility of the HALLIBURTON NUS FTL to ensure the information is available.

  - An inventory of chemical substances used on site, with corresponding Material Safety Data Sheets.

  - Site personnel records regarding medical treatment concerns (medical data sheets).

  - A log book identifying personnel present on site each day.

- Identifying a chain of command for emergency response.

11.3 EMERGENCY RECOGNITION AND PREVENTION

11.3.1 Recognition

These situations will generally be recognizable by visual observation. An injury or illness will be considered an emergency if it requires treatment other than first-aid (i.e. requires treatment by a medical professional).

11.3.2 Prevention

HALLIBURTON NUS will prevent emergencies by ensuring compliance with the site-specific health and safety plan.

11.4 SAFE DISTANCES AND PLACES OF REFUGE

In the event that the site must be evacuated, all personnel will immediately stop activities and report to the support zone. Upon reporting to the refuge location, personnel will remain there until directed otherwise by the HALLIBURTON NUS FOL. The SSO will take roll at this location, using the log book, to confirm the location of all site personnel.

11.5 EVACUATION ROUTES AND PROCEDURES

An evacuation mist be initiated whenever personnel show signs or symptoms of overexposure to potential site contaminants. In the event of an evacuation, personnel will proceed immediately to the support zone, unless doing so would further jeopardize the welfare of workers. Personnel will proceed to an alternate location until instructed otherwise by the HALLIBURTON NUS FTL.

Evacuation procedures will be discussed prior to the initiation of any work at the site. Evacuation from the site is dependent upon the location at which work is being performed at the site. In the event that an emergency evacuation is effected during the course of work at any of the areas, personnel shall immediately report to the designated refuge location, and remain there. The Site Health and Safety Officer shall conduct a roll call (using the site log book) to account for all personnel to ensure that a total work site evacuation has taken place.

11.6 DECONTAMINATION PROCEDURES/EMERGENCY MEDICAL TREATMENT

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

11.7 EMERGENCY ALERTING AND RESPONSE PROCEDURES

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

In the event of an emergency situation, Base Security and appropriate emergency services will be contacted using Figure 11-1.

11.8 PPE AND EMERGENCY EQUIPMENT

A first-aid kit will be maintained on site and immediately available for use in the event of an emergency.

FIGURE 11-1
EMERGENCY REFERENCE
NAVAL EDUCATION AND TRAINING CENTER
NEWPORT, RHODE ISLAND

Contact	Phone Number
Newport Emergency Numbers:	
Police	911 or (401) 847-1212
Fire	911 or (401) 846-2211
Newport Hospital	(401) 846-6400
NETC Emergency Numbers:	
Command Duty Officer	(401) 841-3456 or 3457
Security Office - Police	(401) 841-3241
NETC Fire Protection	(401) 841-3333
Public Works	(401) 841-4001
NETC Safety Officer:Robert Hanley	(401) 841-2478
NETC Env. Coord.:Rachel Marino	(401) 841-3735
Utilities:	
Rhode Island Dig Safe	(800) 225-4977
Base Dig Safe:Linda Farric	(401) 841-4497
NETC Engineering:Jack Belleveau	(401) 841-3735
Defense Fuel Support:Warren Pretti	(401) 841-2451
Chemtrec:	(800) 424-9300
National Response Center:	(800) 424-8802
HNUS Project Manager:	
Walter Martin	(508) 658-7899
CLEAN Health and Safety Manager:	
Matthew M. Soltis	(412) 921-8912
HNUS Medical Consultant:	
Health Resources	(617) 935-8581

FIGURE 11-1
EMERGENCY REFERENCE
NAVAL EDUCATION AND TRAINING CENTER
NEWPORT, RHODE ISLAND
PAGE TWO

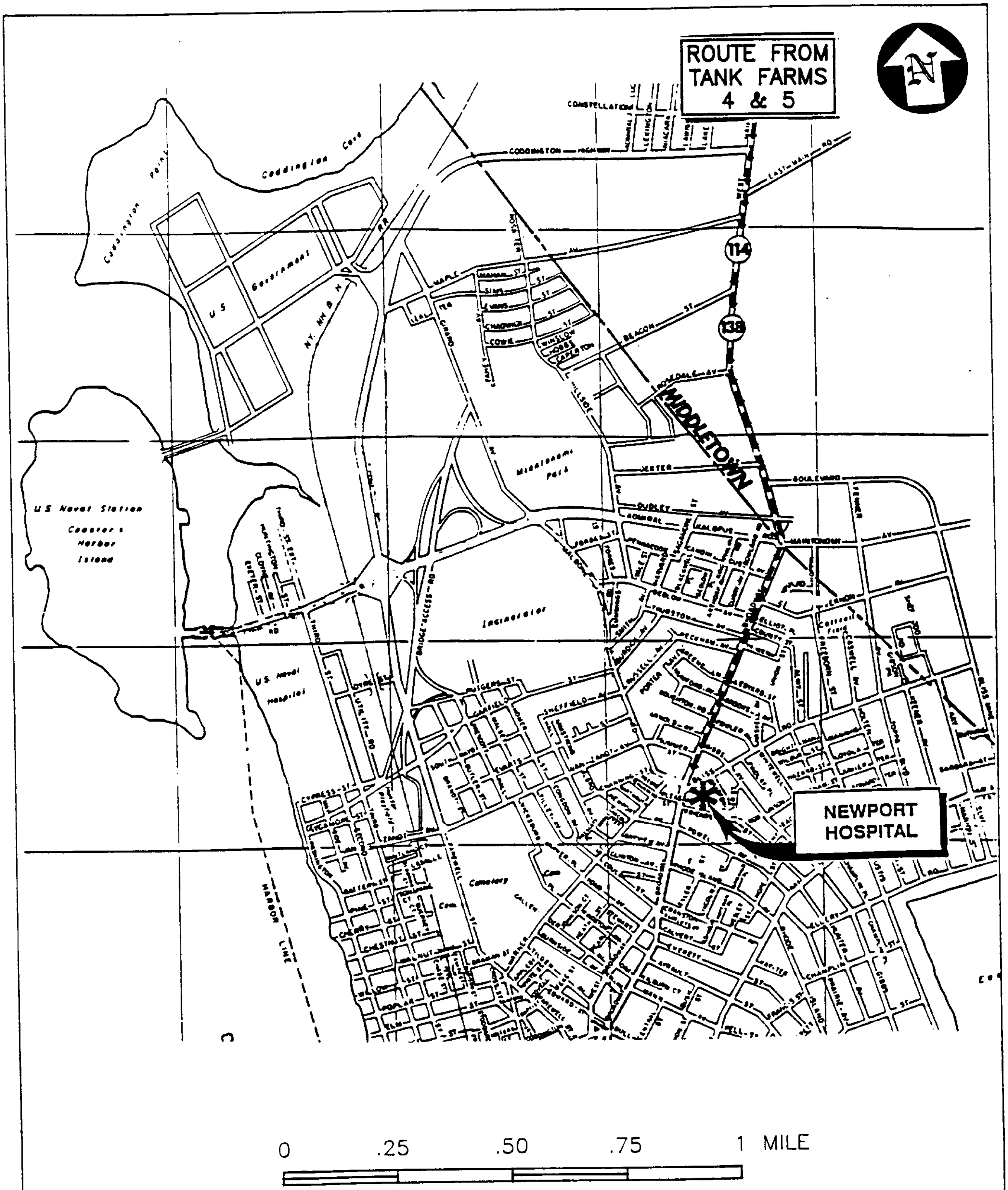
EMERGENCY ROUTE TO HOSPITAL (See Map Figure 11-2 and 11-3)

HOSPITAL ROUTE DIRECTIONS:

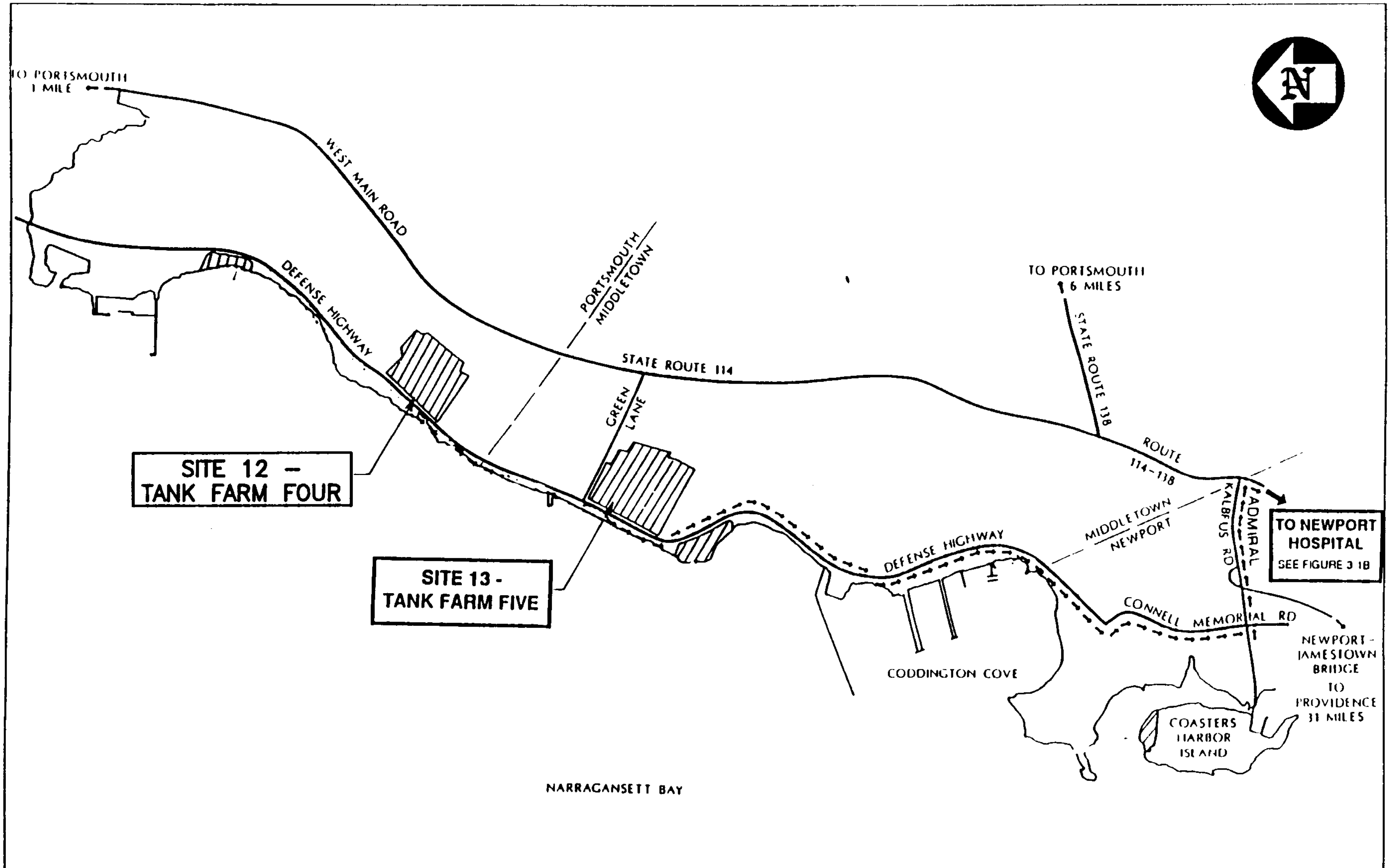
Newport Hospital
Friendship St.
Newport, RI

Phone: (401) 846-6400

1. Leave site and take a left onto Defense Highway.
2. Bear left onto Connell Memorial Road.
3. Take a left onto Kalbfus Road.
4. Follow to end and take a right onto Route 114/138 South.
5. Bear right onto Broadway Street.
6. Take a left onto Friendship Street. Hospital will be on your left.



NEWPORT HOSPITAL ROUTE MAP				FIGURE 11-2
NETC – NEWPORT, RI				Halliburton NUS CORPORATION
DRAWN BY:	R. SARGENT	REV.:	0	
CHECKED BY:	W. MARTIN	DATE:	11 NOV 93	
SCALE:	AS SHOWN	PROJECT NO.:	7758 CTO #114:	187 Ballardvale St. Wilmington, MA 01887 (508)658-7899



NEWPORT HOSPITAL ROUTE MAP				FIGURE 11-3
NETC - NEWPORT, RI				Halliburton NUS CORPORATION
DRAWN BY:	R. SARGENT	REV.:	0	187 Ballardvale St. Wilmington, MA 01887 (508)658-7899
CHECKED BY:	W. MARTIN	DATE:	11 NOV 93	
SCALE:	AS SHOWN	PROJECT NO.:	7758 CTO #114:	

ATTACHMENT A

CHEMICAL, PHYSICAL, AND HEALTH HAZARD INFORMATION FOR SITE CONTAMINANT

OILS, FUEL: 5

OFV

Common Synonyms			
Residual fuel oil No. 5	Oily liquid	Dark	Strong lube oil odor
	Usually floats on water.		

Stop discharge if possible.
Call fire department.
Avoid contact with liquid.
Isolate and remove discharged material.
Notify local health and pollution control agencies.

Fire

Combustible.
Extinguish with dry chemical, foam or carbon dioxide.
Water may be ineffective on fire.
Cool exposed containers with water.

Exposure

CALL FOR MEDICAL AID.

LIQUID
Irritating to skin and eyes.
Harmful if swallowed.
Remove contaminated clothing and shoes.
Flush affected areas with plenty of water.
IF IN EYES, hold eyelids open and flush with plenty of water.
IF SWALLOWED and victim is CONSCIOUS, have victim drink water or milk.
DO NOT INDUCE VOMITING.

Water Pollution

Effect of low concentrations on aquatic life is unknown.
Fouling to shoreline.
May be dangerous if it enters water intakes.

Notify local health and wildlife officials.
Notify operators of nearby water intakes.

1. RESPONSE TO DISCHARGE

(See Response Methods Handbook)

Mechanical containment
Should be removed
Chemical and physical treatment

2. LABEL

2.1 **Category:** None
2.2 **Class:** Not pertinent

3. CHEMICAL DESIGNATIONS

3.1 **CG Compatibility Class:** Miscellaneous Hydrocarbon Mixtures
3.2 **Formula:** Not applicable
3.3 **IMO/UN Designation:** 3.3/1223
3.4 **DOT ID No.:** 1223
3.5 **CAS Registry No.:** Data not available

4. OBSERVABLE CHARACTERISTICS

4.1 **Physical State (as shipped):** Liquid
4.2 **Color:** Brown
4.3 **Odor:** Characteristic

5. HEALTH HAZARDS

5.1 **Personal Protective Equipment:** Protective gloves; goggles or face shield.
5.2 **Symptoms Following Exposure:** INGESTION: gastrointestinal irritation. ASPIRATION: treatment probably not required; delayed development of pulmonary irritation can be detected by serial chest x-rays; consider prophylactic antibiotic regime if condition warrants. EYES: wash with copious quantity of water. SKIN: wipe off and wash with soap and water.
5.3 **Treatment of Exposure:** Data not available
5.4 **Threshold Limit Value:** Data not available
5.5 **Short Term Inhalation Limits:** Not pertinent
5.6 **Toxicity by Ingestion:** Grade 1; LD_{50} = 5 to 15 g/kg
5.7 **Late Toxicity:** Data not available
5.8 **Vapor (Gas) Irritant Characteristics:** None
5.9 **Liquid or Solid Irritant Characteristics:** Minimum hazard. If spilled on clothing and allowed to remain, may cause smarting and reddening of the skin.
5.10 **Odor Threshold:** Data not available
5.11 **IDLH Value:** Data not available

6. FIRE HAZARDS

6.1 **Flash Point:** >130°F C.C.
6.2 **Flammable Limits in Air:** 1%-5%
6.3 **Fire Extinguishing Agents:** Dry chemical, foam, or carbon dioxide
6.4 **Fire Extinguishing Agents Not to be Used:** Water may be ineffective.
6.5 **Special Hazards of Combustion Products:** Not pertinent
6.6 **Behavior in Fire:** Not pertinent
6.7 **Ignition Temperature:** Data not available
6.8 **Electrical Hazard:** Not pertinent
6.9 **Burning Rate:** 4 mm/min.
6.10 **Adiabatic Flame Temperature:** Data not available
6.11 **Stoichiometric Air to Fuel Ratio:** Data not available
6.12 **Flame Temperature:** Data not available

7. CHEMICAL REACTIVITY

7.1 **Reactivity With Water:** No reaction
7.2 **Reactivity with Common Materials:** No reaction
7.3 **Stability During Transport:** Stable
7.4 **Neutralizing Agents for Acids and Caustics:** Not pertinent
7.5 **Polymerization:** Not pertinent
7.6 **Inhibitor of Polymerization:** Not pertinent
7.7 **Molar Ratio (Reactant to Product):** Data not available
7.8 **Reactivity Group:** 33

8. WATER POLLUTION

8.1 **Aquatic Toxicity:** Data not available
8.2 **Waterfowl Toxicity:** Data not available
8.3 **Biological Oxygen Demand (BOD):** Data not available
8.4 **Food Chain Concentration Potential:** None

9. SHIPPING INFORMATION

9.1 **Grades of Purity:** Fuel oil No. 5 (heavy); Fuel oil No. 5 (light)
9.2 **Storage Temperature:** Ambient
9.3 **Inert Atmosphere:** No requirement
9.4 **Venting:** Open (flame arrester)

10. HAZARD ASSESSMENT CODE

(See Hazard Assessment Handbook)

A-T-U

11. HAZARD CLASSIFICATIONS

11.1 **Code of Federal Regulations:** Combustible liquid
11.2 **NAS Hazard Rating for Bulk Water Transportation:** Not listed
11.3 **NFPA Hazard Classification:**

Category	Classification
Health Hazard (Blue)	0
Flammability (Red)	2
Reactivity (Yellow)	0

12. PHYSICAL AND CHEMICAL PROPERTIES

12.1 **Physical State at 15°C and 1 atm:** Liquid
12.2 **Molecular Weight:** Not pertinent
12.3 **Boiling Point at 1 atm:** 426—>1062°F = 218—>570°C = 491—>843°K
12.4 **Freezing Point:** 0°F = −18°C = 255°K
12.5 **Critical Temperature:** Not pertinent
12.6 **Critical Pressure:** Not pertinent
12.7 **Specific Gravity:** (liquid) 0.936 at 16°C
12.8 **Liquid Surface Tension:** Data not available
12.9 **Liquid Water Interfacial Tension:** Data not available
12.10 **Vapor (Gas) Specific Gravity:** Not pertinent
12.11 **Ratio of Specific Heats of Vapor (Gas):** Not pertinent
12.12 **Latent Heat of Vaporization:** Not pertinent
12.13 **Heat of Combustion:** −18,000 Btu/lb = −10,000 cal/g = −418.68 X 10^5 J/kg
12.14 **Heat of Decomposition:** Not pertinent
12.15 **Heat of Solution:** Not pertinent
12.16 **Heat of Polymerization:** Not pertinent
12.25 **Heat of Fusion:** Data not available
12.26 **Limiting Value:** Data not available
12.27 **Reid Vapor Pressure:** Data not available

NOTES

OILS, FUEL: 6

OSX

Common Synonyms	Thick liquid	Black	Tar odor
Bunker C oil Residual fuel oil No. 6	Usually floats on water.		

Stop discharge if possible.
Call fire department.
Avoid contact with liquid.
Isolate and remove discharged material.
Notify local health and pollution control agencies.

Fire

Combustible.
Extinguish with dry chemical, foam or carbon dioxide.
Water may be ineffective on fire.
Cool exposed containers with water.

Exposure

CALL FOR MEDICAL AID

LIQUID
Irritating to skin and eyes.
Harmful if swallowed.
Remove contaminated clothing and shoes.
Flush affected areas with plenty of water.
IF IN EYES, hold eyelids open and flush with plenty of water.
IF SWALLOWED and victim is CONSCIOUS, have victim drink water or milk.
DO NOT INDUCE VOMITING.

Water Pollution

Dangerous to aquatic life in high concentrations.
Fouling to shoreline.
May be dangerous if it enters water intakes.

Notify local health and wildlife officials.
Notify operators of nearby water intakes.

1. RESPONSE TO DISCHARGE

(See Response Methods Handbook)

Mechanical containment
Should be removed
Chemical and physical treatment

2. LABEL

2.1 **Category:** None
2.2 **Class:** Not pertinent

3. CHEMICAL DESIGNATIONS

3.1 **CG Compatibility Class:** Miscellaneous hydrocarbon mixture
3.2 **Formula:** Not listed
3.3 **IMO/UN Designation:** 3.3/1223
3.4 **DOT ID No.:** 1223
3.5 **CAS Registry No.:** Data not available

4. OBSERVABLE CHARACTERISTICS

4.1 **Physical State (as shipped):** Liquid
4.2 **Color:** Dark
4.3 **Odor:** Tarry; like kerosene

5. HEALTH HAZARDS

5.1 **Personal Protective Equipment:** Protective gloves; goggles or face shield.
5.2 **Symptoms Following Exposure:** INGESTION: gastrointestinal irritation. ASPIRATION: pulmonary irritation is normally minimal but may become more severe several hours after exposure.
5.3 **Treatment of Exposure:** INGESTION: do NOT lavage or induce vomiting. ASPIRATION: treatment probably not required; delayed development of pulmonary irritation can be detected by serial chest x-rays; consider prophylactic antibiotic regime if condition warrants. EYES: wash with copious quantity of water. SKIN: wipe off and wash with soap and water.
5.4 **Threshold Limit Value:** Data not available
5.5 **Short Term Inhalation Limits:** Not pertinent
5.6 **Toxicity by Ingestion:** Grade 1; LD_{50} = 5 to 15 g/kg
5.7 **Late Toxicity:** Data not available
5.8 **Vapor (Gas) Irritant Characteristics:** None
5.9 **Liquid or Solid Irritant Characteristics:** Minimum hazard. If spilled on clothing and allowed to remain, may cause smarting and reddening of the skin.
5.10 **Odor Threshold:** Data not available
5.11 **IDLH Value:** Data not available

6. FIRE HAZARDS

6.1 **Flash Point:** >150°F C.C.
6.2 **Flammable Limits in Air:** 1%-5%
6.3 **Fire Extinguishing Agents:** Dry chemical, foam, or carbon dioxide
6.4 **Fire Extinguishing Agents Not to be Used:** Water may be ineffective
6.5 **Special Hazards of Combustion Products:** Not pertinent
6.6 **Behavior in Fire:** Not pertinent
6.7 **Ignition Temperature:** 765°F
6.8 **Electrical Hazard:** Not pertinent
6.9 **Burning Rate:** 4 mm/min.
6.10 **Adiabatic Flame Temperature:** Data not available
6.11 **Stoichiometric Air to Fuel Ratio:** Data not available
6.12 **Flame Temperature:** Data not available

7. CHEMICAL REACTIVITY

7.1 **Reactivity With Water:** No reaction
7.2 **Reactivity with Common Materials:** No reaction
7.3 **Stability During Transport:** Stable
7.4 **Neutralizing Agents for Acids and Caustics:** Not pertinent
7.5 **Polymerization:** Not pertinent
7.6 **Inhibitor of Polymerization:** Not pertinent
7.7 **Molar Ratio (Reactant to Product):** Data not available
7.8 **Reactivity Group:** 33

8. WATER POLLUTION

8.1 **Aquatic Toxicity:**
2400 ppm/48 hr/juvenile American shad/TL_m/fresh water
2417 mg/l/48 hr/juvenile American shad/TL_m/salt water
8.2 **Waterfowl Toxicity:** Data not available
8.3 **Biological Oxygen Demand (BOD):** Data not available
8.4 **Food Chain Concentration Potential:** Data not available

9. SHIPPING INFORMATION

9.1 **Grades of Purity:** Commercial
9.2 **Storage Temperature:** Elevated
9.3 **Inert Atmosphere:** No requirement
9.4 **Venting:** Open (flame arrester)

10. HAZARD ASSESSMENT CODE

(See Hazard Assessment Handbook)

A-T-U

11. HAZARD CLASSIFICATIONS

11.1 **Code of Federal Regulations:** Combustible liquid
11.2 **NAS Hazard Rating for Bulk Water Transportation:** Not listed
11.3 **NFPA Hazard Classification:**

Category	Classification
Health Hazard (Blue)	0
Flammability (Red)	2
Reactivity (Yellow)	0

12. PHYSICAL AND CHEMICAL PROPERTIES

12.1 **Physical State at 15°C and 1 atm:** Liquid
12.2 **Molecular Weight:** Not pertinent
12.3 **Boiling Point at 1 atm:** 415—>>1093°F = 212—>>588°C = 485—>>861°K
12.4 **Freezing Point:** 25 to 55°F = —4 to +13°C = 269 to 286°K
12.5 **Critical Temperature:** Not pertinent
12.6 **Critical Pressure:** Not pertinent
12.7 **Specific Gravity:** 0.95 (approx.) at 20°C (liquid)
12.8 **Liquid Surface Tension:** (est.) 25 dynes/cm = 0.025 N/m at 20°C
12.9 **Liquid Water Interfacial Tension:** (est.) 50 dynes/cm = 0.05 N/m at 20°C
12.10 **Vapor (Gas) Specific Gravity:** Not pertinent
12.11 **Ratio of Specific Heats of Vapor (Gas):** Not pertinent
12.12 **Latent Heat of Vaporization:** Not pertinent
12.13 **Heat of Combustion:** —18,000 Btu/lb = —10,000 cal/g = —418.68 X 10^5 J/kg
12.14 **Heat of Decomposition:** Not pertinent
12.15 **Heat of Solution:** Not pertinent
12.16 **Heat of Polymerization:** Not pertinent
12.25 **Heat of Fusion:** Data not available
12.26 **Limiting Value:** Data not available
12.27 **Reid Vapor Pressure:** Data not available

NOTES

ATTACHMENT B

HEAT AND COLD STRESS MONITORING

HEAT STRESS MONITORING

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 HALLIBURTON NUS 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.

<u>Work-Rest Regimen</u>

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 (ECT) 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

PETRO RISC OPERATING MANUAL

Rev. 2 8/19/93

ENSYS INC.
ENVIRONMENTAL PRODUCTS

PETRO RISC® SOIL TEST SYSTEM

RAPID IMMUNOASSAY SCREEN

User's Guide
Multiple Level Test

This method correctly identifies 95% of samples that are petroleum fuels-free and those containing 10 ppm gasoline and 15 ppm for other petroleum fuels. A sample that develops less color than the standard is interpreted as positive. It contains petroleum fuels. A sample that develops more color than the standard is interpreted as negative. It contains less than 10 ppm gasoline or 15 ppm other petroleum fuels.

IMPORTANT NOTICE

This test system should be used only under the supervision of a technically qualified individual who is capable of understanding any potential health and environmental risks of this product as identified in the product literature. The components must only be used for the analysis of soil samples for the presence of petroleum hydrocarbons. After use, the kits must be disposed of in accordance with applicable federal and local regulations.

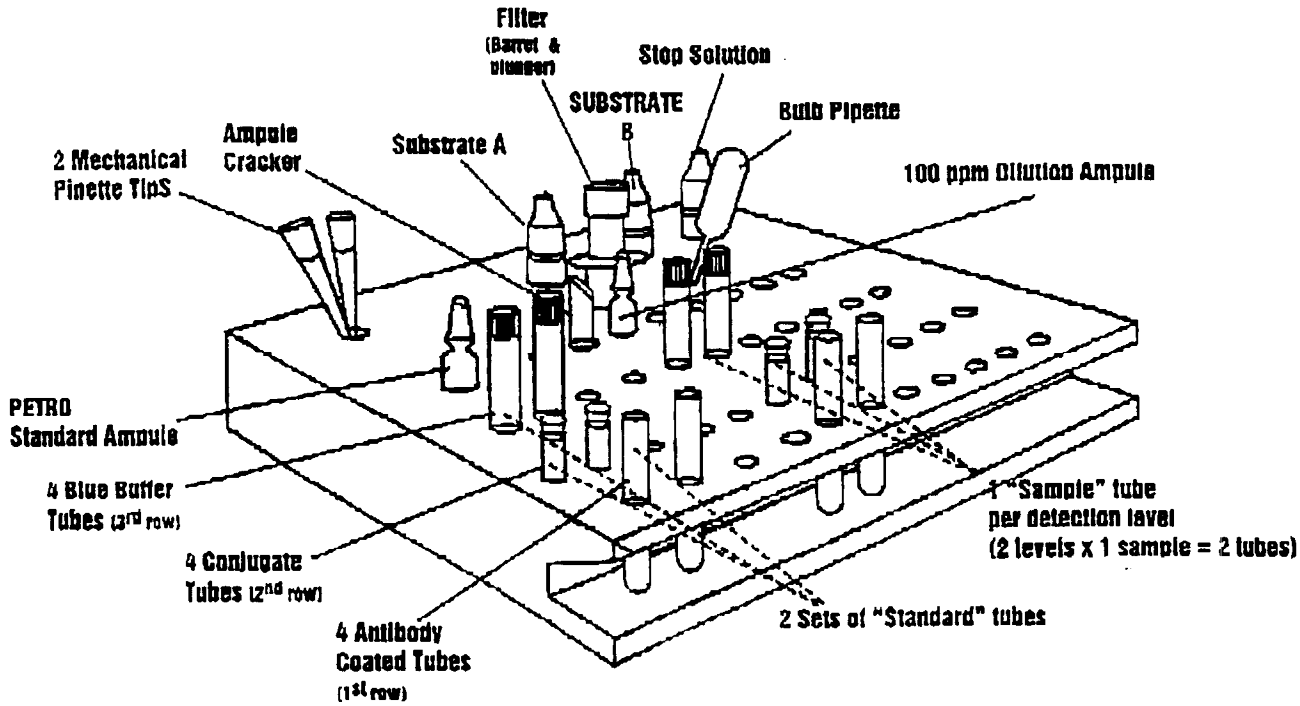
WORKSTATION SET-UP

READ ALL INSTRUCTIONS BEFORE PROCEEDING WITH THE TEST

WORKSTATION SET-UP

- ☐ Mechanical pipette tip
- ☐ Substrate A
- ☐ Substrate B
- ☐ Stop solution
- ☐ Filtration barrel & plunger
- ☐ Bulb pipette
- ☐ PETRO standard ampule
- ☐ 100 ppm dilution ampule
- ☐ 4 blue buffer tubes
- ☐ 4 Conjugate tubes
- ☐ 4 antibody coated tubes

See reverse for individual component illustrations
Workstation shows components for 1 sample tested at 2 levels



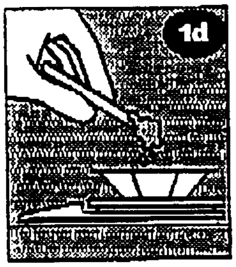
READ BEFORE PROCEEDING

- Follow diagram above to setup workstation.
- Items that you will need that are not provided in the test kit include:
  a permanent marking pen, laboratory tissue (or paper towels), a liquid waste container, and disposable gloves.
- Do not expose reagents to direct sunlight.
- This User's Guide was written for analyzing soil samples for gasoline at 10 and 100 ppm. The detection level for diesel is 15 ppm. See table on page 9 for sensitivity to other compounds.

PHASE ONE EXTRACTION & PREPARATION OF THE SAMPLE

READ ALL INSTRUCTIONS BEFORE PROCEEDING WITH THE TEST

WEIGH SAMPLE



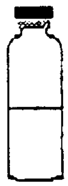
1a Open methanol crimp top vial and pour the entire contents into the extraction jar.

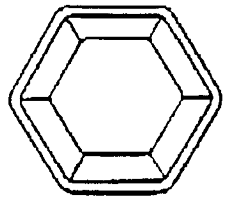
1b Place unused weigh boat on pan balance.

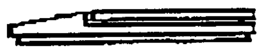
1c Press ON/MEMORY button on pan balance. Balance will beep and display 0.0.

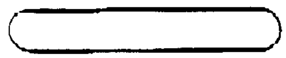
1d Weigh out 10 ±0.1 grams of soil.

1e If balance turns off prior to completing weighing, use empty weigh boat to retare, then continue.


Methanol Crimp Top Vial


Weigh Boat


Pan balance


Wooden spatula

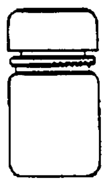
EXTRACT PETROLEUM HYDROCARBONS

2a Using wooden spatula, transfer 10 grams of soil from weigh boat into extraction jar.

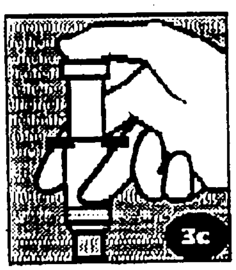
2b Recap extraction jar tightly and shake vigorously for one minute.

2c Allow to settle for one minute.

Repeat steps **1a - 2c** for each sample to be tested.


Sample extraction jar

FILTER SAMPLE



3a Disassemble filtration plunger from filtration barrel.

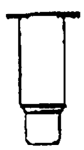
3b Insert bulb pipette into top (liquid) layer in extraction jar and draw up sample. Transfer **at least ½ bulb** capacity into filtration barrel. **Do not use more than one full bulb.**

3c Press plunger firmly into barrel until adequate filtered sample is available (place on table and press if necessary).

Repeat steps **3a - 3c** for each sample to be tested.


Filtration plunger


Bulb pipette


Filtration barrel

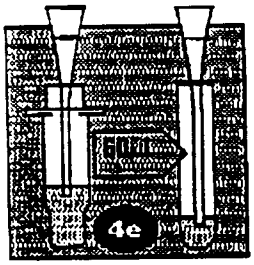
PHASE TWO SAMPLE AND STANDARD PREPARATION

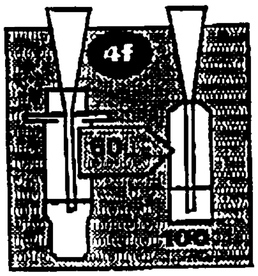
READ ALL INSTRUCTIONS BEFORE PROCEEDING WITH THE TEST

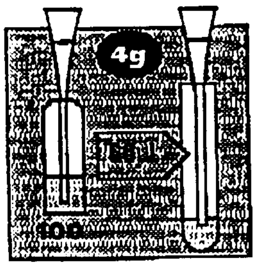
READ BEFORE PROCEEDING

- Label the conjugate and antibody coated tubes with a permanent marking pen.
- "Shake tubes" means to thoroughly mix the contents with special care not to spill or splash.

DILUTE AND BUFFER SAMPLE FOR 10 PPM AND 100 PPM DETECTION LEVELS







4a Open dilution ampule by slipping ampule cracker over top, and then breaking top at scored neck.

4b Uncap enough blue buffer, conjugate, and antibody coated tubes for Samples and Standards.

4c Empty a blue buffer tube into each conjugate tube.

4d Assemble new tip onto mechanical pipette.

4e Withdraw 60 µL of sample from filter unit using mechanical pipette and dispense below the liquid level in 10 ppm conjugate tube. Wipe mechanical pipette tip.

4f Withdraw 60 µL of filtered sample from the filter unit and dispense below the liquid level in the 100 ppm dilution ampule. Shake ampule for 5 seconds.

4g Withdraw 60 µL of diluted sample from 100 ppm dilution ampule and dispense below the liquid level in 100 ppm conjugate tube.

4h Discard mechanical pipette tip.

Repeat steps **4a - 4h** for each sample to be tested.

Dilution ampoles (100 ppm)

Plastic Safety Sleeve

Blue buffer tubes

Conjugate tubes

Antibody coated tubes (contained in resealable "zip-seal" aluminized pouch)

Mechanical pipette

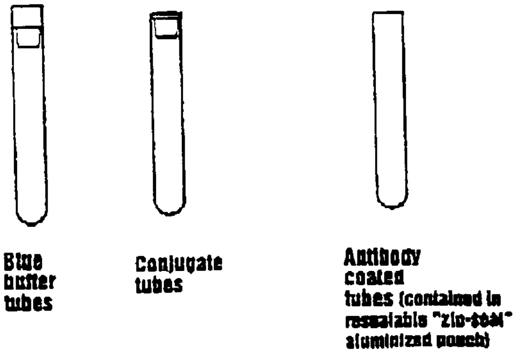
Mechanical pipette tip

PHASE TWO SAMPLE AND STANDARD PREPARATION

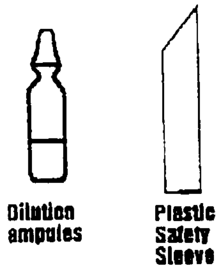
READ ALL INSTRUCTIONS BEFORE PROCEEDING WITH THE TEST

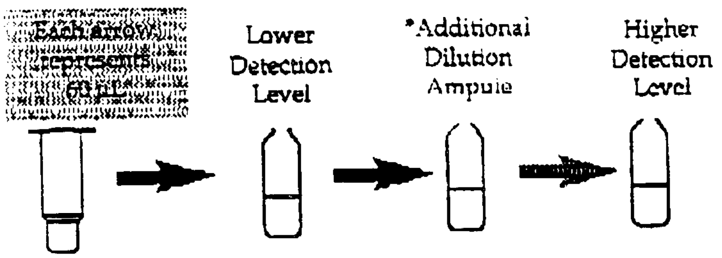
DILUTE AND BUFFER SAMPLE
FOR NONSTANDARD DETECTION LEVELS

- This prodecure replaces the one outlined in Steps 4e-4h for tests designed for detection levels other than 10 and 100 ppm. Follow steps 4a-4d.
- Always transfer 60 µL from filter unit to the lowest level dilution ampule. Then, transfer 60 µL from lower to next higher dilution ampule. Continue until 60 µL has been transferred to highest level dilution ampule.
- Always withdraw and dispense solution with mechanical pipette tip below the liquid level.

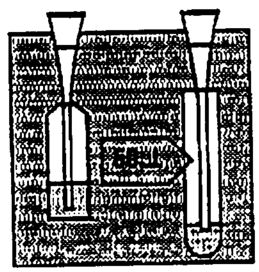


*You may be provided with additional dilution ampules.

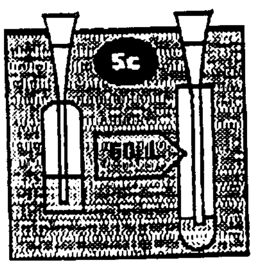




- Select the dilution ampules representing your desired detection levels. Transfer 60 µL from each selected dilution ampule to appropriate conjugate tube
- Wipe mechanical pipette tip after dispensing into conjugate tube.
- If after reviewing this User's Guide you still have questions, contact technical support at 800-242-7472.



BUFFER STANDARDS



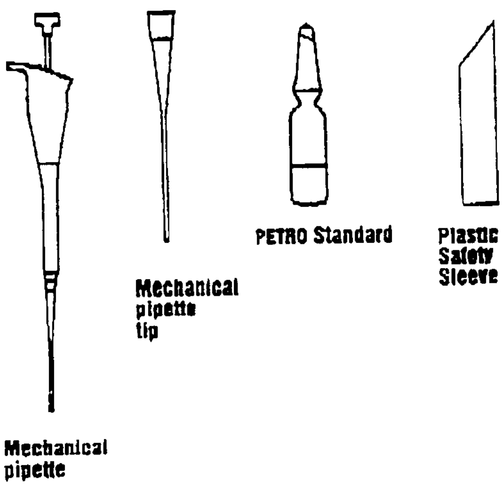
5a Assemble new tip onto mechanical pipette.

5b Open PETRO Standard ampule.

5c Withdraw 60 µL of PETRO Standard and dispense below the liquid level in Standard conjugate tube. Wipe mechanical pipette tip.

5d Repeat step **5c** for the 2nd Standard.

5e Shake all conjugate tubes for 5 seconds.



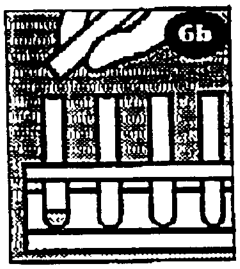
PHASE THREE THE IMMUNOASSAY

READ ALL INSTRUCTIONS BEFORE PROCEEDING WITH THE TEST

READ BEFORE PROCEEDING

- This phase of the procedure requires critical timing and care in handling the antibody coated tubes.

INCUBATION



6a Set timer for exactly 10 minutes.

6b Start timing and immediately pour solution from each conjugate tube into appropriate antibody coated tube.

6c Shake all tubes for 5 seconds.

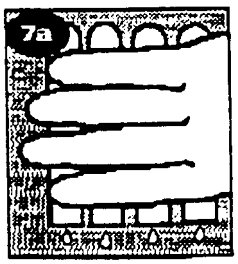
6d Let tubes stand exactly 10 minutes.

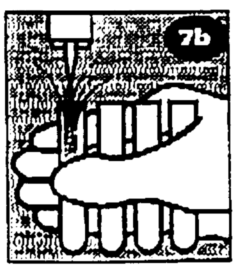
READ BEFORE PROCEEDING

WASH PROCEDURE

- Washing must be done vigorously and with force.
- Place nozzle just above antibody coated tube, squeeze bottle to fill each tube with a vigorous stream and empty into liquid waste container.
- The wash solution is a harmless, dilute solution of detergent. Do not hesitate to wash vigorously even if the solution contacts gloved hands.

WASHING



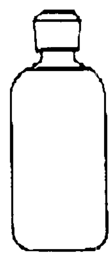


7a After the 10 minute incubation, empty antibody coated tubes into liquid waste container.

7b Wash antibody coated tubes by vigorously filling and emptying a total of 4 times.

7c Tap antibody coated tubes upside down on paper towels to remove excess liquid. Residual foam in the tubes will not interfere with test results.

Antibody coated tubes (contained in resealable "zip-seal" aluminized pouch)



Wash Bottle

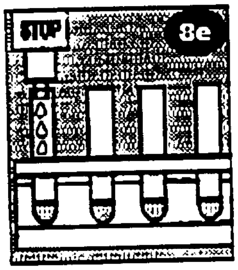
PHASE THREE THE IMMUNOASSAY

READ ALL INSTRUCTIONS BEFORE PROCEEDING WITH THE TEST

READ BEFORE PROCEEDING

- Keep Substrate dropper bottles vertical and direct each drop to bottom of antibody coated tubes. Addition of more or less than 5 drops may give inaccurate results.
- This phase requires accurate timing.

COLOR DEVELOPMENT



8a Add 5 drops of Substrate A (yellow cap) to each antibody coated tube.

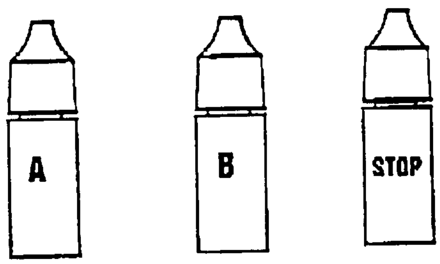
8b Set timer for exactly 2 ½ minutes.

8c Start timer and immediately add 5 drops of Substrate B (green cap) to each antibody coated tube.

8d Shake all tubes for 5 seconds. Solution will turn blue in some or all antibody coated tubes.

8e Stop reaction at end of 2 ½ minutes by adding 5 drops of Stop Solution (red cap).

Note: Blue solution will turn yellow when Stop Solution is added.

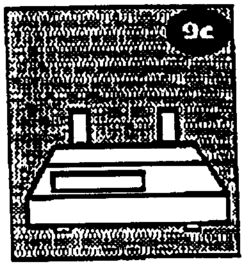


Substrate A Substrate B Stop

PHASE FOUR INTERPRETATION

READ ALL INSTRUCTIONS BEFORE PROCEEDING WITH THE TEST

SELECT DARKER STANDARD



9a Wipe outside of all antibody coated tubes.

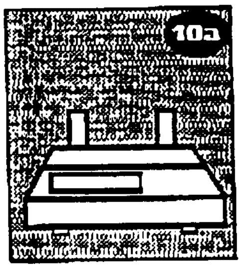
9b Place both Standard tubes in photometer.

9c Switch tubes until the photometer reading is negative or zero. Record reading. If reading is greater than 0.2 in magnitude (+ or -), results are outside of QC limits. Retest the sample(s).

9d Remove and discard tube in right well. The tube in the left well is the darker standard.

INTERPRET RESULTS

10a Place 10 ppm tube in right well of photometer and record reading.



If photometer reading is **negative** or zero, petroleum hydrocarbons are present.

If photometer reading is **positive**, concentration of petroleum hydrocarbons is less than 10 ppm.

See table on page 9 for specific detection levels.

10b Place 100 ppm tube in right well of photometer and record reading shown on display.

If photometer reading is **negative** or zero, petroleum hydrocarbons are present.

If photometer reading is **positive**, concentration of gasoline or petroleum fuel is less than 100 ppm.

QUALITY CONTROL

READ ALL INSTRUCTIONS BEFORE PROCEEDING WITH THE TEST

How it Works

Standards, Samples, and color-change reagents are added to test tubes coated with a chemical specific to petroleum fuels. The concentration of petroleum fuel in an unknown Sample is determined by comparing its color intensity with that of a Standard.

Note: petroleum fuel concentration is inversely proportional to color intensity: the lighter the color development of the sample, the higher the concentration of petroleum fuel.

Quality Control

Standard precautions for maintaining quality control:

- Do not use reagents or test tubes from one Test System with reagents or test tubes from another Test System.
- Do not use the Test System after its expiration date.
- Each analysis must include 2 Standards, with no more than a total of 12 antibody coated tubes.
- Do not exceed incubation periods prescribed by the specific steps.
- Results may not be valid if photometer reading for Standards exceeds 0.2 in magnitude.

Storage and Handling Precautions

- Wear protective gloves and eyewear.
- Store kit at room temperature and out of direct sunlight (less than 80°F).
- Keep aluminized pouch (containing unused antibody coated tubes) sealed when not in use.
- If liquid from the extraction jar, or PETRO Standard comes into contact with eyes, wash thoroughly with cold water and seek immediate medical attention.
- Operate ~~test at~~ temperatures greater than 15° C/60° F and less than 39° C/100° F.
- After use, dispose of kit components in accordance with applicable federal and local regulations.

System Description

Each PETRO RIS©® Soil Test System contains enough material to perform four complete tests, each at **10 and 100** ppm.

The PETRO RIS©® Soil Test is divided into four phases. The instructions and notes should be reviewed before proceeding with each phase.

Hotline Assistance

If you need assistance or are missing necessary Test System materials, call toll free: 1-800-242-RISC (7472).

Validation and Warranty Information

Product claims are based on validation studies carried out under controlled conditions. Data has been collected in accordance with valid statistical methods and the product has undergone quality control tests of each manufactured lot.

Gasoline-free soil and soil containing 10 ppm of gasoline were tested with the EnSys PETRO RIS©® analytical method. The method correctly identified 95% of these samples. A sample that has developed less color than the standard is interpreted as positive. It contains gasoline.

Diesel fuel-free soil and soil containing 15 ppm of diesel fuel were tested with the EnSys PETRO RIS©® analytical method. The method correctly identified 95% of these samples. A sample that has developed less color than the standard is interpreted as positive. It contains diesel fuel.

The company does not guarantee that the results with the PETRO RIS©® Soil Test System will always agree with instrument-based analytical laboratory methods. All analytical methods, both field and laboratory, need to be subject to the appropriate quality control procedures.

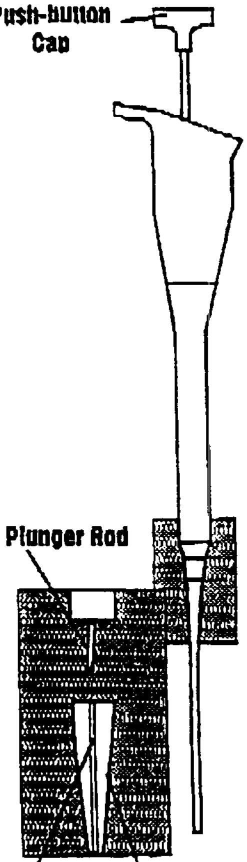
EnSys, Inc. warrants that this product conforms to the descriptions contained herein. No other warranties, whether expressed or implied, including warranties of merchantability and of fitness for a particular purpose shall apply to this product.

EnSys, Inc. neither assumes nor authorizes any representative or other person to assume for it any obligation or liability other than such as is expressly set forth herein.

Under no circumstances shall EnSys, Inc. be liable for incidental or consequential damages resulting from the use or handling of this product.

MECHANICAL PIPETTE

READ ALL INSTRUCTIONS BEFORE PROCEEDING WITH THE TEST



HOW TO OPERATE THE MECHANICAL PIPETTE

To Set Or Adjust Volume

Remove push-button cap and use it to loosen volume lock screw. Turn lower part of push-button to adjust volume up or down. Meter should read "060". Tighten volume lock screw and replace push-button cap.

To Assemble Pipette Tip

Slide larger mounting end of pipette tip onto end of pipette. Holding tip in place, press push-button until plunger rod enters pipette tip. Ensure no gap exists between piston and plunger rod (see illustration).

To Withdraw Sample

With tip mounted in position on pipette, press push-button to first stop and hold it.

Place tip at bottom of liquid sample and slowly release push-button to withdraw measured sample. Ensure that no bubbles exist in liquid portion of sample. If bubbles exist, dispense sample and re-withdraw sample.

To Dispense Sample

Place tip into dispensing vessel (immersing end of the tip if vessel contains liquid) and slowly press push-button to first stop. (Do not push to second stop or tip will eject).

Remove tip from vessel and release push-button.

To Eject Tip

Press push-button to second stop. Tip is ejected.

For additional information regarding operation and use of pipette, please refer to your pipette manual.

TEST SENSITIVITY

The PETRO RISC® Soil Test System has sensitivities to the following chemicals at the stated levels.

	Concentation necessary to give a positive result greater than 95% of the time (ppm)
Petroleum Fuels:	
Gasoline	10
Diesel	15
#2 Fuel Oil	15
Kerosene	15
Jet Fuel A	15
Jet Fuel JP-4	15
#6 Fuel Oil	25
Other Compounds:	
Mineral Spirits	40

For a complete table of sensitivities, consult the PETRO RISC® Soil Test System Technical Guide.

EnSys, Inc.
P.O. Box 14063
RTP, NC 27709

PETRO RISc® Petroleum Fuels Soil Test
Technical Guide

Contamination of soil with petroleum hydrocarbons is a widespread problem due to the ubiquity of underground storage tanks containing petroleum fuels. The federal Underground Storage Tank Act has catalyzed the clean-up and replacement of thousands of leaking storage tanks. Individual state regulatory agencies have control over the clean-up levels and testing for contamination and closure.

Petroleum Hydrocarbons

Petroleum hydrocarbons are a diverse group of chemical compounds consisting of aliphatic and aromatic hydrocarbons. They are sold commercially as mixtures of compounds with similar boiling points. These mixtures are derived from the splitting (cracking) of larger compounds comprising crude oil and subsequent distillation. The lighter, or lower boiling, mixtures obtained in this process are used primarily as fuels or solvents. These include gasoline, mineral spirits, kerosene, jet fuels, diesel fuel, and fuel oils.

The regulatory concern surrounding petroleum fuels contamination lies primarily with the aromatic hydrocarbon fraction of these substances. However, only a few states directly address soil contamination with BTEX or benzene. Most specify regulatory levels relating to total petroleum hydrocarbons or to the substance found to be contaminating the soil at the site. These levels range from sub-ppm to 10,000 ppm depending on the state and the circumstances.

Existing Laboratory Methods

Numerous analytical methods exist that can be (and are) used to analyze soils for the presence of petroleum hydrocarbons (PHC). Unfortunately, these methods usually do not produce intercomparable results, because they rely on different means for calibration and detection. The two most common laboratory methods employed for PHC analysis are EPA methods 418.1 (IR) and 8015 (modified, GC). The IR method is commonly referred to as measuring total recoverable petroleum hydrocarbons (TRPH). A freon extraction of the soil sample is performed, the freon extract cleaned up to remove polar organic compounds not originating from petroleum sources, and the PHC content measured relative to a multi-component synthetic standard by IR. Because of the extract handling protocol, the IR method can badly underestimate soil contamination that is primarily attributable to gasoline. The GC method is usually employed to measure the concentration of the substance of interest rather than the total PHC content of the contaminated soil. The soil sample is either extracted with a solvent or the components vaporized directly (for gasoline) and collected on a temporary storage medium. Either way, the resulting material is analyzed by GC and the results compared to the relevant standard. Standards are made up from the substance to be analyzed or a synthetic mixture that is meant to be representative of the substance to be analyzed.

It is not widely recognized outside of the analytical community that much of the variability observed in PHC analysis data is a result of sampling and sample handling artifacts. This is due largely to the volatility of the analytes present in the sample and the difficulty in providing a homogeneous sample without losing a large fraction of the volatiles.

Existing Field Methods

Several methods are currently available for the field estimation of PHC contamination in soil. Most of these employ organic vapor meters (OVM) of one sort or another. Methods that rely on OVMs for detection of PHCs are headspace methods. While OVM headspace methods are useful for the qualitative detection of PHC contamination, they suffer from several practical shortcomings that limit their accuracy. The primary source of variability with these methods results from the fact that they can only measure PHCs in the vapor phase, rather than directly in soil. For this reason the results obtained are greatly influenced by the temperature at which the measurements are taken. Even if the temperature of measurement could be controlled in the field, headspace methods will still be substantially affected by the fact that different PHC materials have greatly differing volatilities. The nature of the contaminant (i. e. gasoline, diesel, #6 fuel oil) clearly has a very large effect on the outcome of the measurement.

Test Characteristics

The PETRO RISc® Soil Test serves as an accurate field-based alternative to sending all soil samples for analysis by laboratory-based methods. The PETRO RISc® Soil Test measures the petroleum fuel contaminant concentration in the soil rather than relying on headspace analysis. For this reason, the immunoassay-based test is not subject to variation due to temperature, humidity, wind speed, or the volatility of the PHC present.

The results obtained using the PETRO RISc® Soil Test are expressed in terms of the petroleum fuel product being measured, e.g., 10 ppm gasoline or 100 ppm diesel. However, the test does not measure every component of gasoline or diesel to arrive at this result. The immunoassay responds to a selected subset of the chemical components in petroleum fuels. This subset includes a large portion of the aromatic compounds (e.g., toluene, xylenes, naphthalenes) and a significant number of aliphatic compounds (e.g., hexane, isooctane). The balanced response to both aromatic and aliphatic compounds gives the PETRO RISc® Soil Test wide applicability to petroleum fuels at low detection levels.

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Table 1 shows the sensitivity of the PETRO RISc® Soil Test to a variety of commercial substances and chemical compounds. Minimum sensitivities to petroleum fuel products are approximately equal, varying between 10 and 15 ppm in soil. The minimum sensitivity to other commercial formulated petroleum products varies much more widely, roughly correlating with the volatility of the product. The last part of Table 1 shows the two classes of compounds present in petroleum fuels that are measured by the test: the aromatic compounds and the aliphatic compounds ranging from six to ten carbons.

Regulatory Status

The PETRO RISc® Soil Test conforms to EPA SW-846 Method 4030 for screening for petroleum hydrocarbons using immunoassay detection. The EnSys test actually was the basis for the draft method and it is currently the only test kit for which data have been submitted and favorably reviewed by the Office of Solid Waste Organic Methods Work Group.

Correlation with Laboratory Methods

The PETRO RISc® Soil test provides a high degree of accuracy when used to analyze soils contaminated with PHCs. Product validation studies indicate that the test correctly identifies PHC contaminated samples that are spiked with petroleum fuels at or near the chosen action level. The accuracy of the PETRO RISc® Soil test is comparable to that of the modified SW-846 Method 8015 (laboratory GC method) that is commonly used for the determination of petroleum fuel contamination in soil (Table 2).

The PETRO soil test has been used to test samples from a variety of sites contaminated with petroleum fuel products, such as gasoline and diesel fuel, and the results were compared to analytical data obtained using conventional laboratory analysis (Tables 3 through 6). Correlation of these results with the standard analytical methods for petroleum hydrocarbons was very good. The laboratory analytical data in Table 4 shows the difficulty in obtaining good correlation between even the most common standard methods. The volatility of the materials being analyzed makes it difficult to properly homogenize samples to split them for analysis by multiple methods. Effective homogenization results in loss of a substantial fraction of the volatile hydrocarbons.

Field Application

The test is similar in format and operation to other EnSys RISc® tests. The operational temperature range for use in the field with full performance as described above is 60°F to 100°F. Up to 12 tubes can be run in one batch, so that several samples can be tested concurrently. The shelf life of the PETRO RIS® Soil Test is currently 3 months, with longer shelf life expected when the real-time data are available.

The PETRO RIS® Soil Test is available in two configurations supporting the analysis of soil samples at one or two semi-quantitative test levels. The single level test requires the use of a simple hand-held autodilutor, which simplifies the sample extract dilution phase of the test procedure. The two level test retains the use of the hand-held pipettor in order to obtain the flexibility necessary for two detection level testing.

Rather than sending every sample to the laboratory for analysis, samples collected can be analyzed in the field to provide real-time information about PETRO levels to guide further sampling or excavation. The appropriate use of field testing can result in substantial savings in project cost due to more efficient use of project resources. All results from field analysis of soil samples using the PETRO test should be accompanied by supporting QA data. At the least, method and soil blanks should be tested daily. In addition, one duplicate sample should be tested for every twenty samples analyzed. Confirmation of a portion of the field results should also be obtained by modified Method 8015 or another method applicable in the specific state.

The PETRO test can be used to screen soil samples for the presence of petroleum fuels. Field test data have shown that the results from the PETRO Soil Test correlates well with standard total PHC methods. Therefore, the results from the field method can be interpreted as you would normally interpret a total petroleum hydrocarbons measurement with petroleum fuels. The PETRO Soil Test is configured to give less than 5% false negatives for samples containing petroleum fuels at or above the detection level used. The lack of false negatives gives the user confidence that all contaminated soil has been identified correctly. Because the PETRO test is sensitive to a range of fuel constituents that spans the volatile and semi-volatile component classification, the age of a fuel spill is relatively unimportant.

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Table 1
PETRO RISc® Soil Test Sensitivity

Compound or Substance	Concentration Necessary to Result in Positive Test (ppm)#
Petroleum Fuel Products	
gasoline	10
diesel fuel, #2	15
jet A fuel	15
jet fuel, JP-4	15
kerosene	15
fuel oil, #2	15
fuel oil, #6	25
Formulated Petroleum Products	
mineral spirits	40
machine oil	>1000
brake fluid	>1000
unused motor oil	>1000
used motor oil*	50
grease	>1000
mineral oil	>1000
Crude Oil*	
Ingram	60
Vermilion	130
Walker	100
Louisiana	100
Main Pass	100
Aromatic Compounds	
benzene	400
toluene	40
ethylbenzene	7
o-xylene	8.5
m-xylene	8
p-xylene	45
styrene	7
1,2-dichlorobenzene	2.5
hexachlorobenzene	10
naphthalene	0.8
acenaphthene	0.5
biphenyl	10
creosote	1.5

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Table 1
Continued

Compound or Substance	Concentration Necessary to Result in Positive Test (ppm)
Aliphatic Compounds	
2-methylpentane	35
hexanes, mixed	65
heptane	130
iso-octane	8.5
undecane	>1000
trichloroethylene	>1000
MTBE	>1000

Samples with stated concentration will give positive result greater than 95% of the time when tested at stated concentration level.

* Variable, depending on source; consult Technical Services for application guidance

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Table 2
PETRO RISc® Soil Test Spike Correlation

Fuel Type	Spike Level (ppm)	PETRO RISc® Test Results@ (ppm)	Evaluation	GC Result* (ppm)
none	-	<10 (12/12)	•	<1
gasoline	2	<10 (12/12)	•	2.6±0.6
gasoline	14	≥10 (12/12)	•	12.1±2.1
diesel	4.5	<15 (12/12)	•	4.0±0.8
diesel	22.5	≥15 (12/12)	•	19.8±0.8
fuel oil, #2	4.4	<15 (12/12)	•	3.8±0.6
fuel oil, #2	22	≥15 <75 (12/12)	•	19.7±0.8

@Immunoassay performed on 3 spiked samples, 4 replicate determinations each;
* Modified SW-846 Method 8015; mean of 3 spiked sample determinations ± standard deviation
• Immunoassay and spike agree

Table 3
PETRO RISc® Soil Test Customer Trial 1
Gasoline Contaminated Soil

Sample ID	IR Result* (ppm)	100 ppm Test		1000 ppm Test	
		Result	Evaluation	Result	Evaluation
AST-01	<20	< 100	•	< 1000	•
AST-02	520	≥ 100	•	≥ 1000	FP
AST-03	1700	≥ 100	•	≥ 1000	•
AST-04	130	≥ 100	•	< 1000	•
AST-05	20	≥ 100	FP	< 1000	•
AST-06	40	≥ 100	FP	< 1000	•
AST-07	400	≥ 100	•	< 1000	•
AST-08	640	≥ 100	•	< 1000	•
AST-09	1600	≥ 100	•	≥ 1000	•

• - Immunoassay and IR agree
FP - false positive
* Method 418.1

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Table 4
PETRO RIS℠ Soil Test Customer Trial 2
Diesel Contaminated Soil

Sample ID	GC extractibles* (ppm)	IR** (ppm)	75 ppm Test Result	75 ppm Test Evaluation GC	75 ppm Test Evaluation IR	750 ppm Test Result	750 ppm Test Evaluation GC	750 ppm Test Evaluation IR
1-B	5720	20800	≥ 75	•	•	≥ 750	•	•
2-A	610	14700	≥ 75	•	•	≥ 750	FP	•
2-B	370	6800	≥ 75	•	•	≥ 750	FP	•
2-C	2270	1950	≥ 75	•	•	≥ 750	•	•
3-B	4870	18600	≥ 75	•	•	≥ 750	•	•
3-C	760	1180	≥ 75	•	•	< 750	FN*	FN
4-A	66	4100	≥ 75	FP*	•	< 750	•	FN
4-B	303	2100	≥ 75	•	•	< 750	•	FN
5-A	20400	29600	≥ 75	•	•	≥ 750	•	•
5-B	26300	28600	≥ 75	•	•	≥ 750	•	•
5-C	267	330	≥ 75	•	•	≥ 750	FP	FP
6-B	550	22700	≥ 75	•	•	≥ 750	FP	•
8	59300	64400	≥ 75	•	•	≥ 750	•	•
9	26500	12900	≥ 75	•	•	≥ 750	•	•

• - Immunoassay and GC or IR results agree
FP - False positive
FN - False negative
FP* - False positive but within 25% of GC or IR results
FN* - False negative but within 25% of GC or IR results
* Modified SW-846 Method 8015
** Method 418.1

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Table 5
PETRO RIS® Soil Test Customer Trial 3
Diesel Contaminated Soil

Sample ID	GC Result* (ppm)	15 ppm Test Result	15 ppm Test Evaluation
N102504	40.0	≥ 15	•
N91701	83.0	≥ 15	•
N92401	17.0	≥ 15	•
N91801	73.0	≥ 15	•
N100103	16.0	≥ 15	•
N102301	<10	< 15	•
N100502	43.0	≥ 15	•
N91401	<10	< 15	•
NC03004	>200	≥ 15	•
N91501	<10	< 15	•
N102502	44.0	≥ 15	•
NC103003	>200	≥ 15	•
N100902	17.0	< 15	FN*
N100503	26.0	≥ 15	•
N102202	<10	< 15	•
N93001	61.0	≥ 15	•
N101301	<10	< 15	•
N90901	15.0	< 15	FN*
N110111	<10	< 15	•
N110108	<10	< 15	•
N110112	<10	< 15	•
N110110	<10	< 15	•

• - Immunoassay and GC results agree
FN* - False negative but within 25% of GC results
* Modified SW-846 Method 8015

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Table 6
PETRO RIS® Soil Test Customer Trial 4
Crude Oil Contaminated Soil

Sample ID	GC Result* (ppm)	100 ppm Test Result	100 ppm Test Evaluation
E92902	<40	< 100	•
E91901	61	≥ 100	FP
E92002	<40	≥ 100	FP
E100701	<40	< 100	•
E100501	239	≥ 100	•
E100602	<40	≥ 100	FP
E92001	105	≥ 100	•
E101001	<40	≥ 100	FP
E92201	320	< 100	FN
E92802	133	≥ 100	•
E93001	124	≥ 100	•
E100901	<40	< 100	•
E101002	186	≥ 100	•
E101401	<40	< 100	•
E101201	<40	≥ 100	FP
E100403	<40	< 100	•

• - Immunoassay and GC results agree
FP - False positive
FN - False negative
* Modified SW-846 Method 8100

APPENDIX C

APPLICABLE HNUS STANDARD OPERATING PROCEDURES

NUS CORPORATION ENVIRONMENTAL MANAGEMENT GROUP	STANDARD OPERATING PROCEDURES	Number GH-1.3	Page 1 of 13
		Effective Date 05/04/90	Revision 2
		Applicability EMG	
		Prepared Earth Sciences	
Subject SOIL AND ROCK SAMPLING		Approved D. Senovich	

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<u>SECTION</u>

1.0 PURPOSE

The purpose of this procedure is to 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

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

3.0 GLOSSARY

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

Thin-Walled Tube Sampler - A thin-walled metal tube (also called Shelby tube) used to recover relatively undisturbed soil samples. These tubes are available in various sizes, ranging from 2 to 5 inches O.D. and 18 to 54 inches long. A stationary piston device may be included in the sampler to reduce sampling disturbance and increase sample recovery.

Split-Barrel Sampler - A steel tube, split in half lengthwise, with the halves held together by threaded collars at either end of the tube. Also called a split-spoon sampler, this device can be driven into resistant materials using a drive weight mounted in the drilling string. A standard split spoon sampler (used for performing Standard Penetration Tests) is 2 inches outside diameter (OD) and 1-3/8 inches inside diameter (ID). This standard spoon typically is available in two common lengths, providing either 20-inch or 26-inch longitudinal clearance for obtaining 18-inch or 24-inch long samples, respectively. These split-spoon samplers range in size from 2-inch O.D. to 3-1/2-inch O.D., depending upon manufacturer. The larger sizes are commonly used when a larger volume of material is required.

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 alternate for conventional coring, this 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

Field Operations Leader - Responsible for overall management of field activities and ensuring that the appropriate sampling procedures are being implemented.

Site Geologist - The site geologist directly oversees the sampling procedures, classifies soil and rock samples, and directs the packaging and shipping of soil samples. Such duties may also be performed by geotechnical engineers, field technicians, or other qualified field personnel.

5.0 PROCEDURES

5.1 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 the 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.

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, DQOs, 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.

5.1.1 Equipment

The following equipment is used for subsurface soil sampling and test boring:

- Drilling equipment, provided by subcontractor.
- Split barrel (split spoon) samplers, OD 2 inches, ID 1-3/8 inches, either 20-inch or 26 inches long. Larger O.D. samplers are available if a larger volume of sample is needed. A common size is 3-inch O.D. (2-1/2-inch I.D.).
- Thin walled tubes (Shelby), O.D. 2 to 5 inches, 18 to 54 inches long.
- Drive weight assembly, 140-lb. (± 2 lb.) weight, driving head and guide permitting free fall of 30 inches (± 1 inch).
- Drive weight assembly, 300-lb. (± 2 lb.) weight, driving head and guide permitting free fall of 18 inches (± 1 inch).
- Accessory equipment, including labels, logbook, paraffin, and sample jars.

5.1.2 Split Barrel (Split Spoon) Sampling (ASTM D1586-84)

The following method will be used for split barrel sampling:

- Clean out the borehole to the desired sampling depth using equipment that will ensure that the material to be sampled is not disturbed by the operation. In saturated sands and silts, withdraw the drill bit slowly to prevent loosening of the soil around the hole and maintain the water level in the hole at or above groundwater level.

- Side-discharge bits are permissible. A bottom-discharge bit shall not be used. The process of jetting through an open tube sampler and then sampling when the desired depth is reached shall not be permitted. Where casing is used, it may not be driven below the sampling elevation.

- Install the split barrel sampler and sampling rods into the boring to the desired sampling depth. After seating the sampler by means of a single hammer blow, three 6-inch increments shall be marked on the sampling rod so that the progress of the sampler can be monitored.

- The 2-inch OD split barrel sampler shall be driven with blows from a 140-lb. (± 2 lb.) hammer falling 30 inches (± 1 inch) until either a total of 50 blows have been applied during any one of the three 6-inch increments, a total of 100 blows have been applied, there is no observed advance of the sampler for 10 successive hammer blows, or until the sampler has advanced 18 inches without reaching any of the blow count limitation constraints described herein. This process is referred to as the Standard Penetration Test.

- A 300-lb. weight falling 18 inches is sometimes used to drive a 2-1/2-inch or 3-inch O.D. spoon sampler. This procedure is used where dense materials are encountered or when a large volume of sample is required. However, this method does not conform the ASTM specifications.

- Repeat this operation at intervals not greater than 5 feet in homogeneous strata, or as specified in the sampling plan.

- Record the number of blows required to effect each 6 inches of penetration or fraction thereof. The first 6 inches is considered to be seating drive. The sum of the number of blows required for the second and third 6 inches of penetration is termed the penetration resistance, N. If the sampler is driven less than 18 inches, the penetration resistance is that for the last 1 foot penetrated.

- Bring the sampler to the surface and remove both ends and one half of the split barrel so that the soil recovered rests in the remaining half of the barrel. Describe carefully the sample interval, recovery (length), composition, structure, consistency, color, condition, etc., of the recovered soil then put a representative portion of each sample into a jar, without ramming. Jars with samples not taken for chemical analysis shall be sealed with wax, or hermetically sealed (using a teflon cap liner) to prevent evaporation of the soil moisture, if the sample is to be later evaluated for moisture content. Affix labels to the jar and complete Chain-of-Custody and other required sample data forms. Protect samples against extreme temperature changes and breakage by placing them in appropriate cartons stored in a protected area. Pertinent data which shall be noted on the label or written on the jar lid for each sample includes the project number, boring number, sample number, depth interval, blow counts, and date of sampling.

- An addition to the sampler mentioned above is an internal liner, which is split longitudinally and has a thin-wall brass, steel, or paper liner inserted inside, which will preserve the sample. However, since the development of the thin-walled samplers (mentioned below) the split barrel sampler with liner has declined in use.

5.1.3 Thin Walled Tube (Shelby Tube) Sampling (ASTM D1587-83)

When it is desired to take undisturbed samples of soil, thin-walled seamless tube samplers (Shelby tubes) will be used. The following method will be used:

- Clean out the borehole to the sampling depth, being careful to minimize the chance for disturbance of the material to be sampled. In saturated materials, withdraw the drill bit slowly to prevent loosening of the soil around the borehole and maintain the water level in the hole at or above groundwater level.

- The use of bottom discharge bits or jetting through an open-tube sampler to clean out the hole shall not be allowed. Any side discharge bits are permitted.

- A stationary piston-type sampler may be required to limit sample disturbance and aid in retaining the sample. Either the hydraulically operated or control rod activated-type of stationary piston sampler may be used. Prior to inserting the tube sampler in the hole, check to ensure that the sampler head contains a check valve. The check valve is necessary to keep water in the sampling rods from pushing the sample out of the tube sampler during sample withdrawal and to maintain a suction within the tube to help retain the sample.

- To minimize chemical reaction between the sample and the sampling tube, brass tubes may be required, especially if the tube is stored for an extended time prior to testing. While steel tubes coated with shellac are less expensive than brass, they are more reactive, and shall only be used when the sample will be tested within a few days after sampling or if chemical reaction is not anticipated. With the sampling tube resting on the bottom of the hole and the water level in the boring at the groundwater level or above, push the tube into the soil by a continuous and rapid motion, without impacting or twisting. In no case shall the tube be pushed farther than the length provided for the soil sample. Allow about 3 inches in the tube for cuttings and sludge.

- Upon removal of the sampler tube from the hole, measure the length of sample in the tube and also the length penetrated. Remove disturbed material in the upper end of the tube and measure the length of sample again. After removing at least an inch of soil from the lower end and after inserting an impervious disk, seal both ends of the tube with at least a 1/2-inch thickness of wax applied in a way that will prevent the wax from entering the sample. Newspaper or other types of filler must be placed in voids at either end of the sampler prior to sealing with wax. Place plastic caps on the ends of the sampler, tape in the caps place, and dip the ends in wax.

- Affix labels to the tubes as required and record sample number, depth, penetration, and recovery length on the label. Mark the same information and "up" direction on the tube with indelible ink, and mark the end of the sample. Complete Chain-of-Custody and other required forms. Do not allow tubes to freeze and store the samples vertically (with the same orientation they had 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 increased cost and the need for an undisturbed sample. In any case, if a sample cannot be obtained with a tube sampler, an attempt shall be made with a split barrel sampler at the same depth so that at least a sample can be obtained for classification purposes.

5.1.4 Continuous Core Soil Samples

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 samping 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.

5.2 SURFACE SOIL SAMPLES

For loosely packed earth or waste pile samples, stainless steel scoops or trowels can be used to collect representative samples. For densely packed soils or deeper soil samples, a hand or power soil auger may be used.

The following methods are to be used:

- Use a soil auger for deep samples (6 to 24 inches) or a scoop or trowel for surface samples. Remove debris, rocks, twigs, and vegetation before collection of soil. Mark the location with a numbered stake if possible and locate sample points on a sketch of the site.

- Use a new or freshly-decontaminated sampler for each sample taken. Attach a label and identification tag. Record all required information in the field logbook and on the sample log sheet, Chain-of-Custody record, and other required forms.

- Pack and ship accordingly.

- When a representative composited sample is to be prepared (e.g., samples taken from a gridded area or from several different depths), it is best to composite individual samples in the laboratory where they can be more precisely composited on a weight or volume basis. If this is not possible, the individual samples (all of equal volume, i.e., the sample bottles shall be full) shall be placed in a decontaminated stainless steel bucket, mixed thoroughly using a stainless steel spatula or trowel, and a composite sample collected.

5.3 WASTE PILE SAMPLES

The use of stainless steel scoops or trowels to obtain small discrete samples of homogeneous waste piles is usually sufficient for most conditions. Layered (nonhomogeneous) piles require the use of tube samplers to obtain cross-sectional samples.

- Collect small, equal portions of the waste from several points around the pile, penetrating it as far as practical. Use numbered stakes, if possible, to mark the sampling locations and locate sampling points on the site sketch.

- Place the waste sample in a glass container. Attach a label and identification tag. Record all the required information in the field logbook and on the sample log sheet and other required forms.

For layered, nonhomogeneous piles, grain samplers, sampling triers, or waste pile samplers must be used at several representative locations to acquire a cross-section of the pile. The basic steps to obtain each sample are

- Insert a sampler into the pile at a 0- to 45-degree angle from the horizontal to minimize spillage.

- Rotate the sampler once or twice to cut a core of waste material. Rotate the grain sampler inner tube to the open position and then shake the sampler a few times to allow the material to enter the open slits. Move the sampler into position with slots upward (grain sampler closed) and slowly withdraw from the pile.

5.4 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. It can, however, proceed for thousands of feet continuously, depending on the size of the drill rig. It 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. Downhole 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 Attachment No. 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.

ATTACHMENT 1

STANDARD SIZES OF CORE BARRELS AND CASING

Coring bit size	Nominal *		Set size *	
	O.D.	I.D.	O.D.	I.D.
RWT	$1\frac{5}{32}$	$\frac{3}{4}$	1.160	.735
EWT	$1\frac{1}{2}$	$\frac{29}{32}$	1.470	.905
EX, EXL, EWG, EWM	$1\frac{1}{2}$	$\frac{13}{16}$	1.470	.845
AWT	$1\frac{7}{8}$	$1\frac{9}{32}$	1.875	1.281
AX, AXL, AWG, AWM	$1\frac{7}{8}$	$1\frac{3}{16}$	1.875	1.185
BWT	$2\frac{3}{8}$	$1\frac{3}{4}$	2.345	1.750
BX, BXL, BWG, BWM	$2\frac{3}{8}$	$1\frac{5}{8}$	2.345	1.655
NWT	3	$2\frac{5}{16}$	2.965	2.313
NX, NXL, NWG, NWM	3	$2\frac{1}{8}$	2.965	2.155
HWT	$3\frac{29}{32}$	$3\frac{3}{16}$	3.889	3.187
HWG	$3\frac{29}{32}$	3	3.889	3.000
$2\frac{3}{4} \times 3\frac{7}{8}$	$3\frac{7}{8}$	$2\frac{3}{4}$	3.840	2.690
$4 \times 5\frac{1}{2}$	$5\frac{1}{2}$	4	5.435	3.970
$6 \times 7\frac{3}{4}$	$7\frac{3}{4}$	6	7.655	5.970
AX Wire line 1/	$1\frac{7}{8}$	1	1.875	1.000
BX Wire line 1/	$2\frac{3}{8}$	$1\frac{7}{16}$	2.345	1.437
NX Wire line 1/	3	$1\frac{15}{16}$	2.965	1.937

* All dimensions are in inches; to convert to millimeters, multiply by 25.4.

1/ Wire line dimensions and designations may vary according to manufacturer

ATTACHMENT 1
PAGE TWO

Size Designations			Casing coupling					Approximate core diameter	
Casing; Casing coupling; Casing bits; Core barrel bits	Rod; Rod couplings	Casing O.D., inches	O.D., inches	I.D., inches	Casing bit, O.D., inches	Core barrel bit O.D., inches*	Drill rod O.D., inches	Normal, inches	Thinwall, inches
RX	RW	1.437	1.437	1.188	1.485	1.160	1.094	—	735
EX	E	1.812	1.812	1.500	1.875	1.470	1.313	845	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	—	.735
EW	EW	1.812			1.875	1.470	1.375	.845	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/	—	—	—	—	1.875	1.750	1.000	—
—	BX 1/	—	—	—	—	2.345	2.250	1.437	—
—	NX 1/	—	—	—	—	2.965	2.813	1.937	—

* For hole diameter approximation, assume $\frac{1}{32}$ inch larger than core barrel bit.

1/ Wire line size designation, drill rod only, serves as both casing and drill rod. Wire line core bit, and core diameters vary slightly according to manufacturer

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

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).

5.4.1 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 spoon 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, it 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 equpment 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) for Sampling of Soils (see Section 5.1.1 and 5.1.2). 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 the conditions warrant.

- 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.

5.4.2 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 Procedure 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 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 Site 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 (see Attachment 2). 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.

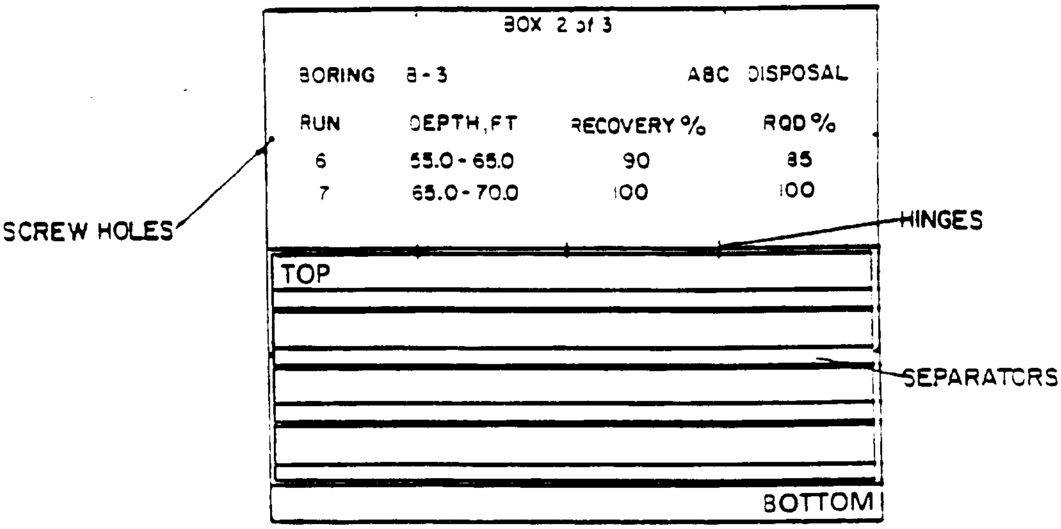
The inside and outside of the core-box lid shall be marked by indelible ink to show all pertinent data on the box's contents. At a minimum, the following information shall be included:

- 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).

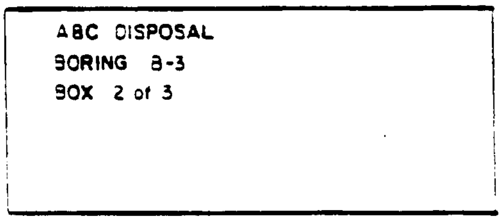
For easy retrieval when core boxes are stacked, the sides and ends of the box shall also be labeled and include project number, boring number, top and bottom depths of core and box number. Attachment No. 2 illustrates a typical rock core box.

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).

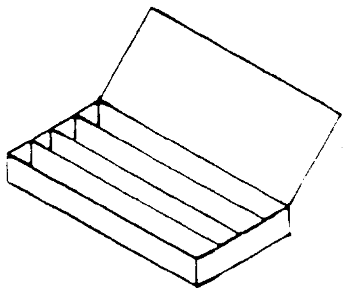
ATTACHMENT 2

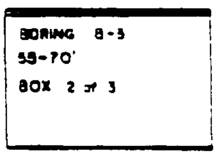


CORE BOX (OBLIQUE VIEW)



CORE BOX (TOP VIEW)





CORE BOX (END VIEW)

TYPICAL ROCK CORE BOX

NOT TO SCALE

NUS CORPORATION
A Halliburton Company

6.0 REFERENCES

American Society for Testing and Materials, 1985. Method for Penetration Test and Split Barrel Sampling of Soils. ASTM Method D 1586-84, Annual Book of Standards, ASTM, Philadelphia, Pennsylvania.

American Society for Testing and Materials, 1985. Thin-Walled Tube Sampling of Soils. Method D-1587-83, Annual Book of Standards, ASTM, Philadelphia, Pennsylvania.

Acker Drill Co., 1958. Basic Procedures of Soil Sampling. Acker Drill Co., Scranton, Pennsylvania.

American Society for Testing and Materials, 1989. Standrd Practice for Diamond Core Drilling for Site Investigation. ASTM Method D2113-83 (reapproved 1987), Annual Book of Standards, ASTM, Philadelphia, Pennsylvania.

U.S. Department of the Interior, 1974, Earth Manual, A Water Resources Technical Publication, 810 pages.

Central Mine Equipment Company, Drilling Equipment, St. Louis, Missouri.

7.0 RECORDS

None.

NUS CORPORATION ENVIRONMENTAL MANAGEMENT GROUP	STANDARD OPERATING PROCEDURES	Number: GH-1.4	Page: 1 of 20
		Effective Date: 05/04/90	Revision: 1
		Applicability: EMG	
		Prepared: Earth Sciences	
Subject: SOIL AND ROCK DRILLING METHODS		Approved: D. Senovich	

TABLE OF CONTENTS

SECTION

1.0 PURPOSE

The purpose of this procedure is to describe the methods, the sequence of operations and the equipment necessary to perform soil and rock borings.

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.

3.0 GLOSSARY

Boulders - Rounded, semi-rounded or naturally angular particles of rock larger than 12 inches in diameter.

Clay - Fine grained soil or portions of soil having certain physical properties, composition and texture. Clay exhibits plastic properties within a range of water contents and exhibits considerable strength when air dried. Clay consists usually of fragments of hydrous aluminum or magnesium silicate minerals, and it consists predominantly of grains with diameters of less than 0.005 mm.

Cobbles - Rounded, semi-rounded or naturally angular particles of rock between 3 inches and 12 inches in diameter.

Gravel - Rounded or semirounded particles of rock that will pass a 3 inch sieve (7.62 cm) and be retained on a No. 4 U.S. standard sieve (4.76 mm). Coarse gravel is larger than 3/4-inches, while fine gravel is finer than 3/4-inches.

Stone - Crushed or naturally angular particles of rock that will pass a 3 inch sieve (7.62 cm) and be retained on a No. 4 U.S. standard sieve (4.76 mm).

Rock - Any consolidated or coherent and relatively hard, naturally formed mass of mineral matter.

Sand - Particles of rock that will pass a No. 4 U.S. standard sieve (4.76 mm) and be retained on a No. 200 U.S. standard sieve (0.074 mm). Coarse sand is larger than a No. 10 sieve, and fine sand is finer than a No. 40 sieve (0.42 mm).

Silt - Material passing the No. 200 U.S. standard sieve (0.074 mm) that is nonplastic or very slightly plastic and that exhibits little or no strength when air dried.

Soil - Sediments or other unconsolidated accumulations of solid particles that are produced by the physical and chemical disintegration of rock and that may contain organic matter.

Undisturbed Sample - A soil sample that has been obtained by methods in which every precaution has been taken to minimize disturbance to the sample.

Water Table - A surface in an aquifer where groundwater pressure is equal to atmospheric pressure.

4.0 RESPONSIBILITIES

Site Manager - In consultation with the project geologist, 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. He should also determine 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.

Site Geologist/Rig Geologist - Responsible for insuring 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 Attachment A of Procedure GH-1.7). 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.

Field Operations Leader - Responsible for overall supervision and scheduling of drilling activities.

Drilling Subcontractor - 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 Field Operations Leader within 24 hours, and must provide advance written notification for any changes in field procedures describing and justifying such changes. No such changes shall be made unless requested and authorized in writing by the Field Operations Leader.

The drilling subcontractor will be responsible for following decontamination procedures specified in the Work Plan. Upon completion of the work, the Drilling Subcontractor will be 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, and
- To install monitoring wells or piezometers.

All drilling and sampling equipment will be cleaned using appropriate decontamination procedures (see Procedure GH-1.6 and SF-2.3) between samples and borings. 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 Procedure GH-1.5) unless the FSAP specifically states that logging is not required. 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, purpose of drilling, waste conditions at the site, 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 screwing 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 will require 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 four 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 object of the 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
- 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 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.

When taking soil samples for chemical analysis, the hollow-stem auger shall be plugged until the desired sampling depth is reached. Samples can be taken using split-spoon or thin wall tube samplers driven into the formation in advance of the auger (see Procedure GH-1.3). If the sample is to be taken at a relatively deep point, the auger may be advanced without a plug to within five feet of the sample depth. Then clean out the auger stem, insert a plug and continue to the sampling depth. The plug is then removed and samples taken as specified by the rig geologist. Samples should be taken according to the specifications of the sampling plan. 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. The sequence shall be repeated for each sample desired.

The hollow-stem auger may be used without the plug when boring for geotechnical examination or for well installation.

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 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 GH-1.7 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, 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 only penetrate the water table aquifer, since loose soil backfill in the boring would still provide a preferred pathway for surface liquids to reach the water table.

5.2.2 Continuous-Flight Solid-Stem Auger Drilling

This method is similar to hollow-stem augering. Practical application of this method is severely restricted as compared with hollow stem augers. Split barrel (split-spoon) sampling cannot be done without pulling the augers which may allow the hole to collapse. The 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 as in the case of the hollow stem auger, 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, the 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. 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 inje d to keep down dust).
- The borehole diameter is large, to allow room for pro 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 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 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 will require 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.
- Ground water 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.

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.

Soil samples shall be taken as specified by the Work Plan or more frequently if requested by the field 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 site geologist.

5.2.4 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.

5.2.5 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 Procedure 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 between which water is used in driving the casing should be 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 four inches larger in diameter than the well casing to be installed. Advantages to this method of drilling include:

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

Some of the disadvantages include:

- This method can only be used in unconsolidated formations.
- The method is slower than other methods (average drilling progress is 30 to 50 feet per day).
- Maximum depth of the borehole varies with the size of the drill rig and casing diameter used, and the nature of the formations drilled.
- The cost per hour or per foot of drilling may be substantially higher than other drilling methods.
- It is difficult and time consuming to pull back the casing if it has been driven very deep (deeper than 50 feet in many formations).

5.2.6 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 need 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 permeabilit…s and rough water quality data from different zones penetrated can be obtained by skill… operators.

- The cable-tool rig ca… …erate satisfactorily in all formations, but is best suited for caving, boulder, c… or coa… …avel type formations (e.g., glacial till) or formations with large cavities abo… …e wat… …le (such as limestones).

- When casing is used, 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 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, such as 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.

5.2.7 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 has been used to install 3- to 4-inch diameter casings to 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.

5.2.8 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 Work Plan. 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). This technique is slow but effective where larger pieces of equipment do not have access and where very shallow holes are desired (less than 5 feet). Surficial soils must be composed of relatively soft and non-cemented formations to allow penetration by the auger.

5.2.9 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 to 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 Work Plan. 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.

5.2.10 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 uses 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 includes:

  - Barrel float rigs - a drill rig mounted on a timber platform buoyed by empty 55-gallc 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.

5.2.11 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" or 7-7/8" bits will nominally drill 6" and 8" holes, respectively).

For obtaining split-barrel samples of a formation, samplers are manufactured in sizes ranging from 2-inches to 4-1/2 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 Work Plan.

5.2.12 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' to 50') 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)
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 5.2.9, except that larger casing is used) or a driven-casing method (see Section 5.2.5 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 insure 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 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 cleanout 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 on 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 to measure 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 for 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 FT-7.01. 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 are procedures for their use must be provided by the site geologist and approved by the site manager. The specific slurry composition and the concentration of selected chemicals 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 at the judgment of the site geologist and noted in the Site Logbook, and only after approval by the site 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.

6.0 REFERENCES

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

U.S. EPA, 1980. Procedure Manual for Ground Water Monitoring at Solid Waste Disposal Facilities. SW-611. Office of Solid Waste, U.S. EPA, Cincinnati, Ohio.

Scalf, M. R., J. F. McNabb, W. J. Dunlap, R. L. Crosby and J. Fryberger, 1981. Manual of Ground-Water Sampling Procedures. NWWA/EPA Series. Kerr Environmental Research Laboratory, Office of Research and Development, U.S. EPA, Ada, Oklahoma.

Procedure GH-1.5 - Borehole and Sample Logging.

American Society for Testing and Materials, 1987. ASTM Standards D1587-83, D1586-84, and D1452-80. ASTM Annual Book of Standards, ASTM, Philadelphia, Pennsylvania, Vol. 4.08.

Dept. of the Navy, Naval Facilities Engineering Command, 1982. Soil Mechanics Design Manual 7.1.

W. L. Acker III, 1974. Basic Procedures for Soil Sampling and Core Drilling. Acker Drill Co., Inc., Scranton, Pennsylvania.

American Institute of Steel Construction, 1978. Manual of Steel Construction, 7th Edition. American Institute of Steel Construction, New York, New York.

Driscoll, Fletcher G., 1986. Groundwater and Wells, 2nd Edition. Johnson Division, St. Paul, Minnesota.

7.0 ATTACHMENTS

Attachment A - Drilling Equipment Sizes

ATTACHMENT A

DRILLING EQUIPMENT SIZES

Drilling Component	Designation or Hole Size (in)	O.D. (in)	I.D. (in)	Coupling I.D. (in)
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 (in)
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

Drilling Component	Designation or Hole Size (in)	O.D. (in)	I.D (in)	Coupling I.D. (in)
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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		Prepared Earth Sciences	
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SECTION

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 onsite 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 HCl
- Ruler (marked in tenths and hundreths of feet)
- Hand Lens

5.2 CLASSIFICATION OF SOILS

All data shall be written directly on the boring log (Exhibit 4-1) 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 Exhibit 4-2. 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 and 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-1.2. 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, and SC (see Exhibit 4-2).

The consistency of cohesive soils is determined by performing field tests and identifying the consistency as shown in Exhibit 4-3. Cohesive soils are given the USCS classifications ML, MH, CL, CH, OL, or OH (see Exhibit 4-2).

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 as follows:

Consistency	Unc. Compressive Str. Tons/Square Foot	Standard Penetration Resistance (Blows per 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
Very stiff	1.0 to 2.0	8 to 15	Readily indented by thumb
Hard	2.0 to 4.0	15 to 30	Readily indented by thumbnail
Hard	More than 4.0	Over 30	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
and or 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 Exhibit 4-4.

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).

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, including sedimentary, igneous and metamorphic rocks. 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. ractures irregularly. Medium thick to thick bedded.

- Claystone - Vary 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. These include 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 names 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. Exhibit 4-5 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 handlens, the rock is a siltstone. If the grains are not distinguishable with a handlens, 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 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.

5.3.5 Fracturing

The degree of fracturing or brokeness 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 in. spacing between fractures
- Broken (BR.) - 2 in. to 1 ft. spacing between fractures
- Blocky (BL.) - 1 to 3 ft. spacing between fractures
- Massive (M.) - 3 to 10 ft. 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 (calcoreous, 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 inch or less), probably continuous layer.

- Some - Indicates significant (15 to 40 percent) amounts of the accessory material. For example, rock composed of seams of sandstone (70 percent) and shale (30 percent) would be "sandstone -- some shale seams."

- Few - Indicates insignificant (0 to 15 percent) amounts of the accessory material. For example, rock composed of seam of sandstone (90 percent) and shale (10 percent) would be "sandstone -- few shale seams."

- Interbedded - Used to indicate thin or very thin alternating seams of material occurring in approximately equal amounts. For example, rock composed of thin alternating seams of sandstone (50 percent) and shale (50 percent) would be "interbedded sandstone and shale."

- Interlayered - Used to indicate thick alternating seams of material occurring in approximately equal amounts.

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

- Basalt - A fine-grained extrusive rock composed primarily of calcic plagioclase and pyroxene.

- Rhyolite - A fine-grained volcanic rock containing abundant quartz and orthoclase. The fine-grained equivalent of a granite.

- Granite - A coarse-grained plutonic rock consisting essentially of alkali feldspar and quartz.

- Diorite - A coarse-grained plutonic rock consisting essentially of sodic plagioclase and hornblende.

- Gabbro - A coarse-grained plutonic rock consisting of calcic plagioclase and clinopyroxene. Loosely used for any coarse grained dark igneous rock.

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

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

5.4 ABBREVIATIONS

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

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

5.5 BORING LOGS AND DOCUMENTATION

This section describes in more detail the procedures to be used in completing boring logs in the field. Information obtained from the preceeding sections shall be used to complete the logs. A sample boring log has been provided as Exhibit 4-6. The field geologist/engineer shall use this example as a guide in completing each borings log. Each boring log shall be fully described by the geologist/engineer <u>as the boring is being drilled</u>. Every sheet contains space for 25 feet of log. Information regarding classification details is provided on the back of the boring log, for field use.

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 a 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 of 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 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 Angular, Subangular, Subrounded, 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 HNu or OVA reading if applicable.
  - Indicate any change in lithology by drawing in line through the lithology change column and indicate the depth. This will help later on when cross-sections are 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 Exhibit 4.6) in columns 5 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 brokeness 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 Exhibit 4-1.

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.

EXHIBIT 4-1

BORING LOG ***NUS CORPORATION***

PROJECT: .... BORING NO.: ....
PROJECT NO.: .... DATE: .... DRILLER: ....
ELEVATION: .... FIELD GEOLOGIST: ....
WATER LEVEL DATA: ....
(Date, Time & Conditions) ....

SAMPLE NO. & 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 / ROCK BROKENESS	REMARKS

REMARKS ____

BORING ________

PAGE ____ OF ____

EXHIBIT 4-2

SOIL TERMS

UNIFIED SOIL CLASSIFICATION (USCS)

COARSE GRAINED SOILS

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

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

FINE GRAINED SOILS

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

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

Boundary classifications: Soils possessing characteristics of two groups are designated by combining group symbols. For example GW-GC, well graded gravel-sand mixture with clay binder.
All sieve sizes on this chart are U.S. standard.

DENSITY OF GRANULAR SOILS

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

CONSISTENCY OF COHESIVE SOILS

CONSISTENCY	UNC. COMPRESSIVE STR. TONS/SQ. FT.	STANDARD PENETRATION RESISTANCE - BLOWS/FOOT	FIELD IDENTIFICATION METHODS
Very soft	Less than 0.25	0 to 2	Easily penetrated several inches by fist
Soft	0.25 to 0.50	2 to 4	Easily penetrated several inches by thumb
Medium stiff	0.50 to 1.0	4 to 8	Can be penetrated several inches by thumb
Stiff	1.0 to 2.0	8 to 15	Readily indented by thumb
Very stiff	2.0 to 4.0	15 to 30	Readily indented by thumbnail
Hard	More than 4.0	Over 30	Indented with difficulty by thumbnail

ROCK TERMS

ROCK HARDNESS (FROM CORE SAMPLES)

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

ROCK BROKENNESS

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

LEGEND

SOIL SAMPLES - TYPES

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

ROCK SAMPLES - TYPES

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

WATER LEVELS

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

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

EXHIBIT 4-3

CONSISTENCY FOR COHESIVE SOILS

Consistency	(Blows per Foot)	Unconfined Compressive Strength (tons/square 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 by thumbnail

EXHIBIT 4-4

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)

EXHIBIT 4-5

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

BORING LOG — **NUS CORPORATION**

PROJECT: HEBELKA SITE
BORING NO.: MW 3A
PROJECT NO.: 619Y
DATE: 9-21-87
DRILLER: B. GOLLIHUE
ELEVATION: 510.07
FIELD GEOLOGIST: SJ CONTI
WATER LEVEL DATA (Date, Time & Conditions): WL 26.35 - TPVC 10-16-87

SAMPLE NO & TYPE/ RQD	DEPTH FT / RUN NO.	BLOWS 6" OR RQD (%)	SAMPLE RECOVERY / SAMPLE LENGTH	LITHOLOGY CHANGE (Depth Ft) OR SCREEN INT	SOIL DENSITY CONSISTENCY OR ROCK HARDNESS	COLOR	MATERIAL CLASSIFICATION	USCS OR ROCK BROKENESS	REMARKS
S-1	0.0	3 / 6	1.5/1.5		STIFF	BRN	CLAYEY SILT - TR SHALE	ML	0-6" TOPSOIL MOIST 0PPM
	1.5	6					FRAG - TR ORG.		RESIDUAL SOIL.
	5.0								
S-2	6.0	11 / 100/.5	0.8/1.0	5.5 / 6.0	M.SOFT TO M.HARD	GRAY BRN	DEC SHALE AND SILT	VBR	DAMP 0PPM; REFUSAL @ 6'; 5.5 TOP OF DEC ROCK
									AUGERED TO 15' W/SOLID STEM AUG.
									CUTTING MOIST @ ≈8' WATER @ 11' ±
									WL @ 12:10 PM WAS ≈ 9' FROM GS.
									SET 4" PVC CAS. @ 15.0'
9-21 / 9-22	15.0				M.HARD	BRN GRAY	SILTY SHALE - FEW QUARTZ PCS	VBR	SEVERAL Fe STAINED JOINTS ON CORE 0 PPM
									THRUOUT RUN. JOINTS AND BREAKS ARE HORIZ TO LO ∠. W/ VUGS ON LOWER PORTION 23 TO 25 OF CORE
9.9/10.0	1	[illegible]	9.9/10.0						
	25.0								

REMARKS: ACKER AD II RIG - SOLID STEM AUGERS USED TO ADVANCE BORING - 140 LB WT @ 30" DROP - TO TAKE 2" ⌀ SP. SPOON SAMPLES - SET UP OVER HOLE @ 11:10 AM. WILL SAMPLE THIS HOLE - SET 4" CASING THEN DO SHALLOW WELL. STARTED TO CORE 9-22-87 USING THE WIRE-LINE CORING METHOD.

* See Legend on Back

BORING MW 3A
PAGE 1 OF 3

BORING LOG — **NUS CORPORATION**

PROJECT: HEBELKA SITE — BORING NO.: MW 3A
PROJECT NO.: 619Y — DATE: 9-22-87 — DRILLER: B. GOLLIHUE
ELEVATION: — FIELD GEOLOGIST: S.J. CONTI
WATER LEVEL DATA
(Date, Time & Conditions)

	SAMPLE NO & TYPE RQD	DEPTH (FT) RUN	BLOWS 6" OR RQD (%)	SAMPLE RECOVERY SAMPLE LENGTH	LITHOLOGY CHANGE (Depth ft)	SOIL DENSITY CONSISTENCY OR ROCK HARDNESS	COLOR	MATERIAL CLASSIFICATION	USCS	REMARKS
9-22		25.0				M.HARD	GRAY	SILTY SHALE	VBR	SHALE IS VBR W/ HORIZ TO LO ∠ JNTS
								(SILTSTONE)		≈26 TO 27 2- VERT
								- FEW QUARTZ		JOINTS. IRON STAINS ON JNTS
								SEAMS		ROCK BECOMES AND BREAKS MORE LIKE
										A SILTSTONE WITH DEPTH.
	0/10.0	②	0%	8.7/10.0						
									BR	≈32 TO 33 FEW QUARTZ PIECES W/
									VBR	VUGS. SL. MICACEOUS
										VF QUARTZ GRAINS IN MATRIX - 30X MAG.
		35.0								≈34 TO 35 - 2 VERT JOINTS
						M.HARD	GRAY	SILTY SHALE (SILTSTONE)	VBR	35.0-35.5 QUARTZ PIECES
								- FEW QUARTZ	BR	
								SEAMS	VBR	BECOMES SL. CALCAR. @ 37± THIN CALCITE
										LAMINATIONS. WATER STAINED JNTS
									BR	THRUOUT RUN MORE SO 35-37±
	1.0/10.0	③	10%	9.3/10.0					VBR	39.5 → 42.0
										42.7 → 43.0 HI ∠ JNT
									BR	42.4 → 42.7 VERT JNT
		45.0							VBR	
										45.3 → 45.5 VERT JNT. & VBR
										47.5 VERT JOINT
									BR	48. HI ∠ JOINT
										SLIGHTLY CALCAREOUS MORE CALCITE
										PRESENT

REMARKS ____________________

BORING MW 3A
PAGE 2 OF 3

* See Legend on Back

BORING LOG — **NUS CORPORATION**

PROJECT: HEBELKA SITE — BORING NO.: MW 3A
PROJECT NO.: 619Y — DATE: 9-22-87 — DRILLER: B. GOLLIHUE
ELEVATION: — FIELD GEOLOGIST: SJ. CONTI
WATER LEVEL DATA
(Date, Time & Conditions)

Sample No. & Type	Depth (ft)	Blows 6" or RQD (%)	Sample Recovery / Sample Length	Lithology Change (Depth ft)	Soil Density Consistency or Rock Hardness	Color	Material Classification	USCS	Remarks
1.9/10.0	(4)	19%	10.0/10.0		M.HARD	GRAY	SILTY SHALE (SILTSTONE)	VBR	50.5 → 51.0 VBR
							SL. CALCAREOUS	BR	51.5 → 54.0 BR w/ SEV LO & JOINTS
	55.0							VBR	POOR RECOVERY w/ SOFT ZONES.
0/10	(5)	0%	1.8/10.0						
	65.0			66					63.0 - DRILLER NOTED SOFT AREA - LOSS OF 1/3 OF WATER - CHANGE IN COLOR OF DRILL WATER TO YELLOW BROWN
0/0	(6)	0%	1.3/10.0						POOR RECOVERY
									FEW CALCAREOUS ZONES.
	75.0			76					

REMARKS AT 75' @ 1:45 PM - PULLING TOOLS - TO REAM HOLE.
AT 1:50 PM CORED HOLE TO 75' REAMED TWICE
DUE TO RUNNING SAND (FRACTURE) AT ≈ 68. REAMED
2ND TIME TO 81'. SET WELL 66-76'.

BORING MW 3A
PAGE 3 OF 3

* See Legend on Back

EXHIBIT 4-6

BORING LOG — *NUS CORPORATION*

PROJECT: WESTLINE SITE — BORING NO: MW 013
PROJECT NO.: 473Y — DATE: 7-7-87 — DRILLER: B ERICSON
ELEVATION: 1462.37 — FIELD GEOLOGIST: SJ CONTI — PENN - DRILL
WATER LEVEL DATA (Date, Time & Conditions): 5.54' @ 9:50 AM 7-23-87 T-PVC — ACKER AD-II

SAMPLE NO. & TYPE OR RQD	DEPTH (FT) OR RUN NO.	BLOWS 6" OR RQD (%)	SAMPLE RECOVERY SAMPLE LENGTH	LITHOLOGY CHANGE (DEPTH/FT) OR SCREEN INT	SOIL DENSITY CONSISTENCY OR ROCK HARDNESS	COLOR	MATERIAL CLASSIFICATION	USCS	REMARKS (HNU HEAD SP)
	0.0	5 / 3	1.4/1.5		LOOSE	BLK BRN	CLAYEY SILT AND CINDER	ML	MOIST (0PPM)
S-1		2					TR. COAL FRAG		3/4" Φ FRAGS - NEAR OLD RR. LINE.
							TR-CC FRAG		
							(FILL)		
	5.0					RED			
S-2		1 / 1	1.3/1.5	6.0	V. LOOSE	BRN TO GRAY	SANDY SILT - TR GRG TO	SM	MOIST → WET (0PPM)
	6.5	3					SILTY SAND - TR GRAVEL		GRAY SAND 2% ± MICACEOUS LOOSE MATRIX
									DRILLER NOTE H2O 8-10'
	10.0								
S-3		11 / 23	1.2/1.5		DENSE	BRN	SILTY SAND AND S.S.	GM	WET (0PPM)
	11.5	27					FRAGS (GRAY)		1" Φ SIZE MAX SIZE SUBANGULAR TO SUBROUNDED GRAVEL
	15.0								
S-4		7 / 47	1.0/1.5		V. DENSE	BRN	SILTY FINE TO C. SAND	GM	WET (0PPM)
	16.5	43					AND GRAVEL		1" Φ SIZE MAX SIZE SUBANGULAR TO SUBROUNDED GRAVEL
	20.0								
S-5	20.9	7 / 50/.4	.9/.9		V. DENSE	ORANG BRN	SILTY SAND - SOME	GM	WET (0PPM)
							GRAVEL AND		MOIST
							S.S FRAGS		BECOMES MORE LIKE SANDY SILT AT BOTM OF SAMPLE

REMARKS: START @ 1:15 PM 7-7-87 — USING 4¼" ID HOLLOW STEMS
S-4 @ 3:30 PM — TO ADVANCE THE BORING USING
S-5 @ 4:30 PM — ACKER DRILL - MOUNTED ON
FWL 3000 TRUCK
SAMPLES TAKEN
USING 140 lb WT AND 30 INCH DROP.

BORING MW 013
PAGE 1 OF 4

BORING LOG — **NUS CORPORATION**

PROJECT: WESTLINE SITE — BORING NO.: MW013
PROJECT NO.: 473Y — DATE: 7-7-87 — DRILLER: [illegible] ERICSON
ELEVATION: — FIELD GEOLOGIST: SJ CONTI
WATER LEVEL DATA
(Date, Time & Conditions)

Sample No. & Type or RQD	Depth (Ft.) or Run No.	Blows / 6" or RQD (%)	Sample Recovery / Sample Length	Lithology Change (Depth/Ft.) or Screen Int.	Soil Density / Consistency or Rock Hardness	Color	Material Classification	USCS	Remarks
S-6	25.0	6 / 17	1.1/1.5		DENSE	OLIVE BLUE	SILTY SAND - SOME	SM	WET 0PPM
	26.5	30				GRAY	GRAVEL - TR CLAY		[illegible] FIRST CHANGE IN
							TR. SS FRAG		COLOR. NOT ENOUGH CLAY TO BE CONFINING
									NOTE: MAY SET ZONE 2
	30.0					MOTTLED			CASING ≈ 28'
S-7		17 / 27	1.4/1.5		V.DENSE	BRN BLUE	SILTY SAND - SOME GRAVEL	SM/GM	MOIST [illegible] 0PPM
	31.5	36				GRAY	[illegible]		[illegible]
							TR CLAY		[illegible] SUBROUNDED [illegible]
									NOT [illegible] CLAY - BUT MAY BE SEMI-CONFINING.
	35.0								
S-8	35.3	30 / 50/.4	0.7/0.9		V.DENSE	BLUE GRAY	SILTY F. TO C. SAND -	SM/	MOIST → WET 0PPM
							SOME GRAVEL	GM	[illegible] LESS
							TR. SS FRAG		[illegible] FRAG - MORE
									[illegible] ABOVE
	40.0					BLUE			POSSIBLE 35 TO 45 SCREEN LOC. [illegible]
S-9		31 / 34	1.2/1.5		V.DENSE	BRN GRAY	SILTY SAND (FINE [illegible])	SM	[illegible] MOIST → WET 0PPM
	41.5	34					SOME GRAVEL TR	/GM	LITTLE MORE CLAY THAN
							CLAY		S-8 SUBROUNDED GRAVEL
									VERY SLOW DRILLING 40-45 (RIG STALLS)
	45.0					BLUE			LESS [illegible] OF SAMPLE
S-10		13 / 34	1.2/1.5		V.DENSE	BRN GRAY	SILTY SAND (FINE [illegible])	SM	MOIST → WET 0PPM
	46.5	50					SOME GRAVEL TR	/GM	[illegible]
							CLAY		[illegible]
									[illegible] 50'

REMARKS: S-6 @ 4:40 PM
S-8 @ 3:36 [illegible]
S-10 @ 10:40 [illegible]

BORING MW013

PAGE 2 OF 4

BORING LOG — **NUS CORPORATION**

PROJECT: NESTLINE SITE
BORING NO.: MW 013
PROJECT NO.: 473Y
DATE: 7-8-87
DRILLER: B. ERICSON
ELEVATION:
FIELD GEOLOGIST: S. CONTI
WATER LEVEL DATA
(Date, Time & Conditions)

					MATERIAL DESCRIPTION				
SAMPLE NO. & TYPE OR RQD	DEPTH (FT.) OR RUN NO.	BLOWS / 6" OR RQD (%)	SAMPLE RECOVERY / SAMPLE LENGTH	LITHOLOGY CHANGE (Depth/Ft.) OR SCREEN INT.	SOIL DENSITY / CONSISTENCY OR ROCK HARDNESS	COLOR	MATERIAL CLASSIFICATION	USCS	REMARKS
S-11	50.0	15 / 41	1.0/1.3		V. DENSE	MOTTLED BUFF	SILTY SAND - SOME GR.	GM	MOIST - (0PPM)
	51.3	50/.3				BRN GRAY	TR. CLAY	SM	MOTTLED W/ PCS OF BLACK COAL/LIGNITE
									MORE CLAY THAN ABOVE PORTIONS OF SAMPLE -
									COHESIVE CLASSIF.
	55.0			55.0					
S-12		11 / 15	1/1.5		V. STIFF TO STIFF	GRAY ORANG BRN	SANDY CLAY / CLAYEY SAND	SC	MOIST → WET (0PPM)
	56.5	26					SOME GRAVEL		NOTE COLOR CHANGE ALSO - MORE CLAY
									THAN ANY SAMPLE; SUB-ROUNDED GRAINS
									FIRST COHESIVE TYPE CLASSIF.
	60.0	40							
S-13	60.9	50/.4	0.7/0.9		V. DENSE	ORANG BRN	SANDY CLAY / CLAYEY SAND - SOME	SC	MOIST → WET (0PPM)
							GRAVEL	GW	NOT AS MUCH CLAY AS S-12 BUT VERY
									COHESIVE.
									SUBROUNDED GRAINS
									SET CAS. @ 62'
	65.0								
S-14	65.8	37 / 50/.3	0.7/0.8		V. DENSE	BRN ORANG	SILTY SAND - SOME GR	SM	MOIST (0PPM)
							AND ROCK FRAG-	GW	MORE CLAY TOWARDS TOP OF SAMPLE
				68.0			TR. CLAY		MAX ¾" D SIZE
						YELLOW BRN			COLOR CHANGE AT ~68' MORE SAND PER
	70.0								DRILLER - BOTH OF SEMI CONF LAYER ?
S-15		39 / 39	1.0/1.5		V. DENSE	YELLOW BRN	CLAYEY SAND (F TO C) SOME	SC	MOIST → WET (0PPM)
	71.5	41					GRAVEL - TR	GC	1" MAX GRAVEL
							ROCK FRAG.		MORE GRAVEL @ 72'
									PER DRILLER

Left margin: 7/13 (at S-14), 7/14 (at S-15)

REMARKS: [illegible] HOLLOW STEM [illegible] BORING [illegible] THRU AUGERS, WHEN NEEDED, TO OBTAIN SAMPLE
S-12 @ 1:46 pm
S-13 → 3:32 pm - LOGGED [illegible] 3:47 PM
SET 6" Ø STEEL CASING TO 62' - WILL DRILL BELOW CASING AFTER GROUT SETS UP. S-14 @ 3:30 PM 7-13-87
S-15 @ [illegible] AM 7-14-87

BORING MW 013
PAGE 3 OF 4

BORING LOG **NUS CORPORATION**

PROJECT: WESTLINE SITE BORING NO.: MW013
PROJECT NO.: 437Y DATE: 7-13-87 / 7-14-87 DRILLER: B. ERICSON
ELEVATION: FIELD GEOLOGIST: S.J. CONTI
WATER LEVEL DATA:
(Date, Time & Conditions)

SAMPLE NO. & TYPE OR RQD	DEPTH (Ft.) OR RUN NO.	BLOWS 6" OR RQD (%)	SAMPLE RECOVERY / SAMPLE LENGTH	LITHOLOGY CHANGE (Depth ft.) OR SCR. INT.	SOIL DENSITY CONSISTENCY OR ROCK HARDNESS	COLOR	MATERIAL CLASSIFICATION	USCS	REMARKS (HNU)
S-16	75.0	28 / 50/.5	0.9/1.0	75	V. DENSE	GRAY ORANG BRN	FINE TO C. CLAYEY SAND - SOME	GC	WET (0PPM)
	76.0						GRAVEL - TR		NOT AS MUCH CLAY AS S-15 - BOTM OF
							ROCK FRAG (S.S.)		SAMPLE BECOMES MORE SANDY
									MAX 1" Ø RC.
	80.0								NO SAMPLE @ 80' -
									DECIDED TO GO TO 85'
	85.0	50/	0.4/0.4		V. DENSE	GRAY ORANG	SILTY F. TO C. SAND - SOME	GW	WET (0PPM)
S-17	85.4	.4		85		BRN	GRAVEL - TR		SUBROUNDED GRAINS
							S.S. FRAG - TR		V. SL TR CLAY - WILL
							CLAY		SET SCREEN ≈ 75 TO 85' IN THIS
									BORING.
							BOTM OF HOLE @ 85.0'		

REMARKS: S-17 @ 2:20 PM 7-14-87 - [illegible] 6" CASING SPUN 4" Ø - 5 7/8" [illegible] TO BOTM. [illegible] WATER AS DRILLING FLUID

BORING MW 013

PAGE 4 OF 4

NUS CORPORATION ENVIRONMENTAL MANAGEMENT GROUP	STANDARD OPERATING PROCEDURES	Number GH-1.7	Page 1 of 17
		Effective Date 05/04/90	Revision 1
		Applicability EMG	
		Prepared Earth Sciences	
Subject GROUNDWATER MONITORING POINT INSTALLATION		Approved D. Senovich	

TABLE OF CONTENTS

1.0 PURPOSE

This procedure describes methods for proper monitoring well design, installation, and development.

2.0 SCOPE

This procedure is applicable to the construction of permanent monitoring wells at hazardous waste sites. 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 ascertained during the development of the investigation and any required permits which may have to 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), 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 to which water in an aquifer would rise by hydrostatic pressure.

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 to perform all phases of proper monitoring well installation and construction. He may also be responsible for obtaining, in advance, any required permits for monitoring well installation and construction.

Rig Geologist - The rig geologist supervises well installation and construction by the Driller, documents all phases of well installation and construction, and insures that well construction is adequate to provide representative ground water 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 while 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 engineers 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, these can be determined through the review of geologic data and the site terrain. In addition, 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 phase to determine groundwater flow direction.

5.2.1 <u>Well Depth, Diameter, and Monitored Interval</u>

The well depth, diameter, and monitored internal 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. Conversly, a fully penetrating well is usually not used to quantify or vertically locate a contamination 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 water bearing zone. The well diameter would depend 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 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, (ie., 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 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 Gal Water (feet)	Total Depth of Standing Water for 4 Gal. (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 in which 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 discussion on this topic). The two most commonly used materials are PVC and stainless steel for wells in which screens are installed and 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 to be used 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 for metal analyses, as zinc and cadmium levels in groundwater samples may be elevated from 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 contamination into the well and therefore should not be used if the well is to be sampled for organic contaminants.

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 Ottowa sand may be used with a 0.010-inch slot screen, however, with a 0.020-inch slot screen, the filter pack material must be the material retained on a No. 20 to No. 30 U.S. standard sieve.)

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 well graded, silica sand. 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 one to three feet of bentonite pellets or equivalent shall be placed above the sand pack. The cement-bentonite grout or equivalent extends 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 will be installed, and the natural formation material will be allowed to collapse around the well screen after the well is installed. This method has been utilized 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 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 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, i.e., a cement-bentonite grout. 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, 3-5 pounds of granular or flake-type bentonite and 6 gallons of water. A neat cement is made up 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'-2') 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 for 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

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 engineers rule to ensure proper well 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, then the sand pack can be installed. A weighted tape measure must be used during the procedure in order 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. A typical overburden monitoring well sheet is shown.

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. 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 which will be determined by the rig geologist, must be allowed for setting of the grout prior to drilling through the confined layer. A typical confining layer monitoring well sheet is shown in Attachment C.

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 is 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. Typical well construction forms for bedrock monitoring wells are shown in Attachment C.

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 from 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 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 other 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).

<u>Overpumping and Backwashing</u> - 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.

<u>Surging with a Surge Plunger</u> - 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 rpulls 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.

<u>Compressed Air</u> - Compressed air can be used to develop a well by either of two methods: backwashing or surging. Backwashing is done by forcing water out through the screens, using increasing air pressure inside a sealed well, then releasing the pressurized air to allow the water to flow back into the well. Care should be taken when using this method so that the water level does not drop below the top of the screen, thus reducing well yield. Surging, or the "open well" method, consists of alternately releasing large volumes of air suddenly into an open well below the water level

to produce a strong surge by virtue of the resistance of water head, friction, and inertia. Pumping the well is subsequently done with the air lift method.

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

Scalf, M. R., J. F. McNabb, W. J. Dunlap, R. L. Cosby, and J. Fryberger, 1981. Manual of Groundwater Sampling Procedures. R. S. Kerr Environmental Research Laboratory, Office of Research and Development, U.S. EPA, Ada, Oklahoma.

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

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

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

7.0 RECORDS

A critical part of monitoring well installation is recording of significant details and events in the 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 (Attachment C) shall be used which allows 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. The 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 determine the driller's final fee.

ATTACHMENT A

TABLE 7-4 RELATIVE COMPATIBILITY OF RIGID WELL-CASING MATERIAL (PERCENT)

	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
Miner Acid/High Solids	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)

	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	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
Source: Barcelona et al., 1983
* Trademark of DuPont

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 not critical.
Weight	Relatively heavier	Lightweight, 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 HC
Ease of Use	Difficult to adjust size or length in the field.	Easy to handle and work in the field.
Preparation for Use	Should be steam-cleaned for organics sampling	Never use glue fittings--pipes should be threaded or pressure-fitted. Should be steam cleaned if 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.

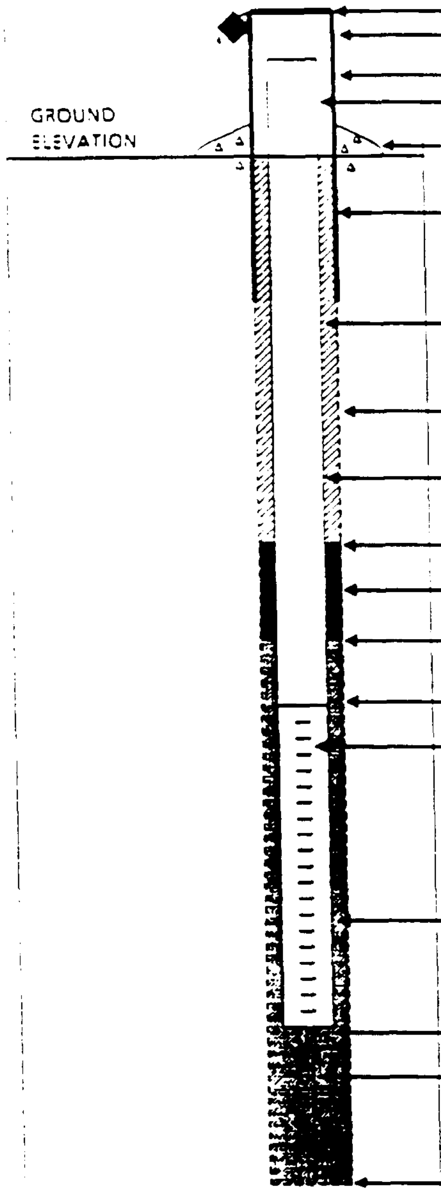
ATTACHMENT C

NUS CORPORATION
A Halliburton Company

BORING NO. ____________

OVERBURDEN
MONITORING WELL SHEET

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



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

ATTACHMENT C
PAGE TWO

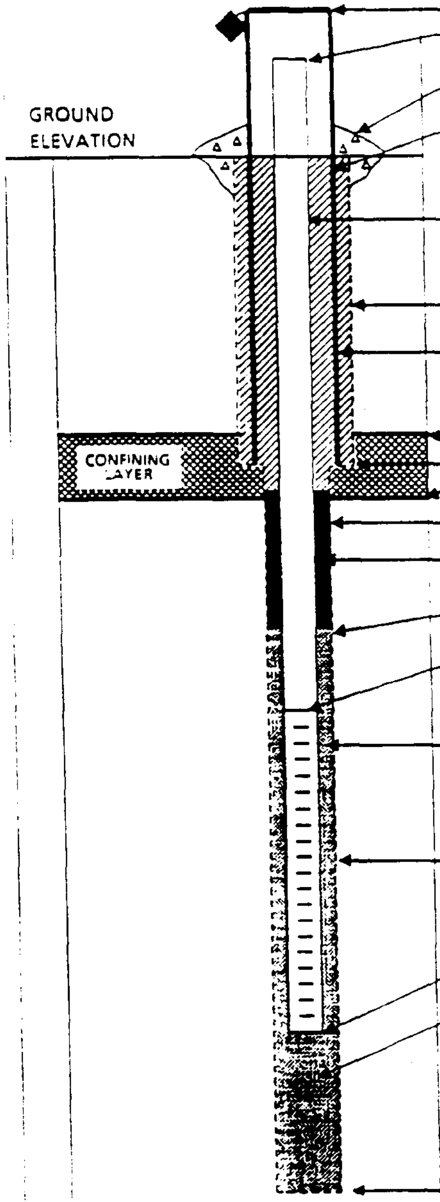
NUS CORPORATION

BORING NO.: ________

CONFINING LAYER
MONITORING WELL SHEET

11-5-87

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



ELEVATION OF TOP OF PERM. CASING: ________
ELEVATION OF TOP OF RISER PIPE: ________
TYPE OF SURFACE SEAL: ________
I.D. OF PERM. CASING: ________
TYPE OF SURFACE CASING: ________
RISER PIPE I.D. ________
TYPE OF RISER PIPE: ________
BOREHOLE DIAMETER: ________
PERM. CASING I.D. ________
TYPE OF CASING & BACKFILL: ________
ELEVATION / DEPTH TOP CONFINING LAYER: ________
ELEVATION / DEPTH BOTTOM OF CASING: ________
ELEVATION / DEPTH BOT. CONFINING LAYER: ________
ELEVATION / DEPTH TOP OF SEAL: ________
TYPE OF SEAL: ________
DEPTH TOP OF SAND PACK: ________
ELEVATION/DEPTH TOP OF SCREEN: ________
TYPE OF SCREEN: ________
TYPE OF SAND PACK: ________
BOREHOLE DIA. BELOW CASING: ________
ELEVATION / DEPTH BOTTOM OF SCREEN: ________
ELEVATION / DEPTH BOTTOM OF SAND PACK: ________
TYPE OF BACKFILL BELOW OBSERVATION WELL: ________
ELEVATION / DEPTH OF HOLE: ________

ATTACHMENT C
PAGE THREE

NUS CORPORATION
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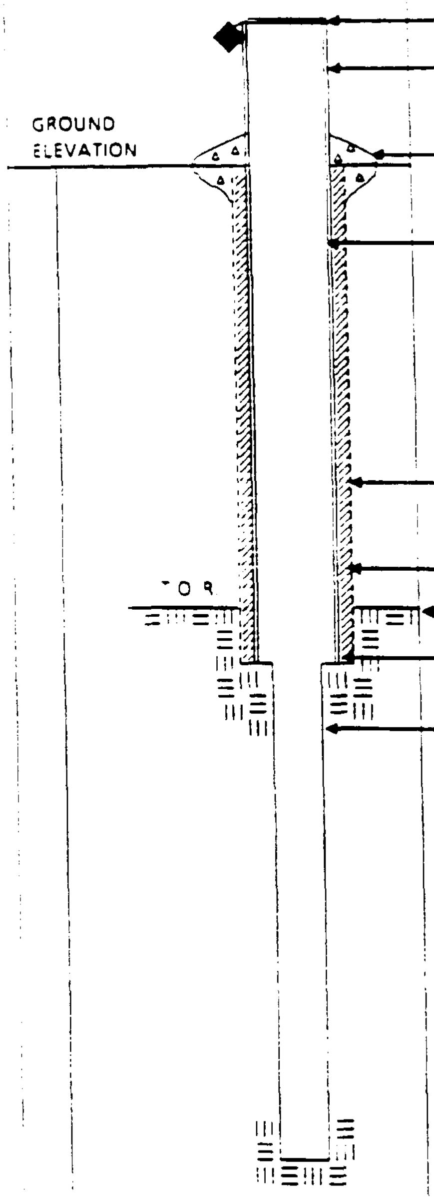
BORING NO.: ____________

BEDROCK MONITORING WELL SHEET
OPEN HOLE WELL

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



ELEVATION OF TOP OF CASING: ____________

STICK UP OF CASING ABOVE GROUND SURFACE: ____________

TYPE OF SURFACE SEAL: ____________

I.D. OF CASING: ____________
TYPE OF CASING: ____________

TEMP. / PERM.: ____________

DIAMETER OF HOLE: ____________

TYPE OF CASING SEAL: ____________

DEPTH TO TOP OF ROCK: ____________

DEPTH TO BOTTOM CASING: ____________

DIAMETER OF HOLE IN BEDROCK: ____________

DESCRIBE IF CORE / REAMED WITH BIT:
____
____
____

DESCRIBE JOINTS IN BEDROCK AND DEPTH:
____
____
____

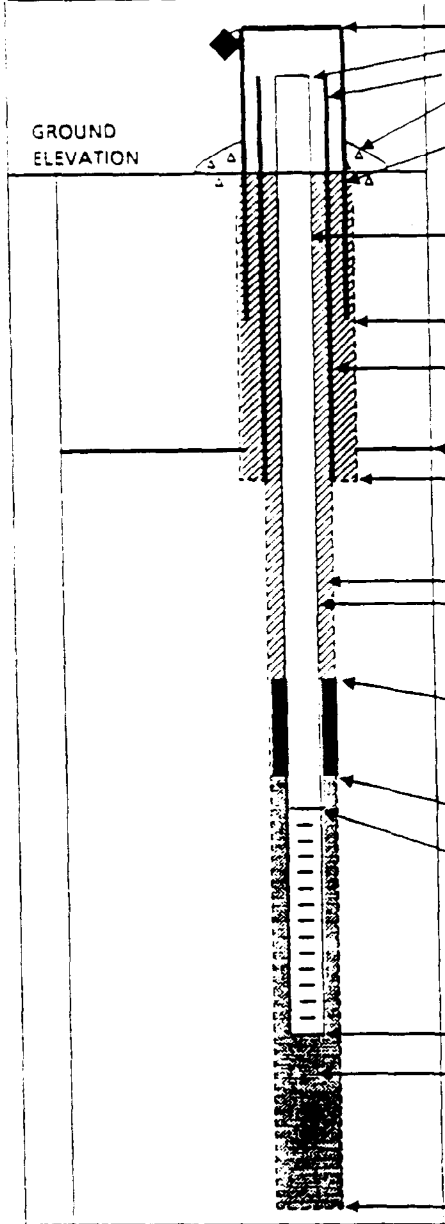
ELEVATION / DEPTH OF HOLE: ____________

ATTACHMENT C
PAGE FOUR

BORING NO.: ____________

BEDROCK
MONITORING WELL SHEET
WELL INSTALLED IN BEDROCK

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



ELEVATION OF TOP OF SURFACE CASING: ____________
ELEVATION OF TOP OF RISER PIPE: ____________
ELEVATION TOP OF PERM. CASING: ____________
TYPE OF SURFACE SEAL: ____________
____
I.D. OF SURFACE CASING: ____________
TYPE OF SURFACE CASING: ____________
____
RISER PIPE I.D. ____________
TYPE OF RISER PIPE: ____________
____
BOREHOLE DIAMETER: ____________
PERM. CASING I.D. ____________
TYPE OF CASING & BACKFILL: ____________
____
ELEVATION / DEPTH TO BEDROCK: ____________
ELEVATION/DEPTH BOTTOM OF CASING: ____________
BOREHOLE DIA. BELOW CASING: ____________
TYPE OF BACKFILL: ____________
____
ELEVATION / DEPTH TOP OF SEAL: ____________
TYPE OF SEAL: ____________
____
ELEVATION / DEPTH TOP OF SAND PACK: ____________
ELEVATION/DEPTH TOP OF SCREEN: ____________
TYPE OF SCREEN: ____________
____
TYPE OF SAND PACK: ____________
____
ELEVATION / DEPTH BOTTOM OF SCREEN: ____________
ELEVATION / DEPTH BOTTOM OF SAND PACK: ____________
TYPE OF BACKFILL BELOW OBSERVATION WELL: ____________
____
ELEVATION / DEPTH OF HOLE: ____________

ATTACHMENT C
PAGE FIVE

NUS CORPORATION
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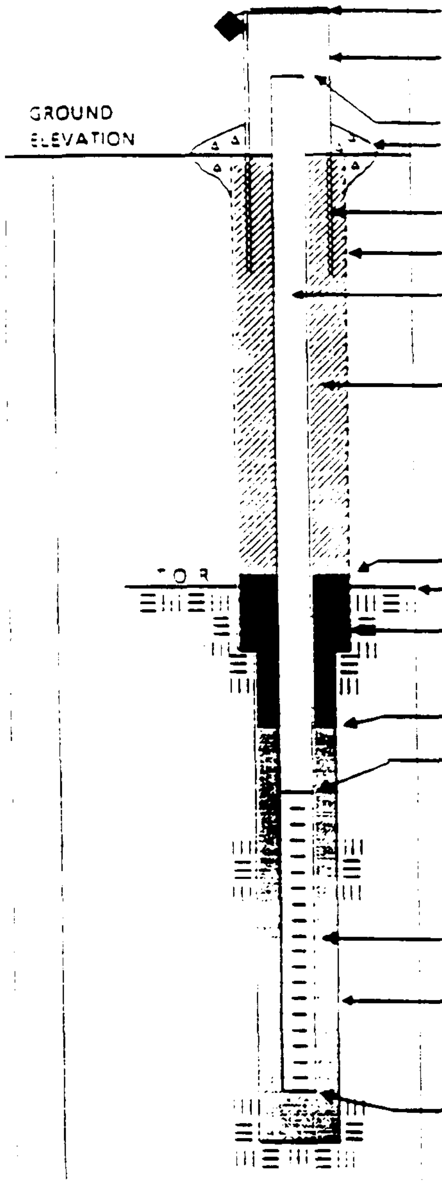
BORING NO. ________

BEDROCK
MONITORING WELL SHEET
WELL INSTALLED IN BEDROCK

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



ELEVATION OF TOP OF SURFACE CASING ________

STICK UP OF CASING ABOVE GROUND SURFACE. ________

ELEVATION TOP OF RISER ________

TYPE OF SURFACE SEAL. ________

I.D. OF SURFACE CASING: ________

DIAMETER OF HOLE: ________

RISER PIPE I.D. ________

TYPE OF RISER PIPE: ________

TYPE OF BACKFILL. ________

ELEVATION / DEPTH TOP OF SEAL. ________

ELEVATION / DEPTH TOP OF BEDROCK ________

TYPE OF SEAL. ________

ELEVATION / DEPTH TOP OF SAND: ________

ELEVATION / DEPTH TOP OF SCREEN: ________

TYPE OF SCREEN: ________

SLOT SIZE x LENGTH: ________

I.D. SCREEN: ________

TYPE OF SAND PACK. ________

DIAMETER OF HOLE IN BEDROCK: ________

CORE / REAM: ________

ELEVATION / DEPTH BOTTOM SCREEN: ________

ELEVATION / DEPTH BOTTOM OF HOLE. ________

NUS CORPORATION ENVIRONMENTAL MANAGEMENT GROUP	STANDARD OPERATING PROCEDURES	Number GH-2.5	Page 1 of 10
		Effective Date 05/04/90	Revision 1
		Applicability EMG	
		Prepared Earth Sciences	
Subject WATER LEVEL MEASUREMENT/CONTOUR MAPPING		Approved D. Senovich	

TABLE OF CONTENTS

1.0 PURPOSE

The objective of this procedure is to provide general reference information and technical guidance on the measurement of hydraulic head levels and the determination of the direction of groundwater flow, using contour maps of the water table or the potentiometric surface of an unconfined or confined aquifer.

2.0 SCOPE

This procedure gives overall technical guidance for obtaining hydraulic head measurements in wells (frequently conducted in conjunction with groundwater sampling) and preparation of groundwater contour maps. The specific methods could be modified by requirements of project-specific plans.

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).

Potentiometric Surface - A surface which is defined by the levels to which water will rise in wells which are screened or open in a specified zone of an unconfined or confined aquifer.

Unconfined (water table) Aquifer - An aquifer in which the water table forms the upper boundary.

Confined Aquifer - An aquifer confined between two low permeability layers (aquitards).

Artesian Conditions - A common condition in a confined aquifer in which the water level in a well completed within the aquifer rises above the top of the aquifer.

Flow Net - A diagram of groundwater flow, showing flow lines and equipotential lines.

Flow Line - A line indicating the direction of groundwater movement within the saturated zone. Flow lines are drawn perpendicular to equipotential lines.

Equipotential Line - A contour line on the potentiometric surface or water table showing uniform hydraulic head levels. Equipotential lines on the water table are also called water-table contour lines.

4.0 RESPONSIBILITIES

Project Hydrogeologist - has overall responsibility for obtaining water level measurements and developing groundwater contour maps. The hydrogeologist 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

5.1 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 geologist'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 bariometric 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 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.

5.2 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 onsite hydrogeologist.

In most instances, preparation of accurate potentiometric surface requires that static water level measurements be obtained to a precision of 0.01 feet. To obtain such measurements in individual accessible wells, the 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.

5.2.1 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's field notebook or on the Groundwater Level Measurement Sheet.

   a. Well number.
   b. Record 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.
   c. Record the 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 (see Section 5.2.3).

5.2.2 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 band is not a permanent marking band, spacing shall be checked periodically as described in Section 5.2.3.

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 samples. 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.

Borehole 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.

Bailer Line Method

Water levels can be measured during a bailing test of a well by marking and measuring the bailer line from the bottom of the bailer (where water is first encountered) to the point even with the top of the well casing. This is a useful technique during bailing tests (particularly if recovery is rapid) if the bailer is heard hitting the water. However, it is not recommended for measuring static water levels because it is not usually as accurate as some of the other methods described above.

5.2.3 Data Recording

Water level measurements, time, data, and weather conditions shall be recorded in the geologist'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.

5.2.4 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.

Some devices used to measure groundwater levels may need to be calibrated. These devices shall be calibrated to 0.01 foot accuracy periodically. A water level indicator calibration sheet shall be completed each time the measuring device is checked. A water level indicator calibration form is shown in Attachment A. The "actual reading" column on the sheet is the actual length of the interval from the end of the indicator to the appropriate marked depth interval. In many cases, these measurements are different because the water level measuring device is connected to the end of the measuring tape or line, and may extend beyond "0" feet on the measuring line.

5.3 POTENTIOMETRIC SURFACE MAPPING

5.3.1 Selection of Wells

All wells used to prepare a flow net in a plan or map view should represent the same hydrogeologic unit, be it aquifer or aquitard. All water level measurements used shall be collected on the same day.

Before mapping, review the recorded water levels and monitoring-well construction data, site geology and topographic setting to ascertain that the wells are completed in the same hydrogeologic unit and to determine if strong vertical hydraulic gradients may be present. Such conditions will be manifested by a pronounced correlation between well depth and water level, or by a difference in water level between two wells located near each other but set to different depths or having different screen lengths. Professional judgment of the hydrogeologist is important in this decision. If vertical gradients are significant, the data to be used must be limited vertically, and only wells finished in a chosen vertical zone of the hydrogeologic unit can be used.

At least three wells must be used to provide an estimation of the direction of groundwater flow, and many more wells will be needed to provide an accurate contour map. Generally, shallow systems require more wells than deep systems for accurate contour mapping.

5.3.2 Construction of Equipotential Lines

Plot the water elevations in the chosen wells on a site map. Other hydrogeologic features associated with the zone of interest -- such as seeps, wetlands, and surface-water bodies -- should also be plotted along with their elevations.

The data should then be contoured, using mathematically valid and generally accepted techniques. Linear interpolation is most commonly used, as it is the simplest technique. However, quadratic interpolation or any technique of trend-surface analysis or data smoothing is acceptable. Computer-generated contour maps may be useful for large data sets. Contour lines shall be drawn as smooth, continuous lines which never cross one another.

Inspect the contour map, noting known features, such as pumping wells and site topography. The contour lines must be adjusted in accordance with these, utilizing the professional judgment of the hydrogeologist. Closed contours should be avoided unless a known sink exists. Groundwater mounding is common under landfills and lagoons; if the data imply this, the feature must show in the contour plot.

5.3.3 Determination of Groundwater-Flow Direction

Flow lines shall be drawn so that they are perpendicular to equipotential lines. Flow lines will begin at high head elevations and end at low head elevations. Closed highs will be the source of additional flow lines. Closed depressions will be the termination of some flow lines. Care must be used in areas with significant vertical gradients to avoid erroneous conclusions concerning gradients and flow directions.

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 (HNU) or FID (OVA) and combustible gas meters shall be performed to determine required levels of protection.

6.0 REFERENCES

Freeze, R. A. and J. A. Cherry, 1979. Groundwater. Prentice-Hall, Englewood Cliffs, New Jersey, 604 pp.

Cedergren, H. R., 1977. Seepage, Drainage and Flow Nets (2nd edition). John Wiley and Sons, New York.

Fetter, C. W., 1980. Applied Hydrogeology. Me , Columbus, Ohio, 488 pp.

7.0 ATTACHMENTS

Attachment A - Groundwater Level Measurem heet

Attachment B - Water Level Indicator Calibration Sheet.

ATTACHMENT A

GROUNDWATER LEVEL MEASUREMENT SHEET

LOCATION

Project Name: ____________________
Project No.: ____________________
Personnel: ____________________
Date: ____________________

Municipality: ____________________
County: ____________________
State: ____________________
Street or Map Location (If Off-Site) ____________________

WEATHER CONDITIONS

Temperature Range: ____________________
Precipitation: ____________________
Barometric Pressure: ____________________

Equipment No.: ____________________
Equipment Name: ____________________
Latest Calibration Date: ____________________

Tidally-Influenced: [ ] Yes [ ] No

Well or Piezometer Number	Date/Time	Elevation of Reference Point (Feet)*	Water Level Indicator Reading (Feet)*	Adjusted Depth (Feet)*	Groundwater Elevation (Feet)*

* All elevations to nearest 0.01 foot.

ATTACHMENT B

WATER LEVEL INDICATOR CALIBRATION SHEET

Project Name __________________ Date __________________

Project No. __________________

Equipment No. __________________

Equipment Name __________________

Water Level Indicator Marking (Feet)	Actual Reading* (Feet)
0.0	
5.0	
10.0	
15.0	
20.0	
25.0	
30.0	
35.0	
40.0	
45.0	
50.0	
55.0	
60.0	
65.0	
70.0	
75.0	
80.0	
85.0	
90.0	
95.0	
100.0	

* Record readings to the nearest 0.01 foot. The actual reading may be different than marking because the water level measuring device (electrode, popper, etc.) may extend beyond the "0" feet mark on the measuring line.

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		Prepared Earth Sciences	
Subject GROUNDWATER SAMPLE ACQUISITION		Approved D. Senovich	

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1.0 PURPOSE

The purpose of this procedure is to provide general reference information on the sampling of groundwater wells. The methods and equipment described are for the collection of water samples from the saturated zone of the subsurface.

2.0 SCOPE

This procedure provides information on proper sampling equipment 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 adjustments in methodology.

3.0 GLOSSARY

None.

4.0 RESPONSIBILITIES

Site Hydrogeologist or Geochemist - responsible for selecting and detailing the specific groundwater sampling techniques and equipment to be used, documenting these in the Project Operations Plan (POP), and properly briefing the site sampling personnel.

Site Geologist - The Site Geologist is primarily responsible for the proper acquisition of the groundwater samples. When appropriate, such responsibilities may be performed by other qualified personnel (engineers, field technicians).

Site Manager - The Site Manager is responsible for reviewing the sampling procedures used by the field crew and for performing in-field spot checks for proper sampling procedures.

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 testing 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 for a representative sample. In a high-yielding groundwater formation and where there is no stagnant water in the well above the screened section, evacuation prior to sample withdrawal is not as critical.

2. For wells that can be purged to dryness with the sampling equipment being used, 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 preferred.

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, 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 decreases. 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 may be used to collect the sample for chemical analysis.

- The inlet 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 rate equal to the well's recovery rate.

Stratification of contaminants may exist in the aquifer formation, both in terms of a concentration gradients due to mixing and dispersion processes in a homogeneous layer, and in layers of variable permeability into which a greater or lesser amount of the contaminant plume has flowed. Excessive pumping can dilute or increase the contaminant concentrations in the recovered sample compared to what is representative of the integrated water column at that point, and thus result in the collection of a non-representative sample.

5.2 SAMPLING, MONITORING, AND EVACUATION EQUIPMENT

Sample containers shall conform with EPA regulations for the appropriate contaminants.

The following equipment shall be on hand when sampling ground water wells:

- Sample packaging and shipping equipment - Coolers for sample shipping and cooling, chemical preservatives, appropriate packing containers and filler, ice, labels and chain-of-custody documents.

- Field tools and instrumentation - Thermometer; pH paper/meter; camera and film; tags; appropriate keys (for locked wells); engineers rule; water-level indicator; where applicable, specific-conductivity meter.

- 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 monofilament line with tripod-pulley assembly (if necessary). Bailers shall be used to obtain samples for volatile organics from shallow and deep groundwater wells.

- Pails - Plastic, graduated.

- Decontamination solutions - Distilled water, Alconox, methanol, acetone.

Ideally, sample withdrawal equipment shall be completely inert, economical, easily cleaned, sterilized, and reused, 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 field logbook and on the field data form (Attachment A):

- 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 (if not known from past records) 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 ($V = 0.163Tr^2$).

  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.

- Determine the minimum amount to be evacuated before sampling.

5.4 EVACUATION OF STATIC WATER (PURGING)

5.4.1 General

The amount of flushing 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, and pH have stabilized. Onsite measurements of these parameters shall be recorded on the field data form.

For defining a contaminant plume, a representative sample of only a small volume of the aquifer is required. These circumstances require that the well be pumped enough to remove the stagnant water but not enough to induce significant groundwater flow from other areas. Generally three to five well volumes are considered effective for purging a well.

The site hydrogeologist, geochemist and risk assessment personnel shall define the objectives of the groundwater sampling program in the Work Plan, and provide appropriate criteria and guidance to the sampling personnel on the proper methods and volumes of well purging.

5.4.2 Evacuation Devices

The following discussion is limited to those devices commonly used at hazardous waste sites. Attachment B 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.

5.4.2.1 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.

5.4.2.2 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 (therefore not suitable for well purging) 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. In addition, the complex internal components of these pumps may be difficult to decontaminate.

5.4.2.3 Gas-Lift Samplers

This group of 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. 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.

5.4.2.4 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 is difficult and time-consuming.

5.5 SAMPLING

5.5.1 Sampling Plan

The sampling approach consisting of the following, shall be developed as part of the POP prior to the field work:

- 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.
- Working 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.

5.5.2 Sampling Methods

The collection of a groundwater sample is made up of the following steps:

1. HSO or designee will first open the well cap and use volatile organic detection equipment (HNU or OVA) 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 in a well sampling data sheet (Attachment A); then calculate the fluid volume in the well pipe.
3. Calculate well volume to be removed as stated in Section 5.3.
4. Select appropriate purging equipment (see Attachment B). If an electric submersible pump with packer is chosen, go to Step 10.
5. Lower 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. Lower the purging device, as required, to maintain submergence.
6. Measure rate of discharge frequently. A bucket and stopwatch are most commonly used; other techniques include using pipe trajectory methods, weir boxes or flow meters.
7. Observe 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.
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 sampling level before filling (this requires use of other than a 'bucket-type' bailer)

Purged water shall be collected in a designated container and disposed of in an acceptable manner.

10. (For pump and packer assembly only). Lower assembly into well so that packer is positioned just above the screen or open section and inflate. 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), sample collection can be delayed until the following day. If the well has been bailed 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 in the logbook.

12. Add preservative if required. Label, tag, and number the sample bottle(s).

13. Replace the well cap. Make sure the well is readily identifiable as the source of the samples.

14. Pack the samples for shipping. Attach a custody seal to the front and back of the shipping package. Make sure that traffic reports and chain-of-custody forms are properly filled out and enclosed or attached.

15. Decontaminate all equipment

5.5.3 Sample Containers

For most samples and analytical parameters, either glass or plastic containers are satisfactory.

5.5.4 Preservation of Samples and Sample Volume Requirements

Sample preservation techniques and volume requirements depend on the type and concentration of the contaminant and on the type of analysis to be performed. Procedure SF-1.2 describes the sample preservation and volume requirements for most of the chemicals that will be encountered during hazardous waste site investigations. Procedure SA-4.3 describes the preservation requirement for microbial samples.

5.5.5 Handling and Transporting Samples

After collection, samples shall be handled as little as possible. It is preferable to use self-contained "chemical" ice (e.g., "blue ice") to reduce the risk of contamination. If water ice is used, it shall be bagged and steps taken to ensure that the melted ice does not cause sample containers to be submerged and thus possibly become cross-contaminated. All sample containers shall be enclosed in plastic bags or cans to prevent cross-contamination. Samples shall be secured in the ice chest to prevent movement of sample containers and possible breakage. Sample packing and transportation requirements are described in SA-6.2.

5.5.6 Sample Holding Times

Holding times (i.e. allowed time between sample collection and analysis) for routine samples are given in Procedure SF-1.2.

5.6 RECORDS

Records will be maintained for each sample that is taken. The sample log sheet will be used to record the following information:

- Sample identification (site name, location, project number; sample name/number and location; sample type and matrix; time and date; sampler's identity).
- Sample source and source description.
- Purge data - prior to removal of each casing volume and before sampling, pH, electrical conductance, temperature, color, and turbidity shall be measured and recorded.
- Field observations and measurements (appearance; volatile screening; field chemistry; sampling method).
- Sample disposition (preservatives added; lab sent to, date and time; lab sample number, EPA Traffic Report or Special Analytical Services number, chain-of-custody number.
- Additional remarks - (e.g., sampled in conjunction with state, county, local regulatory authorities; samples for specific conductance value only; sampled for key indicator analysis; etc.).

5.7 CHAIN-OF-CUSTODY

Proper chain-of-custody procedures play a crucial role in data gathering. Procedure SA-6.1 describes the requirements for a correct chain-of-custody.

6.0 REFERENCES

U.S. EPA, 1980. Procedures Manual for Ground Water Monitoring at Solid Waste Disposal Facilities. Office of Solid Waste, United States Environmental Protection Agency, Washington, D.C.

Johnson Division, UOP, Inc. 1975. Ground Water and Wells, A Reference Book for the Water Well Industry. Johnson Division, UOP, Inc., Saint Paul, Minnesota.

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

Scalf, M. R., J. F. McNabb, W. J. Dunlap, R. L. Crosby and J. Fryberger, 1981. Manual of Ground Water Sampling Procedures. R. S. Kerr Environmental Research Laboratory, Office of Research and Development, U.S. EPA, Ada, Oklahoma.

Nielsen, D. M. and G. L. Yeates, 1985. A Comparison of Sampling Mechanisms Available for Small-Diameter Ground Water Monitoring Wells. Ground Water Monitoring Review 5:83-98.

7.0 ATTACHMENTS

Attachment A - Well Sampling Data Sheet
Attachment B - Purging Equipment Selection

ATTACHMENT A
SAMPLE LOG SHEET

NUS CORPORATION
A Halliburton Company

SAMPLE LOG SHEET

☐ Monitoring Well Data
☐ Domestic Well Data
☐ Other ________

Page ____ of ____

Case # ________

By ________

Project Site Name ____________________ Project Site Number ____________________

NUS Source No. ____________________ Source Location ____________________

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

Sample Date & Time:	Sample Data			
	pH	S.C.	Temp. (°C)	Color & Turbidity
Sampled By:				
Signature(s):	Observations / Notes:			

Type of Sample

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

Analysis:	Preservative		Organic	Inorganic
		Traffic Report #		
		Tag #		
		AB #		
		Date Shipped		
		Time Shipped		
		Lab		
		Volume		

ATTACHMENT B
PURGING EQUIPMENT SELECTION

Purging Equipment Selection

Diameter Casing	Bailer	Peristaltic Pump	Vacuum Pump	Airlift	Diaphragm "Trash" Pump	Submersible Diaphragm Pump	Submersible Electric Pump	Submersible Electric Pump w/Packer
1.25-inch								
Water level <25 ft		X	X	X	X			
Water level >25 ft				X				
2-inch								
Water level <25 ft	X	X	X	X	X	X		
Water level >25 ft	X			X		X		
4-inch								
Water level <25 ft	X	X	X	X	X	X	X	X
Water level >25 ft	X			X		X	X	X
6-inch								
Water level <25 ft				X	X		X	X
Water level >25 ft				X			X	X
8-inch								
Water level <25 ft				X	X		X	X
Water level >25 ft				X			X	X

Manufacturer	Model name/ number	Principle of operation	Maximum outside diameter/length (inches)	Construction materials (w/lines & 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 ft 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
Galtek Corp.	Bailer 219-4	portable; grab (positive displacement)	1.66/38	Teflon®	no limit	1075 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	app. 1 liter for each 10 ft 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	0-2800 mL/min	1500-3000	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 vol.	1100	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, Delrin® acetal	0-150	0-7500 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	0-4500 mL/min	3500	DC operated
Leonard Mold and Die Works, Inc.	GeoFilter Small Dia. Well Pump (#0500)	portable; bladder (positive displacement)	1.75/38	SS, Teflon®, PC, Neoprene®	0-400	0-3500 mL/min	1400-1500	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, Delrin®	no limit	app. 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	0-2000 mL/min	300-400	requires compressed gas, piezometric level indicator; other materials available

Source: Barcelona et al., 1983

Manufacturer	*Model name/ number*	*Principle of operation*	*Maximum outside diameter/length (inches)*	*Construction materials (w/lines & tubing)*	*Lift range (ft)*	*Delivery rates or volumes*	*1982 price (dollars)*	*Comments*
Randolph Austin Co	Model 500 Vari Flow Pump	portable, peri staltic (suction)	< 0.5/N/A	(not submersible) rubber, Tygon®, or Neoprene®	0-30	see comments	1200-1300	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	0-1800 mL/min	2600-2700	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	0-1100	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	1300-1800	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	0-4000 mL/min	800-1000	compressed gas required; DC control module; custom built

Construction Materials 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 ground water 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

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NUS CORPORATION ENVIRONMENTAL MANAGEMENT GROUP	STANDARD OPERATING PROCEDURES	Number SA-6.1	Page 1 of 14
		Effective Date 05/04/90	Revision 2
		Applicability EMG	
		Prepared Earth Sciences	
Subject SAMPLE IDENTIFICATION AND CHAIN-OF-CUSTODY		Approved D. Senovich	

TABLE OF CONTENTS

1.0 PURPOSE

This purpose of this procedure is to provide information on chain-of-custody procedures to be used under the NUS Program.

2.0 SCOPE

This procedure describes the steps necessary for transferring samples through the use of Chain-of-Custody Records. A Chain-of-Custody Record is required, without exception, for the tracking and recording of all samples collected for on-site or off-site analysis (chemical or geotechnical) during program activities. Use of the Chain-of-Custody Record Form creates an accurate written record that can be used to trace the possession and handling of the sample from the moment of its collection through analysis and its introduction as evidence. This procedure identifies the necessary custody records and describes their completion.

This procedure does not take precedence over region-specific or site-specific requirements for chain-of-custody.

3.0 GLOSSARY

Chain-of-Custody Record Form - A Chain-of-Custody Record Form is a printed two-part form that accompanies a sample or group of samples as custody of the sample(s) is transferred from one custodian to another custodian. A Chain-of-Custody Record Form is a controlled document, provided by the regional office of EPA.

The chain-of-custody form is a two-page carbon-copy type form. The original form accompanies the samples during shipment, and the pink carbon-copy is retained in the project file.

Controlled Document - A consecutively-numbered form released by EPA or Program Management Office (PMO) for use on a particular work assignment. All unused forms must be returned or accounted for at the conclusion of the assignment.

Custodian - The person responsible for the custody of samples at a particular time, until custody is transferred to another person (and so documented), who then becomes custodian. A sample is under your custody if:

- it is in your actual possession.
- it is in your view, after being in your physical possession.
- it was in your physical possession and then you locked it up to prevent tampering.
- it is in a designated and identified secure area.

Sample - A sample is physical evidence collected from a facility or the environment, which is representative of conditions at the point and time that it was collected.

4.0 RESPONSIBILITIES

Field Operations Leader - Responsible for determining that chain-of-custody procedures are implemented up to and including release to the shipper.

Field Samplers - Responsible for initiating the Chain-of-Custody Record and maintaining custody of samples until they are relinquished to another custodian, to the shipper, or to the common carrier.

Remedial Investigation Leader - Responsible for determining that chain-of-custody procedures have been met by the sample shipper and analytical laboratory.

5.0 PROCEDURES

5.1 OVERVIEW

The term "chain-of-custody" refers to procedures which ensure that evidence presented in a court of law is what it is represented to be. The chain-of-custody procedures track the evidence from the time and place it is first obtained to the courtroom and, secondly, provide security for the evidence as it is moved and/or passes from the custody of one individual to another.

Chain-of-custody procedures, recordkeeping, and documentation are an important part of the management control of samples. Regulatory agencies must be able to provide the chain of possession and custody of any samples that are offered for evidence, or that form the basis of analytical test results introduced as evidence. Written procedures must be available and followed whenever evidence samples are collected, transferred, stored, analyzed, or destroyed.

5.2 SAMPLE IDENTIFICATION

The method of identification of a sample depends on the type of measurement or analysis performed. When in-situ measurements are made, the data are recorded directly in bound logbooks or other field data records, with identifying information.

5.2.1 Sample Label

Samples, other than in-situ measurements, are removed and transported from the sample location to a laboratory or other location for analysis. Before removal, however, a sample is often divided into portions, depending upon the analyses to be performed. Each portion is preserved in accordance with the Sampling Plan. Each sample container is identified by a sample label (see Attachment B). Sample labels are provided by the PMO. The information recorded on the sample label includes:

- **Project:** EPA Work Assignment Number (can be obtained from the Sampling Plan).
- **Station Location:** The unique sample number identifying this sample (can be obtained from the Sampling Plan).
- **Date:** A six-digit number indicating the day, month, and year of sample collection; e.g., 12/21/85.
- **Time:** A four-digit number indicating the 24-hour time of collection (for example: 0954 is 9:54 a.m., and 1629 is 4:29 p.m.).
- **Medium:** Water, soil, sediment, sludge, waste, etc.

- **Concentration:** The expected concentration (i.e., low, medium, high).
- **Sample Type:** Grab or composite.
- **Preservation:** Type of preservation added and pH levels.
- **Analysis:** VOA, BNAs, PCBs, pesticides, metals, cyanide, other.
- **Sampled By:** Printed name of the sampler.
- **Case Number:** Case number assigned by the Sample Management Office.
- **Traffic Report Number:** Number obtained from the traffic report labels.
- **Remarks:** Any pertinent additional information.

Using just the work assignment number of the sample label maintains the anonymity of sites. This may be necessary, even to the extent of preventing the laboratory performing analysis from knowing the identity of the site (e.g., if the laboratory is part of an organization that has performed previous work on the site).

5.2.2 Sample Identification Tag

A Sample Identification Tag (Attachment F) must also be used for samples collected for CLP (Contract Laboratory Program) analysis. The Sample Identification Tag is a w e, waterproof paper label, approximately 3-by-6 inches, with a reinforced eyelet, and string or w or attachment to the neck of the sample bottle. The Sample Tag is a controlled document, and vided by the regional EPA office. Following sample analysis, the Sample Tag is retained by the la story as evidence of sample receipt and analysis.

The following information is recorded on the tag:

- **Project Code:** Work Assignment Number.
- **Station Number:** The middle portion of the Station Location Number, (between the hyphens).
- **Month/Day/Year:** Same as Date on Sample Label.
- **Time:** Same as Time on Sample Label.
- **Designate - Comp/Grab:** Composite or grab sample.
- **Station Location:** Same as Station Location on Sample Label.
- **Samplers:** Same as Sampled By on Sample Label.
- **Preservative:** Yes or No.
- **Analyses:** Check appropriate box(es).

- **Remarks:** Same as Remarks on Sample Label (make sure the Case Number and Traffic Report numbers are recorded).

- **Lab Sample Number:** For laboratory use only.

The tag is then tied around the neck of the sample bottle.

If the sample is to be split, it is aliquoted into similar sample containers. Identical information is completed on the label attached to each split.

Blank, duplicate, or field spike samples shall not be identified as such on the label, as they may compromise the quality control function. Sample blanks, duplicates, spikes, and splits are defined in Procedure SA-6.6.

5.3 CHAIN-OF-CUSTODY PROCEDURES

After collection, separation, identification, and preservation, the sample is maintained under chain-of-custody procedures until it is in the custody of the analytical laboratory and has been stored or disposed of.

5.3.1 Field Custody Procedures

- Samples are collected as described in the site-specific Sampling Plan. Care must be taken to record precisely the sample location and to ensure that the sample number on the label matches the sample log sheet and Chain-of-Custody Record exactly.

- The person undertaking the actual sampling in the field is responsible for the care and custody of the samples collected until they are properly transferred or dispatched.

- When photographs are taken of the sampling as part of the documentation procedure, the name of the photographer, date, time, site location, and site description are entered sequentially in the site logbook as photos are taken. Once developed, the photographic prints shall be serially numbered, corresponding to the logbook descriptions.

- Sample labels shall be completed for each sample, using waterproof ink unless prohibited by weather conditions, e.g., a logbook notation would explain that a pencil was used to fill out the sample label because a ballpoint pen would not function in freezing weather.

5.3.2 Transfer of Custody and Shipment

Samples are accompanied by a Chain-of-Custody Record Form. Chain-of-Custody Record Forms used in EPA Regions I-IV are shown in Attachments A through D. The appropriate form shall be obtained from the EPA Regional Office. When transferring the possession of samples, the individuals relinquishing and receiving will sign, date, and note the time on the Record. This Record documents sample custody transfer from the sampler, often through another person, to the analyst in the laboratory. The Chain-of-Custody Record is filled out as follows:

- Enter header information (project number, samplers, and project name -- project name can be obtained from the Sampling Plan).

- Sign, date, and enter the time under "Relinquished by" entry.

- Enter station number (the station number is the middle portion of the station location number, between the hyphens).
- Check composite or grab sample.
- Enter station location number (the same number as the station location on the tag and label).
- Enter the total number of containers per station number and the type of each bottle.
- Enter either the inorganic traffic report number, the organic traffic report number, or the SAS number for each station number in the remarks column.
- Enter the tag number from the bottom of the sample identification tag in the remarks column for each station location.
- Make sure that the person receiving the sample signs the "Received by" entry, or enter the name of the carrier (e.g., UPS, Federal Express) under "Received by." Receiving laboratory will sign "Received for Laboratory by" on the lower line and enter the date and time.
- Enter the bill-of-lading or Federal Express airbill number under "Remarks," in the bottom right corner, if appropriate.
- Place the original (top, signed copy) of the Chain-of-Custody Record Form in the appropriate sample shipping package. Retain the pink copy with field records.
- Sign and date the custody seal, a 1- by 3-inch white paper label with black lettering and an adhesive backing. Attachment G is an example of a custody seal. The custody seal is part of the chain-of-custody process and is used to prevent tampering with samples after they have been collected in the field. Custody seals are provided by ZPMO on an as-needed basis.
- Place the seal across the shipping container opening so that it would be broken if the container is opened.
- Complete other carrier-required shipping papers.

The custody record is completed using black waterproof ink. Any corrections are made by drawing a line through and initialing and dating the change, then entering the correct information. Erasures are not permitted.

Common carriers will usually not accept responsibility for handling Chain-of-Custody Record Forms; this necessitates packing the record in the sample container (enclosed with other documentation in a plastic zip-lock bag). As long as custody forms are sealed inside the sample container and the custody seals are intact, commercial carriers are not required to sign off on the custody form.

If sent by mail, the package will be registered with return receipt requested. If sent by common carrier or air freight, proper documentation must be maintained.

The laboratory representative who accepts the incoming sample shipment signs and dates the Chain-of-Custody Record, completing the sample transfer process. It is then the laboratory's responsibility to maintain internal logbooks and custody records throughout sample preparation and analysis.

5.3.3 Receipt for Samples Form

Whenever samples are split with a private party or government agency, a separate Receipt for Samples Record Form is prepared for those samples and marked to indicate with whom the samples are being split. The person relinquishing the samples to the party or agency shall require the signature of a representative of the appropriate party acknowledging receipt of the samples. If a representative is unavailable or refuses to sign, this is noted in the "Received by" space. When appropriate, as in the case where the representative is unavailable, the custody record shall contain a statement that the samples were delivered to the designated location at the designated time. This form must be completed and a copy given to the owner, operator, or agent-in-charge even if the offer for split samples is declined. The original is retained by the Field Operations Leader.

6.0 REFERENCES

U.S. EPA, 1984. User's Guide to the Contract Laboratory Program, Office of Emergency and Remedial Response, Washington, D.C.

7.0 ATTACHMENTS

Attachment A - Chain-of-Custody Record Form for use in Region I
Attachment B - Chain-of-Custody Record Form for use in Region II
Attachment C - Chain-of-Custody Record Form for use in Region III
Attachment D - Chain-of-Custody Record Form for use in Region IV
Attachment E - Sample Label
Attachment F - Sample Identification Tag
Attachment G - Chain-of-Custody Seal

ATTACHMENT A
CHAIN-OF-CUSTODY RECORD FORM FOR USE IN REGION I
(Original is 8-1/2 by 11)

	PROJECT NAME					NO. OF CONTAINERS							REMARKS
SAMPLERS: *(Signature)*													
STA. NO.	DATE	TIME	COMP.	GRAB	STATION LOCATION								

Relinquished by: *(Signature)*	Date / Time	Received by: *(Signature)*	Relinquished by: *(Signature)*	Date / Time	Received by: *(Signature)*
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:	

ATTACHMENT B
CHAIN-OF-CUSTODY RECORD FORM FOR USE IN REGION II
(Original is 8 by 10-1/2)

CHAIN OF CUSTODY RECORD

ENVIRONMENTAL PROTECTION AGENCY – REGION II
SURVEILLANCE & ANALYSIS DIVISION
EDISON, NEW JERSEY 08817

Name of Unit and Address		
Sample Number	**Number of Containers**	**Description of Samples**

Person Assuming Responsibility for Sample	Time	Date

Sample Number	Relinquished By:	Received By:	Time	Date	Reason for Change of Custody

Sample Number	Relinquished By:	Received By:	Time	Date	Reason for Change of Custody

Sample Number	Relinquished By:	Received By:	Time	Date	Reason for Change of Custody

Sample Number	Relinquished By:	Received By:	Time	Date	Reason for Change of Custody

ATTACHMENT C
CHAIN-OF-CUSTODY RECORD FORM FOR USE IN REGION III
(Original is 8-1/2 x 11-3/4")

ENVIRONMENTAL PROTECTION AGENCY
Office of Enforcement

REGION 3
Curtis Bldg., 6th & Walnut Sts.
Philadelphia, Pennsylvania 19106

CHAIN OF CUSTODY RECORD

PROJ NO.	PROJECT NAME					NO OF CON-TAINERS							REMARKS
SAMPLERS: (Signature)													
STA. NO.	DATE	TIME	COMP	GRAB	STATION LOCATION								

Relinquished by: (Signature)	Date / Time	Received by: (Signature)	Relinquished by: (Signature)	Date / Time	Received by: (Signature)
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	

Distribution: Original Accompanies Shipment, Copy to Coordinator Field Files

3-15966

ATTACHMENT D
CHAIN-OF-CUSTODY RECORD FORM FOR USE IN REGION IV
(Original is 8-1/2 by 14)

U S ENVIRONMENTAL PROTECTION AGENCY
REGION 4

CHAIN OF CUSTODY RECORD

ENVIRONMENTAL SERVICES DIVISION
COLLEGE STATION ROAD
ATHENS, GEORGIA 30613

PROJ NO	PROJECT NAME					NO OF CONTAINERS	Water/Wastewater: Col G (oil org); Col G (EP); 40 ml vial (VOA); Col P (BOD COD TSS); Pl G (phenol); Pl G (metals Hg); Pl P (metals); Pl P (S⁻⁻); Pl P (TOC COD); Ol G (O&G or Phenol); [illegible] Pl P (CN); [illegible] Pl P (Cl F) SO4); Ol G (oil org [illegible]); 8 oz G (VOA); Pl P (metals Hg CN S⁻⁻)	Sed/Soil: [illegible] oz G (oil org VOA metals Hg CN); 8 oz G (EP S⁻⁻ FP)	Sldg/Waste	Misc	REMARKS/TAG NUMBERS
SAMPLERS (Signature)											
STA NO	DATE	TIME	COMP	GRAB	STATION LOCATION						

Relinquished by (Signature)	Date/Time	Received by (Signature)	Relinquished by (Signature)	Date/Time	Received by (Signature)	Remarks
Relinquished by (Signature)	Date/Time	Received by (Signature)	Relinquished by (Signature)	Date/Time	Received by (Signature)	

DISTRIBUTION: Original and Pink copies accompany sample shipment to laboratory. Pink copy retained by laboratory.
Yellow copy retained by samplers. Blue copy extra copy as needed.

Nº 4 3526

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ATTACHMENT E
SAMPLE LABEL

NUS CORPORATION PROJECT: ______________________

STATION LOCATION: ______________________

DATE: ____/____/____ TIME: ____________ hrs.

MEDIA: WATER ☐ SOIL ☐ SEDIMENT ☐ ____________ ☐

CONCENTRATION: LOW ☐ MED ☐ HIGH ☐

TYPE: GRAB ☐ COMPOSITE ☐

ANALYSIS	PRESERVATION
VOA ☐ BNA's ☐	Cool to 4°C ☐
PCB's ☐ PESTICIDES ☐	HNO_3 to pH <2 ☐
METALS: TOTAL ☐ DISSOLVED ☐	NAOH to pH>12 ☐
CYANIDE ☐	____________ ☐
____________ ☐	

Sampled by: ______________________

Case No.: ________ Traffic Report No.: ____________

Remarks:

ACFILE: FORMS\BOTLABL

ATTACHMENT F
SAMPLE IDENTIFICATION TAG

☆ GPO 505-552

Designate: Grab / Comp

Time

Month/Day/Year

Station No

Project Code

Samplers (Signatures)

Station Location

Preservative:
Yes ☐ **No** ☐

ANALYSES

BOD Anions Solids (TSS) (TDS) (SS)	
COD, TOC, Nutrients	
Phenolics	
Mercury	
Metals	
Cyanide	
Oil and Grease	
Organics GC/MS	
Priority Pollutants	
Volatile Organics	
Pesticides	
Mutagenicity	
Bacteriology	

Remarks:

Tag No.	Lab Sample No.
3 60966	

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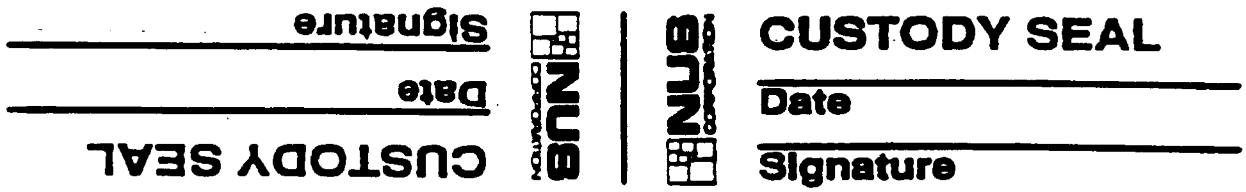
ATTACHMENT G
CHAIN-OF-CUSTODY SEAL



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Subject SAMPLE PACKAGING AND SHIPPING		Approved D. Senovich	

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1.0 PURPOSE

This procedure provides instruction for sample packaging and shipping in accordance with U.S. Department of Transportation (DOT) regulations.

2.0 SCOPE

Samples collected at hazardous waste sites usually have to be transported elsewhere for analysis. This requires that the samples be appropriately preserved to prevent or minimize chemical alteration prior to analysis, and be transported to protect their integrity, as well as to protect against any detrimental effects from leakage or breakage. Regulations for packaging, marking, labeling, and shipping hazardous materials and wastes are promulgated by the U.S. Department of Transportation and described in the Code of Federal Regulations (49 CFR 171 through 177, in particular 172.402h, Packages Containing Samples). In general, these regulations were not intended to cover shipment of samples collected at controlled or uncontrolled hazardous waste sites or samples collected during emergency responses. However, the EPA has agreed through a memorandum of agreement to package, mark, label, and ship samples observing DOT procedures. The information presented here is for general guidance.

This procedure is applicable to all samples taken from uncontrolled hazardous substance sites for analysis at laboratories away from the site.

3.0 GLOSSARY

Carrier - A person or firm engaged in the transportation of passengers or property.

Hazardous Material - A substance or material in a quantity and form which may pose an unreasonable risk to health and safety or property when transported in commerce ("commerce" here to include any traffic or transportation). Defined and regulated by DOT (49 CFR 173.2) and listed in Attachment A of this guideline.

Hazardous Waste - Any substance listed in 40 CFR Subpart D (§261.20 et seq) or otherwise characterized as ignitable, corrosive, reactive, or EP toxic as specified under 40 CFR Subpart C (§261.20 et seq) that would be subject to manifest requirements specified in 40 CFR 262. Defined and regulated by EPA.

Marking - Applying the descriptive name, instruction, cautions, weight, or specification marks or combination thereof required to be placed outside containers of hazardous materials.

n.o.i. - Not otherwise indicated.

n.o.s. - Not otherwise specified.

ORM - Other regulated material.

Packaging - The assembly of one or more containers and any other components necessary to assure compliance with the minimum packaging requirements of 49 CFR 174, including containers (other than freight containers or overpacks), portable tanks, cargo tanks, tank cars, multiunit tank car tanks.

Placard - Color-coded, pictorial sign depicting the hazard class symbol and name to be placed on all four sides of a vehicle transporting certain hazardous materials.

Reportable Quantity (RQ) - A parenthetical note of the form "(RQ-1000/454)" following an entry in the DOT Hazardous Materials table (49 CFR 172.101) indicates the reportable quantity of the substance in pounds and kilograms. If a spill of that amount or more of the substance occurs during transit or storage, a report must be filed with DOT according to ¥171.15-15 concerning hazardous materials incidents reports. If the material spilled is a hazardous waste, a report must always be filed, regardless of the amount, and must include a copy of the manifest. If the RQ notation appears, it must be shown either immediately before or after the proper shipping name on the shipping paper (or manifest). Most shipping papers and manifests will have a column designated "HM" which may be used for this purpose.

4.0 RESPONSIBILITIES

Field Operations Leader or Team Sampling Leader - responsible for determining that samples are properly packaged and shipped.

Sampling Personnel - responsible for implementing the packaging and shipping requirements.

5.0 PROCEDURES

5.1 INTRODUCTION

Samples collected for shipment from a site shall be classified as either environmental or hazardous material (or waste) samples. In general, environmental samples are collected off-site (for example from streams, ponds, or wells) and are not expected to be grossly contaminated with high levels of hazardous materials. On-site samples (for example, soil, water, and materials from drums or bulk storage tanks, obviously contaminated ponds, lagoons, pools, and leachates from hazardous waste sites) are considered hazardous. A distinction must be made between the two types of samples in order to:

- Determine appropriate procedures for transportation of samples. If there is any doubt, a sample shall be considered hazardous and shipped accordingly.
- Protect the health and safety of laboratory personnel receiving the samples. Special precautions are used at laboratories when samples other than environmental samples are received.

5.2 ENVIRONMENTAL SAMPLES

5.2.1 Packaging

Environmental samples may be packaged following the procedures outlined in Section 5.4 for samples classified as "flammable liquids" or "flammable solids." Requirements for marking, labeling, and shipping papers do not apply.

Environmental samples may also be packed without being placed inside metal cans as required for flammable liquids or solids.

- Place sample container, properly identified and with a sealed lid, in a polyethylene bag, and seal the bag.
- Place sample in a fiberboard container or metal picnic cooler which has been lined with a large polyethylene bag.
- Pack with enough noncombustible, absorbent, cushioning materials to minimize the possibility of the container breaking.
- Seal large bag.
- Seal or close outside container.

5.2.2 Marking Labeling

Sample containers must have a completed sample identification tag and the outside container must be marked "Environmental Sample." The appropriate side of the container must be marked "This End Up" and arrows placed appropriately. No DOT marking or labeling are required.

5.2.3 Shipping Papers

No DOT shipping papers are required. However, the appropriate chain-of-custody forms must be included with the shipment.

5.2.4 Transportation

There are no DOT restrictions on mode of transportation.

5.3 **DETERMINATION OF SHIPPING CLASSIFICATION FOR HAZARDOUS MATERIAL SAMPLES**

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

5.3.1 Known Substances

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

Unz and Company have published the following steps to help in locating a proper shipping name from the Hazardous Materials Table, 49 CFR 172.101.

1. Look first for the chemical or technical name of the material, for example, ethyl alcohol. Note that many chemicals have more than one technical name, for example, perchloroethylene (not listed in 172.101) is also called tetrachloroethylene (listed 172.101). It may be useful to consult a chemist for all possible technical names a material can have. If your material is not listed by its technical name then. . . . . . .

2. Look for the chemical family name. For example, pentyl alcohol is not listed but the chemical family name is: alcohol, n.o.s. (not otherwise specified). If the chemical family name is not listed then. . . . .

3. Look for a generic name based on end use. For example, Paint, n.o.s or Fireworks, n.o.s. If a generic name based on end use is not listed then. . . . .

4. Look for a generic family name based on end use, for example, drugs, n.o.s. or cosmetics, n.o.s. Finally, if your material is not listed by a generic family name but you suspect or know the material is hazardous because it meets the definition of one or more hazardous classes, then. . . . .

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

5.3.2 Unknown Substances

For samples of hazardous substances of unknown content, select the appropriate transportation category according to the DOT Hazardous Materials Classification (Attachment A), a priority system of transportation categories.

The correct shipping classification for an unknown sample is selected through a process of elimination, utilizing Attachment A. Unless known or demonstrated otherwise (through the use of radiation survey instruments), the sample is considered radioactive and appropriate shipping regulations for "radioactive material" followed.

If a radioactive material is eliminated, the sample is considered to contain "Poison A" materials (Attachment B), the next classification on the list. DOT defines "Poison A" as extremely dangerous poisonous gases or liquids of such a nature that a very small amount of gas, or vapor of the liquids, mixed with air is dangerous to life. Most Poison A materials are gases or compressed gases and would not be found in drum-type containers. Liquid Poison A would be found only in closed containers; however, all samples taken from closed drums do not have to be shipped as Poison A, which provides for a "worst case" situation. Based upon information available, a judgment must be made whether a sample from a closed container is a Poison A.

If Poison A is eliminated as a shipment category, the next two classifications are "flammable" or "nonflammable" gases. Since few gas samples are collected, "flammable liquid" would be the next applicable category. With the elimination of radioactive material, Poison A, flammable gas, and nonflammable gas, the sample can be classified as flammable liquid (or solid) and shipped accordingly. These procedures would also suffice for shipping any other samples classified below flammable liquids in the DOT classification table (Attachment A). For samples containing unknown materials, categories listed below flammable liquids/solids on Attachment A are generally not used because showing that these materials are not flammable liquids (or solids) requires flashpoint testing, which may be impractical and possibly dangerous at a site. Thus, unless the sample is known to consist of materials listed as less hazardous than flammable liquid (or solid) on Attachment A, it is considered a flammable liquid (or solid) and shipped as such.

For any hazardous material shipment, utilize the shipping checklist (Attachment C) as a guideline to ensure that all sample-handling requirements are satisfied.

5.4 PACKAGING AND SHIPPING OF SAMPLES CLASSIFIED AS FLAMMABLE LIQUID (OR SOLID)

5.4.1 Packaging

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

1. Collect sample in the prescribed container with a nonmetallic, Teflon-lined screw cap. To prevent leakage, fill container no more than 90 percent full.

2. Complete sample label and sample identification tag and attach securely to sample container.

3. Seal container and place in 2-mil thick (or thicker) polyethylene bag, one sample per bag. Position sample identification tag so that it can be read through bag. Seal bag.

4. Place sealed bag inside metal can and cushion it with enough noncombustible, absorbent material (for example, vermiculite or diatomaceous earth) between the bottom and sides of the can and bag to prevent breakage and absorb leakage. Pack one bag per can. Use clips, tape, or other positive means to hold can lid securely, tightly and permanently. Mark can as indicated in Paragraph 1 of Section 5.4.2, below.

5. Place one or more metal cans (or single 1-gallon bottle) into a strong outside container, such as a metal picnic cooler or a DOT-approved fiberboard box. Surround cans with noncombustible, absorbent cushioning materials for stability during transport. Mark container as indicated in Paragraph 2 of Section 5.4.2.

5.4.2 Marking/Labeling

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

   - Laboratory name and address.

   - "Flammable Liquid, n.o.s. UN1993" or "Flammable Solid, n.o.s. UN1325."

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

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

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

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

5.4.3 Shipping Papers

1. Use abbreviations only where specified. Complete the carrier-provided bill of lading and sign certification statement (if carrier does not provide, use standard industry form, see Attachment D). Provide the following information in the order listed (one form may be used for more than one exterior container).

   - "Flammable Liquid, n.o.s. UN1993" or "Flammable Solid, n.o.s. UN1325."
   - "Limited Quantity" (or "Ltd. Qty.").
   - "Cargo Aircraft Only."
   - Net weight (wt) or net volume (vol), just before or just after "Flammable Liquid, n.o.s." or "Flammable Solid, n.o.s.," by item, if more than one metal can is inside an exterior container.
   - "Laboratory Samples" (if applicable).

2. Include Chain-of-Custody Record, properly executed in outside container.

3. "Limited Quantity" of "Flammable Liquid, n.o.s." is limited to one pint per inner container. For "Flammable Solid, n.o.s.," net weight of inner container plus sample shall not exceed one pound; total package weight shall not exceed 25 pounds.

5.4.4 Transportation

1. Transport unknown hazardous substance samples classified as flammable liquids by rented or common carrier truck, railroad, or express overnight package services. Do not transport by any passenger-carrying air transport system, even if they have cargo-only aircraft. DOT regulations permit regular airline cargo-only aircraft, but difficulties with most suggest avoiding them. Instead, ship by airline carriers that only carry cargo.

2. For transport by government-owned vehicle, including aircraft, DOT regulations do not apply. However, procedures described above, with the exception of execution of the bill of lading with certification, shall still be used.

6.0 REFERENCES

U.S. Department of Transportation, 1983. Hazardous Materials Regulations, 49 CRF 171-177.

NUS Standard Operating Procedure SA-6.1 - Sample Identification and Chain-of-Custody

NUS Standard Operating Procedure SA-1.2 - Sample Preservation

NUS Standard Operating Procedure SF-1.5 - Compatibility Testing

7.0 ATTACHMENTS

Attachment A - DOT Hazardous Material Classification (49 CFR 173.2)
Attachment B - DOT List of Class "A" Poisons (49 CFR 172.101)
Attachment C - Hazardous Materials Shipping Checklist
Attachment D - Standard Industry Certification Form

ATTACHMENT A

DOT HAZARDOUS MATERIAL CLASSIFICATION (49 CFR 173.2)

1. Radioactive material (except a limited quantity)
2. Poison A
3. Flammable gas
4. Nonflammable gas
5. Flammable liquid
6. Oxidizer
7. Flammable Solid
8. Corrosive material (liquid)
9. Poison B
10. Corrosive material (solid)
11. Irritating material
12. Combustible liquid (in containers having capacities exceeding 110 gallons [416 liters])
13. ORM-B
14. ORM-A
15. Combustible liquid (in containers having capacities of 110 gallons [416 liters] or less)
16. ORM-E

ATTACHMENT B

DOT LIST OF CLASS "A" POISON (49 CFR 172.101)

Material	Physical State at Standard Temperature
Arsine	Gas
Bromoacetone	Liquid
Chloropicrin and methyl chloride mixture	Gas
Chloropicrin and nonflammable,nonliquefied compressed gas mixture	Gas
Cyanogen chloride	Gas (> 13.1°C)
Cyanogen gas	Gas
Gas identification set	Gas
Gelatin dynamite (H. E. Germaine)	----
Grenade (with Poison "A" gas charge)	----
Hexaethyl tetraphosphate/compressed gas mixture	Gas
Hydrocyanic (prussic) acid solution	Liquid
Hydrocyanic acid, liquefied	Gas
Insecticide (liquefied) gas containing Poison "A" or Poison "B" material	Gas
Methyldichloroarsine	Liquid
Nitric oxide	Gas
Nitrogen peroxide	Gas
Nitrogen tetroxide	Gas
Nitrogen dioxide, liquid	Gas
Parathion/compressed gas mixture	Gas
Phosgene (diphosgene)	Liquid

ATTACHMENT C
HAZARDOUS MATERIALS SHIPPING CHECKLIST

PACKAGING

1. Check DOT 172.500 table for appropriate type of package for hazardous substance.
2. Check for container integrity, especially the closure.
3. Check for sufficient absorbent material in package.
4. Check for sample tags and log sheets for each sample, and chain-of-custody record.

SHIPPING PAPERS

1. Check that entries contain only approved DOT abbreviations.
2. Check that entries are in English.
3. Check that hazardous material entries are specially marked to differentiate them from any nonhazardous materials being sent using same shipping paper.
4. Be careful all hazardous classes are shown for multiclass materials.
5. Check total amounts by weight, quantity, or other measures used.
6. Check that any limited-quantity exemptions are so designated on the shipping paper.
7. Offer driver proper placards for transporting vehicle.
8. Check that certification is signed by shipper.
9. Make certain driver signs for shipment.

RCRA MANIFEST

1. Check that approved state/federal manifests are prepared.
2. Check that transporter has the following: valid EPA identification number, valid driver's license, valid vehicle registration, insurance protection, and proper DOT labels for materials being shipped.
3. Check that destination address is correct.
4. Check that driver knows where shipment is going.
5. Check that the driver is aware of emergency procedures for spills and accidents.
6. Make certain driver signs for shipment
7. Make certain one copy of executed manifest and shipping document is retained by shipper.

ATTACHMENT D

STANDARD INDUSTRY CERTIFICATION FORM

NO PCS	SIZE	GROSS WEIGHT	HM	DOT PROPER SHIPPING NAME	HAZARD CLASS	CODE	[illegible]	CONTAINER NUMBERS	PIC	[illegible]
1	55 gal	200 lbs.	x	Nitric Acid, Fuming	Oxidizer	55-BM	C	1	✓	
1	55 gal	450 lbs.	x	Flammable Liquid, n.o.s.	Flammable Liquid	55-ABF	—	2		✓
1	55 gal	250 lbs.	x	Flammable liquid, n.o.s.	Flammable Liquid	55-BM	B	3	✓	
1	16 A	12 lbs.	x	Bromine	Corrosive Material	55-BM	C	4	✓	

SHIPPER'S CERTIFICATION

This is to certify that the above named materials are properly classified, described, packaged, marked and labeled and are in proper condition for transportation according to the applicable regulations of the Department of Transportation.

Shipper's Signature

Placards Req'd ______

Shipment Date ______ Manifest No ______

Disposal Work Order ______

Service Order No ______

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Subject SITE LOGBOOK		Approved D. Senovich	

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1.0 PURPOSE

This procedure describes the process for keeping a site logbook.

2.0 SCOPE

The site logbook is a controlled document which records all major on-site activities during a Remedial Investigation/Feasibility Study. At a minimum, the following activities/events shall be recorded in the site logbook:

- Arrival/departure of site visitors
- Arrival/departure of equipment
- Sample pickup (chain-of-custody form numbers, carrier, time)
- Sampling activities/sample logsheet numbers
- Start or completion of borehole/trench/monitoring well installation or sampling activities
- Health and Safety issues

The site logbook is initiated at the start of the first on-site activity (e.g., initial reconnaissance survey). Entries are made for every day that on-site activities take place which involve RI/FS contractor personnel. One current site logbook is maintained per site.

The site logbook becomes part of the permanent site file maintained in the RI contractor's office. Because information contained in the site logbook may be admitted as evidence in cost recovery or other legal proceedings, it is critical that this document be properly maintained.

3.0 GLOSSARY

Site Logbook - The logbook is a bound notebook with consecutively numbered pages that cannot be removed. Upon entry of data, the logbook requires signature by the responsible site leader (see Section 5.1).

4.0 RESPONSIBILITIES

The site logbook is issued by the Regional Manager (or his designee) to the Site Manager for the duration of the project. The Site Manager releases the site logbook to the Field Operations Leader or other person responsible for the direction of on-site activities (e.g., Reconnaissance Survey Team Leader, Sampling Team Leader). It is the responsibility of this person (or his designee) to keep the site logbook current while in his possession, and return it to the Site Manager or turn it over to another field team. Following the completion of all fieldwork, the site logbook is returned to the Site Manager for inclusion in the permanent site files.

5.0 PROCEDURES

5.1 GENERAL

The cover of each site logbook contains the following information:

- Project Name
- NUS Project Number
- RI/FS Contractor and Site Manager's Name
- Sequential Book Number

- Start Date
- End Date

Daily entries into the logbook may contain a variety of information. At the beginning of each day the following information must be recorded:

- Date
- Start time
- Weather
- All field personnel present
- Any visitors present

During the day, a summary of all site activities and level of personal protection shall be recorded in the logbook. The information need not duplicate that recorded in other field notebooks (e.g., sample logbook, Site Geologist's notebook, Health and Safety Officer's notebook, etc.), but shall summarize the contents of these other notebooks and refer to the page locations in these notebooks for detailed information. An example of a site logbook page is shown in Attachment A.

The sample logsheet for each sample collected (see Procedure SA-6.6) must be referenced. If measurements are made at any location, the measurements and equipment used must either be recorded in the site logbook or reference must be made to the notebook and page number(s) on which they are recorded (see Attachment A).

All entries shall be made in black pen. No erasures are permitted. If an incorrect entry is made, the data shall be crossed out with a single strike mark, and initialed and dated. At the completion of entries by any individual, the logbook must be signed. It must also be signed by the Field Operations Leader or responsible site leader at the end of each day.

5.2 PHOTOGRAPHS

When movies, slides, or photographs are taken of a site or any monitoring location, they are numbered to correspond to logbook entries. The name of the photographer, date, time, site location, site description, and weather conditions are entered in the logbook as the photographs are taken. A series entry may be used for rapid-sequence photographs. The photographer is not required to record the aperture settings and shutter speeds for photographs taken within the normal automatic exposure range. However, special lenses, films, filters, and other image-enhancement techniques must be noted in the logbook. If possible, such techniques shall be avoided, since they can adversely affect the admissibility of photographs as evidence. Chain-of-custody procedures depend upon the subject matter, type of film, and the processing it requires. Film used for aerial photography, confidential information, or criminal investigation require chain-of-custody procedures. Adequate logbook notation and receipts may be used to account for routine film processing. Once processed, the slides of photographic prints shall be serially numbered and labeled according to the logbook descriptions.

6.0 REFERENCES

None.

7.0 ATTACHMENTS

Attachment A - Typical Site Logbook Entry

ATTACHMENT A
TYPICAL SITE LOGBOOK ENTRY

START TIME: ____________ DATE: ____________

SITE LEADER: ____________________
PERSONNEL:

NUS	DRILLER	EPA

WEATHER: Clear, 68°F, 2-5 mph wind from SE

ACTIVITIES:

1. Steam jenney and fire hoses were set up.

2. Drilling activities at well ______ resumes. Rig geologist was ______________. See Geologist's Notebook, No. 1, page 29-30, for details of drilling activity. Sample No. 123-21-S4 collected; see sample logbook, page 42. Drilling activities completed at 11:50 and a 4 inch stainless steel well installed. See Geologist's Notebook, No. 1, page 31, and well construction details for well ________.

3. Drilling rig No. 2 steam-cleaned at decontamination pit. Then set up at location of well ________.

4. Well ________ drilled. Rig geologist was ____________________. See Geologist's Notebook, No. 2, page ______ for details of drilling activities. Sample numbers 123-22-S1, 123-22-S2, and 123-22-S3 collected; see sample logbook, pages 43, 44, and 45.

5. Well ________ was developed. Seven 55-gallon drums were filled in the flushing stage. The well was then pumped using the pitcher pump for 1 hour. At the end of the hour, water pumped from well was "sand free."

6. EPA remedial project manger arrives on-site at 14:25 hours.

7. Large dump truck arrives at 14:45 and is steam-cleaned. Backhoe and dump truck set up over test pit ________.

8. Test pit ________ dug with cuttings placed in dump truck. Rig geologist was ______________. See Geologist's Notebook, No. 1, page 32, for details of test pit activities. Test pit subsequently filled. No samples taken for chemical analysis. Due to shallow groundwater table, filling in of test pit _____ resulted in a very soft and wet area. A mound was developed and the area roped off.

9. Express carrier picked up samples (see Sample Logbook, pages 42 through 45) at 17:50 hours. Site activities terminated at 18:22 hours. All personnel offsite, gate locked.

____
Field Operations Leader

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Subject SAMPLE PRESERVATION		Approved D. Senovich	

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1.0 PURPOSE

This procedure describes the appropriate containers to be used for samples depending on the analyses to be performed, and the steps necessary to preserve the samples when shipped offsite for chemical analysis.

2.0 SCOPE

Different types of chemicals react differently with sample containers made of various materials. For example, trace metals adsorb more strongly to glass than to plastic, while many organic chemicals may dissolve various types of plastic containers. It is therefore critical to select the correct container in order to maintain the quality of the sample prior to analysis.

Many water and soil samples are unstable, and therefore require preservation when the time interval between field collection and laboratory analysis is long enough to produce changes in either the concentration or the physical condition of the constituent(s) requiring analysis. While complete and irreversible preservation of samples is not possible, preservation does retard the chemical and biological changes that inevitably take place after the sample is collected.

Preservation techniques are usually limited to pH control, chemical addition(s) and refrigeration/ freezing. Their purpose is to (1) retard biological activity, (2) retard hydrolysis of chemical compounds/complexes, (3) reduce constituent volatility, and (4) reduce adsorption effects.

3.0 GLOSSARY

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

Normality (N) - Concentration of a solution expressed as equivalent per liter, an equivalent being the amount of a substance containing one gram-atom of replaceable hydrogen or its equivalent. Thus, a one molar solution of HCl, containing one gram-atom of H, is "one-normal," while a one molar solution of H_2SO_4 containing two gram-atoms of H, is "two-normal."

4.0 RESPONSIBILITIES

Field Operations Leader - retains overall responsibility for the proper storage and preservation of samples. During the actual collection of samples, the sampling technician(s) will be directly responsible for the bottling, preservation, labeling, and custody of the samples they collect until released to another party for storage or transport to the analytical laboratory.

5.0 PROCEDURES

5.1 SAMPLE CONTAINERS

For most samples and analytical parameters either glass or plastic containers are satisfactory. In general, if the analyte(s) to be determined is organic in nature, the container shall be made of glass. If the analyte(s) is inorganic, then the container shall be plastic. Since container specification will depend on the analyte and sample matrix types (as indicated in Attachment A) duplicate samples shall be taken when both organic and inorganic analyses are required. Containers shall be kept in the dark (to minimize biological or photooxidation/photolysis breakdown of constituent) until they reach the analytical laboratory. The sample container shall allow approximately 5-10 percent air space ("ullage") to allow for expansion/vaporization if the sample is heated during transport (1 liter of water at 4°C expands by 15 ml if heated to 130°F/55°C), however, head space for volatile organic analyses shall be omitted.

For CLP laboratories, containers will be obtained through the CLP Sample Management Office. For Responsible party actions or non-CLP laboratories, the laboratory shall provide containers that have been cleaned according to U.S. EPA procedures. Sufficient lead time shall be allowed. Shipping containers for samples, consisting of sturdy ice chests, are provided by the laboratory of the remedial investigation contractor.

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

General sample container and sample volume requirements are listed in Attachment A. Specific container requirements are listed in Attachment B.

5.2 PRESERVATION TECHNIQUES

The preservation techniques to be used for various analytes are listed in Attachments A and B. Reagents required for sample preservation will either be added to the sample containers by the laboratory prior to their shipment to the Field or added in the Field. In general, aqueous samples of low concentration organics (or soil samples of low or medium concentration organics) are cooled to 4°C. Medium concentration aqueous samples and high hazard organics sample are not preserved. Low concentration aqueous samples for metals are acidified with HNO_3, while medium concentration and high hazard aqueous metal samples are not preserved. Low or medium concentration soil samples for metals are cooled to 4°C while high hazard samples are not preserved.

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

5.2.1 Addition of Acid (H_2SO_4, HCl, or HNO_3) or Base

Addition of the following acids or bases may be specified for sample preservation; these reagents shall be analytical reagent (AR) grade and shall be diluted to the required concentration with double-distilled, deionized water in the laboratory, before Field sampling commences:

Acid Base	Concentration	Normality	Amount for Acidification*
HCl	1:1 dilution of concentrated HCl	6N	5-10 ml
H_2SO_4	1:1 dilution of concentrated H_2SO_4	18N	2-5 ml
HNO_3	Undiluted concentrated HNO_3	16N	2-5 ml
NaOH	400 grams solid NaOH in 870 ml water	10N	2 ml**

* Amount of acid to add (at the specified strength) per liter of water to reduce the sample pH to less than 2, assuming that the water is initially at pH 7, and is poorly buffered and does not contain particulate matter.

** To raise pH of 1 liter of water to 12.

The approximate volumes needed to acidify one liter of neutral water to a pH of less than 2 (or raise the pH to 12) are shown in the last column of the above table. These volumes are only approximate; if the water is more alkaline, contains inorganic or organic buffers, or contains suspended particles, more acid may be required. The final pH must be checked using narrow-range pH paper.

Sample acidification or base addition shall proceed as follows:

- Check initial pH of sample with wide range (0-14) pH paper.
- Fill sample bottle to within 5-10 ml of final desired volume and add about 1/2 of estimated acid or base required, stir gently and check pH with medium range pH paper (pH 0-6 or pH 7.5-14, respectively).
- Add acid or base a few drops at a time while stirring gently. Check for final pH using narrow range (0-2.5 or 11-13, respectively) pH paper; when desired pH is reached, cap sample bottle and seal.

  Never dip pH paper into the sample; apply a drop of sample to the pH paper using the stirring rod.

5.2.2 Cyanide Preservation

Pre-sample preservation is required if oxidizing agents such as chlorine are suspected to be present. To test for oxidizing agents, place a drop of the sample on KI-starch paper; a blue color indicates the need for treatment. Add ascorbic acid to the sample, a few crystals at a time, until a drop of sample produces no color on the KI-starch paper. Then add an additional 0.6 g of ascorbic acid for each liter of sample volume. Add NaOH solution to raise pH to greater than 12 as described in 5.2.1. If oxidizing agents are not suspected, add NaOH as directed.

5.2.3 Sulfide Preservation

Samples for sulfide analysis must be preserved by addition of 4 drops (0.2 ml) of 2N zinc acetate solution per 100 ml sample. The sample pH is then raised to 9 using NaOH. The 2N zinc acetate solution is made by dissolving 220 g of zinc acetate in 870 ml of distilled water to make 1 liter of solution.

5.2.4 Preservation of Organic Samples Containing Residual Chlorine

Some organic samples containing residual chlorine must be treated to remove this chlorine upon collection (See Attachment A). Test the samples for residual chlorine using EPA methods 330.4 or 330.5 (Field Test Kits are available for this purpose). If residual chlorine is present, add 0.008% sodium thiosulfate (80 mg per liter of sample).

5.2.5 Field Filtration

When the objective is to determine concentration of dissolved inorganic constituents in a water system, the sample must be filtered through a non-metallic 0.45 micron membrane filter immediately after collection. A filtration system is recommended if large quantities of samples must be filtered in the field. The filtration system shall consist of a Büchner funnel inserted into a single-hole rubber stopper, sized to form a seal when inserted into the top of a vacuum filter flask equipped with a single side arm. Heavy-wall Tygon tubing shall be attached to the single side arm of the vacuum filter flask and the suction port of a vacuum pump. The stem of the Büchner funnel shall extend below the level of the side arm of the vacuum filter flask to prevent any solvent from entering the tubing leading to the vacuum pump. Before filtration, the filter paper, which shall be of a size to lay flat on the funnel plate, shall be wetted with the solvent in order to "seal" it to the funnel. Slowly pour the solvent into the funnel and monitor the amount of solvent entering the vacuum filter flask. When the rate of solvent entering the flask is reduced to intermittent dripping and the added aliquot of solvent in the funnel has passed through the filter, the used filter paper shall be replaced with new filter paper. If the solvent contains a high percentage of suspended solids, a coarser-sized nonmetallic membrane filter may be used prior to usage of the 0.45 micron membrane filter. This "prefiltering" step may be necessary to expedite the filtration procedure. Discard the first 20 to 50 ml of filtrate from each sample to rinse the filter and filtration apparatus to minimize the risk of altering the composition of the samples by the filtering operation. For analysis of dissolved metals, the filtrate is collected in a suitable bottle (see Section 5.1) and is immediately acidified to pH 2.0 or less with nitric acid whose purity is consistent with the measurement to be made. Inorganic anionic constituents may be determined using a portion of the filtrate that has not been acidified.

Samples used for determining temperature, dissolved oxygen, Eh, and pH should not be filtered. Do not use vacuum filtering prior to determining carbonate and bicarbonate concentration because it removes dissolved carbon dioxide and exposes the sample to the atmosphere. Pressure filtration can be done using water pressure from the well. If gas pressure is required, use an inert gas such as argon or nitrogen.

Do not filter samples for analysis of volatile organic compounds. If samples are to be filtered for analyzing other dissolved organic constituents, use a glass-fiber or metal-membrane filter and collect the samples in a suitable container (see Section 5.1). Because most organic analyses require extraction of the entire sample, do not discard any of it. After filtering, the membrane containing the suspended fraction can be sealed in a glass container and analyzed separately as soon as practicable. Total recoverable inorganic constituents may be determined using a second, unfiltered sample collected at the same time as the sample for dissolved constituents.

6.0 REFERENCES

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

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

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

7.0 ATTACHMENTS

Attachment A - General Sample Container and Preservation Requirements CERCLA/RCRA Samples

Attachment B - Required Containers, Preservation Techniques, and Holding Times (3 sheets)

ATTACHMENT A
GENERAL SAMPLE CONTAINER AND PRESERVATION REQUIREMENTS CERCLA/RCRA SAMPLES

FT-7.06
REVISION 0

	SAMPLE TYPE & CONCENTRATION	CONTAINER[1]	SAMPLE SIZE	PRESERVATION[2]	HOLDING TIME[2]
WATER					
Organics (GC & GC/MS)	VOA	borosilicate glass	2 x 40 ml	Cool to 4°C	7 days
	Extractables				
	Low	amber glass	2 x 2 l or 4 x 1 l	Cool to 4°C	5 days to extraction 40 days after extraction
	Medium	wide-mouth glass	4 x 32 oz	None	Same as above
Inorganics	Metals				
	Low	high density (h.d.) polyethylene	1 l	HNO_3 to pH ≤2	6 months (Hg-30 days)
	Medium	wide-mouth glass	16 oz	None	6 months
	Cyanide				
	Low	h.d. polyethylene	1 l	NaOH to pH >12	14 days
	Medium	wide-mouth glass	16 oz	None	
Organic/Inorganic	High Hazard	8 oz wide-mouth glass	6 oz	None	14 days
COD	--	h.d. polyethylene	0.5 l	H_2SO_4 to pH <2	28 days
TOC	--	h.d. polyethylene	0.5 l	HCl to pH <2	28 days
Oil & Grease	--	glass	1.0 l	H_2SO_4 to pH <2	28 days
Phenols	--	h.d. polyethylene	1.0 l	H_2SO_4 to pH <2	28 days
General Chemistry	--	h.d. polyethylene	1.0 l	None	---
SOIL					
Organics (GC & GC/MS)	VOA	2 x 120 ml (4 oz) wide-mouth glass	240 ml	Cool to 4°C	10 days
	Extractables				
	Low/Medium	8 oz or 2 x 4 oz (120 ml) wide-mouth glass	6 oz	Cool to 4°C	10 days to extraction 40 days after extraction
Inorganics	Low/Medium	8 oz or 2 x 4 oz (120 ml) wide-mouth glass	6 oz	Cool to 4°C	NA
Organic/Inorganic	High Hazard	8 oz (120 ml) wide-mouth glass	6 oz	None	NA
Dioxin	All	4 oz (120 ml) wide-mouth glass	4 oz	None	NA
EP Toxicity	All	250 ml h.d. polyethylene	200 grams	None	NA
Air					
Volatile Organics	Low Medium	Charcoal Tube 7 cm long, 6 mm OD, 4 mm ID	100 l air	Cool to 4°C	NA

1. All glass containers should have Teflon cap liners or septa.
2. See Attachment B.

SAMPLE CONTAINER AND PRESERVATION REQUIRMENTS CERCLA/RCRA SAMPLES

ATTACHMENT B
REQUIRED CONTAINERS, PRESERVATION TECHNIQUES, AND HOLDING TIMES
PAGE 1

Parameter No./Name	Container[1]	Preservation[2,3]	Maximum Holding Time[4]
INORGANIC TESTS:			
Acidity	P,G	Cool, 4°C	14 days
Alkalinity	P,G	Cool, 4°C	14 days
Ammonia	P,G	Cool, 4°C, H_2SO_4 to pH 2	28 days
Biochemical Oxygen Demand	P,G	Cool, 4°C	48 hours
Bromide	P,G	None required	28 days
Biochemical Oxygen Demand, Carbonaceous	P,G	Cool, 4°C	48 hours
Chemical Oxygen Demand	P,G	Cool, 4°C, H_2SO_4 to pH 2	28 days
Chloride	P,G	None required	28 days
Chlorine, Total Residual	P,G	None required	Analyze immediately
Color	P,G	Cool, 4°C	48 hours
Cyanide, Total and Amenable to Chlorination	P,G	Cool, 4°C, NaOH to pH 12, 0.6g ascorbic acid[5]	14 days[6]
Fluoride	P	None required	28 days
Hardness	P,G	HNO_3 to pH 2, H_2SO_4 to pH 2	6 months
Hydrogen Ion (pH)	P,G	None required	Analyze immediately
Kjeldahl and Organic Nitrogen	P,G	Cool, 4°C, H_2SO_4 to pH 2	28 days
Nitrate	P,G	Cool, 4°C	48 hours
Nitrate-Nitrite	P,G	Cool, 4°C, H_2SO_4 to pH 2	28 days
Nitrite	P,G	Cool, 4°C	48 hours
Oil and Grease	G	Cool, 4°C, H_2SO_4 to pH 2	28 days
Organic Carbon	P,G	Cool, 4°C, HCl or H_2SO_4 to pH 2	28 days
Orthophosphate	P,G	Filter immediately, Cool, 4°C	48 hours
Oxygen, Dissolved-Probe	G Bottle and top	None required	Analyze immediately
Oxygen, Dissolved-Winkler	G Bottle and top	Fix on site and store in dark	8 hours
Phenols	G	Cool, 4°C, H_2SO_4 to pH 2	28 days
Phosphorus (elemental)	G	Cool, 4°C	48 hours
Phosphorus, Total	P,G	Cool, 4°C, H_2SO_4 to pH 2	28 days
Residue, Total	P,G	Cool, 4°C	7 days
Residue, Filterable	P,G	Cool, 4°C	48 hours
Residue, Nonfilterable (TSS)	P,G	Cool, 4°C	7 days
Residue, Settleable	P,G	Cool, 4°C	48 hours
Residue, Volatile	P,G	Cool, 4°C	7 days
Silica	P	Cool, 4°C	28 days
Specific Conductance	P,G	Cool, 4°C	28 days
Sulfate	P,G	Cool, 4°C	28 days
Sulfide	P,G	Cool, 4°C, add zinc acetate plus sodium hydroxide to pH 9	7 days
Sulfite	P,G	None required	Analyze immediately
Surfactants	P,G	Cool, 4°C	48 hours
Temperature	P,G	None required	Analyze immediately
Turbidity	P,G	Cool, 4°C	48 hours
METALS:[7]			
Chromium VI	P,G	Cool, 4°C	24 hours
Mercury	P,G	HNO_3 to pH 2	28 days
Metals, except Chromium VI and Mercury	P,G	HNO_3 to pH 2	6 months

ATTACHMENT B
REQUIRED CONTAINERS, PRESERVATION TECHNIQUES, AND HOLDING TIMES

PAGE 2

Parameter No./Name	Container[1]	Preservation[2,3]	Maximum Holding Time[4]
ORGANIC TESTS:[8]			
Purgeable Halocarbons	G, Teflon-lined septum	Cool, 4°C, 0.008% $Na_2S_2O_3$[5]	14 days
Purgeable Aromatic Hydrocarbons	G, Teflon-lined septum	Cool, 4°C, 0.008% $Na_2S_2O_3$[5] HCl to pH 2[9]	14 days
Acrolein and Acrylonitrile	G, Teflon-lined septum	Cool, 4°C, 0.008% $Na_2S_2O_3$[5] adjust pH to 4-5[10]	14 days
Phenols[11]	G, Teflon-lined cap	Cool, 4°C, 0.008% $Na_2S_2O_3$[5]	7 days until extraction, 40 days after extraction[13]
Benzidines[11]	G, Teflon-lined cap	Cool, 4°C, 0.008% $Na_2S_2O_3$[5]	7 days until extraction
Phthalate Esters[11]	G, Teflon-lined cap	Cool, 4°C	7 days until extraction, 40 days after extraction
Nitrosamines[11,14]	G, Teflon-lined cap	Cool, 4°C, store in dark, 0.008% $Na_2S_2O_3$[5]	7 days until extraction, 40 days after extraction
PCBs[11] Acrylonitrile	G, Teflon-lined cap	Cool, 4°C	7 days until extraction, 40 days after extraction
Nitroaromatics and Isophorone[11]	G, Teflon-lined cap	Cool, 4°C, 0.008% $Na_2S_2O_3$[5], store in dark	7 days until extraction, 40 days after extraction
Polynuclear Aromatic Hydrocarbons[11]	G, Teflon-lined cap	Cool, 4°C, 0.008% $Na_2S_2O_3$[5], store in dark	7 days until extraction, 40 days after extraction
Haloethers[11]	G, Teflon-lined cap	Cool, 4°C, 0.008% $Na_2S_2O_3$[5]	7 days until extraction, 40 days after extraction
Chlorinated Hydrocarbons[11]	G, Teflon-lined cap	Cool, 4°C	7 days until extraction, 40 days after extraction
TCDD[11]	G, Teflon-lined cap	Cool, 4°C, 0.008% $Na_2S_2O_3$[5]	7 days until extraction, 40 days after extraction
PESTICIDES TESTS:			
Pesticides[11]	G, Teflon-lined cap	Cool, 4°C, pH 5-9[15]	7 days until extraction, 40 days after extraction
RADIOLOGICAL TESTS:			
1-5 Alpha, beta and radium	P, G	HNO_3 to pH 2	6 months

TABLE 1 Notes

(1) Polyethylene (P) or Glass (G).

(2) Sample preservation should be performed immediately upon sample collection. For composite chemical samples each aliquot should be preserved at the time of collection. When use of an automated sampler makes it impossible to preserve each aliquot, then chemical samples may be preserved by maintaining at 4°C until compositing and sample splitting is completed.

(3) When any sample is to be shipped by common carrier or sent through the United States Mails, it must comply with the Department of Transportation Hazardous Materials Regulations (49 CFR Part 172).

(4) Samples should be analyzed as soon as possible after collection. The times listed are the maximum times that samples may be held before analysis and still be considered valid. Samples may be held for longer periods only if the permittee, or monitoring laboratory, has data on file to show that the specific types of samples under study are stable for the longer time, and has received a variance from the Regional Administrator.

(5) Should only be used in the presence of residual chlorine.

ATTACHMENT B
REQUIRED CONTAINERS, PRESERVATION TECHNIQUES, AND HOLDING TIMES

(6) Maximum holding time is 24 hours when sulfide is present. Optionally, all samples may be tested with lead acetate paper before pH adjustments in order to determine if sulfide is present. If sulfide is present, it can be removed by the addition of cadmium nitrate powder until a negative spot test is obtained. The sample is filtered and then NaOH is added to pH 12.

(7) Samples should be filtered immediately on-site before adding preservative for dissolved metals.

(8) Guidance applies to samples to be analyzed by GC, LC, or GC/MS for specific compounds.

(9) Sample receiving no pH adjustment must be analyzed within seven days of sampling.

(10) The pH adjustment is not required if acrolein will not be measured. Samples for acrolein receiving no pH adjustment must be analyzed within 3 days of sampling.

(11) When the extractable analytes of concern fall within a single chemical category, the specified preservative and maximum holding times should be observed for optimum safeguard of sample integrity. When the analytes of concern fall within two or more chemical categories, the sample may be preserved by cooling to 4°C, reducing residual chlorine with 0.008% sodium thiosulfate, storing in the dark, and adjusting the pH to 6-9; samples preserved in this manner may be held for seven days before extraction and for forty days after extraction. Exceptions to this optional preservation and holding time procedure are noted in footnote 5 (re: the requirement for thiosulfate reduction of residual chlorine) and footnotes 12, 13 (re: the analysis of benzidine).

(12) If 1,2-diphenylhydrazine is likely to be present, adjust the pH of the sample to 4.0±0.2 to prevent rearrangement to benzidine.

(13) Extracts may be stored up to 7 days before analysis if storage is conducted under an inert (oxidant-free) atmosphere.

(14) For the analysis of diphenylnitrosamine add 0.008% $Na_2S_2O_3$ and adjust pH to 7-10 with NaOH within 24 hours of sampling.

(15) The pH adjustment may be performed upon receipt at the laboratory and may be omitted if the samples are extracted within 72 hours of collection. For the analysis of aldrin, add 0.008% $Na_2S_2O_3$.

NUS CORPORATION

ENVIRONMENTAL MANAGEMENT GROUP

STANDARD OPERATING PROCEDURES

Number: ME-02	Page:
Effective Date: 05/04/90	Revision: 1
Applicability: EMG	
Prepared: Health and Safety	
Approved: D. Senovich	

Subject: OVA 128 ORGANIC VAPOR ANALYZER

TABLE OF CONTENTS

1.0 OBJECTIVE

To establish procedures for the use, maintenance, and calibration of the OVA 128 Vapor Analyzer.

2.0 SCOPE

Applies to each usage of the OVA instrument in implementation of the NUS/EMG Program.

3.0 GLOSSARY

None.

4.0 RESPONSIBILITIES

Office Health and Safety Supervisor (OHSS) - The OHSS shall insure that the user has been appropriately trained and certified in the usage of the OVA. He shall also insure that the instrument is properly maintained and calibrated prior to its release for field service.

Instrument User - The user should be personally secure that he or she has been adequately trained, understands the operation of the OVA, and limitations of the instrument. He or she should also be sure that the instrument has been calibrated and is working properly.

5.0 PROCEDURES

5.1 PRINCIPLE OF OPERATION

The OVA operates in two different modes. In the survey mode, it can determine the approximate concentration of all detectable species in air. With the gas chromatograph option, individual components can be detected and measured independently, with some detection limits as low as a few parts per billion.

5.2 GAS CHROMATOGRAPH FUNCTION

In the Gas Chromatograph (GC) mode, a small sample of ambient air is injected into a chromatographic column and carried through the column by a stream of hydrogen gas. Contaminants with different chemical structures are retained on the column for different lengths of time (known as retention times) and, hence, are detected separately by the flame ionization detector. A strip chart recorder can be used to record the retention times, which are then compared to the retention times of a standard with known chemical constituents. The sample can be injected into the column either from the air-sampling hose or directly from a gas-tight syringe.

5.3 CALIBRATION

The OVA is internally calibrated to methane by the manufacturer. When measuring methane, it indicates the true concentration. In response to all other detectable compounds, however, the instrument reading may be higher or lower than the true concentration. Relative response ratios for substances other than methane are available. To interpret the readout correctly, it is necessary either to make calibration charts relating the instrument readings to the true concentrations or to adjust the instrument, so that it reads correctly. This second procedure is done by turning the 10-turn, gas-select knob, which adjusts the response of the instrument. The knob is normally set at 300 when calibrated to methane. Secondary calibration to another gas is done by sampling a known concentration of the gas and adjusting the gas-select knob, until the instrument reading equals the true concentration.

5.4 LIMITATIONS

The OVA has an inherent limitation in that it can detect only organic molecules. Also, it should not be used at temperatures lower than about 40°F, because gases condense in the pump and column. It has no temperature control and, since retention times vary with ambient temperatures for a given column, absolute determinations of contaminants are difficult. Despite these limitations, the GC mode can often provide tentative information on the identity of contaminants in air without relying on costly, time-consuming laboratory analysis.

5.5 CAUTIONS

The instrument can monitor only certain vapors and gases in air. Many nonvolatile liquids, toxic solids, particulates, and other toxic gases and vapors cannot be detected. Because the types of compounds that the OVA can potentially detect are only a fraction of the chemicals possibly present at an incident, a zero reading does not necessarily signify the absence of air contaminants.

The instrument is nonspecific, and its response to different compounds is relative to the calibration setting. Instrument readings may be higher or lower than the true concentrations. These discrepancies can be especially serious problems when monitoring for total contaminant concentrations, if several different compounds are being detected at once. In addition, the response of this instrument is not linear over the entire detection range. Care must, therefore, be taken when interpreting the data. All identifications should be reported as tentative until they can be confirmed by more precise analysis. Concentrations should be reported in terms of the calibration gas and span potentiometer or gas-select knob setting.

This instrument cannot be used as an indicator for combustible gases or oxygen deficiency.

6.0 REFERENCES

Century Systems (Foxboro). Service Procedures: Organic Vapor Analyzer; 128GC.

7.0 ATTACHMENTS

Attachment A – Start-up and Shutdown Procedures (2 Sheets)
Attachment B – Maintenance and Calibration Schedule
Attachment C – Calibration Procedure (2 Sheets)
Attachment D – Pump System Checkout
Attachment E – Burner Chamber Cleaning
Attachment F – Quad Ring Service
Attachment G – Troubleshooting (2 Sheets)
Attachment H – Shipping
Attachment I – D.O.T. Exemption Permit (2 Sheets)
Attachment J – D.O.T. Exemption Permit Extension
Attachment K – Hydrogen Recharging
Attachment L – Particle Filter Servicing
Attachment M – Flow Diagram - Gas Handling System

ATTACHMENT A

START-UP AND SHUTDOWN PROCEDURES

START-UP

1. Connect the probe/read out connectors to the side-pack assembly.

2. Check battery condition and hydrogen supply.

3. For measurement taken as methane equivalent, check that the GAS SELECT Dial is set at 300.

4. Turn the electronics on by moving the INSR switch to the ON position and allow five (5) minutes for warm-up.

5. Set CALIBRATE switch to X10, use CALIBRATE knob to set indicator at 0.

6. Open the H_2 tank valve and the H_2 supply valve all the way. Check that the hydrogen supply gauge reads between 8.0 and 12.0 psig.

7. Turn the PUMP switch ON and check the flow system, according to the procedures in Attachment D.

8. Check that the BACKFLUSH and INJECT valves are in the UP position.

9. To light the flame, depress the igniter switch until a meter deflection is observed. The igniter switch may be depressed for up to five (5) seconds. Do not depress for longer than five (5) seconds, since it may burn out the igniter coil. If the instrument does not light, allow it to run several minutes and repeat ignition attempt.

10. Confirm OVA operational state by sniffing an organic source, such as a magic marker.

11. Establish a background level in a clean area, by using the charcoal scrubber (depress the sample inject valve) and recording measurements referenced to background.

12. Set the alarm level, if desired.

SHUT DOWN

1. Close H_2 supply valve and H_2 tank valve (Do Not Overtighten Valves).

2. Turn INSTR switch to OFF.

3. Wait until H_2 supply gauge indicates system is purged of H_2, then switch off pump.

4. Put instrument on electrical charger at completion of day's activities.

ATTACHMENT B

MAINTENANCE AND CALIBRATION SCHEDULE

• Check Particle Filters	Weekly or as-needed
• Check Quad Rings	Monthly or as-needed
• Clean Burner Chamber	Monthly or as-needed
• Secondary Calibration Check	Prior to project start-up
• Primary Calibration Check	Monthly or if secondary check is off by more than ± 10%
• Check Pumping System	Prior to project start-up
• Replace Charcoal	120 hours of use or when background readings are higher with the inject valve down than with the inject valve up, in a clean environment.
• Factory Service	At least annually

* Instruments which are not in service for extended periods of time need not meet the above schedule. However, they must be given a complete check-out prior to their first use addressing the above maintenance items.

ATTACHMENT C

CALIBRATION PROCEDURE

PRIMARY CALIBRATION

1. Remove instrument components from the instrument shell.

2. Turn on Electronics and Zero instrument on X10 scale. Gas select dial to 300.

3. Turn on Pump and Hydrogen. Ignite Flame. Go to Survey Mode.

4. Introduce a Methane Standard near 100 ppm.

5. Adjust R-32 Trimpot on Circuit Board to make meter read to standard.

6. Turn off hydrogen flame and adjust meter needle to read 40 ppm (calibrate @ X10) using the calibration adjust knobs.

7. Switch to X100 Scale. The meter should indicate 0.4 on the 1-10 meter markings (0.4 x 100 = 40 ppm). If the reading is off, adjust with R33 Trimpot.

8. Return to X10 Scale and adjust meter needle to 40 ppm with calibration adjust knob, if necessary.

9. At the X10 Scale, adjust meter to read 0.4 on the 1-10 meter markings using the calibration adjust. Switch to X1 scale. The meter should read 4 ppm. If the reading is off, adjust using the R-31 Trimpot.

SECONDARY CALIBRATION

1. Fill an air sampling bag with 100 ppm (Certified) methane calibration gas.

2. Connect the outlet of the air sampling bag to the air sampling line of the OVA.

3. Record the reading obtained off the meter onto the calibration record.

DOCUMENTATION

Each office shall develop a system, whereby the following calibration information is recorded.

a. Instrument calibrated (I.D. or Serial No.)

b. Date of calibration

c. Method of calibration

d. Results of the calibration

e. Identification of person who calibrated the instrument

f. Identification of the calibration gas (source, type, concentration, Lot No.)

ATTACHMENT D

PUMP SYSTEM CHECKOUT

1. With pump on hold unit upright and observe flow gauge.
2. Ball level significantly below a reading of 2 is inadequate flow.
3. Check connections at the sample hose.
4. Clean or replace particle filters, if flow is impaired or it is time for scheduled service.
5. Reassemble and retest flow.
6. If flow still inadequate, replace pump diaphragm and valves.
7. If flow normal, plug air intake. Pump should slow and stop.
8. If no noticeable change in pump, tighten fittings and retest.
9. If still no change, replace pump diaphragm and valves.
10. Document this function in the maintenance records.

ATTACHMENT E

BURNER CHAMBER CLEANING

1. Remove plastic exhaust port cover.
2. Unscrew exhaust port.
3. Use wire brush to clean burner tip and electrode. Use wood stick to clean Teflon.
4. Brush inside of exhaust port.
5. Blow out chamber with a gentle air flow.
6. Reassemble and test unit.
7. Document this function in the maintenance records.

ATTACHMENT F

QUAD RING SERVICE

1. Remove OVA guts from protective shell.
2. Remove clip ring from bottom of valve.
3. Unscrew nut from top of valve.
4. Gently pull valve shaft upward and free of housing.
5. Observe rings for signs of damage - replace as necessary.
6. Lightly grease rings with silicone grease.
7. Reassemble valve - do not pinch rings during shaft insertion.
8. Document this function in the maintenance records.

ATTACHMENT G

TROUBLESHOOTING

Indication	Possible Causes
• High Background Reading (More than 10 ppm)	1. Contaminated Hydrogen 2. Contaminated Sample Line
• Continual Flameout	1. Hydrogen Leak 2. Dirty Burner Chamber 3. Dirty Air Filters
• Low Air Flow	1. Dirty Air Filter 2. Pump Malfunction 3. Line Obstruction
• Flame Will Not Light	1. Low Battery 2. Ignitor Broken 3. Hydrogen Leak 4. Dirty Burner Chamber 5. Air Flow Restricted
• No Power to Pump	1. Low Battery 2. Short Circuit
• Hydrogen Leak (Instrument Not in Use)	1. Leak in Regulator 2. Leak in Valves

ATTACHMENT G
TROUBLESHOOTING
PAGE TWO

To be performed by qualified technician only.

1. No meter response in any switch position (including BATT CHK).

   A. Broken meter movement.
      (1) Tip instrument rapidly from side to side. Meter needle should move freely and return to zero.

   B. Electrical connection to meter is broken.
      (1) Check all wires leading to meter and clean the contacts of quick-disconnects.

   C. Battery is completely dead.
      (1) Disconnect battery and check voltage with a volt-ohm meter.

   D. If none of the above solves the problem, consult the factory.

2. Meter responds in BATT CHK position, but reads zero or near zero for all others.

   A. Power supply defective.
      (1) Check power supply voltages per Figure 11 of the HNU owner's manual. If any voltage is out of specification, consult the factory.

   B. Input transistor or amplifier has failed.
      (1) Check input connector on printed circuit board. The input connector should be firmly pressed down.
      (2) Check components on back side of printed circuit board. All connections should be solid and no wires should touch any other object.
      (3) Check all wires in readout for solid connections.

ATTACHMENT H

SHIPPING

Since the OVA-128 contains hydrogen, it is subject to shipping restrictions.

As Personal Luggage

The OVA-128 can be taken on a plane as luggage, since a permit has been issued from the Department of Transportation to the manufacturer (Foxboro). Please refer to the original permit (Attachment 9) and the extended permit (Attachment 10).

Air Express

The following labels must be affixed to both sides of the OVA case when shipping OVA by Air Express.

- Danger - Peligro
- Flammable Gas
- Inside Container Complies with D.O.T. Regulations
- Hydrogen UN #1049
- Name and Address of Recipient

A hazardous air bill must be filled out. The following information is requested.

Proper Shipping Name	Hydrogen
Classification	Flammable Gas
I.D. No.	UN 1049
Net Quantity	75 Cubic Centimeters

In addition, the shipping's certification must be signed and marked CARGO AIRCRAFT ONLY.

ATTACHMENT I
D.O.T. EXEMPTION PERMIT

DEPARTMENT OF TRANSPORTATION
RESEARCH AND SPECIAL PROGRAMS ADMINISTRATION
WASHINGTON DC 2059

DRAFT

DOT-E 7607
(FIRST REVISION - CORRECTED COPY)

1. Century Systems Corporation, Arkansas City, Kansas, is hereby granted an exemption from those provisions of this Department's Hazardous Materials Regulations specified in paragraph 5 below to offer packages prescribed herein of a flammable gas for transportation in commerce subject to the limitations and special requirements specified herein. This exemption authorizes the shipment of hydrogen in certain non-DOT specification cylinders as described in paragraph 7 below, and provides no relief from any regulation other than as specifically stated. Each of the following is hereby granted the status of a party to this exemption:

U.S. Department of Health, Education and Welfare, Rockville, Maryland - PTE-1.

2. BASIS. This exemption is based on Century Systems Corporation's application dated March 10, 1978, submitted in accordance with 49 CFR 107.105 and the public proceeding thereon. The granting of party status is based on the following application submitted in accordance with 49 CFR 107.111 and the public proceeding thereon:

The U.S. Department of Health, Education and Welfare's application dated March 13, 1978.

3. HAZARDOUS MATERIALS (Descriptor and class). Hydrogen, flammable gas.

4. PROPER SHIPPING NAME (49 CFR 172.101). Hydrogen.

5. REGULATION AFFECTED. 49 CFR 172.101, 175.3.

6. MODE OF TRANSPORTATION AUTHORIZED. Passenger-carrying aircraft.

7. SAFETY CONTROL MEASURES. Packaging prescribed is a non-DOT specification seamless stainless steel cylinder of not more than 7.22 cubic inch water capacity; each cylinder to be pressure tested to at least 4000 psig, and charged to not more than 2100 psig at 70°F. The cylinder is a component part of a portable gas chromatograph.

8. SPECIAL PROVISIONS.

a. Each device must be shipped in a strong outside packaging as prescribed in 49 CFR 173.301(h).

b. A copy of this exemption must be carried aboard each aircraft used to transport packages covered by this exemption.

c. The pilot in command must be advised when the gas chromatograph is placed on board the aircraft.

d. The gas chromatograph must be appropriately secured.

DRAFT

Continuation of 1st Rev. DOT-E 7607 corrected copy

9. REPORTING REQUIREMENTS. Any incident involving loss of contents of the package must be reported to the Office of Hazardous Materials Regulation as soon as practicable.

10. EXPIRATION DATE. May 1, 1980.

ued at Washington, D.C.:

9-7-78
(DATE)

Alan I. Roberts
Associate Director for
Hazardous Materials Regulation
Materials Transportation Bureau

Address all inquiries to: Associate Director for Hazardous Materials Regulation, Materials Transportation Bureau, Research and Special Programs Administration, Department of Transportation, Washington, D.C., 20590. Attention: Exemptions Branch.

Dist: 3 of 1, FAA

DEPARTMENT OF TRANSPORTATION
RESEARCH AND SPECIAL PROGRAMS ADMINISTRATION
WASHINGTON, D.C. 20590

DOT-E 7607
(PTE)

In accordance with 49 CFR 107.111 of the Department of Transportation (DOT) Hazardous Materials Regulations the party(s) listed below are granted the status of party to DOT-E 7607.

The expiration date of the exemption is March 11, 1982 for the party(s) listed below. This authorization forms part of the exemption and must be attached to it.

13 JUN 1980
(DATE)

Alan I. Roberts
Associate Director for
Hazardous Materials Regulation
Materials Transportation Bureau

Dist: FAA

EXEMPTION HOLDER	APPLICATION DATE
Clayton Environmental Consultants, Inc. Southfield, Michigan	December 5, 1979
Foxboro Company Burlington, MA	March 24, 1980

ATTACHMENT J

D.O.T. EXEMPTION PERMIT EXTENSION

U.S. Department of Transportation

Research and Special Programs Administration

400 Seventh Street, S.W.
Washington, D.C. 20590

DOT-E 7607
(EXTENSION)

In accordance with 49 CFR 107.105 of the Department of Transportation (DOT) Hazardous Materials Regulations DOT-E 7607 is hereby extended by changing the expiration date in paragraph 10 from December 1, 1983 to September 1, 1985.

This extension applies only to party(s) listed below based on the application received in accordance with 49 CFR 107.105. All other terms of the exemption remain unchanged. This extension forms part of the exemption and must be attached to it.

Alan I. Roberts
Associate Director for
Hazardous Materials Regulation
Materials Transportation Bureau

OCT 27 1983
(DATE)

Dist: FAA

EXEMPTION HOLDER	APPLICATION DATE
Foxboro Company South Norwalk, Ct.	September 16, 1983

ATTACHMENT K

HYDROGEN RECHARGING

1. High grade hydrogen (99.999%) is required.
2. Connect the fill hose to the REFILL FITTING on the side Pack Assembly, with the FILL/BLEED valve in the OFF position.
3. Open H_2 supply bottle valve.
4. Place FILL/BLEED valve on fill hose in BLEED position momentarily to purge any air out of the system.
5. Crack the instrument TANK VALVE.
6. Open REFILL valve on instrument.
7. Place FILL/BLEED valve in FILL position until the instrument PRESSURE GAUGE equalizes with the H_2 SUPPLY BOTTLE PRESSURE GAUGE.
8. Shut REFILL valve, FILL/BLEED valve, and H_2 SUPPLY BOTTLE valve, in quick succession.
9. Turn FILL/BLEED valve to BLEED until hose pressure equalizes to atmospheric pressure.
10. Turn FILL/BLEED valve to FILL Position, then to BLEED position, then to OFF.
11. Close TANK on instrument.
12. Disconnect the FILL HOSE and replace protective nut on the REFILL FITTING.

ATTACHMENT L

PARTICLE FILTER SERVICING

There are two points in the air sampling line of the OVA where filters have been placed to keep particulates from entering the instrument. The location of these filters are indicated on the figure in Attachment M. The first filter is located in the probe assembly and the second filter (primary filter) is located on the side pack assembly. Cleaning procedures are as follows:

1. Detach the probe assembly from the readout assembly.

2. Disassemble the probe (the components unscrew).

3. The particle filter located within the probe can be cleaned by blowing air through the filter.

4. Reassemble the probe.

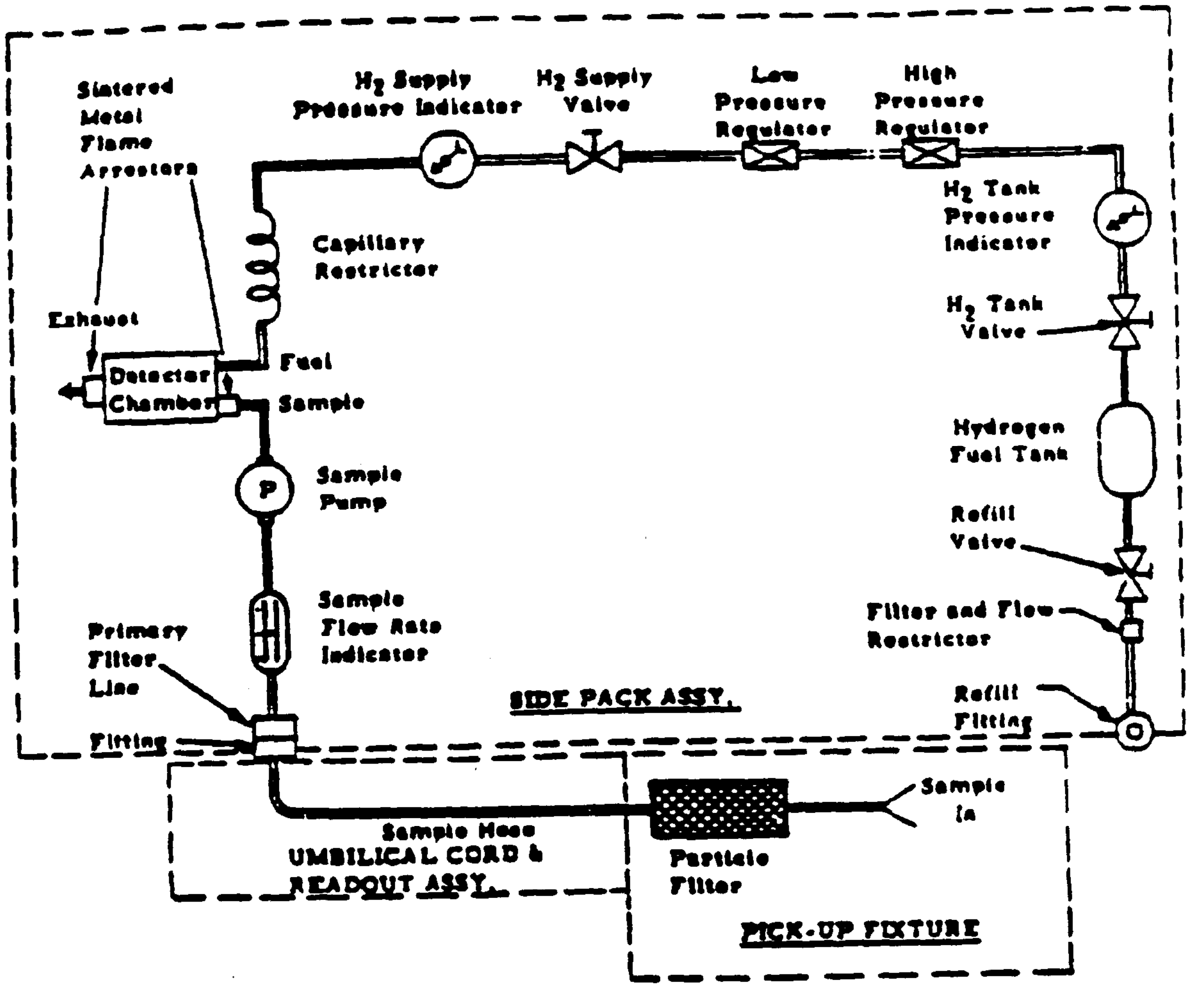
5. The primary filter, located behind the sample inlet connector on the side pack assembly, is accessed by removing the sample inlet connector with a thin-walled 7/16 inch socket wrench. Remove the filter and clean as above.

6. Reassemble the sample inlet fitting and filter to the side pack assembly.

7. Check sample flow rate.

ATTACHMENT M

FLOW DIAGRAM - GAS HANDLING SYSTEM



APPENDIX D

CONSTRUCTION DOCUMENTS

NARRATION

VI. APPENDIX "A"

#1. GENERAL DESIGN

The design of these buried tanks is interesting, especially on account of their size, and is also somewhat unusual. Some of the major considerations were the limitation of flotation effect as accomplished by drains around the periphery of the tank, and also the definitely assumed limitation in hydrostatic head. Then there was the question of prestressing.

The following assumptions were made: -

Floor of tank and walls were designed to withstand a hydrostatic head of 10' above the tank floor.

The roof was designed to withstand a fill load of 4' of earth amounting to 400# per s.

and a live load of 275# "

Concrete designed for a safe working stress of: -

For the fuel oil tanks, Class G-1	4000#	p.
" " Diesel " " " E-1	3000#	p.
Safe working stress of the steel	20000#	p.

The grade of concrete was chosen for its density or impermeability rather than for strength, the oil pressure and penetrating power also being factors.

As previously stated under Narration XI-F-2, pumping facilities were installed in the sump of each pump pit of the fuel oil tanks to prevent building up a dangerous accumulation of water in the backfilled excavation on the outside of the tank. In this connection while computations show that an empty tank is not sub to flotation until a surrounding external water depth more than 20' exists above the tank floor, a critical point is reached with an external water depth corres ing to only 12'. This is for the reason that under latter condition, the lift imposed on the tank bottom results in over-stressing the inverted continuous floor system supported only by the columns, which in turn are limited to the reaction or total weight of the roof slab above them. This combined reaction is made up of the weight of the column plus the weight of the roof panel, plus the superimposed dead load.

The design of the fuel oil tanks was worked out previously under contract NOy-5131, after careful review by the Bureau as to the alternative possibilities and comparisons of the conventional design versus prestressed design. The latter was selected by the Bureau on the ground that the prestressed type compared favorably, not only in structural adequacy, speed, and cost of construction, but was definitely superior to the conventional design in leakproof qualities. The latter factor or leakproof quality was considered to outweigh the slight advantage against bombing that the thicker walls of the conventional design would offer.

The design was based upon information forwarded by the Bureau drawn from previous experience in the construction of similar storage tanks up to 50,000 barrels capacity.

It might be added that the design developed by the Bureau of Yards and Docks was based upon original work on this type of structure by William S. Hewett, Consulting Engineer, Chicago, Illinois, and in collaboration with him.

Of course, the roof slab and column design, also floor slab and footing design, would be identical for either the prestressed or conventional type of construction.

One particular detail emphasized, however, in the prestressed type was the necessity of providing a leakproof ring joint at the right angle intersection of the floor and cylindrical wall. That this was solved satisfactorily is evident by the fact that all have been tested and accepted, having been found free from appreciable leakage.

NARRATION

VI. APPENDIX "A"

In explanation of the system of prestressing the reinforced concrete walls, the following is offered: -

Such a system of reinforced concrete construction consists in first building the cylindrical tank wall, - in the case of the fuel oil tanks to a thickness of 12" for its entire height of some 35', and reinforced lightly to resist temperature stresses only. After setting a sufficient length of time, load carrying steel hoops, in the form of rods, are placed around the tank, and are prestressed or preloaded in tension by means of turnbuckles, to act against the concrete, which reacts in such a way that when the live load is applied (that is, when the tanks are filled) the effect is merely to reduce the compression in the concrete, instead of placing the latter in tension as would be the case in the conventionally designed structure. That is, prestressing the circumferential band rods in tension, also prestresses the concrete (against which the steel acts) in compression, with the result that the application of the live load, accomplished by filling the tank, only makes the concrete give up some of its compression, - all at the expense, of course, of additional tension in the steel. This design results therefore, in eliminating cracks and consequent leaks due to tension from loading, shrinkage, or temperature changes.

With proper design, providing for stress reversals due to fillings, emptyings, and soil pressure; and selection of proper stresses in concrete and steel bands - each functioning to its own value and characteristics - the result is structural economy and high efficiency, especially in connection with the storage of liquids. Of course, careful and accurate field methods are requisite to satisfactory performance.

Provided the attainment of crackless concrete is assured, the next problem is its surface treatment to resist penetration of liquid contents or damage therefrom. This is covered under Item #7.

The general design of the fuel oil tanks is as follows: -

Access to the interior of the tanks is provided by two shafts or chambers extending from the roof of the tank to slightly above the finished grade. Within each chamber is a 36" cast iron manhole and cover leading to a safety ladder extending to the bottom of the tank. There is also a 6" tank vent and a 6" thief hatch. These chambers are located on opposite sides of the tank. One of the chambers is near the adjacent tank pump room and contains additionally a direct reading float-operated gauge calibrated to give the depth of oil in feet and inches. Gauges are read by means of reading glasses located in the access pit.

Tanks are filled through a 10" line entering the side wall of the tank near the top, then dropping to within 2' of the bottom of the tank and having its terminus along the inside periphery of the tank about 90° from the 20" outlet to the heat exchanger. This line is also used for heating and recirculating oil.

The bottom outlet for the discharge of oil is a casting 20" in diameter with a flared wide-mouthed inlet set 12" above the floor and looking up from the tank to provide for the collection of bottom sediment and water.

A sump 4' square and 12" deep with a 6" connection for the removal of bottom sediment and water has been provided nearby in each tank.

Within each fuel oil tank there is also suspended over the 20" outlet a 20" emergency plug valve with a neoprene gasket which can be lowered over said 20" outlet which leads to the pump room. Fusible links are provided so that in case of fire in the pump room, the links will separate and the valve drop, closing the discharge opening and preventing any additional oil from entering the pump room. A screen is provided over the oil discharge outlets in all tanks to protect equipment in adjacent pump rooms against clogging from foreign materials. In Areas #3 and #5, the pump rooms are constructed separately from, and are adjacent to the tanks.

NARRATION

VI. APPENDIX "A"

Access to each pump room is accomplished through a manhole located at the ground surface as previously described. Removable slabs have also been provided in the roof so that equipment may be removed for major repairs or replacement.

In each pump room push button control of four important motor-operated valves is arranged from a near vantage point. These are: -

4" steam main to turbine-driven pump.
10" oil main to line.
20" pump suction to tank.
3/4" live steam to heater.

Much of the electrical wiring to starters and equipment within the individual tank-pump rooms is not waterproof, and none of it is explosion-proof.

There is also in each pump pit a telephone connected to an intercommunicating central switchboard telephone system.

Incidentally consideration has been given in the design of earth cover for tanks, (and instructions to be issued as to operating oil temperatures,) to avoid melting snow in areas over the tank roofs which, of course, would create dark areas within snow-covered surroundings, and thus clearly define tank locations from the air. Likewise, it is felt that these same construction precautions will eliminate either forced rates of crop growth resulting in bright green areas over tank tops in the growing seasons, or equally revealing parched brown areas from dried up vegetation.

To provide against the siphoning of tanks into each other, or into the main line, there is installed a 4" vacuum breaker valve in each 10" fill line in the tank pump rooms. Under pressure these valves close, but under partial vacuum they will open and admit sufficient air to break the siphoning action.

The Diesel oil tanks are similar in design except that they are smaller and without pumping sumps or provision for heating the oil, oil being thin and withdrawn by means of deep well type pumps.

NOTES:

DEVELOPED FROM PLANS PROVIDED BY NETC PUBLIC WORKS ENTITLED "PRE-STRESSED CONCRETE FUEL OIL STORAGE TANKS" DATED JUNE 9, 1942, ORIGINAL SCALE 3/8"=1'-0" DRAWING NO. 5032-57, AND "PRE-STRESSED CONCRETE FUEL OIL STORAGE TANKS" DATED 10/9/43, ORIGINAL SCALE 1/4"=1'-0" DRAWING NO. 6062-67 AND "FUEL DISTRIBUTION SYSTEM TYPICAL PUMPING SUMPS" DATED 11 JUNE 1954 ORIGINAL SCALE 1/4"=1'-0" DRAWING NO. 12062-127

FIGURE D-1 COMPILED FROM DRAWING C-3, PROJECT NO. 14114-N81-80, TRC ENVIRONMENTAL CORPORATION, JUNE 18, 1993

PRELIMINARY

TYPICAL TANK SYSTEM			
NETC – NEWPORT, RI			
WORK PLAN			
DRAWN BY:	R. SARGENT	REV.:	0
CHECKED BY:	W. MARTIN	DATE:	18 JUN 93
SCALE:	AS SHOWN	PROJECT NO.:	0288 CTO #143:

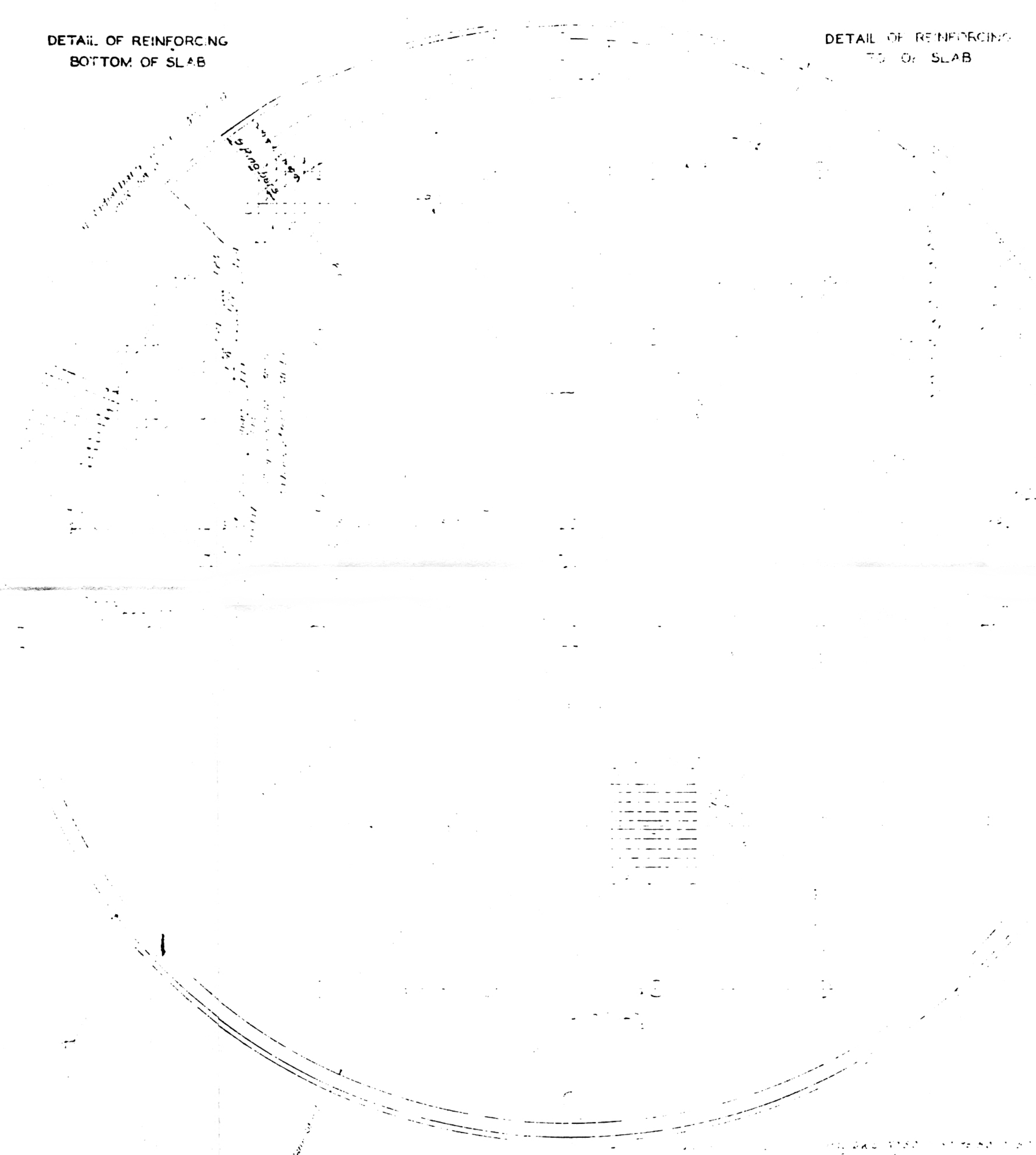
FIGURE C–1

Halliburton NUS CORPORATION

187 Ballardvale St. Wilmington, MA 01887 (508)658-7899

DETAIL OF REINFORCING BOTTOM OF SLAB

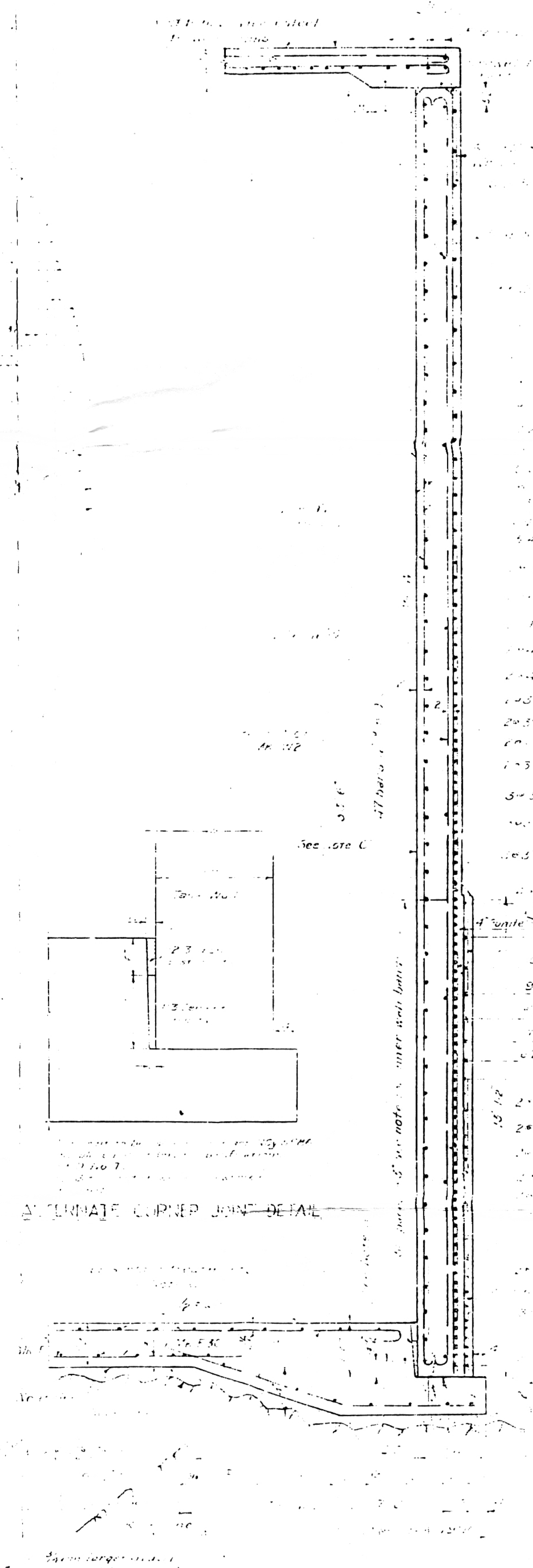
DETAIL OF REINFORCING TOP OF SLAB



FOUNDATION PLAN

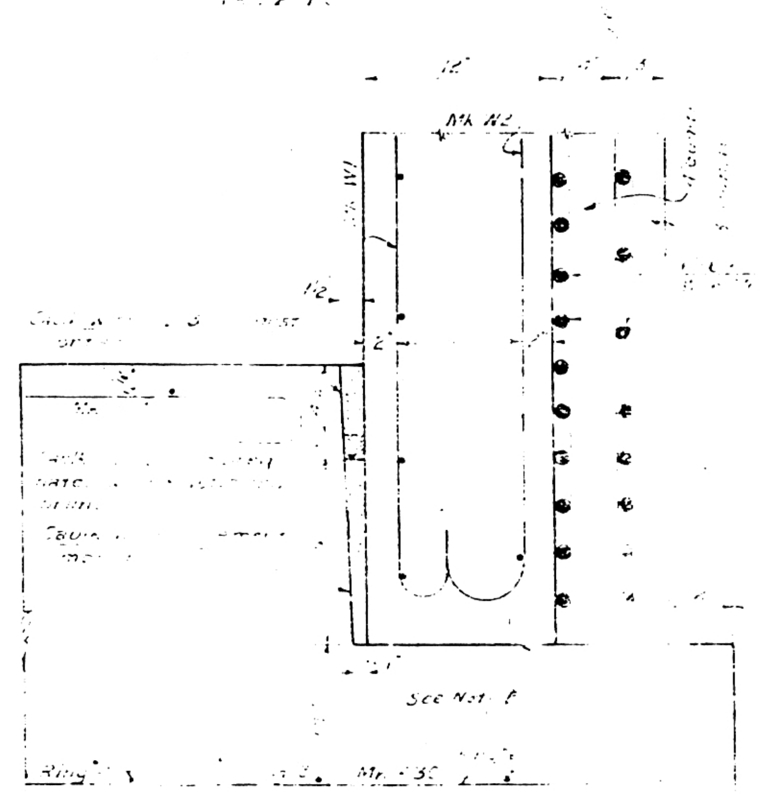
GENERAL NOTES

This design conforms to Bureau of Yards & Docks requirement.



ALTERNATE CORNER JOINT DETAIL

WALL SECTION



CORNER JOINT DETAIL

SCHEDULE OF REINFORCEMENT

Mark	Number Required	Size	Spacing	Cut length	Type	A	B	Location
W1	483	1/2"	9	[illegible]	III	8	34'3"	Wall
W2	483	3/4"	9	35'-9"	III	[illegible]	33'9"	do
W3	770	1/2"	9"	[illegible]	Straight			do
W5	[illegible]	1/2"	[illegible]	[illegible]	do			do
W7	188	1/2"	9"	[illegible]	do			[illegible]
W9	[illegible]	[illegible]	9	6'-0"	do			do
[illegible]	[illegible]	1/2"	12"	40'-0"	do			Top & Bottom
F2	44	1/2"	12	20'-10"	I	8	20'2"	Top
F3	44	1/2"	12	[illegible]	do	8	[illegible]	
F4	32	1/2"	12"	20'-0"	do	8	19'4"	do
F5	32	1/2"	12"	19'-0"	do	8	18'4"	do
F6	16	1/2"	12"	17'-8"	do	8	17'0"	do
F7	16	1/2"	12	16'-10"	do	8	16'2"	do
F8	16	1/2"	12	16'-0"	do	8	15'4"	do
F9	[illegible]	1/2"	12"	15'-0"	do	8	14'4"	do
F10	16	1/2"	12"	14'-0"	do	8	13'4"	do
F11	16	1/2"	12"	13'-0"	do	8	12'4"	do
F12	24	1/2"	12"	11'-9"	do	8	11'1"	do
F13	16	1/2"	12"	10'-6"	do	8	9'10"	do
F14	16	1/2"	12"	9'-0"	do	8	8'4"	do
F15	16	1/2"	12	7'-6"	do	8	6'10"	do
F16	24	1/2"	12	5'-6"	do	8	[illegible]	
F17	121	1/2"	12"	16'-0"	Straight			Bottom
F18	33	1/2"	12"	14'-0"	do			do
F19	16	1/2"	12"	12'-0"	do			do
F20	16	1/2"	12	11'-0"	do			do
F21	24	1/2"	12"	10'-0"	do			do
F22	1312	1/2"	12"	9'-0"	do			Bottom
F23	16	1/2"	12"	8'-0"	do			Bottom
F24	16	1/2"	12"	6'-0"	do			do
F25	41	1/2"	12"	35'-0"	do			do
F26	[illegible]	1/2"	12"	32'-0"	do			do
F27	[illegible]	[illegible]	12"	29'-0"	do			do
F28	26	1/2"	12"	22'-0"	do			do
F29	16	1/2"	12"	17'-0"	do			do
F30	304	1/2"	12	9'-2"	II	8	3'6"	Top & Bot
F31	24	1/2"	12	35'-0"	I	8	34'4"	Top
F32	[illegible]	1/2"	12	[illegible]	I	8	29'0"	do
F33	320	7/8"		[illegible]	I	[illegible]	3'10"	Col. [illegible]

Remarks:

Type III

Diameter of pins: 1/2" – 3"; 3/4" – 3"; 7/8" – [illegible]

Steel listed only for one tank, [illegible] wall and footing steel

For location of column bars see drawing #4

FIGURE D-2 COMPILED FROM DRAWING #2, LEONARD CONSTRUCTION CO., 1942

LEONARD CONSTRUCTION CO.

DRAWING 2

U.S. NAVAL OPERATING BASE NEWPORT R.I.

NAVAL FUEL OIL DEPOT MELVILLE

PRE-STRESSED CONCRETE FUEL OIL STORAGE TANKS

[illegible] BBL. CAPACITY

FOUNDATION PLAN & WALL SECTION

FOUNDATION PLAN AND WALL SECTION	FIGURE D-2
NETC – NEWPORT, RI	Halliburton NUS CORPORATION
WORK PLAN	187 Ballardvale St. Wilmington, MA 01887 (508)658-7899

DRAWN BY:	R. SARGENT	REV.:	0
CHECKED BY:	W. MARTIN	DATE:	09 SEP 94
SCALE:	AS SHOWN	PROJECT NO.:	0288 CTO #143

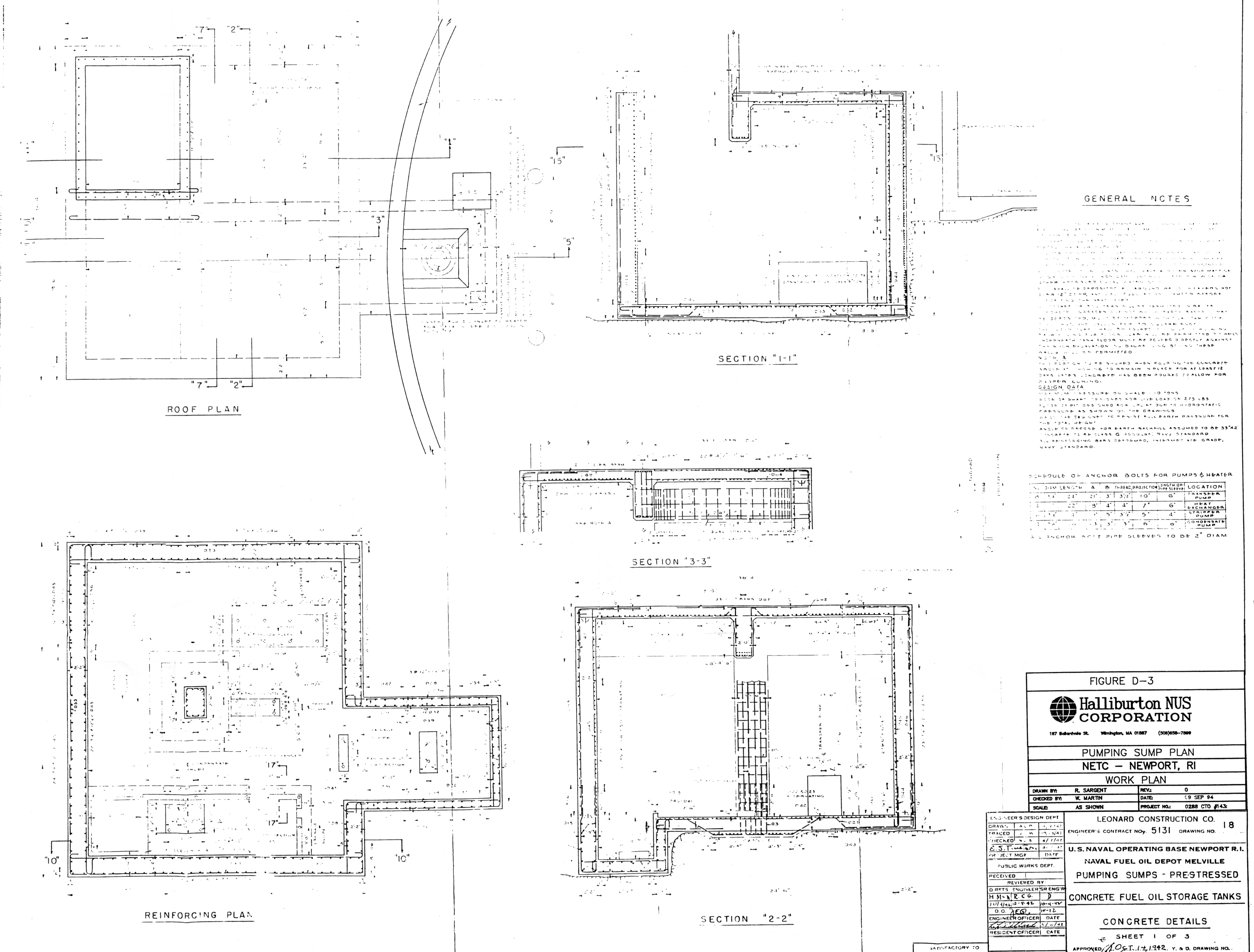


FIGURE D-3 COMPILED FROM DRAWING #18, LEONARD CONSTRUCTION CO., 1942