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Work Plan
for
Waste Oil Tank 5
for
Naval Submarine Base - New London
Groton, Connecticut

98

Northern Division
Naval Facilities Engineering Command
Contract Number N62472-90-D-1298
Contract Task Order 0129

February 1994

Halliburton NUS
CORPORATION

Halliburton NUS
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C-49-02-4-162

February 16, 1994

Halliburton NUS Project No. 9594

Commanding Officer, Northern Division
Naval Facilities Engineering Command
10 Industrial Highway
Mail Stop #82
Lester, Pennsylvania 19113-2090

Attention: Mr. Brian Helland

Reference: CLEAN Contract N62472-90-D-1298
Contract Task Order No. 0129
Cost Impact Letters No. 2 and 3 and
Navy Comment Letter Dated February 10, 1994

Subject: Final Work Plan for Waste Oil Tank 5
Naval Submarine Base, New London, Groton, Connecticut

Dear Mr. Helland:

Enclosed are 10 copies of the subject document for your files and distribution. The document has been revised based on your comment letter dated February 10, 1994; and our subsequent telephone conversation. The start of field work activities is scheduled for February 21, 1994.

If you have any questions or comments concerning this document, please call me at (412) 921-8418.

Very truly yours,

Matthew G. Cochran

Matthew G. Cochran, P.G.
Project Manager

Enclosures

MGC/blb

cc: Mr. Roger Boucher, NORTHDIV (Letter only)
Mr. John Trepanowski, Halliburton NUS, Wayne
Ms. Debra Wroblewski, Halliburton NUS, Pittsburgh
CTO 0129 File

R-12-93-12

WORK PLAN
FOR
WASTE OIL TANK 5
FOR
NAVAL SUBMARINE BASE - NEW LONDON
GROTON, CONNECTICUT

COMPREHENSIVE LONG-TERM
ENVIRONMENTAL ACTION NAVY (CLEAN) CONTRACT

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

Submitted by:
Halliburton NUS Corporation
993 Old Eagle School Road, Suite 415
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CONTRACT NUMBER N62472-90-D-1298
CONTRACT TASK ORDER 0129

FEBRUARY 1994

SUBMITTED BY:

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1.0 INTRODUCTION

1.1 AUTHORIZATION

The Northern Division of the Naval Facilities Engineering Command (NAVFAC) issued Contract Task Order (CTO) 0129, under the Comprehensive Long-Term Environmental Action Navy (CLEAN) Contract No. N62477-90-D-1298 to Halliburton NUS Corporation (Halliburton NUS). The CTO is an assignment to perform remedial investigation activities at Subase, New London, located in Groton, Connecticut.

A Scope Change Letter dated November 24, 1993 directed Halliburton NUS to perform investigation activities at Waste Oil Tank 5. Halliburton NUS responded to the Scope Change Letter by preparing a Cost Impact Letter, which was dated December 9, 1993 and submitted to the Navy on December 10, 1993. The scope of work was negotiated on December 29, 1993 and a Confirmation of Negotiation Letter was submitted to the Navy on December 30, 1993.

A second Scope Change Letter, dated January 11, 1994, directed Halliburton NUS to prepare a Cost Impact Letter, which was completed on February 3, 1994 and submitted to the Navy on February 4, 1994. Negotiations were conducted on February 16, 1994, and a Confirmation of Negotiation Letter is scheduled to be submitted to the Navy in the near future.

A draft version of this work plan was submitted to the Navy on December 31, 1993. Navy comments dated January 11, 1994 to the draft work plan were received by Halliburton NUS on January 13, 1994. The comments were used to develop the second draft version which was submitted to the Navy on January 28, 1994. Navy comments, dated and received on February 10, 1994, to the second draft work plan were used to develop this final version. Both sets of Navy comments are included in Appendix A for reference purposes.

This section is the introduction to the Work Plan and includes a discussion of the scope and objectives in addition to a description and history of the tank. Section 2 contains a detailed description of the required work tasks and Section 3 provides the details of the field activities.

1.2 SCOPE AND OBJECTIVES

The primary objectives of this investigation are to collect the necessary data to determine the environmental impact that Waste Oil Tank 5 has on the surrounding media and to collect the necessary data to adequately abandon or remove the tank. Specific objectives of the project are as follows:

- To determine the magnitude and extent of PCB and petroleum-related contamination that has permeated the concrete tank.

- To determine if soil or groundwater contamination exists beneath the tank resulting from leaks within the tank bottom.

1.3 TANK DESCRIPTION AND HISTORY

The tank is located in the southern portion of Subase, New London, immediately north of Crystal Lake Road and between Sculpin Avenue and Tang Avenue. The tank is reported to be round, reinforced concrete approximately 112 feet in diameter and 11 feet deep with a calculated capacity of approximately 810,000 gallons[1] (see calculation below). A concrete slab covers the tank and is supported by 37 concrete columns spaced 16 feet on center. The top of the tank is approximately 4 feet beneath the ground surface.

The tank was constructed in the 1940s and initially used for fuel oil storage. Ten to 15 years ago, the tank was converted for waste storage, predominantly bilge water. The tank was placed out of service and the contents which contained floating product, sludge, and water, were removed in mid-1993. One to two inches of sludge remains on the tank floor with a small amount of concrete rubble under the tank opening. The sludge and rubble could not be removed due to the rapidly rising water level in the tank when the contents were removed. Most of the soil cover which was originally on the tank top has also been removed. The tank bottom occasionally fills with water which has been pumped out by contractors during attempts to clean and close the tank. At the present time, approximately 6 feet of water is present in the tank.

Investigations conducted to date have included demolishing the pumphouse, soil cover removal, waste removal from within the tank, and sampling of the waste and surrounding media from around the tank. Several investigations were conducted by GZA Geoenvironmental, Inc., and the results are included in Appendix B for reference purposes.

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[1] $56^2 \times 3.14 \times 11 \times 7.48 = 810{,}214$ gallons

2.0 WORK TASKS

A total of three work tasks were identified in the Navy Scope Change Letter and are described in this section.

2.1 TASK 1 - WORK PLAN

This task includes preparation of a first draft, second draft, and final version of a work plan which is this document. The work plan includes detailed procedures for completing the scope of work, and will be used as a reference document by Halliburton NUS and Navy personnel for completing the work activities.

2.2 TASK 2 - FIELD WORK

The field work activities will consist of the sampling of concrete, soil borings with temporary monitoring well installations, and soil and groundwater sampling. A detailed discussion of the necessary subtasks to complete the field work are included in Section 3 of this Work Plan.

2.3 TASK 3 - REPORT

Both a draft and final report will be completed for this project that will summarize the results of the investigation. The report will include a site map showing the sample locations, a cross-section figure, and tables comparing contaminant concentrations to regulatory standards. No calculations will be included in the report. The report format will be as follows:

- Section 1 - Introduction
- Section 2 - Field Activities Methodology
- Section 3 - Investigation Results

3.0 FIELD ACTIVITIES

A discussion of the field work activities are included in this section. Halliburton NUS Standard Operating Procedures (SOPs) will be referenced whenever possible regarding detailed procedures for a particular activity. Referenced SOPs are included in Appendix C. A summary of the samples to be collected are included in Table 3-1 and the proposed sample locations are shown on Figure 3-1. A typical well construction detail is included in Figure 3-2.

3.1 MOBILIZATION/DEMOBILIZATION

Following approval of the Work Plan, Halliburton NUS will begin mobilization activities. All field team members will review the Work Plan. In addition, an addendum to the Health and Safety Plan (HASP) for Subase, New London, will be completed to address the work activities to be conducted at Tank 5. A field team orientation meeting will be held to familiarize personnel with the scope of the field activities.

The Field Operations Leader (FOL) will coordinate the mobilization activities. The FOL will also make any arrangements for equipment and supplies required to conduct the field investigation. The equipment required for the field activities will be loaded in Pittsburgh, Pennsylvania, and sent to the site by the equipment manager. Much of the equipment is already on site in support of work activities currently being performed by Halliburton NUS in accordance with the original scope of this CTO. Therefore, mobilization activities will be minimal. The FOL will also coordinate with the Navy regarding clearing utilities prior to drilling activities.

3.2 TANK WATER SAMPLING

Two samples of the water in the tank will be collected and analyzed for TCL/TAL analyses to determine treatment and disposal requirements. The water will be sampled using a Kemmerer sampling device until the total water column has been composited into a sample. One sample will be collected at the tank opening and the second from the center-most boring hole, before the tank bottom is drilled. These samples will be sent to the laboratory for TCL/TAL analyses. One measurement of pH, specific conductance, temperature, ORP, turbidity, and dissolved oxygen will be taken prior to sample collection in accordance with SOP SF-1.1.

R-12-93-12

TABLE 3-1

SAMPLE SUMMARY
WASTE OIL TANK 5
SUBASE, NEW LONDON, CT

Media and Parameter	Number of Samples	Analytical Method	Number of Containers Per Sample	Container Type	Preservation Requirements	Holding Time	Detection Limit	NEESA QC Level
CONCRETE								
PCB	12 samples 2 duplicate	OLM01.8	1	8-oz. jar	Cool to 4°C	7 days to extraction; 40 days to analysis	CRDL	D
TCLP (organics and inorganics)	12 samples 2 duplicate	SW/1311/ 40 CFR 261	2	8-oz. jar	Cool to 4°C	7 days to TCLP extraction; 7 days to prep. extraction Then, same as *	Per Method	C
SOIL								
TCL VOAs	12 samples 2 duplicate	OLM01.8	1	4-oz. jar	Cool to 4°C	10 days*	CRDL	D
TCL BNAs	12 samples 2 duplicate	OLM01.8	1	8-oz. jar	Cool to 4°C	7 days to extraction; 40 days to analysis*	CRDL	D
TAL Inorganics	12 samples 2 duplicate	ILM02.1	1	8-oz. jar	Cool to 4°C	6 months Hg - 28 days*	CRDL	D
WATER (TANK SAMPLE AND GROUNDWATER)								
TCL VOAs	6 samples, 1 duplicate, 2 field blanks, 1 rinsate, 4 trip blanks	OLM01.8	3	40-mL VOA vials	HCl pH <2 Cool to 4°C	14 days to analysis	CRDL	D
TCL BNAs	6 samples, 1 duplicate, 2 field blanks, 1 rinsate	OLM01.8	2	80-oz. amber glass	Cool to 4°C	7 days to extraction; 40 days to analysis	CRDL	D
TAL Metals (dissolved and total)	6 samples, 1 duplicate, 2 field blanks, 1 rinsate	ILM02.1	2	1-L polyethylene	Dissolved - 45μ Filter, HNO_3 pH<2, Cool 4°C Total - HNO_3 to pH<2, Cool to 4°C	6 months Hg - 28 days	CRDL	D

-50 GRAMS

180 GRAMS

3-2

+ PEST

+ PCB

+ PEST

[redacted]

CALCULATION WORKSHEET Order No. 19116 (01-91) PAGE _____ OF _____

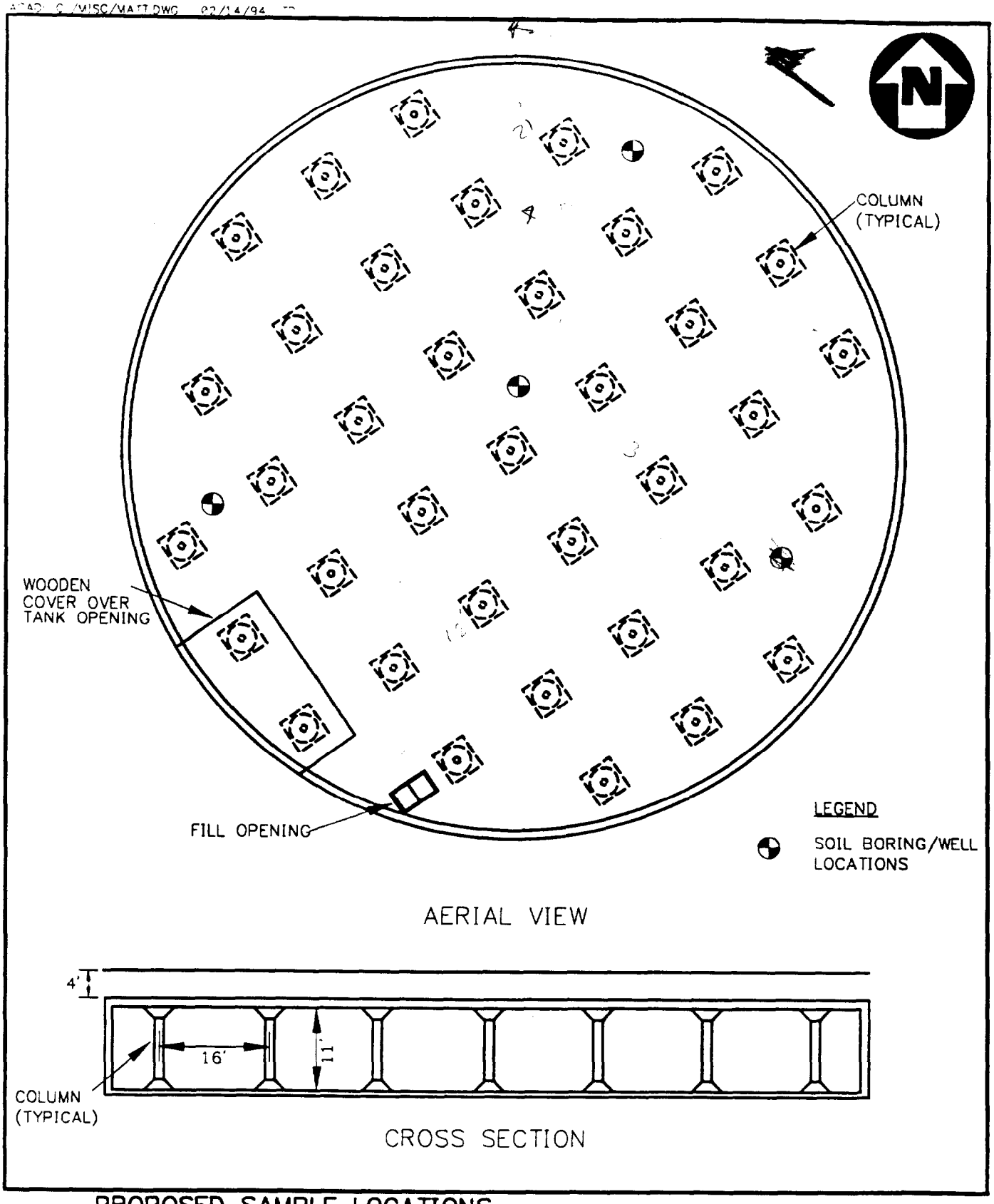
CLIENT		JOB NUMBER	
SUBJECT			
BASED ON		DRAWING NUMBER	
BY	CHECKED BY	APPROVED BY	DATE

3 TPH

1 TCL VOAS / BNAs / TCLP / Engineering parameters grain size, ~~bulk~~, SG, etc.

IR site w/ diesel tank

Address to trailer
GET FROM TIM - No sig. required for receipt

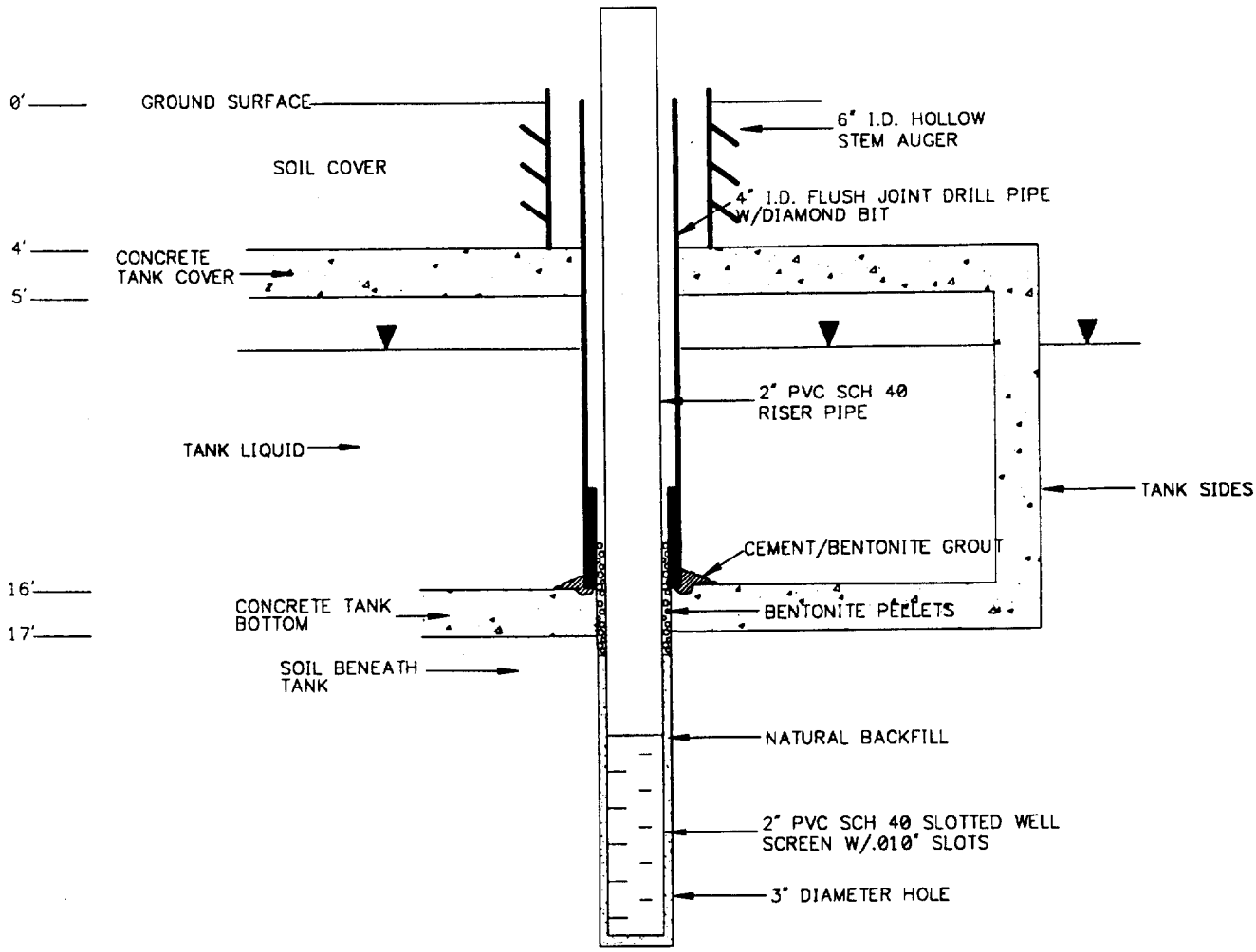


PROPOSED SAMPLE LOCATIONS
WASTE OIL TANK NO. 5
SUBASE, NEW LONDON, CT

0 20 40
SCALE IN FEET

FIGURE 3-1

HALLIBURTON NUS
Environmental Corporation



TYPICAL WELL CONSTURCTION DETAILS
WASTE OIL TANK NO. 5
SUBASE, NEW LONDON, CT
NOT TO SCALE

FIGURE 3-2

HALLIBURTON NUS
Environmental Corporation

3.3 SOIL BORINGS AND CONCRETE SAMPLING

A total of four borings shall be drilled through the tank at the approximate locations shown on Figure 3-1. The borings will be drilled using minimum 6-inch inside-diameter hollow-stem auger techniques through the soil cover to the tank top (approximately 4 feet each boring). Split-spoon samples shall be collected from each boring continuously in accordance with ASTM methods until the top of the tank is reached. The use of drilling fluids is prohibited while drilling through the soil. One soil sample from each boring will be collected from the soil cover above the tank top to be analyzed for TCL/TAL analyses, to determine if contamination has resulted from surface spillage during tank filling activities. The specific sample interval to be sampled will be determined in the field based on the presence of contamination including visible observations, noticeable odors, and/or organic vapor monitor readings. If no contamination is noticed, then samples representative of both the near surface and from immediately above the tank top will be collected. Soil samples will be collected in accordance with Halliburton NUS SOP GH-1.3.

After drilling each boring to the tank top, the concrete will be cored through the center of the augers with a 3-inch-diameter diamond core bit, until the tank top is completely penetrated (approximately 10 inches thick). One sample of the concrete tank top will be collected from each boring to be analyzed for TCLP and PCB analyses to determine if contamination exists in the tank top.

The boring through the tank top will then be reamed with a minimum 4-inch-diameter roller bit to allow a 4-inch outside-diameter drill pipe and diamond bit to pass freely through the tank top. The 4-inch outside-diameter drill pipe and hollow bit will then be drilled 6 inches into the tank bottom, without penetrating the tank bottom completely. After the drill pipe is advanced to the desired depth, a cement/bentonite slurry will be pressure grouted through the center of the drill pipe and along the outside annulus. The grout will be allowed to cure for 24 hours before resuming drilling.

After the grout has been allowed to cure, all water above the grout plug will be evacuated from the inside of the 4-inch-diameter drill pipe to check for leakage. If leakage is observed, then the field geologist shall notify the Halliburton NUS Project Manager for further instruction.

The grout plug and underlying tank bottom will then be cored with the 3-inch-diameter core bit through the center of the 4-inch-diameter drill pipe until the tank bottom is penetrated completely (thickness is 9-1/2 inches). The core will be removed from each boring and the portion that is representative of the grout plug will be separated from the portion representative of tank concrete. The tank concrete core will then be split in half horizontally, and each half will be sent to the laboratory for TCLP and PCB analyses to establish a vertical profile of contamination extent in the concrete.

The soil beneath the tank at each of the 4 boring locations will also be drilled and sampled through the center of the 4-inch-diameter drill pipe using continuous split-spoon sampling in accordance with ASTM methods. Two soil samples from each boring will be collected beneath the tank bottom to be analyzed for TCL/TAL analyses, to establish a vertical profile of contamination extent in the soil. Soil samples will be collected in accordance with Halliburton NUS SOP GH-1.3. The specific samples selected for laboratory analyses will be based on field observations for the presence of contamination including visible observations, noticeable odors, and/or organic vapor monitor readings. All attempts will be made to sample both apparent contamination and beneath the apparent contamination; in order to establish a vertical profile of soil contamination. Each boring will be advanced approximately 5 feet into groundwater or to auger refusal, whichever is encountered first. The estimated total depth of each boring is 7 feet beneath the tank bottom.

A lithologic description will be made of each split-spoon sample and a complete log of each boring will be maintained by Halliburton NUS in accordance with SOP GH-1.5. At a minimum, the Halliburton NUS boring log will contain the following information:

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

In addition, depths of changes in lithology, depth to water, organic vapor monitor readings, drilling methods, and total depth of each boring will be included on each boring log.

3.4 TEMPORARY MONITORING WELL INSTALLATION

A temporary monitoring well will be installed after each boring is drilled to the desired depth (4 total). The wells will consist of 5-foot-long, 2-inch-diameter PVC well screen with 0.010-inch slot size screwed onto riser pipe. Natural backfill material will be allowed to collapse around the well screen to a depth of 1 foot below the tank floor. The top of the well annulus will be backfilled with a 1-foot-thick bentonite seal. The wells will be constructed and a monitoring well construction log will be completed in accordance with SOP GH-1.7. After groundwater samples are collected from each well, the screen and riser pipe shall be removed and

each well boring shall be grouted to the ground surface with a cement/bentonite slurry pumped through a tremie pipe.

3.5 GROUNDWATER SAMPLING

One groundwater sample will be collected from each temporary well to be sent to the laboratory for TCL/TAL analyses (see Table 3-1). The samples will be collected using a peristaltic sampling pump with a low-flow sample rate to minimize sample turbidity.

Prior to obtaining the groundwater samples, the static water level shall be measured to determine the amount of water in one casing volume. The wells shall be purged at a rate of 0.3 liters per minute using a low-flow suction lift peristaltic pump and dedicated hose to minimize turbulence. Measurements of pH, specific conductance, temperature, oxidation reduction potential (REDOX), and turbidity shall be recorded every 5 minutes during purging in accordance with SOP SF-1.1. If two consecutive readings of pH, specific conductance, temperature, ORP, and turbidity are similar ($\pm$10 percent), then the well can be sampled. Purging will continue until stabilization is reached or a maximum of five casing volumes are purged, whichever comes first. One measurements of dissolved oxygen shall also be taken prior to sample collection, in accordance with SOP SF-1.1. If the well is purged dry before three casing volumes, the water level will be allowed to recover and a sample shall be taken. In the event that recovery is too slow to adequately fill all sample bottles, the sample shall be collected the following day.

The wells shall be sampled directly from the pump outlet for all analytes except volatile organics with a flow rate of 0.3 liters per minute. Sample vials for volatile organic analysis will be filled by crimping the discharge end of the sample tubing when filled, while removing the inlet end of the sample tubing from the well. The inlet end will be suspended above the vial and the discharge end will be opened, allowing water to fill each vial by gravity flow. Purge water shall be containerized pending analysis. The groundwater samples shall be collected in accordance with SOP SA-1.1.

3.6 DECONTAMINATION

The equipment involved in field sampling activities will be decontaminated prior to and during drilling and sampling activities. This equipment includes downhole drilling tools, augers, well riser pipe and screens, and all non-dedicated sampling equipment. Specific decontamination procedures are discussed in the following subsections.

3.6.1 Major Equipment

All downhole drilling equipment and sampling tools shall be steam cleaned prior to beginning work, between well borings, any time the drilling rig leaves the site prior to completing a boring, and at the completion of the drilling program. In addition, well riser pipe and screen shall be steam cleaned prior to being installed into the borings.

These decontamination operations will consist of washing the equipment using a high-pressure steam wash. All decontamination activities will take place at the designated decontamination area. Additional requirements for drilling equipment decontamination can be found in Halliburton NUS SOP GH-1.6.

3.6.2 Sampling Equipment

All sampling equipment used for collecting samples will be decontaminated both prior to beginning field sampling and between samples. This equipment includes the split-spoon samplers and the jackhammer chisel. The following decontamination steps will be taken:

- Potable water and Alconox or Liquinox detergent wash
- Potable water rinse
- 10% Nitric acid rinse
- Distilled/Deionized water rinse (analyte free)
- Methanol rinse
- Hexane rinse
- Distilled/Deionized water rinse (analyte free)
- Air dry

Field analytical equipment such as instrument probes will be rinsed first with analyte-free water, then with the sample liquid.

3.7 WASTE HANDLING

All decontamination and purge liquids will be collected, containerized, and stored on site in Department of Transportation (DOT)-approved (Specification 17-C), 55-gallon drums. All drill cuttings will also be collected and stored on site in the DOT-approved drums. All drums will be sealed and labeled with drum contents, and well/boring number. The drums will be stored at a centralized location on base pending analyses results. Halliburton NUS will dispose of the waste in an appropriate manner based on the analyses results.

3.8 SAMPLING IDENTIFICATION SYSTEM

Each sample collected 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 and location, sample depth (in the case of soil samples), and duplicate designation, if applicable. Any other pertinent information regarding sample identification will be recorded in the field log books and sample logsheets.

The alpha-numeric coding to be used in the sample system is explained in the following diagram and the subsequent definitions:

(AANN)	-	(NNNN)	-	(A)
(Medium & Location)		(Sample depth)		(Duplicate designation)

Character Type:

A = Alpha
N = Numeric

Medium:

CO = Concrete
GW = Groundwater
SO = Soil samples

Sample Location:

Sample number (Numeric, starting with 01 for each medium)

Sample Depth:

For soil and concrete samples only = Start and end depth, in feet, of sample

Duplicate Designation (for duplicate samples only):

D = duplicate sample

Field quality control (QC) samples will be designated using a coding system. The designation will consist of a two-segment, alpha-numeric code that identifies the QC sample identifier and number. The sample number will begin with "1" and will increment for each additional QC sample obtained from the same medium during the investigation activities. Following is a summary of the QC sample coding system.

TB = Trip Blank

FB = Field Blank

RB = Rinsate Blank

Examples: a duplicate of groundwater sample GW01 would be designated as:

GW01-D

Soil sample SO01-0204 is a soil sample collected from well boring MW01 at a depth of 2 to 4 feet.

3.9 SAMPLE PACKAGING AND SHIPPING

Samples will be packaged and shipped in accordance with Halliburton NUS SOP SA-6.2. The following forms will be completed during the field activity:

- Sample Labels
- Chain-of-Custody Forms
- Chain-of-Custody Seals
- Sample Logsheets
- Overnight Courier Air Bills

Copies of applicable forms are included in Halliburton NUS SOP SA-6.4

3.10 SAMPLE CUSTODY

Custody of samples must be maintained and documented at all times. Chain-of-custody begins with the collection of the samples in the field. Section 5.3 of Halliburton NUS SOP SA-6.1 provides a description of the chain-of-custody procedures to be followed.

3.11 QUALITY CONTROL SAMPLES

In addition to standard sample acquisition, quality control (QC) samples will be collected or generated during the sampling activities. QC samples include trip blanks, field duplicates, field blanks, and equipment rinsate blanks. Table 3-1 presents the type and number of required QC samples. Each type of field QC sample is defined as follows:

- **Trip Blanks**. Trip blanks are samples which originate from analyte-free water collected in sample vials at the point of origin of the sample containers. The vials are shipped with the sample containers to the sampling site and returned to the laboratory with the Volatile Organic Compound (VOC) samples. One trip blank is assigned to each cooler containing VOCs. Trip blanks are only analyzed for volatile organic compounds.

- **Field Duplicates**. A field duplicate is one sample collected that is split into two portions and analyzed in duplicate. Field duplicates are obtained during a single act of sampling and are used to assess the overall precision of the sampling and analysis program. Field duplicates shall be analyzed in the laboratory for the same parameters as the associated environmental samples.

- **Equipment Rinsate Blanks**. Equipment rinsate blanks are obtained under representative field conditions by running analyte-free water through sample collection equipment (split-spoon or chisel) after decontamination and placing the runoff water in the appropriate sample containers for analysis. Equipment blanks will be used to assess the effectiveness of decontamination procedures. Equipment blanks will be collected for each type of non-dedicated sampling equipment used and will be submitted at a frequency of one per day per sampling event. However, only every other day's samples will be analyzed. Those not analyzed will be marked "hold" on the associated chain-of-custody form and will be retained by the laboratory until completion of field activities.

- **Field Blanks**. Field blanks are obtained by sampling the water(s) used for decontamination during the field investigation. Samples consist of the source water used in: (1) steam cleaning of large equipment and (2) analyte-free water used for decontamination of sampling equipment. Field blanks will be used to confirm the effectiveness of decontamination procedures, and to determine if the analyte-free water or the potable water (used for steam cleaning) may be contributing to sample contamination. Field blanks will be collected for each type of water used for decontamination and will be submitted at a frequency of one per source per sampling event (two estimated).

3.12 EQUIPMENT CALIBRATION

Several monitoring instruments may be used during field activities; these include:

- Organic vapor monitor
- Temperature probe
- Specific conductance meter
- pH meter
- Turbidity meter
- Oxidation reduction potential meter
- Dissolved Oxygen meter
- Electronic water-level meter
- Carbon Monoxide 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 in the field logbook. 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.

3.13 RECORD KEEPING

In addition to the previously mentioned forms, other types of records must be kept. These records include notebooks and logbooks.

A bound/weatherproof field notebook shall be maintained by the field crew. All information related to sampling or field activities will be recorded in the field notebook. This information will include, but is not limited to, sampling time, weather conditions, unusual events, field measurements, descriptions of photographs, etc.

A bound/weatherproof site logbook shall be maintained by the FOL. 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.

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 logsheet, drilling logs, etc.

REFERENCES

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GZA Geoenvironmental, 1992. Environmental Testing, Waste Oil Tank 5, Naval Submarine Base, New London, Connecticut.

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U.S. Navy, Scope Change Letter, November 24, 1993.

APPENDIX A

NAVY COMMENTS

DEPARTMENT OF THE NAVY
NORTHERN DIVISION
NAVAL FACILITIES ENGINEERING COMMAND
10 INDUSTRIAL HIGHWAY
MAIL STOP #82
LESTER, PA 19113-2090

6280 IN REPLY REFER TO
Ser 940111/1812/BJH

JAN 13 1994

Mr. Matthew G. Cochran, P.G.
Project Manager
Halliburton NUS
661 Andersen Drive
Pittsburgh, PA 15220

Subj: U.S. NAVY CONTRACT N62472-90-D-1298, CTO 129, COST IMPACT LETTER NO. 2 INVESTIGATION OF WASTE OIL TANK #5, NAVAL SUBMARINE BASE NEW LONDON

Dear Mr. Cochran:

Your draft work plan prepared under the subject task order has been reviewed by NSB New London and Northern Division. A significant problem has developed which makes it infeasible to carry out the work plan at this time.

A sounding of the tank on 10 January 1994 indicated over six feet of water had infiltrated into the tank. At present, the Navy has no method to remove this water to allow the work plan to be carried out. It is questionable whether the work plan could be carried out even if the tank were empty, due to the high groundwater.

Due to the above conditions, it has been decided to modify the approach to the investigation. Please modify your work plan to address the attached comments, and resubmit in draft form. A schedule impact letter will be required following finalization of our course of action.

Any questions may be addressed to the undersigned at (215) 595-0567, extension 124.

Sincerely,

Brian J. Helland

BRIAN J. HELLAND
Senior Environmental Engineer
By direction of the Commanding Officer

Encl: (1) Government comments dtd 11 Jan 94

Copy to:
NSB NEW LONDON (Code 1600/R. Brown)
ROICC NEW LONDON (LT. Rios)

11 January 1994

GOVERNMENT COMMENTS
WORK PLAN FOR WASTE OIL TANK 5
NSB New London
December 1993

1. The concrete coring and well installation methods do not address the infiltration of groundwater that can be expected when the tank floor is penetrated. Although this may no longer be relevant, it was a major deficiency of the work plan.

2. Is there a method of drilling through the tank floor without entering the tank, such as drilling through the roof? Is horizontal drilling from the outside feasible? Propose a feasible method for sampling the soil beneath the tank.

3. If representative groundwater samples cannot be obtained by drilling through the tank floor, conventional monitoring wells will be required on the perimeter of the tank. If necessary, include these wells in the work plan.

4. If it is still possible to obtain concrete chip samples, the sampling locations should be concentrated within 3 feet of the tank bottom, as this was the level of the most contaminated materials (sludge).

5. A future CTO change will be required to dispose of investigation derived waste from this project. Your collection, identification and storage procedures should be developed assuming disposal by HNUS in the near future.

6. Incorporate sampling and analysis of the water within the tank. This analysis will determine treatment and disposal requirements for the water.

7. Page 1-2, 2nd paragraph of work plan: The majority of the contents of OT5 were removed in mid-1993. 1 to 2 inches of sludge remains on the tank floor, along with a small amount of concrete rubble under the main opening. The remaining sludge and rubble could not be removed due to the rapidly rising water level.

MEMORANDUM 10 February 1994

From: Northern Division, Naval Facilities Engineering Command, B. Helland
To: Halliburton NUS, M. Cochran

Subj: U.S. NAVY CONTRACT N62472-90-D-1298, CTO 129, INVESTIGATION OF OT5 NAVAL SUBMARINE BASE NEW LONDON, GROTON, CT

Encl: (1) Government Comments

1. Your second draft work plan for the subject investigation has been reviewed by NSB New London and Northern Division. Overall, the work plan is much improved.

2. Please address the attached comments in your final work plan. Any questions may be referred to the undersigned at (610) 595-0567, Ext 124.

Brian J. Helland
BRIAN J. HELLAND

Copy to:
4051
NSB New London, Code 1600/R. Brown
ROICC New London, Lt. Rios

OPTIONAL FORM 99 (7-90)
FAX TRANSMITTAL # of pages ▶ 2

To Matt Cochran	From Brian Helland
Dept/Agency HNUS	Phone # 215-595-0567 x124
Fax # (412) 921-4040	Fax # 0555

NSN 7540-01-317-7368 5099-101 GENERAL SERVICES ADMINISTRATION

GOVERNMENT COMMENTS

"WORK PLAN FOR WASTE OIL TANK 5"
NSB NEW LONDON
SECOND DRAFT

1. Section 1.2 - PCB, as well as Petroleum-Related, contamination is of concern in the concrete.

2. Section 1.3, 2nd para - Delete the statement implying that SUBASE personnel occasionally pump water out of OT5. This is not the case. Water has only been pumped out by contractors during attempts to clean and close the tank.

3. Section 3.2 - Suggest a composite sample of the water be obtained from several locations and depths within the tank. We have encountered much variability in the levels of contaminants in OT5 due to the large surface area of the tank as compared to the relatively shallow depth.

4. Figure 3-1 - Is there a reason (such as fear of tank roof collapse) that your boring/well locations are so near the outer wall of the tank? These locations will provide limited information about what is beneath the center of the tank. If possible, one well should be installed near the center.

APPENDIX B

PREVIOUS INVESTIGATION DATA

MEMORANDUM 30 November 1993

From: Northern Division, Naval Facilities Engineering Command, B. Helland
To: Halliburton NUS, M. Cochran

Subj: U.S. NAVY CONTRACT N62472-90-D-1298, CTO 129, OIL TANK #5
NAVAL SUBMARINE BASE, NEW LONDON, CT

Encl: (1) NAVFAC DWG NO'S 2156153, 2156154 and 2156155
(2) GZA GeoEnvironmental, Inc., ltr dtd 8 May 92
(3) "Environmental Services, UST Removal - Waste Oil Tank #5, Naval Submarine Base, Groton, CT", GZA, Dec 91

1. Enclosures (1) - (3) are forwarded as you requested today.

2. If you have any questions, please call me at (215) 595-0567, Ext 124.

Brian J. Helland
BRIAN J. HELLAND
Environmental Engineer

Copy to:
1812

ENVIRONMENTAL SERVICES
UST REMOVAL - WASTE OIL TANK #5
NAVAL SUBMARINE BASE
GROTON, CONNECTICUT

PREPARED FOR:
The EADS Group
1126 Eighth Avenue
Altoona, Pennsylvania

PREPARED BY:
GZA GeoEnvironmental, Inc.
Providence, Rhode Island

File No. 30894
December 1991

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December 13, 1991
File No. Y-30894-C,PC

Mr. Edwin Baker
The EADS Group
1126 Eighth Avenue
P.O. Box 1887
Altoona, PA 16603

Re: Environmental Services
UST Removal - Waste Oil Tank #5
Naval Submarine Base - New London
Groton, Connecticut

140 Broadway
Providence
Rhode Island 02903
401-421-4140
FAX 401-751-8613

Dear Mr. Baker:

GZA GeoEnvironmental, Inc. (GZA) is pleased to provide you with this report containing our observations and conclusions relating to the apparent environmental conditions at the site of the above-referenced project. As outlined in our proposal dated October 7, 1991, the primary objectives of the study were to (1) perform a topographic survey in the general area of the tank; (2) perform a limited subsurface environmental investigation in the area surrounding Waste Oil Tank #5; and (3) obtain samples of the sludge in Tank #5 for laboratory analysis.

This report has been prepared in accordance with the Limitations and Terms and Conditions set forth in Appendix A. No other warranty, expressed or implied, is made.

We have appreciated the opportunity to work with you on this project and trust that this report satisfies your current needs. Should you have any questions or comments, please do not hesitate to contact the undersigned.

Very truly yours,

GZA GEOENVIRONMENTAL, INC.

William L. Ladd
Project Engineer

Hilary Downes Fortune
Consultant/Reviewer

David R. Carchedi, P.E.
Associate

A Subsidiary of GZA
GeoEnvironmental
Technologies, Inc.

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1.00 INTRODUCTION

In accordance with our October 7, 1991 proposal, GZA GeoEnvironmental (GZA) has prepared this report containing our observations and conclusions relating to the apparent environmental conditions at the Waste Oil Tank #5 site. The primary objectives of the study were to (1) perform a topographic survey in the general area of the tank; (2) perform a limited subsurface environmental investigation in the area surrounding Waste Oil Tank #5; and (3) obtain and test samples of the sludge in the tank.

The scope of services as requested by the Navy included:

- a review of record drawings and existing utility data sheets of the work area;
- a topographic survey of the site, covering approximately one acre;
- subsurface explorations, in the form of four shallow test borings around the tank;
- the analysis of selected soil samples from the borings for volatile organic compounds (VOCs), total petroleum hydrocarbons (TPH), petroleum hydrocarbon (PHC) fingerprinting, polychlorinated biphenyls (PCBs) and pesticides by EPA Method 8080, and total metals;
- the collection of two sludge samples from the bottom of the tank for total petroleum hydrocarbon (TPH) analysis, analysis for polychlorinated biphenyls (PCBs) and pesticides by EPA Method 8080, and total metals analysis; and
- the preparation of this report containing an opinion as to the presence of oil or hazardous materials in the soil at the site.

Information obtained during the course of the study revealed that residual waste oil and water, as well as waste oil sludge, was present inside Waste Oil Tank #5. Although not included in our original scope of work, samples of the waste oil were collected and analyzed for TPH, PCBs and pesticides, and VOCs. We felt that this information would be valuable in evaluating disposal options.

The findings of our study are subject to the Limitations contained in Section 6.00 and Appendix A of this report.

2.00 BACKGROUND

The following paragraphs describe the physical layout of the site, its hydrogeological setting, and the history of its use.

2.10 SITE DESCRIPTION AND HYDROGEOLOGICAL SETTING

The project site is an area roughly one acre in size surrounding Oil Tank #5 (OT5), located on the Naval Submarine Base - New London, in Groton, Connecticut (refer to Figure 1, Locus Plan). The site is situated just north of Crystal Lake Road, between Sculpin Avenue and Tang Avenue.

According to the 1984 U. S. Geological Survey topographical map for the Uncasville, Connecticut quadrangle, the site is located in the eastern portion of a fairly level, open area on the east side of the Thames River. The Thames River is located approximately 0.3 miles to the west of the site. The topography of the surrounding area is generally hilly, rising to elevations in excess of two hundred feet above sea level within one-half mile to the north, east and south. Bedrock outcrops were observed on the north side of Tang Avenue, across from the site.

Information provided by the Base's Public Works Department (PWD) indicates that the site is located at the east end of an area formerly occupied by Crystal Lake. Crystal Lake was filled, reportedly with sand, to the present grades. The area is currently used as an underground fuel and waste oil tank farm, and recreational playing fields.

As part of this study, a topographic plan (Figure 2, Topographic Plan) was developed based on a field survey performed by GZA personnel. As shown on Figure 2, the ground surface surrounding OT5 is fairly uniform in grade at an elevation of approximately 22 feet above sea level, rising abruptly several feet in elevation at the edge of Tang Avenue. The landscaping of the site appears to be well maintained, and consists predominantly of mown grass. Intermittent oak trees are present alongside Tang Avenue, and several maple and small pine trees are located southeast of the tank.

Several small structures, utility manholes and fenced enclosures are located within the immediate area of the tank. Additionally, several subsurface utilities consisting of electrical, drainage, and waste lines are located within the immediate area of OT5. GZA reviewed existing site plans at the PWD to identify and locate subsurface utilities. All topographical and man-made features, including subsurface utilities, are shown on Figure 3, Site/Utility Plan. The actual field "as-built" locations of the utilities may differ from those shown on Figure 3; the locations shown should be considered approximate, and should be verified in the field prior to any construction work.

A plan provided by the PWD entitled "Demolition, Oil Tank Five (5), Existing Conditions", dated August 2, 1989, shows the tank as a round, reinforced concrete structure with an outer diameter of 112'-4", and a depth of 11'-0". The 10-inch thick cover slab is supported by thirty-seven 16-inch diameter columns spaced at 16 feet on-center. The top of the concrete tank cover slab is located at a depth of approximately 4 feet below existing grade.

Based on a review of the area's topography and the USGS reference, GZA anticipates that the regional groundwater flow across the site is generally to the west, towards the Thames River.

2.20 SITE HISTORY

PWD personnel provided information to GZA regarding the history and usage of OT5. OT5 was constructed in the 1940's (possibly 1942), during World War II, and was initially used as a fuel oil storage tank. Ten to fifteen years ago the tank was converted for use as a waste storage tank. The waste deposited in the tank was reported to be predominantly oily bilge water pumped from Navy vessels.

OT5 was recently taken out of service, and was replaced with a new system consisting of a 30,000-gallon oily waste containment tank, an oil/water separator, and a waste oil tank. The truck dumping pad and trough located partially above OT5 on the southern edge is currently used to receive bilge water from tank trucks, with the waste line running over OT5 to the new oily waste containment tank.

In 1989, a contract was awarded to a construction company to abandon OT5 in-place. The work was to include removal of residual waste oil in OT5, and the cleaning, partial demolition and filling of the concrete structure. Several of the subsurface utilities described above were scheduled to be removed under this contract, however no as-built drawings were developed to document the actual work performed. All subsurface utilities, including those scheduled to be removed, are shown on Figure 3.

In order to gain machinery access to the tank's interior, the sump house formerly located on the east edge of the tank was demolished, and the soil cover over the tank top in this area was excavated to expose the concrete. A hole approximately 10 feet by 15 feet was broken through the cover at this location. Additionally, the soil beside OT5 at this location was excavated roughly five feet below the top of the tank to provide a sump hole for groundwater and runoff control.

The water and waste oil inside the tank was pumped to tank trucks and was hauled off site for disposal. Reportedly, complications arose when the fluid level in the tank was drawn down to approximately 6 inches above the bottom of the tank. At this point, the remaining waste consisted predominantly of heavier oil sludge material that did not flow as easily.

A small bulldozer was used inside the tank to push the sludge towards the opening for removal. Analytical testing performed during the removal of this waste indicated that the sludge in the bottom of the tank contained polychlorinated biphenyls (PCBs) in excess of 10 parts per million (ppm).

At this time, demolition work was terminated because the original budget and scope of work did not include the handling and disposal of PCBs. It was determined that a more comprehensive work plan would have to be developed prior to any additional work. The findings of this study are to be used to aid in the development of specifications for additional work.

3.00 SUBSURFACE EXPLORATIONS AND CONDITIONS

As part of this study, GZA completed a limited field exploration program, consisting of the completion of four shallow test borings. Exploration locations are shown on Figure 2.

3.10 TEST BORINGS AND SOIL SAMPLING

GZA completed four borings, designated GZ-1 through GZ-4, around the perimeter of OT5. The explorations were performed by GZA Drilling, Inc. of Brockton, Massachusetts, on October 29, 1991, and were observed by a GZA engineer. The borings were advanced to depths ranging from 20 to 22 feet below existing grade. The locations and elevations of the borings were obtained during a topographic survey performed by GZA personnel. Boring locations are shown on Figure 2; logs of the borings may be found in Appendix B.

The drilling was performed using 3-3/4" hollow stem augers with no drilling fluids. Split spoon soil samples were obtained at 5-foot intervals in conformance with ASTM D-1586, the Standard Penetration Test (SPT). The soil samples were placed in clean, 8-oz glass jars, packed in a cooler with ice, and transported to GZA's Providence, Rhode Island office for preliminary VOC screening.

Groundwater measurements were obtained within the hollow stem augers at the completion of the borings. Groundwater was allowed to stabilize approximately 10 minutes prior to the readings.

3.20 SUBSURFACE CONDITIONS

The generalized subsurface profile at the site consists of a layer of medium dense to very dense sand and gravel fill to a depth of less than five feet, underlain by a very loose to loose silty sand fill to depths ranging from 14 feet at GZ-3 to 18 feet at GZ-1, -2, and -4. The silty sand fill frequently possessed trace amounts of organic material. Underlying the fill was a layer of dense, stratified sand and silt to the full depths of the borings.

Groundwater was encountered at depths ranging from 5.7 to 8.2 feet below ground surface at an average elevation of 16 feet above mean sea level. It should be noted that the groundwater readings were obtained in the borehole with a stabilization time of approximately ten minutes. With the lack of observation wells and fully stabilized readings, the groundwater level measurements should only be considered approximate. Groundwater levels may vary due to seasonal effects and other factors that are different from the conditions at the time the borings were performed.

Bedrock was not encountered in any of the borings, however a massive rock outcrop is located on the north side of Tang Avenue, within an estimated 100 feet of the site. Refusal of the split spoon sampler was encountered at 15 and 20 feet in boring GZ-3. It was not determined whether the refusal at 20 feet was due to bedrock or boulders.

4.00 ENVIRONMENTAL SAMPLING AND ANALYSES

Samples of soil, waste oil and sludge were collected during the subsurface exploration program. Selected samples were submitted for a series of chemical screenings and analyses, as detailed below.

4.10 SOIL SAMPLING, CHEMICAL SCREENING, AND ANALYSES

Split spoon soil samples were collected at five-foot intervals in each of the four auger borings. The samples were placed in clean, 8-oz jars, packed in ice, and transported to GZA's Providence, Rhode Island office. A series of chemical screenings and laboratory analyses were performed on the soil samples, as described below. Laboratory data sheets, with copies of the Chain of Custody forms, are contained in Appendix C.

4.11 PID Screening

All thirty-nine soil samples collected from the borings were screened for total volatile organic compounds (VOCs) in GZA's Providence office. The preliminary screening was performed in the sample jar headspace using an HNU Model PI-101 photoionization detector (PID) with a 10.2 electron-volt lamp. The PID measures relative

levels of VOCs referenced to a benzene in air standard. Although the PID screening cannot be directly used to quantify VOC concentrations or identify individual compounds, the results can serve as a relative indicator of the levels of VOCs in each sample. Laboratory PID screening procedures are presented in Appendix C.

The PID screening results, summarized in Table 1, indicate that of the 39 samples screened, only four registered total VOC levels of 1.0 ppm or greater, with a peak of 4.8 ppm recorded. The sample with the highest total VOC reading was collected from a depth of 10 to 12 feet in boring GZ-1, located on the down-gradient side of Waste Oil Tank #5. PID readings between 0 (ND) and 1.0 ppm were recorded in 10 other samples obtained from all four borings.

4.12 GC Screening

Based on the PID screening results, six soil samples (GZ-1/S-3dup., GZ-1/S-5b, GZ-2/S-5, GZ-3/S-2dup., GZ-4/S-1, and GZ-4/S-2) were submitted to GZA's Environmental Chemistry Laboratory for screening by static headspace gas chromatograph (GC) techniques using a Hewlett Packard Model 5890A GC. GC screening identifies individual compounds present and estimates their respective concentrations. Descriptions and results of GZA's GC screening procedures are included in Appendix C. As summarized below, various "unknown" VOC compounds were detected in four of the samples, three of which were samples with elevated HNU readings from borings GZ-1 and GZ-4.

SAMPLE NO.	COMPOUNDS DETECTED	METHANE	# UNKNOWN COMPOUNDS	NOTES
GZ-1/S-3	ND	ND	39	1.
GZ-1/S-5B	ND	ND	NONE	—
GZ-2/S-5	ND	ND	NONE	—
GZ-3/S-2	ND	ND	1	2.
GZ-4/S-1	ND	ND	18	3.
GZ-4/S-2	ND	ND	4	4.

NOTES:

1. Unknowns tentatively identified as a petroleum distillate, such as fuel oil.
2. Unknown tentatively identified as methanol, an artifact inherent to the test method and most likely not present in the sample.
3. One of the unknown compounds is tentatively identified as methanol, as described in Note 2. The remaining compounds are tentatively identified as an unknown petroleum distillate, such as fuel oil.

4. One of the unknown compounds is tentatively identified as methanol, as described in Note 2. The remaining compounds are not identified.

4.13 Total Petroleum Hydrocarbons

Based on the GC screening results, which indicate the possible presence of fuel oil contamination, soil samples GZ-1/S-3dup., GZ-4/S-1, and GZ-4/S-2 were submitted to GZA's Environmental Chemistry Laboratory for total petroleum hydrocarbon (TPH) analysis. The samples were analyzed for TPH using EPA Method 418.1 (spectrophotometric, infrared), which indicates the total concentration of petroleum hydrocarbons present in the sample. The results of the of the analyses are contained in Appendix C, and are summarized in the table in Section 4.14.

4.14 Petroleum Hydrocarbon Fingerprinting

Sample GZ-1/S-3dup. and sample GZ-4/S-1 were submitted for petroleum hydrocarbon (PHC) fingerprinting analysis at GZA's Environmental Chemistry Laboratory using modified ASTM Method D3328. The analysis identifies the type of petroleum product present and the relative degree of weathering. Laboratory data sheets are included in Appendix C; the results are presented in the following table, along with the TPH test results.

SAMPLE	TPH (ppm)	PHC FINGERPRINT
GZ-1/S-3dup	590	75% #4 FUEL OIL (SEVERE WEATHERING) 25% #6 FUEL OIL
GZ-4/S-1	9200	50% #4 FUEL OIL (MODERATE WEATHERING) 50% #6 FUEL OIL
GZ-4/S-2	380	(NOT TESTED)

4.15 Polychlorinated Biphenyls and Pesticides

Two soil samples, GZ-1/S-3dup. and GZ-4/S-1, were analyzed at GZA's Environmental Chemistry Laboratory for polychlorinated biphenyls (PCBs) and pesticides by EPA Method 8080. Laboratory results are included in Appendix C and are summarized in the following table.

8080 COMPOUNDS	CONCENTRATION (ppb)	
	GZ-1/S-3	GZ-4/S-1
PCBs:		
AROCLOR 1260	ND	32
PESTICIDES:		
ALPHA-BHC	930	530
BETA-BHC	ND	120
DELTA-BHC	230	ND
HEPTACHLOR EPOXIDE	240	110

4.20 WASTE OIL AND SLUDGE SAMPLING AND ANALYSES

Measurements of the fluid levels in the tank were obtained at the time the samples were collected. The measurements indicated that there is a total of approximately 3.3 feet of fluid in the tank, comprised of three separate layers: floating oil product, water, and sludge/sediment. The material in the tank appeared to consist predominantly of water, with approximately 1 to 2 inches of a thick, black oil floating layer. The sludge thickness at the bottom of the tank was estimated to be approximately 6 inches, with a greater thickness in the sump pit located under the transfer pump house. According to available structural drawings of the tank, the sump pit is two feet deep by five foot square. A second sump pit exists near the west edge of the tank at the location of the former sump pump house.

The consistency of the floating oil product is similar to #4 fuel oil, while the sludge is a very thick, jelly-like viscous fluid, non-uniform in consistency. According to PWD personnel, miscellaneous debris may be mixed with the sludge/sediments. During the previous contract to abandon OT5, debris observed in the bottom of the tank included leaves, rags, cans, wood, and a 55-gallon drum. Additionally, detergents used to clean the ship's bilges may be mixed with the waste materials, causing the water and oil to emulsify.

Two samples of the waste oil sludge in the bottom of OT5 were obtained by GZA personnel on November 2, 1991. The samples, designated S-1 and S-2, were taken from two separate locations: from the opening in the floor of the existing transfer pump house near the center of the tank (S-1), and from the existing fill opening on the southwestern edge of the tank (S-2). The samples were collected using a clean, plastic scoop mounted on a 3/4 -inch diameter steel rod. The scoop was pushed into the sludge and removed to obtain the sample.

Two samples of the floating oil layer, designated S-1a and S-2a, were also obtained from each location for possible laboratory analysis. The collection of these two additional samples was not included in our scope of work, however we felt that analysis of the floating waste oil would provide valuable information. It was not anticipated at the time the original scope was developed that materials other than sludge and sediments were present inside OT5.

The samples were placed in clean 8-oz jars, packed on ice in a cooler, and transported to GZA's Providence office. Duplicates of each sample were obtained to provide a sufficient quantity of sludge and waste oil for analysis.

The samples of waste oil sludge (S-1 and S-2) and waste oil floating product (S-1a and S-2a) were submitted for a series of laboratory analyses as described below.

4.21 Volatile Organic Compounds (VOCs)

One sample of the floating oil product, S-1a, was submitted to GZA's Environmental Chemistry Laboratory for volatile organic compounds (VOCs) analysis by EPA Method 8240. This analysis was intended for soil samples in our scope of work, however we felt that the information could aid in the evaluation of disposal options. This analysis identifies compounds present and their respective concentrations. The laboratory results are attached in Appendix C, and are presented in the following table.

COMPOUND	CONCENTRATION (ppb) SAMPLE S-1a
METHYLENE CHLORIDE	7,700
TETRACHLOROETHENE	5,700
TOLUENE	8,600
ETHYL BENZENE	9,200
ACETONE	26,000
2-BUTANONE (MEK)	79,000
TOTAL XYLENES	52,000

4.22 Total Petroleum Hydrocarbons

Both sludge samples, S-1 and S-2, and one floating oil product sample, S-1a, were analyzed at GZA's Environmental Chemistry Laboratory for TPH by modified ASTM Method D3328. The laboratory results are included in Appendix C. The results of the tests are presented in the following table.

SAMPLE NO.	S-1	S-2	S-1a
TPH (ppm)	110,000	280,000	540,000

4.23 Polychlorinated Biphenyls (PCBs) and Pesticides

The two sludge samples (S-1 and S-2) and both floating oil product samples (S-1a and S-2a) were submitted to GZA's Environmental Chemistry Laboratory for analysis for pesticides and PCBs using EPA Method 8080. The laboratory results are included in Appendix C and are presented in the following table.

8080 COMPOUNDS	CONCENTRATION (ppb)			
	S-1	S-1a	S-2	S-2a
PCBs:				
AROCLOR 1260	36,000	57,000	650,000	160,000
PESTICIDES:				
ALPHA-BHC	2,800	490	2,600	ND
BETA-BHC	ND	ND	ND	ND
DELTA-BHC	800	ND	ND	ND
HEPTACHLOR EPOXIDE	850	ND	ND	ND

4.24 Metals

The two sludge samples, S-1 and S-2, were submitted to Rhode Island Analytical Laboratories, Inc. in Warwick, Rhode Island for priority pollutant metals analysis (total basis). The laboratory data sheets are included in Appendix C; the results are presented in the following table.

PARAMETER	CONCENTRATION (mg/kg)	
	S-1	S-2
ANTIMONY	3.84	4.67
ARSENIC	0.54	0.76
BERYLLIUM	<1.00	141
CADMIUM	7.14	6.67
CHROMIUM	123	103
COPPER	868	647
LEAD	217	275
MERCURY	1.00	1.00
NICKEL	75.0	70.5
SELENIUM	<0.50	<0.50
SILVER	3.57	3.81
THALLIUM	<0.50	<0.50
ZINC	9.82	894

5.00 SUMMARY AND CONCLUSIONS

A limited environmental study was conducted at the Waste Oil Tank #5 (OT5) site, located between Tang Avenue and Sculpin Avenue on the Naval Submarine Base - New London, in Groton, Connecticut. The study included the development of a site topographic plan, a limited subsurface exploration program, the sampling of residual waste in OT5, and the chemical screening and/or analyses of soil, waste oil, and sludge samples. The purpose of the study was to characterize the nature and extent of contaminants at the site in order to aid in the development of specifications for the abandonment of OT5 in-place.

On the basis of the work conducted as part of this study, GZA has reached the following conclusions.

(1) OT5 is a 275,000-gallon underground concrete tank constructed in the early 1940's. OT5 was initially used as a fuel oil storage tank, but was converted 10 to 15 years ago to a waste oil storage tank. The waste deposited in OT5 was reported to consist predominantly of oily bilge water pumped from Navy vessels, however,

access to the tank was not secured. OT5 was abandoned in-place in 1989; demolition work was terminated when PCBs were discovered in the waste oil sludge at the bottom of the tank.

(2) Four shallow auger borings (GZ-1 through GZ-4) were conducted as part of this study to depths of 20 to 22 feet around the perimeter of OT5. The subsurface conditions in the vicinity of OT5 consist of sand and gravel fill to a depth of less than 5 feet, underlain by a silty fine sand fill, with trace amounts of organics, to depths of 14 to 18 feet below ground surface. Underlying the fill is a stratum of dense, naturally deposited stratified sand, gravel and silt. Groundwater was encountered at depths ranging from 5.7 to 8.2 feet below existing ground surface. Based on the area geology and surrounding topography, GZA anticipates that groundwater flow across the site is generally to the west, towards the Thames River.

(3) During the field exploration and sampling program, a total of thirty-nine soil samples were collected from the auger borings. Additionally, two waste oil sludge, and two waste oil samples were collected from within OT5. A series of chemical screenings and/or analyses were performed on the samples as follows:

- PID Screening: All thirty-nine soil samples collected from borings GZ-1 through GZ-4 were screened for volatile organic compounds (VOCs) using a photoionization detector.

- GC Screening: Six soil samples were screened for VOCs using a gas chromatograph.

- Total Petroleum Hydrocarbons: Three soil samples and three waste oil/sludge samples were tested for total petroleum hydrocarbon content using EPA Method 418.1 and modified ASTM Method D3328.

- Hydrocarbon Fingerprint: Two soil samples were analyzed using petroleum hydrocarbon fingerprinting, modified ASTM Method D3328, in order to identify the type of petroleum product present in the samples.

- PCBs and Pesticides: Two soil samples and four waste oil/sludge samples were analyzed using EPA Method 8080 to determine if PCBs or pesticides were present.

- VOCs - EPA Method 8240: One sample of waste oil was analyzed for VOCs by EPA Method 8240.

- Metals: Two sludge samples were analyzed for priority pollutant metals on a total basis.

(4) The results of the chemical screening and analyses performed on soil samples identified at least two areas of contamination in the soil surrounding OT5. One area was detected by analyses of a sample collected from a depth of 10 to 12 feet at boring GZ-1, roughly four to six feet below the existing groundwater table. The soil sample at this location contained fuel oil and pesticides. Boring GZ-1 is located on the downgradient side of OT5. The occurrence of petroleum contamination below the groundwater level may indicate that leakage from OT5 has occurred. The second area of contaminated soil detected by analyses of soil samples collected from depths of 0 to 2 and 5 to 7 feet at boring GZ-4. The soil samples collected at this location contained fuel oil and pesticides. The sample collected from 0 to 2 feet also contained PCBs. The occurrence of contamination above the groundwater table, and the proximity of GZ-4 to the former fill opening and current truck dumping pad, suggest that surficial spills have occurred in the past.

(5) The 3.3 feet of residual material inside OT5 consists of three separate layers: floating oil product, water, and sludge/sediments. The floating oil layer was approximately 1 to 2 inches in thickness, while the sludge layer was roughly 6 inches thick; the remainder was water. The sludge thickness was observed to be greater in one of two sump pits located in the floor of OT5. Two sump pits are shown on available structural drawings. The waste oil and waste oil sludge are very high in petroleum hydrocarbon content, with measured levels ranging from 110,000 ppm to 540,000 ppm. Aroclor 1260 (PCB) was detected at concentrations ranging from 36,000 ppb to 650,000 ppb, as well as several pesticide compounds. Total metals analysis indicated the presence of several priority pollutant metals, most notably beryllium, chromium, copper, lead, nickel, and zinc. VOCs analysis of the floating oil product indicated the presence of the following compounds: Methylene chloride, tetrachloroethene, toluene, ethyl benzene, acetone, 2-butanone (MEK), and xylenes; concentrations of these compounds ranged from 7.7 to 52 ppm. The use of detergents to clean ship's bilges suggests that emulsified hydrocarbons may be present in the water layer, as well as VOCs.

In conclusion, the waste oil and sludge within OT5 contains PCBs, pesticides, VOCs, and metals. Petroleum and pesticides contamination outside OT5 occurs below the groundwater table on the downgradient (west) side of the tank, and above the groundwater table in the vicinity of the former fill area and current truck dumping pad. PCBs were also detected near the ground surface adjacent to the former fill area and truck dumping pad. The occurrence and nature of the contamination suggests that both leakage from the tank and surficial spills have occurred in the past. This limited subsurface exploration program did not identify the extent of contamination in the soil outside OT5.

WHITE COPY - Original (Accompanies Samples) YELLOW COPY - Project Manager PINK COPY - Lab Files

CHAIN-OF-CUSTODY RECORD

Sample I.D.	Time (24 hr.)	Bailer #	Collector's Initials	Location Description	Sample Type	VOA 624	VOA 601	VOA 602	ABN 625	PEST/PCB	P.P. METAL	RCRA-8	E.P. TOX.	PHC-IR	FNGRPRNT	METALS (Tot) SEE NOTE					Total # of Cont.	Note #
S-1 SLUDGE			WLL	CONTR	OIL SLUDGE										X						1	1, 2
S-2 SLUDGE			WLL	FILL AREA	"										X						1	
TOTAL NUMBER OF CONTAINERS																					2	

RELINQUISHED BY: (Signature)	DATE/TIME	RECEIVED BY: (Signature)
William J. Ladd	11/5/91 4:55	Pierce Hill
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)

NOTES:

1. SAMPLE CONTAINERS ARE DIRTY - OIL MAY CONTAIN PCBS; HANDLE W/CARE.
2. ANALYSIS FOR PRIORITY POLLUTANT METALS (TOTAL): Sb, As, Be, Cd, Cr, Cu, Pb, Hg, Ni, Se, Ag, Tl, Zn. ½ Acid Digestion

ANALYTICAL LABORATORY: RIAL PHONE: 737 8500

LABORATORY CONTACT:

GZA CONTACT: Bill Ladd EXT.:

Goldberg-Zoino & Associates, Inc.
The GEO Building
320 Needham Street
NEWTON UPPER FALLS, MA 02164
Phone: 617-969-0050 Fax: 617-965-7769

GZA FILE NO. 30894 P.O. NO. 34361

PROJECT TANK NO. 5

LOCATION GROTON CT

COLLECTOR(S) WLL/WTF

DATE(S) OF COLLECTION 11-2-91 SHEET ____ OF ____

TE COPY - Original (Accompanies Samples) YELLOW COPY - Project Man PINK COPY - Lab Files

CHAIN-OF-CUSTODY RECORD

Sample I.D.	Time (24 hr.)	Bailer #	Collector's Initials	Location Description	Sample Type	VOA 624	VOA 601	VOA 602	ABN 625	PESTIPCB	P.P. METAL	RCRA-8	E.P. TOX.	FINGERPRINT	8080 PCB	8240 VOC	Total # of Cont.	Note #
S-1 SLUDGE			WLL	CENTER	OIL SLUDGE								X	X			2	1.
S-1a FLOATER			WLL	CENTER	OIL								X	X	X		3	
S-2 SLUDGE			WLL	FILL AREA	OIL SLUDGE								X	X			2	
S-2a FLOATER			WLL	FILL AREA	OIL									X			1	
TOTAL NUMBER OF CONTAINERS													3	4	1		8	

RELINQUISHED BY: (Signature)	DATE/TIME	RECEIVED BY: (Signature)
[illegible]	10/5/91 4:30pm	[illegible]
RELINQUISHED BY: (Signature)	DATE/TIME	RECEIVED BY: (Signature)
[illegible]	10/6/91 1:30	[illegible]
RELINQUISHED BY: (Signature)	DATE/TIME	RECEIVED BY: (Signature)
[illegible]		[illegible]
RELINQUISHED BY: (Signature)	DATE/TIME	RECEIVED BY: (Signature)
RELINQUISHED BY: (Signature)	DATE/TIME	RECEIVED BY: (Signature)

NOTES: 1. SAMPLES CONSIST OF FLOATING OIL & OIL SLUDGE FROM TWO LOCATIONS. FOR SLUDGE TESTS, PLEASE USE THE THICKEST SLUDGE FROM JAR BOTTOM, IF POSSIBLE.

NOTE: SAMPLES SUSPECTED OF CONTAINING PCB'S. CONTAINERS ARE DIRTY ON OUTSIDE - HANDLE WITH CARE. PLASTIC BAGS ON SAMPLES ARE CLEAN.

ANALYTICAL LABORATORY: _____ PHONE: _____

LABORATORY CONTACT: _____

GZA CONTACT: _____ EXT.: _____

Goldberg-Zoino & Associates, Inc.
The GEO Building
320 Needham Street
NEWTON UPPER FALLS, MA 02164
Phone: 617-969-0050 Fax: 617-965-7769

GZA FILE NO. 30804 PO. NO. _____

PROJECT TANK #5

LOCATION GROTON CT

COLLECTOR(S) WLL/WTF

DATE(S) OF COLLECTION 11-2-91 SHEET 1 OF 1

(15E) 23-2

WHITE COPY - Original (Accompanies Samples) YELLOW COPY - Project Ma( ) PINK COPY - Lab Files

CHAIN-OF-CUSTODY RECORD

Sample I.D.	Time (24 hr.)	Bailer #	Collector's Initials	Location Description	Sample Type	VOA 624	VOA 601	VOA 602	ABN 625	PEST/PCB	P.P. METAL	RCRA-8	E.P. TOX.	PHC-IR	FNGRPRNT	TPH-IR	8080 PEST				Total # of Cont.	Note #
GZ-1 (S-3)			WLL		SOIL									X	X	X					1.	1.
GZ-4 (S-1)			WLL		SOIL									X	X	X					1	
GZ-4 (S-2)			WLL		SOIL										X						1	
TOTAL NUMBER OF CONTAINERS																					3	3

RELINQUISHED BY: (Signature)	DATE/TIME	RECEIVED BY: (Signature)
William J. Todd	10/5/91 4:30	K. Quelen
K. Quelen	10/6/91 8:30	[illegible]
[illegible]		[illegible]

NOTES:

1. SAMPLES INCLUDED ARE DUPLICATES OF SAMPLES YOU HAVE ALREADY RUN GC SCREEN ON.

* PLEASE PERFORM TPH-IR ANALYSIS ON SAMPLES YOU RAN GC SCREEN ON (& HELD). USE OTHER SAMPLES INCLUDED HERE AS NECESSARY.

ANALYTICAL LABORATORY: _____ PHONE: _____

LABORATORY CONTACT: _____

GZA CONTACT: _____ EXT.: _____

Goldberg-Zoino & Associates, Inc.
The GEO Building
320 Needham Street
NEWTON UPPER FALLS, MA 02164
Phone: 617-969-0050 Fax: 617-965-7769

GZA FILE NO. 30894 P.O. NO. _____

PROJECT TANK NO. 5

LOCATION GROTON CT

COLLECTOR(S) WLL

DATE(S) OF COLLECTION 10-29-91 SHEET _____ OF _____

157 1-3

WHITE COPY - Original (Accompanies Samples) YELLOW COPY - Project Manager PINK COPY - Lab Files

CHAIN-OF-CUSTODY RECORD

Sample I.D.	Time (24 hr.)	Bailer #	Collector's Initials	Location Description	Sample Type	VOA 624	VOA 601	VOA 602	ABN 625	PEST/PCB	P.P. METAL	RCRA-8	E.P. TOX.	PHC-IR	FNGRPRNT	GC SCREEN	Total # of Cont.	Note #
GZ-1 (S-3 DUP.)			WLL	GZ-1 10-12'	SOIL										X		1	1
GZ-1 (S-5b)			WLL	GZ-1 20-22'	SOIL										X		1	↓
GZ-2 (S-5)			WLL	GZ-2 20-22'	SOIL										X		1	
GZ-4 (S-1)			WLL	GZ-1 0-2'	SOIL										X		1	
GZ-4 (S-2 DUP.)			WLL	GZ-4 5-7'	SOIL										X		1	
GZ-3 (S-2 DUP.)			WLL	GZ-3 5-7'	SOIL										X		1	
																	6	

TOTAL NUMBER OF CONTAINERS

RELINQUISHED BY: (Signature)	DATE/TIME	RECEIVED BY: (Signature)
[signature]	10/30/91 1500	[signature]
RELINQUISHED BY: (Signature)	DATE/TIME	RECEIVED BY: (Signature)
[signature]	10/31/91 9:10	[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)

NOTES: 1. PLEASE PROVIDE BILL LADD OR DAVE CARCHEDE WITH VERBAL RESULTS IN 48 hrs. THE VERBAL RESULTS WILL BE USED TO SELECT SAMPLES FOR ADDITIONAL ANALYSES. PLEASE HOLD SAMPLES FOR ADDITIONAL ANALYSES

THANKS BILL LADD

ANALYTICAL LABORATORY: _____ PHONE: _____

LABORATORY CONTACT: _____

GZA CONTACT: _____ EXT.: _____

Goldberg-Zoino & Associates, Inc.
The GEO Building
320 Needham Street
NEWTON UPPER FALLS, MA 02164
Phone: 617-969-0050 Fax: 617-965-7769

GZA FILE NO. 30894 P.O. NO. _____

PROJECT TANK NO. 5 NAVY SUB BASE

LOCATION GROTON CT

COLLECTOR(S) WLL

DATE(S) OF COLLECTION 10/29/91 SHEET 1 OF 1

CHAIN OF CUSTODY FORMS

CERTIFICATE OF ANALYSIS

GZA/GEO Environmental
Date Received: 11/05/91 **Invoice #:** D5584
Date Reported: 12/02/91 **P.O. #:**

PARAMETER	S-1 (SLUDGE)		S-2 (SLUDGE)	
Total Metals:				
Antimony	3.84	mg/kg	4.67	mg/kg
Arsenic	0.54	"	0.76	"
Beryllium	<1.00	"	141	"
Cadmium	7.14	"	6.67	"
Chromium	123	"	103	"
Copper	868	"	647	"
Lead	217	"	275	"
Mercury	1.00	"	1.00	"
Nickel	75.0	"	70.5	"
Selenium	<0.50	"	<0.50	"
Silver	3.57	"	3.81	"
Thallium	<0.50	"	<0.50	"
Zinc	9.82	"	894	"

RI ANALYTICAL LABORATORIES, INC.

R.I. Analytical

Specialists in Environmental Services

CERTIFICATE OF ANALYSIS

GZA/GEO Environmental
Attn: Mr. William Ladd
140 Broadway
Providence, RI 02903

DATE RECEIVED: 11/05/91
DATE REPORTED: 12/02/91
P.O. #: 34361
INVOICE #: D5584

SAMPLE DESCRIPTION: Two (2) oil sludge samples labelled Tank #5, Groton, CT

Subject samples have been analyzed by our laboratory with the attached results.

Reference: Test Methods for Evaluating Solid Waste, Physical/ Chemical Methods, U.S. EPA, SW-846, July 1982, second edition.

If you have any question regarding this work or if we may be of further assistance, please contact us.

Approved by:

Michael S. Rose
Laboratory Manager

Anthony E. Perrotti
President

djr

R.I. Analytical Laboratories, Inc.
41 Illinois Ave., Warwick, RI 02888, (401) 737-8500 · Fax: (401) 738-1970

METALS

LABORATORY CONTACT PERSON:

Edward W. Pickering, Manager
Environmental Chemistry Laboratory
GZA GeoEnvironmental, Inc.
Massachusetts Laboratory I.D. No. MA 092
Phone #: (617) 969-0050 x169

REFERENCES

Commonwealth of Massachusetts DEP, "Minimum Standards for Analytical Data for Remedial Response Actions Under M.G.L.c. 21E", Policy #WSC-89-004 (1990).

McNally, M.E. and R.L. Grob, "A Review: Current Applications of Static and Dynamic Headspace Analysis: Part One: Environmental Applications", Am. Lab. 20 (1) 20-33, (1985).

U.S. EPA, "Handbook for Analytical Quality Control in Water and Waste Water Laboratories", EP-600\4-79-1019 (1979).

U.S. EPA "Methods for Organic Chemical Analysis of Municipal and Industrial Wastewater", Appendix A. 40CFR Part 136, Federal Register, Vol. 49, No. 209. Method 624-Purgeables (1984).

U.S. EPA, "Test Methods for Evaluating Solid Waste, Physical/Chemical Methods", SW-846, Third Edition, Volume 1B, Update Method 8240: GC/MS for Volatile Organics. Update Method 8260: Gas Chromatography/Mass Spectrometry for Volatile Organics: Capillary Column Technique. Method 5030: Purge and Trap. May 1989.

9/23/91 DM

EPA METHOD 8240\8260 ANALYSIS FOR VOLATILE ORGANICS BY GC/MS

OVERVIEW

EPA Method 8240\8260 is a purge and trap gas chromatographic method for the identification and quantification of volatile organic compounds in aqueous and solid samples. Purge and trap is a dynamic headspace technique where volatiles in an aqueous/solid sample are completely stripped from the aqueous/solid phase to vapor phase. The volatiles from the depleted sample are collected on an absorbent trap, thermally desorbed to a gas chromatograph for separation using a capillary column, and routed to a mass spectrometer.

METHODOLOGY

A Tekmar Model LSC-2000 Liquid Sample Concentrator is used in conjunction with a Tekmar Model ALS2016 Automatic Laboratory Sampler to purge volatile compounds by bubbling helium gas through a 5 ml aqueous matrix and passing the vapor through a tenax/silica gel sorbent trap. Aqueous samples are introduced directly into the sample sparging apparatus. Solid samples are prepared using two methods: a high level and a low level method. The high level method is a solvent extraction of the sample using capillary grade methanol of which an aliquot is spiked into reagent water and subsequently treated as an aqueous sample. The low level method involves the transfer of a five gram solid subsample to the sparging device, the addition of reagent water to the sample, and utilizing a sample heater to purge volatile components. The purgeable compounds retained on the tenax/silica gel trap are then thermally desorbed and passed through a heated line into the gas chromatograph. GZA performs this method on a Hewlett-Packard UP 5890A Gas Chromatograph and a Hewlett Packard Model 597OB Mass Selective Detector which is interfaced to a Hewlett-Packard HP 1000 RTE A Series Micro 24 System with Aquarius data acquisition software. The information for the report is entered manually onto a Lotus Symphony spreadsheet. Calibration and quality control are performed in accordance with the protocols established by the EPA and Massachusetts DEP published in the references cited below.

REPORT FORMAT

The quantitation limit is stated for every report and is adjusted when dilutions are made to bring sample response data within the calibrated range of the method. Concentrations less than the quantitation limit may be identified as Beneath Method Quantitation Limit (BMQL).

DISCLAIMER

Identities and concentrations of purgeable organic compounds by this dynamic headspace technique are subject to limitations inherent to these methods.

EPA METHOD 8240 ANALYSIS
FOR VOLATILE ORGANICS BY GC/MS

JOB DESCRIPTION: TANK #5 – GROTON, CT
JOB #: 30894
SAMPLE #: S–1a FLOATER
MATRIX: OIL
LABORATORY #: A9387

HAZARDOUS SUBSTANCE LIST 8240 COMPOUNDS	CONCENTRATION ug/l or ug/kg (PPB)	QUANTITATION LIMIT ug/l or ug/kg (PPB)
ACETONE	—26,000—	25,000
CARBON DISULFIDE	ND	2,500
2–BUTANONE (MEK)	—79,000—	50,000
VINYL ACETATE	ND	10,000
2–HEXANONE (MBK)	ND	10,000
4–METHYL–2–PENTANONE (MIBK)	ND	10,000
TOTAL XYLENES	—52,000—	2,500
STYRENE	ND	2,500

MISCELLANEOUS 8240 COMPOUNDS:	CONCENTRATION ug/l or ug/kg (PPB)	QUANTITATION LIMIT ug/l or ug/kg (PPB)
METHYL–t–BUTYL ETHER	ND	5,000
TRICHLOROFLUOROMETHANE	ND	10,000

SURROGATES	% RECOVERY
1,2–DICHLOROETHANE – D4	104
TOLUENE – D8	91.5
4–BROMOFLUOROBENZENE	97.4

COMMENTS:

ANALYZED BY: V Leong

REVIEWED BY: K Wall

GZA GEOENVIRONMENTAL, INC., ENVIRONMENTAL CHEMISTRY LABORATORY
320 NEEDHAM STREET, NEWTON UPPER FALLS, MA 02164 (617) 969-0050
MASSACHUSETTS LABORATORY I.D. NO. MA092

EPA METHOD 8240/8260 ANALYSIS FOR VOLATILE ORGANICS BY GC/MS

JOB DESCRIPTION: TANK #5 – GROTON, CT
JOB #: 30894
SAMPLE #: S-1a FLOATER
MATRIX: OIL
LABORATORY #: A9387

DATE SAMPLED: 11/02/91
DATE EXTRACTED: ——
DATE TESTED: 11/08/91
DILUTION FACTOR: 500

PRIORITY POLLUTANT LIST 8240 COMPOUNDS:	CONCENTRATION ug/l or ug/kg (PPB)	QUANTITATION LIMIT ug/l or ug/kg (PPB)
CHLOROMETHANE	ND	5,000
BROMOMETHANE	ND	5,000
VINYL CHLORIDE	ND	5,000
CHLOROETHANE	ND	5,000
METHYLENE CHLORIDE	--7,700--	5,000
1,1-DICHLOROETHENE	ND	2,500
1,1-DICHLOROETHANE	ND	2,500
TOTAL 1,2-DICHLOROETHENES	ND	2,500
CHLOROFORM	ND	2,500
1,2-DICHLOROETHANE	ND	2,500
1,1,1-TRICHLOROETHANE	ND	2,500
CARBON TETRACHLORIDE	ND	2,500
BROMODICHLOROMETHANE	ND	2,500
1,2-DICHLOROPROPANE	ND	2,500
TRANS 1,3-DICHLOROPROPENE	ND	2,500
TRICHLOROETHENE	ND	2,500
DIBROMOCHLOROMETHANE	ND	2,500
1,1,2-TRICHLOROETHANE	ND	2,500
BENZENE	ND	2,500
CIS 1,3-DICHLOROPROPENE	ND	2,500
BROMOFORM	ND	2,500
1,1,2,2-TETRACHLOROETHANE	ND	2,500
TETRACHLOROETHENE	--5,700--	2,500
TOLUENE	--8,600--	2,500
CHLOROBENZENE	ND	2,500
ETHYL BENZENE	--9,200--	2,500
1,2-DICHLOROBENZENE	ND	5,000
1,3-DICHLOROBENZENE	ND	5,000
1,4-DICHLOROBENZENE	ND	5,000

SEE PAGE 2 – FOR REMAINING COMPOUNDS

VOC ANALYSIS (EPA METHOD 8240)

GZA GEOENVIRONMENTAL, INC.
320 NEEDHAM STREET, NEWTON UPPER FALLS, MA 02164
(617) 969-0050

EPA 8080 ANALYSIS
PCB's/PESTICIDES SCREENING

JOB DESCRIPTION:	TANK #5 - GROTON, MA		
JOB #:	30894	DATE SAMPLED:	11/02/91
SAMPLE #:	GZ-4, S-1	DATE TESTED:	11/08/91
LABORATORY #:	22390 - PCB/PEST	DILUTION FACTOR:	0.1

PCB'S

8080 COMPOUNDS: POLYCHLORINATED BIPHENYLS	CONCENTRATION ug/kg-Soil (PPB)	DETECTION LIMIT ug/kg-Soil (PPB)
AROCLOR 1260	--32--	5.0
AROCLOR 1254	ND	5.0
AROCLOR 1248	ND	5.0
AROCLOR 1242/1016	ND	5.0
AROCLOR 1232	ND	5.0
AROCLOR 1221	ND	5.0

PESTICIDES

8080 COMPOUNDS: PESTICIDES	CONCENTRATION ug/kg-Soil (PPB)	DETECTION LIMIT ug/kg-Soil (PPB)
ALPHA - BHC	--530--	0.5
GAMMA - BHC	ND	0.5
BETA - BHC	--120--	0.5
HEPTACHLOR	ND	0.5
DELTA - BHC	ND	0.5
ALDRIN	ND	0.5
HEPTACHLOR EPOXIDE	--110--	0.5
ENDOSULFAN I	ND	0.5
4,4'-DDE	ND	0.5
DIELDRIN	ND	0.5
ENDRIN	ND	0.5
4,4'-DDD	ND	0.5
ENDOSULFAN II	ND	0.5
4,4'-DDT	ND	0.5
ENDRIN ALDEHYDE	ND	0.5
ENDOSULFAN SULFATE	ND	0.5
METHOXYCHLOR	ND	5.0
TOXAPHENE	ND	5.0
CHLORDANE	ND	5.0

COMMENTS:

ANALYZED BY: VL L. Faulkner REVIEWED BY: KW K Walsh

GZA GEOENVIRONMENTAL, INC.
320 NEEDHAM STREET, NEWTON UPPER FALLS, MA 02164
(617) 969-0050

EPA 8080 ANALYSIS
PCB's/PESTICIDES SCREENING

JOB DESCRIPTION:	TANK #5 – GROTON, MA		
JOB #:	30894	DATE SAMPLED:	11/02/91
SAMPLE #:	GZ-1, S-3	DATE TESTED:	11/08/91
LABORATORY #:	22389 – PCB/PEST	DILUTION FACTOR:	0.1

PCB'S

8080 COMPOUNDS: POLYCHLORINATED BIPHENYLS	CONCENTRATION ug/kg-Soil (PPB)	DETECTION LIMIT ug/kg-Soil (PPB)
AROCLOR 1260	ND	5.0
AROCLOR 1254	ND	5.0
AROCLOR 1248	ND	5.0
AROCLOR 1242/1016	ND	5.0
AROCLOR 1232	ND	5.0
AROCLOR 1221	ND	5.0

PESTICIDES

8080 COMPOUNDS: PESTICIDES	CONCENTRATION ug/kg-Soil (PPB)	DETECTION LIMIT ug/kg-Soil (PPB)
ALPHA – BHC	--930--	0.5
GAMMA – BHC	ND	0.5
BETA – BHC	ND	0.5
HEPTACHLOR	ND	0.5
DELTA – BHC	--230--	0.5
ALDRIN	ND	0.5
HEPTACHLOR EPOXIDE	--240--	0.5
ENDOSULFAN I	ND	0.5
4,4'-DDE	ND	0.5
DIELDRIN	ND	0.5
ENDRIN	ND	0.5
4,4'-DDD	ND	0.5
ENDOSULFAN II	ND	0.5
4,4'-DDT	ND	0.5
ENDRIN ALDEHYDE	ND	0.5
ENDOSULFAN SULFATE	ND	0.5
METHOXYCHLOR	ND	5.0
TOXAPHENE	ND	5.0
CHLORDANE	ND	5.0

COMMENTS:

ANALYZED BY: VL L. Faulkner REVIEWED BY: KW KWalsh

GZA GEOENVIRONMENTAL, INC.
320 NEEDHAM STREET, NEWTON UPPER FALLS, MA 02164
(617) 969-0050

EPA 8080 ANALYSIS
PCB's/PESTICIDES SCREENING

JOB DESCRIPTION:	TANK #5 – GROTON, MA		
JOB #:	30894	DATE SAMPLED:	11/02/91
SAMPLE #:	S-2A	DATE TESTED:	11/08/91
LABORATORY #:	22394 – PCB/PEST	DILUTION FACTOR:	50

PCB'S

8080 COMPOUNDS: POLYCHLORINATED BIPHENYLS	CONCENTRATION ug/kg-Oil (PPB)	DETECTION LIMIT ug/kg-Oil (PPB)
AROCLOR 1260	--160,000--	2,500
AROCLOR 1254	ND	2,500
AROCLOR 1248	ND	2,500
AROCLOR 1242/1016	ND	2,500
AROCLOR 1232	ND	2,500
AROCLOR 1221	ND	2,500

PESTICIDES

8080 COMPOUNDS: PESTICIDES	CONCENTRATION ug/kg-Oil (PPB)	DETECTION LIMIT ug/kg-Oil (PPB)
ALPHA – BHC	ND	250
GAMMA – BHC	ND	250
BETA – BHC	ND	250
HEPTACHLOR	ND	250
DELTA – BHC	ND	250
ALDRIN	ND	250
HEPTACHLOR EPOXIDE	ND	250
ENDOSULFAN I	ND	250
4,4'-DDE	ND	250
DIELDRIN	ND	250
ENDRIN	ND	250
4,4'-DDD	ND	250
ENDOSULFAN II	ND	250
4,4'-DDT	ND	250
ENDRIN ALDEHYDE	ND	250
ENDOSULFAN SULFATE	ND	250
METHOXYCHLOR	ND	2,500
TOXAPHENE	ND	2,500
CHLORDANE	ND	2,500

COMMENTS:

ANALYZED BY: VL L. Faulkner REVIEWED BY: KW K Walsh

GZA GEOENVIRONMENTAL, INC.
320 NEEDHAM STREET, NEWTON UPPER FALLS, MA 02164
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EPA 8080 ANALYSIS
PCB's/PESTICIDES SCREENING

JOB DESCRIPTION:	TANK #5 - GROTON, MA		
JOB #:	30894	DATE SAMPLED:	11/02/91
SAMPLE #:	S-2	DATE TESTED:	11/08/91
LABORATORY #:	22393 - PCB/PEST	DILUTION FACTOR:	50

PCB'S

8080 COMPOUNDS: POLYCHLORINATED BIPHENYLS	CONCENTRATION ug/kg-Oil (PPB)	DETECTION LIMIT ug/kg-Oil (PPB)
AROCLOR 1260	--650,000--	2,500
AROCLOR 1254	ND	2,500
AROCLOR 1248	ND	2,500
AROCLOR 1242/1016	ND	2,500
AROCLOR 1232	ND	2,500
AROCLOR 1221	ND	2,500

PESTICIDES

8080 COMPOUNDS: PESTICIDES	CONCENTRATION ug/kg-Oil (PPB)	DETECTION LIMIT ug/kg-Oil (PPB)
ALPHA - BHC	--2,600--	250
GAMMA - BHC	ND	250
BETA - BHC	ND	250
HEPTACHLOR	ND	250
DELTA - BHC	ND	250
ALDRIN	ND	250
HEPTACHLOR EPOXIDE	ND	250
ENDOSULFAN I	ND	250
4,4'-DDE	ND	250
DIELDRIN	ND	250
ENDRIN	ND	250
4,4'-DDD	ND	250
ENDOSULFAN II	ND	250
4,4'-DDT	ND	250
ENDRIN ALDEHYDE	ND	250
ENDOSULFAN SULFATE	ND	250
METHOXYCHLOR	ND	2,500
TOXAPHENE	ND	2,500
CHLORDANE	ND	2,500

COMMENTS:

ANALYZED BY: VL L. Faulkner REVIEWED BY: KW Kwalek

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EPA 8080 ANALYSIS
PCB's/PESTICIDES SCREENING

JOB DESCRIPTION:	TANK #5 – GROTON, MA		
JOB #:	30894	DATE SAMPLED:	11/02/91
SAMPLE #:	S-1A	DATE TESTED:	11/08/91
LABORATORY #:	22392 – PCB/PEST	DILUTION FACTOR:	50

PCB'S

8080 COMPOUNDS: POLYCHLORINATED BIPHENYLS	CONCENTRATION ug/kg-Oil (PPB)	DETECTION LIMIT ug/kg-Oil (PPB)
AROCLOR 1260	--57,000--	2,500
AROCLOR 1254	ND	2,500
AROCLOR 1248	ND	2,500
AROCLOR 1242/1016	ND	2,500
AROCLOR 1232	ND	2,500
AROCLOR 1221	ND	2,500

PESTICIDES

8080 COMPOUNDS: PESTICIDES	CONCENTRATION ug/kg-Oil (PPB)	DETECTION LIMIT ug/kg-Oil (PPB)
ALPHA - BHC	--490--	250
GAMMA - BHC	ND	250
BETA - BHC	ND	250
HEPTACHLOR	ND	250
DELTA - BHC	ND	250
ALDRIN	ND	250
HEPTACHLOR EPOXIDE	ND	250
ENDOSULFAN I	ND	250
4,4'-DDE	ND	250
DIELDRIN	ND	250
ENDRIN	ND	250
4,4'-DDD	ND	250
ENDOSULFAN II	ND	250
4,4'-DDT	ND	250
ENDRIN ALDEHYDE	ND	250
ENDOSULFAN SULFATE	ND	250
METHOXYCHLOR	ND	2,500
TOXAPHENE	ND	2,500
CHLORDANE	ND	2,500

COMMENTS:

ANALYZED BY: VL REVIEWED BY: KW

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EPA 8080 ANALYSIS
PCB's/PESTICIDES SCREENING

JOB DESCRIPTION:	TANK #5 – GROTON, MA		
JOB #:	30894	DATE SAMPLED:	11/02/91
SAMPLE #:	S-1	DATE TESTED:	11/08/91
LABORATORY #:	22391 – PCB/PEST	DILUTION FACTOR:	50

PCB'S

8080 COMPOUNDS: POLYCHLORINATED BIPHENYLS	CONCENTRATION ug/kg-Oil (PPB)	DETECTION LIMIT ug/kg-Oil (PPB)
AROCLOR 1260	--36,000--	2,500
AROCLOR 1254	ND	2,500
AROCLOR 1248	ND	2,500
AROCLOR 1242/1016	ND	2,500
AROCLOR 1232	ND	2,500
AROCLOR 1221	ND	2,500

PESTICIDES

8080 COMPOUNDS: PESTICIDES	CONCENTRATION ug/kg-Oil (PPB)	DETECTION LIMIT ug/kg-Oil (PPB)
ALPHA - BHC	--2,800--	250
GAMMA - BHC	ND	250
BETA - BHC	ND	250
HEPTACHLOR	ND	250
DELTA - BHC	--800--	250
ALDRIN	ND	250
HEPTACHLOR EPOXIDE	--850--	250
ENDOSULFAN I	ND	250
4,4'-DDE	ND	250
DIELDRIN	ND	250
ENDRIN	ND	250
4,4'-DDD	ND	250
ENDOSULFAN II	ND	250
4,4'-DDT	ND	250
ENDRIN ALDEHYDE	ND	250
ENDOSULFAN SULFATE	ND	250
METHOXYCHLOR	ND	2,500
TOXAPHENE	ND	2,500
CHLORDANE	ND	2,500

COMMENTS:

ANALYZED BY: VL REVIEWED BY: KW

PCB/PESTICIDE ANALYSIS

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HYDROCARBON FINGERPRINTING
MODIFIED ASTM METHOD D3328
CONCENTRATION (PPM-ug/g or ug/ml)

JOB DESCRIPTION: TANK NO. 5 - GROTON, CT
JOB #: 30894
DATE SAMPLED: 10/29/91
DATE TESTED: 11/8/91

SAMPLE NAME: GZA LAB #:	METHOD BLANK 110891-QC	GZ-4, S-1 03370-FP
1. HYDROCARBON CONTENT	<10	440
2. PERCENT SOLID CONTENT	N/A	93%
3. MATRIX	N/A	SOIL
4. DETECTION LIMIT (TOTAL PRODUCT)	10	10
5. DETECTION LIMIT (INDIVIDUAL HYDROCARBONS)	0.5	0.5
6. SURROGATE RECOVERY (O-TERPHENYL)	103%	102%

QUALITATIVE IDENTIFICATION:

The characteristics of the chromatogram for sample "GZ-4, S-1" indicate the presence of two petroleum products. The first petroleum product is in the boiling range of fuel oil #4, constitutes approximately 50% of the hydrocarbon content, and has a phytane/n-C18 ratio of 7.3 which indicates that moderate weathering has occurred. The second petroleum product is in the boiling range of fuel oil #6 and constitutes approximately 50% of the hydrocarbon content.

ANALYZED BY: J. Faulkner REVIEWED BY: K Walsh

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HYDROCARBON FINGERPRINTING
MODIFIED ASTM METHOD D3328
CONCENTRATION (PPM-ug/g or ug/ml)

JOB DESCRIPTION: TANK NO. 5 – GROTON, CT
JOB #: 30894
DATE SAMPLED: 10/29/91
DATE TESTED: 11/8/91

SAMPLE NAME: GZA LAB #:	METHOD BLANK 110891-QC	GZ-1, S-3 03369-FP
1. HYDROCARBON CONTENT	<10	36
2. PERCENT SOLID CONTENT	N/A	85%
3. MATRIX	N/A	SOIL
4. DETECTION LIMIT (TOTAL PRODUCT)	10	10
5. DETECTION LIMIT (INDIVIDUAL HYDROCARBONS)	0.5	0.5
6. SURROGATE RECOVERY (O-TERPHENYL)	103%	90%

QUALITATIVE IDENTIFICATION:

The characteristics of the chromatogram for sample "GZ-1, S-3" indicate the presence of two petroleum products. The first petroleum product is in the boiling range of fuel oil #4, constitutes approximately 75% of the hydrocarbon content, and has a phytane/n-C18 ratio of greater than 10 which indicates severe weathering has occurred. The second petroleum product is in the boiling range of fuel oil #6 and constitutes approximately 25% of the hydrocarbon content.

ANALYZED BY: J. Faulkner REVIEWED BY: K Walk

PETROLEUM HYDROCARBON FINGERPRINTING

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HYDROCARBON FINGERPRINTING
MODIFIED ASTM METHOD D3328
CONCENTRATION (PPM-ug/g or ug/ml)

JOB DESCRIPTION: TANK NO. 5 - GROTON, CT
JOB #: 30894
DATE SAMPLED: 10/29/91
DATE TESTED: 11/8/91

SAMPLE NAME: GZA LAB #:	METHOD BLANK 110891-QC	S-1A 03375-PHC
1. HYDROCARBON CONTENT	<10	540,000
2. PERCENT SOLID CONTENT	N/A	N/A
3. MATRIX	N/A	OIL
4. DETECTION LIMIT (TOTAL PRODUCT)	10	10,000
5. DETECTION LIMIT (INDIVIDUAL HYDROCARBONS)	0.5	500
6. SURROGATE RECOVERY (O-TERPHENYL)	103%	DILUTED OUT

QUALITATIVE IDENTIFICATION: N/A

ANALYZED BY: J. Hauthner REVIEWED BY: K Walsh

GZA GEOENVIRONMENTAL, INC.
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MASSACHUSETTS LABORATORY I.D. NO. MA092

HYDROCARBON FINGERPRINTING
MODIFIED ASTM METHOD D3328
CONCENTRATION (PPM-ug/g or ug/ml)

JOB DESCRIPTION: TANK NO. 5 - GROTON, CT
JOB #: 30894
DATE SAMPLED: 10/29/91
DATE TESTED: 11/8/91

SAMPLE NAME:	METHOD BLANK	S-2
GZA LAB #:	110891-QC	03373-PHC
1. HYDROCARBON CONTENT	<10	280,000
2. PERCENT SOLID CONTENT	N/A	N/A
3. MATRIX	N/A	OIL
4. DETECTION LIMIT (TOTAL PRODUCT)	10	10,000
5. DETECTION LIMIT (INDIVIDUAL HYDROCARBONS)	0.5	500
6. SURROGATE RECOVERY (O-TERPHENYL)	103%	DILUTED OUT

QUALITATIVE IDENTIFICATION: N/A

ANALYZED BY: Y. Faulkner

REVIEWED BY: K Walsh

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HYDROCARBON FINGERPRINTING
MODIFIED ASTM METHOD D3328
CONCENTRATION (PPM-ug/g or ug/ml)

JOB DESCRIPTION: TANK NO. 5 - GROTON, CT
JOB #: 30894
DATE SAMPLED: 10/29/91
DATE TESTED: 11/8/91

SAMPLE NAME: GZA LAB #:	METHOD BLANK 110891-QC	S-1 03371-PHC
1. HYDROCARBON CONTENT	<10	110,000
2. PERCENT SOLID CONTENT	N/A	N/A
3. MATRIX	N/A	OIL
4. DETECTION LIMIT (TOTAL PRODUCT)	10	10,000
5. DETECTION LIMIT (INDIVIDUAL HYDROCARBONS)	0.5	500
6. SURROGATE RECOVERY (O-TERPHENYL)	103%	DILUTED OUT

QUALITATIVE IDENTIFICATION: N/A

ANALYZED BY: J. Smith MV REVIEWED BY: K Walsh

GZA GEOENVIRONMENTAL, INC.
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EPA METHOD 418.1 PETROLEUM HYDROCARBONS
(SPECTROPHOTOMETRIC, INFRARED)
PHC-IR
CONCENTRATION (PPM, ug/g or ug/ml)

JOB DESCRIPTION: TANK #5 - GROTON, CT
JOB #: 30894
DATE SAMPLED: 10/29/91
DATE TESTED: 11/07/91

SAMPLE NAME:	METHOD BLANK	GZ-4 S-1
GZA LAB #:	110791-QC	02041-IR
1. HYDROCARBON CONTENT	<10	9,200
2. PERCENT SOLID CONTENT	N/A	93%
3. MATRIX	N/A	SOIL
4. DETECTION LIMIT	10	10

COMMENTS:

ANALYZED BY: J. Kunkhorst REVIEWED BY: K. Walsh

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EPA METHOD 418.1 PETROLEUM HYDROCARBONS
(SPECTROPHOTOMETRIC, INFRARED)
PHC-IR
CONCENTRATION (PPM, ug/g or ug/ml)

JOB DESCRIPTION: TANK #5 – GROTON, CT
JOB #: 30894
DATE SAMPLED: 10/29/91
DATE TESTED: 11/07/91

SAMPLE NAME: GZA LAB #:	METHOD BLANK 110791-QC	GZ-1 S-3 02040-IR
1. HYDROCARBON CONTENT	<10	590
2. PERCENT SOLID CONTENT	N/A	85%
3. MATRIX	N/A	SOIL
4. DETECTION LIMIT	10	10

COMMENTS:

ANALYZED BY: J. Kirchner REVIEWED BY: Kuhn

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EPA METHOD 418.1 PETROLEUM HYDROCARBONS
(SPECTROPHOTOMETRIC, INFRARED)
PHC-IR
CONCENTRATION (PPM, ug/g or ug/ml)

JOB DESCRIPTION: TANK #5 – GROTON, CT
JOB #: 30894
DATE SAMPLED: 10/29/91
DATE TESTED: 11/07/91

SAMPLE NAME: GZA LAB #:	METHOD BLANK 110791-QC	GZ-4 S-2 02042-IR
1. HYDROCARBON CONTENT	<10	380
2. PERCENT SOLID CONTENT	N/A	88%
3. MATRIX	N/A	SOIL
4. DETECTION LIMIT	10	10

COMMENTS:

ANALYZED BY: J. Faulkner REVIEWED BY: K Ward

TPH ANALYSIS

GZA GEOENVIRONMENTAL, INC.
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GZA GAS CHROMATOGRAPHIC SCREENING FOR VOLATILE ORGANICS
IN AQUEOUS AND/OR SOLID MATRIX
QUALITY CONTROL

DATE: 10/30/91

AQUEOUS

COMPOUNDS	MATRIX SPIKE RECOVERY (%)	ACCEPTANCE LIMITS (%)	DUPLICATE SPIKE PERCENT DIFFERENCE (%)	ACCEPTANCE LIMITS (%)
Trichloroethene	100	70–130	2	35
Toluene	96.5	70–130	0.1	35

SOLID

COMPOUNDS	MATRIX SPIKE RECOVERY (%)	ACCEPTANCE LIMITS (%)	DUPLICATE SPIKE PERCENT DIFFERENCE (%)	ACCEPTANCE LIMITS (%)
Trichloroethene	—	70–130	—	35
Toluene	—	70–130	—	35

Edward W. Pickering, Manager
Environmental Chemistry Laboratory
GZA GeoEnvironmental, Inc.
Massachusetts Laboratory I.D. No. MA092
Phone #: (617) 969-0050, x169

REFERENCES

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McNally, M.E., and R.L. Grob, "A Review: Current Applications of Static and Dynamic Headspace Analysis: Part One: Environmental Applications," Am. Lab. 17 (1) 20-33, (1985).

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U.S. EPA, "Test Methods for Evaluating Solid Waste, Physical/Chemical Methods", SW-846, Third Edition, Volume 1B, Method 3810: Headspace, (1986).

Wylie, P.L., "Trace Analysis of Volatile Compounds in Water Using the HP 19395A Headspace Sampler", Hewlett-Packard Application Note AN 228-40 (1985).

Wylie, P.L., "Comparing Headspace with Purge and Trap for Analysis of Volatile Priority Pollutants", Jour. AWWA 80:8:65 (1988).

July 1991/EWP-DM

REPORT FORMAT

The method detection limit (MDL) for each compound is stated for every report with 95% certainty in an average chromatographic run. The method quantitation limit (MQL) is considered to be 5 times the MDL. Concentrations measured in the range of 1 to 5 times the MDL are reported as "Trace". Concentrations less than the MDL may be identified as beneath the method detection limit (BMDL) in instances where the compound's presence is 95% certain in that particular chromatogram. The total concentration for all detected compounds for which a calibration has been made, except methane, is summarized in the row designated as "Total Compounds"; none detected, ND, is reported if no known peaks are found. Unidentifiable peaks are reported as the number of unknown peaks are reported in parentheses. Compounds not detected are reported as "ND".

QUALITY CONTROL

The GZA procedure assumes that response factors are constant over the working range of 10 ppb to 10 ppm and that the precision of the analysis for samples is the same as that for the calibration standards. The 95% confidence limits for a measurement are defined as plus or minus two standard deviations as determined by a Student's t Test on replicate analyses of calibration standards. Quality control standards are analyzed daily and accepted if the relative standard deviation of the response factor is less than 20% of the anticipated value. New calibration curves are prepared when quality control limits are exceeded. Method blanks are prepared in the same manner as samples and are analyzed before each job or no less frequently than every ten samples. Field blanks and trip blanks are submitted at the discretion of the sample submitter. Matrix spikes and duplicate analyses are performed at a frequency of not less than one per twenty or fewer samples and results are reported as matrix spike recoveries and percent differences. Analytical results are not blank corrected.

DISCLAIMER

Identities and concentrations of volatile organic compounds reported by this headspace screening technique are subject to limitations inherent to this method. Chromatographic data are quantified by response factors that assume 100% volatilization of sorbed organic compounds into the headspace. Therefore, the reported concentrations probaby represent the lower limits of contamination. If confirmation is desired, duplicate samples should be submitted to a State certified laboratory for analysis by the appropriate EPA protocol methods.

LABORATORY SAMPLE NOTATION:

S – Solid B – Blank

LABORATORY CONTACT PERSON:

GZA RAPID VOLATILE ORGANIC SCREENING OF SOIL SAMPLES BY THE STATIC HEADSPACE TECHNIQUE

SAMPLE PREPARATION AND ANALYTICAL METHODOLOGY

OVERVIEW

The GZA rapid screening technique for volatile organics in soil estimates concentrations of these compounds from gaseous concentrations measured in air above the sample. The method measures concentrations of contaminants released from the soil samples into the headspace. This method has been developed by the GZA Environmental Chemistry Laboratory to provide rapid and cost effective screening of soil samples for volatile organics. Although, this technique is a modification of EPA Method 3810, it is not definitive and is not approved by the EPA for certification purposes.

METHODOLOGY

Soil samples taken in the field are placed in 250 ml glass jars with a teflon gasket lid. The samples are kept at 4 degrees C until the time of analysis. A 10 ml crimp top septum vial is marked and tared with a crimp top on an analytical balance. A subsample of soil is added until all but a 2.5 ml volume of headspace remains. The vial cap is immediately crimped on and the weight of the vial and its contents is again measured to determine the weight of soil added. A 1.0 ml aliquot of headspace gas is withdrawn automatically by a Hewlett Packard 19395A headspace injector. The headspace sample is injected into the sample port of a HP 5890A gas chromatograph where the vapor is split within the injection port and distributed to two 30 meter X 530 micron fused silica capillary columns. Concentrations of eluting volatile organics are measured with dual flame ionization detectors and response data are acquired by a Nelson Analytical 760 Series Intelligent Interface. The chromatographic data are transmitted to an IBM AT personal computer and analyzed using the Nelson Analytical 2600 Series Chromatography Software. The information for the analytical report is entered manually onto a Lotus Symphony spreadsheet.

CALIBRATION

The response of the gas chromatograph is calibrated with external standards prepared for concentrations of 0.1, 1.0, and 10 ug/g (ppm) on a mass response basis and introduced into the chromatograph as headspace samples in the same manner as unknown soil samples. Sample peaks are identified by comparing their retention times from both columns to measured retention times of calibration standards for both columns. Qualitative comparisons are made between the two sets of test data for each sample. Sample peaks identified as known compounds are quantified according to response factors determined from calibration standards.

JOB DESCRIPTION: TANK NO. 5 NAVY SUB BASE – GROTON, CT
JOB #: 30894
DATE SAMPLED: 10/29/91
DATE TESTED: 10/31/91

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LAB I.D. No.: MA092

GZA GC SCREENING FOR VOLATILE ORGANICS IN SOILS
(CONCENTRATION – PPB, ug/kg of wet soil)

SAMPLE NAME: / GZA LAB #:	Method Blank 07393-B	GZ-4 S-2 37398-S					METHOD DETECTION LIMIT
1. TETRACHLOROETHENE	ND	ND					20
2. TRICHLOROETHENE	ND	ND					10
3. 1,1-DICHLOROETHENE	ND	ND					10
4. TOTAL 1,2-DICHLOROETHENES	ND	ND					10
5. METHYLENE CHLORIDE	ND	ND					20
6. VINYL CHLORIDE	ND	ND					20
7. 1,1,1-TRICHLOROETHANE	ND	ND					20
8. 1,1-DICHLOROETHANE	ND	ND					10
9. 1,2-DICHLOROETHANE	ND	ND					10
10. CHLOROETHANE	ND	ND					10
11. METHYL-t-BUTYL ETHER	ND	ND					10
12. BENZENE	ND	ND					10
13. TOLUENE	ND	ND					10
14. ETHYL BENZENE	ND	ND					10
15. m,p-XYLENES	ND	ND					20
16. o-XYLENE	ND	ND					20
17. ACETONE	ND	ND					10
18. METHYL ETHYL KETONE	ND	ND					10
19. METHYL ISOBUTYL KETONE	ND	ND					10
20. CHLOROFORM	ND	ND					40
21. FREON 113 (CCl3-CF3)	ND	ND					30
22. CHLOROBENZENE	ND	ND					20
23. STYRENE	ND	ND					30
TOTAL COMPOUNDS (1-23)	ND	ND					
METHANE (V/V-air, PPM)	ND	ND					10 PPM
UNKNOWNS (#)	ND	(4)					

COMMENTS: A trace level of one (1) early eluting unknown compound, which can be tentatively identified as methanol, was detected in sample GZ-4, S-2. Trace levels of three (3) variously eluting unknown compounds were detected in sample GZ-4, S-2. Methanol is a laboratory artifact that is inherent to this method and is most likely not present in smaple GZ-4, S-2. Results are reported with two (2) significant digits.

ANALYZED BY R. Bowlup

REVIEWED BY J. Blackwell

JOB DESCRIPTION: TANK NO. 5 NAVY SUB BASE – GROTON, CT
JOB #: 30894
DATE SAMPLED: 10/29/91
DATE TESTED: 10/31/91

GZA GEOENVIRONMENTAL, INC.
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LAB I.D. No.: MA092

GZA GC SCREENING FOR VOLATILE ORGANICS IN SOILS
(CONCENTRATION – PPB, ug/kg of wet soil)

SAMPLE NAME: / GZA LAB #:	Method Blank 07393-B	GZ-1 S-3 3R393-S	GZ-1 S-5B 3R394-S	GZ-2 S-5 3R395-S	GZ-3 S-2 37396-S	GZ-4 S-1 37397-S	METHOD DETECTION LIMIT
1. TETRACHLOROETHENE	ND	ND	ND	ND	ND	ND	20
2. TRICHLOROETHENE	ND	ND	ND	ND	ND	ND	10
3. 1,1-DICHLOROETHENE	ND	ND	ND	ND	ND	ND	10
4. TOTAL 1,2-DICHLOROETHENES	ND	ND	ND	ND	ND	ND	10
5. METHYLENE CHLORIDE	ND	ND	ND	ND	ND	ND	20
6. VINYL CHLORIDE	ND	ND	ND	ND	ND	ND	20
7. 1,1,1-TRICHLOROETHANE	ND	ND	ND	ND	ND	ND	20
8. 1,1-DICHLOROETHANE	ND	ND	ND	ND	ND	ND	10
9. 1,2-DICHLOROETHANE	ND	ND	ND	ND	ND	ND	10
10. CHLOROETHANE	ND	ND	ND	ND	ND	ND	10
11. METHYL-t-BUTYL ETHER	ND	ND	ND	ND	ND	ND	10
12. BENZENE	ND	ND	ND	ND	ND	ND	10
13. TOLUENE	ND	ND	ND	ND	ND	ND	10
14. ETHYL BENZENE	ND	ND	ND	ND	ND	ND	10
15. m,p-XYLENES	ND	ND	ND	ND	ND	ND	20
16. o-XYLENE	ND	ND	ND	ND	ND	ND	20
17. ACETONE	ND	ND	ND	ND	ND	ND	10
18. METHYL ETHYL KETONE	ND	ND	ND	ND	ND	ND	10
19. METHYL ISOBUTYL KETONE	ND	ND	ND	ND	ND	ND	10
20. CHLOROFORM	ND	ND	ND	ND	ND	ND	40
21. FREON 113 (CCl3-CF3)	ND	ND	ND	ND	ND	ND	30
22. CHLOROBENZENE	ND	ND	ND	ND	ND	ND	20
23. STYRENE	ND	ND	ND	ND	ND	ND	30
TOTAL COMPOUNDS (1-23)	ND	ND	ND	ND	ND	ND	
METHANE (V/V-air, PPM)	ND	ND	ND	ND	ND	ND	10 PPM
UNKNOWNS (#)	ND	(39)	ND	ND	(1)	(18)	

COMMENTS: A trace level of one (1) early eluting unknown compound, which can be tentatively identified as methanol, was detected in samples GZ-3, S-2 and GZ-4, S-1. Methanol is a laboratory artifact that is inherent to this method and is most likely not present in samples GZ-3, S-2 and GZ-4, S-1. The pattern of the chromatograms for samples GZ-1, S-3 and GZ-4, S-1 indicates the presence of an unknown petroleum distillate such as a fuel oil. Results are reported with two (2) significant digits.

ANALYZED BY R. Sonbul

REVIEWED BY J Blackwell

GC SCREENING

APPENDIX C

CHEMICAL SCREENING & ANALYSES

GZA GEO ENVIRONMENTAL, INC.
140 BROADWAY, PROVIDENCE, RHODE ISLAND

GEOTECHNICAL/GEOHYDROLOGICAL CONSULTANTS

PROJECT
TANK #5, NAVY SUB BASE
Groton, CT

REPORT OF BORING No. GZ-4
SHEET 1 OF 1
FILE No. Y-30894
CHKD. BY HDF

BORING Co. GZA Drilling, Inc.
FOREMAN Paul Wordell
GZA ENGINEER William Ladd

BORING LOCATION See Exploration Location Plan
GROUND SURFACE ELEVATION 22.7 DATUM MSL
DATE START 10-29-91 DATE END 10-29-91

SAMPLER: UNLESS OTHERWISE NOTED, SAMPLER CONSISTS OF A 2" SPLIT SPOON DRIVEN USING A 140 lb. HAMMER FALLING 30 in.

CASING: UNLESS OTHERWISE NOTED, CASING DRIVEN USING A 300 lb. HAMMER FALLING 24 in.

CASING SIZE: OTHER: 3 3/4" Hollow Stem Augers

GROUNDWATER READINGS

DATE	TIME	WATER	CASING	STABIL. TIME
10-29-91		8.2'	10' (Remov)	15 minutes

DEPTH	CASING	BLOWS	SAMPLE No.	PEN./REC	DEPTH (Ft.)	BLOWS/6"	SAMPLE DESCRIPTION (Burmister CLASSIFICATION)	REMKS	STRATUM DESCRIPTION
			S-1	24/20	0-2	15-34	Very dense, light brown, fine to coarse SAND, some fine to coarse Gravel, trace Silt. 2" Topsoil at top of sample. Slight petroleum odor	1.	SAND AND GRAVEL FILL
						13-28			
5			S-2	24/11	5-7	3-4	Loose, light gray, fine(+) to medium SAND, trace fractured rock, little Silt. Slight petroleum odor. Wet at bottom	1.	GRANULAR FILL
						2-2			
10			S-3	24/18	10-12	1-2	Loose, gray, fine(+) to medium SAND, some Silt, trace(-) coarse Sand		
						3-2			
15			S-4	24/18	15-17	WOR/12"	Very loose, gray, fine SAND and SILT, trace(-) fine Gravel	2.	
						1/12"			
20			S-5A	24/7	20-22	3-8	S-5A: Brown, medium to coarse SAND, little fine Gravel		STRATIFIED SAND AND SILT
			S-5B	24/8		11-11	S-5B: Yellow-brown SILT, little fine Sand		22
							Bottom of Boring at 22'		
25									
30									

GRANULAR SOILS Blows/Ft	Density	COHESIVE SOILS Blows/Ft	Density
0- 4	V. LOOSE	< 2	V. SOFT
4-10	LOOSE	2- 4	SOFT
10-30	M. DENSE	4- 8	M. STIFF
30-50	DENSE	8-15	STIFF
> 50	V. DENSE	15-30	V. STIFF
		> 30	HARD

REMARKS: 1. Sample had slight petroleum odor.
2. "WOR" indicates "weight of rods".

NOTES: 1) STRATIFICATION LINES REPRESENT APPROXIMATE BOUNDARY BETWEEN SOIL TYPES, TRANSITIONS MAY BE GRADUAL.
2) WATER LEVEL READINGS HAVE BEEN MADE AT TIMES AND UNDER CONDITIONS STATED, FLUCTUATIONS OF GROUNDWATER MAY OCCUR DUE TO OTHER FACTORS THAN THOSE PRESENT AT THE TIME MEASUREMENTS WERE MADE

GZA

BORING No. GZ-4

GZA GEO ENVIRONMENTAL, INC. 140 BROADWAY, PROVIDENCE, RHODE ISLAND GEOTECHNICAL/GEOHYDROLOGICAL CONSULTANTS	PROJECT TANK #5, NAVY SUB BASE Groton, CT	REPORT OF BORING No. GZ-3 SHEET 1 OF 1 FILE No. Y-30894 CHKD. BY HDF

BORING Co. GZA Drilling, Inc.
FOREMAN Paul Wordell
GZA ENGINEER William Ladd

BORING LOCATION See Exploration Location Plan
GROUND SURFACE ELEVATION 23.8 DATUM MSL
DATE START 10-29-91 DATE END 10-29-91

SAMPLER: UNLESS OTHERWISE NOTED, SAMPLER CONSISTS OF A 2" SPLIT SPOON DRIVEN USING A 140 lb. HAMMER FALLING 30 in.

CASING: UNLESS OTHERWISE NOTED, CASING DRIVEN USING A 300 lb. HAMMER FALLING 24 in.

CASING SIZE: OTHER: 3 3/4" Hollow Stem Augers

GROUNDWATER READINGS

DATE	TIME	WATER	CASING	STABIL. TIME
10-29-91		7.5'	10' (Remov)	10 minutes

DEPTH	CASING	BLOWS	SAMPLE No.	PEN./REC	DEPTH (Ft.)	BLOWS/6"	SAMPLE DESCRIPTION (Burmister CLASSIFICATION)	REMKS	STRATUM DESCRIPTION
			S-1	24/20	0-2	4-7	Medium dense, light brown, fine to medium SAND, some fine Gravel, trace(+) Silt.		
						7-6			
5			S-2	24/16	5-7	1-1/12"	Very loose, brown, fine(+) to medium SAND, little Silt, trace coarse Sand. Wet at bottom.		GRANULAR FILL
						3			
10			S-3	24/22	10-12	1/12"	Very loose, light brown, fine(+) to medium SAND, little Silt, trace coarse Sand		
						1-1			
									14'±
								1.	
15			S-4	1/0	15-15.1	50/1"	No Recovery		NATURAL SOILS
20									20'
			S-5	0/0		50/0	No Recovery		
							Bottom of Boring at 20'		
25									
30									

GRANULAR SOILS Blows/Ft	Density	COHESIVE SOILS Blows/Ft	Density
0- 4	V. LOOSE	< 2	V. SOFT
4-10	LOOSE	2- 4	SOFT
10-30	M. DENSE	4- 8	M. STIFF
30-50	DENSE	8-15	STIFF
> 50	V. DENSE	15-30	V. STIFF
		> 30	HARD

REMARKS: 1. Auger grinding occasionally.

NOTES: 1) STRATIFICATION LINES REPRESENT APPROXIMATE BOUNDARY BETWEEN SOIL TYPES, TRANSITIONS MAY BE GRADUAL.
2) WATER LEVEL READINGS HAVE BEEN MADE AT TIMES AND UNDER CONDITIONS STATED, FLUCTUATIONS OF GROUNDWATER MAY OCCUR DUE TO OTHER FACTORS THAN THOSE PRESENT AT THE TIME MEASUREMENTS WERE MADE

GZA

BORING No. GZ-3

GZA GEO ENVIRONMENTAL, INC. 140 BROADWAY, PROVIDENCE, RHODE ISLAND GEOTECHNICAL/GEOHYDROLOGICAL CONSULTANTS	PROJECT TANK #5, NAVY SUB BASE Groton, CT	REPORT OF BORING No. GZ-2 SHEET 1 OF 1 FILE No. Y-30894 CHKD. BY HDF

BORING Co. GZA Drilling, Inc.
FOREMAN Paul Wordell
GZA ENGINEER William Ladd

BORING LOCATION See Exploration Location Plan
GROUND SURFACE ELEVATION 22.5 DATUM MSL
DATE START 10-29-91 DATE END 10-29-91

SAMPLER: UNLESS OTHERWISE NOTED, SAMPLER CONSISTS OF A 2" SPLIT SPOON DRIVEN USING A 140 lb. HAMMER FALLING 30 In.

CASING: UNLESS OTHERWISE NOTED, CASING DRIVEN USING A 300 lb. HAMMER FALLING 24 In.

CASING SIZE: OTHER: 3 3/4" Hollow Stem Augers

GROUNDWATER READINGS

DATE	TIME	WATER	CASING	STABIL. TIME
10-29-91		6.5'	10' (Remov)	15 minutes

DEPTH	CASING	BLOWS	SAMPLE No.	PEN./REC	DEPTH (Ft.)	BLOWS/6"	SAMPLE DESCRIPTION Burmister CLASSIFICATION	REMKS	STRATUM DESCRIPTION
			S-1A	24/9	0-2	3-6	S-1A: Dark brown, fine to medium SAND and Silt, little roots, Organic. TOPSOIL.		TOPSOIL
			S-1B	24/10		8-12	S-1B: Orange-brown, fine to coarse(-) SAND, some fine Gravel, trace Silt		
5			S-2	24/7	5-7	7-5	Loose, gray, fine SAND, some Silt, trace fine Gravel. Saturated.	1.	GRANULAR FILL
						3-2			
10			S-3	24/16	10-12	5-2	Very loose, gray, fine SAND, some Silt, trace(-) fine Gravel.		
						2-3			
15			S-4	24/18	15-17	1-2	Very loose, gray, fine SAND and Silt, trace coarse Sand, fine Gravel, trace(-) fibrous roots.		
						2-3			
									STRATIFIED SANDS
20			S-5	18/18	20-21.5	10-17	Very dense, brown, medium to coarse SAND, changing to orange-brown, fine to coarse SAND, trace Silt, with 2" zone of gray, fine SAND, some Silt.		
						48-Ref			22'
							Bottom of Boring at 22'		
25									
30									

GRANULAR SOILS Blows/Ft	Density	COHESIVE SOILS Blows/Ft	Density
0- 4	V. LOOSE	< 2	V. SOFT
4-10	LOOSE	2- 4	SOFT
10-30	M. DENSE	4- 8	M. STIFF
30-50	DENSE	8-15	STIFF
> 50	V. DENSE	15-30	V. STIFF
		> 30	HARD

REMARKS: 1. Augers grinding at 7 to 8'+.

NOTES: 1) STRATIFICATION LINES REPRESENT APPROXIMATE BOUNDARY BETWEEN SOIL TYPES, TRANSITIONS MAY BE GRADUAL.
2) WATER LEVEL READINGS HAVE BEEN MADE AT TIMES AND UNDER CONDITIONS STATED, FLUCTUATIONS OF GROUNDWATER MAY OCCUR DUE TO OTHER FACTORS THAN THOSE PRESENT AT THE TIME MEASUREMENTS WERE MADE

GZA

BORING No. GZ-2

GZA GEO ENVIRONMENTAL, INC.
140 BROADWAY, PROVIDENCE, RHODE ISLAND

GEOTECHNICAL/GEOHYDROLOGICAL CONSULTANTS

PROJECT
TANK #5, NAVY SUB BASE
Groton, CT

REPORT OF BORING No. GZ-1
SHEET 1 OF 1
FILE No. Y-30894
CHKD. BY HDF

BORING Co. GZA Drilling, Inc.
FOREMAN Paul Wordell
GZA ENGINEER William Ladd

BORING LOCATION See Exploration Location Plan
GROUND SURFACE ELEVATION 22.0 DATUM MSL
DATE START 10-29-91 DATE END 10-29-91

SAMPLER: UNLESS OTHERWISE NOTED, SAMPLER CONSISTS OF A 2" SPLIT SPOON DRIVEN USING A 140 lb. HAMMER FALLING 30 in.

CASING: UNLESS OTHERWISE NOTED, CASING DRIVEN USING A 300 lb. HAMMER FALLING 24 in.

CASING SIZE: OTHER: 3 3/4" Hollow Stem Augers

GROUNDWATER READINGS

DATE	TIME	WATER	CASING	STABIL. TIME
10-29-91		5.7'	10' (Remov)	10 minutes

DEPTH	CASING	BLOWS	SAMPLE No.	PEN./REC	DEPTH (Ft.)	BLOWS/6"	SAMPLE DESCRIPTION (Burmister CLASSIFICATION)	REMKS	STRATUM DESCRIPTION
			S-1A	24/6	0-2	3-9	S-1A: Dark brown, fine SAND and SILT, Organic, little roots (TOPSOIL)		TOPSOIL
			S-1B	24/9		9-11	S-1B: Medium dense, tan, fine(+) to medium SAND, trace(+) Silt, trace fine to coarse Gravel (fractured). Dry.		
5			S-2	24/12	5-7	1/12"	Very loose, tan, fine(+) to medium SAND, little Silt. Soil in tip of sampler was darker gray in color and contained some Organic Silt, trace fibrous roots. Saturated.		GRANULAR FILL
						1-1			
10			S-3	24/8	10-12	3-3	Loose, tan to gray, fine(+) to medium SAND, little to some Silt, trace fine Gravel, one small piece of non-woven fabric. Organic Odor. Fill		
						5-10			
15			S-4	24/20	15-17	1/12"	Very loose, gray, fine SAND and Organic Silt, trace(-) coarse Sand, trace woody roots. Possibly Natural.		
						1-1			
								1.	18'±
20			S-5A	24/5	20-22	18-23	S-5A: Yellow-brown, fine SAND and Silt		NATURAL STRATIFIED SANDS
			S-5B	24/8		16-15	S-5B: White with black mica flecks, fine to medium(+) SAND, trace(-) Silt. Stratified.		22'
							Bottom of Boring at 22'		
25									
30									

GRANULAR SOILS Blows/Ft	Density	COHESIVE SOILS Blows/Ft	Density
0- 4	V. LOOSE	< 2	V. SOFT
4-10	LOOSE	2- 4	SOFT
10-30	M. DENSE	4- 8	M. STIFF
30-50	DENSE	8-15	STIFF
> 50	V. DENSE	15-30	V. STIFF
		> 30	HARD

REMARKS: 1. Augers grinding slightly at 18'+.

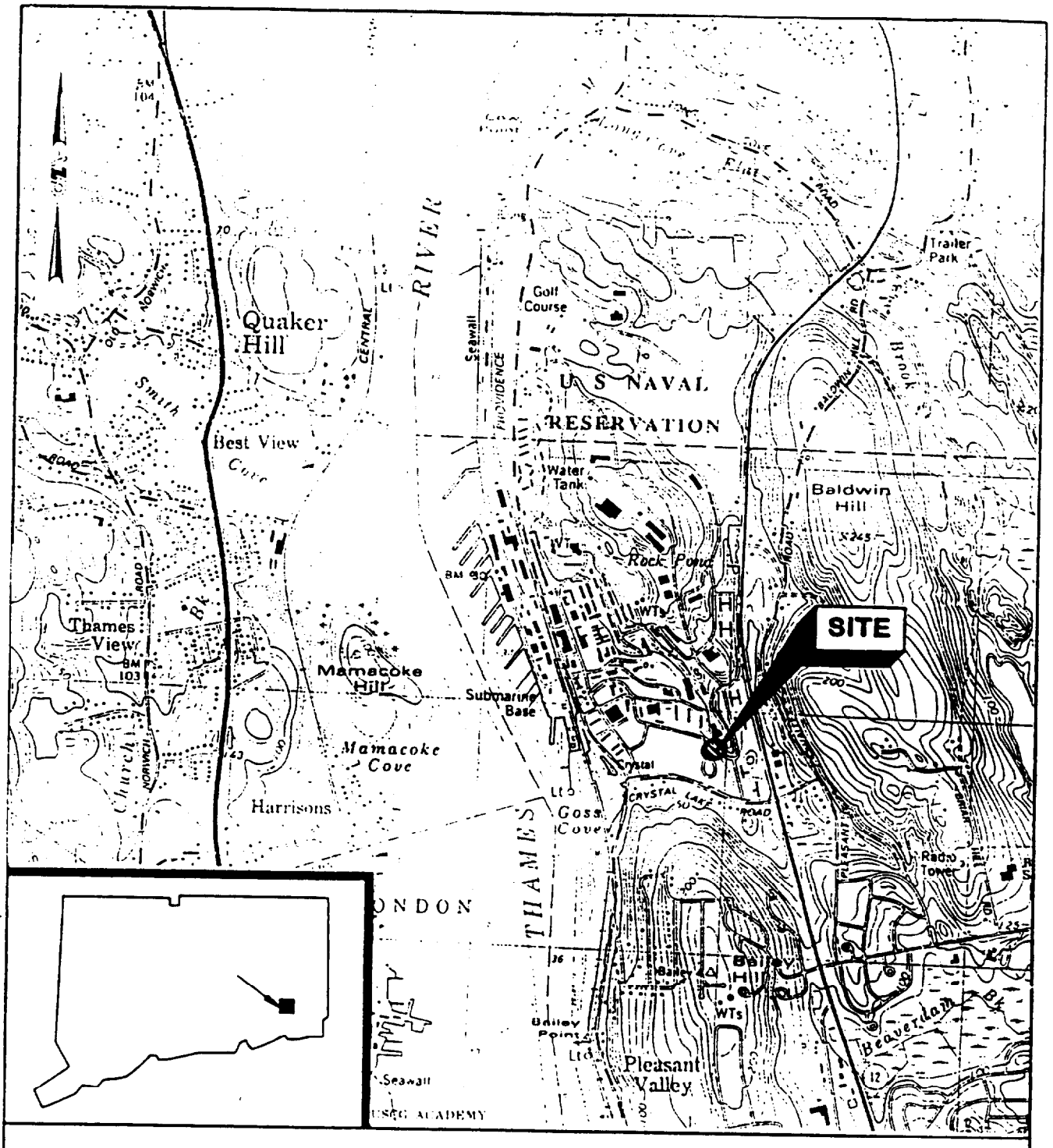
NOTES: 1) STRATIFICATION LINES REPRESENT APPROXIMATE BOUNDARY BETWEEN SOIL TYPES, TRANSITIONS MAY BE GRADUAL.
2) WATER LEVEL READINGS HAVE BEEN MADE AT TIMES AND UNDER CONDITIONS STATED, FLUCTUATIONS OF GROUNDWATER MAY OCCUR DUE TO OTHER FACTORS THAN THOSE PRESENT AT THE TIME MEASUREMENTS WERE MADE

GZA

BORING No. GZ-1

APPENDIX B

BORING LOGS



FROM USGS UNCASVILLE, CONN. QUADRANGLE MAP

SCALE IN FEET

0' 1000' 2000' 4000'

© 1991 GZA GeoEnvironmental, Inc.

File No. 30894

GZA

WASTE OIL TANK NO. 5

GROTON, CONNECTICUT

LOCUS PLAN

DECEMBER 1991

FIGURE NO. 1

FIGURES

TABLE 1

PID SCREENING OF SOIL SAMPLES

BORING NO.	SAMPLE NO.	DEPTH (FT.)	HNU READING
GZ-1	S-1a	0-2	ND
	S-1b	0-2	ND
	S-2	5-7	ND
	S-2 DUP	5-7	ND
	S-3	10-12	1.0
	S-3 DUP	10-12	4.8*
	S-4	15-17	0.2
	S-4 DUPa	15-17	0.2
	S-4 DUPb	15-17	0.4
	S-5a	20-22	0.2
	S-5b	20-22	0.6*
GZ-2	S-1a	0-2	ND
	S-1b	0-2	ND
	S-2	5-7	ND
	S-3	10-12	ND
	S-3 DUP	10-12	ND
	S-4	15-17	ND
	S-4 DUP	15-17	ND
	S-5	20-21.5	0.3*
GZ-3	S-1	0-2	ND
	S-1 DUPa	0-2	0.2
	S-1 DUPb	0-2	0.1
	S-2	5-7	ND
	S-2 DUPa	5-7	ND*
	S-2 DUPb	5-7	ND
	S-3	10-12	ND
	S-3 DUP	10-12	ND
GZ-4	S-1	0-2	1.0*
	S-1 DUP	0-2	0.4
	S-2	5-7	0.7
	S-2 DUP	5-7	1.2*
	S-3	10-12	ND
	S-3 DUPa	10-12	ND
	S-3 DUPb	10-12	ND
	S-4	15-17	ND
	S-4 DUPa	15-17	ND
	S-4 DUPb	15-17	ND
	S-5a	20-22	ND
	S-5b	20-22	ND

NOTES:

-1- PID readings represent total volatile organic compounds detected in soil samples using an HNU photoionization detector, Model PI-101. These concentrations are reported in parts per million (ppm), referenced to a benzene in air standard.

-2- ND indicates "not detected".

-3- * indicates sample selected for additional VOC screening.

TABLES

6.00 LIMITATIONS

GZA's environmental study was performed in accordance with general accepted practices of other consultants undertaking similar studies at the same time and in the same geographical are, and GZA observed that degree of care and skill generally exercised by other consultants under similar circumstances and conditions. GZA's findings and conclusions must be considered not as scientific certainties, but rather as our professional opinion concerning the significance of the limited data gathered during the course of the environmental study. No other warranty, express or implied, is made. Specifically, GZA does not and cannot represent that the site contains no hazardous material, oil, or other latent condition beyond that observed by GZA during its study. This report is subject to the specific limitations contained in Appendix A.

GZA
GeoEnvironmental, Inc.

Engineers and
Scientists

May 8, 1992
File No. 30894.1

Mr. Troy J. Gallaher
The EADS Group
1126 Eight Avenue
Altoona, PA 16603

Re: Environmental Testing
Waste Oil Tank #5
Naval Submarine Base-New London

140 Broadway
Providence
Rhode Island 02903
401-421-4140
FAX 401-751-8613

Dear Mr. Gallaher:

In accordance with our proposal dated January 16, 1992, enclosed are the results of the environmental testing of three water samples obtained from Waste Oil Tank #5. Samples were obtained from three locations including: 1) the tank center; 2) the south manhole: and 3) the west tank entry way. The pH values (standard units) for the samples were as follows:

Tank Center	6.4
South Manhole	6.5
West Entry Way	6.5

We hope that this information satisfies your current needs. If you have any questions, please do not hesitate to contact the undersigned.

Very truly yours,

Subsidiary of GZA
GeoEnvironmental
Technologies, Inc.

GZA GEOENVIRONMENTAL, INC.

David R. Carchedi, P.E.
Associate Principal

for Hilary D. Fortune
Environmental Engineer

DRC/HDF:dc

R.I. Analytical

Specialists in Environmental Services

MAY - 6 1992

GZA - PROVIDENCE

CERTIFICATE OF ANALYSIS

GZA/GEO Environmental
Attn: Ms. Hilary Fortune
140 Broadway
Providence, RI 02903

DATE RECEIVED: 04/17/92
DATE REPORTED: 05/04/92
P.O. #: 3-4736
INVOICE #: E2861

SAMPLE DESCRIPTION: Three (3) water samples from Groton Sub Base, Groton, CT, GZA File #Y30894, Project: Tank #5

Subject samples have been analyzed by our laboratory with the attached results.

Reference: Guidelines Establishing Testing Procedures For The Analysis of Pollutants, 40CFR, Part 136, July 1986.

If you have any questions regarding this work, or if we may be of further assistance, please contact us.

Approved by:

Michael S. Rose
Laboratory Manager

Anthony E. Perrotti
President

djr

CERTIFICATE OF ANALYSIS

GZA/GEO Environmental
DATE RECEIVED: 04/17/92
DATE REPORTED: 05/04/92
INVOICE #: E2861

PARAMETER	TANK CENTER	SOUTH MANHOLE	WEST ENTRY
BOD_5	117 mg/l	117 mg/l	132 mg/l
Total Suspended Solids	918 "	991 "	915 "
Total Metals:			
Antimony	<0.005 mg/l	<0.005 mg/l	<0.005 mg/l
Arsenic	<0.005 "	<0.005 "	<0.005 "
Beryllium	<0.01 "	<0.01 "	<0.01 "
Cadmium	<0.01 "	<0.01 "	0.01 "
Chromium	<0.03 "	<0.03 "	0.03 "
Copper	<0.05 "	0.08 "	0.16 "
Lead	<0.04 "	<0.04 "	0.14 "
Mercury	<0.0005 "	<0.0005 "	<0.0005 "
Nickel	<0.02 "	<0.02 "	0.05 "
Selenium	<0.005 "	<0.005 "	<0.005 "
Silver	0.29 "	0.10 "	0.10 "
Thallium	<0.005 "	<0.005 "	<0.005 "
Zinc	0.02 "	0.26 "	0.57 "

RI ANALYTICAL LABORATORIES, INC.

CHAIN-OF-CUSTODY RECORD

Station Number	Time (24 hr.)	Container ID	Sampler ID	Location Description	Sample Type	VOA 624	VOA 601	VOA 602	ABN	PEST/PCB	TPP METAL	DW METAL	E.P. TOX.	O&G	PHC	TOC	BOD	Total Solids	Total # of Cont.	Note #
	1510			Tank #5 Tank center	H2O											1	1		2	
	1240			" South manhole	↓											1	1		2	
	1400			West entry	↓											1	1		2	

TOTAL NUMBER OF CONTAINERS

RELINQUISHED BY: (Signature)	DATE/TIME	RECEIVED BY: (Signature)
William Fortune	4/17/92 4:10	G. Vendetti
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)

NOTES: BOD AND Total Solids IN SAME CONTAINER

Spec #
E2861

ANALYTICAL LABORATORY: Rinl

LABORATORY CONTACT:

GZA CONTACT: H Fortune / D Carchow PHONE:

Goldberg-Zoino & Associates
140 Broadway
PROVIDENCE, RHODE ISLAND 02903
401-421-4140

GZA FILE NO. 30894 P.O. NO. 3-4736

PROJECT Tank #5 Groton Submase

LOCATION Groton Ct

COLLECTOR W.T. Fortune

DATE OF COLLECTION 4/17/92 SHEET 1 OF 1

GZA GEOENVIRONMENTAL, INC.
320 NEEDHAM STREET
NEWTON UPPER FALLS,MA 02164
(617) 969-0050
MASS. LD.# MA092

EPA 8080 ANALYSIS
POLYCHLORINATED BIPHENYLS (PCB'S)

JOB DESCRIPTION: TANK #5, GROTON SUB BASE - GROTON, CT

JOB #:	30894	DATE SAMPLED:	4/17/92
SAMPLE #:	CENTER	DATE TESTED:	4/24/92
LABORATORY #:	22912	DILUTION FACTOR:	0.002

8080 COMPOUNDS: POLYCHLORINATED BIPHENYLS	CONCENTRATION ug/kg-Soil (PPB)	DETECTION LIMIT ug/kg-Soil (PPB)
AROCLOR 1260	ND	0.5
AROCLOR 1254	ND	0.5
AROCLOR 1248	ND	0.5
AROCLOR 1242/1016	ND	0.5
AROCLOR 1232	ND	0.5
AROCLOR 1221	ND	0.5
SURROGATE RECOVERY (p'p'DDE)	46%	

Mcl

COMMENTS:

ANALYZED BY: R. Sahu

REVIEWED BY: K. Walsh

GZA GEOENVIRONMENTAL, INC.
320 NEEDHAM STREET
NEWTON UPPER FALLS,MA 02164
(617) 969-0050
MASS. I.D.# MA092

EPA 8080 ANALYSIS
POLYCHLORINATED BIPHENYLS (PCB'S)

JOB DESCRIPTION: TANK #5, GROTON SUB BASE - GROTON, CT

JOB #:	30894	DATE SAMPLED:	4/17/92
SAMPLE #:	WEST	DATE TESTED:	4/24/92
LABORATORY #:	22900	DILUTION FACTOR:	0.004

8080 COMPOUNDS: POLYCHLORINATED BIPHENYLS	CONCENTRATION ug/kg-Soil (PPB)	DETECTION LIMIT ug/kg-Soil (PPB)
AROCLOR 1260	ND	1.0
AROCLOR 1254	ND	1.0
AROCLOR 1248	ND	1.0
AROCLOR 1242/1016	ND	1.0
AROCLOR 1232	ND	1.0
AROCLOR 1221	ND	1.0
SURROGATE RECOVERY (p'p'DDE)	84%	

COMMENTS:

ANALYZED BY: R Sohp

REVIEWED BY: K Walsh

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MASS. I.D.# MA092

EPA 8080 ANALYSIS
POLYCHLORINATED BIPHENYLS (PCB'S)

JOB DESCRIPTION: TANK #5, GROTON SUB BASE – GROTON, CT

JOB #:	30894	DATE SAMPLED:	4/17/92
SAMPLE #:	SOUTH	DATE TESTED:	4/24/92
LABORATORY #:	22901	DILUTION FACTOR:	0.004

8080 COMPOUNDS: POLYCHLORINATED BIPHENYLS	CONCENTRATION ug/kg-Soil (PPB)	DETECTION LIMIT ug/kg-Soil (PPB)
AROCLOR 1260	—2.2—	1.0
AROCLOR 1254	ND	1.0
AROCLOR 1248	ND	1.0
AROCLOR 1242/1016	ND	1.0
AROCLOR 1232	ND	1.0
AROCLOR 1221	ND	1.0
SURROGATE RECOVERY (p'p'DDE)	126%	

COMMENTS:

ANALYZED BY: L. Sachs

REVIEWED BY: K Wall

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HYDROCARBON FINGERPRINTING
MODIFIED ASTM METHOD D3328
CONCENTRATION (PPM-ug/g or ug/ml)

JOB DESCRIPTION: TANK #5, GROTON SUB BASE - GROTON, CT
JOB #: 30894
DATE SAMPLED: 4/17/92
DATE TESTED: 4/24/92

SAMPLE NAME: / GZA LAB #:	METHOD BLANK 042492-QC	CENTER (TANK #5) 05298-PHC
1. HYDROCARBON CONTENT	<0.4	<0.4
2. PERCENT SOLID CONTENT	N/A	N/A
3. MATRIX	N/A	AQUEOUS
4. DETECTION LIMIT (TOTAL PRODUCT)	0.4	0.4
5. DETECTION LIMIT (INDIVIDUAL HYDROCARBONS)	0.002	0.002
6. SURROGATE RECOVERY (O-TERPHENYL)	137%	46%

QUALITATIVE IDENTIFICATION: Total hydrocarbon content was not detected in sample "CENTER (TANK #5)" above the method detection limit of 0.4 ug/ml and therefore, the fingerprint analysis was not done.

ANALYZED BY: R. Sobel

REVIEWED BY: K Wall

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HYDROCARBON FINGERPRINTING
MODIFIED ASTM METHOD D3328
CONCENTRATION (PPM-ug/g or ug/ml)

JOB DESCRIPTION: TANK #5, GROTON SUB BASE - GROTON, CT
JOB #: 30894
DATE SAMPLED: 4/17/92
DATE TESTED: 4/24/92

SAMPLE NAME GZA LAB #:	METHOD BLANK 042492-QC	WEST (TANK #5) 05299-FP
1. HYDROCARBON CONTENT	<0.4	1.3
2. PERCENT SOLID CONTENT	N/A	N/A
3. MATRIX	N/A	AQUEOUS
4. DETECTION LIMIT (TOTAL PRODUCT)	0.4	0.8
5. DETECTION LIMIT (INDIVIDUAL HYDROCARBONS)	0.002	0.004
6. SURROGATE RECOVERY (O-TERPHENYL)	137%	84%

QUALITATIVE IDENTIFICATION: The characteristics of the chromatogram for sample "WEST (TANK #5)" indicate the presence of a petroleum product in the boiling range of fuel oil #2/diesel. The phytane n-C18 ratio of less than 0.5 indicates that no weathering has occurred.

ANALYZED BY: R. Sarkis

REVIEWED BY: K. Walsh

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HYDROCARBON FINGERPRINTING
MODIFIED ASTM METHOD D3328
CONCENTRATION (PPM-ug/g or ug/ml)

JOB DESCRIPTION: TANK #5, GROTON SUB BASE – GROTON, CT
JOB #: 30894
DATE SAMPLED: 4/17/92
DATE TESTED: 4/24/92

SAMPLE NAME GZA LAB #:	METHOD BLANK 042492-QC	SOUTH (TANK #5) 05300-FP
1. HYDROCARBON CONTENT	<0.4	1.2
2. PERCENT SOLID CONTENT	N/A	N/A
3. MATRIX	N/A	AQUEOUS
4. DETECTION LIMIT (TOTAL PRODUCT)	0.4	0.8
5. DETECTION LIMIT (INDIVIDUAL HYDROCARBONS)	0.002	0.004
6. SURROGATE RECOVERY (O-TERPHENYL)	137%	126%

QUALITATIVE IDENTIFICATION: The characteristics of the chromatogram for sample "SOUTH (TANK #5)" indicate the presence of a petroleum product in the boiling range of fuel oil #2/diesel. The phytane n-C18 ratio of less than 0.5 indicates that no weathering has occurred.

ANALYZED BY: R Sauke

REVIEWED BY: K Walsh

V I COPY - Original (Accompanies Samples) YELLOW COPY - Collector P COPY - Project Manager

CHAIN-OF-CUSTODY RECORD

Station Number	Time (24 hr.)	Container ID	Sampler ID	Location Description	Sample Type	VOA 624 (8240)	VOA 601	VOA 602	ABN	PEST/PCB	P.P. METAL	D.W. METAL	E.P. TOX.	O&G	PHC (Fingerprinting)	TOC	TPH IR (418.1)	8080 (PCBs) + pest	Total # of Cont.	Note #
	1510		WTF	TANK #5 tank center	H2O	/									/		/	/	4	
	1240			" South manhole	↓	/									/		/	/	4	
	1400			" West entry	↓	/									/		/	/	4	
TOTAL NUMBER OF CONTAINERS																			12	

RELINQUISHED BY: (Signature)	DATE/TIME	RECEIVED BY: (Signature)
[signature]	4/17/92	K. Archer
[signature]		[signature]
[signature]	4/22/92 1100	[signature]

NOTES: 8240 + 418 acid preserved
PHC + 8080 in same container
* expect high levels

ANALYTICAL LABORATORY: GZA

LABORATORY CONTACT:

GZA CONTACT: H Fortune / D. Carchedi PHONE:

Goldberg-Zoino & Associates
140 Broadway
PROVIDENCE, RHODE ISLAND 02903
401-421-4140

GZA FILE NO. 30894 P.O. NO.

PROJECT TANK # 5 Groton Sub Base

LOCATION Groton, CT

COLLECTOR W.T. Fortune

DATE OF COLLECTION 4/17/92 SHEET 1 OF 1

EPA METHOD 8080 ANALYSIS

OVERVIEW

EPA Method 8080 is a solvent extraction/gas chromatographic method for the identification and quantitation of Polychlorinated Biphenyl's (PCB's) and Chlorinated Pesticides in aqueous or solid environmental samples. Solvent extraction with the EPA approved solvents 50:50 Acetone/Hexane or Methylene Chloride strips these chlorinated semivolatile contaminants from the individual media and the collected extract is subsequently concentrated for analysis. An aliquot of the extract is injected into a gas chromatographic system where the individual target compounds are separated and identified utilizing a combination of capillary columns and selective GC detectors.

METHODOLOGY

A Tekmar Model TM-250 Sonic Disruptor is used to extract the PCB/Pesticides from the sample matrix into the selected solvent. This procedure is repeated three times upon the thirty gram sample that has been spiked with the EPA recommended surrogate P'P' -DDE and/or Bibutyl Chlorendate. The collected extract is then elutriated on a solid phase extraction (SPE) column to remove matrix interferences. The purified extract is then concentrated to a known volume using a Zymark Model Turbovap after which it is transferred to two duplicate autosampler vials. A Hewlett Packard Model 7673A Autosampler is loaded with the appropriate method blanks, calibration standards and duplicates for batch analysis. The HP-Model 5890A GC is equipped with an inert glass injection port liner which houses the inlets of two Megabore capillary columns (30m x 0.53 DB-608 and 30m x 0.53 DB-5). The automatically split analysis yields initial and confirmational data simultaneously. The selective GC detectors used are an HP Electron Capture Detector (ECD) and OI Corp. Model 4420 Electrolytic Conductivity Detector (ElCD). The two detectors are chosen to eliminate difficulties often encountered with complex sample matrices. The response data from this system are acquired using a PE/Nelson Analytical Series 2600 Software System and comparison of relative peak patterns are processed on an IBM Personal Computer AT. The information for the laboratory report is entered manually onto a Lotus Symphony spreadsheet. Calibration and quality control are performed in accordance with the protocols established by the US EPA and published in the reference cited below.

REPORT FORMAT

The quantitation limit is stated for every report and is adjusted when dilutions are made to bring sample response data within the calibrated range of the method. Concentrations less than the quantitation limit may be identified as "Trace".

DISCLAIMER

Identities and concentrations of PCB's and Pesticides by this solvent extraction/gas chromatographic method are subject to limitations inherent to these methods.

LABORATORY CONTACT PERSON:

Edward W. Pickering, Manager
Environmental Chemistry Laboratory
Goldberg–Zoino & Associates, Inc.
Massachusetts Laboratory I.D. No. 0092
Phone #: (617) 969–0050, x169.

REFERENCES

U.S. EPA, "Test methods for evaluating solid waste, physical/ chemical methods", SW-846, Method 8080, Organochlorine Pesticides and PCB's, Third Edition Update, (1/89).

Boe, B. and Egaas, E., "Qualitative and Quantitative Analyses of Polychlorinated Biphenyls by Gas-Liquid Chromatography", Jour. Chromatography, 180 (1979) 127–132.

Ogata, J.N., J.D. Okun, J.W. Hylin, and A. Bevenue, "Gas Chromatographic Method for the Analysis of Polychlorinated Biphenyls in Transformer Oil", Jour. Chromatography, 189 (1980) 425–427.

Latady, A.L., K.M. Walsh, E.W. Pickering, and J.D. Okun, "Simplified Sample Preparation and Clean-up for PCB/Pesticied Analyses in Soils and Solid Wastes", Poster presented at the 5th Annual Waste Testing and Quality Assurance Symposium—Washington, D.C., July, 1989.

June, 1990/KW

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WHITE COPY - Original (Accompanies Samples) YELLOW COPY - Collector PINK COPY - Project Manager

CHAIN-OF-CUSTODY RECORD

Station Number	Time (24 hr)	Container ID	Sampler ID	Location Description	Sample Type	VOA 624 (E240)	VOA 601	VOA 602	ABN	PESTIPCB	P.P. METAL	D.W. METAL	E.P. TOX.	O&G	PHC	TOC	Fing (PH 418.1)	PH (9040)	8080 (PCB's)	Total # of Cont.	Note #
	1510		WTF	TANK #5 tank center	H2O	1								1			1	1		4	
	1240			" South manhole		1								1			1	1		4	
	1400			" West entry		1								1			1	1		4	
TOTAL NUMBER OF CONTAINERS																				12	

RELINQUISHED BY: (Signature)	DATE/TIME	RECEIVED BY: (Signature)
[signature]	4/7/92	K. Archer
[signature]		[signature]
[signature]	4/22/92 1100	[signature]

NOTES: E240 + 418 acid preserved
PHC + 8080 in same container
* expect high levels

ANALYTICAL LABORATORY: GZA
LABORATORY CONTACT:
GZA CONTACT: H Fortune / D. Archer PHONE:

Goldberg-Zoino & Associates
140 Broadway
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401-421-4140

GZA FILE NO. 30894 P.O. NO.
PROJECT Tank # 5 Groton Sub Base
LOCATION Groton, Ct
COLLECTOR W.T. Fortune
DATE OF COLLECTION 4/7/92 SHEET 1 OF 1

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MASSACHUSETTS LABORATORY I.D. NO. MA092

EPA METHOD 418.1 PETROLEUM HYDROCARBONS
(SPECTROPHOTOMETRIC, INFRARED)
PHC-IR
CONCENTRATION (PPM, ug/g or ug/ml)

JOB DESCRIPTION: GROTON SUB BASE - GROTON, CT
JOB #: 30894
DATE SAMPLED: 4/17/92
DATE TESTED: 4/27/92

SAMPLE NAME:	METHOD BLANK	SOUTH MANHOLE
GZA LAB #:	042792-QC	02316-IR
1. HYDROCARBON CONTENT	<1.0	1.2
2. PERCENT SOLID CONTENT	N/A	N/A
3. MATRIX	N/A	AQUEOUS
4. DETECTION LIMIT	1.0	1.0

COMMENTS:

ANALYZED BY: Celeste O'Connor

REVIEWED BY: [illegible]

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EPA METHOD 418.1 PETROLEUM HYDROCARBONS
(SPECTROPHOTOMETRIC, INFRARED)
PHC-IR
CONCENTRATION (PPM, ug/g or ug/ml)

JOB DESCRIPTION: GROTON SUB BASE - GROTON, CT
JOB #: 30894
DATE SAMPLED: 4/17/92
DATE TESTED: 4/27/92

SAMPLE NAME:	METHOD BLANK	WEST ENTRY
GZA LAB #:	042792-QC	02317-IR
1. HYDROCARBON CONTENT	<1.0	26
2. PERCENT SOLID CONTENT	N/A	N/A
3. MATRIX	N/A	AQUEOUS
4. DETECTION LIMIT	1.0	1.0

COMMENTS:

ANALYZED BY: REVIEWED BY:

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EPA METHOD 418.1 PETROLEUM HYDROCARBONS
(SPECTROPHOTOMETRIC, INFRARED)
PHC-IR
CONCENTRATION (PPM, ug/g or ug/ml)

JOB DESCRIPTION: GROTON SUB BASE - GROTON, CT
JOB #: 30894
DATE SAMPLED: 4/17/92
DATE TESTED: 4/27/92

SAMPLE NAME:	METHOD BLANK	TANK CENTER
GZA LAB #:	042792-QC	02315-IR
1. HYDROCARBON CONTENT	<1.0	<1.0
2. PERCENT SOLID CONTENT	N/A	N/A
3. MATRIX	N/A	AQUEOUS
4. DETECTION LIMIT	1.0	1.0

COMMENTS:

ANALYZED BY: Celeste O'Connor REVIEWED BY: K Walsh

EPA METHOD 418.1 PETROLEUM HYDROCARBONS, TOTAL RECOVERABLE (SPECTROPHOTOMETRIC, INFRARED)

OVERVIEW

EPA Method 418.1 is a solvent extraction/ infrared spectrophotometric method for the quantification of petroleum hydrocarbons in aqueous or solid environmental samples. Solvent extraction with 1,1,2-trichloro-1,2,2-trifluoroethane (fluorocarbon 113 or Freon 113) removes mineral oils from the individual media and the collected extract is subsequently concentrated for analysis. An aliquot of the sample is placed on the infrared spectrophotometer where the absorbance of the sample is directly compared with the standards for quantification of Total Petroleum Hydrocarbons (TPH).

METHODOLOGY

A Tekmar Model TM-250 Sonic Disruptor is used to extract the petroleum hydrocarbons from the sample matrix into Freon 113. This procedure is repeated three times upon a thirty gram representative sample. The collected extract is then eluriated on a silica gel solid phase extraction (SPE) column to remove hydrocarbon content attributable to such interferences as animal greases and vegetable oils. The purified extract is then concentrated to a known volume using a Zymark Turbovap Evaporator. Absorbance data are acquired by a Foxboro Miran 1 FF Infrared Spectrophotometer which is equipped with a fixed wavelength of 3.4 microns and a cell with a pathlength of 10 mm. The sample is placed in the 10 mm cell and the absorbance is measured and compared with the daily calibration curve to obtain TPH values.

QUALITY CONTROL

The infrared spectrophotometer is calibrated each day with the appropriate standards and blanks. The data are entered into an HP Model 11C Programmable Calculator to determine the exact equation of the calibration curve. Method blanks are prepared two ways : 1 - sonicator blank using the disruptor horn, 2 - a blank of the silica gel SPE column. These blanks check for cross contamination.

REPORT FORMAT

The method quantification limit is 10 ppm (ug/g - soil) and 1 ppm (ug/ml - water). This limit is a function of the dilution factor and detector sensitivity. The quantification limits are adjusted when dilutions are made to bring the sample response data within the calibration range of the method.

DISCLAIMER

Concentrations of petroleum hydrocarbons obtained by this solvent extraction and infrared spectrophotometric technique are subject to limitations inherent to this method. If confirmation is desired, replicate samples should be submitted for identification and enhanced quantification by PHC–Fingerprinting (GC–FID).

LABORATORY CONTACT PERSON:

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Massachusetts Laboratory I.D. No. MA092
Phone: (617) 969–0050, x169

REFERENCES

Commonwealth of Massachusetts DEP, "Minimum Standards for Analytical Data for Remedial Response Actions Under M.G.L. c. 21E", Policy #WSC–89–004 (1990).

Standard Methods "For the Examination of Water and Wastewater", Seventeenth Edition, Part 5000, 5520F Hydrocarbons, (1989) 5–47 to 5–48.

U.S. EPA "Handbook for Analytical Quality Control in Water and Waste Water Laboratories", EP–600/4–79–019 (1979).

U.S. EPA "Methods for Chemical Analysis of Water and Wastes", EPA–600/4–79–020, Chap. 400, Method 418.1, Petroleum Hydrocarbons, Total Recoverable, (1979).

U.S. EPA "Test Methods for Evaluating Solid Waste, Physical/Chemical Methods", SW–846, Third Edition, Volume 1B, Method 3550: Sonication Extraction, Method 3630: Silica Gel Clean Up. (1986).

1/91/DM

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EPA METHOD 8240 ANALYSIS FOR VOLATILE ORGANICS BY GC/MS

JOB DESCRIPTION: TANK #5 GROTON SUB BASE – GROTON, CT
JOB #: 30894 DATE SAMPLED: 4/17/92
SAMPLE #: WEST ENTRY DATE EXTRACTED: ——
MATRIX: AQUEOUS DATE TESTED: 4/24/92
LABORATORY #: B1941 DILUTION FACTOR: 1

PRIORITY POLLUTANT LIST 8240 COMPOUNDS	CONCENTRATION ug/l or ug/kg (PPB)	QUANTITATION LIMIT ug/l or ug/kg (PPB)
CHLOROMETHANE	ND	10
BROMOMETHANE	ND	10
VINYL CHLORIDE	ND	10
CHLOROETHANE	ND	10
METHYLENE CHLORIDE	—BMQL—	10
1,1-DICHLOROETHENE	ND	5
1,1-DICHLOROETHANE	—5.2—	5
TOTAL 1,2-DICHLOROETHENES	—100—	5
CHLOROFORM	ND	5
1,2-DICHLOROETHANE	ND	5
1,1,1-TRICHLOROETHANE	ND	5
CARBON TETRACHLORIDE	ND	5
BROMODICHLOROMETHANE	ND	5
1,2-DICHLOROPROPANE	ND	5
TRANS 1,3-DICHLOROPROPENE	ND	5
TRICHLOROETHENE	—51—	5
DIBROMOCHLOROMETHANE	ND	5
1,1,2-TRICHLOROETHANE	ND	5
BENZENE	—38—	5
CIS 1,3-DICHLOROPROPENE	ND	5
BROMOFORM	ND	5
1,1,2,2-TETRACHLOROETHANE	ND	5
TETRACHLOROETHENE	—BMQL—	5
TOLUENE	—160—	5
CHLOROBENZENE	ND	5
ETHYL BENZENE	—92—	5
1,2-DICHLOROBENZENE	ND	10
1,3-DICHLOROBENZENE	—BMQL—	10
1,4-DICHLOROBENZENE	ND	10

SEE PAGE 2 – FOR REMAINING COMPOUNDS

EPA METHOD 8240 ANALYSIS
FOR VOLATILE ORGANICS BY GC/MS

JOB DESCRIPTION: TANK #5 GROTON SUB BASE – GROTON, CT
JOB #: 30894
SAMPLE #: WEST ENTRY
MATRIX: AQUEOUS
LABORATORY #: B1941

TARGET COMPOUND LIST 8240 COMPOUNDS	CONCENTRATION ug/l or ug/kg (PPB)	QUANTITATION LIMIT ug/l or ug/kg (PPB)
ACETONE	—88—	50
CARBON DISULFIDE	ND	5
2-BUTANONE (MEK)	ND	100
VINYL ACETATE	ND	20
2-HEXANONE (MBK)	ND	20
4-METHYL-2-PENTANONE (MIBK)	—31—	20
TOTAL XYLENES	—160—	5
STYRENE	—6.2—	5

MISCELLANEOUS 8240 COMPOUNDS:	CONCENTRATION ug/l or ug/kg (PPB)	QUANTITATION LIMIT ug/l or ug/kg (PPB)
METHYL-t-BUTYL ETHER	—23—	10
TRICHLOROFLUOROMETHANE	—130—	20

SURROGATES	% RECOVERY
1,2-DICHLOROETHANE – D4	102
TOLUENE – D8	92.1
4-BROMOFLUOROBENZENE	101

COMMENTS:

ANALYZED BY: VWong

REVIEWED BY:

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MASSACHUSETTS LABORATORY I.D. NO. MA092

EPA METHOD 8240 ANALYSIS FOR VOLATILE ORGANICS BY GC/MS

JOB DESCRIPTION: TANK #5 GROTON SUB BASE – GROTON, CT
JOB #: 30894 DATE SAMPLED: 4/17/92
SAMPLE #: SOUTH MANHOLE DATE EXTRACTED: ——
MATRIX: AQUEOUS DATE TESTED: 4/24/92
LABORATORY #: B1940 DILUTION FACTOR: 1

PRIORITY POLLUTANT LIST 8240 COMPOUNDS:	CONCENTRATION ug/l or ug/kg (PPB)	QUANTITATION LIMIT ug/l or ug/kg (PPB)
CHLOROMETHANE	ND	10
BROMOMETHANE	ND	10
VINYL CHLORIDE	ND	10
CHLOROETHANE	ND	10
METHYLENE CHLORIDE	ND	10
1,1-DICHLOROETHENE	ND	5
1,1-DICHLOROETHANE	—5.4—	5
TOTAL 1,2-DICHLOROETHENES	—120—	5
CHLOROFORM	ND	5
1,2-DICHLOROETHANE	ND	5
1,1,1-TRICHLOROETHANE	ND	5
CARBON TETRACHLORIDE	ND	5
BROMODICHLOROMETHANE	ND	5
1,2-DICHLOROPROPANE	ND	5
TRANS 1,3-DICHLOROPROPENE	ND	5
TRICHLOROETHENE	—39—	5
DIBROMOCHLOROMETHANE	ND	5
1,1,2-TRICHLOROETHANE	ND	5
BENZENE	—40—	5
CIS 1,3-DICHLOROPROPENE	ND	5
BROMOFORM	ND	5
1,1,2,2-TETRACHLOROETHANE	ND	5
TETRACHLOROETHENE	ND	5
TOLUENE	—160—	5
CHLOROBENZENE	ND	5
ETHYL BENZENE	—61—	5
1,2-DICHLOROBENZENE	ND	10
1,3-DICHLOROBENZENE	ND	10
1,4-DICHLOROBENZENE	ND	10

SEE PAGE 2 – FOR REMAINING COMPOUNDS

EPA METHOD 8240 ANALYSIS
FOR VOLATILE ORGANICS BY GC/MS

JOB DESCRIPTION: TANK #5 GROTON SUB BASE – GROTON, CT
JOB #: 30894
SAMPLE #: SOUTH MANHOLE
MATRIX: AQUEOUS
LABORATORY #: B1940

TARGET COMPOUND LIST 8240 COMPOUNDS	CONCENTRATION ug/l or ug/kg (PPB)	QUANTITATION LIMIT ug/l or ug/kg (PPB)
ACETONE	—79—	50
CARBON DISULFIDE	ND	5
2-BUTANONE (MEK)	ND	100
VINYL ACETATE	ND	20
2-HEXANONE (MBK)	ND	20
4-METHYL-2-PENTANONE (MIBK)	—35—	20
TOTAL XYLENES	—150—	5
STYRENE	—5.2—	5

MISCELLANEOUS 8240 COMPOUNDS:	CONCENTRATION ug/l or ug/kg (PPB)	
METHYL-t-BUTYL ETHER	—25—	10
TRICHLOROFLUOROMETHANE	—110—	20

SURROGATES	% RECOVERY
1,2-DICHLOROETHANE – D4	103
TOLUENE – D8	93.8
4-BROMOFLUOROBENZENE	109

COMMENTS:

ANALYZED BY: VHong

REVIEWED BY:

GZA GEOENVIRONMENTAL, INC., ENVIRONMENTAL CHEMISTRY LABORATORY
320 NEEDHAM STREET, NEWTON UPPER FALLS, MA 02164 (617) 969-0050
MASSACHUSETTS LABORATORY I.D. NO. MA092

EPA METHOD 8240 ANALYSIS FOR VOLATILE ORGANICS BY GC/MS

JOB DESCRIPTION: TANK #5 GROTON SUB BASE – GROTON, CT
JOB #: 30894 DATE SAMPLED: 4/17/92
SAMPLE #: TANK CENTER DATE EXTRACTED: ——
MATRIX: AQUEOUS DATE TESTED: 4/24/92
LABORATORY #: B1942 DILUTION FACTOR: 1

PRIORITY POLLUTANT LIST 8240 COMPOUNDS:	CONCENTRATION ug/l or ug/kg (PPB)	QUANTITATION LIMIT ug/l or ug/kg (PPB)
CHLOROMETHANE	ND	10
BROMOMETHANE	ND	10
VINYL CHLORIDE	ND	10
CHLOROETHANE	ND	10
METHYLENE CHLORIDE	ND	10
1,1-DICHLOROETHENE	ND	5
1,1-DICHLOROETHANE	—BMQL—	5
TOTAL 1,2-DICHLOROETHENES	—110—	5
CHLOROFORM	ND	5
1,2-DICHLOROETHANE	ND	5
1,1,1-TRICHLOROETHANE	ND	5
CARBON TETRACHLORIDE	ND	5
BROMODICHLOROMETHANE	ND	5
1,2-DICHLOROPROPANE	ND	5
TRANS 1,3-DICHLOROPROPENE	ND	5
TRICHLOROETHENE	—33—	5
DIBROMOCHLOROMETHANE	ND	5
1,1,2-TRICHLOROETHANE	ND	5
BENZENE	—43—	5
CIS 1,3-DICHLOROPROPENE	ND	5
BROMOFORM	ND	5
1,1,2,2-TETRACHLOROETHANE	ND	5
TETRACHLOROETHENE	ND	5
TOLUENE	—170—	5
CHLOROBENZENE	ND	5
ETHYL BENZENE	—60—	5
1,2-DICHLOROBENZENE	ND	10
1,3-DICHLOROBENZENE	ND	10
1,4-DICHLOROBENZENE	ND	10

SEE PAGE 2 – FOR REMAINING COMPOUNDS

EPA METHOD 8240 ANALYSIS
FOR VOLATILE ORGANICS BY GC/MS

JOB DESCRIPTION: TANK #5 GROTON SUB BASE – GROTON, CT
JOB #: 30894
SAMPLE #: TANK CENTER
MATRIX: AQUEOUS
LABORATORY #: B1942

TARGET COMPOUND LIST 8240 COMPOUNDS	CONCENTRATION ug/l or ug/kg (PPB)	QUANTITATION LIMIT ug/l or ug/kg (PPB)
ACETONE	—79—	50
CARBON DISULFIDE	ND	5
2-BUTANONE (MEK)	ND	100
VINYL ACETATE	ND	20
2-HEXANONE (MBK)	ND	20
4-METHYL-2-PENTANONE (MIBK)	—36—	20
TOTAL XYLENES	—170—	5
STYRENE	—6.0—	5

MISCELLANEOUS 8240 COMPOUNDS:	CONCENTRATION ug/l or ug/kg (PPB)	QUANTITATION LIMIT ug/l or ug/kg (PPB)
METHYL-t-BUTYL ETHER	—26—	10
TRICHLOROFLUOROMETHANE	—77—	20

SURROGATES:	% RECOVERY
1,2-DICHLOROETHANE – D4	105
TOLUENE – D8	88.7
4-BROMOFLUOROBENZENE	99.6

COMMENTS:

ANALYZED BY: VKong

REVIEWED BY:

GZA GEOENVIRONMENTAL, INC., ENVIRONMENTAL CHEMISTRY LABORATORY
320 NEEDHAM STREET, NEWTON UPPER FALLS, MA 02164 (617) 969-0050
MASSACHUSETTS LABORATORY I.D. NO. MA092

EPA METHOD 8260/8240/624 ANALYSIS
PURGEABLES IN AQUEOUS AND/OR SOLID MATRIX
QUALITY CONTROL

DATE: 4/22/92 8240 GILBERT

AQUEOUS (ug/l)

	MATRIX SPIKE RECOVERY (%)	ACCEPTANCE LIMITS (%)	DUPLICATE SPIKE PERCENT DIFFERENCE (%)	ACCEPTANCE LIMITS (%)
1,1-DICHLOROETHENE	98.3	60-120	6.59	20
TRICHLORETHENE	96.4	70-130	4.66	20
TOLUENE	105	70-125	6.90	20

SOLID (ug/kg)

	MATRIX SPIKE RECOVERY (%)	ACCEPTANCE LIMITS (%)	DUPLICATE SPIKE PERCENT DIFFERENCE (%)	ACCEPTANCE LIMITS (%)
1,1-DICHLOROETHENE	78.7	60-120	2.97	35
TRICHLORETHENE	80.2	65-130	4.20	35
TOLUENE	85.7	65-125	8.14	35

METHOD BLANK

LABORATORY #: B1901

TOTAL COMPOUNDS DETECTED	ND

SURROGATES	% RECOVERY
1,2-DICHLOROETHANE-D4	102
TOLUENE-D8	93.2
4-BROMOFLUOROBENZENE	103

EPA METHOD 8240 ANALYSIS FOR VOLATILE ORGANICS BY GC/MS

OVERVIEW

EPA Method 8240 is a purge and trap gas chromatographic method for the identification and quantification of volatile organic compounds in aqueous and solid samples. Purge and trap is a dynamic headspace technique where volatiles in an aqueous/solid sample are completely stripped from the aqueous/solid phase to vapor phase. The volatiles from the depleted sample are collected on an absorbent trap, thermally desorbed to a gas chromatograph for separation, and routed to a mass spectrometer.

METHODOLOGY

A Tekmar Model LSC-2000 Liquid Sample Concentrator is used in conjunction with a Tekmar Model ALS2016 Automatic Laboratory Sampler to purge volatile compounds by bubbling helium gas through a 5 ml aqueous matrix and passing the vapor through a tenax/silica gel sorbent trap. Aqueous samples are introduced directly into the sample sparging apparatus. Solid samples are prepared using two methods: a high level and a low level method. The high level method is a solvent extraction of the sample using capillary grade methanol of which an aliquot is spiked into reagent water and subsequently treated as an aqueous sample. The low level method involves the transfer of a five gram solid subsample to the sparging device, the addition of reagent water to the sample, and utilizing a sample heater to purge volatile components. The purgeable compounds retained on the tenax/silica gel trap are then thermally desorbed and passed through a heated line into the gas chromatograph. GZA performs this method on a Hewlett-Packard UP 5890A Gas Chromatograph (equipped with an 105m X 0.53mm RTX-502.2 capillary column) and a Hewlett Packard Model 5970B Mass Selective Detector which is interfaced to a Hewlett-Packard HP 1000 RTE A Series Micro 24 System with Aquarius data acquisition software. The information for the report is entered manually onto a Lotus Symphony spreadsheet. Calibration and quality control are performed in accordance with the protocols established by the EPA and Massachusetts DEP published in the references cited below.

REPORT FORMAT

The quantitation limit is stated for every report and is adjusted when dilutions are made to bring sample response data within the calibrated range of the method. Concentrations less than the quantitation limit may be identified as Beneath Method Quantitation Limit (BMQL).

DISCLAIMER

Identities and concentrations of purgeable organic compounds by this dynamic headspace technique are subject to limitations inherent to these methods.

LABORATORY CONTACT PERSON:

Edward W. Pickering, Manager
Environmental Chemistry Laboratory
GZA GeoEnvironmental, Inc.
Massachusetts Laboratory I.D. No. MA 092
Phone #: (617) 969-0050 x169

REFERENCES

Commonwealth of Massachusetts DEP, "Minimum Standards for Analytical Data for Remedial Response Actions Under M.G.L.c. 21E", Policy #WSC-89-004 (1990).

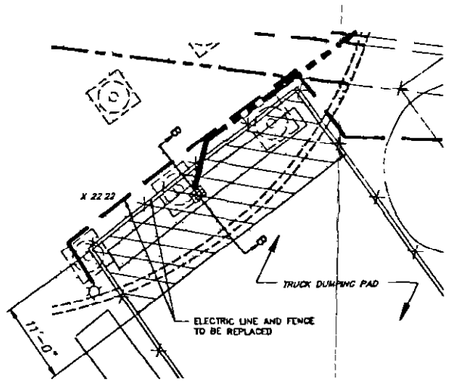
McNally, M.E. and R.L. Grob, "A Review: Current Applications of Static and Dynamic Headspace Analysis: Part One: Environmental Applications", Am. Lab. 20 (1) 20-33, (1985).

U.S. EPA, "Handbook for Analytical Quality Control in Water and Waste Water Laboratories", EP-600\4-79-1019 (1979).

U.S. EPA "Methods for Organic Chemical Analysis of Municipal and Industrial Wastewater", Appendix A. 40CFR Part 136, Federal Register, Vol. 49, No. 209. Method 624-Purgeables (1984).

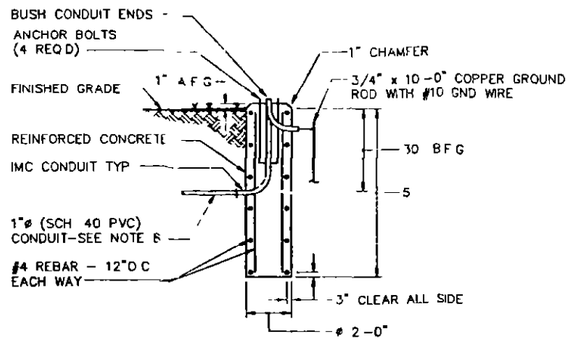
U.S. EPA, "Test Methods for Evaluating Solid Waste, Physical/Chemical Methods", SW-846, Third Edition, Volume 1B, Update Method 8240: GC/MS for Volatile Organics, Method 5030: Purge and Trap. May 1989.

U.S. EPA, "Test Methods for Evaluating Solid Waste, Physical/Chemical Methods", SW-846, Third Edition, Volume 1B, Update Method 8240: GC/MS for Volatile Organics: Capillary Column," December, 1987; Method 5030: "Purge and Trap," December, 1987.
4/92/DM



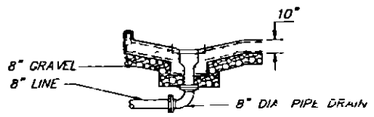
DETAIL 2
TRUCK DUMPING PAD DEMOLITION PLAN

SCALE 1"= 10



TYPICAL POLE BASE DETAIL

NO SCALE



SECTION B–B

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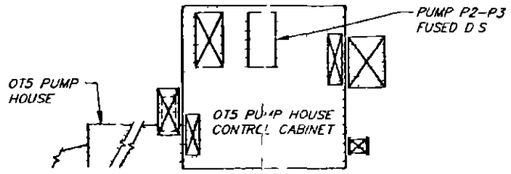
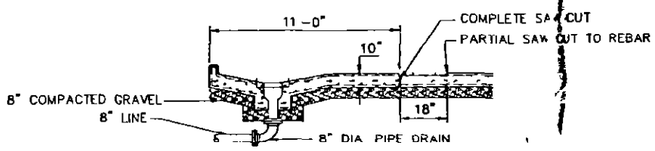


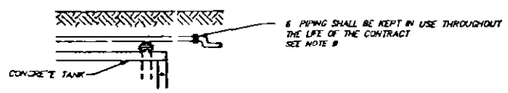
OT5 PUMP HOUSE CONTROL CABINET

NO SCALE



TRUCK DUMPING PAD RECONSTRUCTION DETAIL

NO SCALE



SECTION 3/A

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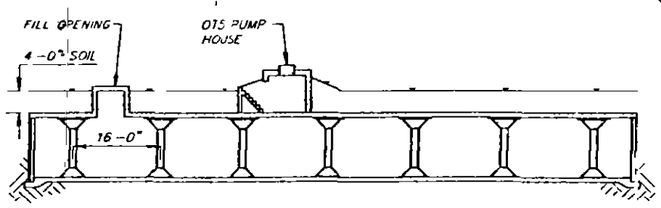


EXTENT OF REMOVAL

NO SCALE

LEGEND

- #6 REBAR
- ELECTRIC LINE
- WASTE LINE
- LINE TO BE REMOVED LINES TO BE CUT AND CAPPED AT END OF EXCAVATION
- LINE TO BE MAINTAINED DURING CONSTRUCTION
- FENCE CHAIN LINK
- INNER COLUMNS
- LIGHT POLE TO BE REMOVED AND REUSED
- SHEET NUMBER / SECTION CALL-OUT
- REMOVAL DEMOLITION AND/OR EXCAVATION AREA
- TRUCK DUMPING PAD SECTION REMOVAL AREA TO BE RESTORED BACK TO PRESENT CONDITION AFTER CONSTRUCTION
- CONCRETE
- CONCRETE

SCALE 1 = 10

CHECK GRAPHIC SCALE BEFORE USING

GENERAL NOTES

1. ALL UNDERGROUND LINES THAT ARE TO BE REMOVED WILL BE CUT AND CAPPED AT THE EDGE OF EXCAVATION AND AT THEIR SOURCE
2. CONTRACTOR MUST PURGE ALL LIQUID CONTAINING LINES THAT SHALL BE CUT AND REMOVED BEFORE CAPPING
3. ELECTRICAL LINES THAT ARE INCAPSULATED IN DUCTS SHALL BE TERMINATED AT POINT OF ORIGIN AND REMOVED FROM THE DUCTS THE DUCTS SHALL THEN BE CAPPED AT THE EDGE OF EXCAVATION
4. SLANT LETTERING DENOTES EXISTING CONDITIONS
5. BLOCK LETTERING DENOTES NEW CONSTRUCTION
6. THE CONTRACTOR SHALL REMOVE THE CONTROL PANEL AND TRANSFER PUMP FROM THE PUMP HOUSE
7. LIGHT POLE TO BE REMOVED DURING CONSTRUCTION AND REINSTALLED AT COMPLETION POLE IS TO BE LOCATED TO ORIGINAL POSITION FOLLOWING RECONSTRUCTION OF TRUCK DUMPING PAD CONDUIT MAY BE TERMINATED AT THE EDGE OF EXCAVATION WIRING TO BE REMOVED TO CONTROL CABINET SPLICING SHALL NOT BE PERMITTED. EXTEND 2 #10 AND 1 #10 IN 1" CONDUIT FROM CONTROL BABINET TO LIGHT AND RECONNECT AS REQUIRED
8. THE CONTRACTOR MUST MAINTAIN AND RELOCATE THIS LINE DURING CONSTRUCTION AFTER CONSTRUCTION IS COMPLETE THE CONTRACTOR MUST REESTABLISH THIS LINE TO ORIGINAL CONDITIONS

THE EADS GROUP
DWN. DBL CK. JDM DATE 7/10/92
SUPV. W. J. WILSON, PE
SUBMITTED BY W. J. WILSON, PE
PREP BY DATE APPVD
REV. DESCRIPTION

NORTHERN DIVISION
NAVAL FACILITIES ENGINEERING COMMAND
PHILADELPHIA, PA.
DEPARTMENT OF THE NAVY
NAVAL BASE NAVAL REBUILDING BASE

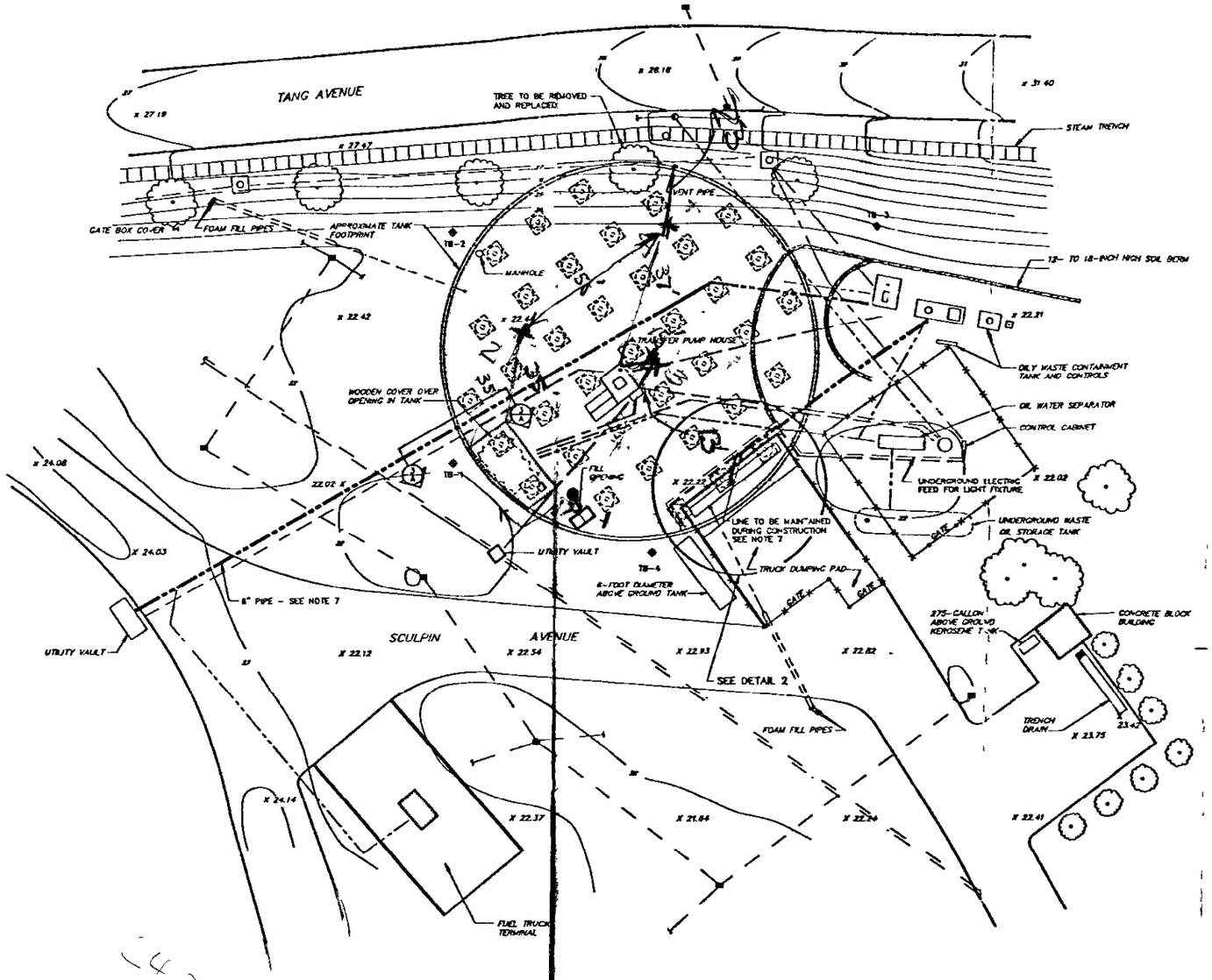
UST REMOVAL – WASTE OIL TANK NO 5
REMOVAL AND CONSTRUCTION PLAN

COMMONWEALTH OF PENNSYLVANIA REGISTERED PROFESSIONAL ENGINEER WILLIAM JOHN WILSON No. 23277-E

SCALE AS SHOWN
SPEC NO. 04-91-0315
CONSTRUCT CONTR. NO. N62472-91-C-0315
NAVFAC DRAWING NO. 2156155
SHEET 3 OF 4
SIZE D

0034 3 01X

HALF SIZE



WASTE OIL TANK NO. 5
PLAN VIEW
SCALE 1"=20

LEGEND

- TB-1 — INDICATES SUBSURFACE BORINGS ON OCTOBER 29 1991
- CATCH BASIN
- SANITARY MANHOLE
- LIGHT POLE TO BE REMOVED AND REUSED
- ELECTRIC LINE
- TELEPHONE LINE
- DRAIN LINE
- WASTE LINE
- SEWER LINE
- FOAM LINES
- INNER COLUMNS
- LINE TO BE REMOVED LINES TO BE CUT AND CAPPED AT END OF EXCAVATION
- LINE TO BE MAINTAINED DURING CONSTRUCTION
- FENCE, CHAIN LINK
- REMOVAL, DEMOLITION AND/OR EXCAVATION AREA
- TRUCK DUMPING PAD SECTION REMOVAL AREA TO BE RESTORED BACK TO PRESENT CONDITION AFTER CONSTRUCTION
- SOIL BERM
- PORTION OF THE SOIL BERM TO BE RELOCATED
- SHEET NUMBER / SECTION CALL-OUT

GENERAL NOTES

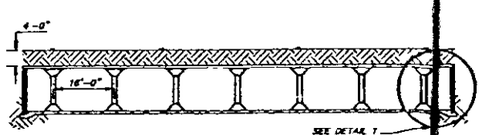
1. MAP WAS DEVELOPED FROM TOPOGRAPHICAL SURVEY PERFORMED ON OCTOBER 24 AND NOVEMBER 2 1991
2. ELEVATIONS ARE REFERENCED TO MEAN SEA LEVEL. BENCHMARK #61 (ELE 26 25) WAS USED TO ESTABLISH ELEVATION CONTOURS BENCHMARK #61 CONSISTS OF A PUNCHMARK IN A 2" BRASS PLATE SET IN CONCRETE RETAINING WALL AT THE INTERSECTION OF TANG AVENUE AND GOLET AVENUE APPROXIMATELY 200 WEST OF SITE.
3. SUBSURFACE UTILITY LOCATIONS SHOULD BE CONSIDERED APPROXIMATE. SUBSURFACE UTILITY LOCATIONS WERE DEVELOPED FROM PLANS ENTITLED "OIL TANK FIVE (5 PIPING & ELECTRICAL LAYOUT" AND "DEMOLITION OIL TANK FIVE (5), EXISITNG CONDITIONS" DATED AUGUST 2, 1989 DEVELOPED BY THE NAVAL FACILITIES ENGINEERING COMMAND NAVAL SUBMARINE BASE NEW LONDON GROTON CONNECTICUT
4. SLANT LETTERING DENOTES EXISTING CONDITIONS
5. BLOCK LETTERING DENOTES NEW CONSTRUCTION
6. THE CONTRACTOR IS RESPONSIBLE FOR THE EXECUTION OF THE EXCLUSION DECONTAMINATION AND THE SUPPORT ZONES. THIS SHALL BE COMPLETED AFTER THE INITIAL SITE VISIT AND BE INCORPORATED INTO THE SAFETY HEALTH EMERGENCY RESPONSE PLAN (SHERP)
7. THE CONTRACTOR MUST MAINTAIN AND RELOCATE THIS LINE DURING CONSTRUCTION AFTER CONSTRUCTION IS COMPLETE, THE CONTRACTOR MUST REESTABLISH THIS LINE TO ORIGINAL CONDITIONS.
8. DISTURBED TURF SHALL BE REPLACED

SCALE 1 = 20'

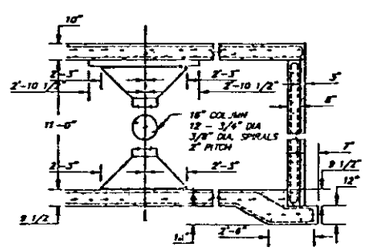
SCALE 1/2" = 1'

CHECK GRAPHIC SCALES BEFORE USING

NORTH

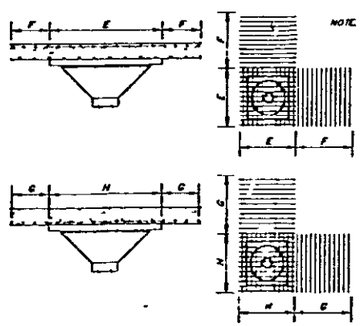


ELEVATION OF TANK
SCALE 1"= 20



DETAIL 1
ELEVATION OF COLUMN — SCALE 1/2"= 1'- 0"

WALL SECTION — SCALE 1/2" = 1'- 0"



NOTE 1. ROOF PLAN SHOWS TYPICAL LOCATIONS. LETTERS DENOTE THE DIAMETES OF THE STEEL AS FOLLOWS:

E - 3/4" DIA. ROD TOP STEEL ROOF SLAB
F - 5/8" DIA. ROD TOP STEEL ROOF SLAB
G - 5/8 DIA. ROD BOTTOM STEEL ROOF SLAB
H - 3/4" DIA. ROD BOTTOM STEEL ROOF SLAB

ROOF PLAN DETAIL
NO SCALE

0034302X

REV.	DESCRIPTION	PREP BY	DATE	APPVD

THE EADS GROUP

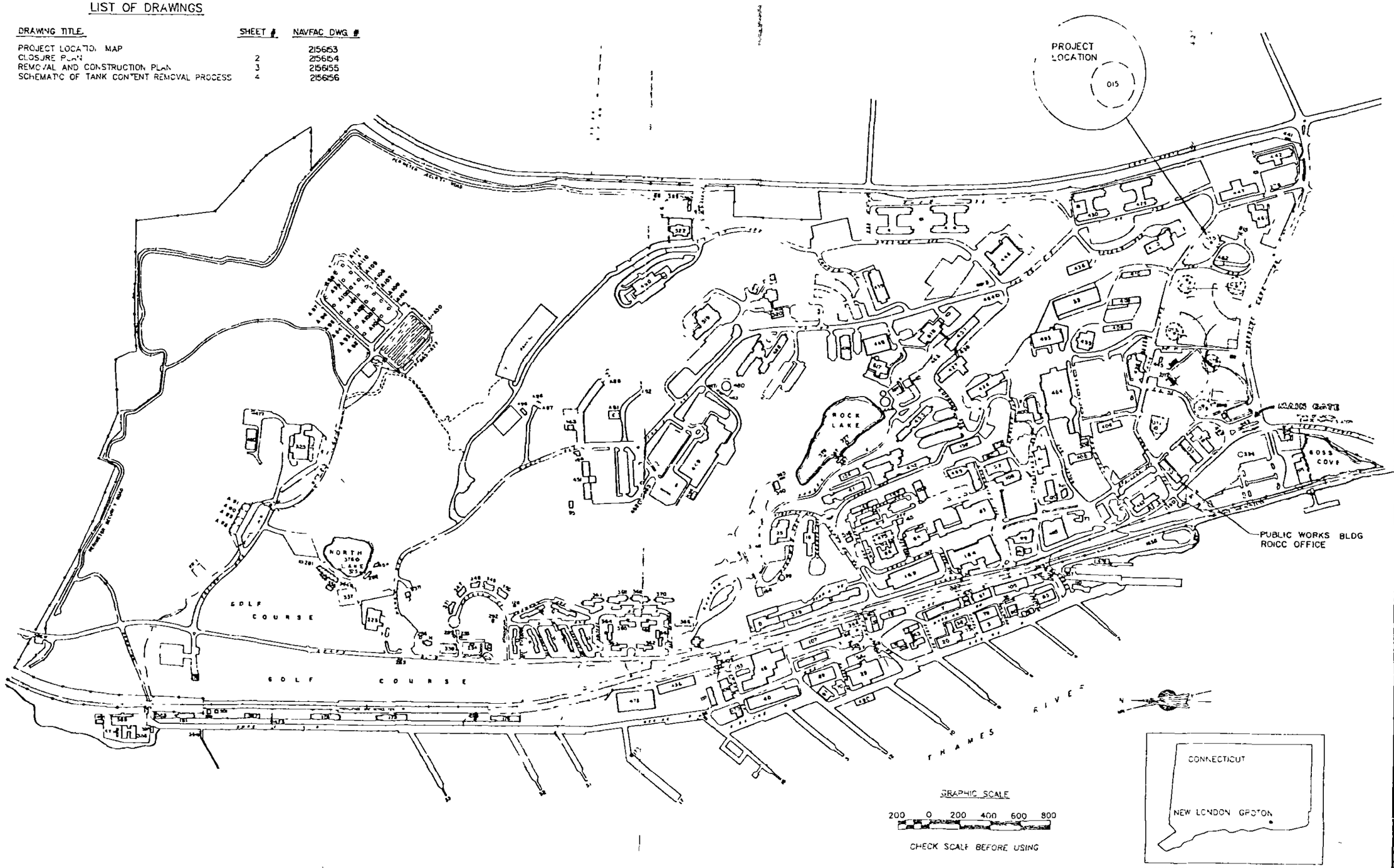
NORTHERN DIVISION

UST REMOVAL - WASTE OIL TANK NO.5
CLOSURE PLAN

AS SHOWN
SPEC NO. 04-91-0315
N62472-91-C-0315
2156154
D

LIST OF DRAWINGS

DRAWING TITLE	SHEET #	NAVFAC DWG #
PROJECT LOCATION MAP		2156153
CLOSURE PLAN	2	2156154
REMOVAL AND CONSTRUCTION PLAN	3	2156155
SCHEMATIC OF TANK CONTENT REMOVAL PROCESS	4	2156156



PROJECT LOCATION MAP

REV.	DESCRIPTION	PREP BY	DATE	APPVD

THE EADS GROUP
DSN. DBL. DR. JDM. CHK. SJL.
SUPV. W. J. WILSON, PE DR. DATE
SUBMITTED BY W. J. WILSON, PE 2/10/92

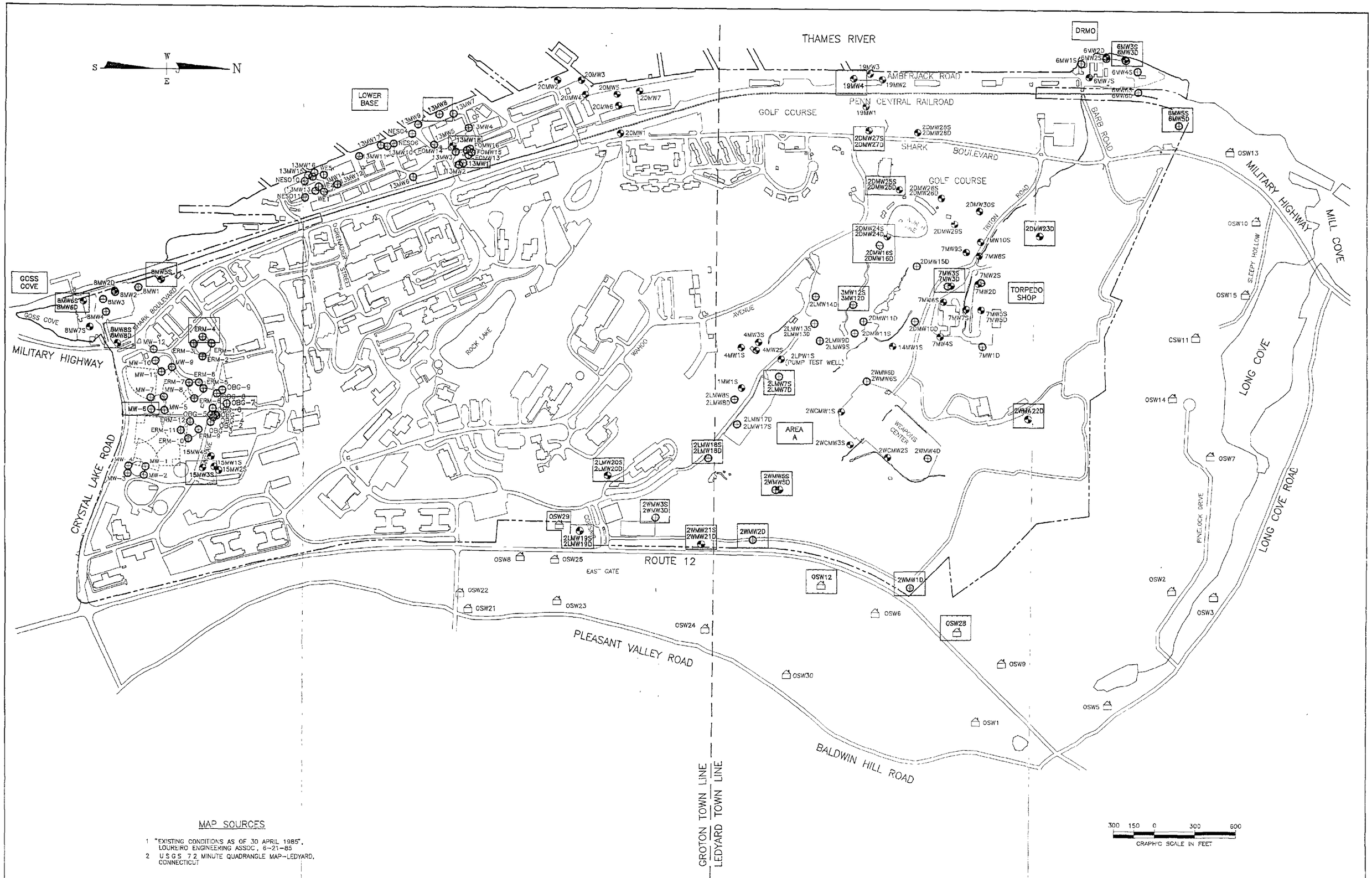
DEPARTMENT OF THE NAVY
NAVAL BASE
NAVAL FACILITIES ENGINEERING COMMAND
PHILADELPHIA, PA.
NORTHERN DIVISION
NAVAL FACILITIES ENGINEERING COMMAND
NEW LONDON, CONNECTICUT

UST REMOVAL – WASTE OIL TANK NO 5
PROJECT LOCATION MAP

SCALE AS SHOWN
SPEC. NO. 04-91-03 5
CONTRACT CONTR. NO. N62472-91-C-0315
NAVFAC DRAWING NO. 2156153
SHEET 1 OF 4
SIZE D

0034303X

HALF SIZE



MAP SOURCES

1 "EXISTING CONDITIONS AS OF 30 APRIL 1985", LOUREIRO ENGINEERING ASSOC., 6-21-85
2 U.S.G.S. 7.2 MINUTE QUADRANGLE MAP-LEDYARD, CONNECTICUT

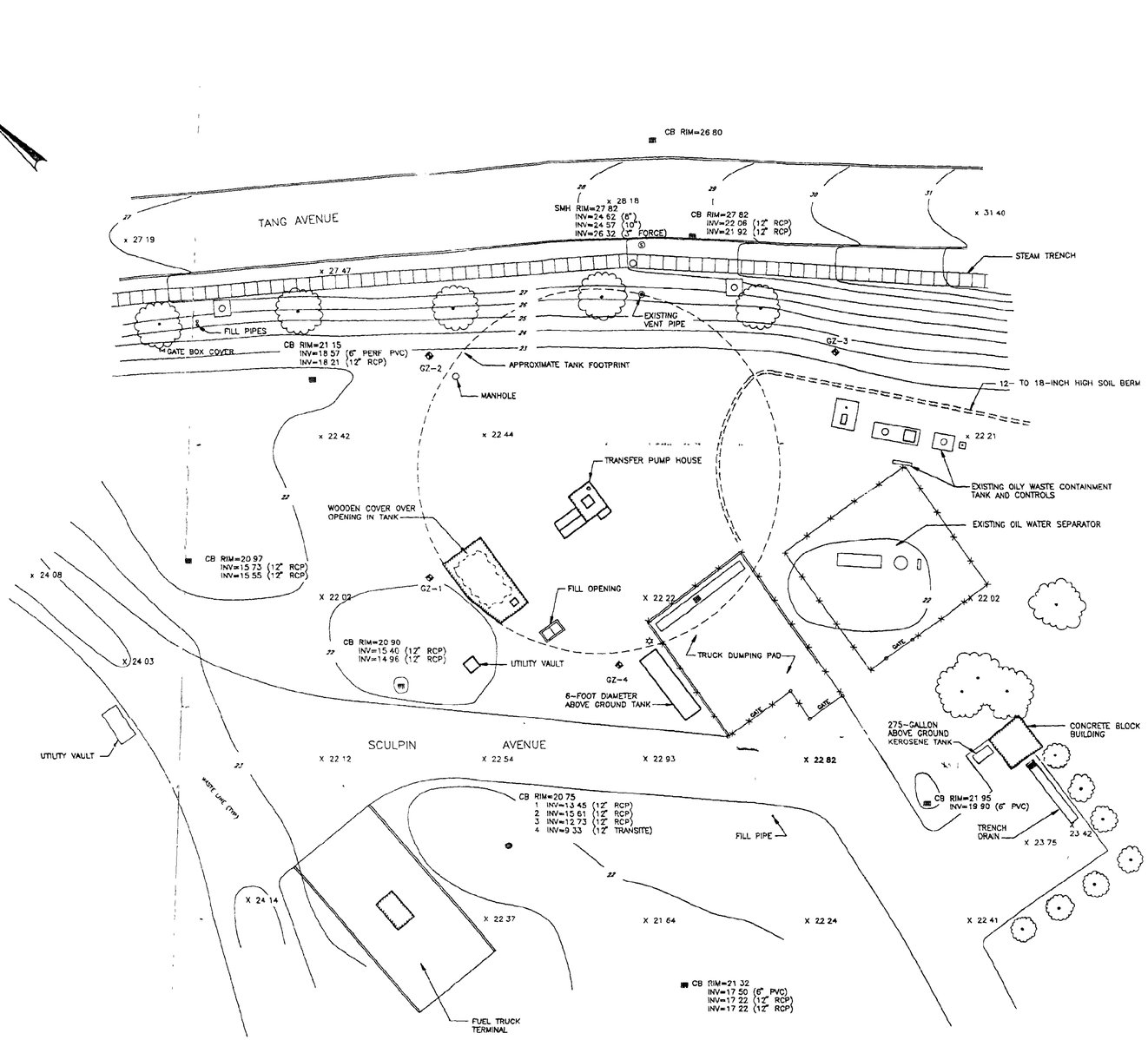
INSTALLATION RESTORATION STUDY
NAVAL SUBMARINE BASE-NEW LONDON
GROTON, CONN

LEGEND
PROPOSED WATER LEVEL MONITORING LOCATION
OFF-SITE RESIDENTIAL WELL
EXISTING MONITORING WELL
PROPOSED MONITORING WELL
TOWN/CITY LINE

PLATE 2
PROPOSED MONTHLY WATER LEVEL MEASUREMENT LOCATIONS

ATLANTIC ENVIRONMENTAL SERVICES, INC.

0034 3 04X



NOTES:

1. MAP WAS DEVELOPED FROM TOPOGRAPHICAL SURVEY PERFORMED BY GZA PERSONNEL ON OCTOBER 24 AND NOVEMBER 2, 1991
2. ELEVATIONS ARE REFERENCED TO MEAN SEA LEVEL BENCHMARK #6: (ELE 26.25') WAS USED TO ESTABLISH ELEVATION CONTOURS. BENCHMARK #6: CONSISTS OF A PUNCHMARK IN A 2" BRASS PLATE SET IN CONCRETE RETAINING WALL AT THE INTERSECTION OF TANG AVENUE AND GOLET AVENUE, APPROXIMATELY 200' WEST OF SITE

LEGEND:

GZ-1	INDICATES SUBSURFACE BORINGS PERFORMED BY GZA DRILLING COMPANY, INC OF BROCKTON, MASSACHUSETTS, ON OCTOBER 29, 1991, OBSERVED BY GZA PERSONNEL
CB	CATCH BASIN
SMH	SANITARY MANHOLE
☼	LIGHT POLE

REV#	DESCRIPTION	BY

SCALE IN FEET 0' 20' 40' 80'

GZA GeoEnvironmental, Inc

PROJ MGR DRC
CHK'D BY WLL
REV'D BY HDF
DRAWN BY. BAW
SCALE 1" = 20'
DATE NOV 1991

WASTE OIL TANK NO. 5
NAVAL SUB BASE – NEW LONDON, GROTON, CT

TOPOGRAPHIC PLAN

PROJECT NO. 30894

DRAWING NO 2

© 1991 GZA GeoEnvironmental, Inc.

0034 3 05X

APPENDIX C

STANDARD OPERATING PROCEDURES

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

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5.0 PROCEDURES

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5.1.2 Split Barrel (Split Spoon) Sampling (ASTM D1586-84)
5.1.3 Thin Walled Tube (Shelby Tube) Sampling (ASTM D1587-83)
5.1.4 Continuous Core Soil Samples
5.2 SURFACE SOIL SAMPLES
5.3 WASTE PILE SAMPLES
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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 field sampling activities.

2.0 SCOPE

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

3.0 GLOSSARY

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

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

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

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

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

4.0 RESPONSIBILITIES

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

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

5.0 PROCEDURES

5.1 SUBSURFACE SOIL SAMPLES

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

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

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

The procedures described here are representative of a larger number of possible drilling and sampling techniques. The choice of techniques is based on a large number of variables such as cost, DQOs, local geology, etc. The final choice of methods must be made with the assistance of drilling subcontractors familiar with the local geologic conditions. Alternative techniques must be based upon the underlying principles of quality assurance implicit in the following procedures.

5.1.1 Equipment

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

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

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

The following method will be used for split barrel sampling:

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

sun at all times. Ship samples protected with suitable resilient packing material to reduce shock, vibration, and disturbance.

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

5.1.4 Continuous Core Soil Samples

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

5.2 SURFACE SOIL SAMPLES

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

The following methods are to be used:

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

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

- Pack and ship accordingly.

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

5.3 WASTE PILE SAMPLES

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

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

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

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

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

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

5.4 ROCK SAMPLING (CORING) (ASTM D2113-83)

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

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

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

ATTACHMENT 1

STANDARD SIZES OF CORE BARRELS AND CASING

Coring bit size	Nominal *		Set size *	
	O.D.	I.D.	O.D.	I.D.
RWT	$1\frac{5}{32}$	$\frac{3}{4}$	1.160	.735
EWT	$1\frac{1}{2}$	$\frac{29}{32}$	1.470	905
EX, EXL, EWG, EWM	$1\frac{1}{2}$	$\frac{13}{16}$	1.470	845
AWT	$1\frac{7}{8}$	$1\frac{9}{32}$	1.875	1 281
AX, AXL, AWG, AWM	$1\frac{7}{8}$	$1\frac{3}{16}$	1.875	1 185
BWT	$2\frac{3}{8}$	$1\frac{3}{4}$	2.345	1 750
BX, BXL, BWG, BWM	$2\frac{3}{8}$	$1\frac{5}{8}$	2.345	1.655
NWT	3	$2\frac{5}{16}$	2 965	2.313
NX, NXL, NWG, NWM	3	$2\frac{1}{8}$	2.965	2.155
HWT	$3\frac{29}{32}$	$3\frac{3}{16}$	3.889	3.187
HWG	$3\frac{29}{32}$	3	3.889	3.000
$2\frac{3}{4} \times 3\frac{7}{8}$	$3\frac{7}{8}$	$2\frac{3}{4}$	3 840	2.690
$4 \times 5\frac{1}{2}$	$5\frac{1}{2}$	4	5 435	3.970
$6 \times 7\frac{3}{4}$	$7\frac{3}{4}$	6	7 655	5.970
AX Wire line 1/	$1\frac{7}{8}$	1	1 875	1.000
BX Wire line 1/	$2\frac{3}{8}$	$1\frac{7}{16}$	2.345	1 437
NX Wire line 1/	3	$1\frac{15}{16}$	2 965	1.937

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

ATTACHMENT 1
PAGE TWO

Size Designations			Casing coupling					Approximate core diameter	
Casing; Casing coupling; Casing bits; Core barrel bits	Rod; Rod couplings	Casing O.D., inches	O.D., inches	I.D., inches	Casing bit, O.D., inches	Core barrel bit O.D., inches*	Drill rod O.D., inches	Normal, inches	Thinwall, inches
RX	RW	1.437	1.437	1.188	1.485	1.160	1.094	—	.735
EX	E	1.812	1.812	1.500	1.875	1.470	1.313	.845	.905
AX	A	2.250	2.250	1.906	2.345	1.875	1.625	1.185	1.281
BX	B	2.875	2.875	2.375	2.965	2.345	1.906	1.655	1.750
NX	N	3.500	3.500	3.000	3.615	2.965	2.375	2.155	2.313
HX	HW	4.500	4.500	3.938	4.625	3.890	3.500	3.000	3.187
RW	RW	1.437	Flush joint	No coupling	1.485	1.160	1.094	—	.735
EW	EW	1.812			1.875	1.470	1.375	.845	.905
AW	AW	2.250			2.345	1.875	1.750	1.185	1.281
BW	BW	2.875			2.965	2.345	2.125	1.655	1.750
NW	NW	3.500			3.615	2.965	2.625	2.155	2.313
HW	HW	4.500			4.625	3.890	3.500	3.000	3.187
PW	—	5.500			5.650	—	—	—	—
SW	—	6.625			6.790	—	—	—	—
UW	—	7.625			7.800	—	—	—	—
ZW	—	8.625			8.810	—	—	—	—
—	AX 1/	—	—	—	—	1.875	1.750	1.000	—
—	BX 1/	—	—	—	—	2.345	2.250	1.437	—
—	NX 1/	—	—	—	—	2.965	2.813	1.937	—

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

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

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

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

5.4.1 Diamond Core Drilling

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

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

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

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

- When soft materials are encountered that produce less than 50 percent recovery, stop the core drilling. If soil samples are desired, secure such samples in accordance with the procedures described in ASTM Method D 1586 (Split Barrel Sampling) or in Method D 1587 (Thin-Walled Tube Sampling) for Sampling of Soils (see Section 5.1.1 and 5.1.2). Resume diamond core drilling when refusal materials are again encountered.

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

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

5.4.2 Rock Sample Preparation and Documentation

Once the rock coring has been completed and the core recovered, the rock core shall be carefully removed from the barrel, placed in a core tray (previously labeled "top" and "bottom" to avoid confusion), classified, and measured for percentage of recovery as well as the rock quality designation (RQD). Each core shall be described, classified, and logged using a uniform system as presented in Procedure GH-1.5. If moisture content will be determined or if it is desirable to prevent drying (e.g.,

to prevent shrinkage of clay formations) or oxidation of the core, the core shall be wrapped in plastic sleeves immediately after logging. Each plastic sleeve shall be labeled with indelible ink. The boring number, run number, and the footage represented in each sleeve shall be included, as well as the top and bottom of the core run.

After sampling, rock cores shall be placed in the sequence of recovery in well-constructed wooden boxes provided by the drilling contractor. Rock cores from two different borings shall not be placed in the same core box unless accepted by the Site Geologist. The core boxes shall be constructed to accommodate at least 20 linear feet of core in rows of approximately 5 feet each and shall be constructed with hinged tops secured with screws, and a latch (usually a hook and eye) to keep the top securely fastened down. Wood partitions shall be placed at the end of each core run and between rows. The depth from the surface of the boring to the top and bottom of the drill run and run number shall be marked on the wooden partitions with indelible ink. A wooden partition (wooden block) shall be placed at the end of each run with the depth of the bottom of the run written on the block. These blocks will serve to separate successive core runs and indicate depth intervals for each run. The order of placing cores shall be the same in all core boxes. Rock core shall be placed in the box so that, when the box is open, with the inside of the lid facing the observer,the top of the cored interval contained within the box is in the upper left corner of the box,and the bottom of the cored interval is in the lower right corner of the box (see Attachment 2). The top and bottom of each core obtained and its true depth shall be clearly and permanently marked on each box. The width of each row must be compatible with the core diameter to prevent lateral movement of the core in the box. Similarly, an empty space in a row shall be filled with an appropriate filler material or spacers to prevent longitudinal movement of the core in the box.

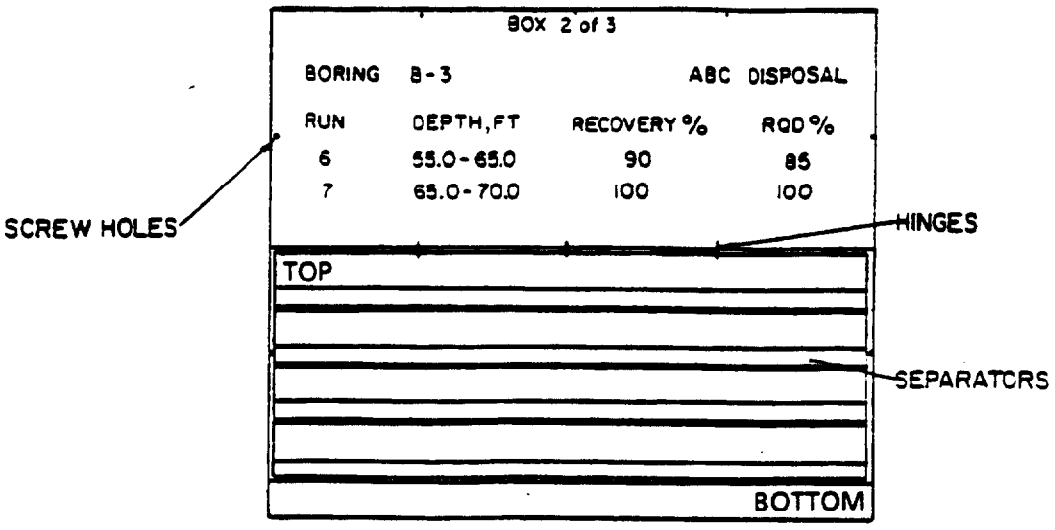
The inside and outside of the core-box lid shall be marked by indelible ink to show all pertinent data on the box's contents. At a minimum, the following information shall be included:

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

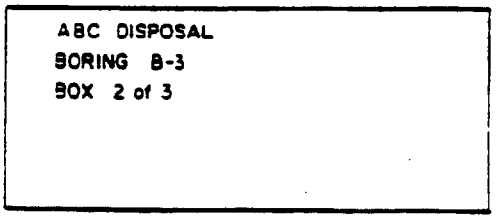
For easy retrieval when core boxes are stacked, the sides and ends of the box shall also be labeled and include project number, boring number, top and bottom depths of core and box number. Attachment No. 2 illustrates a typical rock core box.

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

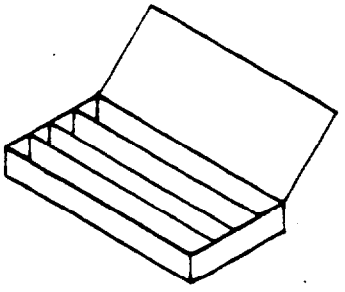
ATTACHMENT 2

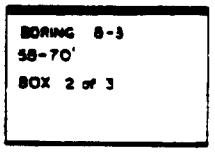


CORE BOX (OBLIQUE VIEW)



CORE BOX (TOP VIEW)





CORE BOX (END VIEW)

TYPICAL ROCK CORE BOX

NOT TO SCALE

NUS CORPORATION
A Halliburton Company

6.0 REFERENCES

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

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7.0 RECORDS

None.

NUS CORPORATION ENVIRONMENTAL MANAGEMENT GROUP	STANDARD OPERATING PROCEDURES	Number GH-1.5	Page 1 of 26
		Effective Date 05/04/90	Revision 2
		Applicability EMG	
		Prepared Earth Sciences	
Subject BOREHOLE AND SAMPLE LOGGING		Approved D. Senovich	

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1.0 PURPOSE

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

2.0 SCOPE

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

3.0 GLOSSARY

None.

4.0 RESPONSIBILITIES

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

5.0 PROCEDURES

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

5.1 MATERIALS NEEDED

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

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

5.2 CLASSIFICATION OF SOILS

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

5.2.1 USCS Classification

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

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

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

5.2.2 Color

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

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

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

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

5.2.3 Relative Density and Consistency

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

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

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

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

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

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

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

5.2.4 Weight Percentages

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

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

Examples:

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

5.2.5 Moisture

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

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

5.2.6 Stratification

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

5.2.7 Texture/Fabric/Bedding

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

5.2.8 Summary of Soil Classification

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

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

5.3 CLASSIFICATION OF ROCKS

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

- Sandstone - Made up predominantly of granular materials ranging between 1/16 to 2 mm in diameter.

- Siltstone - Made up of granular materials less than 1/16 to 1/256 mm in diameter. ractures irregularly. Medium thick to thick bedded.

- Claystone - Vary fine grained rock made up of clay and silt-size materials. Fractures irregularly. Very smooth to touch. Generally has irregularly spaced pitting on surface of drilled cores.

- Shale - A fissile very fine grained rock. Fractures along bedding planes.

- Limestone - Rock made up predominantly of calcite ($CaCO_3$). Effervesces strongly upon the application of dilute hydrochloric acid.

- Coal - Rock consisting mainly of organic remains.

- Others - Numerous other sedimentary rock types are present in lesser amounts in the stratigraphic record. The local abundance of any of these rock types is dependent upon the depositional history of the area. These include conglomerate, halite, gypsum, dolomite, anhydrite, lignite, etc. are some of the rock types found in lesser amounts.

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

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

5.3.1 Rock Type

As described above, there are numerous names of sedimentary rocks. In most cases a rock will be a combination of several grain types, therefore, a modifier such as a sandy siltstone, or a silty sandstone can be used. The modifier indicates that a significant portion of the rock type is composed of the modifier. Other modifiers can include carbonaceous, calcareous, siliceous, etc.

Grain size is the basis for the classification of clastic sedimentary rocks. Exhibit 4-5 is the Udden-Wentworth classification that will be assigned to sedimentary rocks. The individual boundaries are slightly different than the USCS subdivision for soil classification. For field determination of grain sizes, a scale can be used for the coarse grained rocks. For example, the division between siltstone and claystone may not be measurable in the field. The boundary shall be determined by use of a hand lens. If the grains cannot be seen with the naked eye but are distinguishable with a handlens, the rock is a siltstone. If the grains are not distinguishable with a handlens, the rock is a claystone.

5.3.2 Color

The color of a rock can be determined in a similar manner as for soil samples. Rock core samples shall be classified while wet, when possible, and air cored samples shall be scraped clean of cuttings prior to color classifications.

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

5.3.3 Bedding Thickness

The bedding thickness designations applied to soil classification will also be used for rock classification.

5.3.4 Hardness

The hardness of a rock is a function of the compaction, cementation, and mineralogical composition of the rock. A relative scale for sedimentary rock hardness is as follows:

- Soft - Weathered, considerable erosion of core, easily gouged by screwdriver, scratched by fingernail. Soft rock crushes or deforms under pressure of a pressed hammer. This term is always used for the hardness of the saprolite (decomposed rock which occupies the zone between the lowest soil horizon and firm bedrock).

- Medium soft - Slight erosion of core, slightly gouged by screwdriver, or breaks with crumbly edges from single hammer blow.

- Medium hard - No core erosion, easily scratched by screwdriver, or breaks with sharp edges from single hammer blow.

- Hard - Requires several hammer blows to break and has sharp conchoidal breaks. Cannot be scratched with screwdriver.

Note the difference in usage here of the works "scratch" and "gouge." A scratch shall be considered a slight depression in the rock (do not mistake the scraping off of rock flour from drilling with a scratch in the rock itself), while a gouge is much deeper.

5.3.5 Fracturing

The degree of fracturing or brokeness of a rock is described by measuring the fractures or joint spacing. After eliminating drilling breaks, the average spacing is calculated and the fracturing is described by the following terms:

- Very broken (V. BR.) - Less than 2 in. spacing between fractures
- Broken (BR.) - 2 in. to 1 ft. spacing between fractures
- Blocky (BL.) - 1 to 3 ft. spacing between fractures
- Massive (M.) - 3 to 10 ft. spacing between fractures

The structural integrity of the rock can be approximated by calculating the Rock Quality Designation (RQD) of cores recovered. The RQD is determined by adding the total lengths of all pieces exceeding 4 inches and dividing by the total length of the coring run, to obtain a percentage.

Method of Calculating RQD
(After Deere, 1964)

RQD % = r/l x 100

r = Total length of all pieces of the lithologic unit being measured, which are greater than 4 inches length, and have resulted from natural breaks. Natural breaks include slickensides, joints, compaction slicks, bedding plane partings (not caused by drilling), friable zones, etc.

l = Total length of the coring run.

5.3.6 Weathering

The degree of weathering is a significant parameter that is important in determining weathering profiles and is also useful in engineering designs. The following terms can be applied to distinguish the degree of weathering:

- Fresh - Rock shows little or no weathering effect. Fractures or joints have little or no staining and rock has a bright appearance.

- Slight - Rock has some staining which may penetrate several centimeters into the rock. Clay filling of joints may occur. Feldspar grains may show some alteration.

- Moderate - Most of the rock, with exception of quartz grains, is stained. Rock is weakened due to weathering and can be easily broken with hammer.

- Severe - All rock including quartz grains is stained. Some of the rock is weathered to the extent of becoming a soil. Rock is very weak.

5.3.7 Other Characteristics

The following items shall be included in the rock description:

- Description of contact between two rock units. These can be sharp or gradational.
- Stratification (parallel, cross stratified)
- Description of any filled cavities or vugs.
- Cementation (calcoreous, siliceous, hematitic)

- Description of any joints or open fractures.
- Observation of the presence of fossils.
- Notation of joints with depth, approximate angle to horizontal, any mineral filling or coating, and degree of weathering.

All information shown on the boring logs shall be neat to the point where it can be reproduced on a copy machine for report presentation. The data shall be kept current to provide control of the drilling program and to indicate various areas requiring special consideration and sampling.

5.3.8 Additional Terms Used in the Description of Rock

The following terms are used to further identify rocks:

- Seam - Thin (12 inch or less), probably continuous layer.

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

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

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

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

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

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

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

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

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

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

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

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

5.4 ABBREVIATIONS

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

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

5.5 BORING LOGS AND DOCUMENTATION

This section describes in more detail the procedures to be used in completing boring logs in the field. Information obtained from the preceeding sections shall be used to complete the logs. A sample boring log has been provided as Exhibit 4-6. The field geologist/engineer shall use this example as a guide in completing each borings log. Each boring log shall be fully described by the geologist/engineer 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 TOD	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	BORE LOG SCRIBE NOTES	REMARKS

REMARKS _____

BORING _____

PAGE ____ OF ____

EXHIBIT 4-2

SOIL TERMS

UNIFIED SOIL CLASSIFICATION (USCS)

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

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

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

Identification procedures on fraction smaller than No. 40 sieve size

	DRY STRENGTH (Crushing Characteristics)	DILATANCY (Reaction to Shaking)	TOUGHNESS (Consistency Near Plastic Limit)	GROUP SYMBOL	TYPICAL NAMES
SILTS & CLAYS Liquid limit < 50	None to slight	Quick to slow	None	ML	Inorganic silts and very fine sands, rock flour, silty or clayey fine sands with slight plasticity
	Medium to high	None to very slow	Medium	CL	Inorganic clays of low to medium plasticity, gravelly clays, sandy clays, silty clays, lean clays
	Slight to medium	Slow	Slight	OL	Organic silts and organic silt-clays of low plasticity
SILTS & CLAYS Liquid limit > 50	Slight to medium	Slow to none	Slight to medium	MH	Inorganic silts, micaceous or diatomaceous fine sandy or silty soils, elastic silts
	High to very high	None	High	CH	Inorganic clays of high plasticity, fat clays
	Medium to high	None to very slow	Slight to medium	OH	Organic clays of medium to high plasticity
HIGHLY ORGANIC SOILS	Readily identified by color, odor, spongy feel and frequently by fibrous texture.			Pt	Peat and other organic soils

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

DENSITY OF GRANULAR SOILS

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

CONSISTENCY OF COHESIVE SOILS

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

ROCK TERMS

ROCK HARDNESS (FROM CORE SAMPLES)

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

ROCK BROKENNESS

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

LEGEND

SOIL SAMPLES - TYPES

S - 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

12/10
▽ 12.6' Initial Level w/Date & Depth

12/10
▽ 12.6' Stabilized Level w/Date & Depth

D334901

EXHIBIT 4-3

CONSISTENCY FOR COHESIVE SOILS

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

EXHIBIT 4-4

BEDDING THICKNESS CLASSIFICATION

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

(Weir, 1973 and Ingram, 1954)

EXHIBIT 4-5

GRAIN SIZE CLASSIFICATION FOR ROCKS

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

After Wentworth, 1922

BORING LOG — **NUS CORPORATION**

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

SAMPLE NO. & TYPE/ RQD	DEPTH (FT.) / RUN NO.	BLOWS 6" OR RQD (%)	SAMPLE RECOVERY SAMPLE LENGTH	LITHOLOGY CHANGE (Depth ft.) & SCREEN INT	MATERIAL DESCRIPTION* SOIL DENSITY CONSISTENCY OR ROCK HARDNESS	COLOR	MATERIAL CLASSIFICATION	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	VBR	SEVERAL 0 PPM
							QUARTZ PCS		Fe STAINED JOINTS ON CORE
									THRUOUT RUN. JOINTS AND BREAKS
									ARE HORIZ TO LO ∠. W/VUGS ON LOWER
0.7/10.0	①	0.9/0	7.9/10.0						PORTION 23 TO 25 OF CORE
	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

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.)	MATERIAL DESCRIPTION* SOIL DENSITY CONSISTENCY OR ROCK HARDNESS	COLOR	MATERIAL CLASSIFICATION	USCS	REMARKS
9-22		25.0				M.HARD	GRAY	SILTY SHALE	VBR	SHALE IS VBR W/ HORIZ TO 10° 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%/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%/0	9.3/10.0					VBR	39.5 → 42.0
										42.7 → 43.0 HI ∠ JNT
									BR	42.4 → 42.7 VERT JNT
		45.0							VBR	
										45.3 → 45.5 VERT JNT. & VBR
										47.5 VERT JOINT
									BR	48. HI ∠ JOINT
										SLIGHTLY CALCAREOUS MORE CALCITE
										PRESENT

REMARKS

BORING MW 3A

PAGE 2 OF 3

* See Legend on Back

BORING LOG — **NUS CORPORATION**

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

SAMPLE NO. & TYPE	DEPTH (Ft.)	BLOWS 6" OR 400 (Ft.)	SAMPLE RECOVERY SAMPLE LENGTH	LITHOLOGY CHANGE (Depth Ft.)	MATERIAL DESCRIPTION* SOIL DENSITY CONSISTENCY OR ROCK HARDNESS	COLOR	MATERIAL CLASSIFICATION	USCS	REMARKS
1.9/10.0	4	19%/0	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%/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%/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 MATERIAL INV.	MATERIAL DESCRIPTION: SOIL DENSITY CONSISTENCY OR ROCK HARDNESS	COLOR	MATERIAL CLASSIFICATION	USCS	REMARKS (HNU) (HEAD SP)
	0.0	5 / 3	1.4/1.5		LOOSE	BLK BRN	SLAGGY SILT AND CINDER	ML	MOIST (0PPM)
S-1		2					TR- COAL FRAG		3/4 Φ FRAG - NEAR OLD
							TR- CC FRAG		RR. LINE.
							(FILL)		
	5.0					RED			
S-2		1 / 1	1.3/1.5	6.0	V. LOOSE	BRN TO GRAY	SANDY SILT - TR FRAG TO	SM	MOIST TO WET (0PPM)
	6.5	3					SILTY SAND - TR GRAVEL		GRAY SAND @ 6'±
									IRIDESCENT LOOK & NATURAL
									DRILLER NOTE H2O 8-10'
	10.0								
S-3		11 / 23	1.2/1.5		DENSE	BRN	SILTY SAND AND S.S.	GM	WET (0PPM)
	11.5	27					FRAGS (GRAVEL)		1" Φ SIZE MAX SIZE
									SUBANGULAR TO SUBROUNDED GRAVEL
	15.0								
S-4		9 / 47	1.0/1.5		V. DENSE	BRN	SILTY FINE TO C SAND	GM	WET (0PPM)
	16.5	43					AND GRAVEL		1" Φ SIZE MAX SIZE
									SUBANGULAR TO SUBROUNDED GRAVEL
	20.0								
S-5	20.9	17 / 50/2"	.9/.9		V. DENSE	ORANG BRN	SILTY SAND - SOME	GM	WET (0PPM)
							GRAVEL AND		MOIST
							S.S FRAGS		BECOMES MORE LIKE SANDY SILT AT BOTM OF SAMPLE

REMARKS: START @ 1:15 PM - 7-7-87 USING 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

BORING LOG — **NUS CORPORATION**

PROJECT: WESTLINE SITE — BORING NO.: MW013
PROJECT NO.: 473Y — DATE: 7-7-87 — DRILLER: E. EPPSON
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.	MATERIAL DESCRIPTION: SOIL DENSITY-CONSISTENCY OR ROCK HARDNESS	COLOR	MATERIAL CLASSIFICATION	GRADEDNESS ROCK OR USCS	REMARKS (HNU)
S-6	25.0	6/17	1.1/1.5		LOOSE	OLIVE BLUE	SILTY SAND - SOME	SM	MOIST 0 PPM
	26.5	30				GRAY	GRAVEL - TR CLAY		C.S. IS FRIABLE FIRST SAMPLE IN
							TR. SS. FRAG		COLOR. NOT ENOUGH CLAY TO BE CONFINING
									NOTE: MAY SET ZONE 2
7/7	30.0					NOTED			CASING @ 28'
7/8 S-7		17/27	1.4/1.5		V. DENSE	BROWN BLUE	SILTY SAND - SOME GRAVEL	SM/	MOIST → WET (0 PPM)
	31.5	36					TR. SS. FRAG	GM	CONGLOMERATE IS BLUE GRAY & FRIABLE.
							TR CLAY		SEPTUMFEL GRAVEL
									NOT TRUE CLAY - BUT MAY BE SEMI-CON-
	35.0								FINING.
S-8	35.3	30/50/4	0.7/0.9		V. DENSE	BLUE GRAY	SILTY F. TO C. SAND -	SM/	MOIST → WET (0 PPM)
							SOME GRAVEL	GM	V. SL. TR. CLAY - LESS
							TR. SS. FRAG		THAN S-7 1" Ø FRAG. - MORE
									SAMPLE SAND THAN ABOVE.
	40.0					BLUE			POSSIBLE 35 TO 45 SCREEN LOC. SQUEEZED
S-9		31/34	1.2/1.5		V. DENSE	BRN GRAY	SILTY SAND (FINE TO M.)	SM	HOLE [illegible] MOIST → WET (0 PPM)
	41.5	24					SOME GRAVEL - TR	/GM	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/	MOIST → WET (0 PPM)
	46.5	50					SOME GRAVEL - TR	/GM	1" Ø SIZE - HOLDS TO- GETHER WHEN SQUEEZED
							CLAY		BUT NOT COHESIVE CLASS- IFICATION
									SLOW DRILLING TO 50'

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

BORING MW013

PAGE 2 OF 4

BORING LOG — **NUS CORPORATION**

PROJECT: WESTLINE SITE — BORING NO.: MW 013
PROJECT NO.: 473Y — DATE: 7-8-87 — DRILLER: E. 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.	MATERIAL DESCRIPTION: SOIL DENSITY/CONSISTENCY OR ROCK HARDNESS	COLOR	MATERIAL CLASSIFICATION	USCS	REMARKS
S-11	50.0	15 / 41	1.9/1.3		V. DENSE	MOTTLED BLUE	SILTY SAND - SOME GR.	SM	MOIST - (OPPM)
	51.3	50/3				GRAY	TR CLAY	SM	MOTTLE W/ PCS OF BLACK COAL/LIGNITE
									MORE CLAY THAN ABOVE PORTIONS OF SAMPLE - COHESIVE CLASSIF.
	55.0			55.0					
S-12		11 / 15	1.4/1.5		V. STIFF	GRAY ORANG	SANDY CLAY / CLAYEY SAND	SC	MOIST → WET (OPPM)
	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	SC	MOIST → WET (OPPM)
							GRAVEL	GW	1 OR 2 INCH CLAY AS S-12 BUT VERY COMPACT. SUBROUNDED GRAINS
									SET CAS. @ 60'.
	65.0								
7/13 S-14	65.8	37 / 50/.5	0.7/0.8		V. DENSE	BRN ORANG	SILTY SAND - SOME GR.	SM	MOIST (OPPM)
							AND ROCK FRAG -	GW	MORE CLAY TOWARDS TOP OF SAMPLE MAX 3/4" Ø SIZE
				68.0			TR. CLAY		
						YELLOW BRN			COLOR CHANGE AT ≈ 68' MORE SAND PER DRILLER - BOTH OF SEAM 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	MOIST → WET (OPPM)
	71.5	41					GRAVEL - TR	GC	1" MAX GRAVEL
							ROCK FRAG.		MORE GRAVEL @ 72' PER DRILLER

REMARKS USING HOLLOW STEM TO ADVANCE BORING. WASHING OUT THRU AUGERS, UNDER REAMED TO 70' FOR SAMPLE S-12 @ 1:46 PM
S-13 → 3:32 PM - LOGGED IN BY 3:47 PM
SET 6" Ø STEEL CASING TO 66' - WILL DRILL BELOW CASING AFTER GROUT SETS UP. S-14 @ 3:50 PM 7-13-87
S-15 - 7:57 AM 7-14-87

BORING MW 013
PAGE 3 OF 4

BORING LOG — **NUS CORPORATION**

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

SAMPLE NO. & TYPE OR RQD	DEPTH (FL) OR RUN NO	BLOWS 6" OR RQD (%)	SAMPLE RECOVERY SAMPLE LENGTH	LITHOLOGY CHANGE (Depth (FL) or Elev.)	MATERIAL DESCRIPTION: SOIL DENSITY CONSISTENCY OR ROCK HARDNESS	COLOR	MATERIAL CLASSIFICATION	USCS	REMARKS (HNU)
S-16	75.0	28 50/.5	0.9/1.0	75	V. DENSE	GRAY ORANG BRN	FINE TO C. CLAYEY SAND - SOME	SC	WET (0PPM)
	76.0						GRAVEL - TR		NOT AS MUCH CLAY AS S-15 - BOTM OF
							ROCK FRAG (S.S.)		SAMPLE BECOMES MORE SANDY
									MAX 1" Ø RC.
	80.0								NO SAMPLE @ 80' -
									DECIDED TO GO TO 85'.
	85.0	50/.4	0.4/0.4		V. DENSE	GRAY ORANG. BRN	SILTY F. TO C. SAND - SOME	SW	WET (0PPM)
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 - METHOD BEHIND 6" CASING SPUN 4" Ø - 5 7/8" OD CASING TO BOTM. USING WATER AS DRILLING FLUID

BORING MW 013

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NUS CORPORATION ENVIRONMENTAL MANAGEMENT GROUP	STANDARD OPERATING PROCEDURES	Number GH-1.6	Page 1 of 3
		Effective Date 05/04/90	Revision 2
		Applicability EMG	
		Prepared Earth Sciences	
Subject DECONTAMINATION OF DRILLING RIGS AND MONITORING WELL MATERIALS		Approved D. Senovich	

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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 PROCEDURES

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 which might contact environmental sample. 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.

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 RECORDS

None.

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

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6.0 REFERENCES

7.0 RECORDS

1.0 PURPOSE

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

2.0 SCOPE

This procedure is applicable to the construction of permanent monitoring wells at hazardous waste sites. The methods described herein may be modified by project-specific requirements for monitoring well construction. In addition, many regulatory agencies have specific regulations pertaining to monitoring well construction and permitting. These requirements must be ascertained during the development of the investigation and any required permits which may have to be obtained before field work begins. Innovative monitoring well installation techniques, which typically are not used, will be discussed only generally in this procedure.

3.0 GLOSSARY

Monitoring Well - A well which is properly screened (if screening is necessary), cased, and sealed which is capable of providing a groundwater level and groundwater sample representative of the zone being monitored.

Piezometer - A pipe or tube inserted into the water bearing zone, typically open to water flow at the bottom and to the atmosphere at the top, and used to measure water level elevations. Piezometers may range in size from 1/2-inch diameter plastic tubes to well points or monitoring wells.

Potentiometric Surface - The surface to which water in an aquifer would rise by hydrostatic pressure.

Well Point (Drive Point) - A screened or perforated tube (Typically 1-1/4 or 2 inches in diameter) with a solid, conical, hardened point at one end, which is attached to a riser pipe and driven into the ground with a sledge hammer, drop weight, or mechanical vibrator. Well points may be used for groundwater injection and recovery, as piezometers (i.e., to measure water levels) or to provide groundwater samples for water quality data.

4.0 RESPONSIBILITIES

Driller - The driller provides adequate and operable equipment, sufficient quantities of materials, and an experienced and efficient labor force to perform all phases of proper monitoring well installation and construction. He may also be responsible for obtaining, in advance, any required permits for monitoring well installation and construction.

Rig Geologist - The rig geologist supervises well installation and construction by the Driller, documents all phases of well installation and construction, and insures that well construction is adequate to provide representative ground water data from the monitored interval. Geotechnical engineers, field technicians, or other suitable trained personnel may also serve in this capacity.

5.0 PROCEDURES

5.1 EQUIPMENT/ITEMS NEEDED

Below is a list of items that may be needed while installing a monitoring well.

- Health and safety equipment as required by the site safety officer.
- Well drilling and installation equipment with associated materials (typically supplied by the driller).
- Hydrogeologic equipment (weighted engineers tape, water level indicator, retractable engineers rule electronic calculator, clipboard, mirror and flashlight - for observing downhole activities, paint and ink marker for marking monitoring wells, sample jars, well installation forms, and a field notebook).
- Drive point installations tools (Sledge Hammer, drop hammer, or mechanical vibrator; tripod, pipe wrenches, drive points, riser pipe, and end caps).

5.2 WELL DESIGN

The objectives for each monitoring well and its intended use must be clearly defined before the monitoring system is designed. Within the monitoring system, different monitoring wells may serve different purposes and, therefore, require different types of construction. During all phases of the well design, attention must be given to clearly documenting the basis for design decisions, the details of well construction, and the materials to be used. The objectives for installing the monitoring wells may include:

- Determining groundwater flow directions and velocities.
- Sampling or monitoring for trace contaminants.
- Determining aquifer characteristics (e.g., hydraulic conductivity)

Siting of monitoring wells shall be performed after a preliminary estimation of the groundwater flow direction. In most cases, these can be determined through the review of geologic data and the site terrain. In addition, production wells or other monitoring wells in the area may be used to determine the groundwater flow direction. If these methods cannot be used, piezometers, which are relatively inexpensive to install, may have to be installed in a preliminary phase to determine groundwater flow direction.

5.2.1 Well Depth, Diameter, and Monitored Interval

The well depth, diameter, and monitored internal must be tailored to the specific monitoring needs of each investigation. Specification of these items generally depends on the purpose of the monitoring system and the characteristics of the hydrogeologic system being monitored. Wells of different depth, diameter, and monitored interval can be employed in the same groundwater monitoring system. For instance, varying the monitored interval in several wells, at the same location (cluster wells) can help to determine the vertical gradient and the levels at which contaminants are present. Conversly, a fully penetrating well is usually not used to quantify or vertically locate a contamination plume, since groundwater samples collected in wells that are screened over the full thickness of the water bearing zone will be representative of average conditions across the entire monitored interval. However, fully penetrating wells can be used to establish the existence of

contamination in water bearing zone. The well diameter would depend upon the hydraulic characteristics of the water bearing zone. Sampling requirements, drilling method and cost.

The decision concerning the monitored interval and well depth is based on the following information:

- The vertical location of the contaminant source in relation to the water bearing zone.
- The depth, thickness and uniformity of the water bearing zone.
- The anticipated depth, thickness, and characteristics (e.g., density relative to water) of the contaminant plume.
- Fluctuation in groundwater levels (due to pumping, tidal influences, or natural recharge/discharge events).
- The presence and location of contaminants encountered during drilling.
- Whether the purpose of the installation is for determining existence or non-existence of contamination or if a particular stratigraphic zone is being investigated.
- The analysis of borehole geophysical logs.

In most situations where groundwater flow lines are horizontal, depending on the purpose of the well and the site conditions, monitored intervals are 20 feet or less. Shorter screen lengths (1 to 2 feet) are usually required where flow lines are not horizontal, (ie., if the wells are to be used for accurate measurement of the potentiometric head at a specific point).

Many factors influence the diameter of a monitoring well. The diameter of the monitoring well depends on the application. In determining well diameter, the following needs must be considered:

- Adequate water volume for sampling.
- Drilling methodology.
- Type of sampling device to be used.
- Costs

Standard monitoring well diameters are 2, 4, 6, or 8 inches. However, drive points are typically 1-1/4 or 2 inches in diameter. For monitoring programs which require screened monitoring wells, either a 2-inch or 4-inch diameter well is preferred. Typically, well diameters greater than 4 inches are used in monitoring programs in which open hole monitoring wells are required. In the smaller diameter wells, the volume of stagnant water in the well is minimized, and well construction costs are reduced, however, the type of sampling devices that can be used are limited. In specifying well diameter, sampling requirements must be considered. Up to a total of 4 gallons of water may be required for a single sample to account for full organic and inorganic analyses, and split samples. The water in the monitoring well available for sampling is dependent on the well diameter as follows:

Casing Inside Diameter, Inch	Standing Water Depth to Obtain 1 Gal Water (feet)	Total Depth of Standing Water for 4 Gal. (feet)
2	6.13	25
4	1.53	6
6	0.68	3

However, if a specific well recharges quickly after purging, then well diameter may not be an important factor regarding sample volume requirements.

Pumping tests for determining aquifer characteristics may require larger diameter wells; however, in small diameter wells.in-situ permeability tests can be performed during drilling or after well installation is completed.

5.2.2 Riser Pipe and Screen Materials

Well materials are specified by diameter, type of material, and thickness of pipe. Well screens require an additional specification of slot size. Thickness of pipe is referred to as "schedule" for polyvinyl chloride (PVC) casing and is usually Schedule 40 (thinner wall) or 80 (thicker wall). Steel pipe thickness is often referred to as "Strength" and Standard Strength is usually adequate for monitoring well purposes. With larger diameter pipe, the wall thickness must be greater to maintain adequate strength. The required thickness is also dependent on the method of installation;-risers for drive points require greater strength than wells installed inside drilled borings.

The selection of well screen and riser materials depends on the method of drilling, the type of subsurface materials in which the well penetrates, the type of contamination expected, and natural water quality and depth. Cost and the level of accuracy required are also important. The materials generally available are Teflon, stainless steel, PVC, galvanized steel, and carbon steel. Each has advantages and limitations (see Attachment A of this guideline for an extensive discussion on this topic). The two most commonly used materials are PVC and stainless steel for wells in which screens are installed and are compared in Attachment B. Stainless steel is preferred where trace metals or organic sampling is required; however, costs are high. Teflon materials are extremely expensive, but are relatively inert and provide the least opportunity for water contamination due to well materials. PVC has many advantages, including low cost, excellent availability, light weight, and ease of manipulation; however, there are also some questions about organic chemical sorption and leaching that are currently being researched (see Barcelona et al., 1983). Concern about the use of PVC can be minimized if PVC wells are used strictly for geohydrologic measurements and not for chemical sampling. The crushing strength of PVC may limit the depth of installation, but schedule 80 materials normally used for wells greater than 50 feet deep may overcome some of the problems associated with depth. However, the smaller inside diameter of Schedule 80 pipe may be an important factor when considering the size of bailers or pumps to be used for sampling or testing. Due to this problem, the minimum well pipe size recommended for schedule 80 wells is 4 inch I.D.

Screens and risers may have to be decontaminated before use because oil-based preservatives and oil used during thread cutting and screen manufacturing may contaminate samples. Metal pipe, may corrode and release metal ions or chemically react with organic constituents, but this is considered by some to be less of a problem than the problem associated with PVC material. Galvanized steel is not recommended for metal analyses, as zinc and cadmium levels in groundwater samples may be elevated from the zinc coating.

Threaded, flush-joint casing is most often preferred for monitoring well applications. PVC, Teflon, and steel can all be obtained with threaded joints at slightly more costs. Welded-joint steel casing is also acceptable. Glued PVC may release organic contamination into the well and therefore should not be used if the well is to be sampled for organic contaminants.

When the water bearing zone is in consolidated bedrock, such as limestone or fractured granite, a well screen is often not necessary (the well is simply an open hole in bedrock). Unconsolidated materials, such as sands, clay, and silts require a screen. A screen slot size of 0.010 or 0.020 inch is generally used when a screen is necessary and the screened interval is artificially packed with a fine sand. The slot size controls the quantity of water entering the well and prevents entry of natural materials or sand pack. The screen shall pass no more than 10 percent of the pack material, or in-situ aquifer material. The rig geologist shall specify the combination of screen slot size and sand pack which will be compatible with the water bearing zone, to maximize groundwater inflow and minimize head losses and movement of fines into the wells. (For example, as a standard procedure, a Morie No. 1 or Ottowa sand may be used with a 0.010-inch slot screen, however, with a 0.020-inch slot screen, the filter pack material must be the material retained on a No. 20 to No. 30 U.S. standard sieve.)

5.2.3 Annular Materials

Materials placed in the annular space between the borehole and riser pipe and screen include a sand pack when necessary, a bentonite seal, and cement-bentonite grout. The sand pack is usually a fine to medium grained well graded, silica sand. The quantity of sand placed in the annular space is dependent upon the length of the screened interval but should always extend at least 1 foot above the top of the screen. At least one to three feet of bentonite pellets or equivalent shall be placed above the sand pack. The cement-bentonite grout or equivalent extends from the top of the bentonite pellets to the ground surface.

On occasion, and with the concurrence of the involved regulatory agencies, monitoring wells may be packed naturally, i.e., no artificial sand pack will be installed, and the natural formation material will be allowed to collapse around the well screen after the well is installed. This method has been utilized where the formation material itself is a relatively uniform grain size, or when artificial sand packing is not possible due to borehole collapse.

Bentonite expands by absorbing water and provides a seal between the screened interval and the overlying portion of the annular space and formation. Cement-bentonite grout is placed on top of the bentonite pellets to the surface. The grout effectively seals the well and eliminates the possibility for surface infiltration reaching the screened interval. Grouting also replaces material removed during drilling and prevents hole collapse and subsidence around the well. A tremie pipe should be used to introduce grout from the bottom of the hole upward, to prevent bridging and to provide a better seal. However, in boreholes that don't collapse, it may be more practical to pour the grout from the surface without a tremie pipe.

Grout is a general term which has several different connotations. For all practical purposes within the monitoring well installation industry, grout refers to the solidified material which is installed and occupies the annular space above the bentonite pellet seal. Grout, most of the time, is made up of two assemblages of material, i.e., a cement-bentonite grout. A cement bentonite grout normally is a mixture of cement, bentonite and water at a ratio of one 90-pound bag of Portland Type I cement, 3-5 pounds of granular or flake-type bentonite and 6 gallons of water. A neat cement is made up of one ninety-pound bag of Portland Type I cement and 6 gallons of water.

In certain cases, the borehole may be drilled to a depth greater than the anticipated well installation depth. For these cases, the well shall be backfilled to the desired depth with bentonite pellets or equivalent. A short (1'-2') section of capped riser pipe sump is sometimes installed immediately below the screen, as a silt reservoir, when significant post-development silting is anticipated. This will ensure that the entire screen surface remains unobstructed.

5.2.4 Protective Casing

When the well is completed and grouted to the surface, a protective steel casing is often placed over the top for the well. This casing generally has a hinged cap and can be locked to prevent vandalism. A vent hole shall be provided in the cap to allow venting of gases and maintain atmospheric pressure as water levels rise or fall in the well. The protective casing has a larger diameter than the well and is set into the wet cement grout over the well upon completion. In addition, one hole is drilled just above the cement collar through the protective casing which acts as a weep hole for the flow of water which may enter the annulus during well development, purging, or sampling.

A Protective casing which is level with the ground surface is used in roadway or parking lot applications where the top of a monitoring well must be below the pavement. The top of the riser pipe is placed 4 to 5 inches below the pavement, and a locking protective casing is cemented in place to 3 inches below the pavement. A large diameter protective sleeve is set into the wet cement around the well with the top set level with the pavement. A manhole type lid placed over the protective sleeve. The cement should be slightly mounded to direct pooled water away from the well head.

5.3 MONITORING WELL INSTALLATION

5.3.1 Monitoring Wells in Unconsolidated Sediments

After the borehole is drilled to the desired depth, well installation can begin. The procedure for well installation will partially be dictated by the stability of the formation in which the well is being placed. If the borehole collapses immediately after the drilling tools are withdrawn, then a temporary casing must be installed and well installation will proceed through the center of the temporary casing, and continue as the temporary casing is withdrawn from the borehole. In the case of hollow stem auger drilling, the augers will act to stabilize the borehole during well installation.

Before the screen and riser pipe are lowered into the borehole, all pipe and screen sections should be measured with an engineers rule to ensure proper well placement. When measuring sections, the threads on one end of the pipe or screen must be excluded while measuring, since the pipe and screen sections are screwed flush together.

After the screen and riser pipe are lowered through the temporary casing, then the sand pack can be installed. A weighted tape measure must be used during the procedure in order to carefully monitor installation progress. The sand is poured into the annulus between the riser pipe and temporary casing, as the casing is withdrawn. Sand should always be kept within the temporary casing during withdrawal in order to ensure an adequate sand pack. However, if too much sand is within the temporary casing (greater than 1 foot above the bottom of the casing) bridging between the temporary casing and riser pipe may occur.

After the sand pack is installed to the desired depth, (at least 1 foot above the top of the screen) then the bentonite pellet seal or equivalent, can be installed, in the same manner as the sand pack. At least 1 to 3 feet of bentonite pellets should be installed above the sand pack.

The cement-bentonite grout is then mixed and either poured or tremied into the annulus as the temporary casing or augers are withdrawn. Finally, the protective casing can be installed as detailed in Section 5.2.4.

In stable formations where borehole collapse does not occur, the well can be installed as discussed above, and the use of a temporary casing is not needed. However, centralizers may have to be installed, one above, and one below the screen, to assure enough annular space for sand pack placement. A typical overburden monitoring well sheet is shown.

5.3.2 Confining Layer Monitoring Wells

When drilling and installing a well in a confined aquifer, proper well installation techniques must be applied to avoid cross contamination between. Under most conditions, this can be accomplished by installing double-cased wells. This is accomplished by drilling a large diameter boring through the upper aquifer, 1 to 3 feet into the underlying confining layer, and setting and pressure grouting or tremie grouting the outer casing into the confining layer. The grout material must fill the space between the native material and the outer casing. A smaller diameter boring is then continued through the confining layer for installation of the monitoring well as detailed for overburden monitoring wells, with the exception of not using a temporary casing during installation. Sufficient time which will be determined by the rig geologist, must be allowed for setting of the grout prior to drilling through the confined layer. A typical confining layer monitoring well sheet is shown in Attachment C.

5.3.3 Bedrock Monitoring Wells

When installing bedrock monitoring wells, a large diameter boring is drilled through the overburden and approximately 5 feet into the bedrock. A casing (typically steel) is installed and either pressure grouted or tremie grouted in place. After the grout is cured, a smaller diameter boring is continued through the bedrock to the desired depth. If the boring does not collapse, the well can be left open, and a screen is not necessary. If the boring collapses, then a screen is required and can be installed as detailed for overburden monitoring wells. However, if a screen is to be used, then the casing which is installed through the overburden and into the bedrock does not require grouting and can be installed temporary until final well installation is completed. Typical well construction forms for bedrock monitoring wells are shown in Attachment C.

5.3.4 Drive Points

Drive points can be installed with either a sledge hammer, drop hammer, or a mechanical vibrator. The screen is threaded and tightened onto the riser pipe with pipe wrenches. The drive point is simply pounded into the subsurface to the desired depth. If a heavy drop hammer is used, then a tripod and pulley setup is required to lift the hammer. Drive points typically cannot be driven to depths exceeding 10 feet.

5.3.5 Innovative Monitoring Well Installation Techniques

Certain innovative sampling devices have proven advantageous. These devices are essentially screened samplers installed in a borehole with only one or two small-diameter tubes extending to the surface. Manufacturers of these types of samplers claim that four samplers can be installed in a 3-inch diameter borehole. This reduces drilling costs, decreases the volume of stagnant water, and provides a sampling system that minimizes cross contamination from sampling equipment. These samplers also perform well when the water table is within 25 feet from the surface (the typical range of suction pumps). Two manufacturers of these samplers are Timco Manufacturing Company, Inc., of

Prairie du Sac, Wisconsin, and BARCAD Systems, Inc., of Concord, Massachusetts. Each offers various construction materials.

Two additional types of multilevel sampling systems have been developed. Both employ individual screened openings through a small-diameter casing. One of these systems (marketed by Westbay Instruments Ltd. of Vancouver, British Columbia, Canada) uses a screened port and a sampling probe to obtain samples and head measurements or perform permeability tests. this system allows sampling ports at intervals as close as 5 feet, if desired, in boreholes from 3 to 4.8 inches in diameter.

The other system, developed at the University of Waterloo at Waterloo, Ontario, Canada, requires field assembly of the individual sampling ports and tubes that actuate a simple piston pump and force the samples to the surface. Where the depth to ground water is less than 25 feet, the piston pumps are not required. The assembly is made of easily obtained materials; however, the cost of labor to assemble these monitoring systems may not be cost-effective.

5.4 WELL DEVELOPMENT METHODS

The purpose of well development is to stabilize and increase the permeability of the gravel pack around the well screen, and to restore the permeability of the formation which may have been reduced by drilling operations. Wells are typically developed until all fine material and drilling water is removed from the well. Sequential measurements of pH, conductivity and temperature taken during development may yield information (stabilized values) that sufficient development is reached. The selection of the well development method (shall) be made by the rig geologist and is based on the drilling methods, well construction and installation details, and the characteristics of the formation that the well is screened in. The primary methods of well development are summarized below. A more detailed discussion may be found in Driscoll (1986).

Overpumping and Backwashing - Wells may be developed by alternatively drawing the water level down at a high rate (by pumping or bailing) and then reversing the flow direction (backwashing) so that water is passing from the well into the formation. This back and forth movement of water through the well screen and gravel pack serves to remove fines from the formation immediately adjacent to the well, while preventing bridging (wedging) of sand grains. Backwashing can be accomplished by several methods including pouring water into the well and then bailing, starting and stopping a pump intermittently to change water levels, or forcing water into the well under pressure through a water-tight fitting ("rawhiding"). Care should be taken when backwashing not to apply too much pressure, which could damage or destroy the well screen.

Surging with a Surge Plunger - A surge plunger (also called a surge block) is approximately the same diameter as the well casing and is used to agitate the water, causing it to move in and out of the screens. This movement of water rpulls fine materials into the well, where they may be removed by any of several methods, and prevents bridging of sand particles in the gravel pack. There are two basic types of surge plungers; solid and valved surge plungers. In formations with low yields, a valved surge plunger may be preferred, as solid plungers tend to force water out of the well at a greater rate than it will flow back in. Valved plungers are designed to produce a greater inflow than outflow of water during surging.

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

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

High Velocity Jetting - In the high velocity jetting method, water is forced at high velocities from a plunger-type device and through the well screen to loosen fine particles from the sand pack and surrounding formation. The jetting tool is slowly rotated and raised and lowered along the length of the well screen to develop the entire screened area. Jetting using a hose lowered into the well may also be effective. The fines washed into the screen during this process can then be bailed or pumped from the well.

6.0 REFERENCES

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

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

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

7.0 RECORDS

A critical part of monitoring well installation is recording of significant details and events in the field notebook. The Geologist must record the exact depths of significant hydrogeological features screen placement, gravel pack placement, and bentonite placement.

A Monitoring Well Sheet (Attachment C) shall be used which allows the uniform recording of data for each installation and rapid identification of missing information. Well depth, length, materials of construction, length and openings of screen, length and type of riser, and depth and type of all backfill materials shall be recorded. Additional information (shall) include location, installation date, problems encountered, water levels before and after well installation, cross-reference to the geologic boring log, and methods used during the installation and development process. The documentation is very important to prevent problems involving questionable sample validity. Somewhat different information will need to be recorded.depending on whether the well is completed in overburden, in a confined layer, in bedrock with a cased well, or as an open hole in bedrock.

The quantities of sand, bentonite, and grout placed in the well are also important. The Geologist shall calculate the annular space volume and have a general idea of the quantity of material needed to fill the annular space. Volumes of backfill significantly higher than the calculated volume may indicate a problem such as a large cavity, while a smaller backfill volume may indicate a cave-in. Any problems with rig operation or down time shall be recorded and may determine the driller's final fee.

ATTACHMENT A

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

	PVC 1	Galvanized Steel	Carbon Steel	Lo-carbon Steel	Stainless steel 304	Stainless steel 316	Teflon*
Buffered Weak Acid	100	56	51	59	97	100	100
Weak Acid	98	59	43	47	96	100	100
Miner Acid/High Solids	100	48	57	60	80	82	100
Aqueous/Organic Mixtures	64	69	73	73	98	100	100
Percent Overall Rating	91	58	56	59	93	96	100

Preliminary Ranking of Rigid Materials

1 Teflon●
2 Stainless Steel 316
3 Stainless Steel 304
4 PVC 1
5 Lo-Carbon Steel
6 Galvanized Steel
7 Carbon Steel
* Trademark of DuPont

RELATIVE COMPATIBILITY OF SEMI-RIGID OR ELASTOMERIC MATERIALS (PERCENT)

	PVC Flexible	PP	PE Conv.	PE Linear	PMM	Viton●*	Silicone	Neoprene	Teflon●*
Buffered Weak Acid	97	97	100	97	90	92	87	85	100
Weak Acid	92	90	94	96	78	78	75	75	100
Mineral Acid/High Solids	100	100	100	100	95	100	78	82	100
Aqueous/Organic Mixtures	62	71	40	60	49	78	49	44	100
Percent Overall Rating	88	90	84	88	78	87	72	72	100

Preliminary Ranking of Semi-Rigid or Elastomeric Materials

1 Teflon●
2 Polypropylene (PP)
3 PVC flexible/PE linear
4 Viton●
5 PE Conventional
6 Plexiglas/Lucite (PMM)
7 Silicone/Neoprene
Source: Barcelona et al., 1983
* Trademark of DuPont

ATTACHMENT B

COMPARISON OF STAINLESS STEEL AND PVC FOR MONITORING WELL CONSTRUCTION

Characteristic	Stainless Steel	PVC
Strength	Use in deep wells to prevent compression and closing of screen/riser.	Use when shear and compressive strength not critical.
Weight	Relatively heavier	Lightweight, floats in water
Cost	Relatively expensive	Relatively inexpensive
Corrosivity	Deteriorates more rapidly in corrosive water	Non-corrosive--may deteriorate in presence of ketones, aromatics, alkyl sulfides, or some chlorinated HC
Ease of Use	Difficult to adjust size or length in the field.	Easy to handle and work in the field.
Preparation for Use	Should be steam-cleaned for organics sampling	Never use glue fittings--pipes should be threaded or pressure-fitted. Should be steam cleaned if used for monitoring wells.
Interaction with Contaminants*	May sorb organic or inorganic substances when oxidized	May sorb or release organic substances.

* See also Attachment A.

ATTACHMENT C

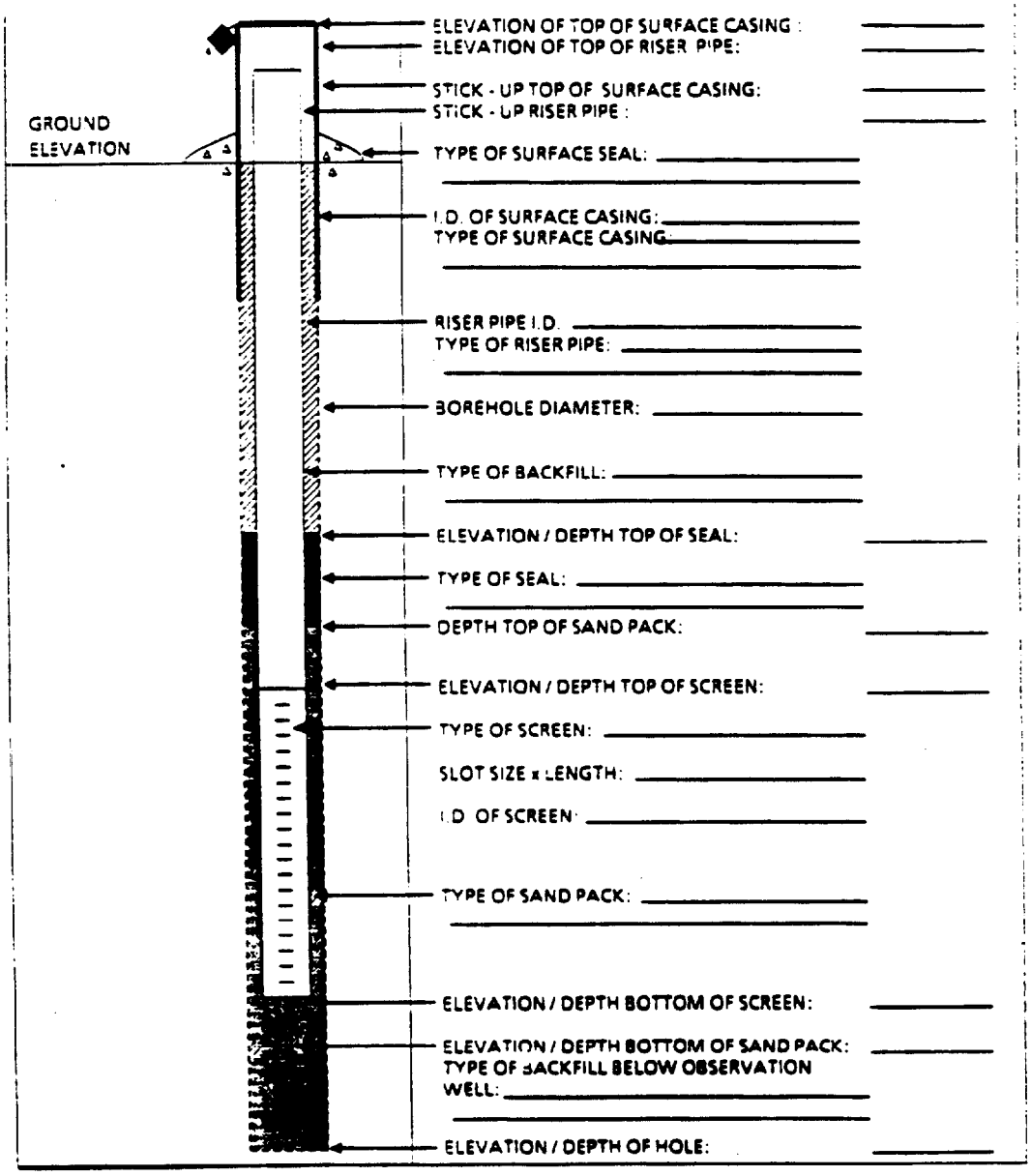
NUS CORPORATION
A Halliburton Company

BORING NO _____

OVERBURDEN
MONITORING WELL SHEET

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

DRILLER _____
DRILLING METHOD _____
DEVELOPMENT METHOD _____



ATTACHMENT C
PAGE TWO

NUS CORPORATION

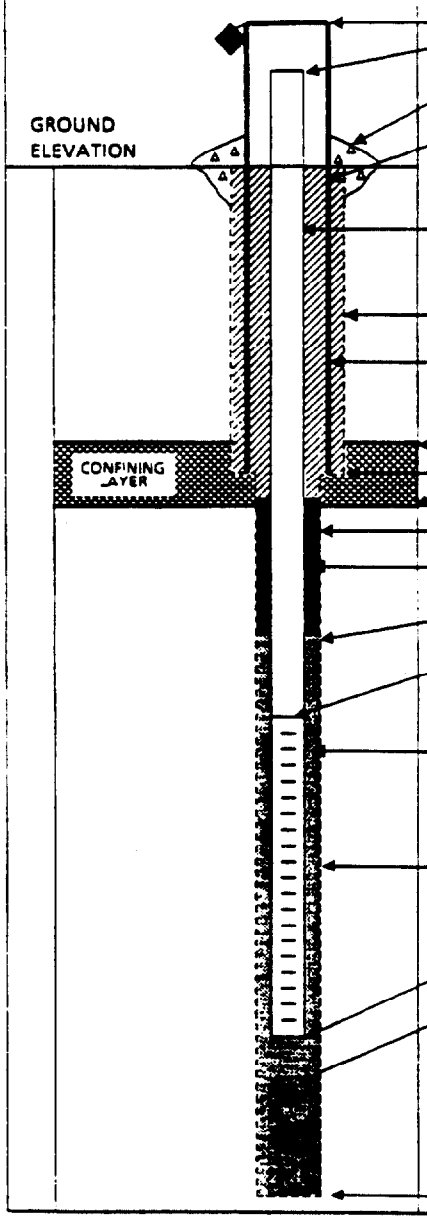
BORING NO.: _____

CONFINING LAYER
MONITORING WELL SHEET

1-5-87

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

DRILLER _____
DRILLING METHOD _____
DEVELOPMENT METHOD _____



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

TYPE OF SURFACE SEAL: _____

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

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

BOREHOLE DIAMETER: _____

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

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

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

DEPTH TOP OF SAND PACK: _____

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

TYPE OF SAND PACK: _____

BOREHOLE DIA. BELOW CASING: _____

ELEVATION / DEPTH BOTTOM OF SCREEN: _____

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

ELEVATION / DEPTH OF HOLE: _____

ATTACHMENT C
PAGE THREE

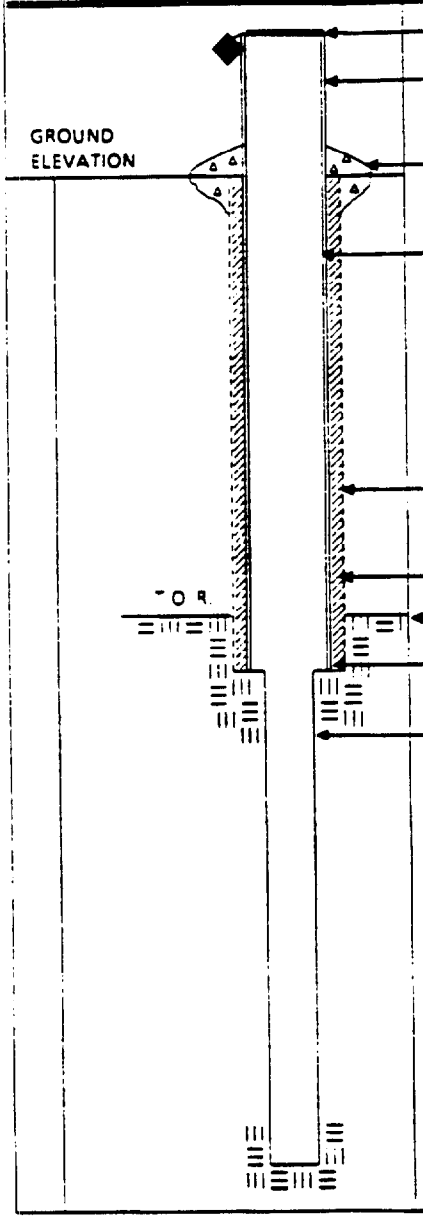
NUS CORPORATION
A Halliburton Company

BORING NO.: _____

BEDROCK
MONITORING WELL SHEET
OPEN HOLE WELL

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

DRILLER _____
DRILLING METHOD _____
DEVELOPMENT METHOD _____



ELEVATION OF TOP OF CASING: _____

STICK UP OF CASING ABOVE GROUND SURFACE: _____

TYPE OF SURFACE SEAL: _____

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

TEMP / PERM.: _____

DIAMETER OF HOLE. _____

TYPE OF CASING SEAL: _____

DEPTH TO TOP OF ROCK: _____

DEPTH TO BOTTOM CASING: _____

DIAMETER OF HOLE IN BEDROCK: _____

DESCRIBE IF CORE / REAMED WITH BIT:

DESCRIBE JOINTS IN BEDROCK AND DEPTH:

ELEVATION / DEPTH OF HOLE: _____

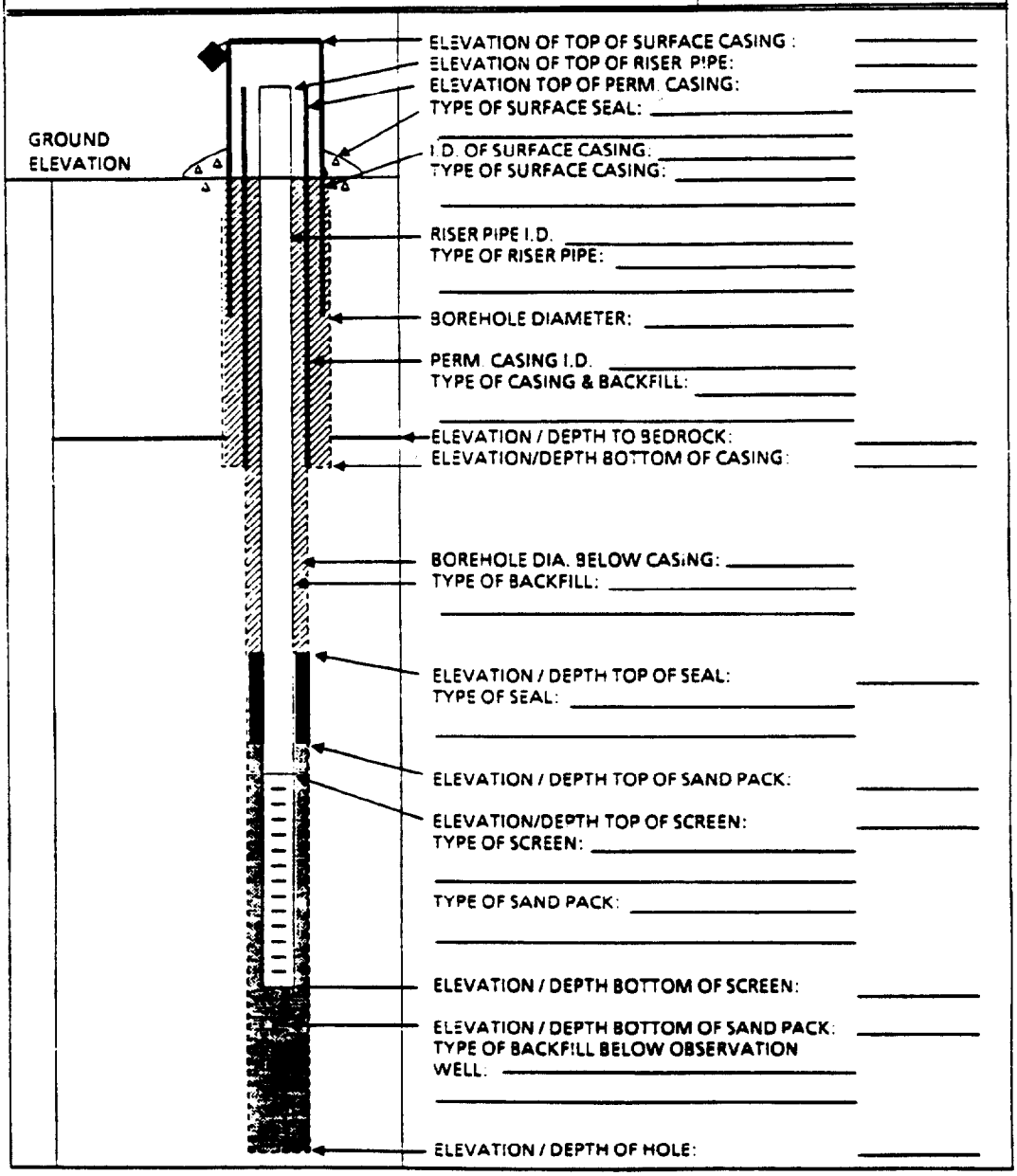
ATTACHMENT C
PAGE FOUR

BORING NO.: _____

BEDROCK
MONITORING WELL SHEET
WELL INSTALLED IN BEDROCK

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

DRILLER _____
DRILLING METHOD _____
DEVELOPMENT METHOD _____



ATTACHMENT C
PAGE FIVE

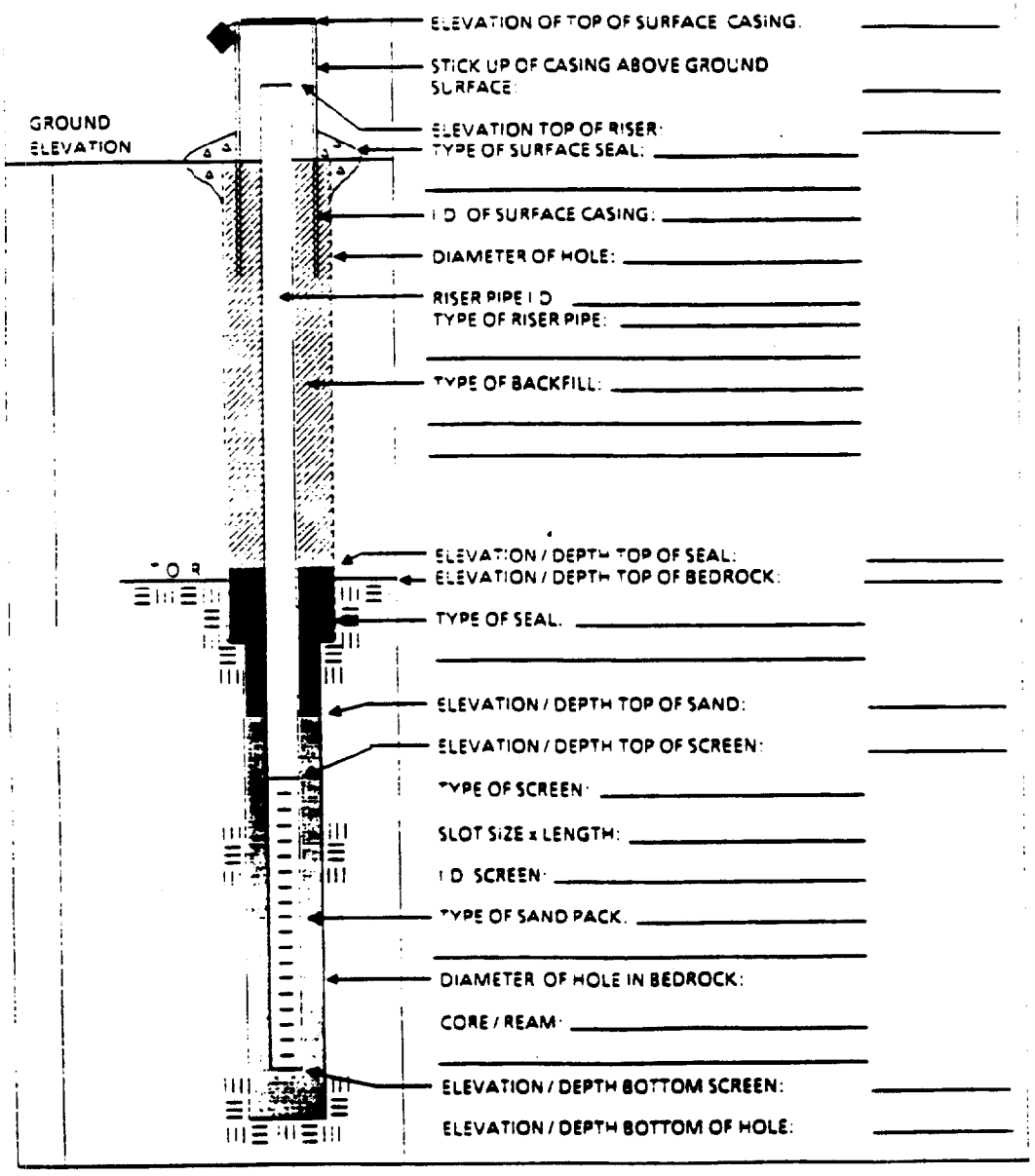
NUS CORPORATION
A Halliburton Company

BORING NO _____

BEDROCK MONITORING WELL SHEET

WELL INSTALLED IN BEDROCK

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



NUS CORPORATION ENVIRONMENTAL MANAGEMENT GROUP	STANDARD OPERATING PROCEDURES	Number SA-1.1	Page 1 of 14
		Effective Date 05/04/90	Revision 2
		Applicability EMG	
		Prepared Earth Sciences	
Subject GROUNDWATER SAMPLE ACQUISITION		Approved D. Senovich	

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5.6 RECORDS
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6.0 REFERENCES

7.0 ATTACHMENTS

1.0 PURPOSE

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

2.0 SCOPE

This procedure provides information on proper sampling equipment and techniques for groundwater sampling. Review of the information contained herein will facilitate planning of the field sampling effort by describing standard sampling techniques. The techniques described shall be followed whenever applicable, noting that site-specific conditions or project-specific plans may require adjustments in methodology.

3.0 GLOSSARY

None.

4.0 RESPONSIBILITIES

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

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

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

5.0 PROCEDURES

5.1 GENERAL

To be useful and accurate, a groundwater sample must be representative of the particular zone of the water being sampled. The physical, chemical, and bacteriological integrity of the sample must be maintained from the time of sampling to the time of testing in order to keep any changes in water quality parameters to a minimum.

Methods for withdrawing samples from completed wells include the use of pumps, compressed air, bailers, and various types of samplers. The primary considerations in obtaining a representative sample of the groundwater are to avoid collection of stagnant (standing) water in the well and to avoid physical or chemical alteration of the water due to sampling techniques. In a non-pumping well, there will be little or no vertical mixing of water in the well pipe or casing, and stratification will occur. The well water in the screened section will mix with the groundwater due to normal flow patterns, but the well water above the screened section will remain isolated and become stagnant. To safeguard against collecting non-representative stagnant water in a sample, the following approach shall be followed prior to sample acquisition:

1. All monitoring wells shall be purged prior to obtaining a sample. Evacuation of three to five volumes is recommended for a representative sample. In a high-yielding groundwater formation and where there is no stagnant water in the well above the screened section, evacuation prior to sample withdrawal is not as critical.

2. For wells that can be purged to dryness with the sampling equipment being used, the well shall be evacuated and allowed to recover prior to sample acquisition. If the recovery rate is fairly rapid, evacuation of more than one volume of water is preferred.

3. For high-yielding monitoring wells which cannot be evacuated to dryness, there is no absolute safeguard against contaminating the sample with stagnant water. One of the following techniques shall be used to minimize this possibility:

- A submersible pump, intake line of a surface pump or bailer shall be placed just below the water surface when removing the stagnant water and lowered as the water level decreases. Three to five volumes of water shall be removed to provide reasonable assurance that all stagnant water has been evacuated. Once this is accomplished a bailer may be used to collect the sample for chemical analysis.

- The inlet line of the sampling pump (or the submersible pump itself) shall be placed near the bottom of the screened section, and approximately one casing volume of water shall be pumped from the well at a rate equal to the well's recovery rate.

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

5.2 SAMPLING, MONITORING, AND EVACUATION EQUIPMENT

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

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

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

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

- Pumps

  - Shallow-well pumps--Centrifugal, pitcher, suction, or peristaltic pumps with droplines, air-lift apparatus (compressor and tubing) where applicable.

  - Deep-well pumps--submersible pump and electrical power generating unit, or air-lift apparatus where applicable.

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

- Pails - Plastic, graduated.

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

Ideally, sample withdrawal equipment shall be completely inert, economical, easily cleaned, sterilized, and reused, able to operate at remote sites in the absence of power sources, and capable of delivering variable rates for well flushing and sample collection.

5.3 CALCULATIONS OF WELL VOLUME

To insure that the proper volume of water has been removed from the well prior to sampling it is first necessary to know the volume of standing water in the well pipe. This volume can be easily calculated by the following method. Calculations shall be entered in the field logbook and on the field data form (Attachment A):

- Obtain all available information on well construction (location, casing, screens, etc.).

- Determine well or casing diameter.

- Measure and record static water level (depth below ground level or top of casing reference point).

- Determine depth of well (if not known from past records) by sounding using a clean, decontaminated weighted tape measure.

- Calculate number of linear feet of static water (total depth or length of well pipe minus the depth to static water level).

- Calculate one static well volume in gallons ($V = 0.163Tr^2$).

  where:

V	=	Static volume of well in gallons.
T	=	Thickness of water table in the well measured in feet, i.e., linear feet of static water.
r	=	Inside radius of well casing in inches.
0.163	=	A constant conversion factor which compensates for the conversion of the casing radius from inches to feet, the conversion of cubic feet to gallons, and pi.

- Determine the minimum amount to be evacuated before sampling.

5.4 EVACUATION OF STATIC WATER (PURGING)

5.4.1 General

The amount of flushing a well shall receive prior to sample collection will depend on the intent of the monitoring program and the hydrogeologic conditions. Programs to determine overall quality of water resources may require long pumping periods to obtain a sample that is representative of a large volume of that aquifer. The pumped volume may be specified prior to sampling so that the sample can be a composite of a known volume of the aquifer. Alternately the well can be pumped until the parameters such as temperature, electrical conductance, and pH have stabilized. Onsite measurements of these parameters shall be recorded on the field data form.

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

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

5.4.2 Evacuation Devices

The following discussion is limited to those devices commonly used at hazardous waste sites. Attachment B provides guidance on the proper evacuation device to use for given sampling situations. Note that all of these techniques involve equipment which is portable and readily available.

5.4.2.1 Bailers

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

Advantages of bailers include:

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

Limitations on the use of bailers include the following:

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

5.4.2.2 Suction Pumps

There are many different types of inexpensive suction pumps including centrifugal, diaphragm, peristaltic, and pitcher pumps. Centrifugal and diaphragm pumps can be used for well evacuation at a fast pumping rate and for sampling at a low pumping rate. The peristaltic pump is a low volume pump (therefore not suitable for well purging) that uses rollers to squeeze a flexible tubing, thereby creating suction. This tubing can be dedicated to a well to prevent cross contamination. The pitcher pump is a common farm hand-pump.

These pumps are all portable, inexpensive and readily available. However, because they are based on suction, their use is restricted to areas with water levels within 20 to 25 feet of the ground surface. A significant limitation is that the vacuum created by these pumps can cause significant loss of dissolved gases and volatile organics. In addition, the complex internal components of these pumps may be difficult to decontaminate.

5.4.2.3 Gas-Lift Samplers

This group of samplers uses gas pressure either in the annulus of the well or in a venturi to force the water up a sampling tube. These pumps are also relatively inexpensive. Gas lift samplers are more suitable for well development than for sampling because the samples may be aerated, leading to pH changes and subsequent trace metal precipitation or loss of volatile organics.

5.4.2.4 Submersible Pumps

Submersible pumps take in water and push the sample up a sample tube to the surface. The power sources for these samplers may be compressed gas or electricity. The operation principles vary and the displacement of the sample can be by an inflatable bladder, sliding piston, gas bubble, or impeller. Pumps are available for 2-inch diameter wells and larger. These pumps can lift water from considerable depths (several hundred feet).

Limitations of this class of pumps include:

- They may have low delivery rates.
- Many models of these pumps are expensive.
- Compressed gas or electric power is needed.
- Sediment in water may cause clogging of the valves or eroding the impellers with some of these pumps.
- Decontamination of internal components is difficult and time-consuming.

5.5 SAMPLING

5.5.1 Sampling Plan

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

- Background and objectives of sampling.
- Brief description of area and waste characterization.
- Identification of sampling locations, with map or sketch, and applicable well construction data (well size, depth, screened interval, reference elevation).

- Intended number, sequence volumes, and types of samples. If the relative degrees of contamination between wells is unknown or insignificant, a sampling sequence which facilitates sampling logistics may be followed. Where some wells are known or strongly suspected of being highly contaminated, these shall be sampled last to reduce the risk of cross-contamination between wells as a result of the sampling procedures.

- Sample preservation requirements.

- Working schedule.

- List of team members.

- List of observers and contacts.

- Other information, such as the necessity for a warrant or permission of entry, requirement for split samples, access problems, location of keys, etc.

5.5.2 Sampling Methods

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

1. HSO or designee will first open the well cap and use volatile organic detection equipment (HNU or OVA) on the escaping gases at the well head to determine the need for respiratory protection.

2. When proper respiratory protection has been donned, sound the well for total depth and water level (using clean equipment) and record these data in a well sampling data sheet (Attachment A); then calculate the fluid volume in the well pipe.

3. Calculate well volume to be removed as stated in Section 5.3.

4. Select appropriate purging equipment (see Attachment B). If an electric submersible pump with packer is chosen, go to Step 10.

5. Lower purging equipment or intake into the well to a short distance below the water level and begin water removal. Collect the purged water and dispose of it in an acceptable manner. Lower the purging device, as required, to maintain submergence.

6. Measure rate of discharge frequently. A bucket and stopwatch are most commonly used; other techniques include using pipe trajectory methods, weir boxes or flow meters.

7. Observe peristaltic pump intake for degassing "bubbles." If bubbles are abundant and the intake is fully submerged, this pump is not suitable for collecting samples for volatile organics. Never collect volatile organics samples using a vacuum pump.

8. Purge a minimum of three-to-five casing volumes before sampling. In low permeability strata (i.e., if the well is pumped to dryness), one volume will suffice.

9. If sampling using a pump, lower the pump intake to midscreen or the middle of the open section in uncased wells and collect the sample. If sampling with a bailer, lower the bailer to sampling level before filling (this requires use of other than a 'bucket-type' bailer).

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

10. (For pump and packer assembly only). Lower assembly into well so that packer is positioned just above the screen or open section and inflate. Purge a volume equal to at least twice the screened interval or unscreened open section volume below the packer before sampling. Packers shall always be tested in a casing section above ground to determine proper inflation pressures for good sealing.

11. In the event that recovery time of the well is very slow (e.g., 24 hours), sample collection can be delayed until the following day. If the well has been bailed early in the morning, sufficient water may be standing in the well by the day's end to permit sample collection. If the well is incapable of producing a sufficient volume of sample at any time, take the largest quantity available and record in the logbook.

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

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

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

15. Decontaminate all equipment

5.5.3 Sample Containers

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

5.5.4 Preservation of Samples and Sample Volume Requirements

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

5.5.5 Handling and Transporting Samples

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

5.5.6 Sample Holding Times

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

5.6 RECORDS

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

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

5.7 CHAIN-OF-CUSTODY

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

6.0 REFERENCES

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7.0 ATTACHMENTS

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

ATTACHMENT A
SAMPLE LOG SHEET

NUS CORPORATION
A Halliburton Company

SAMPLE LOG SHEET

☐ Monitoring Well Data
☐ Domestic Well Data
☐ Other _____

Page _____ of _____
Case # _____
By _____

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

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

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

Type of Sample
☐ Low Concentration
☐ High Concentration
☐ Grab
☐ Composite
☐ Grab - Composite

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

ATTACHMENT B
PURGING EQUIPMENT SELECTION

Purging Equipment Selection

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

Manufacturer	Model name/ number	Principle of operation	Maximum outside diameter/length (inches)	Construction materials (w/lines & tubing)	Lift range (ft)	Delivery rates or volumes	1982 price (dollars)	Comments
BarCad Systems, Inc	BarCad Sampler	dedicated, gas drive (positive displacement)	1 5/16	PE, brass, nylon, aluminum oxide	0 150 with std tubing	1 liter for each 10-15 ft of submergence	220-350	requires compressed gas; custom sizes and materials available; acts as piezometer
Cole-Parmer Inst. Co.	Master Flex 7570 Portable Sampling Pump	portable, peristaltic (suction)	< 1 0/NA	(not submersible) Tygon®, silicone Viton®	0-30	670 mL/min with 7015-20 pump head	500-600	AC/DC; variable speed control available; other models may have different flow rates
ECO Pump Corp.	SAMPLifier	portable; venturi	<1 5 or <2.0/NA	PP, PE, PVC, SS, Teflon®, Tefzel®	0 100	0-500 mL/min depending on lift	400 700	AC, DC, or gasoline driven motors available; must be primed
Geltek Corp.	Bailer 219-4	portable; grab (positive displacement)	1 66/38	Teflon®	no limit	1075 mL	120-135	other sizes available
GeoEngineering, Inc.	GEO-MONITOR	dedicated; gas drive (positive displacement)	1.5/16	PE, PP, PVC, Viton®	probably 0-150	app. 1 liter for each 10 ft of submergence	185	acts as piezometer; requires compressed gas
Industrial and Environmental Analysts, Inc. (IEA)	Aquarius	portable, bladder (positive displacement)	1 75/43	SS, Teflon®, Viton®	0 250	0-2800 mL/min	1500-3000	requires compressed gas; other models available; AC, DC, manual operation possible
IEA	Syringe Sampler	portable, grab (positive displacement)	1 75/43	SS, Teflon®	no limit	850 mL sample vol.	1100	requires vacuum and/or pressure from hand pump
Instrument Specialties Co. (ISCO)	Model 2600 Well Sampler	portable; bladder (positive displacement)	1 75/50	PC, silicone, Teflon®, PP, PE, Delrin® acetal	0-150	0-7500 mL/min	990	requires compressed gas (40 psi minimum)
Keck Geophysical Instruments, Inc.	SP 81 Submersible Sampling Pump	portable, helical rotor (positive displacement)	1.75/25	SS, Teflon®, PP, EPDM, Viton®	0-160	0-4500 mL/min	3500	DC operated
Leonard Mold and Die Works, Inc.	GeoFilter Small Dia. Well Pump (#0500)	portable; bladder (positive displacement)	1.75/38	SS, Teflon®, PC, Neoprene®	0-400	0-3500 mL/min	1400-1500	requires compressed gas (55 PSI minimum); pneumatic or AC/DC control module
Oil Recovery Systems, Inc.	Surface Sampler	portable, grab (positive displacement)	1 75/12	acrylic, Delrin®	no limit	app. 250 mL	125-160	other materials and models available; for measuring thickness of "floating" contaminants
O E D Environmental Systems, Inc.	Well Wizard® Monitoring System (P-100)	dedicated, bladder (positive displacement)	1 66/36	PVC	0-230	0 2000 mL/min	300-400	requires compressed gas; piezometric level indicator; other materials available

Source: Barcelona et al., 1983

Manufacturer	Model name/ number	Principle of operation	Maximum outside diameter/length (inches)	Construction materials (w/lines & tubing)	Lift range (ft)	Delivery rates or volumes	1982 price (dollars)	Comments
Randolph Austin Co	Model 500 Vari Flow Pump	portable, peristaltic (suction)	<0.5/N/A	(not submersible) rubber, Tygon®, or Neoprene®	0-30	see comments	1200-1300	flow rate dependent on motor and tubing selected, AC operated; other models available
Robert Bennett Co.	Model 180	portable; piston (positive displacement)	1.8/22	SS, Teflon®, Delrin®, PP, Viton® acrylic, PE	0-500	0-1800 mL/min	2600-2700	requires compressed gas; water level indicator and flow meter; custom models available
Slope Indicator Co. (SINCO)	Model 514124 Pneumatic Water Sampler	portable; gas drive (positive displacement)	1.9/18	PVC, nylon	0-1100	250 mL/flushing cycle	250-350	requires compressed gas; SS available; piezometer model available; dedicated model available
Solinst Canada Ltd.	5W Water Sampler	portable; grab (positive displacement)	1.9/27	PVC, brass, nylon, Neoprene®	0-330	500 mL	1300-1800	requires compressed gas; custom models available
TIMCO Mfg. Co., Inc.	Std Bailer	portable, grab (positive displacement)	1.66/ custom	PVC, PP	no limit	250 mL/ft of bailer	20-60	other sizes, materials, models available; optional bottom-emptying device available; no solvents used
TIMCO	Air or Gas Lift Sampler	portable, gas drive (positive displacement)	1.66/30	PVC, Tygon®, Teflon®	0-150	350 mL/flushing cycle	100-200	requires compressed gas; other sizes, materials, models available; no solvents used
Tole Devices Co.	Sampling Pump	portable, bladder (positive displacement)	1.38/48	SS, silicone, Delrin®, Tygon®	0-125	0-4000 mL/min	800-1000	compressed gas required; DC control module; custom built

Construction Materials Abbreviations

- PE — Polyethylene
- PP — Polypropylene
- PVC — Polyvinyl Chloride
- SS — Stainless Steel
- PC — Polycarbonate
- EPDM — Ethylene-Propylene Diene (synthetic rubber)

Other Abbreviations

- NA — Not Applicable
- AC — Alternating Current
- DC — Direct Current

NOTE: Other manufacturers market pumping devices which could be used for ground-water sampling, though not expressly designed for this purpose. The list is not meant to be all-inclusive and listing does not constitute endorsement for use. Information in the table is from sales literature and/or personal communication. No skimmer, scavenger-type, or high-capacity pumps are included.

Source: Barcelona et al., 1983

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		Applicability EMG	
		Prepared Earth Sciences	
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1.0 PURPOSE

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

2.0 SCOPE

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

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

3.0 GLOSSARY

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

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

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

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

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

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

4.0 RESPONSIBILITIES

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

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

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

5.0 PROCEDURES

5.1 OVERVIEW

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

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

5.2 SAMPLE IDENTIFICATION

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

5.2.1 Sample Label

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

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

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

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

5.2.2 Sample Identification Tag

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

The following information is recorded on the tag:

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

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

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

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

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

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

5.3 CHAIN-OF-CUSTODY PROCEDURES

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

5.3.1 Field Custody Procedures

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

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

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

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

5.3.2 Transfer of Custody and Shipment

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

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

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

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

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

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

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

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

5.3.3 Receipt for Samples Form

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

6.0 REFERENCES

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

7.0 ATTACHMENTS

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

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

PROJECT NAME

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:	

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

CHAIN OF CUSTODY RECORD

ENVIRONMENTAL PROTECTION AGENCY – REGION II
SURVEILLANCE & ANALYSIS DIVISION
EDISON, NEW JERSEY 08837

Name of User and Address		
Sample Number	Number of Containers	Description of Samples

Person Assuming Responsibility for Samples	Time	Date

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

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

ENVIRONMENTAL PROTECTION AGENCY
Office of Enforcement

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

CHAIN OF CUSTODY RECORD

PROJ. NO.	PROJECT NAME	NO. OF CONTAINERS	REMARKS
SAMPLERS: (Signature)			

STA. NO.	DATE	TIME	COMP.	GRAB	STATION LOCATION	NO. OF CONTAINERS							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

3-15966

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

U. S. ENVIRONMENTAL PROTECTION AGENCY
REGION 4

CHAIN OF CUSTODY RECORD

ENVIRONMENTAL SERVICES DIVISION
COLLEGE STATION ROAD
ATHENS, GEORGIA 30613

PROJ. NO. | PROJECT NAME

SAMPLERS (Signature)

STA. NO	DATE	TIME	COMP	GRAB	STATION LOCATION	NO. OF CONTAINERS	Water/Wastewater																Soil/Sed			Sludge/Waste			Misc			REMARKS/TAG NUMBERS

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

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

Nº 4 3526

ATTACHMENT E
SAMPLE LABEL

NUS CORPORATION PROJECT: _____

STATION LOCATION: _____

DATE: ___/___/___ TIME: _____ hrs.

MEDIA: WATER ☐ SOIL ☐ SEDIMENT ☐ _____ ☐

CONCENTRATION: LOW ☐ MED ☐ HIGH ☐

TYPE: GRAB ☐ COMPOSITE ☐

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

Sampled by: _____

Case No.: _____ Traffic Report No.: _____

Remarks:

ACFILE: FORMS\BOTLABL

ATTACHMENT F
SAMPLE IDENTIFICATION TAG

☆ GPO 505-882

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY

EPA

Designate: Grab / Comp

Time

Month/Day/Year

Station No.

Project Code

Samplers (Signatures)

Station Location

Preservative:
Yes ☐ No ☐

ANALYSES

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

Remarks:

Tag No. 3 60966

Lab Sample No.

ATTACHMENT G
CHAIN-OF-CUSTODY SEAL

CUSTODY SEAL

Date

Signature

NUS CORPORATION

NUS CORPORATION

CUSTODY SEAL

Date

Signature

NUS CORPORATION ENVIRONMENTAL MANAGEMENT GROUP	STANDARD OPERATING PROCEDURES	Number SA-6.2	Page 1 of 12
		Effective Date 05/04/90	Revision 2
		Applicability EMG	
		Prepared Earth Sciences	
Subject SAMPLE PACKAGING AND SHIPPING		Approved D. Senovich	

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1.0 PURPOSE

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

2.0 SCOPE

Samples collected at hazardous waste sites usually have to be transported elsewhere for analysis. This requires that the samples be appropriately preserved to prevent or minimize chemical alteration prior to analysis, and be transported to protect their integrity, as well as to protect against any detrimental effects from leakage or breakage. Regulations for packaging, marking, labeling, and shipping hazardous materials and wastes are promulgated by the U.S. Department of Transportation and described in the Code of Federal Regulations (49 CFR 171 through 177, in particular 172.402h, Packages Containing Samples). In general, these regulations were not intended to cover shipment of samples collected at controlled or uncontrolled hazardous waste sites or samples collected during emergency responses. However, the EPA has agreed through a memorandum of agreement to package, mark, label, and ship samples observing DOT procedures. The information presented here is for general guidance.

This procedure is applicable to all samples taken from uncontrolled hazardous substance sites for analysis at laboratories away from the site.

3.0 GLOSSARY

Carrier - A person or firm engaged in the transportation of passengers or property.

Hazardous Material - A substance or material in a quantity and form which may pose an unreasonable risk to health and safety or property when transported in commerce ("commerce" here to include any traffic or transportation). Defined and regulated by DOT (49 CFR 173.2) and listed in Attachment A of this guideline.

Hazardous Waste - Any substance listed in 40 CFR Subpart D (¥261.20 et seq) or otherwise characterized as ignitable, corrosive, reactive, or EP toxic as specified under 40 CFR Subpart C (¥261.20 et seq) that would be subject to manifest requirements specified in 40 CFR 262. Defined and regulated by EPA.

Marking - Applying the descriptive name, instruction, cautions, weight, or specification marks or combination thereof required to be placed outside containers of hazardous materials.

n.o.i. - Not otherwise indicated.

n.o.s. - Not otherwise specified.

ORM - Other regulated material.

Packaging - The assembly of one or more containers and any other components necessary to assure compliance with the minimum packaging requirements of 49 CFR 174, including containers (other than freight containers or overpacks), portable tanks, cargo tanks, tank cars, multiunit tank car tanks.

Placard - Color-coded, pictorial sign depicting the hazard class symbol and name to be placed on all four sides of a vehicle transporting certain hazardous materials.

Reportable Quantity (RQ) - A parenthetical note of the form "(RQ-1000/454)" following an entry in the DOT Hazardous Materials table (49 CFR 172.101) indicates the reportable quantity of the substance in pounds and kilograms. If a spill of that amount or more of the substance occurs during transit or storage, a report must be filed with DOT according to ¥171.15-15 concerning hazardous materials incidents reports. If the material spilled is a hazardous waste, a report must always be filed, regardless of the amount, and must include a copy of the manifest. If the RQ notation appears, it must be shown either immediately before or after the proper shipping name on the shipping paper (or manifest). Most shipping papers and manifests will have a column designated "HM" which may be used for this purpose.

4.0 RESPONSIBILITIES

Field Operations Leader or Team Sampling Leader - responsible for determining that samples are properly packaged and shipped.

Sampling Personnel - responsible for implementing the packaging and shipping requirements.

5.0 PROCEDURES

5.1 INTRODUCTION

Samples collected for shipment from a site shall be classified as either environmental or hazardous material (or waste) samples. In general, environmental samples are collected off-site (for example from streams, ponds, or wells) and are not expected to be grossly contaminated with high levels of hazardous materials. On-site samples (for example, soil, water, and materials from drums or bulk storage tanks, obviously contaminated ponds, lagoons, pools, and leachates from hazardous waste sites) are considered hazardous. A distinction must be made between the two types of samples in order to:

- Determine appropriate procedures for transportation of samples. If there is any doubt, a sample shall be considered hazardous and shipped accordingly.
- Protect the health and safety of laboratory personnel receiving the samples. Special precautions are used at laboratories when samples other than environmental samples are received.

5.2 ENVIRONMENTAL SAMPLES

5.2.1 Packaging

Environmental samples may be packaged following the procedures outlined in Section 5.4 for samples classified as "flammable liquids" or "flammable solids." Requirements for marking, labeling, and shipping papers do not apply.

Environmental samples may also be packed without being placed inside metal cans as required for flammable liquids or solids.

- Place sample container, properly identified and with a sealed lid, in a polyethylene bag, and seal the bag.
- Place sample in a fiberboard container or metal picnic cooler which has been lined with a large polyethylene bag.
- Pack with enough noncombustible, absorbent, cushioning materials to minimize the possibility of the container breaking.
- Seal large bag.
- Seal or close outside container.

5.2.2 Marking Labeling

Sample containers must have a completed sample identification tag and the outside container must be marked "Environmental Sample." The appropriate side of the container must be marked "This End Up" and arrows placed appropriately. No DOT marking or labeling are required.

5.2.3 Shipping Papers

No DOT shipping papers are required. However, the appropriate chain-of-custody forms must be included with the shipment.

5.2.4 Transportation

There are no DOT restrictions on mode of transportation.

5.3 DETERMINATION OF SHIPPING CLASSIFICATION FOR HAZARDOUS MATERIAL SAMPLES

Samples not determined to be environmental samples, or samples known or expected to contain hazardous materials, must be considered hazardous material samples and transported according to the requirements listed below.

5.3.1 Known Substances

If the substance in the sample is known or can be identified, package, mark, label and ship according to the specific instructions for that material (if it is listed) in the DOT Hazardous Materials Table, 49 CFR 172.101.

Unz and Company have published the following steps to help in locating a proper shipping name from the Hazardous Materials Table, 49 CFR 172.101.

1. Look first for the chemical or technical name of the material, for example, ethyl alcohol. Note that many chemicals have more than one technical name, for example, perchloroethylene (not listed in 172.101) is also called tetrachloroethylene (listed 172.101). It may be useful to consult a chemist for all possible technical names a material can have. If your material is not listed by its technical name then. . . . . .

2. Look for the chemical family name. For example, pentyl alcohol is not listed but the chemical family name is: alcohol, n.o.s. (not otherwise specified). If the chemical family name is not listed then. . . . . .

3. Look for a generic name based on end use. For example, Paint, n.o.s or Fireworks, n.o.s. If a generic name based on end use is not listed then. . . . . .

4. Look for a generic family name based on end use, for example, drugs, n.o.s. or cosmetics, n.o.s. Finally, if your material is not listed by a generic family name but you suspect or know the material is hazardous because it meets the definition of one or more hazardous classes, then. . . . . .

5. You will have to go the the general hazard class for a proper shipping name. For example, Flammable Liquid, n.o.s, or Oxidizer, n.o.s.

5.3.2 Unknown Substances

For samples of hazardous substances of unknown content, select the appropriate transportation category according to the DOT Hazardous Materials Classification (Attachment A), a priority system of transportation categories.

The correct shipping classification for an unknown sample is selected through a process of elimination, utilizing Attachment A. Unless known or demonstrated otherwise (through the use of radiation survey instruments), the sample is considered radioactive and appropriate shipping regulations for "radioactive material" followed.

If a radioactive material is eliminated, the sample is considered to contain "Poison A" materials (Attachment B), the next classification on the list. DOT defines "Poison A" as extremely dangerous poisonous gases or liquids of such a nature that a very small amount of gas, or vapor of the liquids, mixed with air is dangerous to life. Most Poison A materials are gases or compressed gases and would not be found in drum-type containers. Liquid Poison A would be found only in closed containers; however,all samples taken from closed drums do not have to be shipped as Poison A, which provides for a "worst case" situation. Based upon information available, a judgment must be made whether a sample from a closed container is a Poison A.

If Poison A is eliminated as a shipment category, the next two classifications are "flammable" or "nonflammable" gases. Since few gas samples are collected, "flammable liquid" would be the next applicable category. With the elimination of radioactive material, Poison A, flammable gas, and nonflammable gas, the sample can be classified as flammable liquid (or solid) and shipped accordingly. These procedures would also suffice for shipping any other samples classified below flammable liquids in the DOT classification table (Attachment A). For samples containing unknown materials, categories listed below flammable liquids/solids on Attachment A are generally not used because showing that these materials are not flammable liquids (or solids) requires flashpoint testing, which may be impractical and possibly dangerous at a site. Thus, unless the sample is known to consist of materials listed as less hazardous than flammable liquid (or solid) on Attachment A, it is considered a flammable liquid (or solid) and shipped as such.

For any hazardous material shipment, utilize the shipping checklist (Attachment C) as a guideline to ensure that all sample-handling requirements are satisfied.

5.4 PACKAGING AND SHIPPING OF SAMPLES CLASSIFIED AS FLAMMABLE LIQUID (OR SOLID)

5.4.1 Packaging

Applying the word "flammable" to a sample does not imply that it is in fact flammable. The word prescribes the class of packaging according to DOT regulations.

1. Collect sample in the prescribed container with a nonmetallic, Teflon-lined screw cap. To prevent leakage, fill container no more than 90 percent full.

2. Complete sample label and sample identification tag and attach securely to sample container.

3. Seal container and place in 2-mil thick (or thicker) polyethylene bag, one sample per bag. Position sample identification tag so that it can be read through bag. Seal bag.

4. Place sealed bag inside metal can and cushion it with enough noncombustible, absorbent material (for example, vermiculite or diatomaceous earth) between the bottom and sides of the can and bag to prevent breakage and absorb leakage. Pack one bag per can. Use clips, tape, or other positive means to hold can lid securely, tightly and permanently. Mark can as indicated in Paragraph 1 of Section 5.4.2, below.

5. Place one or more metal cans (or single 1-gallon bottle) into a strong outside container, such as a metal picnic cooler or a DOT-approved fiberboard box. Surround cans with noncombustible, absorbent cushioning materials for stability during transport. Mark container as indicated in Paragraph 2 of Section 5.4.2.

5.4.2 Marking/Labeling

1. Use abbreviations only where specified. Place the following information, either hand-printed or in label form, on the metal can (or 1-gallon bottle):

   - Laboratory name and address.

   - "Flammable Liquid, n.o.s. UN1993" or "Flammable Solid, n.o.s. UN1325."

Not otherwise specified (n.o.s) is not used if the flammable liquid (or solid) is identified. Then the name of the specific material is listed before the category (for example, Acetone, Flammable Liquid), followed by its appropriate UN number found in the DOT Hazardous Materials table (49 CFR 172.101).

2. Place all information on outside shipping container as on can (or bottle), specifically:

   - Proper shipping name.
   - UN or NA number.
   - Proper label(s).
   - Addressee and sender.

   Place the following labels on the outside shipping container: "Cargo Aircraft Only" and "Flammable Liquid" (or "Flammable Solid"). "Dangerous When Wet" label shall be used if the solid has not been exposed to a wet environment. "Laboratory Samples" and "THIS SIDE UP" or "THIS END UP" shall also be marked on the top of the outside container, and upward-pointing arrows shall be placed on all four sides of the container.

5.4.3 Shipping Papers

1. Use abbreviations only where specified. Complete the carrier-provided bill of lading and sign certification statement (if carrier does not provide, use standard industry form, see Attachment D). Provide the following information in the order listed (one form may be used for more than one exterior container).

   - "Flammable Liquid, n.o.s. UN1993" or "Flammable Solid, n.o.s. UN1325."
   - "Limited Quantity" (or "Ltd. Qty.").
   - "Cargo Aircraft Only."
   - Net weight (wt) or net volume (vol), just before or just after "Flammable Liquid, n.o.s." or "Flammable Solid, n.o.s.," by item, if more than one metal can is inside an exterior container.
   - "Laboratory Samples" (if applicable).

2. Include Chain-of-Custody Record, properly executed in outside container.

3. "Limited Quantity" of "Flammable Liquid, n.o.s." is limited to one pint per inner container. For "Flammable Solid, n.o.s.," net weight of inner container plus sample shall not exceed one pound; total package weight shall not exceed 25 pounds.

5.4.4 Transportation

1. Transport unknown hazardous substance samples classified as flammable liquids by rented or common carrier truck, railroad, or express overnight package services. Do not transport by any passenger-carrying air transport system, even if they have cargo-only aircraft. DOT regulations permit regular airline cargo-only aircraft, but difficulties with most suggest avoiding them. Instead, ship by airline carriers that only carry cargo.

2. For transport by government-owned vehicle, including aircraft, DOT regulations do not apply. However, procedures described above, with the exception of execution of the bill of lading with certification, shall still be used.

6.0 REFERENCES

U.S. Department of Transportation, 1983. Hazardous Materials Regulations, 49 CRF 171-177.

NUS Standard Operating Procedure SA-6.1 - Sample Identification and Chain-of-Custody

NUS Standard Operating Procedure SA-1.2 - Sample Preservation

NUS Standard Operating Procedure SF-1.5 - Compatibility Testing

7.0 ATTACHMENTS

Attachment A - DOT Hazardous Material Classification (49 CFR 173.2)
Attachment B - DOT List of Class "A" Poisons (49 CFR 172.101)
Attachment C - Hazardous Materials Shipping Checklist
Attachment D - Standard Industry Certification Form

ATTACHMENT A

DOT HAZARDOUS MATERIAL CLASSIFICATION (49 CFR 173.2)

1. Radioactive material (except a limited quantity)
2. Poison A
3. Flammable gas
4. Nonflammable gas
5. Flammable liquid
6. Oxidizer
7. Flammable Solid
8. Corrosive material (liquid)
9. Poison B
10. Corrosive material (solid)
11. Irritating material
12. Combustible liquid (in containers having capacities exceeding 110 gallons [416 liters])
13. ORM-B
14. ORM-A
15. Combustible liquid (in containers having capacities of 110 gallons [416 liters] or less)
16. ORM-E

ATTACHMENT B

DOT LIST OF CLASS "A" POISON (49 CFR 172.101)

Material	Physical State at Standard Temperature
Arsine	Gas
Bromoacetone	Liquid
Chloropicrin and methyl chloride mixture	Gas
Chloropicrin and nonflammable,nonliquefied compressed gas mixture	Gas
Cyanogen chloride	Gas (>13.1°C)
Cyanogen gas	Gas
Gas identification set	Gas
Gelatin dynamite (H. E. Germaine)	----
Grenade (with Poison "A" gas charge)	----
Hexaethyl tetraphosphate/compressed gas mixture	Gas
Hydrocyanic (prussic) acid solution	Liquid
Hydrocyanic acid, liquefied	Gas
Insecticide (liquefied) gas containing Poison "A" or Poison "B" material	Gas
Methyldichloroarsine	Liquid
Nitric oxide	Gas
Nitrogen peroxide	Gas
Nitrogen tetroxide	Gas
Nitrogen dioxide, liquid	Gas
Parathion/compressed gas mixture	Gas
Phosgene (diphosgene)	Liquid

ATTACHMENT C
HAZARDOUS MATERIALS SHIPPING CHECKLIST

PACKAGING

1. Check DOT 172.500 table for appropriate type of package for hazardous substance.
2. Check for container integrity, especially the closure.
3. Check for sufficient absorbent material in package.
4. Check for sample tags and log sheets for each sample, and chain-of-custody record.

SHIPPING PAPERS

1. Check that entries contain only approved DOT abbreviations.
2. Check that entries are in English.
3. Check that hazardous material entries are specially marked to differentiate them from any nonhazardous materials being sent using same shipping paper.
4. Be careful all hazardous classes are shown for multiclass materials.
5. Check total amounts by weight, quantity, or other measures used.
6. Check that any limited-quantity exemptions are so designated on the shipping paper.
7. Offer driver proper placards for transporting vehicle.
8. Check that certification is signed by shipper.
9. Make certain driver signs for shipment.

RCRA MANIFEST

1. Check that approved state/federal manifests are prepared.
2. Check that transporter has the following: valid EPA identification number, valid driver's license, valid vehicle registration, insurance protection, and proper DOT labels for materials being shipped.
3. Check that destination address is correct.
4. Check that driver knows where shipment is going.
5. Check that the driver is aware of emergency procedures for spills and accidents.
6. Make certain driver signs for shipment
7. Make certain one copy of executed manifest and shipping document is retained by shipper.

ATTACHMENT D

STANDARD INDUSTRY CERTIFICATION FORM

NO PCS	SIZE	GROSS WEIGHT	H M	D O T PROPER SHIPPING NAME	HAZARD CLASS	CODE	I O	CONTAINER NUMBERS	PIC	BULK
1	55 gal	200 lbs.	n	Nitric Acid, Fuming	Oxidizer	55-OX	C	1	✓	
1	55 gal	450 lbs	n	Flammable Liquid, n.o.s.	Flammable Liquid	55-ABF	—	2		✓
1	55 gal	250 lbs	n	Flammable Liquid, n.o.s.	Flammable Liquid	55-OX	B	3	✓	
1	16-A	12 lbs.	n	Bromine	Corrosive Material	55-OX	C	4	✓	

SHIPPER'S CERTIFICATION

This is to certify that the above named materials are properly classified, described, packaged, marked and labeled and are in proper condition for transportation according to the applicable regulations of the Department of Transportation.

Shipper's Signature

Placards Req'd _____

Shipment Date _____ Manifest No _____

Disposal Work Order _____

Service Order No _____

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NUS CORPORATION ENVIRONMENTAL MANAGEMENT GROUP	STANDARD OPERATING PROCEDURES	Number SA-6.3	Page 1 of 4
		Effective Date 05/04/90	Revision 2
		Applicability EMG	
		Prepared Earth Sciences	
Subject SITE LOGBOOK		Approved D. Senovich	

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1.0 PURPOSE

This procedure describes the process for keeping a site logbook.

2.0 SCOPE

The site logbook is a controlled document which records all major on-site activities during a Remedial Investigation/Feasibility Study. At a minimum, the following activities/events shall be recorded in the site logbook:

- Arrival/departure of site visitors
- Arrival/departure of equipment
- Sample pickup (chain-of-custody form numbers, carrier, time)
- Sampling activities/sample logsheet numbers
- Start or completion of borehole/trench/monitoring well installation or sampling activities
- Health and Safety issues

The site logbook is initiated at the start of the first on-site activity (e.g., initial reconnaissance survey). Entries are made for every day that on-site activities take place which involve RI/FS contractor personnel. One current site logbook is maintained per site.

The site logbook becomes part of the permanent site file maintained in the RI contractor's office. Because information contained in the site logbook may be admitted as evidence in cost recovery or other legal proceedings, it is critical that this document be properly maintained.

3.0 GLOSSARY

Site Logbook - The logbook is a bound notebook with consecutively numbered pages that cannot be removed. Upon entry of data, the logbook requires signature by the responsible site leader (see Section 5.1).

4.0 RESPONSIBILITIES

The site logbook is issued by the Regional Manager (or his designee) to the Site Manager for the duration of the project. The Site Manager releases the site logbook to the Field Operations Leader or other person responsible for the direction of on-site activities (e.g., Reconnaissance Survey Team Leader, Sampling Team Leader). It is the responsibility of this person (or his designee) to keep the site logbook current while in his possession, and return it to the Site Manager or turn it over to another field team. Following the completion of all fieldwork, the site logbook is returned to the Site Manager for inclusion in the permanent site files.

5.0 PROCEDURES

5.1 GENERAL

The cover of each site logbook contains the following information:

- Project Name
- NUS Project Number
- RI/FS Contractor and Site Manager's Name
- Sequential Book Number

- Start Date
- End Date

Daily entries into the logbook may contain a variety of information. At the beginning of each day the following information must be recorded:

- Date
- Start time
- Weather
- All field personnel present
- Any visitors present

During the day, a summary of all site activities and level of personal protection shall be recorded in the logbook. The information need not duplicate that recorded in other field notebooks (e.g., sample logbook, Site Geologist's notebook, Health and Safety Officer's notebook, etc.), but shall summarize the contents of these other notebooks and refer to the page locations in these notebooks for detailed information. An example of a site logbook page is shown in Attachment A.

The sample logsheet for each sample collected (see Procedure SA-6.6) must be referenced. If measurements are made at any location, the measurements and equipment used must either be recorded in the site logbook or reference must be made to the notebook and page number(s) on which they are recorded (see Attachment A).

All entries shall be made in black pen. No erasures are permitted. If an incorrect entry is made, the data shall be crossed out with a single strike mark, and initialed and dated. At the completion of entries by any individual, the logbook must be signed. It must also be signed by the Field Operations Leader or responsible site leader at the end of each day.

5.2 PHOTOGRAPHS

When movies, slides, or photographs are taken of a site or any monitoring location, they are numbered to correspond to logbook entries. The name of the photographer, date, time, site location, site description, and weather conditions are entered in the logbook as the photographs are taken. A series entry may be used for rapid-sequence photographs. The photographer is not required to record the aperture settings and shutter speeds for photographs taken within the normal automatic exposure range. However, special lenses, films, filters, and other image-enhancement techniques must be noted in the logbook. If possible, such techniques shall be avoided, since they can adversely affect the admissibility of photographs as evidence. Chain-of-custody procedures depend upon the subject matter, type of film, and the processing it requires. Film used for aerial photography, confidential information, or criminal investigation require chain-of-custody procedures. Adequate logbook notation and receipts may be used to account for routine film processing. Once processed, the slides of photographic prints shall be serially numbered and labeled according to the logbook descriptions.

6.0 REFERENCES

None.

7.0 ATTACHMENTS

Attachment A - Typical Site Logbook Entry

ATTACHMENT A
TYPICAL SITE LOGBOOK ENTRY

START TIME: _____ DATE: _____

SITE LEADER: _____
PERSONNEL:

NUS	DRILLER	EPA
_____	_____	_____
_____	_____	_____
_____	_____	_____

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

ACTIVITIES:

1. Steam jenney and fire hoses were set up.

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

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

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

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

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

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

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

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

_____
Field Operations Leader

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6.0 REFERENCES

7.0 ATTACHMENTS

1.0 PURPOSE

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

2.0 SCOPE

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

3.0 GLOSSARY

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

4.0 RESPONSIBILITIES

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

5.0 PROCEDURES

5.1 SAMPLE COLLECTION, LABELING, SHIPMENT AND REQUEST FOR ANALYSIS

5.1.1 Sample Label

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

5.1.2 Sample Identification Tag

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

5.1.3 Chain-of-Custody Record Form

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

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

5.1.4 Chain-of-Custody Seal

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

5.1.5 Bottle Delivery Order (DO) Form

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

5.1.6 Repository Packing List (PL) Form

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

5.1.8 Sample Log Sheet

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

5.1.9 Traffic Reports (for CLP Laboratory Analyses)

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

5.1.10 Traffic Report Label

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

5.1.11 Special Analytical Services (SAS) Packing List

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

5.1.12 Dioxin Shipment Record (DSR)

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

5.1.13 Sample Shipping Log

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

5.2 GEOHYDROLOGICAL AND GEOTECHNICAL FORMS

5.2.1 Groundwater Level Measurement Sheet

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

5.2.2 Data Sheet for Pumping Test (Pumping Well)

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

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

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

5.2.4 Packer Test Reporting Forms

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

5.2.5 Summary Log of Boring

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

The Summary Log of Boring is not a controlled document.

5.2.6 Monitoring Well Construction Details Form

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

5.2.7 Test Pit Log

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

5.3 EQUIPMENT CALIBRATION AND MAINTENANCE FORMS

5.3.1 Equipment Calibration Log

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

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

6.0 REFERENCES

None.

7.0 ATTACHMENTS

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

ATTACHMENT A

TECHNICAL FORMS IN CURRENT USE FOR REMEDIAL INVESTIGATIONS

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

ATTACHMENT B-1

SAMPLE LABEL

NUS CORPORATION PROJECT: _____

STATION LOCATION: _____

DATE: ___/___/___ TIME: _____ hrs.

MEDIA: WATER ☐ SOIL ☐ SEDIMENT ☐ _____ ☐

CONCENTRATION: LOW ☐ MED ☐ HIGH ☐

TYPE: GRAB ☐ COMPOSITE ☐

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

Sampled by: _____

Case No.: _____ Traffic Report No.: _____

Remarks:

ACFILE: FORMS\BOTLABL

ATTACHMENT B-2

SAMPLE IDENTIFICATION TAG

☆ GPO 505-552

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY

EPA

Designate: Grab / Comp.

Time

Month/Day/Year

Station No.

Project Code

Samplers (Signature)

Station Location

Preservative:
Yes ☐ No ☐

ANALYSES

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

Remarks:

Tag No. 3 60966

Lab Sample No.

ATTACHMENT B-3

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

ENVIRONMENTAL PROTECTION AGENCY
Office of Enforcement

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

CHAIN OF CUSTODY RECORD

PROJ. NO.	PROJECT NAME
SAMPLERS: (Signature)	

STA. NO.	DATE	TIME	COMP.	GRAB	STATION LOCATION	NO. OF CONTAINERS							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

3-15966

ATTACHMENT B-4

CHAIN-OF-CUSTODY SEAL

NUS CORPORATION

CUSTODY SEAL

Date

Signature

NUS CORPORATION

CUSTODY SEAL

Date

Signature

ATTACHMENT B-5
CLP SAMPLE BOTTLE REPOSITORY
SUPERFUND DELIVERY REQUEST

REQUEST NO. _____

Date of Request: _____

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

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

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

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

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

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

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

ATTACHMENT B-6

CLP SAMPLE BOTTLE REPOSITORY
SUPERFUND PACKING LIST

REPOSITORY

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

DELIVERY REQUEST NO. _____

Request date: _____

Type of Request: R ☐ FTA ☐ E ☐

Required Delivery Date: _____

DESTINATION (from Delivery Request)

Name: _____

Address: _____

_____

_____

Telephone No: _____

The materials listed below have been shipped as requested.

Date Shipped: _____

Mode of Shipment: _____

Shipment ID No: _____

Signature: _____

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

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

——AUTHORIZED REQUESTOR USE ONLY——

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

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

Date of Receipt: _____ Requestor Signature: _____

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

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

ATTACHMENT B-7

NUS CORPORATION
A Halliburton Company

SAMPLE LOG SHEET

☐ Monitoring Well Data
☐ Domestic Well Data
☐ Other _____

Page _____ of _____
Case # _____
By _____

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

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

Type of Sample
☐ Low Concentration
☐ High Concentration
☐ Grab
☐ Composite
☐ Grab - Composite

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

ATTACHMENT B-8

NUS CORPORATION
A Halliburton Company

SAMPLE LOG SHEET

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

Page _____ of _____

Case # _____

By _____

Project Site Name _____ Project Site Number _____

NUS Source No. _____ Source Location _____

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

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

Analysis:	Observations / Notes

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

ATTACHMENT B-9

NUS CORPORATION
A Halliburton Company

SAMPLE LOG SHEET

Page _____ of _____

☐ Spring
☐ Lake
☐ Stream
☐ Other _____

Case # _____

By _____

Project Site Name _____ Project Site Number _____

NUS Source No. _____ Source Location _____

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

Type of Sample
- ☐ Low Concentration
- ☐ High Concentration
- ☐ Grab
- ☐ Composite
- ☐ Grab - Composite

Analysis:	Preservative

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

ATTACHMENT B-10

NUS CORPORATION
A Halliburton Company

SAMPLE LOG SHEET

Container Data

Page _____ of _____
Case # _____
By _____

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

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

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

	Type of Sample
Monitor Reading:	☐ Low Concentration ☐ High Concentration
Sample Method:	☐ Grab ☐ Composite ☐ Grab - Composite

		Organic	Inorganic
Sample Date & Time:	Traffic Report #		
Sampled By:	Tag #		
Signature(s):	AB #		
	Date Shipped		
Analysis:	Time Shipped		
	Lab		
	Volume		

ATTACHMENT B-11

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

CASE NO:

SAS NO: (IF APPLICABLE)

ORGANIC TRAFFIC REPORT

(FOR CLP USE ONLY)

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

SITE NAME:

CITY, STATE: SITE SPILL ID:

REGION NO: SAMPLING COMPANY ②

SAMPLER: (NAME)

SHIP TO: ③

ATTN: _____

SAMPLING DATE: ④

BEGIN: _____ END: _____

DATE SHIPPED: _____ CARRIER: _____ ⑤

AIRBILL NO: _____

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

TRIPLE VOLUME REQUIRED FOR MATRIX SPIKE/DUPLICATE AQUEOUS SAMPLE

SHIP MEDIUM AND HIGH CONCENTRATION SAMPLES IN PAINT CANS

SEE REVERSE FOR ADDITIONAL INSTRUCTIONS

CLP SAMPLE NUMBER (FROM LABELS)	SAMPLE DESCRIPTION ⑥ (FROM BOX 1) 1 2 3 4 5 6 7	CONCENTRATION ⑦ L - LOW/MED H - HIGH (SAS)	RAS ANALYSIS ⑧ VOLATILE	BASE/NEUT ACID	PESTICIDE /PCBs		SPECIAL HANDLING ⑨	STATION LOCATION ⑩

EPA Form 2075-7 (8-87)

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

ATTACHMENT B-12

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

CASE NO: | SAS NO: (IF APPLICABLE)

INORGANIC TRAFFIC REPORT

(FOR CLP USE ONLY)

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

SITE NAME:

CITY, STATE: SITE SPILL ID:

REGION NO: SAMPLING COMPANY ②

SAMPLER: (NAME)

SHIP TO: ③

ATTN:

SAMPLING DATE: ④

BEGIN: END:

DATE SHIPPED: CARRIER: ⑤

AIRBILL NO:

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

DOUBLE VOLUME REQUIRED FOR MATRIX SPIKE/DUPLICATE AQUEOUS SAMPLE

SHIP MEDIUM AND HIGH CONCENTRATION SAMPLES IN PAINT CANS

SEE REVERSE FOR ADDITIONAL INSTRUCTIONS

CLP SAMPLE NUMBER (FROM LABELS)	⑦ SAMPLE DESCRIPTION (FROM BOX 1) 1 2 3 4 5 6 7	⑧ CONCENTRATION L = LOW M = MED H = HIGH (SAS)	⑨ RAS ANALYSIS: TOTAL METALS	CYANIDE	DISSOLVED METALS	HIGH ONLY (SAS): SULFIDE	pH	CONDUCTIVITY	CHLORIDES	⑩ SPECIAL HANDLING	⑪ STATION LOCATION

EPA Form 2075-8 (8-87)

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

ATTACHMENT B-13

TRAFFIC REPORT LABELS

MAB 342

C 6003

AC 865 · Soil/Sediment (VOA)

ATTACHMENT B-14

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

SAS Number

SPECIAL ANALYTICAL SERVICE
PACKING LIST

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

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

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

ATTACHMENT B-15

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

CASE NO:	BATCH NO:

CLP DIOXIN SHIPMENT RECORD

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

SAMPLE NUMBERS	MATRIX: SOIL SEDIMENT	MATRIX: OTHER:	DESCRIPTION: FIELD SAMPLE	DESCRIPTION: SAMPLE ID DUPLICATE	DESCRIPTION: SAMPLE ID SPIKE	DESCRIPTION: BLANK	DESCRIPTION: EQUIPMENT RINSATE	DESCRIPTION: OTHER (SEE CHELT)	ADD'L ANALYSIS: SPECIFY (SEE CHELT)	FOR LAB USE: SAMPLE CONDITION ON RECEIPT

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

ATTACHMENT B-16

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

CASE#_____ SAS#_____ SITE NAME:_____

Site Leader:_____ EPA Project Officer:_____
Phone:

SAS REQUEST:(details required)

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

D33490

ATTACHMENT C-1

GROUNDWATER LEVEL MEASUREMENT SHEET

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

LOCATION

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

WEATHER CONDITIONS

Temperature Range: _____
Precipitation: _____
Barometric Pressure: _____

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

Tidally-Influenced: [ ] Yes [ ] No

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

* All elevations to nearest 0.01 foot.

ATTACHMENT C-2
PUMPING TEST DATA SHEET

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

PROJECT NAME: _____ MEASURED WELL: _____
PROJECT NO.: _____ DATE: _____ PUMPING WELL: _____
GEOLOGIST: _____ CHECKED: _____ TEST NO. _____
DISTANCE FROM PUMPING WELL(ft.)(r): _____ PUMP SETTING, FEET BELOW MONITORING POINT: _____
STATIC H_2O LEVEL (ft.)(s_0): _____ MONITORING POINT: _____
TIME PURGE START OR STOP (t_0): _____ ELEVATION OF MONITORING POINT (ft. above MSL): _____

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

ATTACHMENT C-3

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

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

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

Rev 3/86

ATTACHMENT C-4
PACKER TESTING REPORT FORM

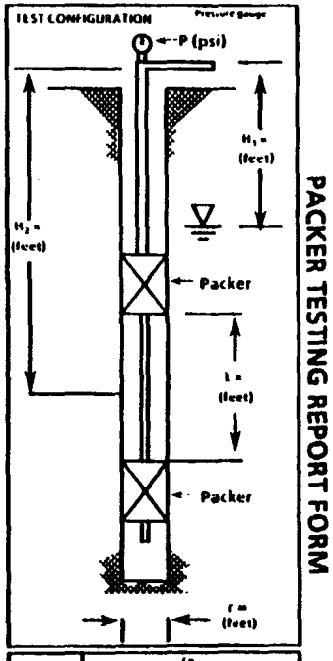
PACKER TEST REPORT

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)	H_2(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 10⁷ K (ft/yr)



Length of Test Section in feet L	Cp			
	Boring Diameter			
	2 in (5.1 cm)	4 in (10.16 cm)	6 in (15.24 cm)	8 in (20.3 cm)
1	21.000	20.500	21.000	23.300
2	19.000	18.300	16.000	15.500
3	9.000	9.000	8.000	8.700
4	6.000	6.500	6.000	5.800
5	5.100	5.000	5.100	4.800
10	2.100	2.000	2.100	2.100
20	1.000	1.100	1.000	1.000

CP = (1/(2 π L)) ln(L/r) (/0.315 S)
7.48 Gallons = 1 ft³
1 psi = 2.31 ft head
Remarks

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

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	COLOR	MATERIAL CLASSIFICATION	USCS OR ROCK BROKENNESS	REMARKS

REMARKS ____

____

____

BORING ________

PAGE _____ OF ______

ATTACHMENT C-5 (CONTINUED)

SOIL TERMS

UNIFIED SOIL CLASSIFICATION (USCS)

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

		FIELD IDENTIFICATION PROCEDURES (Excluding particles larger than 3" & basing fractions on estimated weights)	GROUP SYMBOL	TYPICAL NAMES
GRAVELS 50% + 3/4" ⊗	CLEAN GRAVELS Less % 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 WITH FINES Appr. % 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% - 3/4" ⊗	CLEAN SANDS Less % 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 WITH FINES Appr. % 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.)
T Other Core Sizes, Specify in Remarks

WATER LEVELS

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

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

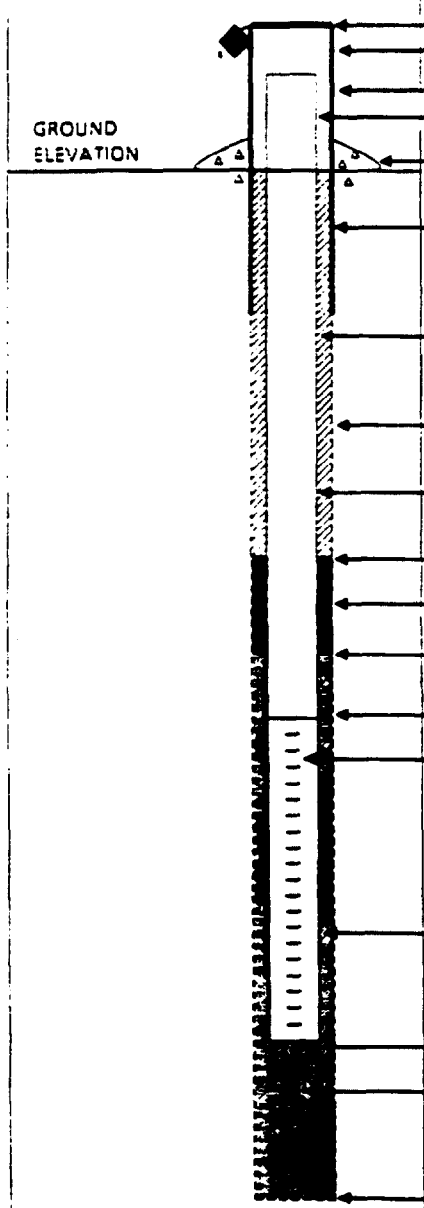
ATTACHMENT C-6

NUS CORPORATION
A Halliburton Company

BORING NO _____

OVERBURDEN
MONITORING WELL SHEET

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



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

ATTACHMENT C-7

NUS CORPORATION

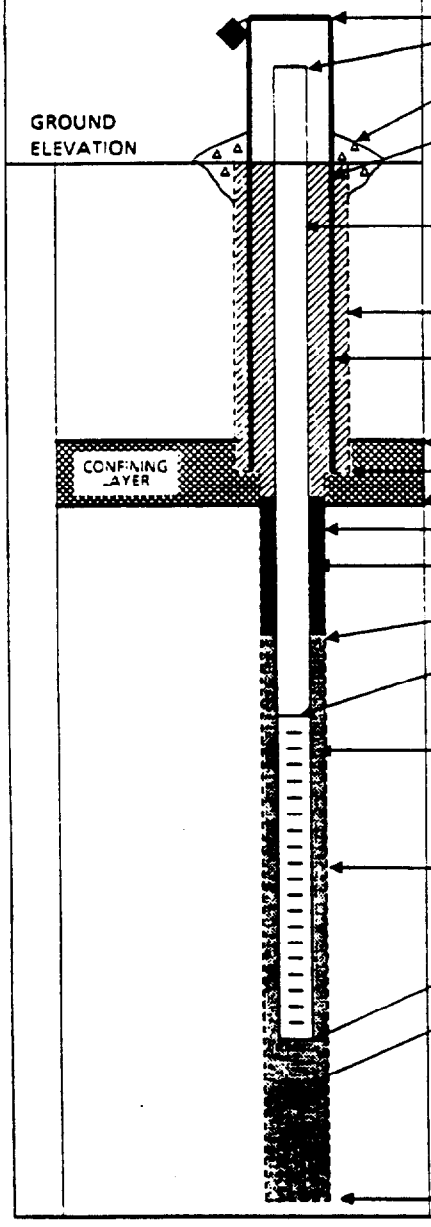
BORING NO.: _____

CONFINING LAYER
MONITORING WELL SHEET

11-5-87

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

DRILLER _____
DRILLING METHOD _____
DEVELOPMENT METHOD _____



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

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

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

BOREHOLE DIAMETER: _____

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

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

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

DEPTH TOP OF SAND PACK: _____

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

TYPE OF SAND PACK: _____

BOREHOLE DIA. BELOW CASING: _____

ELEVATION / DEPTH BOTTOM OF SCREEN: _____

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

ELEVATION / DEPTH OF HOLE: _____

ATTACHMENT C-8

NUS CORPORATION
A Halliburton Company

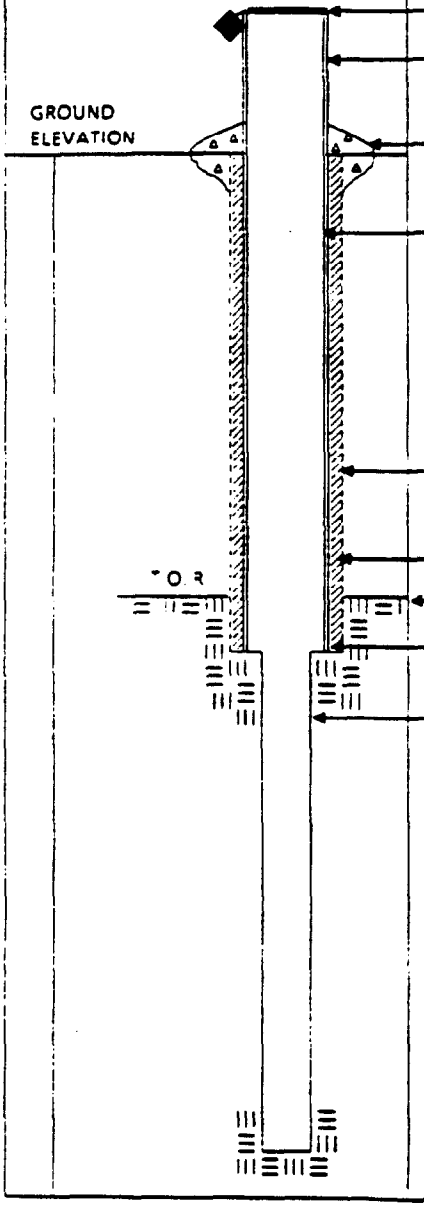
BORING NO : _____

BEDROCK MONITORING WELL SHEET

OPEN HOLE WELL

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

DRILLER _____
DRILLING METHOD _____
DEVELOPMENT METHOD _____



ELEVATION OF TOP OF CASING: _____

STICK UP OF CASING ABOVE GROUND SURFACE: _____

TYPE OF SURFACE SEAL: _____

I.D. OF CASING: _____

TYPE OF CASING: _____

TEMP / PERM : _____

DIAMETER OF HOLE: _____

TYPE OF CASING SEAL: _____

DEPTH TO TOP OF ROCK: _____

DEPTH TO BOTTOM CASING: _____

DIAMETER OF HOLE IN BEDROCK: _____

DESCRIBE IF CORE / REAMED WITH BIT:

_____

DESCRIBE JOINTS IN BEDROCK AND DEPTH:

_____

ELEVATION / DEPTH OF HOLE: _____

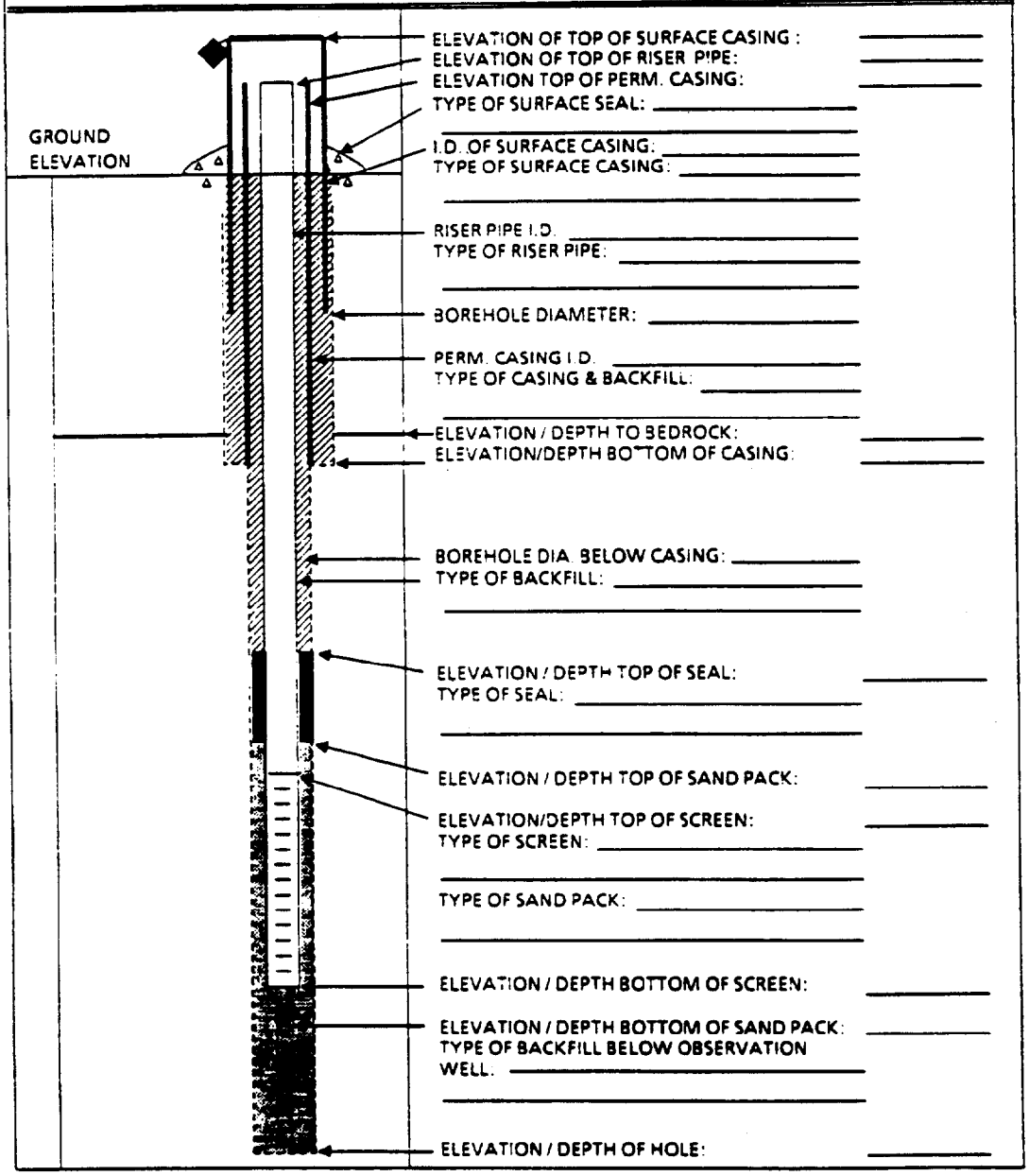
ATTACHMENT C-9

BORING NO.: _____

BEDROCK
MONITORING WELL SHEET
WELL INSTALLED IN BEDROCK

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

DRILLER _____
DRILLING METHOD _____
DEVELOPMENT METHOD _____



ATTACHMENT C-10

NUS CORPORATION
A Halliburton Company

BORING NO _____

BEDROCK
MONITORING WELL SHEET
WELL INSTALLED IN BEDROCK

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

ELEVATION OF TOP OF SURFACE CASING: _____

STICK UP OF CASING ABOVE GROUND SURFACE: _____

ELEVATION TOP OF RISER: _____

TYPE OF SURFACE SEAL: _____

I D OF SURFACE CASING: _____

DIAMETER OF HOLE: _____

RISER PIPE I D _____

TYPE OF RISER PIPE: _____

TYPE OF BACKFILL: _____

ELEVATION / DEPTH TOP OF SEAL: _____

ELEVATION / DEPTH TOP OF BEDROCK: _____

TYPE OF SEAL: _____

ELEVATION / DEPTH TOP OF SAND: _____

ELEVATION / DEPTH TOP OF SCREEN: _____

TYPE OF SCREEN: _____

SLOT SIZE x LENGTH _____

I D SCREEN: _____

TYPE OF SAND PACK: _____

DIAMETER OF HOLE IN BEDROCK:

CORE / REAM: _____

ELEVATION / DEPTH BOTTOM SCREEN: _____

ELEVATION / DEPTH BOTTOM OF HOLE: _____

ATTACHMENT C-11

TEST PIT LOG ***NUS CORPORATION***

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

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

Test Pit Cross Section and / or Plan View

REMARKS .....

PHOTO LOG ..... TEST PIT .....

PAGE.....OF.....

ATTACHMENT D-1

EQUIPMENT CALIBRATION LOG

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

Manufacturer _____ Date Purchased _____

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

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

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1.0 PURPOSE

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

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

2.0 SCOPE

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

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

3.0 GLOSSARY

3.1 pH MEASUREMENT

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

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

3.2 SPECIFIC CONDUCTANCE MEASUREMENT

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

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

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

3.3 TEMPERATURE MEASUREMENT

None.

3.4 DISSOLVED OXYGEN MEASUREMENT

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

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

3.5 OXIDATION-REDUCTION POTENTIAL MEASUREMENT

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

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

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

3.6 SPECIFIC ION ELECTRODES MEASUREMENT

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

4.0 RESPONSIBILITIES

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

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

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

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

5.0 GUIDELINES

5.1 MEASUREMENT OF pH

5.1.1 General

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

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

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

5.1.2 Principles of Equipment Operation

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

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

5.1.3 Equipment

The following equipment is needed for taking pH measurements:

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

5.1.4 Measurement Techniques for Field Determination of pH

1. pH Meter

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

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

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

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

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

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

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

g. Adjust the pH meter to read 7.0.

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

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

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

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

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

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

2. pH Paper

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

5.2 MEASUREMENT OF SPECIFIC CONDUCTANCE

5.2.1 General

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

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

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

5.2.2 Principles of Equipment Operation

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

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

5.2.3 Equipment

The following equipment is needed for taking specific conductance measurements:

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

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

5.2.4 Measurement Techniques for Specific Conductance

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

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

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

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

5.3 MEASUREMENT OF TEMPERATURE

5.3.1 General

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

5.3.2 Equipment

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

5.3.3 Measurement Techniques for Water Temperature

If a thermometer is used on a collected water sample:

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

- Record values in a field logbook or sample log sheet.

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

5.4 MEASUREMENT OF DISSOLVED OXYGEN CONCENTRATION

5.4.1 General

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

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

5.4.2 Principles of Equipment Operation

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

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

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

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

5.4.3 Equipment

The following equipment is needed to measure dissolved oxygen concentration:

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

5.4.4 Measurement Techniques for Dissolved Oxygen Determination

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

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

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

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

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

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

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

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

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

5.5 MEASUREMENT OF OXIDATION-REDUCTION POTENTIAL

5.5.1 General

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

5.5.2 Principles of Equipment Operation

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

5.5.3 Equipment

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

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

5.5.4 Measurement Techniques for Oxidation-Reduction Potential

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

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

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

- Thoroughly rinse the electrode with demineralized water.

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

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

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

5.6 SPECIFIC ION ELECTRODE MEASUREMENTS

5.6.1 General

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

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

5.6.2 Principles of Equipment Operation

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

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

5.6.3 Equipment

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

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

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

5.6.4 Measurement Techniques for Inorganic Ions Using Specific Ion Electrodes

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

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

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

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

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

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

6.0 REFERENCES

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

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

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

7.0 ATTACHMENTS

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

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

ATTACHMENT A

SPECIFIC CONDUCTANCE OF M KCl AT VARIOUS TEMPERATURES[1]

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

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

ATTACHMENT B

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

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

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

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

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