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WASTE MANAGEMENT SERVICES GROUP

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R-33-5-8-7

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PROJECT OPERATIONS PLAN

C&R BATTERY SITE
CHESTERFIELD COUNTY, VIRGINIA

REMEDIAL INVESTIGATION/FEASIBILITY STUDY

EPA WORK ASSIGNMENT
NUMBER 37-01-3LP4
CONTRACT NUMBER 68-W8-0037

NUS PROJECT NUMBER 9851

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1.0 PROJECT DESCRIPTION

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This Project Operations Plan (POP) provides guidance for the remedial investigation (RI) at the C&R Battery Site, Chesterfield County, Virginia, as part of the Alternative Remedial Contracts Strategy (ARCS) Program.

This section provides a brief review of the site history and site description as well as scope of work for the RI.

1.1 SITE DESCRIPTION

The C&R Battery Site is located in Chesterfield County, Virginia, approximately 6 miles southeast of Richmond. The site is located on a 4.5-acre tract of land on the north side of Bellwood Road, approximately 3,800 feet east of Interstate 95. Coordinates for the site are 37°25'04" north latitude and 77°24'56" west longitude on the Drewry's Bluff, Virginia, 7.5-minute series quadrangle map, as shown in Figure 1-1.

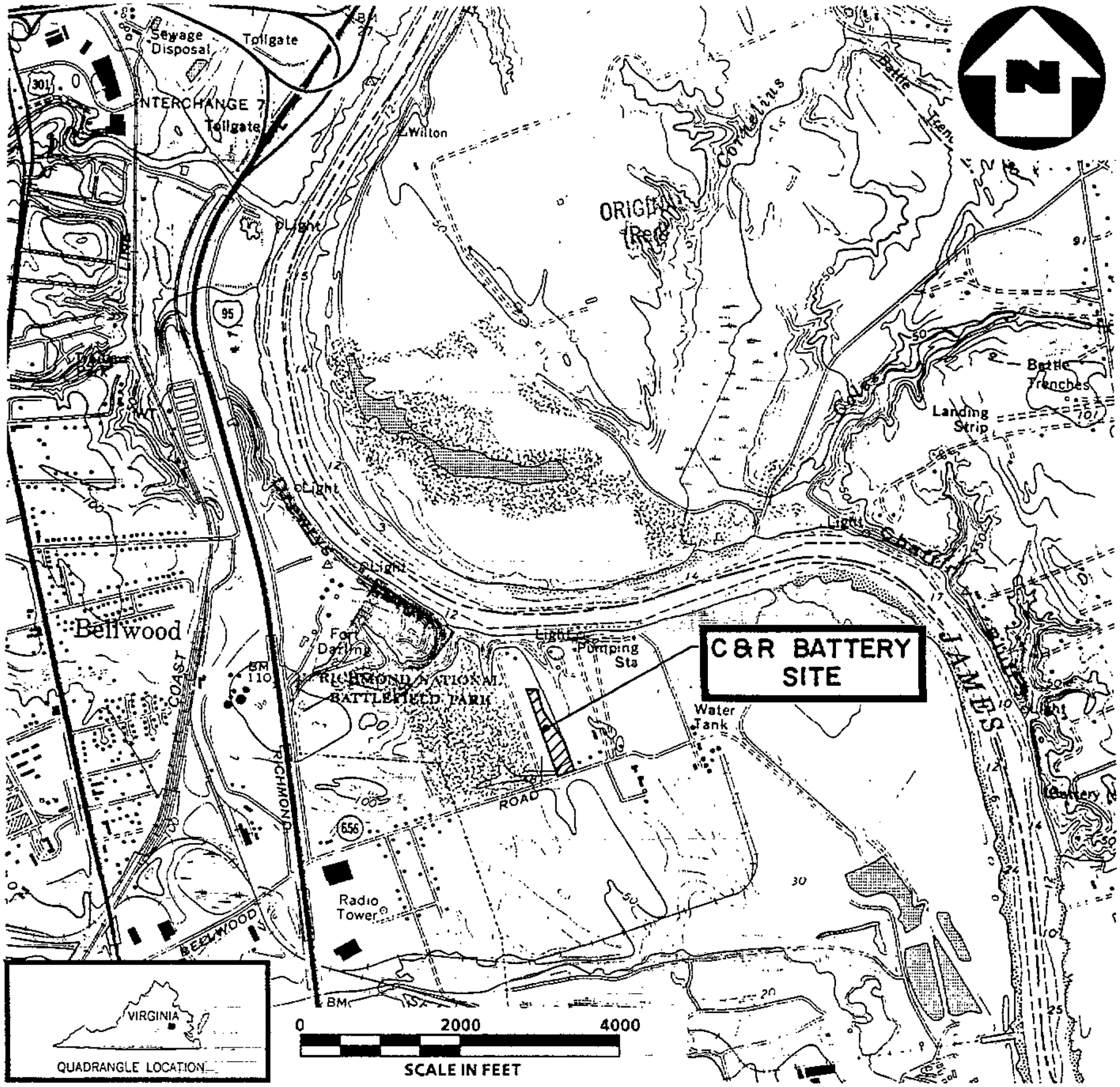
The site is rectangular in shape, approximately 1,260 feet in the north-south direction, and between 100 and 190 feet wide. It is bordered on the north, south, and west by open fields and woods. A small fuel oil distributor, Capitol Oil Company, borders the site on the east. The James River is approximately 650 feet north of the site. Figure 1-2 depicts the general site layout.

The site is located on property that was leased from the Capitol Oil Company by Mr. Charles Guyton. The lease boundary is indicated on Figure 1-2, but processing activities extended beyond the drainage ditch (east of the site) onto the Capitol Oil Company property.

1.2 SITE HISTORY

The C&R Battery Site was a battery-sawing and shredding facility designed to recover lead from discarded auto and truck batteries. It operated from the early 1970s until 1985. The battery breaker was mobile, and operations were moved throughout the site.

The site received bulk shipments of discarded batteries. The first step in recycling was to cut the batteries open and drain the battery acids into onsite ponds. The batteries were then broken open and the lead and lead compounds were recovered and stockpiled for later shipment. The battery



BASE MAP IS A PORTION OF THE USGS 7.5 MINUTE DREWRYS BLUFF, VIRGINIA QUADRANGLE, 1969 PHOTO-REVISED 1980. CONTOUR INTERVAL 10 FEET.

FIGURE I-1

SITE LOCATION MAP
C & R BATTERY SITE, CHESTERFIELD CO., VA

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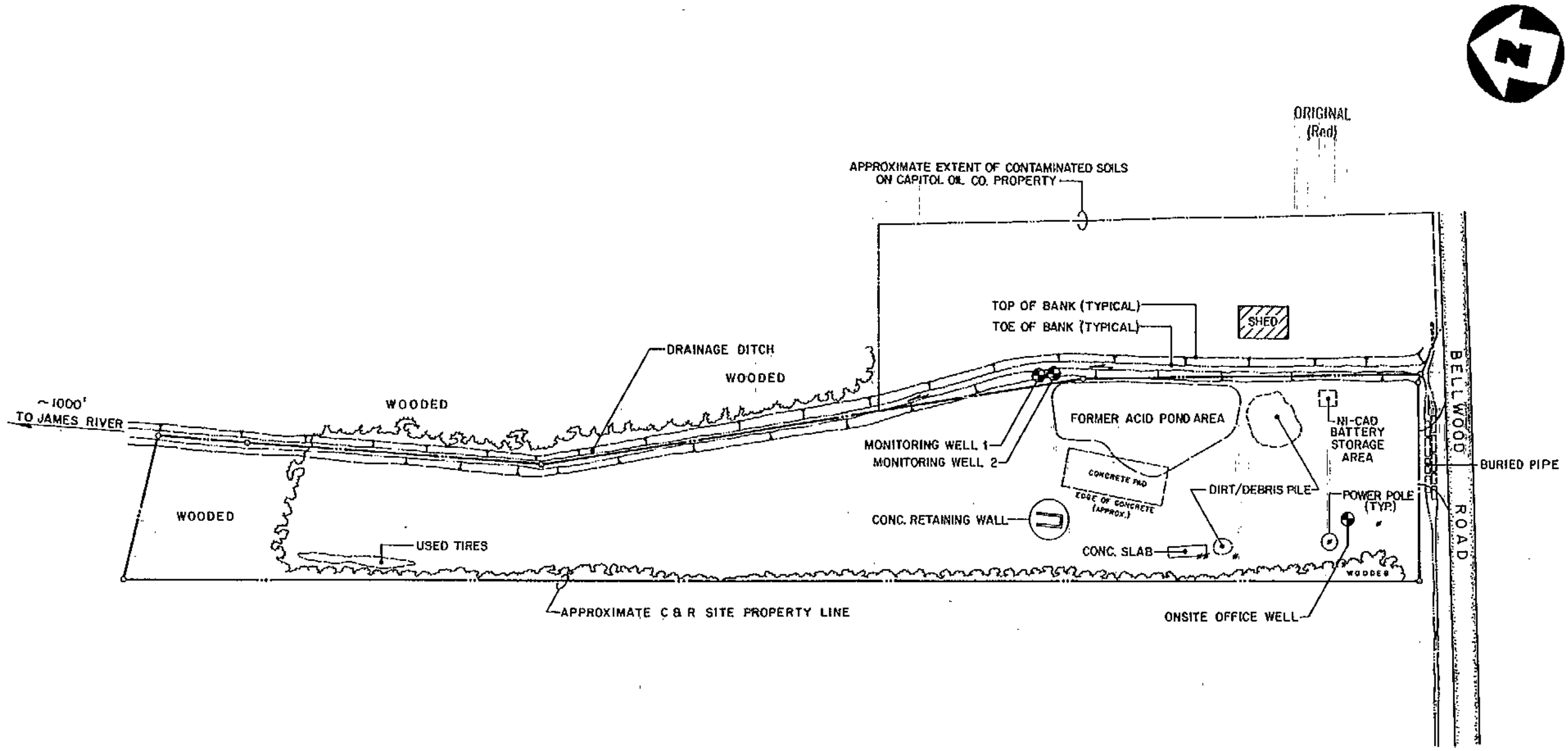

FIGURE 1-2

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GENERAL ARRANGEMENT
C & R BATTERY SITE, CHESTERFIELD CO., VA

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casings were subsequently shredded and stockpiled on the site. Crushed battery casings were observed on site during the April 7, 1988, site visit. No other activities that may have produced additional contaminants are known to have occurred on site (NUS, February 1986).

The Virginia State Water Control Board began monitoring the site in the late 1970s. Several reclamation plans were proposed and permit applications were made by the operator but state approval was never authorized.

The Virginia Occupational Safety and Health Administration (OSHA) first inspected the site in 1983 while the battery processing facility was still in operation. Air monitoring of the breathing zone at several work stations measured lead at concentrations up to 112 $\mu g/m^3$, well above the existing OSHA standard of 50 $\mu g/m^3$. Employees were found to have elevated levels of lead in their blood (NUS, February 1986).

In response to potential public health concerns, the U.S. Environmental Protection Agency (EPA) conducted a removal action at the site in the summer of 1986. EPA removed the acidic liquid from onsite lagoons, raised its pH, and discharged the neutralized liquids into storm sewers. The lagoon sludge was blended with hydrated lime and returned to the lagoon. Soils were disked and mixed with lime to a depth of 2 feet. However, when intact batteries were found in the northern portion of the site, the decision was made to apply lime only to the soil surface in this area. At the same time, a large amount of shredded battery casing material was found east of the drainage ditch. Some of this debris was returned to the site and remains on site in the debris piles (refer to Figure 1-2). The excavated area was subsequently backfilled to reduce hazards to Capitol Oil Company employees. The drainage ditch was graded and rip-rap channels and dams were installed to reduce erosion. A six-foot-tall, chain-link fence was installed inside the tree line to minimize the potential for direct contact with contaminated materials on site (verbal discussion with EPA during April 15, 1988, brainstorming meeting).

1.3 SCOPE OF WORK

Various field investigation activities will be conducted to collect data to meet the RI/FS objectives (see Section 3.0 of the Work Plan [NUS, 1988]). Provided below is a brief description of the activities that will be conducted during the RI at the C&R Battery Site. A detailed description of these tasks is given in Section 4.0 of this POP.

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Hydrogeologic Investigation

- Plug and abandon onsite wells
  - Two monitoring wells
  - One office well

- Drill and install four monitoring wells

- Excavate test pits throughout the site to explore for buried batteries and/or battery casings.

- Obtain water-level elevations at each monitoring well using continuous recorders for a period of time equal to at least one week.

Media Sampling

Soil Investigation (see Table 4-3 of the Work Plan)

- Drill 28 soil b .rings and collect soil samples

  - Approximately 72 soil samples for quick-turnaround lead analysis using X-Ray Fluorescence (XRF) and up to approximately 171 soil samples for Contract Laboratory Program/Special Analytical Services (CLP/SAS) and Routine Analytical Services (RAS) chemical analyses of other parameters.

  - Approximately 16 undisturbed soil samples of various cohesive lithologies within the vadose zone for geotechnical analyses.

  - Approximately 10 soil samples for CLP/SAS EP Toxicity analysis for metals.

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Groundwater Investigation (See Table 4-2 of the Work Plan)

- Collect two rounds of groundwater samples for specified analyses
  - Round 1 includes sampling groundwater of four newly installed monitoring wells for CLP quick-turnaround analysis for lead to determine the necessity of installing additional monitoring wells. Also includes CLP/SAS and RAS chemical analysis of other analytes.
  - Round 2 is to confirm data collected during round 1. Also includes collecting groundwater from one residential well and one business well.
- Collect nine surface-water and sediment samples for CLP/SAS and RAS analysis of various analytes.
- Collect three sediment samples for CLP/SAS EP Toxicity analysis for metals.
- Collect four sediment samples for bioassays, if required.

Debris Pile Sampling (see Table 4-5 of the Work Plan)

- Collect four samples from the two existing debris piles for CLP/SAS and RAS chemical analysis of various analytes.
  - Collect three debris soil samples from the large pile.
  - Collect one debris soil sample from the small pile.
- Collect a debris soil sample from each debris pile for CLP/SAS EP Toxicity analysis for metals.

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2.0 PROJECT ORGANIZATION AND MANAGEMENT

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2.1 SITE CONTROL

This section provides a brief discussion of site access, site security control, and field office/command post for the field work to be performed during the C&R Battery Site remedial investigation.

2.1.1 Site Access

The C&R Battery Site is accessible by public roads, although the site itself is secured by a chain-link fence with a locked gate. Keys to the gate are kept by the U.S. Environmental Protection Agency (EPA).

The ARCS III Project Manager will arrange through the EPA Regional Project Manager (RPM) to obtain keys to open the locked gate for use by NUS prior to initiating the RI field activities.

The field activities will include drilling and monitoring well installation, test pit excavation, plugging and abandoning existing onsite wells, residential well sampling, surface water and sediment sampling, and soil and debris sampling. Table 2-1 identifies the property owners whose land may be affected during the field activities.

No NUS or subcontractor personnel shall enter the properties without first making their presence known to the property owners. Properties which are owned by corporations (or businesses) will be contacted by the NUS Project Manager or designee, through the EPA RPM, to gain permission for site access. Anticipated field dates will be given to the appropriate corporate contacts (e.g., Works Manager, security guards). All offsite activities will be documented with before and after photographs for land restoration. Additionally, homeowners who will have their wells sampled will be contacted by the Project Manager or designee to obtain site access and arrange a suitable time for collecting the well sample.

In addition to notifying the property owners of NUS' presence, no NUS or subcontractor personnel will enter the site until: (1) written or verbal authorization is received from the Project Manager or designee, (2) at least 24-hour notice is given to the RPM before initiation of field activities, and (3) each field team member possesses personal identification in the form of a driver's license, company identification card, or a suitable substitute approved by the Field Operations Leader (FOL).

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TABLE 2-1

ADJACENT PROPERTY OWNERS TO C&R BATTERY SITE

Name	Mailing Address
Wako Chemicals USA, Inc. Mr. Hiroyuki Hayashi	12300 Ford Road, Suite 130 Dallas, TX 75234
June W. Martin	2420 Mt. Blanco Road Chester, VA 23831
Nina V. Shoosmith	12601 Lewis Road Chester, VA 23831 Sediment samples to be collected from drainage ditch which forms western border of this tract.
James L. & Anna C. Wade	1500 Bellwood Road Richmond, VA 23237
Charles C. Featherston	1823 N. Hamilton Street Richmond, VA 23230 (Probable location of upgradient monitoring well. Sediment samples to be collected from drainage ditch which forms northeastern border of this tract.)
Zacharias Brothers	P. O. Box 26664 Richmond, VA 23261
William K. & Carol K. Zacharias Edward A. & Mary D. Zacharias	P. O. Box 26664 Richmond, VA 23261 (Location of soil borings and monitoring well.)
Jack Shoosmith	12601 Lewis Road Chester, VA 23831 (Location of monitoring well.)
Mary H. Shoosmith	(Address unknown)
Industrial Development Authority of the County of Chesterfield	3340 Rosebud Road Loganville, GA 30249
Frank Shoosmith	P.O. Box 34201 Richmond, VA 23234

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2.1.2 Site Security/Control

All hand tools and light equipment will be returned to the command post and secured at the end of each work day. Any equipment (e.g., drilling rig) left on site will be secured to the extent possible to prevent unauthorized removal or vandalism. Any unfinished wells will be covered or capped in such a manner as to prevent tampering. Finished wells will be locked.

2.1.3 Field Office/Command Post

A field-office trailer will be mobilized on site prior to the initiation of any field activities. The office trailer will serve as a central command post through the duration of the field investigation, providing communications, shelter, office space, sanitary facilities, and space for equipment storage and sample handling.

2.2 PROJECT ORGANIZATION

The overall project organization and responsibilities of key management personnel are discussed in Section 5.0 of the RI/FS Work Plan. The organizational chart presented in Section 6.0 of the Work Plan is reproduced here as Figure 2-1 for easy reference. Personnel qualifications for project staff were contained in the ARCS III technical proposal.

Field work will be performed by a single team under the direction of the FOL. As shown in Figure 2-1, the FOL reports directly to the Project Manager. Figure 2-2 details the organization of the field operations team. The FOL will be responsible for coordinating and overseeing all field activities and will interface with the Health and Safety Site Officer (HSSO) in planning and performing the RI tasks. Each of the Field Team Leaders (FTLs) designated for the site RI activities will report to the FOL on a day-to-day basis. In accordance with the Health and Safety Plan (HASP), the HSSO or his designee will interact with the field team members during performance of their tasks.

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FIGURE 2-1
PROJECT ORGANIZATION
C&R BATTERY SITE

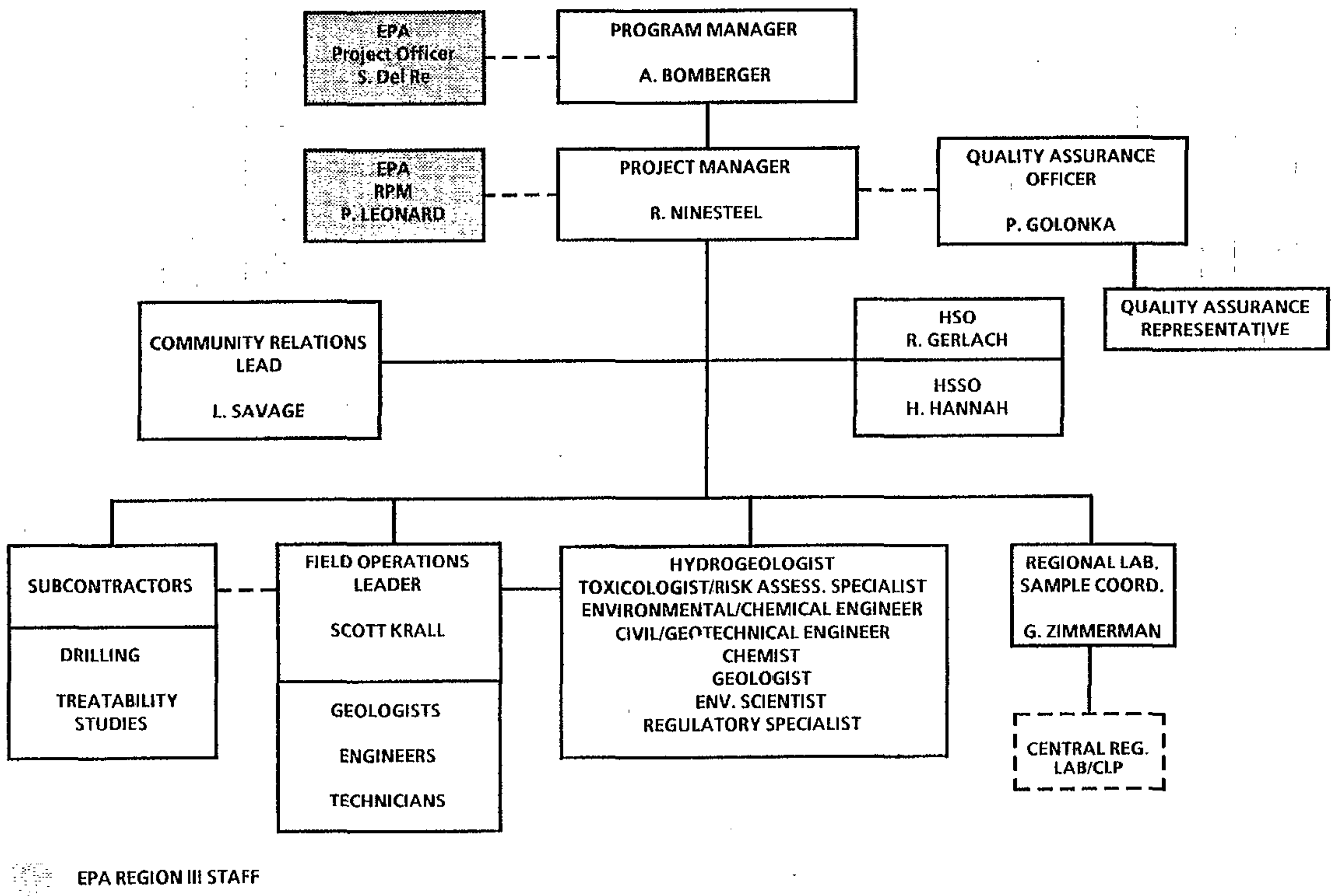

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FIGURE 2-2
FIELD OPERATIONS TEAM
C&R BATTERY SITE

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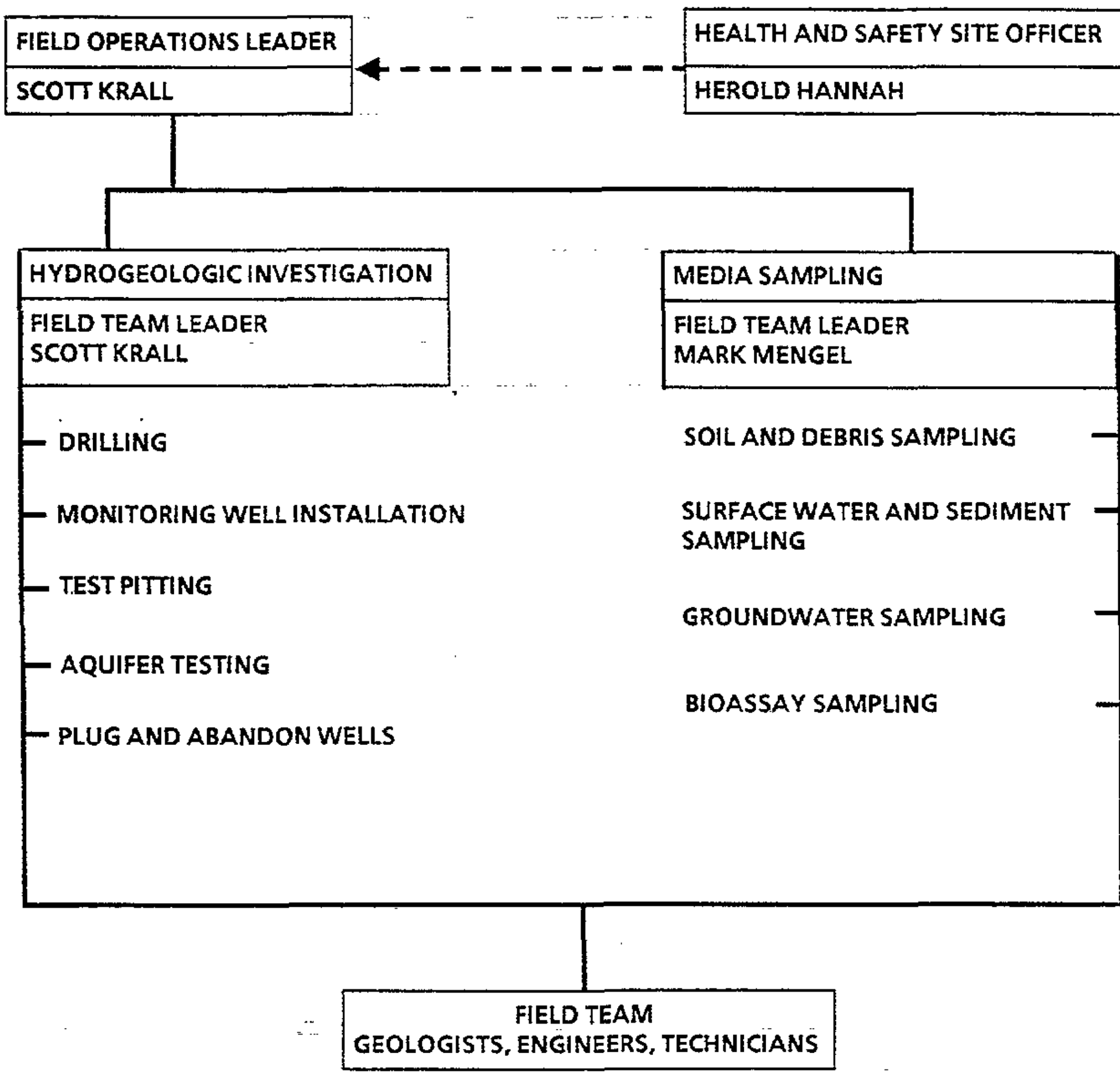

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2.3 RESPONSIBILITIES OF KEY PERSONNEL

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Key personnel for field operations are identified in Figures 2-1 and 2-2. Their specific responsibilities are discussed below.

- Field Operations Leader (FOL) - The FOL is responsible for all day-to-day aspects of the C&R Battery Site RI field work. The responsibilities of the FOL include
  - Assuring that all field team members are familiar with the Project Operations Plan (POP) and Health and Safety Plan (HASP).
  - Assuring that all field team members have completed health and safety training.
  - Coordinating the activities of all field teams.
  - Reporting to the Project Manager on a regular basis regarding the status of all field work and any problems encountered.
  - Completing Task Modification Requests, as necessary, for approval by the Project Manager.
- Field Team Leader (FTL) - The FTL reports directly to the FOL and has the following responsibilities:
  - Providing field team members with daily assignments.
  - Assuring that field team members comply with the procedures outlined in the POP.
  - Coordinating with the FOL to ensure sample shipping schedules are met.
  - Reporting on a daily basis to the FOL on the progress of the team.

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- Health and Safety Site Officer (HSSO) - The HSSO reports to the ARCS III Health and Safety Officer (HSO) and indirectly to the FOL and Project Manager. Details of the HSSO's responsibilities are presented in the HASP and include

  - Controlling specific health and safety related field operations such as personnel decontamination, monitoring of worker heat or cold stress, distribution of safety equipment, etc.

  - Assuring that field team personnel comply with all procedures established by the HASP.

  - Identifying assistant HSSOs or HSSO designees.

  - Terminating work if an imminent safety hazard, emergency situation, or other potentially dangerous situation is encountered.

- Regional Laboratory Sample Coordinator (RLSC) - The RLSC is responsible for the following tasks:

  - Scheduling laboratory service through the EPA Sample Management Office (SMO) and other vendors.

  - Tracking samples and coordinating with EPA Central Regional Laboratory (CRL).

  - Scheduling data validation.

  - Identifying laboratory analytical methods and laboratory QC.

- Quality Assurance Officer (QAO) - The QAO will designate a Quality Assurance Representative (QAR). The QAR is responsible for the following:

  - Field audits

  - Project QA audits

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2.4 SCHEDULE

The schedule for the C&R Battery Site RI field activities is presented in Section 5.3 of the RI/FS Work Plan (NUS, 1988). Key target dates are as follows:

Activity	Anticipated Start	Anticipated Finish
Mobilization	8/15	8/26
Drilling and monitoring well installation	8/30	9/7
Surface and subsurface soil sampling	8/30	9/23
Surface water and sediment sampling	9/6	9/16
Debris pile sampling	9/19	9/21
Round 1 water level elevations	9/7	9/7
Round 1 groundwater sampling	9/7	9/8
Round 2 groundwater sampling	9/21	9/23
Round 2 water level elevations	9/29	9/29
Test pit excavation	9/26	9/28
Aquifer testing	9/29	9/30
Plug and abandon existing wells	9/26	9/30
Bioassay sampling	9/28	9/30
Demobilization	10/3	10/7

3

3.0 QUALITY ASSURANCE OBJECTIVES

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The Draft Work Plan for the C&R Battery Site contained a summary of available site information, defined the data gaps and the RI/FS objectives, and identified the types and amount of data necessary to complete the RI/FS. The RI/FS objectives are summarized below:

- Further define the lateral and vertical extent of contamination in the site soil. Characterize contamination in the groundwater, the drainage ditch, and the debris piles.

- Assess the risks to public health and the environment from exposure to site contaminants.

- Define the engineering data needs, and screen and evaluate potential remedial alternatives for the site, including the no-action scenario.

In order to meet these objectives, additional site data are required. The data collection and quality assurance requirements described in this document are intended to provide data that are adequate in both number and quality to support completion of the RI/FS.

3.1 DATA QUALITY OBJECTIVES

Data quality objectives (DQOs) are qualitative and/or quantitative statements regarding the quality of data needed to support the RI/FS activities. In order to develop site-specific DQOs, the intended use of the data must be defined. This use must be balanced between data quality needs and time as well as cost constraints.

Specific analytical protocols are selected to meet the DQOs in the following ways:

- Compare Applicable or Relevant and Appropriate Requirements (ARARs), risk-based criteria, and data needs for risk assessment or engineering purposes to the detection limits for available analytical methods.

- Select analytical methods to allow quantification of the analytes at levels sufficiently below the ARARs to minimize the number of critical data points.

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- Evaluate the maximum allowable variability in the data based on the ARARs comparison. ORIGINAL (Red)

- Develop site-specific acceptable variability based on the intended data use and method-specific precision and accuracy information.

Table 3-1 presents a summary of the proposed sampling and analysis program for the C&R Battery Site. The information in this table was developed to meet the RI/FS objectives.

3.2 PRECISION, ACCURACY, REPRESENTATIVENESS, COMPLETENESS, AND COMPARABILITY (PARCC) GOALS

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 RI/FS and the intended use of the data define the PARCC goals.

3.2.1 Precision and Accuracy

Precision and accuracy characterize 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:

$$Range = OR - DR$$

$$and \qquad RPD = \frac{OR - DR}{1/2\,(OR + DR)} X\,100\%$$

where:

OR = original sample result
DR = duplicate sample result

The internal laboratory control limits for precision are three times the standard deviation of a series of RPD or range values. RPD values may be calculated for both laboratory and field duplicates, and can be compared to the control limits as a quality assurance check.

TABLE 3-1

SUMMARY OF SAMPLING AND ANALYSIS PROGRAM
C&R BATTERY SITE

Matrix	Analysis	Data Use (A)	Selected Analytical Option	Target Detection Limit	Proposed Analytical Method	Source of Analysis	Number of Samples	Field Duplicates (B)	Equipment Blanks (C)	Field Blank (G)
Groundwater	TAL inorganics	1,2,3,4	IV	CRDL	CLP Protocol	CLP-RAS	18 (E)	4 (E)	0	2
	sulfate	1	III	1 mg/l	EPA 300.0	CLP-SAS	10	2	0	1
	pH	1,5	I	NA	NA	Field Analysis	10	0	0	0
	Eh	1,5	I	NA	NA	Field Analysis	10	0	0	0
	temperature	1,5	I	NA	NA	Field Analysis	10	0	0	0
	conductivity	1,5	I	NA	NA	Field Analysis	10	0	0	0
	alkalinity	1,5	III	4 mg/l	EPA 310.1	CLP-SAS	10	2	0	0
	acidity	1,5	III	10 mg/l	EPA 305.1	CLP-SAS	10	2	0	0
	TSS	1,5,3	III	NA	EPA 160.2	CLP-SAS	10	2	0	0
	TDS	1,5	III	NA	EPA 160.1	CLP-SAS	10	2	0	0
	lead	1	IV	CRDL	CLP Protocol	CLP-SAS (F)	8 (E)	2 (E)	0	2

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TABLE 3-1
SUMMARY OF SAMPLING AND ANALYSIS PROGRAM
C&R BATTERY SITE
PAGE TWO

Matrix	Analysis	Data Use (A)	Selected Analytical Option	Target Detection Limit	Proposed Analytical Method	Source of Analysis	Number of Samples	Field Duplicates (B)	Rinsate Blanks (H)	Field Blanks (G)
Surface and	TAL inorganics	1,2,3,4,5	IV	CRDL	CLP Protocol	CLP-RAS	171	9	9	9
Subsurface	pH	1,5	III	NA	SW846-9045	CLP-SAS	72	4	0	0
Soil	alkalinity	1,5	III	1 mg/l	EPA 310.1	CLP-SAS	72	4	0	0
	acidity	1,5	III	10 mg/kg	EPA 305.1	CLP-SAS	72	4	0	0
	cation exchange capacity	1,5	III	1 meq/100 g	SW846-9081	CLP-SAS	72	4	0	0
	sulfate	1	III	1 mg/kg	SW846-9038	CLP-SAS	72	4	0	0
	EP Toxicity (metals only)	3,4	III	CRDL	(D)	CLP-SAS	10	1	0	0
	lead	1	IV	NA	X-Ray Fluorescence	Field Analysis	171	9	9	9
	permeability	1,5,3,4	III	NA	SW846-9100	CLP-SAS	16	0	0	0
	grain size	1,3,4	III	NA	ASTM D422-63	CLP-SAS	16	0	0	0
	Atterberg limits	1,3,4	III	NA	ASTM D4318-84	CLP-SAS	16	0	0	0
	soil moisture	1,3,4	III	NA	ASTM D2216-80	CLP-SAS	16	0	0	0
	unit weight	1,3,4	III	NA	MSA, section 30, Part 30-2	CLP-SAS	16	0	0	0
	specific gravity	1,3,4	III	NA	ASTM D854-83	CLP-SAS	16	0	0	0

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TABLE 3-1
SUMMARY OF SAMPLING AND ANALYSIS PROGRAM
C&R BATTERY SITE
PAGE THREE

Matrix	Analysis	Data Use (A)	Selected Analytical Option	Target Detection Limit	Proposed Analytical Method	Source of Analysis	Number of Samples	Field Duplicates (B)	Rinsate Blanks (H)	Field Blanks (G)
Sediment	TAL inorganics	1,2,3,4	IV	CRDL	CLP Protocol	CLP-RAS	9	1	1	1
	pH	1,5	III	NA	SW846-9045	CLP-SAS	9	1	0	0
	Eh	1,5	III	NA	CASWS, p 3-52	Field Analysis	9	1	0	0
	lead	1,5	II	NA	X-Ray Fluorescence	Field Analysis	9	1	0	0
	alkalinity	1,5	III	1 mg/l	EPA 310.1	CLP-SAS	9	1	0	0
	acidity	1,5	III	10 mg/kg	EPA 305.1	CLP-SAS	9	1	0	0
	cation exchange capacity	1,5	III	1 meq/100 g	SW846-9081	CLP-SAS	9	1	0	0
	grain size	1,4	III	NA	ASTM D422-63	CLP-SAS	9	1	0	0
	TOC	1,5	III	0.4 mg/kg	MSA 29.3.5.2	CLP-SAS	9	1	1	1
	Volatile residue	1,5	III	NA	EPA 160.4	CLP-SAS	9	1	0	0
	EP Toxicity (metals only)	3,4	III	CRDL	(D)	CLP-SAS	3	1	0	0
	Elutriate bioassays	2	NA	NA	Fathead Minnow & <u>Ceriodaphnia</u> Toxicity, CTERW	CLP-SAS	4	0	0	0

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TABLE 3-1
SUMMARY OF SAMPLING AND ANALYSIS PROGRAM
C&R BATTERY SITE
PAGE FOUR

Matrix	Analysis	Data Use (A)	Selected Analytical Option	Target Detection Limit	Proposed Analytical Method	Source of Analysis	Number of Samples	Field Duplicates (B)	Rinsate Blanks (H)	Field Blanks (G)
Surface Water	TAL inorganics	1,2,3,4,5	IV	CRDL	CLP Protocol	CLP-RAS	18 (E)	2 (E)	0	2
	sulfate	1	III	1 mg/l	EPA 300.0	CLP-SAS	9	1	0	0
	pH	1,2,5	I	NA	NA	Field Analysis	9	1	0	0
	Eh	1,2,5	I	NA	NA	Field Analysis	9	1	0	0
	temperature	1,5	I	NA	NA	Field Analysis	9	1	0	0
	conductivity	1,5	I	NA	NA	Field Analysis	9	1	0	0
	hardness	1,2,5	III	10 mg/l	EPA 130.2	CLP-SAS	9	1	0	0
	alkalinity	1,5	III	4 mg/l	EPA 310.1	CLP-SAS	9	1	0	0
	acidity	1,5	III	10 mg/l	EPA 305.1	CLP-SAS	9	1	0	0
	TSS	1,5,3,2	III	NA	EPA 160.2	CLP-SAS	9	1	0	0
	TDS	1,5,2	III	NA	EPA 160.1	CLP-SAS	9	1	0	0
Debris Pile	TAL inorganics	1,2,3,4,5	IV	CRDL	CLP-Protocol	CLP-RAS	4	1	1	1
	pH	1,5	III	NA	SW846-9045	CLP-SAS	4	1	0	0
	alkalinity	1,5	III	4 mg/l	EPA 310.1	CLP-SAS	4	1	0	0
	acidity	1,5	III	10 mg/l	EPA 305.1	CLP-SAS	4	1	0	0
	cation exchange capacity	1,5	III	1 meq/100mg	SW846-9081	CLP-SAS	4	1	0	0
	grain size	1,5,3,4	III	NA	ASTM D 422-63	CLP-SAS	4	0	0	0
	EP Toxicity (metals only)	3,4	III	CRDL	(D)	CLP-SAS	2	1	0	0

TABLE 3-1
SUMMARY OF SAMPLING AND ANALYSIS PROGRAM
C&R BATTERY SITE
PAGE FIVE

NOTES:

(A) 1 - Site Characterization
2 - Risk Assessment
3 - Evaluation of Alternatives
4 - Engineering Design of Alternatives
5 - Input for Contaminant Transport Evaluation

(B) Field Duplicate - A single sample split into two portions, each of which is submitted blindly to the laboratory. Assesses the overall precision of sampling and analysis program (also known as a Replicate Sample).

(C) Equipment Blank - Sample obtained by pouring analyte-free, deionized water through dedicated sample collection equipment (bailer) before use. Assesses the effectiveness of decontamination procedure.

(D) EP Toxicity Leaching Test, extracts to be analyzed by CLP protocol for metals only.

(E) Includes filtered and unfiltered samples.

(F) Requires quick turnaround

(G) Field Blank - Generated at time of sampling by filling bottles in the field with analyte-free, deionized water.

(G) Rinsate Blank - Sample obtained by pouring analyte-free, deionized water over sample collection equipment (shovel, etc.) after decontamination. Assesses effectiveness of field decontamination procedures.

NA - Not Applicable
CLP - Contract Laboratory Program
SAS - Special Analytical Services - Requires specified preparation, analysis, or reporting techniques available through CLP. Requires coordination with SMO.
CRDL - Contract Required Detection Limit
CLP Protocol - Protocol defined in the CLP Statement of Work
ASTM - American Society for Testing Materials
EPA - Methods for Chemical Analysis of Water and Wastes EPA-600/4-79-020
CASWS - Chemical Analysis of Sediment and Water Samples (EPA, May 1981)
SW846 - Test Methods for Evaluation of Solid Waste, Physical/Chemical Methods
MSA - Methods of Soils Analysis by American Society of Agronomy
CTERW - Short Term Methods for Estimating the Chronic Toxicity of Effluents and Receiving Water to Freshwater Organisms

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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:

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

where:

E = experimental result

T = true value or theoretical result

$$with \qquad Theoretical\, result = \frac{(Sample\, aliq.)(Sample\, conc.) + (Spike\, aliq.)(Spike\, conc.)}{Sample\ aliquot}$$

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

Field and laboratory precision and accuracy performance can affect the attainment of project objectives, particularly when compliance with established criteria is based on laboratory analysis of environmental samples. Such criteria are used in risk assessment and screening of remedial alternatives. Given the uncertainties associated with field work and laboratory activity, the following overall precision and accuracy goals are identified to meet the project objectives:

- Precision: ± 50 percent RPD
- Accuracy: ± 50 percent recovery

Analytical precision and accuracy will be evaluated upon receipt of the laboratory data. Analytical precision will be measured as the relative standard deviation of the data from the laboratory (internal) duplicates. Analytical accuracy measures the bias as the percent recovery from matrix spike and surrogate spike samples. CLP requirements will be used.

Field sampling precision and accuracy are not easily measured. Field contamination, sample preservation, and sample handling will affect precision and accuracy. By following the appropriate NUS ARCS III Program Standard Operating Procedures (SOPs, see Appendix A), precision and accuracy errors associated with field activities can be minimized. Field duplicates and blanks (field, equipment, and rinsate) will be used to estimate field sampling and accuracy.

No project resources will be expended to develop precision and accuracy data for method (field or analytical) validation except those commonly applied in the CERCLA program for collection of routine QA/QC data. Routine QA/QC data will include analyses from field duplicates and equipment rinsate blanks based on the existing guidance that specifies the type and proportion of samples submitted for QA/QC (EPA, March 1987).

Validity of data (i.e., 95-percent confidence limit) with respect to its intended use will be assessed based on laboratory-supplied QA/QC data and protocols routinely employed for validation of CLP-RAS/SAS results. In general, results that are rejected by the validation process will be disqualified from application to the intended use. Qualified data will be used to the greatest extent practicable.

3.2.2 Representativeness

Representativeness describes the degree to which analytical data accurately and precisely define the material being measured. Several elements of the sampling and sample handling process must be controlled to maximize the representativeness of the analytical data. Sample collection, preservation, and storage are discussed in Sections 4.1 and 5.0 of this document. Section 4.3 of the Work Plan contains details on the site sampling program and the rationale for sampling locations. The sampling program is designed to ensure that the data obtained during the RI accurately represent the site conditions.

Representativeness of data is also affected by sampling techniques. Sampling techniques are described in Section 4.3 of the POP. To ensure that the data are representative, NUS' ARCS III Program Standard Operating Procedures will be used.

To ensure that sample aliquots to be analyzed are representative, samples will be homogenized in the laboratory by removing non-representative materials (e.g., sticks and stones), then stirring, shaking, crushing, and/or blending the sample as appropriate to the matrix.

3.2.3 Completeness

Completeness describes the amount of data generated that meets the objectives for precision, accuracy, and representativeness versus the amount of data expected to be obtained. For relatively clean, homogeneous matrices, 100-percent completeness is expected. However, as matrix complexity and heterogenicity increase, completeness may decrease. Where analysis is precluded or where data quality objectives are compromised, effects on the overall investigation must be considered. Whether or not any particular sample is critical to the investigation will be evaluated in terms of the sample location, the parameter in question, the intended data use, and the risk associated with the error.

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

Critical data points may not be evaluated until all the analytical results are evaluated. Additionally, several sampling points, in aggregate, may be considered to be critical either by location (e.g., downgradient monitoring wells) or by analysis (e.g., lead). If in the evaluation of laboratory results it becomes apparent that the data for a specific medium are of insufficient quality, either with respect to the number of samples or an individual analysis, resampling of the deficient data points will be necessary.

3.2.4 Comparability

One of the objectives of the POP is to provide analytical data of comparable quality both between sample locations and with data from previous investigations (i.e., FIT). Both analytical procedures (i.e., CLP) and sample collection techniques (as defined in NUS SOPs) will maximize the comparability of the RI data within this investigation and to the FIT investigation. Additionally, to enhance comparability between samples, consideration will be given to seasonal conditions, stream flow, or other environmental conditions that could influence the analytical results.

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4.0 FIELD INVESTIGATION ACTIVITIES

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The field investigation at the C&R Battery Site will consist of the following tasks:

- Mobilization/demobilization
- Plug and abandon existing onsite wells
- Test pit excavation
- Surface and subsurface soil sampling
- Monitoring well installation
- Groundwater and residential well sampling
- Surface water and sediment sampling
- Debris pile sampling
- Bioassays

4.1 GENERAL FIELD GUIDELINES

4.1.1 Sample Identification System

Each sample taken from the C&R Battery Site will be assigned a unique sample tracking number. The sample tracking number will consist of a three-segment, alpha-numeric code that identifies the sample medium, location, and the sample depth (in the case of soil samples) or 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 alpha-numeric coding to be used in the sample numbering system is explained in the following diagram and the subsequent definitions:

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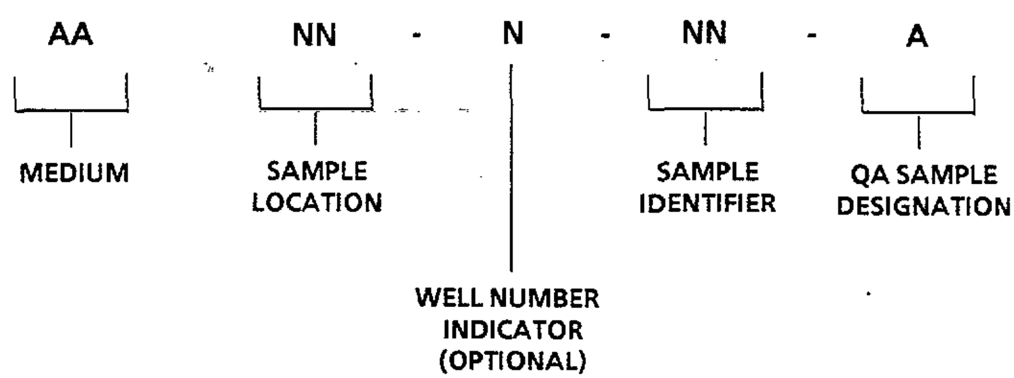

Character type:

A = Alpha

N = Numeric

Medium:

MW = Groundwater from Monitoring Well

RW = Groundwater from Residential Well

SO = Soil

DP = Debris Pile

SW = Surface Water

SD = Sediment

BA = Sediment Bioassays

Sample Location:

Locations of a given medium will be numbered sequentially beginning with "01".

Well number Indicator:

Identifies the phase of drilling:

Sample Identifier:

For soil samples = Depth, in feet, of sample.

For other media = Sample round.

QA Sample Designation:

D = Duplicate

B = Field (Equipment Rinsate) Blank

Omitted for other samples.

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For example, a groundwater sample collected during Round 1 from monitoring well 4 (first phase of drilling) would be designated as:

MW04 - 1 - 01

A duplicate sample from that well would be

MW04 - 1 - 01 - D

A groundwater sample collected during round 2 from a deeper well installed during phase 2 of drilling would be:

MW04 - 2 - 02

A subsurface soil sample taken from Boring No. 7 at a depth of 20 to 21.5 feet would be:

SO07 - 20

Information regarding sample labels and tags to be attached before shipment to a laboratory is contained in Section 5.2 of NUS SOP SA-6.1. Appendix B contains an example of the sample label, sample tag, and chain-of-custody seal for use in Region III. These documents will contain the designation for filtered and unfiltered groundwater samples.

4.1.2 Sample Handling

Sample handling includes the field-related considerations connected with the selection of sample containers, preservatives, allowable holding times, and the analyses requested. The EPA User's Guide to the Contract Laboratory Program (EPA, December 1986), verbal guidance from the Region III Central Regional Laboratory (CRL), and the Federal Register (EPA, October 26, 1984) address the topics of containers and sample preservation. Table 4-1 provides a site-specific summary of all sample handling considerations.

TABLE 4-1

SUMMARY OF ANALYSES, BOTTLE REQUIREMENTS, PRESERVATION REQUIREMENTS, AND HOLDING TIMES C&R BATTERY SITE

Media	Analysis	No. of Samples	No. of Containers per Sample	Type of Container	Preservation Requirements	Holding Time
Surface and	TAL inorganics	198	1	8-oz. wide-mouth glass jar	None	6 months
Subsurface Soil	pH, alkalinity, acidity, CEC, sulfate	76	1	8-oz. wide-mouth glass jar	None	None
	lead (X-Ray Fluorescence)	198	1	8-oz. wide-mouth glass jar	None	6 months
	EP Toxicity (metals only)	11	1	32-oz. wide-mouth glass jar	None	None
	permeability, grain size, Atterberg limits, soil moisture, unit weight, specific gravity	16	1	thin-wall tube	None	None
Groundwater	TAL inorganics (dissolved)	12	1	1-liter polyethylene bottle	HNO_3 to pH<2, Cool to 4°C	6 months
	TAL inorganics (total)	12	1	1-liter polyethylene bottle	HNO_3 to pH<2, Cool to 4°C	6 months
	lead (quick turnaround) (dissolved)	6	1	1-liter polyethylene bottle	HNO_3 to pH<2, Cool to 4°C	6 months
	lead (quick turnaround) (total)	6	1	1-liter polyethylene bottle	HNO_3 to pH<2, Cool to 4°C	6 months
	sulfate	13	1	500-ml polyethylene bottle	Cool to 4°C	28 days
	pH, Eh, temperature, conductivity (field analysis)	10	NA	NA	NA	Analyze immediately
	alkalinity, acidity	12	1	500-ml polyethylene bottle	Cool to 4°C	14 days
	TSS, TDS	12	1	1-liter polyethylene bottle	Cool to 4°C	48 hours (TDS), 7 days (TSS)

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TABLE 4-1
SUMMARY OF ANALYSES, BOTTLE REQUIREMENTS, PRESERVATION REQUIREMENTS, AND HOLDING TIMES
C&R BATTERY SITE
PAGE TWO

Media	Analysis	No. of Samples	No. of Containers per Sample	Type of Container	Preservation Requirements	Holding Time
Sediment	TAL inorganics	12	1	8-oz. wide-mouth glass jar	None	6 months
	Eh (Field analysis)	10	1	4-oz. wide-mouth glass jar	NA	Analyze immediately
	pH, alkalinity, acidity	10	1	8-oz. wide-mouth glass jar	None	None
	Lead (X-Ray Fluorescence)	10	1	8-oz. wide-mouth glass jar	None	6 months
	cation exchange capacity	10	1	8-oz. wide-mouth glass jar	None	None
	grain size	10	1	8-oz. wide-mouth glass jar	None	None
	TOC	12	1	8-oz. wide-mouth glass jar	Cool to 4°C	28 days
	volatile residue	10	1	8-oz. wide-mouth glass jar	Cool to 4°C	None
	EP Toxicity (metals only)	4	1	32-oz. wide-mouth glass jar	None	None
	elutriate bioassays	4	1	3-gal. plastic bucket	Cool to 4°C	Analyze immediately
Surface Water	TAL inorganics (dissolved)	11	1	1-liter polyethylene bottle	HNO_3 to pH<2, Cool to 4°C	6 months
	TAL inorganics (total)	11	1	1-liter polyethylene bottle	HNO_3 to pH<2, Cool to 4°C	6 months
	sulfate	10	1	500-ml polyethylene bottle	Cool to 4°C	28 days
	pH, Eh, conductivity, temperature (field analysis)	10	NA	NA	NA	Analyze immediately
	water for elutriate bioassays	4	1	2.5-gal cubitainer	Cool to4°C	Use immediately

TABLE 4-1
SUMMARY OF ANALYSES, BOTTLE REQUIREMENTS, PRESERVATION REQUIREMENTS, AND HOLDING TIMES
C&R BATTERY SITE
PAGE THREE

Media	Analysis	No. of Samples	No. of Containers per Sample	Type of Container	Preservation Requirements	Holding Time
Surface Water (continued)	hardness	10	1	500-ml polyethylene bottle	HNO_3 to pH<2, Cool to 4°C	6 months
	alkalinity/acidity	10	1	500-ml polyethylene bottle	Cool to 4°C	14 days
	TSS, TDS	10	1	1-liter polyethylene bottle	Cool to 4°C	48 hours (TDS) 7 days (TSS)
Debris Pile	TAL inorganics	7	1	8-oz. wide-mouth glass jar	None	6 months
	pH, alkalinity, acidity, CEC	5	1	8-oz. wide-mouth glass jar	None	None
	EP Toxicity (metals only)	3	1	32-oz. wide-mouth glass jar	None	None
	grain size	4	1	8-oz. wide-mouth glass jar	None	None

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4.1.3 Sample Packaging and Shipping

Samples will be packaged and shipped in accordance with the EPA User's Guide to the Contract Laboratory Program (EPA, December 1986) and NUS SOPs SA-6.2 and 6.6. The Field Operations Leader will be responsible for contacting the EPA Sample Management Office (SMO) for each shipment and will report the following:

- Sampler name and telephone number.
- Case number and/or SAS number of the project.
- Site name/code.
- Number(s), matrix(ces), and concentration(s) of samples shipped.
- Laboratory(ies) to which samples were 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.

4.1.4 Documentation

Custody of samples must be maintained and documented at all times. Chain-of-custody begins with the collection of the samples in the field. Section 5.3 of NUS SOP SA-6.1 (see Appendix A) provides a description of the chain-of-custody procedures to be followed. An example of the chain-of-custody record is included in Appendix B.

In addition to the EPA-required CLP documentation (e.g., traffic reports) and Quality Assurance (QA) of samples, certain standard forms will be completed for sample description and documentation. These shall include the sample log sheet (for water samples taken from monitoring wells) and project sample summaries. An example of these forms can be found in NUS SOP SA-6.6 (See Appendix B).

A bound/weatherproof field notebook shall be maintained by each sampling event leader and the HSSO. The field team leader, or designee, shall record all information related to sampling or field activities. This information may include sampling time, weather conditions, unusual events (e.g., well tampering), field measurements, description of photographs, etc.

A site logbook shall be maintained by the Field Operations Leader. The requirements of the site logbook are outlined in NUS SOP SA-6.3, Sections 5 and 7. This book will contain a summary of the day's activities and will reference the field notebooks when applicable.

Each field team leader who is supervising a drilling subcontractor activity must complete a Daily Record Subsurface Investigation Report. A Weekly Field Summary Report will be completed for all subcontractor activities. The Daily Record Subsurface Investigation Report documents the activities and progress of the daily drilling activities. The information contained within this report is used for billing verification and progress reports. The driller's signature is required at the end of each working day to verify work accomplished, hours worked, standby time, and material used. The Weekly Field Summary Report summarizes the major activities on site for a particular week. The *Daily Record Subsurface Investigation Report and Weekly Field Summary Report will be sent to the* Project Manager at the end of the week. An example of both forms is provided in Appendix B.

At the completion of field activities, the FOL shall submit to the Project Manager all field records, data, field notebooks, logbooks, chain-of-custody receipts, sample log sheets, drilling logs, daily logs, etc. The Project Manager shall ensure that these materials are entered into the ARCS Program 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. Section 7.16 of the NUS Quality Assurance Project Plan provides a detailed description of the procedures to be followed in the event of implementing field changes. A summary of the sequence of events associated with field changes is as follows:

- The FOL notifies the Project Manager of the need for the change.

- If necessary, the Project Manager will discuss the change with the pertinent individuals (e.g., EPA Region III RPM) and will provide a verbal approval or denial to the FOL for the proposed change.

- The FOL will document the change on a Task Modification Request form (See Appendix B) and forward the form to the Project Manager at the earliest convenient time (e.g., end of the workweek).

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* The Project Manager will sign the form and distribute copies to the RPM, Quality Assurance Manager, Field Operations Leader, and the project file.

* A copy of the completed Task Modification Request form will also be attached to the field copy of the affected document (i.e., Work Plan and Project Operations Plan).

4.2 GENERAL FIELD OPERATIONS

4.2.1 Mobilization/Demobilization

Following approval of the Work Plan and this POP, NUS will begin mobilization activities. All field team members will review the Work Plan, the POP, and the Health and Safety Plan (HASP) which is contained in Appendix D of this document. In addition, a field team orientation meeting will be held to familiarize personnel with the scope of the RI field activities.

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

* Field office trailer.
* Sanitary facilities.
* Utility hook-ups.
* Sampling equipment.
* Hydrogeologic monitoring equipment.
* Health, safety, and decontamination equipment.
* Subcontractor equipment.

The Field Operations Leader (FOL) will coordinate the mobilization of the field office, sanitary facilities, and utility hook-ups with the necessary vendors prior to arriving on site. The FOL will also make any necessary equipment purchases in order to conduct the field investigation. The equipment for the hydrogeologic monitoring and the health, safety, and decontamination tasks will be loaded in Pittsburgh and driven to the site by the FOL and a geologist. The two will supervise the locating of the field office and sanitary facilities, and the installation of electric and telephone utilities.

The equipment for the soil, groundwater, surface water, sediment, debris pile, and bioassay sampling will be mobilized separately and transported by field technicians from Pittsburgh to the site. After field activities are completed, the field technicians will demobilize the equipment and drive back to Pittsburgh.

At the end of the field investigation, the field office, sanitary facilities, and utilities will be disconnected and demobilized under the supervision of the FOL and a geologist. The FOL and the geologist will load all the remaining field investigation equipment and drive back to Pittsburgh.

The subcontractor who is awarded the contract to perform the drilling will begin to mobilize equipment immediately after receiving notice to proceed. The subcontractor will be responsible for mobilizing and demobilizing the necessary equipment in order to perform the work outlined in the bid specifications.

4.2.2 Drilling Operations

4.2.2.1 Number and Location of Soil Boring

A total of 28 (to 31) soil borings will be drilled throughout the area of investigation. Four of the 28 borings shall be converted to monitoring wells. Samples for chemical analysis shall be collected in all but one of the 28 borings. The soils in boring MW3-1 will not be analyzed chemically because the well is offsite in an area known not to be affected by site activities and is therefore expected to be clean. In addition, a thin-wall tube sample shall be obtained from each different cohesive lithology encountered while drilling the four borings designated for monitoring well construction. A maximum of four undisturbed thin-wall tube samples shall be collected from each soil boring, for a total of not more than 16 undisturbed thin-wall tube samples. The actual number of samples collected will depend on the number of various cohesive lithologies encountered during drilling of these four soil borings. If the field geologist determines that there is insufficient material for both the thin-wall tube samples and soil samples for chemical analyses from borings MW1-1, MW2-1, and MW4-1, then an additional (contingency) boring adjacent to each of these three soil borings may be necessary to collect the undisturbed thin-wall tube samples, bringing the total number of soil borings to 31.

Four of the proposed 28 borings shall be drilled down to the phreatic zone, which has been estimated to occur at approximately 40 to 42 feet below ground surface. The four borings for monitoring wells will be drilled to an approximate depth of 50 feet. The remaining 20 borings are proposed to penetrate to a depth of 15 feet below ground surface. The additional three contingency soil borings will penetrate to an adequate depth which enables collection of up to four undisturbed thin-walled tube samples of various distinct (cohesive) lithologies within the overburden material as determined in the field by the site geologist. Figure 4-1 illustrates the locations of the 28 proposed soil borings.

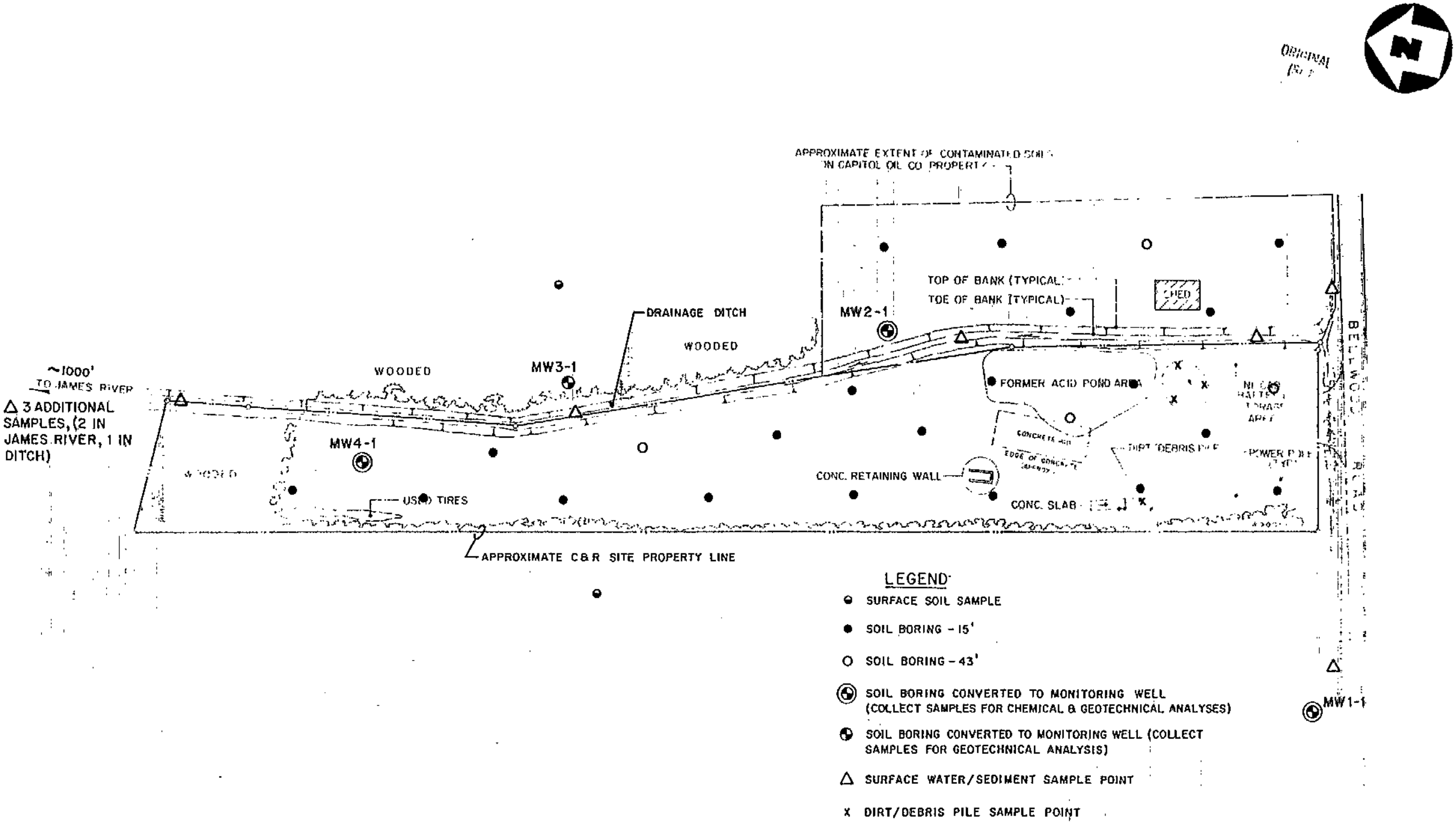

FIGURE 4-1

PROPOSED SAMPLING LOCATIONS
C & R BATTERY SITE, CHESTERFIELD CO., VA

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Table 4-2 and Figure 4-2 highlight the total depth and sampling intervals of each of the 28 proposed soil borings and the three contingency borings.

The proposed locations for soil borings and monitoring wells were selected based on the suspected source areas, the overall expected groundwater flow pattern for the area and the data requirements of the RI.

4.2.2.2 Overburden Drilling Procedures

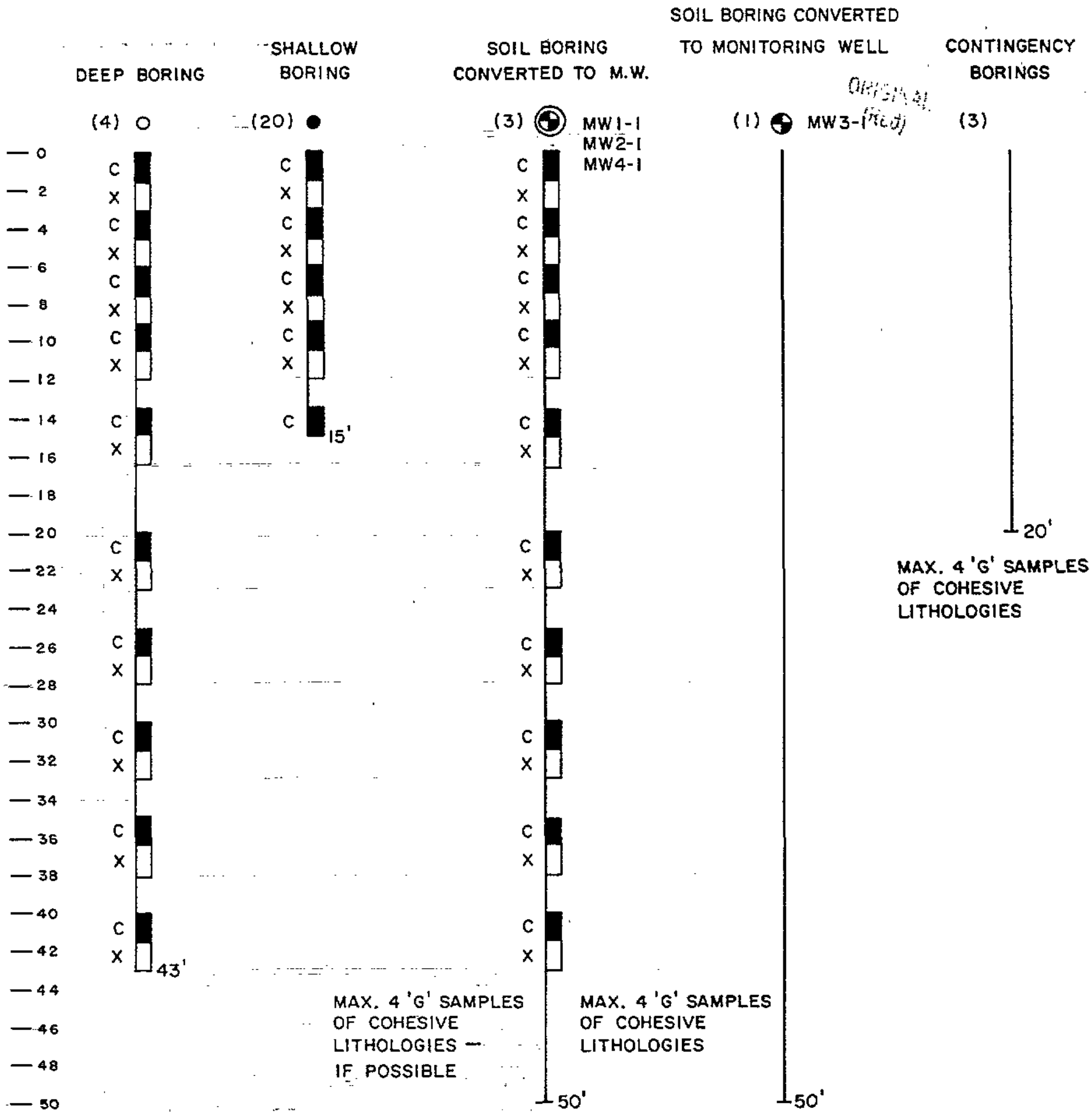
Drilling operations for overburden soil borings will be conducted using any combination of drilling methods needed to drill through the sediments, with the only restriction being that potable water is the only fluid allowed if one is required. The preferred method of drilling is the hollow-stem auger method. The borings shall be advanced in accordance with the drilling specifications developed for this project.

Borings for monitoring wells will be terminated approximately 8 to 10 feet after encountering the water table (about 40 to 42 feet). The depth of the water table will be measured and/or confirmed by the field geologist prior to completion of the well drilling.

During drilling operations of overburden material, standard penetration tests and split-barrel sampling, or thin-wall tube sampling shall be performed, at a minimum, at 5-foot intervals, as directed by the sampling requirements described in Table 4-2 and Section 4.3.1 in this document, or as determined by the field geologist. These sampling procedures shall be performed in accordance with ASTM D1584-84, (Section 7) or ASTM D1587-83 (Sections 6 and 7, see Appendix A) for each soil boring. In order to obtain sufficient soil for chemical analysis, a 3-inch outside diameter split-barrel sampler driven with a 300-pound hammer may be necessary.

Each soil sample collected for lithologic description will be placed in an 8-ounce jar (to be provided by the drilling subcontractor), labeled, and the pertinent data recorded (i.e., project, boring and sample numbers, depth, blow counts, and date) by the field geologist. The driller shall prepare a separate written boring log for each boring drilled, to be submitted to the field geologist at the conclusion of the field activities.

A complete log of each well boring will be maintained by NUS in accordance with NUS SOP SA-6.4, Section 5.2.6, Attachment C-1. Appendix B contains an example of the boring log description form.



– SPLIT-BARREL SAMPLE INTERVALS

C = CHEMICAL ANALYSIS (SPLIT-BARREL)
X = XRF (SPLIT-BARREL)
G = GEOTECHNICAL PARAMETER (THIN-WALL TUBE)
(4) = TOTAL NUMBER OF BORINGS
NOTE: SEE FIGURE 4-1 FOR BORING LOCATIONS

FIGURE 4-2

SOIL SAMPLING INTERVAL SCHEMATIC
C & R BATTERY SITE, CHESTERFIELD CO., VA

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TABLE 4-2

DEPTH AND SAMPLING INTERVALS OF PROPOSED SOIL BORINGS
C&R BATTERY SITE

Number of Soil Borings	Soil Boring Depth (Feet)	Thin-wall Tube Samples	Split-spoon Samples for Chemical Analysis	Installation of Monitoring Well	Contingency Soil Borings
20	15	No	Yes[1]	No	No
4	40	No	Yes [1,2,3]	No	No
3	50	If possible[4]	Yes [1,2,3]	Yes	No
1	50	Yes[4]	No [3,4]	Yes	No
3	15	Yes[4]	No	No	Yes

1 Continuous split-spoon sampling from 0 to 15', every other sample to be sent for chemical analysis.
2 Split-spoon sampling 3' of each 5' increment, from 20' to phreatic zone (i.e., 20-23', 25-28', 30-33', 35-38', 40-43'), every other sample to be sent for chemical analysis.
3 Split-spoon sampling every 5' for lithologic description unless otherwise specified.
4 Undisturbed thin-walled shelby tube for a maximum of 4 distinct types of (cohesive) lithology encountered.

At a minimum the boring log will contain the following information, when applicable, for each overburden well boring:

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

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In addition, depths of changes in lithology, sample moisture observations, depth to water, OVA/HNU readings (if taken), drilling methods, and total depth of each borehole should be included on each log, as well as any other pertinent observations. Sample bottles containing soil samples collected solely for lithologic description from each monitoring well boring will be consecutively numbered starting with S-1. In addition, the following information shall be recorded on the lid of these sample jars:

- Job name and number
- Well number and sample number
- Date
- Depth of sample
- Blow counts

4.2.3 Monitoring Well Construction/Installation

Overburden wells will be constructed of 2-inch-diameter, flush-joint-threaded, Schedule 40 PVC casing and well screens equipped with a PVC end plug. Each section of casing and screen shall be NSF-approved. Figure 4-3 illustrates typical well construction details for overburden wells. Table 4-3 provides a summary of monitoring well construction details.

Well screens will range from 5 to 10 feet in length, depending on observed geologic conditions. The slot size will be determined in the field, but will be no larger than 0.02 inches. The top of the screened interval for the water table well will be positioned approximately 1 to 2 feet above the stabilized water level. Lengths of well screens will be determined in the field based on drilling and sampling observations, yield of the proposed monitored zone, and the anticipated groundwater-level fluctuations.

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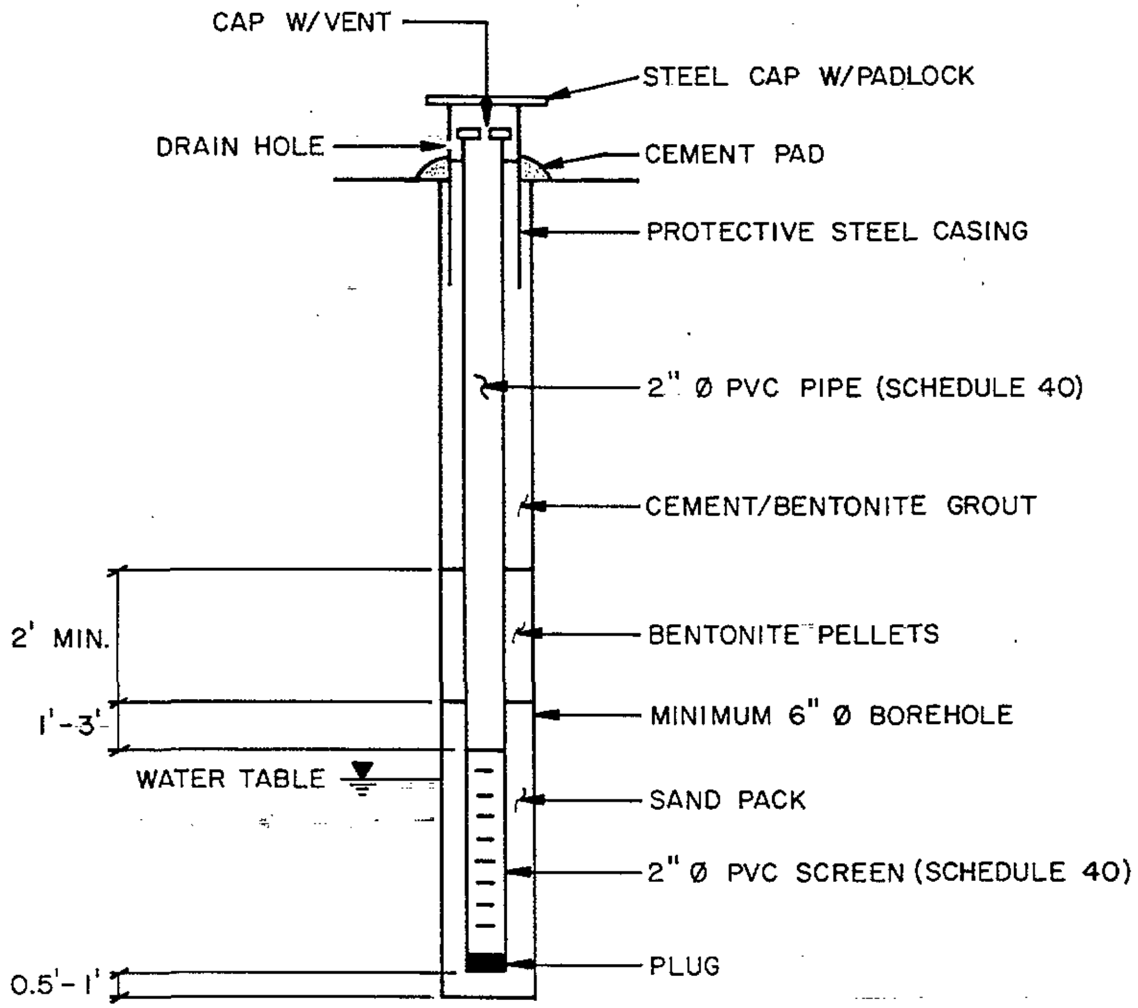

FIGURE 4-3

PROPOSED MONITORING WELL CONSTRUCTION
WATER TABLE WELL
C & R BATTERY SITE, CHESTERFIELD CO., VA

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TABLE 4-3

ESTIMATED MONITORING WELL CONSTRUCTION DETAILS
C&R BATTERY SITE

Well Number	Estimated Depth (Feet)	2" PVC Casing Length (Feet)	Screen Length (Feet)	Soil Sampling		
				Chemical Analysis (split spoon)	Physical Analysis (thin-wall tube)	Lithologic Descriptional (split spoon)
MW1-1	50	42	10	X	X	X
MW2-1	50	42	10	X	X	X
MW3-1	50	42	10		X	X
MW4-1	50	42	10	X	X	X
Totals	200	168	40	--	--	--

The PVC well installation procedure will consist of backfilling the boring (if required) with a sand/bentonite mix to a depth of approximately 1/2 to 1 foot below the position desired for the bottom of the well screen. The PVC pipe and screen will be placed at the desired depth in the completed boring and the annulus of the boring, around the well screen, and 1 to 3 feet above the well screen will be backfilled with clean silica sand (Nos. 20 and 30 U.S. Standard Sieve size or as determined by the site geologist). A bentonite pellet seal (minimum 2-foot thickness) will then be installed and allowed to hydrate as per the manufacturer's recommendation; the remainder of the annulus of the boring (from the seal to ground surface) will then be backfilled with cement/bentonite grout placed using a tremie pipe. The depths of all backfill materials will be constantly monitored during the well installation process by means of a weighted stainless steel or plastic tape.

Protective steel casing equipped with locking steel caps will be installed around all wells. These casings will be grouted a minimum of 3 feet into the ground and will have at least one drain hole positioned approximately 0.5 feet above the ground surface. In addition, a cement apron will be built up around the casing to prevent ponding of water around the well. All locks supplied for the wells will be keyed alike. After installation, the ground surface, the top of the riser pipe, and the top of the protective casing will e surveyed to within 0.01-foot vertical accuracy. In addition, the well will be surveyed to a 0.1-foot horizontal accuracy.

A monitoring well construction diagram will be completed for each well installed. A sample of the monitoring well construction form is provided in Appendix B.

4.2.3.1 Well Development

Monitoring wells will be developed after installation to remove fines and sediments from around the well screens and to remove drill cuttings and residual drilling fluids from the area around the monitored interval of the boring. Wells will be developed by air lift, bailing and surging, or by pumping, as determined by the field geologist. Wells will be developed until water removed is visibly clear of suspended solids or until approved by the field geologist. Development water will be discharged onto the ground in the vicinity of the well being developed and in a manner that minimizes surface disturbance and/or runoff.

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4.2.3.2 Aquifer Testing

Monitoring wells will be used for aquifer testing to determine the groundwater flow conditions in the water-bearing zones investigated by each well. The data generated from these tests will be used to define the water-yielding characteristics of each formation, develop groundwater velocity values, and estimate the rate of groundwater movement throughout the site. It is expected that slug tests will be performed in each of the monitoring wells, which will then be evaluated using the most appropriate evaluation technique for the existing hydrogeologic conditions. Pressure transducers and data loggers will be used for data collection, where appropriate, to obtain sufficiently accurate field data.

At a minimum, the following information will be collected (when applicable) for each well during the performance of aquifer tests:

- Well number/depth/screened interval/inside diameter of screen/diameter of sand pack
- Static water level
- Method of inducing water-level change (for slug tests)
- Total time of test

Data generated by the tests will be documented on the appropriate data sheets and analyzed for the determination of aquifer characteristics. A sample data sheet is provided in Appendix B.

4.2.3.3 Water-Level Monitoring

At least two complete rounds of water level measurements will be obtained from the newly installed monitoring wells during sampling. All measurements for each collection round will be taken within a 24-hour period of consistent weather conditions to minimize atmospheric/precipitation effects on groundwater conditions. Measurements will be taken with an M-scope (electrical water-level indictor), pressure transducer, steel tape and chalk, or popper, using the top of the well casing as the reference point for determining depths to water. Water-level measurements will be recorded to the nearest 0.01 foot in the appropriate field log book. The measuring device will be decontaminated between wells by cleaning the portion of the device that comes into contact with liquid in the monitoring well with methanol, followed by deionized water.

In addition, continuous recorders will be placed on each well for a period of at least one week to monitor water-level fluctuations in response to tidal changes in the James River. A staff gage will be placed in the river during site surveying activities.

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4.2.3.4 Reporting

The following reports and documentation will be the responsibility of the field geologist during the drilling activities. A copy of applicable forms that will be used by the site geologist are located in Appendix B.

Site Logbook - See NUS ARCS III Program Standard Operating Procedure (SOP) SA-6.3.
Daily Activities Record-Field Investigation Form - See Appendix B.
Boring Log - See Appendix B.
Overburden Monitoring Well Sheet - See Appendix B.
Test Pit Log Form - See Appendix B.
Data Sheet for Slug Test - See Appendix B.
Groundwater Level Measurement Sheet - See Appendix B.
Weekly Field Summary Report - See NUS ARCS III Program SOP SA-6.4.

The field geologist's logbook shall contain information about the drilling activities such as start/finish times, standby times, and problems or changes encountered during drilling. Drilling/monitoring well construction information (e.g., footage drilled, depth of casing, etc.) will be recorded daily on the boring log and the overburden monitoring well sheet. The boring log, along with the geologist's logbook, will be used to prepare the Daily Record - Subsurface Investigation Report. This report will identify drilling activity and quantities of material used on a daily basis, and shall be signed by the drilling contractor foreman (or equivalent) and the site geologist. The reports shall be submitted the Project Manager at the completion of each well installation. These reports will also be used to fill out the Daily Logbook.

4.2.4 <u>Test Pit Excavation</u>

Test pits shall be excavated for the purpose of locating buried intact batteries. The location and number as well as depth and areal extent of test pits shall be determined by the FOL based on field observations. Procedures for test pit excavation shall be in accordance with the appropriate sections of the NUS SOP GH-1.8, Section 5 (see Appendix A).

Collection of the proposed EP Toxicity samples may be performed during test pit operations if it becomes impractical to obtain an adequate volume of material required for proper analysis from test borings during drilling operations (as discussed in Section 4.3.1). This decision shall be the responsibility of the FOL and Project Manager, based on field conditions and observations.

Procedures for collection of soil samples from test pits (if necessary) shall be in accordance with the appropriate sections of the NUS SOP SA-1.3, Section 5.1.3 (see Appendix A).

Each test pit shall be logged by the field geologist using the Test Pit Log form (see Attachment A of NUS SOP GH-1.8). A copy of the test pit log form to be completed in the field for each test pit can be found in Appendix B of this POP. Additional information for each test pit should also be recorded in the field logbook. All test pit excavation data should be recorded in accordance with NUS SOP GH-1.8, Section 7.

4.2.5 Plugging and Abandonment of Existing Wells

Two onsite monitoring wells and the onsite office well shall be plugged and abandoned to eliminate the potential for groundwater contamination as a result of improper construction or as a result of cracks in the concrete casing. The following sections explain the procedures for plugging and abandoning the three existing wells.

4.2.5.1 *Onsite Monitoring Wells*

Two monitoring wells were installed on site during a previous environmental study by the operator's consultants. Both wells were improperly constructed according to state and Federal protocols. These two wells were constructed without emplacing 1- to 2-foot-thick clay seals above the gravel pack surrounding the screened interval. Also, the remaining annular space was backfilled with drill cuttings rather than cement/bentonite grout. As a result, the annular spaces of these two wells are potential conduits for contaminated surface water to migrate directly to the groundwater. Therefore, the 2-inch-diameter PVC riser pipes and screen, as well as the backfilled material within the original annular space of these two monitoring wells, shall be milled out and removed with oversized augers (minimum 8-inch outer diameter) using the most appropriate drilling method. Both of the newly drilled soil borings shall be backfilled by lowering a tremie pipe inside the augers to the bottom of each boring. A cement/bentonite grout shall then be pumped into the boring concurrently with the auger removal until the grout fills each boring to the ground surface. This procedure should eliminate the potential for contaminated surface water runoff migrating through the annular space to the groundwater.

4.2.5.2 Onsite Office Well

The onsite office well is described in the FIT Site Investigation Report (NUS, February 1986) as a 36-inch-diameter, concrete-cased well which extends to approximately 30 feet below ground

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surface. According to personnel at the Virginia SWCB, the concrete casing is badly cracked, resulting in open holes. As a result, this well provides a potential conduit for the migration of contaminated surface water directly to the groundwater through cracks or holes in the casing. Therefore, this well will be backfilled with concrete from the bottom to the ground surface to eliminate the potential for surface water contaminant migration. A tremie pipe will be used to pump the grout to assure the well is filled from the bottom. Also, the portion of concrete casing currently extending above ground surface shall be removed prior to backfilling so that the filled well is flush with the ground surface. This procedure may be modified to accommodate field conditions as per the direction of the FOL. All modifications shall be documented in the field logbook.

4.2.6 Investigation Waste Disposal

Onsite drill cuttings will be spread on the ground adjacent to the respective soil boring. Offsite drill cuttings will be collected, transported to the site, and placed on the existing large debris pile located within the fenced area of the site. Decontamination water will be collected and tested for pH due to nitric acid rinse as part of the decontamination procedure. Lime will be added, if necessary, to neutralize the decontamination water to a pH value between 6 and 8 before discharge to the ground on site. Monitoring well development and purge water will be discharged onto the ground adjacent to the monitoring well.

4.3 GENERAL SAMPLING OPERATIONS

4.3.1 Surface and Subsurface Soil Sampling

A soil sampling plan was developed to study the entire leased property as well as a part of the Capitol Oil Company property that may have been involved in site operations. Twenty-six soil borings will be located on the grid nodes, as shown in Figure 4-1. One background boring at location MW1-1 will be located southwest of the site along Bellwood Road. Also, one offsite soil boring at location MW3-1 will be drilled for installation of a monitoring well which is not included in the grid. Refer to Section 4.2.2 of this document for additional details on drilling operations. The rationale for the selection of sample locations was presented in Sections 4.3.3 and 4.3.4 of the Work Plan.

The deep borings will be drilled first. Three deep borings will be converted to monitoring wells, and four will be drilled only for soil sampling. The eighth deep boring will not be sampled for chemical analyses, but will be drilled only for well installation (MW3-1). Samples will be collected for physical description (split-spoons) and for geotechnical description in boring MW3-1. Split-spoon samplers will be used to collect samples for chemical analysis from 10 depths in seven of these borings. Proposed analytes are

- TAL inorganics
- pH
- alkalinity
- acidity
- cation exchange capacity
- sulfate
- EP Toxicity (10 samples for metals only)

Proposed sample depths for chemical analysis are

- 0 - 1.5 feet (two offsite surface soil samples will be substituted for the surface sample in the background boring along Bellwood Road).
- 3.0 - 4.5 feet
- 6.0 - 7.5 feet
- 9.0 - 10.5 feet
- 13.5 - 15.0 feet
- 20.0 - 21.5 feet
- 25.0 - 26.5 feet
- 30.0 - 31.5 feet
- 35.0 - 36.5 feet
- 40.0 - 41.5 feet

Intermediate samples (e.g., 1.5 - 3.0 feet) will be collected and stored for lead analysis in the field by XRF. XRF analysis will begin in the fifth week of the field investigation. The results from the XRF analysis will be used to determine which samples are sent to the CLP laboratories. The corresponding samples for chemical analysis (see Figure 4-2) for all positive detections will be sent to the fixed base laboratory, as well as 10 percent of the samples in which lead was not detected at the XRF detection limit.

Split-spoon samplers will be used to obtain all the soil samples except for the two background surface soil samples. Up to 171 samples will be sent for routine chemical analysis, and 171 samples will be analyzed in the field for lead using XRF.

In addition to the samples collected for chemical analysis, several soil samples will be analyzed for geotechnical parameters, which will be used in remedial alternative design efforts.

In order to collect enough soil for analysis, additional borings or backhoe excavations may be required, as discussed in Section 4.2.2.1 of this POP. A maximum of four undisturbed thin-wall tube samples shall be collected of various cohesive lithologies in each of the four borings designated for monitoring well construction as discussed in Section 4.2.2.1 of this POP. Because three of the four monitoring well borings will be continuously sampled to a depth of 15 feet for chemical analysis, a second soil boring adjacent to each of these three test borings may be necessary to enable collection of the undisturbed material for physical property analysis. Continuous sampling for chemical analysis will not be performed during drilling of the soil boring for monitoring well MW3-1. Therefore, it is not anticipated that it will be necessary to drill a second boring at this proposed monitoring well location.

Approximately 16 undisturbed soil samples (one thin-wall tube sample from each distinct fine-grained soil encountered in the four soil borings for monitoring well construction; a maximum of four samples per boring) will be collected for analysis of:

- Permeability
- Grain size
- Atterberg limits
- Soil moisture
- Unit weight
- Specific gravity

Subsurface soil samples from the borings will be collected using split spoons and thin-walled tubes in accordance with NUS SOP GH-1.3, Section 5.

The backhoe investigation for buried batteries will not require any field sampling or chemical analysis. However, the field activities and locations of buried material will be fully documented and photographed as described in Section 4.2.4 of this POP.

4.3.2 Groundwater Sampling

Two rounds of sampling will be conducted for the four newly installed monitoring wells (see Figure 4-1). The second round of sampling will also include a residential well and business well.

The first round of groundwater samples shall be individually collected immediately following the installation and development of each monitoring well and shall be sent for CLP/SAS quick-turnaround analysis for lead. In addition, these groundwater samples will be sent for CLP/SAS and RAS analysis for the following analyses:

- TAL inorganics (filtered and unfiltered for monitoring wells; unfiltered for private wells)
- Alkalinity
- Acidity
- TSS
- TDS
- Sulfate

The results of this quick-turnaround lead analysis on groundwater samples from the four newly installed monitoring wells will provide the basis for determining whether additional monitoring wells will be necessary for the hydrogeologic investigation. The number, location, and depth of screening of additional wells, as required, will be determined by the Project Manager and the RPM based upon the results of the quick-turnaround lead analyses.

The second round of samples shall follow the first round by approximately two weeks and shall include a residential well and a business well (see Figure 4-4). The second round of samples shall be sent for CLP/SAS and RAS analysis for the following analytes:

- TAL inorganics (filtered and unfiltered)
- Alkalinity
- Acidity
- TSS
- TDS
- Sulfate

Field measurements to be taken on all wells sampled during both sampling rounds include:

- Eh
- pH
- Specific conductance
- Temperature

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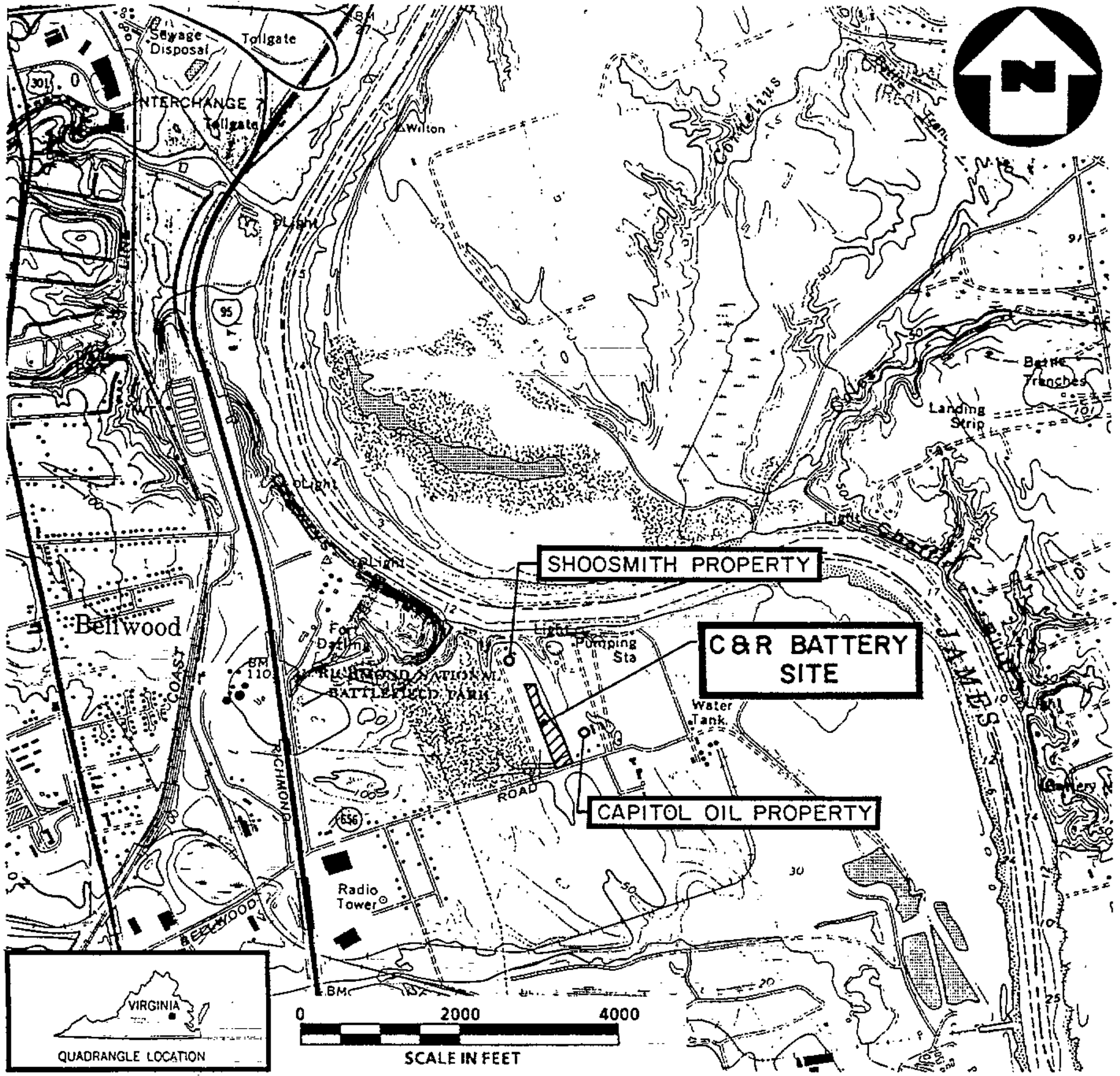

BASE MAP IS A PORTION OF THE USGS 7.5 MINUTE DREWRYS BLUFF, VIRGINIA QUADRANGLE, 1969 PHOTO-REVISED 1980. CONTOUR INTERVAL 10 FEET.

FIGURE 4-4

PROPOSED PRIVATE WELL
SAMPLING LOCATIONS
C & R BATTERY SITE, CHESTERFIELD CO., VA

NUS CORPORATION

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In addition, color and turbidity shall be noted on the sample log form for each water sample obtained and for each purged well volume.

4.3.2.1 Monitoring Wells

Groundwater samples will be collected in accordance with NUS SOP SA-1.1, Section 5.

Prior to obtaining samples, water levels will be measured and the wells will be purged using a dedicated stainless steel bailer or a suction pump. Three to five well volumes will be purged. If the wells are purged dry with less than three well volumes removed, the water level in the well will be allowed to recover at least 70%, then a sample will be collected. In the event that recovery is slow, samples will be collected the following day. Field measurements including pH, Eh, temperature, and specific conductance will be taken at the beginning, middle, and end of purging according to SF-1.1 (Section 5). Both filtered and unfiltered samples will be obtained for metals analysis. Filtering of samples shall be conducted in accordance with SF-1.2 (Section 5.2.5).

Dedicated stainless steel bailers will be used for sample collection. The sample will be poured directly from the bailer into the appropriate sample bottles for analysis.

All pertinent field data shall be recorded using Attachment A of SA-1.1 (Sample Log Sheet in Appendix B) and the field log book.

4.3.2.2 Domestic Well and Business Well

The two wells identified for sampling are shown in Figure 4-3. EPA community relations personnel will be contacted before the sampling begins. Where possible, owners will be asked to provide pertinent well construction and use data.

Wells will be sampled from the first spigot encountered while tracing the discharge line from the well to the residence, prior to any filtration or treatment, if possible. If the volume of the well system cannot be estimated, water will be allowed to run for approximately 15 minutes. If the volume of the water system can be determined, three volumes will be purged. The individual sample bottles will be filled directly from the spigot. One set of field measurements for pH, Eh, temperature, and specific conductance will be taken in accordance with SF-1.1 (Section 5).

All pertinent field data shall be recorded using Attachment A of SA-1.1 (Sample Log Sheet in Appendix B) and the field log book.

4.3.3 Surface Water and Sediment Sampling

According to the Work Plan, surface water (if any) and sediment in the drainage ditch will be sampled at seven locations, both upstream and downstream of the site. In addition, surface water and sediment in the James River will be sampled in two locations (upstream and downstream of the ditch). Proposed sample locations are shown in Figure 4-1. The sampling rationale was presented in Section 4.3.4 of the Work Plan.

Sediment samples from all nine sample locations will be collected for field analysis by XRF. These results may be used to determine the need for bioassays, samples for which would be collected prior to demobilization.

The following analytes will be requested:

- TAL inorganics
- pH (field measurement for water)
- Eh (field measurement for water and sediment)
- Alkalinity
- Acidity
- Cation exchange capacity (sediment only)
- Grain size (sediment only)
- TOC (sediment only)
- Volatile residue (sediment only)
- EP Toxicity (metals only) (sediment only)
- Sulfate (water only)
- Hardness (water only)
- TSS (water only)
- TDS (water only)
- Dissolved oxygen (field measurement, water only)
- Temperature (field measurement, water only)
- Specific conductance (field measurements, water only)

Field Technicians will adhere to NUS SOP SA-1.2 Sections 5.3 and 5.4 for all surface water and sediment sampling activities.

4.3.4 Debris Pile Sampling

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During the field investigation, grab samples will be collected from the two debris piles remaining on site. The smaller, western pile consists primarily of debris, while the larger, eastern pile contains debris mixed with soil that was removed from the area east of the drainage ditch during EPA's remediation effort. Sampling rationale was presented in Section 4.3.4 of the Work Plan. Soil samples from the two piles will be analyzed for the following parameters:

- TAL inorganics
- pH
- Alkalinity
- Acidity
- Sulfate
- Cation exchange capacity
- Grain size
- EP Toxicity (1 composite from each pile for metals only)

Three soil/debris samples will be collected from the larger debris pile and one sample will be collected from the smaller pile (refer to Figure 4-1). Actual sampling locations shall be determined in the field by the FOL.

Field Technicians will adhere to NUS SOP SA-1.2 for all soil/debris sampling activities.

4.3.5 Bioassays

If the sediment analytical results indicate that contaminated sediment has been transported down the drainage ditch toward the James River, up to four sediment samples will be collected for bioassays. Proposed sample locations are one ditch sample upstream of the site, one ditch sample at the process area, and two samples in the James River (upstream and downstream of the ditch). Sediment elutriate tests for toxicity to the fathead minnow and Ceriodaphnia will be performed. Approximately 10 pounds of sediment are required from each test location. Samples will be packaged in accordance with the requirements outlined by the EPA Environmental Research Laboratory (see Appendix C).

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4.4 SAMPLE ANALYSIS

Samples collected at the C&R Battery Site will be submitted for the laboratory analyses presented in Table 3-1. This table indicates the analytical parameters and analytical methods for each sample. Table 4-1 summarizes the analyses, bottle requirements, preservation requirements, and holding times for each sample.

4.5 DECONTAMINATION

The equipment involved in field sampling activities will be decontaminated prior to and during drilling and sampling activities. Such equipment includes drilling rigs, downhole tools, augers, pumps, well casing and screens, soil and water sampling equipment, and water level measurement devices.

4.5.1 Major Equipment

All drilling equipment, including the drill rig and its transport system, shall be steam cleaned prior to beginning work, between the drilling of separate boreholes, any time the drilling rig leaves the drill site prior to completing a boring, and at the conclusion of the drilling program.

Decontamination operations will consist of washing equipment using a high-pressure steam wash. All decontamination activities will take place over an onsite area to be designated during mobilization. Additional requirements for drilling equipment decontamination can be found in NUS SOP GH-1.6, Section 5.

4.5.2 Sampling Equipment

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

- Potable water rinse
- Alconox or liquinox detergent wash
- Potable water rinse
- Distilled/deionized water rinse
- Nitric acid rinse
- Distilled/deionized water rinse
- Air dry

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Field analytical equipment such as instrument probes will be rinsed first with distilled/deionized water then with sample.

4.5.3 Personnel

Personnel decontamination is discussed on page 25 of the Health and Safety Plan (Appendix D).

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5.0 LABORATORY SAMPLE CUSTODY

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To ensure the integrity of a sample from collection through analysis, it is necessary to have an accurate, written record that traces the possession and handling of the sample. This documentation is referred to as the sample chain-of-custody.

A sample is under custody if

- The sample is in the physical possession of an authorized person.
- The sample is in view of an authorized person after being in his/her possession.
- The sample is placed in a secure area by an authorized person after being in his/her possession.
- The sample is in a secure area, restricted to authorized personnel only.

Sample custody during collection and shipping is discussed in Section 4.5.1 of NUS SOP SA-6.1. Laboratory sample custody is discussed in the following sections. Further details are presented in Attachment F of the CLP Statement of Work (EPA, December 1987). All laboratories used in this study must follow these procedures.

5.1 SAMPLE RECEIPT

When samples are received, the shipping manifest is signed and dated to acknowledge sample receipt. The sample custodian must examine the shipping containers and verify that the correct number of containers was received. The shipping containers are then opened and the enclosed sample paperwork is removed.

Samples are removed from the shipping containers and the bottle condition must be noted. The information on the chain-of-custody, the airbill, the packing list, the containers and sample tags, and the laboratory request is reviewed to note any discrepancies. Discrepancies must be resolved through the Sample Management Office (SMO).

5.2 SAMPLE STORAGE

All samples received by the laboratory must be stored at 4°C until analysis. Laboratory holding times are specified by the CLP contract and are presented in Table 4-1.

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5.3 LABORATORY SAMPLE TRACKING

Laboratory sample tracking procedures are discussed in Section F of the CLP Statement of Work (EPA, December 1987). All laboratories used must conform to these requirements.

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6.0 CALIBRATION PROCEDURES AND FREQUENCY

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Instrument used in the field and in the laboratory will be calibrated according to the procedures described below.

6.1 FIELD INSTRUMENTS

Several monitoring instruments may be used during field activities, including

- Temperature probe
- Specific conductance meter
- pH meter
- Eh meter
- Electronic water-level meter
- Dissolved oxygen meter

The electronic water-level meter will be calibrated prior to mobilization and periodically at the discretion of the FOL. The remaining instruments will be calibrated daily or according to the manufacturer's operating manual.

Calibration will be documented on an Equipment Calibration Log (NUS SOP SA-6.4, Attachment D-1). During calibration, an appropriate maintenance check will be performed on each piece of equipment. If damaged or defective parts are identified during the maintenance check and it is determined that the damage could have an impact on the instrument's performance, the instrument will be removed from service until the defective parts are repaired or replaced.

6.2 LABORATORY INSTRUMENTS

Calibration frequency for each of the environmental measurement parameters is presented below.

- Target Analyte List Inorganics - Presented in Attachment E, CLP Statement of Work.

- Sulfate - Calibration verification daily using one standard.

- TOC - Verification standards daily.

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- Alkalinity and Acidity - Calibration verification as per manufacturer's instructions or weekly at a minimum.
- Hardness - Standardization monthly.
- CEC - Calibration verification as per manufacturer's instructions
- EP Toxicity - AA as specified in Attachment E, CLP Statement of Work
- TSS/TDS - Scale calibration daily.
- Volatile residue - Scale calibration daily
- pH - Calibration verification daily
- *Grain Size - Scale calibration daily*
- Atterberg limits - Scale calibration daily; adjust drop height as per manufacturer's specification
- Moisture content - Scale calibration daily
- Specific gravity - Scale calibration daily

The quality control procedures routinely employed in inorganic chemistry analyses are presented below.

<u>Standardization</u>

Precision and accuracy are an integral part of quality control, but they are only effective when instruments, solutions, and procedures have been standardized.

Solutions are standardized by preparing standards of known purity and concentrations and using these standards to evaluate other solutions. Standards are either traceable to the National Bureau of Standards, or they are certified by the manufacturer to contain a known concentration of analyte.

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Standardizations of instruments and methods are accomplished by preparing a series of standard solutions and analyzing the standards according to a written procedure. From the results of the standard analyses, standard curves are constructed and used to determine the concentration of the species in each sample.

Standard curves are particularly useful in quantitative analyses using spectrophotometry. Many spectrophotometric methods adhere to Beer's Law, which states that the absorptivity of a substance is constant with respect to changes in concentration. For those colorimetric methods that adhere to Beer's Law and produce repeatable, stable color complexes, complete standard curves are performed at a minimum of once every 6 months. For metals analyses by atomic absorption spectrophotometry, complete standard curves are performed each day that analyses for a particular metal are performed.

Verification Standards

In general, methods that do not require a complete daily standard curve require the analysis of at least one standard each day to verify instrument and method performance. The result of the daily standard analyses must be within the control limits, which are set at the number of available values ± three times the standard deviation. Appropriate corrective measures must be taken if the acceptance criteria are not met.

Preparation Blanks

As a check for glassware and reagent contamination in the laboratory, an aliquot of deionized water is taken through the sample preparation procedure. A preparation blank is required each day samples that are prepared.

Duplicates

One in twenty samples that are analyzed for a specific parameter is run in duplicate. Different aliquots are often used in many instances to conserve samples and to test for matrix interferences. RPD is calculated and compared to the internally established control limits as described in the quality control section of the QA/QC program summary.

Matrix Spikes

One in twenty samples that are analyzed for a specific parameter is spiked with the analyte, for those parameters for which a stable standard is available. An aliquot of standard solution is added to the sample. Percent recovery is calculated and compared to the internally established control limits as described in the quality control section of the QA/QC program summary.

Standardization and internal QC requirements for inorganic analyses are presented in Table 6-1.

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TABLE 6-1

STANDARDIZATION AND INTERNAL QUALITY CONTROL REQUIREMENTS FOR INORGANIC ANALYSIS OF SAMPLES

Parameter	Standardization	Verification Standard	Method Blank	Matrix Duplicate	Matrix Spike
Indicator metals by flame AA	D	D	E	1/20	1/20
Indicator metals by graphite furnace AA	D	D	E	1/20	1/20
Sulfate	(1)	D	(2)	1/20	
TOC	D	D		1/20	
Alkalinity	W			1/20	
Acidity	W			1/20	
Hardness	M			1/20	
TSS/TDS			E	1/20	
pH	D	D		1/20	
Volatile residue			E	1/20	
EP Toxicity (Metals analysis by flame AA)	D	D	E	1/20	1/20
CEC			E		

(1) A new standard curve is prepared when the daily standard fails to meet recovery criteria.
(2) A blank is analyzed daily or with each set of samples, but it is used to zero the analytical system.
D Each day samples are run.
E Each set of samples prepared.
W Each week samples are run.
M Each month samples are run
1/20 One in twenty samples.

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7.0 ANALYTICAL PROCEDURES

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Solid and aqueous samples will be collected for both chemical and physical analyses. The analytical procedures to be used are summarized in Table 7-1. Method references are included as footnotes.

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TABLE 7-1

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ANALYTICAL METHODS FOR CHEMICAL AND PHYSICAL PARAMETERS
C&R BATTERY SITE

Analytical Parameter	Solid Matrix Analytical Method	Aqueous Matrix Analytical Method
TAL Inorganics/lead	CLP Protocol	CLP Protocol
pH	SW 846-9045	Field analysis
Eh	Field analysis (sediment)	Field analysis
Alkalinity	EPA 310.1	EPA 310.1
Acidity	EPA 305.1	EPA 305.1
Hardness	--	EPA 130.2
TSS	--	EPA 160.2
TDS	--	EPA 160.1
TOC	MSA 29.3.5.2	--
Volatile residue	EPA 160.4	--
EP Toxicity (metals only)	SW846-1310; CLP Protocol	--
CEC	SW 846-9081	--
Sulfate	SW846-9038	EPA 300.0
Permeability	SW 846 Vol 1C	--
Grain size	ASTM D 422-63	--
Atterberg limits	ASTM D 4318-84	--
Soil moisture	ASTM D 2216-80	--
Unit weight	MSA, Section 30, Part 30-2	--
Specific gravity	ASTM D854-83	--

EPA - EPA, March 1983. "Methods for Chemical Analysis of Water and Wastes."
SW - EPA, September 1986. "Test Methods for Evaluating Solid Wastes - Physical/Chemical Method," 3rd edition.
ASTM - American Society for Testing Materials, 1988
MSA - American Society of Agronomy, 1986. "Methods of Soil Analysis." Madison, WI

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8.0 DATA REDUCTION, VALIDATION, AND REPORTING

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Data reduction, validation, and reporting will be conducted as described below.

8.1 DATA REDUCTION

The calculation of final results from raw data varies from parameter to parameter with the calibration approach. The ratio of instrument response to analyte concentration is determined for one or more standards. In general, if the concentration/instrument response ratio is linear, the average of the ratios is used to calculate sample results. If the response is not linear, response is plotted against concentration, and sample results are quantitated from the resultant curve.

Results are generally expressed to two significant figures. Results for aqueous samples are expressed in µg/l. Organic results for solid samples are expressed in µg/kg, whereas inorganic results are expressed in mg/kg.

8.2 DATA VALIDATION AND REPORTING

The results of quality control checks are the primary tools used for data validation. Quality control checks are described in Section 9.0. Acceptance criteria (control limits) are discussed in Section 3.0. Raw data and final results are reviewed by the laboratory group leader on a daily basis. The group leader confirms that documentation is complete and legible; qualitative identifications are accurate; calculations are accurate; results are expressed in the appropriate units and number of significant figures; and the required quality control checks were run and met acceptance criteria. Review and approval of the data is documented by the group leader.

The tabulated chemical-analytical data generated by the CLP and/or other laboratory will be sent to the RLSC who will log it into the validation tracking system. The data will be validated by the NUS Chemistry and Toxicology Department. Validation of the chemical-analytical data will include a quality assurance assessment to determine whether specified protocols were followed by the laboratory personnel. Results for field blanks and duplicates will be reviewed for consistency (i.e., relative percent difference values) and to identify laboratory artifacts. The CLP and/or other laboratory will provide reagent blank, surrogate spike, and matrix spike results. This information will also be reviewed through comparison with the specified control limits (see Section 3.0). All data validation will be performed in accordance with the latest EPA Functional Guidelines.

Documentation of the validity of laboratory results will be provided to the EPA in the form of letter reports.

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Chemical-analytical data generated during the study will be reduced to a concise form for presentation in the RI Report. The analytical results will be managed using an existing computer program developed by NUS specifically for chemical data bases. This program is capable of handling all TCL organic and TAL inorganic chemicals, and will be customized for the C&R Battery Site to accommodate all indicator parameters. Quality assurance procedures will be implemented to assure that no errors occur during data entry. The data entered into the program are checked by the computer operator, and the printouts are checked against the original laboratory sheets by a chemist.

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9.0 INTERNAL QUALITY CONTROL CHECKS

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Quality Control checks to be implemented in the field and in the laboratory are described below.

9.1 FIELD QUALITY CONTROL CHECKS

In addition to periodic calibration of field equipment and appropriate documentation, quality control samples will be collected or generated during environmental sampling activities. Quality control samples include field duplicates and field blanks. Each type of field quality control sample is defined as follows:

Field (Equipment Rinsate) Blanks - Field blanks are obtained under representative field conditions by running analyte-free deionized water through sample collection equipment (bailer, split spoon, corer, etc.) after decontamination and placing it in the appropriate sample containers for analysis. Field blanks will be used to assess the effectiveness of decontamination procedures. Field blanks will be collected for each type of nondedicated sampling equipment used and will be submitted at a frequency of one per every twenty samples or one per sampling trip if less than twenty samples are collected.

Field Duplicates - Field duplicates are samples that are divided into two portions at the time of sampling. Field duplication provides precision information regarding homogeneity, handling, shipping, storing, preparation, and analysis. Field duplicates will be submitted at a frequency of one per every twenty samples, or one per sampling trip if less than twenty samples are collected.

The proposed field quality control samples are included in Table 3-1 (Section 3.0).

9.2 LABORATORY QUALITY CONTROL CHECKS

Laboratory analysis will be conducted in accordance with the appropriate analytical methods (Table 7-1). Internal laboratory quality control checks include surrogate and matrix spike addition and analysis and reagent blank generation and analysis. Laboratory quality control procedures for inorganic analyses are summarized in the CLP Statement of Work, Attachment E.

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10.0 PERFORMANCE AND SYSTEM AUDITS

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Audits to be conducted in the field and in the laboratory are described below.

10.1 FIELD AUDITS

A QA performance audit will be performed by the designated ARCS III Quality Assurance Representative (QAR) during the RI. The audit will include checks on adherence to all applicable Standard Operating Procedures as outlined in this POP.

The auditor shall prepare audit checklists or audit guides. The depth and scope of the audit shall be determined and incorporated into the checklist or guidelines. The audit will cover the following items:

- Adherence to sample collection SOPs
- Chain-of-custody
- Documentation of field activities as per SOPs
- Equipment maintenance and calibration
- Training requirements for site workers
- Documentation of variances from field activities and corrective actions

Where an audit team is involved, the audit team leader shall establish the ground rules for the audit and assign to the various team members the specific areas each is to cover in the audit.

The above audit checklist/guide shall be used to guide the audit and to ensure adequate depth, scope, and continuity. However, the auditor shall not restrict the audit when evidence raises questions not specifically addressed in the check lists. The audit activity shall include the review of objective evidence to verify adequate implementation of the Quality Assurance Program.

The auditor shall record each finding of nonconformance to an ARCS requirement (observation or deficiency) on a Quality Notice form. When a finding is identified, sufficient investigation shall be conducted to determine the basic cause of the finding. Findings shall be written only when there is a clear non-compliance with a specific Standard Operating Procedure.

Any identified findings that require immediate corrective action shall be reported immediately to the Project Manager and the RPM and recorded on a Quality Notice form.

Corrective action is addressed in Section 13.0. Distribution of quality assurance reports is addressed in Section 14.0.

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10.2 LABORATORY AUDITS

Blind or double-blind Performance Evaluation (PE) samples are sent to CLP laboratories on a quarterly basis. The CLP Statement of Work, Attachment E, contains specific requirements for performance and systems audits.

If non-CLP laboratories are used for the SAS analyses, they must be fully certified and approved. Quality assurance/quality control procedures must be in use. An internal audit schedule must be available, as well as a record of audits by certification agencies. The results of all audits and the corrective action process must be available.

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11.0 PREVENTIVE MAINTENANCE

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Measuring equipment used in environmental monitoring or analysis and test equipment used for calibration and maintenance shall be controlled by established procedures. Measuring and test equipment shall have an initial calibration and shall be recalibrated at scheduled intervals against certified standards, according to the CLP Statement of Work, Attachment E, or the procedures for other methods. Equipment will be calibrated periodically. Test equipment used for calibration of sensors shall also be calibrated at least once a year or when maintenance or damage indicates a need for recalibration.

NUS maintains a large inventory of sampling and measurement equipment. In the event that failed equipment cannot be repaired, replacement equipment can be shipped to the site by overnight express carrier to minimize downtime.

In addition, NUS will adhere to Section 5.0 of the ARCS Management Plan (April 28, 1988) which provides a discussion of property management.

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12.0 DATA ASSESSMENT FOR PRECISION, ACCURACY, AND COMPLETENESS

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The procedures used to assess precision, accuracy, and completeness (PAC) of laboratory data are described in Section 3.0. Upon completion of the analytical phases of the project, data will be reviewed and validated as outlined in Section 8.0. In conjunction with the data review and validation, the specific PAC results will be compared with the laboratory quality control criteria and the completeness objective. Discrepancies may affect the usefulness of the data.

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13.0 CORRECTIVE ACTION

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The need for corrective actions may become apparent during surveillance of field activities, procurement of services and supplies, or other operations that may affect the quality of work. Deficiencies and nonconformances will be promptly identified by the QAR's quality assurance checks in the audit reports outlined in this POP. Corrective action will be taken immediately by the Project Manager and/or field personnel.

The identification of significant conditions adverse to quality, the cause of the conditions, and the corrective actions shall be documented by the QAR and reported to the appropriate levels of management. The NUS Project Manager will have overall responsibility for implementing corrective actions, and must identify those responsible for initiating corrective action to remedy immediate effects of the problem.

The corrective action program covers the analysis of the cause of any negative audit findings and the corrective actions required. This program includes the investigation of the cause of significant or repetitious unsatisfactory conditions relating to the quality of sampling, service, or the failure to implement or adhere to required quality assurance practices such as SOPs.

Acceptability of laboratory data is defined by the PARCC parameters in Section 3.2 of this POP. If the data do not meet these criteria, it may be necessary to resample the locations for which deficiencies were noted. CLP laboratories have audit and corrective action procedures in place that they must follow.

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14.0 QUALITY ASSURANCE REPORTS TO MANAGEMENT

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The Quality Assurance Representative (QAR) shall forward to the Quality Assurance Officer a report summarizing the quality assurance and quality control status for the project and any conditions adverse to quality. Topics to be included in the report are as follows:

- Results of any audits
- Results of surveillances
- Any nonconformances initiated
- Training provided to project personnel
- Any significant quality assurance problems, together with recommended solutions

The Quality Assurance Officer will compile the reports from the QAR into a composite report for the Project Manager and the EPA RPM.

Assessment of the measurement data for precision, accuracy, and completeness is performed by the Chemistry/Toxicology Group and is reported to the Project manager and CRL in the form of data validation letters.

It is tentatively planned that one field audit and one office audit will be conducted during the RI/FS.

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REFERENCES

REFERENCES

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(Red)

American Society of Agronomy, 1986, Methods of Soil Analysis. Madison, Wisconsin.

American Society for Testing Materials, 1988. Annual Book of ASTM Standards.

EPA, May 1981. Procedures for Handling and Chemical Analysis of Sediment and Water Samples.

EPA, March 1983. Methods for Chemical Analysis of Water and Wastes. EPA 600/4-79-020.

EPA, October 26, 1984. Federal Register.

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

EPA, December 1986. User's Guide to the Contract Laboratory Program.

EPA, March 1987. Data Quality Objectives for Remedial Response Activities. EPA 540/G-87/003A.

EPA, July 1987. Statement of Work for Inorganics Analysis, Multi-Media, Multi-Concentration.

NUS Corporation, February 24, 1986. Site Inspection of C&R Battery.

NUS Corporation, 1988. Draft Work Plan - C&R Battery Site - Chesterfield County, Virginia - Remedial Investigation/Feasibility Study.

EPA, December, 1985. Short-Term Methods for Estimating the Chronic Toxicity of Effluents and Receiving Waters to Freshwater Organisms.

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APPENDICES

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APPENDIX A

STANDARD OPERATING PROCEDURES FOR RI ACTIVITIES

C&R BATTERY SITE

APPENDIX A

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GH-1.3, Section 5: Soil and Rock Sampling

GH-1.5, Section 5: Borehole and Sample Logging

GH-1.6, Section 5: Decontamination of Drilling Rigs and Sample Equipment

GH-1.8, Sections 5 and 7: Excavation of Exploration Test Pits and Trenches

GH-2.4, Section 5: In-Situ Hydraulic Conductivity Testing

SA-1.1, Section 5: Groundwater Sample Aquisition

SA-1.2, Sections 5.3 and 5.4: Surface Water and Sediment Sampling

SA-1.3, Section 5.1.3 and 5.1.5: Soil Sampling in Test Pits and Trenches

SA-6.1, Sections 5.0: Sample Identification and Chain-of-Custody

SA-6.2: Sample Packaging and Shipping (to be supplied)

SA-6.3: Site Logbook

SA-6.4, Section 5: Forms Used in RI Activities

SA-6.5: Field Reports

SA-6.6: Management of Sampling and Preparation of Required Forms

SF-1.1, Section 5: On-Site Water Quality Testing

SF-1.2, Section 5: Sample Preservation

ASTM D1586-84, Section 7: Penetration Test and Split-Barrel Sampling of Soils

ASTM D1587-83 (Sections 6 & 7): Thin-Walled Tube Sampling of Soils

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NUS CORPORATION WASTE MANAGEMENT SERVICES GROUP	STANDARD OPERATING PROCEDURES	Number GH-1.3	Page 1 of 12
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		Applicability WMSG	
		Prepared Earth Sciences	
Subject SOIL AND ROCK SAMPLING		Approved A. K. Bomberger, P.E.	

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1.0 PURPOSE

The purpose of this procedure is to identify the equipment, sequence of events, and appropriate methods necessary to obtain soil, both surface and subsurface, and rock samples during remedial investigation activities.

2.0 SCOPE

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

3.0 GLOSSARY

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

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

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

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

4.0 RESPONSIBILITIES

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

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

5.0 PROCEDURES

5.2 SUBSURFACE SOIL SAMPLES

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

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

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

5.1.1 Equipment

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

- Drilling equipment, provided by subcontractor.
- Split barrel (split spoon) samplers, OD 2 inches, ID 1-3/8 inches, either 20-inch or 26 inches long
- Thin walled tubes (Shelby), OD 2 to 5 inches, 18 to 54 inches long.
- Drive weight assembly, 140-lb. weight, driving head and guide permitting free fall of 30 inches
- Accessory equipment, including labels, logbook, paraffin, and sample jars.

5.1.2 Split Barrel (Split Spoon) Sampling

The following method will be used for split barrel sampling:

- Clean out the borehole to the desired sampling depth using equipment that will ensure that the material to be sampled is not disturbed by the operation. In saturated sands and silts, withdraw the drill bit slowly to prevent loosening of the soil around the hole and maintain the water level in the hole at or above groundwater level.
- Side-discharge bits are permissible. A bottom-discharge bit shall not be used. The process of jetting through an open tube sampler and then sampling when the desired depth is reached shall not be permitted. Where casing is used, it may not be driven below the sampling elevation.
- Install the split barrel sampler and sampling rods into the boring to the desired sampling depth. After seating the sampler by means of a single hammer blow, three 6-inch increments shall be marked on the sampling rod so that the progress of the sampler can be monitored.
- The 2-inch OD split barrel sampler shall be driven with blows from a 140-pound hammer falling 30 inches until either a total of 50 blows have been applied during any one of the three 6-inch increments, a total of 100 blows have been applied, there is no observed advance of the sampler for 10 successive hammer blows, or until the sampler has advanced

18 inches without reaching any of the blow count limitation constraints described herein. This process is referred to as the Standard Penetration Test.

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

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

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

5.1.3 Thin Walled Tube (Shelby Tube) Sampling

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

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

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

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

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

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

- Affix labels to the tubes as required and record sample number, depth, penetration, and recovery length on the label. Mark the same information and "up" direction on the tube with indelible ink, and mark the end of the sample. Complete Chain-of-Custody and other required forms. Do not allow tubes to freeze and store the samples vertically (with the same orientation they had in the ground, i.e., top of sample is up) in a cool place out of the sun at all times. Ship samples protected with suitable resilient packing material to reduce shock, vibration, and disturbance.

Thin-walled undisturbed tube samplers are restricted in their usage by the consistency of the soil to be sampled. Often, very loose and/or wet samples cannot be retrieved by the samplers, and soils with a consistency in excess of very stiff cannot be penetrated by the sampler. Devices such as Denison or Pitcher core samplers can be used to obtain undisturbed samples of stiff soils. Using these devices normally increases sampling costs and therefore their use shall be weighed against the increased cost and the need for an undisturbed sample. In any case, if a sample cannot be obtained with a tube sampler, an attempt shall be made with a split barrel sampler at the same depth so that at least a sample can be obtained for classification purposes.

5.2 SURFACE SOIL SAMPLES

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

The following methods are to be used:

- Use a soil auger for deep samples (6 to 12 inches) or a scoop or trowel for surface samples. Remove debris, rocks, twigs, and vegetation before collection of soil. Mark the location with a numbered stake if possible and locate sample points on a sketch of the site.

- Attach a label and identification tag. Record all required information in the field logbook and on the sample log sheet, Chain-of-Custody record, and other required forms.

- Use a new or freshly-decontaminated sampler for each sample taken.

- Pack and ship accordingly.

- When a representative composited sample is to be prepared (e.g., samples taken from a gridded area or from several different depths), it is best to composite individual samples in the laboratory where they can be more precisely composited on a weight or volume basis.

If this is not possible, the individual samples (all of equal volume, i.e., the sample bottles shall be full) shall be placed in a stainless steel bucket, mixed thoroughly using a stainless steel spatula or trowel, and a composite sample collected.

5.3 WASTE PILE SAMPLES

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

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

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

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

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

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

5.4 ROCK SAMPLING (CORING)

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

Borehole diameter can be drilled to various sizes, depending on the information needed. Standard sizes of core barrels (showing core diameter) and casing are shown in Attachment No. 1.

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

6.0 REFERENCES

- American Society for Testing and Materials, 1985. Method for Penetration Test and Split Barrel Sampling of Soils. ASTM Method D 1586-84, Annual Book of Standards, ASTM, Philadelphia, PA.
- American Society for Testing and Materials, 1985. Thin-Walled Tube Sampling of Soils. Method D-1587-83, Annual Book of Standards, ASTM, Philadelphia, PA.
- Acker Drill Co., 1958. Basic Procedures of Soil Sampling. Acker Drill Co., Scranton, PA.
- ASTM D 2113-83, 1985.

7.0 RECORDS

None.

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		Applicability WMSG	
		Prepared Earth Sciences	
Subject BOREHOLE AND SAMPLE LOGGING		Approved A. K. Bomberger	

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1.0 PURPOSE

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

2.0 SCOPE

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

3.0 GLOSSARY

None.

4.0 RESPONSIBILITIES

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

5.0 PROCEDURES

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

5.1 MATERIALS NEEDED

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

- Rock hammer
- Knife
- Camera
- Dilute HCl
- Brunton compass
- Ruler (marked in tenths and hundreths of feet)
- Hand Lens

5.2 CLASSIFICATION OF SOILS

All data shall be written directly on the boring log (Exhibit 4-1) or in a field notebook if more space is needed. Details on filling out the boring log are discussed in Section 5.5.

5.2.1 USCS Classification

Soils are to be classified according to the Unified Soil Classification System (USCS). This method of classification is detailed in Exhibit 4-2. This method of classification identifies soil types on the basis of grain size and cohesiveness.

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

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

5.2.2 Color

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

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

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

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

5.2.3 Relative Density and Consistency

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

The density of noncohesive, granular soils is classified according to standard penetration resistances obtained from split barrel sampling performed according to the methods detailed in Standard Operating Procedures GH-1.3 and SA-1.2. Those designations are:

ORIGINAL (Red)

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

Standard penetration resistance is the number of blows required to drive a split-barrel sampler with a 2-inch outside diameter 12 inches into the material using a 140 pound hammer falling freely through 30 inches. The sampler is driven through an 18-inch sample interval, and the number of blows is recorded for each 6-inch increment. The density designation of granular soils is obtained by adding the number of blows required to penetrate the last 12 inches of each sample interval. It is important to note that if gravel or rock fragments are broken by the sampler or if rock fragments are lodged in the tip, the resulting blow count will be erroneously high, reflecting a higher density than actually exists. This shall be noted on the log and referenced to the sample number. Granular soils are given the USCS classifications GW, GP, GM, SW, SP, SM, GC, and SC (see Exhibit 4-2).

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

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

Consistency	Unc. Compressive Str. Tons/Square Foot	Standard Penetration Resistance (Blows per Foot)	Field Identification Methods
Very soft	Less than 0.25	0 to 2	Easily penetrated several inches by fist
Soft	0.25 to 0.50	2 to 4	Easily penetrated several inches by thumb
Medium stiff	0.50 to 1.0	4 to 8	Can be penetrated several inches by thumb
Very stiff	1.0 to 2.0	8 to 15	Readily indented by thumb
Hard	2.0 to 4.0	15 to 30	Readily indented by thumbnail
Hard	More than 4.0	Over 30	Indented with difficulty by thumbnail

5.2.4 Weight Percentages

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

Terms of Identifying Proportion of the Component	Defining Range of Percentages by Weight
trace	0 - 10 percent
some	11 - 30 percent
and or adjective form of the soil type (e.g., "sandy")	31 - 50 percent

Examples:

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

5.2.5 Moisture

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

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

5.2.6 Stratification

Stratification can only be determined after the sample barrel is opened. The stratification or bedding thickness for soil and rock is depending on grain size and composition. The classification to be used for stratification description is shown in Exhibit 4-4.

5.2.7 Texture/Fabric/Bedding

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

5.2.8 Summary of Soil Classification

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

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

5.3 CLASSIFICATION OF ROCKS

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

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

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

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

- Slate - A very fine-grained foliated rock possessing a well developed slaty cleavage. Contains predominantly chlorite, mica, quartz, and sericite.

- Phyllite - A fine-grained foliated rock that splits into thin flaky sheets with a silky sheen on cleavage surface.

- Schist - A medium to coarse-grained foliated rock with subparallel arrangement of the micaceous minerals which dominate its composition.

- Gneiss - A coarse-grained foliated rock with bands rich in granular and platy minerals.

- Quartzite - A fine to coarse-grained nonfoliated rock breaking across grains, consisting essentially of quartz sand with silica cement.

5.4 ABBREVIATIONS

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

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

5.5 BORING LOGS AND DOCUMENTATION

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

5.5.1 Soil Classification

- Identify site name, boring number, job number, etc. Elevations and water level data to be entered when surveyed data is available.

- Enter sample number (from SPT) under appropriate column. Enter depth sample was taken from (1 block = 1 foot). Fractional footages, i.e., change of lithology a 13.7 feet, shall be lined off at the proportional location between the 13 and 14 foot marks. Enter blow counts (Standard Penetration Resistance) diagonally (as shown). Standard penetration resistance is covered in Section 5.2.3.

- Determine sample recovery/sample length as shown. Measure the total length of sample recovered from the split spoon sampler, including material in the drive shoe. Do not include cuttings or wash material that may be in the upper portion of the sample tube.

- Indicate any change in lithology by drawing a line at the appropriate depth. For example, if clayey silt was encountered from 0 to 5.5 feet and shale from 5.5 to 6.0 feet, a line shall be drawn at this increment. This information is helpful in the construction of cross-sections. As an alternative, symbols may be used to identify each change in lithology.

- The density of granular soils is obtained by adding the number of blows for the last two increments. Refer to Density of Granular Soils Chart of back of log sheet. For consistency of cohesive soils refer also to the back of log sheet - Consistency of Cohesive Soils. Enter this information under the appropriate column. Refer to Section 5.2.3.

- Enter color of the material in the appropriate column.

- Describe material using the USCS. Limit this column for sample description only. The predominate material is described last. If the primary soil is silt but has fines (clay) - use clayey silt. Limit soil descriptors to the following:

  - Trace 0 - 10 percent
  - Some 11 - 30 percent
  - And 31 - 50 percent

- Also indicate under Material Classification if the material is fill or natural soils. Indicate roots, organic material, etc.

- Enter USCS symbol - use chart on back of boring log as a guide. If the soils fall into one of two basic groups, a borderline symbol may be used with the two symbols separated by a slash. For example ML/CL or SM/SP.

- The following information shall be entered under the Remarks Column and shall include, but is not limited by the following:

  - Moisture - estimate moisture content using the following terms - dry, moist, wet and saturated. These terms are determined by the individual. Whatever method is used to determine moisture, be consistent throughout the log.

  - Angularity - describe angularity of coarse grained particles using Angular, Subangular, Subrounded, Rounded. Refer to ASTM D 2488 or Earth Manual for criteria for these terms.

  - Particle shape - flat, elongated, or flat and elongated.

  - Maximum particle size or dimension.

  - Water level observations.

  - Reaction with HCl - none, weak or strong.

- Additional comments:

  - Indicate presence of mica, caving of hole, when water was encountered, difficulty in drilling, loss or gain of water.

  - Indicate odor and HNu or OVA reading if applicable.

  - Indicate any change in lithology by drawing in line through the lithology change column and indicate the depth. This will help later on when cross-sections are constructed.

  - At the bottom of the page indicate type of rig, drilling method, hammer size and drop and any other useful information (i.e., borehole size, casing set, changes in drilling method).

  - Vertical lines shall be drawn (as shown in Exhibit 4.6) in columns 5 to 8 from the bottom of each sample to the top of the next sample to indicate consistency of material from sample to sample, if the material is consistent. Horizontal lines shall be drawn if there is a change in lithology, then vertical lines drawn to that point.

  - Indicate screened interval of well, as needed, in the lithology column. Show top and bottom of screen. Other details of well construction are provided on the well construction forms.

5.5.2 Rock Classification

- Indicate depth at which coring began by drawing a line at the appropriate depth. Indicate core run depths by drawing coring run lines (as shown) under the first and fourth columns on the log sheet. Indicate RQD, core run number, RQD percent and core recovery under the appropriate columns.

- Indicate lithology change by drawing a line at the appropriate depth as explained in Section 5.5.1.

- Rock hardness is entered under designated column using terms as described on the back of the log or as explained earlier in this section.

- Enter color as determined while the core sample is wet; if the sample is cored by air, the core shall be scraped clean prior to describing color.

  Enter rock type based on sedimentary, igneous or metamorphic. For sedimentary rocks use terms as described in Section 5.3. Again, be consistent in classification. Use modifiers and additional terms as needed. For igneous and metamorphic rock types use terms as described in Sections 5.3.8.

- Enter brokeness of rock or degree of fracturing under the appropriate column using symbols VBR, BR, BL, or M as explained in Section 5.3.5 and as noted on the back of the Boring Log.

- The following information shall be entered under the remarks column. Items shall include but are not limited to the following:

  - Indicate depths of joints, fractures and breaks and also approximate to horizontal angle (such as high, low), i.e., 70° angle from horizontal, high angle.
  - Indicate calcareous zones, description of any cavities or vugs.
  - Indicate any loss or gain of drill water.
  - Indicate drop of drill tools or change in color of drill water.

- Remarks at the bottom of Boring Log shall include:

  - Type and size of core obtained.
  - Depth casing was set.
  - Type of Rig used.

- As a final check the boring log shall include the following:

  - Vertical lines shall be drawn as explained for soil classification to indicate consistency of bedrock material.

  If applicable, indicate screened interval in the lithology column. Show top and bottom of screen. Other details of well construction are provided on the well construction forms.

5.5.3 Classification of Soil and Rock from Drill Cuttings

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

- Obtain cutting samples at approximately 5 foot intervals, sieve the cuttings (if mud rotary drilling) to obtain a cleaner sample, place the sample into a small sample bottle or "zip lock" bag for future reference, and label the jar or bag (i.e. hole number, depth, date etc.). Cuttings shall be closely examined to determine general lithology.

- Note any change in color of drilling fluid or cuttings, to estimate changes in lithology.

- Note drop or chattering of drilling tools or a change in the rate of drilling, to determine fracture locations or lithologic changes.

- Observe loss or gain of drilling fluids or air (if air rotary methods are used), to identify potential fracture zones.

- Record this and any other useful information onto the boring log as provided in Exhibit 4-1.

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

5.6 REVIEW

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

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

6.0 REFERENCES

Unified Soil Classification System (USCS)

ASTM D2488, 1985

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

7.0 RECORDS

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

EXHIBIT 4-1

BORING LOG ***NUS CORPORATION***

PROJECT: .... BORING NO.: ....

PROJECT NO.: .... DATE: .... DRILLER: ....

ELEVATION: .... FIELD GEOLOGIST: ....

WATER LEVEL DATA: ....

(Date, Time & Conditions) ....

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

REMARKS ____

____

____

BORING ________

PAGE _____ OF _______

EXHIBIT 4-2

SOIL TERMS

UNIFIED SOIL CLASSIFICATION (USCS)

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

FIELD IDENTIFICATION PROCEDURES (Excluding particles larger than 3" & basing fractions on estimated weights)			GROUP SYMBOL	TYPICAL NAMES
GRAVELS 50%(+) > 1/4"Ø	CLEAN GRAVELS Low % fines	Wide range in grain size and substantial amounts of all intermediate particle sizes.	GW	Well graded gravels, gravel-sand mixtures, little or no fines
		Predominantly one size or a range of sizes with some intermediate sizes missing.	GP	Poorly graded gravels, gravel-sand mixtures, little or no fines
	GRAVELS W/FINES High % fines	Non plastic fines (for identification procedures see ML)	GM	Silty gravels, poorly graded gravel-sand-silt mixtures.
		Plastic fines (for identification procedures see CL)	GC	Clayey gravels, poorly graded gravel-sand-clay mixtures.
SANDS 50%(+) < 1/4"Ø	CLEAN SANDS Low % fines	Wide range in grain size and substantial amounts of all intermediate particle sizes.	SW	Well graded sand, gravelly sands, little or no fines
		Predominantly one size or a range of sizes with some intermediate sizes missing.	SP	Poorly graded sands, gravelly sands, little or no fines
	SANDS W/FINES High % fines	Non plastic fines (for identification procedures see ML)	SM	Silty sands, poorly graded sand-silt mixtures.
		Plastic fines (for identification procedures see CL)	SC	Clayey sands, poorly graded sand-clay mixtures.

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

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

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

DENSITY OF GRANULAR SOILS

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

CONSISTENCY OF COHESIVE SOILS

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

ROCK TERMS

ROCK HARDNESS (FROM CORE SAMPLES)

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

ROCK BROKENNESS

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

LEGEND

SOIL SAMPLES - TYPES

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

ROCK SAMPLES - TYPES

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

WATER LEVELS

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

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

EXHIBIT 4-3

Unified (Red)

CONSISTENCY FOR COHESIVE SOILS

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

ORIGINAL (Red)

EXHIBIT 4-4

BEDDING THICKNESS CLASSIFICATION

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

(Weir, 1973 and Ingram, 1954)

EXHIBIT 4-5

GRAIN SIZE CLASSIFICATION FOR ROCKS

ORIGINAL (Red)

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

After Wentworth, 1922

BORING LOG — **NUS CORPORATION**

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

Date	Sample No. & Type / RQD	Depth (Ft.) / Run No.	Blows / 6" or RQD (%)	Sample Recovery / Sample Length	Lithology Change (Depth ft.) or Screen Int.	Soil Density Consistency or Rock Hardness	Color	Material Classification	Rock Brokenness or USCS	Remarks
	S-1	0.0	3 / 6	1.5/1.5		STIFF	BRN	CLAYEY SILT – TR SHALE	ML	0-6" TOPSOIL MOIST 0PPM
		1.5	6							
								FRAG - TR ORG.		RESIDUAL SOIL.
		5.0								
	S-2	6.0	11/100/.5	0.8/1.0	5.5 / 6.0	M.SOFT	GRAY BRN	DEC SHALE AND SILT	VBR	DAMP 0PPM
						TO				REFUSAL @ 6' 5.5 TOP OF DEC ROCK
						M.HARD				
										AUGERED TO 15' W/SOLID STEM AUG. CUTTING MOIST @ ≈8' WATER @ 11' ±
										WL @ 12:10 PM WAS ≈ 9' FROM GS.
										SET 4" PVC CAS. @ 15.0'
9-21		15.0								
9-22						M.HARD	BRN GRAY	SILTY SHALE - FEW QUARTZ PCS	VBR	SEVERAL Fe STAINED JOINTS ON CORE 0 PPM THRUOUT RUN. JOINTS AND BREAKS ARE HORIZ TO LO ∠. W/VUGS ON LOWER PORTION 23 TO 25 OF CORE
	0.0/10.0	①	0%	7.9/10.0						
		25.0								

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

* See Legend on Back

BORING: MW 3A
PAGE 1 OF 3

300241

BORING LOG — **NUS CORPORATION**

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

	SAMPLE NO & TYPE RQD	DEPTH (ft) RUN	BLOWS 6" OR RQD (%)	SAMPLE RECOVERY SAMPLE LENGTH	LITHOLOGY CHANGE (Depth ft)	SOIL DENSITY CONSISTENCY OR ROCK HARDNESS	COLOR	MATERIAL CLASSIFICATION	USCS	REMARKS
						MATERIAL DESCRIPTION*				
9-22		25.0				M.HARD	GRAY	SILTY SHALE	VBR	SHALE IS VBR W/ HORIZ TO LO ∠ JNTS
								(SILTSTONE)		≈26 TO 27 2- VERT
								- FEW QUARTZ		JOINTS. IRON STAINS ON JNTS
								SEAMS		ROCK BECOMES AND BREAKS MORE LIKE
										A SILTSTONE WITH DEPTH.
	0/10.0	②	0%	8.7/10.0						
									BR	≈32 TO 33 FEW QUARTZ PIECES W/
									VBR	VUGS. SL. MICACEOUS
										VF QUARTZ GRAINS IN MATRIX - 30X MAG.
		35.0								≈34 TO 35 - 2 VERT JOINTS
						M.HARD	GRAY	SILTY SHALE (SILTSTONE)	VBR	35.0-35.5 QUARTZ PIECES
								- FEW QUARTZ	BR	
								SEAMS	VBR	BECOMES SL. CALCAR. @ 37± THIN CALCITE
										LAMINATIONS. WATER STAINED JNTS
									BR	THRUOUT RUN MORE SO 35-37±
	1-0/10.0	③	10%	9.3/10.0					VBR	39.5 → 42.0
										42.7 → 43.0 HI ∠ JNT
									BR	42.4 → 42.7 VERT JNT
		45.0							VBR	
										45.3 → 45.5 VERT JNT. & VBR
										47.5 VERT JOINT
									BR	48. HI ∠ JOINT
										SLIGHTLY CALCAREOUS MORE CALCITE
										PRESENT

REMARKS

BORING MW 3A

PAGE 2 OF 3

* See Legend on Back

ORIGINAL (Red)

BORING LOG — **NUS CORPORATION**

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

SAMPLE NO & TYPE	DEPTH (ft)	BLOWS 6" OR RQD (%)	SAMPLE RECOVERY SAMPLE LENGTH	LITHOLOGY CHANGE (Depth ft)	SOIL DENSITY CONSISTENCY OR ROCK HARDNESS	COLOR	MATERIAL CLASSIFICATION	USCS	REMARKS
1.9/10.0	④	19%	10.0/10.0		M.HARD	GRAY	SILTY SHALE (SILTSTONE)	VBR	50.5 → 51.0 VBR
							SL. CALCAREOUS	BR	51.5 → 54.0 BR w/ SEV LO & JOINTS
	55.0								
								VBR	POOR RECOVERY w/ SOFT ZONES.
0/10	⑤	0%	1.8/10.0						
	65.0								
				66					
									68.0 - DRILLER NOTED SOFT AREA - LOSS OF 1/3 OF WATER - CHANGE IN COLOR OF DRILL WATER TO YELLOW BROWN
0/0	⑥	0%	1.3/10.0						
									POOR RECOVERY
									FEW CALCAREOUS ZONES.
	75.0			76					

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

BORING MW 3A
PAGE 3 OF 3

* See Legend on Back

EXHIBIT 4-6

BORING LOG — **NUS CORPORATION**

PROJECT: WESTLINE SITE BORING NO.: MW 013
PROJECT NO.: 473 Y DATE: 7-7-87 DRILLER: B ERICSON
ELEVATION: 1462.37 FIELD GEOLOGIST: S.J CONTI PENN - DRILL
WATER LEVEL DATA 5.54' @ 8:50 AM 7-23-87 T-PVC ACKER AD-II
(Date, Time & Conditions)

SAMPLE NO. & TYPE OR RQD	DEPTH (FT.) OR RUN NO.	BLOWS 6" OR RQD (%)	SAMPLE RECOVERY / SAMPLE LENGTH	LITHOLOGY CHANGE (Depth, ft.) OR SCREEN INT.	MATERIAL DESCRIPTION: SOIL DENSITY CONSISTENCY OR ROCK HARDNESS	COLOR	MATERIAL CLASSIFICATION	ROCK HARDNESS OR USCS	REMARKS (HNU) (HEAD SP)
	0.0	5 / 3	1.4/1.5		Loose	BLK BRN	CLAYEY SILT AND CINDER	ML	MOIST (OPPM)
S-1		2					TR-COAL FRAGS		3/4" Φ FRAG - NEAR OLD RR. LINE.
							TR-SS FRAG		
							(FILL)		
	5.0					RED			
S-2		1 / 1	1.3/1.5	6.0	V. LOOSE	BRN TO	SANDY SILT - TR ORG TO	SM	MOIST TO WET (OPPM)
	6.5	3				GRAY	SILTY SAND - TR GRAVEL		GRAY SAND @ 6' ±
									MICACEOUS LOOKS NATURAL
									DRILLER NOTE H2O
	10.0								8-10'
S-3		11 / 23	1.2/1.5		DENSE	BRN	SILTY SAND AND S.S.	GM	WET (OPPM)
	11.5	27					FRAGS. (GRAV)		1" Φ SIZE MAX SIZE
									SUBANGULAR TO SUBROUNDED GRAVEL
	15.0								
S-4		7 / 47	1.0/1.5		V. DENSE	BRN	SILTY FINE TO C. SAND	SM	WET (OPPM)
	16.5	43					AND GRAVEL		1" Φ SIZE MAX SIZE
									SUBANGULAR TO SUBROUNDED GRAVEL
	20.0								
S-5	20.9	17 / 50/.4	.6/.9		V. DENSE	ORANG BRN	SILTY SAND - SOME	GM	WET (OPPM)
							GRAVEL AND		MOIST
							S.S FRAGS		BECOMES MORE LIKE SANDY SILT AT BOTM
									OF SAMPLE

REMARKS: START @ 1:15 PM - 7-7-87 USING 4 1/4" ID HOLLOW STEMS
S-4 @ 3:30 PM TO ADVANCE THE BORING USING
S-5 @ 4:30 PM ACKER DRILL - MOUNTED ON
FORD 8000 TRUCK.
SAMPLES TAKEN
USING 140 lb WT AND 30 INCH DROP.

BORING MW 013
PAGE 1 OF 4

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BORING LOG — **NUS CORPORATION**

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

SAMPLE NO. & TYPE OR RQD	DEPTH (ft.) OR RUN NO	BLOWS 6" OR RQD (%)	SAMPLE RECOVERY SAMPLE LENGTH	LITHOLOGY CHANGE (Depth, ft.) OR SCREEN INT	SOIL DENSITY CONSISTENCY OR ROCK HARDNESS	COLOR	MATERIAL CLASSIFICATION	USCS	REMARKS (HNU)
S-6	25.0	6 / 17	1.1/1.5		DENSE	OLIVE BLUE	SILTY SAND - SOME	GM	WET 0PPM
	26.5	30				GRAY	GRAVEL - TR CLAY		C.S. IS FRIABLE
									FIRST CHANGE IN
							TR. SS. FRAG		COLOR. NOT ENOUGH CLAY TO BE CONFINING
									NOTE: MAY SET ZONE 2
									CASING @ 28'
7/7	30.0					MOTTLD			
7/8 S-7		17 / 27	1.4/1.5		V.DENSE	BRN BLUE	SILTY SAND - SOME GRAVEL	SM/GM	MOIST → WET (0PPM)
	31.5	36				GRAY	TR. SS. FRAG		CHANGE OF BLUE GRAY & FRIABLE. SUBROUNDED GRAVEL
							TR CLAY		NOT MUCH CLAY - BUT MAY BE SEMI-CONFINING.
	35.0								
S-8	35.9	30 / 50/.4	0.7/0.9		V.DENSE	BLUE GRAY	SILTY F. TO C. SAND -	SM/GM	MOIST → WET (0PPM)
							SOME GRAVEL		V. SL. TR. CLAY - LESS THAN S-7
							TR. SS. FRAG.		1" Φ FRAG. - MORE COARSE SAND THAN ABOVE.
	40.0					BLUE			POSSIBLE 38 TO 45 SCREEN LOC. SQUEEZED
S-9		31 / 34	1.3/1.5		V.DENSE	BRN GRAY	SILTY SAND (FINE TO M.)	SM/GM	HOLDS TOGETHER WHEN MOIST → WET (0PPM)
	41.5	29					SOME GRAVEL - TR.		LITTLE MORE CLAY THAN
							CLAY		S-8 SUBROUNDED GRAVEL
									VERY SLOW DRILLING 40-45 (RIG STALLS)
	45.0					BLUE			LESS CLAY LAST 3" OF SAMPLE
S-10		13 / 34	1.2/1.5		V.DENSE	BRN GRAY	SILTY SAND (FINE TO M.)	SM/GM	MOIST → WET (0PPM)
	46.5	50					SOME GRAVEL - TR		1" Φ SIZE - HOLDS TOGETHER WHEN SQUEEZED
							CLAY		BUT NOT COHESIVE CLASSIFICATION
									SLOW DRILLING TO 50'

REMARKS S-6 @ 4:40 PM
S-8 @ 8:36 AM 7-8-87
S-10 @ 10:40 AM ; S-11 @

BORING MW013
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Subject	Number	Page
BOREHOLE AND SAMPLE LOGGING	GH-1.5	25 of 26
	Revision: 1	Effective Date: 08/10/88

BORING LOG — **NUS CORPORATION**

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

	SAMPLE NO. & TYPE OR RQD	DEPTH (ft) OR RUN NO.	BLOWS 6" OR RQD (%)	SAMPLE RECOVERY / SAMPLE LENGTH	LITHOLOGY CHANGE (Depth/ft) OR SCREEN INT.	SOIL DENSITY CONSISTENCY OR ROCK HARDNESS	COLOR	MATERIAL CLASSIFICATION	USCS	REMARKS
	S-11	50.0	15 / 41	1.3/1.3		V. DENSE	MOTTLED BLUE	SILTY SAND - SOME GR.	GM	MOIST - (0PPM)
		51.3	50/.3				GRN GRAY	TR CLAY	SM	MOTTLED W/ PCS OF BLACK COAL/LIGNITE MORE CLAY THAN ABOVE PORTIONS OF SAMPLE - COHESIVE CLASSIF.
		55.0			55.0					
	S-12		11 / 15	1.1/1.5		V. STIFF	GRAY ORANG	SANDY CLAY / CLAYEY SAND	SC	MOIST → WET (0PPM)
		56.5	26			TO STIFF	BRN	SOME GRAVEL		NOTE COLOR CHANGE ALSO - MORE CLAY THAN ANY SAMPLE SUB-ROUNDED GRAINS FIRST COHESIVE TYPE CLASSIF.
		60.0	40							
	S-13	60.9	50/.4	0.7/0.9		V. DENSE	ORANG BRN	SANDY CLAY/ CLAYEY SAND - SOME GRAVEL	SC/GW	MOIST → WET (0PPM) NOT AS MUCH CLAY AS S-12 BUT VERY COMPACT. SUBROUNDED GRAINS SET CAS. @ 62'.
		65.0								
7/13	S-14	65.8	37 / 50/.3	0.7/0.8		V. DENSE	GRN ORANG	SILTY SAND - SOME GR. AND ROCK FRAG - TR. CLAY	SM/GW	MOIST (0PPM) MORE CLAY TOWARDS TOP OF SAMPLE MAX 3/4" Φ SIZE
					68.0		YELLOW BRN			COLOR CHANGE AT ≈68' MORE SAND PER DRILLER - BOTM OF SEMI CONF LAYER ?
		70.0								
7/14	S-15		39 / 39	1.0/1.5		V. DENSE	YELLOW BRN	CLAYEY SAND (F. TO C.) SOME	SC/GC	MOIST → WET (0PPM)
		71.5	41					GRAVEL - TR ROCK FRAG.		1" MAX GRAVEL. MORE GRAVEL @ 72' PER DRILLER

REMARKS: USING HOLLOW STEM AUGER BORING - WASHING OUT THRU AUGERS, WHEN NEEDED TO OBTAIN SAMPLE
S-12 @ 1:46 PM
S-13 → 3:32 PM - LOGGED IN BY 3:47 PM
SET 6" Φ STEEL CASING TO 62' - WILL DRILL BELOW CASING AFTER GROUT SETS UP. S-14 @ 3:20 PM 7-13-87
S-15 → 7:57 AM 7-14-87

BORING MW 013
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BORING LOG **NUS CORPORATION**

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

SAMPLE NO. & TYPE OR ROD	DEPTH (ft.) OR RUN NO	BLOWS 6" OR ROD (%)	SAMPLE RECOVERY SAMPLE LENGTH	LITHOLOGY CHANGE (Depth ft.) OR SCR. INT 75	SOIL DENSITY CONSISTENCY OR ROCK HARDNESS	COLOR	MATERIAL CLASSIFICATION	USCS	REMARKS (HNU)
S-16	75.0	27 50/.5	0.9/1.0		V. DENSE	GRAY ORANG BRN	FINE TO C. CLAYEY SAND - SOME	GC	WET (OPPM)
	76.0						GRAVEL - TR		NOT AS MUCH CLAY AS S-15 - BOTM OF
							ROCK FRAG (S.S.)		SAMPLE BECOMES MORE SANDY
									MAX 1" Φ FC.
	80.0								NO SAMPLE @ 80' - DECIDED TO GO TO 85'
	85.0	50/.4	0.4/0.4		V. DENSE	GRAY ORANG BRN	SILTY F. TO C. SAND - SOME	GW	WET (OPPM)
S-17	85.4			85			GRAVEL - TR		SUBROUNDED GRAINS
							S.S. FRAG - TR		V. SL TR CLAY - WILL
							CLAY		SET SCREEN ≈ 75 TO 85' IN THIS BORING.
							BOTM OF HOLE @ 85.0'		

REMARKS S-17 @ 2:20 PM 7-14-87 - MFC... BE... 6" CASING SPUN 4" Φ - 5⅞" OD CASING TO BOTM. USING WATER AS DRILLING FLUID

BORING MW 013
PAGE 4 OF 4

NUS CORPORATION WASTE MANAGEMENT SERVICES GROUP	STANDARD OPERATING PROCEDURES	Number: GH-1.6	Page: 1 of 3
		Effective Date: 08/10/88	Revision: 1
		Applicability: WMSG	
		Prepared: Earth Sciences	
Subject: DECONTAMINATION OF DRILLING RIGS AND MONITORING WELL MATERIALS		Approved: A. K. Bomberger	

TABLE OF CONTENTS

1.0 PURPOSE

The purpose of this procedure is to provide reference information regarding the appropriate procedures to be followed when conducting decontamination activities of drilling equipment and monitoring well materials used during field investigations.

2.0 SCOPE

This procedure addresses only drilling equipment and monitoring well materials decontamination, and shall not be considered for use with chemical sampling and field analytical equipment decontamination.

3.0 GLOSSARY

None.

4.0 RESPONSIBILITIES

Field Operations Leader - Responsible for ensuring that project specific plans and the implementation of field investigations are in compliance with these procedures.

5.0 PROCEDURE

To insure that analytical chemical results are reflective of the actual concentrations present at sampling locations, various drilling equipment involved in field investigations must be properly decontaminated. This will minimize the potential for cross-contamination between sampling locations, and the transfer of contamination off site.

Prior to the initiation of a drilling program. all drilling equipment involved in field sampling activities shall be decontaminated by steam cleaning at a predetermined area. The steam cleaning procedure shall be performed using a high-pressure spray of heated potable water producing a pressurized stream of steam. This steam shall be sprayed directly onto all surfaces of the various equipment involved in field investigations. The decontamination procedure shall be performed until all equipment is free of all visible potential contamination (dirt, grease, oil, noticeable odors, etc.) In addition, this decontamination procedure shall be performed at the completion of each sampling and/or drilling location, including soil borings, installation of monitoring wells, test pits, etc. Such equipment shall include drilling rigs, backhoes, downhole tools, augers, well casings, and screens. The steam cleaning area shall be designed to contain decontamination wastes and waste waters, and can be a lined excavated pit or a bermed concrete or asphalt pad. For the latter, a floor drain must be provided which is connected to a holding facility. A shallow above-surface tank may be used or a pumping system with discharge to a waste tank may be installed.

In certain cases, due to budget constraints, such an elaborate decontamination pad is not possible. In such cases, a plastic lined gravel bed pad with a collection system may serve as an adequate decontamination area. The location of the steam cleaning area shall be on site in order to minimize potential impacts at certain sites. Due to the types of contaminants or proximity to residences, concerns may exist about air emissions from steam cleaning operations. These concerns can be alleviated by utilizing an enclosed steam cleaning area. For example, augers and drill rods can be steam cleaned in drums that have been modified. Tarpaulins can also be placed around the steam cleaning area to control emissions.

Guidance to be used when decontaminating equipment shall include:

- As a general rule, any part of the drilling rig which extends over the borehole, shall be steam cleaned.
- All drilling rods, augers, and any other equipment which will be introduced to the hole shall be steam cleaned.
- The drilling rig, all rods and augers, and any other potentially contaminated equipment shall be decontaminated between each well location to prevent cross contamination of potential hazardous substances.

Rinsate samples of well casing and screens may be necessary if specifically required for a given site. If required, at least 1 percent, and no more than 5 percent of steam cleaned lengths of casing and screens combined shall be sampled.

Prior to leaving at the end of each work day and/or at the completion of the drilling program, drilling rigs and transport vehicles used onsite for personnel or equipment transfer shall be steam cleaned. A drilling rig left at the drilling location does not need to be steam cleaned until it is finished drilling at that location.

6.0 REFERENCES

Ebasco Services Incorporated; REM III Field Technical Guideline No. FT-6.03; October 27, 1987.

7.0 RECORDS

None.

NUS CORPORATION WASTE MANAGEMENT SERVICES GROUP	STANDARD OPERATING PROCEDURES	Number GH-1.8	Page 1 of 6
		Effective Date 08/10/88	Revision 1
		Applicability WMSG	
		Prepared Earth Sciences	
Subject EXCAVATION OF EXPLORATORY TEST PITS AND TRENCHES		Approved A.K. Bomberger	

TABLE OF CONTENTS

1.0 PURPOSE

This procedure describes methods for proper excavation of test pits and trenches.

2.0 SCOPE

These procedures give overall technical guidance and may be modified by site-specific requirements for field exploratory test pits and trenches. Conditions which would make trench excavation technically difficult (such as shallow water table), potentially dangerous (presence of explosive materials or underground utilities) or likely to cause even greater environmental problems (such as potential rupture of buried containerized wastes) would require modifications to the methods described herein and may prevent implementation of the exploratory excavation program. Furthermore, the costs and difficulties in disposing of potentially hazardous materials removed from test pits may constrain their use to areas where contamination potential is low. Consequently, the techniques described herein are most applicable in areas of low apparent contamination and where potentially explosive materials are not expected to be present.

3.0 GLOSSARY

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

4.0 RESPONSIBILITIES

Site Manager - is responsible for determining, in consultation with other project personnel (geologist, geochemist, engineer), the need for test pits or trenches, their approximate locations, depths and sampling objectives.

Field Operation Leader (FOL) - is responsible for finalizing the location and depth of test pits/trenches based on site conditions and the site geologist's advice. The FOL is ultimately responsible for the proper construction and backfilling of test pits and trenches, including adherence to OSHA regulations if applicable (see Section 5.0).

Health and Safety Officer - responsible for air quality monitoring during test pit construction and sampling, to ensure that workers and offsite (downwind) individuals are not exposed to hazardous levels of airborne contaminants. He/She may also be required to advise the FOL on other safety-related matters and mitigative measures to address potential physical hazards from unstable trench walls, puncturing of drums, or other hazardous objects, etc.

Site Geologist/Sampler - responsible for recording all information and data pertaining to the test pit excavation. Engineers, field technicians, or other properly trained personnel may also serve in this capacity.

5.0 PROCEDURE

5.1 APPLICABILITY

This subsection presents routine test pit or trench excavation techniques. Specialized techniques that are applicable only under certain conditions are not presented.

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

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

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

5.2 TEST PIT AND TRENCH EXCAVATION

These procedures describe the methods for excavating and logging test pits and trenches to determine subsurface soil and rock conditions.

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

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

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

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

Fifteen feet is considered to be the economical vertical limit of excavation. However, larger and deeper excavations have been used when special problems justified the expense.

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

The construction of test pits and trenches shall be planned and designed in advance as much as possible. However, field conditions may necessitate revisions to the initial plans. The final depth and construction method shall be determined by the field geologist. The actual layout of each test pit, temporary staging area and spoils pile will be predicated on site conditions and wind direction at the time the test pit is made. Prior to excavation, the area can be surveyed by magnetometer or metal detector to identify the presence of underground utilities or drums.

The test pits and trenches shall be excavated in compliance with applicable safety regulations as specified by the health and safety officer.

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

Stabilization of the sides of test pits and trenches, when required, generally is achieved by sloping the walls at a sufficiently flat angle or by using sheeting. Benching or terracing can be used for deeper holes. Shallow excavations are generally stabilized by sheeting. Test pits excavated into fill are generally much more unstable than pits dug into natural in-place soil.

Sufficient space shall be maintained between trenches or pits to place soil that will be stockpiled for cover, as well as to allow access and free movement by haul vehicles and operating equipment. Excavated soil shall be stockpiled to one side, in one location, preferably downwind, away from the edge of the pit to reduce pressure on the pit walls.

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

The overland flow of water from excavated saturated soils and the erosion or sedimentation of the stockpiled soil shall be controlled. A temporary detention basin and a drainage system shall be planned to prevent the contaminated wastes from spreading.

5.3 BACKFILLING OF TRENCHES AND TEST PITS

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

After inspection, backfill material shall be returned to the pit under the direciton of the field supervisor.

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

6.0 REFERENCES

Ebasco Services Inc., EPA Rem III Program Guidelines, FT-6.04, March 25, 1986.; by

NUS and CH_2MHill, August, 1987. Compendium of Field Operation Methods. Prepared for the USEPA.

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

7.0 RECORDS

Test pits and trenches shall be logged by the field geologist in accordance with Procedure GH-1.5.

Test pit logs shall contain a sketch of pit conditions (see Attachment A, Test Pit Log Form). In addition, at least one photograph with a scale for comparison shall be taken of each pit. Included in the photograph shall be a card showing the test pit number. Test pit locations shall be documented by tying in the location of two or more nearby permanent landmarks (trees, house, fence, etc.) and shall be located on a site map. Surveying may also be required, depending on the requirements of each project. Other data to be recorded in the field logbook include the following:

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

ATTACHMENT A

ORIGINAL (Red)

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 ....

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ORIGINAL (Red)

NUS CORPORATION WASTE MANAGEMENT SERVICES GROUP	STANDARD OPERATING PROCEDURES	Number GH-2.4	Page 1 of 7
		Effective Date 08/10/88	Revision 1
		Applicability WMSG	
		Prepared Earth Sciences	
Subject IN-SITU HYDRAULIC CONDUCTIVITY TESTING		Approved A. K. Bomberger	

TABLE OF CONTENTS

1.0 PURPOSE

This guideline is intended to describe procedures for performing in-situ hydraulic conductivity testing (slug testing) in boreholes and monitoring wells, and provide a short description of commonly used evaluation techniques for the data generated. Slug tests are used to provide data regarding the hydraulic properties of the formation tested. A variation of the slug test, called a constant-head test, is also briefly described.

2.0 SCOPE

Slug tests are short-term tests designed to provide approximate hydraulic conductivity values for the portion of a formation immediately surrounding the screened/open interval of a well or boring. These tests are less accurate than pumping tests, as a much more localized area is involved, so a number of slug tests are performed and averaged to determine a representative hydraulic conductivity value for the formation tested. Slug tests may be preferable to pumping tests in situations where handling of large volumes of contaminated water is a concern or when time/budget constraints preclude the more expensive and time-consuming setup and performance of a pumping test.

Constant-head tests also are used to determine hydraulic conductivity values and are similar to slug tests in regards to the quality of data obtained and time/cost considerations. A disadvantage to constant-head tests is that a significant volume of water may be added to the formation, potentially affecting short-term water quality.

3.0 GLOSSARY

Hydraulic Conductivity (K): A quantitative measure of the ability of porous material to transmit water. Volume of water that will flow through a unit cross sectional area of porous material per unit time under a head gradient. Hydraulic conductivity is dependent upon properties of the medium and fluid. Common units of expression include centimeters per second (cm/sec), feet per day (ft/day), and gallons per day per foot^2 (gpd/ft^2).

Transmissivity (T): A quantitative measure of the ability of an aquifer to transmit water. The product of the hydraulic conductivity x saturated thickness.

Slug-test: A rising head or falling head test used to measure hydraulic conductivity. A slug test consists of instantaneously changing the water level within a well and measuring the rate of recovery of the water level to equilibrium conditions. Slug tests are performed by either withdrawing a slug of water (rising head test) or adding a slug of water (falling head test), then measuring recovery over time.

4.0 RESPONSIBILITIES

The project geologist shall evaluate the type(s) and extent of hydraulic testing required for a given project during the planning process, and design the field program accordingly. The project geologist also shall ensure that field personnel have the necessary training and guidance to properly perform the tests, and oversee data reduction activities, including selecting the appropriate evaluation techniques and checking calculations for accuracy.

The field geologist is responsible for performing the planned field tests as specified in the planning documents, or as directed by the project geologist shall the field program require modification, and generally assists in the data evaluation process. The field geologist shall be knowled[illegible] testing methodologies required and is responsible for obtaining the necessary suppo[illegible] required to perform the field tests. All applicable data regarding testing procedures, equipment used, well construction, and geologic/hydrogeologic conditions shall be recorded by the field geologist. The field geologist shall be familiar enough with testing procedures/requirements to be able to recommend changes in methodology, should unanticipated field conditions be encountered.

5.0 PROCEDURES

5.1 In-Situ Hydraulic Conductivity Testing in Wells

Slug tests are commonly performed in completed wells. Prior to testing, the well shall be thoroughly developed and allowed to stabilize, in order to obtain accurate results. Once the water level within the well has stabilized, it shall be quickly raised or lowered and the rate of recovery measured.

One of the basic assumptions of slug testing is that the initial change in water level is instantaneous; therefore, an effort shall be made to minimize the time involved in raising or lowering the water level initially. Various methods can be used to induce instantaneous (or nearly instantaneous) changes in water level within the well. A rise in water levels can be induced by pouring water into the well. A slug of known volume, quickly lowered below the water level within the well, will displace an equivalent volume of water and raise the water level within the well. The same type of slug can be placed below the static water level in the well, left in place until the water level restabilizes at the static water level, then suddenly removed to create a drop in water level within the well. An advantage of using a solid cylinder of known volume to change the water level (slug test) is that no water is removed or added to the monitoring well. This eliminates the need to dispose of contaminated water. A bailer or pump can be used to withdraw water from the well. (If a pump is used, pumping shall not continue for more than several seconds so that a cone of depression is not created which would adversely impact testing results. The pump hose shall also be removed from the well during the recovery period, as data analysis techniques involve volume of recovery versus time, and leaving the hose within the well would distort the calculated testing results by altering the apparent volume of recovery.) Falling head slug tests can only be performed in wells with fully submerged screens, while rising head slug tests can be performed in wells with either partially or fully submerged screens/open intervals.

Other methods that can be used to change water levels within a well include creating a vacuum or a high pressure environment within the well. The vacuum method will raise water levels within the well, while the pressure method will depress the water level in the well. These methods are particularly useful in highly permeable formations where other methods are ineffective in creating measurable changes in water levels. Both methods are limited to wells which have completely submerged screens.

Rate of recovery measurements shall be obtained from time zero (maximum change in water level) until water level recovery exceeds 90 percent of the initial change in water level. In low permeability formations, the test may be cut off short of 90 percent recovery due to time constraints. Time intervals between water level readings will vary according to the rate of recovery of the well. For a moderately fast recovering well, water level readings at 0, 0.1, 0.2, 0.3, 0.4, 0.5, 0.75, 1.0, 1.25, 1.5, 2.0, 2.5, 3.0, 4.0, . . . minutes may be required. With practice, readings at down to 0.05-minute (3 seconds) time intervals can be obtained with reasonable accuracy, using a pressure transducer and hand held readout. For wells which recover very fast, a pressure transducer and data logger may be required to obtain representative data. Time intervals between measurements can be extended for slow recovering wells. A typical schedule for measurements for a slow recovering well would be 0, 0.25, 0.5, 0.75, 1.0, 1.5, 2.0, 3.0, 4.0, 6.0, 8.0, 10.0, 15.0, 20.0, 30.0, . . . minutes from the beginning the test. Measurements shall be taken from the top of the well casing.

Water level measurements can be obtained using an electric water level indicator, popper, or pressure transducer. Chalked steel tape, although very accurate, is a slower method of obtaining water levels and is generally not recommended for use due to the frequency at which water levels need to be taken during the performance of a slug test.

The following data shall be obtained when performing slug tests in wells or borings:

- Well/boring ID no.
- Total depth of well/boring
- Screened/open interval depth and length
- Gravel pack interval depth and length
- Well and boring radii
- Well stickup above ground surface
- Gravel pack radius
- Static water level
- Aquifer thickness
- Depth to confining layer
- Time/recovery data

ORIGINAL (Red)

A variation of the slug test is a test in which water is added to the well at a measured rate sufficient to maintain the water level in the well at a constant height above the static water level, and is called a constant-head test. Once a stable elevated water level has been achieved, discharge (pumping) rate measurements shall be recorded in place of time/recovery data for approximately 10 to 20 minutes, then the hydraulic conductivity calculated from this. This type of test is generally not recommended for monitoring well, as large volumes of water may be introduced into the screened formation, potentially impacting later sampling events.

5.2 In-Situ Hydraulic Conductivity Testing in Borings

Slug tests can be performed in borings while the boring is being advanced. This permits testing of formations at different depths throughout the drilling process. Boreholes to be tested shall be drilled using casing, so that discrete depths may be investigated. Various tests and testing methods are described below. The most appropriate test and testing method to be used in a situation varies with drilling, geologic, and general site conditions and shall be selected after a careful evaluation of the above factors.

Rising head or falling head slug tests can be performed in saturated and unsaturated formations during drilling. There are two ways that the tests can be performed. One way entails setting the casing flush with the bottom of the boring when the desired testing depth has been reached. The hole is then cleaned out to remove loose materials, the drill bit and rods are carefully withdrawn from the boring, and a few feet of sand (of higher permeability than the surrounding formation) is added to the bottom of the boring. After the water level in the boring has stabilized (for saturated formations), the static water level shall be measured and recorded. The water level shall then be raised (falling head test) or lowered (rising head test) and the change in water level measured at time intervals as determined by the field hydrogeologist. Only falling head tests can be performed for depth intervals within the unsaturated (vadose) zone. As described for wells, time intervals for water-level measurements will vary according to the formation's hydraulic conductivity. The faster the rate of recovery expected, the shorter the time intervals between measurements shall be. A predetermined pattern of time intervals shall be used during each test. The rate of change of water level will be used to calculate hydraulic conductivity. The test shall be conducted until the water level again stabilizes, or for a minimum of 20 minutes. In low permeability formations, it is not always practical to run the test until the water level stabilizes, as it may take a long time to do so. The top of the casing shall be used as the reference point for all water level measurements.

The second method consists of placing a temporary well with a short screen into the cleaned out boring, pulling the drilling casing back to expose the screen, allowing the formation to collapse around the screen (or placing a sand/gravel pack around the screen), and performing the appropriate hydraulic conductivity test in the well, as described for the first method. Again, the test shall be conducted until the water level stabilizes or for a minimum of 20 minutes. this method allows for testing a larger section of the formation and results in more reliable hydraulic conductivity estimates.

Constant head tests may also be performed in borings. As described for monitoring wells, once a stable elevated level has been achieved, the discharge rate into the boring is measured for a period of time, usually 10 to 20 minutes, and the hydraulic conductivity calculated from this. This method is the most accurate method depicted in this section and shall be given preference over others if the materials are available to perform the test and the addition of water to the boring does not adversely impact project objectives. Once the test is over, additional information can be gathered by measuring the rate of the drop in water level in the boring (for saturated formations). A limitation of the test is that foreign water is introduced into the formation which must be removed from the well area by natural or artificial means before a representative groundwater sample can be obtained.

Detailed descriptions regarding the performance of borehole hydraulic conductivity tests and subsequent data analysis techniques are provided in Ground Water Manual (1981).

5.3 Data Analysis

There are a number of data analysis methods available for use to reduce and evaluate slug testing data. The determination of which method is most appropriate shall be made based on the testing conditions (including physical setup of the well/boring tested, hydrogeologic conditions, and testing methodology) and the limitations of each test analysis method. Well construction details, aquifer type (confined or unconfined), and screened/open interval (fully or partially penetrating the aquifer) shall be taken into account in selecting an analysis method. Cooper, et al. (1967), and Papadapulos, et al. (1973), have developed test interpretation procedures for fully penetrating wells in confined aquifers. Hvorslev (1951) developed a relatively simple analytical procedure for point piezometers in an infinite isotropic medium. In Cedergren (1967), Hvorslev presents a number of analytical procedures which cover a wide variety of hydrogeologic conditions, testing procedures, and well/boring/ piezometer configurations. Bouwer and Rice (1976) developed an analytical technique applicable to both unconfined and confined conditions, factors in partial/full penetration, and discusses well screen gravel pack considerations. The Ground Water Manual (1981) presents a number of testing and test analysis procedures for wells and borings open above or below the water table, and for both falling-head and constant-head tests. The methods described above do not represent a complete listing of test analysis methods available, but are some of the more commonly used and accepted methods. Other methods can be used, at the discretion of the project hydrogeologist.

One consideration to be noted during data analysis is the determination of the screened/open interval of a tested well. If a well is screened in a relatively low permeability formation, and a gravel pack which is significantly more permeable is installed around the screen, the length of the gravel pack (if longer than the screened interval) shall be used as the screened/open length, rather than the screen length itself. In situations where the formation permeability is judged to be comparable to the gravel pack permeability (within about an order of magnitude) this adjustment is not required.

All data analysis applications and calculations shall be reviewed by senior level personnel thoroughly familiar with testing and test analysis procedures. Upon approval of the calculations and results, the calculation sheets shall be initialed and dated by the reviewer. Distribution copies shall be supplied to appropriate project personnel and the original copy stored in the project file.

6.0 REFERENCES

Cedergren, H. R., 1967. Seepage, Drainage, and Flow Nets. John Wiley and Sons Inc., New York, pp. 78-76.

Cooper, H. H., Jr., J. D. Bredehoeft, and I. S. Papadopulos, 1967. Response of a Finite-Diameter Well to an Instantaneous Change of Water. Water Resources Research, v. 3, No. 1, pp. 263-269.

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Bouwer, H. and R. C. Rice, 1976. "A Slug Test for Determining Hydraulic Conductivity of Unconfined Aquifers with Completely or Partially Penetrating Wells." Water Resources Research, 12:423-28.

United States Department of the Interior, 1981. Ground Water Manual. U.S. Government Printing Office, Denver, CO.

7.0 RECORDS

Field data shall be recorded on the data sheet included as Attachment A. Any notes regarding testing procedures, problems encountered, and general observations not included on the data sheet shall be noted in the field logbook. The boring log and well construction diagrams for each well/boring tested shall be used as references during testing and data analysis activities. Original data sheets shall be placed in the project file, along with the field logbook.

ATTACHMENT A

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

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NUS CORPORATION WASTE MANAGEMENT SERVICES GROUP	STANDARD OPERATING PROCEDURES	Number SA-1.1	Page 1 of 13
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		Applicability WMSG	
		Prepared Earth Sciences	
Subject GROUNDWATER SAMPLE ACQUISITION		Approved A. K. Bomberger, P.E.	

TABLE OF CONTENTS

ORIGINAL (Red)

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

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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.

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

Advantages of bailers include:

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

Limitations on the use of bailers include the following:

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

Suction Pumps - There are many different types of inexpensive suction pumps including centrifugal, diaphragm, peristaltic, and pitcher pumps. Centrifugal and diaphragm pumps can be used for well evacuation at a fast pumping rate and for sampling at a low pumping rate. The peristaltic pump is a low volume pump (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.

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Gas-Lift Samplers

This group of samplers uses gas pressure either in the annulus of the well or in a venture 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.

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.

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- 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

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7.0 RECORDS

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

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 ______

	Purge Data				
Total Well Depth:					
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 Data			
Sample Date & Time:	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		

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ATTACHMENT A

ATTACHMENT B

Purging Equipment Selection

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

Manufacturer	Model name/ number	Principle of operation	Maximum outside diameter/length (inches)	Construction materials (w/lines & tubing)	Lift range (ft)	Delivery rates or volumes	1982 price (dollars)	Comments
BarCad Systems, Inc	BarCad Sampler	dedicated, gas drive (positive displacement)	1.5/16	PE, brass, nylon, aluminum oxide	0-150 with std. tubing	1 liter for each 10-15 ft of submergence	220-350	requires compressed gas; custom sizes and materials available; acts as piezometer
Cole-Parmer Inst. Co.	Master Flex 7570 Portable Sampling Pump	portable; peristaltic (suction)	<1.0/NA	(not submersible) Tygon®, silicone Viton®	0-30	670 mL/min with 7015-20 pump head	500-600	AC/DC; variable speed control available; other models may have different flow rates
ECO Pump Corp.	SAMPLifier	portable; venturi	<1.5 or <2.0/NA	PP, PE, PVC, SS, Teflon®, Tefzel®	0-100	0-500 mL/min depending on lift	400-700	AC, DC, or gasoline driven motors available; must be primed
Galtek Corp.	Bailer 219-4	portable; grab (positive displacement)	1.66/38	Teflon®	no limit	1075 mL	120-135	other sizes available
GeoEngineering, Inc.	GEO-MONITOR	dedicated; gas drive (positive displacement)	1.5/16	PE, PP, PVC, Viton®	probably 0-150	app. 1 liter for each 10 ft of submergence	185	acts as piezometer; requires compressed gas
Industrial and Environmental Analysts, Inc. (IEA)	Aquarius	portable; bladder (positive displacement)	1.75/43	SS, Teflon®, Viton®	0-250	0-2800 mL/min	1500-3000	requires compressed gas; other models available; AC, DC, manual operation possible
IEA	Syringe Sampler	portable; grab (positive displacement)	1.75/43	SS, Teflon®	no limit	850 mL sample vol.	1100	requires vacuum and/or pressure from hand pump
Instrument Specialties Co. (ISCO)	Model 2600 Well Sampler	portable; bladder (positive displacement)	1.75/50	PC, silicone, Teflon®, PP, PE, Delrin® acetal	0-150	0-7500 mL/min	990	requires compressed gas (40 psi minimum)
Keck Geophysical Instruments, Inc.	SP-81 Submersible Sampling Pump	portable; helical rotor (positive displacement)	1.75/25	SS, Teflon®, PP, EPDM, Viton®	0-160	0-4500 mL/min	3500	DC operated
Leonard Mold and Die Works, Inc.	GeoFilter Small Dia. Well Pump (#0500)	portable; bladder (positive displacement)	1.75/38	SS, Teflon®, PC, Neoprene®	0-400	0-3500 mL/min	1400-1500	requires compressed gas (55 PSI minimum); pneumatic or AC/DC control module
Oil Recovery Systems, Inc.	Surface Sampler	portable; grab (positive displacement)	1.75/12	acrylic, Delrin®	no limit	app. 250 mL	125-160	other materials and models available; for measuring thickness of "floating" contaminants
Q E D Environmental Systems, Inc.	Well Wizard® Monitoring System (P-100)	dedicated; bladder (positive displacement)	1.66/36	PVC	0-230	0-2000 mL/min	300-400	requires compressed gas; piezometric level indicator; other materials available

Source: Barcelona et al., 1983

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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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Subject SURFACE WATER AND SEDIMENT SAMPLING		Approved A. K. Bomberger, P.E.	

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1.0 PURPOSE

This procedure describes methods and equipment commonly-used for collecting environmental samples of surface water and aquatic sediment for either on-site examination and chemical testing or for laboratory analysis.

2.0 SCOPE

The information presented in this guideline is generally applicable to all environmental sampling of surface waters (Section 5.3) and aquatic sediments (Section 5.4), except where the analyte(s) may interact with the sampling equipment. The collection of concentrated sludges or hazardous waste samples from disposal or process lagoons often requires methods, precautions and equipment different from those described herein.

3.0 GLOSSARY

Environmental Sample - low concentration sample typically collected offsite and not requiring DOT hazardous waste labeling or CLP handling as a high concentration sample.

Hazardous Waste Sample - medium to high concentration sample (e.g., source material, sludge, leachate) requiring DOT labeling and CLP handling as a high concentration sample.

4.0 RESPONSIBILITIES

Field Operations Leader - has overall responsibility for the correct implementation of surface water and sediment sampling activities, including review of the sampling plan with, and any necessary training of, the sampling technician(s). The actual collection, packaging, documentation (sample label and log sheet, chain-of-custody record, CLP traffic reports, etc.) and initial custody of samples will be the responsibility of the sampling technician(s).

5.0 PROCEDURES

5.1 INTRODUCTION

Collecting a representative sample from surface water or sediments is difficult because of water movement, stratification or patchiness. To collect representative samples, one must standardize sampling bias related to site selection; sampling frequency; sample collection; sampling devices; and sample handling, preservation, and identification.

Representativeness is a qualitative description of the degree to which an individual sample accurately reflects population characteristics or parameter variations at a sampling point. It is therefore an important quality not only of assessment and quantification of environmental threats posed by the site, but also for providing information for engineering design and construction. Proper sample location selection and proper sample collection methods are important to ensure that a truly representative sample has been taken. Regardless of scrutiny and quality control applied during laboratory analyses, reported data are not better than the confidence that can be placed in the representativeness of the samples.

5.2 DEFINING THE SAMPLING PROGRAM

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

5.2.1 Sampling Program Objectives

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

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

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

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

5.2.2 Location of Sampling Stations

Accessibility is the primary factor affecting sampling costs. The desirability and utility of a sample for analysis and description site conditions must be balanced against the costs of collection as controlled by accessibility. Bridges or piers are the first choice for locating a sampling station on a stream because bridges provide ready access and also permit the sampling technician to sample any point across the stream. A boat or pontoon (with an associated increase in cost) may be needed to sample locations on lakes and reservoirs, as well as those on larger rivers. Frequently, however, a boat will take longer to cross a water body and will hinder manipulation of the sampling equipment. Wading for samples is not recommended unless it is known that contaminant levels are low so that skin contact will not produce adverse health effects. This provides a built in margin of safety in the event that wading boots or other protective equipment should fail to function properly. If it is necessary to wade into the water body to obtain a sample, the sampler shall be careful to minimize disturbance of bottom sediments and must enter the water body downstream of the sampling location. If necessary, the sampling technician shall wait for the sediments to settle before taking a sample.

Sampling in marshes or tidal areas may require the use of an all-terrain-vehicle (ATV). The same precautions mentioned above with regard to sediment disturbance will apply.

Under ideal and uniform contaminant dispersion conditions in a flowing stream, the same concentrations of each would occur at all points along the cross section. This situation is most likely downstream of areas of high turbulence. Careful site selection is needed in order to ensure, as nearly as possible, that samples are taken where uniform flow or deposition and good mixing conditions exist.

The availability of streamflow and sediment discharge records can be an important consideration in choosing sampling sites in streams. Streamflow data in association with contaminant concentration data are essential for estimating the total contaminant loads carried by the stream. If a gaging station is not conveniently located on a selected stream, the project hydrologist shall explore the possibility of obtaining streamflow data by direct or indirect methods.

5.2.3 Frequency of Sampling

The sampling frequency and the objectives of the sampling event will be defined by the work plan. For single-event site- or area-characterization sampling, both bottom material and overlying water samples shall be collected at the specified sampling stations. If valid data are available on the distribution of the contaminant between the solid and aqueous phases it may be appropriate to sample only one phase, although this is not often recommended. If samples are collected primarily for monitoring purposes, consisting of repetitive, continuing measurements to define variations and trends at a given location, water samples shall be collected at a pre-established and constant interval as specified in the work plan (often monthly or quarterly) and during droughts and floods. Samples of bottom material shall be collected from fresh deposits at least yearly, and preferably during both spring and fall seasons.

The variability in available water-quality data shall be evaluated before deciding on the number and collection frequency of samples required to maintain an effective monitoring program.

5.3 SURFACE WATER SAMPLE COLLECTION

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

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

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

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

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

5.3.2 Lakes, Ponds and Reservoirs

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

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

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

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

Many lake measurements are now made in-situ using sensors and automatic readout or recording devices. Single and multiparameter instruments are available for measuring temperature, depth, pH, oxidation-reduction potential (ORP), specific conductance, dissolved oxygen, some cations and anions, and light penetration.

5.3.3 Estuaries

Estuarine areas are by definition zones where inland freshwaters (both surface and ground) mix with oceanic saline waters. Estuaries are generally categorized into three types dependent upon freshwater inflow and mixing properties. Knowledge of the estuary type is necessary to determine sampling locations:

- Mixed estuary - characterized by the absence of a vertical halocline (gradual or no marked increase in salinity in the water column) and a gradual increase in salinity seaward. Typically this type of estuary is shallow and is found in major freshwater sheetflow areas. Being well mixed, the sampling location are not critical in this type of estuary.

- Salt wedge estuary - characterized by a sharp vertical increase in salinity and stratified freshwater flow along the surface. In these estuaries the vertical mixing forces cannot override the density differential between fresh and saline waters. In effect, a salt wedge tapering inland moves horizontally, back and forth, with the tidal phase. If contamination is being introduced into the estuary from upstream, water sampling from the salt wedge may miss it entirely.

- Oceanic estuary - characterized by salinities approaching full strength oceanic waters. Seasonally, freshwater inflow is small with the preponderance of the fresh-saline water mixing occurring near, or at, the shore line.

Sampling in estuarine areas is normally based upon the tidal phases, with samples collected on successive slack tides (i.e. when the tide turns). Estuarine sampling programs shall include vertical salinity measurements at 1 to 5 foot increments coupled with vertical dissolved oxygen and temperature profiles.

5.3.4 Surface Water Sampling Equipment

The selection of sampling equipment depends on the site conditions and sample type required. The most frequently used samplers are:

- Open tube
- Dip sampler
- Hand pump
- Kemmerer
- Depth-Integrating Sampler

The dip sampler and the weighted bottle sampler are used most often.

The criteria for selecting a sampler include:

- Disposable and/or easily decontaminated
- Inexpensive (if the item is to be disposed of)
- Ease of operation
- Nonreactive/noncontaminating - Teflon-coating, glass, stainless steel or PVC sample chambers are preferred (in that order)

Each sample (grab or each aliquot collected for compositing) shall be measured for:

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

as soon as it is recovered. These analyses will provide information on water mixing/stratification and potential contamination.

Dip Sampling

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

Weighted Bottle Sampling

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

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

- Gently lower the sampler to the desired depth so as not to remove the stopper prematurely (watch for bubbles).

- Pull out the stopper with a sharp jerk of the sampler line.

- Allow the bottle to fill completely, as evidenced by the absence of air bubbles.

- Raise the sampler and cap the bottle.

- Decontaminate the outside of the bottle. The bottle can be used as the sample container (as long as original bottle is an approved container).

Kemmerer

If samples are desired at a specific depth, and the parameters to be measured do not require a Teflon coated sampler, a standard Kemmerer sampler may be used. The Kemmerer sampler is a brass cylinder with rubber stoppers that leave the ends open while being lowered in a vertical position to allow free passage of water through the cylinder. "Messenger" is sent down the line when the sampler is at the designated depth, to cause the stoppers to close the cylinder, which is then raised. Water is removed through a valve to fill sample bottles.

5.3.5 Surface Water Sampling Techniques

Most samples taken during site investigations are grab samples. Typically, surface water sampling involves immersing the sample container in the body of water; however, the following suggestions are made to help ensure that the samples obtained are representative of site conditions:

- The most representative samples are obtained from mid-channel at 0.6 stream depth in a well-mixed stream.
- Even though the containers used to obtain the samples are previously laboratory cleaned, it is suggested that the sample container be rinsed at least once with the water to be sampled before the sample is taken.
- For sampling running water, it is suggested that the farthest downstream sample be obtained first and that subsequent samples be taken as one works upstream. Work from zones suspected of low contamination to zones of high contamination.
- To sample a pond or other standing body of water, the surface area may be divided into grids. A series of samples taken from each grid is combined into one sample, or several grids are selected at random.
- Care should be taken to avoid excessive agitation of the water that results in the loss of volatile constituents.
- When obtaining samples in 40 ml septum vials for volatile organics, analysis, it is important to exclude any air space in the top of the bottle and to be sure that the Teflon liner faces in after the bottle is filled and capped. The bottle can be turned upside down to check for air bubbles.
- Do not sample at the surface, unless sampling specifically for a known constituent which is immiscible and on top of the water. Instead, the sample container should be inverted, lowered to the approximate depth, and held at about a 45-degree angle with the month of the bottle facing upstream.

5.4 SEDIMENT SAMPLING

5.4.1 General

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

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

5.4.2 Sampling Equipment and Techniques

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

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

The following samplers may be used to collect bottom materials:

- Scoop sampler
- Dredge samplers

Scoop Sampler

A scoop sampler consists of a pole to which a jar or scoop is attached. The pole may be made of bamboo, wood or aluminum and be either telescoping or of fixed length. The scoop or jar at the end of the pole is usually attached using a clamp.

If the water body can be sampled from the shore or if it can be waded, the easiest and "cleanest" way to collect a sediment sample is to use a scoop sampler. This reduces the potential for cross-contamination. This method is accomplished by reaching over or wading into the water body and, while facing upstream (into the current), scooping in the sample along the bottom in the upstream direction. It is very difficult not to disturb fine-grained materials of the sediment-water interface when using this method.

Dredges

Dredges are generally used to sample sediments which cannot easily be obtained using coring devices (i.e., coarse-grained or partially-cemented materials) or when large quantities of materials are required. Dredges generally consist of a clam shell arrangement of two buckets. The buckets may either close upon impact or be activated by use of a messenger. Most dredges are heavy (up to several hundred pounds) and require use of a winch and crane assembly for sample retrieval. There are three major types of dredges: Peterson, Eckman and Ponar dredges.

The Peterson dredge is used when the bottom is rocky, in very deep water, or when the flow velocity is high. The dredge shall be lowered very slowly as it approaches bottom, because it can force out and miss lighter materials if allowed to drop freely.

The Eckman dredge has only limited usefulness. It performs well where bottom material is unusually soft, as when covered with organic sludge or light mud. It is unsuitable, however, for sandy, rocky, and hard bottoms and is too light for use in streams with high flow velocities.

The Ponar dredge is a Peterson dredge modified by the addition of side plates and a screen on the top of the sample compartment. The screen over the sample compartment permits water to pass through the sampler as it descends thus reducing the "shock wave" and permitting direct access to the secured sample without opening the closed jaws. The Ponar dredge is easily operated by one person in the same fashion as the Peterson dredge. The Ponar dredge is one of the most effective samplers for general use on all types of substrates. Access to the secured sample through the covering screens permits subsampling of the secured material with coring tubes or Teflon scoops, thus minimizing the change of metal contamination from the frame of the device.

6.0 REFERENCES

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7.0 RECORDS

None

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Subject SOIL SAMPLING IN TEST PITS AND TRENCHES		Approved A. K. Bomberger, P.E.	

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1.0 PURPOSE

This procedure describes the method for logging and sampling of test pits and trenches to determine subsurface soil and rock conditions and recover small-volume or bulk samples. The methods apply only to data collection and do not apply to the construction of excavations.

2.0 SCOPE

The procedure is applicable to the collection of bulk and small-volume samples of subsurface soils for laboratory testing which are exposed through excavating at hazardous substance sites.

3.0 GLOSSARY

Test pit or trench - A pit or trench, either machine or manually excavated, from which large quantities of soil may be removed.

4.0 RESPONSIBILITIES

Site Manager - responsible for determining, in consultation with other project personnel (geologist, geochemist), the need for test pits or trenches, their approximate locations, depths and sampling objectives.

Field Operations Leader (FOL) - responsible for finalizing the location, orientation and depth of test pits/trenches based on on-site conditions and the site geologist's advice. The FOL is ultimately responsible for the proper construction, sampling and backfilling of test pits and trenches, including adherence to OSHA regulations.

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

Site Geologist/Sampler - responsible for recording all information and data on test pit/trench construction and for the proper collection and logging of samples according to this procedure.

5.0 PROCEDURES

5.1 DATA COLLECTION AND SAMPLING

5.1.1 General

Test pits and trenches are usually logged as they are excavated. Records of each test pit/trench will be made on prepared forms or in a field notebook. If the log is made in a field notebook, it will be transcribed to the prepared forms. These records include plan and profile sketches of the test pit/trench showing materials encountered, their depth and distribution in the pit/trench, and sample locations. These records will also include safety and sample screening information.

Requirements for sampling shall be determined by the Site Manager, and shall be documented in the Project Operation Plan (POP). A copy of this plan shall be maintained by the Field Operations Leader. To expedite sampling, the crew shall have sufficient tools and equipment to sample each pit. The tools and equipment must be properly decontaminated prior to use.

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

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

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

5.1.2 Sampling Equipment

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

- Backhoe or other excavating machinery.
- Shovels, picks and hand augers, stainless steel trowels.
- Sample container - bucket with locking lid for large samples and glass bottles for chemical or geotechnical analysis samples.
- Polyethylene bags for enclosing sample; buckets.
- Remote sampler consisting of ten foot sections of steel conduit (one inch diameter), hose clamps and right angle adapter for conduit (See Attachment A).

5.1.3 Sampling Methods

The methods discussed in this section refer to test pit sampling from grade level. If test pit entry is required, see Section 5.1.4.

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

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

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

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

- Remove loose material to the greatest extent possible with backhoe.
- Secure walls of pit if necessary. (There is seldom any need to enter a pit or trench which would justify the expense of shoring the walls. All observations and samples can generally be taken from the ground surface.)
- Samples of the test pit material will be obtained either directly from the backhoe bucket or from the material once it has been deposited on the ground. The sampler or Field Operations Leader directs the backhoe operator to remove material from the selected depth or location within the test pit/trench. The bucket is brought to the surface and moved away from the pit. The sampler and/or HSO then approaches the bucket and monitors its contents with a photoionization (HNU) or OVA meter. The sample is collected from the center of the bucket or pile and placed in sample jars using a clean stainless steel trowel or spatula.
- If a composite sample is desired, several depths or locations within the pit/trench are selected and a bucket is filled from each area. It is preferable to send individual sample bottles filled from each bucket to the laboratory for compositing under the more controlled laboratory conditions. However, if compositing in the field is required, each sample bottle shall be emptied into a mixing container (e.g., stainless steel bucket) and thoroughly stirred prior to being placed into the sample jars. Composite sampling is not appropriate for samples which will undergo analysis for volatile organic compounds.

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

- Prepare shipping papers, labels, and chain-of-custody records, as described in SA-6.2, Sample Packaging and Shipping.

5.1.4 In-Pit Sampling

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

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

- The project will benefit significantly from the improved quality of the logging and sampling data obtained if personnel enter a pit or trench rather than conduct such operations from the ground surface.

- There is no practical alternative means of obtaining such data.

- The Site Health & Safety Officer determines that such action can be accomplished without breaching site safety protocol. This determination will be based on actual monitoring of the pit/trench after it is dug (including, at a minimum, measurements of volatile organics, explosive gases and available oxygen).

- An experienced geotechnical professional determines that the pit/trench is stable or is made stable prior to entrance of any personnel (by grading the sidewalls or using shoring). OSHA requirements (Reference 1) must be strictly implemented.

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

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

5.1.5 Geotechnical Sampling

In addition to the equipment described in Section 5.1.2, the following equipment is needed for geotechnical sampling:

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

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

Relatively undisturbed samples are usually extracted in cohesive soils using open tube samplers, and such samples are then tested in a geotechnical laboratory for their strength, permeability and/or compressibility. The techniques for extracting and preserving such samples are similar to those used in performing Shelby tube sampling in borings, except that the sampler is advanced by hand or backhoe, rather than a drill rig. Also, the sampler may be extracted from the test pit by excavation around the sampler when it is difficult to pull it out of the ground. If this excavation requires entry of the test pit the requirements described in Section 5.1.4 must be followed. The open tube sampler shall be pushed or driven <u>vertically</u> into the floor or steps excavated in the test pit at the desired sampling elevations. Extracting tube samples horizontally from the walls of the test pit is not appropriate, because the sample will not have the correct orientation.

A sledge hammer or the backhoe may be used to drive or push the sampler or tube into the ground. Place a piece of wood over the top of the sampler or sampling tube to prevent damage during driving/pushing of the sample. Pushing the sampler with a constant thrust is always preferable to driving it with repeated blows, to minimize disturbance to the sample. If the sample cannot be extracted by rotating it at least two revolutions (to shear off the sample at the bottom), hand excavation to remove the soil from around the sides of the sampler and slice off the sample at its bottom may be required. If this requires entry of the test pit, the requirements in Section 5.1.4 must *be followed. Prepare, label, pack and transport the sample in the required manner,* as described in SA-6.2, Sample Packaging and Shipping.

Hand-carved block samples are extracted in a similar manner to open tube samples, except that the sampling container (usually a large tube or box with no top or bottom) is not used to cut the sample. Instead, the surrounding sections of the test pit floor are carved away by hand to leave a sample slightly smaller in plan dimensions than the container, with the sample remaining connected to the test pit floor at its bottom. The container is slipped over the sample, and the annular space and top of the sample is covered with melted wax. The bottom of the sample is then sliced away from the test pit floor, the container is inverted, about 1/2 inch of soil removed, and the space filled with melted wax. Caps are then installed, taped, and dipped in hot wax for each end of the container, and the block sample is labeled and shipped in the same manner as a tube sample.

5.2 RECORDS

The following information will be recorded on the test pit/trench log form and in the field notebook:

- Name, work assignment number, and location of job.
- Date of digging or trenching.
- Surface elevation.
- Depth, surface area and orientation of pit or trench.
- Sample numbers.
- Method of taking samples, type and size of samples.
- Approximate water levels after stabilization (if below the water table), and location and depth of any seeps.
- Description of soil.
- Other pertinent information, such as HNU or OVA readings, weather conditions, etc.
- List of photographs.
- Name of contractor, backhoe (or other equipment) operator and sampler.
- Date and type of backfill.

6.0 REFERENCES

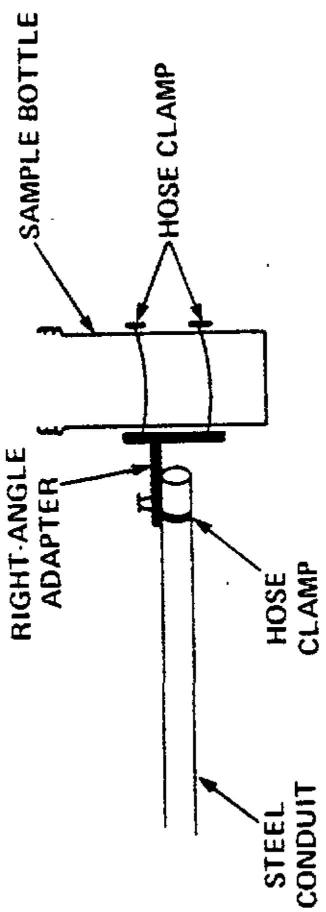
OSHA, 1979. Excavation Trenching and Shoring, 29 CFR 1926.650-653.

Ebasco Services Incorporated; REM III Field Technical Guideline No. FT-7.09. March 25, 1986.

7.0 RECORDS

Attachment A - Remote Sampling/Sample Holder for Test Pit/Trench

ATTACHMENT A



REMOTE SAMPLE HOLDER FOR TEST PIT/ TRENCH SAMPLING

NUS CORPORATION WASTE MANAGEMENT SERVICES GROUP	STANDARD OPERATING PROCEDURES	Number SA-6.1	Page 1 of 11
		Effective Date 08/10/88	Revision 1
		Applicability WMSG	
		Prepared Earth Sciences	
Subject SAMPLE IDENTIFICATION AND CHAIN-OF-CUSTODY		Approved A. K. Bomberger, P.E.	

TABLE OF CONTENTS

1.0 PURPOSE

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

2.0 SCOPE

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

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

3.0 GLOSSARY

Chain-of-Custody Record Form - A Chain-of-Custody Record Form is a printed two-part form that accompanies a sample or group of samples as custody of the sample(s) is transferred from one custodian to another custodian. Attachment A shows the Chain-of-Custody Record Form used by EPA Region III. 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 Project Operations Plan).
Station Location	The unique sample number identifying this sample (can be obtained from the Project Operations 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 #	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 EPA 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 B) must also be used for samples collected for CLP (Contract Laboratory Program) analysis. The Sample Identification Tag is a white, waterproof paper label, approximately 3-by-6 inches, with a reinforced eyelet, and string or wire for attachment to the neck of the sample bottle. The Sample Tag is a controlled document, and is provided by the regional EPA office. Following sample analysis, the Sample Tag is retained by the laboratory as evidence of sample receipt and analysis.

The following information is recorded on the tag:

Project Code	EPA 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 No. and Traffic Report numbers are recorded).
Lab Sample No.	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. The Chain-of-Custody Record Form used in EPA Region III is shown in Attachment A. 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 Project Operations 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 D 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

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

Ebasco Services Incorporated; REM III Field Technical Guideline No. FT-7.04, October 30, 1987.

Ebasco Services Incorporated; REM III Field Technical Guideline No. 7.05, October 30, 1987.

7.0 RECORDS

Attachment A - Chain-of-Custody Record Form for use in Region III
Attachment B - Sample Label
Attachment C - Sample Identification Tag
Attachment D - Chain-of-Custody Seal

ATTACHMENT A
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

CHAIN OF CUSTODY RECORD

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

3-15966

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

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

ATTACHMENT B
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 C
SAMPLE IDENTIFICATION TAG

☆ GPO 505-552

Designate: Grab / Comp.

Time

Month/Day/Year

Station No.

Project Code

Samplers (Signatures)

Station Location

Preservative: Yes ☐ No ☐

ANALYSES

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

Remarks:

Tag No.	Lab Sample No.
3 60966	

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY

EPA

ATTACHMENT D
CHAIN-OF-CUSTODY SEAL

NUS CORPORATION WASTE MANAGEMENT SERVICES GROUP	STANDARD OPERATING PROCEDURES	Number SA-6.2	Page 1 of 12
		Effective Date 08/10/88	Revision 1
		Applicability WMSG	
		Prepared Earth Sciences	
Subject SAMPLE PACKAGING AND SHIPPING		Approved A. K. Bomberger, P.E.	

TABLE OF CONTENTS

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

EBASCO Services Incorporated; REM III Field Technical Guideline No. FT-7.07; January 8, 1986.

7.0 RECORDS

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	[illegible]	CONTAINER NUMBERS	P/C	BULK
1	55 gal	200 lbs.	x	Nitric Acid, Fuming	Oxidizer	55-BN	C	1	✓	
1	66 gal	450 lbs	x	Flammable Liquid, n o s	Flammable Liquid	55-ABF	—	2		✓
1	55 gal	258 lbs	x	Flammable Liquid, n o s	Flammable Liquid	55-BN	B	3	✓	
1	15-A	12 lbs.	x	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

Disposer Work Order

Service Order No

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		Prepared Earth Sciences	
Subject SITE LOGBOOK		Approved A. K. Bomberger, P.E.	

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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 DEFINITIONS

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 and EPA Work Assignment Number
- 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

Ebasco Services Incorporated; REM III Field Technical Guideline No. 13.03. October 30, 1987.

7.0 RECORDS

Attachment A - Typical Site Logbook Entry

ATTACHMENT A
TYPICAL SITE LOGBOOK ENTRY

START TIME: ______________________ DATE: ______________

SITE LEADER: ______________________
PERSONNEL:

NUS	DRILLER	EPA

WEATHER: Clear, 68°F, 2-5 mph wind from SE

ACTIVITIES:

1. Steam jenney and fire hoses were set up.

2. Drilling activities at well _______ resumes. Rig geologist was ______________________. See Geologist's Notebook, No. 1, page 29-30, for details of drilling activity. Sample No. 123-21-S4 collected; see sample logbook, page 42. Drilling activities completed at 11:50 and a 4 inch stainless steel well installed. See Geologist's Notebook, No. 1, page 31, and well construction details for well __________.

3. Drilling rig No. 2 steam-cleaned at decontamination pit. Then set up at location of well ___________.

4. Well __________ drilled. Rig geologist was ______________________. See Geologist's Notebook, No. 2, page _______ for details of drilling activities. Sample numbers 123-22-S1, 123-22-S2, and 123-22-S3 collected; see sample logbook, pages 43, 44, and 45.

5. Well _________ was developed. Seven 55-gallon drums were filled in the flushing stage. The well was then pumped using the pitcher pump for 1 hour. At the end of the hour, water pumped from well was "sand free."

6. EPA remedial project manger arrives on-site at 14:25 hours.

7. Large dump truck arrives at 14:45 and is steam-cleaned. Backhoe and dump truck set up over test pit ______________.

8. Test pit __________ dug with cuttings placed in dump truck. Rig geologist was ______________________. See Geologist's Notebook, No. 1, page 32, for details of test pit activities. Test pit subsequently filled. No samples taken for chemical analysis. Due to shallow groundwater table, filling in of test pit _____ resulted in a very soft and wet area. A mound was developed and the area roped off.

9. *Express carrier picked up samples (see Sample Logbook, pages 42 through 45) at 17:50 hours.* Site activities terminated at 18:22 hours. All personnel offsite, gate locked.

____
Field Operations Leader

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Subject FORMS USED IN RI ACTIVITIES		Approved A. K. Bomberger, P.E.	

TABLE OF CONTENTS

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, or in consultation with ARCS III Project Office.

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 form (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. This form is available from the RSCC. Procedures for filling out Chain-of-Custody Record forms are contained in SA-6.1

ORIGINAL (Red)

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 (See Appendix B)

Attachment A - Technical Forms in Current Use for Remedial Investigations in the REM III Program (2 sheets)

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

ORIGINAL (Red)

ATTACHMENT A

TECHNICAL FORMS IN CURRENT USE FOR REMEDIAL INVESTIGATIONS

	Attachment Number	Form Usage Described in SOP No.	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 Llist	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~~

ATTACHMENT A
TECHNICAL FORMS IN CURRENT USE FOR REMEDIAL INVESTIGATIONS
PAGE TWO

	Attachment Number	Form Usage Described in SOP No.	Controlled/ Required Document
~~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

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		Prepared Earth Sciences	
Subject FIELD REPORTS		Approved A. K. Bomberger, P.E.	

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300330

1.0 PURPOSE

This procedure describes the periodic field reports which are required to be filled out during the conduct of Remedial Investigation (RI) field studies. These reports on the progress of field assignments are not to be confused with the forms associated with boring and well installation, sampling, sample custody and equipment maintenance described in Procedure SA-6.4.

These reports serve several purposes:

- To maintain a written record of major events/accomplishments/problems related to the field work.
- To allow ongoing monitoring of the actual progress of field tasks in comparison to the planned schedule, and to allow timely corrective action (if required).
- To inform Site Managers of progress/accomplishments for inclusion in The Monthly Project Tracking System.

2.0 SCOPE

The reports described herein are to be used during field investgiations, but do not replace or take precedence over project-specific or subcontractor-specific required reports. Additional reporting may particularly be required at enforcement-lead sites.

3.0 GLOSSARY

None

4.0 RESPONSIBILITIES

Field Operations Leader - responsible for assuring that the appropriate reports are completed in the required time-frame. Responsibilities for filling out individual reports are identified within the description of the reports (see below).

5.0 PROCEDURES

5.1 PROGRAM DESIGN

The primary means of recording onsite activities is the site logbook (see Procedure SA-6.3) and other field logbooks (e.g. geologists notebook, health and safety officer's logbook, sample logbooks). However, these logbooks and notebooks usually contain extremely detailed information which is required for data interpretation or documentation, but not for tracking and reporting of progress. Furthermore, the field logbooks remain onsite for extended periods of time and are thus not accessible for review by project management. The reports described in this procedure are, in essence, simplified summaries of the logbooks, which are designed to provide only the information needed by project management to keep informed of the progress of field activities.

5.2 DAILY ACTIVITIES REPORT

5.2.1 Description

The Daily Activities Report documents the activities and progress for each day's field work. This report is filled out on a daily basis whenever there are drilling, test pitting, well construction, or other related activities occurring which involve subcontractor personnel. These sheets summarize the work performed and form the basis of payment to subcontractors. (see Attachment A).

5.2.2 Responsibilities

It is the responsibility of the rig geologist to complete the report and obtain the driller's signature acknowledging that the times and quantities of material entered are correct.

5.2.3 Submittal and Approval

At the end of the shift, the rig geologist submits the Daily Activities Report to the Field Operations Leader (FOL) for review and filing. The Daily Activities Report is not a formal report and thus requires no further approval. The reports are retained by the FOL for use in preparing the site logbook and weekly Field Summaries, and are submitted to the Site Manager weekly along with the *Weekly Field Summary.*

5.3 WEEKLY FIELD SUMMARY

5.3.1 Description

The Weekly Field Summary is an abstract of the Site Logbook, summarizing the major activities onsite for a particular week (Sunday through Saturday). It should be organized on a day-by-day basis, and contain the following information at a minimum (see Attachment B):

- Date (week ending)
- Personnel onsite (contractor, subcontractors, visitors)
- Weather conditions encountered during the week
- Site activities
- Number and type of samples collected (including C.O.C. form numbers)
- Issues impacting progress of the project.

5.3.2 Responsibilities

The Field Operations Leader or responsible individual onsite if not the FOL (e.g., geophysics team leader, sampling team leader) is responsible for completing the Weekly Field Summary at the end of each week of ongoing site activity, or at the completion of an activity (if no further activity will take place during that week).

5.3.3 Submittal and Approval

The summary, along with Daily Activities Reports, Health & Safety Officer's Reports, and any other documentation, must be delivered or sent to the Site Manager at the end of each week.

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DAILY ACTIVITIES RECORD - FIELD INVESTIGATION — **NUS CORPORATION**

PROJECT NAME: ______ PROJECT NO.: ______
CLIENT: ______ LOCATION: ______
DATE: ______ ARRIVAL TIME: ______ DEPARTURE TIME: ______
CONTRACTOR: ______ DRILLER: ______
BORING NO.: ______ NUS REPRESENTATIVE: ______

ITEM (1)	ORIGINAL QUANTITY (2) ESTIMATE	QUANTITY (2) TODAY	PREVIOUS TOTAL (2) QUANTITY	CUMULATIVE QUANTITY (2) TO DATE
1. Mobilization/Demobilization	Job			
2. Overburden Drilling/Sampling, minimum 6-inch	100 ft.			
3. Overburden Drilling, 10-inch	250 ft.			
4. Overburden Drilling 14-inch	450 ft.			
5. Bedrock Drilling 6-inch	530 ft.			
6. Bedrock Drilling 10-inch	650 ft.			
7. Bedrock Drilling 14-inch	150 ft.			
8. Temporary 6-inch Steel Casing	250 ft.			
9. Temporary 10-inch Steel Casing	200 ft.			
10. Temporary 14-inch Steel Casing	250 ft.			
11. Permanent 6-inch Steel Casing	1,250 ft.			
12. Permanent 10-inch Steel Casing	400 ft.			
13. PVC Well Construction/Installation	1,120 ft.			
14. Mine Void Sealing	8			
15. Boring Backfilling	NA			
16. Well Development	24 hrs.			
17. Test Borings	200 ft.			
18. Test Pit Excavation	50 hrs.			
19. Standby	20 hrs.			

COMMENTS: ______

(1) AS LISTED IN SPECS
(2) INCLUDE QUANTITY AND UNITS
(Ex. 20 ft., 6 hrs.)

APPROVED BY:

______
NUS FIELD REPRESENTATIVE

______
DRILLER OR REPRESENTATIVE

ATTACHMENT A

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ATTACHMENT B
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WEEKLY FIELD SUMMARY REPORT

SUNDAY

Date : ____________ Personnel ____________ ____________
Weather: ____________ Onsite ____________ ____________
____________ ____________

Site Activities: ______________________________

MONDAY

Date : ____________ Personnel ____________ ____________
Weather: ____________ Onsite ____________ ____________
____________ ____________

Site Activities: ______________________________

TUESDAY

Date : ____________ Personnel ____________ ____________
Weather: ____________ Onsite ____________ ____________
____________ ____________

Site Activities: ______________________________

ATTACHMENT B
PAGE 2 OF 2

WEDNESDAY

Date : ________________ Personnel ________________ ________________
Weather: ________________ Onsite ________________ ________________
________________ ________________

Site Activities: ____
____
____
____

THURSDAY

Date : ________________ Personnel ________________ ________________
Weather: ________________ Onsite ________________ ________________
________________ ________________

Site Activities: ____
____
____
____

FRIDAY

Date : ________________ Personnel ________________ ________________
Weather: ________________ Onsite ________________ ________________
________________ ________________

Site Activities: ____
____
____
____

SATURDAY

Date : ________________ Personnel ________________ ________________
Weather: ________________ Onsite ________________ ________________
________________ ________________

Site Activities: ____
____
____

The Weekly Field Summary is an internal informational document and is not subject to project management review or approval.

6.0 REFERENCES

Ebasco Services Incorporated; REM III Field Technical Guideline No. 13.02. October 30, 1987.

Ebasco Services Incorporated; REM III Field Technical Guideline No. 2.06. June 2, 1986.

Ebasco Services Incorporated; REM III Field Technical Guideline No. 13.03. October 30, 1987.

Ebasco Services Incorporated; REM III Field Technical Guideline No. 13.01. October 29, 1987.

7.0 RECORDS

Attachment A - Rig Shift Report
Attachment B - Weekly Field Summary Report (2 pages)

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		Applicability: WMSG	
		Prepared: Earth Sciences	
Subject: MANAGEMENT OF SAMPLING AND PREPARATION OF REQUIRED FORM		Approved: A. K. Bomberger, P.E.	

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300337

TABLE OF CONTENTS (Continued)

1.0 PURPOSE

The purpose of this procedure is to describe the method used in planning and managing sample shipments to the EPA Contract Laboratory Program (CLP).

2.0 SCOPE

This procedure applies to all NUS staff involved in preparation of the Project Operations Plans (POP) Plan (FSAP), and personnel involved in RI field work, involving collection of samples for off-site chemical analysis.

3.0 GLOSSARY

Authorized Requestor (AR) - The EPA contact person(s) in the Regional Sample Control Center through which CLP's analytical services must be accessed.

Contract Laboratory Program (CLP) - A system of contractor-run laboratories providing analytical services and support for EPA's Superfund program. Data produced from this program is subject to rigorous QA/QC and documentation procedures to ensure its admissibility as evidence in any EPA enforcement proceedings.

Deputy Project Officer (DPO) - Appointed by the EPA Regional Administrator for each region, the EPA's DPO has partial responsibility for monitoring the laboratory contractors actually located in the region. Additional duties currently include resolution of problems in laboratory operations and laboratory site evaluations.

Environmental Monitoring and Support Laboratory/Las Vegas (EMSL/LV) and National Enforcement Investigations Center (NEIC) - Current responsibilities of EMSL/LV and NEIC include methods development, QA, and automated data transfer.

Laboratory Services Manager (LSM) - The ARCS III PMO Manager responsible for all ARCS III laboratory analytical services, including ARCS III subcontractor laboratories and submission of samples to CLP.

National Enforcement Investigations Center (NEIC) - The EPA unit responsible for developing guidance and providing technical assistance to EPA enforcement efforts.

RAS Sample - A quantity of soil, water or sediment, taken from the field at a single point at a single time and submitted for a set of Routine analytical Service (RAS) analyses. One sample collected and submitted for both organic and inorganic analysis would be counted as two RAS samples.

Regional Laboratory Services Coordinator (RLSC) - The ARCS III person responsible for coordination of ARCS III Laboratory analytical services. The RLSC is in general the single point of contact for the EPA Regional Sample Control Center (RSCC). The RLSC will usually be an employee of the lead firm, but will coordinate laboratory services for all sites, regardless of which ARCS III team member firm is performing site work.

Regional Sample Control Center (RSCC) - The EPA regional offices which serve as the central contact with the CLP for each region. The RSCC coordinates the level of regional sampling activities to correspond with monthly allocations of CLP capacity, places all requests for CLP analyses, coordinates sampling and sample shipment, and resolves any problems that may arise concerning the samples.

Repository Authorized Requestor (RAR) - The ARCS III personnel (one for each region) recognized by the Sample Management Office (SMO), through whom all requests for sample containers must be forwarded to the CLP Sample Bottle Repository. The RAR is usually the Regional Laboratory Services Coordinator (RLSC),

Routine Analytical Services (RAS) - Offered through CLP, for the determination of common organic and inorganic parameters and dioxin. The nature of these services is specified in contracts with each laboratory. For a detailed description of these services, see the "User's Guide to the Contract Laboratory Program" (Reference 1 of this guideline).

Sample Bottle Repository - A contractor-operated, centralized source for the most commonly-used sizes of pre-cleaned and QC-tested sampling containers for CLP samples.

Sample Management Office (SMO) - The contractor-operated office through which CLP receives analytical requests from the regions. Duties of SMO include sample scheduling and tracking, Special Analytical Services (SAS) subcontracting, laboratory invoice processing, maintenance of CLP records and management reporting, and NPO (National Program Office at EPA Headquarters) management and administrative support.

Special Analytical Services (SAS) - Analyses requiring special protocols or handling (e.g., high-hazard, non-routine parameters, enhanced detection limits) are available through this option. Individual contracts for these services are solicited, awarded and administered by SMO. For a description of these services, see Reference 1 of this guideline.

Traffic Report (TR) - Documentation used to track CLP samples from the field to the laboratory. Separate versions exists for inorganic and organic samples. One traffic report is used per twenty samples.

4.0 RESPONSIBILITIES

Site Manager (SM) - responsible for thorough understanding of the CLP (or non-CLP) requirements and incorporation of these requirements into the POP and project schedule. The SM retains overall responsibility for the success of the sampling and analysis and serves as the prime interface with EPA staff, although certain aspects of sampling (e.g., preparation for sampling and shipment, coordination with RSCC) may be delegated to other project personnel (e.g., Regional Laboratory Services Coordinator and Field Operations Leader).

With regard to sampling, the SM's specific responsibilities include:

- Preparation of EPA-approved POP (including QA/QC protocols and SAS analytical protocols) for CLP analysis;
- Coordination with RAR to order sample containers
- For non-CLP analysis, coordination with the PMO Laboratory Services Manager (LSM) through the Regional Laboratory Services Coordinator (RLSC) to identify the laboratory and analytical protocols, and management of the non-CLP Laboratory's subcontract;
- Obtaining required EPA and NUS document forms, site logbook and sample logbook;
- Assigning and preparing the sampling team.

Field Operations Leader (FOL) - responsible for thorough understanding of CLP (or non-CLP) requirements and retains overall responsibility for the correct collection, bottling, documentation, preservation, and shipment of samples to the analytical laboratories, including notification of RSCC and SMO of sample shipment. Some of these responsibilities may be delegated to a sampling technician.

Field Sampling Technicians - responsible for correctly collecting samples, filling out the required sample documentation, traffic reports and chain-of-custody forms and following the directions of the Project Operations Plan, relevant NUS Procedures, and the FOL regarding sample collection, preservation, and shipment methods.

EPA Remedial Project Manager (RPM) - The designated EPA representative for the work assignment, the RPM is responsible for EPA's activity in all phases of the assignment. With regard to sampling, the RPM is responsible for:

- *Assisting with regard to site entry;*
- Contacts with the state agencies and responsible parties in the local community;
- Approval of plans, subcontracts, and reports; data validation and data entry.

5.0 PROCEDURES

5.1 OVERVIEW

Sampling and analysis, as conducted in accordance with EPA and NUS procedures and requirements, are extremely complex operations. From 6 to 12 agencies, organizations, or offices are involved in the overall program, and each has its own procedures and requirements. There are at least eight separate and distinct administrative and management activities needed to establish a sampling and analysis program. These are:

1 Planning
2 Logistics
3 Subcontracting
4 Site activities, including sampling, drilling, surveying, test pit excavation, boring etc.
5 Packaging and shipping, including documentation
6 Analysis
7 Data Validation
8 Reporting

Activities 1 and 2 shall be covered in detail in the POP and are the responsibility of the SM, FOL, and other staff assigned to the project. Activity 3 should be initiated by the SM, through the NUS Contracting Officer at PMO, during the RI/FS Initial Tasks and Activities.

Activities 4 and 5 are field activities to be conducted by the NUS field personnel. Activity 6 shall be conducted by CLP (not including field analysis, which will be conducted by field personnel), and Activity 7 may be conducted by various branches of EPA. Finally, Activity 8 is the responsibility of the NUS contractor for that work assignment.

Frequent communications with the offices and organizations involved are necessary to maintain effective coordination. Throughout the entire operation, quality assurance and quality control requirements must be satisfied in accordance with the Quality Assurance Program Plan. Extensive documentation is needed to assure adequate management tracking of samples through the complex system and to maintain a chain-of-custody record for litigation purposes. Attachment A presents a summary of the timing of activities for scheduling CLP samples.

5.1.1 Sampling Equipment

Proper and sufficient sampling equipment is a basic necessity for a successful sampling effort. Attachment I contains an equipment checklist which shall be used by the SM or FOL when preparing for a sampling program. To avoid delays in the sampling programs, it is in the interest of the SM to provide this equipment request with sufficient advance notice (usually 2 to 3 weeks minimum).

Additionally, if Special Analytical Services (SAS) are requested, the POP must include specific methods and protocols required for these analyses. These protocols must be approved by EPA before requesting SAS from SMO.

5.2 PLANNING FOR SAMPLING ACTIVITIES

Planning for work assignments involving the collection of samples to be submitted for CLP analyses consists of several major steps:

- Develop Project Operations Plan;
- Schedule CLP Analysis;
- Obtain CLP Sample Bottles;
- Obtain Sample Shipping Coolers, and any other materials required for shipping samples.

The NUS Site Manager (SM) shall communicate regularly with the EPA Remedial Project Manager (RPM) to ensure that site planning activities progress in a smooth and timely fashion, through each of the major steps listed above. In addition, the Regional Laboratory Services Coordinator (RLSC) shall communicate regularly with the EPA Regional Sample Control Center (RSCC) to ensure smooth approval and coordination of the sampling effort. Responsibilities in each step are discussed in turn.

5.2.1 Project Operations Plan

The Project Operations Plan (POP) is the major document outlining all planned sampling activities for a RI/FS, including elements of site-specific quality assurance. For non-RI/FS work assignments which nevertheless involve field work and analysis of samples (e.g., PA/SI, oversight, confirmational sampling for enforcement cases), an equivalent task specific POP will be developed.

The POP must be approved by EPA before CLP sample scheduling procedures can be initiated. The POP must therefore be prepared by the NUS Site Manager (SM) and submitted to the EPA Remedial Project Manager (RPM) at least two months prior to the date that samples will be submitted for CLP analysis. Additionally, if Special Analytical Services (SAS) and analysis.are requested, the POP must include specific methods and protocols and the SAS Request Forms required for these analyses. Requirements for SAS should be defined in consultation with chemists, engineers and risk assessment personnel during the development as Data Quality Objectives (DQO's) for inclusion in the Work Plan for the site.

Requirements for notifying EPA of sampling requirements and gaining approval of the POP vary among EPA Regions. The requirements of EPA Region III are outlined below:

- Region III: Region III requires that the SM prepare and submit duplicate copies of the POP one month in advance of planned sampling for CLP analysis. One copy must be sent to the RPM and another copy sent to the RSCC at the Central Regional Laboratory in Annapolis, MD. Following RPM and RSCC review and approval of the POP, the SM is authorized to schedule samples for CLP analysis through the RSCC. Because of some past difficulties in obtaining CLP capacity for SAS samples, Region III requires 6-8 weeks notice in order to schedule these types of samples for CLP analysis.

5.2.2 General Steps in Scheduling CLP Analyses

Following EPA approval of the POP, the Regional Laboratory Services Coordinator (RLSC) contacts the EPA Regional Sample Control Center (RSCC) to schedule samples for CLP analysis. The precise information required by the RSCC in order to schedule sample analyses is discussed in Section 5.2 and on pages 52-62 of the CLP User's Guide (Reference 1 of this Guideline). However, the general steps in initiating this process include:

- RLSC submits request to RSCC for specific CLP RAS analytical support at least one week prior to sampling dates. The RLSC should also request CLP and evidence documentation forms from the RSCC, e.g., Traffic Reports, Chain-of-Custody forms, evidence seals, and sample tags, several weeks in advance of sampling.

- The RSLC submits SAS Request Forms with the POP and to the RSCC between 6-8 weeks prior to the start of sampling.

- RSCC requests Sample Management Office (SMO) to schedule samples for CLP analysis, informing SMO of the sampling requirements identified by the RLSC.

- Initiation of SMO sample scheduling activities with CLP laboratories.

- SMO calls RSCC confirming sample scheduling with CLP laboratories.

- RSCC calls RLSC with information on sample scheduling.

When there is sufficient CLP capacity, the RAS scheduling process usually takes one to three days to complete. If there is a shortage of CLP capacity RAS, sample scheduling can take up to one week. Where CLP capacity is limited, the RSCC may allocate available capacity to another project with a higher regional priority.

Once CLP laboratory assignments have been made, it is important to notify the RSCC immediately of any changes in the sampling plan or schedule. If postponements or cancellations in sampling activities are necessary, this too must be communicated to the RSCC or RPM with reasonable justification for the cancellation. When possible, the RLSC should have a replacement sampling activity to substitute for the postponed or canceled activity to ensure that the assigned CLP capacity is used.

5.2.3 Obtaining CLP Sample Bottles

The CLP Sample Bottle Repository program may be used by any organization scheduling samples through the CLP, and is commonly accessed by regional and NUS contractor clients. One staff member from each region, usually the RLSC, is designated by SMO as a Repository Authorized Requestor (RAR) and only these individuals may place bottle orders through the program using a Sample Bottle Repository Delivery Order (Attachment C). Once designated, the RAR orders bottles directly from the Repository. Because the Repository can respond only to orders submitted by an SMO-designated RAR, NUS regional staff must contact SMO to request any changes in RAR designees.

CLP clients may obtain eleven types of bottles for use in sampling activities. The Sample Bottle Repository Program provides bottles in numbered lots, packing in protective cardboard containers, that are pre-cleaned and QC-tested to ensure no contamination exists that may affect sample data results. The identification number of the bottle lot used for each sample shall be written on the Traffic Report or other sample document form (e.g., Dioxin Shipment Record, Packing List - see Section 5.3).

There are three types of bottle orders; Routine (fifteen or more working days lead time for delivery), Fast-turnaround (more than three days, but less than fifteen days lead time for delivery), and emergency (three days lead time for delivery). Shall it be necessary to cancel an order, contact the Repository either directly or through the RAR, by telephone. Follow up with a cancellation memo to the repository (see CLP User's Guide, Reference 1 of this guideline) with a copy to the work assignment file.

Some common problems which have been experienced with the bottle repository program include:

- Bottles shipped directly to sampling locations occasionally arrive at local hotels or agencies before sampling crews. Consequently, these bottles are sometimes stored improperly, broken or lost. Shipping the bottles to the nearest Federal Express or other carrier's office, marked "For Pick-Up" will avoid these problems. Alternatively, the bottles may be shipped directly to the contractor's office, laboratory, or other field sampling staging location.

- Bottle types are prepared specifically for the type of analyses specified in the CLP User's Guide (Reference 1 of this guideline). Use the correct bottle for the parameter of interest.

5.2.4 Obtaining Sample Shipping Coolers

The CLP does not provide sample shipping coolers. It is therefore the responsibility of the SM to obtain the required number of coolers through his/her firm prior to sampling activities.

All shipping coolers shall have clearly visible return address labels on the outside. Shipping coolers that are labeled in this manner will be returned to the sampler by the CLP laboratory usually within 14 days following laboratory sample receipt. NUS staff shall be sure that the return address label is distinct from, and not obscured by, other shipping labels.

5.3 CLP SAMPLE SCHEDULING AND COLLECTION

The two keys to using the CLP successfully are first, rapid and effective communication among the sampler, RSCC, and SMO, particularly when changes in the sampling plan are necessary, and, second, accurate completion and routing of all required documentation. The appropriate steps in sample scheduling are collection under the CLP's RAS and SAS programs are summarized below. For more complete information on these activities, consult the CLP User's Guide (Reference 1 of this guideline).

5.3.1 Routine Analytical Services (RAS)

To initiate a RAS request, a SM must request the RLSC to contact the RSCC who will in turn contact the SMO by telephone with a description of the analytical requirements. It is the responsibility of the

SM to maintain a working knowledge of RAS protocols and analytical services. The analytical protocols described in the CLP User's Guide (Reference 1) contain specific information on sample types suited to RAS analysis, target analytes, detection limits, and other information.

The RSCC will require the following information from the SM:

- Name(s), firm name, and telephone number(s) of sampling personnel.
- Name and location of the site to be sampled.
- Number of samples and matrix of each sample to be collected.
- Type of analyses required for each sample; i.e., inorganic, organic, dioxin.
- Cyanide analysis requirement (inorganics only).
- Scheduled sample collection and shipment dates.
- Nature of sampling event (i.e., investigation, monitoring, enforcement, remedial construction).
- Other pertinent information which may affect sample scheduling or shipment (i.e., potential delays due to site access, weather conditions, or drilling or sampling equipment difficulties).

Once the RAS laboratory arrangements have been made, the SMO will confirm the field investigation plans with the RSCC and identify the laboratories to which the samples will be sent. The RSCC will, in turn, pass this information back to the RLSC.

For a more detailed description of how to request RAS, see pp. 52-54 of the CLP User's Guide (Reference 1).

5.3.2 Special Analytical Services (SAS)

Analytical services other than those specified in the RAS analytical protocols may be obtained by requesting Special Analytical Services (SAS). Examples of SAS needs include quick turnaround, multiphase, or non-RAS protocol analyses. Although the RSCC will assist in identifying appropriate SAS protocols, it is the responsibility of the SM and project chemist to select and provide to the laboratory the applicable analytical protocols to be used. These protocols must also be included in the Project Operation Plan (POP) for review by ESD before SAS can be requested. The lead time requirement for requesting SAS samples may be lengthened on the basis of the availability and familiarity of these protocols. In addition to the information required for RAS, the RSCC will require the following information from the RLSC for SAS:

- Specific analyses required, appropriate analytical protocols and required detection limits.
- Matrix spike and duplicate frequency.
- Justification of fast turnaround request, if applicable.
- RI/FS contractor contact person for immediate problem resolution, usually the RLSC or the lead environmental chemist assigned to the project.

Once the RSCC requests SAS by telephone, SMO will initiate SAS subcontracting procedures and assign a sequential SAS number for each sampling activity. If the request is made concurrently with a RAS request, SMO will also issue a Case Number. The RSCC will record both of these numbers (if applicable) and use them to reference the samples. The RLSC must complete a SAS Client Request Form (see Attachment D) and submit it to the RSCC prior to sample scheduling for clarification and confirmation purposes.

Following is a brief summary of SAS procedures. SMs may request assistance from the RLSC or the LSM in choosing appropriate SAS protocols. For a more detailed description of how to request SAS, see pp. 55-59, of the CLP User's Guide (Reference 1).

5.3.3 High Concentration Analyses

The steps in scheduling analytical services for high concentration samples are similar to those described above for SAS. High concentration samples require SAS, not RAS analysis. For a description of this option, see pp. 59-61 of the CLP User's Guide (Reference 1).

> Note: Samples no longer travel to EPA EMSL/LV or NEIC for preparation; high concentration samples are now being handled directly by CLP laboratories.

5.3.4 Weekend Shipments

Occasionally, it will be necessary to ship samples on Friday afternoon or evening. If this is the case, the sampler must notify the RSCC and SMO at the latest by 3:00 p.m. eastern standard time, Friday.

5.3.5 Changes in Sampling Plans

Sometimes, due to unforeseen circumstances, it will be necessary to change the sampling plan. This may entail changes in the number of samples, sample matrix, shipment date, or other items. The *sampler must notify the RSCC of any changes.* *Do not ship any samples that differ from those described in the sampling plan without authorization of the RSCC.*

5.3.6 Sample Collection, Preservation, and Holding Times

Detailed guidance on approved sampling procedures may be obtained by consulting other Standard Operating Procedures.

Samples requiring preservatives shall be identified and the necessary techniques to maintain sample quality shall be described in the POP. Common preservation techniques may include the addition of acids or other materials to the sample container, or refrigeration of the sample. Refrigerated samples require special packaging (see Section 5.5.1 below).

Regardless of the method of preservation used (if any), strict adherence to holding times is necessary. Holding times represent the maximum amount of time that a preserved sample may be held from the time of sampling until extraction or analysis without compromising the validity of the analytical results. Maximum holding times at the laboratories are specified in the CLP laboratories scopes-of-work. The difference between those times and the total maximum holding times is the time allowed for shipment to the laboratory. If the laboratory receives a sample with less than the allowable laboratory holding time remaining, the laboratory is not contractually liable for analysis within the holding time (although the laboratories will try to meet the maximum holding times). In general, the following shipping frequencies should be followed:

- Samples requiring organics analysis Shall be shipped the same day collected, or on the following day.
- Samples for inorganic analysis may be held until the shipping container is full. Three days is the maximum recommended period for holding of inorganic samples prior to shipping.

Different EPA regions, however, may have different requirements as to holding times for samples in the field. For a detailed description of holding times, packaging, and transportation see the CLP User's Guide (Reference 1), pp. 71-73 and Appendix C of the User' Guide.

5.4 DOCUMENTATION FOR CLP AND EPA CHAIN-OF-CUSTODY

Requests for analytical services through the CLP must be documented properly. Documentation serves to ensure timely, correct and complete analysis for all requested parameters, provides support data for use in potential enforcement actions, and provides a means by which results may be validated. The CLP User's Guide (Reference 1) provides descriptions of various sample documentation forms and their applicability to CLP analytical requests.

5.4.1 Traffic Reports

All RAS samples must be accompanied by a Traffic Report (TR). TRs are uniquely numbered and come in two varieties: Organic, and Inorganic, (see Attachment E-1, E-2. Following are general guidelines for TRs.

- Use one TR for twenty samples. A sample is a collection of material from a single point at one time and submitted for a single type of analysis (e.g., inorganic or organic). The use of multiple containers does not necessarily mean multiple samples: for example, an organic CL sample may be submitted in three containers for volatile, semi-volatile and pesticide analyses.
- Several spare TR forms shall be brought to the field to replace damaged or improperly completed forms prior to sample shipment.
- The sampler shall complete the following information: Case Number, site name or code, location, analytical laboratory to which the samples are shipped, firm name and sampler's name, dates of samples collection and shipment, number of sample bottles used, sample concentration (e.g., high, medium or low) and matrix.
- Samples for SAS only, (i.e., those for which no RAS is required) will be tracked using a SAS packing List (see Attachment E-3). No TR is to be completed for these samples.
- For samples requiring both RAS and SAS, a TR is used with both the Case number and SAS number entered.
- Samples requiring RAS dioxin analysis only, will be tracked using a Dioxin Shipment Record (see Attachment E-4), not a TR.
- Two copies of the TR go to the laboratory, one to SMO, one to the sampler's files.

Examples of sample TRs are included in Attachment E of this guideline. For a detailed description of these forms and instructions on their usage, see pp. 63-64 of the CLP User's Guide (Reference 1).

5.4.2 *Dioxin Shipment Record*

Samples destined for the RAS dioxin program must be accompanied by the CLP Dioxin Shipment Record (DSR). Only 2,3,7,8 TCDD is considered a RAS parameter. All other isomers are shipped as SAS parameters. These will be used in lieu of the TR for dioxin samples only. A sample form is included as

Attachment E-4 of this guideline. For a description of this form, see p. 65 of the CLP User's Guide (Reference 1).

5.4.3 SAS Packing List

Samples that require SAS only are to be accompanied by an SAS Packing List (PL) instead of a TR. Do not use this form for RAS-plus-SAS samples. A sample form is included as Attachment E-4 of this guideline. See p. 66 of the CLP User's Guide (Reference 1) for a description of this form.

5.4.4 Sample Identification Tags

Sample identification tags are required for all samples. Check off the desired analytical parameters directly on the tag and attach it securely to the sample container. The tags will be retained by the laboratory as physical evidence that the sample was received, and may be used by EPA in litigation.

Care shall be taken in filling out the sample tag. Improperly completed tags require time-consuming telephone inquiries to verify the actual parameters intended.

These tags may not accurately reflect the most recent CLP protocols. Mercury, for example, is considered part of the CLP metals analysis package, but is a separate parameter on these tags . In requesting metals analysis, be sure to check mercury along with metals.

5.4.5 Chain-of-Custody

In order for analytical results to be introduced as evidence in court, the custody of samples must be maintained and documented at all times. Chain-of-custody begins with the taking of the samples in the field. A detailed description of this requirement may be found on pp. 69-70 in the CLP User's Guide (Reference 1).

It is strongly recommended that a second person or persons be used to verify the accuracy and correctness of the chain-of-custody and all other documentation. The second person shall cross-check the chain-of-custody form with packing lists, TRs, sample tags, and logbooks. This cross-check shall be done prior to shipment.

5.5 NUS Program Sample Documentation

In addition to the required EPA QA, and CLP or non-CLP laboratory documentation of samples, certain standard forms are required for NUS program sample description and documentation. These include the well sampling data sheet (for water samples taken from monitoring wells) and the sample logbook, which contains sample log sheets for all samples collected.

5.5.1 Well Sampling Data Sheet

A well sampling data sheet shall be filled out whenever samples are collected from a monitoring well. This form records information about the well evacuation and other parameters (see Attachment F) which may be necessary for sample validation or interpretation. The well sampling data sheet shall be retained in the sample logbook (see Section 5.5.2), attached to the sample logsheet(s) for that well sampling event.

5.5.2 Sample Logbook

The sample logbook is a 3-ring binder which contains sample log sheets for each sample collected, and also well sampling data sheets. A sample log sheet (Attachment F) is filled out for each and every sample collected. This form records vital information concerning the sample source, sampling methods, sample conditions, and field measurements, and is used for sample validation and report preparation. The sample log sheets are numbered in order when placed in the sample logbook, and the sample number and log sheet page numbers are recorded on the sample logbook table of contents sheet (which is placed at the front of the sample logbook) for easy reference and access.

5.6 SAMPLE SHIPMENT AND NOTIFICATION

5.6.1 Sample Packaging

Samples must be properly prepared for shipment to the recipient laboratory. This preparation includes packaging and labeling sample coolers to comply with current U.S. DOT and commercial carrier regulations. The CLP User's Guide (Reference 1) should be consulted for specific guidance in this area. Specific points to note include:

- Dioxin samples shall be shipped as Poison B, rather than flammable liquid or solid.
- The use of bubble wrap sample bottles, after they have been placed in plastic bags, has proven very successful in reducing breakage. The material may be purchased from GSA, local office suppliers or direct from the manufacturer (e.g., Sealed Air Corporation). *Under no circumstances shall earth or ice be used to cushion samples.* Vermiculite or similar material shall be used.

Ice or "blue ice" refrigerant packages may be packed in contact with the sample bottle, and the entire package (bottle and ice) overpacked with plastic bands and bubble wrap.

5.6.2 Use of Common Carriers

Where possible, the use of reputable, overnight couriers, such as Federal Express, DHL, Purolater, and Emery, is strongly encouraged.

5.6.3 Shipment Notification

Immediately after shipping, the sampler must notify the RLSC who will inform the RSCC that samples have been collected and shipped. Under certain circumstances, the FOL or SM can contact the RSCC directly to inform of sample shipment or problems. The sampler should be prepared to provide the following information:

- Sampler Name.
- Case Number and/or SAS Number of the project.
- Batch numbers (dioxin only).
- Exact number(s) and matrices of sample(s) shipped.
- Carrier and airbill number(s) for the shipment.

- Method of shipment.
- Any irregularities or anticipated problems with the samples, including special handling instructions, or deviations from established sampling procedures.
- Status of the sampling project (e.g., final shipment, update of future shipping schedule).
- SMO must be notified by 3:00 p.m. eastern standard time Friday, for samples due to arrive on Saturdays. Failure to do so may result in the laboratory not having anyone on hand to accept the samples. In notifying SMO of weekend or any other deliveries, the airbill number is critical.
- Do not write the site name on the airbill. Use the CLP case number or the NUS charge number to maintain confidentiality at the laboratory.

5.7 POST-SAMPLING ACTIVITIES

Following sample collection and shipment activities, and upon return to the NUS office, the SM or designated staff member must meet the specific information requirements of Region III.

5.7.1 Region III Information Requirements

The SM or FOL must complete the EPA Region III sample shipping log for all samples sent through the CLP (Attachment G) and submit it to the RSCC during the week following sample collection.

5.7.2 Receipt of Data from CLP Laboratories

CLP laboratories are required to analyze RAS samples and report the data within either 30 or 40 days (depending on the specific contract). Often the analysis takes longer, depending on the total CLP sample load and other factors. CLP laboratories are required to send the analytical data directly to the region in which the samples were collected. All data must be reviewed and validated by the region or designated validation contractor before release to the SM for use, and this data review process can often take a month to complete. The EPA data review and validation process is shown in Attachment H. As the attachment indicates, at least two months pass between the time samples were collected to the time the SM receives data that is authorized for use.

6.0 REFERENCES

USEPA, 1984. User's Guide to the Contract Laboratory Program. Office of Emergency and Remedial Response, EPA, Washington, D.C. (revision planned for publication in late 1986).

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U. S. Environmental Protection Agency, 1981. Determination of Polychlorinated Biphenyls in Transformer Fluid and Waste Oils. EPA 600/4-81-045.

U.S. Environmental Protection Agency, 1985. Groundwater Technical Enforcement Guidance Document. Draft - August 1985.

EBASCO Services Incorporated; REM III Field Technical Guideline No. FT-7.04, May 5, 1986.

7.0 ATTACHMENTS (See Appendix B)

~~Attachment A - CLP Sample Scheduling Timeline~~
~~Attachment B - Three-Month Sample Projection Plan~~
~~Attachment C - Sample Bottle Repository Delivery Order~~
~~Attachment D - SAS Client Request Form~~
Attachment E-1 - Inorganic Traffic Report
~~Attachment E-2 - Organic Traffic Report~~
Attachment E-3 - SAS Packing List
~~Attachment E-4 - Dioxin Shipment Record~~
Attachment F - Well Sample Data Sheet
Attachment G - Sample Shipping Log
~~Attachment H - EPA Data Review Process~~

NUS CORPORATION WASTE MANAGEMENT SERVICES GROUP	STANDARD OPERATING PROCEDURES	Number: SF-1.1 Page: 1 of 16 Effective Date: 08/10/88 Revision: 1 Applicability: WMSG Prepared: Earth Sciences
Subject: ON-SITE WATER QUALITY TESTING		Approved: A. K. Bomberger, P.E.

TABLE OF CONTENTS

300352

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 an 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 USEPA.

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.

USEPA, 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. Dept. of the Interior, Reston, VA.

Ebasco Services Incorporated; REM III Field Technical Guideline FT-7.10. February 3, 1986.

7.0 RECORDS

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

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

ATTACHMENT 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

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. concentraiton) using Attachment A.

NUS CORPORATION WASTE MANAGEMENT SERVICES GROUP	STANDARD OPERATING PROCEDURES	Number: SF-1.2	Page: 1 of 10
		Effective Date: 08/10/88	Revision: 1
		Applicability: WMSG	
		Prepared: Earth Sciences	
Subject: SAMPLE PRESERVATION		Approved: A. K. Bomberger, P.E.	

TABLE OF CONTENTS

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.

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

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

Ebasco Services Incorporated; REM III Field Technical Guideline No. FT-7.06. March 4, 1986.

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

FT-7.06
REVISION 0

	SAMPLE TYPE & CONCENTRATION	CONTAINER[1]	SAMPLE SIZE	PRESERVATION[2]	HOLDING TIME[2]
WATER Organics (GC & GC/MS)	VOA	40 ml glass vial	2 x 40 ml	Cool to 4°C	7 days
	Extractables Low/Med.	amber glass	2 x 2 l or 4 x 1 l	Cool to 4°C	5 days to extraction 40 days after extraction
Inorganics	**Metals** Low	high density (h.d.) polyethylene	1 l	HNO_3 to pH ≤2	6 months (Hg-26 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 Concentration	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	40 ml glass vial	3 x 40 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 Concentration	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 Joe of collection. When use of an automated sampler makes it impossible to preserve each aliquot, then chemical samples may be preserved by maintaining at .° 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 4 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.

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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% $Na_2S_2O_3$.

Standard Method for
PENETRATION TEST AND SPLIT-BARREL SAMPLING OF SOILS[1]

This standard is issued under the fixed designation D 1586; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval. A superscript epsilon (ε) indicates an editorial change since the last revision or reapproval.

This method has been approved for use by agencies of the Department of Defense and for listing in the DOD Index of Specifications and Standards.

1. Scope

1.1 This method describes the procedure, generally known as the Standard Penetration Test (SPT), for driving a split-barrel sampler to obtain a representative soil sample and a measure of the resistance of the soil to penetration of the sampler.

1.2 *This standard may involve hazardous materials, operations, and equipment. This standard does not purport to address all of the safety problems associated with its use. It is the responsibility of whoever uses this standard to consult and establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.* For a specific precautionary statement, see 5.4.1.

1.3 The values stated in inch-pound units are to be regarded as the standard.

2. Applicable Documents

2.1 *ASTM Standards:*

D 2487 Test Method for Classification of Soils for Engineering Purposes[2]

D 2488 Practice for Description and Identification of Soils (Visual-Manual Procedure)[2]

D 4220 Practices for Preserving and Transporting Soil Samples[2]

3. Descriptions of Terms Specific to This Standard

3.1 *anvil*—that portion of the drive-weight assembly which the hammer strikes and through which the hammer energy passes into the drill rods.

3.2 *cathead*—the rotating drum or windlass in the rope-cathead lift system around which the operator wraps a rope to lift and drop the hammer by successively tightening and loosening the rope turns around the drum.

3.3 *drill rods*—rods used to transmit downward force and torque to the drill bit while drilling a borehole.

3.4 *drive-weight assembly*—a device consisting of the hammer, hammer fall guide, the anvil, and any hammer drop system.

3.5 *hammer*—that portion of the drive-weight assembly consisting of the 140 ± 2 lb (63.5 ± 1 kg) impact weight which is successively lifted and dropped to provide the energy that accomplishes the sampling and penetration.

3.6 *hammer drop system*—that portion of the drive-weight assembly by which the operator accomplishes the lifting and dropping of the hammer to produce the blow.

3.7 *hammer fall guide*—that part of the drive-weight assembly used to guide the fall of the hammer.

3.8 *N-value*—the blowcount representation of the penetration resistance of the soil. The *N*-value, reported in blows per foot, equals the sum of the number of blows required to drive the sampler over the depth interval of 6 to 18 in. (150 to 450 mm) (see 7.3).

3.9 *ΔN*—the number of blows obtained from each of the 6-in. (150-mm) intervals of sampler penetration (see 7.3).

3.10 *number of rope turns*—the total contact angle between the rope and the cathead at the

[1] This method is under the jurisdiction of ASTM Committee D-18 on Soil and Rock and is the direct responsibility of Subcommittee D18.02 on Sampling and Related Field Testing for Soil Investigations.

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[2] *Annual Book of ASTM Standards*, Vol 04.08.

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6. Drilling Procedure

6.1 The boring shall be advanced incrementally to permit intermittent or continuous sampling. Test intervals and locations are normally stipulated by the project engineer or geologist. Typically, the intervals selected are 5 ft (1.5 mm) or less in homogeneous strata with test and sampling locations at every change of strata.

6.2 Any drilling procedure that provides a suitably clean and stable hole before insertion of the sampler and assures that the penetration test is performed on essentially undisturbed soil shall be acceptable. Each of the following procedures have proven to be acceptable for some subsurface conditions. The subsurface conditions anticipated should be considered when selecting the drilling method to be used.

6.2.1 Open-hole rotary drilling method.

6.2.2 Continuous flight hollow-stem auger method.

6.2.3 Wash boring method.

6.2.4 Continuous flight solid auger method.

6.3 Several drilling methods produce unacceptable borings. The process of jetting through an open tube sampler and then sampling when the desired depth is reached shall not be permitted. The continuous flight solid auger method shall not be used for advancing the boring below a water table or below the upper confining bed of a confined non-cohesive stratum that is under artesian pressure. Casing may not be advanced below the sampling elevation prior to sampling. Advancing a boring with bottom discharge bits is not permissible. It is not permissible to advance the boring for subsequent insertion of the sampler solely by means of previous sampling with the SPT sampler.

6.4 The drilling fluid level within the boring or hollow-stem augers shall be maintained at or above the in situ groundwater level at all times during drilling, removal of drill rods, and sampling.

7. Sampling and Testing Procedure

7.1 After the boring has been advanced to the desired sampling elevation and excessive cuttings have been removed, prepare for the test with the following sequence of operations.

7.1.1 Attach the split-barrel sampler to the sampling rods and lower into the borehole. Do not allow the sampler to drop onto the soil to be sampled.

7.1.2 Position the hammer above and attach the anvil to the top of the sampling rods. This may be done before the sampling rods and sampler are lowered into the borehole.

7.1.3 Rest the dead weight of the sampler, rods, anvil, and drive weight on the bottom of the boring and apply a seating blow. If excessive cuttings are encountered at the bottom of the boring, remove the sampler and sampling rods from the boring and remove the cuttings.

7.1.4 Mark the drill rods in three successive 6-in. (0.15-m) increments so that the advance of the sampler under the impact of the hammer can be easily observed for each 6-in. (0.15-m) increment.

7.2 Drive the sampler with blows from the 140-lb (63.5-kg) hammer and count the number of blows applied in each 6-in. (0.15-m) increment until one of the following occurs:

7.2.1 A total of 50 blows have been applied during any one of the three 6-in. (0.15-m) increments described in 7.1.4.

7.2.2 A total of 100 blows have been applied.

7.2.3 There is no observed advance of the sampler during the application of 10 successive blows of the hammer.

7.2.4 The sampler is advanced the complete 18 in. (0.45 m) without the limiting blow counts occurring as described in 7.2.1, 7.2.2, or 7.2.3.

7.3 Record the number of blows required to effect each 6 in. (0.15 m) of penetration or fraction thereof. The first 6 in. is considered to be a seating drive. The sum of the number of blows required for the second and third 6 in. of penetration is termed the "standard penetration resistance", or the "N-value". If the sampler is driven less than 18 in. (0.45 m), as permitted in 7.2.1, 7.2.2, or 7.2.3, the number of blows per each complete 6-in. (0.15-m) increment and per each partial increment shall be recorded on the boring log. For partial increments, the depth of penetration shall be reported to the nearest 1 in. (25 mm), in addition to the number of blows. If the sampler advances below the bottom of the boring under the static weight of the drill rods or the weight of the drill rods plus the static weight of the hammer, this information should be noted on the boring log.

7.4 The raising and dropping of the 140-lb

(63.5-kg) hammer shall be accomplished using either of the following two methods:

7.4.1 By using a trip, automatic, or semi-automatic hammer drop system which lifts the 140-lb (63.5-kg) hammer and allows it to drop 30 ± 1.0 in. (0.76 m ± 25 mm) unimpeded.

7.4.2 By using a cathead to pull a rope attached to the hammer. When the cathead and rope method is used the system and operation shall conform to the following:

7.4.2.1 The cathead shall be essentially free of rust, oil, or grease and have a diameter in the range of 6 to 10 in. (150 to 250 mm).

7.4.2.2 The cathead should be operated at a minimum speed of rotation of 100 RPM, or the approximate speed of rotation shall be reported on the boring log.

7.4.2.3 No more than 2¼ rope turns on the cathead may be used during the performance of the penetration test, as shown in Fig. 1.

NOTE 4—The operator should generally use either 1¾ or 2¼ rope turns, depending upon whether or not the rope comes off the top (1¾ turns) or the bottom (2¼ turns) of the cathead. It is generally known and accepted that 2¾ or more rope turns considerably impedes the fall of the hammer and should not be used to perform the test. The cathead rope should be maintained in a relatively dry, clean, and unfrayed condition.

7.4.2.4 For each hammer blow, a 30-in. (0.76-m) lift and drop shall be employed by the operator. The operation of pulling and throwing the rope shall be performed rhythmically without holding the rope at the top of the stroke.

7.5 Bring the sampler to the surface and open. Record the percent recovery or the length of sample recovered. Describe the soil samples recovered as to composition, color, stratification, and condition, then place one or more representative portions of the sample into sealable moisture-proof containers (jars) without ramming or distorting any apparent stratification. Seal each container to prevent evaporation of soil moisture. Affix labels to the containers bearing job designation, boring number, sample depth, and the blow count per 6-in. (0.15-m) increment. Protect the samples against extreme temperature changes. If there is a soil change within the sampler, make a jar for each stratum and note its location in the sampler barrel.

8. Report

8.1 Drilling information shall be recorded in the field and shall include the following:

8.1.1 Name and location of job.

8.1.2 Names of crew.

8.1.3 Type and make of drilling machine.

8.1.4 Weather conditions.

8.1.5 Date and time of start and finish of boring.

8.1.6 Boring number and location (station and coordinates, if available and applicable).

8.1.7 Surface elevation, if available.

8.1.8 Method of advancing and cleaning the boring.

8.1.9 Method of keeping boring open.

8.1.10 Depth of water surface and drilling depth at the time of a noted loss of drilling fluid, and time and date when reading or notation was made.

8.1.11 Location of strata changes.

8.1.12 Size of casing, depth of cased portion of boring.

8.1.13 Equipment and method of driving sampler.

8.1.14 Type sampler and length and inside diameter of barrel (note use of liners).

8.1.15 Size, type, and section length of the sampling rods, and

8.1.16 Remarks.

8.2 Data obtained for each sample shall be recorded in the field and shall include the following:

8.2.1 Sample depth and, if utilized, the sample number.

8.2.2 Description of soil.

8.2.3 Strata changes within sample.

8.2.4 Sampler penetration and recovery lengths, and

8.2.5 Number of blows per 6-in. (0.15-m) or partial increment.

9. Precision and Bias

9.1 Variations in N-values of 100 % or more have been observed when using different standard penetration test apparatus and drillers for adjacent borings in the same soil formation. Current opinion, based on field experience, indicates that when using the same apparatus and driller, N-values in the same soil can be reproduced with a coefficient of variation of about 10 %.

9.2 The use of faulty equipment, such as an extremely massive or damaged anvil, a rusty cathead, a low speed cathead, an old, oily rope, or massive or poorly lubricated rope sheaves can significantly contribute to differences in N-values

300380

Designation: D 1587 - 83

Standard Practice for THIN-WALLED TUBE SAMPLING OF SOILS[1]

This standard is issued under the fixed designation D 1587; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval. A superscript epsilon (ε) indicates an editorial change since the last revision or reapproval.

This practice has been approved for use by agencies of the Department of Defense and for listing in the DOD Index of Specifications and Standards.

1. Scope

1.1 This practice covers a procedure for using a thin-walled metal tube to recover relatively undisturbed soil samples suitable for laboratory tests of structural properties. Thin-walled tubes used in piston, plug, or rotary-type samplers, such as the Denison or Pitcher, must comply with the portions of this practice which describe the thin-walled tubes (5.3).

NOTE 1—This practice does not apply to liners used within the above samplers.

2. Applicable Documents

2.1 *ASTM Standards:*

D 2488 Practice for Description and Identification of Soils (Visual-Manual Procedure)[2]

D 3550 Practice for Ring-Lined Barrel Sampling of Soils[2]

D 4220 Practices for Preserving and Transporting Soil Samples[2]

3. Summary of Practice

3.1 A relatively undisturbed sample is obtained by pressing a thin-walled metal tube into the in-situ soil, removing the soil-filled tube, and sealing the ends to prevent the soil from being disturbed or losing moisture.

4. Significance and Use

4.1 This practice, or Practice D 3550, is used when it is necessary to obtain a relatively undisturbed specimen suitable for laboratory tests of structural properties or other tests that might be influenced by soil disturbance.

5. Apparatus

5.1 *Drilling Equipment*—Any drilling equipment may be used that provides a reasonably clean hole; that does not disturb the soil to be sampled; and that does not hinder the penetration of the thin-walled sampler. Open borehole diameter and the inside diameter of driven casing or hollow stem auger shall not exceed 3.5 times the outside diameter of the thin-walled tube.

5.2 *Sampler Insertion Equipment*, shall be adequate to provide a relatively rapid continuous penetration force. For hard formations it may be necessary, although not recommended, to drive the thin-walled tube sampler.

5.3 *Thin-Walled Tubes*, should be manufactured as shown in Fig. 1. They should have an outside diameter of 2 to 5 in. and be made of metal having adequate strength for use in the soil and formation intended. Tubes shall be clean and free of all surface irregularities including projecting weld seams.

5.3.1 *Length of Tubes*—See Table 1 and 6.4.

5.3.2 *Tolerances*, shall be within the limits shown in Table 2.

5.3.3 *Inside Clearance Ratio*, should be 1 % or as specified by the engineer or geologist for the soil and formation to be sampled. Generally, the inside clearance ratio used should increase with the increase in plasticity of the soil being sampled. See Fig. 1 for definition of inside clearance ratio.

5.3.4 *Corrosion Protection*—Corrosion, whether from galvanic or chemical reaction, can damage or destroy both the thin-walled tube and the sample. Severity of damage is a function of

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[1] This practice is under the jurisdiction of ASTM Committee D-18 on Soil and Rock and is the direct responsibility of Subcommittee D18.02 on Sampling and Related Field Testing for Soil Investigations.

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[2] *Annual Book of ASTM Standards*, Vol 04.08.

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time as well as interaction between the sample and the tube. Thin-walled tubes should have some form of protective coating. Tubes which will contain samples for more than 72 h shall be coated. The type of coating to be used may vary depending upon the material to be sampled. Coatings may include a light coat of lubricating oil, lacquer, epoxy, Teflon, and others. Type of coating must be specified by the engineer or geologist if storage will exceed 72 h. Plating of the tubes or alternate base metals may be specified by the engineer or geologist.

5.4 *Sampler Head* serves to couple the thin-walled tube to the insertion equipment and, together with the thin-walled tube, comprises the thin-walled tube sampler. The sampler head shall contain a suitable check valve and a venting area to the outside equal to or greater than the area through the check valve. Attachment of the head to the tube shall be concentric and coaxial to assure uniform application of force to the tube by the sampler insertion equipment.

6. Procedure

6.1 Clean out the borehole to sampling elevation using whatever method is preferred that will ensure the material to be sampled is not disturbed. If groundwater is encountered, maintain the liquid level in the borehole at or above ground water level during the sampling operation.

6.2 Bottom discharge bits are not permitted. Side discharge bits may be used, with caution. Jetting through an open-tube sampler to clean out the borehole to sampling elevation is not permitted. Remove loose material from the center of a casing or hollow stem auger as carefully as possible to avoid disturbance of the material to be sampled.

NOTE 2—Roller bits are available in downward-jetting and diffused-jet configurations. Downward-jetting configuration rock bits are not acceptable. Diffuse-jet configurations are generally acceptable.

6.3 Place the sample tube so that its bottom rests on the bottom of the hole. Advance the sampler without rotation by a continuous relatively rapid motion.

6.4 Determine the length of advance by the resistance and condition of the formation, but the length shall never exceed 5 to 10 diameters of the tube in sands and 10 to 15 diameters of the tube in clays.

NOTE 3—Weight of sample, laboratory handling capabilities, transportation problems, and commercial availability of tubes will generally limit maximum practical lengths to those shown in Table 1.

6.5 When the formation is too hard for push-type insertion, the tube may be driven or Practice D 3550 may be used. Other methods, as directed by the engineer or geologist, may be used. If driving methods are used, the data regarding weight and fall of the hammer and penetration achieved must be shown in the report. Additionally, that tube must be prominently labeled a "driven sample."

6.6 In no case shall a length of advance be greater than the sample-tube length minus an allowance for the sampler head and a minimum of 3 in. for sludge-end cuttings.

NOTE 4—The tube may be rotated to shear bottom of the sample after pressing is complete.

6.7 Withdraw the sampler from the formation as carefully as possible in order to minimize disturbance of the sample.

7. Preparation for Shipment

7.1 Upon removal of the tube, measure the length of sample in the tube. Remove the disturbed material in the upper end of the tube and measure the length again. Seal the upper end of the tube. Remove at least 1 in. of material from the lower end of the tube. Use this material for soil description in accordance with Practice D 2488. Measure the overall sample length. Seal the lower end of the tube. Alternatively, after measurement, the tube may be sealed without removal of soil from the ends of the tube if so directed by the engineer or geologist.

NOTE 5—Field extrusion and packaging of extruded samples under the specific direction of a geotechnical engineer or geologist is permitted.

NOTE 6—Tubes sealed over the ends as opposed to those sealed with expanding packers should contain end padding in end voids in order to prevent drainage or movement of the sample within the tube.

7.2 Prepare and immediately affix labels or apply markings as necessary to identify the sample. Assure that the markings or labels are adequate to survive transportation and storage.

8. Report

8.1 The appropriate information is required as follows:

8.1.1 Name and location of the project.

8.1.2 Boring number and precise location on project.

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E

APPENDIX B

FORMS FOR RI ACTIVITIES

C&R BATTERY SITE

APPENDIX B FORMS FOR RI ACTIVITIES

Attachment B-1	-	Sample Label
Attachment B-2	-	Sample Identification Tag
Attachment B-3	-	Chain-of-Custody Record Form, 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-12	-	Inorganics Traffic Report Form
Attachment B-13	-	Traffic Report Labels
Attachment B-14	-	Special Analytical Services (SAS) Packing List
Attachment B-16	-	Sample Shipping Log
Attachment C-1	-	Groundwater Level Measurement Sheet
Attachment C-3	-	Hydraulic Conductivity Testing Data Sheet
Attachment C-5	-	Summary Log of Boring
Attachment C-6	-	Overburden Monitoring Well Construction Sheet
Attachment C-11	-	Test Pit Log Form
Attachment D-1	-	Equipment Calibration Log
Attachment A	-	SA-6.3, Typical Site Logbook Entry
QAPP Fig. 7-2	-	Task Modification Request Form
Attachment A	-	SA-6.5, Daily Activities Record-Field Investigation Form
Attachment B	-	SA-6.5, Weekly Field Summary Report Form
Attachment B	-	SA-6.6, Planned Sampling Activity Requiring CLP Analysis Form
Attachment C	-	SA-6.6, CLP Sample Bottle Repository Superfund Delivery Request Form
Attachment D	-	SA-6.6, Special Analytical Services Client Request From

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

Designate: Grab | Comp.

Time

Month/Day/Year

Station No.

Project Code

Samplers (Signatures)

Station Location

Preservative:
Yes ☐ **No** ☐

ANALYSES

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

Remarks:

Tag No.	Lab Sample No.
3 60966	

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY

EPA

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

CHAIN OF CUSTODY RECORD

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

3-15966

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

ATTACHMENT B-4

CHAIN-OF-CUSTODY SEAL

ORIGINAL

Signature
Date
CUSTODY SEAL

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY

CUSTODY SEAL
Date
Signature

ATTACHMENT B-5
CLP SAMPLE BOTTLE REPOSITORY
SUPERFUND DELIVERY REQUEST

ORIGINAL (Red)

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

ORIGINAL (Red)

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

☐ Spring
☐ Lake
☐ Stream
☐ Other ____

Page ____ of ____

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-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)

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

SITE NAME:

CITY, STATE: SITE SPILL ID:

② REGION NO: SAMPLING COMPANY

SAMPLER: (NAME)

③ SHIP TO:

ATTN: ____________

④ SAMPLING DATE:

BEGIN: __________ END: __________

⑤ DATE SHIPPED: ______ CARRIER: ______

AIRBILL NO: ____________

⑥ SAMPLE DESCRIPTION (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

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-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:

SAS REQUEST: (details required)

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: LAB NAME	DATE SHIPPED	DATA RECEIVED (XX out items not requested): VOA	BNA	PEST	TCDD	METALS	CN	SAS REQUEST: LAB NAME	SAS REQUEST (itemize)	DATE SHIPPED	DATA REC'D

ATTACHMENT B-17

PROJECT SAMPLE SUMMARY

NAME ______________

____

____

DATE ______________

SAMPLERS INITIALS ______________

CASE NO / SAS NO	LABORATORY NAME	SAMPLE MEDIA	ANALYSES	NO OF SAMPLES	TRAFFIC REPORT NO s	BLANK TRAFFIC REPORT NO s	DUPLICATE TRAFFIC REPORT NO s	DATE SHIPPED

ORIGINAL (Red)

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-4
PACKER TESTING REPORT FORM

PACKER TEST REPORT

PROJECT: ____________________
BORING NO.: __________ CASING DEPTH: __________
TEST INTERVAL: ____________________

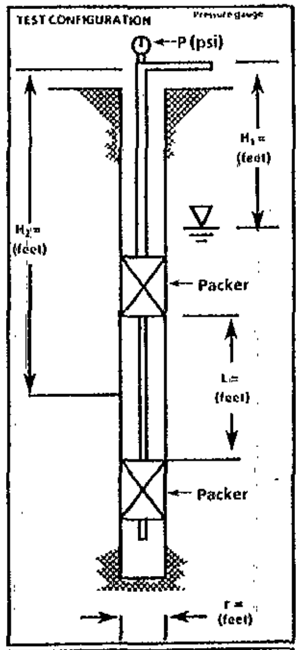
PROJECT NO.: __________ TEST NO: __________
CONTRACTOR: ____________________
BY: ____________________ CHECKED: __________

PAGE ______ OF ______
STATIC WATER LEVEL ______
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)

$CP = (1/(2\pi L))\ln(L/r)(70{,}315.5)$
7.48 Gallons = 1 Ft^3
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 (2.37")	NX (3")
1	31,000	28,500	25 800	23 300
2	19,400	18,100	16 800	15 500
5	9 800	9,300	8 600	8,200
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 RQD	DEPTH (ft.) OR RUN NO.	BLOWS/ 6" OR RQD (%)	SAMPLE RECOVERY /SAMPLE LENGTH	LITHOLOGY CHANGE (Depth.ft.) OR SCREENED INTERVAL	MATERIAL DESCRIPTION: SOIL DENSITY/ CONSISTENCY OR ROCK HARDNESS	MATERIAL DESCRIPTION: COLOR	MATERIAL DESCRIPTION: MATERIAL CLASSIFICATION	USCS OR ROCK BROKENESS	REMARKS

REMARKS ____
____
____

BORING ________

PAGE ____ OF ____

300402

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%(+) > ¼" Ø	CLEAN GRAVELS Low % fines	Wide range in grain size and substantial amounts of all intermediate particle sizes.	GW	Well graded gravels, gravel-sand mixtures, little or no fines
		Predominantly one size or a range of sizes with some intermediate sizes missing.	GP	Poorly graded gravels, gravel-sand mixtures, little or no fines.
	GRAVELS W/FINES High % fines	Non-plastic fines (for identification procedures see ML)	GM	Silty gravels, poorly graded gravel-sand-silt mixtures.
		Plastic fines (for identification procedures see CL)	GC	Clayey gravels, poorly graded gravel-sand-clay mixtures.
SANDS 50%(+) < ¼" Ø	CLEAN SANDS Low % fines	Wide range in grain size and substantial amounts of all intermediate particle sizes.	SW	Well graded sand, gravelly sands, little or no fines.
		Predominantly one size or a range of sizes with some intermediate sizes missing.	SP	Poorly graded sands, gravelly sands, little or no fines.
	SANDS W/FINES High % fines	Non plastic fines (for identification procedures see ML)	SM	Silty sands, poorly graded sand-silt mixtures.
		Plastic fines (for identification procedures see CL)	SC	Clayey sands, poorly graded sand-clay mixtures.

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

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

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

DENSITY OF GRANULAR SOILS

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

CONSISTENCY OF COHESIVE SOILS

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

ROCK TERMS

ROCK HARDNESS (FROM CORE SAMPLES)

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

ROCK BROKENNESS

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

LEGEND

SOIL SAMPLES - TYPES

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

ROCK SAMPLES - TYPES

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

WATER LEVELS

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

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

ORIGINAL (Red)

300403

ATTACHMENT C-10

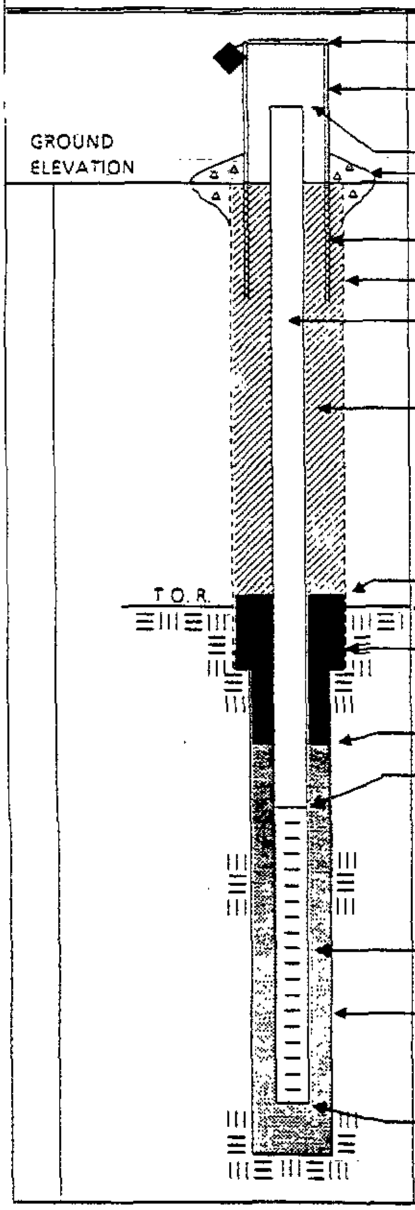
NUS CORPORATION
A Halliburton Company

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 ....

FIGURE 7-2

NUS CORPORATION
ARCS III PROGRAM
TASK MODIFICATION REQUEST

EPA Work Assignment Number ______ Project Number ______ TMR Number ______

To ______ Location ______ Date ______

Description:

______

Reason for Change:

______

Recommended Disposition:

______

Field Operations Leader (Signature) ______ Date ______

Disposition:

______

Project Manager ______ Date ______

Distribution: Program Manager
Quality Assurance Officer
Project Manager
Field Operations Leader

Others as required ______

DAILY ACTIVITIES RECORD - FIELD INVESTIGATION

NUS CORPORATION

PROJECT NAME: ______ PROJECT NO.: ______
CLIENT: ______ LOCATION: ______
DATE: ______ ARRIVAL TIME: ______ DEPARTURE TIME: ______
CONTRACTOR: ______ DRILLER: ______
BORING NO.: ______ NUS REPRESENTATIVE: ______

ITEM (1)	ORIGINAL QUANTITY (2) ESTIMATE	QUANTITY (2) TODAY	PREVIOUS TOTAL (2) QUANTITY	CUMULATIVE QUANTITY (2) TO DATE
1. Mobilization/Demobilization	Job			
2. Overburden Drilling/Sampling, minimum 6-inch	100 ft.			
3. Overburden Drilling, 10-inch	250 ft.			
4. Overburden Drilling 14-inch	450 ft.			
5. Bedrock Drilling 6-inch	530 ft.			
6. Bedrock Drilling 10-inch	650 ft.			
7. Bedrock Drilling 14-inch	150 ft.			
8. Temporary 6-inch Steel Casing	250 ft.			
9. Temporary 10-inch Steel Casing	200 ft.			
10. Temporary 14-inch Steel Casing	250 ft.			
11. Permanent 6-inch Steel Casing	1,250 ft.			
12. Permanent 10-inch Steel Casing	400 ft.			
13. PVC Well Construction/Installation	1,120 ft.			
14. Mine Void Sealing	8			
15. Boring Backfilling	NA			
16. Well Development	24 hrs.			
17. Test Borings	200 ft.			
18. Test Pit Excavation	50 hrs.			
19. Standby	20 hrs.			

COMMENTS: ______

(1) AS LISTED IN SPECS
(2) INCLUDE QUANTITY AND UNITS
(Ex. 20 ft., 6 hrs.)

APPROVED BY:

______
NUS FIELD REPRESENTATIVE

______
DRILLER OR REPRESENTATIVE

ATTACHMENT A

ATTACHMENT B
PAGE 1 OF 2

WEEKLY FIELD SUMMARY REPORT

SUNDAY

Date : ______________ Personnel ______________ ______________

Weather: ______________ Onsite ______________ ______________

______________ ______________

Site Activities: ______________________________

____

____

____

MONDAY

Date : ______________ Personnel ______________ ______________

Weather: ______________ Onsite ______________ ______________

______________ ______________

Site Activities: ______________________________

____

____

____

TUESDAY

Date : ______________ Personnel ______________ ______________

Weather: ______________ Onsite ______________ ______________

______________ ______________

Site Activities: ______________________________

____

____

____

ATTACHMENT B

PLANNED SAMPLING ACTIVITY REQUIRING CLP ANALYSES

Region ________ Site ________ Month/Year of Activity ________ Case ________

Sampling Organization (State, REM, FIT, etc.) ________ Regional Contact ________ Telephone ________

Type of Investigation (RI/FS, Enforcement, etc.) ________ Activity Status (Definite, Conditional or Tentative) ________

Sampling Date(s) ________ Alternate Sampling Date(s) ________

Sample Shipment Date(s) ________ Alternate Shipment Date(s) ________

Routine Analytical Services Required	Media/Concentration									Total		
	Liquid or Water			Solid, Soil or Sediment			Other (SAS)					
	Low	Med	High	Low	Med	High	Low	Med	High	Low	Med	High
Full HSL Organics												
VOA Fraction Only												
Semi-VOA Fraction Only												
Pesticide/PCB Fraction Only												
Dioxin Only												
HSL Metals & Cyanide												
HSL Metals Only												

Special Analytical Services Required: Specify (Method, QA, Reporting Requirements to be Provided via SMO Client Request Form)

Submittal Status: ________ (Current, 1, 2 or 3 Month Projection)

Notification Status: ________ (Initial Notification or Resubmittal)

Resubmittal Status: ________ (Resubmittal With or Without Changes)

Submitted By: Date: Phone:

Approved By: Date:

Date Notification Received By SMO:

Date Laboratory(ies) Assigned:

ORIGINAL (Red)

300409

ATTACHMENT C

ORIGINAL (Red)

CLP SAMPLE BOTTLE REPOSITORY
SUPERFUND DELIVERY REQUEST

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: 415/782-3905

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-L	polyethylene bottle	12	______
D	120-mL	wide-mouth glass vial	12	______
E	16-oz	wide-mouth glass jar	12	______
F	8-oz	wide-mouth glass jar	12	______
G	4-oz	wide-mouth glass jar	12	______
H	1-L	amber glass bottle	12	______
J	32-oz	wide-mouth glass jar	12	______
K	4-L	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 D - page 1

ORIGINAL (Red)

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 SERVICES

Client Request

☐ Regional Transmittal ☐ Telephone Request

A. EPA Region/Client: ____________________

B. Representative: ____________________

C. Telephone Number: ____________________

D. Date of Request: ____________________

Please provide below description of your request for Special Analytical Services under the Contract Laboratory Program. In order to most efficiently obtain laboratory capability for your request, please address the following considerations, if applicable. Incomplete or erroneous information may result in a delay in the processing of your request. Please continue response on additional sheets, or attach supplementary information as needed.

1. General description of analytical service requested: ____________________

2. Definition and number of work units involved (specify whether whole samples or fractions; whether organics or inorganics; whether aqueous or soil and sediments; and whether low, medium or high concentration):

3. Purpose of analysis (specify whether enforcement, remedial action, etc.):

4. Estimated date(s) of collection: ____________________

5. Estimated date(s) and method of shipment: ____________________

ATTACHMENT D - page 2

6. Approximate number of days results required after lab receipt of samples: ____________________

7. Analytical protocol required (attach copy if other than a protocol currently used in this program): ____________________

8. Special technical instructions (if outside protocol requirements, specify compound names, CAS numbers, detection limits, etc.): ____________________

9. Analytical results required (if known, specify format for data sheets, QA/QC reports, Chain of Custody documentation, etc.) If not completed, format of results will be left to program discretion. ____________________

10. Other (use additional sheets or attach supplementary information, as needed): ____________________

11. Name of sampling/shipping contact: ____________________
    Phone: ____________________

Please return this request to the Sample Management Office as soon as possible to expedite processing of your request for special analytical services. Should you have any questions or need any assistance, please call us at the Sample Management Office.

ORIGINAL

C

APPENDIX C

COLLECTION PROCEDURES OF

VARIOUS MEDIA SAMPLES FOR BIOASSAYS

C&R BATTERY SITE

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
ENVIRONMENTAL RESEARCH LABORATORY
200 S.W. 35TH STREET
CORVALLIS, OREGON 97333

RECEIVED
10-5-87

November 26, 1985

SUBJECT: Collection of Wastesite Samples

FROM: William E. Miller

TO: All Personnel Responsible for Collecting Samples at Waste Sites for Shipment to the HMAT, Corvallis, OR.

ORIGINAL (Red)

The proper collection, packaging and shipping of waste site samples of critical importance. Proper sampling and shipping insures sample integrity, safety in handling, and an adequate data base for sample processing, and future sampling requirements. This memo outlines the mir requirements for collection and shipment of waste site samples to the Hazardous Materials Assessment Team (HMAT) Corvallis, Or.

Sample Containers

3.0 gallon plastic pails with lids
cardinal plastics # 384-P, or equivalent
Akron Ohio (216) 562-9600

5.0 gallon steel paint cans with crimp lids
Freund Can Company # 1260-4450, or equivalent
1-800-621-2808

2.5 gallon cubitainers
VWR Scientific # 243000-155, or equivalent

Plastic Trash Bags 1 x 2'
VWR Scientific #11215-392, or equivalent

ORM-E Labels - Labelmaster, Chicago, IL 60646

Sample Collection

Soils and Sediments: Completely fill the double inner plastic bag plastic pail with soil or sediment. Seal the plastic bags with tape. S lid on pail and insert the sample container into a plastic outer bag. S the outer bag with tape and insert soil or sediment sample into the 5.0 gallon metal paint can. Crimp lid on can. Affix strips of tape (which identify the packager and the date) over the crimped edges in at least t places.

Water Samples: Fill the 2.5 gallon cubitainers with surface or gro water sample. Seal screw cap with tape. Place sample container into tw plastic bags. Seal bags with tape and place sealed water sample into 5.

gallon metal paint can. Crimp lid on bucket and seal with tape as described above.

All containers will be identified according to the following labelin requirements. In addition to the labeling requirements a data sheet (see attachment) must be filled out for each sample in as much detail as possible.

Labeling Requirements

Scrutiny of department of Transportation (DOT) regulations by our laboratory Toxic Substances Control Officer (TSCO) and safety officer (SO, reveals that environmental samples collected from hazardous materials disposal sites are to be labeled as -- Other Regulated Materials, "E" Cla (ORM-E). This label will be affixed to the lid and the bucket itself for all environmental samples collected by or for HMAT use. This label identifies the sample as being potentially hazardous, flammable, corrosive poisonous, etc., but containing less than a reportable quantity (RQ) of th substances. All such designations should be clearly identifiable (white, black or vice versa) and affixed with a permanent ink or paint. A high-lighting outline is required to provide at least a one inch border (Figure 1). If sample contents are known, or if reportable quantities (R of various substances (corrosive, poison etc.) are contained or expected t be contained in the sample, then labeling must comply with DOT, CFR-49 specifications. These specifications are found in Section 172 of DOT hazardous materials shipping and handling regulations. These regulations can be found at the office of any carrier authorized to haul hazardous materials.

Figure 1. Other Regulated Material -- E Class Label Designation

Send soil and water samples to:
William Miller or Cathy Bartels
US EPA, Corvallis Environmental Research Laboratory
200 SW 35th Street
Corvallis, Or 97333

Attachment

300416

D

300417

ORIGINAL (Red)

APPENDIX D

HEALTH AND SAFETY PLAN

C&R BATTERY SITE

NUS CORPORATION WASTE MANAGEMENT SERVICES GROUP	HEALTH AND SAFETY STANDARD OPERATING PROCEDURES	Number: HS01	Page: 1 of 44
		Effective Date: 03/15/87	Revision: 3
		Applicability: WMSG	
		Prepared: Health and Safety Group	
Subject: HEALTH AND SAFETY PLANS		Approved: R. C. Gerlach, CIH	

HEALTH AND SAFETY PLAN
BACKGROUND

ORIGINAL (Red)

Site Name: C&R Battery
Client Contact: EPA RPM Mr. Paul Leonard
Address: Chesterfield County, Virginia
Phone No.: (215) 597-8257
Other Contacts:
Phone No.:
Phone No.:

Date Plan Requested: May 26, 1988
Purpose of Site Visit: Environmental Assessment
Proposed Date of Work: 08-15-88 to 09-26-88

Proposed Site Investigation Team:

NUS Personnel:	Discipline/Tasks Assigned:
Richard Ninesteel	Project Manager
Richard Bethel	Geologist
Kevin Kenney	Health and Safety Officer (HSO)
TBA	Sampler
TBA	Sampler

Other	Purpose:

Plan Preparation:

Prepared by: Kevin Kenney (06/01/88)
Reviewed and Approved by: Richard C Gerlach (/ /)
Reviewed: Marilyn M. Hoff 6/15/88
NUS Project Manager: Richard Ninesteel 6/15/88
Follow Up Report:
Responsible Person: Scott Krall (Must fill out Follow Up Report)

300419

FACILITY DESCRIPTION

ORIGINAL (Red)

Location

The C&R Battery Site is located approximately 6 miles southeast of Richmond, along the north side of Bellwood Road, approximately, 3,750 feet east of Interstate 95. The site is within Chesterfield County, at 37° 35' 04" latitude and 75° 24' 56" longitude on the Drewry's Bluff, Virginia, 7.5-minute United States Geological Survey (U.S.G.S.) topographic quadrangle maps.

Site Layout

The site consists of a battery processing saw/shredder designed to separate and recover lead from discarded auto and truck batteries. The battery crusher machine, reclaimed materials, waste materials, and all other related activities and equipment are confined to a single area of approximately 4 acres.

The site is basically a rectangular property which slopes generally 3 to 5 percent to the southeast. The battery breaker itself is located within the south central portion of the lot. An acid storage/containment area is also located within the central area of the site adjacent to the battery crusher. Material stockpile areas (both reclaimed lead and scrap) are located just west and north of the battery crusher. According to Mr. Charles Guyton, the site operator, and available site diagrams as prepared by private consultants under contract to the operator, the battery crusher has been constructed on a large concrete pad. The lateral extent of this pad and its structural continuity could not be field verified since it was buried by battery casings and soil.

The site is bordered on the south and west by open fields and wood lots. Capital Oil Company, a small fuel oil distributor, borders the site on the east. North of the site are residential properties and the James River. Adjoining terrain is generally topographically similar to the site, with the exception of the Drewry's Bluff area, located approximately 1,400 feet due northwest of the site. The Drewry's Bluff, an historic area, is characterized by a steep 100- to 120-foot-high bluff overlooking the James River.

Status (active, inactive, unknown):

The C&R Battery Site, approximately 4 acres in size, is a relatively flat, open parcel of land located within a somewhat sparsely populated area. The chief activities on site have been lead reclamation from discarded batteries. A saw/breaker facilitates the reclamation process. Sulfuric acid is drained and stored in open areas on site. Lead sulfide and raw lead is stored in piles and/or drums. The site was active during initial site visits. The Virginia State Water Control Board (VA WCB) has reported that it is now abandoned.

History (worker or non-worker injury; complaints from public; previous agency action):

Virginia OSHA first inspected the site in 1983 while the battery processing facility was still in operation. Air monitoring of the breathing zone at several work stations measured lead at concentrations up to 112 $\mu g/m^3$, well above the existing OSHA standard of 50 $\mu g/m^3$. Employees were found to have elevated levels of lead in their blood.

Monitoring used on previous site work; previous sampling data:

All sampling data has been reviewed and the most recent and serious contaminant levels can be found in Table 1 on page 7.

ORIGINAL

Regulatory History

Federal:

The EPA has initiated applicable preliminary assessment report, non-sampling site reconnaissance report, site inspection report, and hazard ranking system reports. Refer to EPA file VA 281 for details.

State:

VA State Water Control Board (VA WCB) has had extensive involvement with the site beginning in the late 1970s. Generally, orders for the submission of a wastewater treatment permit application and a site reclamation plan have been issued to the operator. Upon several submissions of proposed reclamation plans, and amended permit applications, the operator has yet to be declared in compliance. Subsequent court orders have been issued and several court appearances have been made in relation to the Water Control Board's attempts at bringing the site into compliance. As of the latest date of site operation (early 1985) compliance had not been achieved. The WCB noted serious concerns over the financial stability of C&R Battery and its ultimate ability to assume the cost of site reclamation.

VA Occupational Safety and Health Administration (VA OSHA) has also had extensive involvement with the C&R Battery Site. According to Mr. Richard Anderson of VA OSHA, his first inspection of the site in 1983 revealed numerous violations of current OSHA standards. Air monitoring of the breathing zone on site, at several work stations, have indicated conditions well above existing standards (standard for lead is 50 µg/cu meter). Levels have been measured at ranges from 5 to 112 µg/cubic meters. Additionally, employees at the site have been found to have elevated levels of lead in blood samples. According to Mr. Anderson, excessive fines have been issued to the operator for noncompliance. (Although not confirmed, penalties in excess of $60,000 have been issued.)

ORIGINAL (Red)

Characteristics of Waste:

Corrosive	X	Flammable		Radioactive			
Toxic	X	Volatile		Reactive		Inert	

Physical Hazards of Site:

Aside from hazards presented by chemical substances, physical hazards must also be addressed. Physical hazards could involve such items as

- Contact with energized sources.
- Exposure to moving machinery, particularly during drilling activities.
- Uneven or unstable terrain (slip, trip hazards).
- Manual lifting techniques.

Control efforts for these potential hazards include that subcontractor personnel utilizing items of machinery on site (e.g., drill rigs) shall ensure that they are properly guarded, maintained, and operated. No masts or any other such projecting items shall be permitted within a 20-foot radius of overhead energized sources. Also, any areas targeted for subsurface investigation shall first be investigated to determine the presence of underground utilities.

Personnel are to be advised in regard to hand/clothing contact with moving machinery pinch points. Protective gear must fit properly and be taped, not only to control chemical exposure but also to avoid becoming caught in moving machinery. Additionally, equipment shall be shut down and locked out before maintenance functions are performed.

During any manual material handling tasks, personnel are to lift the load with their legs and not with their backs. Also, the correct number of personnel must be used to lift or handle heavy/bulky equipment. These procedures are to be employed to attempt to avoid back strain.

SCOPE OF WORK (Task 1, Task 2, etc.)

Task 1 - *Mobilization and Demobilization*

Task 2 - Hydrogeologic Investigation

Task 3 - Sampling

a) Groundwater

b) Surface and subsurface soils

c) Surface water and sediment

d) Debris pile investigation

Task 4 - Surveying

TABLE 1

PROTECTION AGAINST POTENTIAL HAZARDS
C&R BATTERY SITE

Substance	CAS No.	In Sample (Water, Air, Waste) g/Kg	Toxicity			C
			TLV (mg/m^3)	Route of Exposure	Comments	
Lead	7439-92-1	67.7	0.15	Inhalation, ingestion, skin	Attacks the G.I. tract CNS, kidneys, and blood OSHA PEL = 50 $\mu g/m^3$	
Arsenic	7440-38-2	0.06	0.2	Inhalation, ingestion, skin	Attacks the liver, kidneys, skin, lungs and nasal septum	X
Cadmium	7440-43-9	0.10	0.05	Inhalation, ingestion	Attacks respiratory system, kidneys, prostate, and blood	X
Copper	7440-50-8	0.14	1.0	Inhalation, ingestion, skin	Attacks respiratory system, skin, liver, and kidneys	X
Nickel	7440-02-0	0.06	1.0	Inhalation, ingestion, skin	Attacks nasal cavities, lungs, skin, and may cause cancer.	X
Zinc	1314-13-2	0.22	10.0	Inhalation	Attacks respiratory system	
Sulfuric Acid	7664-93-9	Undetermined	1.0	Inhalation, ingestion, skin	Attacks respiratory system, eyes, skin and teeth.	

C Carcinogenicity
CNS Central nervous system
GI Gastro Intestinal
TLV American Conference of Governmental Industrial Hygienists Threshold Limit Value
CAS No. Chemical Abstract Services Identification Number
mg/m^3 *milligrams of substance per cubic meter of air*
g/Kg gram of substance per kilogram of soil
$\mu g/m^3$ *micrograms of substance per cubic meter of air*

RISK ANALYSIS - FOR EACH SITE TASK AND OPERATION

Mobilization/Demobilization - Very few chemical hazards will be involved; however, physical hazard potentials may exist. See initial levels of protection for tasks.

Hydrogeologic Investigation (Drilling) - Highest degree of hazard potential of all tasks. Personnel must wear the appropriate PPE designated in this HASP. If dusty conditions are present the HSO will require the use of air-purifying respirators with a particulate cartridge.

Sampling - All sampling tasks present similar hazards. Personnel shall wear the appropriate PPE to begin the task. The use of this clothing is to prevent contamination from sulfuric acid possibly being in the groundwater and soils.

Surveying - Same hazard potentials as stated for the mobilization/demobilization tasks.

Of the identified indicator compounds, only arsenic, cadmium, and nickel are known to be or are suspected of being human carcinogens. All of the indicator metals exhibit noncarcinogenic health effects. The following is a breakdown of each contaminant of concern at the site and the problems associated with each:

Lead - Data concerning the carcinogenicity of lead in humans are inconclusive. However, several lead salts have been shown to cause kidney tumors in mice and rats. Ingestion or inhalation of lead may cause toxic effects in the brain, central nervous system, or the kidneys. Anemia is an early manifestation of lead poisoning in humans.

Arsenic - Upon ingestion, arsenic has been shown to cause skin cancer. There is also evidence that arsenic causes lung cancer in occupationally exposed individuals. Arsenic compounds also produce noncancerous skin changes and progressive polyneuropathy.

ORIGINAL (Red)

RISK ANALYSIS - FOR EACH SITE TASK AND OPERATION

(page 2)

Cadmium - Cadmium has been linked to prostate cancer in humans. Inhalational exposure to cadmium caused lung tumors in rats. Toxic effects attributed to cadmium include renal dysfunction, anemia, pulmonary disease, and bone damage.

Copper - Copper does not appear to have any carcinogenic, mutagenic, or teratogenic effects in animals or humans. Copper salts act as skin irritants upon dermal contact. Inhalation of copper dust and fumes can cause short-term illness and respiratory tract irritation. Conjunctivitis may result from direct contact of ionic copper with the eye.

Nickel - Nickel is a known human carcinogen. Workers exposed to insoluble nickel in the work place exhibit lung and nasal cavity cancer. Soluble nickel salts do not appear to be carcinogenic. Dermatitis, rhinitis, and nasal mucosal injury are the most frequent effects of exposure to nickel and nickel-containing compounds.

Zinc - The presence of zinc appears to be necessary for tumor growth, but zinc does not appear to be carcinogenic, mutagenic, or teratogenic in humans. Zinc is an essential dietary trace element. However, ingestion of excessive amounts of zinc may cause a copper deficiency and result in anemia as well as fever, vomiting, stomach cramps, and diarrhea.

ORIGINAL (Red)

SITE OPERATIONS

Respiratory and dermal requirements (P.P.E. - personal protection equipment for each of the site tasks and operations to be conducted):

Mobilization/Demobilization - Level D

Hydrogeologic Investigation (Drilling) - Begin in Level D with PVC or neoprene coveralls and gloves. If HSO determines that dusty conditions present an inhalation threat, Level C air-purifying respirators (APRs) with particulate cartridges will be donned for protection against particulates.

Sampling - Groundwater - Level D protection with boot covers, and PVC or neoprene coveralls and gloves.

Surface and subsurface soils - same as groundwater.

Surface water and sediment - Tyvek coveralls with PVC or neoprene gloves. If personnel enter a deep-water area, waders may be used instead of coveralls.

Debris pile - Same as the protection under the hydrogeologic investigation task.

Surveying - Same protection as that found under the mobilization/demobilization task.

Selection criteria:

Arthur D. Little Guidelines for the selection of chemical protective clothing. Because of the possibility of contacting sulfuric acid during sampling of groundwater and drilling, personnel will need PVC or neoprene coveralls and gloves.

Modifications for personal protection requirements: If HSO determines that the conditions have become too dusty, personnel shall be required to wear APRs with particulate cartridges.

Level C protection should be selected when the type of hazardous airborne substance is known, concentration measured, criteria for using air-purifying respirators met, and skin and eye exposure is unlikely. Monitoring of the air must be performed to comply with OSHA regulations and to ensure respirator effectiveness.

X ____ Half-face, air-purifying respirator (MSHA/NIOSH approved) with cartridge type H (REQUIRED) - MSA

X ____ Chemical resistant clothing (one-piece coverall; hooded, two-piece, chemical-splash suit, chemical-resistant hood and apron, disposable chemical resistant coveralls) (REQUIRED) PVC or neoprene.

X ____ TLD Badge for radiation (REQUIRED)

____ Personal radiation detector

X ____ Chemical-resistant inner and outer gloves (REQUIRED). Type: PVC or neoprene

X ____ Boots (steel toe) chemical-resistant (REQUIRED)

____ Two-way radio communications (intrinsically safe)

X ____ Hard hat (if overhead hazards exist)

____ Escape mask (respirator)

Level D is primarily a work uniform. It should not be worn on any site where respiratory or skin hazards exist.

____ Protective coveralls and protective gloves. Type? ____

X ____ TLD Badge for radiation (REQUIRED)

____ Personal radiation detector

X ____ Boots or shoes with steel toe (REQUIRED)

X ____ Hard hat (if overhead hazard is present)

____ Safety eye wear (If eye hazard is present)

REQUIRED LEVEL(S) OF PROTECTION

Task	Name	Respiratory	Clothing	Gloves	Boots	Other Modifications
Team Leader	Bethel	None or HF-APR	N	N	B	--
Site Safety Officer	Kenney	None or HF-APR	N	N	B	--
Samplers	TBA	None or HF-APR	N or T	N or T	B	--
Other		None or HF-APR	N	N	B	--
Decon		None or HF-APR	N	N	B	--

Tyvek = T Latex = L Saranex = S Butyl = B
Neoprene = N Viton = V Covers = C Other = Other (specify)
Half-face = HF
Air-purifying respirator = APR

Operations and Monitoring/Sampling Equipment Checklist

Type of Equipment	Number Needed	Calibrated	Field Ready
LEL/O_2	2	Yes	Yes

Operating Procedures and Methods for Surveillance:

The LEL/O_2 meter shall be used during all drilling activities. If LEL levels exceed 10%, personnel shall limit operations to non-spark generating activities. If the level exceeds 20%, personnel shall leave the area.

Methods of Maintenance and Calibration

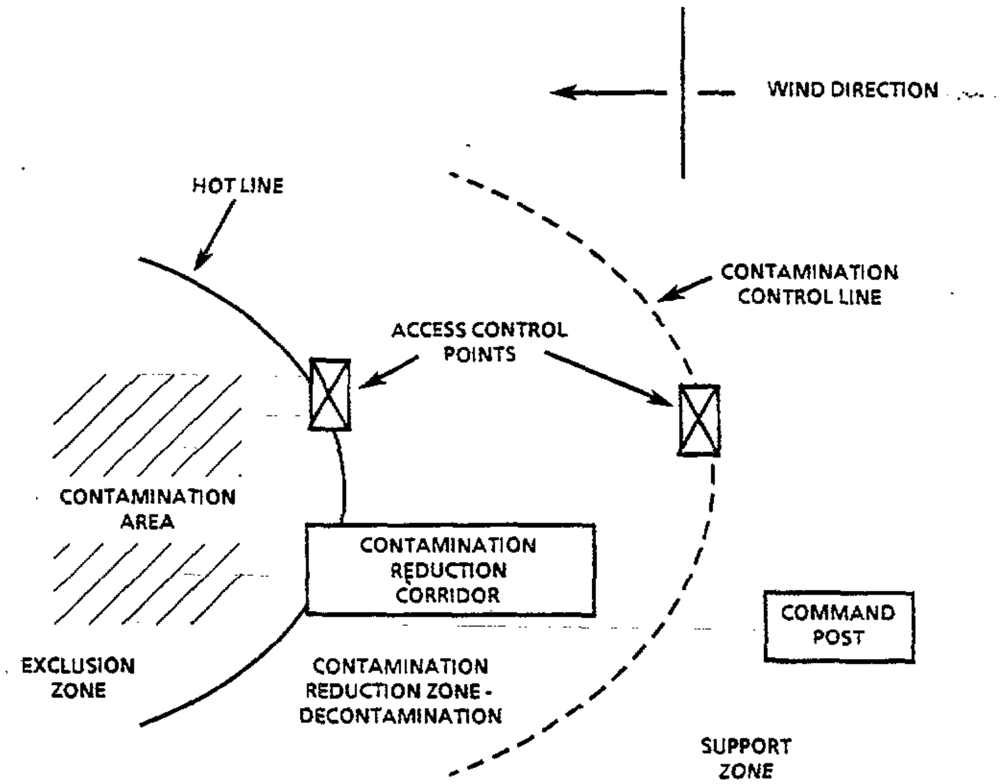
All equipment maintenance and calibration efforts shall be conducted by Mr. Tom Patton at the NUS equipment facility. These efforts shall be performed in accordance with the following NUS Health and Safety Standard Operating Procedures.

_____ No. ME01; Use, Calibration, and Maintenance of the HNU PI-101

X____ No. ME05; *Combustible Gas Indicator (attached)*

_____ No. ME02; Use, Calibration, and Maintenance of the OVA 128

Perimeter Establishment:



The above is a general diagram of a site set-up for work on hazardous waste sites. It shall be established for each work station as the project progresses.

Site Control Measures:

The following procedures and measures shall be observed to minimize the potentials for contaminant transfer and personnel exposures (e.g., site security, site zonation, etc.). If applicable, attach maps.

Personnel shall partition off the immediate area around all work sites with cones and ropes or by some other method, to control the access to these areas.

ORIGINAL (Red)

Ionizing Radiation:

Normal background 0.01 to 0.02 mR/hr. If less than 2 mR/hr, continue investigation with caution. If greater than 2 mR/hr, evacuate site. Note: normal background is 10 to 20 counts per minute (CPM).

ORIGINAL (Red)

Site Standard Operating Procedures (SOPs)

The following SOPs shall be observed by all personnel during site activities:

All drilling/excavating requires a check (plus documentation) for underground utilities.

No drilling within a 20-foot radius of overhead power lines.

No hand-to-mouth contact is permitted during site activities.

No facial hair which interferes with mask fit.

No flames or open fires will be permitted on site.

No working outdoors will be permitted during electrical storms.

All subcontractor personnel will be responsible for employing safe operating procedures and complying with OSHA while drilling and conducting related field activities.

All ARCS health and safety requirements plus the contents of this HASP must be followed by all applicable site workers.

Work areas must be partitioned off by some method to combat unauthorized entry.

The HSO will post an 8-1/2" x 14" poster, e.g., similar to the one attached to this HASP, at a conspicuous place visible to all employees at the site (e.g., next to a telephone).

ORIGINAL (Red)

Confined Space Entry (CSE) Procedures

Specify the nature of any CSE procedures to be performed, and the procedures and restrictions required to protect the involved personnel.

No confined space entry will be conducted on this project.

ORIGINAL (Red)

MEDICAL

All subcontracting personnel whose presence is required on site must first be examined by a licensed physician (or under the supervision of a licensed physician) in accordance to OSHA standards 29 CFR 1910.120 and 1910.134. The physician's clearance for site work on the C&R Battery Site shall be documented and reviewed by the OHSS before the individual(s) is (are) permitted to be on site. NUS personnel whose work may require their presence in areas where potential exposures to hazardous materials exist shall participate in the NUS medical monitoring program as specified in the NUS Health and Safety Standard Operating Procedures, Subject: Medical Program Operating Procedure, No. MD01. All medical examinations performed for NUS personnel and NUS subcontracting personnel for these purposes shall be conducted in accordance with OSHA General Industry standards 29 CFR 1910.120 and 1910.134.

ORIGINAL (Red)

EMERGENCY REFERENCE
(Post On Site)

Site: C&R Battery Project No.: 9851-0105

Emergency Information:

Local Resources:		
Office:	Park West Two	(412) 788-1080
Ambulance (Name):	Chesterfield County	(804) 748-2291
Hospital (Name):	John Randolph Memorial	(804) 541-7401
Police (Local or State):	Chesterfield County	(804) 748-5881
Fire Department (Name):	Chesterfield County	(804) 748-2291
Project Manager:	Richard Ninesteel	(412) 788-1080 ext 314
Site Health and Safety Officer:	Kevin Kenney	(412) 788-1080 ext 464
Alternate Site Health and Safety Officer:	Richard Bethel	(412) 788-1080 ext 353

Emergency Contacts (Medical and Health):

- Dr. Michael Hodgsen (NUS Consulting Physician - University of Pittsburgh)
  Office: (412) 648-3240
- NUS ARCS III Health and Safety Officer Dr. Richard C. Gerlach
  Office: 412) 788-1080 ext 390
- Poison Information Center: 804-786-9123
- National Response Center (for Environmental Emergency Only): 1-800-424-8802
- Office: 412-788-1080

Directions to Hospital: Get on Bellwood Road; follow this east to Route I-301; make left onto I-301; head south to Route 10; turn left onto Route 10; head east to Hopewell; John Randolph Memorial is at the second light on the right side.

American Red Cross

First Aid

EMERGENCY TELEPHONE NUMBERS	
Police	804-748-5881
Fire Department	804-748-2291
Doctor	412-648-3240
Ambulance	804-748-2291
Hospital	804-541-7401
Poison Control Center	804-786-9123

BITES Animal Bites - Thoroughly wash the wound with soap and water. Flush the area with running water and apply a sterile dressing. Immobilize affected part until the victim has been attended by a physician. See that the animal is kept alive and in quarantine. Obtain name and address of the owner of the animal.

Insect Bites - Remove "stinger" if present. Keep affected part down below the level of the heart. Apply ice bag. For minor bites and stings apply soothing lotions, such as calamine.

BURNS AND SCALDS Minor Burns - DO NOT APPLY VASELINE OR GREASE OF ANY KIND. Apply cold water applications until pain subsides. Cover with a dry, sterile gauze dressing. Do not break blisters or remove tissue. Seek medical attention.

Severe Burns - Do not remove adhered particles of clothing. Do not apply ice or immerse in cold water. *Do not apply ointment,* grease or vaseline. Cover burns with thick sterile dressings. Keep burned feet or legs elevated. Seek medical attention immediately.

Chemical Burns - Wash away the chemical soaked clothing with large amounts of water. Remove victim's chemical soaked *clothing. If dry lime, brush away before flushing. Apply sterile* dressing and seek medical attention.

CRAMPS Symptoms - Cramps in muscles of abdomen and extremities. Heat exhaustion may also be present.

Treatment - Same as for heat exhaustion.

CUTS Apply pressure with sterile gauze dressing, and elevate the area until bleeding stops. Apply a bandage and seek medical attention.

EYES Foreign Objects - Keep the victim from rubbing his *his eye. Flush the eye with water. If flushing fails to remove* the object, apply a dry, protective dressing and consult a physician.

Chemicals - Flood the eye thoroughly with water for 15 minutes. Cover the eye with a dry pad and seek medical attention.

FAINTING Keep the victim lying down. Loosen tight clothing. If victim vomits, roll him onto his side or turn his head to the side. If necessary wipe out his mouth. Maintain an open airway. Bathe his face gently with cool water. Unless recovery is prompt, seek medical attention.

FRACTURES *Deformity of an injured part usually* means a fracture. If fracture is suspected, splint the part. DO NOT ATTEMPT TO MOVE INJURED PERSON, seek medical attention immediately.

FROSTBITE Symptoms - Just before frostbite occurs skin may be flushed, then change to white or grayish-yellow. Pain may be felt early then subsides. Blisters may appear, affected part feels very cold and numb.

Treatment - Bring victim indoors, cover the frozen area, provide extra clothing and blankets. Rewarm frozen area quickly by immersion in warm water---NOT HOT WATER. DO NOT RUB THE PART. Seek medical attention immediately.

HEAT EXHAUSTION Caused by exposure to heat - either sun or indoors. Symptoms - Near normal body temperature. Skin is pale and clammy. Profuse sweating, tiredness, weakness, headache, perhaps cramps, nausea, dizziness, and possible fainting.

Treatment - Keep in lying position and raise victim's feet. Loosen clothing, apply cool wet cloths. If conscious, give sips of salt water (1 teaspoon of salt per glass) over a period of one hour. If vomiting occurs, discontinue the salt water. Seek medical attention immediately.

SUNSTROKE Symptoms - Body temperature is high (106 degrees F or higher). Skin is hot, red, and dry. Pulse is rapid and strong. Victim may be unconscious.

Treatment - Keep victim in lying position with head elevated. Remove clothing and repeatedly sponge the bare skin with cool water or rubbing alcohol. Seek medical attention immediately.

POISONING Call the poison control center for instruction on immediate care. If victim becomes unconscious, keep the airway open. If breathing stops give artificial respiration, by mouth to mouth breathing. Call an emergency squad as soon as possible.

POISON IVY Remove contaminated clothing; wash all exposed areas thoroughly with soap and water followed by *rubbing alcohol. If rash is mild, apply calamine or other soothing* skin lotion. If a severe reaction occurs, seek medical attention.

PUNCTURE WOUNDS If puncture wound is deeper than skin surface, seek medical attention. Serious infection can arise unless proper treatment is received.

SPRAINS Elevate injured part and apply ice bag or cold packs. DO NOT SOAK IN HOT WATER. If pain and swelling persist, seek medical attention.

UNCONSCIOUSNESS Never attempt to give anything by mouth. Keep victim lying flat, maintain open airway. If victim is not breathing provide artificial respiration by mouth to mouth breathing and call an emergency squad as soon as possible.

FIRST AID

(Red)

Emergency Resources

Ambulance	Chesterfield County - 804-748-2291
Hospital (Emergency Room)	John Randolph Memorial - 804-541-7401
Fire	Chesterfield County - 804-748-2291
Police	Chesterfield County - 804-748-5881
Poison Control Center	Richmond - 804-786-9123

Emergency Contacts

HSO - Richard Gerlach	(Day)	(412) 788-1080 ext 390
WMSG Physician - Dr. Hodgeson	(Office)	(412) 648-3240

Alternates: Dr. Karpf and Sue Comisky

Hospital: Get on Bellwood Road; follow this east to Route I-301; make left onto I--301, Head south to Route 10; turn left onto Route 10; Head east to Hopewell; John Randolph Memorial is at the second light on the right side.

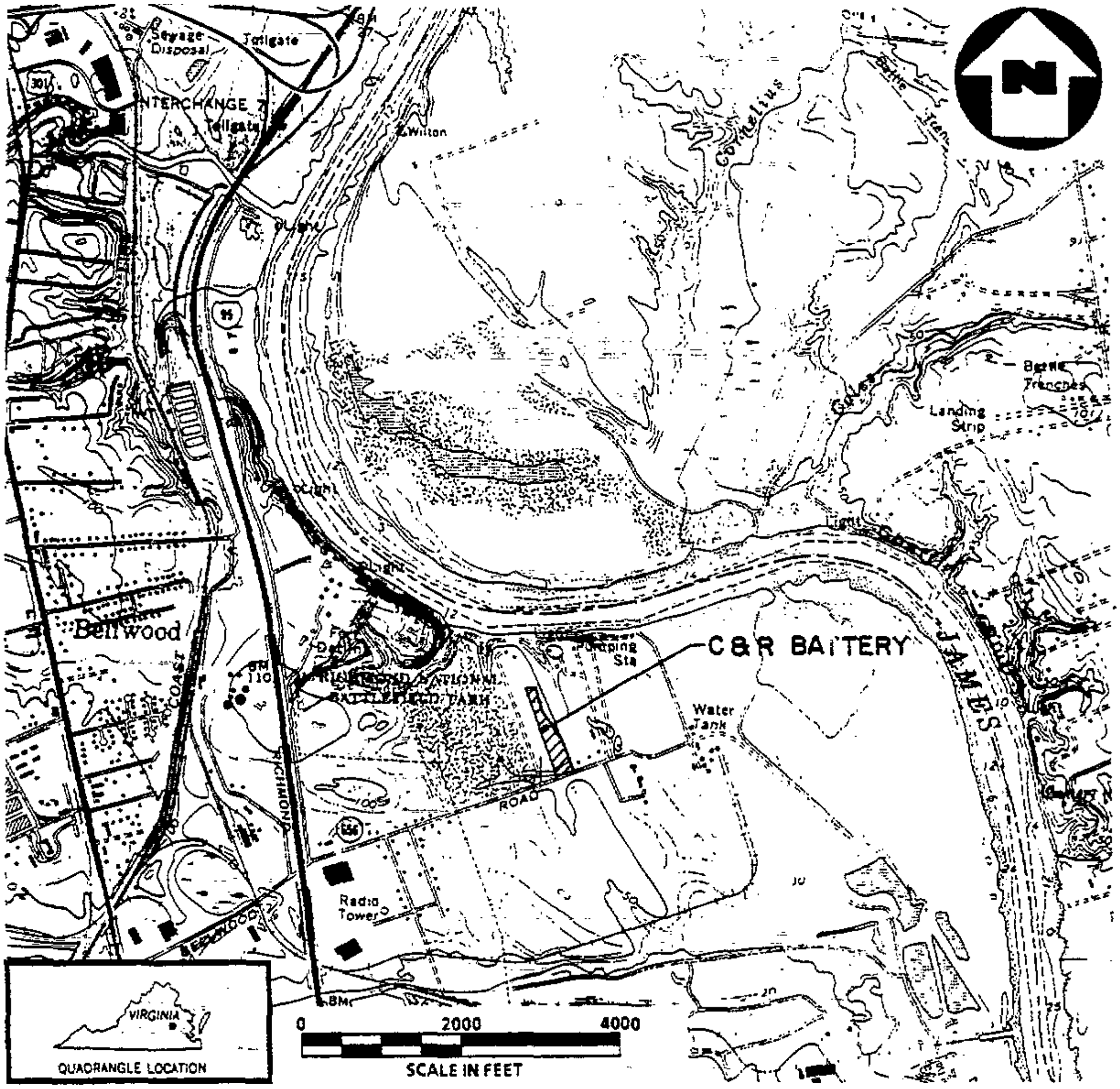
Map attached? Yes X No

Alternate Emergency Facilities to be noted: Will be determined by Site HSO prior to the commencement of operations.

Procedures for inclement weather: No drilling during lightning and heavy storms.

Emergency Procedure for Overt Personnel Exposure:

- Skin Contact: Remove contaminated clothing. Wash immediately with water. Use soap if available.
- Inhalation: Remove from contaminated atmosphere. Artificial respiration is necessary. Transport to hospital.
- Ingestion: Never induce vomiting on an unconscious person. Also never induce vomiting when acids, alkalis, or petroleum products are suspected. Contact the poison control center.



BASE MAP IS A PORTION OF THE USGS 7.5 MINUTE DREWRYS BLUFF, VIRGINIA QUADRANGLE, 1969 PHOTO-REVISED 1980. CONTOUR INTERVAL 10 FEET.

FIGURE 2-1

SITE LOCATION MAP
C & R BATTERY SITE, CHESTERFIELD CO., VA

NUS CORPORATION

ORIGINAL (Red)

Medical Data Sheet

This form must be completed by all onsite personnel prior to the commencement of activities, and shall be kept in the site command post during site activities. This form must be delivered to any attending physician when medical assistance is needed.

Site C&R Battery ____________________

Name ____________________ Home Telephone ( ) ____________

Address ____________________

Age ________ Height ________ Weight ________

Name of next of kin ____________________ Telephone ( ) ____________

Drug allergies or other allergies ____________________

____

Previous Illnesses or Exposures to Hazardous Substances:

____

____

Current Medication (prescription and non-prescription):

____

____

Medical Restrictions ____________________

____

Name, address and phone number of personal physician ____________________

____

____

DECONTAMINATION PROCEDURES

Map of site showing restricted access zones, protection levels, decontamination areas, equipment layout, and clean zones is found in the section entitled Perimeter Establishment on page 14 of this *document*.

Decontamination procedures are as illustrated below:

WASH AND RINSE OUTER GARMENTS

↓

REMOVE TAPE

↓

REMOVE OUTER GLOVES

↓

REMOVE PVC OR NEOPRENE SUIT

↓

REMOVE BOOT COVERS

↓

REMOVE APR (IF WORN)

↓

REMOVE INNER GLOVES

↓

FULL BODY WASH AS SOON AS POSSIBLE

Disposal Procedures

On Site:

As per client direction. Perferably, this is to consist of double bag and drum material on site.

Original
(Rev)

TRAINING CONDUCTED ON SITE

Attendees	Subject-Coverage	Instructor	Date

EMERGENCY PLAN

(To be Completed Upon Arrival at the Site, and Prior to Work Initiation)

Through the course of site activities, potentials for emergency response efforts exist. Pre-emergency planning (such as determining and contacting appropriate offsite emergency response agencies) is the responsibility of the Site Health and Safety Officer. *This information is included in the emergency information sections of this Health and Safety Plan.*

(A) Personnel Roles, Lines of Authority and Communication

Personnel	Responsibilities

(B) Emergency Recognition and Prevention

(C) Site Evacuation Routes, Procedures, Safe Distances, and Places of Refuge

(D) Site Security and Control During Emergencies

(E) Emergency Decontamination Procedures

(F) Emergency Altering and Response Procedures

(G) PPE and Emergency Equipment

(H) Emergency Personnel Training Requirements

EMERGENCY PHYSICIAN ACCESS PLAN

(1) MONDAY THROUGH FRIDAY, 8:00 A.M. - 4:00 P.M. (Central Standard Time)

Dial the (412) 648-3240 number. When answered state that

(a) you are calling from NUS Corporation;

(b) this is an emergency call.

Program staff will be alerted how to contact the physician designated to provide emergency coverage on that day. Collect calls will be accepted.

(2) EVENINGS, WEEKENDS, AND HOLIDAYS:

Dial the (412) 648-3240 number. An operator from the answering service will answer the telephone. Do the following.

(a) Tell the operator that you are calling from NUS Corporation.

(b) Tell the operator that this is an emergency call.

(c) Give her your name.

(d) Give her the telephone number where the physician is to call. Be certain that she has written the correct number (area code and seven digits).

(e) If you do not receive a call back within 15 minutes, place a second call to (412) 648-3240.

Collect calls will be accepted.

(3) SITUATIONS WHERE EMPLOYEE REQUIRES IMMEDIATE TRANSPORT TO A HOSPITAL:

If the situation is life-threatening, e.g., cardiac arrest or person not breathing, call the emergency medical services system and transport the person to the nearest hospital with advanced life support capabilities.

- Report the accident to the Site Safety Officer and the Office Health and Safety Supervisor
- Develop safe operating procedures to prevent a recurrence
- File an incident report with the Manager of Health and Safety Department in Pittsburgh, Pennsylvania

(J) Site Topography, Layout, and Prevailing Weather Conditions (attach map). Explanation:

(K) Procedures for Contacting Local, State, and Federal Agencies to Report Site Incidents

(L) Employee Alarm System

The following methods will be utilized to notify onsite personnel of the appropriate procedures

Signal

Signal	
______	Work cessation
______	Onsite emergency situation
______	Lower background noise to speed communication
______	Beginning emergency procedures

Other (specify) ______

(M) Emergency First Aid Procedures (see Page 28)

Other: ______

ORIGINAL
(Red)

FIELD TEAM REVIEW

Must be signed by each field team member prior to the first site visit.

I have read and understand the contents of this HASP and will comply to its provisions, requirements, and restrictions.

Site C&R Battery

Name (PRINT)	Signature	Date

SITE SAFETY FOLLOW-UP REPORT

This section must be filled out and returned to the Site Safety Officer after each site visit or task.

Person responsible for follow-up report: Scott Krall

Actual date of work: ______

Actual Site Investigation Team:

NUS Personnel:	Responsibility:

Other:	Purpose:

ORIGINAL (Red)

PERSONAL PROTECTIVE EQUIPMENT

• Level of Respiratory Protection Used	Activity Performed

• Field Dress	Activity

MONITORING EQUIPMENT

HNU

- Background reading ______________________
  - Readings above background? ______________________
  - Location of high readings ______________________

____

____

Radiation

- Readings above background? ______ Yes ______ No
- If yes, specify where readings were found and what action was taken.

____

____

____

GENERAL SAFETY

ORIGINAL
(Red)

Were any safety problems encountered while on site?

Explain: ____

____

____

____

____

____

____

____

ACCIDENT REPORT INFORMATION

Did any team member report:	Yes	No
• Chemical exposure	____	____
• Illness, discomfort, or unusual symptoms	____	____
• Environmental problems (heat, cold, etc.)	____	____

Explain: ____

____

____

____

____

____

____

____

Was an Employee Exposure/Injury Incident Report Completed? ____ Yes ____ No

ORIGINAL (Red)

SITE SAFETY REVIEW - CHANGES AND OVERALL EVALUATION

(To be Completed for Each Field Change in Plan)

Was the Safety Plan followed as presented? ______ yes ______ no

Describe, in detail, all changes to the Safety Plan:

____

____

____

____

____

Reason for changes: ____

____

____

____

____

Follow-up, review, and evaluation prepared by: ____________ Date ____________

Discipline ______________________

Approved by: Site Manager ____________ Date ____________

Site Safety Officer ____________ Date ____________

Approved by: Office Health & Safety Supervisor ____________ Date ____________

Evaluation of Site Safety Plan

Was the Safety Plan adequate? ______ yes ______ no

What changes would you recommend?

____

____

____

____

ORIGINAL (Red)

HEAT STRESS MONITORING LOG

Date	Name	Weight Change	Pulse Rate	Blood Pressure	Oral Temperature	WBGT

ORIGINAL (Red)

FIRST-AID SUPPLY USAGE FORM

Project No.	Date	Item(s) Used	Kit No.

Please submit this form as soon as possible to to the NUS/WMSG Equipment Manager for first-aid supply replenishment.

ORIGINAL (Red)

SCBA LOG

Site: C&R Battery

Location:

Dates of Investigation:

User	Date of Use	SCBA #	Satisfactory Check-Out (Yes/No - Initials)	Date Cleaned

SCBA Performance Comments:

Site Manager Date

Return to HSO at Completion of Activity

(ULTRA TWIN)
RESPIRATOR LOG

ORIGINAL (Red)

Site: C&R Battery

Location:

Dates of Investigation:

User	Date of Use	Cleaned and Inspected Prior To Use (Initials)	Cartridges Changed Prior to Use (Yes/No)	Total Hours On Cartridge

Site Manager Date

Return to HSO at Completion of Activity

INCIDENT REPORT ORIGINAL (Red)

Report No. ____

Site: C&R Battery Project No. ____

Location: ____

Date of Report: ____ Preparer's Name: ____

Name and Address of Injured: ____ SSN: ____ Age: ____

Sex: ____

Years of Service: ____ Time of Present Job: ____ Title/Classification: ____

Division/Department: ____ Date of Incident: ____ Time: ____

Incident Category: ____ Motor Vehicle ____ Property Damage ____ Fire

____ Chemical Exposure ____ Near Miss ____ Other

Severity of Injury or Illness: ____ Non-disabling ____ Disabling

____ Medical Treatment ____ Fatality

Amount of Damage: $ ____ Property Damage: ____

Estimated Number of Days Away from Job: ____

Nature of Injury or Illness: ____

Classification of Injury:

____ Fractures	____ Heat Burns	____ Cold Exposure
____ Dislocations	____ Chemical Burns	____ Frostbite
____ Sprains	____ Radiation Burns	____ Heat Stroke
____ Abrasions	____ Bruises	____ Heat Exhaustion
____ Lacerations	____ Blisters	____ Concussion
____ Punctures	____ Toxic Respiratory Exposure	____ Faint/Dizziness
____ Bites	____ Toxic Ingestion	____ Toxic Respiratory
____ Respiratory Allergy	____ Dermal Allergy	

Part of Body Affected: ____

Degree of Disability: ____

Date Medical Care Was Received: ____

Where Medical Care Was Received: ________________

Address (if off site): ________________

Incident Location ________________

Causative agent most directly related to accident (object, substance, material, machinery, equipment, conditions): ________________

Was weather a factor? ________________

Unsafe mechanical/physical/environmental condition at time of accident (Be specific):

Unsafe act by injured and/or others contributing to the accident (Be specific, must be answered):

Personal factors (improper attitude, lack of knowledge or skill, slow reaction, fatigue):

Level of personal protection equipment required in Site Safety Plan:

Modifications: ________________

Was injured using required equipment: ________________

If not, how did actual equipment use differ from plan? ______________________

What can be done to prevent a recurrence of this type of accident (modification of machine; mechanical guards; correct environment; training)?

Detailed narrative description (how did accident occur, why; objects, equipment, tools used, circumstances, assigned duties). Be specific:

(Use back of sheet, as required)

Witnesses to accident: ______________________

Signature of Preparer ______________________

Signature of Site Manager ______________________

Department Appraisal and Recommendation

In your opinion, what actions or equipment contributed to this accident?

Your recommendation:

Date: __________ Signature of Department Manager ______________________

FOR HEALTH AND SAFETY USE ONLY

Temporary Total	______	Permanent Partial	______
Death or Permanent Total	______		
Started losing time	______	Part of Body	______
Returned to work	______	Percent loss or	
Time charge	______	Loss of use	______
		Time charge	______
Compensation	$______	Medical	$______
Other	$______	Total	$______

Name and Address of Hospital ______________________

Name and Address of Physician ______________________

cc: OHSS
Administrative Manager
DHST
Medical Consultant

rds.

ORIGINAL
(Red)

INCIDENT FOLLOW-UP

Date of Incident: ____________________

Name: ____________________ Employee No. ____________

Site: C&R Battery

Brief description of incident: ____________________

Outcome of incident: ____________________

Physician's recommendations: ____________________

Date returned to work: ____________________

ATTACH ANY ADDITIONAL INFORMATION TO THIS FORM

cc: OHSS
Administrative Manager
DHST
Medical Consultant

NUS CORPORATION
WASTE MANAGEMENT SERVICES GROUP

PARK WEST TWO
CLIFF MINE ROAD
PITTSBURGH, PA 15275-1071
(412) 788-1080

ORIGINAL
(Red)

R-33-5-8-7

August 12, 1988

NUS Project Number 9851

Mr. Paul Leonard
U.S. Environmental Protection Agency
841 Chestnut Street
Philadelphia, Pennsylvania 19107

Reference: ARCS III Program
EPA Contract No. 68-W8-0037

Subject: C&R Battery Site RI/FS
EPA Work Assignment Number 37-01-3LP4
Submittal of Final Project Operations Plan

Dear Mr. Leonard:

Enclosed please find seven (7) copies of the final Project Operations Plan for the C&R Battery Site Remedial Investigation/Feasibility Study, two of which are for distribution to Ms. Stephany Del Ré, ARCS III Project Officer (copy No. 6) and Mr. Sidney Ozer, ARCS III Contracting Officer (copy No. 7). The Special Analytical Services Request forms (Appendix E) will be sent under a separate cover at a later date. Two copies of Appendix E will be sent to Pat Krantz at CRL and one copy will be sent to you.

Copies of the Project Operations Plan have also been sent to the following:

- Ms. Pat Krantz, EPA Region III Central Regional Laboratory (copy No. 8).
- Mr. Jim Adams, Virginia Department of Waste Management (copy No. 9).

If you have any questions or comments concerning this Project Operations Plan, please do not hesitate to call me.

Very truly yours,

Richard M. Ninesteel
Project Manager

RMN/drp

cc: Mr. J. Adams (w/enclosure)
Ms. P. Krantz (w/enclosure)
Ms. S. Del Ré
Mr. S. Ozer
Mr. A. Bomberger, Devon
Mr. P. Goldstein, Pittsburgh