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Work Plan for Third Round of Groundwater Sampling Abandoned Chemical Disposal Pit (Site 8)

The Naval Surface Warfare Center White Oak Detachment Silver Spring, Maryland

Northern Division Naval Facilities Engineering Command

Contract No. N62472-90-D-1298
Contract Task Order 0111

April 1993

Halliburton NUS CORPORATION

WORK PLAN
THIRD ROUND OF GROUNDWATER SAMPLING
ABANDONED CHEMICAL DISPOSAL PIT (SITE 8)
NAVAL SURFACE WARFARE CENTER
WHITE OAK DETACHMENT
SILVER SPRING, MARYLAND

COMPREHENSIVE LONG-TERM
ENVIRONMENTAL ACTION NAVY (CLEAN) PROGRAM

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1.0 INTRODUCTION

1.1 PURPOSE

The work to be performed under Contract N62472-90-D-1298, Contract Task Order (CTO) 0111, is to conduct a third round of groundwater sampling and analysis at the Abandoned Chemical Disposal Pit (Site 8), Naval Surface Warfare Center, White Oak Detachment (NSWCWODET) in Silver Spring, Maryland. The purpose of this third round of groundwater sampling is to provide confirmation of potential groundwater contamination in existing monitoring wells at the Abandoned Chemical Disposal Pit, and to evaluate potential risks to human health associated with currently identified levels of contamination. The specific objective of this investigation is to determine the presence and levels of volatile organics, semivolatile organics, polychlorinated biphenyls (PCBs), and metals in groundwater in the vicinity of the site.

This work is part of the Navy's Installation Restoration Program, which is designed to identify contamination of Navy and Marine Corps lands and facilities resulting from past operations and to institute corrective measures, as needed. There are typically three distinct phases of investigation and remediation under the IRP program. Phase 1 consists of a Preliminary Assessment (PA) which examines historical records to determine potential wastes and waste disposal activities conducted at the site and to determine those needing further investigation, and a Site Investigation (SI) which augments the information collected in the Preliminary Assessment. Phase 2 is the Remedial Investigation/Feasibility Study (RI/FS) which characterizes the contamination at a facility and develops options for remediating the site. Phase 3 is the Remedial Design/Remedial Action (RD/RA) which results in the design of control or cleanup strategies for the contamination and implementation of these strategies.

Initial environmental investigations of the entire NSWCWODET facility, including the Abandoned Chemical Disposal Pit, were conducted under the Navy Assessment and Control of Installation Pollutants (NACIP) program, the precursor to the current Navy IRP program. Phase 1 of that program included the Initial Assessment Study (IAS), completed by the Navy Energy and Environmental Support Activity (NEESA) in 1984. This study included records searches, on-site surveys, personnel interviews, and site ranking. Additional study of several sites, including Site 8, was recommended on the basis of the IAS study. Under Phase 2 of the NACIP program, a Confirmation Study was conducted at

NSWCWODET by Malcolm Pirnie (1987). At Site 8, this study involved an on-site environmental field investigation to determine the presence of potential groundwater contamination. Groundwater sampling of four monitoring wells installed near Site 8 during the study resulted in recommendations for installation of one additional well and another round of groundwater sampling and analysis. Phases I and II of the RI (Malcolm Pirnie, 1992), identified the presence of organic and inorganic chemicals above background levels in groundwater immediately downgradient of the site. Limited soil sampling conducted under the Phase I RI also indicated the presence of metals above background levels. A third round of groundwater sampling is required to confirm the results of previous investigations, and to provide additional analytical data for mercury and semivolatile organic compounds. The laboratory data for these analytes collected under the Phase II RI were rejected based on quality assurance/quality control (QA/QC) deficiencies. The data collected will also be used, along with the results of previous studies, to evaluate the need for remedial action at the site, and to evaluate potential remedial options during the FS.

1.2 REPORT ORGANIZATION

This work plan consists of six sections. Section 1.0 is this introduction to the investigation; Section 2.0 presents the Site Background Information; Section 3.0 provides the scoping of the investigation; Section 4.0 describes the specific tasks to be conducted under this CTO; Section 5.0 provides the management structure and preliminary schedule of activities; and Section 6.0 presents the Quality Assurance Project Plan (QAPP). Costing information was provided in the proposal dated January 29, 1993, and as amended by the negotiation between the Navy and Halliburton NUS Environmental Corporation (Halliburton NUS) on February 9, 1993 and accepted by the Navy on February 11, 1993.

The QAPP, which has been included in the Work Plan for this CTO, details the policy, organization, functional activities, and Quality Assurance/Quality Control (QA/QC) protocols necessary to achieve project Data Quality Objectives (DQOs). The QAPP also includes a Field Sampling Plan (FSP), which specifies the sampling rationale, locations, methods and approach of the field-related activities associated with the conduct of the investigation. The FSP will ensure that groundwater sampling will be conducted in accordance with established project objectives. A Health and Safety Plan (HASP) has been prepared and covers the health and safety aspects of personnel conducting field activities at the Abandoned Chemical Disposal Pit (Site 8).

2.0 SITE BACKGROUND INFORMATION

2.1 SITE DESCRIPTION

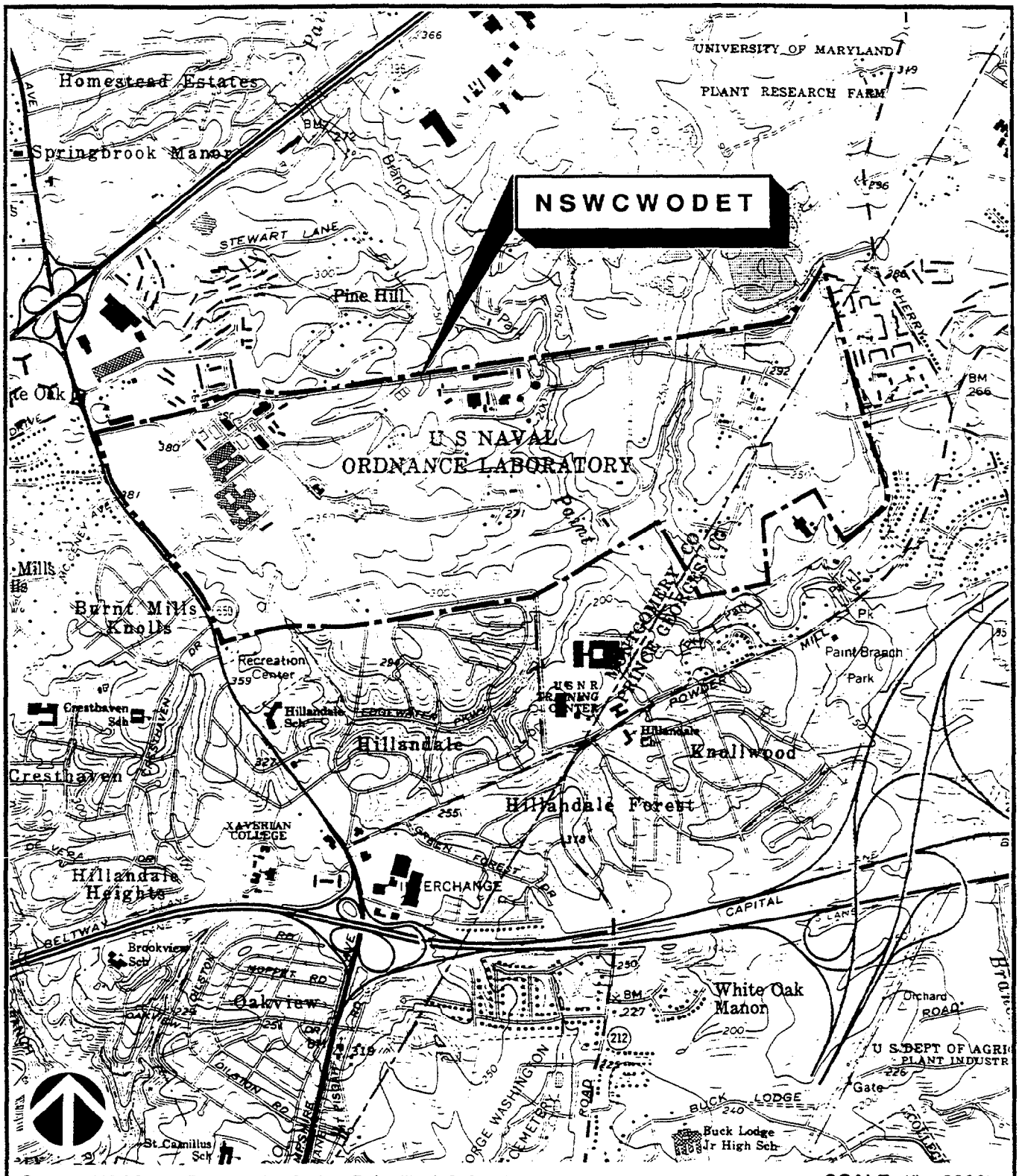
The Naval Surface Warfare Center, White Oak Detachment (NSWCWODET) is located in Silver Spring, Montgomery County, Maryland. The NSWCWODET facility is located approximately 5 miles north of Washington, D.C., off New Hampshire Avenue. The facility extends east from New Hampshire Avenue (Montgomery County) across the border into Prince George's County, Maryland as shown on the general location map (Figure 2-1).

The NSWCWODET consists of about 732 acres of land bordered to the north by a mixture of residential, park and industrial/commercial properties, to the east by residential properties, to the southeast by the Harry Diamond Laboratory and U.S. Naval Research training center, to the southwest by the Hillandale residential community, and to the west by New Hampshire Avenue.

The Abandoned Chemical Disposal Pit (Site 8) is located on an upland area along the south-central facility boundary at the end of Perimeter Road (Figure 2-2). The buried pit, as determined by ground-penetrating radar (GPR), is located in a cleared area at the end of the road, surrounded by wooded areas on the north, east and west, and a residential area on the south just beyond the property boundary. Paint Branch Creek appears to be located approximately 900 feet east of the pit. Estimates of the size of the pit vary from 10 feet by 10 feet (NEESA, 1984) to approximately 30 by 30 feet (Malcolm Pirnie, 1992) with a depth of about 12 feet.

2.2 ACTIVITY MISSION AND HISTORY

The Navy acquired 870 acres of land in White Oak, Maryland in 1944 for expansion of the Washington Navy Yard-based Naval Ordnance Laboratory (NOL). The mission of the NOL was to carry out research and development for naval ordnance including explosives, projectiles, mines, and related munitions and control systems. In 1969, 137 acres of land were transferred from the NOL to the U.S. Army. This area is now the location of the Harry Diamond Laboratories. In 1974, the NOL was renamed the Naval Surface Weapons Center during consolidation of NOL with the Naval Weapons Laboratory in Dahlgren, Virginia. The facility now serves as a detachment to Dahlgren Division, and has been renamed the Naval Surface Warfare Center, Dahlgren Division Detachment, White Oak (NSWCWODET).



Source: USGS 7.5" Topographic Series, Beltsville, MD Quadrangle.

SCALE: 1" = 2000'

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FIGURE 2-1

FACILITY LOCATION

WHITE OAK, MARYLAND

NSWCWODET RI/FS

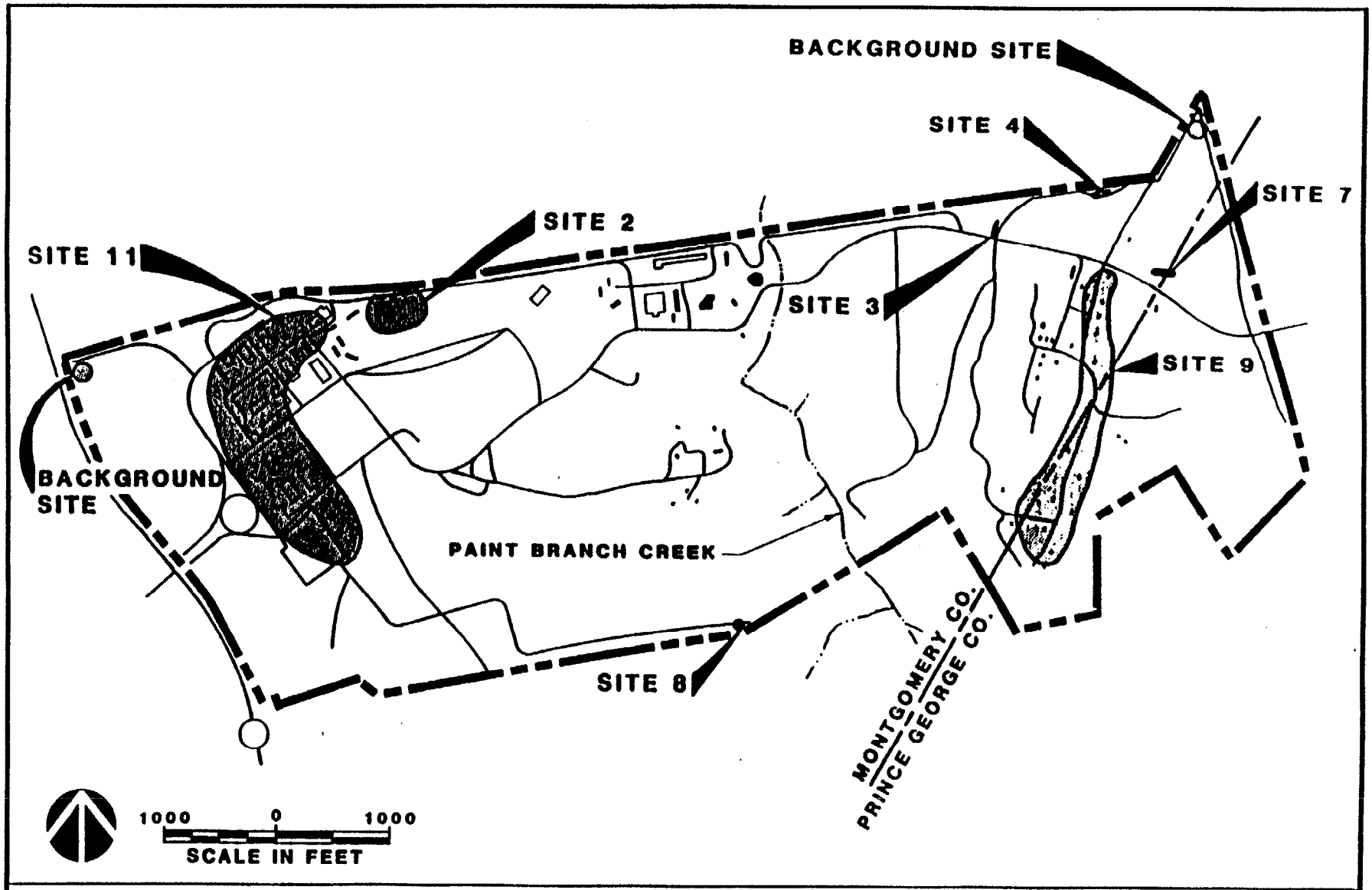

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FIGURE 2-2

SITE LOCATION MAP

WHITE OAK, MARYLAND

NSWCWODET RI/FS

The Abandoned Chemical Disposal Pit (Site 8) is an unlined hole which was used from 1951 to 1971 for disposal of known and unknown waste chemicals from various laboratories at the facility. Wastes were disposed monthly at the site and included acids, mercury, solvents, and numerous unidentified waste chemicals. Based on information collected during the Initial Assessment Study, it was estimated that as much as 60,000 pounds of chemical waste, including 180 pounds of mercury, may have been disposed in the pit over its 20 year period of use (NEESA, 1984). Reportedly, a layer of soil or gravel was placed on top of the wastes every two to three months. A number of glass laboratory containers were reportedly broken during disposal at the site. At the time of a site visit conducted by Halliburton NUS (March 1993), the ground surface in the vicinity of the pit appeared to consist of undisturbed soils with low-growing vegetation.

2.3 GEOLOGY

The NSWCWODET lies within the boundary of the Piedmont and Coastal Plain Physiographic Provinces. The boundary between the two provinces is a zone in which the sedimentary units of the Coastal Plain form a wedge-like deposit that thins along the western margin at the fall line. Coastal Plain deposits consist of unconsolidated, interbedded, sand, silt, gravel and clay. The sediments overlie the igneous and metamorphic rocks of the Piedmont Province.

The Piedmont Province in this region consists of igneous and metamorphic rocks. The piedmont units are covered by Coastal Plain sediments, thick residual soils, or saprolite (weathered bedrock). The saprolite varies greatly in thickness, but at the facility ranges between 20 and 50 feet thick.

Two geologic units are present below site the Abandoned Chemical Disposal Pit (site 8). The upper unit is the Upland Sand and Gravel which ranges in thickness from 0 to 10 feet. The underlying unit is the saprolite member (Wds) of the Wissahickon Formation encountered approximately 5 to 10 feet below ground surface. Fractured gneiss bedrock was encountered at 31 feet below ground surface during drilling of borehole 8GW53. The Wds Formation ranges in thickness from 20 to 39 feet throughout the site (Malcolm Pirnie, Inc., 1992).

2.4 HYDROGEOLOGY

The lithology beneath Site 8 consists of the Upland Sand and Gravel unit which lies on the saprolite member of the Wissahickon Formation. The average saturated thickness of the water table aquifer, based on 1991 measurements, was 20 feet (Malcolm Pirnie, 1992). Based on water level

measurements taken during the Phase II RI, the depth to the water table aquifer at Site 8 ranged from 28.51 feet to 34.97 feet from the ground surface. The water table gradient ranges from 2 to 4 percent in the vicinity of Site 8. Predominant groundwater flow direction in the vicinity of Site 8, determined from graphical analysis of water levels in the five monitoring wells, appears to be to the north. However, due to the topographically high location of the site, there may be some radial flow of groundwater from the site. This flow has not been confirmed because of the lack of water level data south of the site beyond the property boundary. The estimated hydraulic conductivity for the unconfined aquifer, based on slug test data, was 2.28×10^{-3} (Malcolm Pirnie, 1992).

2.5 SURFACE WATER HYDROLOGY

Surface water runoff from Site 8 drains into Paint Branch Creek approximately 900 feet to the east or to an unnamed tributary of Paint Branch Creek approximately 400 feet south of the site (Figure 2-2). No surface water bodies exist within the immediate vicinity of Site 8.

3.0 SCOPING OF THE INVESTIGATION

This section presents a summary of existing data from previous investigations of the Abandoned Chemical Disposal Pit (Site 8), and a summary of the preliminary risk assessment prepared by Malcolm Pirnie under the RI. This information was reviewed to provide background information for conducting a third round of groundwater sampling to be performed by Halliburton NUS under this CTO. The task plan described in Section 4.0 of this Work Plan was developed to address the need for supplemental groundwater data in the vicinity of Site 8, and includes elements such as the types and numbers of samples to be collected, specific analytical parameters, and the level of required QA/QC.

The NACIP Program Confirmation Study (1987) and the Phase I and Phase II Remedial Investigations (1992) for the NSWCWODET, both performed by Malcolm Pirnie, Inc., are the primary sources of data and information reviewed for the purpose of scoping the third round of groundwater sampling.

3.1 SUMMARY OF EXISTING ANALYTICAL DATA

The records search and personnel interviews conducted as part of the Initial Assessment Study (IAS) of NSWC (NEESA, 1984) concluded that the Abandoned Chemical Disposal Pit presents a potential threat to human health or the environment, because of the mercury and acids disposed there, and the potential for mercury compounds to migrate through groundwater. Based on these findings, the site was recommended for a Confirmation Study under the NACIP program.

Under the Confirmation Study (Malcolm Pirnie, 1987), four groundwater monitoring wells (8GW33, 8GW34, 8GW35, and 8GW36) were installed in the area immediately surrounding the suspected disposal site (Figure 3-1). (Monitoring well 8GW53 was installed as part of the Phase I RI, completed in 1990.) Two rounds of groundwater sampling and analysis were conducted during the Confirmation Study (February and May, 1986). In each sampling round, mercury analyses were performed for groundwater samples from each well, with additional metals analyses only for samples collected from monitoring well 8GW35. Metals analyses other than mercury were not performed on groundwater samples collected from monitoring wells 8GW33, 8GW34, or 8GW36. All metals analyses were conducted on unfiltered samples. It was noted in the Confirmation Study report that the groundwater samples contained significant quantities of sediment, which may result in higher chemical concentrations for unfiltered samples. Additional analyses performed on groundwater samples during

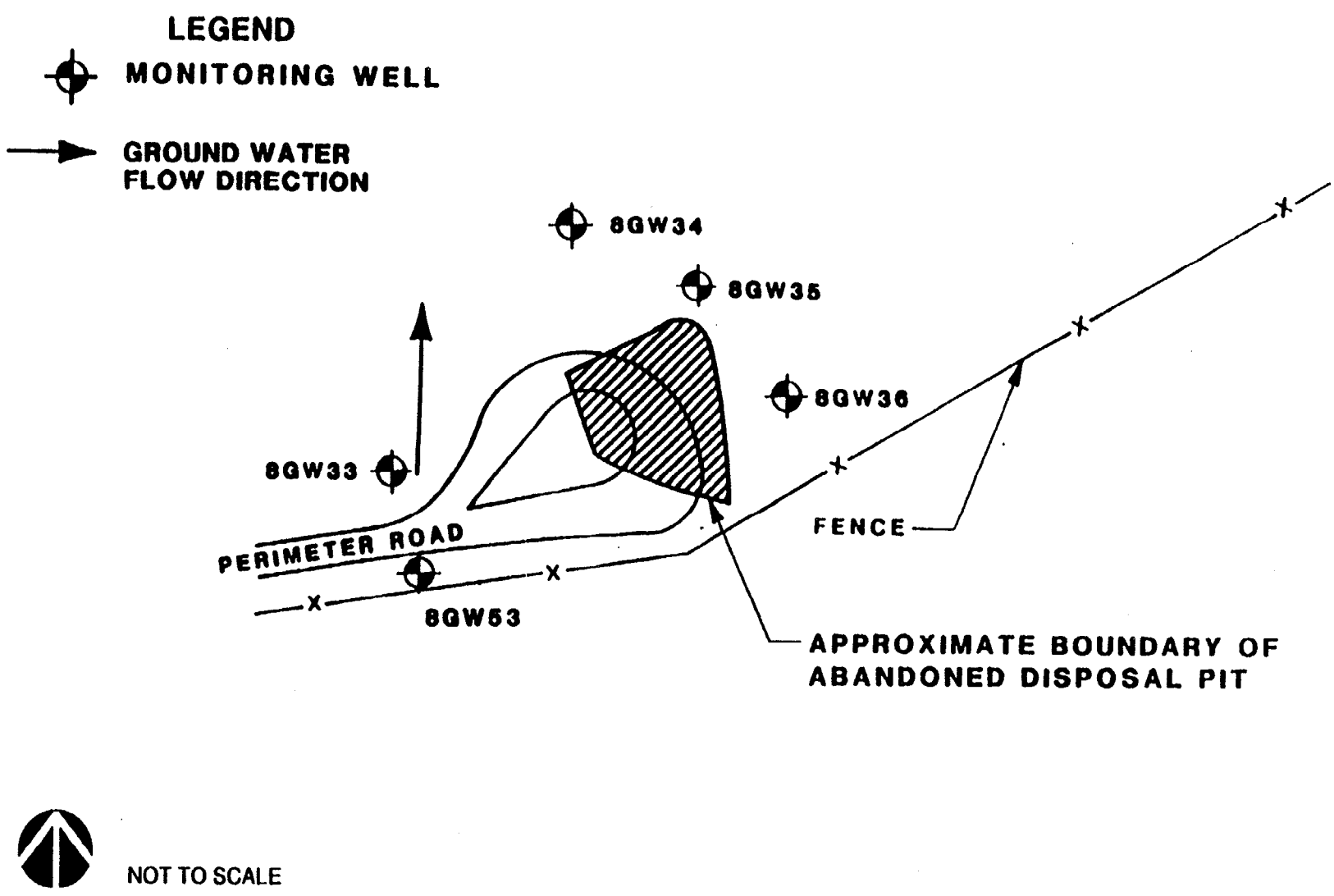

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FIGURE 3-1

SITE 8 – GROUNDWATER SAMPLING LOCATIONS

WHITE OAK, MARYLAND

NSWCWODET RI/FS

the Confirmation Study were total organic carbon (TOC), total organic halogen (TOX); total dissolved solids (TDS); pH; volatile organic compounds (VOCs); conductivity; and oil and grease.

The results of these analyses are summarized in Table 3-1, which also compares the range of detected concentrations to the appropriate current drinking water regulatory standard [Maximum Contaminant Levels (MCLs)]. As shown in the table, levels of chromium, nickel, and lead detected in groundwater during the study exceed their corresponding drinking water standards. Mercury was detected in each of the four monitoring wells, at concentrations ranging from 0.22 to 1.4 micrograms per liter (ug/L). Cadmium, chromium, copper, nickel, zinc, and lead were also present at detectable concentrations in monitoring well 8GW35. It is of interest to note that concentrations of these metals were consistently higher in the first round of groundwater sampling (February) than in the second round (May). The reason for this is not evident from information presented in the Confirmation Study report. Contamination by the Volatile Organic Compounds (VOCs) toluene (8GW33) and chloroform (8GW35) was identified at concentrations below MCLs, but it was recommended by Malcolm Pirnie, Inc. that additional sampling be performed to confirm these results.

The Confirmation Study also recommended installation of one additional monitoring well, performance of a slug test to characterize site hydrogeologic conditions, and at least one additional round of sampling to better characterize potential groundwater contamination at the site.

A Phase I Remedial Investigation was completed in 1990. This investigation included collection and analysis of two soil samples to determine chemical concentrations of semivolatile organics and metals in surficial soil; performance of a Ground Penetrating Radar (GPR) geophysical survey to define the location of the abandoned disposal pit; installation of one additional monitoring well (8GW53); and groundwater sampling from all five monitoring wells in the vicinity of Site 8. The GPR survey indicated that one burial area was present at the site, underneath Perimeter Road. Soil sampling results indicated that chromium, lead, copper, and zinc were present at levels higher than facility-specific background concentrations (refer to RI tables in Appendix A).

Groundwater samples collected in the Phase I RI were analyzed for volatile organic compounds (VOCs); semi-volatile organics; total and dissolved metals; TOC; TOX; TDS; and total suspended solids (TSS). The results of these analyses identified the metals chromium, copper, lead, mercury and zinc at levels above background concentrations in unfiltered samples. Chromium levels in unfiltered groundwater samples were three to four times higher than the drinking water MCL for chromium (100 ug/L). Levels of lead were approximately two times higher than the MCL of 50 μg/L. Mercury levels of 4.5 μg/L detected in Phase I sampling exceeded the MCL in one of the five wells (8GW33). The organic

TABLE 3-1

RANGES OF DETECTABLE CHEMICAL CONCENTRATIONS (μg/L)
GROUNDWATER SAMPLE ANALYSES
NSWC-WHITE OAK CONFIRMATION STUDY (1987)

Analyte	Range of Concentration	MCL
INORGANICS		
Cadmium	< 5 - 6	5
Chromium	172 - 267	100
Copper	128 - 258	1000*
Nickel	109 - 282	100
Zinc	398 - 801	5000*
Lead	42 - 90	50
Mercury	0.22 - 1.4	2
ORGANICS		
Toluene	137	1000
Chloroform	5 - 7	100

MCL - Maximum Contaminant Level
* Secondary Drinking Water Standard

constituents detected in Phase I RI groundwater samples were chloroform (10 μg/L), 1,1,2-trichloroethane (1,1,2-TCA) (7 μg/L), and bis(2-ethylhexyl)phthalate (13 to 18 μg/L). The Phase I RI summary data tables are included in Appendix A.

All five monitoring wells at Site 8 were resampled during the Phase II RI, completed in October, 1992. Each groundwater sample was analyzed for VOCs, semivolatile organics; total and dissolved metals; and PCBs. Total metals concentrations in groundwater decreased from Phase I to Phase II, and only cadmium (5 μg/L) and zinc (17 to 165 μg/L) were detected above background levels. Phase II analytical results for mercury and all semivolatile compounds in groundwater were rejected due to QA/QC deficiencies. The only VOCs detected in groundwater were 1,1,2-TCA, chloroform and methylene chloride, which were present at low levels (refer to Appendix A for data summary tables).

The RI concluded that the decrease in concentration of metals in the groundwater from Phase I to Phase II suggests a reduction in metals leachate generation from the abandoned chemical disposal pit. Mercury, although not detected in analyses for the Confirmation Study, was detected in low concentrations in two wells during the Phase I RI. The rejection of the mercury analytical results during Phase II limits further confirmation of the extent of mercury contamination in groundwater at Site 8.

Volatile organic compounds were detected at low levels in the groundwater at Site 8. The compound 1,1,2-TCA, although not detected during the Confirmation Study, was identified in one well (8GW36) during both Phase I and Phase II. The RI concludes that the low levels of contamination suggest that the extent of contamination is localized near the abandoned disposal pit area. Furthermore, the RI results indicate the potential for radial migration of contamination from the abandoned pit, although the predominant direction of plume migration is toward the north.

3.2 PRELIMINARY RISK ASSESSMENT

A risk assessment was prepared by Malcolm Pirnie, Inc. as part of the Remedial Investigation for the Abandoned Chemical Disposal Pit. The risk assessment addressed potential risks to human health and ecological receptors potentially exposed to contaminants present at Site 8. A summary of key risk assessment findings is summarized below.

The risk assessment identified two site-related contaminants as chemicals of concern, which are carried through a more detailed quantitative risk analysis. These compounds are 1,1,2-trichloroethane (1,1,2-TCA) and bis(2-ethylhexyl)phthalate. Both chemicals were selected for further consideration in the risk assessment based on their frequency of detection and concentrations in groundwater

samples. The metals detected at the site were not selected as chemicals of concern since their concentrations in filtered groundwater samples did not exceed drinking water MCLs and levels in soil did not exceed natural background concentrations for United States soils. PCBs were not detected in any of the groundwater samples and were therefore not selected as chemicals of potential concern.

The exposed population determined to be of primary concern at the site were potential future off-site residents who would be exposed through use of groundwater from domestic wells that could be installed. The risk assessment stated that there are currently no domestic wells in use for bathing or drinking purpose in the vicinity of the site. The surrounding communities are on a regional water supply system (surface water from the Potomac River). Exposure pathways considered in the risk assessment included ingestion and dermal contact with groundwater, and inhalation of volatilized contaminants while showering or bathing.

For the chemical constituents, hypothetical receptor populations, and exposure pathways described above, both potential carcinogenic risk and non-cancer health hazards were estimated. The risk assessment concluded that it is unlikely that the residential population considered (both adults and children) would have non-carcinogenic adverse health effects associated with exposure to contaminated groundwater from Site 8. The cancer risk estimates derived in the risk assessment are within the range of Superfund remediation goals used by EPA to define acceptable risk. In conclusion, the risk assessment determined that, based on the existing database for Site 8, remediation does not appear necessary to protect public health.

3.3 DATA LIMITATIONS/REQUIREMENTS

Additional groundwater sampling and analysis is necessary to expand the available database for the site, and reduce uncertainty regarding the levels of both organic and inorganic constituents in groundwater. Groundwater quality data for mercury and the semivolatile organics is particularly limited due to rejection of data collected during the Phase II RI. Supplemental data for these constituents will allow a more complete assessment of contaminant levels at the site, and may contribute to a better understanding of contaminant migration by analysis of trends in concentrations over time. The source of variability in inorganics analyses between sampling events could not be determined from the information currently available.

In addition, there remains considerable uncertainty regarding the potential for radial flow of groundwater contaminants from the site. Additional water level measurements from existing on-site monitoring wells would be useful in confirming the primary direction of groundwater flow, but would

not enable a conclusive determination regarding the potential for radial flow. Off-site water level measurements from one or more locations beyond the facility boundary would be necessary for such a determination.

4.0 CTO TASK PLAN

The CTO Task Plan is divided into six tasks as follows:

Task 1 - Scoping for the Third Round of Groundwater Sampling
Task 2 - Work Plan for the Groundwater Sampling
Task 3 - Site Investigation
Task 4 - Site Investigation Analysis
Task 5 - Groundwater Sampling Investigation Report
Task 6 - Meetings and Presentations

4.1 TASK SCOPING OF THE THIRD ROUND OF GROUNDWATER SAMPLING

Task 1 consists of scoping for the third round of groundwater sampling and analysis. This task is used to gain a complete understanding and precise reason for conducting the investigation. It also provides a point at which project personnel can become familiar with the background information on the site, and evaluate the potential impact of the site on human health and the environment.

During the initiation of this task, a site visit was conducted by Halliburton NUS and the Navy Remedial Project Manager (RPM) on March 8, 1993 in order to observe the site topography and other physical features, and assess logistical concerns. The site is close to the road and all monitoring wells were identified. The site is located in a restricted wooded area, however residential areas were observed on the opposite side of the NSWCWODET fence, less than 100 feet south of the suspected pit area(s). In addition to the Site 8 visit, Halliburton NUS personnel obtained further documentation pertinent to the RI while at the activity.

4.2 TASK 2 - WORK PLAN

The Work Plan has been prepared to provide a detailed discussion of the technical approach and procedures to be used in the sampling investigation. It also presents information on description, history, and previous investigations of the study area. The Work Plan includes a CTO Task Plan, a Project Management Approach, and Quality Assurance Project Plan (QAPP) presented in Sections 4.0, 5.0, and 6.0, respectively. The Field Sampling Plan (FSP) is contained in the QAPP which meets the

USEPA requirements for a Sampling and Analysis Plan (SAP). The FSP provides procedures for all fieldwork activities by defining in detail the field data-gathering methods to be employed. The QAPP details the procedures for ensuring the quality of data collected. The QAPP describes the policy, organization, functional activities, and QA/QC procedures necessary to achieve Data Quality Objectives (DQOs) dictated by the intended use of the data.

A separate Health and Safety Plan (HASP) has been prepared. The HASP details the procedures to be employed to ensure that the field program is conducted in a safe manner.

4.3 TASK 3 - SITE INVESTIGATION

4.3.1 Mobilization

Mobilization consists of preparation for the field activities. The equipment and expendable materials will be collected and checked prior to shipment to the site. Also, site-specific health and safety training will be provided to field personnel at this time.

4.3.2 Water Level Measurements

Static water-level measurements will be determined from the five monitoring wells (8GW33 through 8GW36, and 8GW53) during the groundwater sampling investigation (Figure 3-1). Water-level measurements from all five wells will be recorded prior to any purging and sampling. An electronic water-level indicator will be used to record measurements to the nearest 0.01 foot. Well survey data for the top of the PVC riser will be used as a reference point for determining depths to static water. The water-level indicator will be decontaminated with an alconox solution and rinsed with deionized water before and after each well measurement. The water-level measurements collected shall be converted into elevations based on RI well survey data for the purpose of developing a potentiometric surface contour map. Water level measurements and contour mapping will be conducted in accordance with Halliburton NUS SOP GH-2.5 (Appendix B).

4.3.3 Groundwater Sampling

One groundwater sample will be collected from each of the five (5) existing monitoring wells at Site 8. In addition, one (1) field duplicate and one (1) trip blank will be collected. No equipment rinsate blanks or field blanks are required since dedicated disposable bailers will be used for sampling. All groundwater samples will be collected in accordance with Halliburton NUS SOP SA-1.1 (Appendix B).

Three to five well volumes will be purged from each well prior to sampling. If the wells are purged dry with less than three well volumes removed, the water level will be allowed to recover at least 70 percent before a sample is collected. In the event recovery is slow, samples may be collected the following day but within 24 hours of purging the well dry. Field measurements including pH, temperature, and specific conductance, will be recorded at the beginning, middle, and end of purging, according to Halliburton NUS SOP SF-1.1, (Appendix B) to ensure that the sample is representative of the groundwater regime.

All purge water generated during the groundwater investigation will be containerized in 55-gallon drums provided by Halliburton NUS. The drums will be clearly marked as to their contents and origin. Purge water from background well (8GW53) will be collected in a separate drum. Purge water from the four remaining wells will be combined. Drums containing purge water will be left at Site 8. The Navy will arrange for sampling, storage and appropriate disposal of purge water.

Total and filtered samples will be collected for metals analysis. Filtering and preservation of samples in the field will be in accordance with SOP SF-1.2, Section 5.25 (Appendix B). All pertinent field data shall be recorded on sample log sheets and in the field logbook. Dedicated disposable bailers will be used to purge all wells and collect all groundwater samples. Groundwater samples for VOC analysis will be collected first.

4.4 TASK 4 - SITE INVESTIGATION ANALYSIS

4.4.1 Sample Analysis

A total of six (6) groundwater samples, including one blind duplicate, will be submitted through proper chain-of-custody for laboratory analysis. All groundwater samples will be analyzed for Target Compound List (TCL) volatiles and semivolatiles, PCBs, and Target Analyte List (TAL) total and filtered metals. Analyses will not be performed for cyanide or pesticides. It is anticipated that only one (1) trip blank will be required for shipment with all VOC samples collected. The Trip blank will be analyzed for TCL volatile organics only. Field blanks and rinsate blanks will not be collected since dedicated disposable bailers will be used for groundwater sample aquisition (see Table 4-1) .

All chemical analyses for the samples collected for this project will be performed by Southwest Laboratory of Oklahoma, Inc., a NEESA certified laboratory. Laboratory Quality Control will comply

TABLE 4-1

NAVAL SURFACE WARFARE CENTER - WHITE OAK, SILVER SPRING, MARYLAND
ABANDONED CHEMICAL DISPOSAL PIT (SITE 8)
CONTRACT NO. N62472-90-1298, CTO 111

SUMMARY GROUNDWATER SAMPLING

Parameter	Method	No. of Samples	Equipment Rinsate[1]	Field Blanks[1]	Trip Blanks	Field Duplicates	Total Sample[2]
TCL Volatiles	CLP Protocol (3/90)[3]	5	0	0	1	1	7
TCL Semivolatiles	CLP Protocol (3/90)[3]	5	0	0	0	1	6
TCL PCBs	CLP Protocol (3/90)[3]	5	0	0	0	1	6
TAL Metals (Total)	CLP Protocol (3/90)[4]	5	0	0	0	1	6
TAL Metals (Dissolved)	CLP Protocol (3/90)[4]	5	0	0	0	1	6
TOTAL WATER SAMPLES		25				5	30
TOTAL WATER QA SAMPLES			0	0	1		1

(1) Field blanks and equipment rinsate samples will not be required, since disposable bailers will be used in groundwater sampling.

(2) Matrix spike/matrix spike duplicate (MS/MSD) analyses for organic fraction analyses are to be performed at a frequency of one MS/MSD analyses per twenty samples. Likewise, matrix spike (MS) and laboratory duplicate (LD) analyses for the inorganic fraction analyses are to be performed at a frequency of one MS and LD analysis per twenty samples. One blank spike analysis is to be performed per extraction batch of PCB fraction samples. The sample tallies as presented do not include these analyses.

(3) Organic Analysis: Multi-Media, Multi-Concentration, Contract Laboratory Program (CLP) Statement of Work (SOW), OLM01.8, March 1990/rev. Analyses will not be conducted for pesticides.

(4) Inorganic Analysis: Multi-Media, Multi-Concentration, Contract Laboratory Program (CLP) Statement of Work (SOW), ILM02.1, March 1990/rev.

with NEESA level D, which requires Contract Laboratory Program (CLP) methods and CLP deliverables. Criteria defining NEESA level D requirements are contained in "Sampling and Chemical Analysis Quality Assurance Requirements for the Navy Installation Restoration Program" (NEESA 20.2-0478; 6/88).

4.4.2 Data Validation

Data validation is an essential and significant aspect of the data evaluation process. Data validation consists of a stringent review of each analytical chemical data package with respect to sample receipt and handling, analytical methods, data reporting, deliverables, and document control. A qualified chemist will review the data package and assess its value for incorporation into the findings of the groundwater investigation report.

4.4.3 Data Evaluation

Evaluation of data collected in the third round of groundwater sampling will include a comparison of chemical compounds and concentrations in the hydraulically upgradient groundwater well versus the chemical concentrations in downgradient groundwater wells. Chemical concentrations in the groundwater will be compared to Applicable or Relevant and Appropriate Requirements (ARARs) such as the Safe Drinking Water Act Maximum Contaminant Levels and other criteria for protection of human health and the environment. A shallow groundwater contour map will be constructed utilizing the static water level measurements from the five wells in the Site 8 area. Groundwater flow directions and lateral hydraulic gradients will be interpreted with respect to potential source areas using this map. Nearby populations and potential pathways for human exposure will be described.

4.4.4 Contamination Assessment Report

A brief non-technical contamination assessment report will be prepared under this task. This report will be made available to persons attending a planned public meeting, which will be held prior to issuance of the Record of Decision (ROD) for Site 8. The Contamination Assessment Report will present the objectives of the groundwater sampling conducted by Halliburton NUS and will summarize the results of the groundwater investigation. The significance of the groundwater sampling findings will also be addressed, in terms of potential health or environmental impacts. The report will address only the analytical and hydrogeological data associated with the third round of groundwater sampling at Site 8 to be performed by Halliburton NUS. Results of previous site investigations performed by other Navy contractors will not be addressed in this report.

4.5 TASK 5 - REPORT

Halliburton NUS will prepare a brief report, presenting the results of the sampling investigation. The report will describe project objectives; a brief site history; a review of physical site characteristics; a description of field activities and methods; an overview of laboratory analytical methods; a summary of analytical results; a comparison of detected concentrations to national, state and local standards and criteria; and an assessment of potential health and environmental impacts. The report will not address the results of previous site investigations, or interpret the findings of other studies on Site 8.

Halliburton NUS will submit a draft sampling investigation report within 45 days after completion of field work. The final report will be submitted within two weeks after receiving all government comments. Halliburton NUS will also present the results of the investigation at a public meeting to be held prior to issuance of the Record of Decision (ROD). The presentation, which will be given by the Project Manager and Project Geologist, will summarize only the results of the third round of groundwater sampling for Site 8. Halliburton NUS will not be responsible for presenting the results of other site investigations at this meeting.

4.6 TASK 6 - MEETINGS AND PRESENTATIONS

Halliburton NUS will make a formal presentation to the Technical Review Committee (TRC) summarizing the objectives, methods, and preliminary findings of the third round of groundwater sampling at Site 8. Since the draft report will not be completed prior to the TRC meeting, a brief letter report will be prepared which summarizes analytical results of the groundwater sampling, and addresses potential impacts of site contaminants on human health and the environment. The schedule date for the TRC meeting is contingent on meeting schedules for completion of laboratory analysis and data validation tasks. The TRC meeting will be attended by the Project Manager and the Project Geologist.

5.0 PROJECT MANAGEMENT APPROACH

5.1 ORGANIZATION AND APPROACH

The Program Manager for Halliburton NUS is Mr. John J. Trepanowski, P.E., and the Deputy Program Manager is Mr. Michael A. Turco, P.E. Ms. Carolyn F. Poppell will serve as the Project Manager (PM). The PM has primary responsibility for implementing and executing the investigation. The Project Geologist will be Mr. Frank R. Morris. The PM will be assisted by various health and safety personnel, risk assessment personnel, and other technical staff. In accordance with the CLEAN Program Management Plan presented to the Navy, the QA Manager is Ms. Deb Scheib and the Health and Safety Manager is Mr. Matthew Soltis. Questions regarding QA and health and safety protocols will be directed to Ms. Scheib and Mr. Soltis, respectively. The roles of each of these individuals and the relationships between their functions are discussed in the Quality Assurance Project Plan (QAPP; Section 6.0 of this Work Plan).

5.2 PROJECT SCHEDULE

The project schedule is presented in Table 5-1. It consists of deliverable dates defined by the CTO and tentative dates for critical-path items such as field activities.

TABLE 5-1

PROJECT SCHEDULE
ABANDONED CHEMICAL DISPOSAL PIT (SITE 8)
NSWC-WHITE OAK DETACHMENT
SILVER SPRING, MARYLAND

Draft Work Plan to Navy	03/22/93
Navy Comments on Work Plan to Halliburton NUS	03/31/93
Final Work Plan to Navy	04/07/93
Field Sampling Activities	04/14/93
Complete Laboratory Analyses	04/28/93
TRC Meeting	05/07/93
Draft Report to Navy	05/28/93
Navy Comments to Halliburton NUS	06/11/93
Final Report to Navy	06/25/93

6.0 QUALITY ASSURANCE PROJECT PLAN

6.1 PROJECT ORGANIZATION

The key firms and personnel involved in the third round of groundwater sampling, as well as the chain of communication and responsibility of the project personnel, are as follows.

Chesapeake Division
Naval Facilities Engineering Command
Building 212 (Code 181)
Washington Navy Yard
Washington, DC 20374-2121

Heath Wells
Remedial Project Manager

Halliburton NUS Corporation
910 Clopper Road
Gaithersburg, Maryland 20878-1399
(301) 258-6000

John Trepanowski
Program Manager (Wayne, PA Office)

Carolyn Poppell
Project Manager/Site Health and Safety Officer

Deb Scheib
Quality Assurance Manager (Pittsburgh, PA Office)

Frank Morris
Project Geologist

Matthew Soltis
Health and Safety Manager (Pittsburgh, PA Office)

The Project Manager has the primary responsibility for project and technical management. She is responsible for coordinating all on-site personnel and for providing technical assistance for all activities that are directly related to the determination of the hydrogeologic conditions and the environmental quality of the site. The review of all environmental and hydrogeologic data will be conducted by the Project Manager or her designee. If Quality Assurance (QA) problems or deficiencies requiring special action are identified, the Project Manager and project Quality Assurance/Quality Control (QA/QC) officer will identify the appropriate corrective action.

The Halliburton NUS field investigation team will be organized according to the activity planned. For on-site sampling, the sampling team will consist of a combination of the following personnel:

- Field hydrogeologist/geologist
- Site health and safety officer (doubles as sampler)

The Project Geologist or his designee will coordinate and be present during all sampling activities and will ensure the availability and maintenance of all sampling materials/equipment. The Project Geologist will be responsible for all sampling, and chain-of-custody documentation, and will assume custody of all samples and ensure the proper handling and shipment of samples.

The QA/QC officer will be responsible for adherence to all QA/QC guidelines as defined in this Quality Assurance Project Plan (QAPP). Strict adherence to these procedures is critical to the collection of acceptable and representative data.

The site health and safety officer will be responsible for ensuring that all team members adhere to site health and safety requirements. Additional responsibilities of the Site Health and Safety Officer are as follows:

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

- Modifying the levels of protection based upon site observations.

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

- Notifying the NSWC-White Oak emergency response personnel, including the base Fire Department, of the nature of the team's operations and posting these departments' telephone numbers.

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

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

6.2 PROJECT QUALITY ASSURANCE

The overall Quality Assurance (QA) objective is to develop and implement procedures for field sampling, chain of custody, laboratory analysis, and reporting that will provide environmental monitoring data of known and acceptable quality. Specific procedures to be used for sampling, chain of custody, calibration of field instruments, laboratory analysis, reporting, internal Quality Control (QC), audits, preventive maintenance, and corrective actions are described in later sections of this Quality Assurance Project Plan (QAPP). The purpose of this section is to address the Data Quality Objectives (DQOs) in terms of the precision, accuracy, representativeness, comparability, and completeness (PARCC) parameters; quantitation and detection limits; field blanks, trip blanks; rinsate blanks; and bottleware cleanliness.

6.2.1 Data Quality Objectives

DQOs are qualitative and/or quantitative statements regarding the quality of data needed to support the groundwater sampling investigation activities. The use of Contract Laboratory Program (CLP) Statement of Work (SOW) protocols is expected to satisfy data quality needs in accordance with NEESA requirements.

6.2.2 Quantitation Limits

Aqueous quantitation limits are those required as Contract Required Quantitation Limits (CRQLS) and Contract Required Detection Limits (CRDLs) for the current CLP SOWs with allowances for dilutions and dry weight conversions. The TCL and TAL analytes and CRQLs and CRDLs are presented in Table 6-1.

6.2.3 Detection Limits

Instrument detection limits (IDL) are reported quarterly under CLP protocol. The quarterly IDLs applicable at the date of analysis will be supplied in each data package. IDLs must be less than or equal to CRDLs.

6.2.4 PARCC Parameters

The quality of a data set is measured by certain characteristics of the data, namely the PARCC parameters. Some of the parameters are expressed quantitatively, while others are expressed qualitatively. The objectives of the investigation and the intended use of the data define the PARCC goals.

6.2.4.1 Precision

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

$$Range = [OR - DR]$$

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

where

OR = original sample result

TABLE 6-1

TARGET COMPOUND LIST (TCL) ANALYTES AND CONTRACT REQUIRED QUANTITATION LIMITS (CRQL)[1]
NSWC-WHITE OAK
SILVER SPRING, MARYLAND

Volatiles	CAS Number	Quantitation Limits[2]	
		Water (ug/L)	Low Soil/Sediment[3] (ug/kg)
Chloromethane	74-87-3	10	10
Bromomethane	74-83-9	10	10
Vinyl Chloride	75-01-4	10	10
Chloroethane	75-00-3	10	10
Methylene Chloride	75-09-2	5	5
Acetone	67-64-1	10	10
Carbon Dilsulfide	75-15-0	5	5
1,1-Dichloroethene	75-35-4	5	5
1,1-Dichloroethane	75-34-3	5	5
1,2-Dichloroethene (total)	540-59-0	5	5
Chloroform	67-66-3	5	5
1,2-Dichloroethane	107-06-2	5	5
2-Butanone	78-93-3	10	10
1,1,1-Trichloroethane	71-55-6	5	5
Carbon Tetrachloride	56-23-5	5	5
Vinyl Acetate	108-05-4	10	10
Bromodichloromethane	75-87-5	5	5
1,2-Dichloropropane	78-87-5	5	5
cis-1,3-Dichloropropene	10061-01-5	5	5
Trichloroethene	79-01-6	5	5
Dibromochloromethane	124-48-1	5	5
1,1,2-Trichloroethane	79-00-5	5	5
Benzene	71-43-2	5	5
trans-1,3-Dichloropropene	10061-02-6	5	5
Bromoform	10061-02-6	5	5

(1) Specific quantitation limits are highly matrix dependent. The quantitation limits listed herein are provided for guidance and may not always be achievable.

(2) Quantitation limits listed for soil/sediment are based on wet weight. The quantitation limits calculated by the laboratory for soil/sediment, calculated on dry weight basis as required by the contract, will be higher.

(3) Medium soil/sediment CRQL for volatile TCL compounds are 125 times the individual low soil/sediment CRQL.

(4) Medium soil/sediment CRQLs for semivolatile TCL compounds are 60 times the individual low soil/sediment CRQL.

(5) Medium soil/sediment CRQLs for pesticide/PCB TCL compounds are 15 times the individual low soil/sediment CRQL.

TABLE 6-1
TARGET COMPOUND LIST (TCL) ANALYTES AND
CONTRACT REQUIRED QUANTITATION LIMITS (CRQL)[1]
NSWC - WHITE OAK
SILVER SPRING, MARYLAND
PAGE TWO

Volatiles	CAS Number	Quantitation Limits(2)	
		Water (ug/L)	Low Soil/Sediment(3) (ug/kg)
4-Methyl-2-pentanone	108-10-1	10	10
2-Hexanone	75-15-0591-78-6	10	10
Tetrachloroethene	127-18-4	5	5
Toluene	108-88-3	5	5
1,1,2,2-Tetrachloroethane	79-34-5	5	5
Chlorobenzene	108-90-7	5	5
Ethyl Benzene	100-41-4	5	5
Styrene	100-42-5	5	5
Xylenes (total)	1330-20-7	5	5

(1) Specific quantitation limits are highly matrix dependent. The quantitation limits listed herein are provided for guidance and may not always be achievable.

(2) Quantitation limits listed for soil/sediment are based on wet weight. The quantitation limits calculated by the laboratory for soil/sediment, calculated on dry weight basis as required by the contract, will be higher.

(3) Medium soil/sediment CRQL for volatile TCL compounds are 125 times the individual low soil/sediment CRQL.

TABLE 6-1
TARGET COMPOUND LIST (TCL) ANALYTES AND
CONTRACT REQUIRED QUANTITATION LIMITS (CRQL)[1]
NSWC-WHITE OAK
SILVER SPRING, MARYLAND
PAGE THREE

Semivolatiles	CAS Number	Quantitation Limits(2)	
		Water (ug/L)	Low Soil/Sediment(4) (ug/kg)
Phenol	108-95-2	10	330
bis(2-Chloroethyl)ether	111-44-4	10	330
2-Chlorophenol	95-57-8	10	330
1,3-Dichlorobenzene	541-73-1	10	330
1,4-Dichlorobenzene	106-46-7	10	330
Benzyl Alcohol	100-51-6	10	330
1,2-Dichlorobenzene	95-50-1	10	330
2-Methylphenol	95-48-7	10	330
bis(2-Chloroisopropyl)ether	108-60-1	10	330
4-Methylphenol	106-44-5	10	330
N-Nitroso-di-n-dipropylamine	621-64-7	10	330
Hexachloroethane	67-72-1	10	330
Nitrobenzene	98-95-3	10	330
Isophorone	78-59-1	10	330
2-Nitrophenol	88-75-5	10	330
2,4-Dimethylphenol	105-67-9	10	330
Benzoic Acid	65-85-0	50	1600
bis(2-Chloroethoxy)methane	111-91-1	10	330
2,4-Dichlorophenol	120-83-2	10	330
1,2,4-Trichlorobenzene	120-82-1	10	330
Naphthalene	91-20-3	10	330
4-Chloroaniline	106-47-8	10	330
Hexachlorobutadiene	87-68-3	10	330
4-Chloro-3-methylphenol (para-chloro-meta-cresol)	59-50-7	10	330
2-Methylnaphthalene	91-57-6	10	330
Hexachlorocyclopentadiene	77-47-4	10	330
2,4,6-Trichlorophenol	88-06-2	10	330
2,4,5-Trichlorophenol	95-95-4	50	1600
2-Chloronaphthalene	91-58-7	10	330
2-Nitroaniline	88-74-4	50	1600

(1) Specific quantitation limits are highly matrix dependent. The quantitation limits listed herein are provided for guidance and may not always be achievable.

(2) Quantitation limits listed for soil/sediment are based on wet weight. The quantitation limits calculated by the laboratory for soil/sediment, calculated on dry weight basis as required by the contract, will be higher.

(4) Medium soil/sediment CRQLs for semivolatile TCL compounds are 60 times the individual low soil/sediment CRQL.

TABLE 6-1
TARGET COMPOUND LIST (TCL) ANALYTES AND
CONTRACT REQUIRED QUANTITATION LIMITS (CRQL)[1]
NSWC-WHITE OAK
SILVER SPRING, MARYLAND
PAGE FOUR

Semivolatiles	CAS Number	Quantitation Limits(2)	
		Water (ug/L)	Low Soil/Sediment(4) (ug/kg)
Dimethylphthalate	131-11-3	10	330
Acenaphthylene	208-96-8	10	330
2,6-Dinitrotoluene	606-20-2	10	330
3-Nitroaniline	99-09-2	50	1600
Acenaphthene	83-32-9	10	330
2,4-Dinitrotoluene	51-28-5	50	1600
4-Nitrophenol	100-02-7	10	1600
Dibenzofuran	132-64-9	10	330
2,4-Dinitrotoluene	121-14-2	10	330
Diethylphthalate	84-66-2	10	330
4-Chlorophenyl-phenyl ether	7005-72-3	10	330
Fluorene	86-73-7	10	330
4-Nitroaniline	100-01-6	50	1600
4,6-Dinitro-2-methylphenol	534-52-1	50	1600
n-Nitrosodiphenylamine	86-30-6	10	330
4-Bromophenyl-phenyl ether	101-55-3	10	330
Hexachlorobenzene	118-74-1	10	330
Pentachlorophenol	87-86-5	50	1600
Phenanthrene	85-01-8	10	330
Anthracene	120-12-7	50	1600
Di-n-butylphthalate	84-74-2	10	330
Fluoranthene	206-44-0	10	330
Pyrene	129-00-0	10	330
Butylbenzylphthalate	85-68-7	10	330
3,3'-Dichlorobenzidine	91-94-1	20	660
Benzo(a)anthracene	56-55-3	10	330
Chrysene	218-01-9	10	330
bis(2-Ethylhexyl)phthalate	117-81-7	10	330
Di-n-octylphthalate	117-84-0	10	330
Benzo(b)fluoranthene	205-99-2	10	330

(1) Specific quantitation limits are highly matrix dependent. The quantitation limits listed herein are provided for guidance and may not always be achievable.

(2) Quantitation limits listed for soil/sediment are based on wet weight. The quantitation limits calculated by the laboratory for soil/sediment, calculated on dry weight basis as required by the contract, will be higher.

(4) Medium soil/sediment CRQLs for semivolatile TCL compounds are 60 times the individual low soil/sediment CRQL.

TABLE 6-1
TARGET COMPOUND LIST (TCL) ANALYTES AND
CONTRACT REQUIRED QUANTITATION LIMITS (CRQL)[1]
NSWC-WHITE OAK
SILVER SPRING, MARYLAND
PAGE FIVE

Semivolatiles	CAS Number	Quantitation Limits(2)	
		Water (ug/L)	Low Soil/Sediment(4) (ug/kg)
Benzo(k)fluoranthene	207-08-9	10	330
Benzo(a)pyrene	50-32-8	10	330
Indeno(1,2,3-cd)pyrene	193-39-5	10	330
Dibenz(a,h)anthracene	53-70-3	10	330
Benzo(g,h,i)perylene	191-24-2	10	330

(1) Specific quantitation limits are highly matrix dependent. The quantitation limits listed herein are provided for guidance and may not always be achievable.

(2) Quantitation limits listed for soil/sediment are based on wet weight. The quantitation limits calculated by the laboratory for soil/sediment, calculated on dry weight basis as required by the contract, will be higher.

(4) Medium soil/sediment CRQLs for semivolatile TCL compounds are 60 times the individual low soil/sediment CRQL.

TABLE 6-1
TARGET COMPOUND LIST (TCL) ANALYTES AND
CONTRACT REQUIRED QUANTITATION LIMITS (CRQL)[1]
NSWC-WHITE OAK
SILVER SPRING, MARYLAND
PAGE SIX

PCBs	CAS Number	Quantitation Limits(2)	
		Water (ug/L)	Low Soil/Sediment(5) (ug/kg)
Toxaphene	18001-35-2	1.0	160.0
Aroclor-1016	12674-11-2	0.5	80.0
Aroclor-1221	11104-28-2	0.5	80.0
Aroclor-1232	11141-16-5	0.5	80.0
Aroclor-1242	53469-21-9	0.5	80.0
Aroclor-1248	12672-29-6	0.5	80.0
Aroclor-1254	11097-69-1	1.0	160.0
Aroclor-1260	11096-82-5	1.0	160.0

(1) Specific quantitation limits are highly matrix dependent. The quantitation limits listed herein are provided for guidance and may not always be achievable.

(2) Quantitation limits listed for soil/sediment are based on wet weight. The quantitation limits calculated by the laboratory for soil/sediment, calculated on dry weight basis as required by the contract, will be higher.

(5) Medium soil/sediment CRQLs for pesticide/PCB TCL compounds are 15 times the individual low soil/sediment CRQL.

TABLE 6-1
INORGANIC TARGET ANALYTE LIST (TAL)
AND CONTRACT REQUIRED DETECTION LIMITS (CRDLs)
NSWC-WHITE OAK
SILVER SPRING, MARYLAND
PAGE SEVEN

Analyte	Contract Required Detection Limit	
	Water (ug/L)	Soil (100% Solids) (mg/kg)
Aluminum	200	40
Antimony	60	12
Arsenic	10	2
Barium	200	40
Beryllium	5	1
Cadmium	5	1
Calcium	5000	1000
Chromium	10	2
Cobalt	50	10
Copper	25	5
Iron	100	20
Lead	3	0.6
Magnesium	5000	1000
Manganese	15	3
Mercury	0.2	0.1
Nickel	40	8
Potassium	5000	1000
Selenium	5	1
Silver	10	2
Sodium	5000	1000
Thallium	10	2
Vanadium	50	10
Zinc	20	4

DR = duplicate sample result

The internal laboratory control limits for precision are three times the standard deviation of a series of RPD or range values. RPD values may be calculated for both laboratory and field duplicates, and can be compared to the control limits as a QA check. Laboratory duplicates will be analyzed at the rate required by the CLP. Field duplicates will be collected for 10 percent of all samples collected.

6.2.4.2 Accuracy

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

$$\%R = \frac{E}{T} X\ 100$$

where

E = experimental result

T = true value (theoretical result)

and

$$T = \frac{(sample\ aliq.)\ (sample\ conc.) + (spike\ aliq.)\ (spike\ conc.)}{sample\ aliq. + conc.}$$

Control limits for accuracy are set at the mean plus or minus three times the standard deviation of a series or %R values. Organic %R values are set at the mean plus or minus two times the standard deviation.

Accuracy for aqueous and solid samples will be evaluated by use of surrogate and matrix spikes at the CLP-required incidences. CLP acceptance criteria and corrective actions apply. Out-of-criteria results will be reviewed for data applicability as a part of data validation.

6.2.4.3 Representativeness

All data obtained should be representative of actual conditions at the sampling location. The Work Plan is designed so that the samples taken will be an accurate representation of actual site conditions. All sampling activities will conform to the protocols given in this QAPP. The use of CLP analytical protocols and data deliverables will ensure that analytical results and deliverables are representative and that they are both performed and reported consistently.

6.2.4.4 Comparability

Comparability will be achieved by utilizing standardized sampling and analysis methods and data reporting format. Both analytical procedures and sample collection techniques will maximize the comparability of these new data to previous data. Using consistent units will also ensure that data are comparable. Both field and laboratory data will be expressed in Standard International Units (SIUs), usually μg/L or μg/kg. Additionally, consideration will be given to seasonal conditions and other environmental conditions that could influence analytical results.

6.2.4.5 Completeness

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

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

6.2.5 <u>Trip Blanks</u>

To determine whether contamination of samples or bottleware has occurred in the field, trip blanks will be used. Trip blanks consist of analyte-free water taken from the laboratory to the site and returned.

Trip blanks are taken at the rate of one per cooler of volatile organics and will be analyzed for TCL VOCs only. No other types of field quality control blanks are required since dedicated disposable bailers will be used to conduct the sampling.

6.2.6 Bottleware

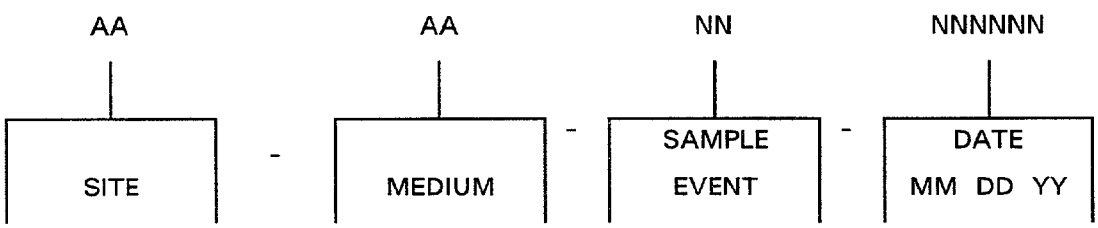
NEESA requires specific bottleware cleaning procedures. Precleaned bottles will be used at Site 8. A listing of bottleware requirements for this project is presented in Table 6-2.

6.3 FIELD SAMPLING PLAN

6.3.1 Sample Designation

For each sample collected at Site 8 a unique sample tracking number will be assigned. The sample tracking number will consist of a three-segment, alphanumeric code that identifies the sample medium, location, the sampling event (in the case of monitoring well samples). Any other pertinent information regarding sample identification will be recorded in the field logbooks.

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



Character type:

A = Alpha
N = Numeric

Medium:

GW = Groundwater from Monitoring Well

TABLE 6-2

SUMMARY OF ANALYSES, BOTTLE REQUIREMENTS, PRESERVATION REQUIREMENTS, AND HOLDING TIMES

Medium	Analysis/ Methodology	Number of Samples(1)	No. of Containers per Sample(2)	Type of Container	Preservation Requirements	Holding Time(3)
Groundwater	Volatile Organics	5	3	40-ml VOC vials teflon-septum	HCl to pH<2 Cool to 4° C	14 days
	Semivolatile organics, PCBs	5	2	1-liter amber glass bottles, teflon-lined lid	Cool to 4° C	7 days until extraction, 40 days after extraction
	Metals (4)	5	2	1-liter polyethylene bottle	HNO_3 to pH<2 Cool to 4° C	6 months; Hg - 28 days

(1) Exclusive of QA/QC samples.
(2) Additional containers will be required for matrix spike/matrix spike duplicate samples.
(3) Holding times shown are from the date of sample collection.
(4) Groundwater samples collected for metals analysis will be both unfiltered and field filtered to accommodate total and dissolved TM metals analyses, respectively.

For example, a monitoring well 33 in site 8 will be designated as:

8GW33

Sample Identifier:

For other media = Sample round

Sample Collection Date:

For example, all samples will be dated numerically with MM DD YY. A groundwater sample from monitoring well number 8GW33 collected during event III from monitoring well number 8GW33 would be designated as:

GW33-III-041093

Field duplicate samples will be submitted as blinds in order not to identify the QC sample to the laboratory. QC samples will be noted as such in the field log. For example, a duplicate of sample 8GW36 could be designated 8GW37. NEESA does not require submission of trip blanks as blinds to the laboratory. The trip blank collected during event III could be designated as GWTB-III-041093. Information regarding sample labels to be attached before shipment to a laboratory is contained in Section 5.2 of Halliburton NUS Standard Operating Procedure (SOP) SA-6.1 (see Appendix B). An example of the sample label and chain-of-custody seal for use in USEPA Region III are included in Halliburton NUS SOP SA-6.1 (Appendix B).

6.3.2 Sample Handling

Sample handling includes the field-related considerations connected with the selection of sample containers, preservatives, allowable holding times, and analyses requested. The USEPA User's Guide to the Contract Laboratory Program (CLP) (EPA, 1986a), the October 26, 1984 Federal Register (49 FR 43260), and the Resource Conservation and Recovery Act (RCRA) Groundwater Monitoring Technical Enforcement Guidance Document (EPA, 1988b) address the topics of containers and sample preservation. Table 6-2 provides a site-specific summary of all sample handling considerations.

6.3.3 Sample Packaging and Shipping

Samples will be packaged and shipped in accordance with Halliburton NUS SOPs SA-6.2 and 6.6 (see Appendix B), which are in accordance with the EPA User's Guide to the Contract Laboratory Program (EPA, 1986a). The Project Geologist will be responsible for contacting the laboratory representative for each shipment and will report the following:

- Sampler name and telephone number
- Site name/code
- Number(s), matrix(ces), and concentration(s) of samples shipped
- Carrier name and air bill number(s) for the shipment
- Method of shipment (e.g., overnight, 2-day)
- Date of shipment
- Suspected hazards associated with the samples or site

6.3.4 Documentation

Custody of samples must be maintained and documented at all times. Chain of custody begins with the mobilization of sample containers and contaminant-free water. Section 5.3 of Halliburton NUS SOP SA-6.1 (Appendix B) provides a description of the chain-of-custody procedures to be followed.

In addition, a sample log sheet will be completed for each sample collected. This form will contain the sample description and will document time and date, location, field measurements, and other pertinent data relative to the various samples. One form is specifically used for groundwater samples. An example of this form can be found in Halliburton NUS SOP SA-6.4 (Appendix B).

Separate bound/weatherproof field notebooks will be maintained by each sampling event leader and the site safety officer (SSO). The Project Geologist, sampling event leader (or designee), and SSO will record all information related to sampling or field activities. This may include such information as sampling time, weather conditions, unusual events (e.g., well tampering), field measurements, and description of photographs.

A site logbook will be maintained by the Project Geologist. The requirements of the site logbook are outlined in Halliburton NUS SOP SA-6.3, Sections 5 and 7 (Appendix B). This book will contain a summary of the day's activities and will reference the field notebook(s), when applicable.

At the completion of field activities, the Project Geologist will provide the Project Manager all field records, data, field notebooks, logbooks, chain-of-custody receipts, sample log sheets, drilling logs, daily logs, etc. The Project Manager will ensure that these materials are entered into the Halliburton NUS document control system in accordance with appropriate administrative guidelines.

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 Site Geologist notifies the Project Manager of the need for the change.
- If necessary, the Project Manager will discuss the change with the pertinent individuals (Remedial Project Manager) and will provide a verbal approval or denial to the Project Geologist for the proposed change.
- The Site Geologist will document the change on a Task Modification Request form (Appendix A) and forward the form to the Halliburton NUS Project Manager at the earliest convenient time (e.g., end of the work week).
- The Halliburton NUS Project Manager will sign the form and distribute copies to the White Oak Remedial Project Manager, Quality Assurance Manager, Project Geologist, and the project file.
- A copy of the completed Task Modification Request form will be attached to the field copy of the affected document (i.e., this Field Sampling Plan).

6.4 FIELD OPERATIONS

6.4.1 Mobilization/Demobilization

Following approval of the Work Plan for the third round of groundwater sampling, Halliburton NUS will begin mobilization activities. All field team members will review the Work Plan, including the project-specific Health and Safety Plan (HASP). In addition, a field team orientation meeting will be held to familiarize personnel with the scope of the field sampling activities.

Equipment mobilization may include, but will not be limited to, the mobilization and setup of the following equipment:

- Sampling equipment
- Hydrogeologic monitoring equipment

6.4.2 Groundwater Sampling Methods

Groundwater samples will be collected in accordance with methodologies and standard operating procedures (SOPs) described in Section 4.3 of this Work Plan.

6.5 SAMPLE CUSTODY

Sample custody procedures are designed to provide documentation of preparation, handling, storage, and shipping of all samples collected. An example of the chain-of-custody form that will be used during this investigation is included in Halliburton NUS SOP SA-6.1 (Appendix B).

Samples collected during the groundwater investigation will be the responsibility of identified persons from the time they are collected until they, or their derived data, are incorporated into the final report. Stringent chain-of-custody procedures will be followed to document sample possession.

6.5.1 Field Custody

- The Site Geologist or his designee, is responsible for the care and custody of the samples collected until they are delivered to the analyzing laboratory or entrusted to a carrier.

- Sample logs or other records will always be signed and dated.

- Chain-of-custody sample forms will be completed to the fullest extent possible prior to sample shipment. They will include the following information: project name, sample number, time collected, source of sample and location, description of sample location, matrix, type of sample, grab or composite designation, preservative, and name of sampler. These forms will be filled out 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 the general analyses

to be conducted. In addition, sampling forms will be used to document collection, filtration, and preparation procedures.

6.5.2 Transfer of Custody and Shipment

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

- Samples will always be accompanied by a chain-of-custody record. When samples are transferred, the individuals relinquishing and receiving them will sign, date, and note the time of the chain-of-custody record. This record documents the sample custody transfer from the sampler to the laboratory, often through another person or agency (common carrier). Upon the sample's arrival at the laboratory, internal sample custody procedures will be followed.

- Prior to being shipped to the laboratory for analysis, samples will be properly packaged. Individual custody records will accompany each shipment. Shipping containers will then be sealed for shipment to the laboratory. The methods of shipment, courier name, and other pertinent information will be entered in the remarks section of the custody record.

- All shipments will be accompanied by the chain-of-custody record identifying the contents. The original record will accompany the shipment and a copy will be retained by the field sampler.

- Proper documentation such as copies of the carrier Air Bill will be maintained for shipments by common carrier.

6.5.3 Sample Shipment Procedures

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

- Samples requiring refrigeration will be promptly chilled with ice or Blue Ice to a temperature of 4°C and will be packaged in an insulated cooler for transport to the laboratory. Ice will be sealed in containers to prevent leakage of water. Samples will not be frozen.

- Only shipping containers that meet all applicable state and Federal standards for safe shipment will be used.

- Shipping containers will be sealed with nylon strapping tape, and custody seals will be signed, dated, and affixed, in a manner that will allow the receiver to quickly identify any tampering during transport to the laboratory.

- The field chain-of-custody document will be placed inside the shipping container in a sealed plastic envelope after the courier has signed the document.

- Shipment will be made by overnight courier. After samples have been taken, they must be sent to the laboratory within 24 hours.

6.5.4 Field Documentation Responsibilities

It will be the responsibility of the Project Geologist to secure all documents produced in the field (sampling logs, communications) at the end of each workday.

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

Data generated by the laboratory will be sent to Halliburton NUS, validated, and stored by Halliburton NUS until completion and acceptance of the groundwater sampling investigation report. A final QC data report will be issued to the NCR at least 3 weeks before the final report is issued.

6.6 CALIBRATION PROCEDURES

Field equipment such as the portable gas chromatograph (GC), the photoionization equipment (TIP or HNU), pH and specific conductance meters, will be calibrated and operated in accordance with the manufacturer's instructions and manuals. A log will be kept documenting the calibration results for each field instrument. The log will include the date, standards, personnel, and results of the calibration.

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

6.7 DATA REDUCTION, VALIDATION, AND REPORTING

Data reduction, validation, and reporting are basic steps in the control and processing of field and laboratory project-generated data. Data validation procedures are described below.

Data validation consists of a stringent review of an analytical chemical data package with respect to sample receipt and handling, analytical methods, data reporting and deliverables, and document control. The quality of data generated by a laboratory is extremely important; it is an integral part of the investigation and should be clearly tied to the project goals. Data used to develop qualitative trends, for example, will not have the same data validation requirements as data used for litigation purposes.

A qualified Halliburton NUS chemist will evaluate the analytical data package using National Functional Guideline protocols which are applicable for use with CLP analysis procedures. After the data have been validated, a listing of nonconformities will be generated and used to determine whether the data can be utilized for their intended purpose (assessment, enforcement, litigation).

Nonconformities require data qualifiers, which are used to alert the data user to inaccurate or imprecise data. For example, if holding times are exceeded, the data reviewer must qualify all positive results as estimated and all sample quantitation limits as estimated. In instances where holding times are grossly exceeded, associated non-detects are rejected as unreliable. For situations in which there are several QC criteria out of specification (with regard to the limits specified in the NEESA 20.2-047B; 6/85 guidance document), the data validator may make professional judgments and comments on the validity of the overall data package. In situations where the validity of an entire data package is in question, it may be necessary for the sample(s) to be reanalyzed. The reviewer will then prepare a technical memorandum presenting changes in the data, if necessary, and the rationale for making such changes.

The net result is a data package that has been carefully reviewed for its adherence to prescribed requirements and that is suitable for its intended use. Data validation thus plays a major role in determining the confidence with which key technical evaluations may be made.

The laboratory data for each sample will be reported in an appendix. These data will be presented in a spreadsheet format with all field quality control samples marked. The format recommended by the Navy will be used.

6.8 INTERNAL QC CHECKS

Quality control samples generated by Halliburton NUS will include field duplicates, field blanks, and laboratory-prepared trip blanks. No other types of field quality control blanks are required since dedicated disposable bailers will be used for sampling. Trip blanks (VOCs only) will be shipped along with the sample bottles and will be analyzed concurrently with the collected environmental samples. An approximate 10 percent replication -- one per 10 samples or one per sample matrix if fewer than 10 samples have been collected--will be observed to meet field duplicate requirements. Procedures for collecting these QC samples are contained in Section 6.0.

Two types of QA mechanisms are used to ensure the production of analytical data of known and documented quality. The internal QC procedures for the analytical services are specified in the CLP protocol. These specifications include the types of control samples required (sample spikes, surrogate spikes, controls, and blanks), the frequency of each control, the compounds to be used for sample spikes and surrogate spikes, and the QC acceptance criteria. It will be the laboratory's responsibility to document in each package that both initial and ongoing instrument and analytical QC criteria have been met. This documentation will be included in the data packages generated by the contract laboratory.

Analytical results of field-collected QC samples will also be compared to acceptance criteria, and documentation will be performed showing that these criteria have been met. Any samples not in conformance with the QC criteria will be identified and reanalyzed by the laboratory, if possible. The following procedures will be employed for the Site 8 samples:

- Proper storage of samples
- Use of qualified and/or certified technicians
- Use of calibrated equipment traceable to the CLP Protocol
- Formal independent confirmation of all computation and reduction of laboratory data and results
- Use of standardized test procedures
- Inclusion of replicate samples at a frequency of one replicate per 10 samples or one per sample matrix if fewer than 10 samples have been collected

REFERENCES

Malcolm Pirnie, Inc., 1992. Remedial Investigation Report, Dahlgren Division Detachment, White Oak, Silver Spring, Maryland. October.

Malcolm Pirnie, Inc., 1987. NACIP Program Confirmation Study, Verification Phase. Naval Surface Weapons Center, White Oak, Maryland. April.

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

Naval Energy and Environmental Support Activity (NEESA), 1984. Initial Assessment Study of Naval Surface Weapons Center, White Oak Laboratory, Silver Spring, Maryland. Naval Engineering and Environmental Support Activity. August.

APPENDIX A

ANALYTICAL DATA TABLES
NSWC - WHITE OAK
ABANDONED CHEMICAL DISPOSAL PIT
SITE 8

(SOURCE: RI REPORT, MALCOLM PIRNIE, INC., 1992)

SITE 8 - ABANDONED CHEMICAL DISPOSAL PIT
SURFICIAL SOIL ANALYTICAL RESULTS
(Phase I - 1989)

Parameter	Sample Locations		Detection Limit	Units
	8SL1	8SL2		
METALS:				
Cadmium	U	U	0.78	mg/kg
Chromium	14.6	58.5	0.70	mg/kg
Copper	7.7	12.4	0.30	mg/kg
Lead	30.0	57.2	3.60	mg/kg
Mercury	U	U	0.15	mg/kg
Zinc	28.1	47.7	0.50	mg/kg
SEMIVOLATILE ORGANICS:				
Benzoic Acid	U	280 JX	2,500	ug/kg

Notes: U - Not detected.
J - Compound is present but below the detection limit.
X - EPA CLP criteria not met for confirmation but compound is present.

28-May-92

SITE 8 – ABANDONED CHEMICAL DISPOSAL PIT
GROUNDWATER ANALYTICAL RESULTS

(Phase I – 1989)

Parameter	Sample Locations					Detection Limit	Units
	8GW33	8GW34	8GW35	8GW36	8GW53		
TOTAL METALS:							
Cadmium	U	U	U	U	U	5.0	ug/l
Chromium	395.0	162.0	381.0	344.0	462.0	7.0	ug/l
Copper	505.0	167.0	357.0	269.0	452.0	3.0	ug/l
Lead	106.0	57.3	102.0	101.0	123.0	28.0	ug/l
Mercury	4.5	0.51	U	U	U	0.20	ug/l
Zinc	1,280.0	385.0	910.0	876.0	1,350.0	3.0	ug/l
FILTERED METALS:							
Cadmium	U	2.7	U	U	U	5.0	ug/l
Chromium	U	U	U	U	U	7.0	ug/l
Copper	U	U	U	U	U	3.0	ug/l
Lead	U	U	U	U	U	28.0	ug/l
Mercury	U	U	U	U	U	0.20	ug/l
Zinc	16.8	24.3	18.2	18.1	37.6	3.0	ug/l
pH	8.30	4.80	5.10	4.80	6.00	--	su
TOC	1,700	600	1,100	1,100	500	500	ug/l
TOX	8	18	11	U	--	8	ug/l
TDS	U	U	U	22	U	20	mg/l
TSS	14,800	3,920	9,410	9,000	11,100	4	mg/l
VOLATILE ORGANICS:							
Chloroform	U	U	10	U	U	5	ug/l
1,1,2-Trichloroethane	U	U	U	7	U	5	ug/l
SEMIVOLATILE ORGANICS:							
bis(2-ethylhexyl)phthalate	19	U	13	7 J	15	10	ug/l

Notes: U – Not detected.
J – Compound is present but below the detection limit.

03-Jun-92

BACKGROUND WELLS
GROUNDWATER ANALYTICAL RESULTS
(Phase I - 1989)

Parameter	Sample Locations		Detection Limit	Units
	BGW16	BGW40		
TOTAL METALS:				
Cadmium	7.6	U	3.0	ug/l
Chromium	213.0	97.2	7.0	ug/l
Copper	135.0	50.5	3.0	ug/l
Lead	51.9	50.7	28.0	ug/l
Mercury	1.2	U	0.20	ug/l
Zinc	101.0	244.0	3.0	ug/l
Chromium VI	U	U	10.0	ug/l
FILTERED METALS:				
Cadmium	4.3	U	3.0	ug/l
Chromium	U	U	7.0	ug/l
Copper	U	U	3.0	ug/l
Lead	U	U	28.0	ug/l
Mercury	U	U	0.20	ug/l
Zinc	34.4	36.2	3.0	ug/l
Chromium VI	U	U	10.0	ug/l
pH	4.70	4.60	—	su
TOC	12,500	1,100	500	ug/l
TOX	U	11	8	ug/l
TDS	116	150	20	mg/l
TSS	5,150	2,920	4	mg/l
VOLATILE ORGANICS:	U	U	—	ug/l
SEMIVOLATILE ORGANICS:	U	U	—	ug/l

Note: U - Not detected.

SITE 8 – ABANDONED CHEMICAL DISPOSAL PIT
GROUNDWATER ANALYTICAL RESULTS
(PHASE II - 1991)

Parameter	Sample Locations					Detection Limit	Units
	8GW33	8GW34	8GW35	8GW36	8GW53		
TOTAL METALS:							
Cadmium	U	U	U	5.0	U	5.0	ug/l
Chromium	63	U	U	2.9	U	10	ug/l
Copper	131	51	15	53	36	25	ug/l
Lead	29	6.9	5.2	8.2	2.5	3	ug/l
Mercury	R	R	R	R	R	0.2	ug/l
Zinc	159	17	42	165	27	20	ug/l
FILTERED METALS:							
Cadmium	U	U	U	U	U	5.0	ug/l
Chromium	U	U	U	U	U	10	ug/l
Copper	45	U	11	20	U	25	ug/l
Lead	7.3	U	U	U	U	3	ug/l
Mercury	R	R	R	R	R	0.2	ug/l
Zinc	31	138	39	60	51	20	ug/l
PCBs (1)	U	U	U	U	U	1.0	ug/l
VOLATILE ORGANICS:							
Chloroform	U	U	8	U	U	5	ug/l
1,1,2-Trichloroethane	U	U	U	4	U	5	ug/l
Methylene Chloride	10	13	U	U	U	5	ug/l
Acetone	R	R	U	U	U	10	ug/l
SEMIVOLATILES:							
bis(2-ethylhexyl)phthalate	R	R	R	R	R	10	ug/l

NOTES: (1) The PCB compound for which values are given here is AR1260.
U - Not detected.
R - Quantitation Rejected

18-May-92

BACKGROUND WELLS
GROUNDWATER ANALYTICAL RESULTS
(PHASE II - 1991)

Parameter	Sample Locations		Detection Limit	Units
	BGW16	BGW40		
TOTAL METALS:				
Cadmium	U	U	5	ug/l
Chromium	109	U	10	ug/l
Copper	190	35	25	ug/l
Lead	47	3.4	3	ug/l
Mercury	R	R	0.2	ug/l
Zinc	101	26	20	ug/l
FILTERED METALS:				
Cadmium	U	U	5	ug/l
Chromium	U	U	10	ug/l
Copper	U	11	25	ug/l
Lead	U	U	3	ug/l
Mercury	R	R	0.2	ug/l
Zinc	13	17	20	ug/l
PCBs (1)	U	U	1.0	ug/l
NITROAROMATICS:				
RDX	U	R	1.6	ug/l
VOLATILE ORGANICS:	U	U	5	ug/l
SEMIVOLATILE ORGANICS:	U	U	10	ug/l

NOTES: (1) The PCB compound for which values are given is AR1260
U Not detected above method detection limit
R - Quantitation Rejected

APPENDIX B

HALLIBURTON NUS
STANDARD OPERATING PROCEDURES

SF-1.1	ON-SITE WATER QUALITY TESTING
SF-1.2	SAMPLE PRESERVATION
SA-1.1	GROUNDWATER SAMPLE ACQUISITION
SA-6.1	SAMPLE IDENTIFICATION AND CHAIN-OF-CUSTODY
SA-6.2	SAMPLE PACKAGING AND SHIPPING
SA-6.3	SITE LOGBOOK
SA-6.4	FORMS USED IN RI ACTIVITIES
GH-2.5	WATER LEVEL MEASUREMENTS/CONTOUR MAPPING

NUS CORPORATION ENVIRONMENTAL MANAGEMENT GROUP	STANDARD OPERATING PROCEDURES	Number SF-1.1	Page 1 of 16
		Effective Date 05/04/90	Revision 2
		Applicability EMG	
		Prepared Earth Sciences	
Subject ONSITE WATER QUALITY TESTING		Approved D. Senovich	

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1.0 PURPOSE

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

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

2.0 SCOPE

This procedure is applicable for use in an on-site groundwater quality monitoring program to be conducted during a remedial investigation or site investigation program at a hazardous or non-hazardous site. The procedures and equipment described are applicable to nearly all aqueous samples, including potable well water, monitoring well water, surface water, leachate and drummed water, etc. and are not, in general, subject to solution interferences from color, turbidity and colloidal material, or suspended matter.

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

3.0 GLOSSARY

3.1 pH MEASUREMENT

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

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

3.2 SPECIFIC CONDUCTANCE MEASUREMENT

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

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

Conductance - The conductance of a conductor 1 centimeter long and 1 square centimeter in cross-sectional area. Conductivity and specific conductance are used synonymously.

3.3 TEMPERATURE MEASUREMENT

None.

3.4 DISSOLVED OXYGEN MEASUREMENT

Galvanic Cell - An electrochemical cell in which chemical energy is spontaneously converted to electrical energy. The electrical energy produced is supplied to an external circuit.

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

3.5 OXIDATION-REDUCTION POTENTIAL MEASUREMENT

Oxidation - The process in which an atom or group of atoms loses electrons to achieve an increasing positive charge.

Reduction - The gaining of electrons by an atom or group of atoms and subsequent increase in negative charge.

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

3.6 SPECIFIC ION ELECTRODES MEASUREMENT

Specific Ion Electrode - An electrode which develops a potential difference across a membrane in response to the concentration differences for selected ions on either side of that membrane.

4.0 RESPONSIBILITIES

Site Manager - in consultation with the Project Geochemist, is responsible for determining which on-site water quality measurements can contribute to the RI, when these measurements shall be made, and the data quality objectives (DQOs) for these measurements. The Project Operations Plan (POP) shall contain details of type, frequency and locations of the desired measurements.

Project Geochemist - primarily responsible for determining the type, frequency and locations for on-site water quality measurements as presented in the POP and for interpreting the results, including determination of which measurements are unrepresentative.

Field Operations Leader - responsible for implementing the POP, and also for deciding under what field conditions a particular on-site measurement will be unrepresentative or unobtainable.

Field Samplers/Analysts - responsible for the actual analyses that take place, including calibration, quality control and recording of results, as well as for the care and maintenance of the equipment in the field.

5.0 GUIDELINES

5.1 MEASUREMENT OF pH

5.1.1 General

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

Measurements of pH can also be used to check the quality and corrosivity of soil and solid waste samples. However, these samples must be immersed in water prior to analysis, and specific techniques are not described.

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

5.1.2 Principles of Equipment Operation

Use of pH papers for pH measurement relies on a chemical reaction caused by the acidity or basicity of the solution with the indicator compound on the paper. Depending on the indicator and the pH range of interest, a variety of different colors can be used. Typical indicators are weak acids or bases, or both. Process chemistry and molecular transformations leading to the color change are variable and complex.

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

5.1.3 Equipment

The following equipment is needed for taking pH measurements:

- Accumet 150 portable pH meter, or equivalent.
- Combination electrode with polymer body to fit the above meter (alternately a pH electrode and a reference electrode can be used if the pH meter is equipped with suitable electrode inputs.
- pH indicator paper, such as Hydrion or Alkacid, to cover the pH range 2 through 12.
- Buffer solutions of pH 4, 7 and 10, or other buffers which bracket the expected pH range.

5.1.4 Measurement Techniques for Field Determination of pH

1. pH Meter

The following procedure is used for measuring pH with a pH meter (Standardization is according to manufacturers instructions):

a. The instrument and batteries shall be checked and calibrated prior to initiation of the field effort.

b. The accuracy of the buffer solutions used for field and laboratory calibration shall be checked. Buffer solutions need to be changed often due to degradation upon exposure to the atmosphere.

c. Immerse the tip of the electrodes in water overnight. If this is not possible due to field conditions, immerse the electrode tip in water for at least an hour before use. The electrode tip may be immersed in a rubber or plastic sack containing buffer solution for field transport or storage. This is not applicable for all electrodes as some must be stored dry.

d. Make sure all electrolyte solutions within the electrode(s) are at their proper levels and that no air bubbles are present within the electrode(s).

e. Immerse the electrode(s) in a pH-7 buffer solution.

f. Adjust the temperature compensator to the proper temperature (on models with automatic temperature adjustment, immerse the temperature probe into the buffer solution). Alternately, the buffer solution may be immersed in the sample and allowed to reach temperature equilibrium before equipment calibration. It is best to maintain buffer solution at or near expected sample temperature before calibration.

g. Adjust the pH meter to read 7.0.

h. Remove the electrode(s) from the buffer and rinse well with demineralized water. Immerse the electrode(s) in pH-4 or 10 buffer solution (depending on the expected pH of the sample) and adjust the slope control to read the appropriate pH. For best results, the standardization and slope adjustments shall be repeated at least once.

i. Immerse the electrode(s) in the unknown solution, slowly stirring the probe until the pH stabilizes. Stabilization may take several seconds to minutes. If the pH continues to drift, the sample temperature may not be stable, a chemical reaction (e.g., degassing) may be taking place in the sample, or the meter or electrode may be malfunctioning. This must be clearly noted in the logbook.

j. Read and record the pH of the solution, after adjusting the temperature compensator to the sample temperature. pH shall be recorded to the nearest 0.1 pH unit. Also record the sample temperature.

k. Rinse the electrode(s) with deionized water.

l. Keep the electrode(s) immersed in deionized water when not in use.

The sample used for pH measurement shall never be saved for subsequent conductivity or chemical analysis. All pH electrodes leak small quantities of electrolytes (e.g., sodium or potassium chloride) into the solution. Precipitation of saturated electrolyte solution, especially at colder temperatures, or in cold water, may result in slow electrode response. Any visual observation of conditions which may interfere with pH measurement, such as oily materials, or turbidity, shall be noted.

2. pH Paper

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

5.2 MEASUREMENT OF SPECIFIC CONDUCTANCE

5.2.1 General

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

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

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

5.2.2 Principles of Equipment Operation

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

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

5.2.3 Equipment

The following equipment is needed for taking specific conductance measurements:

- YSI Model 33 portable conductivity, meter, or equivalent
- Probe for above meter

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

5.2.4 Measurement Techniques for Specific Conductance

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

- Check batteries and calibrate instrument before going into the field.
- Calibrate the instrument daily when used. Potassium chloride solutions with a specific conductance closest to the values expected in the field shall be used. Attachment A may be used for guidance.
- Rinse the cell with one or more portions of the sample to be tested or with deionized water.
- Immerse the electrode in the sample and measure the conductivity. Adjust the temperature setting to the sample temperature.
- Read and record the results in a field logbook or sample log sheet.

If the specific conductance measurements become erratic, or inspection shows that any platinum black has flaked off the electrode, replatinization of the electrode is necessary. See the manufacturer's instructions for details.

Note that specific conductance is occasionally reported at temperatures other than ambient.

5.3 MEASUREMENT OF TEMPERATURE

5.3.1 General

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

5.3.2 Equipment

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

5.3.3 Measurement Techniques for Water Temperature

If a thermometer is used on a collected water sample:

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

If a temperature meter or probe is to be used, the instrument shall be calibrated according to manufacturer's recommendations with an approved thermometer before each measurement or group of closely spaced measurements.

5.4 MEASUREMENT OF DISSOLVED OXYGEN CONCENTRATION

5.4.1 General

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

The method monitoring discussed herein is limited to the use of dissolved oxygen meters only. Chemical methods of analysis (i.e., Winkler methods) are available, but require more equipment and greater sample manipulation. Furthermore, DO meters, using a membrane electrode, are suitable for highly polluted waters, because the probe is completely submersible, and are free from interference caused by color, turbidity, colloidal material or suspended matter.

5.4.2 Principles of Equipment Operation

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

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

Dissolved oxygen probes are relatively free of interferences. Interferences that can occur are reactions with oxidizing gases (such as chlorine) or with gases such as hydrogen sulfide which are not

easily depolarized from the indicating electrode. If the gaseous interference is suspected, it shall be noted in the field log book and checked if possible. Temperature variations can also cause interference because probes exhibit temperature sensitivity. Automatic temperature compensation is normally provided by the manufacturer.

5.4.3 Equipment

The following equipment is needed to measure dissolved oxygen concentration:

- YSI Model 56 dissolved oxygen monitor or equivalent.
- Dissolved oxygen/temperature probe for above monitor.
- Sufficient cable to allow the probe to contact the sample.

5.4.4 Measurement Techniques for Dissolved Oxygen Determination

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

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

- The probe shall be conditioned in a water sample for as long a period as practical before use in the field. Long periods of dry storage followed by short periods of use in the field may result in inaccurate readings.

- The instrument shall be calibrated in the field before each measurement or group of closely spaced measurements by placing the probe in a water sample of known dissolved oxygen concentration (i.e., determined by Winkler method) or in a freshly air-saturated water sample of known temperature. Dissolved oxygen values for air-saturated water can be determined by consulting a table listing oxygen solubilities as a function of temperature and salinity (see Attachment B).

- Immerse the probe in the sample. Be sure to provide for sufficient flow past the membrane, either by stirring the sample, or placing the probe in a flowing stream. Probes without stirrers placed in wells can be moved up and down.

- Record the dissolved oxygen content and temperature of the sample in a field logbook or sample log sheet.

- Recalibrate the probe when the membrane is replaced, or as needed. Follow the manufacturer's instructions.

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

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

5.5 MEASUREMENT OF OXIDATION-REDUCTION POTENTIAL

5.5.1 General

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

5.5.2 Principles of Equipment Operation

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

5.5.3 Equipment

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

- Accumet 150 portable pH meter or equivalent, with a millivolt scale.
- Platinum electrode to fit above pH meter.
- Reference electrode such as a calomel, silver-silver chloride, or equivalent.

5.5.4 Measurement Techniques for Oxidation-Reduction Potential

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

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

- Check that the platinum probe is clean and that the platinum bond or tip is unoxidized. If dirty, polish with emery paper or, if necessary, clean the electrode using aqua regia, nitric acid, or chromic acid, in accordance with manufacturer's instructions.

- Thoroughly rinse the electrode with demineralized water.

- Verify the sensitivity of the electrodes by noting the change in millivolt reading when the pH of the test solution is altered. The ORP will increase when the pH of the test solution decreases and the ORP will decrease if the test solution pH is increased. Place the sample in a clean glass beaker and agitate the sample. Insert the electrodes and note the ORP drops sharply when the caustic is added, the electrodes are sensitive and operating properly. If the ORP increases sharply when the caustic is added, the polarity is reversed and must be corrected in accordance with the manufacturer's instructions. If the ORP does not respond as above when the caustic is added, the electrodes shall be cleaned and the above procedure repeated.

- After the assembly has been checked for sensitivity, wash the electrodes with three changes of water or by means of a flowing stream of water from a wash bottle. Place the sample in a clean glass beaker or sample cup and insert the electrodes. Set temperature

compensator throughout the measurement period. Read the millivolt potential of the solution, allowing sufficient time for the system to stabilize and reach temperature equilibrium. Measure successive portions of the sample until readings on two successive portions differ by no more than 10 mV. A system that is very slow to stabilize properly will not yield a meaningful ORP. Record all results in a field logbook, including ORP (to nearest 10 mV), sample temperature and pH at the time of measurement.

5.6 SPECIFIC ION ELECTRODE MEASUREMENTS

5.6.1 General

Use of specific ion electrodes can be beneficial in the field for determining the presence and concentration of dissolved inorganic species which may be associated with contaminant plumes or leachate. Thus, electrodes can be used for rapid screening of water quality and determination of water migration pathways.

This procedure provides generic information for specific ion electrodes commonly used in groundwater quality monitoring programs and describes the essential elements of a field investigation program. Analytical methods using some specific ion electrodes have not been approved by the USEPA. In addition, calibration procedures and solutions, interferences and conditions and requirements for use for various electrodes vary greatly. Consequently, review of manufacturer's literature is mandatory prior to use.

5.6.2 Principles of Equipment Operation

All specific ion electrode measurements involve the use of a reference electrode, a pH meter, and a specific ion electrode (SIE). When the SIE and the reference electrode are immersed in a solution of the ion to be measured, a potential difference is developed between the two electrodes. This potential can be measured by a pH meter and related to the concentration of the ion of interest through the use of standard solutions and calibration curves.

Several different types of SIEs are in use: glass, solid-state, liquid-liquid membrane, and gas-sensing. All of the electrodes function using an ion exchange process as the potential determining mechanism. Glass electrodes are used for pH measurement. The glass in the tip of the electrode actually acts as a semi-permeable membrane to allow solution. Solid-state electrodes replace the glass membrane with an ionically-conducting membrane, (but act in essentially the same manner) while liquid-liquid membrane electrodes have an organic liquid ion exchanger contained in the pores of a hydrophobic membrane. Maintenance of the conducting interface, in combination with a reference electrode, allows completion of the electrical circuit and subsequent measurement of the potential difference. Gas-sensing electrodes have a membrane that permits the passage of gas only, thus allowing for the measurement of gas concentration. Regardless of the mechanism involved in the electrode, most SIEs are easy to use under field conditions. The sensitivity and applicable concentration range for various membranes and electrodes will vary.

5.6.3 Equipment

The following equipment is required for performing quantitative analyses using a specific ion electrode:

- A pH meter with a millivolt scale, or equivalent.
- The specific ion electrode for the parameter to be measured. A partial list of ions which can be measured includes cyanide, sulfide, ammonia, lead, fluoride and chloride.
- A suitable reference electrode to go with the above SIE.

Specific electrodes for other ions have also been developed, but are not widely used for field investigation efforts at this time. Note that of the specific electrodes referenced above, only fluoride and ammonia have analytical methods approved by the U.S. EPA.

5.6.4 Measurement Techniques for Inorganic Ions Using Specific Ion Electrodes

Different types of electrodes are used in slightly different ways and are applicable for different concentration ranges. Following the manufacturer's instructions, the general steps given below are usually followed:

- Immerse the electrode in water for a suitable period of time prior to sample analysis.

- Standardize the electrode according to the manufacturer's instructions, including necessary chemical additions for ionic strength adjustment, etc. Standard solutions normally differ by factors of ten in concentration. Constant stirring is needed for accurate readings.

- Immerse the electrode in the sample. Allow the reading to stabilize and record the results in a site logbook. Stir the sample at the same rate as the standards. Air bubbles near the membrane shall be avoided, since this may cause interference in millivolt readings.

(NOTE: Each SIE has substances which interfere with proper measurement. These may be eliminated using pretreatment methods as detailed by the manufacturer. It is important to know if interferences are present so that suspect readings may be noted as such.)

- If the pH meter does not read out directly, plot millivolts versus concentration for the standards and then determine sample concentration.

6.0 REFERENCES

American Public Health Association, 1980. Standard Methods for the Examination of Water and Wastewater, 15th Edition, APHA, Washington, D.C.

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

U.S. Geological Survey, 1984. National Handbook of Recommended Methods for Water Data Acquisition, Chapter 5: Chemical and Physical Quality of Water and Sediment. U.S. Department of the Interior, Reston, Virginia.

7.0 ATTACHMENTS

Attachment A - Specific Conductance of KC1 Solutions at 25 degrees Centigrade

Attachment B - Variation of Dissolved Oxygen Concentration in Water as a a Function of Temperature and Salinity.

ATTACHMENT A

SPECIFIC CONDUCTANCE OF M KCl AT VARIOUS TEMPERATURES[1]

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

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

ATTACHMENT B

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

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

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

Temperature °C	Dissolved Oxygen mg/l					
	Chloride Concentration in Water					Difference/100 mg chloride
	0	5,000	10,000	15,000	20,000	
25	8.4	8.0	7.6	7.2	6.7	0.008
26	8.2	7.8	7.4	7.0	6.6	0.008
27	8.1	7.7	7.3	6.9	6.5	0.008
28	7.9	7.5	7.1	6.8	6.4	0.008
29	7.8	7.4	7.0	6.6	6.3	0.008
30	7.6	7.3	6.9	6.5	6.1	0.008
31	7.5					
32	7.4					
33	7.3					
34	7.2					
35	7.1					
36	7.0					
37	6.9					
38	6.8					
39	6.7					
40	6.6					
41	6.5					
42	6.4					
43	6.3					
44	6.2					
45	6.1					
46	6.0					
47	5.9					
48	5.8					
49	5.7					
50	5.6					

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

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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

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	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
Benzidines(11)	G, Teflon-lined cap	Cool, 4°C, 0.008% $Na_2S_2O_3$(5)	7 days until extraction(13)
Phthalate Esters(11)	G, Teflon-lined cap	Cool, 4°C	7 days until extraction, 40 days after extraction
Nitrosamines(11,14)	G, Teflon-lined cap	Cool, 4°C, store in dark, 0.008% $Na_2S_2O_3$(5)	7 days until extraction, 40 days after extraction
PCBs(11) 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 ime 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° 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 zardous 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 d 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 ic 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% $Na_2S_2O_3$.

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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.

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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
Geltek 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; peristaltic (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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		Applicability EMG	
		Prepared Earth Sciences	
Subject SAMPLE IDENTIFICATION AND CHAIN-OF-CUSTODY		Approved D. Senovich	

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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[illegible]e, waterproof paper label, approximately 3-by-6 inches, with a reinforced eyelet, and string or w[illegible] or attachment to the neck of the sample bottle. The Sample Tag is a controlled document, and i[illegible]ovided by the regional EPA office. Following sample analysis, the Sample Tag is retained by the la[illegible]atory 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 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:	

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 Samples	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

D334901

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

SAMPLERS (Signature)

STA NO	DATE	TIME	COMP.	GRAB	STATION LOCATION	NO. OF CONTAINERS	Water/Wastewater																	Soil/Sed			Sldg/Waste			Misc	REMARKS/TAG NUMBERS
							Gal G (sent orgs)	Gal G (EP)	½ gal poly (VOA)	Gal P (BOD, COD, TSS)	Pt G (phenols)	Pt P (metals, Hg)	Pt P (S⁻²)	Pt P (TOC, COD)	Qt G (Oil G or meat)	½ gal P (CN)	Qt G (sent orgs)	8 oz G (VOA)	Pt P (meat, Hg, CN, S⁻²)	8 oz G (sent orgs)	8 oz G (EP, S⁻², FP)									

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

№ 4 3526

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

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY

EPA

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. 3 60966

Lab Sample No.

ATTACHMENT G
CHAIN-OF-CUSTODY SEAL

NUS CORPORATION

CUSTODY SEAL

Date

Signature

NUS CORPORATION

CUSTODY SEAL

Date

Signature

NUS CORPORATION ENVIRONMENTAL MANAGEMENT GROUP	STANDARD OPERATING PROCEDURES	Number SA-6.2	Page 1 of 12
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		Applicability EMG	
		Prepared Earth Sciences	
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	H M	D O T PROPER SHIPPING NAME	HAZARD CLASS	CODE	P G	CONTAINER NUMBERS	PLC	BULK
1	55 gal	200 lbs.	s	Nitric Acid, Fuming	Oxidizer	55-BN	C	1	✓	
1	55 gal	450 lbs	s	Flammable Liquid, n o s.	Flammable Liquid	55-ABF	—	2		✓
1	55 gal	250 lbs	s	Flammable liquid, n o s	Flammable Liquid	55-BN	B	3	✓	
1	16-A	12 lbs.	s	Bromine	Corrosive Material	55-BN	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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		Prepared Earth Sciences	
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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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1.0 PURPOSE

This procedure contains examples of forms in current use for RI activities, and a brief explanation of the function of these forms. The intent of this procedure is simply to compile and introduce these forms, and not to provide detailed explanations of the Forms.

2.0 SCOPE

Attachment A lists the forms illustrated in this procedure. Forms identified as controlled documents are issued by EPA, are sequentially numbered, and may not be altered. Those which are not listed as controlled documents and not required documents issued by EPA may be altered or revised for project-specific needs, with notification of.

3.0 GLOSSARY

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

4.0 RESPONSIBILITIES

Field Operations Leader - The Field Operations Leader is responsible for ensuring that the appropriate forms illustrated in this guideline are correctly used and accurately filled out. In general, the sampling technician or Field Operations Leader will fill out forms related to sample labeling, shipment and analysis (see Section 5.1); the site geologist/geohydrologist will fill out borings logs, groundwater level and geohydrological test forms (see Section 5.2); and the Field Operations Leader, site Health and Safety Officer, or field technicians, will fill out equipment calibration and maintenance records (see Section 5.3).

5.0 PROCEDURES

5.1 SAMPLE COLLECTION, LABELING, SHIPMENT AND REQUEST FOR ANALYSIS

5.1.1 Sample Label

The sample label is a 2- by 4-inch white label with black lettering and an adhesive backing. Attachment B-1 is an example of a sample label. These labels are required on every sample but are not controlled documents. Guidelines for filling out sample labels are contained in SA-6.1.

5.1.2 Sample Identification Tag

The Sample Identification Tag (Attachment B-2) must be used with samples collected for Contract Laboratory Program (CLP) analysis. The tag is a white, heavy paper label that is attached to the neck of the sample bottle with a string or wire. The Sample Identification Tag is a controlled document, and is available from the Regional Sample Control Center (RSCC). Procedure SA-6.1 provides the steps in filling out Sample Identification Tags.

5.1.3 Chain-of-Custody Record Form

The Chain-of-Custody Record Form accompanies a sample (or group of samples) as it is transferred from person to person. This form must be used for any samples collected for chemical or geotechnical analysis, whether on-site or off-site. It is a controlled document. Each EPA Region in Zone 1 uses a

slightly different Chain-of-Custody form. Attachment B-3 illustrates a Chain-of-Custody Record form used by Region III. Chain-of-custody record forms for Regions I, II, and IV are illustrated in SA-6.1 as well as procedures for filling out forms.

5.1.4 Chain-of-Custody Seal

Attachment B-4 is an example of a custody seal. The Custody seal is a 1- by 3-inch adhesive-backed label. It is part of a chain-of-custody process and is used to prevent tampering with samples after they have been collected in the field. It is used whenever samples are shipped with an accompanying Chain-of-Custody Record form. The chain-of-custody seal is available from the RSCC. Procedure SA-6.1 describes the procedures for using chain-of-custody seals.

5.1.5 Bottle Delivery Order (DO) Form

If CLP analyses are requested, a Delivery Order (DO) form (Attachment B-5) is completed by the Authorized Requestor and submitted to the CLP Sample Bottle Repository (see Procedure SA-6.6). This form is required but not a controlled document.

5.1.6 Repository Packing List (PL) Form

The Repository Packing List form (Attachment B-6) is used for CLP analyses. This form is completed by the Sample Bottle Repository when the requested sample bottles are shipped. A copy of the PL is received with the sample bottle shipment and is retained by the Authorized Requestor.

5.1.8 Sample Log Sheet

A Sample Log Sheet is a notebook (3-ring binder) page that is used to record specified types of data while sampling. Attachments B-7 to B-10 are examples of Sample Log Sheets. The data recorded on these sheets are useful in describing the waste source and sample as well as pointing out any problems encountered during sampling. Guidelines for filling out the Sample Log Sheet are contained in SA-6.6. These forms are not controlled documents.

5.1.9 Traffic Reports (for CLP Laboratory Analyses)

A Traffic Report (TR) is a preprinted form that is provided by the EPA Sample Management Office to each Region through the Regional Sample Control Center (RSCC). These forms are obtained from the RSCC as needed for specific work assignments. These forms are part of the EPA sample-tracking system and are used to trace the shipment of samples for CLP laboratory analysis. Presently, these forms are for two types of samples: organics (OTR) and inorganics (ITR) (see Attachments B-11 and B-12, respectively). The organics and inorganics forms are used to document and identify the collection of low- and medium-concentrations samples for organic and inorganic analysis. Up to 20 samples can be recorded on each traffic report. Guidelines for filling out traffic report forms are contained in SA-6.6

5.1.10 Traffic Report Label

The Traffic Report Label is a small prenumbered white label with black lettering and an adhesive backing. Attachment B-13 provides examples of several traffic report labels. The number which appears on a traffic report label is uniquely numbered and used to track samples for CLP analysis. In addition to the number, each label contains a designation as to the type of analysis to be performed (VOA, etc.) or as to preservation of the sample (preserved unpreserved, etc.). Use of these labels is described in Procedure SA-6.6.

5.1.11 Special Analytical Services (SAS) Packing List

In addition to routine analytical services (RAS), some special analytical services (SAS) are available through the CLP. These may include quick turnaround or verification analyses, non-priority pollutant analyses, analyses requiring lower detection limits than RAS methods provide, or other specific analyses (e.g., EP toxicity testing). For all "all SAS" type of request (in contrast to "RAS plus SAS," see Procedure SA-6.6), the SAS Packing List (Attachment B-14) is used rather than a traffic report. SAS Packing Lists are provided by the SMO to each region through the RSCC, which provides forms as required. Use of the SAS form is further described in Procedure SA-6.6

5.1.12 Dioxin Shipment Record (DSR)

The Dioxin Shipment Record (DSR) provides a record for one shipment batch (up to 24 samples) of dioxin samples to a CLP laboratory. Samples are individually numbered using the pre-printed labels provided with the DSR (see Attachment B-15). DSRs are provided by the SMO to each region through the RSCC. DSRs must be used to track shipment of dioxin samples submitted for CLP analysis. See Procedure SA-6.6 for detailed description of the use of DSRs.

5.1.13 Sample Shipping Log

The sample shipping log, shown in Attachment B-16 is required by Region III EPA and is to be completed whenever samples are shipped to a CLP Laboratory. The sample shipping log is then submitted to the RSCC the week following sample collection.

5.2 GEOHYDROLOGICAL AND GEOTECHNICAL FORMS

5.2.1 Groundwater Level Measurement Sheet

A groundwater level measurement sheet, shown in Attachment C-1 should be filled out for each round of water level measurements at a site. These sheets are not controlled documents.

5.2.2 Data Sheet for Pumping Test (Pumping Well)

During the performance of a pumping test, a large amount of data must be recorded, often within a short time period. The pumping test data sheet (Attachment C-2) facilitates this task by standardizing the data collection format, and allowing the time interval for collection to be laid out in advance. This form is not a controlled document.

5.2.3 Data Sheet for Pumping Test (Observation Well) or In-Situ Hydraulic Conductivity Test

This data sheet (Attachment C-3) is similar to that described in Section 5.2.2. However, somewhat different data must be recorded for pumping test observation wells and in-situ hydraulic conductivity tests, as shown on this sheet. This form is not a controlled document.

5.2.4 Packer Test Reporting Forms

A packer test reporting form shown in Attachment C-4 is used for collecting data when conducting packer tests during monitoring well drilling. These sheets are not controlled documents.

5.2.5 Summary Log of Boring

During the progress of each boring, a log of the materials encountered, operation and driving of casing, and location of samples must be kept. The Summary Log of Boring (Attachment C-5) is used for this purpose. In addition, if volatile organics are monitored on cores, samples or cuttings from the borehole (using HNU or OVA detectors), the results are entered on the boring log at the appropriate depth. The boring log also provides space for entry of the laboratory sample number and the concentration of a few key analytical results. This feature allows direct comparison of contaminant concentrations with soil characteristics.

The Summary Log of Boring is not a controlled document.

5.2.6 Monitoring Well Construction Details Form

A Monitoring Well Construction Details Form must be completed for every monitoring well installed. This form contains specific information on length and type of well riser pipe and screen, backfill, filter sand and grout characteristics, and surface seal characteristics. This information is important in evaluating the performance of the monitoring well, particularly in areas where water levels show temporal variation, or where there are multiple (immiscible) phases of contaminants. Depending on the type of monitoring well (in overburden or bedrock), different forms are used (see Attachments C-6 through C-10). The Monitoring Well Construction Details Form is not a controlled document. Guidelines on completing this form are contained in GH-1.7.

5.2.7 Test Pit Log

When a test pit or trench is constructed for investigative or sampling purposes, a Test Pit Log must be filled out by the responsible field geologist or sampling technician. Test Pit Logs (Attachment C-11) are not controlled documents.

5.3 EQUIPMENT CALIBRATION AND MAINTENANCE FORMS

5.3.1 Equipment Calibration Log

The calibration or standardization of monitoring, measuring or test equipment is necessary to assure the proper operation and response of the equipment, to document the accuracy, precision or sensitivity of the measurement, and determine if correction should be applied to the readings. Some items of equipment require frequent calibration, other infrequent. Some are calibrated by the manufacturer, other by the user.

Each instrument requiring calibration has its own Equipment Calibration Log (Attachment D-1) which documents that the manufacturer's instructions were followed for calibration of the equipment, including frequency and type of standard or calibration device. This form is not a controlled document.

6.0 REFERENCES

None.

7.0 ATTACHMENTS

Attachment A - Technical Forms in Current Use for Remedial Investigations
Attachment B-1 - Sample Label
Attachment B-2 - Sample Identification Tag
Attachment B-3 - Chain-of-Custody Record From, Region III
Attachment B-4 - Chain-of-Custody Seal
Attachment B-5 - CLP Sample Bottle Repository Order Form
Attachment B-6 - Repository Packing List Form
Attachment B-7 - Groundwater Sample Log Sheet Form
Attachment B-8 - Soil Sample Log Sheet Form
Attachment B-9 - Surface Water Sample Log Sheet Form
Attachment B-10 - Container Sample Log Sheet Form
Attachment B-11 - Organics Traffic Report Form
Attachment B-12 - Inorganics Traffic Report Form
Attachment B-13 - Traffic Report Labels
Attachment B-14 - Special Analytical Services (SAS) Packing List
Attachment B-15 - Dioxin Shipment Record Form
Attachment B-16 - Sample Shipping Log
Attachment C-1 - Groundwater Level Measurement Sheet
Attachment C-2 - Pumping Test Data Sheet
Attachment C-3 - Hydraulic Conductivity Testing Data Sheet
Attachment C-4 - Packer Testing Report Form
Attachment C-5 - Summary Log of Boring
Attachment C-6 - Overburden Monitoring Well Construction Sheet
Attachment C-7 - Confining Layer Monitoring Well Construction Sheet
Attachment C-8 - Bedrock (Open Hole) Monitoring Well Construction Sheet
Attachment C-9 - Bedrock (Well Installed) Monitoring Well Construction Sheet
Attachment C-10 - Bedrock (Well Installed) Monitoring Well Construction Sheet
Attachment C-11 - Test Pit Log Form
Attachment D-1 - Equipment Calibration Log

ATTACHMENT A

TECHNICAL FORMS IN CURRENT USE FOR REMEDIAL INVESTIGATIONS

	Attachment Number	Form Usage Described in SOP Number	Controlled/ Required Document
B-1	Sample Label	SA-6.1	Required
B-2	Sample Identification Tag	SA-6.1	Controlled
B-3	Chain of Custody Record, Region III	SA-6.1	Controlled
B-4	Chain-of-Custody Seal	SA-6.6	Controlled
B-5	CLP Sample Bottle Repository Form	SA-6.6	Required
B-6	Repository Packing List Form	SA-6.6	Required
B-7	Groundwater Sample Log Sheet	SA-6.6	Required
B-8	Soil Sample Log Sheet	SA-6.6	Required
B-9	Surface Water Sample Log Sheet	SA-6.6	Required
B-10	Container Sample Log Sheet	SA-6.6	Required
B-11	Organics Traffic Report Form	SA-6.6	Controlled
B-12	Inorganics Traffic Report Form	SA-6.6	Controlled
B-13	Traffic Report Labels	SA-6.6	Controlled
B-14	Special Analytical Services (SAS) Packing List	SA-6.6	Required
B-15	Dioxin Shipment Record Form	SA-6.6	Required
B-16	Sample Shipping Log	SA-6.4	Required
C-1	Groundwater Level Measurement Sheet	GH-2.5	Required
C-2	Pumping Test Data Sheet	GH-2.3	Required
C-3	Hydaulic Conductivity Testing Data Sheet	GH-2.4	Required
C-4	Packer Testing Report Form	GH-2.2	Required
C-5	Summary Log of Boring	GH-1.5	Required
C-6	Overburden Monitoring Well Construction Sheet	GH-1.5	Required
C-7	Confining Layer Monitoring Well Construction Sheet	GH-1.5	Required
C-8	Bedrock (Open Hole) Monitoring Well Construction Sheet	GH-1.5	Required
C-9	Bedrock (Well Installed) Monitoring Well Construction Sheet	GH-1.5	Required
C-10	Bedrock (Well Installed) Monitoring Well Construction Sheet	GH-1.5	Required
C-11	Test Pit Log	GH-1.8	Required
D-1	Equipment Calibration Log	----	Required

ATTACHMENT B-1

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 B-2

SAMPLE IDENTIFICATION TAG

☆ GPO 505-552

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY

EPA

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. 3 60966

Lab Sample No.

ATTACHMENT B-3

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

D334901

ATTACHMENT B-4

CHAIN-OF-CUSTODY SEAL

CUSTODY SEAL

Date

Signature

NUS CORPORATION

NUS CORPORATION

CUSTODY SEAL

Date

Signature

ATTACHMENT B-5
CLP SAMPLE BOTTLE REPOSITORY
SUPERFUND DELIVERY REQUEST

REQUEST NO. _____

Date of Request: _____

Type of Request:
Routine [ ]
Fast Turnaround [ ] _____
Emergency [ ] _____
(Date/Time request called in)

From (Name): _____
Affiliation: _____
Telephone: _____
AR Signature: _____

TO: I-Chem Research Corporation
23787-F Eichler Street
Hayward, CA 94545
Phone: 415/782/3095

Ship the following items for arrival by: _____ (Date)
(If applicable) Ship to arrive no earlier than: _____ (Date)

Item		Description	No. of Items Per Case	No. of Cases Requested
A	80-oz.	amber glass bottle	6	
B	40-ml	glass vial	72	
C	1-liter	polyethylene bottle	12	
D	120-ml	wide-mouth glass vial	12	
E	1-oz.	wide-mouth glass jar	12	
F	8-oz.	wide-mouth glass jar	12	
G	4-oz.	wide-mouth glass jar	12	
H	1-liter	amber glass bottle	12	
J	32-oz.	wide-mouth glass jar	12	
K	4-liter	amber glass bottle	4	
L	500-ml	polyethylene bottle	24	

Ship To: _____
(Provide _____
street address) _____
Attention: _____
Call before delivery: _____
(Phone No.): _____

DISTRIBUTION: *White-Repository* *Yellow-Requestor* *Pink-SMO*

ATTACHMENT B-6

CLP SAMPLE BOTTLE REPOSITORY
SUPERFUND PACKING LIST

REPOSITORY

I-Chem Research Corporation
23787-F Eichler Street
Hayward, CA 94545
Phone: 415/782-3905

DELIVERY REQUEST NO. _____

Request date: _____

Type of Request: R ☐ FTA ☐ E ☐

Required Delivery Date: _____

DESTINATION (from Delivery Request)

Name: _____

Address: _____

_____

_____

Telephone No: _____

The materials listed below have been shipped as requested.

Date Shipped: _____

Mode of Shipment: _____

Shipment ID No: _____

Signature: _____

Type of Shipment: ___ Complete ___ Partial ___ Partial/Completes Request

Item No.	Description		No. of Cases Shipped	Lot Number(s)	QC Clearance Number(s)
A	80-oz	glass	_____	_____	_____
B	40-mL	glass	_____	_____	_____
C	1-L	poly	_____	_____	_____
D	120-mL	glass	_____	_____	_____
E	16-oz	glass	_____	_____	_____
F	8-oz	glass	_____	_____	_____
G	4-oz	glass	_____	_____	_____
H	1-L	glass	_____	_____	_____
J	32-oz	glass	_____	_____	_____
K	4-L	glass	_____	_____	_____
L	500-mL	poly	_____	_____	_____

——AUTHORIZED REQUESTOR USE ONLY——

Sign below and forward the yellow copy to the Sample Management Office (SMO) within 7 days of shipment receipt. Keep the pink copy for your file.

The above request was received by the designee, inspected, and accepted.

Date of Receipt: _____ Requestor Signature: _____

Send yellow copy to: USEPA Sample Management Office
P.O. Box 818
Alexandria, VA 22313

DISTRIBUTION: *White—Shipment Designee*
Blue—Shipping Contractor
Green—SMO
Yellow—Requestor (for return to SMO)
Pink—Requestor
Gold—Repository

ATTACHMENT B-7

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-8

NUS CORPORATION
A Halliburton Company

SAMPLE LOG SHEET

- ☐ Surface Soil
- ☐ Subsurface Soil
- ☐ Sediment
- ☐ Lagoon / Pond
- ☐ Other _____

Page _____ of _____

Case # _____

By _____

Project Site Name _____ Project Site Number _____

NUS Source No. _____ Source Location _____

Sample Method:	Composite Sample Data		
	Sample	Time	Color / Description
Depth Sampled:			
Sample Date & Time:			
Sampled By:			
Signature(s):			
Type of Sample ☐ Low Concentration ☐ High Concentration ☐ Grab ☐ Composite ☐ Grab - Composite			

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

Analysis:	Observations / Notes

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

ATTACHMENT B-9

NUS CORPORATION
A Halliburton Company

SAMPLE LOG SHEET

Page _____ of _____

☐ Spring
☐ Lake
☐ Stream
☐ Other _____

Case # _____

By _____

Project Site Name _____ Project Site Number _____

NUS Source No. _____ Source Location _____

Sample Method:	Sample Data			
	pH	S.C.	Temp. (°C)	Color & Turbidity
Depth Sampled:				
Sample Date & Time:				
Sampled By:				
Signatures:				

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-10

NUS CORPORATION
A Halliburton Company

SAMPLE LOG SHEET

Container Data

Page _____ of _____
Case # _____
By _____

Project Site Name _____ Project Site Number _____
NUS Source No. _____ Source Location _____

Container Source	Container Description
☐ Drum ☐ Bung Top ☐ Lever Lock ☐ Bolted Ring ☐ Other _____ _____ ☐ Bag / Sack ☐ Tank ☐ Other _____ _____	Color _____ Condition _____ Markings _____ Vol. of Contents _____ Other _____

Disposition of Sample	Sample Description	Layer 1	Layer 2	Layer 3
☐ Container Sampled ☐ Container opened but not sampled. Reason _____ _____ Container not opened. Reason _____ _____	Phase	☐Sol. ☐Liq.	☐Sol. ☐Liq.	☐Sol. ☐Liq.
	Color	_____	_____	_____
	Viscosity	☐L ☐M ☐H	☐L ☐M ☐H	☐L ☐M ☐H
	% of Total Volume	_____	_____	_____
	Other _____	_____	_____	_____

	Type of Sample		
Monitor Reading:	☐ Low Concentration ☐ High Concentration	☐ Grab ☐ Composite ☐ Grab - Composite	
Sample Method:			
Sample Date & Time:		Organic	Inorganic
	Traffic Report #		
Sampled By:	Tag #		
Signature(s):	AB #		
	Date Shipped		
Analysis:	Time Shipped		
	Lab		
	Volume		

ATTACHMENT B-11

USEPA CONTRACT LABORATORY PROGRAM
SAMPLE MANAGEMENT OFFICE
P.O. BOX 818 ALEXANDRIA, VA 22313
703/557-2490 FTS-557-2490

CASE NO:

SAS NO: (IF APPLICABLE)

ORGANIC TRAFFIC REPORT

(FOR CLP USE ONLY)

TYPE OF ACTIVITY (CIRCLE ONE) ①
SUPERFUND—PA SI ESI RIFS RD RA ER
NPLD O&M OTHER _____
NON-SUPERFUND—_____PROGRAM

SITE NAME:

CITY, STATE: SITE SPILL ID:

REGION NO: SAMPLING COMPANY ②

SAMPLER: (NAME)

SHIP TO: ③

ATTN: _____

SAMPLING DATE: ④

BEGIN: _____ END: _____

DATE SHIPPED: _____ CARRIER: _____ ⑤

AIRBILL NO: _____

SAMPLE DESCRIPTION ⑥
(ENTER IN BOX A)
1. SURFACE WATER
2. GROUND WATER
3. LEACHATE
4. SOIL
5. SEDIMENT
6. OIL (SAS)
7. WASTE (SAS)

TRIPLE VOLUME REQUIRED FOR MATRIX SPIKE/DUPLICATE AQUEOUS SAMPLE

SHIP MEDIUM AND HIGH CONCENTRATION SAMPLES IN PAINT CANS

SEE REVERSE FOR ADDITIONAL INSTRUCTIONS

CLP SAMPLE NUMBER (FROM LABELS)	SAMPLE DESCRIPTION Ⓐ (FROM BOX 1) 1 2 3 4 5 6 7	CONCENTRATION Ⓑ L - LOW/MED H - HIGH (SAS)	RAS ANALYSIS Ⓒ VOLATILE	BASE/NEUT /ACID	PESTICIDE /PCB's		SPECIAL HANDLING Ⓓ	STATION LOCATION Ⓔ

EPA Form 2075-7 (8-87)

WHITE — SMO COPY PINK — CLIENT COPY WHITE — LAB COPY FOR RETURN TO SMO YELLOW — LAB COPY

ATTACHMENT B-12

USEPA CONTRACT LABORATORY PROGRAM
SAMPLE MANAGEMENT OFFICE
P.O. BOX 818 ALEXANDRIA, VA 22313
703/557-2490 FTS-557-2490

CASE NO:

SAS NO: (IF APPLICABLE)

INORGANIC TRAFFIC REPORT

(FOR CLP USE ONLY)

TYPE OF ACTIVITY (CIRCLE ONE) ①
SUPERFUND—PA SI ESI RIFS RD RA ER NPLD O&M OTHER _____
NON-SUPERFUND—_____PROGRAM

SITE NAME:

CITY, STATE: SITE SPILL ID:

REGION NO: SAMPLING COMPANY ②

SAMPLER: (NAME)

SHIP TO: ③

ATTN: _____

SAMPLING DATE: ④

BEGIN: _____ END: _____

DATE SHIPPED: _____ CARRIER: _____ ⑤

AIRBILL NO: _____

SAMPLE DESCRIPTION ⑥
(ENTER IN BOX A)
1. SURFACE WATER
2. GROUND WATER
3. LEACHATE
4. SOIL
5. SEDIMENT
6. OIL (SAS)
7. WASTE (SAS)

DOUBLE VOLUME REQUIRED FOR MATRIX SPIKE/DUPLICATE AQUEOUS SAMPLE

SHIP MEDIUM AND HIGH CONCENTRATION SAMPLES IN PAINT CANS

SEE REVERSE FOR ADDITIONAL INSTRUCTIONS

CLP SAMPLE NUMBER (FROM LABELS)	Ⓐ SAMPLE DESCRIPTION (FROM BOX 1) 1 2 3 4 5 6 7	Ⓑ CONCENTRATION L = LOW M = MED H = HIGH (SAS)	Ⓒ RAS ANALYSIS: TOTAL METALS	CYANIDE	DISSOLVED METALS	HIGH ONLY (SAS): SULFIDE	pH	CONDUCTIVITY	OXIDANTS	Ⓓ SPECIAL HANDLING	Ⓔ STATION LOCATION

EPA Form 2075-6 (8-87)

WHITE — SMO COPY PINK — CLIENT COPY WHITE — LAB COPY FOR RETURN TO SMO YELLOW — LAB COPY

ATTACHMENT B-13

TRAFFIC REPORT LABELS

MAB 342

C 6003

AC 865 · Soil/Sediment (VOA)

ATTACHMENT B-14

U.S. ENVIRONMENTAL PROTECTION AGENCY
CLP Sample Management Office
P.O. Box 818 - Alexandria, Virginia 22313
Phone: 703/557-2490 - FTS/557-2490

SAS Number

SPECIAL ANALYTICAL SERVICE
PACKING LIST

Sampling Office:	Sampling Date(s):	Ship To:	For Lab Use Only
Sampling Contact: (name)	Date Shipped:		Date Samples Rec'd:
(phone)	Site Name/Code:	Attn:	Received By:

	Sample Numbers	Sample Description i.e., Analysis, Matrix, Concentration	Sample Condition on Receipt at Lab
1.			
2.			
3.			
4.			
5.			
6.			
7.			
8.			
9.			
10.			
11.			
12.			
13.			
14.			
15.			
16.			
17.			
18.			
19.			
20.			

For Lab Use Only

White - SMO Copy, Yellow - Region Copy, Pink - Lab Copy for return to SMO, Gold - Lab Copy

ATTACHMENT B-15

USEPA Contract Laboratory Program
Sample Management Office
P O Box 818 Alexandria Virginia 22313
FTS 8-557-2490 703 557-2490

CASE NO:	BATCH NO:

CLP DIOXIN SHIPMENT RECORD

Site Name	Sampling Office	Ship To	FOR LAB USE ONLY
City & State	City & State		Date Samples Rec'd
EPA Site No	Sampling Contact (name)	Date Shipped	Received By
Latitude	Sampling Date	Transfer To	Date Samples Rec'd
Longitude		Date Shipped	Received By
Tier 1 2 3 4 5 6 7 (circle one)	Data Turnaround 15-Day ____ 30-Day ____		

SAMPLE NUMBERS	MATRIX: SOIL SEDIMENT	MATRIX: OTHER:	DESCRIPTION: FIELD SAMPLE	DESCRIPTION: SAMPLE TO DUPLICATE	DESCRIPTION: SAMPLE TO SPIKE	DESCRIPTION: BLANK	DESCRIPTION: EQUIPMENT RINSEATE	DESCRIPTION: OTHER (BAS ONLY)	ADD'L ANALYSIS: SPECIFY (BAS ONLY)	FOR LAB USE: SAMPLE CONDITION ON RECEIPT

WHITE [illegible] YELLOW Region Copy PINK [illegible] GOLD- [illegible] Copy

ATTACHMENT B-16

page___ of ___ EPA SAMPLE SHIPPING LOG FOR ALL SAMPLES SENT THROUGH THE CONTRACT LAB PROGRAM (12/85 version)

CASE#_____ SAS#_____ SITE NAME:_____

Site Leader:_____ EPA Project Officer:_____

Phone:

QC SAMPLE INFO AND/OR COMMENTS	CONC. (low/ med/ high)	SAMPLE PHASE (aq/ sol)	TYPE OF REQUEST org,dio inor, SAS	SAMPLE TRAFFIC REPORT NUMBER	ORGANICS OR INORGANICS DATA RECEIVED XX out items not requested								SAS REQUEST:(details required)			
					LAB NAME	DATE SHIPPED	VOA	BNA	PEST	TCDD	METALS	CN	LAB NAME	SAS REQUEST (itemize)	DATE SHIPPED	DATA REC'D

ATTACHMENT C-1

GROUNDWATER LEVEL MEASUREMENT SHEET

Project Name: _____
Project No.: _____
Personnel: _____
Date: _____

LOCATION

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 C-2
PUMPING TEST DATA SHEET

PUMPING TEST DATA SHEET ***NUS CORPORATION***

PROJECT NAME: _____ MEASURED WELL: _____
PROJECT NO.: _____ DATE: _____ PUMPING WELL: _____
GEOLOGIST: _____ CHECKED: _____ TEST NO. _____
DISTANCE FROM PUMPING WELL(ft.)(r): _____ PUMP SETTING, FEET BELOW MONITORING POINT: _____
STATIC H_2O LEVEL (ft.)(s_o): _____ MONITORING POINT: _____
TIME PURGE START OR STOP (t_o): _____ ELEVATION OF MONITORING POINT (ft. above MSL): _____

TIME	(t) MIN. SINCE PUMP START OR STOP	WATER LEVEL MEASUREMENTS (ft.)			(s) DD Or RECOVERY (ft.)	PUMPING RATE (Q) GPM	REMARKS
		READING	CORRECTION	DTW			

ATTACHMENT C-3

HYDRAULIC CONDUCTIVITY TESTING DATA SHEET ***NUS CORPORATION***

PROJECT NAME: ..... WELL/BORING NO.: .....
PROJECT NO.: ..... GEOLOGIST: .....
WELL DIAMETER: ..... SCREEN LENGTH/DEPTH: ..... TEST NO.: .....
STATIC WATER LEVEL (Depth/Elevation): ...../..... DATE: .....
TEST TYPE (Rising/Falling/Constant Head): ..... CHECKED: .....
METHOD OF INDUCING WATER LEVEL CHANGE: ..... PAGE ___ OF ___

TIME	ELAPSED TIME (min. or sec.)	MEASURED DEPTH TO WATER (ft.)	CORRECTION	DEPTH TO WATER (ft.)	DRAWDOWN OR HEAD (ft.)	REMARKS

kac 3/88

ATTACHMENT C-4
PACKER TESTING REPORT FORM

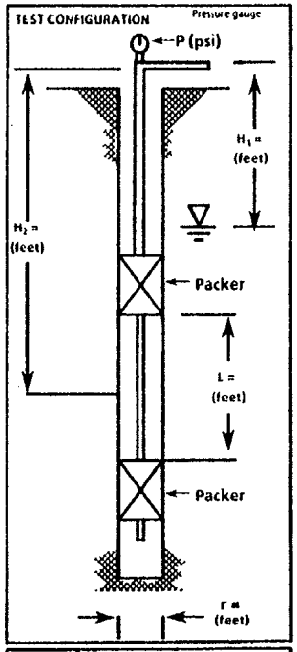
PACKER TEST REPORT

PROJECT: _____ PROJECT NO.: _____ TEST NO: _____ PAGE ____ OF ____
BORING NO.: _____ CASING DEPTH: _____ CONTRACTOR: _____ STATIC WATER LEVEL _____
TEST INTERVAL: _____ BY: _____ CHECKED: _____ PACKER PRESSURE _____

Flow Test					Calculated Results							
Pressure, p (psi)	Elapsed Time (min)	Flow Reading	Δ Flow, ΔQ (ft³)	Δ Flow, ΔQ (gal)	Flow Rate Q (gal/min)	H_1* (ft)	Hp(ft) = 2.31·(psi)	H_2* (ft)	H = Hp + (H1 or H2)	Cp	K (ft/yr) = Cp·Q/H	K (cm/sec) = 9.67 x 10⁻⁷ · K (ft/yr)

CP = (1/(2 π L)) ln(L/r) (70,315.5)
7.48 Gallons = 1 Ft³
1 psi = 2.31 ft head
Remarks: _____

* H_1 is used when the test length is below the water table.
H_2 is used when the test length is above the water table.



Length of Test Section in feet, L	Cp — Drilling Bit Size EX (1.5")	AX (1.875")	BX (2.31")	NX (3")
1	31,000	28,500	25,800	23,350
2	19,400	18,100	16,800	15,500
5	9,800	9,300	8,800	8,300
8	6,800	6,500	6,100	5,800
10	5,700	5,400	5,200	4,900
15	4,100	3,900	3,700	3,600
20	3,200	3,100	3,000	2,800

ATTACHMENT C-5

BORING LOG ***NUS CORPORATION***

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

SAMPLE NO. & TYPE OR ROD	DEPTH (ft.) OR RUN NO.	BLOWS/ 6" OR RQD (%)	SAMPLE RECOVERY /SAMPLE LENGTH	LITHOLOGY CHANGE (Depth,ft.) OR SCREENED INTERVAL	MATERIAL DESCRIPTION			BORE USCS ROCK	REMARKS
					SOIL DENSITY/ CONSISTENCY OR ROCK HARDNESS	COLOR	MATERIAL CLASSIFICATION		

REMARKS _____

BORING _____

PAGE ____ OF ____

ATTACHMENT C-5 (CONTINUED)

SOIL TERMS

UNIFIED SOIL CLASSIFICATION (USCS)

COARSE GRAINED SOILS — More than half of material is LARGER than No. 200 sieve size

		FIELD IDENTIFICATION PROCEDURES (Excluding particles larger than 3" & basing fractions on estimated weights)	GROUP SYMBOL	TYPICAL NAMES
GRAVELS 50%(+)>#4	CLEAN GRAVELS Low % fines	Wide range in grain size and substantial amounts of all intermediate particle sizes.	GW	Well graded gravels, gravel-sand mixtures, little or no fines
		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%(+)<#4	CLEAN SANDS Low % fines	Wide range in grain size and substantial amounts of all intermediate particle sizes.	SW	Well graded sand, gravelly sands, little or no fines.
		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

Identification procedures on fraction smaller than No. 40 sieve size

FIELD IDENTIFICATION PROCEDURES (Excluding particles larger than 3" & basing fractions on estimated weights)	DRY STRENGTH (Crushing Characteristics)	DILATANCY (Reaction to Shaking)	TOUGHNESS (Consistency Near Plastic Limit)	GROUP SYMBOL	TYPICAL NAMES
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 - 3" O.D. Split Barrel Sample
ST - 3" O.D. Undisturbed Sample
O - Other Samples, Specify in Remarks

ROCK SAMPLES - TYPES

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

WATER LEVELS

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

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

ATTACHMENT C-6

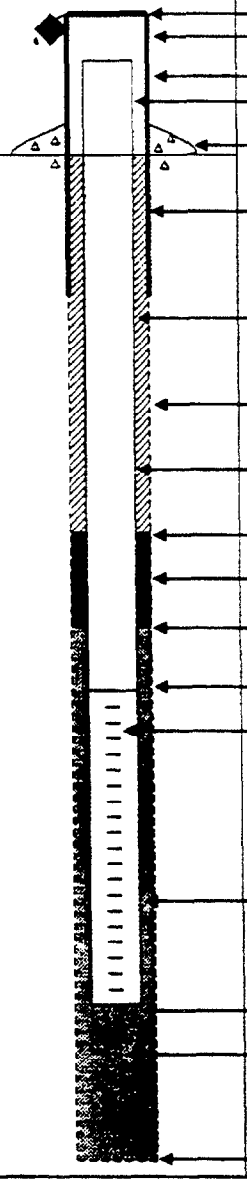
NUS CORPORATION
A Halliburton Company

BORING NO _____

OVERBURDEN
MONITORING WELL SHEET

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

DRILLER _____
DRILLING METHOD _____
DEVELOPMENT METHOD _____



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

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

TYPE OF SURFACE SEAL: _____

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

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

BOREHOLE DIAMETER: _____

TYPE OF BACKFILL: _____

ELEVATION / DEPTH TOP OF SEAL: _____

TYPE OF SEAL: _____

DEPTH TOP OF SAND PACK: _____

ELEVATION / DEPTH TOP OF SCREEN: _____

TYPE OF SCREEN: _____

SLOT SIZE x LENGTH: _____

I.D. OF SCREEN: _____

TYPE OF SAND PACK: _____

ELEVATION / DEPTH BOTTOM OF SCREEN: _____

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

ELEVATION / DEPTH OF HOLE: _____

ATTACHMENT C-7

NUS CORPORATION

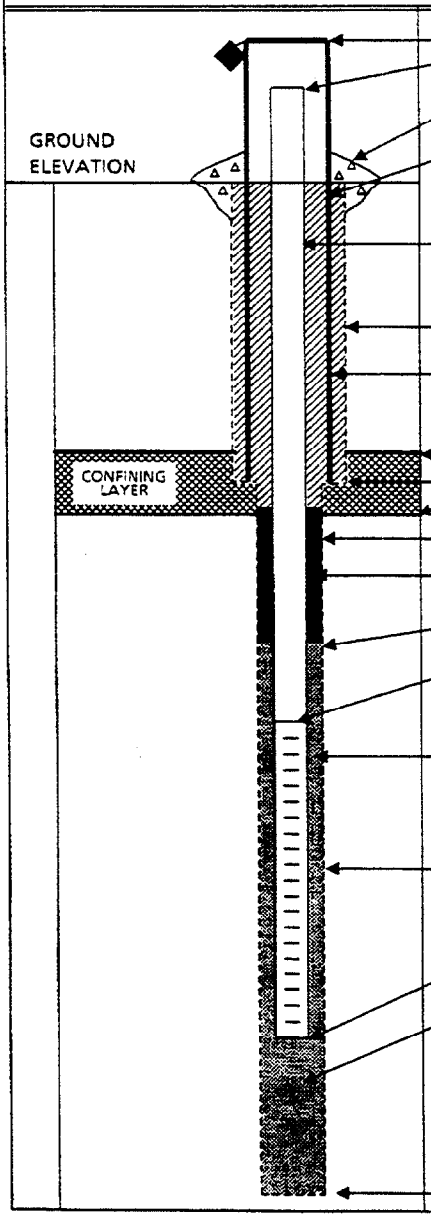
BORING NO.: _____

CONFINING LAYER
MONITORING WELL SHEET

13/5-87

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

DRILLER _____
DRILLING METHOD _____
DEVELOPMENT METHOD _____



ELEVATION OF TOP OF PERM. CASING : _____
ELEVATION OF TOP OF RISER PIPE: _____

TYPE OF SURFACE SEAL: _____

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

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

BOREHOLE DIAMETER: _____

PERM. CASING I.D. _____
TYPE OF CASING & BACKFILL: _____

ELEVATION / DEPTH TOP CONFINING LAYER: _____
ELEVATION / DEPTH BOTTOM OF CASING: _____
ELEVATION / DEPTH BOT. CONFINING LAYER: _____

ELEVATION / DEPTH TOP OF SEAL: _____
TYPE OF SEAL: _____

DEPTH TOP OF SAND PACK: _____

ELEVATION/DEPTH TOP OF SCREEN: _____
TYPE OF SCREEN: _____

TYPE OF SAND PACK: _____

BOREHOLE DIA. BELOW CASING: _____

ELEVATION / DEPTH BOTTOM OF SCREEN: _____

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

ELEVATION / DEPTH OF HOLE: _____

ATTACHMENT C-8

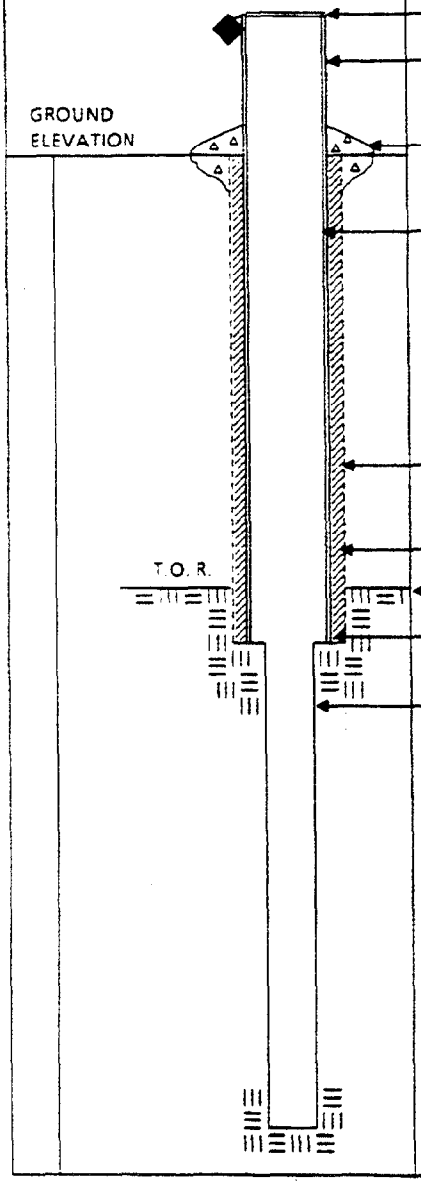
NUS CORPORATION
A Halliburton Company

BORING NO.: _____

BEDROCK
MONITORING WELL SHEET
OPEN HOLE WELL

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

DRILLER _____
DRILLING METHOD _____
DEVELOPMENT METHOD _____



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: _____

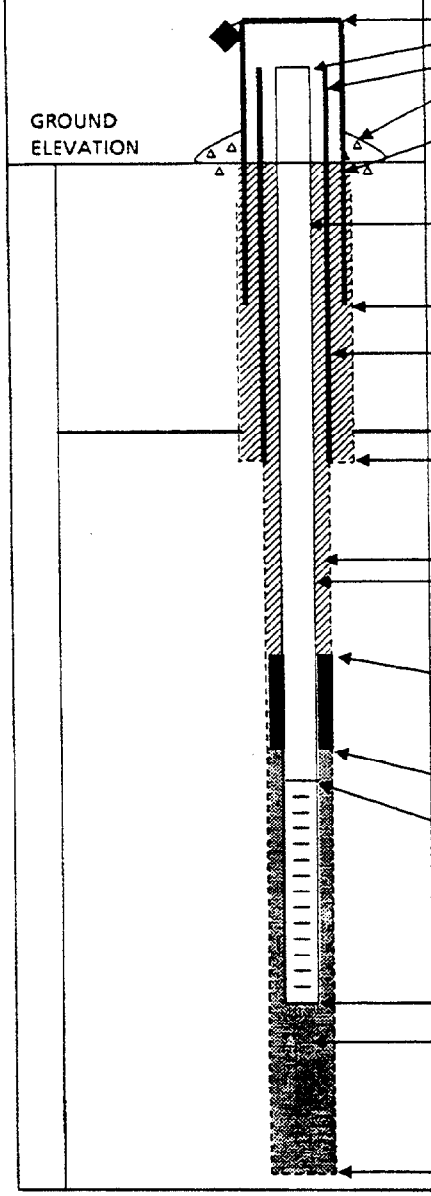
ATTACHMENT C-9

BORING NO.: _____

BEDROCK
MONITORING WELL SHEET
WELL INSTALLED IN BEDROCK

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

DRILLER _____
DRILLING METHOD _____
DEVELOPMENT METHOD _____



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-10

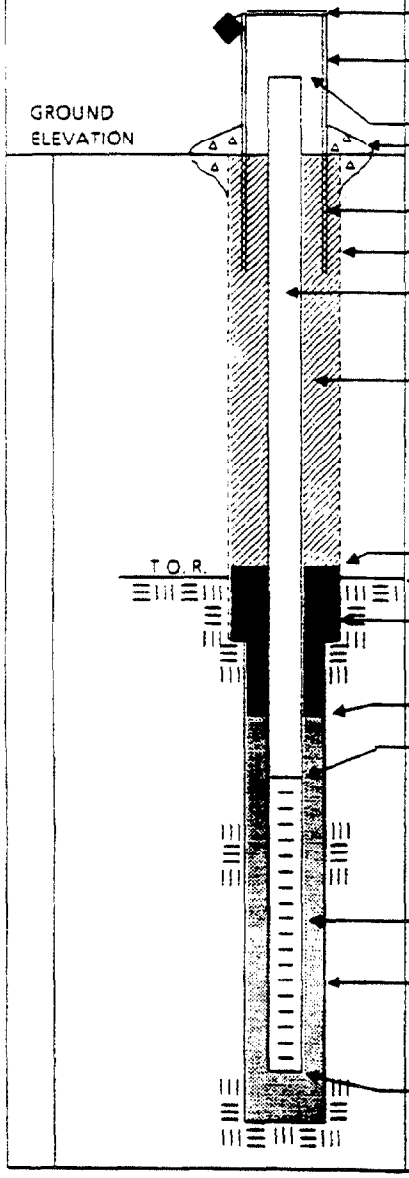
NUS CORPORATION
A Halliburton Company

BORING NO: _____

BEDROCK
MONITORING WELL SHEET
WELL INSTALLED IN BEDROCK

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

DRILLER _____
DRILLING METHOD _____
DEVELOPMENT METHOD _____



ELEVATION OF TOP OF SURFACE CASING: _____

STICK UP OF CASING ABOVE GROUND SURFACE: _____

ELEVATION TOP OF RISER: _____

TYPE OF SURFACE SEAL: _____

I.D. OF SURFACE CASING: _____

DIAMETER OF HOLE: _____

RISER PIPE I.D.: _____

TYPE OF RISER PIPE: _____

TYPE OF BACKFILL: _____

ELEVATION / DEPTH TOP OF SEAL: _____

ELEVATION / DEPTH TOP OF BEDROCK: _____

TYPE OF SEAL: _____

ELEVATION / DEPTH TOP OF SAND: _____

ELEVATION / DEPTH TOP OF SCREEN: _____

TYPE OF SCREEN: _____

SLOT SIZE x LENGTH: _____

I.D. SCREEN: _____

TYPE OF SAND PACK: _____

DIAMETER OF HOLE IN BEDROCK:

CORE / REAM: _____

ELEVATION / DEPTH BOTTOM SCREEN: _____

ELEVATION / DEPTH BOTTOM OF HOLE: _____

ATTACHMENT C-11

TEST PIT LOG ***NUS CORPORATION***

PROJECT: ..... TEST PIT NO.: .....
PROJECT NO.: ..... DATE: .....
LOCATION: .....
FIELD GEOLOGIST: .....

DEPTH (ft.)	LITHOLOGY CHANGE (Depth,ft.)	MATERIAL DESCRIPTION (Soil Density / Consistency, Color)	USCS	REMARKS

Test Pit Cross Section and / or Plan View

REMARKS .....
.....
.....
.....

PHOTO LOG ..... TEST PIT .....
.....
.....
..... PAGE.....OF.....

ATTACHMENT D-1

EQUIPMENT CALIBRATION LOG

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

Manufacturer _____ Date Purchased _____

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

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	

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5.2.2 Water Level Measuring Devices
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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 neet

Attachment B - Water Level Indicator Calibration Sheet.

ATTACHMENT A

GROUNDWATER LEVEL MEASUREMENT SHEET

Project Name: _____
Project No.: _____
Personnel: _____
Date: _____

LOCATION

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.