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RFI DATA GAP WORK PLAN

for

PORTSMOUTH NAVAL SHIPYARD
KITTERY, MAINE

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

Contract Task Order 0148

June 1994

Halliburton NUS
CORPORATION

R-10-93-24

RFI DATA GAP WORK PLAN
FOR
PORTSMOUTH NAVAL SHIPYARD
KITTERY, MAINE

COMPREHENSIVE LONG-TERM
ENVIRONMENTAL ACTION NAVY (CLEAN) CONTRACT

Submitted to:
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The RFI data gap work plan and the Groundwater Monitoring Plan submitted by Halliburton NUS in compliance with the RCRA Corrective Action/Corrective Measures Study for the remediation of hazardous waste sites at the Portsmouth Navel Shipyard, Kittery Maine, has been review by Woodard & Curran and has been found complete.

STATE OF MAINE
ERIC T. CARLSON
236
CERTIFIED GEOLOGIST

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1.0 INTRODUCTION

1.1 PURPOSE

This Resource Conservation and Recovery Act (RCRA) Facility Investigation (RFI) Data Gap Work Plan for the Portsmouth Naval Shipyard (NSY Portsmouth), Kittery, Maine, has been prepared in response to the RFI "Approval with Conditions" granted by the United States Environmental Protection Agency (USEPA) Region I in April 1993 as part of the Hazardous and Solid Waste Amendments of 1984 (HSWA) Permit. The permit was prepared after a RCRA Facility Assessment (RFA) of the Shipyard was conducted by the USEPA at the facility. The RFA identified specific Solid Waste Management Units (SWMUs) where known or potential releases of hazardous wastes or hazardous constituents have occurred. The final HSWA permit specifies plans and investigations to be carried out by the Shipyard to determine the extent and nature of the releases and to identify cleanup measures.

The primary objective of the subject RFI Data Gap Work Plan is to address deficiencies in the original RFI. Specific objectives of the RFI Data Gap Work Plan are as follows:

- Verify that the concrete sewer pipe at Mercury Burial Site I (SWMU #9) is capped or does not contain mercury-contaminated waste.

- Locate and determine the integrity of the concrete blocks at Mercury Burial Site II (SWMU #9).

- Investigate groundwater to determine if the bedrock aquifer discharges into the surficial aquifer; further define general hydrogeologic conditions at the facility.

- Determine the nature and extent of plumes of volatile and semi-volatile organic compounds detected in the vicinity of the Mercury Burial Site II, at the former buried Waste Oil Tanks (SWMU #11), and at monitoring well JW-13B at the JILF (SWMU #8). Also, investigate groundwater and soils in the vicinity of the new planned Hazardous Waste Storage Facility to be located near the former Waste Oil Tanks (SWMU #11).

- Re-evaluate the effects of the tides in the Piscataqua River on the groundwater at the DRMO (SWMU #6) and the JILF (SWMU #8).

1.2 SUMMARY OF PLANNED RFI DATA GAP ACTIVITIES

A concise summary of the planned RFI Data Gap activities follows:

DRMO (SWMU #6)

(1) Groundwater Contamination at DRMO

- Analyze groundwater samples from the 3 wells in the DW-07 cluster (existing monitoring wells DW-07/DW-07B and new deep bedrock monitoring well [DW-07DB]) for TCL/TAL analytes (plus Freon) and common water quality parameters.

- Conduct slug testing and water level measurements as per Section 3.3 "Groundwater Investigation."

(2) Tidal Study

- Conduct tidal correlation study at the DRMO, measuring actual tidal fluctuations and tidal fluctuations in the well previously utilized as a tidal gauge (DW-03). and comparing the tidal responses.

- Evaluate correlation of RFI tidal well data at the DRMO with RFI Data Gap tidal gauge data and correct as necessary (non field activity).

- Redefine gradients at the DRMO Area.

Jamaica Island Landfill (SWMU #8)

(1) Groundwater Contamination Near JW-13 at JILF Landfill

- Analyze groundwater samples from the four wells in the JW-13 cluster (existing monitoring

wells JW-13S, JW-13B, and JW-13D and one new deep bedrock monitoring well [JW-13DB]) for TCL/TAL analytes (plus Freon) and common water quality parameters.

- Conduct slug testing and water level measurements as per Section 3.3 "Groundwater Investigation."

(2) Tidal Study

- Redefine gradients at the JILF area.

<u>Mercury Burial Site Areas (SWMU #9)</u>

(1) Mercury Burial Site I

- Carefully excavate existing concrete sewer pipe and document physical characteristics.

- If both ends of the concrete sewer pipe are capped/sealed, confirm lack of mercury contamination by collecting one soil sample at each pipe end and conducting quick-turnaround analyses for mercury.

- If the concrete pipe is open, hand auger to collect three samples from materials within the pipe. Additionally, collect an additional 10 samples outside of the pipe area. All samples will undergo quick-turnaround analyses for mercury to investigate the presence or absence of contamination.

- Conduct limited remedial action if mercury contamination is encountered by containerizing mercury-contaminated soil. If directed by the Navy, remove concrete pipe.

- Backfill, revegetate with seed and mulch.

(2) Mercury Burial Site II

- Conduct trenching at the staked location in the J-boat asphalted area to located Mercury Burial Site II.

- If the concrete blocks/pipes are encountered, conduct same program used during initial RFI for Mercury Site I (inspect concrete blocks/pipes for integrity, sample surrounding soils, sample concrete block/pipe contents if open). Twelve samples will be collected around the site and analyzed for TCL/TAL analytes (plus Freon), and TAL metals. Quick-turnaround analysis will be employed for mercury analyses. If mercury contamination is present, an additional 10 samples will be collected and analyzed for mercury, using quick-turnaround analysis, to determine the extent of contamination.

- Conduct limited remedial action if mercury contamination is encountered by containerizing mercury-contaminated soil. If directed by the Navy, remove concrete blocks and/or concrete pipes.

- Backfill and repave asphalt/repair fencing.

(3) Groundwater Contamination Investigation Near Mercury Burial Site II Area

- Utilize "Direct Push" methods to locate permanent monitoring well location. Analyze "Direct Push" groundwater locations for volatile organics and perform petroleum product fingerprinting.

- Conduct soil gas readings at each "Direct Push" location.

- Install one permanent shallow monitoring well. No soil samples for chemical analysis are required from the associated soil boring.

- Measure for free product, if present, using an interface probe.

- Analyze groundwater samples from the permanent monitoring well for TCL organics, fuel oil and gasoline, lead, and salinity.

- Conduct slug testing and water level measurements as per Section 3.3 "Groundwater Investigation."

Waste Oil Tanks (SWMU #11)

(1) Groundwater Contamination Investigation Near Waste Oil Tanks

- Since buried chlorine and acetylene cylinders were landfilled in 1955, conduct intrusive (drilling) operations in Level B in areas landfilled between 1950 and 1960.

- Utilize "Direct Push" methods to locate five permanent monitoring well locations. Analyze "Direct Push" groundwater locations for volatile organics and perform petroleum product fingerprinting.

- During "Direct Push" in the vicinity of the new Hazardous Waste Storage Facility, collect soil samples and send to an offsite laboratory for full TCL/TAL analyses (plus Freon).

- Conduct soil gas readings at each "Direct Push" location for groundwater.

- Install up to 5 permanent shallow monitoring wells; collect soil lithology samples only.

- Measure for free product using an interface probe.

- Analyze groundwater samples from permanent wells for TCL/TAL analytes, fuel oil and gasoline, and salinity.

- Conduct slug testing and water level measurements as per Section 3.3 "Groundwater Investigation."

- Repair asphalt, as necessary

Hydrogeology Investigation

(1) Groundwater Investigation

- Conduct facility-wide mapping effort to investigate relationship between bedrock islands, fill areas, shallow and deep groundwater, and ponds (non field activity). The maps will initially be prepared using RFI data, then updated upon evaluation of RFI Data Gap

results.

- Install 5 monitoring well clusters primarily for hydrogeologic information:

  - One new 2-well cluster in middle of Dennett's Island; one well approximately 20-25 feet into bedrock and one well approximately 80-100 feet into bedrock.
  - One new 2-well cluster on Seavey Island near the ponds; one well approximately 20-25 feet into bedrock and one well approximately 80-100 feet into bedrock.
  - One new 3-well cluster in the fill area between Dennett's and Seavey Islands; one shallow well, one well approximately 20-25 feet into bedrock and one well approximately 80-100 feet into bedrock.
  - One deep bedrock well at Jamaica Island, to be paired with an existing well cluster at JW-13; the deep bedrock well will extend approximately 80-100 feet into bedrock.
  - One deep bedrock well at the DRMO, to be paired with an existing well cluster at DW-7; the deep bedrock well will extend approximately 80-100 feet into bedrock.

- Analyze samples for TCL/TAL analytes, common cations and anions, tritium (for age dating purposes), and salinity.

- Conduct slug testing for each new monitoring well previously described.

- Conduct two rounds of water level measurements at all existing and new monitoring wells.

- Incorporate/reference the Offshore Study seep results in evaluating groundwater flow (non field activity).

- Conduct visual observation/mapping of seeps three times per week during low tide, during Halliburton NUS on-site presence Select seeps will be analyzed for salinity via hydraulic conductivity.

(2) Pond Investigation

- Install staff gauges at each pond.

- Collect two surface water/sediment samples from each of the two ponds and analyze for TCL/TAL analytes (plus Freon) and salinity.

- Install 18 piezometers within each pond; 10 in the large pond and 8 in the small pond to measure head differential between pond surface water elevation and shallow groundwater levels.

- Install flow monitoring device (continuous flowmeter) at discharge box of downstream pond; measure flow during on-site presence of Halliburton NUS and correlate with precipitation events, as measured with a rain gauge.

- To determine pond discharge location, conduct dye tracer test and monitor surface seeps and monitoring wells downgradient of the ponds.

(3) Tidal Investigation

- Present global facility interpretation of original RFI (and new RFI data gap information at the DRMO and JILF) tide data.

2.0 BACKGROUND INFORMATION

2.1 SITE LOCATION AND DESCRIPTION

Situated within the town of Kittery, Maine, the Portsmouth Naval Shipyard (NSY Portsmouth) is composed of four islands located in the Piscataqua River. The Piscataqua River is a tidal estuary which forms the southern boundary between New Hampshire and Maine.

The shipyard is engaged in the conversion, overhaul, and repair of submarines for the U.S. Navy. The shipyard has a long history dating back to 1690 when the first warship launched in North America, the *Falkland*, was built. The shipyard was first established as a government facility in 1800. The shipyard served as a repair and building facility for ships during the Civil War. The first government-built submarine was designed and built at the shipyard during World War I and a large number of submarines were designed and constructed at the yard from 1917 to the present. The shipyard has continued servicing submarines to this day.

As the workload at the shipyard expanded, fill material was used to create man-made-land adjacent to the original islands Today the shipyard is composed of 376 buildings on 278 acres of continuous land surface that extends between three of the original four islands Much of the shipyard is built on fill overlying former tidal flats as shown in Figure 2-1

Detailed topographic maps of the DRMO and the JILF were produced by Emery Engineering Associates under subcontract to McLaren/Hart. The maps will be used as base maps for all work to be conducted as part of this RFI Data Gap Work Plan

2.2 PHYSIOGRAPHY

The NSY Portsmouth is located on Seavey Island in the Piscataqua River immediately south of the town of Kittery, Maine The location of the shipyard is shown in Figure 2-2 The shipyard is built on an area comprising Dennett's, Seavey, Jamaica, and Clark's Islands, as well as man-made-land between these islands Approximate elevations on-site range from sea level to a maximum of sixty feet above MSL. Two-thirds of the site is high-density industrial area containing 376 buildings, while the remaining areas are flat-lying to gently sloping grass-covered fields. Minor wooded areas exist on the east side of Jamaica Island.

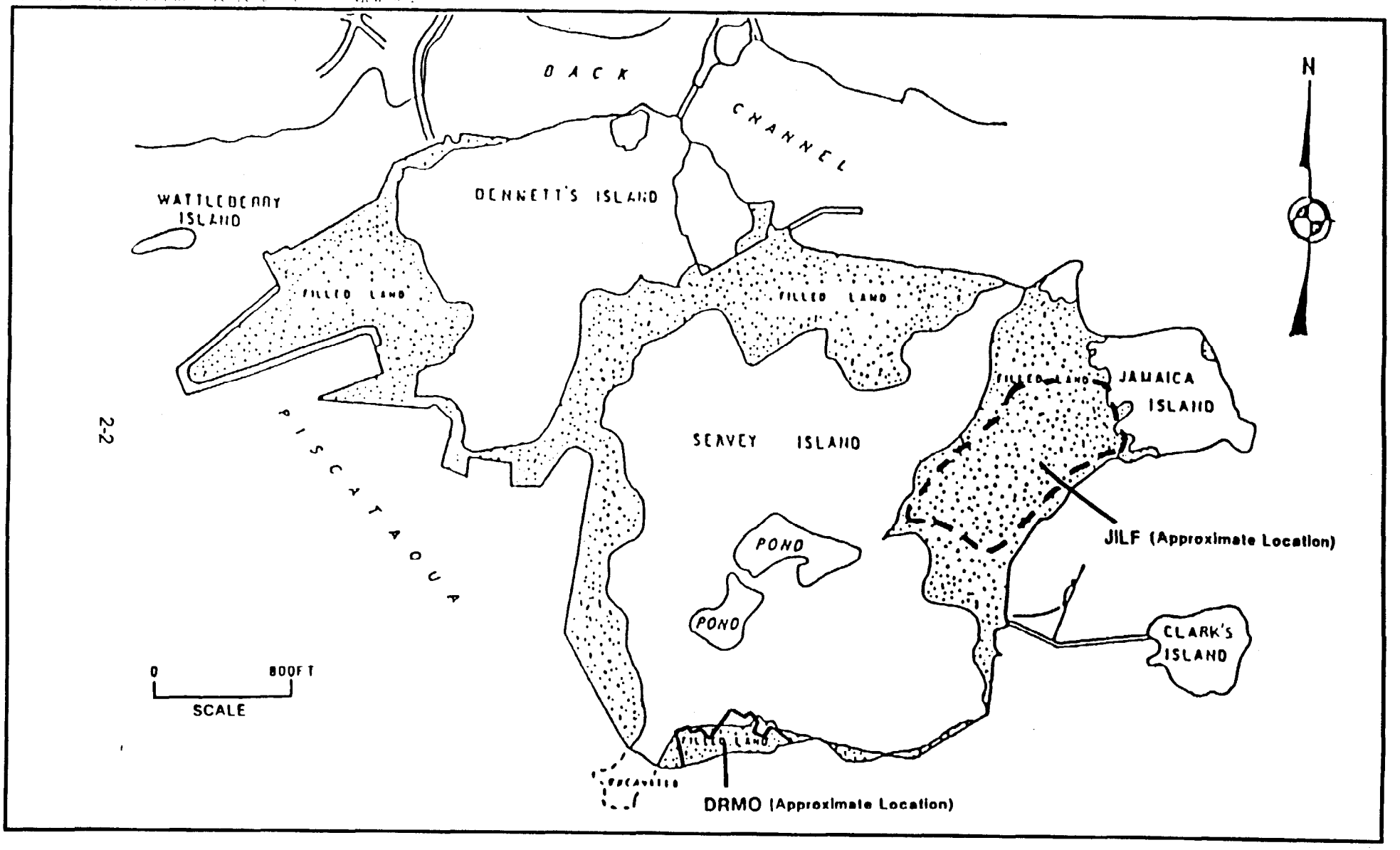

FIGURE 2-1

PORTSMOUTH NSY LAND MAP
PORTSMOUTH NAVAL SHIPYARD
KITTERY, MAINE

HALLIBURTON NUS CORPORATION

FIGURE 2-2

LOCATION MAP
PORTSMOUTH NAVAL SHIPYARD
KITTERY, MAINE

HALLIBURTON NUS CORPORATION

The shoreline in the Portsmouth area is described as an embayed coast produced by partial submergence of a fluvially eroded land mass (Strahler, 1971). Valleys show some degree of straightening and deepening by ice; hilltops are blunted by ice erosion; and deposits of till block smaller valleys in the Maine version.

This type of shoreline is closely associated with the drowned river valley type estuary. The Great Bay Estuary would be classed as a drowned river valley in a geomorphological classification (Duxbury, 1971).

2.3 SITE HISTORIES

The following subsections present brief summaries of the sites investigated during the recent RFI. More complete discussions of these sites are contained in the RFI Report (McLaren/Hart).

2.3.1 Mercury Burial Sites (SWMU #9)

The following subsections describe the historical information available regarding Mercury Burial Sites I and II. Mercury Burial Site I has been found and investigated, but the exact location of Mercury Burial Site II is currently unknown.

A Ground Penetrating Radar (GPR) survey was conducted during the RFI in an attempt to locate the Mercury Burial Sites. The general locations of the sites had been identified by site workers and the GPR survey was designed to cover these locations and confirm the presence, depth and dimensions of the poured concrete blocks. The penetration depth of the GPR was limited to approximately three feet as a result of the conductive nature of the landfill material and soil properties. Possible explanations for this high conductivity include a 2.7 to 3.5 foot near surface clayey silt layer in the vicinity of Mercury Burial Site I and diffused metal fragments in soils in the vicinity of Mercury Burial Site II. As a result of the limited signal penetration, no useful site location information was obtained using the GPR at either Mercury Burial Site.

2.3.1.1 Mercury Burial Site I

The following table summarizes information available from the RFA:

Description:	Two Mercury Burial Areas located within the Jamaica Island Landfill Area.
Period of Operation :	1973 to 1975.
Wastes :	Mercury contaminated wastes including fluorescent bulbs, thermometers, mercury switches, and rags, brooms, and dust pans contaminated with mercury.
Release Controls :	As reported prior to the RFI the wastes were encapsulated in 4- foot-diameter concrete pipe sections with the ends capped with one foot of pored concrete. The concrete vaults were buried under 8 to 10 feet of fill. There are approximately six vaults, three in each of the areas. Visual inspection indicated that the areas are vegetated with no signs of erosion or distress. There is no record of a release from the concrete capsules.
History of Release :	Encased in concrete and presumed secure.
Condition :	

Site Description - Mercury Burial Sites, taken from RCRA Facility Assessment, Portsmouth Naval Shipyard, Phase II Report, Kearney, A T, Inc and Baker/ TSA, Inc., July 1, 1986

During the resulting RFI, Mercury Burial Site I was excavated to a depth of approximately 16.5 feet below grade, where native soils were encountered Fill material consisted of scrap metal, wood fragments, plastic, and red sand Three separate poured concrete blocks and one vertical section of concrete sewer pipe (all presumed to contain mercury contaminated material) were encountered The dimensions of each poured block and the sewer pipe are summarized below as they were aligned east to west

I.D.	Diameter	Length	Width	Height
Vertical Sewer Pipe	4 5	NA	NA	4'4"
Block No. 1	NA	4'	5'	2' 11"
Block No. 2	NA	8' 7"	7'	2' 11"
Block No. 3	NA	4'	5'	2' 11"

Each poured concrete block was supported by a one foot thick concrete pad except for the section of concrete sewer pipe. The hollow section of concrete sewer pipe appeared to be filled with soil at the surface and did not appear to be capped. All of the poured concrete blocks appeared to be intact. Three soil samples were collected from within the excavation. After checking the integrity of the concrete blocks and obtaining dimensions the excavated area was backfilled with the original soil and backfill material. Locations of the poured concrete blocks and concrete sewer pipe were measured from monitoring wells MW-04 and MW-05 and are described in the RFI field notebook (Figure 2-3).

2.3.1.2 Mercury Burial Site II

During the original RFI, Mercury Burial Site II was excavated at the existing location of the concrete plaque marker to a depth of approximately 15.5 feet below grade where saturated native soils were encountered. Fill material consisted of concrete, brick, scrap metal, wood fragments, Herculite, plastic and sandblast grit. Several bags of asbestos-containing material were also uncovered within the fill material. There was no evidence of any poured concrete blocks or mercury contaminated soils. Soil samples were collected from three separate intervals within the excavation. The excavation was then backfilled with the original soil and fill material.

NSY Portsmouth personnel interviewed retired employees and people working on base that had any recollection of the burial of poured concrete blocks at Mercury Burial Site II. Based on these interviews, an alternate location was chosen for trench excavation. A total of nine exploratory trenches were dug at Mercury Burial Site II during the Phase IVA investigation. Trenches were excavated to depths of 12.5 feet to 17.0 feet below grade where native soils or bedrock were encountered. Excavated trenches east of the nearby fenced-in paved parking lot had a strong solvent-like odor that was also detected in the adjacent monitoring wells during groundwater sampling. Bedrock was encountered below the water table at approximately 17.0 feet. There was no evidence of poured concrete blocks or mercury contaminated soils in any of the trenches.

Soil samples were taken and analyzed during excavation activities at Mercury Burial Site II. There were no volatile organic compound concentrations above New Jersey ECRA Guidance Values or proposed Federal Action Levels.

Soil samples MTP-01(2-4') and MTP-01(5-7') had total base neutral concentrations of 176 mg/Kg and 118.5 mg/Kg, respectively. These concentrations exceed the New Jersey ECRA Guidance Value of 10 ppm for total base neutrals in soil.

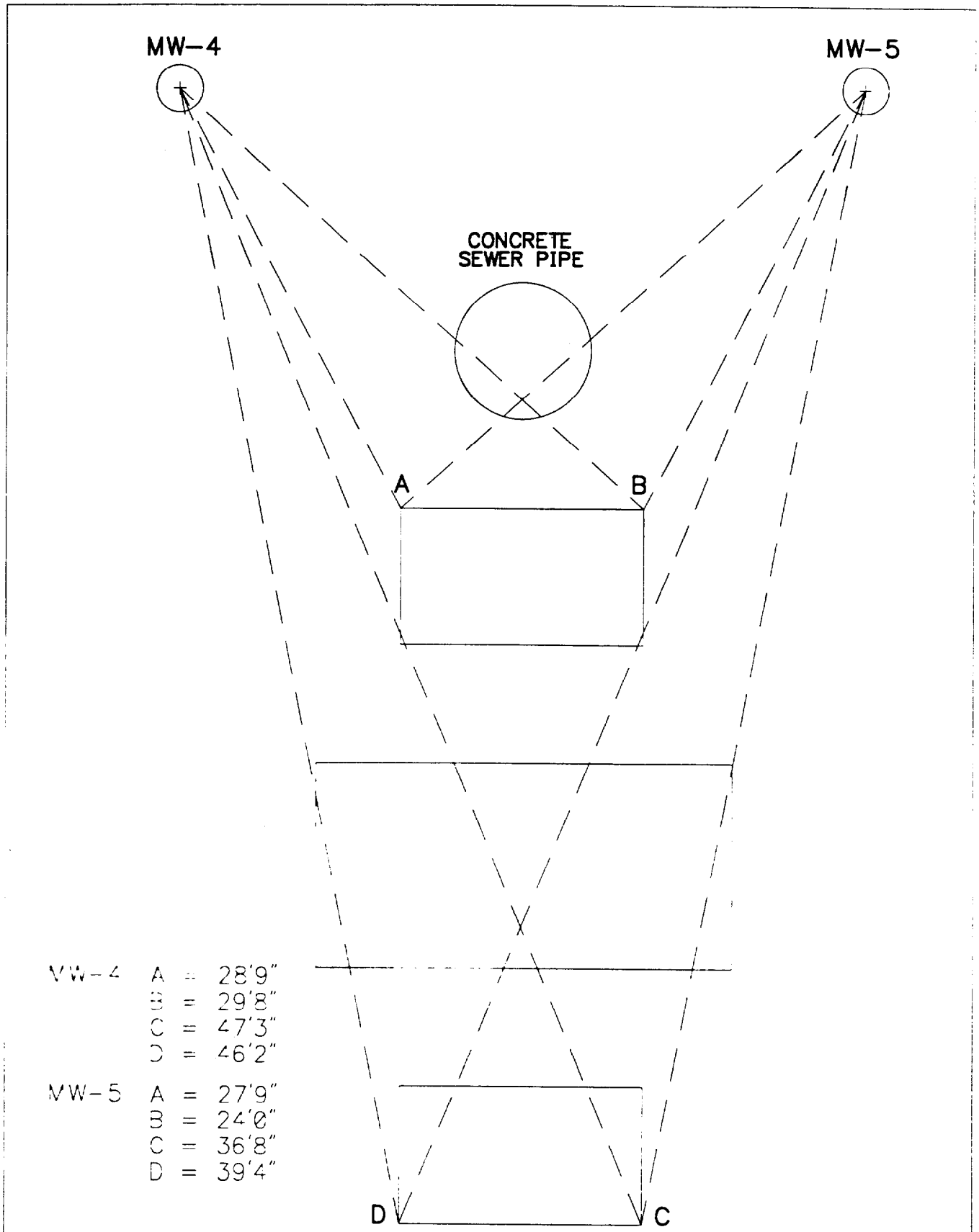

FIGURE 2-3

CONCRETE SEWER PIPE LOCATION PORTSMOUTH NAVEL SHIP YARD

HALLIBURTON NUS
Environmental Corporation

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Soil samples MTP-01(2-4') and MTP-01(5-7') also had total PAH concentrations that exceed the New Jersey ECRA Guidance Value of 10 ppm for total PAHs in soil. These samples had concentrations of 174 mg/Kg and 119 mg/Kg, respectively. No proposed Federal Action Levels are available for total base neutrals or PAHs.

Concentrations of TCL volatiles, TCL semi-volatiles, and a review of chromatograms and listed TICs indicate a light petroleum product (i.e., gasoline) and a heavier petroleum product present in subsurface soil samples MTP-01(5-7') and MTP-01(10-12'). Chromatograms and TICs also indicate a heavier petroleum product in the remaining Phase IV subsurface soil sample MTP-01(2-4').

The source of petroleum contamination is unknown at this time, but could be a result of contaminated fill material placed in the landfill.

2.3.2 Jamaica Island Landfill (JILF) (SWMU #8)

The following table summarizes the RFA information available regarding the history of the JILF.

Description :	The landfill covers an area of twenty-five acres and contains an unknown amount of materials considered as hazardous waste. Prior to landfilling activities, tidal flats separated Jamaica Island from Seavey Island. Over a 20-30 year period this area was filled with hazardous and nonhazardous wastes. In 1978, the shipyard received approval to dredge over 100,000 cubic yards of sediment from berths 6, 11 and 13, and to dispose of the material in the area of the landfill. The material was placed on top of a portion of the landfill and was encapsulated by a clay barrier wall along the Piscataqua River and a clay cap to prevent infiltration.
Period of Operation :	Approximately 1945 to 1978.
Wastes :	In addition to general refuse, trash and construction rubble, the unit accepted incinerator ash, plating sludges containing chrome, lead and cadmium; asbestos insulation; volatile organics including TCE, methylene chloride, toluene and MEK; acetylene and chlorine gas cylinders; contaminated dredge spoils containing chromium, lead, small amounts of PCB, mercury and possibly phenols; waste oils containing PCBs may also have been disposed at the site prior to construction of a holding tank in 1972.
Corrective Actions :	A 2-foot clay cap has been placed over the portion of the landfill that accepted contaminated dredge spoils. In addition, a clay barrier has been constructed lining the inside of the rock dike in the area of the dredge spoils.
History of Releases :	Sampling and testing of sediments along the face of the landfill have indicated elevated levels of chromium, lead, and nickel. However, this data does not confirm the landfill as the source of the contamination.
Condition	Partially capped with clay soil, contained and apparently stable. Visually, there is no apparent stress to vegetation on the surface of the dredge spoil area nor in the drainage ditch on the southwest flank. The clay soil cap is intact; there is no significant erosion or apparent cracking from desiccation and shrinkage. Snow cover when present does not seem to be affected.

Site Description - Jamaica Island Landfill, taken from RCRA Facility Assessment, Portsmouth Naval Shipyard, Phase II Report, Kearney, A T Inc and Baker/TSA, Inc., July 1, 1986

One RFI objective for the JILF was to develop a description of the direction, rate, and variation (i e, seasonal or tidal) of groundwater flow underlying Jamaica Island Landfill areas The data utilized in the groundwater hydraulics investigation were derived primarily from hydraulic conductivity tests and continuous monitoring of tide and groundwater levels The following narrative briefly describes the previous hydraulic investigation activities

Hydraulic conductivity estimates computed for wells at the JILF show the fill material underlying the JILF to be highly permeable, particularly along the Clark's Island Embayment. The mean hydraulic conductivity of the bedrock is an order of magnitude lower than that in the overburden. The hydraulic conductivity in

the bedrock also is more variable than that in the overburden. Hydrographs generated from hourly water-level data indicate that the tide influences 14 JILF wells. The patterns exhibited on the hydrographs also indicate that 1) wells on and near Jamaica Island do not respond to the tide and those installed in bedrock respond slightly or not at all; 2) the low permeability barrier inhibits the movement of groundwater to and from the southern landfill area; and 3) relatively good hydraulic connection exists between Clark's Island Embayment and the southern area south of the landfill, at least up to JW-9.

Average groundwater elevations indicate that relatively high groundwater elevations exist on Jamaica Island. Salinity data indicate that groundwater consists of fresh water, indicating the likelihood of mounded fresh water lenses. Shallow groundwater was interpreted to flow westward from Jamaica Island to and area near the equipment laydown area, where it meets groundwater flowing eastward. Groundwater in this area is interpreted to diverge southward toward the landfill and Clark's Island Embayment and northward toward the backchannel. Groundwater from within the southern landfill area likely flows eastward from a central high point toward Clark's Island Embayment. The low permeability barrier encompassing the landfill likely impedes groundwater flow from the landfill and deflects groundwater around the landfill.

Lateral groundwater flow in the bedrock is believed to generally mimic that in the overburden. However, groundwater flow in the bedrock is complicated by the occurrence of apparent significant upward discharge of fresh water

The RFI Report does not specifically address any known groundwater discharge around the Jamaica Island Landfill (specifically in the back channel and the Clark's Island Embayment). However, elevated concentrations of some VOAs, SVOAs, and metals were detected in monitoring wells situated near the current shoreline

The detection of volatile organic compounds (VOCs) in wells at the edge of the JILF; e.g., along the Clark's Island Embayment, indicate that relatively low concentrations of VOCs are discharging into the estuary

Pesticides were generally in low concentrations in groundwater samples from nine (9) JILF wells. PCBs were detected only in the Phase III groundwater sample from JW-15. Pesticide/PCB concentrations exceeding proposed Federal Action Levels or NPDWR were detected in JW-15 and JW-19.

Elevated groundwater concentrations of metals are present throughout the JILF. Most of the metal

concentrations detected in the groundwater have been associated with unfiltered groundwater samples and thus apparently are not dissolved in the groundwater. However, some filtered samples also exhibited elevated metal concentrations.

2.3.3 Former Buried Waste Oil Tanks (SWMU #11)

Underground storage tanks (USTs) No. 6 and No. 7 were utilized for liquid storage of waste lubricating oils and degreasers. Both tanks were tested in November 1986 and reportedly did not fail the tightness test. The tanks were removed from the ground and disposed of in June 1989. The MEDEP was on site during tank removal, and visibly stained soils were removed and disposed of. Although large amounts of soil were removed during the tank removal action, significant quantities may remain. Confirmation sampling of the excavation was not performed.

The following table summarizes RFA information:

Description :	Waste Oil Tanks (2) No. 6 and No. 7. These units were two 8000-gallon underground steel tanks from railroad cars. The tanks were buried side by side at the northeastern end of the Jamaica Landfill Area. The tanks were used to store oily wastes prior to off-site disposal.
Period of Operation :	Waste oils from facility shops including cooling and cutting oils, motor oils, transmission oils, and hydraulic oils. A Consent and Agreement Order (15) has indicated that degreaser solvents have in the past been labeled as waste oils and may have been stored in these tanks. In addition, a February 1985 Industrial Survey Report (13) indicated that plant personnel have admitted placing small quantities of waste cleaning solvents into dumpsters which were emptied into the underground waste oil tanks at Jamaica Island Waste oils may also contain various metals
Release Controls	Standard Operating Procedures existed, but there was occasional spillage due to overfilling or misalignment of fill hose with neck of tanks
History of Release :	In 1979 the tanks were excavated, inspected, and reburied There was no evidence of releases at that time. In 1986, both tanks were precision tested and found to be tight.
Condition :	These tanks were excavated and removed in 1989. Soil sampling by the shipyard and State was conducted; elevated levels of lead were found in excavated material. The contaminated soil was disposed of in a RCRA approved Solid Waste Landfill.

Site Description - Former Buried Waste Oil Tanks, taken from RCRA Facility Assessment, Portsmouth Naval Shipyard, Phase II Report, Kearney, A.T., Inc. and Baker/TSA, Inc., July 1, 1986.

During the RFI, two soil borings were completed as monitoring wells (JW-16 and JW-16B). The wells are in the immediate vicinity of the waste oil tanks previous location. The overburden encountered during drilling at this location is composed of fill material. These deposits were found to consist of brown, fine to coarse grained sand and gravel alternating with grey silt and clay. Bedrock was encountered at approximately 10.5 feet. Overburden soils exhibited visual and olfactory evidence of petroleum contamination.

There were no volatile concentrations found in soils at levels exceeding New Jersey ECRA Guidance Values or proposed Federal Action Levels. Only toluene was consistently detected in the soil samples, being present in all but one sample.

A review of the chromatograms indicate a petroleum product present in several soil samples. Since petroleum identification was not performed on the samples, a determination as to the type of petroleum present cannot be made at this time.

No semi-volatile organic compounds were detected in the surface soil samples in concentrations exceeding New Jersey ECRA Guidance Values or proposed Federal Action Levels. Relatively low concentrations of primarily PAHs were detected in virtually all samples.

Based on salinity and conductivity measurements, monitoring well JW-16B contains brackish water conditions. No field parameters were obtained from well JW-16 due to visual and olfactory evidence of petroleum contamination in the groundwater.

The volatile organic compounds detected in JW-16 and JW-16B were generally solvents and/or petroleum products. A review of listed TICs revealed 1,1,2-(trichloro)-1,2,2-(trifluoroethane) (Freon) and daughter products in both JW-16 and JW-16B. Estimated concentrations in JW-16 were 2,500 and 62,000 ppb respectively. Estimated concentrations in JW-16B were 970 and 40 ppb respectively. The majority of the VOCs that exceeded the comparison values were detected in groundwater samples from JW-16.

Semi-volatile organic compounds were detected in monitoring well JW-16. The SVOA compounds detected are characteristic of a petroleum product.

2.3.4 Tidal Effects Investigations

During the original RFI, tidal studies were conducted at the following SWMUs.

- DRMO (SWMU #6)
- JILF (SWMU #8)
- Mercury Burial Sites (SWMU #9)

The objective of the tidal studies was to determine the direction, rate and variation (i.e., seasonal or tidal) of groundwater flow underlying the above referenced SWMUs. The data utilized in the tidal studies were derived primarily from hydraulic conductivity tests and continuous tide and groundwater level monitoring.

Continuous (hourly) water-level monitoring was performed during Phase IV at the DRMO, JILF and Mercury Burial Sites. The purpose of the monitoring was to provide tide and groundwater level data necessary to identify any tidal influence in wells and to develop and interpret groundwater flow patterns and groundwater flow velocities.

Hydrographs of the hourly water-level data were constructed by converting the depth-to-water levels to groundwater elevations and plotting such elevations against time. In addition, to show possible groundwater responses to precipitation, a graph of daily total precipitation from at least 3 days prior to and including the days over which water levels were measured was incorporated on each hydrograph.

Wells responding to the tide were identified based on review of the hydrographs. To determine the relative response to the tide between wells, the tidal response range and high tide lag time were determined for each well. The tidal response range was taken simply as the maximum groundwater reading minus the minimum groundwater elevation reading. Although this variable is not the true tidal range, since many wells exhibited asymmetric or high-tide only responses to the tide, it is sufficiently accurate and appropriate for determining relative response to the tide between wells. In addition, the high tide lag time was determined for each well responding to the tide, where the high tide lag time was selected from the hydrographs as the time differential between high tide and each peak water elevation in the well.

Groundwater at the DRMO levels were monitored in the wells from September 24 to 27, 1991. To facilitate and permit the placement of transducer cables away from heavy machinery traffic, all three dataloggers had to be used to record water levels. In consequence of using all of the data loggers at the DRMO and given that the tidal gauge stilling well was located in Clark's Island Embayment, tide levels could not be

recorded concurrent with the water levels. The National Ocean Services, Navy personnel, and the appropriate University of New Hampshire departments/personnel were contacted regarding tide data for the time period September 24 to 27, 1991; tide data were not collected in the estuary during this time period.

Water-level data indicate that the tide influences all DRMO wells, and that shallow groundwater underlying the DRMO flows generally southward into the estuary.

3.0 SCOPE OF WORK

The following subsections present each RFI Report Comment that is to be addressed under this work assignment, followed by the proposed scope of work to address each comment. Details of the investigation, such as the technical approach, selection of drilling locations, and sample collection activities, are found in Field Sampling Plan (FSP), attached as Appendix A of the Work Plan. The QAPP is Appendix B of the Work Plan. The Health and Safety Plan (HASP) is attached as Appendix C. Field forms to be used during the RFI activities are included as Appendix D, and the Standard Operating Procedures (SOPs) to support the investigative activities are attached as Appendix E. Appendix F provides the QAPP for PACE New England, which is the analytical laboratory conducting the work.

3.1 MERCURY BURIAL SITE I (SWMU #9)

3.1.1 RFI Report Comment

Verify that the buried concrete pipe does not contain mercury contaminated waste.

3.1.2 Response

Mercury Burial Site I will be excavated to determine; 1) the condition of the concrete pipe and 2) if the concrete pipe is capped on one or both ends.

The location of Mercury Burial Site I is known and documented. Figure 2-3 shows the exact site of the buried concrete blocks and concrete pipe with references to nearby monitoring wells. The burial site will be re-excavated to visually inspect and sample as necessary. All excavation will strictly adhere to OSHA requirements regarding trench excavation. Test pits will be roped off upon completion of each day's work activities. It is anticipated that a track-mounted backhoe will be necessary to perform the digging activities, due to the depth and volume of fill that needs to be removed. A probe will be used as the excavation depth nears the concrete blocks and concrete pipe to keep the backhoe from damaging the containers.

Upon excavation of the soils around the concrete pipe, a detailed physical inspection will be made regarding the condition of the concrete pipe (i.e., cracks, condition of concrete, open ends, capped ends, fill material, etc.). One of following scenarios is expected:

Scenario 1 - Concrete Pipe Intact and Capped

If the concrete pipe is capped on both ends, one soil sample at each end of the concrete sewer pipe will be taken and analyzed for total mercury only, employing quick-turnaround analysis. Standard CLP methods for total mercury will be employed but with quick reporting. The purpose of these samples is to confirm lack of mercury contamination.

Scenario 2 - Concrete Pipe Not Capped and/or Not Structurally Intact

If the concrete sewer pipe is found to be not capped on top or not structurally intact, then a total of three samples from one boring within the concrete pipe will be taken with a hand auger or trowel; one near the top, one near the middle, and one near the bottom of the pipe. Additionally, 10 samples from near the concrete pipe will be collected to ascertain the extent of soil contamination, if any, outside of the pipe area. All samples will be analyzed for total mercury, employing quick-turnaround analysis. Standard CLP methods for total mercury will be employed but with quick reporting.

For either Scenario 1 or 2, if the analytical results indicate mercury contamination, limited corrective action is included to address the problem while the excavation is still open. Limited corrective action includes the removal of limited volumes of mercury-contaminated soil. Additionally, if directed by the Navy, the concrete pipe itself will be removed from the excavation. The action level for excavation will be 20 mg/kg in accordance with RCRA Proposed Subpart S criteria for mercury. Note that a site-specific Media Protection Standard (MPS) value for mercury was not developed since mercury has not been detected to date at significant concentrations. Disposal of any containerized/labeled mercury-contaminated soil and/or the concrete pipe at an approved hazardous waste landfill will be the responsibility of NSY Portsmouth. Note that the concrete pipe is as large (and heavy) as the concrete blocks and it would be difficult, and perhaps unnecessary, to attempt removal without a health and safety evaluation and spill plan. If removal is selected, the work will be conducted by the excavator subcontractor, who must have experience in this type of work. Any limited corrective action conducted during the field work, does not preclude further corrective measures at a later date.

For either Scenario, Draeger tubes for volatile mercury and a Jerome analyzer may potentially aid in determining sample locations, although inorganic mercury would not be detected via these means. As discussed in the Health and Safety Plan (Appendix C), Draeger tubes and the Jerome analyzer will also support health and safety considerations, in combination with cartridge respirators.

Also, for each Scenario, after all samples and field measurements are taken and after all limited removal actions are complete, the excavated area will be backfilled with the original fill material. There are no special compaction requirements, other than compaction in 12-inch lifts with a backhoe bucket. Once the excavation area is backfilled it will be seeded using grass species indigenous to the area (and approved by a NSY Portsmouth representative), and mulched with straw.

3.2 MERCURY BURIAL SITE II (SWMU #9)

3.2.1 RFI Report Comment

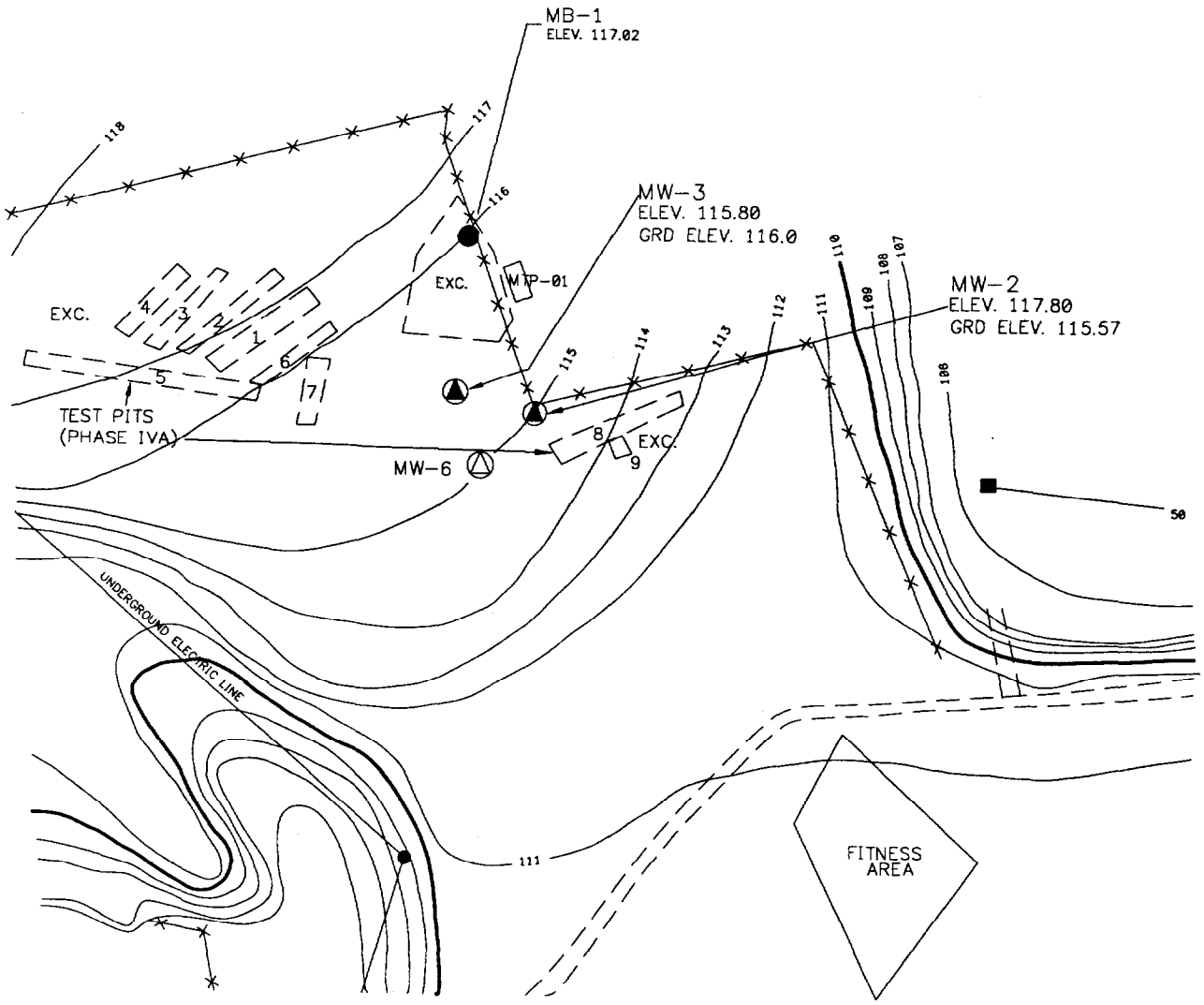
Determine the location and condition of the concrete blocks/concrete pipes buried at Mercury Burial Site II (SWMU #9).

3.2.2 Response

During the RFI Phase IV the Mercury Burial Site II (SWMU #9) was not found. A concrete marker denotes the location of the site; however, the location of the concrete marker is questionable since it was installed several years after burial of the concrete blocks. Several potential locations of Mercury Burial Site II have been excavated in the past without finding the site. A final attempt will be made to find the site based on a recent evaluation of historical photographs. As a result, the asphalted area now used to store small boats will be excavated. This location is adjacent to the original marked location of Mercury Burial Site II. Recently obtained photographs and survey interpretation supports this location. If Mercury Burial Site II is found, soil samples will be obtained at and around Mercury Burial Site II to investigate mercury contamination in the soil.

Several specialty geophysics companies were contacted in an attempt to locate the site through specialty geophysical techniques. However, based on past experience with geophysical techniques and geologic conditions in the Mercury Burial Site II area, none of the contacted companies thought that further geophysical investigation would be successful.

One excavation will be attempted at the recently staked location to find Mercury Burial Site II. Figure 3-1 shows the proposed excavation location. The excavation will begin at the staked location and work outward to the north, east, and west. Note that the area to the south has been previously excavated.



LEGEND

- EXISTING MONITORING WELL
- SOIL BORING LOCATION (EXISTING)
- APPROXIMATE LOCATION OF BURIAL VAULT

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MERCURY BURIAL SITE II
TEST PIT LOCATIONS
PORTSMOUTH SHIP YARD
KITTERY, MAINE

FIGURE 3-1

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For this activity, as well as all other intrusive activities, NSY Portsmouth will assist with the location of utilities and furnish up to date drawings and/or a Facilities & Maintenance (Public Works) point of contact (POC). Halliburton NUS will secure clearance for excavation at each location with the POC before intrusion. Before excavation begins, a magnetometer survey will also be performed as an additional check for underground utilities in the area and check for the presence of buried ferromagnetic objects. All excavation will strictly adhere to OSHA requirements regarding trench excavation. It is anticipated that a track-mounted backhoe will be necessary to perform the digging activities, due to the depth and volume of fill that needs to be removed. One of following scenarios is expected:

Scenario 1 - Mercury Burial Site II Located

If the site is located, the test pit will be enlarged and sloped to expose all concrete blocks/pipes present at the site and allow for physical entry into the excavation. A detailed physical inspection will be made on the condition of all concrete blocks/pipes (i.e., cracks, condition of concrete, open ends, capped ends, fill material, etc.) and entered in the field notebook.

A total of twelve soil samples will be taken from around the site. Samples will be analyzed for TCL volatile organics (plus Freon), TCL semi-volatile organics, and TAL metals. Quick-turnaround analysis for total mercury will be employed to determine whether or not a mercury problem exists at the site. If the quick-turnaround analytical results indicate mercury contamination, limited corrective action is included to address the problem. Standard CLP methods for total mercury will be employed but with quick reporting.

If mercury contamination is present, corrective action may be more difficult than Mercury Burial Site I. At Mercury Burial Site I, the extent of contaminated soils are expected to be minimal since the three concrete blocks have already been investigated and the only remaining issue is one concrete pipe. Conversely, Mercury Burial Site II has not yet been found. Volumes of contaminated soil may be significant. Also, contaminants other than mercury may be present.

In any case, if obvious mercury contamination is encountered, it is preferable to address the problem while the excavation is still open. Therefore, if mercury contamination is not widespread, limited corrective action is recommended. Limited corrective action includes excavation of any mercury-contaminated soil. An additional 10 samples will be collected and analyzed (if warranted) only for total mercury, upon receiving the analytical results from the initial mercury analysis. These samples will attempt to determine the extent of contamination. Quick turnaround analysis will again be employed. The action level for excavation will be 20 mg/kg in accordance with RCRA Proposed Subpart S criteria for mercury. Note that

a site-specific Media Protection Standard (MPS) value for mercury was not developed since mercury has not been detected to date at significant concentrations. Disposal of any containerized/labeled mercury-contaminated soil and/or concrete vault(s)/pipe(s) at an approved hazardous waste landfill will be the responsibility of NSY Portsmouth. Note that the concrete block(s)/concrete pipe(s) are expected to be large (and heavy) and it would be difficult, and perhaps unnecessary, to attempt removal without a health and safety evaluation and spill plan. If removal is selected, the work will be conducted by the excavator subcontractor, who must have experience in this time of work. Oversight will be provided by Halliburton NUS. Any limited corrective action conducted during the field work, does not preclude further corrective measures at a later date.

Test pits will be roped off upon completion of each day's work activities. Draeger tubes and a Jerome analyzer for volatile mercury may aid in determining sample locations, although inorganic mercury would not be detected. As discussed in the Health and Safety Plan (Appendix C), Draeger tubes and the Jerome analyzer will also support health and safety considerations, in combination with cartridge respirators.

Also, after all samples and field measurements are taken and after all limited removal actions are complete, the excavated area will be backfilled with the original fill material and the entire lot repaved. Due to slope considerations, it is anticipated that a large area will be affected, necessitating repaving of the lot rather than simple asphalt repair. Special compaction procedures may be employed to provide a level surface suitable for paving. Compaction will be conducted so as not to result in settlement of the paved surface. Repaving will be the responsibility of Halliburton NUS (via a subcontractor), since NSY Portsmouth requires that all IR investigations restore any site to existing conditions. Additionally, repair of the existing fencing around the J-Boat area will be required.

Scenario 2 - Mercury Burial Site II Not Located

If Mercury Burial Site II is not located, no contingency plans are provided at this time, other than evaluating long-term groundwater monitoring considerations.

3.3 GROUNDWATER INVESTIGATIONS

3.3.1 RFI Report Comment

Confirm that groundwater discharges from the bedrock aquifer to the surficial aquifer.

3.3.2 Response

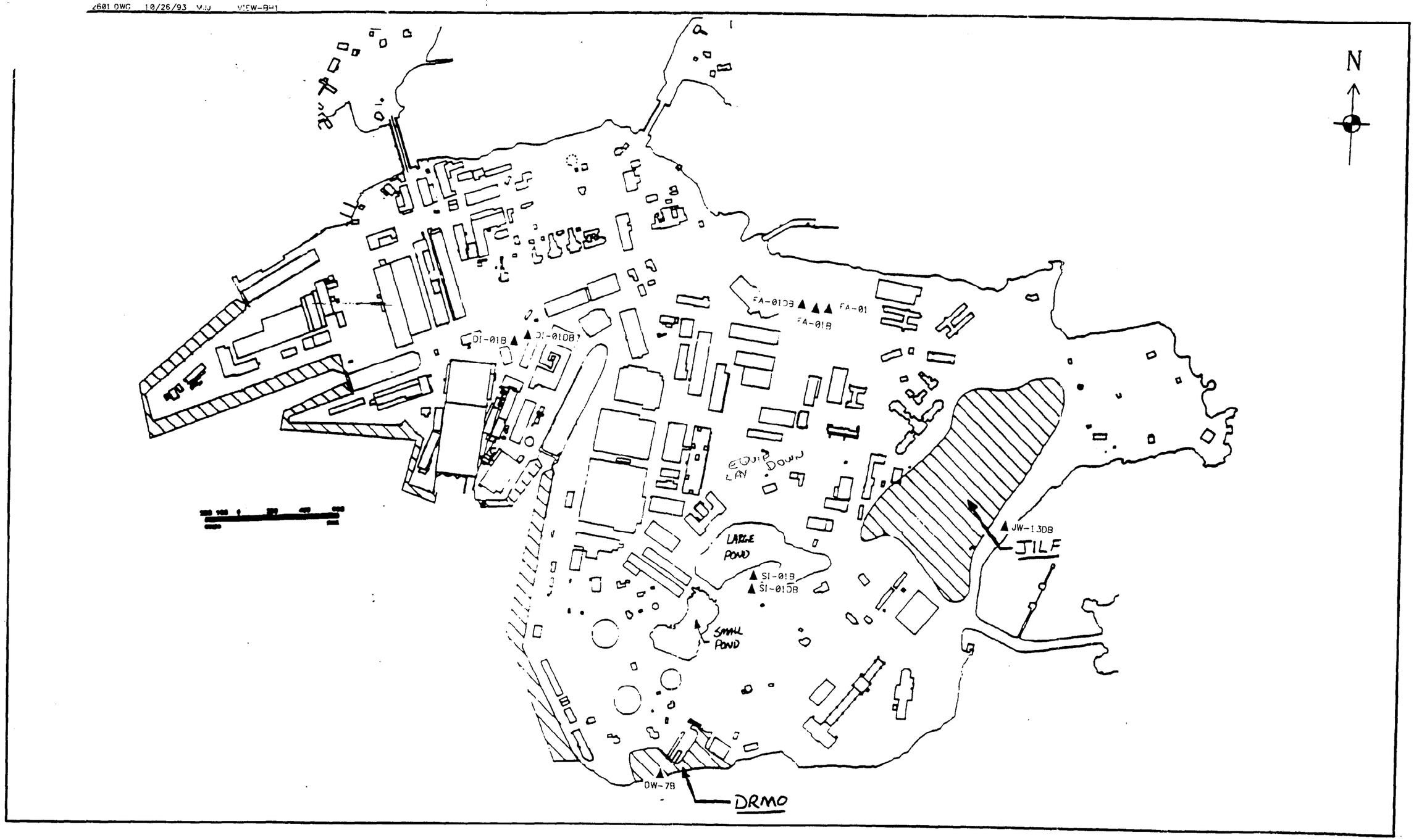
To help fully understand bedrock groundwater movement, a facility-wide mapping effort will be constructed to investigate the relationship between the original bedrock islands, fill areas, groundwater, and ponds. General mapping of contaminated vs. noncontaminated areas will be conducted as well. (Additionally, although not part of the facility-wide mapping effort, groundwater isoconcentration maps may be prepared for plumes identified through the effort described in Section 3.4). The mapping effort is not a groundwater modelling effort. Instead, it will allow overall visual interpretation of the conditions at the facility.

Three new shallow/deep bedrock well clusters are planned to investigate groundwater flow conditions in bedrock and to evaluate bedrock/surficial aquifer/pond interrelationships; 1 in the center of Dennett's Island, 1 near the ponds on Seavey Island, and 1 in the fill area between Seavey and Dennett's Island. In addition, deep bedrock wells will be installed on Jamaica Island adjacent to existing shallow bedrock well JW-13B to form a 4th cluster (this new well is also described in Section 3.4.2.3) and at the DRMO adjacent to existing shallow bedrock DW-07B to form a 5th cluster (this new well is also described in section 3.4.2.4. Each cluster will consist of two bedrock wells; 1 approximately 20-25 feet into bedrock and 1 approximately 80-100 feet into bedrock. Additionally a shallow overburden well will be installed within the fill area cluster between Seavey and Dennett's Island. Figure 3-2 locates the proposed well locations.

Upon completion of the field operations the locations all new wells will be located vertically (elevation) and horizontally. Slug tests and water level measurements are also required for each new well. All existing monitoring wells at the facility will also require water level measurements.

The use of slug test data will provide information on horizontal hydraulic conductivity but only limited information on vertical hydraulic conductivity. The slug test data for wells screened at various depths and in different units will be analyzed to develop overall hydraulic conductivity estimates for each strata/depth. These hydraulic conductivity values will be compared to evaluate trends in hydraulic conductivity both vertically within a hydrogeologic unit and in different hydrogeologic units.

Groundwater samples will be collected from the eight newly installed bedrock wells, the new overburden well in the fill area, and associated existing wells for each cluster. Samples will be analyzed for TCL volatiles (plus Freon) and TCL semi-volatiles, total and dissolved TAL metals, fuel oil and gasoline, common water quality cations and anions, tritium, and salinity. The common cations and anions, tritium, and salinity analyses will be used to determine the source of the bedrock groundwater and the degree of



BEDROCK WELL CLUSTERS
PORTSMOUTH NAVAL SHIPYARD
KITTERY, MAINE

FIGURE 3-2

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mixing with overburden groundwater and/or surface water. Tritium analysis is conducted for groundwater age dating purposes only and not as a contaminant of concern.

Several field activities will be performed to investigate the interrelationship between the two ponds on Seavey Island and the groundwater in order to quantify the groundwater discharge rate to the ponds and to help in conceptualizing the hydrogeologic conditions at NSY Portsmouth. Piezometers installed at the ponds will aid in the determination of whether potential upwelling of groundwater is occurring. A dye tracer study and outflow measurement (including rain gauge) will aid in determining the pond discharge location and will aid in evaluating shallow groundwater flow rates and directions near the southern end of the JILF. Collection of a few surface water/sediment samples will aid in data evaluation by having all information at one point in time.

Staff gauges will be installed within the two ponds to obtain surface water elevation data. Ten piezometers will be installed within the bottom sediments in the larger pond and 8 in the smaller pond to determine the direction and source of water flow at the surface water/groundwater interface. Piezometers will be constructed of 1 to 2-inch diameter clear plastic tubing/pipe. The piezometers will be evenly distributed across each pond. Samples will be collected from each piezometer and analyzed only for tritium for groundwater age dating purposes.

Two surface water/sediment samples will be obtained from each pond. These samples are being collected as a possible aid in the hydrogeology investigation. Although surface water/sediment samples were collected as part of the initial RFI, it is recommended that all data in support of the hydrogeology investigation be collected at one point in time. Additionally, the executive summary of the original RFI report notes that the source of volatile compounds is not known. It is possible that the unknown source is groundwater upwelling. Figure 3-3 shows the approximate locations of the surface water/sediment samples. Samples will be analyzed for TCL volatile organics and TCL semi-volatile organics, total and dissolved TAL metals, common groundwater cations and anions, tritium for groundwater age dating purposes, and salinity.

To determine the rate of outflow from the ponds a mechanical continuous flow monitor will be fitted in the existing discharge box at the downstream pond. Note that the upstream pond discharges to the downstream pond. Additionally, a rain gauge will be utilized to monitor rainfall during the RFI Data Gap investigation.

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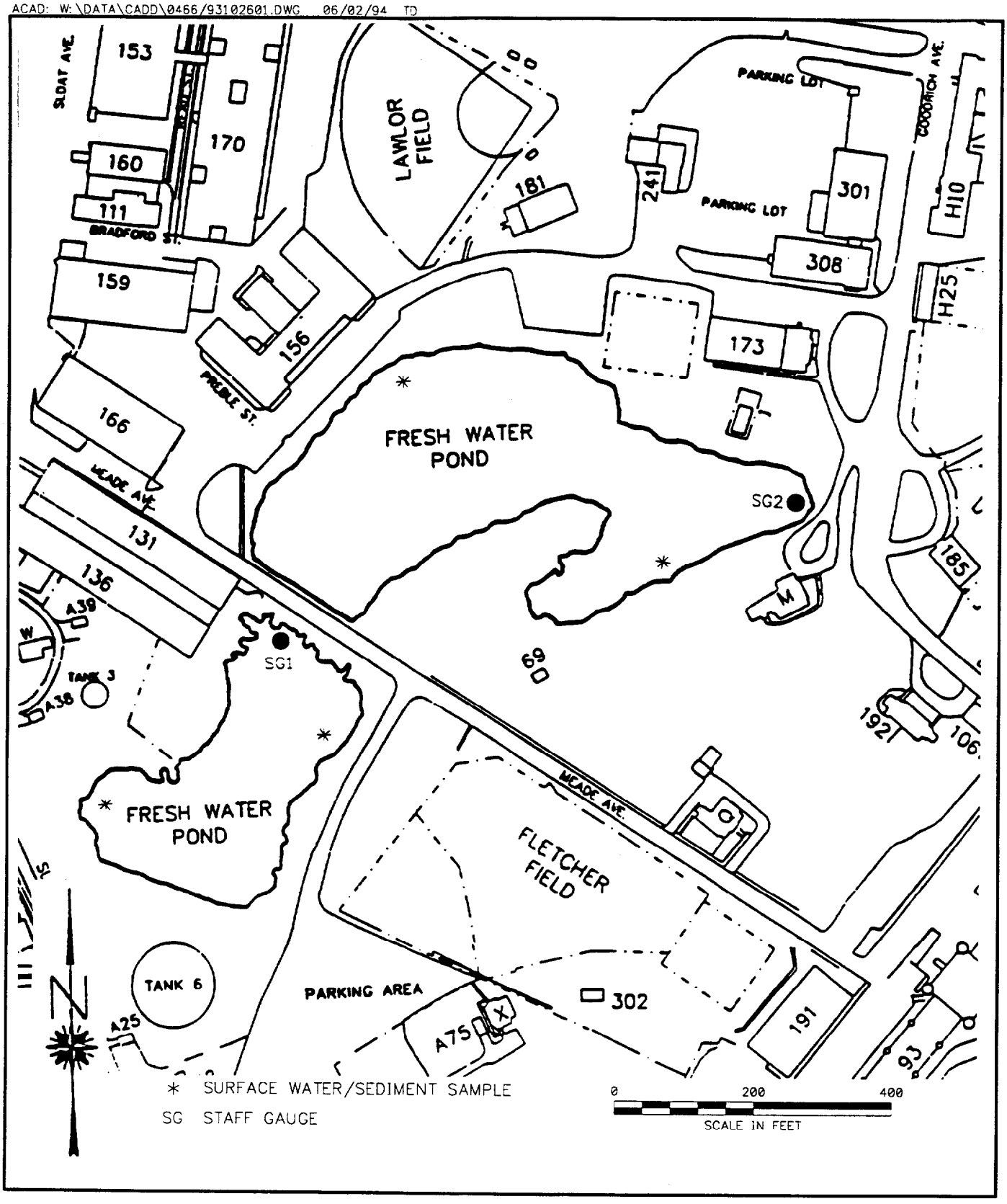

FRESH WATER PONDS
PORTSMOUTH NAVAL SHIPYARD
KITTERY, MAINE

FIGURE 3-3

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The discharge area for the ponds will be determined by a dye tracer test using Rhodamine WT, a fluorescent dye. A dye tracer test is important because the discharge location of the ponds is currently unknown. The continuous discharge of water from the ponds to the overburden aquifer will influence local groundwater flow patterns (and potentially groundwater quality); thus identification of the location of the discharge will enhance the overall understanding of groundwater flow patterns.

Figure 3-4 shows likely discharge areas. Prior to beginning the tracer test, samples will be obtained from two nearby monitoring wells (JW-9 and MW-6) and seep locations and analyzed for Rhodamine WT, to ensure that Rhodamine WT or a false indicator is not present. If a positive result is obtained from the samples due to background interferences, a substitute tracer will be identified for use.

Dye tracer test samples will be collected twice a week (until the dye is detected) at likely discharge areas, including the monitoring wells near Mercury Burial Site II and nearby surface seeps. If the dye test is not successful by the end of the other field activities, the test will be terminated.

Dye tracer test samples will be analyzed using a filter fluorometer. The filter fluorometer is an instrument that detects the presence of dye through fluorescence, using an ultraviolet light source, and a variety of filters which correspond to the adsorption and emission wavelengths of the dye. A filter fluorometer was selected for use as it is relatively quick and simple to use and produces dependable results. During the tracer test, grab samples will be obtained directly from the wells/seeps monitored, using bailers for wells and glass bottles/vials for seeps. Sample preparation and equipment preparation (instrument calibration, sample pH and turbidity adjustment) will take place in accordance with the analytical instrument manufacturer's recommendations. Additionally, charcoal packets will be installed as part of the dye tracer study to detect possible releases which may be occurring not during the sampling period.

The collection of groundwater discharge (seeps) from the JILF is included as part of the ongoing offshore study to aid in the determination of nature and extent of contamination being released from the JILF (SWMU #8). Data from the offshore study will be incorporated/referenced to enhance the overall understanding of the site hydrogeology and the discharge of contaminants from the JILF into Clark's Island Embayment. In addition, seeps emanating from the JILF will be observed at low tide and at a frequency of three times a week, preliminarily. Then three seeps will be selected for additional observation and sampling. Sampling will consist of field measurement of specific conductivity to evaluate salinity. No chemical analysis for seeps is planned; chemical analysis for seeps was included as part of the offshore study.

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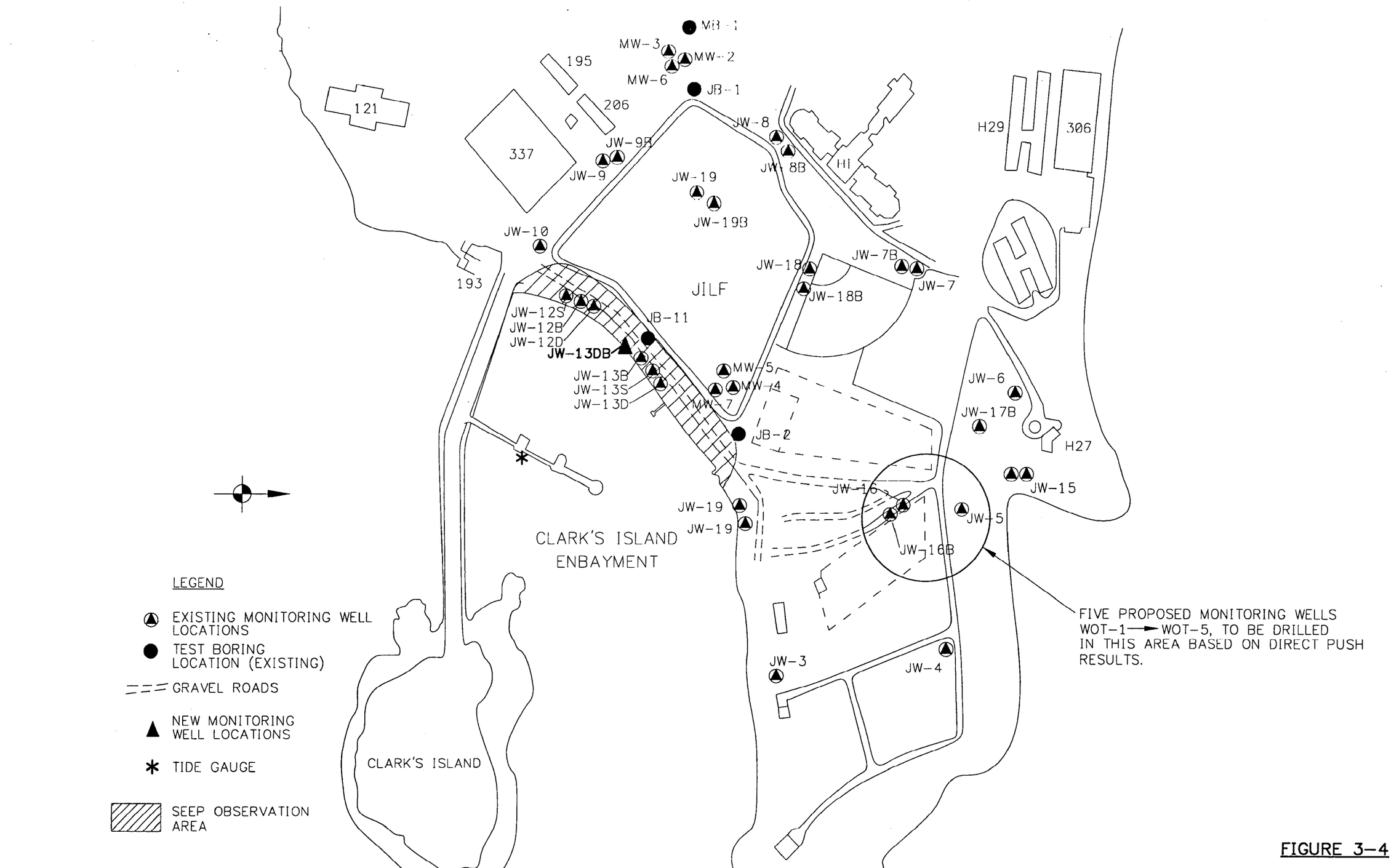

JILF (SWMU #8 SMWU #11) MONITORING WELL, TIDAL GAUGE MONITORING WELL LOCATION AND TIDAL GAUGE PORTSMOUTH NAVAL SHIPYARD, KITTERY, MAINE

FIGURE 3-4

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Frequency for each of the three seeps will be one sample per hour for 1 day. However, seep sampling will only take place during groundwater discharge. Locations and relative flow rates of the seeps will be recorded to document any seep discharges from the landfill.

3.4 EXTENT OF GROUNDWATER CONTAMINATION

3.4.1 RFI Report Comment

Investigate and determine the nature and extent of plumes of volatile and semi-volatile organic compounds detected in the vicinity of Mercury Burial Site II (SWMU #9), the former Buried Waste Oil Tanks (SWMU #11), and monitoring well JW-13B at the JILF (SWMU #8).

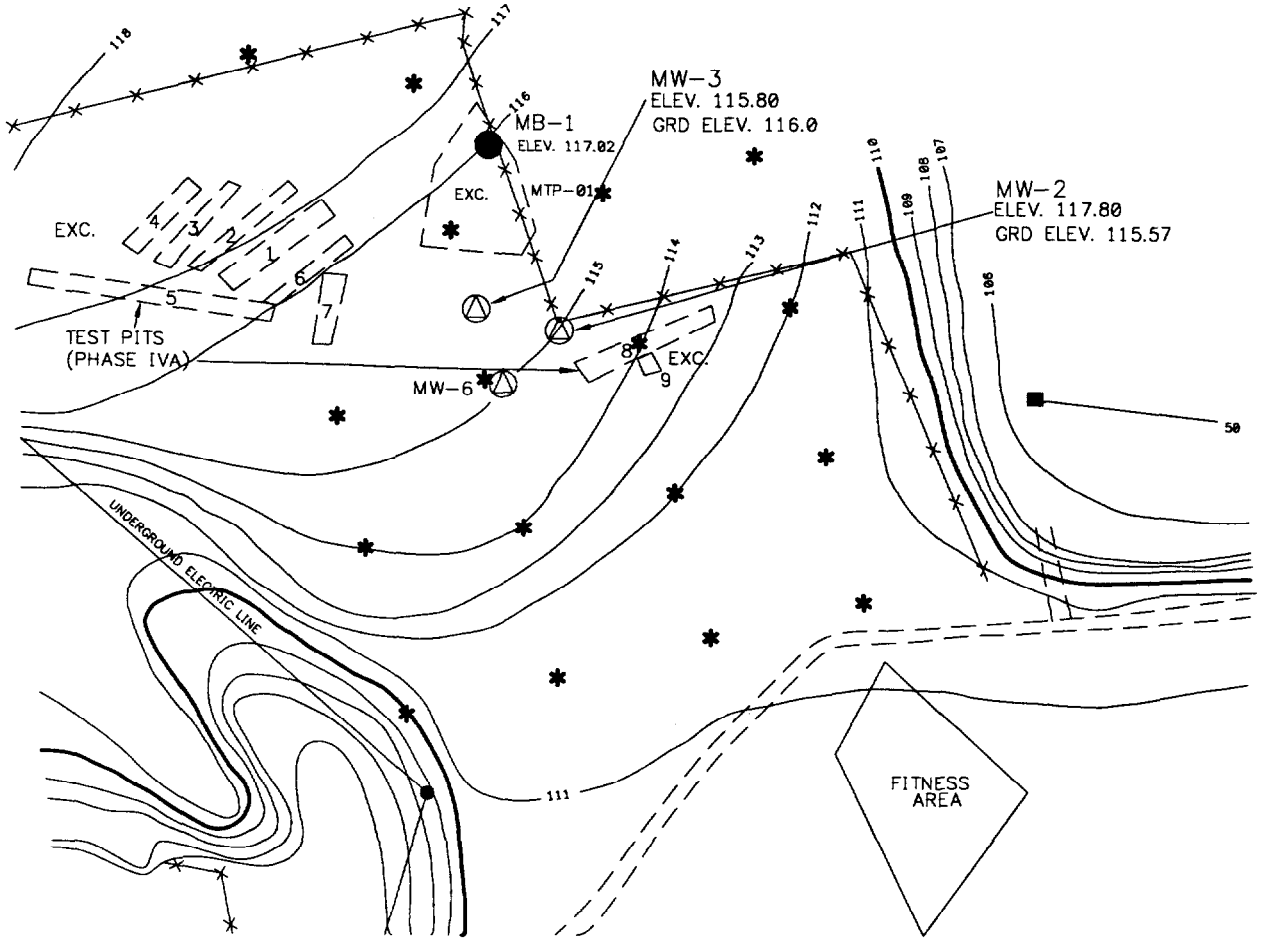
3.4.2 Response

3.4.2.1 Mercury Burial Site II Area (Upgradient of SWMU #9)

The organics plume near Mercury Burial Site II is likely due to the use of residual contaminated fill placed in that area of the JILF Landfill or an abandoned upgradient gas station.

This work scope is written to allow a flexible approach to conducting the work. Either temporary wells and conventional soil boring drilling or direct push technology is acceptable in accomplishing the work. Similarly, either on-site mobile laboratory capabilities or use of an offsite laboratory is acceptable, provided that analytical results are available on a 24-hour quick turnaround basis. Soil gas field screening for volatiles should be conducted using an OVA, or equivalent. Results will be immediately provided to Halliburton NUS. Chemical-specific analysis is not required for soil gas samples.

"Direct Push" technology, or the use of temporary monitoring wells, will be used to sample groundwater in numerous locations, thereby allowing optimum placement of subsequent permanent monitoring wells. A subcontractor will be required to conduct this specialty work. Groundwater samples will be collected from each direct push location and analyzed for volatile organics (and petroleum product fingerprinting) using the subcontractor's onsite mobile laboratory, or a portable GC, or an offsite laboratory with quick turnaround analysis. Figure 3-5 illustrates the planned locations for the initial grid. The complete work scope is summarized below:



LEGEND

- EXISTING MONITORING WELL
- SOIL BORING LOCATION (EXISTING)
- SOIL GAS LOCATION/ DIRECT PUSH LOCATION

NOTE: ONE MONITORING WELL, MW-08, TO BE INSTALLED WITHIN GRID AREA BASED ON DIRECT PUSH RESULTS

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SOIL GAS LOCATIONS/DIRECT PUSH LOCATIONS
SWMU #9 PLUME (MERCURY BURIAL SITE II AREA)
PORTSMOUTH NAVAL SHIPYARD
KITTERY, MAINE

FIGURE 3-5

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- Collect 1 soil gas sample and 1 groundwater sample at each of 18 initial locations shown on Figure 3-5. Analyze groundwater sample for select volatile organics and conduct petroleum product fingerprinting.

- Based on HNUS evaluation of analytical results, collect 1 soil gas sample and 1 groundwater sample at up to 4 additional locations. Analyze groundwater sample for select volatile organics and conduct petroleum product fingerprinting.

- For each direct push point, one soil gas sample will be collected and screened using an OVA. Soil gas readings will be taken until readings peak and begin to recede, or for a maximum time interval of 3 minutes. Soil gas data will aid in identifying the potential source area(s). Additionally correlations, or lack thereof, between soil gas data and groundwater samples from direct push methods can be established.

The groundwater samples will be analyzed by the subcontractor for volatile organics using method SW 846 5030/8010 or equivalent procedure approved by Halliburton NUS. The reportable detection limits will be 5 to 10 ug/l. Internal quality assurance and equipment calibration will be conducted by the subcontractor on a daily basis in accordance with the equipment manufacturer. This documentation will be provided to Halliburton NUS with the final report. The samples, at a minimum, shall be analyzed for the following volatile organic target compounds:

Benzene	Ethylbenzene
1,1-dichloroethene (DCE)	c-1,2-DCE
t-1,2-DCE	1,1-dichloroethane (DCA)
Trichloroethene (TCE)	Tetrachloroethene (PCE)
1,1,1 trichloroethane (TCA)	1,1,2-TCA
Chloroform	Carbon tetrachloride
Toluene	Total (m-, p-, and o-,) xylenes
Methylene chloride	Freon-113

The petroleum product fingerprinting will be conducted to determine the type of petroleum product (gasoline, fuel oil, etc.) and to determine the approximate concentration.

Soil gas readings will be taken until readings peak and begin to recede, or for a maximum time interval of 3 minutes. Soil gas data will aid in identifying the potential source area(s). Additionally correlations,

or lack thereof, between soil gas data and groundwater samples from direct push methods can be established.

It is possible that results will show there is no real contaminant problem associated with the potential petroleum plume. The RFI SWMU #9 investigation centers around MW-03 where gasoline and lube oil were indicated (refer to RFI Table 5-11). The source is unidentified and contaminated fill is suspected. According to Table 5-26 of the RFI, benzene, chlorobenzene, and ethylbenzene were present at this location at low to low/moderate exceedences of drinking water standards. It is therefore planned to include petroleum product fingerprinting for each direct push point location and each permanent monitoring well to aid in defining the potential plume. Note that a plume may be difficult to identify since SWMU #9 is located very near the JILF Landfill.

Based on the findings of the direct push technology/soil gas survey one shallow monitoring well will be installed. The permanent monitoring well will be installed within a hot spot area indicated by the direct push/soil gas survey, and is to be used to determine if groundwater has been impacted by petroleum product. The well will be installed so that the screen straddles the water table, so that any free product present will be detected. Before drilling begins, a magnetometer survey will be performed as a check for the presence of underground utilities.

A groundwater sample will be collected using a Teflon bailer and analyzed for TCL volatile organics (plus Freon) and TCL semi-volatile organics, lead, and fuel oil and gasoline. Also free product will be measured (if encountered) with an interface probe.

Upon completion of the field operations the monitoring well will be located vertically (elevation) and horizontally. Slug tests and water level measurements are also required.

3.4.2.2 Former Buried Waste Oil Tanks (SWMU #11)

This work scope is written to allow a flexible approach to conducting the work. Either temporary wells and conventional soil boring drilling <u>or</u> direct push technology is acceptable in accomplishing the work. Similarly, either on-site mobile laboratory capabilities or use of an offsite laboratory is acceptable, provided that analytical results are available on a 24-hour quick turnaround basis. Soil gas field screening for volatiles should be conducted using an OVA, or equivalent. Results will be immediately provided to Halliburton NUS. Chemical-specific analysis is not required for soil gas samples.

The intent of the investigation at the former Buried Waste Oil Tanks is to determine the nature and extent of plumes of volatile and semi-volatile organic compounds associated with the former Buried Waste Oil Tanks (SWMU #11). Additionally, the investigation will support installation of a new hazardous waste storage area near this SWMU. The investigation will consist of "Direct Push" technology (or temporary monitoring wells), a soil gas survey, and the installation/sampling of up to five shallow monitoring wells to determine the extent of contamination.

"Direct Push" technology (or temporary monitoring wells) will be used to sample groundwater in numerous locations, thereby allowing optimum placement of subsequent permanent monitoring wells. A subcontractor will be required to conduct this specialty work. Groundwater samples will be collected from each direct push location and analyzed for volatile organics (and petroleum product fingerprinting) using the subcontractor's onsite mobile laboratory, or a portable GC, or an offsite laboratory using quick turnaround analysis. Figure 3-6 illustrates the planned locations for the initial grid. A complete summary of the work scope is summarized as follows:

- Collect 1 soil gas sample and 1 groundwater sample at each of 32 initial locations shown on Figure 3-6. Analyze groundwater sample for select volatile organics and conduct petroleum product fingerprinting.

- Based on HNUS evaluation of analytical results, collect 1 soil gas sample and 1 groundwater sample at up to 4 additional locations. Analyze groundwater sample for volatile organics and conduct petroleum product fingerprinting.

- Collect one "contaminated" soil sample at very near 14 (7 transects x 2 locations/transect) of the 32 initial locations, based on HNUS evaluation of soil gas and groundwater results. Also, two duplicate samples will be collected. These samples will be sent offsite by Halliburton NUS for TCL volatile organics (plus Freon), TCL semi-volatile organics, TCL pesticides/PCBs, and TAL analysis.

- Collect one "clean" soil sample at up to 6 additional locations along a given transect (3 transects x 2 locations/transect). Also, 1 duplicate sample will be collected. These samples will be sent offsite by Halliburton NUS for TCL volatile organics (plus Freon), TCL semi-volatile organics, TCL pesticides/PCBs, and TAL analysis.

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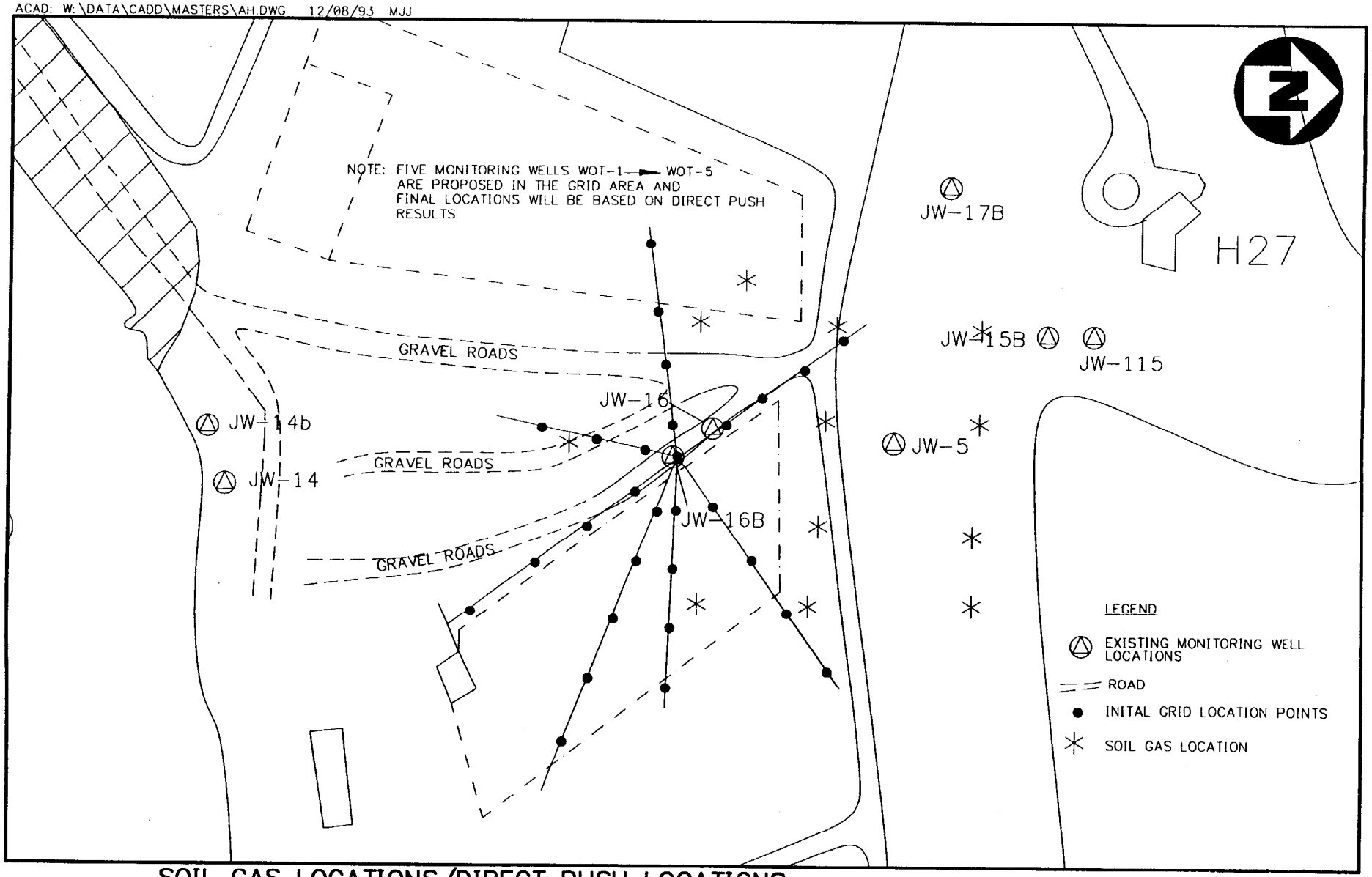

SOIL GAS LOCATIONS/DIRECT PUSH LOCATIONS
SWMU #11 PLUME (FORMER WASTE OIL STORAGE TANKS)
PORTSMOUTH NAVAL SHIPYARD – KITTERY, MAINE

FIGURE 3-6

HALLIBURTON NUS
Environmental Corporation

- In collecting the "clean" soil samples, one "contaminated" soil sample at up to 3 additional locations along a given transect (3 transects x 1 location/transect) may be collected. These samples will be sent offsite by Halliburton NUS for TCL volatile organics (plus Freon), TCL semi-volatile organics, TCL pesticides/PCBs, and TAL analysis.

The groundwater samples will be analyzed by the subcontractor for volatile organics using method SW 846 5030/8010 or equivalent procedure approved by Halliburton NUS. The reportable detection limits will be 5 to 10 ug/l. Internal quality assurance and equipment calibration will be conducted on a daily basis in accordance with the equipment manufacturer. This documentation will be provided to Halliburton NUS with the final report. The samples, at a minimum, will be analyzed for the following volatile organic target compounds:

Benzene	Ethylbenzene
1,1-dichloroethene (DCE)	c-1,2-DCE
t-1,2-DCE	1,1-dichloroethane (DCA)
Trichloroethene (TCE)	Tetrachloroethene (PCE)
1,1,1 trichloroethane (TCA)	1,1,2-TCA
Chloroform	Carbon tetrachloride
Toluene	Total (m-, p-, and o-,) xylenes
Methylene chloride	Freon-113

The petroleum product fingerprinting will be conducted to determine the type of petroleum product (gasoline, fuel oil, etc.) and to determine the approximate concentration.

Soil gas readings will be taken until readings peak and begin to recede, or for a maximum time interval of 3 minutes. Soil gas data will aid in identifying the potential source area(s). Additionally correlations, or lack thereof, between soil gas data and groundwater samples from direct push methods can be established.

It is possible that results will show there is no real contaminant problem associated with the potential petroleum plume. The RFI SWMU #11 investigation centers around JW-16 near where the former waste oil tanks were located. The RFI (Table 5-11) indicates that #4 Fuel Oil and #6 Fuel Oil were present. According to Table 5-17 of the RFI, only benzene was identified as exceeding drinking water standards; however, the maximum benzene concentration at this location was only 11 ug/l. It is therefore planned to include petroleum product fingerprinting for each direct push point location and each permanent

monitoring well to aid in defining the potential plume. Note that a plume may be difficult to identify since SWMU #11 lies adjacent to the JILF Landfill.

Based on the direct push technology/soil gas survey findings, up to 5 shallow wells will be installed at SWMU #11 to determine extent of contamination. For three of the five new wells, the screens will be installed to cross the water table, so that any free product present will be detected. For the remaining two wells, the screens will be installed just above bedrock to investigate potential Freon contamination or other Dense Non-Aqueous Phase Layer (DNAPL).

An examination of historical aerial photos of the JILF landfill was conducted to determine if drilling locations are in areas filled in or around 1955 (i.e., 1950 through 1960 to allow a safety factor), the period on record when chlorine gas and acetylene cylinders were reportedly buried in this area. Field activities will proceed in Level B health and safety for the area designated in Figure 3-6, as described in the Health and Safety Plan (Appendix C). In addition a magnetometer survey will be conducted before drilling to check for the presence of buried ferromagnetic objects.

Groundwater samples will be collected from the five newly installed wells using Teflon bailers and analyzed for TCL volatile organics (plus Freon), TCL semi-volatile organics, TCL pesticides/PCBs, total and dissolved TAL metals, fuel oil and gasoline. Also, free product will be measured (if encountered) with an interface probe.

Upon completion of the field operations the locations of the monitoring wells will be located vertically (elevation) and horizontally. Slug tests and water level measurements are also required.

3.4.2.3 Monitoring Well JW-13B at the JILF (SWMU #8)

The intent of the investigation at monitoring well cluster JW-13 is to determine the nature and extent of volatile and semi-volatile organic contamination associated with monitoring well JW-13B. The JW-13 well cluster is on the edge of the island, with well clusters located to either side and upgradient. These wells adequately define the lateral extent of contamination, however the vertical extent is not yet delineated. The proposed investigation for this area will consist of the installation of one deep bedrock well adjacent to monitoring well JW-13B. This new well is also described in Section 3.3.2. Before drilling begins, a magnetometer survey of the area will be performed to check for underground utilities and to check for the presence of buried ferromagnetic objects.

Groundwater samples will be collected from both the new monitoring well and 3 existing wells at well cluster JW-13. Samples will be analyzed for TCL volatile organics, TCL semi-volatile organics, common groundwater quality cations and anions, tritium for groundwater age dating purposes, and salinity. (Additionally, hexavalent chromium analysis will be included as a field measurement).

Upon completion of the field operations the location of the new monitoring well will be located vertically (elevation) and horizontally. Slug tests and water level measurements are also required.

3.4.2.4 DRMO (SWMU #6)

In addition to the plume investigations requested in the RFI Report comment, a limited investigation of the vertical extent of groundwater contamination at the DRMO (SWMU #6) will be performed. Also, this well will aid in the hydrogeology investigation by creating a well cluster at DW07. The new deep bedrock well will be installed adjacent to existing monitoring wells DW-07 and DW-07B, which are located along the downgradient edge of the DRMO. This will provide information regarding vertical gradients, differences in tide effects with depth, and vertical trends in chemical characteristics for groundwater.

The DRMO was capped in the fall of 1993. The cap consisted of a geotextile layer which was placed over the graded DRMO surface soils, then a geocomposite "Bentomat" layer was placed over the geotextile, which was covered with 12 inches of a stone/concrete aggregate. Because the new bedrock monitoring well lies within the capped area, the well will be flush mounted and backfilled with bentonite pellets to maintain the integrity of the existing cap.

This new well is also described in Section 3.3.2. Before drilling begins, a magnetometer survey of the area will be performed to check for underground utilities. Figure 3-7 shows the approximate location for the placement of DW-07DB.

Groundwater samples will be collected from the new monitoring well and the two existing monitoring wells at cluster location DW-07. Samples will be analyzed for TCL volatile organics (plus Freon) and TCL semi-volatile organics, total and dissolved TAL metals, common groundwater quality cations and anions, tritium for groundwater age dating purposes, and salinity. (Additionally, hexavalent chromium analysis will be included as a field measurement).

Upon completion of the field operations the location of the monitoring well will be located vertically (elevation) and horizontally. Slug tests and water level measurements are also required.

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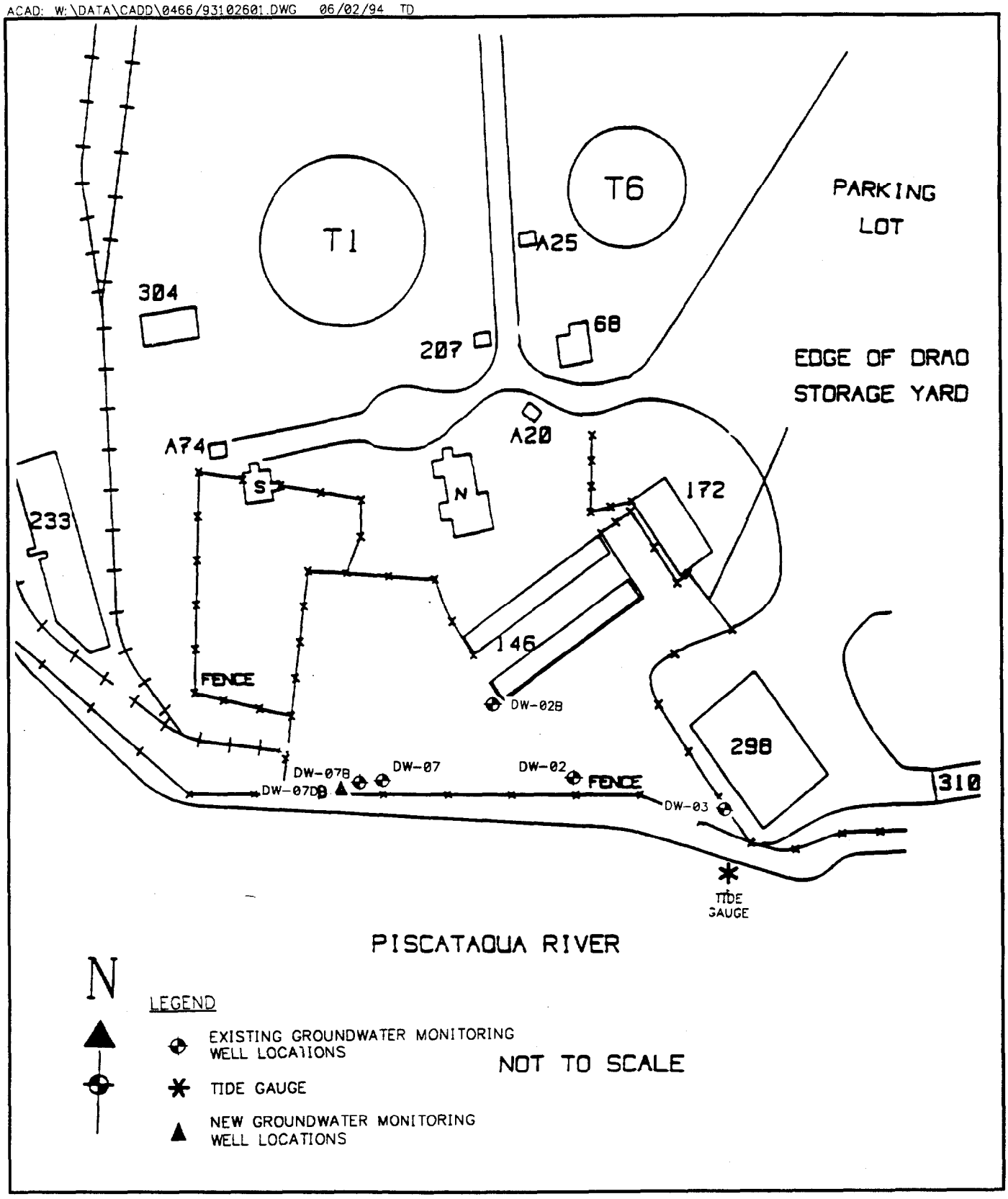

DRMO FACILITY
& TIDAL GAUGE LOCATION
PORTSMOUTH NAVAL SHIPYARD
KITTERY, MAINE

FIGURE 3-7

Halliburton NUS CORPORATION

3.5 TIDAL STUDY

3.5.1 RFI Comment

Investigate and re-evaluate the effect of the tides in the Piscataqua River on the groundwater at the DRMO (SWMU #6) and the JILF (SWMU #11).

3.5.2 Response

Extensive field work was performed during the recent RFI to characterize tidal fluctuations in groundwater. Based on a review of the data, two data gaps were identified; the lack of actual tidal gauge information at the DRMO and a need to perform a comprehensive overall assessment of tidal effects on groundwater. Limited field work and data reinterpretation are proposed to address these data gaps, since a considerable data base regarding water levels already exists and detailed long-term water level monitoring can be costly to perform and evaluate.

The acquisition of additional field data from only the select monitoring wells identified in the RFI Data Gap Work Plan are deemed necessary. Other monitoring well data will be calibrated from the extensive tidal study conducted as part of the original RFI, and all wells will be considered in the re-evaluation of the tide data.

To address the lack of tidal information for the DRMO, a tidal gauge will be installed in the immediate vicinity of the DRMO Site. Water levels will be measured over a 50 hour period at the tidal gauge and the well previously used to represent tidal fluctuations (DW-3). The data will then be correlated against the data generated during the RFI Phase IV investigation. Based on the correlation between the tide and DW-3 well measurements, corrections will be made to the original RFI data and the RFI tidal study will be reevaluated.

Gradients established during the initial RFI for the DRMO and the JILF will be redefined. A sufficient number of pressure transducers/data loggers would be required to obtain water level data from select wells at varying distances from the river to evaluate the magnitude and timing of tidal responses. DRMO wells DW-03, DW-04, and DW-07 are the minimum number recommended for simultaneous long-term water level measuring, in addition to the tidal gauge. Data would be collected for 25 hours, in 15-minute increments from both the shallow aquifer and the bedrock aquifer. The 25 hour period ensures that data from two complete tidal cycles will be collected.

Additionally, all new wells (17) at the facility will be data logged (not simultaneously except for well clusters) in both bedrock and shallow wells for 25 hours in 15 minute intervals. Tidal gauges at the JILF and the DRMO will support this activity. Refer to Figure 3-7 and Figure 3-4 for approximate locations of the tidal gauges for the DRMO and the JILF, respectively.

The data interpretation performed for the RFI will be expanded to provide a more comprehensive assessment of tidal effects on groundwater. The mapping effort for bedrock/fill/groundwater will be used in conjunction with the tidal information to provide a more complete picture of tidal effects on the island. The high tide and low tide measurements will provide the maximum range of tidal influence for the given day of testing. However, tidal influences are a significant influence at the site which cannot be completely captured by the potentiometric water table maps.

4.0 SITE MANAGEMENT

4.1 PROJECT STAFFING

The Halliburton NUS Project Manager is:

Linda Klink
Halliburton NUS
Foster Plaza 7
661 Andersen Drive
Pittsburgh, PA 15220
Phone: (412) 921-8650
Fax: (412) 921-4040

Support staff include geology, engineering, chemistry, health and safety, and drafting personnel.

4.2 BASE SUPPORT

The Navy Remedial Project Manager (RPM) is:

Lt. Jim Conroy, Remedial Project Manager
Northern Division
Naval Facilities Engineering Command
10 Industrial Highway, Mail Stop #82
Lester, PA 19113
Phone: (215) 595-0567
Fax: (215) 595-0555

The NSY Point of Contact is:

Jim Tayon, Environmental Engineer
Portsmouth Naval Shipyard
Portsmouth, NH 03801-2032
Attn: Code 121.5
Phone (207) 438-3832
Fax: (207) 438-1535

During field work, all deliverables should be mailed to the following address:

Dennis Gagnon, TSD
Building 313
Portsmouth Naval Shipyard
Portsmouth, NH 03801-2032
Phone: (207) 438-2558

Throughout the duration of the site characterization activities, various support functions will be provided by NSY Portsmouth personnel as described below:

- NSY Portsmouth will assist with the location of utilities and furnish up to date drawings and/or a Facilities & Maintenance (Public Works) point of contact. (Halliburton NUS will secure clearance for intrusive activities at each location with the point of contact before intrusion and will employ magnetometer as an additional measure of clearing utilities. Prior to mobilization, Halliburton NUS will conduct a site visit and stake out sample locations).
- Take custody of any drill cuttings, well development fluids or decontamination fluids suspected to be hazardous and requiring proper disposal according to applicable state and/or Federal regulations. Drums will be provided by NSY Portsmouth.
- Arrange for removal of boats, etc. in the area slated for trench excavation at Mercury Burial Site II. Access is required until the area is repaved.

In addition, NSY Portsmouth personnel will aid in arranging the following:

- Secure staging areas for decontamination operations and for storing equipment and supplies. More than one area may be required. The Navy suggests that a decon pad be located immediately behind and adjacent to Building 337 where a water hose bibb is usable on the outside of the building and a 110v outlet is available inside the building.
- A supply (e.g., fire hydrant, stand pipe, etc.) of large quantities of potable water and electricity for equipment cleaning, etc.
- Provide area for set up of field trailer near electric and phone service (Halliburton NUS will be responsible for arranging for connections).

4.3 CONTINGENCY PLAN

In the event of problems which may be encountered during the site inspection activities, the Halliburton NUS Project Manager will be notified immediately, followed by the NSY Portsmouth Point of Contact. The Project Manager will determine a course of action so as to not interfere with the schedule or budget. All contingency plans will be approved through the Navy RPM before being enacted.

REFERENCES

RCRA Facility Investigation Work Plan, August 1991. Portsmouth Naval Shipyard, U.S. Department of the Navy, Naval Facilities Engineering Command, Philadelphia, PA.

Draft RCRA Facility Investigation Report, July 1992. Portsmouth Naval Shipyard, U.S. Department of the Navy, Naval Facilities Engineering Command, Philadelphia, PA.

APPENDIX A

FIELD SAMPLING PLAN

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1.0 GENERAL FIELD GUIDELINES

1.1 SAMPLE IDENTIFICATION SYSTEM

Each sample collected will be assigned a unique sample tracking number. The sample tracking number will consist of a two-segment, alpha-numeric code that identifies the sample medium and location, and sample round identifier (in the case of groundwater samples). Any other pertinent information regarding sample identification will be recorded in the field log books.

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

(AAAA[N])	-	**(AANN)**	-	**(AANN)**
(Site ID)		(Location)		(Medium & Round Identifier)

Character Type:

A	=	Alpha
N	=	Numeric

Site ID:

JIL	=	Jamaica Island Landfill
MB1	=	Mercury Burial Site 1
MB2	=	Mercury Burial Site 2
DI	=	Dennets Island
SI	=	Seavey Island
FA	=	Fill Area
DRM	=	DRMO Facility
WOT	=	Former Waste Oil Tanks

Sample Location:

Groundwater sample = Monitoring well number

Surface water sample = Sample location number

Sediment sample = Sample location number

Soil sample = Soil boring number

Medium:

GW	=	Groundwater from monitoring well
SW	=	Surface water
SD	=	Sediment
SO	=	Soil

Sample Round Identifier:

For all samples = sampling round (this will be Phase 06 of the investigation for all sampling)

For example, a groundwater sample collected during from monitoring well 13DB at Jamaica Island Land Fill would be designated as: JILF-13DB-GW06

Field quality control (QC) samples will be designated using a different coding system. The QC code will consist of a two-segment, alpha-numeric code that identifies the sample medium (for duplicates only), QC type, and date. The same sample medium codes will be used as for the standard environmental samples (GW, SW, SD, and SO). The QC types are identified as:

TB = Trip Blanks
FB = Field Blanks
FD = Duplicates
RB = Rinsate Blanks

Matrix Spikes and Matrix Spike Duplicates (MS/MSD) samples will be designated on the field documentation forms and sample label. MS/MSDs are collected at a frequency of one per 20 samples per matrix and double or triple volumes of sample are required.

For example, a duplicate of a groundwater sample obtained on July 6, 1994 would be designated as: GWFD-070694

The sampling time recorded on the chain-of-custody form for duplicate and Matrix Spike/Matrix Spike duplicates samples will be 00:00 so that the samples are "blind" to the laboratory. Notes detailing the sample number, time, date, and type will be recorded in the field log book. Matrix Spike/Matrix Spike Duplicate samples will be collected from the same locations as duplicate samples in order to provide a "blind" sample to the laboratory.

1.2 SAMPLE HANDLING

Sample handling includes the field related considerations connected with the selection of sample containers, preservatives, allowable holding times, and analyses requested. Table 1-1 provides a summary of the analytical program and Table 1-2 presents all sample handling considerations. Section 5.0 of SOP-SF-1.2 provides a description of Sample Preservation Requirements.

1.3 SAMPLE PACKAGING AND SHIPPING

Samples will be packaged and shipped in accordance with SOP SA-6.2. The Halliburton NUS field representative will be responsible for completion of the following forms:

- Sample Labels
- Chain of Custody Forms
- Chain of Custody Seals
- Sample Log Sheets
- Federal Express Air Bills

Custody of samples must be maintained and documented at all times. Section 5.3 of SOP SA-6.1 provides a description of the chain of custody procedures to be followed. An example of the forms to be used is included in Appendix D

1.4 DOCUMENTATION

In addition to chain of custody records associated with sample handling and packaging, certain standard forms will be completed for sample description and documentation. These shall include sample log sheets, daily record forms, and logbooks. An example of these forms can be found in Appendix D.

A bound/weatherproof field notebook shall be maintained by each sampling event leader and shall record all information related to field activities. Section 5.0 of SOP-SF-6.3 provides a description of Site Logbook documentation requirements. Copies of all field notebooks will be forwarded to Northern Division (Attention: Rich Fini) at the end of each month.

TABLE 1-1
ANALYTICAL PROGRAM
NSY PORTSMOUTH
KITTERY, MAINE

Media	Analysis	Method	No. Samples	Trip Blank[1]	Rinsate Blank[2]	Field Blank[3]	Duplicate[4]	Total Samples
Groundwater	TCL volatiles plus Freon	CLP OLM01.8	20	5	5	2	2	34
	TCL semi-volatiles	CLP OLM01.8	19	-	4	2	2	27
	TCL pesticides/ PCBs	CLP OLMO1.8	5	-	2	2	1	10
	TAL metals[5] (Total)	CLP ILM03.0	17	-	4	2	2	25
	TAL metals[6] (Dissolved)	CLP ILM03.0	17	-	4	-	2	23
	Lead[5] (Total)	CLP ILMO3.0	1	-	1	2	1	5
	Lead[6] (Dissolved)	CLP ILMO3.0	1	-	1	-	1	3
	Tritium	EPA 906.0	32	-	-	-	4	36
	Chloride	EPA 325.2	14	-	-	-	2	16
	SO_4	EPA 375.4	14	-	-	-	2	16
	CO_3/HCO_3	SM 403	14	-	-	-	2	16
	Salinity	ALPHA 2520B	14	-	-	-	2	16
	TPH (Gasoline range)	Modified SW 846/8015	20	-	-	-	2	22
	TPH (Diesel Range)	Modified SW 846/8100	20	-	-	-	2	22
Surface Water	TCL volatiles	CLP OLM01.8	4	1	1	-	1	7
	TCL semi-volatiles	CLP OLM01.8	4	-	1	-	1	6
	TAL metals[5] (Total)	CLP ILM03.0	4	-	1	-	1	6
	TAL metals[6] (Dissolved)	CLP ILM03.0	4	-	1	-	1	6
	Chloride	EPA 325.2	4	-	-	-	1	5
	SO_4	EPA 375.4	4	-	-	-	1	5
	CO_3/HCO_3	SM 403	4	-	-	-	1	5
	Salinity	ALPHA 2520B	4	-	-	-	1	5

TABLE 1-1
ANALYTICAL PROGRAM
PORTSMOUTH NSY
KITTERY, MAINE
PAGE 2

Media	Analysis	Method	No. Samples	Trip Blank(1)	Rinsate Blank(2)	Field Blank(3)	Duplicate(4)	Total Samples
Sediment	TCL volatiles	CLP OLM01.8	4	1	1	-	1	7
	TCL semi-volatiles	CLP OLM01.8	4	-	1	-	1	6
	TAL metals	CLP ILM03.0	4	-	1	-	1	6
Soil	TCL volatiles plus Freon	CLP OLM01.8	35	6	6	-	5	52
	TCL semi-volatiles	CLP OLM01.8	35	-	6	-	5	46
	TAL metals	CLP ILM03.0	35	-	6	-	5	46
	TCL Pesticides/PCBs	CLP OLMO1.8	23	-	4	-	3	30
	Mercury (7)	CLP ILMO3.0	35	-	3	-	4	42

(1) Trip Blanks - Samples which originate from analyte-free water taken from the laboratory to the sampling site and returned to the laboratory with the volatile organic (VOA) samples. One trip blank per each cooler containing VOAs.

(2) Rinsate Blank - Samples obtained by pouring analyte-free water over sample collection equipment (bailer, etc.) after decontamination. Assesses the effectiveness of field decontamination procedure. Obtained at a frequency of 1/day/media/analysis. Number of samples reflects the number of actual laboratory analyses performed. Only samples from every other day will be analyzed.

(3) Field Blank - Samples consisting of the source water used in (1) steam cleaning and/or (2) decontamination. Obtained at a frequency of 1/event/media.

(4) Duplicates - A single sample split into two portions during a single act of sampling. Assess the overall precision of the sampling and analysis program. Obtained at a frequency of 10 percent of the number of samples.

(5) Total Metals - For the determination of total metals the sample is not filtered before acidification.

(6) Dissolved Metals - For the determination of dissolved metals the sample is filtered to 0.45μ before acidification.

(7) Quick turnaround analysis for mercury.

TABLE 1-2
SAMPLE CONTAINERS, PRESERVATION METHODS, AND HOLDING TIMES
NSY PORTSMOUTH
KITTERY, MAINE

Method	Parameter	Container Material	Sample Volume	Preservation	Holding Time	No. of Samples (a)
GROUNDWATER						
CLP OLM01.8	TCL Volatiles	Glass, Teflon-lined septa	(2) 40 ml	4 C; 4 drops HCl, pH < 2	14 days	20
CLP OLM01.8	TCL Semi-volatiles	Glass, Teflon-lined septum	2,500 ml	Cool, 4 C	Extract 7 days; Analyze 40 days	19
CLP OLMO1.8	Pesticides/ PCBs	Glass, Teflon-lined septum	4 liter	Cool, 4 C	Extract 7 days; Analyze 40 days	5
CLP ILMO3.0	TAL Metals (Total)	Plastic, glass	1 liter	4 C; HNO_3 to pH < 2	6 months*	17
CLP ILMO3.0	TAL Metals (Dissolved)	Plastic, glass	1 liter	4 C; HNO_3 to pH < 2	6 months*	17
CLP ILMO3.0	Lead (Total)	Plastic	1 liter	4 C; HNO_3 to pH < 2	6 months	1
CLP ILMO3.0	Lead (Dissolved)	Plastic	1 liter	4 C; HNO_3 to pH < 2	6 months	1
EPA 906.0	Tritium	Plastic	1 liter	None required	None	32
EPA 325.2	Chloride	Plastic, glass	50 ml	None required	28 days	14
EPA 375.4	SO_4	Plastic, glass	50 ml	Cool, 4 C	28 days	14
SM 403	CO_3/HCO_3	Plastic	1 liter	Cool, 4 C	14 days	14
ALPHA 2520B	Salinity	Wide mouth glass jar with Teflon-lined lid	240 ml	Cool, 4 C	7 days	14
Modified SW 846/8015	TPH (Gasoline Range)	Glass	(3) 40 ml	4 C; Hcl to pH < 2	14 days	20

TABLE 1-2
SAMPLE CONTAINERS, PRESERVATION METHODS, AND HOLDING TIMES
PORTSMOUTH NSY
KITTERY, MAINE
PAGE 2

Method	Parameter	Container Material	Sample Volume	Preservation	Holding Time	No. of Samples (a)
Modified SW 846/8100	TPH (Diesel Range)	Glass	1 liter	Cool, 4 C	Extract 14 days Analyze 40 days	20
SURFACE WATER						
CLP OLM01.8	TCL Volatiles	Glass, Teflon lined septa	(2) 40 ml	4 C; 4 drops HCl, pH < 2	14 days	4
CLP OLM01.8	TCL Semi-volatiles	Glass, Teflon lined septum	2,500 ml	Cool, 4 C	Extract 7 days; Analyze 40 days	4
CLP ILM03.0	TAL Metals (Total)	Plastic, glass	1 liter	Cool, 4 C	6 months*	4
CLP ILM03.0	TAL Metals (Dissolved)	Plastic, glass	1 liter	Cool, 4 C	6 months*	4
EPA 325.2	Chloride	Plastic, glass	50 ml	None required	28 days	4
EPA 375.4	SO_4	Plastic, glass	50 ml	Cool, 4 C	28 days	4
SM 403	CO_3/HCO_3	Plastic	1 liter	Cool, 4 C	14 days	4
ALPHA 2520B	Salinity	Wide-mouth glass jar with Teflon-lined lid	240 ml	Cool, 4 C	7 days	4
SEDIMENT						
CLP OLM01.8	TCL Volatiles	Wide-mouth amber glass jar with Teflon lined lid	120 ml (4 oz.)	Cool, 4 C	14 days	4
CLP OLM01.8	TCL Semi-volatiles	Wide-mouth amber glass jar with Teflon lined lid	120 ml (4 oz.)	Cool, 4 C	Extract 7 days; Analyze 40 days	4

TABLE 1-2
SAMPLE CONTAINERS, PRESERVATION METHODS, AND HOLDING TIMES
PORTSMOUTH NSY
KITTERY, MAINE
PAGE 3

Method	Parameter	Container Material	Sample Volume	Preservation	Holding Time	No. of Samples (a)
CLP ILM03.0	TAL Metals	Wide-mouth glass jar	240 ml (8 oz.)	Cool, 4 C	6 months*	4
SOIL						
CLP OLM01.8	TCL Volatiles	Wide-mouth glass jar with Teflon-lined lid	240 ml (8 oz.)	Cool, 4 C	14 days	35
CLP OLM01.8	TCL Semi-volatiles	Wide-mouth glass jar with Teflon-lined lid	240 ml (8 oz.)	Cool, 4 C	Extract 7 days; Analyze 40 days	35
CLP OLMO1.8	TCL Pesticides/ PCBs	Wide-mouth glass jar with Teflon-lined lid	240 ml (8 oz.)	Cool, 4 C	Extract 7 days; Analyze 40 days	23
CLP ILM03.0	TAL Metals	Wide-mouth glass jar	240 ml (8 oz.)	Cool, 4 C	6 months*	35
CLP ILMO3.0	Mercury (Quick turn-around analysis)	Wide-mouth glass jar	120 ml (4 oz.)	Cool, 4 C	28 days	35

* Except for mercury which has a 28 day holding time

(a) Excludes field and laboratory QA/QC samples. Refer to Table 3-1 for field QA/QC samples.

Each field operations leader who is supervising a subcontractor activity must complete a Daily Record Subsurface Investigation Report, which documents the activities and progress of the subcontractor. The information contained within this report is used for billing verification and progress reports.

2.0 GENERAL FIELD OPERATIONS

The Work Plan describes the field work to be performed at the NSY Portsmouth Site. The Field Sampling Plan provides more detail as to how the field work is to be performed and provides more figures and tables as to the location of field activities and the analyses of samples taken.

2.1 MOBILIZATION/DEMOBILIZATION

Following approval of the RFI Data Gap Work Plan, Halliburton NUS will prepare drilling, test pit, surveying and analytical services specifications, obtain subcontractors, and begin mobilization activities. A site visit will be conducted to stake out sample locations such that utility clearances can be provided by NSY Portsmouth prior to mobilization. Additionally, the RFI Data Gap Work Plan will be certified by a Maine certified geologist as required by the MEDEP. Woodward & Curran has recently been procured to fulfill this requirement. All field team members will review the Work Plan, Field Sampling Plan, Health and Safety Plan (HASP), and Quality Assurance Project Plan (QAPP). In addition a field team orientation meeting will be held to familiarize personnel with the scope of the field activities. Upon mobilization at the site, the Halliburton NUS Site Safety Officer (SSO), or representative will provide site-specific health and safety training to the field team and subcontractor field personnel.

The Field Operations Leader (FOL) will coordinate the mobilization activities upon arrival at the facility. The FOL will also make any equipment purchases required to conduct the field investigation. The schedule for performing the site investigation will consist of approximately 8-10 weeks working 10 hours per day. Field work is anticipated to begin in June of 1994.

All site preparation will be coordinated through NSY Portsmouth personnel. When necessary, temporary barriers will be installed and traffic control provided at drilling locations as a safety precaution.

2.2 DRILLING AND MONITORING WELL INSTALLATION

General bedrock groundwater conditions across the NSY Portsmouth site will be assessed by installing 5 bedrock well clusters. Three shallow bedrock wells, designated as "B", will be installed approximately 20 to 25 feet into bedrock and five deep bedrock wells, designated as "DB" will be installed approximately 80 to 100 feet into bedrock. Wells (DI-01B, DI-01DB) will be installed in a central location on Dennet's Island. Two wells (SI-01B and SI-01DB) will be installed near the two ponds on Seavey Island. Two wells (FA-01B and FA-01DB) will be installed in the filled area between Seavey Island and Dennet's Island. Well

JW-13DB will be installed with the existing JW-13 well cluster and DW-07DB will be installed with the existing DW-07 well cluster.

A total of up to seven shallow overburden wells will be installed. Well MW-08 will be installed downgradient from the former gas station near Mercury Burial Site II and will be drilled down to approximately 10 feet below the water table or the top of bedrock (whichever is encountered first). The location will be determined after evaluating direct drive point results. Well FA-01 will be installed in the filled area between Dennet's and Seavey Island and will be drilled down to approximately 10 feet below the water table or the top of bedrock (whichever is encountered first). In addition to these wells, new shallow overburden wells WOT-01, WOT-02, WOT-03, WOT-04, and WOT-05 at the Former Waste Oil Tank Site (SWMU #11) will be installed. The locations will be determined after evaluating direct drive point results.

Locations of all new monitoring wells (except MW-08, WOT-01, WOT-02, WOT-03, WOT-04, and WOT-05 which will be placed after evaluation of direct drive point results) are illustrated in Figure 2-1. Table 2-1 provides a well construction summary, including the required health and safety level of protection.

The hollow stem auger drilling method is the preferred method for drilling the overburden well borings. Soil samples will be collected at 5 foot intervals from the ground surface, to the top of the water table using split-barrel sampling techniques, as referenced in specification ASTM-1586-84. Section 5.0 of SOP-GH-1.4 provides a description of Soil and Rock Drilling Methods.

All samples obtained from the boreholes shall be monitored with an organic vapor analyzer (OVA) and/or HNu as specified in the Health and Safety Plan (HASP). Each split spoon sampler will be screened immediately upon opening. These readings will be recorded on the boring logs. The lithologic samples will be placed in an 8-ounce jar (to be provided by the drilling subcontractor), labeled, and the pertinent data recorded by the field geologist. In addition, head space readings will be obtained for all soil samples obtained for lithological classification. No soil samples will be collected from the well borings for chemical analyses. The use of drilling fluids is prohibited during overburden well boring activities. Unless requested by the field geologist, all lithologic samples will be discarded at the end of the field activities. The driller shall prepare a separate written boring log for each boring drilled to be submitted to the field geologist at the conclusion of the daily field activities.

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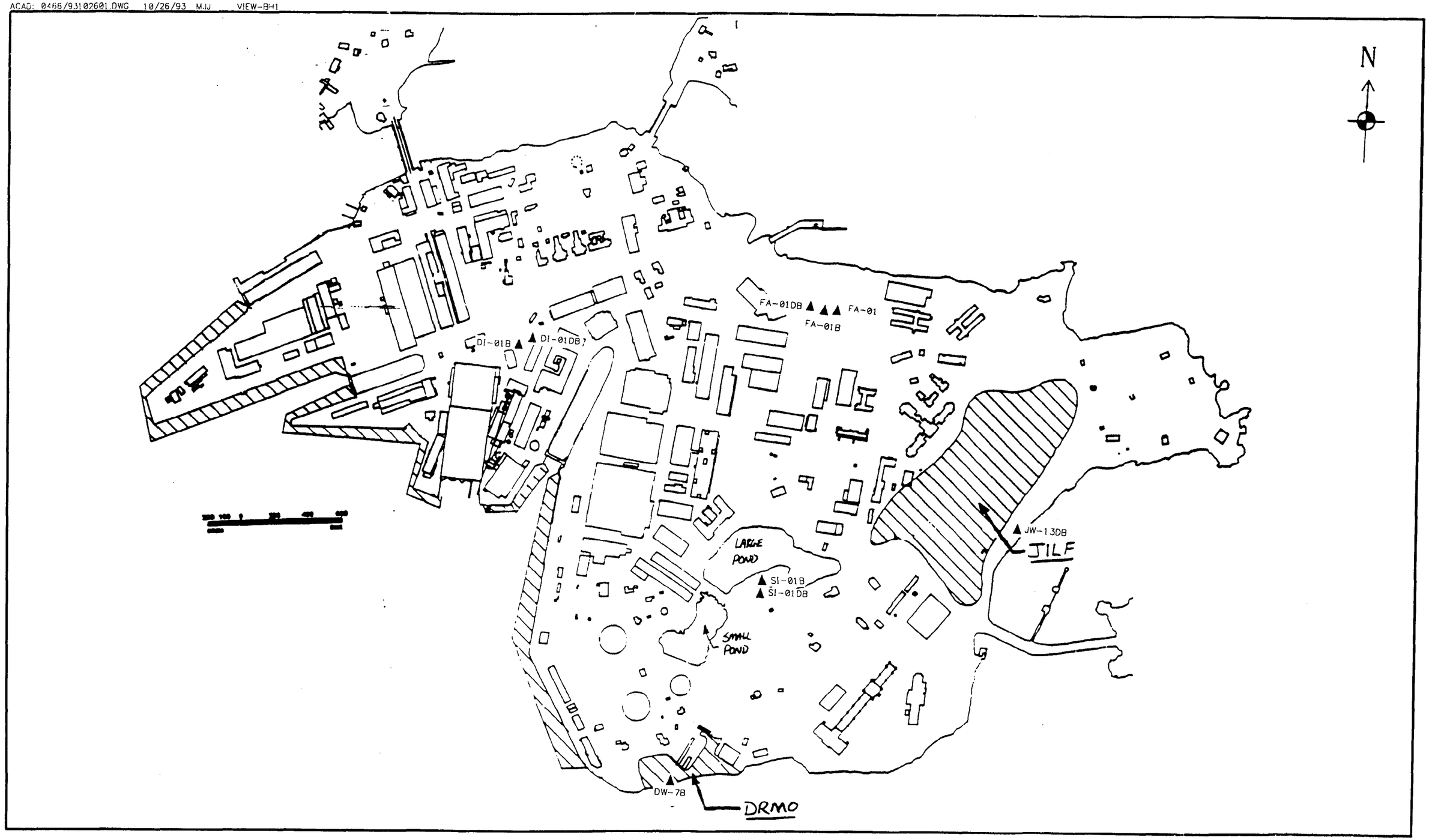

BEDROCK WELL CLUSTERS
PORTSMOUTH NAVAL SHIPYARD
KITTERY, MAINE

FIGURE 2-1

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TABLE 2-1

WELL CONSTRUCTION SUMMARY TABLE
NSY PORTSMOUTH, KITTERY, MAINE

Well Type	WELL No.	LOP	EST Total Depth (Ft)	EST O.B. Drill (Ft)	EST BR (5-7/8") Drill (Ft)	EST 2" Screen (Ft)	EST 2" Riser[2] (Ft)	EST 6" Temp Casing (Ft)	Recommended Drilling Method
OVERBURDEN (Min 4-1/4" ID H.S.A.)	FA-01	D	25	25	--	10	17	--	HSA
	MW-10	D	25	25	--	10	17	--	HSA
	WOT-01	B	25	25	--	10	17	--	HSA
	WOT-02	B	25	25	--	10	17	--	HSA
	WOT-03	B	25	25	--	10	17	--	HSA
	WOT-04	B	25	25	--	10	17	--	HSA
	WOT-05	B	25	25	--	10	17	--	HSA
SHALLOW BEDROCK (Min 9"0 Hole in O.B.)	DI-01B	D	50	30[1]	20	10	42	30	AR
	SI-01B	D	40	10[1]	30	10	32	10	AR
	FA-01B	D	40	10[1]	30	10	32	10	AR
DEEP BEDROCK (Min 9"0 Hole in O.B.)	DI-01DB	D	120	10[1]	110	10	112	10	AR
	SI-01DB	D	120	10[1]	110	10	112	10	AR
	FA-01DB	D	130	35[1]	95	10	122	35	AR
	JW-13DB	D	130	35[1]	95	10	122	35	AR
	DW-07DB	D	130	35[1]	95	10	122	35	AR
LEVEL "B"	TOTALS	5	125	125	--	0	0		
LEVEL "D"	TOTALS	10	810	225	585	150	815	175	
	TOTAL	15	935	350	585	150	815	175	

NOTE: Actual depths for wells may vary based on field conditions.
1 - Includes 5' minimum hole into bedrock (9" min diameter)
2 - Includes ≈ 2' stick up
LOP - Level of Protection
FA - Fill Area Well
MW - Mercury Burial Site Well
DW - DRMO Well
WOT - Waste Oil Tank Well
DW - DRMO Well
DI - Dennet's Island Well
SI - Seaveys Island Well
JW - Jamaica Island Landfill Well
HSA - Hollow Stem Auger
AR - Air/Mud Rotary
EST - Estimated footages

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

- Boring or Well Identification
- Name of Drilling Contractor
- Sample Numbers and Types
- Sample Depths
- Standard Penetration Test Blow Counts
- Sample Recovery/Sample Interval
- Soil Density or Cohesiveness
- Soil Color
- USCS Material Description
- Location of Boring

In addition, depths of changes in lithology, sample moisture observations, depth to water, organic vapor readings, drilling methods, and total depth of each borehole shall be included on each log, as well as any other pertinent observations. Section 5.0, SOP-GH-1.5 provides a description of Borehole and Sampling Logging. An example of the boring log form is attached in Appendix D.

The bedrock wells will be drilled using air rotary methods. A minimum 9-inch diameter hole will be drilled through the overburden materials and approximately 5 to 10 feet into the underlying rock, so that a temporary 6-inch I.D. steel casing can be set. After the 6-inch casing is set, a 5-7/8-inch bit will be used to advance the hole into bedrock to the required depth. The well borings will be advanced until a water yielding fracture zone is encountered within or near the target completion depth. Section 5.0 of SOP-GH-1.4 provides a description of Soil and Rock Drilling Methods.

All wells (both overburden and bedrock) will be constructed of 2-inch-diameter PVC well screen and casing The 20 slot by 10 to 15 feet long well screens will be installed across the desired monitoring/ fracture zone interval, then a sand pack (20 to 30 sieve size) installed around and to approximately 2 feet above the screen. The well screens were selected to retain 90 percent of the filter pack and to allow sufficient surface area for groundwater to enter. The sand pack size was selected based on Halliburton NUS experience. A bentonite seal will then be emplaced and the remaining borehole annulus backfilled with cement-bentonite grout, to ground surface.

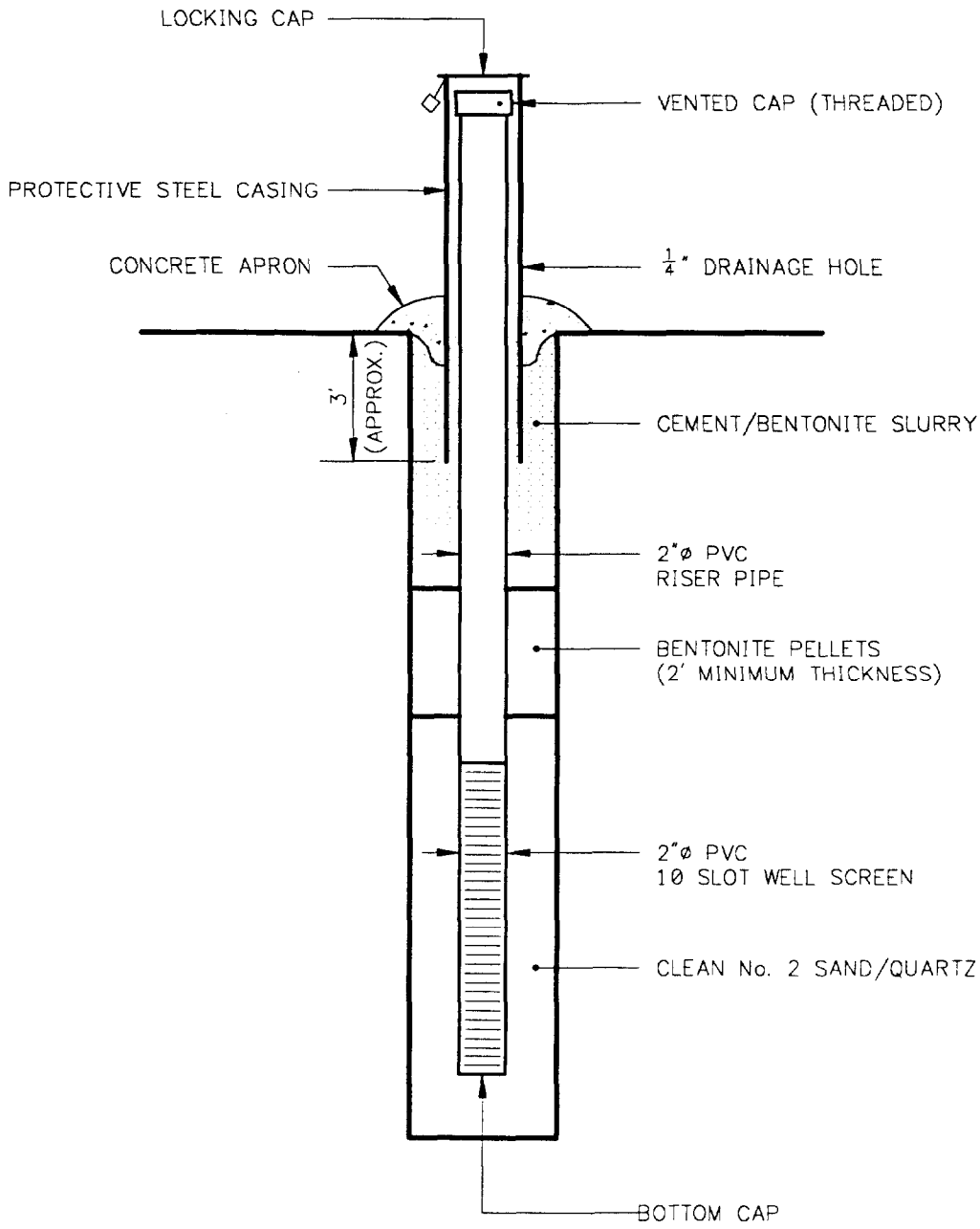
For the Former Waste Oil Tank site (SWMU # 11), three of the five new wells will be screened cross the water table, so that any free product present will be detected. For the remaining two wells, the screens will be installed just above bedrock to investigate potential Freon contamination or other Dense Non-Aqueous Phase Layer (DNAPL). For the new well near Mercury Burial Site II (MW-98), the screen will be installed to straddle the water table, so that any free product present will be detected.

Frost damage to monitoring wells is a significant concern at the facility, and in fact, repair of several existing monitoring wells will be conducted by the driller for this project (including replacement of incorrect monitoring well covers). For these monitoring wells and the new wells, frost damage will be minimized by replacing grout with bentonite pellets near the surface. Also, the protective casing will be grouted in place and an approximate 12-inch sand layer will be placed within and around the bottom of the protective casing to allow percolation of water.

Painting, labeling, and protective casings will be consistent with that of existing monitoring wells. Not every location will require protective barriers. An NSY Portsmouth representative will identify which monitoring wells require barriers. It is anticipated that steel protective casings (4-inch minimum diameter) equipped with locking caps will be installed around most monitoring wells. These casings will be cemented a minimum of 3 feet into the ground and will have at least one drain hole positioned approximately 0.5 feet above the ground surface. A 0.5-foot thick concrete apron measuring 2 feet by 2 feet is anticipated equally portioned around the casing of each well. Several monitoring wells will be completed as flush mounted installations. At flush-mounted installations the well riser pipe will be cut off immediately below surface grade and provided with a locking, packer-type cap. A steel flush-mounted protective casing will be cemented in place over the riser pipe. The protective casing must be pre-approved by the FOL, and be installed flush with the ground surface. Flush-mounted covers must identify the location as a "Monitoring Well". All well locations will be secured with Master locks and will be keyed alike. Keys will be turned over to the NSY Portsmouth Point of Contact. Monitoring well installation will be in compliance with Section 5.0, SOP GH1.7, provided in Appendix E of this Work Plan.

After installation, the wells will be surveyed to determine horizontal location and vertical elevations. Figures 2-2 and 2-3 depict typical Bedrock monitoring wells.

The monitoring wells will be developed no sooner than 24 hours after installation to remove fines from the area around the monitored interval of the well. Wells will be developed by use of a small submersible pump. Wells will be developed until the water is visibly clear of sediment or until approved by the field representative. Additionally, development will proceed until the variation between turbidity meter readings



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TYPICAL MONITORING WELL CONSTRUCTION
PORTSMOUTH NSY
KITTERY, MAINE
NOT TO SCALE

FIGURE 2-2

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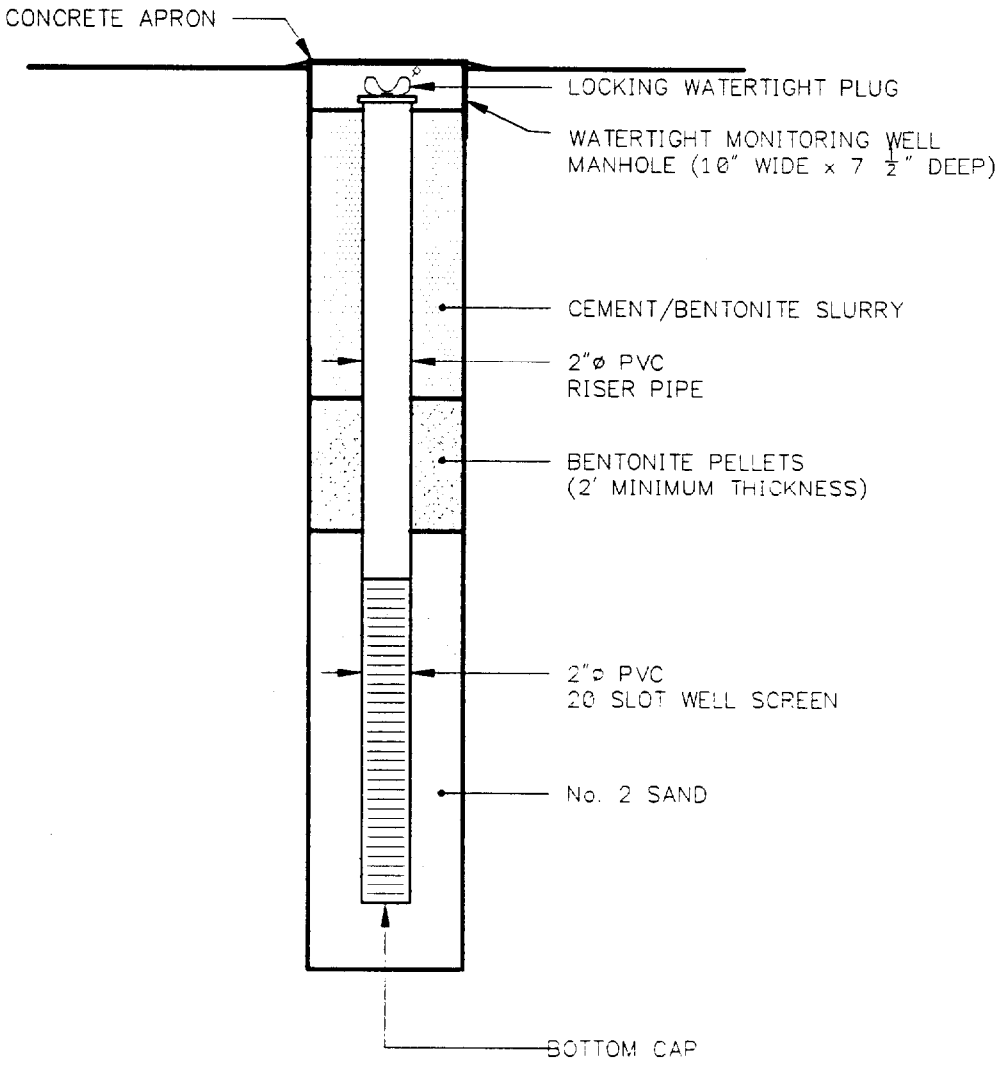

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TYPICAL FLUSH MOUNT
MONITORING WELL CONSTRUCTION
PORTSMOUTH NAVAL SHIP YARD
KITTERY, MAINE
NOT TO SCALE

FIGURE 2-3

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is less than 10 percent; however, development will not exceed 2 hours per well. Other development methods may be used with permission by Halliburton NUS.

Boring logs and well construction diagrams will be completed for each monitoring well boring/well installed. A sample of these forms are provided in Appendix D. Logging procedures are provided in the Halliburton NUS SOPs, which are provided in Appendix E.

2.3 GROUNDWATER SAMPLING

One round of groundwater sampling is proposed for the NSY Portsmouth Site as part of the RFI Data Gap scope of work. Future groundwater monitoring will be conducted in accordance with the Long-term Groundwater Monitoring Plan, currently in preparation. Wells proposed for sampling are listed in Table 2-2. Well sampling and sample handling shall be in accordance with U.S. EPA protocols and Halliburton NUS SOPs. Sample analytes are listed in Table 2-2.

Prior to obtaining samples, water levels will be measured and the wells will be purged using a dedicated Teflon bailer or a 2-inch submersible pump (Grundfos Redi-Flo II variable speed). Three to six well volumes will be purged. If the wells are purged dry with less than three volumes removed, the water in the well will be allowed to recover at least 70 percent, then a sample will be collected. In the event that recovery is slow, samples will be collected within 24 hours of purging. Field measurements of pH, temperature, and specific conductance will be taken after each well volume is purged. Stabilization of the above parameters is defined as follows: temperature ± 1.0°C, pH ± 0.1 units, specific conductance ± 5 percent. If these parameters do not stabilize after 3 volumes, up to 6 volumes maximum will be removed. Section 5.0 of SOP-SA-1.1 and SOP-SF-1.1 provide a description of Groundwater Sample Acquisition and On-Site Water Quality Testing respectively.

Dedicated teflon bailers with dedicated polyethylene rope as bailing line will be used for sample collection. At monitoring wells MW-08, WOT-01, WOT-02, WOT-03, WOT-04, and WOT-05, an interface probe will be utilized to measure free product, if present. The sample will be poured directly from the bailer into the appropriate sample bottles for analysis. Samples to be analyzed for volatile constituents shall be taken first and immediately sealed in a container so that no head space exists.

Where dissolved metals analysis is required for groundwater or surface water, field filtration will be necessary. The sample must be filtered through a non-metallic 0.45 micron membrane filter immediately

TABLE 2-2
GROUNDWATER SITE SPECIFIC SAMPLE ANALYSIS
NSY PORTSMOUTH, KITTERY, MAINE

Well Identification	TCL Volatiles	TCL Semi-volatiles	TCL Pesticides/PCBs	TAL Metals (Total)	TAL Metals (Dissolved)	Lead	TPH (Gasoline Range)	TPH ((Diesel Fuel Range)	Water Quality Parameters (a)	Hexavalent Chromium (c)	Dissolved Oxygen (c)
DI-01B DI-01DB SI-01B SI-01DB FA-01 FA-01B FA-01DB	7	7	---	7	7	---	7	7	7	---	7
JW-13S[b] JW-13D[b] JW-13B[b] JW-13DB	4	4	---	---	---	---	4	4	4	4	4
DW-07[b] DW-07B[b] DW-07DB	3	3	---	3	3	---	3	3	3	3	3
MW-8	1	---	---	---	---	1	1	1	---	---	1
WOT-01 WOT-02 WOT-03 WOT-04 WOT-05	5	5	5	5	5	---	5	5	---	---	5
TOTAL	20	19	5	15	15	1	20	20	14	7	20

Well IDs

DI - Dennett's Island Well
SI - Seaveys Island Well
FA - Fill Area Well
JW - Jamicia Island Landfill Well
DW - DRMO Well
MW - Mercury Burial Site Well
WOT - Waste Oil Tank Well

(a) Water Quality Parameters include tritium chloride, SO_4 CO_3/HCO_3, and salinity.
(b) Existing monitoring wells installed during the original RFI.
(c) Field Measurement. Additionally, all new monitoring wells will be measured for temperature, pH, specific conductance, Eh,and turbidity.

after collection. Samples will be filtered using a Buchner funnel in accordance with SOP SF1.2, Section 5.2.5 provided in Appendix E.

A summary of the groundwater sampling program is shown on Table 2-2. Additionally, field measurements for hexavalent chromium will be conducted at the JW-13 well cluster at the JILF (SWMU #8) and at the DW-07 well cluster at the DRMO (SWMU #6). Also, free product, if present, will be measured with an interface probe at MW-08, WOT-01, WOT-02, WOT-03, WOT-04, and WOT-05. All pertinent field and sampling data will be recorded using the appropriate forms attached in Appendix D, and the field logbook.

2.4 WATER LEVEL MEASUREMENTS/TIDAL EFFECTS

Two comprehensive rounds of water level measurements are proposed for the investigation to provide updated, more detailed information regarding groundwater flow patterns and flow gradients across the NSY Portsmouth Site. Water levels will be obtained from all new and existing monitoring wells one round during mean high tide and one round during mean low tide (on the same day). In addition, water level measurements will be obtained from the staff gauges and piezometers located in the ponds on Seavey Island. Each set of water level measurements will be obtained within an 2-hour period, and no sooner than 48 hours after a significant precipitation event, to minimize the effects of short-term water level fluctuations on the data sets. One location near each of the two staff gauges will require surveying, vertical, to allow correlation of data with monitoring well water levels.

Measurements will be taken with an M-Scope (electrical water level indicator) using the top of the inner well casing as the reference point for determining depths to water. This well casing shall be notched and marked so that the same point will be referenced for all measurements. Water level measurements will be recorded to the nearest 0.01 foot in the field logbook and on a groundwater level measurement form, attached in Appendix D. Section 5.0 of SOP-GH-2.5 provides a description of Water Level Measurement procedures

Pressure transducers and data loggers will be utilized at select DRMO and JILF Landfill locations to supplement the previous water level monitoring done at the base. Tidal gages will be installed at the DRMO and the JILF. The following wells are the minimum number recommended for a long-term water level measuring program. Additionally, tidal gauges will be installed at the DRMO and the JILF, as shown in Figures 2-4 and 2-5, respectively. Each of the two tidal gauges will be surveyed to allow correlation of data with monitoring well water levels.

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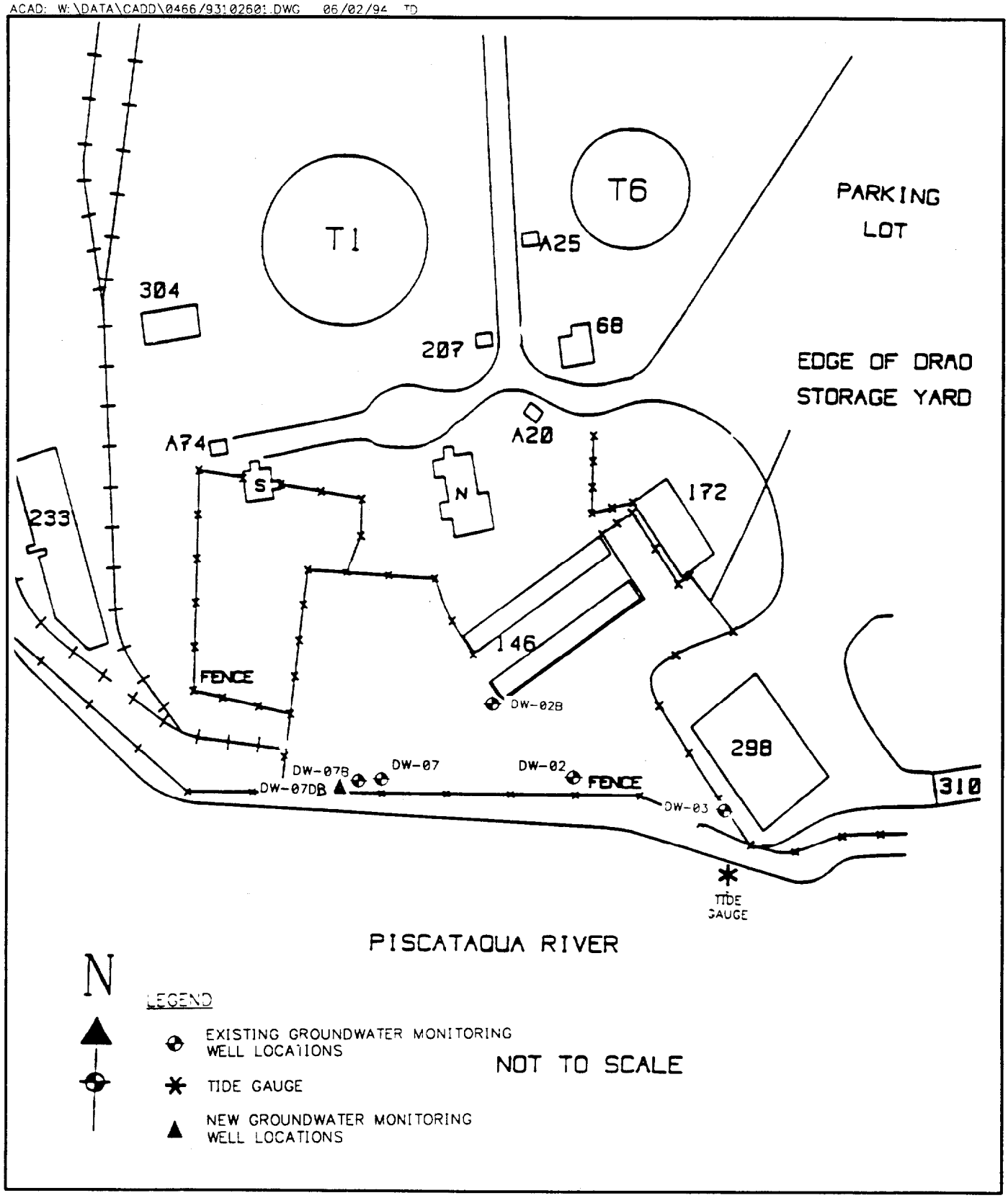

DRMO FACILITY
& TIDAL GAUGE LOCATION
PORTSMOUTH NAVAL SHIPYARD
KITTERY, MAINE

FIGURE 2-4

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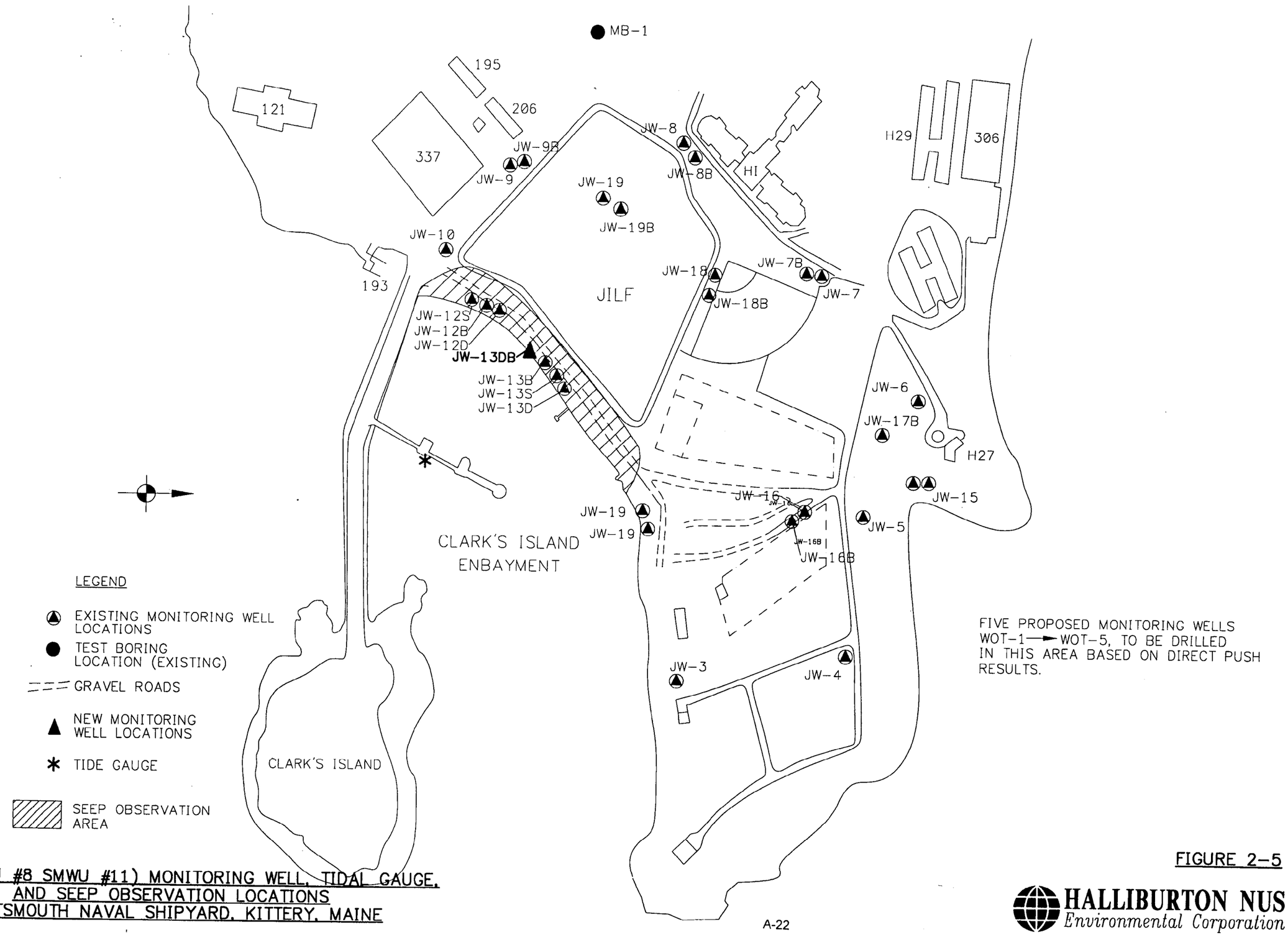

JILF (SWMU #8 SMWU #11) MONITORING WELL, TIDAL GAUGE, AND SEEP OBSERVATION LOCATIONS
PORTSMOUTH NAVAL SHIPYARD, KITTERY, MAINE

FIGURE 2-5

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All new monitoring wells: DI-01B, DI-01DB, SI-01B, SI01-DB, FA-01, FA-01B, FA-01DB, JW-13DB, DW-07DB, MW-8, WOT-1, WOT-2, WOT-3, WOT-4, and WOT-5

Limited existing monitoring wells: JW-13S, JW-13D, JW-13B, DW-03, DW-04, DW-07, and DW-07B

Data will be collected for 25 hours from the shallow aquifer and 25 hours from the bedrock aquifer at each location. Data does not need to be collected concurrently for all monitoring wells; however, tidal data from a given well cluster should be collected concurrently (Dennett's Island, Seaveys Island, Fill Area, Jamaica Island [at JW-13] and the DRMO [at DW07] clusters). During periods of data collection, tidal data from the tidal gauges at the DRMO and the JILF will be collected concurrently. Data would be collected in 15 minute increments. The key well for tying previous monitoring data in with tidal effects at the DRMO is DW-03.

2.5 AQUIFER TESTING

Insitu hydraulic conductivity testing (slug tests) will be performed in all new permanent monitoring wells. Slug testing will be performed after the newly installed wells have been developed and the water levels have returned to static. Procedures for performing these slug tests will be in accordance with Section 5 of Halliburton NUS SOP GH-2.4 (attached in Appendix E). Pressure transducers and data loggers will be used for data collection to obtain sufficiently accurate field data.

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

- Well number/depth/screened interval/ inside diameter of screen/ diameter of sand pack
- Static water level
- Method of inducing water level change
- Time/recovery data
- Total time of test

Data generated during the tests will be documented on the appropriate data sheets and analyzed according to the SOP, using the most appropriate evaluation technique for the existing hydrogeologic conditions. Data generated during the slug tests will be recorded on the appropriate forms, attached in Appendix D.

2.6 DIRECT PUSH TECHNOLOGY/SOIL GAS SURVEY

"Direct Push" technology and a soil gas survey will be conducted near Mercury Burial Site II (SWMU #9) and the Former Waste Oil Tanks area (SWMU #11) by a specialized subcontractor. At each of these two areas, groundwater samples will be collected from each direct push location and analyzed using the subcontractor's onsite mobile laboratory (or a portable GC, or offsite laboratory with quick-turnaround analysis). Additionally, for each direct push point, one soil gas sample will be obtained and screened with an OVA. Soil gas readings will be taken until readings peak and begin to recede, or for a maximum time interval of 3 minutes. In addition to the oversight of the subcontractor's work, Halliburton NUS will be responsible for packaging and shipment of subsurface soil samples at SWMU #11 to PACE, New England.

This work scope is written to allow a flexible approach to conducting the work. Either temporary wells and conventional soil boring drilling <u>or</u> direct push technology is acceptable in accomplishing the work. Similarly, either on-site mobile laboratory capabilities or use of an offsite laboratory is acceptable, provided that analytical results are available on a 24-hour quick turnaround basis. Soil gas field screening for volatiles should be conducted using an OVA, or equivalent. Results will be immediately provided to Halliburton NUS. Chemical-specific analysis is not required for soil gas samples. Soil samples will be collected only for the Former Waste Oil Tank area (SWMU #11).

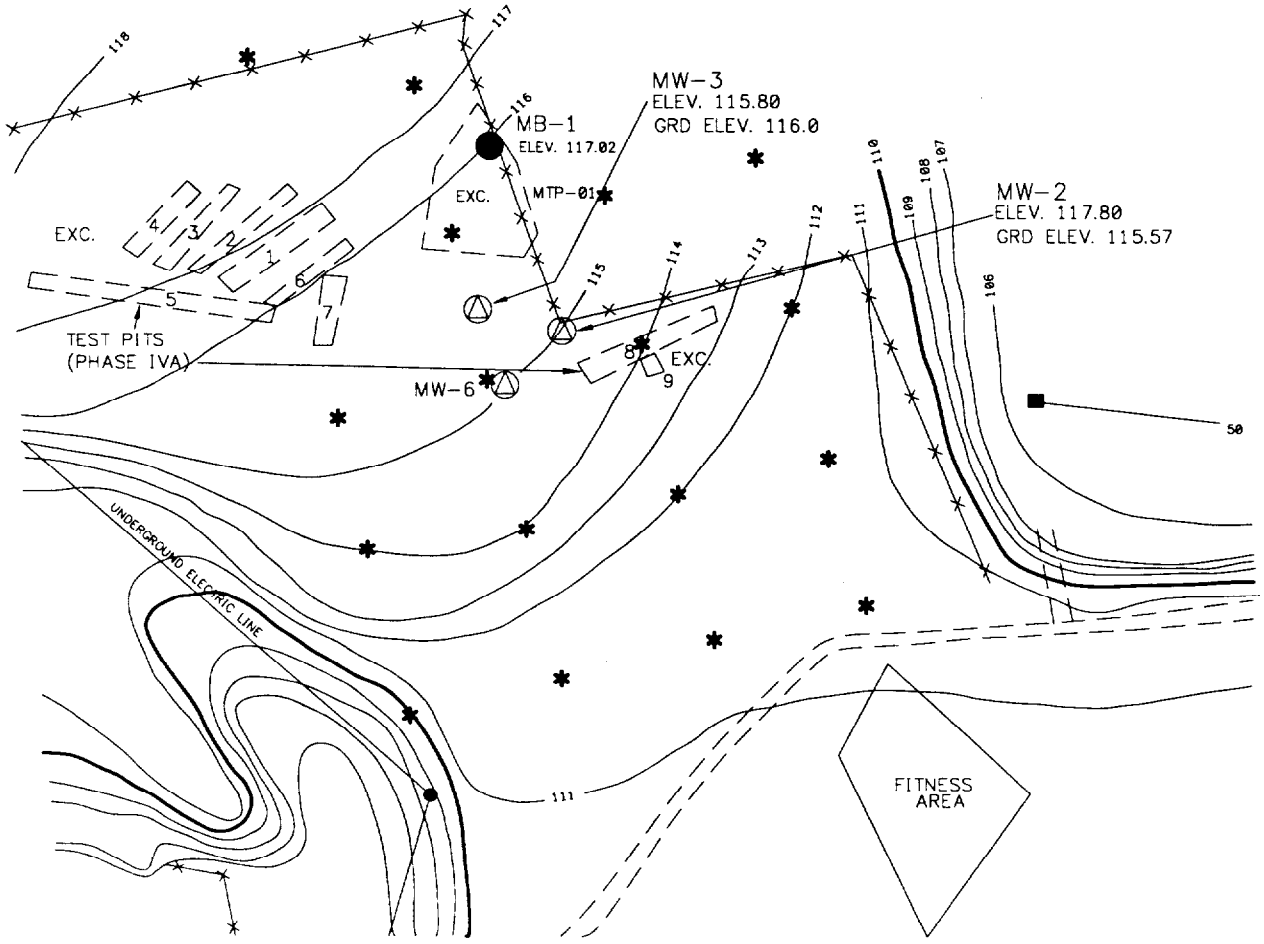
<u>Area Near Mercury Burial Site II</u>

The objective of the program will be to generate data to support placement of one permanent monitoring well (MW-08). Work scope is summarized as follows:

- Collect 1 soil gas sample and 1 groundwater sample at each of 18 initial locations shown on Figure 2-6. Analyze groundwater sample for select volatile organics and conduct petroleum product fingerprinting.

- Based on HNUS evaluation of analytical results, collect 1 soil gas sample and 1 groundwater sample at up to 4 additional locations. Analyze groundwater sample for select volatile organics and conduct petroleum product fingerprinting.

- For each direct push point, one soil gas sample will be collected and screened using an OVA. Soil gas readings will be taken until readings peak and begin to recede, or for a maximum time interval of 3 minutes. Soil gas data will aid in identifying the potential



LEGEND

- EXISTING MONITORING WELL
- SOIL BORING LOCATION (EXISTING)
- SOIL GAS LOCATION/ DIRECT PUSH LOCATION

NOTE: ONE MONITORING WELL, MW-08, TO BE INSTALLED WITHIN GRID AREA BASED ON DIRECT PUSH RESULTS

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SOIL GAS LOCATIONS/DIRECT PUSH LOCATIONS

SWMU #9 PLUME (MERCURY BURIAL SITE II AREA)

PORTSMOUTH NAVAL SHIPYARD

KITTERY, MAINE

FIGURE 2-6

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source area(s). Additionally correlations, or lack thereof, between soil gas data and groundwater samples from direct push methods can be established.

Based on the direct push technology/soil gas survey findings, one shallow well will be installed to within a hot spot area to determine if groundwater has been impacted by petroleum product. Refer to Sections 2.2 and 2.3 for monitoring well installation and sampling requirements. In addition to the specified analysis, an interface probe will be used to measure free product, if present, at each well.

Former Waste Oil Tank Area

The intent of the investigation at the former Buried Waste Oil Tanks is to determine the nature and extent of plumes of volatile and semi-volatile organic compounds associated with the former Buried Waste Oil Tanks (SWMU #11). Additionally, the investigation will support installation of a new hazardous waste storage area near this SWMU. The investigation will consist of "Direct Push" technology (or temporary monitoring wells), a soil gas survey, and the installation/sampling of up to five shallow monitoring wells to determine the extent of contamination. The program is summarized as follows:

- Collect 1 soil gas sample and 1 groundwater sample at each of 32 initial locations shown on Figure 2-7. Analyze groundwater sample for select volatile organics and conduct petroleum product fingerprinting.

- Based on HNUS evaluation of analytical results, collect 1 soil gas sample and 1 groundwater sample at up to 4 additional locations. Analyze groundwater sample for volatile organics and conduct petroleum product fingerprinting.

- Collect one "contaminated" soil sample at very near 14 (7 transects x 2 locations/transect) of the 32 initial locations, based on HNUS evaluation of soil gas and groundwater results. Also, two duplicate samples will be collected. These samples will be sent offsite by Halliburton NUS for TCL volatile organics (plus Freon), TCL semi-volatile organics, TCL pesticides/PCBs, and TAL analysis.

- Collect one "clean" soil sample at up to 6 additional locations along a given transect (3 transects x 2 locations/transect). Also, 1 duplicate sample will be collected. These samples will be sent offsite by Halliburton NUS for TCL volatile organics (plus Freon), TCL semi-volatile organics, TCL pesticides/PCBs, and TAL analysis.

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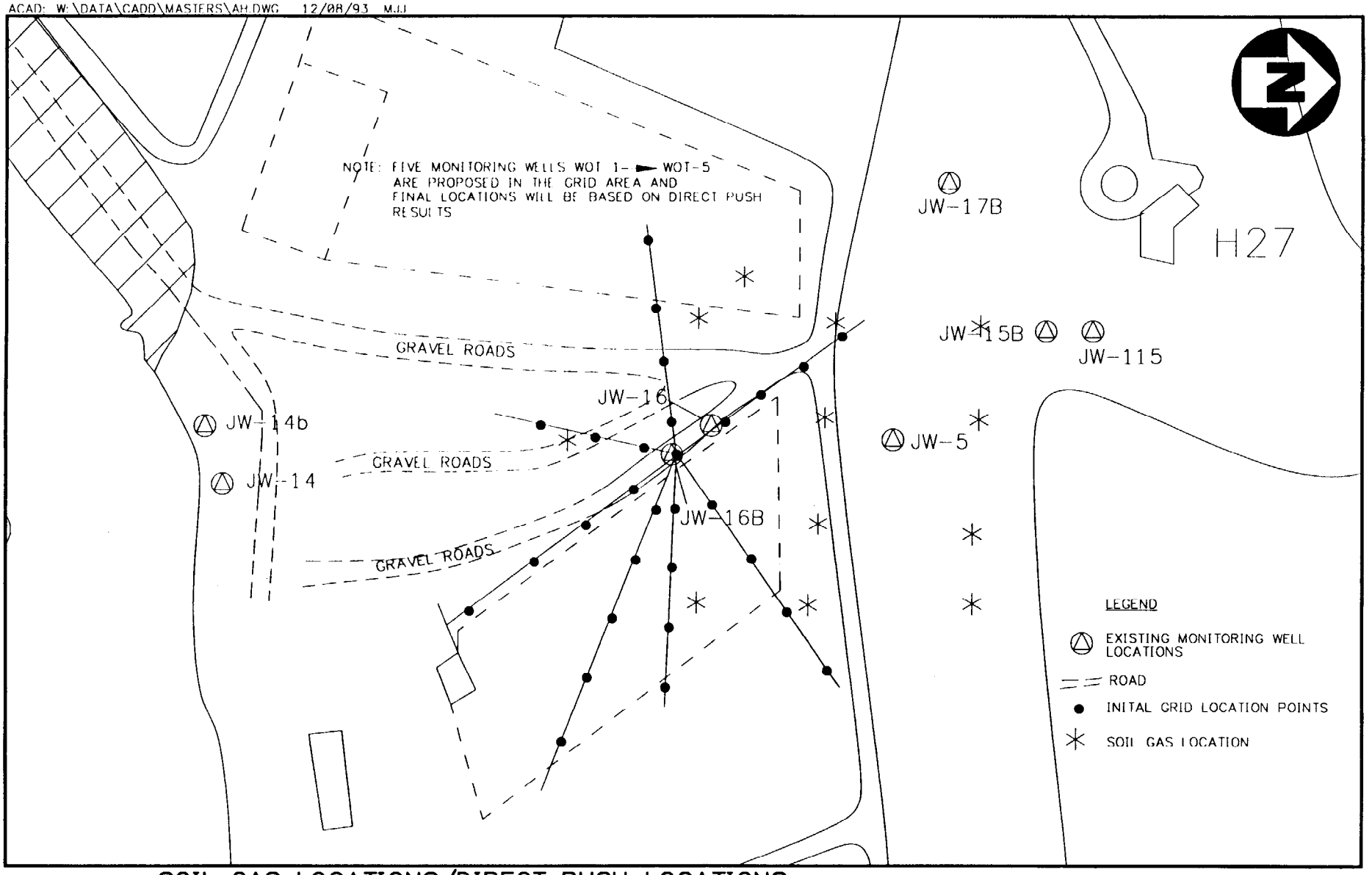

SOIL GAS LOCATIONS/DIRECT PUSH LOCATIONS
SWMU #11 PLUME (FORMER WASTE OIL STORAGE TANKS)
PORTSMOUTH NAVAL SHIPYARD – KITTERY, MAINE

FIGURE 2-7

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- In collecting the "clean" soil samples, one "contaminated" soil sample at up to 3 additional locations along a given transect (3 transects x 1 location/transect) may be collected. These samples will be sent offsite by Halliburton NUS for TCL volatile organics (plus Freon), TCL semi-volatile organics, TCL pesticides/PCBs, and TAL analysis.

Based on the direct push technology/soil gas survey findings, up to 5 shallow wells will be installed at SWMU #11 to determine extent of contamination, as discussed in Sections 2.2 and 2.3. In addition to the specified analysis, an interface probe will be used to measure free product, if present, at each well. Soil samples described for SWMU #11 are discussed in this section since drive points are being conducted for sample collection purposes. Soil sampling information is repeated in Section 2.8.

An examination of historical aerial photos of the JILF landfill was conducted to determine if drilling locations are in areas filled in or around 1955 (i.e., 1950 through 1960 to allow a safety factor), the period on record when chlorine gas and acetylene cylinders were reportedly buried in this area. Field activities will proceed in Level B health and safety for the area designated in Figure 2-7, as described in the Health and Safety Plan (Appendix C). In addition a magnetometer survey will be conducted before drilling to check for the presence of buried ferromagnetic objects.

Subcontractor Analysis

The groundwater samples will be analyzed by the subcontractor for volatile organics using method SW 846 5030/8010 or equivalent procedure approved by Halliburton NUS. The reportable detection limits will be 5 to 10 ug/l Internal quality assurance and equipment calibration will be conducted by the subcontractor on a daily basis in accordance with the equipment manufacturer. This documentation will be provided to Halliburton NUS with the final report. The samples, at a minimum, shall be analyzed for the following volatile organic target compounds:

Benzene	Ethylbenzene
1,1-dichloroethene (DCE)	c-1,2-DCE
t-1,2-DCE	1,1-dichloroethane (DCA)
Trichloroethene (TCE)	Tetrachloroethene (PCE)
1,1,1 trichloroethane (TCA)	1,1,2-TCA
Chloroform	Carbon tetrachloride
Toluene	Total (m-, p-, and o-,) xylenes
Methylene chloride	Freon-113

The petroleum product fingerprinting will be conducted to determine the type of petroleum product (gasoline, fuel oil, etc.) and to determine the approximate concentration.

Soil gas readings will be taken until readings peak and begin to recede, or for a maximum time interval of 3 minutes. Soil gas data will aid in identifying the potential source area(s). Additionally correlations, or lack thereof, between soil gas data and groundwater samples from direct push methods can be established.

2.7 GEOPHYSICAL SURVEY

All drilling locations will be surveyed, prior to any excavation or drilling activities, with a flux gate magnetometer to check for the presence of buried ferromagnetic objects.

2.8 SOIL SAMPLING

Mercury Burial Site I (SWMU #9)

Subsurface soil samples will be collected at Mercury Burial Site I. One of the following scenarios is expected; 1) If concrete sewer pipe is found to be capped on both ends, one soil sample at each end of the concrete sewer pipe will be taken and analyzed for mercury only using quick-turnaround analysis or 2) If the concrete sewer pipe is found to be not capped on top or not structurally intact, then a total of three samples from within the concrete pipe shall be taken with a hand auger or trowel; one near the top, one near the middle, and one near the bottom of the pipe. Under Scenario 2, ten additional samples will be collected. Samples will be analyzed for mercury using quick-turnaround analysis. The excavation will remain open until sample results are available and have been evaluated.

Draeger tubes for volatile mercury and a Jerome analyzer will be used to aid in establishing sample locations, although inorganic mercury would not be detected by this method.

Subsurface soil samples will be collected with a stainless steel bucket-type auger or stainless steel trowel, depending upon the required sample depth and access. Samples to be analyzed for volatile constituents will be collected first and immediately sealed in the sample container so that no head space exists. The remaining material will be homogenized in a stainless steel bowl and distributed to the remaining sample containers. Sampling tools will be decontaminated between sampling locations as described in Section 6.7 of the QAPP (attached in Appendix B). Section 5.0 of SOP-GH-1.3 provides a description of Soil and

Rock Sampling procedures.

Mercury Burial Site II (SWMU #9)

Subsurface soil samples will be collected at Mercury Burial Site II only if the concrete burial vaults are found. If the vaults are located, the test pit will be enlarged and sloped to expose all concrete vaults present at the site and allow for physical entry into the excavation. A detailed physical inspection will be made on the condition of all concrete vaults (i.e., cracks, condition of concrete, open ends, capped ends, fill material, etc.) and entered in the field notebook. A total of twelve soil samples will be taken from around the vault site. Samples will be analyzed for full TCL volatiles and semi-volatiles, and TAL metals. Additionally, quick-turnaround analysis for mercury will be employed. If mercury contamination is indicated, an additional 10 samples will be collected and analyzed for mercury using quick-turnaround analysis.

Draeger tubes for volatile mercury and a Jerome analyzer will be used to aid in establishing sample locations, although inorganic mercury would not be detected by this method.

Subsurface soil samples will be collected with a stainless steel bucket-type auger or stainless steel trowel, depending upon the required sample depth and access. Samples to be analyzed for volatile constituents will be collected first and immediately sealed in the sample container so that no head space exists. The remaining material will be homogenized in a stainless steel bowl and distributed to the remaining sample containers. Sampling tools will be decontaminated between sampling locations as described in Section 6.7 of the QAPP (attached in Appendix B). Section 5.0 of SOP-GH-1.3 provides a description of Soil and Rock Sampling procedures.

Former Waste Oil Tank Site (SWMU #11)

Soil samples will be collected as described in Section 2.6 concerning the direct drive point work (Also refer to Figure 2-7 of this previous section). The soils scope of work is repeated below:

- Collect one "contaminated" soil sample at very near 14 (7 transects x 2 locations/transect) of the 32 initial locations, based on HNUS evaluation of soil gas and groundwater results. Also, two duplicate samples will be collected. These samples will be sent offsite by Halliburton NUS for TCL volatile organics (plus Freon), TCL semi-volatile organics, TCL pesticides/PCBs, and TAL analysis.

- Collect one "clean" soil sample at up to 6 additional locations along a given transect (3 transects x 2 locations/transect). Also, 1 duplicate sample will be collected. These samples will be sent offsite by Halliburton NUS for TCL volatile organics (plus Freon), TCL semi-volatile organics, TCL pesticides/PCBs, and TAL analysis.

- In collecting the "clean" soil samples, one "contaminated" soil sample at up to 3 additional locations along a given transect (3 transects x 1 location/transect) may be collected. These samples will be sent offsite by Halliburton NUS for TCL volatile organics (plus Freon), TCL semi-volatile organics, TCL pesticides/PCBs, and TAL analysis.

Sampling tools will be decontaminated between sampling locations as described in Section 6.7 of the QAPP (attached in Appendix B). Section 5.0 of SOP-GH-1.3 provides a description of Soil and Rock Sampling procedures.

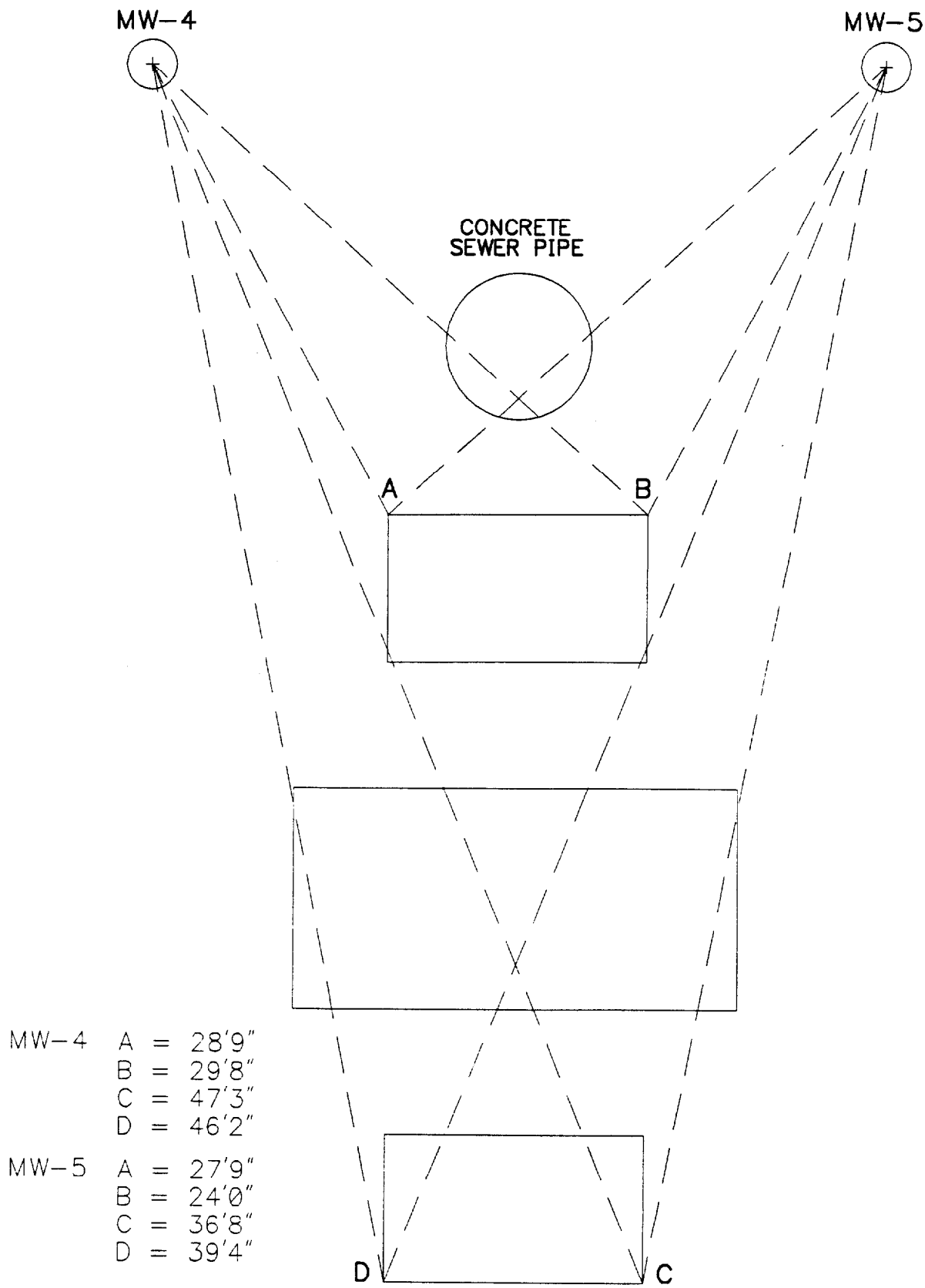
2.9 TEST PIT EXCAVATIONS

Test pitting is scheduled to be performed at Mercury Burial Sites I and II (SWMU #9). A total of two test pits will be excavated in areas identified in Figures 2-8 and 2-9. A description of each test pit will be completed by the field geologist. An example test pit log is included in Appendix D. All excavation will adhere to OSHA requirements regarding trench excavation. Section 5.0 of SOP-GH-1.8 provides a description of Exploratory Test Pits and Trench excavation procedures.

The log will include, at a minimum, the following information:

- Test pit number
- Test pit location
- Test pit dimensions
- Detailed description of subsurface materials
- Organic Vapor readings
- Sample numbers/depths
- Total depth

Probes will be used as the excavation proceeds to ensure that underlying concrete blocks/pipes are not damaged during the excavation effort.



TEST PIT TO LOCATE
MERCURY BURIAL SITE I
CONCRETE SEWER PIPE
PORTSMOUTH NAVAL SHIP YARD
KITTERY, MAINE

FIGURE 2-8

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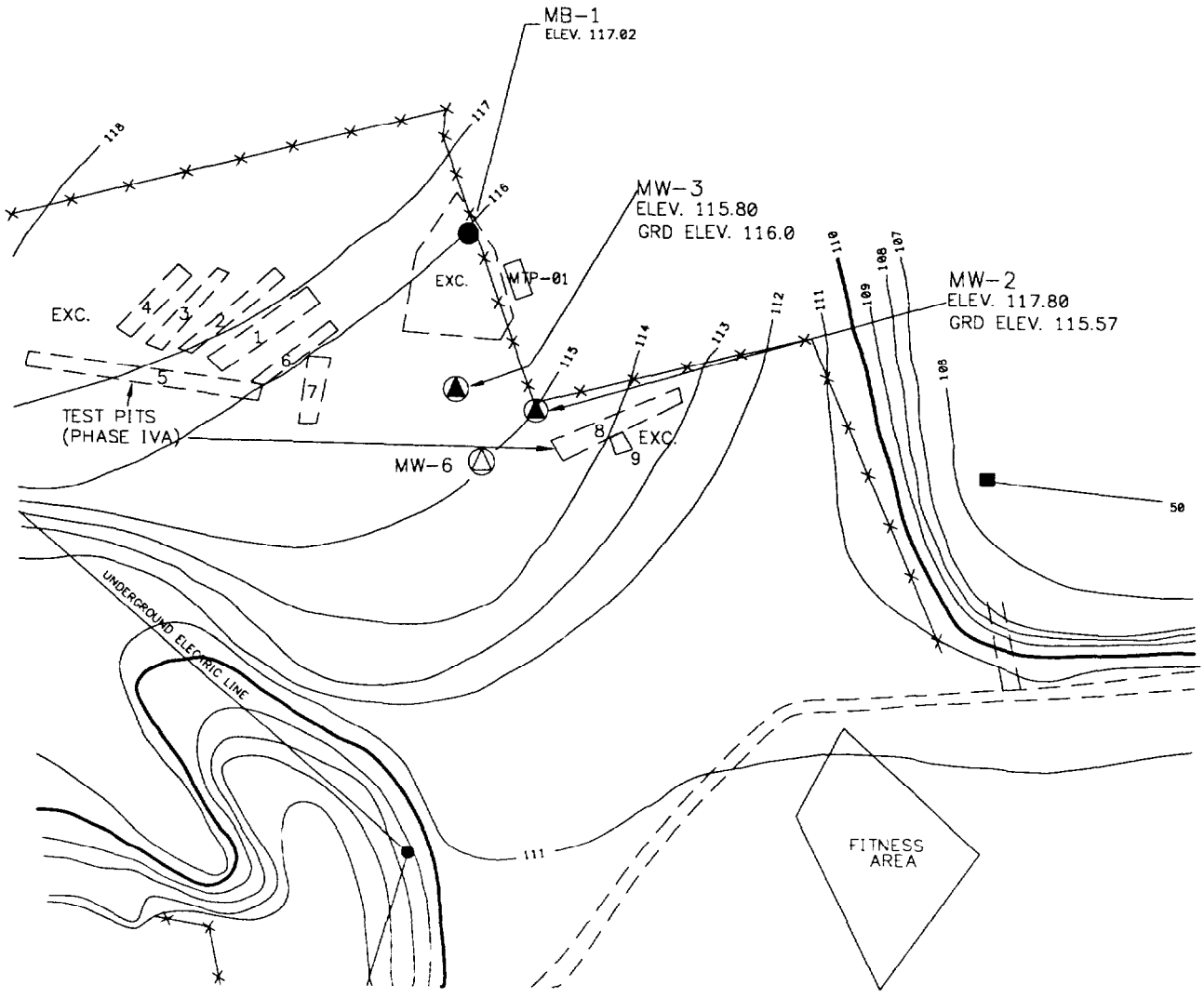

LEGEND

- EXISTING MONITORING WELL
- SOIL BORING LOCATION (EXISTING)
- APPROXIMATE LOCATION OF BURIAL VAULT

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MERCURY BURIAL SITE II
TEST PIT LOCATIONS
PORTSMOUTH SHIP YARD
KITTERY, MAINE

FIGURE 2-9

HALLIBURTON NUS
Environmental Corporation

For this activity, utility clearances will be obtained before work begins. Also, a magnetometer survey will be performed as an additional check. All excavation will strictly adhere to OSHA requirements regarding trench excavation. Test pits will be roped off upon completion of each day's work activities.

Upon completion of all sampling, field measurement, and removal action activities at the Mercury Burial Sites (SWMU #9), the excavated area will be backfilled with the original fill material. Compaction will take place to restore the areas to their original conditions. At Mercury Burial Site I, the area will be reseeded using grass species indigenous to the area (and approved by a NSY Portsmouth representative), and mulched with straw. At Mercury Burial Site II, the lot will be compacted to provide a level surface suitable for paving. Compaction will be conducted so as not to result in settlement of the paved surface. Repaving and repair of existing fencing is a separate subcontract.

2.10 LIMITED CORRECTIVE ACTION AT MERCURY BURIAL SITES (SWMU #9)

Removal of Contaminated Soil

Limited corrective action is included if mercury-contaminated soils exist at SWMU #9. Limited corrective action includes repair of the concrete pipe(s)/vault(s). Also, to the extent possible, any mercury-contaminated soil will be containerized and labeled. If drums are utilized for containerization, drums will comply with DOT specification 17-C.

The action level for mercury-contaminated soil removal is 20 mg/kg in accordance with RCRA Proposed Subpart S criteria for mercury. Disposal of any containerized soil at an approved facility is the responsibility of NSY Portsmouth. Removal of concrete pipes/concrete blocks will be conducted by a subcontractor, with oversight and soil sample collection/analysis by Halliburton NUS.

Removal of Concrete Blocks/Pipes

Disposal of any concrete pipes/concrete blocks at an approved facility is the responsibility of NSY Portsmouth. Removal of concrete pipes/concrete blocks will be conducted by a subcontractor, with oversight by Halliburton NUS.

2.11 SURFACE WATER SAMPLING

Surface water samples will be collected as grab samples from surface water from the two ponds on Seavey Island. Immediately prior to sampling, the temperature, pH, and conductivity of the sample water will be measured and recorded on the surface water sample form (attached in Appendix D). During sampling, the sample bottle will be submerged just below the water surface and allowed to fill. After the sample bottle has been completely filled, preservations will be added (if required) and the sample bottle will be capped. Samples to be analyzed for volatile constitutes shall be collected first and immediately sealed in a container so that no head space exists. If there is an insufficient depth of water to use the direct fill method of sample collection, a stainless steel beaker will be used to fill the sample bottles. Sample beakers will be decontaminated between samples as described in Section 6.7 of the QAPP (attached in Appendix B). Sample locations are shown of Figure 2-10.

Sample handling and chain of custody requirements are addressed in Sections 6.6 and 7.0 of the QAPP. All pertinent field data will be recorded using a surface water sample form (attached in Appendix D) and in the field log book.

2.12 SEDIMENT SAMPLING

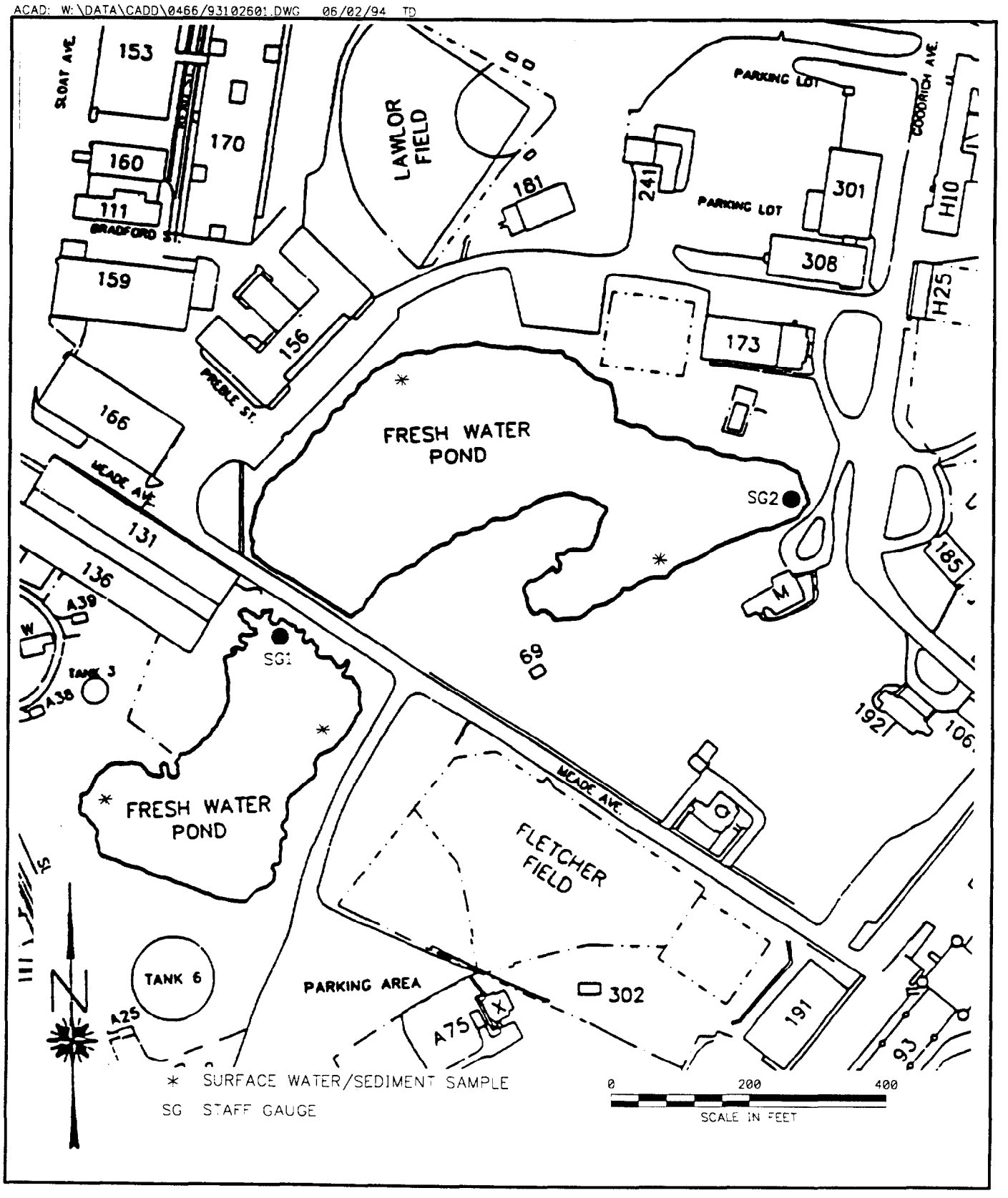
Sediment samples will be collected as grab samples from pond perimeters and bottoms. A stainless-steel trowel or hand auger will be used to collect the sediment sample. Upon sample retrieval, a sufficient volume will be obtained for volatile organics analysis and sealed with no head space. The remaining material will be homogenized and distributed to the remaining sample containers. Sample equipment will be decontaminated between samples as described in Section 6-7 of the QAPP (attached in Appendix B). Sample locations are shown on Figure 2-10.

All pertinent field data will be recorded using a sediment sampling form (attached in Appendix B) and the field log book.

2.13 POND INVESTIGATION/SEEP SAMPLING

Pond Staff Gauges and Piezometers

Staff gauges will be installed within the two ponds to obtain surface water elevation data. Ten piezometers will be installed within the bottom sediments in the larger pond and 8 in the smaller pond to determine the



FRESH WATER PONDS
PORTSMOUTH NAVAL SHIPYARD
KITTERY, MAINE

FIGURE 2-10

Halliburton NUS CORPORATION

direction and source of water flow at the surface water/groundwater interface. Piezometers will be constructed of 1 to 2-inch diameter clear plastic tubing/pipe. The piezometers will be evenly distributed across each pond. Samples will be collected from each piezometer and analyzed only for tritium for groundwater age dating purposes.

Pond Discharge Measurement

To determine the rate of outflow from the ponds a mechanical continuous flow monitor will be fitted in the existing discharge box at the downstream pond. Note that the upstream pond discharges to the downstream pond. Additionally, a rain gauge will be utilized to monitor rainfall during the RFI Data Gap investigation.

Dye Tracer Study

The discharge area for the ponds will be determined by a dye tracer test using Rhodamine WT, a fluorescent dye. A dye tracer test is important because the discharge location of the ponds is currently unknown. The continuous discharge of water from the ponds to the overburden aquifer will influence local groundwater flow patterns (and potentially groundwater quality); thus identification of the location of the discharge will enhance the overall understanding of groundwater flow patterns.

Figure 2-6 shows likely discharge areas. Prior to beginning the tracer test, samples will be obtained from two nearby monitoring wells (JW-9 and MW-6) and seep locations and analyzed for Rhodamine WT, to ensure that Rhodamine WT or a false indicator is not present. If a positive result is obtained from the samples due to background interferences, a substitute tracer will be identified for use.

Dye tracer test samples will be collected twice a week (until the dye is detected) at likely discharge areas, including the monitoring wells near Mercury Burial Site II and nearby surface seeps. If the dye test is not successful by the end of the other field activities, the test will be terminated.

Dye tracer test samples will be analyzed using a filter fluorometer. The filter fluorometer is an instrument that detects the presence of dye through fluorescence, using an ultraviolet light source, and a variety of filters which correspond to the adsorption and emission wavelengths of the dye. A filter fluorometer was selected for use as it is relatively quick and simple to use and produces dependable results. During the tracer test, grab samples will be obtained directly from the wells/seeps monitored, using bailers for wells and glass bottles/vials for seeps. Sample preparation and equipment preparation (instrument calibration,

sample pH and turbidity adjustment) will take place in accordance with the analytical instrument manufacturer's recommendations. Additionally, charcoal packets will be installed as part of the dye tracer study to detect possible releases which may be occurring not during the sampling period.

Seep Sampling

The collection of groundwater discharge (seeps) from the JILF is included as part of the ongoing offshore study to aid in the determination of nature and extent of contamination being released from the JILF (SWMU #8). Data from the offshore study will be incorporated/referenced to enhance the overall understanding of the site hydrogeology and the discharge of contaminants from the JILF into Clark's Island Embayment. In addition, seeps emanating from the JILF will be observed at low tide and at a frequency of three times a week, preliminarily. Then three seeps will be selected for additional observation and sampling. Sampling will consist of field measurement of specific conductivity to evaluate salinity. No chemical analysis for seeps is planned; chemical analysis for seeps was included as part of the offshore study.

Frequency for each of the three seeps will be one sample per hour for 1 day. However, seep sampling will only take place during groundwater discharge. Locations and relative flow rates of the seeps will be recorded to document any seep discharges from the landfill.

2.14 SURVEYING

Several points require surveying as follows:

- Each of the 15 new monitoring wells
- Two staff gauges; one at each of the ponds
- Two tidal gauges; one at the DRMO and one at the JILF
- Mercury Burial Site II location (if found)

Surveying will be conducted using benchmarks established during the previous investigation.

3.0 SAMPLE ANALYSIS

Samples collected at NSY Portsmouth will be submitted to the subcontracted Laboratory for the analyses presented in Table 1-1.

4.0 EQUIPMENT DECONTAMINATION

The equipment involved in the field activities will be decontaminated prior to and during drilling and sampling activities. This equipment includes drilling rigs, downhole tools, well casing and screens, backhoe buckets, and soil and water sampling equipment.

4.1 MAJOR EQUIPMENT

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

Well casings and screens shall be steam cleaned prior to being installed into the borings. The backhoe bucket shall also be steam cleaned between digging each pit.

These operations will consist of washing equipment using high-pressure steam wash from a potable water supply. All decontamination activities will take place at a predetermined area designated by the field representative. Additional requirements for drilling equipment decontamination can be found in SOP GH-1.6, attached in Appendix E.

4.2 SAMPLING EQUIPMENT

All equipment such as trowels and nondedicated bailers will be decontaminated both prior to beginning field sampling and between samples. The following steps will be taken:

- Tap water rinse
- Tap water and Alconox detergent wash
- Reagent Grade II water rinse
- Isopropanol rinse
- Reagent Grade II water rinse
- Air Dry
- Wrap in aluminum foil until used

Additional requirements for sampling equipment decontamination can be found in SOP SF-2.3, attached in Appendix E.

Field analytical equipment such as pH, conductivity and temperature instrument probes will be rinsed first with tap water, then with Reagent Grade II water, and finally with the sample liquid.

5.0 RESIDUE MANAGEMENT

Five types of potentially contaminated residues are expected to be generated during this field investigation, namely Personal Protective Equipment (PPE), drill rig decontamination fluids, sampling equipment decontamination fluids, auger soil cuttings, and purge and development waters. Based on the activities and types of contaminants present, none of these residues are expected to represent a significant risk to human health or the environment if properly managed. Planned management of each of these residues is provided below.

PPE - PPE will be placed in the trash receptacles at the facility.

Drill Rig Decontamination Fluids - Drill rig decontamination fluids will be containerized in 55-gallon drums (as per DOT specification 17-C) and stored at a designated location specified by NSY Portsmouth personnel. Pending the results of the RFI testing, these decontamination fluids will be properly disposed of by the base.

Sampling Equipment Decontamination Fluids - Equipment decontamination fluids will be containerized and handled with the drill rig decontamination fluids.

Auger Soil Cuttings - Contaminated auger soil cuttings, as determined by visual observation and field screening with an HNu/OVA, will be containerized in 55-gallon drums (as per DOT specification 17-C). Drums will be provided by NSY Portsmouth. Non-contaminated soil cuttings will be spread on the ground near the point of origin.

Purge and Development Water - Contaminated groundwater, as determined by visual observation and field screening with an HNu/OVA, which is generated during monitoring well development and sampling activities will be containerized with the drill rig decontamination fluids. Drums will be provided by NSY Portsmouth. Non-contaminated groundwater will be released to the ground near the point of origin.

APPENDIX B

QUALITY ASSURANCE PROJECT PLAN (QAPP)

QUALITY ASSURANCE PROJECT PLAN
PORTSMOUTH NAVAL SHIPYARD
KITTERY, MAINE

COMPREHENSIVE LONG-TERM
ENVIRONMENTAL ACTION NAVY (CLEAN) CONTRACT

Submitted to:
Northern Division
Environmental Branch, Code 1823
Naval Facilities Engineering Command
10 Industrial Highway, Mail Stop #82
Lester, Pennsylvania 19113-2090

Submitted by:
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Contract Number N62472-90-D-1298
Contract Task Order 0148

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1.0 PROJECT DESCRIPTION

As requested by the U.S. Navy, Halliburton NUS has prepared this Quality Assurance Project Plan (QAPP) for a RCRA Facility Investigation (RFI) at the Portsmouth Naval Shipyard (NSY Portsmouth), Kittery, Maine. The scope of work for this project includes multiple activities at several sites within NSY Portsmouth as summarized in Section 1 of the Work Plan. A detailed description of the RFI data gaps and proposed response is detailed in Section 3 of the Work Plan.

Halliburton NUS has established quality assurance/quality control (QA/QC) measures and a program to ensure that these measures are applied to the collection and interpretation of all environmental data at the facility The QAPP is designed to assure that the precision, accuracy, representativeness, comparability, and completeness (the PARCC parameters) of the data are known, documented, and adequate to satisfy the data quality objectives of the study.

This plan represents the policies, organization, objectives, data collection activities, and QA/QC activities that will be utilized to ensure that all data collected during, and reported by, this study are representative of existing conditions This QAPP is in compliance with NEESA guidance provided in the document titled Sampling and Chemical Analysis Quality Assurance Requirements for the Navy Installation Restoration Program NEESA 20 2-047B, Naval Energy and Environmental Support Activity, Port Hueneme, California 93043 Chemical analyses will be conducted by a laboratory subcontractor The laboratory will be NEESA certified and have site-specific Navy approval PACE Laboratories New England has been selected to perform the analytical work and has received site-specific NEESA approval QA/QC procedures for the chemical analyses will satisfy NEESA requirements for Level C and D QC Level D QA/QC will be applied for the TCL organics and TAL inorganics analysis Level C QA/QC will be applied for quick-turnaround mercury analysis and for water quality parameters (i e tritium chloride, sulfate, carbonate/bicarbonate, salinity and gasoline/fuel oil

2.0 SCOPE OF WORK

The RFI to be performed at NSY Portsmouth will be implemented to obtain representative hydrogeologic and environmental data of sufficient quality to refine the conditions at the Portsmouth facility. These data will be used to evaluate the nature and extent of potential contamination and refine the potential method of remediation.

The purpose of the RFI as well as a summary of the proposed investigative activities are presented in Section 1 of the Work Plan. Background information such as location and description of the project sites, physiography, and site histories are presented in Section 2 of the Work Plan. Section 3 of the Work Plan identifies the existing data gaps, proposed response, investigative summary, and investigative rationale. Section 4 describes the project management structure and schedule.

Details of the investigation, such as the technical approach, selection of drilling locations, and sample collection activities, are found in Field Sampling Plan (FSP), attached as Appendix A of the Work Plan. This QAPP is Appendix B of the Work Plan. The Health and Safety Plan (HASP) is attached as Appendix C Field forms to be used during the RFI activities are included as Appendix D, and the Standard Operating Procedures (SOPs) to support the investigative activities are attached as Appendix E The QAPP for PACE Laboratories New England is provided as Appendix F

3.0 SAMPLE MATRICES, PARAMETERS, AND FREQUENCY COLLECTION

As part of the proposed RFI activities, environmental samples will be collected from the following matrices: soil, groundwater, surface water, and sediment.

A listing of the sample matrices, parameters, and frequency of collection is found in Table 3-1. Sampling protocols to be used in this study are provided in Section 6.0 of this QAPP. Environmental samples to be submitted for laboratory analysis include the following:

SOIL	
TCL Volatiles (plus Freon), TCL Semivolatiles, TCL Pesticides/PCBs, TAL Metals, Mercury	
GROUNDWATER	
TCL Volatiles (plus Freon), TCL Semivolatiles, TAL Metals (total and dissolved), TCL Pesticides/PCBs, Lead (total and dissolved), Tritium, Chloride, SO_4, CO_3/HCO_3, Salinity, TPH (Gasoline Range), TPH (Diesel Range)	
SURFACE WATER	
TCL Volatiles, TCL Semivolatiles, TAL Metals (total and dissolved), Chloride, SO_4, CO_3/HCO_3, Salinity	
SEDIMENT	
TCL Volatiles, TCL Semivolatiles, TAL Metals	

In addition, Table 3-2 presents the sample containers, preservation requirements, volume requirements, and allowable holding times for all analyses requested for the RFI activities at NSY Portsmouth.

TABLE 3-1
ANALYTICAL PROGRAM
NSY PORTSMOUTH
KITTERY, MAINE

Media	Analysis	Method	No. Samples	Trip Blank[1]	Rinsate Blank[2]	Field Blank[3]	Duplicate[4]	Total Samples
Groundwater	TCL volatiles plus Freon	CLP OLM01.8	20	5	5	2	2	34
	TCL semi-volatiles	CLP OLM01.8	19	-	4	2	2	27
	TCL pesticides/ PCBs	CLP OLMO1.8	5	-	2	2	1	10
	TAL metals[5] (Total)	CLP ILM03.0	17	-	4	2	2	25
	TAL metals[6] (Dissolved)	CLP ILM03.0	17	-	4	-	2	23
	Lead[5] (Total)	CLP ILMO3.0	1	-	1	2	1	5
	Lead[6] (Dissolved)	CLP ILMO3.0	1	-	1	-	1	3
	Tritium	EPA 906.0	32	-	-	-	4	36
	Chloride	EPA 325.2	14	-	-	-	2	16
	SO_4	EPA 375.4	14	-	-	-	2	16
	CO_3/HCO_3	SM 403	14	-	-	-	2	16
	Salinity	ALPHA 2520B	14	-	-	-	2	16
	TPH (Gasoline range)	Modified SW 846/8015	20	-	-	-	2	22
	TPH (Diesel Range)	Modified SW 846/8100	20	-	-	-	2	22
Surface Water	TCL volatiles	CLP OLM01.8	4	1	1	-	1	7
	TCL semi-volatiles	CLP OLM01.8	4	-	1	-	1	6
	TAL metals[5] (Total)	CLP ILM03.0	4	-	1	-	1	6
	TAL metals[6] (Dissolved)	CLP ILM03.0	4	-	1	-	1	6
	Chloride	EPA 325.2	4	-	-	-	1	5
	SO_4	EPA 375.4	4	-	-	-	1	5
	CO_3/HCO_3	SM 403	4	-	-	-	1	5
	Salinity	ALPHA 2520B	4	-	-	-	1	5

TABLE 3-1
ANALYTICAL PROGRAM
PORTSMOUTH NSY
KITTERY, MAINE
PAGE 2

Media	Analysis	Method	No Samples	Trip Blank[1]	Rinsate Blank[2]	Field Blank[3]	Duplicate[4]	Total Samples
Sediment	TCL volatiles	CLP OLM01 8	4	1	1	-	1	7
	TCL semi-volatiles	CLP OLM01 8	4	-	1	-	1	6
	TAL metals	CLP ILM03 0	4	-	1	-	1	6
Soil	TCL volatiles plus Freon	CLP OLM01 8	35	6	6	-	5	52
	TCL semi-volatiles	CLP OLM01 8	35	-	6	-	5	46
	TAL metals	CLP ILM03 0	35	-	6	-	5	46
	TCL Pesticides/PCBs	CLP OLMO1 8	23	-	4	-	3	30
	Mercury [7]	CLP ILMO3 0	35	-	3	-	4	42

(1) Trip Blanks - Samples which originate from analyte free water taken from the laboratory to the sampling site and returned to the laboratory with the volatile organic (VOA) samples. One trip blank per each cooler containing VOAs

(2) Rinsate Blank - Samples obtained by pouring analyte-free water over sample collection equipment (bailer, etc.) after decontamination. Assesses the effectiveness of field decontamination procedure Obtained at a frequency of 1/day/media/analysis Number of samples reflects the number of actual laboratory analyses performed. Only samples from every other day will be analyzed

(3) Field Blank - Samples consisting of the source water used in (1) steam cleaning and/or (2) decontamination. Obtained at a frequency of 1/event/media.

(4) Duplicates - A single sample split into two portions during a single act of sampling Assess the overall precision of the sampling and analysis program. Obtained at a frequency of 10 percent of the number of samples

(5) Total Metals - For the determination of total metals the sample is not filtered before acidification

(6) Dissolved Metals - For the determination of dissolved metals the sample is filtered to 0 45μ before acidification

(7) Quick turnaround analysis for mercury

TABLE 3-2
SAMPLE CONTAINERS, PRESERVATION METHODS, AND HOLDING TIMES
NSY PORTSMOUTH
KITTERY, MAINE

Method	Parameter	Container Material	Sample Volume	Preservation	Holding Time	No. of Samples (a)
GROUNDWATER						
CLP OLM01.8	TCL Volatiles	Glass, Teflon lined septa	(2) 40 ml	4 C; 4 drops HCl, pH < 2	14 days	20
CLP OLM01.8	TCL Semi-volatiles	Glass, Teflon lined septum	2,500 ml	Cool, 4 C	Extract 7 days; Analyze 40 days	19
CLP OLMO1.8	Pesticides/ PCBs	Glass, Teflon lined septum	4 liter	Cool, 4 C	Extract 7 days; Analyze 40 days	5
CLP ILM03.0	TAL Metals (Total)	Plastic, glass	1 liter	4 C; HNO_3 to pH < 2	6 months*	17
CLP ILM03.0	TAL Metals (Dissolved)	Plastic, glass	1 liter	4 C; HNO_3 to pH < 2	6 months*	17
CLP ILMO3.0	Lead (Total)	Plastic	1 liter	4 C; HNO_3 to pH < 2	6 months	1
CLP ILMO3.0	Lead (Dissolved)	Plastic	1 liter	4 C; HNO_3 to pH < 2	6 months	1
EPA 906.0	Tritium	Plastic	1 liter	None required	None	32
EPA 325.2	Chloride	Plastic, glass	50 ml	None required	28 days	14
EPA 375.4	SO_4	Plastic, glass	50 ml	Cool, 4 C	28 days	14
SM 403	CO_3/HCO_3	Plastic	1 liter	Cool, 4 C	14 days	14
ALPHA 2520B	Salinity	Wide mouth glass jar with Teflon lined lid	240 ml	Cool, 4 C	7 days	14
Modified SW 846/8015	TPH (Gasoline Range)	Glass	(3) 40 ml	4 C; HCl to pH < 2	14 days	20

TABLE 3-2
SAMPLE CONTAINERS, PRESERVATION METHODS, AND HOLDING TIMES
PORTSMOUTH NSY
KITTERY, MAINE
PAGE 2

Method	Parameter	Container Material	Sample Volume	Preservation	Holding Time	No. of Samples (a)
Modified SW 846/8100	TPH (Diesel Range)	Glass	1 liter	Cool, 4 C	Extract 14 days Analyze 40 days	20
SURFACE WATER						
CLP OLM01.8	TCL Volatiles	Glass, Teflon lined septa	(2) 40 ml	4 C; 4 drops HCl, pH < 2	14 days	4
CLP OLM01.8	TCL Semi volatiles	Glass, Teflon lined septum	2,500 ml	Cool, 4 C	Extract 7 days; Analyze 40 days	4
CLP ILM03.0	TAL Metals (Total)	Plastic, glass	1 liter	Cool, 4 C	6 months*	4
CLP ILM03.0	TAL Metals (Dissolved)	Plastic, glass	1 liter	Cool, 4 C	6 months*	4
EPA 325.2	Chloride	Plastic, glass	50 ml	None required	28 days	4
EPA 375.4	SO_4	Plastic, glass	50 ml	Cool, 4 C	28 days	4
SM 403	CO_3/HCO_3	Plastic	1 liter	Cool, 4 C	14 days	4
ALPHA 2520B	Salinity	Wide mouth glass jar with Teflon lined lid	240 ml	Cool, 4 C	7 days	4
SEDIMENT						
CLP OLM01.8	TCL Volatiles	Wide mouth amber glass jar with Teflon lined lid	120 ml (4 oz.)	Cool, 4 C	14 days	4
CLP OLM01.8	TCL Semi-volatiles	Wide mouth amber glass jar with Teflon lined lid	120 ml (4 oz.)	Cool, 4 C	Extract 7 days; Analyze 40 days	4

TABLE 3-2
SAMPLE CONTAINERS, PRESERVATION METHODS, AND HOLDING TIMES
PORTSMOUTH NSY
KITTERY, MAINE
PAGE 3

Method	Parameter	Container Material	Sample Volume	Preservation	Holding Time	No. of Samples (a)
CLP ILM03.0	TAL Metals	Wide mouth glass jar	240 ml (8 oz.)	Cool, 4 C	6 months*	4
SOIL						
CLP OLM01.8	TCL Volatiles	Wide mouth glass jar with Teflon lined lid	240 ml (8 oz.)	Cool, 4 C	14 days	35
CLP OLM01.8	TCL Semi volatiles	Wide mouth glass jar with Teflon lined lid	240 ml (8 oz.)	Cool, 4 C	Extract 7 days; Analyze 40 days	35
CLP OLM01.8	TCL Pesticides/ PCBs	Wide mouth glass jar with Teflon lined lid	240 ml (8 oz.)	Cool, 4 C	Extract 7 days; Analyze 40 days	23
CLP ILM03.0	TAL Metals	Wide-mouth glass jar	240 ml (8 oz.)	Cool, 4 C	6 months*	35
CLP ILM03.0	Mercury (Quick turn around analysis)	Wide mouth glass jar	120 ml (4 oz.)	Cool, 4 C	28 days	35

* Except for mercury which has a 28 day holding time

(a) Excludes field and laboratory QA/QC samples. Refer to Table 3-1 for field QA/QC samples.

4.0 PROJECT ORGANIZATION AND RESPONSIBILITIES

Halliburton NUS will be responsible for the overall management of the project, including the field inspection and implementation of all drilling and sampling activities. Personnel from Navy will be actively involved in the investigation and will coordinate with personnel from Halliburton NUS in a number of areas.

4.1 PROJECT ORGANIZATION

The key firms and personnel involved in the investigation, as well as the chain of communication and responsibility of the project personnel, are as follows:

The Navy Remedial Project Manager (RPM) is:

Lt. Jim Conroy, Remedial Project Manager
Northern Division
Naval Facilities Engineering Command
10 Industrial Highway, Mail Stop #82
Lester, PA 19113
Phone (215) 595-0567
Fax (215) 595-0555

The NSY Portsmouth Point of Contact is

Jim Tayon, Environmental Engineer
Portsmouth Naval Shipyard
Portsmouth, NH 03801-2032
Attn: Code 121.5
Phone (207) 438-3832
Fax (207) 438-1535

During fieldwork, all deliverables should be mailed to the following address

Dennis Gagnon, TSD
Building 313
Portsmouth Naval Shipyard
Portsmouth, NH 03801-2032
Phone (207) 438-2558

Halliburton NUS personnel are as follows

Halliburton NUS Corporation
Foster Plaza 7
661 Andersen Drive
Pittsburgh, Pennsylvania 15220
(412) 921-7090

Linda Klink
Project Manager

Debra Scheib
Quality Assurance/Quality Control

Matt Soltis
Health and Safety Manager

John Trepanowski
Program Manager
993 Old Eagle School Road, Suite 415
Wayne, Pennsylvania 19087-1710

The Project Manager has the primary responsibility for project and technical management of this project. She is responsible for the coordination of all onsite personnel, and for providing technical assistance for all activities that are directly related to the determination of the hydrogeologic conditions and the environmental quality of the site The review of all environmental and hydrogeologic data will also be conducted by the Project Manager If quality assurance problems or deficiencies requiring special action are identified the Project Manager and project QA/QC advisor will identify the appropriate corrective action

4.2 FIELD ORGANIZATION

The Halliburton NUS field investigation team will be organized according to the activities planned For onsite sampling the sampling team members will be selected based upon the type and extent of effort required The team will consist of a combination of the following personnel

- Field Team Leader (FTL)
- Field hydrogeologist/geologist
- Health and Safety specialist

The FTL will be responsible for the coordination of all onsite personnel and for providing technical assistance when required The FTL or his or her designee will coordinate and be present during all sampling activities and will assure the availability and maintenance of all sampling materials/equipment The FTL will be responsible for the completion of all sampling, well construction, and chain-of-custody documentation, and will assume custody of all samples and ensure the proper handling and shipping of samples

The FTL will also be responsible for providing technical supervision of the drilling subcontractor and for maintaining a geologic log of all borings drilled. Copies of the forms to be used in this investigation are provided as Appendix D.

The QA Manager, although not formally part of the field team, will be responsible for the adherence of all guidelines as defined in this QAPP. Strict adherence to these procedures is critical to the collection of acceptable and representative data.

A site safety officer will be designated prior to field activities and will be responsible for assuring that all team members adhere to the designated health and safety requirements.

5.0 QUALITY ASSURANCE OBJECTIVES

The overall QA objective is to develop and implement procedures for field sampling, chain-of-custody, laboratory analysis, and reporting that will provide environmental monitoring data of known and acceptable quality. Specific procedures to be used for sampling, chain-of-custody, calibration of field instruments, laboratory analysis, reporting, internal quality control, audits, preventative maintenance, and corrective actions are described in later sections of this QAPP. The purpose of this section is to address the data quality objectives in terms of the (PARCC) parameters, quantitation and detection limits, field blanks, rinsate blanks, duplicates, and bottleware cleanliness.

5.1 DATA QUALITY OBJECTIVES

Data Quality Objectives (DQOs) are qualitative and/or quantitative statements regarding the quality of data needed to support the field activities. The sampling rationale provided in the Work Plan explains the choice of sample locations and media which will supply information needed for the site investigation.

5.2 PARCC PARAMETERS

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

5.2.1 Precision

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

$$\text{Range} = OR - DR$$

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

where **OR** = original sample result

DR = duplicate sample result

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

5.2.2 Accuracy

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

$$\% R = E/T \times 100\%$$

where **E** = experimental result

T = true value (theoretical result)

and

$$T = \frac{(Sample\ Aliquot)\ (Sample\ Conc.) - (Spike\ Aliquot)\ (Spike\ Conc.)}{Sample\ Aliquot - Spike\ Aliquot}$$

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

Accuracy for aqueous and solid samples will be evaluated by use of surrogate and matrix spikes Out-of-criteria results will be reviewed for data applicability as a part of data validation

5.2.3 Representativeness

All data obtained should be representative of actual conditions at the sampling location The Work Plan is designed so that the samples taken will present an accurate representation of actual site conditions. The rationales discussed in the Work Plan and QAPP are designed to ensure this. All sampling activities will conform to the protocols given in Section 6.0 of this QAPP. The use of NEESA approved analytical

protocols and data deliverables will ensure that analytical results and deliverables are representative, and both consistently performed and reported.

5.2.4 Comparability

Comparability will be achieved by utilizing standardized sampling and analysis methods and data reporting format. Both analytical procedures and sample collection techniques will maximize the comparability of this new data to previous data. Additionally, consideration will be given to seasonal conditions and other environmental conditions that could influence analytical results.

5.2.5 Completeness

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

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

5.3 FIELD BLANKS

Field blanks are obtained by sampling the water(s) used in decontamination during the field investigation activities. 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 sampling event. Field blanks will be obtained during the first week of the sampling activities.

5.4 RINSATE BLANKS

Equipment rinsate blanks are obtained under representative field conditions by running analyte-free water through sample collection equipment (bailer, split-spoon, corer, etc.) after decontamination and placing it 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 media. However, only every other day's samples will be analyzed, unless positive detections are recorded in the prior rinsate blank. For dedicated or precleaned equipment, rinsate blanks will be collected and analyzed at a frequency of one per lot for a specific equipment type. It will be the responsibility of the FTL to communicate to the laboratory whether an equipment blank is, or is not, to be analyzed as stated above.

5.5 FIELD DUPLICATES

Field duplicates are two samples collected: (1) independently at a sampling location in the case of groundwater or surface water, or (2) a single sample split into two portions in the case of soil or sediment. Duplicates are obtained during a single act of sampling and are used to assess the overall precision of the sampling and analysis program. Ten percent of all samples for each media shall be field duplicates. Duplicates shall be analyzed for the same parameters in the laboratory and will be labeled so as to make the identity of the duplicate unknown to the laboratory

5.6 TRIP BLANKS

Trip blanks are samples which originate from analyte-free water taken from the laboratory to the sampling site and returned to the laboratory with the volatile organic analysis (VOA) samples (such as TCL volatiles or BTEX) One trip blank will be collected per each cooler containing VOAs Trip blanks are only analyzed for the volatile constituents that are being shipped in a given cooler

5.7 BOTTLE WARE

NEESA requires specific bottleware cleaning procedures Precleaned, certified-clean, bottles will be used at the NSY Portsmouth Site Precleaned bottles will be provided by the subcontracted laboratory who will also be responsible for providing the required certification All bottles must meet ICHEM Series 300 cleanliness criteria or equivalent

6.0 SAMPLING PROCEDURES

6.1 SITE BACKGROUND

Site specific background information is provided in Section 2.0 of the Work Plan.

6.2 SAMPLING OBJECTIVES

The overall objective of the RFI will be to refine the extent of contamination and fill existing data gaps that exist at the NSY Portsmouth. The data collected will also be used to assess potential migration pathways as well as vertical and horizontal extent of contamination and recommend potential remediation strategies. A detailed discussion of the existing data gaps and sampling objectives is presented in Section 3 of the Work Plan.

6.3 SAMPLE LOCATION AND FREQUENCY

Soil, groundwater surface water, and sediment samples will be collected during the RFI field activities. These samples will be analyzed in accordance with NEESA methodology for those compounds and analytes identified in Section 3 0 of this QAPP A list of the analyses, field QC samples, analytical method, containers preservatives, volume requirements and holding times are provided in Tables 3-1 and 3-2 of this QAPP

The sampling program consists of seven investigative activities These activities are as follows and are described in detail in Sections 3 0 of the Work Plan and in The Field Sampling Plan attached as Appendix A

- Monitoring Well Installation and Sampling
- Surface Water and Sediment Sampling
- Subsurface Soil Sampling
- Test Pit Excavation and Sampling
- Soil Gas Sampling

6.4 SAMPLE DESIGNATION

Each sample collected will be assigned a unique sample tracking number. The sample tracking number will consist of a two-segment, alpha-numeric code that identifies the sample medium and location, and sample round identifier (in the case of groundwater samples).

Any other pertinent information regarding sample identification will be recorded in the field log books.

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

(AAAA[N])	-	**(AANN)**	-	**(AANN)**
(Site ID)		(Location)		(Medium & Round Identifier)

Character Type

A	=	Alpha
N	=	Numeric

Site ID

JILF	=	Jamaica Island Landfill
MBS1	=	Mercury Burial Site 1
MBS2	=	Mercury Burial Site 2
DI	=	Dennett s Island
SI	=	Seavy Island
FA	=	Fill Area
DRMO	=	DRMO Facility
WOT	=	Former Waste Oil Tanks

Sample Location

Groundwater sample = Monitoring well number

Surface water sample = Sample location number

Sediment sample = Sample location number

Soil sample = Soil boring number

Medium:

GW	=	Groundwater from monitoring well
SW	=	Surface water
SD	=	Sediment
SO	=	Soil

Sample Round Identifier:

For all samples = sampling round (this will be round 06)

For example, a groundwater sample collected during from monitoring well 13DB at Jamaica Island Land Fill would be designated as: JILF-13DB-GW06

Field quality control (QC) samples will be designated using a different coding system. The QC code will consist of a two-segment, alpha-numeric code that identifies the sample medium (for duplicates only), QC type, and date The same sample medium codes will be used as for the standard environmental samples (GW, SW, SD, and SO) The QC types are identified as:

TB = Trip Blanks
FB = Field Blanks
FD = Duplicates
RB = Rinsate Blanks

Matrix Spike and Matrix Spike Duplicate (MS/MSD) samples will be designated on the field documentation forms and sample labels MS/MSDs are collected at a frequency of 1 per 20 samples per matrix and double or triple volumes of sample are required MS/MSDs will be collected at the same location as the duplicates to provide a "blind" sample to the laboratory

For example a duplicate of a groundwater sample obtained on July 6 1994 would be designated as GWFD-070694

The sampling time recorded on the chain-of-custody form for duplicate and matrix spike/matrix spike duplicate samples will be 00 00 so that the samples are "blind" to the laboratory Notes detailing the sample number, time, date, and type will be recorded in the field log book.

6.5 SAMPLE EQUIPMENT AND PROTOCOLS

The sampling equipment and protocols to be used are presented in Appendix E of the Work Plan.

6.6 SAMPLE HANDLING AND ANALYSIS

Sample handling and analysis are presented in Sections 5.0, 6.0, and 7.0 of this QA/QC Plan.

6.7 EQUIPMENT DECONTAMINATION

The equipment involved in field sampling activities will be decontaminated prior to and during drilling and sampling activities This equipment includes drilling rigs, downhole tools, augers, well casing and screens, and all sampling equipment.

6.7.1 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 casing and screens 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 a location determined during mobilization Additional requirements for drilling equipment decontamination can be found in Halliburton NUS SOP GH-1 6 (Section 5) included in Appendix E

6.7.2 Sampling Equipment

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

- Potable water rinse
- Alconox or Liquinox detergent wash
- Potable water rinse
- Nitric acid rinse

- Analyte-free water rinse
- Methanol rinse
- Analyte-free water rinse
- Air dry

7.0 SAMPLE CUSTODY

Sample custody procedures are designed to provide documentation of preparation, handling, storage, and shipping of all samples collected. An example of the chain-of-custody form, which will be used during this investigation, is included in Appendix D of the Work Plan. A copy of the procedure is included in Appendix E.

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

7.1 FIELD CUSTODY

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

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

- Chain-of-custody sample forms will be completed to the fullest extent possible prior to sample shipment They will include the following information project name, sample number, time collected, source of sample and location, description of sample location, matrix type of sample, grab or composite designation, preservative, and name of sampler (see attached form)

  These forms will be filled out in a legible manner, using waterproof ink, and will be signed by the sampler Similar information will be provided on the sample label which will be securely attached to the sample bottle The label will also include the general analyses to be conducted In addition sampling forms will be used to document collection, filtration, and preparation procedures Copies of all forms used during field activities are provided in Appendix D

7.2 TRANSFER OF CUSTODY AND SHIPMENT

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

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

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

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

- Proper documentation will be maintained for shipments by common carrier.

7.3 SAMPLE SHIPMENT PROCEDURES

The following procedures will be followed when shipping samples for laboratory analysis.

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

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

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

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

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

7.4 FIELD DOCUMENTATION RESPONSIBILITIES

It will be the responsibility of the FTL to secure all documents produced in the field (geologist's daily logs, lithologic and sampling logs, calibration forms, communications) at the end of each work day. A copy of all forms used during field activities are included in Appendix D. Copies of all field notebooks will be forwarded to Rich Fini of Northern Division at the end of each month.

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

7.5 LABORATORY SAMPLE CUSTODY

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

A sample is under custody if

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

Sample custody during collection and shipping is discussed in Section 5 3 of Halliburton NUS SOP SA-6 1 Laboratory sample custody is discussed in the following sections

7.5.1 Sample Receipt

When samples are received, the shipping manifest is signed and dated to acknowledge sample receipt. The sample custodian must examine the shipping containers and verify that the correct number of containers was received. The shipping containers are then opened and the enclosed sample paperwork is removed. Samples are removed from the shipping containers and the bottle condition must be noted. The information on the chain-of-custody, the airbill, the containers, and the laboratory request is reviewed to note any discrepancies.

7.5.2 Sample Storage

All samples received by the laboratory must be stored at 4°C until analysis. Laboratory holding times are specified by the contract and are presented in Table 3-2.

8.0 CALIBRATION PROCEDURES AND FREQUENCY

Instrument used in the field and in the laboratory will be calibrated according to the procedures described below. Several monitoring instruments will be used during field activities, including:

- Temperature probe
- Specific conductance meter
- pH meter
- Electronic water-level meter
- HNu/OVA organic vapor detector
- LEL/O_2 explosimeter
- Turbidity meter
- Jerome mercury vapor analyzer
- Flowmeter
- Hexavalent chromium analyzer

The electronic water-level meter will be calibrated prior to field use and periodically at the discretion of the Field Team Leader (FTL) The remaining instruments will be calibrated daily or according to the manufacturer s operating manual

Calibration will be documented on an Equipment Calibration Log (Appendix D) The SOP for calibration procedures is included in Appendix E 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

Calibration of equipment at the analytical laboratory will comply with the specified analytical method

9.0 ANALYTICAL PROCEDURES

Environmental samples collected during the field investigation for chemical analyses will be analyzed using the appropriate analytical procedures as outlined in Section 3.0 of this QAPP.

10.0 DATA REDUCTION, VALIDATION, AND REPORTING

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

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

A qualified Halliburton NUS chemist (or a qualified subcontracted data validation firm, if requested by the Navy) will review the analytical data packages using EPA procedures. One hundred percent of the total number of environmental samples will be validated. Data validation will not be conducted on common water quality parameters or other parameters such as salinity, and TPH (Gasoline and Diesel range). After the data is validated, a listing of non-conformities will be generated and used to determine whether the data can be utilized for its intended purpose. Non-conformities require data qualifiers, which are used to alert the data user to inaccurate or imprecise data. For example, if holding times are exceeded, the data reviewer must qualify all positive results as estimated and all sample quantitation limits as estimated. For situations in which there are several quality control criteria out of specification (with regard to the limits specified in the Sampling and Chemical Analysis Quality Assurance Requirements for the Navy Installation Restoration Program, NEESA 20.2-047B, June 1988), the data validator may make professional judgments and/or comments on the validity of the overall data package. In situations where the validity of an entire data package is in question, it may be necessary for the sample(s) to be re-analyzed. The reviewer will then prepare a technical memorandum presenting changes in the data, if necessary, and the rationale for making such changes.

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

The final report will include a data summary. The summary of analytical data will exclude non-detected compounds. No subtraction of blanks will be allowed. Data will be flagged if blank contamination occurs. All data flags will follow the result in the summary.

The laboratory data for each sample will be reported in an appendix. These data will be presented in a spreadsheet format with all field, and blanks marked. The format recommended by NEESA will be used. Field logs and forms will be included in another appendix.

11.0 INTERNAL QUALITY CONTROL CHECKS

Quality control samples generated by Halliburton NUS will include the collection of field duplicates, the preparation of field blanks, trip blanks, and the preparation of equipment/rinsate blanks. An approximate 10 percent duplication (one per 10 samples or one per sample matrix if less than 10 samples) will be collected. See Table 3-1 for the required number of sample duplicates.

Trip blanks will be prepared on a one per day frequency. Rinsates, prepared by running distilled water through the sampling equipment, will be analyzed to determine whether the sampling procedures may be biasing the data Field blanks will be prepared at a rate of one per source per event. Procedures for collecting these samples are contained in the Section 6.0 of this QA/QC Plan.

There are two types of quality assurance mechanisms used to ensure the production of analytical data of known and documented quality. The internal quality control procedures for the analytical services are specified under NEESA guidelines and Table 3-1. These specifications include the types of control samples required (sample spikes, surrogate spikes, controls, and blanks), the frequency of each control, the compounds to be used for sample spikes and surrogate spikes, and the quality control acceptance criteria It will be the laboratory's responsibility to document, in each package, that both initial and ongoing instrument and analytical QC criteria are met This documentation will be included in the data packages generated by the contract laboratory

Analytical results of field-collected quality control samples will also be compared to acceptance criteria and documentation will be performed showing that criteria have been met Any samples in nonconformance with the QC criteria will be identified and reanalyzed by the laboratory if possible The following procedures will be employed for the samples

- Proper storage of samples
- Use of qualified and/or certified technicians
- Use of calibrated equipment
- Formal independent confirmation of all computation and reduction of laboratory data and results
- Use of standardized test procedures
- Inclusion of replicate samples at a frequency of one replicate per 10 samples or one per sample matrix if less than 10 samples are collected

12.0 PERFORMANCE AND SYSTEM AUDITS

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

- The FTL will supervise and check on a daily basis that the monitoring wells are installed and developed correctly, field measurements are made accurately, equipment is thoroughly decontaminated, samples are collected and handled properly, and the field work is accurately and neatly documented.

- The data validator will review (on a timely basis) the data packages submitted by the laboratory. The data validator will check that the data was obtained through the approved methodology, that the appropriate level of QC effort and reporting was conducted, that holding times were met, and that the results are in conformance with the QC criteria. On the basis of these factors, the data validator will evaluate the data quality and limitations.

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

- System audits for the laboratory are conducted by NEESA on a regular basis as required.

- A formal audit of the field sampling procedures may be conducted in addition to the auditing that is an inherent part of the daily project activities.

- The auditors will check that sample collection, sample handling, decontamination protocols and instrument calibration and use are in accordance with the approved project SOPs. The auditors will also check that the field documentation logs and chain-of-custody forms are being filled out properly.

The subcontracted analytical laboratory must be approved by NEESA, be eligible to perform the required analysis under NEESA protocols, and must have site-specific approval prior to commencement of work.

13.0 PREVENTATIVE MAINTENANCE

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

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

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

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

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

14.0 DATA ASSESSMENT PROCEDURES

14.1 REPRESENTATIVENESS, ACCURACY, AND PRECISION

All data generated in the investigation will be assessed for its representativeness, accuracy, and precision. The completeness of the data will also be assessed by comparing the valid acquired data to the project objectives to see that these objectives are being addressed and met. The specific procedures used to determine data precision, accuracy, and completeness will be provided in the analytical reports. Accuracy will be determined using laboratory spiked samples and laboratory field blanks.

The representativeness of the data will be assessed by determining if the data are consistent with known or anticipated hydrogeologic or chemical conditions and accepted principles. Field measurements will be checked for completeness of procedures and documentation of procedures and results.

Precision and accuracy will be determined using replicate samples and blank and spiked samples, respectively. The specific procedures for determining PARCC parameters are outlined in Section 5.0.

14.2 VALIDATION

One hundred percent of the analytical data packages for each media will be validated. Data validation will not be conducted on common water quality parameters or other parameters such as salinity and TPH (Gasoline and Diesel range).

14.3 DATA EVALUATION

The evaluation of the data collected during the field investigation will be a comparison of chemical concentrations in the hydraulically upgradient groundwater well versus the chemical concentration in the downgradient groundwater wells, chemical concentrations in groundwater versus ARARs (such as the Safe Drinking Water Act MCLs) and risk-based concentrations, and chemical concentrations in soils versus background and risk-based concentrations.

If downgradient groundwater concentrations for contaminants of concern are statistically higher than that of the background well, this would indicate that the site is a source of the contamination. The conclusions of the data collected is expected to either conclusively indicate that the site is, or is not, causing groundwater contamination, or the data may be inconclusive and indicate that additional data collection

is required. Relatively conclusive data that the site is causing groundwater contamination would occur if there is a significant (one or more orders of magnitude) increase in contaminant concentrations from the upgradient wells to the downgradient wells. If the contaminant concentrations are nearly identical (+/-25%) in the upgradient and downgradient wells, then this would indicate that the site is not causing the groundwater contamination. Otherwise, the data is inconclusive and additional rounds of groundwater sampling would be required to allow a statistical evaluation.

The approach for evaluating concentrations in surface water, soils, and sediments is similar to that for groundwater. The evaluation of the data collected during the field investigation will be a statistical comparison of chemical concentrations in natural or background samples versus the chemical concentration in the onsite samples; and chemical concentrations in onsite media versus MCLs, action levels, and/or risk-based concentrations.

15.0 CORRECTIVE ACTION

The QA program will enable problems to be identified, controlled, and corrected. Potential problems may involve nonconformance with the SOPs and/or analytical procedures established for the project or other unforeseen difficulties. Any person identifying an unacceptable condition will notify the project manager. The project manager, with the assistance of the project QA/QC officer, will be responsible for developing and initiating appropriate corrective action and verifying that the correction action has been effective. Corrective actions may include the following resampling and/or reanalysis of sample, amending or adjusting project procedures. If warranted by the severity of the problem (for example, if a change in the approved work plan is required), the Navy will be notified in writing and their approval will be obtained prior to implementing any change. Minor changes will be documented to the main file by the Halliburton NUS project manager. Additional work that is dependent on a nonconforming activity will not be performed until the problem has been eliminated.

The laboratory maintains an internal closed-loop corrective action system that operates under the direction of the laboratory QA coordinator.

16.0 QUALITY ASSURANCE REPORTS

The QA/QC advisor will review all aspects of the implementation of the QA/QC Plan on a regular basis and prepare a summary report. Also, monthly progress reports will be sent to NFESC's subcontractor for QA/QC review. Reviews will be performed at the completion of each field activity and reports will be completed at this time. These reports will include an assessment of data quality and the results of system and/or performance audits. Any significant QA deficiencies will be reported and identified, and corrective action possibilities discussed. The laboratory will issue monthly progress reports.

Other QA/QC reports are listed in Section 8.0.

17.0 REFERENCES

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

U.S. EPA, September 1991. Contract Laboratory Program Statement of Work for Inorganics Analysis. CLP SOW ILM02.1.

U.S. EPA, October 1992. Contract Laboratory Program Statement of Work for Organics Analysis. CLP SOW OLM01.8.

U.S.EPA, April 1993. Region III Modifications to National Functional Guidelines for Inorganic Data Review.

U.S.EPA, May 1993. Region III Modifications to National Functional Guidelines for Organic Data Review.

APPENDIX C

HEALTH & SAFETY PLAN (HASP)

RFI DATA GAP HEALTH AND SAFETY (HASP)

COMPREHENSIVE LONG-TERM
ENVIRONMENTAL ACTION NAVY (CLEAN) PROGRAM

PORTSMOUTH NAVAL SHIPYARD
KITTERY, MAINE

SUBMITTED TO:
NORTHERN DIVISION, ENVIRONMENTAL BRANCH, CODE 1423/FK
NAVAL FACILITIES ENGINEERING COMMAND
BUILDING 77-L, U.S. NAVAL BASE
PHILADELPHIA, PENNSYLVANIA 19112-5094

SUBMITTED BY:
HALLIBURTON NUS ENVIRONMENTAL CORPORATION

CONTRACT NUMBER N62472-90-D-1298

CONTRACT TASK ORDER 0148

JUNE 1994

APPROVED BY:

Linda Klink

LINDA E. KLINK
PROJECT MANAGER

APPROVED FOR SUBMISSION BY:

James K. Laffey for

MATTHEW M. SOLTIS, CSP
CLEAN HEALTH & SAFETY MANAGER

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1.0 INTRODUCTION AND ORGANIZATION

1.1 PURPOSE

The purpose of this Health and Safety Plan (HASP) is to provide for the protection of personnel performing activities planned at the Portsmouth Naval Shipyard site in the Data Gap Remedial Field Investigation effort. This HASP specifies personnel responsibilities and restrictions, establishes requirements (such as the use of personal protective equipment, adherence to standard work practices, etc.), and the use of evaluation techniques that will be utilized (such as the use of real-time monitoring instrumentation) throughout the planned site activities.

This HASP has been prepared to satisfy the requirements of applicable OSHA standards, most specifically standard 29 CFR §1910 120, entitled "Hazardous Waste Operations and Emergency Response". This HASP has been developed based on available information regarding potential chemical and physical hazards which may be encountered by field personnel during the performance of the planned site activities. If additional or revised information becomes available, this HASP will be modified accordingly It is the responsibility of the Halliburton NUS Project Manager to communicate any such information to the CLEAN Health and Safety Manager (HSM), Matthew M Soltis, CSP, who will determine any HASP modification needs

1.2 KEY PROJECT PERSONNEL AND ORGANIZATION

Key project personnel and their associated project positions (responsibilities) including identifying safety and health responsibilities are identified in Figure 1-1 The Halliburton NUS Project Manager (PM) has overall responsibility for the direction and implementation of health and safety for this project The Halliburton NUS Field Team Leader (FTL) is responsible for the implementation of this HASP with technical assistance and support from the Site Safety Officer (SSO) The SSO is the individual assigned the responsibility of overseeing the implementation of this HASP throughout all site activities, and is a member of the onsite field team The Project Health and Safety Officer is a member of the Halliburton NUS Health Sciences staff, and is the primary contact for technical health and safety support for this project The CLEAN HSM is responsible for providing health and safety technical oversight, review and approval duties for all CLEAN projects, and for monitoring compliance with this HASP and the CLEAN Health and Safety Management Plan

1.3 SITE BACKGROUND

A detailed discussion of the history and background of the Portsmouth Naval Shipyard, and of the individual site areas where work activities are planned to be performed under this project, is presented in a previous section of this Work Plan, and is not repeated here.

FIGURE 1-1

KEY PROJECT PERSONNEL AND RESPONSIBILITIES

NAME	RESPONSIBILITY
Linda E. Klink	Project Manager
Stan Conti	Field Team Leader
Clyde Snyder	Project Health and Safety Officer (HSO)
Clyde Snyder	Site Safety Officer (SSO)
TBA	Field Technicians/Geologists
Matthew M. Soltis, CSP	CLEAN Health and Safety Manager (HSM)

TBA: To be announced. Assignments have not yet been made.

2.0 SCOPE OF WORK

Detailed discussions on the planned activities, methods, and equipment for this effort are presented in previous sections of this Work Plan. These are summarized as follows:

- Task 1: Surveying, geophysics, and soil gas surveys
- Task 2: Fieldwork at the two mercury burial sites, as follows:

  Subtask 2.1: Determine the location and condition of the Mercury Burial Site II

  Subtask 2.2: Excavation and soil sampling at Mercury Burial Site I

  Subtask 2.3: Containerization of suspected mercury contaminated soils
- Task 3 Groundwater investigations
- Task 4 Visual inspections for groundwater discharges from the JILF landfill
- Task 5 Tidal study

Each of these tasks have been considered to identify potential hazards that may be posed to site personnel in their performance The results of those considerations are presented in the Risk Assessment section (Section 3 0) of this HASP Additionally necessary evaluation and control efforts for those identified potential hazards are also contained in various sections of this HASP

3.0 RISK ASSESSMENT

This section of this HASP presents information regarding the known and suspected chemical and physical hazards which may be encountered in, or associated with, the planned activities, schedules, and work areas as described in this HASP. This assessment is based on the information available at the time of the preparation of this HASP. If new or revised information becomes available, it will be promptly reviewed to determine any needs to modify this risk assessment. Hazard control measures are presented in following sections of this HASP.

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

The potential hazards recognized for the planned site activities are summarized and presented (by task) in section 3.1 of this HASP. In general, these potential hazards include personnel exposure to site contaminants via inhalation (gas/vapor or airborne particulate form), dermal contact, and (to a much lesser extent) ingestion. Other hazards include those of a physical nature. Each of two categories, chemical hazards and physical hazards, is presented in later subsections of this risk assessment discussion.

3.1 TASK-SPECIFIC RISK ASSESSMENT

In accordance with the requirements of OSHA standard 29 CFR 1910.120 (b) (4) (A), a task-specific risk assessment for the planned activities is as follows:

Task 1 - Surveying, Geophysics, and Soil Gas Surveys

While these are separate and distinct activities, these three operations have been grouped together in this HASP for several reasons. First, they present minimal hazard potentials since they are nonintrusive in

nature (although soil gas is somewhat intrusive, it is a surficial activity and not anticipated to present significant risks). Second, these tasks have also been grouped together as they are planned activities at several site areas.

The performance of these activities has been assessed as presenting minimal hazard potentials to personnel. If they must be performed concurrently with other tasks that involve more significant hazards, then the more restrictive controls and requirements will apply to persons performing these tasks as well. Otherwise, minimal protective equipment will be required, consisting of standard field dress and nitrile gloves (whenever handling potentially-contaminated equipment or media such as soils, water, etc.), and observance of applicable standard work practices and other requirements specified in this HASP.

Task 2 - Field Work At the Two Mercury Burial Sites

Subtask 2.1 - The determination of the location and condition of Mercury Burial Site II is one of the subtasks in this effort. Previous efforts have been unsuccessful in locating this site. Planned activities in this effort will initially include performing geophysics, which present minimal hazard potentials. If these efforts are unsuccessful, the alternate approach will be to excavate ditches in the suspected general location to attempt to find the burial site. If this approach becomes necessary, more significant hazard potentials will be presented. In fact, even if the site can be located via geophysical techniques, excavation will still be necessary to confirm the location and to obtain soil samples. Therefore, the hazards involved with excavation activities will be encountered in either event. These potential hazards include encountering and exposure to site contaminants, contact with underground or overhead energized sources, and the hazards presented with operating heavy machinery.

In regard to addressing the potential for personnel to be exposed to suspected contaminants at this site, the obvious contaminant of concern is mercury. To minimize this threat, personnel will utilize Level C protection, which will consist of respiratory protection (as described in the next sentence), full dermal protection including protective coveralls, inner and outer chemical protective gloves, and protective boot covers. Additionally, due to the reported use of this site, and the identified concern for volatile mercury releases, real-time monitoring for the early detection of mercury vapor emissions will be performed by the Site Safety Officer. This will be accomplished using a Jerome Model 411 Gold Film Mercury Vapor Analyzer. This instrument will be operated in its Survey mode on a periodic basis during all nonintrusive operations at the two mercury burial site locations, and on a continuous basis throughout all intrusive

activities at those two locations. It will be operated in a manner that concentrates on evaluating worker breathing zone areas. If any positive readings are noted through the use of this instrument in its Survey mode of operation, it will be switched to its Sample mode to obtain more accurate (yet slightly less timely) mercury vapor concentration readings. The use of this instrument, and corresponding personnel response action levels that will be observed, are presented in detail in section 5.0 of this Health and Safety Plan.

In addition to using this real-time monitoring instrumentation, sampling personnel will wear full face air purifying respirators equipped with Mersorb H cartridges with colorimetric end-of-service life indicators. If, during this task, the end-of-service life indicators on these cartridges change from an orange to a brown color, sampling personnel will immediately evacuate the area to obtain new cartridges. In such an instance, the Site Safety Officer will use the Jerome instrument to attempt to locate and quantify the possible emission source(s) that my be responsible for the cartridges' response. Sampling efforts will not recommence until and unless the results of that real-time monitoring indicate that mercury concentrations are less than the action levels specified in section 5.3 of this Plan.

In regard to controlling the potential hazards of contacting energized sources, this is addressed in greater detail in section 3.3 of this risk assessment. In regard to heavy machinery hazards, control efforts will include the following

- Only trained and qualified persons will be permitted to operate items of heavy equipment

- All personnel who are not necessary to the operation at hand will be restricted from areas where heavy equipment is in operation

- The requirements of all OSHA General Industry and Construction industry standards applicable to the equipment or operation will be observed

- Items of heavy equipment will be inspected initially before use and periodically thereafter. Any deficiencies found as a result of these inspections, of identified by the operator during use, will be immediately addressed via either repair or taken out of service

If neither of these approaches successfully locate this burial site, two downgradient monitoring wells will be installed. If this approach becomes necessary, the potential hazards and corresponding control efforts

for this task will be the same as those specified under Task 3 of this section. Also, if this drilling task is performed, it is anticipated that the personal protective equipment needs will be downgraded from Level C protection to Level D (no respiratory protection required), as defined for groundwater investigation activities in section 6.1.5 of this HASP. The use of respiratory protection in this task is not anticipated to be necessary, as readings and other information (i.e. end-of-service life indicators and real-time monitoring instrument readings) obtained during the excavation tasks are expected to demonstrate. However, as with other protective equipment modification determinations, it will be the responsibility of the SSO (with support from the HSO and the HSM) to determine any respiratory protection upgrading needs for this task.

Also, in this task, no personnel may enter any excavation that may be considered as a permit-required confined space as defined in OSHA standard 29 CFR 1910.146. Further, entry into any trench or excavation will be strictly prohibited until and unless the excavation has been adequately prepared in regard to providing for easy and ready personal access/egress, proper angles of repose have been incorporated for excavated material, proper shoring sloping procedures have been implemented, and other applicable requirements of OSHA Construction Industry standards specified in 29 CFR 1926 Subpart P "Excavations" are properly complied with. All excavation sites will be closely controlled to prevent unauthorized access. This will include cordoning the area with barricades and appropriate signage.

Any excavations present at the end of a work shift must be clearly marked and barricaded. If at all possible excavations are to be covered at the end of each shift (e.g. placing plywood or other suitable covers over trenches, etc.).

In regard to sampling activities, wherever possible samples are to be taken in a manner that does not require entry into an excavation (i.e. out of the bucket of the excavation vehicle). However, it is expected that certain activities will require personnel entry into excavations. When this is necessary, then the specifications of all of the above-referenced requirements will be observed as minimum requirements. However, absolutely no persons will be permitted to be in an excavation while excavation activities are being performed (e.g. while the back hoe or track hoe is digging). No exceptions to this restriction will be permitted.

<u>Subtask 2.2</u> - Excavation and soil sampling at Mercury Burial Site I is the second subtask in this effort. As the location of this site is known, the efforts specified under subtask 2.1 for locating this site will not be necessary. However, the hazards are essentially the same, and the therefore the control items

specified previously will be implemented for this effort as well. Personnel protective equipment required for this task will be the same as that specified for intrusive activities at the Mercury Burial Site II location. After the burial site has been excavated, samples will be taken from a cylindrical concrete pipe previously uncharacterized. This pipe is believed to have also been used for the disposal of mercury contaminated items. This effort will present several potential hazards.

The first and most obvious hazard potential involved with this task involves the potential for workers to be exposed to mercury contamination. Control efforts for this threat will be the same as those presented for intrusive activities. In summary, this will primarily consist of utilizing dermal protection, full face air purifying respiratory protection equipped with mercury vapor cartridges (with HEPA filters), and the use of monitoring instruments, as presented in section 5.0 of this HASP.

Remaining concerns and corresponding control efforts in this task are similar to those specified for Subtask 2.1 (regarding restrictions for confined space work, heavy vehicle operations, and excavation activities) are also applicable to this task, and those control efforts will be implemented and enforced as appropriate.

Subtask Task 2.3 - Soils Containerization has been identified as a potential subtask in the excavation efforts at the Mercury Burial site locations. This subtask will be initiated only if during those excavation activities the real-time mercury vapor analyzer instrument indicates that soils have been encountered that may have mercury concentrations that exceed 20 mg/kg for mercury (RCRA proposed subparts). If this occurs site personnel will collect the suspected contaminated soils and place them in 55-gallon drums for removal and disposal.

This subtask represents an increased level of hazard potential than that presented previously in regard to excavation efforts. This increased concern is founded on the prospect that if the performance of this task becomes necessary it is the result of observed sustained detection of mercury vapors. If those readings exceed the action levels specified in section 5.3 of this Health and Safety Plan, then Level C protection (air purifying respiratory protection) may be inadequate to protect site personnel from potentially harmful inhalation exposures to this contaminant. In such an event, this remedial task will only be permitted to be performed in Level B (supplied air respiratory protection). Dermal protection requirements will remain unchanged from that specified in this Plan for the other intrusive activities at these locations.

Task 3 - Groundwater Investigations

Numerous groundwater monitoring wells, both deep and shallow, are planned to be installed at several site areas, including on Dennetts, Jamaica, and Seavey islands, in the Jamaica Island landfill (JILF), and in the fill area between the islands. In addition, "direct push" temporary wells will be installed by a subcontractor near the waste oil tanks (SWMU #11) and Mercury Burial Site II (SWMU #9). Drilling operations present numerous hazard potentials, both chemical and physical. These are addressed individually in sections 3.2 and 3.3 of this HASP.

One significant potential risk requiring attention in this task involves the installation of shallow monitoring wells at the Waste Oil Tank locations (SWMU #11) located within the JILF landfill. This is in regard to the potential for encountering buried compressed gas cylinders during well installation. It has been reported that as many as 100 to 200 cylinders of acetylene and chlorine gas were disposed in this landfill in approximately 1955. As the accuracy of this timeframe is questionable, Halliburton NUS will instead assume that this alleged cylinder disposal occurred some time in a ten-year window (1950-1960). The concern in contacting a cylinder during intrusive activities (i.e. drilling or excavation operations) at the JILF location is that the cylinder may rupture, resulting in either sudden pressure release, release of a cloud of chlorine gas, or the generation of rapid combustion (depending on whether a cylinder of acetylene or chlorine is involved)

To minimize this concern the initial approach will involve the performance of an extensive document review which will include reviewing aerial photographs of the JILF Those photographs will be reviewed to identify the size and extent of the landfill prior to the time period of this suspected cylinder disposal event The goal of this effort is to determine investigation locations on the landfill that are not in a suspect location If this cannot be accomplished with a great level of confidence the following precautionary measures will be implemented

- The investigation location will be subjected to a thorough geophysical investigation

- Only personnel whose presence is essential to the operation will be permitted in the work area

- All personnel whose presence is required in the work area will wear full dermal protection, with taped seams.

- All associated personnel will be required to wear supplied air respiratory protection (Level B).

- Based on preliminary air modelling efforts (see Attachment III), an area of 150 meters will be cordoned off around the work location. Access inside of that area will be restricted to necessary personnel, who are appropriately outfitted in full dermal and Level B protection.

Although this landfill currently extends to the two Mercury Burial Sites, and the proposed location of a new deep bedrock well within the landfill, it apparently did not encompass these areas in 1955, when the reported cylinder disposal event occurred. Therefore, the threat of encountering buried compressed gas cylinders at those locations is reduced. However, as all of the details of this event are still unclear, all intrusive activities in any areas near the JILF landfill site will be subject to the restrictions and procedures specified above for intrusive operations (i e review of aerial photographs and other historical documents, geophysical investigatory efforts, etc as above) In fact, as a minimum, all drilling and excavation locations will be cleared at least for the presence of subsurface utilities, and undergo a thorough geophysical survey prior to the initiation of any intrusive activities (Note Any anomalies detected during geophysical surveys will have their locations marked, and be avoided by at least an eight foot radius)

Another concern in this task is that several drilling locations are anticipated to be near bodies of water (i e ponds) As a result concerns associated with uneven or unstable terrain, and working near bodies of water are addressed in the discussion on physical hazards in this risk assessment Other potential hazards include contact with energized sources (e g overhead power lines, underground gas/electric/steam lines, etc), contact with moving or rotating machinery, and other physical hazards These are addressed in greater detail in sections 3 3 and 11 0 of this HASP

Task 4 - JILF Discharge Inspections

This task presents minimal hazard potentials as it is nonintrusive in nature, and only involves visual inspections for seeps or other possible groundwater discharges, to be performed several times per week during this investigation.

Task 5 - Tidal Study

This task will involve very limited field work. This task will involve measuring tidal data via installing and reading a tidal gage in a site estuary. As a result, minimal hazard potential concerns are recognized in this task Basically, these are limited to uneven or unstable terrain, and the hazards of working in and around bodies of water. Both of these potentials are addressed in greater detail in latter portions of this section

3.2 CHEMICAL HAZARDS

The chemical contaminants which may be present and encountered in the performance of site activities have been identified based on information such as the histories of the site areas, and the results of previous investigatory activities Information regarding these substances is presented in Table 3-1

The potential for worker exposure to hazardous concentrations of site chemical contaminants is generally considered to be low However as previously specified this concern is predominantly recognized in the performance of intrusive activities Hazard control efforts such as engineering controls (i e dust suppression via area wetting) administrative controls (i e observance of instrument action levels and appropriate responses adherence to standard work procedures and site restrictions as presented in this HASP) and the proper use of items of personal protective equipment will be implemented and enforced as appropriate throughout all site activities

3.3 PHYSICAL HAZARDS

Certain physical hazards may also be presented to site personnel involved with field activities These may be intrinsic to the nature of the operation being performed, or the result of factors such as the work location or schedule These potential risks include the following

- Uneven or unstable terrain (Slip/trip hazards)
- Strain/muscle pulls from manual lifting.
- Fall from elevated surfaces.
- Exposure to pinch/compression points.
- Water hazards
- Inclement weather
- Rotating machinery
- Heat stress
- Cold stress
- Natural hazards(e.g. snakes, ticks, mosquitos, poisonous plants, etc.)
- Noise in excess of 85 dBA
- Contact with Energized Sources

Each of the above mentioned items are further detailed below.

3.3.1 Uneven/Unstable Terrain

Planned activities described in the scope of work for this remedial action will bring field personnel into areas where this potential hazard exists. It will be the FTL's responsibility to inspect the work areas, and implement necessary controls or restrictions prior to placing heavy equipment or personnel at risk. As planned activities move from one area to another, this hazard (and others associated with that area or task) will be discussed as part of the safety briefing prior to the commencement of activities.

3.3.2 Strain/Muscle Pulls

The potential exists for workers to be injured while lifting or maneuvering cumbersome and/or heavy objects during the performance of various tasks. During labor intensive activities such as soil boring, workers have the potential to over-exert themselves while maneuvering the auguring device during sample extraction. In addition, various tasks may require lifting heavy pieces of equipment. If objects are improperly lifted, debilitating back strain and/or other injuries can result. Workers shall obtain help from others when necessary, employ proper lifting techniques, and use machinery, where possible, to assist when handling heavy objects.

3.3.3 Pinch/Compression Points

Pinch and compression points of drilling or sampling equipment may result in injury. All equipment must be maintained in proper working order, with machine guarding devices in place. Any equipment found to be lacking in these areas shall be removed from service. Additionally, all personnel shall be properly trained in the use and function of all equipment used within the investigating activity.

3.3.4 Water Hazards

Several of the planned activities involve locations that are near bodies of water. To avoid potential hazards associated with working on or over water (drowning) the field team shall employ lifelines, safety harnesses, and U.S. Coast Guard approved personal flotation devices and lifeline (tie-off) procedures will be used when working within four feet of the waters edge. Due to the obvious hazards associated with working on or near waters edge during inclement weather, all field activities may be temporarily suspended or terminated at the discretion and direction of the FTL, or SSO representative.

3.3.5 Inclement Weather

As all work will be conducted outdoors, inclement weather may be encountered. As conditions may vary, it will be at the discretion of the FTL and the SSO representative to temporarily suspend or terminate activities as conditions dictate. All activities will be terminated in the advent of electrical storms.

3.3.6 Rotating Machinery

Monitoring well installations, soil borings will be accomplished using rotating equipment as proposed in the execution of the scope of work. The most predominant physical hazard associated with this type of work is entanglement of safety equipment or clothing into the rotating augers. To address this hazard, a thorough inspection of all equipment will be performed to remove or guard potential snag points. Also, efforts will be taken to ensure that emergency stop devices operate properly, and that all members of the field team know the location and operation of these devices. Persons working in close proximity to or in the operation of the drill rig will be required to secure all loose clothing or protective equipment to avoid possible entanglement. All mechanized equipment brought onsite (including drilling equipment and

excavation equipment) to complete this scope of work will be inspected initially prior to the commencement of onsite activities and then periodically thereafter. These inspections will be performed by the SSO and include the following:

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

3.3.7 Heat Stress

Worker overexposure to heat is a recognized potential hazard due to the planned schedule for field activities (may extend into the Spring months) and due to the use of items of chemical protective clothing which can contribute to this threat It will be the responsibility of the FTL, with assistance from the SSO, to determine the need to employ heat stress monitoring techniques and control measures based observations of site conditions and personnel Generally consideration for these efforts are to commence if/when ambient weather conditions involve temperatures in excess of 70 degrees Fahrenheit Evaluation and control efforts for this potential hazard shall observe the recommendations for heat stress, as specified by the American Conference of Governmental Industrial Hygienists and in accordance with the information provided in Attachment I of this HASP

3.3.8 Cold Stress

As the planned schedule for the initiation of field activities is to commence in the late winter months, and due to the geographical location of this facility, the potential for workers to be exposed to cold stress environments is recognized. The recognition, evaluation, and control of this potential hazard is presented in Attachment I of this HASP.

3.3.9 Natural Hazards (ticks, snakes, and other indigenous creatures)

Natural hazards such as poisonous plants, bites from poisonous or disease carrying animals or insects (e.g. snakes, ticks, mosquitos) cannot be avoided in this type of environment. However in an effort to offset the impact of this hazard, field personnel will have access to commercially available snake bite kits and insect repellents. Potential nesting areas in and about work areas shall be avoided to the greatest extent possible. Lastly, within recent years a marked increase in Lyme's Disease has been reported. Ticks have been shown to be the primary vector in the transmission of this disease. In an effort to control this hazard, close attention will be given during operations and decontamination with regard to personal hygiene to detect and remove any ticks from personnel. The information provided in Attachment II will be reviewed with site personnel to aid in the recognition and control of this threat.

3.3.10 Noise in Excess of 85 dBA

Since many of the tasks to be performed require the use of heavy machinery, workers have the potential to be exposed to noise in excess of 85 dBA. Excessive noise exposure can cause permanent hearing loss. The use of approved hearing protection shall be required of all personnel while performing activities which require the use of heavy or motorized equipment or machinery.

As a general rule-of-thumb, hearing protection will be required when noise levels are such that persons standing within 2 feet of each other must raise their voice in order to effectively communicate.

The SSO will be responsible for determining the need to employ quantitative measurements of potential noise sources to more specifically determine whether additional measures are required or downgrading

the level of hearing protection is an alternative. It shall also be the responsibility of the SSO to ensure the application, use, and maintenance of occupational noise protective measures in accordance with 29 CFR 1910.95.

3.3.11 Contact with Energized Sources

One of the hazards associated with the execution of this scope of work is the potential for encountering energized sources (i.e. pressurized lines, water lines, telephone lines, and buried utilities such as gas or electric lines), primarily while engaged in drilling activities. Due to the obvious ramifications associated with this hazard, extreme caution and strict adherence to procedures to detect, identify, and take evasive action shall be followed during the completion of the scope of work. Also, any areas targeted for subsurface activities shall first be investigated to determine the presence of underground utilities. Any such utilities identified shall be physically marked and avoided. Efforts will be made through local contacts, as-built drawings (where available) along with geophysical surveys to identify potential locations. Positive readings will require the relocation of a soil boring point. To further avoid hazards of this type, no drilling mast or any other such projecting items shall be permitted within a 20-foot radius of any energized source.

3.4 GENERAL REQUIREMENTS

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

- Loose items of clothing will be secured when working around items of moving machinery Also personal items such as jewelry which can become caught or entangled will be prohibited around such operations

- Electrical cords (such as on hand tools or electrical extension cords) shall be inspected prior to being put in use, and periodically thereafter Also, these devices will be used and stored in a manner that protects them from damage Cords found to be defective (i e plug damaged, ground prong removed, insulation damaged, etc) will be immediately removed from service and either effectively repaired or replaced

- Eye protection will be required wherever potential eye hazards are recognized.

- Any use or storage of compressed gas cylinders on site will be will be done in a manner that complies with applicable OSHA standards and Compressed Gas Association specifications. This includes (but is not limited to) proper labeling of container contents, marking and segregating containers as "full" or "empty", securing in an upright position, placing valve end caps in place when cylinders are not in use, etc.

- Incidents of inclement weather will be evaluated by the FTL, with input from the SSO, in regard to limiting or interrupting site operations. At a minimum, however, site operations will be interrupted in the event of electrical storms.

- The "buddy system" will be required throughout all onsite operations, intrusive and nonintrusive

TABLE 3-1
CHEMICAL, PHYSICAL, AND TOXICOLOGICAL DATA
PORTSMOUTH NAVAL SHIPYARD

SUBSTANCE	CAS No	AIR MONITORING/SAMPLING INFORMATION			EXPOSURE LIMITS	WARNING PROPERTY RATING	PHYSICAL PROPERTIES	HEALTH HAZARD INFORMATION
Mercury vapor	7439 97 6	Jerome Gold Film Mercury Vapor Analyzer used to locate and quantify mercury vapor emissions. Range of detection specified by manufacturer 0 000 to 1 999 mg m³ mercury I P Not determined No response with PID No response with FID		Air sample using [illegible] passive [illegible] badge (OSHA ID 140)	0 05 mg m3 TWA ACGIH and NIOSH and 1 0 mg 10 m3 ceiling OSHA	Inadequate warning properties However air purifying respirators with a protection factor of at least 10 and End of Service Life indicators are acceptable for concentrations up to 0 5 mg/m3	**Boiling Pt**: 674° F **Solubility**: Insoluble **Flash Pt**: Not Applicable **LEL/LFL**: Not Applicable **Vapor Pressure**: 0 0012 mmHg **Incompatibilities:** Acetylene, ammonia, chlorine dioxide, azides, calcium, sodium carbide, lithium, rubidium, and copper **Appearance and Odor:** Silver-white, heavy, odorless liquid	Overexposure may result in cough, chest pain, dyspnea, bronchial pneuitis, tremor, insomnia, irritability,, indecision, headache, fatigue, weakness, salivation, gastrointestinal (GI) disturbances, anorexia, loss in weight, proteinuria, eye and/or skin irritation
Benzene	71 43 2	I P 9 24 eV 100% response with PID and 10 2 eV lamp	150% response with FID	Air sample using charcoal tube and carbon disulfide desorption OSHA 07	1 ppm OSHA 10 ppm ACGIH 0 1 ppm NIOSH	Inadequate - OSHA accepts the use of air-purifying respirators with organic vapor cartridge up to 10 ppm despite the inadequate warning properties	**Boiling Pt**: 80°C **Melting Pt**: 5 5°C **Solubility**: 0 07% **Flash Pt**: -11°C **LEL/LFL**: 1 3% **UEL/UFL**: 7 9% **Vapor Density**: 2 77 **Vapor Pressure**: 75 mmHg **Specific Gravity**: 0 88 **Incompatibilities**: Strong oxidizers, perchlorates, acids **Appearance and Odor:** Colorless to a light yellow liquid with an aromatic odor	Overexposure may result in irritation to the eyes, nose, throat, and respiratory system. Central Nervous System (CNS) effects include giddiness, lightheadedness, headaches, staggered gait, fatigue, and lassitude and depression. Additional effects may include nausea Long duration exposures may result in respiratory collapse Regulated as an OSHA carcinogen May cause damage to the blood forming organs and may cause a form of cancer called leukemia
Ethylbenzene	100 41 4	I P 8 76 High response with PID and 10 2 eV lamp	100% response with FID	Air sample using charcoal tube and carbon disulfide desorption OSHA 07	100 ppm TWA 125 ppm STEL OSHA ACGIH & NIOSH	Adequate - Can use air-purifying respirator with organic vapor cartridge up to 1,000 ppm **Recommended gloves**: Neoprene or nitrile w/ silver shield when potential for saturation	**Boiling Pt**: 277°F **Melting Pt**: -139°F **Solubility**: 0 01% **Flash Pt**: 55°F **LEL/LFL**: 1 0% **UEL/UFL**: 6 7% **Vapor Density**: 3 66 **Vapor Pressure**: 10 mmHg @ 79°F **Specific Gravity**: 0 87 **Incompatibilities**: Strong oxidizers **Appearance and odor:** Colorless liquid with an aromatic odor Odor Threshold of 0 092-0 60	Regulated primarily because of its potential to irritate the eyes and respiratory system. In addition, effects of overexposure may include headaches, narcotic effects, CNS changes (i e coordination impairment, impaired reflexes, tremors) difficulty in breathing, possible chemical pneumonia, and potentially respiratory failure

TABLE 3-1
CHEMICAL, PHYSICAL, AND TOXICOLOGICAL DATA
PORTSMOUTH NAVAL SHIPYARD

SUBSTANCE	CAS No	AIR MONITORING/SAMPLING INFORMATION			EXPOSURE LIMITS	WARNING PROPERTY RATING	PHYSICAL PROPERTIES	HEALTH HAZARD INFORMATION
Methylene chloride	75 09 2	I P 11 32 eV High response with PID and 11 [illegible] eV lamp	[illegible] response with FID	Air sample using [illegible] Anasorb [illegible] sorbent tube [illegible] carbon disulfide [illegible] gas chromatography flame ionization detector OSHA 59 [illegible] NIOSH 1005	500 ppm TWA OSHA 1 000 ppm ceiling OSHA 50 ppm TWA ACGIH Lowest feasible concentration NIOSH	Inadequate - Must use a supplied air respirator (airline respirator with emergency escape cylinder or a Self-Contained Breathing Apparatus - SCBA)	**Boiling Pt**: 39 8°C **Melting Pt**: -96°C **Solubility**: 2% **Flash Pt**: N A **LEL/LFL**: 15 5% **UEL/UFL**: 66 4% **Vapor Density**: 2 93 **Vapor Pressure**: 380 mmHg @ 22°C **Specific Gravity**: 1 33 **Incompatibilities**: Strong oxidizers caustics, metals (i e aluminum, magnesium, potassium, sodium, lithium), and concentrated acids **Appearance and Odor**: Colorless liquid with a chloroform-like odor (Note A gas above 104°F) Odor Threshold of 160 ppm	Regulated primarily because of its ability to cause sleepiness, fatigue, weakness, lightheadedness, numbness of the limbs, altered cardiac rate and incoordination. These signs and symptoms may be accompanied by nausea, gastric and pulmonary irritation leading possibly to pulmonary edema In addition to the narcosis log term effects may include liver injury. Listed as possessing carcinogenic properties by NTP, IARC, and ACGIH.
Toluene	108 88 3	I P 8 82 eV High response with PID and 10 2 eV lamp	[illegible] response with FID	Air sample using charcoal tube and carbon disulfide desorption OSHA 07	100 ppm TWA OSHA 150 ppm STEL OSHA 50 ppm TWA ACGIH	Adequate - Can use air-purifying respirator with organic vapor cartridge up to 500 ppm **Recommended gloves**: Neoprene or nitrile w/ silver shield when potential for saturation	**Boiling Pt: 232°F** **Melting Pt**: -139°F **Solubility**: 0 05% (61°F) **Flash Pt**: 40°F **LEL/LFL**: 1 2% **UEL/UFL**: 7 1% **Vapor Density**: 3 14 **Vapor Pressure**: 20 mmHg @ 65°F **Specific Gravity**: 0 87 **Incompatibilities**: Strong oxidizers **Appearance and odor**: Colorless liquid with a sweet pungent aromatic odor Odor Threshold of 0 16-37 ppm	Overexposure to this substance may result in mild to moderate irritation at all points of contact, CNS changes. At 200-500 ppm exposure has resulted in headaches, nausea, eye irritation, loss of appetite, bad taste, impair coordination, fatigue, and weariness

TABLE 3-1
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SUBSTANCE	CAS No	AIR MONITORING/SAMPLING INFORMATION			EXPOSURE LIMITS	WARNING PROPERTY RATING	PHYSICAL PROPERTIES	HEALTH HAZARD INFORMATION
Trichloroethylene	79 01 6	I P 9 45 eV High response with PID and 10 2 eV lamp	[illegible] Response with PID	Air sample using charcoal tube and carbon disulfide desorption OSHA 07	50 ppm OSHA TWA 200 ppm OSHA STEL 50 ppm ACGIH TWA 25 ppm NIOSH TWA	Inadequate Should use pressure-demand supplied air respirator above exposure limits	**Boiling Pt**: 86 7°C **Melting Pt**: 73°C **Solubility**: 0 1% @ 25°C **Flash Pt**: 32°C **LEL/LFL**: 12 5% **UEL/UFL**: 90% **Vapor Density**: 4 53 **Vapor Pressure**: 100 mmHg @ 32°C **Specific Gravity**: 1 46 **Incompatibilities**: Strong caustics and alkalis chemically active metals (barium lithium, sodium, magnesium, titanium, and beryllium) **Appearance and Odor**: Colorless liquid with a chloroform type odor	Central nervous system effects (euphoria, analgesia, anesthesia, paresthesia, headaches, tremors, vertigo, and somnolence) are the limiting factors in decreasing the exposures Damage to the liver, kidneys, heart, lungs, and skin have also been reported Contact may result in irritation to the eyes, skin, and mucous membranes Ingestion may result in GI disturbances including nausea, and vomiting NIOSH lists this substance a potential human carcinogen.
Xylene All isomers o-,m-, p-	1330 20 7	I P 8 56 eV High response with PID and 10 2 eV lamp	110% response with PID	Air sample using charcoal tube and carbon disulfide desorption OSHA 07	100 ppm TWA 150 ppm STEL OSHA ACGIH & NIOSH	Adequate Can use air-purifying respirator with organic vapor cartridge up to 1,000 ppm **Recommended gloves**: Neoprene or nitrile w/ silver shield when potential for saturation	**Boiling Pt**: 269-281°F **Melting Pt**: -13/-54/56°F **Solubility**: Insoluble **Flash Pt**: 63-81°F **LEL/LFL**: 1 0% **UEL/UFL**: 7 0% **Vapor Density**: 3 66 **Vapor Pressure**: 7-9 mmHg @ 70°F **Specific Gravity**: 0 86-0 88 **Incompatibilities**: Strong oxidizers **Appearance and odor**: Colorless liquid with an aromatic odor Odor Threshold of 20 ppm	Regulated primarily because of its potential to irritate the eyes and respiratory system In addition, effects may include CNS changes (i e dizziness, excitement, drowsiness, incoherent, staggering gait), difficulty in breathing, pulmonary edema, and possibly respiratory failure.

TABLE 3-1
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PORTSMOUTH NAVAL SHIPYARD

SUBSTANCE	CAS No.	AIR MONITORING/SAMPLING INFORMATION			EXPOSURE LIMITS	WARNING PROPERTY RATING	PHYSICAL PROPERTIES	HEALTH HAZARD INFORMATION
Cadmium	7440 43 9	Substance is not volatile. Unable to be easily detected by PID or FID	Not detected by FID	Air sample using a mixed cellulose ester filter / acid desorption and analysis by atomic absorption flame NIOSH 7300 or 7048	0 2 mg/m³ TWA OSHA 0 05 mg/m³ TWA ACGIH	The use of an air purifying full face-piece respirator with a high efficiency particulate air filter	**Boiling Pt:** 767°C **Melting Pt:** 320 9°C **Solubility:** Insoluble **Flash Pt:** Not applicable (Airborne dust may burn or explode when exposed to heat, flame, or incompatible chemicals) **LEL/LFL:** Not applicable **UEL/UFL:** Not applicable **Vapor Density:** N A **Vapor Pressure:** 1 mmHg @ 394°C **Specific Gravity:** 8 65 @ 32°C **Incompatibilities:** Strong oxidizers, elemental sulfur, selenium, tellurium, zinc, nitric acid, and hydrazoic acid **Appearance and Odor:** Metal Silver-white, blue-tinged lustrous, odorless solid Fume yellow-brown, finely divided particulate dispersed in air.	Overexposure to this substance may result in irritation to the respiratory tract, dyspnea, tightness in the chest, coughing, possibly pulmonary edema. Overexposure to fumes causes symptoms characteristic of the flu (headaches, chills, muscle aches, nausea, vomiting, diarrhea). Chronic exposure may result in damage to the lungs, kidneys and liver. This substance has been identified as a confirmed animal; potential human carcinogen by IARC and NTP.
Chromium Compounds	7440 47 3 (Element)	Properties vary depending upon the specific compounds. Not detectable by PID	Not detectable by FID	Air sample using mixed cellulose ester filter / acid desorption and analysis by atomic absorption NIOSH 7024	0 5 mg/m³ TWA OSHA & NIOSH 0 05 mg/m³ TLV ACGIH	The use of a air purifying, full face-piece respirator with a high efficiency particulate filter.	**Boiling Pt:** 2642°C **Melting Pt:** 1900°C **Solubility:** Insoluble **Flash Pt:** Not applicable (Airborne dust may burn or explode when exposed to heat, flame, or incompatible chemicals) **LEL/LFL:** Not applicable **UEL/UFL:** Not applicable **Vapor Density:** N A. **Vapor Pressure:** 0 mmHg **Specific Gravity:** 7 14 **Incompatibilities:** Strong oxidizers, peroxides and alkalis **Appearance and Odor:** Appearance and odor vary depending upon the specific compound	Health hazards are characterized normally through chronic exposure manifesting as histologic fibrosis of the lungs and ulceration of the nasal septum and skin. IARC, NTP and ACGIH list various chromium compounds as possessing carcinogenic properties.

TABLE 3-1
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SUBSTANCE	CAS No	AIR MONITORING/SAMPLING INFORMATION			EXPOSURE LIMITS	WARNING PROPERTY RATING	PHYSICAL PROPERTIES	HEALTH HAZARD INFORMATION
Copper	7440 50 8 (Cu)	Substance is not volatile Unable to be detected by PID or FID	Not detected by FID	Air sample using a mixed cellulose ester filter inductively coupled plasma atomic emission spectroscopy NIOSH 7300	0 10 mg/m³ TWA OSHA and NIOSH 0 2 mg/m³ TWA ACGIH	The use of an air-purifying full-face respirator with a high efficiency particulate air filter	**Boiling Pt:** 2324°C **Melting Pt:** 1083°C **Solubility:** Insoluble **Flash Pt:** Not applicable (Airborne dust may burn or explode when exposed to heat, flame, or incompatible chemicals) **LEL/LFL:** Not applicable **UEL/UFL:** Not applicable **Vapor Density:** N A **Vapor Pressure:** 1 mmHg @ 1628°C **Specific Gravity:** 8 94 **Incompatibilities:** Oxidizers, alkalis, sodium azide, acetylene, bromates, chlorates, iodates, and acids **Appearance and Odor:** Metal Reddish, lustrous malleable, odorless solid Fume Finely divided black particulate dispersed in air.	Irritation to the nose, throat, and respiratory tract Metallic taste Discoloration of skin (potential dermatitis) and hair. Chronic exposure may result in dermatitis and damage to the liver and kidneys Overexposure to fumes causes symptoms characteristic of the flu (headaches, chills, muscle aches, nausea, vomiting, diarrhea) Ingestion may cause burning in the mouth, throat, and stomach Metallic taste with colicky abdominal pain. Individuals with Wilson's disease are at greater risk of chronic exposure as a result of the bodies tendency to absorb and retain copper
Lead	7439 92-1	Substance is not volatile Unable to be detected by either PID or FID	Unable to be detected by FID	Air sample using a mixed cellulose ester filter / HNO_3 or H_2O_2 desorption / Atomic absorption NIOSH 7082 or 7300	0 05 mg/m³ TWA, OSHA 0 15 mg/m³ TWA, ACGIH 0 10 mg/m³ TWA NIOSH	The use of a air purifying, full-face respirator with high efficiency particulate air filter	**Boiling Pt:** 1740°C **Melting Pt:** 327°C **Solubility:** Insoluble **Flash Pt:** Not applicable (Airborne dust may burn or explode when exposed to heat, flame, or incompatible chemicals) **LEL/LFL:** Not applicable **UEL/UFL:** Not applicable **Vapor Density:** N A **Vapor Pressure:** 0 mmHg **Specific Gravity:** 11 34 **Incompatibilities:** Strong oxidizers, peroxides, sodium acetylide, zirconium, and acids **Appearance and Odor:** Metal A heavy ductile, soft gray solid	Overexposure to this substance via ingestion or inhalation may result in metallic taste in the mouth, dry throat, thirst, Gastrointestinal disorders (burning stomach pain, nausea, vomiting, possible diarrhea sometimes bloody or black, accompanied by severe bouts of colic), CNS effects (muscular weakness, pain, cramps, headaches, insomnia, depression, partial paralysis possibly coma and death Extended exposure may result in damage to the kidneys, brain, and blood.

TABLE 3-1
CHEMICAL, PHYSICAL, AND TOXICOLOGICAL DATA
PORTSMOUTH NAVAL SHIPYARD

SUBSTANCE	CAS No	AIR MONITORING/SAMPLING INFORMATION			EXPOSURE LIMITS	WARNING PROPERTY RATING	PHYSICAL PROPERTIES	HEALTH HAZARD INFORMATION
Aroclor-1260 (Polychlorinated Biphenyl PCB)	11096-82-5	Substance is not volatile (VP: 0.00006 mmHg) no IP exists therefore PID will not detect substance	Substance is non-combustible and as a result will not be detected by FID	A [illegible] mg a [illegible] sorbent tube with glass fiber filter thermal desorption [illegible] gas chromatography electron capture detector NIOSH 5503	0.5 mg/m³ TWA OSHA ACGIH 0.001 mg/m³ TWA NIOSH	Inadequate However due to the low volatility it is assumed unless agitated this substance does not present a volatile vapor or gas respiratory threat For dusty conditions where this material may cling to particulates use a HEPA filter	**Boiling Pt**: distillation range 365-390°C **Melting Pt**: N A **Solubility**: Insoluble **Flash Pt**: Not applicable **LEL/LFL**: Not applicable **UEL/UFL**: Not applicable **Vapor Density**: N A **Vapor Pressure**: 0 mmHg **Specific Gravity**: 1 566 @ 15 5°C **Incompatibilities**: Strong oxidizers **Appearance and Odor**: Colorless to pale yellow viscous liquid or solid (below 50°F) with a mild, hydrocarbon odor	Regulated primarily because of its potential to cause liver damage and chloracne This substance is irritating to the eyes and skin Recognized a possessing carcinogenic properties by NIOSH, and NTP.
Bis(2-ethylhexyl) phthalate	117-81-7	No information found	This is a combustible liquid therefore the FID should detect it However the relative response ratio is unknown	NIOSH Method # 5020	OSHA NIOSH ACGIH 5 mg/m³ STEL 10 mg/m³	Irritating tingling sensation **Recommended APR Cartridge**: Suitable for dust and fume Organic vapor acid gases with HEPA filter **Recommended gloves**: Nitrile has been the one most widely used for the other substances and is acceptable for this substance	**Boiling Pt**: 386°C **Melting Pt**: freezes -14°C **Solubility**: Insoluble **Flash Pt**: 215°C **LEL/LFL**: 0.3% @ 245°C **UEL/UFL**: N A **Vapor Density**: N A **Vapor Pressure**: <0 01 mmHg **Specific Gravity**: 0 99 **Incompatibilities**: Nitrates, strong oxidizers, acids, and caustics **Appearance and odor**: Colorless, oily liquid, odorless	This substance is a mild skin, eye, mucous membrane irritant, and mild gastric disturbance.
Waste Oils All information is based on mineral oil	N E 8012 95 1 for mineral oil	varies between fractions however waste oils tend to be less volatile	varies between fractions however waste oils tend to be less volatile This instrument tends to handle the longer chained aliphatic hydrocarbons more efficiently than its PID counterpart	#5026 is the recommended method for mineral oil mist	ACGIH OSHA NIOSH 5 mg/m³ 10 mg/m³ STEL	Non-volatile substance, therefore no respiratory protection is required Any glove suitable to prevent skin contact (Nitrile has been the one most widely used for the other substances and will be acceptable)	**Boiling Pt**: 360°C **Melting Pt**: N A **Solubility**: Insoluble **Flash Pt**: 275-500°F depends on the distillation fraction **LEL/LFL**: N A **UEL/UFL**: N A **Vapor Density**: N A **Vapor Pressure**: N A **Specific Gravity**: 0 90 **Incompatibilities**: None reported **Appearance and odor**: Colorless, oily, with an odor of burned lubricating oil	Minor irritation to the skin

TABLE 3-1
CHEMICAL, PHYSICAL, AND TOXICOLOGICAL DATA
PORTSMOUTH NAVAL SHIPYARD

SUBSTANCE	CAS No	AIR MONITORING/SAMPLING INFORMATION			EXPOSURE LIMITS	WARNING PROPERTY RATING	PHYSICAL PROPERTIES	HEALTH HAZARD INFORMATION
Methyl ethyl ketone	78-93-3	I.P. = 9.54 High response with PID with 10.2 eV lamp	[illegible] response with FID	Air sample using [illegible] tube with GC FID Analysis NIOSH Method 2500	200 ppm TWA OSHA NIOSH ACGIH with a STEL of 300 ppm	Adequate warning properties odor threshold (ACGIH) approximately 6 ppm	**Boiling point:** 175 °F **Solubility:** 28% **Flash Point:** 16 °F **Vapor Pressure:** 71 mmHg **LEL=** 1.4% @ 200° F **UEL=** 11.4% @ 200° F **Incompatibilities:** Strong oxidizers, amines, ammonia, inorganic acids, caustics, copper, isocyanates, and pyridines **Appearance and odor:** Colorless liquid with a moderately sharp, fragrant, mint- or acetone-like odor	Exposure symptoms include irritation of the eyes and upper respiratory tract, headache, dizziness, and vomiting
Asbestos (amosite and chrysotile)	1332-21-4	No response	No response	Air sample using filter analyze via PCM or TEM	Vary by type range from 0.2 fibers per cubic centimeter (f/cc) to 2.0 f/cc	Inadequate	**Boiling Point:** Decomposes **Solubility:** Insoluble **Flash Point:** Not applicable **Vapor Pressure:** 0.0 mmHg **LEL:** Not applicable **UEL:** Not applicable **Incompatibilities:** None **Appearance and odor:** Odorless, fibrous solids, color varies by type (white or greenish = chrysotile, blue = crocidolite, or gray-green = amosite	Carcinogenic. Symptoms of exposure include dyspnea, interstitial fibrosis, restricted pulmonary function, finger clubbing.
Acetylene	74-86-2	Not determined	Excellent response	Air sampling not applicable	OSHA and ACGIH do not have established limits for acetylene NIOSH has proposed a limit of 2,500 ppm for common impurities	Warning property acceptable (for commercial grades-which are the likely grades involved)	**Boiling point:** -75° F **Specific Gravity:** 0.91 **Solubility:** 1.1 @ 15 C **Flash Point:** Gaseous at room temperature **LEL:** 2.5% (explosive) **UEL:** 81% **Appearance and odor:** Colorless, odorless gas when pure, commercial grades have a garlic-like odor from impurities	A simple asphyxiant Exposure to high concentrations may result in narcosis At 20% concentration dyspnea and headache At 40% or higher concentrations collapse

TABLE 3-1
CHEMICAL, PHYSICAL, AND TOXICOLOGICAL DATA
PORTSMOUTH NAVAL SHIPYARD

SUBSTANCE	CAS No	AIR MONITORING/SAMPLING INFORMATION			EXPOSURE LIMITS	WARNING PROPERTY RATING	PHYSICAL PROPERTIES	HEALTH HAZARD INFORMATION
Chlorine	7782 50 5	PID with an 11.7 eV lamp will respond	No response	Air sample using [illegible] Analyze via [illegible] electrode OSHA ID 101	1 ppm ceiling OSHA 0 5 ppm ACGIH NIOSH with a STEL of 1 0 ppm	Adequate warning properties odor threshold less than 1 0 ppm APRs can be used for concentrations up to 10 0 ppm	**Boiling Point:** -29° F **Solubility:** 0 7% **Flash Point:** Not applicable (N/A) **Vapor Pressure:** >1 atm **LEL:** N/A **UEL:** N/A **Incompatibilities:** Reacts explosively or forms explosive compounds with many common substances such as acetylene, ether, turpentine, ammonia, fuel gas, hydrogen & finely divided metals **Appearance and odor:** Greenish-yellow gas with a pungent, irritating odor	Symptoms of exposure include burning of the eyes,nose, and mouth, lacrimation, rhinitis, cough, choking, nausea, vomiting, headache, dizziness, pulmonary edema, pneumonia, hypoxemia, dermatitis, and eye and skin burns.
Gasoline	8006 61 9	Acceptable PID response with 10 2 eV or stronger probe	Acceptable response	Air sample using charcoal coconut sorbent tube Analyze via GC FID OSHA IMIS1340	ACGIH TLV of 300 ppm and STEL of 500 ppm	Adequate warning properties Air purifying respiratory protection acceptable to 50 ppm (considering possible presence of benzene)	Vary by type and purity	Vary by type and purity. Common symptoms may include headache, dizziness, defatting of skin
Freon (1,1 2-[trichloro]-1 2 2-[trifluoroethane)	76-13 1	Poor response on PID (ionization potential 11 9 eV)	Poor response	Air sample using charcoal sorbent tube with carbon disulfide desorption and GC FID analysis OSHA IMIS2485	1 000 ppm TWA OSHA/NIOSH/ ACGIH 1 250 PPM STEL (ACGIH)	Moderate warning properties APR acceptable for concentrations up to 4,500 ppm	**Boiling Point:** 118° F **Solubility:** 0 02% @ 77° F. **Vapor Pressure:** 285 mmHg **Flash Point:** Undetermined **LEL:** Undetermined **UEL:** Undetermined **Incompatibilities:** Chemically-active metals such as calcium, powdered aluminum, zinc, magnesium & beryllium **Appearance and odor:** Colorless to water-white liquid with an odor like carbon tetrachloride at high concentrations	Exposure symptoms include irritation of the throat, drowsiness, and dermatitis

TABLE 3-1
CHEMICAL, PHYSICAL, AND TOXICOLOGICAL DATA
PORTSMOUTH NAVAL SHIPYARD

SUBSTANCE	CAS No	AIR MONITORING/SAMPLING INFORMATION			EXPOSURE LIMITS	WARNING PROPERTY RATING	PHYSICAL PROPERTIES	HEALTH HAZARD INFORMATION
Chloroform	67 66 3	Acceptable PID response with 11 7 eV probe	65 response rate w/ FID	Air sample using charcoal sorbent tube with carbon disulfide desorption and GC FID analysis NIOSH 1003 or OSHA 05	50 ppm OSHA ceiling NIOSH Lowest feasible conc 10 ppm ACGIH TWA Supplied air respiratory protection must be used for any appreciable conc s	Recognized odor threshold over 1 400 ppm (ACGIH) Inadequate warning properties	**Boiling Point**: **Solubility**: **Flash Point**: **Vapor Pressure**: **Specific Gravity**: **LEL**: **UEL**: **Incompatibilities**: Strong caustics, strong oxidizers, chemically-active metals such as aluminum or magnesium powder, sodium & potassium **Appearance and odor**: Colorless liquid with a pleasant odor	Carcinogenic concerns recognized by NIOSH and ACGIH Symptoms of exposure include dizziness, mental dullness, nausea, disorientation, headache, fatigue, anesthesia, and eye and skin irritation.
Bromochloro-methane	74 97 5	PID with 11 7 eV probe will respond	Not detected by FID	Air sample using charcoal coconut sorbent tube with carbon disulfide desorption and GC FID analysis OSHA IMIS0627 or NIOSH 1003	200 ppm TWA OSHA/NIOSH/ACGIH APRs acceptable for lower conc s	Moderate warning properties Has a characteristic odor of chloroform However, no odor threshold accepted or published by the ACGIH	**Boiling Point**: 155° F **Solubility**: Insoluble **Flash Point** N/A **Specific Gravity**: 1 93 **Vapor Pressure**: 77° F @ 160 mmHg **LEL**: N/A **UEL**: N/A **Incompatibilities**: Chemically-active metals such as calcium, powdered aluminum, zinc & magnesium **Appearance and odor**: Colorless to pale yellow liquid with a chloroform-like odor	Symptoms of exposure include disorientation, dizziness, pulmonary edema, and irritation or the eyes, throat, and skin
1,1-dichloroethene	75-35-4	Not determined	40% response on FID	Air sample using charcoal/ coconut sorbent tube Analyze via GC FID OSHA 19 or NIOSH 1015	No OSHA PEL established ACGIH TLV TWA of 5 ppm with a STEL of 20 ppm Adequacy of warning properties not determined	Adequacy of warning properties not determined However, this is not a substance listed as not recommended for APR use APR use up to 8 ppm reading on FID acceptable (STEL of 20 ppm X 40% response ratio)		

TABLE 3-1
CHEMICAL, PHYSICAL, AND TOXICOLOGICAL DATA
PORTSMOUTH NAVAL SHIPYARD

SUBSTANCE	CAS No.	AIR MONITORING/SAMPLING INFORMATION			EXPOSURE LIMITS	WARNING PROPERTY RATING	PHYSICAL PROPERTIES	HEALTH HAZARD INFORMATION
Sulfuric Acid	7664 93 9	N A Not a gaseous or vaporous threat	N A Not a gaseous or vaporous threat	Numerous air sampling methods available	OSHA/NIOSH/ ACGIH 1 0 mg/m³ TWA Also ACGIH STEL of 3 0 mg/m³	Not applicable	**Boiling Point:** 554° F **Solubility:** Miscible **Vapor Pressure:** 295° F @ 1 mmHg **Specific Gravity:** 1.84 **Incompatibilities:** Organic materials, chlorates, carbides, fulminates, water, powdered metals Reacts violently with water with evolution of heat **Appearance and odor:** Colorless to dark-brown, oily, odorless liquid	Eye, nose, and throat irritant, pulmonary edema, bronchitis, emphysema, conjunctivitis, stomatis, dental erosion, skin and eye burns, and dermatitis.

4.0 CONFINED SPACE ENTRY OPERATIONS

None of the planned operations have any potential to require activities that would involve personnel entry into structures or containers that could be considered to be permit-required confined spaces, as defined by OSHA standard §1910.146. Therefore, no activities of this kind are addressed further in, or authorized by, this HASP.

Any efforts that require the entry of personnel into an excavation will be limited to excavations that are significantly sloped to allow for ready personnel access and egress, and all applicable requirements of OSHA Construction Industry standards for excavation (29 CFR 1926, Subpart P: "Excavations") will be observed as minimum requirements. Also, any such excavations will be thoroughly evaluated in accordance with the requirements of OSHA standard §1910.146 to ensure that the space is not a permit-required confined space. To satisfy this requirement, and to allow personnel entry, **all** of the following conditions must be satisfied:

- The space may not contain (or have the potential to contain) a hazardous atmosphere (as defined in that OSHA regulation)

- The space must not contain a material that has the potential to engulf or entrap an entrant

- Must be excavated so that the configuration is not such that an entrant could be trapped or asphyxiated by inwardly converging sides or by a floor which slopes downward in the work area and tapers to a smaller cross-section

- Space does not contain any other recognized serious safety or health threat

If any one of these conditions is suspected to exist, absolutely no entry will be permitted. In such an instance, the Project HSO or the CLEAN HSM must be contacted for guidance.

5.0 AIR MONITORING

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

5.1 INSTRUMENTS AND USE

The information provided in this section addresses the use of real-time monitoring instrumentation during onsite activities. These instruments will be used primarily to monitor worker breathing zone areas, while observing conservative instrument action levels. This approach (coupled with the use of engineering controls such as area wetting to control the generation of particulate hazards, and the observance of the other control requirements presented in this Health and Safety Plan) has been selected to minimize any potentials for personnel exposures to hazardous concentrations of airborne contaminants. As a result, personnel air sampling efforts will not be necessary during the planned activities. These real-time monitoring instruments will be operated on a continuous basis during all intrusive activities, concentrating on worker breathing zone areas. In this approach, it can be assumed that the absence of any significant instrument responses in those immediate work areas would preclude any concerns regarding emission concerns at site perimeter locations. However, periodic perimeter monitoring with these instruments will also be performed as a confirmatory/precautionary measure.

5.1.1 Jerome Model 411 Gold Film Mercury Vapor Analyzer

A Jerome Model 411 Gold Film Mercury Vapor Analyzer will be used throughout all activities at the two Mercury Burial Site locations to monitor for emissions of mercury vapors. This instrument will be primarily used in its Survey mode of operation to allow for a quick detection and evaluation of any mercury vapor emissions. If any instrument readings are observed to indicate the possible presence of any mercury vapor concentrations, the instrument mode will be switched to the Sample mode of operation, which involves a slower response time (10 seconds in comparison to only 1 second response in the Survey mode). However, this mode provides for a more accurate analysis of mercury vapor concentrations.

This instrument will be operated on a periodic basis for all nonintrusive activities (i.e., surficial tasks), and continuously throughout all intrusive operations (i.e., soil disturbing activities such as excavations). It shall be calibrated, operated, and maintained in strict accordance with its manufacturer's specifications, as presented in its operating manual. A copy of that document will be maintained onsite. Any positive readings on this instrument will be recorded as presented in section 5.6 of this Health and Safety Plan.

This instrument will be used observing the action levels specified in section 5.3 of this Health and Safety Plan, and, in conjunction with Level C (air purifying respiratory) protection at the mercury burial sites.

5.1.2 HNu-PI101 Photoionization Detector

A HNu PI-101 photoionization detector (PID) with a 11.7 eV lamp will be used to monitor potential source areas and to screen the breathing zones of employees during any intrusive activities. The PID has been selected because it is capable of detecting organic gases and vapors and some inorganic gases and vapors, including most of the identified contaminants of concern for this site. Detection is based on the contaminants' ionization potentials in comparison to the lamp energy (which has to be equal to or greater than the ionization potential of the contaminant).

Prior to the commencement of any field activities, the background levels of the site must be determined and noted. Daily background readings will be taken away from any areas of potential contamination. These readings, any influencing conditions (i.e., weather, temperature, humidity), location, and the other information specified on the form included as Figure 5-1 of this HASP must be documented throughout the performance of site activities (documenting the information on Figure 5-1 in a field Health and Safety Logbook is a suitable recordkeeping alternative).

5.1.3 OVA-Model 128 Flame Ionization Detector

The use of an Organic Vapor Analyzer (OVA) Model 128 (Flame Ionization Detector) may also be utilized to screen potential source emissions and the breathing zones of employees during the execution of the scope of work, and specifically during any intrusive activities which possess the potential to generate airborne gaseous emissions. The OVA has been selected because it may detect the presence of long chain hydrocarbons more efficiently than a photoionization detector (PID). The relative response of this

instrument to most of the contaminants of concern is high (relatively accurate). Both the PID and the FID instruments are suitable for use, and are offered here as alternatives. Instrument selection will consider the field technicians knowledge and level of comfort in using these instruments.

If positive readings are indicated by either the HNu PI-101, or the OVA-Model 128, colorimetric tubes (Draeger tubes) will be used to determine if either methylene chloride or benzene is the contaminant that is detected. Exposure to either of these substances at concentrations that could present a health hazard is unlikely, given the low percentage detected in previous samples, the low probability of free product being present at the sites, and the anticipated site conditions (due to the geographical location of the site and the scheduled time of year that work will be performed). These instruments are primarily used to detect airborne (volatile) contaminants which may be released into the environment, which may pose an exposure concern to site workers.

NOTE: It should be realized that some of the contaminants of concern are nondetectable using these types of screening instruments. Therefore, in addition to the use of these screening instruments, emphasis will also be given to visual observation, as these contaminants may present themselves as particulates (or may be bound to particulates).

5.1.4 Draeger (Colorimetric Tubes)

Draeger tubes shall be employed in conjunction with the HNu or OVA as part of the air monitoring program supporting site activities. This approach has been specified in order to meet the requirements of 29 CFR 1910.120 (h). That regulation specifies that efforts must be taken to determine the identity and quantity of potential site contaminants. The use of the HNu or the OVA in the survey mode of operation will not identify airborne substances only detect them at very low levels. However the use of the Draeger tubes in conjunction with these instruments permits a semi-quantitative result with positive identification within the restrictions of the limitations of the instrument.

Draeger tube 100/a for methylene chloride (tube no. 6724601) has been selected for use due to the previous detection of this substance in groundwater and soils. An action level of any color change from white to brownish green indicating layer will indicate this substances' presence. The measuring range for

these tubes begins at 100 ppm. The effective use of these tubes, and appropriate timely response to retreat if the color change is observed, will effectively minimize the potentials for workers to be over exposed to this substance.

Draeger tube 0.5/c for benzene (tube no. 8101841) will be used to detect the presence of this substance. These tube will detect concentrations of benzene in concentrations ranging form 0.5 to 10 ppm. Effective use of these tubes, and prompt response (as above) will minimize potentials for personnel over exposures to benzene

Any positive instrument responses on the HNu, or OVA observed above background levels will be considered to indicate contaminant release. As such, the following actions will be taken:

- Monitor work areas continuously, concentrating on worker breathing zones (BZ) areas (head and face regions) when positive source results are reported. If readings are observed at these areas to be at background levels, continue monitoring and work efforts.

- If sustained or repeated intermittent readings in the workers' BZ are detected above determined background levels, workers are to retreat to an unaffected area, upgrade the level of protection to Level C (Air Purifying respirator equipped with organic vapor cartridges with High Efficiency Particulate Air Filters) Additional analysis (colorimetric tubes) will be used to confirm that the contaminant is not methylene chloride or benzene Further actions will be dependant upon results of colorimetric tube analysis and levels of contaminant concentration as indicated by the HNu or OVA (refer to Table 5-2 Instrument Action Levels)

5.2 AIR MONITORING REQUIREMENTS - Mercury Analyzer, HNu and OVA

Air monitoring with the Jerome Gold Film Mercury Vapor Analyzer, HNu PI-101 and the OVA will be initiated at potential sources of vapor emissions Examples of potential sources and corresponding activities are as follows

- All intrusive activities (i e excavations, soil boring, drill cuttings, and sampling)
- Decontamination procedures

- If site personnel detect any chemical odors

5.2.1 Air Monitoring Frequency

As previously specified, all site readings must be recorded using Figure 5-1. Recording this information in a site Health and Safety Logbook is an acceptable alternative to using Figure 5-1, provided that all of the specified information is recorded. Other relevant influencing factors (e.g. weather conditions, wind direction and speed, humidity, etc.) should also be recorded.

In general, continuous instrument monitoring will be required throughout all intrusive activities. For nonintrusive efforts, initial and periodic monitoring frequencies will be considered to be adequate. However, based on instrument responses and site observations, the Site Safety Officer may decide to increases these use frequencies. Reduction in monitoring frequencies will not be permitted without obtaining the prior consent of the Project Health and Safety Officer and the CLEAN HSM.

Table 5-1 presents the frequencies that air monitoring instruments are to be utilized, along with the corresponding potential hazards, on a task-specific basis for this project.

TABLE 5-1

AIR MONITORING TYPE AND FREQUENCY

TASK(S)	ATMOSPHERIC HAZARD(S)	MONITORING TYPE & FREQUENCY
Geophysical and land surveying tasks	None anticipated	None required
Soil gas surveys	Toxic gas/vapor or particulate	**PID/OVA:** Initial and then periodic screening at each boring location This is to be performed at the bore hole and at worker Breathing Zones (BZs) **Visual observation:** For dusty conditions as contaminants may be present in particulate form, or may be bound to particulates **Draeger tubes:** As conditions or results dictate

TASK(S)	ATMOSPHERIC HAZARD(S)	MONITORING TYPE & FREQUENCY
Location and sampling activities at the two Mercury Burial Sites	Mercury vapor releases	**Jerome Mercury Vapor Analyzer:** Periodic during all surficial activities, and continuously during intrusive efforts.
	Toxic gas/vapor or particulate	**PID/OVA:** For gas/vapor detection, continuous monitoring throughout all intrusive activities. **Draeger tubes:** As conditions or results indicate. **Visual Observation:** For dusty conditions as contaminants may be present in particulate form, or may be bound to particulates.
	Flammable or explosive threats	**LEL/O2:** During all intrusive activities. NOTE: PID/OVA, and LEL/O2 must also be used in accordance with OSHA §1910 146 prior to any personnel entry into an excavation. Refer to section 4 0 of this HASP
Groundwater investigations	Toxic gas/vapor or particulate Flammable/explosive threats	**PID/OVA:** Continuously monitor potential sources (i e borehole, drill cuttings, etc) and the workers' BZs **Visual observation:** Same as that specified above **Draeger tubes:** As conditions or instrument results indicate **LEL/O2:** Periodically monitor borehole
Inspections for groundwater discharges from the JILF landfill	None anticipated	None required
Tidal study	None anticipated	None required

5.3 ACTION LEVELS

The following monitoring instrument action levels will apply to this project:

TABLE 5-2
INSTRUMENT ACTION LEVELS

INSTRUMENT	ACTION LEVEL	RESULTANT ACTION
HNu PID	Above background levels at a potential point source release (i.e. borehole reading, in an excavated depression, etc.).	Continue work while closely monitoring the workers' Breathing Zone (BZ) areas.
	Background levels are exceeded in worker BZ areas	Retreat to an unaffected area and let the work area ventilate. Reapproach work area cautiously with monitoring instruments. If background levels are not regained, don APRs with organic vapor-HEPA filtered cartridges and perform Draeger tube analysis. Test first for methylene chloride and then for benzene. If any positive indication is seen in either analysis, immediately retreat and contact the Project HSO or the CLEAN HSM for guidance. If the presence of methylene chloride and benzene is positively ruled out, work may resume using the APR protection with periodic retesting with the Draeger tubes
	Greater than 50 ppm	Retreat to an unaffected area. Work can continue with APR protection when readings decrease to levels below 50 ppm. Otherwise, work can continue only in Level B (supplied air respiratory protection)
OVA FID	Same action levels as those specified for the HNu PID	Same response actions as those specified for the HNu PID
Draeger tubes	Observe the directions provided with the tubes	Any positive indication on either the methylene chloride or the benzene tube will be cause for immediate retreat to an unaffected area

INSTRUMENT	ACTION LEVEL	RESULTANT ACTION
LEL/O2 meter	<19.5% or >23.5% oxygen content in air	Retreat immediately. If situation involves oxygen deficiency, work can continue in Level B protection. If oxygen enriched atmosphere is the concern, contact the Project HSO or the CLEAN HSM for guidance and do not resume until O2 levels decrease to less than this action level.
	>10% LEL readings	If potentially-explosive action levels are indicated by the exceedence of this action level, retreat immediately to an unaffected area and contact the Project HSO or the CLEAN HSM for guidance.
Mercury Vapor Analyzer	Any positive readings while operated in Survey Mode	Workers will retreat to an unaffected area, Site Safety Officer will switch the device to operate in the Sample Mode to better assess the work atmosphere for mercury vapor concentrations.
	<0 01 mg/m³ in Sample Mode	Continue work with caution, continue monitoring in Sample Mode
	>0 01 mg/m³ in Sample Mode	Retreat to unaffected area and let work area ventilate Return only if/when acceptable levels are regained Site Safety Officer will also perform perimeter monitoring in this event If positive readings at the site perimeter are observed, this SSO will immediately notify the Project Manager, the CLEAN HSM and the Base Contact as specified in Table 12-1

5.4 VISUAL OBSERVATION

Based on the hazard assessment several of the suspected contaminants of concern may be encountered in the form of a particulate (or may be bound to particulates) Controlling particulate generation and dispersal will be the primary control against worker exposure to this potential hazard This control effort is accomplished through work practices such as wetting down areas of potential contamination and contaminant-ladened particulate generation Only when this control approach cannot be effectively implemented will site personnel resort to the use of APRs. In other words, the initial effort will be to control

the potential hazard, with the secondary effort being on protecting workers from being overexposed to it. The only exception to this is that APR protection will be used during intrusive operations at the two Mercury Burial Site locations.

5.5 INSTRUMENT MAINTENANCE AND CALIBRATION

Air monitoring instruments will be maintained and pre-field calibrated by the equipment supplier. Operational checks will be performed on all instruments each day prior to their use. Field calibration will be performed on instruments which require it (for example, the HNu -if used- must be field calibrated daily. An additional field calibration must be done on this instrument at the end of each day to determine any significant instrument drift). These operational checks and calibration efforts will be performed in a manner that complies with the employees health and safety training, the manufacturer's recommendations, and with applicable Halliburton NUS instrument Standard Operating Procedures (a copy of which will be maintained on site for reference). All calibration efforts must be documented. Figure 5-2 is provided for documenting these calibration efforts. This information may instead be recorded in a field Health and Safety Logbook provided that all of the information specified in Figure 5-2 is recorded. This required information includes the following

- Date calibration was performed
- Individual calibrating the instrument
- Instrument name, model, and serial number
- Any relevant instrument settings and resultant readings (before and after) calibration
- Identification of the calibration standard (lot no., source concentration, supplier)
- Any relevant comments or remarks

Field maintenance will consist of daily cleaning of the instruments using a damp towel or rag to wipe off the instrument's outer casing and overnight battery recharging.

5.6 RECORDKEEPING

All instrument readings above and including background levels must be recorded using Figure 5-1, or in a field book or field Health and Safety Logbook. This recordkeeping should also indicate any corrective actions taken. In addition, results of any colorimetric analysis must be recorded in the log book.

Instrument calibration efforts and results must also be recorded, as specified in section 5.5. Lastly, information concerning potential influencing factors on instrument responses (i.e. weather, activities, interferences) shall also be recorded.

FIGURE 5-1

DIRECT-READING INSTRUMENT RESPONSE DATA

Site Name: Portsmouth Naval Shipyard **Project No.:** 0466

Page 1 **of** _____

Date and Time(s)	Instrument Operator Name	Instrument Used	Instrument Reading and Duration	Location (e.g., Borehole vs. Breathing Zone)	Operation(s) Being Performed	Personnel in Vicinity at Time of Readings and Level of PPE Worn
Example 2-12-94 14:30	Joe Field	HNu 101	15 ppm 15 min	Breathing Zone	Installation of Well No. 12	Jim Technician/Level B, George Jones/Level B

FIGURE 5-1
DIRECT-READING INSTRUMENT RESPONSE DATA
Page _____ of _____

Date and Time(s)	Instrument Operator Name	Instrument Used	Instrument Reading and Duration	Location (e.g., Borehole vs. Breathing Zone)	Operation(s) Being Performed	Personnel in Vicinity at Time of Readings and Level of PPE Worn

FIGURE 5-2

DOCUMENTATION OF FIELD CALIBRATION

Site Name: Portsmouth Naval Shipyard

Project No.: 0466

Date of Calibration	Instrument Name and Model	Instrument ID Number	Person Performing Calibration	Instrument Settings		Instrument Readings		Calibration Standard (Lot No.)	Remarks/ Comments
				Pre-Calibration	Post-Calibration	Pre-Calibration	Post-Calibration		

6.0 PERSONAL PROTECTIVE EQUIPMENT (PPE)

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

6.1 ANTICIPATED LEVELS OF PROTECTION

The levels of protection which may be used in the various tasks of this project include levels D, C, and possibly B (as defined in Appendix B of OSHA Standard 29 CFR 1910.120 - "Hazardous Waste Operations and Emergency Response"). It is anticipated that Level D will be appropriate for the majority of work in this effort However, work at the two Mercury Burial Site locations will involve the use of Level C protection (full face respirators equipped with mercury vapor cartridges with end-of-service life indicators and HEPA filters) At other locations, this level of protection may be required based of conditions such as dry and dusty conditions in areas where particulate contamination may be encountered (if controls such as area wetting techniques are not possible or effective), or based on data such as monitoring instrument readings or colorimetric tube analyses results Also if the subtask for containerization of suspected mercury contaminated soils becomes necessary at those sites Level B protection (air supplied respiratory protection) may become necessary Level B protection may also become necessary for intrusive operations at the JILF landfill as described under Task 3 in section 3 0 of this HASP In regard to dermal protection many of the planned activities will require the use of chemical protective clothing such as coveralls gloves and boot covers as presented in the task breakdown which follows Where activities overlap the more protective requirements will be applied Lastly upgrading the level of protection for Halliburton NUS (and subcontractor) personnel will be reserved to the discretion of the FTL and SSO based on factors such as site observations worker comments and other conditions and circumstances, in addition to monitoring instrument results

6.1.1 Minimum Requirements (All Tasks)

Minimum requirements include steel-toe and steel shank work boots, chemical resistant boot covers with standard field dress consisting of long pants and long-sleeved shirts Hard hats and safety glasses will be worn when overhead or eye hazards exist based on the task, or if working in and around operating

machinery that could present or contribute to these threats. The use of protective equipment specified as optional will be at the discretion of the FTL or the SSO based on tasks, site conditions, and other influencing factors. This is of course providing that action levels or the requirements of this plan are not compromised, indicating a need for additional elements of personal protection.

6.1.2 Mobilization/Demobilization and Site Reconnaissance Activities

As mobilization and demobilization present limited potential for contacting any hazardous materials that could adversely effect site personnel, the minimum requirements specified in 6.1.1, above, will be adhered to for these efforts Disposable boot covers will be worn in areas where surface contamination may reasonably be anticipated to exist.

6.1.3 Surveying and Geophysics/JILF Discharge Inspections/Tidal Study

These activities have been categorized together in this section as they are all nonintrusive activities which present minimal hazard potentials. PPE requirements for these tasks will be the same as those specified for the Mobilization/Demobilization and Site Reconnaissance tasks One exception is in regard to those activities that will be performed near or over bodies of water For those efforts, personnel must also wear U S Coast Guard approved personal flotation devices be properly tied-off with lifelines and lifeline attendants and (if wading into water bodies is necessary to perform the task), wear appropriate hip or chest waders Also for any activities where personnel may handle potentially contaminated media, tools, or equipment at least nitrile inner gloves and cotton work over gloves will be worn If handling liquid media is anticipated nitrile outer gloves will be used in place of the cotton work gloves

6.1.4 Investigation and Sampling Activities at The Two Mercury Burial Sites

All intrusive activities performed at these locations will require the minimum gear specified in 6 1 1 and the following items of PPE

- Saranex coveralls
- Nitrile inner and outer gloves
- Nitrile (or neoprene or rubber) boots or boot covers
- Taped ankle and wrist joints

- Full face APRs with mercury cartridges (MSA Mersorb type H)
- Hard hats, hearing and eye protection (optional per SSO direction, as conditions or operations indicate)

Nonintrusive activities will only require the use of the minimum gear with boot covers and inner gloves. However, Tyvek® coveralls may be required if dry and dusty conditions exist.

The air purifying respirator (APR) cartridges identified for use during intrusive activities are equipped with colorimetric end-of-service life indicators which are positioned on the sides of the cartridge. This positioning allows for the wearer to be able to see the device, and recognize when the color change has occurred. This end-of-service life indicating device is incorporated into the cartridge to provide a clear, timely indication of when the useful life of the cartridge is ending. This is indicated when the orange indicator turns to a brown color. This cartridge is approved for use for mercury vapor concentrations of up to 0.5 mg/m^3. According to the manufacturer of the device, at that maximum allowable concentration, the cartridge has been tested to provide adequate protection for more than an eight hour period. Also, the color change on the end-of service life indicator has been tested and shown to occur (at that concentration) after a period of only approximately 2 hours. Therefore, the color change indication represents a safety factor of approximately 4. That is, the end-of-service life indicator will notify the wearer that cartridge replacement is necessary while nearly 75% of the cartridges useful life still remains. All site personnel will be instructed to frequently check for the occurrence of this color change on themselves and on their coworkers, and that any perceived color change will warrant the immediate exit from the work area to obtain new cartridges. Also, as an added precaution, workers will be instructed to obtain new cartridges at least on a daily basis.

As mentioned in the previous section of this Health and Safety Plan, a real-time mercury vapor analyzer monitoring instrument will also be utilized on a continuous mode during all intrusive activities at the two Mercury Burial Site locations. As the specified mercury vapor APR cartridges are approved for use in mercury vapor concentrations up to 0.50 mg/m^3, any instrument readings near worker breathing zones approaching the action level of 0.3 mg/m^3 will initiate an immediate site evacuation response. This instrument action level employs a safety factor of 40% of the cartridges approved limit. This is addressed in greater detail in Section 5.0 of this Health and Safety Plan.

Finally, if readings from the Mercury Vapor Analyzer indicate that soils encountered may be contaminated with mercury, and that the capacity of the Level C devices may be threatened to be exceeded, then personnel will evacuate and upgrade to Level B protection for any remedial efforts (i.e., containerizing the suspected contaminated soils, as presented as subtask 2.3 in section 2.0 of this Health and Safety Plan).

6.1.5 Groundwater Investigations

Minimum requirements include steel-toe, steel shank work boots, chemical resistant boot covers, Tyvek® coveralls, and nitrile outer gloves over cotton work gloves. In addition, hard hat and safety glasses will be worn when working in close proximity to operating machinery or equipment (e.g. drill rig), or when the potential for eye or overhead hazards are observed to exist. If the potential for saturation of work clothes exists the use of PVC or PE-coated Tyvek® will be substituted in place of the Tyvek® coveralls. Additional personal protective items shall include hearing protection during the operation of mechanized equipment as specified in section 3.3.10.

This task may involve the use of levels D, C, or B, depending on conditions at the site, and depending on the success of the information gathering efforts at the JILF landfill location, as specified in this Plan The determination for the use of Level C protection will be based on factors such as site conditions (weather, potentials for activities to generate respiratory hazard potentials via airborne particulates etc), monitoring instrument readings and other factors as specified in this Plan If the information gathering process fails to determine that the potential for encountering a buried cylinder is extremely remote then intrusive tasks at that area of concern will be performed only in Level B protection

6.1.6 Decontamination Activities

The requirements for decontamination activities will include the minimum requirements for all tasks (See Section 7 1 1) and the use of PE-coated Tyvek® or PVC with nitrile outer and inner gloves when the potential for saturation of work clothing exists and splash shield as necessary or as directed by the FTL or SSO This will be the required level of protection when performing large scale decontamination activities such as when steam cleaning augers and drill flights The general rule of thumb for respiratory protection will be to use the same level as, or one level below, that of the field personnel who were using the equipment This will be determined by the SSO for specific decontamination activities

6.2 PPE SELECTION CRITERIA

Based on the relatively low volatility and anticipated low concentrations of the identified contaminants of concern, as well as the probabilities for dispersion of any potential vapor releases via natural ventilation (i.e. wind currents), vapor concentrations in worker breathing zones are not anticipated to be at levels which would warrant a respiratory hazard protection. This is reinforced by the anticipated colder ambient temperatures that will be present during the field investigation tasks. However, the potential exists for dust emissions containing site contaminants to be generated. These dust emissions can be inhaled or ingested and result in exposure. If dust emissions are observed and cannot be controlled (i.e. via area wetting techniques), the use of full-face air-purifying respirators equipped with a combination High Efficiency Particulate Air (HEPA) filter and Organic Vapor mist cartridge will be implemented. Initiation of this action will be determined by the FTL and the SSO. However, due to the anticipated climatic conditions, the potential for encountering dry or dusty conditions is not likely.

Due to the toxicity characteristics of mercury vapors, and in recognition of the established OSHA Permissible Exposure Limits and the ACGIH Threshold Limit Values for that substance, air purifying respiratory protection will be used for intrusive operations at the mercury burial sites. These devices will be equipped with end-of-service life indicators that will alert the workers if the capability of the cartridge is being exceeded

Nitrile gloves were selected to provide protection against the potential site contaminants that could be encountered and to help reduce the potential for the ingestion of transferred contaminants as a result of incidental hand-to-mouth contact Nitrile was selected as the glove construction material based on available research data on permeation characteristics of the contaminants of concern Hard hats, safety glasses and work boots were selected to provide protection against some of the physical hazards associated with the proposed operations Disposable boot covers were selected to help minimize the spread of contamination Tyvek® coveralls were selected to minimize the potential for contamination of street clothes and PVC coveralls were selected for use in the event that activities could have the potential to result in the saturation of work clothes Saranex® coveralls were selected for the mercury burial site activities based on their effectiveness to prevent the permeation of mercury contamination, should it be encountered

6.3 PPE MODIFICATION CRITERIA

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

6.3.1 Chemical Protective Clothing Modification Criteria

Tyvek® coveralls and boot covers must be worn anytime there is a reasonable potential for contamination of street clothes. Polyvinyl chloride (PVC) or PE-coated Tyvek® coveralls must be worn anytime there is a reasonable potential for saturation of work clothes. Saranex® coveralls must be worn during intrusive activities at the Mercury Burial Site locations. Nitrile gloves (inner and outer) must be worn anytime there is a reasonable potential for hand contact with site contaminants.

6.3.2 Respiratory Protection Modification Criteria

Full face air purifying respirators (APRs) equipped with high efficiency particulate air (HEPA) filters must be worn anytime dry and dusty conditions are observed and these emissions cannot be suppressed with water spray. Full face APRs equipped with mercury vapor cartridges with end-of-service life indicators will be worn during intrusive operations at Mercury Burial Sites I and II. In addition, the use or modification of required items of respiratory protection will be in accordance with the action levels specified in Section 5.3.

The use of supplied air respiratory protection (Level B) will be used if nesecssary during intrusive activities at the JILF Landfill and Mercury Burial site locations. The determination for this need for the JILF Landfill location will primarily be dependent on the success of the information gathering effort demonstrating that encountering any buried compressed gas cylinders during the well drilling effort is not a reasonable probability. In regard to the possible use of Level B protection during intrusive work at the Mercury Burial Site location, this will be chosen if the action levels specified in section 5.3 of this Plan for mercury vapor emissions are exceeded. In fact, that potential exists throughout activities at all of the site locations, but at a lesser extent as compared to the potential for its use at the Mercury Burial Sites.

FIGURE 6-1
AIR PURIFYING
RESPIRATOR USE LOG

Site:_____

Location:_____

Dates of Investigation:_____

User	Date of Use	Cleaned and Inspected Prior to Use (Initials)	Cartridges Changed Prior to Use (Yes/No)	Total Hours on Cartridge

SUBMIT TO HEALTH SCIENCES DEPT. AT COMPLETION OF PROJECT

_____ Site Manager (FTL)

_____ Date

FIGURE 6-2
SCBA LOG

Site:_____

Location:_____

Dates of Investigation:_____

User	Date of Use	SCBA #	Satisfactory Check-Out (Yes/No-Initials)	Date Cleaned

SUBMIT TO HEALTH SCIENCES DEPT. AT COMPLETION OF PROJECT

_____ Site Manager (FTL)

_____ Date

7.0 DECONTAMINATION

Decontamination is the procedure to be employed to remove and/or neutralize site contaminants encountered through the execution of the scope of work. This procedure will be employed for the purpose of preventing cross contamination, protecting onsite personnel, and protecting the individuals outside this operation from the spread of contamination.

7.1 STANDARD PROCEDURES

1. Establish a personnel decontamination station (PDS) suitable to handle the activities, type and the amount of contamination, and level of protection. This area will be located adjacent to the exclusion zone or work area, and will consist of the stations described in Section 7.2.

2. Upon leaving the contamination area (exclusion zone), all personnel shall proceed through the appropriate contamination reduction sequence.

3. All protective gear should be left onsite during any lunch break following decontamination procedures.

4. Locate a central decontamination area for heavy equipment. The equipment upon completing the task at hand will require that at least the wheels and tires to be cleaned prior to moving to the decontamination area. This area should be accessible to resources and emergency services.

5. All equipment will be inspected by the FTL or SSO and approved prior to leaving the decontamination area within the contamination reduction corridor.

6. All discarded materials (i.e. drill cuttings, decontamination fluids, used PPE) will be drummed, labeled, and staged to await sample analyses and ultimate disposal fate.

7.2 PERSONNEL DECONTAMINATION REQUIREMENTS

The decontamination of personnel and their protective clothing shall be performed in sequential stages. These stages shall include:

- Removing contamination from protective clothing and equipment with a detergent/water solution and soft bristle scrub brushes.

- Removal of protective clothing (disposable items shall be discarded into a container conspicuously marked "Potentially Contaminated Clothing").

- Workers washing hands and face with potable water and soap whenever they remove PPE and leave the exclusion zone.

The maximum decontamination layout is described in the following table. Within this format the **bolded** sections represent the minimum requirements for all tasks conducted in an established exclusion zone. Should the task or scope require use of the material identified as optional, those sections will become mandatory (at the discretion of the onsite safety representative).

Maximum/Minimum Measures for Decontamination

Station 1:	**Segregated Equipment Drop**	**Deposit equipment used onsite (tools, sampling devices and containers, monitoring instruments, radios, clipboards, etc.) on plastic drop cloths or in different plastic-lined containers. Segregation at the drop reduces the probability of cross contamination.**
Station 2:	**Boot Cover and Glove Wash**	**Scrub outer boot covers and gloves with detergent and water.**
Station 3:	**Boot Cover and Glove Rinse**	**Rinse off from Station 2 using only as much water as necessary.**
Station 4	Suit and Safety Boot Wash As applicable as not all operations will require the use of protective suits and not all suits are amenable to washing/rinsing (i e Tyvek® coveralls are merely removed and discarded and not washed or rinsed)	Wash splash suit gloves. and safety boots Scrub with long-handled scrub brush and decontamination solution
Station 5	Suit and Safety Boot Rinse	Rinse off decontamination solution using water Rinse Repeat as many times as necessary
Station 6	Tape Removal	Remove tape around boots and gloves and deposit them in the plastic-lined container

Station 7:	**Boot Cover Removal**	**Remove boot covers and deposit them in the plastic-lined container for decontamination and reuse.**
Station 8:	**Outer Glove Removal**	**Remove outer gloves and deposit them in a plastic-lined container for disposal.**
Station 9:	Cartridge, Mask, or Tank Change. As applicable, not all operations will require respiratory protection.	If worker leaves exclusion zone to change cartridges (or mask or tank), this is the last step in the decontamination procedure. Worker's cartridges exchanged, new outer gloves and boot covers donned, and joints taped. Worker returns to duty.
Station 10:	Coverall Removal	With the helper's assistance, remove coveralls. Deposit in the plastic-lined container.
Station 11:	Respirator Removal (if worn)	Remove face piece. Deposit it in a plastic-lined container. Avoid touching face.
Station 12:	**Inner Glove Removal**	**Remove inner gloves and deposit them in the plastic-lined container.**
Station 13:	**Field Wash**	**Wash hands and face with potable water.**
Station 14	Heat or cold stress evaluation/Break Heat/cold stress monitoring will be conducted on an as needed basis	Observe the monitoring procedures presented in the attachments to this HASP

7.3 MINIMAL DECONTAMINATION

Less extensive procedures for decontamination can be established when Level D protection is utilized, when the type and degree of contamination are known, or when the potential for contaminant transfer is judged to be minimal by the SSO. These procedures generally may involve one or two washdowns only, and/or progressive removal (and disposal, as appropriate) of items of PPE.

7.4 EQUIPMENT DECONTAMINATION

The drill rig and all drilling tools, hand augers, etc. will be steam cleaned between boreholes. All downhole tools, samplers, and other downhole equipment will be steam cleaned between boreholes. Under muddy conditions, the back end of the drill rig and wheels will also be steam cleaned, as needed, between boreholes. It has been assumed that an appropriate decontamination area near the site will be designated by the facility for drill rig steam cleaning/decontamination operations.

7.5 DECONTAMINATION OF SAMPLING TOOLS

All sampling equipment will be cleaned between sample acquisitions in accordance with the requirements established in the sampling plan. In addition, all sampling equipment that will be leaving the site will require a thorough decontamination, and approval by the FTL or SSO to verify it has been properly decontaminated, prior to leaving the site. This can be accomplished either by steam cleaning or by a detergent wash and potable water rinse until tools are visibly clean.

7.6 CLOSURE OF THE PERSONNEL DECONTAMINATION STATION

Decontamination-generated liquid wastes, all disposable clothing and plastic sheeting used during the operation will be containerized, labeled, and staged onsite to await disposal. The disposal method used will be based upon available information regarding the characteristics of the site, sample analyses, and contaminant levels Reusable protective equipment will be cleaned, dried, and prepared for future use. (If gross contamination has occurred, the item will be properly disposed.)

All wash tubs pail containers, etc., will be thoroughly washed, rinsed, and dried prior to removal from the site The Site Safety Officer will be responsible for inspecting and clearing equipment to leave the site

7.7 PPE REQUIREMENTS FOR DECONTAMINATION OPERATIONS

All equipment decontamination efforts will require the use of chemical protective clothing as described below

- PVC or PE coated Tyvek® coveralls
- Nitrile outer gloves
- Latex or nitrile inner gloves (surgeons)
- Rubber boots (or rubber boot covers)
- Splash shield (if respirator not worn)
- Respiratory protection (if needed*)
- * The same level of respiratory protection worn for the work assignment will be worn when decontaminating the equipment used for that assignment

7.8 EMERGENCY DECONTAMINATION PROCEDURES

In addition to routine decontamination procedures, emergency procedures will establish the protocol to be followed in the event of a medical emergency. This procedure will be established and conducted based on the severity of the injury including procedures for potential loss of life, and injury requiring first-aid. (NOTE: An emergency first aid instruction poster has been attached to this HASP. This shall be posted at the site at a convenient location.)

Potential loss of life:

- Delay decontamination (if necessary), or modify it to perform as much decontamination of the injured person as possible.
- Stabilize victim
- Wrap the victim in blankets, or plastic sheeting to reduce the potential of contamination to medical personnel
- All medical support will be informed of the suspected hazards associated with the task. All receiving facilities however must be alerted to the potential hazards. Clearance from the hospital for accepting potentially contaminated personnel will be obtained by the SSO prior to the commencement of onsite activities

Injury

In situations where the contamination is extremely toxic or corrosive (not anticipated)

- Implement immediate decontamination procedures
- Administer First-Aid (if qualified to do so)
- For heat related disorders: remove all protective clothing, wash as appropriate, treat for heat stress. Extremely toxic or corrosive contamination is not expected to be encountered based upon known site characteristics

7.9 DECONTAMINATION EVALUATION

The decontamination process effectiveness will be judged in the following manner:

- Visual observation - Discoloration, stains, dirt, and alterations of the fabric due to chemical contact will be the primary method used to determine effectiveness

The following methods may be used if gross contamination is encountered:

- Monitoring Instrumentation - Instruments used to detect site contaminants may be employed to scan garments and equipment for the presence of site contaminants after decontamination procedures have been employed.

- Decontamination Solution Analyses - An analyses of the solution (final rinse) and the presence of contaminants may suggest additional cleaning is required. This information may be useful in the ultimate disposal of the fluids generated

- Sample Analyses - sample analyses may indicate the level of contamination and therefore the potential for contamination. Once again this information may be useful in the ultimate disposal.

It is suggested that a combination of methods be used to determine the effectiveness of the decontamination of the process used.

8.0 TRAINING REQUIREMENTS

This section describes the minimum requirements for initial, refresher, and site-specific training.

8.1 INTRODUCTORY AND REFRESHER TRAINING

8.1.1 Requirements for HALLIBURTON NUS Personnel

All Halliburton NUS personnel must complete 40 hours of introductory hazardous waste site training prior to performing work at the Portsmouth Naval Shipyard. Additionally, HALLIBURTON NUS personnel who have had introductory training more than 12 months prior to site work must have completed 8 hours of refresher training within the past 12 months before being cleared for site work.

All Halliburton NUS personnel functioning in the supervisory capacity will have had Management and Supervisory training as required by 29 CFR 1910.120 (e)(4).

Documentation of Halliburton NUS introductory, supervisory, and refresher training and a site-specific training will be maintained at the project. Copies of certificates or other official documentation will be used to fulfill this requirement.

8.1.2 Requirements for Subcontractors

All Halliburton NUS subcontractor personnel must have completed introductory hazardous waste site training or equivalent work experience as defined in OSHA Standard 29 CFR 1910.120(e) and 8 hours of refresher training (as appropriate) meeting the requirements of 29 CFR 1910.120(e)(8) prior to performing field work at the Portsmouth Naval Shipyard. All subcontractor personnel serving in the supervisory capacity will have had Management and Supervisory training as required by 29 CFR 1910.120(e)(4). Halliburton NUS subcontractors must certify that each employee has had such training by sending Halliburton NUS a letter, on company letterhead, containing the information in the example letter provided as Figure 8-1. Figures 8-1 and 9-2 can be combined into one letter.

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8.1.3 Subcontractor Exceptions

Subcontractors, such as surveying subcontractors, who will not perform any activities in the exclusion zone during intrusive activities such as excavation, well installation, and sampling tasks, or where this is no potential for exposure, will be excluded from the requirements stipulated in Section 8.1.2. The use of these exceptions is permitted only by obtaining the prior approval of the CLEAN HSM.

8.2 SITE-SPECIFIC TRAINING

Halliburton NUS will provide site-specific training to all HALLIBURTON NUS employees and subcontractor personnel who will perform work on this project. Site-specific training will include:

- Names of personnel and alternates responsible for site safety and health
- Safety, health and other hazards present on site
- Use of personal protective equipment
- Work practices to minimize risks from hazards
- Safe use of engineering controls and equipment
- Medical surveillance requirements
- Signs and symptoms of overexposure
- The contents of the health and safety plan and addendum
- Emergency response procedures (evacuation and assembly points)
- Review the contents of relevant Material Safety Data Sheets

8.2.1 Site-Specific Training Documentation

Halliburton NUS and subcontractor personnel will be required to sign a statement indicating receipt of site-specific training and understanding of site hazards and control measures. Figure 8-2 will be used to document site-specific training.

FIGURE 8-1

OSHA TRAINING CERTIFICATION

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

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

Month, day, year

Ms. Linda E. Klink
Project Manager
Halliburton NUS Environmental Corp.
Foster Plaza VII 661 Andersen Drive
Pittsburgh, Pennsylvania 15220

Subject Hazardous Waste Site Training - Portsmouth Naval Shipyard

Dear Ms Klink

The employees listed below have had introductory hazardous waste site training or equivalent work experience as required by 29 CFR 1910 120(e) In addition, those employees listed below who have received their introductory training more than 12 months ago have also received 8 hours of refresher training in accordance with 29 CFR 1910 120 (e)(8) within the past 12 months

LIST FULL NAMES OF EMPLOYEES AND THEIR SOCIAL SECURITY NUMBERS HERE

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

Sincerely

(Name of Company Officer)

FIGURE 8-2

SITE-SPECIFIC TRAINING DOCUMENTATION

My signature below indicates that I am aware of the potential hazardous nature of performing investigation activities at Portsmouth Naval Shipyard, and that I have received site-specific training which included the elements presented below:

- Names of personnel and alternates responsible for site safety and health
- Safety, health and other hazards present on site
- Use of personal protective equipment
- Work practices to minimize risks from hazards
- Safe use of engineering controls and equipment
- Medical surveillance requirements
- Signs and symptoms of overexposure
- The contents of the health and safety plan
- Emergency response procedures (evacuation and assembly points)
- Review contents of relevant Material Safety Data Sheets

I further state that I have been given the opportunity to ask questions and that all of my questions have been answered to my satisfaction.

NAME	SIGNATURE	DATE

9.0 MEDICAL SURVEILLANCE

9.1 REQUIREMENTS FOR HALLIBURTON NUS PERSONNEL

All Halliburton NUS personnel participating in project field activities will have had a physical examination meeting the requirements of Halliburton NUS' medical surveillance program and will be medically qualified to perform hazardous waste site work using respiratory protection. At the Pittsburgh office, the Medical Surveillance Program is administered by the Health Sciences Department, with consultation provided by the Partners in Corporate Health Care department of Ohio Valley General Hospital. Our Medical Consultant at that hospital is Teresa Silvaggio, M.D., MPH, Director. Dr. Silvaggio is experienced, very knowledgeable (and Board eligible) in Occupational Medicine, as required by OSHA standard 1910.120 (f) (5), and residency-trained. She has over five years experience in serving as the Pittsburgh Office's Medical Consultant. All Ohio Valley General Hospital physicians participating in this program have been thoroughly informed of the nature of operations that Halliburton NUS employees perform, and on the potential chemical and physical hazards that may be encountered in fulfilling their assigned duties. This has also included educating these physicians in the various types of respiratory and other personal protective equipment commonly used by our personnel.

Documentation for medical clearances will be maintained in the HALLIBURTON NUS Pittsburgh office and made available as necessary.

9.2 REQUIREMENTS FOR SUBCONTRACTORS

Subcontractors are required to obtain a certificate of their ability to perform hazardous waste site work and to wear respiratory protection. The "Subcontractor Medical Approval Form" (Figure 9-1) can be used to satisfy this requirement providing it is properly completed and signed by a licensed physician.

Subcontractors who have a company medical surveillance program meeting the requirements of paragraph (f) of OSHA 29 CFR 1910.120 can substitute Figure 9-1 with a letter, on company letterhead, containing all of the information in the example letter presented as Figure 9-2. Figures 8-1 and 9-2 can be combined into one letter.

9.3 EXCEPTIONS FOR SUBCONTRACTORS

Subcontractor personnel who will not perform any activities in the exclusion zones during intrusive operations, or where there is no potential for exposure will be exempted from the requirements stipulated in Section 9.2. This exception can be utilized only with the prior approval of the CLEAN HSM.

9.4 REQUIREMENTS FOR ALL FIELD PERSONNEL

Each field team member (including subcontractors) shall be required to complete and submit a copy of Medical Data Sheet. These will be handed out and collected as part of the site-specific training. This shall be provided to the SSO, prior to participating in site activities.

FIGURE 9-1

SUBCONTRACTOR MEDICAL APPROVAL FORM

For employees of _____
Company Name

Participant Name: _____ Date of Exam: _____

Part A

The above-named individual has:

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

   ( ) qualified to perform work at the Portsmouth Naval Shipyard work site
   ( ) not qualified to perform work at the Portsmouth Naval Shipyard work site

and,

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

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

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

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

Part B

I, _____ have examined _____
Physician's Name (print) Participant's Name (print)
and have determined the following information

FIGURE 9-1
SUBCONTRACTOR MEDICAL APPROVAL FORM
PAGE TWO

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

_____

_____

_____

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

_____

_____

_____

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

_____

_____

_____

_____

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

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

( ) may
( ) may not

perform his/her assigned task

Physician s Signature _____

Address _____

Phone Number _____

NOTE Copies of test results are maintained and available at

_____
Address

FIGURE 9-2

MEDICAL SURVEILLANCE LETTER

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

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

Month, day, year

Ms. Linda E. Klink
Project Manager
Halliburton NUS Environmental Corp.
Foster Plaza VII 661 Andersen Drive
Pittsburgh, Pennsylvania 15220

Subject: Medical Surveillance - Portsmouth Naval Shipyard

Dear Ms. Klink

As an officer of XYZ Corporation, I hereby state that the persons listed below participate in a medical surveillance program meeting the requirements contained in paragraph (f) of Title 29 of the Code of Federal Regulations (CFR), Part 1910.120 entitled "Hazardous Waste Operations and Emergency Response Final Rule." I further state that the persons listed below have had physical examinations under this program within the past 12 months and that they have been cleared, by a licensed physician, to perform hazardous waste site work and to wear positive and negative pressure respiratory protection. I also state that, to my knowledge, no person listed below has any medical restriction that would preclude him/her from working at the Portsmouth Naval Shipyard worksite.

LIST FULL NAMES OF EMPLOYEES AND THEIR SOCIAL SECURITY NUMBERS HERE

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

Sincerely,

(Name of Company Officer)

10.0 SITE CONTROL

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

10.1 EXCLUSION ZONE

The exclusion zone will be considered those areas of the site of known or suspected contamination. In many cases, however, significant amounts of surface contamination will not be encountered in the proposed work areas of this site until/unless contaminants are brought to the surface by intrusive activities. Furthermore, once such activities have been completed and surface contamination has been removed, the potential for exposure is again diminished and the area can then be reclassified as part of the contamination reduction zone Therefore, the exclusion zones for this project will be limited to those areas of the site where active work is being performed and/or anywhere there is believed to be the potential for encountering any of the potential hazards defined in this HASP

10.2 CONTAMINATION REDUCTION ZONE

The contamination reduction zone (CRZ) will be a buffer area between the exclusion zone and any area of the site where contamination is not suspected The personnel and equipment decontamination area established for this project will take place in the CRZ This area will serve as a focal point in supporting exclusion zone activities In addition this area will serve as the access and control points to the exclusion zone

10.3 SUPPORT ZONE

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

10.4 SITE MAP

Site maps are presented in previous sections of this Work Plan, and are therefore not repeated here.

10.5 BUDDY SYSTEM

Personnel engaged in onsite activities will practice the "buddy system" to insure the safety of all personnel involved in this operation.

10.6 MATERIAL SAFETY DATA SHEET (MSDS) REQUIREMENTS

Halliburton NUS personnel will provide MSDS's for all chemicals brought on site. The contents of these documents will be reviewed by the Site Safety Officer with the user(s) of the chemical substances prior to any actual use or application of the substances on site. The MSDS's will then be maintained in a central location (i e temporary office) and will be available for anyone to review upon request. Subcontractors will be required to similarly satisfy these requirements

10.7 COMMUNICATION

As personnel may not always be working in close proximity to one another during field activities, a secondary means of communication may be necessary If this need arises 2-way radio communication may be used All means of communication will have the approval of the Shipyard prior to its use

External communication will be done so utilizing the telephones at predetermined and approved locations External communication will primarily be used for the purpose of resource and emergency resource communications Prior to the commencement of site activities the FTL and Shipyard contact will determine and arrange for telephone communications

11.0 STANDARD WORK PRACTICES

The following Standard Work Practices are to be applied in addition to the Health and Safety Standard Operating procedures:

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

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

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

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

- All personnel must satisfy all training requirements (40-hr Introductory, 8-hr Refresher, Site-specific training, Emergency response training, and Supervisory as applicable) prior to commencing site activities.

- All personnel must have a working knowledge of this HASP, including being aware of the action levels for upgrading/downgrading levels of protective equipment, and emergency procedures.

- All personnel must satisfy medical monitoring procedures.

- All personnel must complete a medical data sheet, to be maintained on site.

- All personnel working in sight restriction areas of heavy vegetation or where the topography does not permit line of sight contact must utilize the buddy system.

* When lifting or moving equipment or material, use proper lifting techniques, the proper number of personnel, or equipment to move heavy loads.

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

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

* Site personnel must immediately notify HALLIBURTON NUS Health Sciences of all incidents for OSHA recordkeeping purposes.

* If personnel note any warning properties of chemicals (irritation, odors, symptoms, etc.) or even remotely suspect the occurrence of exposure, they must immediately notify the SSO for further direction

* Site personnel are not to undertake any activity which would be considered a confined-space entry

* A full-sized copy of the OSHA poster included as part of this HASP shall be conspicuously posted on site

* Any new information must be promptly conveyed to the Project SSO and the Field Team Leader

* All compressed gas cylinders used (empty or full) must be stored, secured and used properly to protect from damage

DRILLING OPERATIONS

* No drilling or any other operation which will bring a drill mast or any other projecting device within 20 feet in any direction of overhead power lines will be permitted. Prior to any subsurface investigations the FTL shall ensure the locations of all underground utilities will be identified and marked prior to initiating any subsurface activity

* Hand signals with the driller will be established prior to the commencement of drilling activities.

* All drill rigs and other machinery with exposed moving parts must be equipped with an operational emergency stop device. All personnel working in a close proximity must be aware of the location of this emergency stop device and its operation. This device will be tested initially (and then periodically) to insure its operational status. The driller and the helper shall not simultaneously handle moving augers or flights unless there is a standby person to activate the emergency stop device.

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

* A long handled shovel or the equivalent shall be used to clear away drill cuttings from the hole and rotating equipment. Hands or feet shall **not** be used for this purpose.

* A remote sampling device must be used to sample drill cuttings near rotating tools. The driller shall shutdown operations if the sampler must near the tools to obtain samples.

* All personnel working in the vicinity of the drill rig while its operating shall secure all loose clothing

* Only manufacturer approved equipment may be used in conjunction with site equipment (i e pins for auger flights etc) Pins or other protruding items from rotating equipment shall not be permitted

* No person shall climb a drill mast while equipment is rotating

* No person shall climb a drill mast without use of ANSI approved fall protection (i e belts, lanyards and a fall protection slide rail) or portable ladders which meet OSHA's requirements

TEST PITTING AND EXCAVATION ACTIVITIES

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

* Entrance into an excavation is forbidden without strict observance to the requirements of this HASP, and to the specifications of OSHA standards. Whenever possible, operations are to be performed in a manner that does not require personnel entry (i.e. the use of remote samplers to collect samples, collect samples from the backhoe bucket, etc.).

* Fill material must be located near all excavations prior to the beginning of the job. This material is to be used in the event of any emergency situations in order to reduce potential emissions.

* Personnel must not lean over excavations.

* All Personnel must stand upwind of the excavations and away from the reach of the backhoe (or track hoe), tires, and outriggers.

* Personnel may not approach an excavation closer than 2 feet from the edge. Unstable excavations must be properly sloped at the sides to prevent cave-in.

* Open pits must staffed by site personnel at all times.

* The backhoe (or track hoe) operator must be instructed not to undermine the excavation

* The Site Safety Officer shall frequently inspect test pits for slide or cave-in potential

* Proper shoring materials and techniques must be used wherever appropriate

* All work areas must be kept free of ground clutter

HEAVY EQUIPMENT MAINTENANCE AND OPERATION

* Heavy equipment must be operated in accordance with 29 CFR 1926 Subpart O

* Heavy equipment will not be operated in a manner that could cause the equipment to roll over or slide into an excavation.

12.0 EMERGENCY RESPONSE

In the event of an emergency, all site personnel will be evacuated to a predetermined location away from the work place. As a result of this approach, this Emergency Response Plan has been developed in accordance with OSHA standard 29 CFR 1910.38(a), as provided for in 29 CFR 1910.120 (l) (1) (ii). Halliburton NUS shall utilize Base Fire Protection and Emergency Services and offsite emergency response agencies ,as necessary and appropriate, in order to respond to emergency situations.

12.1 PRE-PLANNING

Upon initial arrival at the base, the HALLIBURTON NUS FTL/SSO will meet with the Shipyard Fire Department and available emergency services to notify coordinators of the nature, location, and schedule of planned activities Representatives from these organizations, as well as representatives of the offsite emergency response organizations specified in Table 12-1 will be contacted as part of initial site mobilization efforts and invited to the initial Site-Specific Health and Safety training session referenced in section 8 2 of this Health and Safety Plan. This will enable all parties to understand the nature of the work to be performed the types of possible emergency response activities which could conceivably arise in the performance of those activities, and their potential role in participating in those response activities

Based on the nature of the planned activities the occurrence of any significant emergency situation is not anticipated (i e major spills or releases fires or explosions, etc) However, as a precautionary measure, all site personnel will be trained in the contents of these Health and Safety and Emergency Response Plans and will be directed to follow base emergency procedures Halliburton NUS will rely on base services and (if/as necessary) offsite emergency support services to handle emergency situations, if encountered

12.2 EMERGENCY ESCAPE PROCEDURES AND ASSIGNMENTS

Upon notification of a site emergency requiring evacuation, all site personnel will proceed to predetermined locations based on emergency location and wind directions If personnel cannot reach those locations without endangering life or health, they shall instead report to a previously-selected alternate meeting place Personnel shall be instructed to remain at this refuge location until directed to either resume work or leave the site

12.3 PROCEDURE TO ACCOUNT FOR SITE PERSONNEL

The site work force will be small enough so that accounting for personnel will easily accomplished Accounting for personnel will be the FTL's responsibility. This will be accomplished by taking a roll call using the site log book.

12.4 RESCUE AND MEDICAL DUTIES

Site personnel shall be prohibited from participating in any emergency rescue or response operations. The only authorized response for site personnel in the event of an emergency situation will be to evacuate the work site and await further instructions.

12.5 ACTIVATION OF EMERGENCY RESPONSE PROCEDURES

Should any emergency occur which requires the support of outside services, the appropriate contacts shall be made by the FTL/SSO. A list of the appropriate contacts can be found in Table 12-1.

Examples requiring outside services are as follows

- Any field crew member involved in an accident or experiencing signs and symptoms of exposure
- A condition discovered which suggests the activity is more hazardous than anticipated
- Emergency conditions in the nearby areas which directly impact operations

Persons who observe an emergency situation must notify Shipyard contacts and Halliburton NUS office contacts (as presented in this HASP), as appropriate based on the emergency situation

TABLE 12-1

EMERGENCY INFORMATION

Police (Shipyard)	(207) 438-2555 or Ext. 2555
Fire Department (Shipyard)	(207) 438-2333 or Ext. 2333
Ambulance (Shipyard)	(207) 438-2555 or Ext. 2555
Hospital: Shipyard Portsmouth	 (207) 438-2555 or Ext. 2555 (603) 433-4042
Poison Control Center: Maine New Hampshire	 1-800-442-6305 1-800-562-8236
Base Contact: Jim Tayon, Environmental Affairs	(207) 438-3832 or Ext. 3832
Halliburton NUS Project Manager Ms Linda Klink	(412) 921-8650
Halliburton NUS Site Safety Officer	To Be Announced
CLEAN Health and Safety Manager Matthew M Soltis, CSP	(412) 921-8912
Agency for Toxic Substances and Disease Registry (ATSDR)	(404) 639-6300

Maps depicting directions from the site to the hospitals shall be obtained and attached to this Health and Safety Plan prior to the commencement of site activities

Directions to the hospital

On Base To be obtained as part of initial site mobilization efforts

Off Base Portsmouth Regional Hospital

Exit the Shipyard through Gate No 1 At signal light, continue straight down Walker Street Proceed to second set of signal lights, and continue straight until road ends at Route 1 Bypass Enter underpass rotary on left side Go under Route 1 Bypass and loop onto Route 1 Bypass South. Cross

bridge and continue straight to traffic circle. At traffic circle, go around to the right 270 degrees, 3/4 circle from entrance to traffic circle. Exit right. Go straight through first set of lights. At second set of traffic lights, turn right onto Borthwick Ave. Ext. Follow Borthwick Ave. Ext. 1/2 to 1 mile. Portsmouth Regional Hospital will be on the right side.

12.6 INCIDENT FOLLOW-UP

On receiving a report of an incident (or near incident) occurrence the FTL/SSO shall immediately investigate and make the appropriate recommendations to prevent reoccurrence. The CLEAN HSM shall be immediately be notified by telephone on occurrence of an incident. At his discretion he may wish to participate in the investigation. Details of the incident shall be documented on an Incident Report within 24 hours of the occurrence and distributed to the Project Manager and CLEAN HSM.

13.0 SPILL CONTAINMENT PROGRAM

13.1 SCOPE AND APPLICATION

It is not anticipated that bulk hazardous materials (over 55-gallons) will be handled at any given time as part of this scope of work. It is also not anticipated that such spillage would constitute a danger to human health or the environment. However, as the job progresses, the potential for accumulating decontamination fluids in a central staging area exists. Once characterized, these fluids can be removed from this area for proper disposal. While these fluids are stored in the staging area await characterization, this spill containment program will be instituted.

13.2 POTENTIAL SPILL AREAS

In an ongoing attempt to prevent and control further potential contamination of the environment, efforts will be taken to minimize the potential for spill releases. Based on planned activities and available information there are limited areas and/or operations where this potential threat can be reasonably expected One of these is the area intended to be used for the central staging area for potentially contaminated soils and decontamination fluids Additionally, the handling, loading and unloading areas present limited potential for leaks or spills At the time of the preparation of this Health and Safety Plan, it is anticipated all investigation derived wastes (such as decontamination fluids) generated, as a result of this scope of work will be containerized, labeled, and staged to await determination of proper disposal procedures Until the ultimate fate of these substances can be determined there exists a possibility to accumulate multiple drums of waste materials

13.2.1 <u>55-Gallon Drums</u>

All drums containing liquids will be staged within a constructed (temporary) lined bermed area capable of holding a maximum of 10 drums The capacity of the bermed area should be capable of containing the contents of the largest container placed within it (plus volumes reduced caused by the displacement of the containers or approximately 110% of the total capacity of the largest container) Rainwater captured inside the lined area will be allowed to evaporate providing it does not exceed 1% of the bermed areas'

capacity. If this capacity is exceeded, the collected rainwater will be removed (provided that close inspection of the bermed area and all containers located within it do not indicate any possibility that captured rainwater may be contaminated).

13.3 LEAK AND SPILL DETECTION

To establish an early detection of potential spills or leaks, a daily walk around by the personnel staging or disposing of drums will be conducted during working hours to visually determine that containers are not leaking, and that the bermed staging area is not compromised. If a leak is detected, the drum contents will be transferred using a hand pump into a new 55-gallon drum. The leak will be collected and contained using absorbents such as Oil-dry, vermiculite, or sand, stored at the staging area in a drum conspicuously marked This material will then also be handled as discussed for other investigation derived wastes. All inspections will be documented in the Project logbook.

13.4 PERSONNEL TRAINING AND SPILL PREVENTION

As specified in Section 12.0 of this Health and Safety Plan, Halliburton NUS personnel will not be authorized to participate in any emergency response or emergency rescue activities This prohibition includes spill response activities However, all personnel will be instructed on appropriate spill prevention procedures as part of the site-specific health and safety training This will include training on the following

- using only appropriate (and approved as applicable) drums or other vessels to contain substances used stored or generated as a result of site activities

- inspecting such containers frequently for signs of damage or leaks

- inspecting the integrity of the berms of drum storage areas for damage, and immediately notifying the FTL or the SSO of any evidence that the berms have been (or appear to be imminently) compromised

- placing any such containers in appropriate, designated locations, where they will be protected from hazards such as those presented by vehicular traffic

The FTL and the SSO will serve as the Spill Response Coordinators, should the need arise. This will principally involve only overseeing the evacuation of all site personnel, contacting the necessary personnel as presented in the attached Emergency Response Plan, and relinquishing command and supporting base or off-site responders upon their arrival.

13.5 SPILL PREVENTION AND CONTAINMENT EQUIPMENT

The following represents the minimum equipment which will be maintained at the staging area at all times for the purpose of supporting this Spill Prevention/Containment Program.

- Sand, clean fill, vermiculite, or other noncombustible absorbent (oil-dry);
- Drums (55-gallon U.S. DOT 17-E or 17-H)
- Shovels, rakes, and brooms
- Hand operated drum pump with hose
- Container Labels

This equipment is only to be used by Halliburton NUS personnel for non-emergency, incidental spill response efforts and will be made available to base or off site emergency responders, as necessary

13.6 SPILL CONTROL PLAN

This section describes the procedures the Halliburton NUS field crew members will employ upon the detection of a spill or leak

1) Notify the SSO or FTL immediately upon the detection of a leak or spill

2) Follow the direction of the SSO and the FTL Retreat to the designated refuge location, if so directed and await further instruction

It is not anticipated that a spill will occur in which the field crews cannot handle Should this occur notification of the Base Hazardous material teams will be carried out by the FTL or SSO

14.0 DOCUMENTATION AND EQUIPMENT

This section summarizes documentation and equipment required for the support of this Health and Safety Plan (HASP). Its purpose is a final checklist to help ensure all of the necessary resources are available to carry out the requirements of this HASP.

14.1 Documentation

The use of any level of respiratory protection must be documented by the SSO For the tasks performed in Level C protection, this is to include the completion of all entries in Figure 6-1 ("Air Purifying Respirator Use Log"). In the event that Level B protection is used, the SSO is to document its use using the form provided as Figure 6-2 ("SCBA Log"). In both instances, appropriate entries on these documents are to be made for each instance of use, on at least a daily basis. All entries must be completed, and the site manager (in this instance, the FTL) must sign and date these forms and submit them to the Health Sciences Department upon the completion of this project

Other health and safety documentation requirements relative to this project are defined as follows

- Health and Safety Log Book
- HASP (Signed Copy)
- OSHA Poster 11 x 14 (posted on site)
- MSDS s (as applicable)
- Medical Data Sheets
- Employee Training Certificates
- Medical Surveillance Documentation
- Incident Reports
- Fit Test Records
- Instrument Calibration Logs
- Instrument Response Data Logs

14.2 Health and Safety Equipment

- ANSI approved eye wash

- Self-contained breathing apparatus (SCBA) units
- Spare SCBA cylinders
- Full face air purifying respirators (APRs): MSA Ultra Twin
- APR cartridges: MSA Mersorb type H, and MSA GMC type H
- Respirator Cleaner/Sanitizer solution
- Nitrile gloves (inner and outer)
- Tyvek®, Saranex®, PVC/PE coated coveralls
- Barricade tape, cones, etc.
- Boot covers
- Duct tape
- Decontamination kit (Alconox, wash/rinse tubs, brushes, sorbents, step stool)
- Hard hats, safety glasses
- Splash shield
- Steel toe/shank boots
- Hearing protection
- Personal flotation devices (life vests)
- Hip and/or chest waders
- Rope for lifeline tie-offs
- Barricade tape cones signs etc

ATTACHMENT I

HEAT/COLD STRESS

ATTACHMENT I
HEAT/COLD STRESS

Heat Stress

The SSO shall visually monitor personnel to note for signs of heat stress. Field personnel will also be instructed to observe for symptoms of heat stress and methods on how to control it. One or more of the following control measures can be used to help control heat stress:

- Provide adequate liquids to replace lost body fluids. Personnel must replace water and salt lost from sweating. Personnel must be encouraged to drink more than the amount required to satisfy thirst. Thirst satisfaction is not an accurate indicator of adequate salt and fluid replacement.

- Replacement fluids can be commercial mixes such as Gatorade®.

- Establish a work regime that will provide adequate rest periods for cooling down. This may require additional shifts of workers

- Cooling devices such as vortex tubes or cooling vests can be worn beneath protective garments

- Breaks are to be taken in a cool rest area (77°F is best)

- Personnel shall remove impermeable protective garments during rest periods

- Personnel shall not be assigned other tasks during rest periods

- Personnel shall be informed of the importance of adequate rest, acclimation, and proper diet in the prevention of heat stress

The heat stress of personnel on-site may be monitored utilizing biological monitoring or the Wet Bulb Globe Temperature Index (WBGT) technique when workers are not wearing protective coveralls (i.e. Tyvek®). This method will require the use of a heat stress monitoring device. The reason for this distinction is in recognition of the recommendations of the American Conference of Governmental Industrial

Hygienists, as published in the most-recent edition of the Threshold Limit Values for Chemical Substances and Physical Agents and Biological Exposure Indices booklet. That source recognizes that special clothing (such as Tyvek®) that impedes the sweat evaporation process reduces worker's heat tolerance capabilities. While the WBGT methodology in that referenced text include correction factors for certain types of clothing, it does not include addressing impermeable coveralls of this nature. Therefore, the use of a heat stress monitoring device (worn beneath the coveralls) would be a more appropriate and accurate heat stress monitoring approach that the WBGT index procedure.

One of the following biological monitoring procedures shall be followed when the workplace temperature is 70°F or above

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

PERMISSIBLE HEAT EXPOSURE THRESHOLD LIMIT VALUES

Work-Rest Regimen	Work Load		
	Light	Moderate	Heavy
Continuous	86 0°F	80 0°F	77 0°F
75% Work - 25% Rest Each Hour	87 0°F	82 4°F	78 6°F
50% Work - 50% Rest Each Hour	88 5°F	85 0°F	82 2°F
25% Work - 75% Rest Each Hour	90 0°F	88 0°F	86 0°F

- Body temperature shall be measured orally with a clinical thermometer as early as possible in the resting period Oral temperature at the beginning of the rest period should not exceed 99°F If it does, the next work period should be shortened by 10 minutes (or 33 percent), while the length of the rest period stays the same. However, if the oral temperature exceeds 99 7°F at the beginning of the next rest period, the following work

cycle shall be further shortened by 33 percent. OT should be measured at the end of the rest period to make sure that it has dropped below 99°F. At no time shall work begin with the oral temperature above 99°F.

NOTE: External temperatures in excess of those stated above shall be regarded as inclement weather. Work continuation, termination, or alteration of the work schedule will be at the discretion of the FTL and on site health and safety representative. The heat and cold stress related sections of this are applicable to the season when work will be completed.

Cold Stress

The cold stress TLVs are intended to protect workers from the severest effects of cold stress (hypothermia) and cold injury and to describe exposures to cold working conditions under which it is believed that nearly all workers can be repeatedly exposed without adverse health effects. The TLV objective is to prevent the deep body temperature from falling below 36°C (96.8°F) and to prevent cold injury to body extremities (deep body temperature is the core temperature of the body determined by conventional methods for rectal temperature measurements). For a single, occasional exposure to a cold environment a drop in core temperature to no lower that 35°C (95°F) should be permitted. In addition to provisions for total body protection, the TLV objective is to protect all parts of the body with emphasis on hands, feet, and head from cold injury.

Introduction

Fatal exposures to cold among workers have almost always resulted from accidental exposures involving failure to escape from low environmental air temperatures or from immersion in low temperature water. The single most important aspect of life-threatening hypothermia is the fall in the deep core temperature of the body. The clinical presentations of victims of hypothermia are shown in Table 1. Workers should be protected from exposure to cold so that the deep core temperature does not fall below 36°C (96.8°F), lower body temperatures will very likely result in reduced mental alertness, reduction in rational decision making, or loss of consciousness with the threat of fatal consequences.

Pain in the extremities may be the first early warning of danger to cold stress. During exposure to cold, maximum severe shivering depends when the body temperature has fallen to 35°C (95°F). This must be taken as a sign of danger to the workers and exposure to cold should be immediately terminated for any

workers when severe shivering becomes evident. Useful physical or mental work is limited when severe shivering occurs.

Since prolonged exposure to cold air, or to immersion in cold water, at temperatures well above freezing can lead to dangerous hypothermia, whole body protection must be provided.

1. Adequate insulating dry clothing to maintain core temperatures above 36°C (96.8°F) must be provided to workers if work is performed in air temperatures below 4°C (40°F). Wind chill cooling rate and the cooling power of air are critical factors. [Wind chill cooling rate is defined as heat loss from a body expressed in watts per meter squared which is a function of the air temperature and wind velocity upon the exposed body.] The higher the wind speed and the lower the temperature in the work area, the greater the insulation value of the protective clothing required. An equivalent chill temperature chart relating the actual dry bulb air temperature and the wind velocity is presented in Table 2. The equivalent chill temperature should be used when estimating the combined cooling effect of wind and low air temperatures on exposed skin or when determining clothing insulation requirements to maintain the deep body core temperature

2 Unless there are unusual or extenuating circumstances (i e working on or near the bodies of water associated with this site, where splash or immersion potentials may exist), cold injury to other than hands feet and head is not likely to occur Older workers or workers with circulatory problems require special precautionary protection against cold injury The use of extra insulating clothing and/or a reduction in the duration of the exposure period are among the special precautions which should be considered The precautionary actions to be taken will depend upon the physical condition of the worker and should be determined with the advice of a physician with knowledge of the cold stress factors and the individual s medical condition and history However as cold stress situations may exist the information provided in this section will be utilized to minimize this potential threat to the worker

TABLE 1
PROGRESSIVE CLINICAL PRESENTATIONS OF HYPOTHERMIA*

Core Temperature		Clinical Signs
°C	°F	
37.6	99.6	"Normal" rectal temperature
37	98.6	"Normal" oral temperature
36	96.8	Metabolic rate increases in an attempt to compensate for heat loss
35	95.0	Maximum shivering
34	93.2	Victim conscious and responsive, with normal blood pressure
33	91.4	Severe hypothermia below this temperature
32	86.0	Consciousness clouded; blood pressure becomes difficult to obtain, pupils dilated but react to light; shivering ceases
31	87.8	
30	86.0	Progressive loss of consciousness, muscular rigidity increases, pulse and blood pressure difficult to obtain, respiratory rate decreases
29	84.2	
28	82.4	Ventricular fibrillation possible with myocardial irritability
27	80.6	Voluntary motion ceases, pupils nonreactive to light, deep tendon and superficial reflexes absent
26	78.8	Victim seldom conscious
25	77.0	Ventricular fibrillation may occur spontaneously
24	75.2	Pulmonary edema
22	71.6	Maximum risk of ventricular fibrillation
21	69.8	
20	68.0	Cardiac standstill
18	64.4	Lowest accidental hypothermia victim to recover
17	62.6	Isoelectric electroencephalogram
9	48.2	Lowest artificially cooled hypothermia patient to recover

* Presentations approximately related to core temperature. Reprinted from the January 1982 issue of American Family Physician, published by the American Academy of Family Physicians.

Evaluation and Control

For exposed skin, continuous exposure should not be permitted when the air speed and temperature results in an equivalent chill temperature of -32°C(-25.6°F). Superficial or deep local tissue freezing will occur only at temperatures below -1°C (30.2°F) regardless of wind speed.

At air temperatures of 2°C (35.6°F) or less, it is imperative that workers who become immersed in water or whose clothing becomes wet be immediately provided a change of clothing and be treated for hypothermia.

TLVs recommended for properly clothed workers for periods of work at temperatures below freezing are shown in Table 3.

Special protection of the hands is required to maintain manual dexterity for the prevention of accidents:

1 If fine work is to be performed with bare hands for more than 10-20 minutes in an environment below 16°C (60 8°F), special provisions should be established for keeping the workers' hands warm For this purpose, warm air jets radiant heaters (fuel burner or electric radiator), or contact warm plates may be utilized Metal handles of tools and control bars should be covered by thermal insulating material at temperatures below -1°C (30 2°F)

2 If the air temperature falls below 16°C (60 8°F) for sedentary, 4°C (39 2°F) for light -7°C (19 4°F) for moderate work and fine manual dexterity is not required, then gloves should be used by the workers

To prevent contact frostbite the workers should wear anti-contact gloves

1 When cold surfaces below -7°C (19 4°F) are within reach, a warning should be given to each worker by the supervisor to prevent inadvertent contact by bare skin

2 If the air temperature is -17 5°C (0°F) or less, the hands should be protected by mittens Machine controls and tools for use in cold conditions should be designed so that they can be handled without removing the mittens

Provisions for additional total body protection are required if work is performed in an environment at or below 4°C (39.2°F). The workers should wear cold protective clothing appropriate for the level of cold and physical activity:

1. If the air velocity at the job site is increased by wind, draft, or artificial ventilating equipment, the cooling effect of the wind should be reduced by shielding the work area or by wearing an easily removable windbreak garment.

TABLE 2
COOLING POWER OF WIND ON EXPOSED FLESH EXPRESSED AS EQUIVALENT TEMPERATURE
(under calm conditions)*

Estimated Wind Speed (in mph)	Actual Temperature Reading (°F)											
	50	40	30	20	10	0	-10	-20	-30	-40	-50	-60
	Equivalent Temperature (°F)											
Calm	50	40	30	20	10	0	-10	-20	-30	-40	-50	-60
5	48	37	27	16	6	-5	-15	-26	-36	-47	-57	-68
10	40	28	16	4	-9	-24	-33	-46	-58	-70	-83	-95
15	36	22	9	5	18	-32	-45	-58	-72	-85	-99	-112
20	32	18	4	10	-25	-39	-53	-67	-82	-96	-110	-121
25	30	16	0	-15	-29	-44	-59	-74	-88	-104	-118	-133
30	28	13	-2	-18	-33	-48	-63	-79	-94	-109	-125	-140
35	27	11	-4	-20	-35	-51	-67	-82	-98	-113	-129	-145
40	26	10	6	-21	-37	-53	-69	-85	-100	-116	-132	-148

(Wind speeds greater than 40 mph have little additional effect)	LITTLE DANGER In < hr with dry skin. Maximum danger of false sense of security	INCREASING DANGER Danger from freezing of exposed flesh within one minute.	GREAT DANGER Flesh may freeze within 30 seconds.
	Trenchfoot and immersion foot may occur at any point on this chart.		

* Developed by U.S. Army Research Institute of Environmental Medicine, Natick MA.

TABLE 3
THRESHOLD LIMIT VALUES WORK/WARM-UP SCHEDULE FOR FOUR-HOUR SHIFT*

Air Temperature Sunny Sky		No Noticeable Wind		5 mph Wind		10 mph Wind		15 mph Wind		20 mph Wind	
°C (approx)	°F (approx)	Max Work Period	No. of Breaks	Max Work Period	No. of Breaks	Max Work Period	No. of Breaks	Max. Work Period	No. of Breaks	Max. Work Period	No. of Breaks
-26° to -28°	-15 to -19	(Norm Breaks)	1	(Norm Breaks)	1	75 min	2	55 min	3	40 min	4
-29° to -31°	-20° to -24	(Norm Breaks	1	75 min	2	55 min	3	40 min	4	30 min	5
-32° to -34°	-25° to -29	75 min	2	55 min	3	40 min	4	30 min	5	Non-emergency work should cease	
-35° to -37°	-30° to -34	55 min	3	40 min	2	30 min	5	Non-emergency work should cease		Non-emergency work should cease	
-38° to -39°	-35 to -39	40 min	4	30 min	1	Non-emergency work should cease		Non-emergency work should cease		Non-emergency work should cease	
-40° to -42°	-40 to 44	30 min	5	Non emergency work should cease		Non-emergency work should cease		Non-emergency work should cease		Non-emergency work should cease	
-43° & below	-45 & below	Non emergency work should cease		Non emergency work should cease		Non-emergency work should cease		Non-emergency work should cease		Non-emergency work should cease	

NOTES:

1 Schedule applies to moderate to heavy work activity with warm-up breaks of ten (10) minutes in a warm location. For Light-to-Moderate Work (limited physical movement): apply the schedule one step lower. For example at -35°C (-30°F) with no noticeable wind (Step 4), a worker at a job with little physical movement should have a maximum work period of 40 minutes with 4 breaks in a 4-hour period (Step 5)

2 The following is suggested as a guide for estimating wind velocity if accurate information is not available: 5 mph: light flag moves; 10 mph: light flag fully extended; 15 mph: raises newspaper sheet. 20 mph: blowing and drifting snow

3 If only the wind chill cooling rate is available, a rough rule of thumb for applying it rather than the temperature and wind velocity factors given above would be: 1) special warm-up breaks should be initiated at a wind chill cooling rate of about 1750 W/M^2, 2) all non-emergency work should have ceased at or before a wind chill of 2250 W/m^2. In general, the warm-up schedule provided above slightly under-compensates for the wind at the warmer temperatures, assuming acclimatization and clothing appropriate for winter work. On the other hand, the chart slightly over-compensates for the actual temperatures in the colder ranges, since windy conditions rarely prevail at extremely low temperatures

4 TLVs apply only for workers in dry clothing

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* Adapted from Occupational Health & Safety Division, Saskatchewan Department of Labor

2. If only light work is involved and if the clothing on the worker may become wet on the job site, the outer layer of the clothing in use may be of a type impermeable to water. With more severe work under such conditions, the outer layer should be water repellent, and the outerwear should be changed as it becomes wetted. The outer garments should include provisions for easy ventilation in order to prevent wetting of inner layers of sweat. If work is done at normal temperatures or in a hot environment before entering the cold area, the employee should make sure that clothing is not wet as a consequence of sweating. If clothing is wet, the employee should change into dry clothes before entering the cold area. The workers should change socks and any removable felt insoles at regular daily intervals or use vapor barrier boots. The optimal frequency of change should be determined empirically and will vary individually and according to the type of shoe worn and how much the individual's feet sweat.

3. If exposed areas of the body cannot be protected sufficiently to prevent sensation of excessive cold or frostbite, protective items should be supplied in auxiliary heated versions.

4. If the available clothing does not give adequate protection to prevent hypothermia or frostbite, work should be modified or suspended until adequate clothing is made available or until weather conditions improve

5. Workers handling evaporative liquid (gasoline, alcohol or cleaning fluids) at air temperatures below 4°C (39.2°F) should take special precautions to avoid soaking of clothing or gloves with the liquids because of the added danger of cold injury due to evaporative cooling. Special note should be taken of the particularly acute effects of splashes of "cryogenic fluids" or those liquids with a boiling point that is just above ambient temperature

Work - Warming Regimen

If work is performed continuously in the cold at an equivalent chill temperature (ECT) or below -7°C (19.4°F), heated warming shelters (tents, cabins, rest rooms, etc.) should be made available nearby. The workers should be encouraged to use these shelters at regular intervals, the frequency depending on the severity of the environmental exposure. The onset of heavy shivering, frostnip, the feeling of excessive fatigue, drowsiness, irritability, or euphoria are indications for immediate return to the shelter. When entering the heated shelter, the outer layer of clothing should be removed and the remainder of the clothing loosened to permit sweat evaporation or a change of dry work clothing provided. A change of dry

work clothing should be provided as necessary to prevent workers from returning to work with wet clothing. Dehydration, or the loss of body fluids, occurs insidiously in the cold environment and may increase the susceptibility of the worker to cold injury due to a significant change in blood flow to the extremities. Warm sweet drinks and soups should be provided at the work site to provide caloric intake and fluid volume. The intake of coffee should be limited because of the diuretic and circulatory effects.

For work practices at or below -12°C (10.4°F) ECT, the following should apply:

1. The worker should be under constant protective observation (buddy system or supervision).

2. The work rate should not be so high as to cause heavy sweating that will result in wet clothing; if heavy work must be done, rest periods should be taken in heated shelters and opportunity for changing into dry clothing should be provided.

3. New employees should not be required to work full time in the cold during the first days of employment until they become accustomed to the working conditions and required protective clothing

4. The weight and bulkiness of clothing should be included in estimating the required work performance and weights to be lifted by the worker

5. The work should be arranged in such a way that sitting still or standing still for long periods is minimized. Unprotected metal chair seats should not be used. The worker should be protected from drafts to the greatest extent possible

6. The workers should be instructed in safety and health procedures. The training program should include as a minimum instruction in

   a. Proper rewarming procedures and appropriate first aid treatment
   b. Proper clothing practices
   c. Proper eating and drinking habits
   d. Recognition of impending frostbite
   e. Recognition of signs and symptoms of impending hypothermia or excessive cooling of the body even when shivering does not occur.
   f. Safe work practices

Special Workplace Recommendations

Special wind protective clothing should be provided based upon air velocities to which workers may be exposed.

Special caution should be exercised when working with toxic substances and when workers are exposed to vibration. Cold exposure may require reduced exposure limits.

Eye protection for workers employed out-of-doors in a snow and/or ice-covered terrain should be supplied. Special safety goggles to protect against ultraviolet light and glare (which can produce temporary conjunctivitis and/or temperature loss of vision) and blowing ice crystals should be required when there is an expanse of snow coverage causing a potential eye exposure hazard.

Workplace monitoring is required as follows.

1 Suitable thermometry should be arranged at any workplace where the environmental temperature is below 16°C (60.8°F) so that overall compliance with the requirements of the TLV can be maintained

2 Whenever the air temperature at a workplace falls below -1°C (30.2°F), the dry bulb temperature should be measured and recorded at least every 4 hours

3 In indoor workplaces the wind speed should also be recorded at least every 4 hours whenever the rate of air movement exceeds 2 meters per second (5 mph)

4 In outdoor work situations, the wind speed should be measured and recorded together with the air temperature whenever the air temperature is below -1°C (30.2°F)

5 The equivalent chill temperature should be obtained from Table 2 in all cases where air movement measurements are required it should be recorded with the other data whenever the equivalent chill temperature is below -7°C (19.4°F)

Employees should be excluded from work in cold at -1°C (30.2°F) or below if they are suffering from diseases or taking medication which interferes with normal body temperature regulation or reduces tolerance to work in cold environments Workers who are routinely exposed to temperatures below -24°C

(-11.2°F) with wind speeds less than five miles per hour, or air temperatures below -18°C (0°F) with wind speeds above five miles per hour, should be medically certified as suitable for such exposures.

Trauma sustained in freezing or subzero conditions requires special attention because an injured worker is predisposed to cold injury. Special provisions should be made to prevent hypothermia and freezing of damaged tissues in addition to providing for first aid treatment.

Note This information has been adopted from the **1992-1993 "Threshold Limit Values** for Chemical Substances and Physical Agents and **Biological Indices"** by the American Conference of Governmental Industrial Hygienists (ACGIH).

ATTACHMENT II
TICK CONTROL
AND
LYME DISEASE

TICK CONTROL
AND
LYME DISEASE

The occurrence of Lyme disease has become a worldwide problem since its identification in 1976. This disease is characteristically recognized as being transmitted by ticks, which may be encountered by field personnel while working at this site. As a result, this discussion has been included with this Health and Safety Plan to provide for adequate recognition, evaluation, and control efforts to minimize the occurrence and effects of this potential hazard.

The discovery of Lyme disease is credited to Dr. Allen Steere of Yale University Medical School, and is named after the community where it was (reportedly) first encountered, Lyme, Connecticut. This disease can be transmitted to man through the bite of ticks that are infected with a cork screw-shaped microbe (spirochete). The spread of this disease has been so rapid that in 1984 it surpassed Rocky Mountain Spotted fever as the most common tick-borne disease in the United States. In this country, most of the incidents of this disease have been recorded in the Northeast, and the tick species most commonly attributed with its spread is the deer tick.

Recognition

This hazard potential exists primarily in the spring and summer months, as these are the seasons that tick populations and activity flourish. In fact, 90 percent of the reported cases have occurred from early June through September. Also, this concern exists primarily in heavily vegetated areas. Therefore, recognition of these factors can aid in the awareness and control of this threat.

To aid in the recognition and identification of these insects, an example illustration of the tick species common to the region where this site is located has been included with this discussion. This species (the American Dog tick) is common in the eastern half of the United States, and typically exists in areas covered with grass or underbrush. These insects will attach themselves to animals (including man) that pass through the area and rub against them. After finding a host, the tick inserts its mouthparts and sucks blood until it is fully engorged. This requires a time period of three to twelve days, then the tick will drop off. In addition to Lyme disease concerns, this tick has also been identified as a transmitter of Rocky Mountain Spotted Fever, and the organisms of tularemia and possibly relapsing fever. The wounds left by tick bites can be painful, and can also have a paralyzing effect commonly referred to as tick paralysis.

The earliest symptom of the onset of this disease is the occurrence of an unusual red skin rash. This is commonly the first indication since it has been evidenced that many persons who have contracted this disease were, in fact, unaware that they had been bitten. This rash can appear at the site of the bite anywhere from several days to a few weeks after the bite. It typically starts as a small red spot, and then expands as the spirochetes expand from the bite location. Rash sizes can vary, but have been most commonly associated in a 2 to 3 inch diameter size range. This rash will fade (with or without treatment) after a few weeks. Close inspection is necessary to detect this symptom as the rashes are easy to miss because they're often very faint. Body sites where rashes frequently occur include the thigh areas, groin, and armpits. Also, it is not uncommon for a rash to develop in more than one place.

Other early symptoms include profound fatigue, a stiff neck, and flu-like symptoms such as headache, chills, fever, and muscle aches. Recognition of the onset of any of these symptoms is important since tick bites do not always produce a rash. If left untreated, the disease will progress to its second stage within weeks or months after the infection. This stage involves affects to the heart and nervous system. A common second stage symptom is a paralysis on one or both sides of the face. Others include severe headache, encephalitis, or meningitis. The third and final stage involves the development of chronic inflammatory arthritis, which can occur up to a year or more after the bite.

Evaluation

Evaluation of this hazard potential principally involves field personnel performing close self-inspections for the presence of ticks each time they leave the site. This should involve careful examination, especially of the individual's heads. Personnel should be aware that when a tick attaches itself to its host, it inserts its entire head under the surface of the skin.

Control

Control of this threat involves several components. First, field personnel must be aware of the climate and area conditions which are commonly associated with being conducive to tick infestation. Second, when working in or walking through potential infested areas, personnel must ensure that they do not have exposed body parts (i.e. at least long sleeved shirts and long pants, particularly when protective coveralls are not worn). In heavily vegetated areas where infestation is likely, Tyvek coveralls will be required to minimize this hazard potential. Also, several commercial products have been demonstrated as being effective in repelling ticks. Examples include Permanone, Off!, and Cutter. These types of repellents will be used at the direction and discretion of the Brown & Root Environmental Health and Safety Officer, and

only in accordance and observation of manufacturer's recommendations. In most instances, however, such repellents are typically applied to the outside surfaces of clothing (and not directly onto the skin), and should be applied also to shoe tops, socks, pants cuffs, and other areas most susceptible to ticks.

Tick Removal

In the event that a tick is discovered to be attached to a member of the field team, timely removal of the insect is critical to reducing the potential for contracting the disease. According to available information and research, there is apparently a grace period of at least a few hours from the time of the bite before the tick transmits the microbe (the spirochetes are not present in the mouth parts of the tick). However, the incident of a tick bite is frequently unnoticed, and the discovery of the tick may not occur until after this suspected grace period has already elapsed. Therefore, timely removal is very important. The preferred method of tick removal is to pull it out using tweezers or small forceps. In this method, the tick should be grasped as close to the mouth as possible, and then pulled steadily upward. Care must be exercised so as not to pull in a jerking motion as this can result in the head becoming detached. After the tick has been removed, disinfect the bite with rubbing alcohol or povidone iodine (Betadine). The tick must not be handled as the microbes can enter the body through any breaks in intact skin. The bite should be checked occasionally for at least a two-week period to see if a rash forms. If it does, medical attention must be promptly sought

In order to provide for proper and timely response to the occurrence of a tick bite, the Health and Safety Officer will ensure that the site First Aid kit is properly equipped with medical forceps and rubbing alcohol, in addition to the standard kit contents. Also, an adequate supply of commercial insect (tick) repellents will be maintained onsite and all personnel will be trained in its proper application and will be required to use it at the direction of the Health and Safety Officer

ATTACHMENT III
AIR DISPERSION
MODELING ANALYSIS
FOR CHLORINE GAS RELEASE

PORTSMOUTH NAVAL SHIPYARD
DATA GAP PROJECT AIR DISPERSION MODELING ANALYSIS
FOR A CHLORINE GAS RELEASE

An air dispersion modeling analysis was conducted to simulate the release of chlorine gas during drilling operations at the Portsmouth Shipyard. The analysis assumed that the chlorine gas was released during drilling operations in which a buried cylinder of chlorine gas is punctured by the drilling apparatus. To evaluate this threat from a worst-case scenario, the gas in the cylinder was assumed to be laboratory grade, 99.99% pure chlorine (Cl_2) gas. Therefore, the chlorine gas concentration was assumed to be 1,000,000 ppm. The volume of gas in the cylinder was assumed to be 311 ft^3, and the release was assumed to occur over a period of 1 minute. The plume was assumed to be at ambient temperature and have either a 2.5 or 5.0 meter per second release velocity, based on the dimensions of the bore hole and the expected volume of gas released.

As this model assumed that the release would occur over a relatively short time period, a puff dispersion model was used to calculate 1-minute average concentrations. The INPUFF instantaneous release dispersion model was used to simulate the 1-minute release and calculate 1-minute average concentrations. Recognizing that the ACGIH has established a 15-minute short-term exposure limit (STEL) of 2,900 $\mu g/m^3$ for chlorine, this value was used as the action level to determine how large of an area would need to be controlled to prevent unprotected personnel from being overexposed to chlorine concentrations. Therefore, the 1-minute modeling concentrations were used to calculate 15-minute averages. Model calculations were made for a group of receptors located immediately downwind of the release point (again, this approach was selected to allow for worst-case scenario considerations).

The results of the modeling study indicated that the worst case conditions occurred during stable atmospheric conditions and a 1.0 meter per second wind speed. Ambient ground level concentrations of chlorine gas were calculated to potentially exceed the 15-minute STEL at distances ranging from about 50 meters to 140 meters downwind of the release.

Therefore, adding a moderate safety factor, it has been determined that if the drilling location at the Waste Oil Tank location (SWMU #11) within the Jamaica Island Landfill (and, potentially, the deep bedrock monitoring well proposed location at this landfill) cannot be selected to eliminate this potential hazard, a 150 meter radius working area around the drilling location will need to be marked and controlled, so that no unprotected or unnecessary personnel are endangered.

ATTACHMENT IV
OSHA POSTER

JOB SAFETY & HEALTH PROTECTION

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

Employers

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

Employees

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

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

Inspection

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

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

Complaint

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

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

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

Citation

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

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

Proposed Penalty

The Act provides for mandatory penalties against employers of up to $1,000 for each serious violation and for optional penalties of up to $1,000 for each nonserious violation. Penalties of up to $1,000 per day may be proposed for failure to correct violations within the proposed time period. Also, any employer who willfully or repeatedly violates the Act may be assessed penalties of up to $10,000 for each such violation.

Criminal penalties are also provided for in the Act. Any willful violation resulting in death of an employee, upon conviction, is punishable by a fine of not more than $10,000, or by imprisonment for not more than six months, or by both. Conviction of an employer after a first conviction doubles these maximum penalties.

Voluntary Activity

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

Such voluntary action should initially focus on the identification and elimination of hazards that could cause death, injury, or illness to employees and supervisors. There are many public and private organizations that can provide information and assistance in this effort, if requested. Also, your local OSHA office can provide considerable help and advice on solving safety and health problems or can refer you to other sources for help such as training.

Consultation

Free consultative assistance, without citation or penalty, is available to employers, on request, through OSHA supported programs in most State departments of labor or health.

More Information

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

Atlanta, Georgia
Boston, Massachusetts
Chicago, Illinois
Dallas, Texas
Denver, Colorado
Kansas City, Missouri
New York, New York
Philadelphia, Pennsylvania
San Francisco, California
Seattle, Washington

Telephone numbers for these offices, and additional area office locations, are listed in the telephone directory under the United States Department of Labor in the United States Government listing.

Washington, D.C.
1988 (Revised)
OSHA 2203

Ann McLaughlin, Secretary of Labor

U.S. Department of Labor

Occupational Safety and Health Administration

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

GPO : 1988 O - 219-467

APPENDIX D

FIELD INVESTIGATION FORMS

HALLIBURTON NUS
Environmental Corporation

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

BORING LOG **HALLIBURTON NUS**

PROJECT: _____ BORING NO.: _____

PROJECT NO.: _____ DATE: _____ DRILLER: _____

ELEVATION: _____ FIELD GEOLOGIST: _____

WATER LEVEL DATA : _____

(Date, Time & Conditions) _____

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

REMARKS _____

BORING _____

PAGE ____ OF ____

* See Legend on Back

HYDRAULIC CONDUCTIVITY TESTING DATA SHEET — HALLIBURTON NUS CORPORATION

PROJECT NAME: ..... WELL/BORING NO.: .....

PROJECT NO.: ..... GEOLOGIST: .....

WELL DIAMETER: ..... SCREEN LENGTH/DEPTH: ..... TEST NO.: .....

STATIC WATER LEVEL (Depth/Elevation): ..... DATE: .....

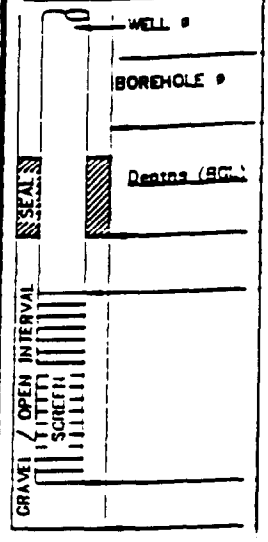
TEST TYPE (Rising/Falling/Constant Head): ..... CHECKED: .....

METHOD OF INDUCING WATER LEVEL CHANGE: ..... PAGE ..... OF .....

REFERENCE PT. FOR WL MEAS. (Top of Casing, Transducer, etc.): .....

ELAPSED TIME (min. or sec.)	MEASURED WATER LEVEL (feet)	DRAWDOWN OR HEAD (ΔH) (feet)	ELAPSED TIME (min. or sec.)	MEASURED WATER LEVEL (feet)	DRAWDOWN OR HEAD (ΔH) (feet)

WELL SCHEMATIC



Indicate SWL Depth on Drawing

REMARKS:

CALCS, SKETCH MAPS, ETC.:

GROUNDWATER LEVEL MEASUREMENT SHEET

HALLIBURTON NUS

Project Name: _____ Location: _____
Project No.: _____ Weather Conditions: _____
Personnel: _____ Measuring Device: _____
Date: _____ Remarks: _____
Tidally Influenced: Yes _____ No _____ _____

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

* ALL MEASUREMENTS TO NEAREST 0.01 FOOT

ACAD: 1049\GW-LEVEL.DWG 3/18/91 MJJ

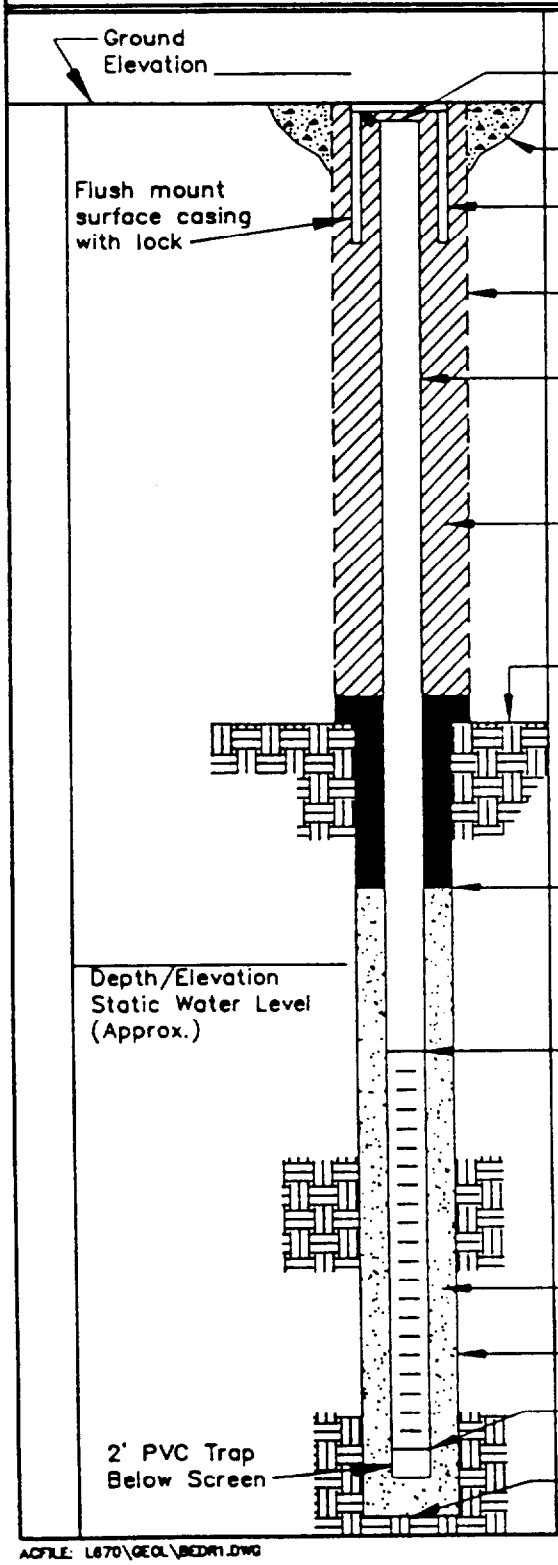
HALLIBURTON NUS
Environmental Corporation

WELL NO.: _____

BEDROCK MONITORING WELL SHEET

WELL INSTALLED IN BEDROCK

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



ELEVATION TOP OF RISER: _____

TYPE OF SURFACE SEAL: _____

TYPE OF PROTECTIVE CASING: _____

I.D. OF PROTECTIVE CASING: _____

DIAMETER OF HOLE: _____

TYPE OF RISER PIPE: _____

RISER PIPE I.D.: _____

TYPE OF BACKFILL/SEAL: _____

_____

DEPTH/ELEVATION TOP OF BEDROCK: _____ / _____

DEPTH/ELEVATION TOP OF SAND: _____ / _____

DEPTH/ELEVATION TOP OF SCREEN: _____ / _____

TYPE OF SCREEN: _____

SLOT SIZE x LENGTH: _____

TYPE OF SAND PACK: _____

DIAMETER OF HOLE IN BEDROCK: _____

DEPTH/ELEVATION BOTTOM OF SCREEN: _____ / _____

DEPTH/ELEVATION BOTTOM OF SAND: _____ / _____

DEPTH/ELEVATION BOTTOM OF HOLE: _____ / _____

BACKFILL MATERIAL BELOW SAND: _____

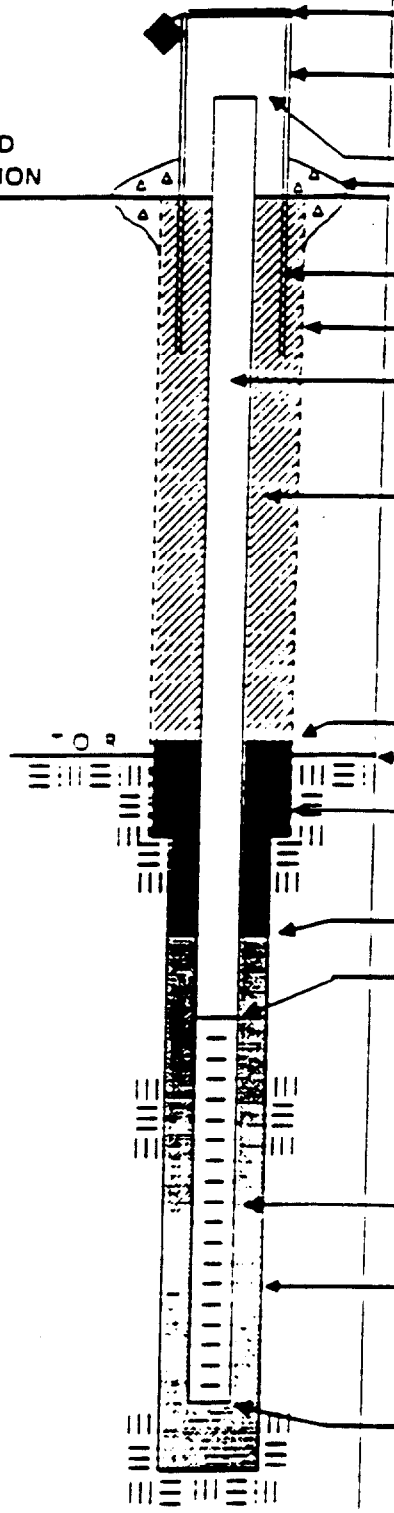
ACFILE: L670\GEOL\BEDR1.DWG

HALLIBURTON NUS
Environmental Corporation

BORING NO: _____

BEDROCK
MONITORING WELL SHEET
WELL INSTALLED IN BEDROCK

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



ELEVATION OF TOP OF SURFACE CASING: _____

STICK UP OF CASING ABOVE GROUND SURFACE: _____

ELEVATION TOP OF RISER: _____

TYPE OF SURFACE SEAL: _____

I.D. OF SURFACE CASING: _____

DIAMETER OF HOLE: _____

RISER PIPE I.D.: _____

TYPE OF RISER PIPE: _____

TYPE OF BACKFILL: _____

ELEVATION / DEPTH TOP OF SEAL: _____

ELEVATION / DEPTH TOP OF BEDROCK _____

TYPE OF SEAL: _____

ELEVATION / DEPTH TOP OF SAND: _____

ELEVATION / DEPTH TOP OF SCREEN: _____

TYPE OF SCREEN: _____

SLOT SIZE x LENGTH: _____

I.D. SCREEN: _____

TYPE OF SAND PACK: _____

DIAMETER OF HOLE IN BEDROCK:

CORE / REAM: _____

ELEVATION / DEPTH BOTTOM SCREEN: _____

ELEVATION / DEPTH BOTTOM OF HOLE _____

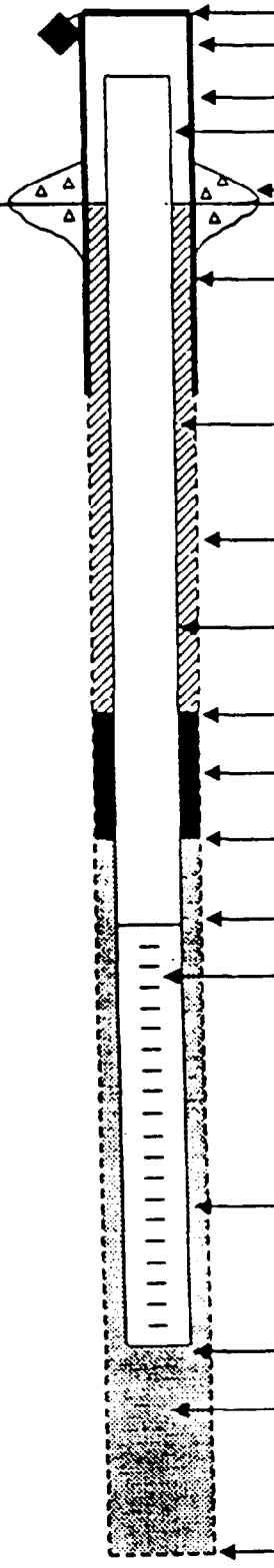
NUS CORPORATION

BORING NO.: _____

OVERBURDEN
MONITORING WELL SHEET

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

DRILLER _____
DRILLING METHOD _____
DEVELOPMENT METHOD _____



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

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

TYPE OF SURFACE SEAL: _____

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

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

BOREHOLE DIAMETER: _____

TYPE OF BACKFILL: _____

ELEVATION / DEPTH TOP OF SEAL: _____

TYPE OF SEAL: _____

DEPTH TOP OF SAND PACK: _____

ELEVATION / DEPTH TOP OF SCREEN: _____

TYPE OF SCREEN: _____

SLOT SIZE x LENGTH: _____

I.D. OF SCREEN: _____

TYPE OF SAND PACK: _____

ELEVATION / DEPTH BOTTOM OF SCREEN: _____

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

ELEVATION / DEPTH OF HOLE: _____

TEST PIT LOG — HALLIBURTON NUS

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 .....

HALLIBURTON NUS
Environmental Corporation

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				

SAMPLE LOG SHEET

HALLIBURTON NUS
Environmental Corporation

- ☐ 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:	Preserv. :	Observations / Notes

HALLIBURTON NUS
Environmental Corporation

SAMPLE LOG SHEET

PAGE____OF____

☐ SURFACE SOIL
☐ SUBSURFACE SOIL
☐ SEDIMENT
☐ LAGOON/POND
☐ OTHER

SAMPLERS SIGNATURE_____

SITE NAME_____

SITE NUMBER_____

SAMPLE No.	SAMPLE METHOD	DEPTH (FT)	DATE	TIME	SAMPLED BY	CONCENTRATION (L)LOW (H)HIGH	(G)GRAB (C)COMPOSITE	ANALYSES							No. OF CONT TOTAL	SOIL DESCRIPTION

REMARKS:

LAB:

ACAD: FORMS\LOG.DWG 2/11/93 MB

HALLIBURTON NUS Environmental Corporation and Subsidiaries

CHAIN OF CUSTODY RECORD

PROJECT NO.:	SITE NAME:
SAMPLERS (SIGNATURE):	

STATION 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:	

NUS 440 REVISED 0891

CHAIN-OF-CUSTODY SEAL

HALLIBURTON NUS Environmental Corporation

CUSTODY SEAL

Date

Signature

HALLIBURTON NUS Environmental Corporation

CUSTODY SEAL

Date

Signature

HALLIBURTON NUS
Environmental Laboratories
5350 CAMPBELLS RUN ROAD
PITTSBURGH, PA. 15205

NUS SAMPLE #

Client Name _____

Date Sampled _____ Time _____

Client Sample # _____

Sample Source _____

_____

DAILY ACTIVITIES RECORD **HALLIBURTON NUS**

PROJECT _____ LOCATION _____
CLIENT _____ ARRIVAL TIME _____ JOB NO. _____
DATE _____ DEPARTURE TIME _____
CONTRACTOR _____ DRILLER _____
BORING NO. _____ HNUS REPRESENTATIVE _____

ITEM	QUANTITY ESTIMATE	QUANTITY TODAY	PREVIOUS TOTAL QUANTITY	CUMULATIVE QUANTITY TO DATE

COMMENTS: _____

APPROVED BY:

_____ _____
HNUS FIELD REPRESENTATIVE DRILLER OR REPRESENTATIVE

APPENDIX E

STANDARD OPERATING PROCEDURES (SOPs)

STANDARD OPERATING PROCEDURES (SOPs)

Geology

GH-1.3, Section 5.0: Soil and Rock Sampling

GH-1.4, Section 5.0: Soil & Rock Drilling Methods

GH-1.5, Section 5.0: Borehole and Sample Logging

GH-1.6, Section 5.0: Decontamination of Drilling Rigs and Monitoring Well Materials

GH-1.8, Section 5.0: Excavation of Exploratory Test Pits and Trenches

Hydrogeology

GH-2.4, Section 5.0: In-Situ Hydraulic Conductivity Testing

GH-2.5, Section 5.0: Water Level Measurement/Contour Mapping

Sampling

SA-1.1, Section 5.0: Groundwater Sample Acquisition

SA-1.2, Section 5.0: Surface Water and Sediment Sampling

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

SA-6.2, Section 5.0: Sampling Packaging and Shipping

SA-6.3, Section 5.0: Site Logbook

Support Field Methods

SF-1.1, Section 5.0 On-Site Water Quality Testing

SF-1.2, Section 5.0 Sample Preservation

SF-2.3, Section 5.0 Decontamination of Chemical Sampling and Field Analytical Equipment

ASTM D 1586-84, Section 7.0: Penetration Test and Split-Barrel Sampling of Soils

5.0 PROCEDURES

5.1 SUBSURFACE SOIL SAMPLES

Subsurface soil samples are used to characterize subsurface stratigrapny. 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 <u>Thin Walled Tube (Shelby Tube) Sampling (ASTM D1587-83)</u>

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	$1\frac{9}{32}$	$\frac{3}{4}$	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	$2\frac{9}{16}$	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
$2\frac{7}{8} \times 3\frac{7}{8}$	$3\frac{7}{8}$	$2\frac{5}{8}$	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	$1\frac{13}{16}$	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 equipment is the most commonly used size.

- When soft materials are encountered that produce less than 50 percent recovery, stop the core drilling. If soil samples are desired, secure such samples in accordance with the procedures described in ASTM Method D 1586 (Split Barrel Sampling) or in Method D 1587 (Thin-Walled Tube Sampling) 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.

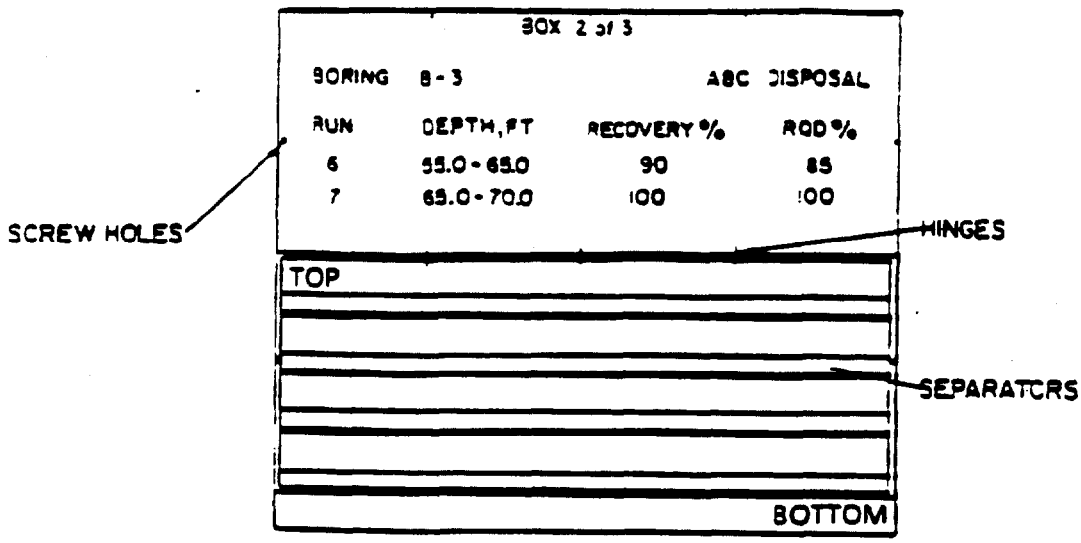
The inside and outside of the core-box lid shall be marked by indelible ink to show all pertinent data on the box's contents. At a minimum, the following information shall be included:

- 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).

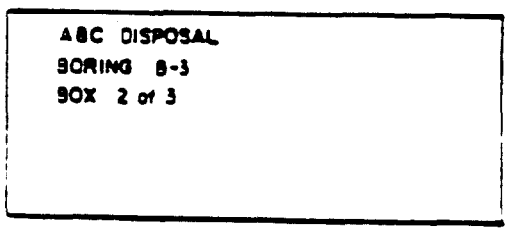
For easy retrieval when core boxes are stacked, the sides and ends of the box shall also be labeled and include project number, boring number, top and bottom depths of core and box number. Attachment No. 2 illustrates a typical rock core box.

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).

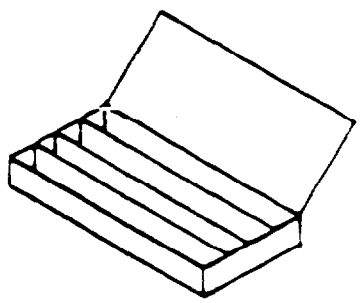
ATTACHMENT 2

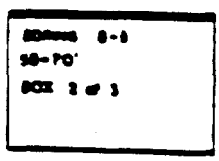


CORE BOX (OBLIQUE VIEW)



CORE BOX (TOP VIEW)





CORE BOX (END VIEW)

TYPICAL ROCK CORE BOX

NOT TO SCALE

NUS CORPORATION
A Halliburton Company

4.0 RESPONSIBILITIES

Site Manager - In consultation with the project geologist, responsible for evaluating the drilling requirements for the site and specifying drilling techniques that will be successful given the study objectives and geologic conditions at the site. He should also determine the disposal methods for products generated by drilling, such as drill cuttings and well development water, as well as any specialized supplies or logistical support required for the drilling operations.

Site Geologist/Rig Geologist - Responsible for insuring that standard and approved drilling procedures are followed. The geologist will generate a detailed boring log for each test hole. This log shall include a description of materials, samples, method of sampling, blow counts, and other pertinent drilling and testing information that may be obtained during drilling (see Attachment A of Procedure GH-1.7). Often this position for inspecting the drilling operations may be filled by other geotechnical personnel, such as soils and foundation engineers, civil engineers, etc.

Determination of the exact location for borings is the responsibility of the site geologist. The final location for drilling must be properly documented on the boring log. The general area in which the borings are to be located will be shown on a site map included in the Work Plan.

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

Drilling Subcontractor - Responsible for obtaining all drilling permits and clearances, and supplying all services (including labor), equipment and material required to perform the drilling, testing, and well installation program, as well as maintenance and quality control of such required equipment except as stated in signed and approved subcontracts.

The driller must report any major technical or analytical problems encountered in the field to the Field Operations Leader within 24 hours, and must provide advance written notification for any changes in field procedures describing and justifying such changes. No such changes shall be made unless requested and authorized in writing by the Field Operations Leader.

The drilling subcontractor will be responsible for following decontamination procedures specified in the Work Plan. Upon completion of the work, the Drilling Subcontractor will be responsible for demobilizing all equipment, cleaning up any materials deposited on site during drilling operations, and properly backfilling any open borings.

5.0 PROCEDURES

5.1 GENERAL

The purpose of drilling boreholes is:

- To determine the type, thickness, and certain physical and chemical properties of the soil, water and rock strata which underlie the site, and
- To install monitoring wells or piezometers.

All drilling and sampling equipment will be cleaned using appropriate decontamination procedures (see Procedure GH-1.6 and SF-2.3) between samples and borings. Unless otherwise specified, it is generally advisable to drill borings at "clean" locations first, and at the most contaminated locations last, to reduce the risk of spreading contamination between locations. All borings must be logged by the rig geologist as they proceed (see Procedure GH-1.5) unless the FSAP specifically states that

logging is not required. Situations where logging would not be required would include installation of multiple well points within a small area, or a "second attempt" boring adjacent to a boring that could not be continued through resistant material. In the latter case, the boring log can be resumed 5 feet above the depth at which the initial boring was abandoned, although the rig geologist should still confirm that the stratigraphy at the redrilled location conforms essentially with that encountered at the original location. If significant differences are seen, each hole should be logged separately.

5.2 DRILLING METHODS

The selected drilling methods described below apply to drilling in subsurface materials, including, but not limited to, sand, gravel, clay, silt, cobbles, boulders, rock and man-made fill. Drilling methods should be selected after studying the site geology and terrain, purpose of drilling, waste conditions at the site, and the overall subsurface investigation program proposed for the site. The full range of different drilling methods applicable to the proposed program should be identified with final selection based on relative cost, availability, time constraints, and how well each method meets the sampling and testing requirements of the individual drilling program.

5.2.1 Continuous-Flight Hollow-Stem Auger Drilling

This method of drilling consists of screwing augers with a hollow stem into the ground. Cuttings are brought to the surface by the rotating action of the auger. This method is relatively quick and inexpensive. Advantages of this type of drilling include:

- Samples can be obtained without pulling the augers out of the hole. However, this is a poor method for obtaining grab samples from thin, discrete formations because of mixing of soils which occurs as the material is brought to the surface. Sampling of such formations will require the use of split-barrel or thin-wall tube samplers advanced through the hollow core of the auger.

- No drilling fluids are required.

- A well can be installed inside the auger stem and backfilled as the augers are withdrawn.

Disadvantages and limitations of this method of drilling include:

- Augering can only be done in unconsolidated materials.

- The inside diameter of hollow stem augers used for well installation should be at least four inches greater than the well casing. Use of such large diameter hollow stem augers is more expensive than the use of small diameter augers in boreholes not used for well installation. Furthermore, the density of unconsolidated materials and depths become more of a limiting factor. More friction is produced with the larger diameter auger and subsequently greater torque is needed to advance the boring.

- The maximum effective depth for drilling is 150 feet or less, depending on site conditions and the size of augers used.

- In augering through clean sand formations below the water table, the sand will tend to flow into the hollow stem when the plug is removed for soil sampling or well installation. If the condition of "running" or "flowing" sands is persistent at a site, an alternative method of drilling is recommended, in particular for wells or boreholes deeper than 25 feet. Hollow stem auger drilling is the preferred method of drilling. Most alternative

methods require the introduction of water or mud downhole (air rotary is the exception) to maintain the open borehole. With these other methods great care must be taken to ensure that the method does not interfere with the collection of a representative sample which is the object of the construction. With this in mind, the preferred order of choice of drilling method after hollow stem augering (HSA) is:

- Cable tool
- Casing drive (air)
- Air rotary
- Mud rotary
- Drive and wash
- Jetting

However, the use of any method will also depend on efficiency and cost-effectiveness. In many cases, mud rotary is the only feasible alternative to hollow stem augering. Thus, mud rotary drilling is generally acceptable as a first substitute for HSA.

The procedures for sampling soils through holes drilled by hollow-stem auger shall conform with the applicable ASTM Standards: D1587-83 and D1586-84. The hollow stem auger may be advanced by any power-operated drilling machine having sufficient torque and ram range to rotate and force the auger to the desired depth. The machine must, however, be equipped with the accessory equipment needed to perform required sampling, or rock coring.

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

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

When drilling below the water table, specially-designed plugs which allow passage of formation water but not solid material shall be used (see Reference 1 of this guideline). This method also prevents blow back and plugging of the auger when the plug is removed for sampling.

Alternately, it may be necessary to keep the hollow stem full of water, at least to the level of the water table, to prevent blowback and plugging of the auger. If water is added to the hole, it must be sampled and analyzed to determine if it is free from contaminants prior to use. In addition, the amount of water introduced, the amount recovered upon attainment of depth, and the amount of water extracted during well development must be carefully logged in order to ensure that a representative sample of the formation water can be obtained. Well development should occur as soon after well completion as practicable (see GH-1.7 for Well Development Procedures). If gravelly or hard material is encountered which prevents advancing the auger to the desired depth, augering should be halted and either driven casing or hydraulic rotary methods should be attempted. If the depth to the bedrock/soil interface and bedrock lithology must be determined, then a 5-foot confirmatory core run should be conducted (see Section 5.2.9).

At the option of the Field Operations Leader, when resistant materials prevent the advancement of the auger, a new boring can be attempted. The original boring must be properly backfilled and the new boring started a short distance away at a location determined by the site geologist. If multiple water bearing strata were encountered, the original boring must be grouted. In some formations it may be prudent to also grout borings which only penetrate the water table aquifer, since loose soil backfill in the boring would still provide a preferred pathway for surface liquids to reach the water table.

5.2.2 Continuous-Flight Solid-Stem Auger Drilling

This method is similar to hollow-stem augering. Practical application of this method is severely restricted as compared with hollow stem augers. Split barrel (split-spoon) sampling cannot be done without pulling the augers which may allow the hole to collapse. The method is therefore very time consuming and is not cost effective. Also, augers would have to be withdrawn before installing a monitoring well, which again, may allow the hole to collapse. Furthermore, geologic logging by examining the soils brought to the surface is unreliable as in the case of the hollow stem auger, and depth to water may be difficult to determine while drilling.

There would be very few situations where use of a solid stem auger would be preferable to other drilling methods. The only practical applications of this method would be to drill boreholes for well installation where no lithologic information is desired and the soils are such that the borehole can be expected to remain open after the augers are withdrawn. Alternatively, the technique can be used to find depth to bedrock in an area when no other information is required from drilling.

5.2.3 Rotary Drilling

Direct rotary drilling includes air-rotary and fluid-rotary drilling. Air-rotary drilling is a method of drilling where the drill rig simultaneously turns and exerts a downward pressure on the drilling rods and bit while circulating compressed air down the inside of the drill rods, around the bit, and out the annulus of the borehole. Air circulation serves to both cool the bit and remove the cuttings from the borehole. Advantages of this method include:

- The drilling rate is high (even in rock).
- The cost per foot of drilling is relatively low.
- Air rotary rigs are common in most areas.
- No drilling fluid is required (except when water is inje d to keep down dust).
- The borehole diameter is large, to allow room for pro well installation procedures.

Disadvantages to using this method include:

- Formations must be logged from the cuttings that are blown to the surface and thus the depths of materials logged are approximate.
- Air blown into the formation during drilling may "bind" the formation and impede well development and natural groundwater flow.
- In-situ samples cannot be taken, unless the hole is cased.
- Casing must generally be used in unconsolidated materials.
- Air rotary drill rigs are large and heavy.

A variation of the typical air-rotary drill bit is a down hole hammer which hammers the drill bit down as it drills. This makes drilling in hard rock faster. Air-rotary drills can also be adapted to use for rock coring although they are generally slower than other types of core drills. A major application of the air-rotary drilling method would be to drill holes in rock for well installation.

Fluid-Rotary drilling operates in a similar manner to air rotary drilling except that a drilling fluid ("mud") or clean water is used in place of air to cool the drill bit and remove cuttings. There are a variety of fluids that can be used with this drilling method, including bentonite slurry and synthetic slurries. If a drilling fluid other than water/cuttings is used, it must be a natural clay (i.e., bentonite) and a "background" sample of the fluid should be taken for analysis of possible organic or inorganic contaminants.

Advantages to the fluid-rotary drilling method include:

- The ability to drill in many types of formations.
- Relatively quick and inexpensive.
- Split barrel (split-spoon) or thin-wall tube samples can be obtained without removing drill rods if the appropriate size drill rods and bits (i.e., fish-tail or drag bit) are used.
- In some borings temporary casing may not be needed as the drilling fluids may keep the borehole open.
- Drill rigs are readily available in most areas.

Disadvantages to this method include:

- Formation logging is not as accurate as with hollow stem auger method if split barrel (split-spoon) samples are not taken (i.e., the depths of materials logged from cuttings delivered to the surface are approximate).
- Drilling fluids reduce permeability of the formation adjacent to the boring to some degree, and require more extensive well development than "dry" techniques (augering, air-rotary).
- No information on depth to water is obtainable while drilling.
- Fluids are needed for drilling, and there is some question about the effects of the drilling fluids on water samples obtained. For this reason as well, extensive well development may be required.
- In very porous materials (i.e., rubble fill, boulders, coarse gravel) drilling fluids may be continuously lost into the formation. This will require either constant replenishment of the drilling fluid, or the use of casing through this formation.
- Drill rigs are large and heavy, and must be supported with supplied water.
- Ground water samples can be potentially diluted with drilling fluid.

The procedures for performing direct rotary soil investigations and sampling shall conform with the applicable ASTM standards: D2113-83, D1587-83, and D1586-84.

For air or fluid-rotary drilling, the rotary drill may be advanced to the desired depth by any power-operated drilling machine having sufficient torque and ram range to rotate and force the bit to the desired depth. The drilling machine must, however, be equipped with any accessory equipment needed to perform required sampling, or coring. Prior to sampling, any settled drill cuttings in the borehole must be removed.

Soil samples shall be taken as specified by the Work Plan or more frequently if requested by the field geologist. Any required sampling shall be performed by rotation, pressing, or driving in accordance with the standard or approved method governing use of the particular sampling tool.

When field conditions prevent the advancement of the hole to the desired depth, a new boring may be drilled at the request of the Field Operations Leader. The original boring shall be backfilled using methods and materials appropriate for the given site and a new boring started a short distance away at a location determined by the site geologist.

5.2.4 Reverse Circulation Rotary Drilling

The common reverse-circulation rig is a water or mud rotary rig with a large diameter drill pipe which circulates the drilling water down the annulus and up the inside of the drill pipe (reverse flow direction from direct mud rotary). This type of rig is used for the construction of large-capacity production water wells and is not suited for small, water-quality sampling wells because of the use of drilling muds and the large diameter hole which is created. A few special reverse-circulation rotary rigs are made with double-wall drill pipe. The drilling water or air is circulated down the annulus between the drill pipes and up inside the inner pipe.

Advantages of the latter method include:

- The formation water is not contaminated by the drilling water.
- Formation samples can be obtained, from known depths.
- When drilling with air, immediate information is available regarding the water-bearing properties of formations penetrated.
- Collapsing of the hole in unconsolidated formations is not as great a problem as when drilling with the normal air rotary rig.

Disadvantages include:

- Double-wall, reverse-circulation drill rigs are very rare and expensive to operate.
- Placing cement grout around the outside of the well casing above a well screen often is difficult, especially when the screen and casing are placed down through the inner drill pipe before the drill pipe is pulled out.

5.2.5 Drill-through Casing Driver

The driven-casing method consists of alternately driving casing (fitted with a sharp, hardened casing shoe) into the ground using a hammer lifted and dropped by the drill rig or an air hammer and cleaning out the casing using a rotary chopping bit and air or water to flush out the materials. The casing is driven down in stages (usually 5 feet per stage). A continuous record is kept of the blows per foot in driving the casing (see Procedure GH-1.5). The casing is normally advanced by a 300-pound

hammer falling freely through a height of 30-inches. Simultaneous washing and driving of the casing is not recommended. If this procedure is used, the elevations between which water is used in driving the casing should be recorded.

The driven casing method is used in unconsolidated formations only. When the boring is to be used for later well installation, the driven casing used should be at least four inches larger in diameter than the well casing to be installed. Advantages to this method of drilling include:

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

Some of the disadvantages include:

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

5.2.6 Cable Tool Drilling

A cable tool rig uses a heavy, solid-steel, chisel-type drill bit ("tool") suspended on a steel cable, which when raised and dropped chisels or pounds a hole through the soils and rock. Drilling progress may be expedited by the use of "slip-jars" which serve as a cable-activated down hole percussion device to hammer the bit ahead.

When drilling through the unsaturated zone, some water must be added to the hole. The cuttings are suspended in the water and then bailed out periodically. Below the water table, after sufficient ground water enters the borehole to replace the water removed by bailing, no further water need be added.

When soft caving formations are encountered, it is usually necessary to drive casing as the hole is advanced to prevent collapse of the hole. Often the drilling can be only a few feet below the bottom of the casing. Because the drill bit is lowered through the casing, the hole created by the bit is smaller than the casing. Therefore, the casing (with a sharp, hardened casing shoe on the bottom) must be driven into the hole (see Section 5.2.5 of this guideline).

Advantages of the cable-tool method include the following:

- Information regarding water-bearing zones is readily available during the drilling. Even relative permeabilities and rough water quality data from different zones penetrated can be obtained by skilled operators.

- The cable-tool rig can operate satisfactorily in all formations, but is best suited for caving, boulder, cobble or coarse gravel type formations (e.g., glacial till) or formations with large cavities above the water table (such as limestones).

- When casing is used, the casing seals formation water out of the hole, preventing down-hole contamination and allowing sampling of deeper aquifers for field-measurable water quality parameters.

- Split barrel (split spoon) or thin-wall tube samples can be collected through the casing.

Disadvantages include:

- Drilling is slow compared with rotary rigs.

- The necessity of driving the casing in unconsolidated formations requires that the casing be pulled back if exposure of selected water-bearing zones is desired. This process complicates the well completion process and often increases costs. There is also a chance that the casing may become stuck in the hole.

- The relatively large diameters required (minimum of 4-inch casing) plus the cost of steel casing result in higher costs compared to rotary drilling methods where casing is not required, such as use of a hollow stem auger.

- Cable-tool rigs have largely been replaced by rotary rigs. In some parts of the U.S., availability may be difficult.

5.2.7 Jet Drilling (Washing)

Jet drilling, which should be used only for piezometer or vadose zone sampler installation, consists of pumping water or drilling mud down through a small diameter (1/2 to 2-inch) standard pipe (steel or PVC). The pipe may be fitted with a chisel bit or a special jetting screen. Formation materials dislodged by the bit and jetting action of the water are brought to the surface through the annulus around the pipe. As the pipe is jetted deeper, additional lengths of pipe may be added at the surface.

Jet percussion is a variation of the jetting method, in which the casing is driven with a drive weight. Normally, this method is used to place 2-inch diameter casing in shallow, unconsolidated sand formations but has been used to install 3- to 4-inch diameter casings to 200 feet.

Jetting is acceptable in very soft formations, usually for shallow sampling, and when introduction of drilling water to the formation is acceptable. Such conditions would occur during rough stratigraphic investigation or installation of piezometers for water level measurement. Advantages of this method include:

- Jetting is fast and inexpensive.
- Because of the small amount of equipment required, jetting can be accomplished in locations where access by a normal drilling rig would be very difficult. For example, it would be possible to jet down a well point in the center of a lagoon at a fraction of the cost of using a drill rig.
- Jetting numerous well points just into a shallow water table is an inexpensive method for determining the water table contours, hence flow direction.

Disadvantages include the following:

- A large amount of foreign water or drilling mud is introduced above and into the formation to be sampled.
- Jetting is usually done in very soft formations which are subject to caving. Because of this caving, it is often not possible to place a grout seal above the screen to assure that water in the well is only from the screened interval.
- The diameter of the casing is usually limited to 2 inches; therefore, samples must be obtained by methods applicable to small diameter casings.
- Jetting is only possible in very soft formations that do not contain boulders or coarse gravel, and the depth limitation is shallow (about 30 feet without jet percussion equipment).
- Large quantities of water are often needed.

5.2.8 Drilling with a Hand Auger

This method is applicable wherever the formation, total depth of sampling, and the site and groundwater conditions are such as to allow hand auger drilling. Hand augering can also be considered at locations where drill rig access is not possible. All hand auger borings will be performed according to ASTM D1452-80.

Samples should be taken continuously unless otherwise specified by the Work Plan. Any required sampling is performed by rotation, pressing, or driving in accordance with the standard or approved method governing use of the particular sampling tool. Typical equipment used for sampling and advancing shallow "hand auger" holes are Iwan samplers (which are rotated) or post hole diggers (which are operated like tongs). This technique is slow but effective where larger pieces of equipment do not have access and where very shallow holes are desired (less than 5 feet). Surficial soils must be composed of relatively soft and non-cemented formations to allow penetration by the auger.

5.2.9 Rock Drilling and Coring

When soil borings cannot be continued using augers or rotary methods due to the hardness of the soil or when rock or large boulders are encountered, drilling and sampling can be performed using a diamond bit corer in accordance with ASTM D2113.

Drilling is done by rotating and applying downward pressure to the drill rods and drill bit. The drill bit is a circular, hollow, diamond studded bit attached to the outer core barrel in a double tube core barrel. The use of single tube core barrels is not recommended, as the rotation of the barrel erodes the sample and limits its use for detailed geological evaluation. Water or air is circulated down through the drill rods and annular space between the core barrel tubes to cool the bit and remove the cuttings. The bit cuts a core out of the rock which rises into an inner barrel mounted inside the outer barrel. The inner core barrel and rock core are removed by lowering a wire line with a coupling into the drill rods, latching onto the inner barrel and withdrawing the inner barrel. A less efficient variation to this method utilizes a core barrel that cannot be removed without pulling all of the drill rods. This variation is practical only if less than 50 feet of core is required.

Core borings are made through the casing used for the soil borings. The casing must be driven and sealed into the rock formation to prevent seepage from the overburden into the hole to be cored (see Section 5.3 of this guideline). A double-tube core barrel with a diamond bit and reaming shell or equivalent should be used to recover rock cores of a size specified in the Work Plan. The most common core barrel diameters are listed in Attachment A. Soft or decomposed rock should be sampled with a driven split-barrel whenever possible or cored with a Denison or Pitcher sampler.

When coring rock, including shale and claystone, the speed of the drill and the drilling pressure, amount and pressure of water, and length of run can be varied to give the maximum recovery from the rock being drilled. Should any rock formation be so soft or broken that the pieces continually fall into the hole, causing unsatisfactory coring, the hole should be reamed and a flush joint casing installed to a point below the broken formation. The size of the flush joint casing must permit securing the core size specified. When soft or broken rock is anticipated, the length of core runs should be reduced to less than 5 feet to avoid core loss and minimize core disturbance.

Advantages of core drilling include:

- Undisturbed rock cores can be recovered for examination and/or testing.
- In formations in which the cored hole will remain open without casing, water from the rock fractures may be recovered from the well without the installation of a well screen and gravel pack.
- Formation logging is extremely accurate.
- Drill rigs are relatively small and mobile.

Disadvantages include:

- Water or air is needed for drilling.
- Coring is slower than rotary drilling (and more expensive).

- Depth to water cannot accurately be determined if water is used for drilling.

- The size of the borehole is limited.

This drilling method is useful if accurate determinations of rock lithology are desired or if open wells are to be installed into bedrock. To install larger diameter wells in coreholes, the hole must be reamed out to the proper size after boring, using air or mud rotary drilling methods.

5.2.10 Drilling & Support Vehicles.

In addition to the drilling method required to accomplish the objectives of the field program, the type of vehicle carrying the drill rig and/or support equipment, and its suitability for the site terrain, will often be an additional deciding factor in planning the drilling program. The types of vehicles available are extensive, and depend upon the particular drilling subcontractor's fleet. Most large drilling subcontractors will have a wide variety of vehicle and drill types suited for most drilling assignments in their particular region, while smaller drilling subcontractors will usually have a fleet of much more limited diversity. The weight size, and means of locomotion (tires, tracks, etc.) of the drill rig must be selected to be compatible with the site terrain, to assure adequate mobility between borehole locations. Such considerations also apply to necessary support vehicles used to transport water and/or drilling materials to the drill rigs at the borehole locations. When the drill rigs or support vehicles do not have adequate mobility to easily traverse the site, provisions must be made for assisting equipment, such as bulldozers, winches, timber planking, etc., to maintain adequate progress during the drilling program.

Some of the typical vehicles which are usually available for drill rigs and support equipment are:

- Totally portable drilling/sampling equipment, where all necessary components (tripods, samplers, hammers, catheads, etc.) may be hand-carried to the borehole site. Drilling/sampling methods used with such equipment include:

  - Hand augers and lightweight motorized augers
  - Retractable plug samplers-driven by hand (hammer)
  - Motorized cathead - a lightweight aluminum tripod with a small gas-engine cathead mounted on one leg, used to install small diameter cased borings. This rig is sometimes called a "monkey on a stick."

- Skid-mounted drilling equipment containing a rotary drill or engine-driven cathead (to lift hammers and drill string), a pump, and a dismounted tripod. The skid is pushed, dragged, or winched (using the cathead drum) between boring locations.

- Small truck-mounted drilling equipment uses a jeep, stake body or other light truck (4 to 6 wheels), upon which are mounted the drill and/or a cathead, a pump, and a tripod or small drilling derrick. On some rigs the drill and/or a cathead are driven by a power take-off from the truck, instead of by a separate engine.

- Track-mounted drilling equipment is similar to truck-mounted rigs, except that the vehicle used has wide bulldozer tracks for traversing soft ground. Sometimes a continuous-track "all terrain vehicle" is also modified for this purpose. Some types of tracked drill rigs are called "bombardier" or "weasel" rigs.

- Heavy truck-mounted drilling equipment is mounted on tandem or dual tandem trucks to transport the drill, derrick, winches, and pumps or compressors. The drill may be provided

with a separate engine or may use a power take-off from the truck engine. Large augers, hydraulic rotary and reverse circulation rotary drilling equipment are usually mounted on such heavy duty trucks. For soft-ground sites, the drilling equipment is sometimes mounted on and off the road vehicle having low pressure, very wide diameter tires and capable of floating; these vehicles are called "swamp buggy" rigs.

- Marine drilling equipment is mounted on various floating equipment for drilling borings in lakes, estuaries and other bodies of water. The floating equipment varies, and is often manufactured or customized by the drilling subcontractor to suit specific drilling requirements. Typically, the range of flotation vehicles includes:

  - Barrel float rigs - a drill rig mounted on a timber platform buoyed by empty 55-gallc drums or similar flotation units.

  - Barge-mounted drill rigs.

  - Jack-up platforms - drilling equipment mounted on a floating platform having retractable legs to support the unit on the sea or lake bed when the platform is jacked up out of the water.

  - Drill ships - for deep ocean drilling.

In addition to the mobility for the drilling equipment, similar consideration must be given for equipment to support the drilling operations. Such vehicles or floating equipment are needed to transport drill water, drilling supplies and equipment, samples, drilling personnel, etc. to and/or from various boring locations.

5.2.11 Equipment Sizes

In planning subsurface exploration programs, care must be taken in specifying the various drilling components, so that they will fit properly in the boring or well.

For drilling open boreholes using rotary drilling equipment, tri-cone drill bits are employed with air, water or drilling mud to remove cuttings and cool the bit. Tri-cone bits are slightly smaller than the holes they drill (i.e., 5-7/8" or 7-7/8" bits will nominally drill 6" and 8" holes, respectively).

For obtaining split-barrel samples of a formation, samplers are manufactured in sizes ranging from 2-inches to 4-1/2 inches in outside diameter. However, the most commonly used size is the 2-inch O.D., 1-3/8-inch I.D. split-barrel sampler. When this sampler is used, and driven by a 140-pound (± 2 pound) hammer dropping 30-inches (± 1 inch), the procedure is called a Standard Penetration Test, and the blows per foot required to advance the sampler into the formation can be correlated to the formation's density or strength.

In planning the drilling of boreholes using hollow stem augers or casing, in which thin-wall tube samples or diamond core drilling will be performed, refer to the various sizes and clearances provided in Attachment A of this guideline. Sizes selected must be stated in the Work Plan.

5.2.12 Estimated Drilling Progress

To estimate the anticipated rates of drilling progress for a site the following must be considered:

- The speed of the drilling method employed.
- Applicable site conditions (e.g., terrain, mobility between borings, difficult drilling conditions in bouldery soils, rubble fill or broken rock, etc.).
- Project-imposed restrictions (e.g., drilling while wearing personal protective equipment, decontamination of drilling equipment, etc.).

Based on recent experience in drilling average soil conditions (no boulders) and taking samples at 5-foot intervals, for moderate depth (30' to 50') boreholes (not including installation or development of wells), the following daily rates of total drilling progress may be anticipated for the following drilling methods:

Drilling Method	Average Daily Progress (linear feet)
Hollow-stem augers	75'
Solid-stem augers	50'
Mud Rotary Drilling	100' (cuttings samples)
Reverse Circulation Rotary	100' (cuttings samples)
Skid Rig with driven casing	30'
Rotary with driven casing	50'
Cable Tool	30'
Hand Auger	Varies
Continuous Rock Coring	50'

5.3 PREVENTION OF CROSS-CONTAMINATION

A telescoping or multiple casing technique minimizes the potential for the migration of contaminated groundwater to lower strata below a confining layer. The telescoping technique consists of drilling to a confining layer utilizing a spun casing method with a diamond cutting or augering shoe, (a method similar to the rock coring method described in Section 5.2.9, except that larger casing is used) or a driven-casing method (see Section 5.2.5 of this guideline), and installing a specified diameter steel well casing. The operation consists of three separate steps. Initially, a drilling casing usually of 8-inch diameter is installed followed by installation of the well casing (6-inch diameter is common for 2-inch wells). This well casing is driven into the confining layer to insure a tight seal at the bottom of the hole. The well casing is sealed at the bottom with a bentonite-cement slurry. The remaining depth of the boring is drilled utilizing a narrower diameter spun or driven casing technique within the outer well casing. A smaller diameter well casing with an appropriate length of slotted screen on the lower end is installed to the surface.

Clean sand is placed in the annulus around and to a point about 2 feet above the screen prior to withdrawal of the drilling casing. The annular space above the screen and to a point 2 feet above the bottom of the outer well casing is sealed with a tremied cement-bentonite slurry which is pressure-grouted or displacement-grouted into the hole. The remaining casing annulus is backfilled with clean material and grouted at the surface, or it is grouted all the way to the surface.

5.4 CLEANOUT OF CASING PRIOR TO SAMPLING

The boring hole must be completely cleaned of disturbed soil, segregated coarse material and clay adhering to the inside walls of the casing. The cleaning must extend to the bottom edge of the casing and, if possible, a short distance further (1 or 2 inches) to bypass disturbed soil resulting from the advancement of the casing. Loss of wash water during cleaning should be recorded.

For disturbed samples both above and below the water table and where introduction of relatively large volumes of wash water is permissible, the clean-out operation is usually performed by washing the material out of the casing with water; however, the cleaning should never be accomplished with a strong, downward directed jet which will disturb the underlying soil. When clean-out has reached the bottom of the casing or slightly below (as specified above), the string of tools should be lifted one foot off the bottom with the water still flowing, until the wash water coming out of the casing is clear of granular soil particles. In formations where the cuttings contain gravel and other larger particles, it is often useful to repeatedly raise and lower the drill rods and wash bit while washing out the hole, to surge these large particles upward out of the hole. As a time saver, the drilling contractor may be permitted to use a split barrel (split-spoon) sampler with the ball check valve removed as the clean out tool, provided the material below the spoon is not disturbed and the shoe of the spoon is not damaged. However, because the ball check valve has been removed, in some formations it may be necessary to install a flap valve or spring sample retainer in the split spoon bit, to prevent the sample from falling out as the sampler is withdrawn from the hole. The use of jet-type chopping bits is discouraged except where large boulders and cobbles or hard-cemented soils are encountered. If water markedly softens the soils above the water table, clean out should be performed dry with an auger.

For undisturbed samples below the water table, or where wash water must be minimized, clean out is usually accomplished with an appropriate diameter clean out auger. This auger has cutting blades at the bottom to carry loose material up into the auger, and up-turned water jets just above the cutting blades to carry the removed soil to the surface. In this manner there is a minimum of disturbance at the top of the material to be sampled. If any gravel material washes down into the casing and cannot be removed by the cleanout auger, a split-barrel sample can be taken to remove it. Bailers and sandpumps should not be used. For undisturbed samples above the groundwater table, all operations must be performed in a dry manner.

If all of the cuttings created by drilling through the overlying formations are not cleaned from the borehole prior to sampling, some of the problems which may be encountered during sampling include:

- When sampling is attempted through the cuttings remaining in the borehole, all or part of the sampler may become filled with the cuttings. This limits the amount of sample from the underlying formation which can enter and be retained in the sampler, and also raises questions on the validity of the sample.

- If the cuttings remaining in the borehole contain coarse gravel and/or other large particles, these may block the bit of the sampler and prevent any materials from the underlying formation from entering the sampler when the sampler is advanced.

- In cased borings, should sampling be attempted through cuttings which remain in the lower portion of the casing, these cuttings could cause the sampler to become bound into the casing, such that it becomes very difficult to either advance or retract the sampler.

- When sampler blow counts are used to estimate the density or strength of the formation being sampled, the presence of cuttings in the borehole will usually give erroneously high sample blow counts.

To confirm that all cuttings have been removed from the borehole prior to attempting sampling, it is important that the rig geologist measure the "stickup" of the drill string. This is accomplished by measuring the assembled length of all drill rods and bits or samplers (the drill string) as they are lowered to the bottom of the hole, below some convenient reference point of the drill string; then to measure the height of this reference point above the ground surface. The difference of these measurements is the depth of the drill string (lower end of the bit or sampler) below the ground surface, which must then be compared with the depth of sampling required (installed depth of casing or depth of borehole drilled). If the length of drill string below grade is more than the drilled or casing depth, the borehole has been cleaned too deeply, and this deeper depth of sampling must be recorded on the log. If the length of drill string below grade is less than the drilled or casing depth, the difference represents the thickness of cuttings which remain in the borehole. In most cases, an inch or two of cuttings may be left in the borehole with little or no problem. However, if more than a few inches for cuttings are encountered, the borehole must be recleaned prior to attempting sampling.

5.5 MATERIALS OF CONSTRUCTION

The effects of monitoring well construction materials on specific chemical analytical parameters are described and/or referenced in FT-7.01. However, there are several materials used during drilling, particularly drilling fluids and lubricants, which must be used with care to avoid compromising the representativeness of soil and ground water samples.

The use of synthetic or organic polymer slurries is not permitted at any location where soil samples for chemical analysis are to be collected. These slurry materials could be used for installation of long term monitoring wells, but the early time data in time series collection of ground water data may then be suspect. If synthetic or organic polymer muds are proposed for use at a given site, a complete written justification including methods are procedures for their use must be provided by the site geologist and approved by the site manager. The specific slurry composition and the concentration of selected chemicals for each site must be known.

For many drilling operations, potable water is an adequate lubricant for drill stem and drilling tool connections. However, there are instances, such as drilling in tight clayey formations or in loose gravels, when threaded couplings must be lubricated to avoid binding. In these instances, to be determined in the field at the judgment of the site geologist and noted in the Site Logbook, and only after approval by the site manager, a vegetable oil or silicone based lubricant should be used. Petroleum based greases, etc. will not be permitted. Samples of lubricants used must be provided and analyzed for chemical parameters appropriate to the given site.

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, annydrite, 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 <u>Rock Classification</u>

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

REMARKS _____

BORING _____

PAGE ____ OF ____

SOIL TERMS

UNIFIED SOIL CLASSIFICATION (USCS)

COARSE GRAINED SOILS

More than half of material is LARGER than the 200 sieve size

		FIELD IDENTIFICATION PROCEDURES (Excluding particles larger than 3" & basing fractions on estimated weights)	GROUP SYMBOL	TYPICAL NAMES
GRAVELS More than 50% of coarse fraction retained on No. 4 sieve	CLEAN GRAVELS Little or no 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 Appreciable amount of 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% or more of coarse fraction passes No. 4 sieve	CLEAN SANDS Little or no fines	Wide range in grain size and substantial amounts of all intermediate particle sizes.	SW	Well graded sands, 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 Appreciable amount of 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 the 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 the 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 considerably (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
- U 3" O.D. Undisturbed Sample
- O Other Samples, Specify in Remarks

ROCK SAMPLES TYPES

- R NQ (Diamond) Core (1-1/8" O.D.)
- B BQ (Diamond) Core (1-7/8" O.D.)
- X Other Core Bits, Specify in Remarks

WATER LEVELS

10-10
T.M.A. Indicated Level Where Observed

10-10
T.M.A. Stabilized Level Where Observed

EXHIBIT 4-2

Subject	Number	Page
BOREHOLE AND SAMPLE LOGGING	GH-1.5	5 of 26
Revision 2		Effective Date 05/04/90

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) or Scribing Int	Consistency or Rock Hardness	Color	Material Classification	USCS	Remarks
S-1	0.0	2/6 6	1.5/1.5		STIFF	BRN	CLAYEY SILT - TR SHALE	ML	0-6" TOPSOIL MOIST 0PPM
	1.5						FRAG - TR ORG.		RESIDUAL SOIL.
	5.0								
S-2	6.0	11/100/.5	3.8/1.0	5.5 / 6.0	M. SOFT	GRAY BRN	DEC SHALE AND SILT	VBR	DAMP 0PPM
					TO				REFUSAL @ 6' 5.5 TOP OF DEC
					M. HARD				ROCK
									AUGERED TO 15' W/SOLID STEM AUG
									CUTTING MOIST @ 2.8' WATER @ 11.2
									WL @ 12:10 PM WAS
									≈ 9' FROM G.S.
									SET 4" PVC CAS. @ 19.0'
9-21	15.0								
9-22					M. HARD	BRN GRAY	SILTY SHALE - FEW	VBR	SEVERAL 0 PPM
							JUNETZ PCS		Fe STAINED JOINTS ON CORE
									THRUOUT RUN
									JOINTS AND BREAKS
									ARE HORIZ TO LO ∠.
0.2/10.0	①	0.2/10	7.8/10.0						W/VUGS ON LOWER
									PORTION 23 TO 25 OF CORE
	25.0								

REMARKS: ACCESS 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 in / Run	Blows / 6"	Sample Recovery / Sample Length	Lithology Changes	Soil Density Consistency / 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.
	9/10.0	②	90%	8.7/10.0						
									BR	≈32 TO 33 FEW QUARTZ PIECES W/
									VBR	VUGS. SL. MICACEOUS
										VF QUARTZ GRAINS IN MATRIX - 30% 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. SALTY. @ 37± THIN CALCITE
										LAMINATIONS WITH STAINED JNTS
									BR	THRUOUT RUN MORE SO 35-37±
	10/10.0	③	100%	9.7/10.0					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. GOLLINUE
ELEVATION: — FIELD GEOLOGIST: SJ CONTI
WATER LEVEL DATA
(Date, Time & Conditions)

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

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

* See Legend on Back

BORING MW 3A

EXHIBIT 4-6

BORING LOG — **NUS CORPORATION**

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

SAMPLE NO & TYPE OR RQD	DEPTH INT OR RUN NO	BLOWS 6" OR RQD (%)	SAMPLE RECOVERY SAMPLE LENGTH	LITHOLOGY CHANGE DEPTH OR BLOCK INT	MATERIAL DESCRIPTION: SOIL DENSITY CONSISTENCY OR ROCK HARDNESS	COLOR	MATERIAL CLASSIFICATION	USCS	REMARKS (HNU) (PPM)
	0.0	5 3 2	L4/1.5		LOOSE	BLK BRN	SILTY SILT AND GRAVEL	ML	MOIST (0PPM)
S-1							TR. COAL FELS		3/4 DEBRIS - MAKE OLD
							TR-CC FRAG		RR. LINE.
							(FILL)		
	5.0					RED			
S-2		1	1.3/1.5	6.0	V. LOOSE	BRN TO GRAY	SANDY SILT - TR FRG	SM	MOIST → WET (0PPM)
	6.5	3					SILTY SAND → TO GRAVEL		GRAY SAND & G ±
									NICE EDGES LOOKS NATURAL
									DRILLER NOTE H2O @ 10'
	10.0								
S-3		1 23 27	1.2/1.5		DENSE	BRN	SILTY SAND AND S.S.	SM	WET (0PPM)
	11.5						FRAGS (GRAY)		1" Ø SIZE MAX SIZE
									SUBANGULAR TO SUBROUNDED GRAVEL
	15.0								
S-4		7 44 43	1.0/1.5		V DENSE	BRN	SILTY FINE TO SAND	SM	WET (0PPM)
	16.5						AND GRAVEL		1" Ø SIZE MAX SIZE
									SUBANGULAR TO SUBROUNDED GRAVEL
	20.0								
S-5	20.0	17 [illegible]	[illegible] 9		V. DENSE	DARK BRN	SILTY SAND TRACE	SM	WET (0PPM)
							GRAVEL AND		MORE
							S.S FRAGS		BECOMES MORE LIKE SANDY SILT AT BOTM OF SAMPLE

REMARKS: START @ 1:15 PM - 7-7-87 USING 4¼" ID HOLLOW STEMS
S-4 @ 3:30 PM - TO LOWER 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.: 4734 — DATE: 7-7-87 — DRILLER: E ERIKSON
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 (DEGREES OF BEDDING INT)	MATERIAL DESCRIPTION: SOIL DENSITY CONSISTENCY OR ROCK HARDNESS	COLOR	MATERIAL CLASSIFICATION	USCS	REMARKS
S-6	25.0	6/17	1.1/1.5		DENSE	OLIVE BLUE	SILTY SAND - SOME	SM	[illegible] OPPM
	26.5	30				GRAY	GRAVEL - TR CLAY		C.S. STABLE FIRST SAMPLE IN
							TR. SS PEBS		SOLAR. NOT ENOUGH CLAY TO BE CONFINING
									NOTES: MAY SET ZONE 2
7/7	30.0					UNITED			CASING @ 28'
7/8	S-7	17/27	1.4/1.5		V. DENSE	BLUE GRAY	SILTY SAND - SOME GRAVEL	SM/GM	[illegible] (OPPM)
	31.5	36					[illegible]		[illegible]
							TR CLAY		GRAY & PEBBLES. SLIGHTLY SOFT FIL
									NOT TOO 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 (OPPM)
							SOME GRAVEL	GM	VISCOUS CLAY - LESS
							TR SS PEB		[illegible] - MORE
									SAMPLE. SAID THAT
	40.0								POSSIBLE 35 TO 45 SCREEN LOC. SUSPECTED
	S-9	31/34	1.3/1.5		V. DENSE	BLUE GRAY	SILTY SAND (FINE TO C)	SM	POOR [illegible] MOIST → WET (OPPM)
	41.5	24					SOME GRAVEL - TR	GM	LITTLE MORE CLAY THAN
							CLAY		S-8 SUBROUNDED GRAVEL
									VERY SLOW DRILLING 120-45 (RIG STALLS)
	45.0					BLUE			LESS CLAY LAST 3" OF SAMPLE
	S-10	13/34	1.3/1.5		V. DENSE	BLUE GRAY	SILTY SAND (FINE TO C)	SM/	MOIST → WET (OPPM)
	46.5	50					SOME GRAVEL - TR	GM	[illegible] SIZE - HOLDS SO - GETHER WHEN SQUEEZED
							CLAY		BUT NOT COHESIVE CLASS- IFICATION
									[illegible] 50'

REMARKS: S-6 @ 4:40 PM
S-7 @ 8:36 [illegible] 7-8-87
S-10 @ 10:40 [illegible] 7-11-5

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: B. ERICSSON
ELEVATION: — FIELD GEOLOGIST: S. COLETTI
WATER LEVEL DATA
(Date, Time & Conditions)

SAMPLE NO. & TYPE OF RIG	DEPTH FT. OR BLOW NO.	BLOWS 6" OR RQD FT.	SAMPLE RECOVERY SAMPLE LENGTH	LITHOLOGY CHANGE (GRAPHICAL OR NUMBERED)	MATERIAL DESCRIPTION: RELATIVE DENSITY CONSISTENCY OR ROCK HARDNESS	COLOR	MATERIAL CLASSIFICATION	USCS	REMARKS
S-11	50.0	15/41	1.9/1.3		V. DENSE	MEDIUM BROWN	SILTY SAND - SOME GR.	SM	MOIST - (0 PPM)
	51.3	50/4				LIGHT GRAY	TR CLAY	SM	PARTICLES W/ PCS OF BLACK/BRN/LIGHTER
									MORE CLAY THAN ABOVE PORTIONS OF SAMPLE - COHESIVE [illegible]
	55.0			55.0					
S-12		11/15/20	1.4/.5		V. STIFF TO STIFF	GRAY OTTING BRN	SANDY CLAY / CLAYEY SAND	SC	MOIST → WET (0 PPM)
	56.5						SOME GRAVEL		NOTE COLOR CHANGE ALSO - MORE CLAY THAN ANY SAMPLE SUB-ROUNDED GRAINS
									FIRST COHESIVE TYPE SAMPLE
	60.0	40							
S-13	60.9	50/4	0.7/0.9		V. DENSE	ORANGE BRN	SANDY CLAY / CLAYEY SAND - SOME	SC	MOIST - WET (0 PPM)
							GRAVEL	GW	[illegible] AS S-12 BUT FEW CRANITE SUB-ROUNDED GRAINS
									SEE CAL. [illegible]
	65.0								
7/13 S-14	65.8	37/50/4	0.7/0.8		V DENSE	DARK ORANGE	SILTY SAND - SOME GR	SM	MOIST (0 PPM)
							AND ROCK FRAG -	GW	MORE CLAY THREADS
				72.0			TR. CLAY		TOP OF SAMPLE HAS 3/4" D SIZE
						YELLOW BRN			COLOR CHANGE AT [illegible] MORE SAND PER DRILLER - BOTTOM OF SEAM COAL LAYER 2
	70.0								
7/14 S-15		50/5	1.0/1.5		V. DENSE	YELLOW BRN	CLAYEY SAND (F TO C) SOME	SC	MOIST → WET (0 PPM)
	71.5	41					GRAVEL - TR	GC	1" MAX GRAVEL
							ROCK FRAG.		MORE GRAVEL [illegible] PER DRILLER

REMARKS: USING HOLLOW STEM — BOULDER [illegible] NOT THRU AUGERS, WHEN TRIED TO [illegible] SAMPLE
S-12 @ 1:46 PM
S-13 → 3:32 PM - LOGGED IN BY 5:47 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
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BORING LOG — **NUS CORPORATION**

PROJECT: WESTLINE SITE
PROJECT NO.: -37Y
ELEVATION:
WATER LEVEL DATA
(Date, Time & Conditions)

DATE: 7-13-87 / 7-14-87
FIELD GEOLOGIST: SJ. CONTI

BORING NO. MW013
DRILLER: B. ERICSON

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

REMARKS S-17 @ 2:20 PM 7-14-87 - METHOD HELLOW 6" CASING SPUN 4" ø - 5 7/8" OD BITS TO 70TH. USING WATER AS DRILLING FLUID

BORING MW 013

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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.

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

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

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

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

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

7.0 RECORDS

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

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

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

ATTACHMENT A

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

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

Preliminary Ranking of Rigid Materials

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

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

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

Preliminary Ranking of Semi-Rigid or Elastomeric Materials

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

ATTACHMENT B

COMPARISON OF STAINLESS STEEL AND PVC FOR MONITORING WELL CONSTRUCTION

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

* See also Attachment A.

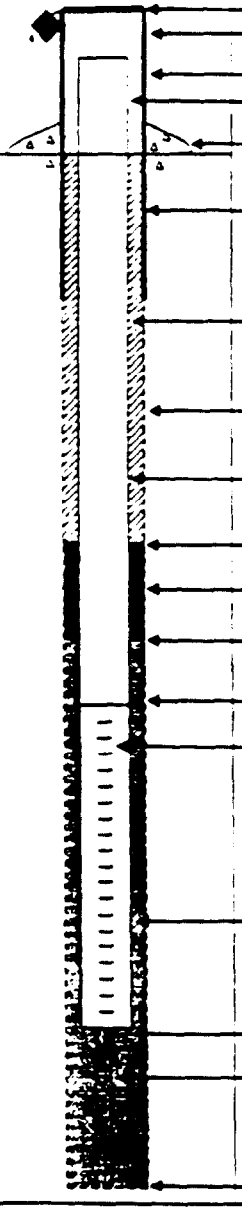
ATTACHMENT C

NUS CORPORATION
A Halliburton Company

BORING NO _____

OVERBURDEN
MONITORING WELL SHEET

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



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

ATTACHMENT C
PAGE TWO

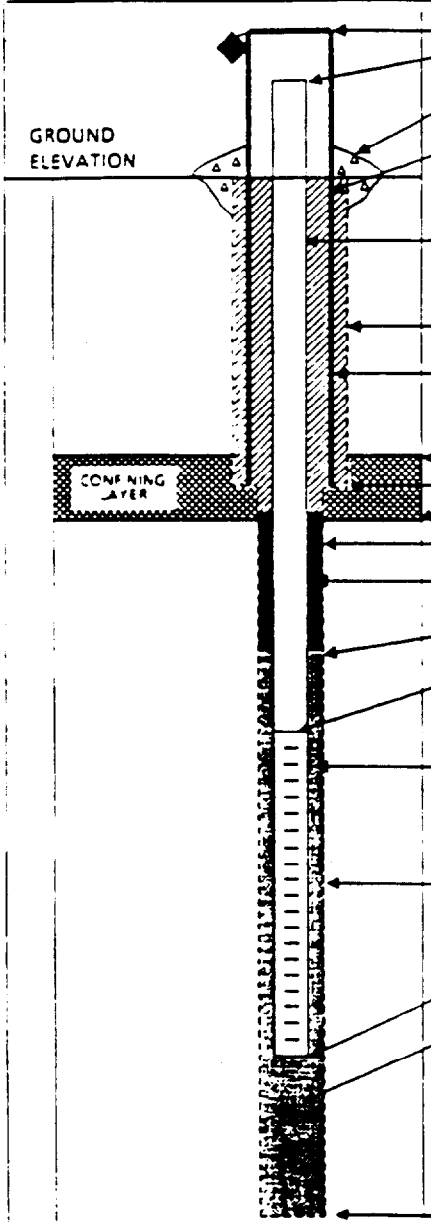
NUS CORPORATION

BORING NO.: _____

CONFINING LAYER
MONITORING WELL SHEET

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

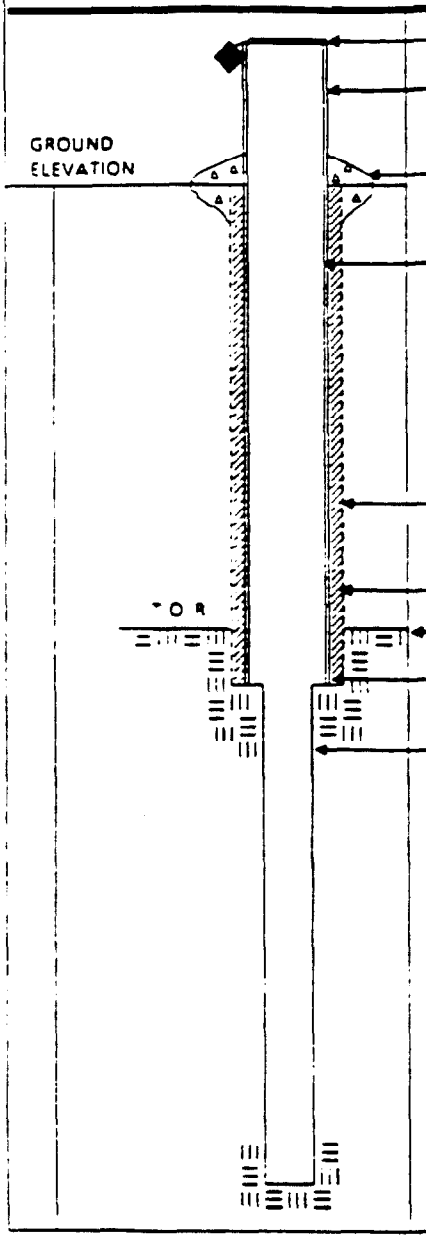
NUS CORPORATION
A Halliburton Company

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: _____

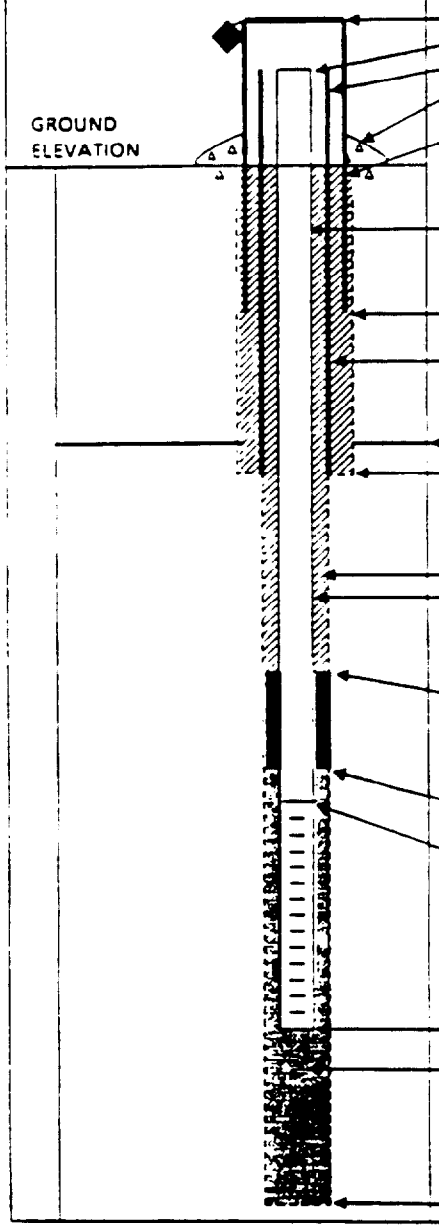
ATTACHMENT C
PAGE FOUR

BORING NO.: _____

BEDROCK
MONITORING WELL SHEET
WELL INSTALLED IN BEDROCK

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

DRILLER _____
DRILLING METHOD _____
DEVELOPMENT METHOD _____



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

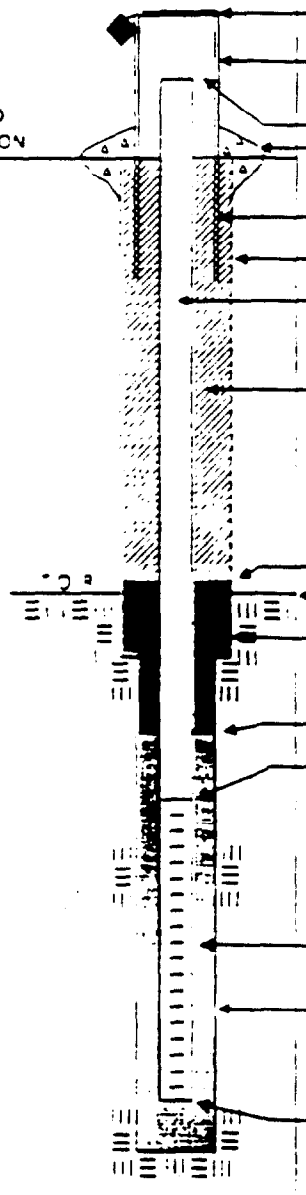
ATTACHMENT C
PAGE FIVE

NUS CORPORATION
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: _____

1.0 PURPOSE

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

2.0 SCOPE

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

3.0 GLOSSARY

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

4.0 RESPONSIBILITIES

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

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

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

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

5.0 PROCEDURES

5.1 APPLICABILITY

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

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

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

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

5.2 TEST PIT AND TRENCH EXCAVATION

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

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

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

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

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

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

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

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

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

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

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

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

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

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

5.3 BACKFILLING OF TRENCHES AND TEST PITS

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

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

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

6.0 REFERENCES

NUS and CH_2MHill, August, 1987. Compendium of Field Operation Methods. Prepared for the U.S. EPA.

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

7.0 RECORDS

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

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

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

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

5.0 PROCEDURES

5.1 IN-SITU HYDRAULIC CONDUCTIVITY TESTING IN WELLS

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

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

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

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

recovering wells. A typical schedule for measurements for a slow recovering well would be 0, 0.25, 0.5, 0.75, 1.0, 1.5, 2.0, 3.0, 4.0, 6.0, 8.0, 10.0, 15.0, 20.0, 30.0, . . . minutes from the beginning the test. Measurements shall be taken from the top of the well casing.

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

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

- Well/boring ID number
- Total depth of well/boring
- Screened/open interval depth and length
- Gravel pack interval depth and length
- Well and boring radii
- Well stickup above ground surface
- Gravel pack radius
- Static water level
- Aquifer thickness
- Depth to confining layer
- Time/recovery data
- Gravel pack porosity

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

5.2 IN-SITU HYDRAULIC CONDUCTIVITY TESTING IN BORINGS

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

Rising head or falling head slug tests can be performed in saturated and unsaturated formations during drilling. There are two ways that the tests can be performed. One way entails setting the casing flush with the bottom of the boring when the desired testing depth has been reached. The hole is then cleaned out to remove loose materials, the drill bit and rods are carefully withdrawn from the boring, and a few feet of sand (of higher permeability than the surrounding formation) is added to the bottom of the boring. After the water level in the boring has stabilized (for saturated formations), the static water level shall be measured and recorded. The water level shall then be raised (falling head test) or lowered (rising head test) and the change in water level measured at time intervals as determined by the field hydrogeologist. Only falling head tests can be performed for depth intervals within the unsaturated (vadose) zone. As described for wells, time intervals for water-level measurements will vary according to the formation's hydraulic conductivity. The faster the rate

of recovery expected, the shorter the time intervals between measurements shall be. A predetermined pattern of time intervals shall be used during each test. The rate of change of water level will be used to calculate hydraulic conductivity. The test shall be conducted until the water level again stabilizes, or for a minimum of 20 minutes. In low permeability formations, it is not always practical to run the test until the water level stabilizes, as it may take a long time to do so. The top of the casing shall be used as the reference point for all water level measurements.

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

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

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

5.3 DATA ANALYSIS

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

One consideration to be noted during data analysis is the determination of the screened/open interval of a tested well. If a well with a fully submerged screen is installed in a relatively low permeability formation, and a gravel pack which is significantly more permeable is installed around the screen, the length of the gravel pack (if longer than the screened interval) may be used as the

screened/open length, rather than the screen length itself. In situations where the formation permeability is judged to be comparable to the gravel pack permeability (within about an order of magnitude) this adjustment is not required.

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

6.0 REFERENCES

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

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

Hvorslev, M. J., 1951. Time Lag and Soil Permeability in Ground Water Observations. U.S. Army Corps of Engineers, Waterways Experiment Station, Washington, D.C., Bull. No. 36.

Papadopulos, I. S., J. D. Bredehoeft, and H. H. Cooper, 1973. On the Analysis of Slug Test Data. Water Resources Research, V. 9, No. 4, pp. 1087-1089.

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

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

7.0 RECORDS

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

* If an automated data recorder is used, the data may be displayed using the printer output from the unit. Such printouts should be annoted to include the relevant data form, or attached to the form shown as Attachment A.

5.0 PROCEDURES

5.1 GENERAL

Groundwater level measurements can be made in monitoring wells, private or public water wells, piezometers, open boreholes, or test pits (after stabilization). Groundwater measurements should generally not be made in boreholes with drilling rods or auger flights present. If groundwater sampling activities are to occur, groundwater level measurements shall take place prior to well evacuation or sampling.

All groundwater level measurements shall be made to the nearest 0.01 foot, and recorded in the geologist's field notebook or on the Groundwater Level Measurement Sheet (Attachment A), along with the date and time of the reading. The total depth of the well shall be measured and recorded, if not already known. Weather changes that occur over the period of time during which water levels are being taken, such as precipitation and bariometric pressure changes, should be noted.

In measuring groundwater levels, there shall be a clearly-established reference point of known elevation, which is normally identified by a mark on the upper edge of the inner well casing. The reference point shall be noted in the field notebook. To be useful, the reference point should be tied in with an established USGS benchmark or other properly surveyed elevation datum. An arbitrary datum could be used for an isolated group of wells if necessary.

Cascading water within a borehole or steel well casings can cause false readings with some types of sounding devices (chalked line, electrical). Oil layers may also cause problems in determining the true water level in a well. Special devices (interface probes) are available for measuring the thickness of oil layers and true depth to groundwater if required.

Water level readings shall be taken regularly, as required by the site hydrogeologist. Monitoring wells or open-cased boreholes that are subject to tidal fluctuations should be read in conjunction with a tidal chart (or preferably in conjunction with readings of a tide staff or tide level recorder installed in the adjacent water body); the frequency of such readings shall be established by the site hydrogeologist All water level measurements at a site used to develop a groundwater contour map shall be made in the shortest practical time to minimize affects due weather changes, and at least during the same day.

5.2 WATER LEVEL MEASURING TECHNIQUES

There are several methods for determining standing or changing water levels in boreholes and monitoring wells. Certain methods have particular advantages and disadvantages depending upon well conditions. A general description of these methods is presented, along with a listing of various advantages and disadvantages of each technique. An effective technique shall be selected for the particular site conditions by the onsite hydrogeologist.

In most instances, preparation of accurate potentiometric surface requires that static water level measurements be obtained to a precision of 0.01 feet. To obtain such measurements in individual accessible wells, the Chalked Tape or Electrical Water Level Indicator methods have been found best, and thus are the most often utilized. Other, less precise methods, such as the Popper or Bell Sound or Bailer Line methods, may be appropriate for developing preliminary estimates of hydraulic conditions. When a large number of (or continuous) readings are required, time-consuming individual readings are not usually feasible. In such cases, it is best to use the Float Recorder or Pressure Transducer methods. When conditions in the well limit readings (i.e., turbulence in the

water surface or limited access through small diameter tubing), less precise, but appropriate, methods such as the Air Line or Capillary Tubing methods can be used.

5.2.1 Methods

Water levels can be measured by several different techniques, but the same steps shall be followed in each case. The proper sequence is as follows:

1. Check operation of recording equipment above ground. Prior to opening the well, don personal protective equipment as required.

2. Record all information specified below in the geologist's field notebook or on the Groundwater Level Measurement Sheet.

   a. Well number.
   b. Record water level to the nearest 0.01 foot (0.3 cm). Water levels shall be taken from the surveyed reference mark on the top edge of the inner well casing.
   c. Record the time and day of the measurement.

Water level measuring devices with permanently marked intervals shall be used when possible. If water level measuring devices marked by metal or plastic bands clamped at intervals along the measuring line are used, the spacing and accuracy of these bands shall be checked frequently as they may loosen and slide up or down the line, resulting in inaccurate reference points (see Section 5.2.3).

5.2.2 Water Level Measuring Devices

Chalked Steel Tape

The water level is measured by chalking a weighted steel tape and lowering it a known distance (to any convenient whole foot mark) into the well or borehole. The water level is determined by subtracting the wetted chalked mark from the total length lowered into the hole.

The tape shall be withdrawn quickly from the well because water has a tendency to rise up the chalk due to capillary action. A water finding paste may be used in place of chalk. The paste is spread on the tape the same way as the chalk, and turns red upon contacting water.

Disadvantages to this method include the following: depths are limited by the inconvenience of using heavier weights to properly tension longer tape lengths; ineffective if borehole/well wall is wet or inflow is occurring above the static water level; chalking the tape is time consuming; difficult to use during periods of precipitation.

Electric Water Level Indicators

These devices consist of a spool of small-diameter cable and a weighted probe attached to the end. When the probe comes in contact with the water, an electrical circuit is closed and a meter, light, and/or buzzer attached to the spool will signal the contact.

There are a number of commercial electric sounders available, none of which is entirely reliable under all conditions likely to occur in a contaminated monitoring well. In conditions where there is oil on the water, groundwater with high specific conductance, water cascading into the well, steel well casing, or a turbulent water surface in the well, measuring with an electric sounder may be difficult.

For accurate readings, the probe shall be lowered slowly into the well. The electric tape is marked at the measuring point where contact with the water surface was indicated. The distance from the mark to the nearest tape band is measured using an engineer's folding ruler or steel tape and added to the band reading to obtain the depth to water. If band is not a permanent marking band, spacing shall be checked periodically as described in Section 5.2.3.

Popper or Bell Sounder

A bell- or cup-shaped weight that is hollow on the bottom is attached to a measuring tape and lowered into the well. A "plopping" or "popping" sound is made when the weight strikes the surface of the water. An accurate reading can be determined by lifting and lowering the weight in short strokes, and reading the tape when the weight strikes the water. This method is not sufficiently accurate to obtain water levels to 0.01 feet, and thus is more appropriate for obtaining only approximate water levels quickly.

Float Recorder

A float or an electromechanically actuated water-seeking probe may be used to detect vertical changes of the water surface in the hole. A paper-covered recording chart drum is rotated by the up and down motion of the float via a pulley and reduction gear mechanism, while a clock drive moves a recording pen horizontally across the chart. To ensure continuous records, the recorder shall be inspected, maintained, and adjusted periodically. This type of device is useful for continuously measuring periodic water level fluctuations, such as tidal fluctuations or influences of pumping wells.

Air Line

An air line is especially useful in pumped wells where water turbulence may preclude the use of other devices. A small-diameter weighted tube of known length is installed from the surface to a depth below the lowest water level expected. Compressed air (from a compressor, bottled air, or air pump) is used to purge the water from the tube, until air begins to escape the lower end of the tube, and is seen (or heard) to be bubbling up through the water in the well. The pressure needed to purge the water from the air line multiplied by 2.307 (feet of water for 1 psi) equals the length in feet of submerged air line. The depth to water below the center of the pressure gauge can be calculated by subtracting the length of air line below the water surface from the total length of the air line.

The disadvantages to this method include the need for an air supply and lower level of accuracy (unless a very accurate air pressure gauge is used, this method cannot be used to obtain water level readings to the nearest 0.01 ft).

Capillary Tubing

In small diameter piezometer tubing, water levels are determined by using a capillary tube. Colored or clear water is placed in a small "U"-shaped loop in one end of the tube (the rest of the tube contains air). The other end of the capillary tube is lowered down the piezometer tubing until the water in the loop moves, indicating that the water level has been reached. The point is then measured from the bottom of the capillary tube or recorded if the capillary tube is calibrated. This is the best method for very small diameter tubing monitoring systems such as Barcad and other multilevel samples. Unless the capillary tube is calibrated, two people may be required to measure the length of capillary tubing used to reach the groundwater. Since the piezometer tubing and capillary tubing usually are somewhat coiled when installed, it is difficult to accurately measure absolute water level elevations using this method. However, the method is useful in accurately measuring differences or changes in water levels (i.e., during pumping tests).

Pressure Transducer

Pressure transducers can be lowered into a well or borehole to measure the pressure of water and therefore the water elevation above the transducer. The transducer is wired into a recorder at the surface to record changes in water level with time. The recorder digitizes the information and can provide a printout or transfer the information to a computer for evaluation (using a well drawdown/recovery model). The pressure transducer should be initially calibrated with another water level measurement technique to ensure accuracy. This technique is very useful for hydraulic conductivity testing in highly permeable material where repeated, accurate water level measurements are required in a very short period of time. A sensitive transducer element is required to measure water levels to 0.01 foot accuracy.

Borehole Geophysics

Approximate water levels can be determined during geophysical logging of the borehole (although this is not the primary purpose for geophysical logging and such logging is not cost-effective if used only for this purpose). Several logging techniques will indicate water level. Commonly-used logs which will indicate saturated/unsaturated conditions include the spontaneous potential (SP) log and the neutron log.

Bailer Line Method

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

5.2.3 Data Recording

Water level measurements, time, data, and weather conditions shall be recorded in the geologist's field notebook or on the Groundwater Level Measurement Sheet. All water level measurements shall be measured from a known reference point. The reference point is generally a marked point on the upper edge of the inner well casing that has been surveyed for an elevation. The exact reference point shall be marked with permanent ink on the casing since the top of the casing may not be entirely level. It is important to note changes in weather conditions because changes in the barometric pressure may affect the water level within the well.

5.2.4 Specific Quality Control Procedures for Water Level Measuring Devices

All groundwater level measurement devices must be cleaned before and after each use to prevent cross contamination of wells.

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

5.3 POTENTIOMETRIC SURFACE MAPPING

5.3.1 Selection of Wells

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

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

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

5.3.2 Construction of Equipotential Lines

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

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

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

5.3.3 Determination of Groundwater-Flow Direction

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

5.4 HEALTH AND SAFETY CONSIDERATIONS

Groundwater contaminated by volatile organic compounds may release toxic vapors into the air space inside the well pipe. The release of this air when the well is initially opened is a Health/Safety hazard which must be considered. Initial monitoring of the well headspace and breathing zone

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

6.0 REFERENCES

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

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

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

7.0 ATTACHMENTS

Attachment A - Groundwater Level Measurem heet

Attachment B - Water Level Indicator Calibration Sheet.

- 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.

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.

1.0 PURPOSE

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

2.0 SCOPE

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

3.0 GLOSSARY

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

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

4.0 RESPONSIBILITIES

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

5.0 PROCEDURES

5.1 INTRODUCTION

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

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

5.2 DEFINING THE SAMPLING PROGRAM

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

5.2.1 Sampling Program Objectives

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

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

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

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

5.2.2 Location of Sampling Stations

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

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

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

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

5.2.3 Frequency of Sampling

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

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

5.3 SURFACE WATER SAMPLE COLLECTION

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

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

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

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

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

5.3.2 Lakes, Ponds and Reservoirs

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

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

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

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

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

5.3.3 Estuaries

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

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

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

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

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

5.3.4 Surface Water Sampling Equipment

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

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

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

The criteria for selecting a sampler include:

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

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

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

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

5.3.4.1 Dip Sampling

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

5.3.4.2 Weighted Bottle Sampling

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

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

- Gently lower the sampler to the desired depth so as not to remove the stopper prematurely (watch for bubbles).
- Pull out the stopper with a sharp jerk of the sampler line.
- Allow the bottle to fill completely, as evidenced by the absence of air bubbles.
- Raise the sampler and cap the bottle.
- Decontaminate the outside of the bottle. The bottle can be used as the sample container (as long as original bottle is an approved container).

5.3.4.3 Kemmerer

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

5.3.5 Surface Water Sampling Techniques

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

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

5.4 SEDIMENT SAMPLING

5.4.1 General

Sediment samples are usually collected at the same verticals at which water samples were collected. If only one sediment sample is to be collected, the site shall be approximately at the center of water body. Generally, the coarser grained sediments are deposited near the headwaters of the reservoir Bed sediments near the center will be composed of fine-grained materials which may, because of their lower porosity and greater surface area available for adsorption, contain greater concentrations

of contaminants. The shape, flow pattern, bathometry (depth distribution), and water circulation patterns must all be considered when selecting sediment sampling sites. In streams, areas likely to have sediment accumulation (bends, behind islands or boulders, quiet shallow areas or very deep, low-velocity areas) shall be sampled while areas likely to show net erosion (high-velocity, turbulent areas) and suspension of fine solid materials shall be avoided.

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

5.4.2 Sampling Equipment and Techniques

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

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

The following samplers may be used to collect bottom materials:

- Scoop sampler
- Dredge samplers

5.4.2.1 Scoop Sampler

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

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

5.4.2.2 Dredges

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

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

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

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

6.0 REFERENCES

Feltz, H. R., 1980. Significance of Bottom Material Data in Evaluating Water Quality in Contaminants and Sediments. Ann Arbor, Michigan, Ann Arbor Science Publishers, Inc., V. 1, p. 271-287.

Kittrell, F. W., 1969. A Practical Guide to Water Quality Studies of Streams. U.S. Federal Water Pollution Control Administration, Washington, D.C., 135p.

U.S. EPA, 1980. Standard Operating Procedures and Quality Assurance Manual. Water Surveillance Branch, USEPA Surveillance and Analytical Division, Athens, Georgia.

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

7.0 ATTACHMENTS

None.

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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 i[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

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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

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 _____ :rilled. 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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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.

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1.0 PURPOSE

This procedure describes the appropriate containers to be used for samples depending on the analyses to be performed, and the steps necessary to preserve the samples when shipped offsite for chemical analysis.

2.0 SCOPE

Different types of chemicals react differently with sample containers made of various materials. For example, trace metals adsorb more strongly to glass than to plastic, while many organic chemicals may dissolve various types of plastic containers. It is therefore critical to select the correct container in order to maintain the quality of the sample prior to analysis.

Many water and soil samples are unstable, and therefore require preservation when the time interval between field collection and laboratory analysis is long enough to produce changes in either the concentration or the physical condition of the constituent(s) requiring analysis. While complete and irreversible preservation of samples is not possible, preservation does retard the chemical and biological changes that inevitably take place after the sample is collected.

Preservation techniques are usually limited to pH control, chemical addition(s) and refrigeration/freezing. Their purpose is to (1) retard biological activity, (2) retard hydrolysis of chemical compounds/complexes, (3) reduce constituent volatility, and (4) reduce adsorption effects.

3.0 GLOSSARY

HCl - Hydrochloric Acid
H_2SO_4 - Sulfuric Acid
HNO_3 - Nitric Acid
NaOH - Sodium Hydroxide

Normality (N) - Concentration of a solution expressed as equivalent per liter, an equivalent being the amount of a substance containing one gram-atom of replaceable hydrogen or its equivalent. Thus, a one molar solution of HCl, containing one gram-atom of H, is "one-normal," while a one molar solution of H_2SO_4 containing two gram-atoms of H, is "two-normal."

4.0 RESPONSIBILITIES

Field Operations Leader - retains overall responsibility for the proper storage and preservation of samples. During the actual collection of samples, the sampling technician(s) will be directly responsible for the bottling, preservation, labeling, and custody of the samples they collect until released to another party for storage or transport to the analytical laboratory.

5.0 PROCEDURES

5.1 SAMPLE CONTAINERS

For most samples and analytical parameters either glass or plastic containers are satisfactory. In general, if the analyte(s) to be determined is organic in nature, the container shall be made of glass. If the analyte(s) is inorganic, then the container shall be plastic. Since container specification will depend on the analyte and sample matrix types (as indicated in Attachment A) duplicate samples shall be taken when both organic and inorganic analyses are required. Containers shall be kept in the

dark (to minimize biological or photooxidation/photolysis breakdown of constituent) until they reach the analytical laboratory. The sample container shall allow approximately 5-10 percent air space ("ullage") to allow for expansion/vaporization if the sample is heated during transport (1 liter of water at 4°C expands by 15 ml if heated to 130°F/55°C), however, head space for volatile organic analyses shall be omitted.

For CLP laboratories, containers will be obtained through the CLP Sample Management Office. For Responsible party actions or non-CLP laboratories, the laboratory shall provide containers that have been cleaned according to U.S. EPA procedures. Sufficient lead time shall be allowed. Shipping containers for samples, consisting of sturdy ice chests, are provided by the laboratory of the remedial investigation contractor.

Once opened, the container must be used at once for storage of a particular sample. Unused but opened containers are to be considered contaminated and must be discarded; because of the potential for introduction of contamination, they cannot be reclosed and saved for later use. Likewise, any unused containers which appear contaminated upon receipt, or which are found to have loose caps or missing Teflon liner (if required for the container) shall be discarded.

General sample container and sample volume requirements are listed in Attachment A. Specific container requirements are listed in Attachment B.

5.2 PRESERVATION TECHNIQUES

The preservation techniques to be used for various analytes are listed in Attachments A and B. Reagents required for sample preservation will either be added to the sample containers by the laboratory prior to their shipment to the Field or added in the Field. In general, aqueous samples of low concentration organics (or soil samples of low or medium concentration organics) are cooled to 4°C. Medium concentration aqueous samples and high hazard organics sample are not preserved. Low concentration aqueous samples for metals are acidified with HNO_3, while medium concentration and high hazard aqueous metal samples are not preserved. Low or medium concentration soil samples for metals are cooled to 4°C while high hazard samples are not preserved.

The following subsections describe the procedures for preparing and adding chemical preservatives. Attachments A and B indicate the specific analytes which require these preservatives.

5.2.1 Addition of Acid (H_2SO_4, HCl, or HNO_3) or Base

Addition of the following acids or bases may be specified for sample preservation; these reagents shall be analytical reagent (AR) grade and shall be diluted to the required concentration with double-distilled, deionized water in the laboratory, before Field sampling commences:

Acid Base	Concentration	Normality	Amount for Acidification*
HCl	1:1 dilution of concentrated HCl	6N	5-10 ml
H_2SO_4	1:1 dilution of concentrated H_2SO_4	18N	2-5 ml
HNO_3	Undiluted concentrated HNO_3	16N	2-5 ml
NaOH	400 grams solid NaOH in 870 ml water	10N	2 ml**

* Amount of acid to add (at the specified strength) per liter of water to reduce the sample pH to less than 2, assuming that the water is initially at pH 7, and is poorly buffered and does not contain particulate matter.

** To raise pH of 1 liter of water to 12.

The approximate volumes needed to acidify one liter of neutral water to a pH of less than 2 (or raise the pH to 12) are shown in the last column of the above table. These volumes are only approximate; if the water is more alkaline, contains inorganic or organic buffers, or contains suspended particles, more acid may be required. The final pH must be checked using narrow-range pH paper.

Sample acidification or base addition shall proceed as follows:

- Check initial pH of sample with wide range (0-14) pH paper.
- Fill sample bottle to within 5-10 ml of final desired volume and add about 1/2 of estimated acid or base required, stir gently and check pH with medium range pH paper (pH 0-6 or pH 7.5-14, respectively).
- Add acid or base a few drops at a time while stirring gently. Check for final pH using narrow range (0-2.5 or 11-13, respectively) pH paper; when desired pH is reached, cap sample bottle and seal.

  Never dip pH paper into the sample; apply a drop of sample to the pH paper using the stirring rod.

5.2.2 Cyanide Preservation

Pre-sample preservation is required if oxidizing agents such as chlorine are suspected to be present. To test for oxidizing agents, place a drop of the sample on KI-starch paper; a blue color indicates the need for treatment. Add ascorbic acid to the sample, a few crystals at a time, until a drop of sample produces no color on the KI-starch paper. Then add an additional 0.6 g of ascorbic acid for each liter of sample volume. Add NaOH solution to raise pH to greater than 12 as described in 5.2.1. If oxidizing agents are not suspected, add NaOH as directed.

5.2.3 Sulfide Preservation

Samples for sulfide analysis must be preserved by addition of 4 drops (0.2 ml) of 2N zinc acetate solution per 100 ml sample. The sample pH is then raised to 9 using NaOH. The 2N zinc acetate solution is made by dissolving 220 g of zinc acetate in 870 ml of distilled water to make 1 liter of solution.

5.2.4 Preservation of Organic Samples Containing Residual Chlorine

Some organic samples containing residual chlorine must be treated to remove this chlorine upon collection (See Attachment A). Test the samples for residual chlorine using EPA methods 330.4 or 330.5 (Field Test Kits are available for this purpose). If residual chlorine is present, add 0.008% sodium thiosulfate (80 mg per liter of sample).

5.2.5 Field Filtration

When the objective is to determine concentration of dissolved inorganic constituents in a water system, the sample must be filtered through a non-metallic 0.45 micron membrane filter immediately after collection. A filtration system is recommended if large quantities of samples must be filtered in the field. The filtration system shall consist of a Büchner funnel inserted into a single-hole rubber stopper, sized to form a seal when inserted into the top of a vacuum filter flask equipped with a single side arm. Heavy-wall Tygon tubing shall be attached to the single side arm of the vacuum filter flask and the suction port of a vacuum pump. The stem of the Büchner funnel shall extend below the level of the side arm of the vacuum filter flask to prevent any solvent from entering the tubing leading to the vacuum pump. Before filtration, the filter paper, which shall be of a size to lay flat on the funnel plate, shall be wetted with the solvent in order to "seal" it to the funnel. Slowly pour the solvent into the funnel and monitor the amount of solvent entering the vacuum filter flask. When the rate of solvent entering the flask is reduced to intermittent dripping and the added aliquot of solvent in the funnel has passed through the filter, the used filter paper shall be replaced with new filter paper. If the solvent contains a high percentage of suspended solids, a coarser-sized nonmetallic membrane filter may be used prior to usage of the 0.45 micron membrane filter. This "prefiltering" step may be necessary to expedite the filtration procedure. Discard the first 20 to 50 ml of filtrate from each sample to rinse the filter and filtration apparatus to minimize the risk of altering the composition of the samples by the filtering operation. For analysis of dissolved metals, the filtrate is collected in a suitable bottle (see Section 5.1) and is immediately acidified to pH 2.0 or less with nitric acid whose purity is consistent with the measurement to be made. Inorganic anionic constituents may be determined using a portion of the filtrate that has not been acidified.

Samples used for determining temperature, dissolved oxygen, Eh, and pH should not be filtered. Do not use vacuum filtering prior to determining carbonate and bicarbonate concentration because it removes dissolved carbon dioxide and exposes the sample to the atmosphere. Pressure filtration can be done using water pressure from the well. If gas pressure is required, use an inert gas such as argon or nitrogen.

Do not filter samples for analysis of volatile organic compounds. If samples are to be filtered for analyzing other dissolved organic constituents, use a glass-fiber or metal-membrane filter and collect the samples in a suitable container (see Section 5.1). Because most organic analyses require extraction of the entire sample, do not discard any of it. After filtering, the membrane containing the suspended fraction can be sealed in a glass container and analyzed separately as soon as practicable. Total recoverable inorganic constituents may be determined using a second, unfiltered sample collected at the same time as the sample for dissolved constituents.

1.0 PURPOSE

The purpose of these procedures is to provide a general methodology, protocol, and reference information on the proper decontamination procedures to be used on chemical sampling and field analytical equipment.

2.0 SCOPE

This procedure addresses chemical sampling and field analytical equipment only, and should be consulted when equipment decontamination procedures are being developed as part of project-specific plans.

3.0 GLOSSARY

None.

4.0 RESPONSIBILITIES

Site Manager - responsible for ensuring that project-specific plans and the implementation of field investigations are in compliance with these guidelines.

Field Operations Leader - responsible for ensuring that decontamination procedures for all chemical sampling and field analytical equipment are programmed prior to the actual field effort and that personnel required to accomplish the task have been briefed and trained to execute the task.

5.0 PROCEDURES

In order to assure that chemical analysis results are reflective of the actual concentrations present at sampling locations, chemical sampling and field analysis equipment must be properly decontaminated prior to the field effort, during the sampling program (i.e., between sample points) and at the conclusion of the sampling program. This will minimize the potential for cross-contamination between sample points and the transfer of contamination offsite.

This procedure incorporates only those aspects of decontamination not addressed in other procedures. Specifically it incorporates those items involved in decontamination of chemical sampling and field analytical equipment.

5.1 ACCESS FOR SAMPLING

5.1.1 Bailers and Bailing Line

The potential for cross-contamination between sampling points via the use of common bailer, or its attached line, is high unless strict procedures for decontamination are followed. It is preferable, for the aforementioned reason, to dedicate an individual bailer and its line to each sample point, although this does not eliminate the need for decontamination of dedicated bailers. For non-dedicated sampling equipment, the following conditions and/or decontamination procedures should be followed.

Before the initial sampling and after each succeeding sampling point, the bailer must be decontaminated. The following steps should be followed if sampling for organic contaminants:

- Potable water rinse
- Alconox or Liquinox detergent wash
- Scrubbing of the line and bailer with a scrub brush may be required if the sample point if heavily contaminated with heavy or extremely viscous compounds
- Potable water rinse
- Rinse with 10 percent nitric acid solution*
- Deionized water rinse
- Acetone or methanol rinse
- Hexane rinse**
- Distilled/Deionized water rinse
- Air dry

If sampling for organics only, the nitric acid, acetone, methanol, and hexane rinses may be omitted. Contract-specific requirements may permit alternative procedures.

Braided nylon or polypropylene lines may be used with a bailer, however, the same line must not come in contact with the sample medium, otherwise, the line must be discarded in an approved receptacle and replaced. Prior to use, the bailer should be wrapped in aluminum foil or polyethylene sheeting.

5.1.2 Sampling Pumps

Most sampling pumps are normally low volume (less than 2 gpm) pumps. These include peristaltic, diaphragm, air-lift, pitcher and bladder pumps, to name a few. If these pumps are used for sampling from more than one sampling point, they must be decontaminated.

The procedures to be used for decontamination of sampling pumps compare to those used for a bailer except the 10 percent nitric acid solution is omitted. Each of the liquid factions is to be pumped through the system. The amount of pumping is dependent upon the size of the pump and the length of the intake and discharge hoses. Certain types of pumps are unacceptable for sampling purposes.

An additional problem is introduced when the pump relies on absorption of water via an inlet or outlet hose. For organic sampling, this hose should be Teflon. Other types of hoses leach organics into the water being sampled (especially the phthalate esters) or adsorb organics from the sampled water. For all other sampling, the hose should be Viton, polyethylene, or polyvinyl chloride (in order of preference). Whenever possible, dedicated hoses should be used.

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* Due to the leaching ability of nitric acid, on stainless steel, this step is to be omitted if a stainless steel sampling device is being used and metals analysis is required with detection limits less than approximately 50 ppb; or the sampling equipment is dedicated.

** If sampling for pesticides, PCBs, or fuels.

5.1.3 Filtering Equipment

Part of the sampling plan may incorporate the filtering of groundwater samples, and subsequent preservation. This should occur as soon after sample retrieval as possible; preferably in the field as soon as the sample is obtained. To this end, three basic filtration systems are most commonly used - the in-line disposable Teflon filter, the inert gas over-pressure filtration system, and the vacuum filtration system.

For the in-line filter, decontamination is not required since the filter cartridge is disposable, however, the cartridge must be disposed of in an approved receptacle and the intake and discharge lines must still be decontaminated.

For the over-pressure and the vacuum filtration systems, the portions of the apparatus which come in contact with the sample must be decontaminated as outlined in the paragraphs describing the decontamination of bailers. (Note: Varieties of both of these systems come equipped from the manufacturer with Teflon-lined surfaces for those that would come into contact with the sample. These filtration systems are preferred when decontamination procedures must be employed.)

5.2 FIELD ANALYTICAL EQUIPMENT

5.2.1 Water Level Indicators

Water level indicators that come into contact with groundwater must be decontaminated using the following steps:

- Rinse with potable water
- Rinse with deionized water
- Acetone or methanol rinse
- Rinse with deionized water

Water level indicators that do not come in contact with the groundwater but may encounter incidental contact during installation or retrieval need only undergo the first and last steps stated above.

5.2.2 Probes

Probes, e.g., pH or specific ion electrodes, geophysical probes, or thermometers which would come in direct contact with the sample, will be decontaminated using the procedures specified above unless manufacturer's instructions indicate otherwise; in those cases, the methods of decontamination must be clearly described in the FSAP. Probes that contact a volume of groundwater not used for laboratory analyses can be rinsed with deionized water. For probes which make no direct contact, e.g., OVA equipment, the probe will be wiped with clean paper-towels or cloth wetted with alcohol.

6.0 REFERENCES

None.

7.0 RECORDS

None.

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Designation: D 1586 – 84

Standard Method for PENETRATION TEST AND SPLIT-BARREL SAMPLING OF SOILS[1]

This standard is issued under the fixed designation D 1586; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval. A superscript epsilon (ε) indicates an editorial change since the last revision or reapproval.

This method has been approved for use by agencies of the Department of Defense and for listing in the DOD Index of Specifications and Standards.

1. Scope

1.1 This method describes the procedure, generally known as the Standard Penetration Test (SPT), for driving a split-barrel sampler to obtain a representative soil sample and a measure of the resistance of the soil to penetration of the sampler.

1.2 *This standard may involve hazardous materials, operations, and equipment. This standard does not purport to address all of the safety problems associated with its use. It is the responsibility of whoever uses this standard to consult and establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.* For a specific precautionary statement, see § 4.1.

1.3 The values stated in inch-pound units are to be regarded as the standard.

2. Applicable Documents

2.1 *ASTM Standards:*

D 2487 Test Method for Classification of Soils for Engineering Purposes[2]

D 2488 Practice for Description and Identification of Soils (Visual-Manual Procedure)[2]

D 4220 Practices for Preserving and Transporting Soil Samples[2]

3. Descriptions of Terms Specific to This Standard

3.1 *anvil*—that portion of the drive-weight assembly which the hammer strikes and through which the hammer energy passes into the drill rods.

3.2 *cathead*—the rotating drum or windlass in the rope-cathead lift system around which the operator wraps a rope to lift and drop the hammer by successively tightening and loosening the rope turns around the drum.

3.3 *drill rods*—rods used to transmit downward force and torque to the drill bit while drilling a borehole.

3.4 *drive-weight assembly*—a device consisting of the hammer, hammer fall guide, the anvil, and any hammer drop system.

3.5 *hammer*—that portion of the drive-weight assembly consisting of the 140 ± 2 lb (63.5 ± 1 kg) impact weight which is successively lifted and dropped to provide the energy that accomplishes the sampling and penetration.

3.6 *hammer drop system*—that portion of the drive-weight assembly by which the operator accomplishes the lifting and dropping of the hammer to produce the blow.

3.7 *hammer fall guide*—that part of the drive-weight assembly used to guide the fall of the hammer.

3.8 *N-value*—the blow-count representation of the penetration resistance of the soil. The N-value, reported in blows per foot, equals the sum of the number of blows required to drive the sampler over the depth interval of 6 to 18 in. (150 to 450 mm) (see 7.3).

3.9 *ΔN*—the number of blows obtained from each of the 6-in. (150-mm) intervals of sampler penetration (see 7.3).

3.10 *number of rope turns*—the total contact angle between the rope and the cathead at the

[1] This method is under the jurisdiction of ASTM Committee D-18 on Soil and Rock and is the direct responsibility of Subcommittee D18.02 on Sampling and Related Field Testing for Soil Investigations.

[2] Annual Book of ASTM Standards, Volume

6. Drilling Procedure

6.1 The boring shall be advanced incrementally to permit intermittent or continuous sampling. Test intervals and locations are normally stipulated by the project engineer or geologist. Typically, the intervals selected are 5 ft (1.5 m) or less in homogeneous strata with test and sampling locations at every change of strata.

6.2 Any drilling procedure that provides a suitably clean and stable hole before insertion of the sampler and assures that the penetration test is performed on essentially undisturbed soil shall be acceptable. Each of the following procedures have proven to be acceptable for some subsurface conditions. The subsurface conditions anticipated should be considered when selecting the drilling method to be used.

6.2.1 Open-hole rotary drilling method.

6.2.2 Continuous flight hollow-stem auger method.

6.2.3 Wash boring method.

6.2.4 Continuous flight solid auger method.

6.3 Several drilling methods produce unacceptable borings. The process of jetting through an open tube sampler and then sampling when the desired depth is reached shall not be permitted. The continuous flight solid auger method shall not be used for advancing the boring below a water table or below the upper confining bed of a confined non-cohesive stratum that is under artesian pressure. Casing may not be advanced below the sampling elevation prior to sampling. Advancing a boring with bottom discharge bits is not permissible. It is not permissible to advance the boring for subsequent insertion of the sampler solely by means of previous sampling with the SPT sampler.

6.4 The drilling fluid level within the boring or hollow-stem augers shall be maintained at or above the in situ groundwater level at all times during drilling, removal of drill rods, and sampling.

7. Sampling and Testing Procedure

7.1 After the boring has been advanced to the desired sampling elevation and excessive cuttings have been removed, prepare for the test with the following sequence of operations.

7.1.1 Attach the split-barrel sampler to the sampling rods and lower into the borehole. Do not allow the sampler to drop onto the soil to be sampled.

7.1.2 Position the hammer above and attach the anvil to the top of the sampling rods. This may be done before the sampling rods and sampler are lowered into the borehole.

7.1.3 Rest the dead weight of the sampler, rods, anvil, and drive weight on the bottom of the boring and apply a seating blow. If excessive cuttings are encountered at the bottom of the boring, remove the sampler and sampling rods from the boring and remove the cuttings.

7.1.4 Mark the drill rods in three successive 6-in. (0.15-m) increments so that the advance of the sampler under the impact of the hammer can be easily observed for each 6-in. (0.15-m) increment.

7.2 Drive the sampler with blows from the 140-lb (63.5-kg) hammer and count the number of blows applied in each 6-in. (0.15-m) increment until one of the following occurs:

7.2.1 A total of 50 blows have been applied during any one of the three 6-in. (0.15-m) increments described in 7.1.4.

7.2.2 A total of 100 blows have been applied.

7.2.3 There is no observed advance of the sampler during the application of 10 successive blows of the hammer.

7.2.4 The sampler is advanced the complete 18 in. (0.45 m) without the limiting blow counts occurring as described in 7.2.1, 7.2.2, or 7.2.3.

7.3 Record the number of blows required to effect each 6 in. (0.15 m) of penetration or fraction thereof. The first 6 in. is considered to be a seating drive. The sum of the number of blows required for the second and third 6 in. of penetration is termed the "standard penetration resistance", or the "N-value". If the sampler is driven less than 18 in. (0.45 m), as permitted in 7.2.1, 7.2.2, or 7.2.3, the number of blows per each complete 6-in. (0.15-m) increment and per each partial increment shall be recorded on the boring log. For partial increments, the depth of penetration shall be reported to the nearest 1 in. (25 mm), in addition to the number of blows. If the sampler advances below the bottom of the boring under the static weight of the drill rods or the weight of the drill rods plus the static weight of the hammer, this information should be noted on the boring log.

7.4 The raising and dropping of the 140-lb

(63.5-kg) hammer shall be accomplished using either of the following two methods:

7.4.1 By using a trip, automatic, or semi-automatic hammer drop system which lifts the 140-lb (63.5-kg) hammer and allows it to drop 30 ± 1.0 in. (0.76 m ± 25 mm) unimpeded.

7.4.2 By using a cathead to pull a rope attached to the hammer. When the cathead and rope method is used the system and operation shall conform to the following:

7.4.2.1 The cathead shall be essentially free of rust, oil, or grease and have a diameter in the range of 6 to 10 in. (150 to 250 mm).

7.4.2.2 The cathead should be operated at a minimum speed of rotation of 100 RPM, or the approximate speed of rotation shall be reported on the boring log.

7.4.2.3 No more than 2¼ rope turns on the cathead may be used during the performance of the penetration test, as shown in Fig. 1.

NOTE 4—The operator should generally use either 1¾ or 2¼ rope turns, depending upon whether or not the rope comes off the top (1¾ turns) or the bottom (2¼ turns) of the cathead. It is generally known and accepted that 2¾ or more rope turns considerably impedes the fall of the hammer and should not be used to perform the test. The cathead rope should be maintained in a relatively dry, clean, and unfrayed condition.

7.4.2.4 For each hammer blow, a 30-in. (0.76-m) lift and drop shall be employed by the operator. The operation of pulling and throwing the rope shall be performed rhythmically without holding the rope at the top of the stroke.

7.5 Bring the sampler to the surface and open. Record the percent recovery or the length of sample recovered. Describe the soil samples recovered as to composition, color, stratification, and condition, then place one or more representative portions of the sample into sealable moisture-proof containers (jars) without ramming or distorting any apparent stratification. Seal each container to prevent evaporation of soil moisture. Affix labels to the containers bearing job designation, boring number, sample depth, and the blow count per 6-in. (0.15-m) increment. Protect the samples against extreme temperature changes. If there is a soil change within the sampler, make a jar for each stratum and note its location in the sampler barrel.

8. Report

8.1 Drilling information shall be recorded in the field and shall include the following:

8.1.1 Name and location of job.

8.1.2 Names of crew.

8.1.3 Type and make of drilling machine.

8.1.4 Weather conditions.

8.1.5 Date and time of start and finish of boring.

8.1.6 Boring number and location (station and coordinates, if available and applicable).

8.1.7 Surface elevation, if available.

8.1.8 Method of advancing and cleaning the boring.

8.1.9 Method of keeping boring open.

8.1.10 Depth of water surface and drilling depth at the time of a noted loss of drilling fluid, and time and date when reading or notation was made.

8.1.11 Location of strata changes.

8.1.12 Size of casing, depth of cased portion of boring.

8.1.13 Equipment and method of driving sampler.

8.1.14 Type sampler and length and inside diameter of barrel (note use of liners).

8.1.15 Size, type, and section length of the sampling rods, and

8.1.16 Remarks.

8.2 Data obtained for each sample shall be recorded in the field and shall include the following:

8.2.1 Sample depth and, if utilized, the sample number.

8.2.2 Description of soil.

8.2.3 Strata changes within sample.

8.2.4 Sampler penetration and recovery lengths, and

8.2.5 Number of blows per 6-in. (0.15-m) or partial increment.

9. Precision and Bias

9.1 Variations in N-values of 100 % or more have been observed when using different standard penetration test apparatus and drillers for adjacent borings in the same soil formation. Current opinion, based on field experience, indicates that when using the same apparatus and driller, N-values in the same soil can be reproduced with a coefficient of variation of about 10 %.

9.2 The use of faulty equipment, such as an extremely massive or damaged anvil, a rusty cathead, a low speed cathead, an old, oily rope, or massive or poorly lubricated rope sheaves, can significantly contribute to differences in N-values.

APPENDIX F

PACE LABORATORIES NEW ENGLAND

QUALITY ASSURANCE PROJECT PLAN (QAPP)

PACE NEW ENGLAND, INC.

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ANALYTICAL LABORATORY
NEESA QUALITY ASSURANCE MANUAL

TITLE: PACE New England, INC. NEESA Laboratory Quality Assurance Manual

Prepared By/Date: Stephanie Beck/Wendy E. Harris October 1993

Approved By/Date:

Stephanie Beck 10·8·93
QA Officer Date

Dennis L. Hufnagle 10/08/93
Regional Director Date

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1.0 INTRODUCTION

1.1 Purpose and Scope

This manual details the quality assurance program in effect in the PACE NE Analytical Chemistry Laboratory. It is meant to be a teaching tool and source of information for laboratory personnel. The Manual is divided into logical sections, each dealing with a different phase of laboratory operation, yet all sections overlap and function together to form a complete quality assurance program. The Manual is based on Good Laboratory Practices, common sense, and industry-accepted standard analytical practices.

The Manual must be read and understood by all laboratory personnel as part of their training program. The Manual should also be referred to regularly as a source of information. A system of continuous updating is built into the Manual to allow it to change as laboratory conditions change or as new regulations are promulgated. This manual is a controlled document, which means that its identity, development, distribution, and status must be known and traceable at all times. All PACE NE permanent laboratory personnel will be assigned a controlled copy.

Whenever a technician or analyst is in doubt as to proper procedures in a specific circumstance, the Manual should be consulted. Omissions or errors should be immediately reported to the Quality Assurance Officer, for corrective action. **IT IS THE RESPONSIBILITY OF EACH LABORATORY WORKER TO ENSURE THAT THE PROVISIONS OF THIS MANUAL ARE FOLLOWED.** Disagreement with specific requirements or knowledge of changes causing deviation from the procedures should be discussed with the immediate supervisor before further work is completed. Laboratory personnel are encouraged to comment on the Manual and make recommendations for more efficient procedures.

The latest revision of each section of the Manual is the applicable rule. Therefore, revisions will be announced to all laboratory personnel. An uncontrolled copy of the Manual is offered to clients and regulatory agencies as the definitive quality assurance program used at PACE NE.

1.2 QA Policy and Objectives of the Program

PACE NE is committed to quality as priority number one. PACE NE's quality assurance policy is based on the definition of quality as conformance to requirements; and further, on the premise that the requirements are governed by Company policies and standard

operating procedures. This commitment recognizes the need for data to be representative of the environmental conditions under consideration, and for data to be generated within a system of functions that that is designed to meet applicable regulatory compliance criteria. To this end, PACE NE has developed a company-wide Quality Assurance (QA) Plan and maintains an ongoing QA Program. Our Quality Assurance Program contains provisions for establishing, maintaining and executing protocols which lead to results of known, appropriate and acceptable quality; documentation of these activities is an integral part of the QA program. No other concern will be permitted to interfere with the quality of data PACE NE provides to clients.

This manual describes the set of policies and principles which guide day-to-day operations. Specific protocols are included by reference and are contained in a series of volumes cited in Section 8.0 of this document.

1.3 Quality Assurance Documents

1.3.1 QA Manual

This document describes management policies related to operation of the analytical laboratories. It provides overall guidance regarding acceptable practices and discusses each element of the Quality Assurance Program. It functions as the Project QA Manual where no other Quality Assurance Project Plan, Statement of Work or other contractually mandated project plan has been specified. Adherence to the practices described in this manual is required of all employees. This manual may be revised and/or superseded only with the written authority of the PACE NE Regional Director. Copies of this manual are controlled and distribution is administered by the QA Officer.

1.3.2 Standard Operating Procedures Manuals

All procedures related to sample collection, storage, preparation, analysis, disposal, data validation, data reporting and employee training and safety shall be contained in written Standard Operating Procedures Manuals (SOP's). Each SOP shall contain the elements outlined in PACE NE SOP QA-553, Preparation of SOP's. All sections shall be structured in a step-wise manner using numbered sections. All record-keeping requirements shall be described at each step in the SOP. Examples of forms used shall be included as tables or figures and referenced within the text. Preparation of SOP's shall be the responsibility of each Group Supervisor. SOP's shall be assigned a number from the Inventory List for SOP's maintained by the Quality Assurance Department. This number

shall become part of the document control number when the SOP is accepted for implementation by PACE NE management. SOP's shall be reviewed and approved by the Group Supervisor (and Lab Manager for all SOP's related to analytical procedures) and the QA Officer, and submitted by the QA Department to the Technical Directors and the Regional Director for approval prior to implementation.

1.3.3 Project QA Manuals

Project QA Manuals shall be implemented as required. These shall include such documents as Quality Assurance Project Plans (QAPP's). For those projects which require specific QA/QC criteria, a QAPP which has been approved by a regulatory agency, usually the EPA, is provided to PACE NE by the client.

1.3.4 Document Control, Distribution and Revision

In order that this document achieve the goals outlined in Section 1.2, it is necessary that each PACE NE laboratory employee be familiar with the current provisions of this document. It is also necessary that this document represent a consensus among PACE NE Management and operational personnel as to the quality level desired and the means to that end.

Prior to its publication as a controlled document, this manual must be approved by the Quality Assurance Officer, the Laboratory Technical Directors, and the Regional Director. To obtain such approval, the document proceeds through an iterative process of review and revision, involving the affected managers and their designated representatives. The signature page at the beginning of the manual represents acceptance.

Each time a revision is made to this manual, it must also be approved. The Quality Assurance Officer must approve each revision. If the revision constitutes a complete rewrite of the document, then review and approval by the Quality Assurance Officer, the Laboratory Technical Directors, and the Regional Director becomes necessary. The appropriate approval process will be decided in each case by the Quality Assurance Officer.

1.4 Terms and Definitions

Accuracy: The degree of agreement between a measured value and the true or expected value.

Aliquot: A measured portion of a sample taken for analysis.

Analyte: The specific entity an analysis seeks to determine.

Batch: A grouping of samples of similar matrix which are prepared and analyzed together with the same method and the same lots of reagents within the same time frame. A sample may be analyzed in a different analytical batch than the one with which it was prepared.

Blank: A blank is an artificial sample designed to detect and/or monitor the contribution of analyte and non-analyte contamination, instrumental background and sample processing to the measurement system.

Blind Sample: A sample submitted for analysis whose composition is known to the submitter but unknown to the analyst.

Calibration: The process of establishing the relationship between instrument response and known, traceable quantities of analytes of interest.

Comparability: Comparability is a qualitative parameter expressing the confidence with which one data set can be compared to another. Comparable data are produced through the use of standardized procedures and techniques.

Completeness: Measure of the amount of valid data obtained from a measurement system compared to the amount that was expected to be obtained under correct normal conditions.

Continuing Calibration: The process of analyzing standards periodically to verify the maintenance of calibration of the analytical system.

Control Chart: A graphical plot of test results with respect to time or sequence of measurement, together with limits within which they are expected to lie when the system is in a state of statistical control.

Control Limit: A range within which specified measurement results must fall to signify compliance. Control limits may be mandatory, requiring corrective action if exceeded, or advisory, requiring that nonconforming data be flagged.

Detection Limit: The minimum concentration of a substance that can be measured and reported with 99% confidence that the analyte concentration is greater than zero.

Dry Weight: The weight of a sample based on percent solids. The weight after drying in an oven.

Duplicate Analysis: A second measurement made on the same sample extract or digestion to assist in the evaluation of precision of analysis.

Duplicate Sample: A second aliquot of the same sample that is treated the same as the original sample in order to determine the precision of the method.

Equipment Blank: Special type of field blank used primarily as a check on equipment decontamination procedures. Laboratory deionized water is passed over sampling equipment after decontamination.

Field Blank: A quality control sample used to assess the contamination effects on accuracy due to the combined activities of sampling and analysis. Typically, it is composed of a reagent and analyte free matrix (deionized water) provided by the laboratory.

Field Sample: A portion of material received by the laboratory to be analyzed, that is contained in single or multiple containers and identified by a unique field ID number.

Holding Time: The elapsed time expressed in days from the date of sample collection by the field personnel until the date of its processing/analysis. For the Contract Laboratory Program, holding times start at the Verified Time of Sample Receipt by the laboratory. Holding time requirements are dictated by the method or QAPjP.

Homogeneity: The degree to which a property or substance is evenly distributed throughout a material.

Instrument Detection Limit: The minimum concentration of a substance that can be measured and reported with 99% confidence that the analyte concentration is greater than zero. The instrument detection limit is generally more sensitive than the method detection limit.

Initial Calibration: The process of analyzing standards, prepared at specified concentrations, to define the quantitative response, linearity and dynamic range of the instrument to the analytes of interest. Initial calibration is performed whenever the results of a continuing calibration do not conform to the requirements of the method in use or at a frequency specified in the method.

Internal Standards: Analytes added to every standard blank, matrix spike, matrix spike duplicate, and sample at a known concentration, prior to analysis for the purpose of adjusting the response factor used in quantitating target analytes. Internal standards are used as the basis for quantitation of the target compounds, and are generally applicable to organic analyses.

Lab. Control Sample: A control sample of known composition spiked with known concentration of analytes of interest. Aqueous and solid laboratory control samples are analyzed using the same preparation, reagents, and analytical methods employed for field samples received.

LABUX: The Hewlett-Packard A900 based Laboratory Information Management System. It is used to collect data from instrumentation and preparation laboratories for later combination into final reports. Data is collected a number of ways including direct ports from instrument computers, interactive manual entry direct to the database using HP provided procedures, importing data from spreadsheets, and importing batch data entered manually. Data is combined, calculated, and formatted either by HP provided or custom reporters and stored in directories where it can be printed initially for manager review and later as part of a final report.

LAS: Hewlett-Packards' A900 based 3350a Laboratory Automation System. Its function is to collect, calculate, and present chromatographic data. The system allows the operator to calibrate for, identify and quantitate the data. Requantitation is possible without reinjection of the sample. Typically the data provided to the analyst by the LAS is entered into LABUX for combination with data from the preparation laboratory to generate a final report. Alternatively, the preparation information can be entered into the analysis sequence on the LAS to generate results corrected for preparation volumes, dilutions, and dry weights.

Lot: A quantity of bulk material of similar composition processed or manufactured at the same time.

Matrix: The predominant material of which the sample to be analyzed is composed.

Matrix Spike: Aliquot of sample fortified (spiked) with known quantities of specified compounds and subjected to the entire procedure in order to indicate the appropriateness of the method for the matrix by measuring recovery.

Matrix Spike Duplicate: A second aliquot of the sample that is treated the same as the original matrix spike sample. The relative percent difference between the matrix spike and matrix spike duplicate is calculated and used to assess analytical precision.

Method Blank: An analytical control consisting of all reagents, internal standards and surrogate standards, that is carried through the entire analytical procedure. The method blank is used to define the level of laboratory background contamination in the associated sample batch.

Method Detection Limit: Method Detection Limits may be determined using replicate spike samples The detection limit is calculated using the appropriate student's t-parameter times the standard deviation of a series of spiked samples.

Performance Audit or Evaluation: A process to evaluate the proficiency of an analyst or laboratory by evaluation of the results obtained on known test materials.

Precision: The measurement of agreement of a set of replicate results among themselves without any prior information as to the true result. Precision is assessed by means of duplicate/replicate sample analysis.

Protocol: A stated plan that clearly defines the objectives, methods and procedures for accomplishing a task.

QAPP: A Quality Assurance Project Plan or QAPP is a project specific document that describes the policies, organization, objectives, functional activities, and specific QA and QC activities designed to achieve the data quality goals of a specific project.

Quality Assurance: A system of policies and procedures whose purpose is to ensure, confirm and document that the product or service rendered fulfills the requirements of PACE NE and its client. Quality Assurance includes quality planning, quality control, quality assessment (auditing), quality reporting and corrective action.

Quality Control: A system of checks and corrective measures, integrated with the activities that directly generate the product or service, that serves to monitor and adjust the process to maintain conformance to predetermined requirements.

Replicate Samples: A second, separate sample collected at the same time, from the same place, for the same analysis, as the original sample in order to determine overall precision.

Reporting Limit: The level at which method, permit, regulatory and client specific objectives are met. The reporting limit may never be lower than the statistically determined MDL, but may be higher based on any of the above considerations. Reporting limits are corrected for sample amounts, including the dry weight of solids, unless otherwise specified.

Rounding Rules: If the figure following those to be retained is less than 5, the figure is dropped, and the retained figures are kept unchanged. As an example,

11.443 is rounded off to 11.44. If the figure following those to be retained is greater than 5, the figure is dropped, and the last retained figure is raised by 1. As an example, 11.446 is rounded off to 11.45. If the figure following those to be retained is 5, and if there are no figures other than zeros beyond the five, the figure 5 is dropped, and the last-place figure retained is increased by one if it is an odd number or it is kept unchanged if an even number. As an example, 11.435 is rounded off to 11.44, while 11.425 is rounded off to 11.42. If a series of multiple operations is to be performed (add, subtract, divide, multiply), all figures are carried through the calculations. Then the final answer is rounded to the proper number of significant figures.

Sensitivity: Capability of methodology or instrumentation to discriminate between samples having differing concentrations or containing differing amounts of an analyte.

Split Sample: A portion or subsample of a total sample obtained in such a manner that is not believed to differ significantly from other portions of the same sample.

Standard: A substance or material the properties of which are believed to be known with sufficient accuracy to permit its use to evaluate the same property in a sample.

Standard Blank: An analytical control sample consisting of the same solvent/reagent matrix used to prepare the calibration standards without the analytes. It is used to construct the calibration curve by establishing instrument background.

Standard Operating Procedure: A procedure adopted for repetitive use when performing specific measurement or sampling operation. It may be an industry accepted standard method or one developed by the user.

Surrogates: When employed, these are compounds added to every blank, sample, matrix spike, matrix spike duplicate, and standard prior to any processing or preparation; used to evaluate analytical efficiency by measuring recovery. Surrogate compounds are not expected to be detected in environmental media, but are similar to the analytes of interest. Surrogates are generally utilized for organic analyses.

Systems Audit: An on-site inspection or assessment of a laboratories' quality control system.

Traceability: The ability to trace the source and accuracy of a material (i.e. standard) to a recognized primary reference source such as the National Institute of Standards and Technology (NIST) or USEPA. Also, the ability to independently reconstruct and review all aspects of the measurement system through available laboratory notebooks and documentation and reach the same results.

Trip Blank: This blank is used to detect sample contamination from the container and preservative during transport and storage of the sample. A cleaned sample container is filled with laboratory pure water; any preservative used in the sample is added; and then the blank is stored, shipped, and analyzed with its group of samples.

Validation: The process by which a sample, measurement, method, or piece of data is deemed useful for a specified purpose.

Warning Limits The limits (typically 2 standard deviations either side of the mean) shown on a control chart within which most results are expected to lie (within a 95% probability) while the system remains in a state of statistical control.

2.0 QA ORGANIZATION AND PERSONNEL

It is important for efficient laboratory operation that all laboratory employees understand the operational structure, specific areas of responsibility and lines of authority within the organization.

It is equally important for laboratory personnel to understand that the structures of the Quality Organization may be separate from other laboratory operations but that the quality function is totally integrated into every aspect of laboratory operation. All laboratory personnel are responsible for knowing and following proper methods and standard operating procedures; recording quality control information required by those procedures in the proper location; and suspending analyses when quality control criteria are not met.

The organizational structure of the analytical chemistry laboratory is provided in Figure 2-1. Under the direction of the laboratory technical directors, the technical staff of the laboratory is organized into the following functional groups:

Sample Management (Receipt and Log-in)
Sample Preparation - Organic
Sample Preparation - Metals
Wet Chemistry
Metals Analysis
GC Analysis
GC/MS Volatiles Analysis
GC/MS Semivolatiles Analysis
Reporting
Project Management (Client Services)

Each group is headed by a Group Supervisor who is responsible for operations on a daily basis. Environmental chemists, analysts, laboratory technicians and laboratory assistants report to the Group Supervisors. See Appendix A for resumes of all technical staff employed as of this revision date.

2.1 Laboratory Organization

It is the individual responsibility of each analyst and technician to perform their assigned tasks according to the applicable SOPs, QA Project Plans, Study Protocols, and Work Plans. This includes responsibility for performing quality control analyses as specified in the method SOP and for entering the QC data in the appropriate method control file

system. The analyst shall report out-of-control results to the Group Supervisor.

Group Supervisors shall assure that analysts and technicians are instructed in the requirements of the PACE NE Laboratory QA Manual, study-specific QA Project Plans, SOPs, Protocols, and Work Plans for the analytical method or other procedure. Group Supervisors shall review sample QC data at frequent intervals designed to assure that QC analyses are being performed at the required frequency, that data are documented in the method control file system and that established corrective action procedures for out-of-control situations are followed and the results documented. It is the responsibility of the Group Supervisor to assure that data have been validated and reported to the Laboratory Manager. Group Supervisors shall report to Laboratory Managers.

Laboratory Managers shall be the Technical Directors and shall take overall responsibility for technical conduct, evaluation and reporting of all analytical tasks associated with each study. Laboratory Managers assure that approved procedures are documented and followed, that all data are recorded and verified and that all deviations from approved procedures are documented. Laboratory Managers shall assure that Group Supervisors are instructed in the requirements of the PACE NE Laboratory QA Manual, study-specific QA Project Plans, SOPs, Protocols, and Work Plans. Laboratory Managers approve standards for QC control limits for methods and work with Group Supervisors to bring out-of-control methods back to within established acceptance limits. Laboratory Managers shall report to the Regional Director.

The Quality Assurance Department, under the direction of the Quality Assurance Officer, shall be responsible for conducting systems audits and inspections for compliance with this manual, SOP's and QA Project Plans or other project-specific protocols, maintaining the archives, maintaining historical files of all QA documents, reviewing QC charts, documenting findings and corrective actions, and reporting findings to management. The Quality Assurance Officer shall report directly to the Regional Director of PACE NE.

The PACE NE Regional Director shall designate Laboratory Manager(s)/Technical Director(s) and replace if necessary. The PACE NE Regional Director shall assure that there is a Quality Assurance Department, that personnel and other resources are adequate, that personnel have been informed of their responsibilities, that deficiencies are reported to Laboratory Managers and that corrective actions are taken and documented. Any significant changes to written SOP's shall be authorized in writing by the Regional Director of PACE NE.

2.2 Training and Orientation

Each new permanent employee receives a four part orientation: a human resources orientation, a safety department orientation, a quality assurance department orientation, and a supervisory orientation. The human resources orientation involves matters of immediate personal concern such as benefits, salary, and company policies. The safety department orientation is an in-depth examination of the PACE NE Chemical Hygiene Plan and safety program, which are consistent with the requirements of OSHA's Hazard Communication Program (29 CFR 1910.1200). The Quality Assurance orientation provides the new employee with information on the PACE NE QA program through a brief introduction to the QA manual and SOPs, acceptable recordkeeping practices, and the individuals responsibility. The new employee's group supervisor provides the employee with a basic understanding of the role of the laboratory within the structure of PACE, Inc. and the basic elements of that individual's position within the laboratory. The training of a new employee concentrates on his/her scientific background and work experience to provide the employee with a level of competence so that the individual will be able to function within the defined responsibilities of his/her position ASAP.

Training is a process used to assist laboratory personnel in their professional development. The training techniques utilized include:

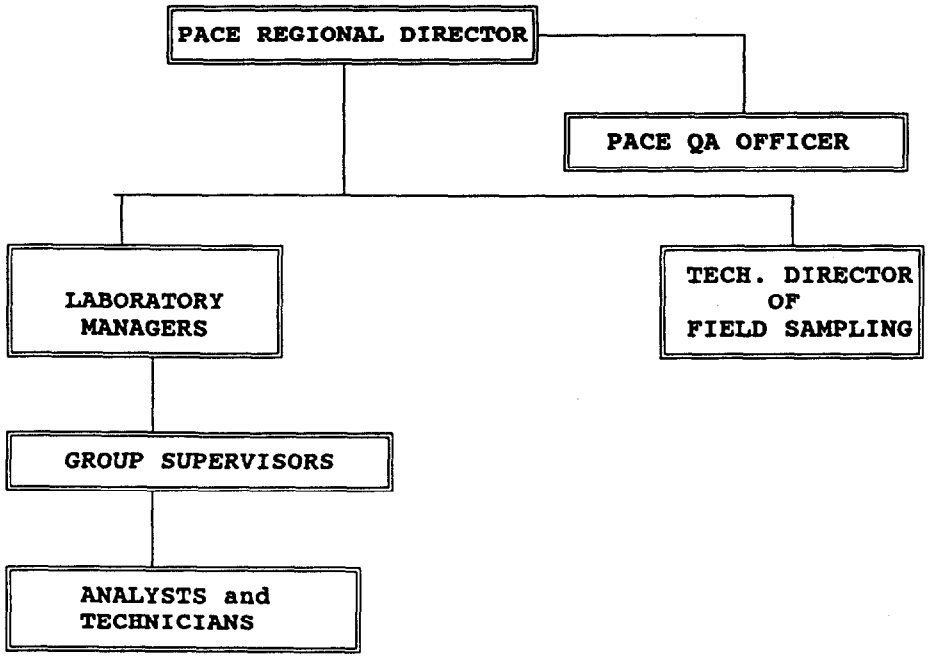
- on-the-job training
- lectures
- programmed learning
- conferences and seminars
- short courses
- specialized training by instrument manufacturers
- participation in check-sample or proficiency sample programs.

Group Supervisors shall be responsible for providing documentation of training and proficiency for each employee under their supervision. The Training Documentation File indicates what procedures (SOPs) a technician is capable of performing either solo or only with supervision. The files shall also include logbook pages and sample reports indicating performance of passing QC samples. The Group Supervisor is responsible for keeping training documentation updated and current. The QA department shall maintain a file for each technical employee. In addition to the training documentation, these files shall include a current CV and proofs of education such as college transcripts or certificates from continuing education coursework or specialized training.

Temporary employees receive the same orientation as permanent staff with the exception of the human resources orientation.

Figure 2-1

PACE New England, Inc.
QUALITY ASSURANCE
ORGANIZATION CHART



APPENDIX A

Resumes For PACE NE Technical Staff
Employed As Of This Revision Date

DEBORAH F. MCGRATH
Regional Director
PACE New England, Inc.

Experience

As Regional Director, Ms. McGrath is responsible for the overall management of PACE New England which includes the oversight and coordination of Laboratory and Field Operations, Quality Assurance, Support Systems, Administrative, and Sales/Marketing departments. In addition, she serves as liaison for PACE NE on behalf of both clients and other laboratories within the PACE network.

Prior to joining PACE NE in 1993, Ms. McGrath served as Vice President and Division Manager of NET Inc., Cambridge Division, in Bedford, MA (formerly Cambridge Analytical Associates, Inc.), from 1989-1993 where her responsibilities included oversight of the technical operations and business development of the division. She was Vice President of Environmental Services for one year and Director of Analytical Services for two while employed by Cambridge Analytical Associates, Inc. from 1986-1989.

Ms. McGrath served in the position of Manager of the Laboratory Analysis Department and Inorganic Section while employed by GCA Technology Division, Bedford, MA from 1981-1986.

Previous to her management positions, Ms. McGrath held the position of analytical chemist at Kennecott Copper Ledgemont Laboratory, Lexington, MA.

Education

B.S. Chemistry, Simmons College, Boston, MA 1971

Publications

Ms. McGrath is the author/co-author of over 15 publications on methods development and comparison studies, waste oil and biota analysis, combustion assessments and waste minimization.

STEPHANIE BECK
Quality Assurance Officer
Pace New England, Inc.

Experience

Ms. Beck is responsible for quality assurance activities at Pace New England, Inc. She is responsible for auditor training and Quality Assurance training for new employees. She performs internal inspections of PACE NE labs and is responsible for the implementation of quality programs at Pace NE, Inc. She reviews data for internal and regulatory compliance. Ms. Beck prepares Quality Assurance Project Plans. She reviews SOPs. Ms. Beck reports to Deborah McGrath, Regional Director.

Prior to joining PACE NE, INC. Ms. Beck worked in the same capacity for Resource Analysts, Inc. which was acquired by PACE NE, INC. in June 1992. Ms. Beck came to PACE NE, INC. with over 4 years laboratory experience performing inorganic chemistry analysis. Ms. Beck has over 2 years experience in the Quality Assurance department (1990 - present) performing the duties to assure management that facilities, equipment, personnel, methods, practices, records, and controls are adequate and in conformance with regulations. She has over 2 years experience reviewing Aquatic Tox. studies and Organic and Inorganic Chemistry data for FIFRA, TSCA, OECD, and FDA compliance as a GLP auditor. She has experience reviewing CLP data packages.

QA Officer, PACE NE, INC., Inc., Hampton, NH 5/92 - Pres

QA Auditor, Resource Analysts, Inc., Hampton, NH 4/90 - 5/92

Education

B.S., Environmental Economics, University of New Hampshire, 1988

Continuing Education

Environmental and Natural Resource Law, 1992 U. of N.H. Durham, NH
Introduction to Computer Validation SQA Annual Meeting 1991, Kansas City, MO
Intro. and Advanced WordPerfect 1991 OMC, Portsmouth NH
Producing Results with Others, 1991 Millipore, Bedford MA
SQA Basic Training GLP SQA Annual Meeting Oct 1990, Orlando FL
Lotus 123, 1990 Millipore, Bedford MA

RICHARD L. WELLMAN
Inorganic Laboratory Director
New England Regional Office

Experience

As Inorganic Laboratory Manager, Mr. Wellman manages the groups providing wet chemistry, metals prep and metals analysis. He reports to Ms. McGrath, Regional Director.

Prior to joining PACE, Mr. Wellman worked in similar capacities for Resource Analysts, Inc. which was acquired by PACE in June 1992. Mr. Wellman joined RAI in 2/88 and worked as the GC Lab Director until 1/91 when his responsibilities changed to managing the Metals Labs and the Reporting/Data Review and Lab Data Services Departments.

Mr. Wellman has extensive experience in the analytical chemistry field as a Consultant and Chemist. Mr. Wellman has over thirteen years of experience in Gas Chromatography, High Pressure Liquid Chromatography, Infrared Spectrophotometry, UV-VIS Spectrophotometry, GPC, and NMR.

Consultant, Medical & Scientific Enterprises, Sudbury, MA Summer 1986

Consultant, Acadia Management, Boston, MA Summer 1986

Systems Specialist, DuPont/NEN Products, Boston, MA 1984 - 1985

Group Leader Analytical Chemistry, DuPont/NEN Products, Boston, MA 1978 - 1984

Education

M.B.A., Business Administration, Boston University, Boston, MA, 1987

B.S., Chemistry, Union College, 1975

Continuing Education

"Environmental Data Requirements", conference, April 25, 1989

"HP RTE System Managers Course", May 22-26, 1989"

"Newest Analytical Methods and Techniques", Hewlett Packard Video Teleconference, April 19, 1990

STEVEN F. RHODE
Organics Laboratory Director
New England Regional Office

Experience

Mr. Rhode manages the Organics Extractions, GC and GC/MS organics laboratories through four laboratory group supervisors. He and his staff conduct standard EPA analyses as well as non-routine GC/MS approaches to special analytical problems. Mr. Rhode is Project Manager for PACE NE, Inc.'s CLP contract work. He is responsible for workflow and technical review and approval of all data generated by the GC and GC/MS organics laboratories. Mr. Rhode reports to Deborah McGrath, Regional Director.

Prior to joining PACE NE, Inc., Mr. Rhode worked for four years for National Environmental Testing, Inc. (NET) managing the CLP GC and organic preparation laboratories. He had two years experience working as a GCMS analyst for Cambridge Analytical Associates using EPA methods and CLP protocol. His experience includes the programming of HP1000 data systems to automate data analysis and also includes management of RTE-6 and RTE-6A series data systems.

Mr. Rhode was a teaching fellow at Boston University Department of Chemistry for four years. There he organized and taught laboratory and discussion sections for graduate and undergraduate courses in instrumental analysis, qualitative analysis and general chemistry.

Education

Ph.D. candidate, Chemistry, Boston University

M.S., Chemistry, University of New Hampshire, 1983

B.S., magna cum laude, Marine Science/Biology/Chemistry, University of Tampa, FL, 1980

ELIZABETH A. DUPERE
Volatiles Group Supervisor
Pace New England, Inc.

Experience

Ms. Dupere is responsible for the supervision of the GC/MS Volatile Organics Laboratory. As a Supervisor-in-Training, she reports to Mr. Rhode, Organics Laboratory Manager, who maintains the ultimate responsibility for work performed by the Volatiles Lab.

Prior to joining PACE NE, INC. Ms. Dupere worked as an analyst for Resource Analysts, Inc. which was acquired by PACE NE, INC. in June 1992. She joined RAI in 1987 as a technician in the Wet Lab. She became a GC operator in 1988 and in 1990 became a GC/MS operator. Ms. Dupere currently has approximately two and a half years experience in volatile organics analysis. While employed in the organics laboratory, Ms. Dupere has received approximately two years' training in gas chromatography. She has experience in the use of detectors, including Hall and ECD, as well as FID, FPD, and NPD. As a Laboratory Technician in the wet lab, she has also received 10 months training in wet chemistry techniques.

Education

B.S., Biochemistry, University of New Hampshire, 1987

Continuing Education

"Use of Widebore Columns", By Restek, Inc., Boston, MA, December, 1989

"Mass Spectral Interpretation", By Bill Rounds, University of New Hampshire, spring, 1990

"Air Analysis Symposium" By Tekmar, Inc., Lexington, MA. May 1991.

"GC/MS Troubleshooting", seminar, Hewlett Packard, Burlington, MA, Spring 1992

LIANE HALL
Semi-Volatiles Group Supervisor
New England Regional Office

Experience

Ms. Hall is responsible for the supervision of the Semi-volatiles laboratory, analysis of environmental samples by GC and GC/MS, performance and documentation of all specified QC measures and instrument maintenance and troubleshooting. Ms. Hall reports to Mr. Rhode, Organics Laboratory Manager.

Prior to joining PACE NE, INC., Ms. Hall worked in the same capacity for Resource Analysts, Inc. which was acquired by PACE NE, INC. in June 1992. Ms. Hall joined RAI in 1989 and worked as an Analytical Chemist until 1/91 when she became Supervisor of the Semivolatiles lab.

Ms. Hall has over 3 years experience, prior to RAI, in the environmental field. As a Research Assistant/Technician for the University of Maine, Ms. Hall was responsible for analyses of microbial processes in marine sediments utilizing GC, HPLC, UV/VIS Spectroscopy and AA. While employed as a Chemist II, GC/MS Operator for the State of Maine, Ms. Hall was responsible for timely VOA and SVO analyses, adherence to QC procedures and accurate report generation utilizing HP 5996 and 5970.

Education

Candidate for Doctor of Philosophy degree, Loyola University of Chicago, 1980 - 1984

M.S., Chemistry, Northwestern University, 1980

B.S., Chemistry, Massachusetts Institute of Technology, 1979

Continuing Education

"GC/MS Operator I" by Jim Stacy, Hewlett Packard, April, 1989

"Aquarius Software" by Jim Stacy/Pam Kelly, Hewlett Packard, May, 1989

"Mass Spectral Interpretation", by Bill Rounds, University of New Hampshire, Spring, 1990

"Capillary Chromatography" by Neil Mosesman/David Shelow, Restek, November, 1990

PETER LEMAY
GC Operator/Group Supervisor
Radiation Safety Officer
New England Regional Office

Experience

Mr. Lemay is responsible for the analysis of PCB's, Pesticides, PNA's, PHC's, DI solvents, and Herbicides and for the supervision of three GC analysts. He reports to Mr. Rhode, Organics Laboratory Manager.

Prior to joining PACE, Mr. Lemay worked in the same capacity for Resource Analysts, Inc. which was acquired by PACE in June 1992. Mr. Lemay joined RAI in 1987. While employed at RAI, Mr. Lemay acquired three and a half year's experience on the following GC's: HP 5890, HP 5880, HP 5840, Tracon and waters dimension GC using the following detectors: ECD, ELCD, NPD, FID, FPD with either packed or capillary columns.

Mr. Lemay served as a chemist for Burgess Analytical Laboratory, North Adams, MA from 1985 to 1987. His duties included performing chemical analyses on a variety of materials, sample preparation, operation of instruments, evaluating and reporting results, and training new employees.

Medical Laboratory Specialist, United States Air Force. 1977 - 1981

Education

B.A., Chemistry, University of Maine, Orono, ME 1985

Continuing Education

Intro to GC/MS - Hewlett Packard, 1988

Occupational and Environmental Radiation Protection, Harvard School of Public Health, Aug 1991

PAUL RAITI
Organics Extractions Lab Supervisor
New England Regional Office

Experience

Mr. Raiti is responsible for the supervision of a staff of technicians performing sample preparation for ABN, PCB, PHC, PNA, pesticide and other organic methods. The Organics Prep Lab is also responsible for the oil and grease and phenol methods which Mr. Raiti oversees. As part of the organics sample preparation process, Mr. Raiti also performs and directs the operation of two GPC/HPLC units for sample clean-up. As supervisor, Mr. Raiti monitors all holding times and schedules daily workflow to ensure timeliness of all extract preparation. He is also responsible for the training of technicians to meet all PACE specific and general method requirements for data quality. As a supervisor-in-training, Mr. Raiti reports to Mr. Rhode, Organics Laboratory Manager, who has the ultimate responsibility for the Extractions Lab.

Prior to becoming the lab supervisor, Mr. Raiti had over two years experience as a Senior Technician in the Organics Prep Lab. He was hired as a Senior Tech by Resource Analysts, Inc. in 8/90 and continued to work in the same capacity after RAI was acquired by PACE in June 1992. Mr. Raiti is fully qualified in all organics sample preparation procedures performed at PACE.

Education

B.S., Plant Science, University of New Hampshire, 1989

A.S., Horticulture, Essex Agricultural and Technical Institute, 1987

Continuing Education

"Laws in Natural Resource and Environment", University of NH, Spring 1991

"Wetland Resource Management", University of NH, Fall 1991

"Analytical Chemistry", University of Massachusetts, 1992

CLIFFORD CHASE
Metals Instrument Group Supervisor
New England Regional Office

Experience

Mr. Chase presently supervises the metals instrument laboratory, and provides operation for the instrumental analyses of metals. Mr. Chase reports to Mr. Wellman, the Inorganics Laboratory Manager.

Prior to joining PACE, Mr. Chase supervised the organic extraction laboratory for Resource Analysts, Inc. which was acquired by PACE in June 1992. Mr. Chase joined RAI in 1988 and worked as an analyst until 1990 when he became Organics Extractions Group Supervisor. Mr. Chase has over three years of supervisory experience and a strong background in instrumentation. He is experienced in the analysis of environmental samples and has 6 months training on the Extrel ELQ-400 GC/MS, the HP 5880 and HP 5840 GC/FID, and the HP 5890/5970 GC/MSD.

During a five year tenure at the University of New Hampshire, Mr. Chase was responsible for analyses, operator training, repair and maintenance of JEOL FX90Q FTNMR, Instrumentation Laboratory Model 951 AA and a Varian Cary 219 UV/VIS.

Education

B.S. Chemistry, University of New Hampshire, 1986

Continuing Education

"Mass Spectral Interpretation", University of New Hampshire, April/May 1988

"Aquarius GC/MS Data System Training Seminar", Hewlett Packard Co., Andover, MA, September 13-14, 1988

"Management Lead Skills Training", Millipore Corp., Bedford, MA, July 17, 24, 31, Aug. 7, 1990

"UV Detector Service Training", Waters Chromatography Division, MILLIPORE Corp., Marlborough, MA, April 20-21, 1992

THERESA I. HENNESSEY
Wet Chemistry Group Supervisor
New England Regional Office

Experience

Ms. Hennessey is responsible for managing and overseeing all Wet Lab workflow, analyses, spreadsheet review, raw data review, data handling and tracking, report generation, review and timely completeness. Ms. Hennessey supervises a staff of 7 - 8 technicians and is responsible for scheduling work hours, vacation and bi-annual performance and salary reviews. Ms. Hennessey reports to Mr. Wellman, Inorganics Laboratory Manager.

Prior to joining PACE, Ms. Hennessey worked in the same capacity for Resource Analysts, Inc. which was acquired by PACE in June 1992. While employed at RAI, Ms. Hennessey gained over six year's experience on the pH meter, Specific Conductance Meter, Zero Headspace Extractors, High Pressure Filtration System, Spectronic 20, Flashpoint Apparatus, Top Loading Balances, Analytical Balance and BTU. Ms. Hennessey has experience in the proper preparation of sample digests for trace metal analysis, including the digestion of tissues, solids, waxes, oils, plastics and polymers as well as the usual soils and water samples. Ms. Hennessey supervised the Metals Digests Lab for two and a half years with a staff of 3. For one year, she managed both the Wet Lab and Metals Digests Lab with a staff of 11-12. She has one year's experience in reviewing final Wet Lab data and reports and one year's experience in the use of Lotus Quattro.

Education

B.S., Environmental Conservation/Resource Economics, UNH 1984

Continuing Education

"General Chemistry" University of New Hampshire, Spring, 1987

"Leadership Skills for Women" March, 1988

"Introduction to Lotus", Millipore Corp., Bedford, MA, Nov. 1990

"Quantatative Analysis", University of New Hampshire 1992

"Organic Chemistry", University of New Hampshire 1992

KATHLEEN LAWSON
Laboratory Technician
New England Regional Office

Experience

As Lead Technician for the Metals Prep Laboratory, Ms. Lawson is reponsible for digestion of samples by EPA methods 3010, 3020, 7060, 3050 (HNO_3), 3050 (HCL) and filtering of samples for ICP and furnace analysis, fluoride distillation, calibration of: hoods, pipettes, extractors, and pH meters. Her Metals Prep responsibilities also include TCLP, EPTOX, and California W.E.T. She is responsible for the wet chemistry tests: Specific conductance, Total Phosphorus, Alkalinity, and BOD. Ms. Lawson reports to Mr. Rick Wellman, Metals Prep Lab Manager.

Prior to joining PACE, Ms. Lawson worked in the same capacity for Resource Analysts, Inc. which was acquired by PACE in June 1992. Ms. Lawson joined RAI in February 1991.

Ms. Lawson was a Cardiac Technician at Sisters of Charity Hospital, Buffalo, NY where she gained 8 years of experience in EKG, Holter monitoring and record keeping in an 800 bed hospital.

Education

H.S. Diploma, Mt. Mercy Academy, Buffalo NY

CHRISTINE PAQUETTE STELZER
Senior Data Validator/Reporter
New England Regional Office

Experience

Ms. Stelzer is primarily responsible for the review, validation, and reporting of organics data as it pertains to special projects. Special projects include those under USEPA CLP protocol, state or government agency protocols, or unique PACE/client contracts. Part of her job involves reviewing Statements of Work, Quality Assurance Plans, and Bid Requests to identify special analytical, QC, or reporting requirements. Findings are communicated to Sales and Analytical staff to help ensure appropriate bidding and compliant analyses. Ms. Stelzer subsequently reviews organics data generated for these jobs to ensure accuracy and scientific defensibility. Ms. Stelzer is responsible for generating special forms and diskettes as required to complete the data package. She is the Project Manager/Data Reporting and Delivery Officer for the EPA CLP Organics Contract 68D20026. Ms. Stelzer reports to Mr. Rhode, Organics Laboratory Manager.

Prior to joining PACE, Mrs. Stelzer worked in the same capacity for Resource Analysts, Inc. which was acquired by PACE in June 1992. Ms. Stelzer joined RAI in 1987. She has worked as a Technician and Analyst in the Volatile Organics and Semivolatiles Lab. She has experience in GC/MS analysis using both packed and capillary columns under USEPA methods 624, 8240, 524.1, 501.3, 625, 8270 and 1988 CLP protocol. She is also experienced with gas chromatographs equipped with FID, PID, and Hall ELCD detectors for methods including 601, 8010, 602, 8020. Ms. Stelzer has thorough familiarity with the HP RTE software used for GC/MS data acquisition and reporting and is proficient in using HP LAS and LIMS data systems. She has a thorough understanding of USEPA CLP requirements for volatiles, semivolatiles, and pesticide/PCB's under 1988 and 1991 protocols.

Laboratory Technician, Environmental Testing Lab, Chicopee, MA. 1986 - 1987

Research Assistant, Elms College, Chicopee, MA. 1985 - 1986

Laboratory Assistant, Chemical Specialties, Springfield, MA. 1984

Education

B.A., Chemistry and Biology, Elms College, Chicopee, MA, Magna cum laude 1986

Continuing Education

"Systems Maintenance and Wastewater Treatment" Springfield Technical Community College, Springfield, MA, 1/19-5/29, 1987

Hewlett Packard RTE-6 Operator School by Hewlett Packard, New Orleans, LA, September 14-18, 1987

"Statistics" Springfield Tech. Comm. College, Springfield, MA, '87

"Custom Reporting", Hewlett Packard class by Hewlett Packard, 1988

Mass Spectral Interpretation Course University of New Hampshire, April 23 - May 18, 1988

Career Track Communication Skills Workshop August 17, 1988

Capillary Chromatography Seminar Restek, 12/11/89

"Train the Trainer", seminar by Maggie Dean, RAI, 4/92

Publications

Wright, M.L., and S.T. Jorey, Y.M. Myers, M.L. Fieldstad, C.M. Paquette, and M.B. Clark, 1988. Influence of Photoperiod, Daylength, and Feeding Schedule on Tadpole Growth and Development. Development Growth and Differentiation, 30, 315-323.

Wright, M.L. et al, 1988. Effect of Changing the Light/Dark Schedule, the Time of Onset of the Light or Dark Period, or the Daylength, on Rhythms of Epidermal Cell Proliferation. Chronobiology International, 5, 317-330.

Wright, M.L. and L.S. Blanchard, S.T. Jorey, C.A. Basso, Y.M. Myers and C.M. Paquette, 1990. Metamorphic Rate as a Function of the Light/Dark Cycle in Rana pipiens Larvae. Comp. Biochem. Physiol., 96A, 215-220.

KERRY HUNTER
Data Validator
New England Regional Office

Experience

Ms. Hunter is responsible for the review, validation and reporting of organics data (specifically pesticide/PCB packages) as it pertains to work conducted under specific protocols such as USEPA CLP protocol, state or government agency protocols or unique PACE/client contracts. Ms. Hunter is responsible for the generation of specific forms and diskette deliverables required to complete a data package. Ms. Hunter reports to Mr. Rhode, Organics Laboratory Manager and Technical Director.

Prior to her position as a Data Validator, Ms. Hunter worked in the Reporting Department where she was responsible for the generation of commercial reports for organic and inorganic analyses. Prior to joining PACE NE, Inc., Ms. Hunter worked in the same capacity for Resource Analysts, Inc. (RAI) which was acquired by PACE NE, Inc. in June 1992. Ms. Hunter joined RAI in 1986 and worked as a GC operator until 1990 when she became an analyst for the Product Registration Group (PRL) of RAI. In this capacity she was responsible for method validation and analysis of samples in support of GLP aquatic toxicology studies. In 1991, she was promoted to Senior Analyst for the PRL. Ms. Hunter has more than four years experience on the HP 5880, HP 5840, HP 5890 Capillary ECD, and the Tracor Hall, 5890 Hall, NPD, TCD, FID, LAS and EPA software, and HPLC experience using the Waters 490, 470, and 430 detectors.

Education

B.S., Biology, University of New Hampshire, 1985

Continuing Education

Laboratory Health and Safety - 1986

Fundamentals of LC - Hewlett Packard - 9/90

Radiation Safety Training course - Dr. George Chabot, Univ. of Lowell - 3/91

Waters service training for 420 and 470 detectors - Millipore Corp. - 4/91

DAVID BUCK
Computer Systems Manager
Pace New England, Inc.

Experience

Mr. Buck is responsible for performing daily, weekly and monthly housekeeping duties on the PACE Network, LAS, and LABUX computer systems. He designs and implements new procedures for data entry and reporting. Mr. Buck is responsible for computer networks and their security. Mr. Buck reports to Ms. Deborah McGrath, Regional Director.

Prior to joining PACE NE, INC. Mr. Buck worked in the same capacity for Resource Analysts, Inc. which was acquired by PACE NE, INC. in June 1992. He joined RAI in 1988 and has had more than four years experience as a Computer Systems Manager and six years training on Hewlett Packard 1000 computers, RTE-A/RTE-6/RTE-IVB. Mr. Buck has converted order tracking systems to database systems and centralized collection of electronic test data.

Computer Analyst, Sprague Electric, Sanford, ME 1987 - 1988

Computer Analyst, Fairchild Semiconductor, South Portland, ME 1985 - 1987

Education

M.B.A., Business Administration, Nasson College, 1987

B.S., Mathematics, University of Maine, 1982

Continuing Education

"Second Annual LIMS Conference", June, 1988

"LABSAM System Manager Course", January, 1989

"Novell System Manager", February 1991

"Unix Basics I and II", December 1991

"Unix System Manager", January 1992

JAMES CUTTER
Senior Technical Specialist
New England Regional Office

Experience

Mr. Cutter is responsible for technical support for all analytical chemistry. This includes instrument operator supervision and training, instrument trouble shooting and maintenance, method development, and analysis of samples. He is responsible for analyses by various methodologies including but not limited to HPLC, GC, and GC/MS. Mr. Cutter reports to Mr. Rhode, Organics Laboratory Director.

Prior to joining PACE, Mr. Cutter worked in a similar capacity for Resource Analysts, Inc. which was acquired by PACE in June 1992. Mr. Cutter joined Envirosystems, Inc., a division of RAI in 10/91 as Product Registration Chemistry Manager. In 3/92 he became Senior Technical Specialist.

Mr. Cutter has more than sixteen years of experience in the areas of environmental and life science analysis and methods development using HPLC, GC, GC/MS, NMR, AAS.

Senior Scientist, ENSECO Inc., Cambridge, MA 10/88 - 10/91

Chromatography Group Leader, ESA Labs, Inc., Bedford, MA 10/86 - 10/90

Chromatography Section Manager, Cambridge Analytical Assoc., Boston, MA 4/86 - 10/86

Chemist II, DuPont/NEN Products, Boston, MA 4/78 - 4/86

Chemist, ESA, Inc., Boston, MA 10/75 - 10/77

Education

B.S., Chemistry, University of Massachusetts, Amherst, MA 1974

Continuing Education

Waters Assoc. training courses in HPLC methods development and maintenance

Axiom Labs training in asbestos analysis (PLM and PCM)

KATHLEEN HUDSON
Project Management/Sample Management Supervisor
New England Regional Office

Experience

Ms. Hudson is responsible for the management of the Sales and Marketing programs and Client Service Department at PACE New England, Inc. Her duties include the development and implementation of marketing strategies and programs, preparation and maintenance of sales forecasts, and supervision of the sales force. The Client Services/Project Management staff also report to Ms. Hudson. Ms. Hudson reports to Ms. McGrath, Regional Director.

Prior to joining PACE NE, INC., Ms. Hudson worked in the same capacity for Resource Analysts, Inc. which was acquired by PACE NE, INC. in June 1992. Ms. Hudson has over seven years of experience in the service industry. She has experience in the environmental, engineering and banking industries.

6/92 - Pres Marketing Manager

8/89 - 6/92 Dir. of Client Svcs., Resource Analysts, Inc., Hampton, N.H.

1/89 - 8/9 Client Services Representative, R.A.I. Hampton, N.H.

1986 - 1987 Commercial Lender, Granite State National Bank, Rochester, N.H.

1985 - 1986 Officer's Assistant/Analyst, Bank of Vermont, Brattleboro, Vt.

Education

B.S. Management Science, Keene State College, Keene, N.H., 1983

M.B.A. New Hampshire College (In Process)

STUART BRONSON
Senior Project Manager
New England Regional Office

Experience

Mr. Bronson serves as a Project Manager for clients who specialize in large scale, complex and on-going site work. He reviews Quality Assurance Project Plans for completeness, applicability and conformance to established protocols. QAPP information is condensed for Laboratory Project Alert Forms. Negotiates project specifications with clients, insures specifications are met by the lab and delivered to the client in the required time frame. Fields questions from a diverse clientele to determine testing needs; issues advice and answers technical questions about the lab, data, methodologies, protocols and procedures. He also maintains communication channels with the Sales Dept. and the Laboratory Staff and serves as the USEPA-CLP contact person for the lab. He gives tours of the Sample Management Dept. to visitors and auditors. Mr. Bronson reports to Ms. Hudson, Project Management/Sample Management Supervisor.

Prior to joining PACE, Mr. Bronson worked as Director of Sample Management for Resource Analysts, Inc. which was acquired by PACE NE, INC. in June 1992. Mr. Bronson joined RAI in 1990.

Mr. Bronson worked at Laucks Testing Laboratory in Seattle, Washington for four years prior to RAI in the capacity of analyst and manager.

Education

B.A. Ecology and Evolutionary Biology, University of Arizona, Tucson, Arizona, 1985.

Coursework towards M.S. in Limnology, University of Washington, Seattle, Washington, 9/89 - 5/90.

Continuing Education

Customer Service Seminar. Dun and Bradstreet, held at Nashua, New Hampshire, May 1991

GRETCHEN FRANZHEIM
Project Manager
New England Regional Office

Experience

Ms. Franzheim currently serves as a Project Manager for clients specializing in large-scale, protocol-specific projects. She reviews Requests For Proposal (RFPs) and Quality Assurance Project Plans (QAPPs) for completeness, applicability and conformance to established protocols. She is responsible for communicating special project requirements to laboratory staff to ensure adherence to protocol or specific client project requirements. Ms. Franzheim serves as primary PACE NE contact with designated clients and is responsible for managing analytical projects from onset to completion. In addition, she fields questions from a diverse clientele to determine testing needs and to answer technical questions regarding protocol, methods, reporting and procedures. Ms. Franzheim reports to Ms. Hudson, Project Management/Sample Management Supervisor.

Previous to her position as a Project Manager, Ms. Franzheim functioned as a Senior Data Reviewer, Ms. Franzheim was responsible for the review of Inorganic CLP data and also served as a backup Organics CLP data reviewer. She is experienced in the review of environmental data for a wide variety of Organic and Inorganic Methods and Protocols including USEPA SAS (Special Analytical Services) projects, NJ ECRA, NYASP, NEESA, and HAZWRAP.

Prior to joining PACE, Ms. Franzheim worked for Resource Analysts, Inc. which was acquired by PACE in June 1992. She joined RAI in 1987 and served in the capacity of Data Review Supervisor until June 1992. Her responsibilities included the tracking of samples and documents through the analytical process while under contract to EPA. She supervised the assembly, review and validation of data for Organics CLP case packages, as well as handling the responsibility of training staff to perform these duties.

Ms. Franzheim has extensive experience in the chemistry field within a variety of areas. Ms. Franzheim gained experience in data review and quality assurance at Aquatec, Inc. and a Chemist at Ladd Research Industries, Inc. From 1977 to 1982, she taught chemistry, biology, physics, and mathematics in public schools.

Education

B.S., Chemistry, St. Lawrence University, 1975

M.S. Candidate, Environmental Studies, U. MASS, Lowell, MA

Continuing Education

"Seminar on CLP Organics", Technical Management Consulting, January, 1988

"Mass Spectral Interpretation", University of New Hampshire, Durham, NH, April - May, 1988

"In Search of Excellence", seminar by Tom Peters, October 18, 1988

"CLP/Superfund Automated Analytical Data Management Caucus", June 28-30, 1989

"Superfund Data Management Caucus", Raleigh, NC, June 12-13, 1990

"Sixth Annual Waste Testing and Quality Assurance Symposium", Washington, D.C., July 16-20, 1990

"Ward CLP Training Class", Ward Scientific, Ltd., Burlington, MA, Aug. 7-8, 1990

"Law of Natural Resources and Environment", University of New Hampshire, Durham, NH, Spring 1991

"Industrial Pretreatment Pollution Prevention", by New England Interstate Environmental Training Center, Westford, MA, February 12, 1992.

"Environmental Law Update 1992", sponsored by Sheehan Phinney Bass + Green Professional Association, Nashua, NH, April 9, 1992.

"Environmental Chemistry Laboratory", University of Massachusetts, Lowell, MA, Fall 1992.

LILLIAN PEPIN
Project Manager
New England Regional Office

Experience

Ms. Pepin is responsible for project management from initiation to completion. Ms. Pepin is the point of client contact for projects, priorities, preliminary data, bottle orders and price quotes for commercial work. Ms. Pepin also serves as liaison for Network projects that New England Regional Office is involved with. Ms. Pepin reports to Ms. Hudson, Project Management/Sample Management Supervisor.

Prior to joining PACE, Ms. Pepin worked in sample management for Resource Analysts, Inc. which was acquired by PACE in June 1992. Ms. Pepin joined RAI in 8/90 and worked in Sample Management where she was responsible for the receiving, handling, storage, and distribution of incoming samples. Her duties also included client contact, data entry, maintenance of sample storage area security, and sample separation for proper disposal.

Ms. Pepin has significant previous experience in the health care industry and has pursued an education in data processing.

Education

Data Processing Certificate, Hesser College, Portsmouth, NH 1989

Nursing Assistant Certificate, State of NH 1985

Continuing Education

"Exceptional Customer Service", Seminar, Dun & Bradstreet, Portland, ME May 1991

MICHAEL K. CAMPBELL
Sample Management Technician
Pace New England, Inc.

Experience

Mr. Campbell is responsible for maintenance of internal custody of samples, preservation of samples, scheduling sample analysis, sample storage, bottle orders, resolving client difficulties, writing SOP's, and documentation of client and sample related information. Mr. Campbell assists in coordinating projects within Sample Management that require special client protocol such as CLP, NEESA, ECRA, and NPDES. He also assists in the supervision of department employees. During periods of high sample volume, Mr. Campbell has assisted in performing certain inorganic analyses. Mr. Campbell reports to Ms. Hudson, Sample Management Supervisor.

Prior to joining PACE NE, INC. Mr. Campbell worked in the same capacity for Resource Analysts, Inc. which was acquired by PACE NE, INC. in June 1992. Mr. Campbell joined RAI in 1990 and worked as Lab Safety Assistant until 1991. His responsibilities as Safety Assistant included managing lab chemical inventories, MSDSs, and hazardous waste shipping manifests. He assisted in implementing the Chemical Hygiene Plan and laboratory safety practices.

Mr. Campbell has experience in customer service, civil engineering, and consumer electronics as well as academic training in the sciences.

Education

B.G.S., Planetary Geology, University of Iowa, 1986

Schoolteacher Certification, State of Maine, Spring 1987.

Intro. to Surveying (20 hours), UNH DCE, Fall, 1988.

Continuing Education

"Hazardous Waste Management in NH", Seminar, BIA/NHDES, March 19, 1992

Excellent Customer Service seminar, Dun & Bradstreet Business Education Services, May 13, 1991

Standard First Aid and Adult CPR Certification, October 15, 1990

"New Hampshire Safety Council Conference & Exhibition", 4/90

3.0 OBJECTIVES

PACE NE is committed to the philosophy that quality operations result from quality planning, design, and work performance by skilled operational personnel. PACE NE's policy is to perform its varied types of technical work in accordance with standard quality assurance practices such as Good Laboratory Practices (GLP) and the EPA Contract Laboratory Program (CLP). PACE NE has a Quality Assurance Officer responsible for maintenance of standard operating procedures, laboratory audits, performance evaluations, federal and state certifications and quality assurance documentation.

Each laboratory worker is responsible for checking standard operating procedures when necessary; following these procedures during routine analyses; recording quality control information required by those procedures in the proper location, and taking appropriate corrective action including suspending analyses when quality control criteria are not met.

Objectives of the quality program are:

- to provide a quality organization independent of the pressures of project performance with the responsibility and authority for auditing and recommending corrective action;
- to provide a quality organization with clear paths of communication with management;
- to perform regularly scheduled audits and thereby document an objective evaluation of quality-related practices;
- to promptly identify variances and implement corrective actions;
- to maintain readily identifiable and retrievable records that provide documentary evidence of the quality of activities performed;
- to provide procedures for implementing project-specific quality plans;
- to define responsibility and authority for developing and implementing quality plans;
- to provide quality reference documentation for each project.

Quality Assurance objectives for measurement data can be expressed in terms of completeness, representativeness, accuracy, precision, comparability and traceability.

3.1 Completeness

Completeness is a measure of the amount of valid data obtained from a measurement system compared to the amount that was expected. The QA objective for completeness is to maximize the number of valid results. This can be attained by:

- minimizing sample loss and breakage
- performing sufficient QC samples to document control
- documenting all aspects of the analytical system

The laboratory goal for completeness is 95% where:

$$\frac{D}{n} \times 100 = \%\ \text{complete}$$

D : number of samples analyzed that met the Data Quality Objectives

n : number of samples recieved for analysis

3.2 Representativeness

Representativeness is the extent to which reported analytical results truly depict the chemistry of the sampled environment. Representativeness is a qualitative objective which is optimized through proper selection of holding times and procedures, through proper sample preservation, and through prompt extraction and analysis. Refer to Table 6.1.

USEPA guidance is followed for sample preservation and field preservation is checked upon sample receipt in the laboratory. Refer to PACE NE SOP QA-400, Sample Receiving and Identification, current revision.

Sample holding times follow EPA recommendations. In cases where no formal recommendation has been made, the holding time for that analyte in a different matrix or a similar analyte in a similar matrix is applied.

3.3 Accuracy and Precision

Accuracy and precision data are optimized through the use of analytical procedures that minimize biases through the use of standard procedures, through the meticulous calibration of analytical equipment and by implementing corrective action whenever measured accuracy and precision exceed pre-established limits.

Accuracy and precision are assessed through the analysis of Laboratory Control Check Samples. Laboratory generated QC samples, such as method blanks and Laboratory Control Spike/Spike Duplicate Samples are used to assess the accuracy and precision of measurements due to laboratory activities. QC Samples, such as surrogate spikes and matrix spike/matrix spike duplicates are used to monitor the effects of the sample matrix on precision and accuracy. QC Check Samples such as field blanks, field duplicates and trip blanks are used to assess the accuracy and precision of both sampling and laboratory activities. Accuracy and precision goals for the laboratory are based on laboratory historical data, specific method requirements and the requirements of each specific project. A more detailed discussion of these goals is provided in Section 11.

3.4 Comparability

Comparability is the extent to which comparisons among different measurements of the same quantity or quality will yield valid conclusions. Comparability is a qualitative objective that will be attained by utilizing standard techniques for sample analysis and by reporting analytical data in appropriate units. Comparability between PACE NE analytical results and those obtained by other researchers will be ensured through the use of EPA, ASTM, and other recognized methods.

3.5 Traceability

Traceability is the extent to which results can be substantiated by hard-copy documentation. Traceability documentation exists in two forms: that which links final numerical results to authoritative measurement standards, and that which explicitly describes the history of each sample from collection to analysis. Refer to Sections 6 and 10 for more specifics on PACE NE procedures.

4.0 STANDARD PRACTICES

4.1 Laboratory Safety

Sample receiving areas and laboratories shall be equipped with suitable hoods, respirators, protective clothing and eye wear, gloves, barrier creams and other measures to prevent or minimize staff contact with hazardous substances. Safety equipment such as eyewash stations, drench showers, spill adsorbents and neutralizers, fire extinguishers, first aid materials, and breathing oxygen shall be available.

As a matter of policy, PACE NE shall not accept known initiator explosives, known dioxin-contaminated materials or unusual biohazard materials. PACE NE shall accept only those radioactive materials for which the isotope and emissions are clearly identified, and are in compliance with the terms and conditions of any and all applicable license(s). PACE NE shall accept nitroaromatics and nitroamines providing that the client makes provisions for disposal of samples with a positive explosive identification.

A laboratory staff member shall be designated as Safety Manager by the Regional Director. The Safety Manager prepares and maintains safety-related SOP's, conducts safety and occupational health orientation, training and review sessions as required, and maintains up to date familiarity with safety and occupational health issues pertinent to the laboratory.

The Safety Manager prepares and maintains educational programs as required to comply with state and federal "right to know" legislation.

The Safety Manager or his designee shall conduct an orientation session with each new staff member to familiarize him/her with routine and emergency safety procedures and equipment. Generally, the first one to three days shall be devoted primarily to health and safety concerns. Eye protection and a lab coat shall be issued to the employee. A respirator will be issued, as required, after respiratory protection training. Refer to PACE NE NE SOP QA-607, Respiratory Protection. A tour of the laboratory shall be conducted. During the tour, needs for eye, skin, and respiratory protection shall be discussed as well as the use of safety glasses, face shields, goggles, partial and full-face respirators, ventilated work areas, fume hoods, gloves, barrier creams, and Tyvek coveralls. The location of eye wash stations, drench showers, fire extinguishers, and first aid equipment shall be shown to the employee and their use shall be described or demonstrated. Fire and spill notification, emergency procedures, and evacuation stations shall be taught during this session. Refer to PACE NE NE SOP QA-602, Employee Training Safety Tours. The orientation concludes with an introduction to potential

chemical hazards and the Material Safety Data Sheets (MSDS). MSDS shall be made available for review.
Employees shall be responsible for their own safety. Laboratory Managers and Group Supervisors may require that certain levels of protective equipment be worn when in their judgement it is appropriate. Failure of an employee to wear required protective equipment will result in immediate disciplinary action.

4.2 Training

Laboratory Manager(s) shall be responsible for staff training programs, which may be administered by the Laboratory Managers and Group Supervisors.

Training shall be conducted for each individual on each procedure that he or she is to perform.

No individual shall conduct any analysis, experimental procedure or other professional function without continuous direct supervision until training in that procedure has been completed and the individual's ability to produce acceptable results has been documented.

Training Documentation Forms and written records of training activities shall be generated and maintained by the Laboratory Managers or Group Supervisors.

Records of attendance at professional development seminars, conferences, courses and the like shall be kept by the Quality Assurance Department in individual training files maintained for all technical staff. Refer to PACE NE SOP QA-556, Training Files.

4.3 Security and Confidentiality

Three tiers of security shall be maintained within all PACE NE, Inc. facilities with the purpose of controlling external influences on samples, analytical processes, and data. This helps assure the completeness, representativeness, accuracy, and precision of analytical results.

The first tier of security maintained shall be controlled access to laboratory buildings. Exterior doors to laboratory buildings shall remain either locked or continuously monitored by a PACE NE, Inc. staff member. Keyless door-lock combinations shall be changed every time an employee terminates employment at PACE NE. Posted signs shall direct visitors to the reception office and mark all other areas as off limits to unauthorized personnel. All visitors to the facilities must sign the Visitors' Logbook maintained by the receptionist. All visitors shall be accompanied by a staff member during the duration of their stay on the premises. The staff member shall escort the

visitor back to the reception area at the end of their visit where they shall sign out in the Visitor's Logbook. Prior to departure of the last staff member at the close of each day, all windows shall be locked and all doors checked and locked by the last staff member.

The second security level shall be within the facility and may be designated as required by the Laboratory Managers in consultation with the Regional Director. Individual Laboratory Managers or Group Supervisors may close specific areas under their responsibility to entry by unauthorized persons. A list of authorized persons shall be prepared and signed by the Regional Director. "Closed Areas" shall be designated by prominent postings at all points of access.

The final tier of security shall be comprised of specific secure areas for sample, data and client report storage which shall be lockable within the facilities, and to which access shall be limited to specific individuals or their designees. Security of sample storage areas shall be the responsibility of the Sample Manager. Refer to PACE NE SOP QA-401, Sample Storage. Security of samples and data during analysis and data reduction shall be the responsibility of Group Supervisors and Laboratory Managers. Security of client report archives shall be the responsibility of the Quality Assurance Officer. Refer to PACE NE SOP QA-550, Data Archives. These secure areas will be locked whenever these individuals or their designees are not present in the facility.

Designated laboratory sample storage locations are designed to limit access to authorized personnel only, and provisions for lock and key access shall be provided. No samples are to be removed without authorization, which consists of having a worklist requesting analysis on an aliquot and without filling out the associated chain-of-custody records.

Standard business practices of confidentiality shall apply to all documents and information regarding client analyses. Specific protocols for handling confidential documents are described in PACE NE SOP QA-557. Additional protocols for internal identification of samples and data by number only shall be implemented as required under contract-specific Quality Assurance Project Plans.

4.4 Traceability of Standards, Instrumentation, and Data

Since standard solutions used for analytical method calibration affect all data derived from the method, the importance of quality and traceability shall be paramount.

Laboratory staff may order only materials of certified purity from reputable suppliers. Records of reference material purchased shall be maintained by the appropriate department.

PACE NE strives to purchase only the highest quality materials. To that end, reference materials shall be NIST traceable, EPA certified (CRADA), or American Association for Laboratory Accreditation certified whenever possible.

If assayed materials are unavailable, the material of highest purity available shall be obtained and assayed in-house before use.

Reference material containers shall be identified with the standard serial reference number and dated upon receipt.

Bound laboratory notebooks shall be used by analysts and technicians to record preparation of working standards from identified reference material. The following information shall be recorded:

date of preparation
analyst's initials
source of reference material
amounts used
final volume
serial reference number and expiration date of the stock standard used
expiration date of the working standard made

All standards containers shall be labelled with, at minimum (as on small glass ampules), the standard serial reference number; when possible, the name, concentration, date of preparation and expiration date of the stock standard.

All diluted working standards not consumed during an analytical session shall be labelled fully, including the serial reference number of any stock standard used in its preparation.

Instrumentation used shall be as prescribed in the SOP for the analytical method.

All instruments used to collect samples, generate sample results and/or reduce data shall be designated by a unique alphanumeric identifier. This instrument identifier shall appear on the instrument, in the analysts' notebooks, instrument logbooks and/or computer-generated hardcopy for all sample analyses.

Preventive maintenance shall be provided for all instruments and equipment as specified by the manufacturer, or as established by the Laboratory Manager (or Group Supervisor), whichever is more frequent. Preventive maintenance shall be conducted in order to assure timely, accurate and reproducible analytical processes in a safe laboratory or field environment.

All maintenance activities shall be recorded in either the instrument run log or a separate logbook unique to the instrument.

All data generated in and/or reported from the laboratory shall include reference to the person(s) who performed the analysis, the date of analysis, the method used, the identification of the instrument and the acceptability of the results in the context of the QC system.

The Laboratory Control Sheet issued to laboratory departments shall be used to initiate a laboratory data file for the project.

All data pertinent to sample preparation shall be recorded by the laboratory staff in bound notebooks with numbered pages, on preprinted bench sheet forms and/or in LABUX. If bench sheets are used, the original forms will be retained in a 3 ring binder and a true copy will be forwarded to the reporting group for inclusion with the archived report package. During the sample preparation process, a preparation sheet shall be prepared for the project by the preparation specialist. It shall contain the following information:

Sample identification numbers
Date of preparation
Method reference
Analyst's initials
Preparation weights and/or volumes
Relevant blank
Spike and surrogate data including the serial reference number and the instrumental analysis to be performed on each extract.

The preparation sheet shall be filed with the Laboratory Control Sheet in the Laboratory Project File.

At the time of sample analysis, the laboratory identification number, amount injected or otherwise analyzed, any dilution of the original sample and/or extract and other relevant sample data shall be entered into either an analyst's notebook or instrument logbook, or if possible into the instrument header.

All data relevant to the calculations should, where possible, be entered onto the instrument header including sample weight or volume, final volume, dilution, and spike level.

4.5 Accountability

All areas of the laboratory in which samples are received, stored, processed, or analyzed shall be kept in a condition that minimizes the risk of samples becoming lost or accidentally destroyed, contaminated, degraded, misidentified, improperly handled or otherwise compromised. The following practices shall be followed to assure that data reported represent results on the sample as submitted to the facility.

All employees shall be responsible for the cleanliness and order of their work areas. The Laboratory Manager(s) shall routinely tour the facilities noting major and minor infractions. These shall be brought to the attention of the respective group supervisors who formulate and institute corrective action through their staff.

Each sample, defined as a unit of matrix enclosed by a single container, shall be assigned a Laboratory Control Number by the Sample Management staff member who receives the sample. Provisions to identify field replicates and additional sample volume shall be incorporated into this procedure as described in PACE NE SOP QA-400, Sample Receiving and Identification.

Cross-referencing of Laboratory Control Numbers and Client Sample ID's shall be implemented in Sample Management documents as described in PACE NE SOP QA-400, Sample Receiving and Identification.

Sample analyses shall be identified by Laboratory Control Number in analysts' notebooks or instrument logbooks, which shall consist of bound laboratory notebooks with prenumbered pages or on pre-printed benchsheets.

Transfers of samples in and out of storage shall be recorded in Internal Custody Records maintained by the Sample Manager.

Standards shall be stored separately from samples and extracted samples.

Computerized systems for data generation designed in house shall be validated prior to implementation and shall contain provisions for password access and additional security measures as required.

Where commercial computer software is used for data generation within PACE NE, the software producer is responsible for validation of their system.

4.6 Sample Analysis

Samples shall be analyzed within holding times as specified in Table 6.1, unless a more restrictive holding time is prescribed under a contract-specific QA Project Plan.

Samples shall be analyzed and experimental procedures conducted following written Standard Operating Procedures (SOP's) which have been approved in writing by management. Where PACE NE SOPs differ from EPA or Standard Methods, these differences will be noted in the SOP. Refer to Section 8.0, Analytical Procedures. Substantial changes to established procedures shall be authorized in writing by management via an SOP revision process as described in PACE NE SOP QA-553, Preparation of SOP's.

Departures from SOP's need management approval prior to implementation and shall be recorded in the raw data and on an SOP Deviation Form obtained from the QA Department (Figure 12-1). A copy of the form should be filed with the associated report file.

Laboratory Managers shall assure that samples are scheduled for analysis in compliance with the analytical request as issued by the Sample Manager in the form of a Laboratory Control Sheet(s).

A written Worklist System approved by the Technical Director shall be used to assign work to preparatory and instrumentation lab staff members.

4.7 Data Validation

Each department shall have written procedures for data validation which incorporate the quality assurance goals of traceability, accountability completeness, precision and accuracy.

No written reports shall be issued which have not undergone the data validation process.

4.8 Documentation

All information related to the quality assurance practices outlined in this manual shall be contained in records. This shall include, but not be limited to, standard operating procedures, study protocols, results of instrument calibrations, analysis of quality control samples, analysis of samples, sample custody and disposal, preparation of standards, corrective action reports, audits and inspections.

The Quality Assurance Office shall keep written inventories of quality-related documents.

5.0 MATERIALS AND APPARATUS

5.1 Reagents, Solvents and Gases

Chemical reagents, solvents, gases, and standards, supplied by reputable chemical suppliers, are used in the laboratory. All chemical reagents used for analyses shall be at least "Analytical Reagent Grade". Individual method references may indicate specific reagent requirements.

Materials are dated upon receipt in the laboratory. Solvents are checked for purity before use (Section 5.2.2, Solvent Lot Checks). Filters are placed on gas lines supplying instruments as an extra precaution.

All solvents and gases used shall be chosen to assure compliance with specific method and SOP requirements.

5.2 Laboratory Equipment

5.2.1 Refrigerator/Freezer Temperature Logs

Refrigerators and freezers are checked every weekday to ensure that they are operating properly and within established temperature ranges. All information is recorded on monthly data sheets taped to the door of each unit. Routine maintenance such as defrosting is performed as needed. Refer to PACE NE SOPs QA-800 and QA-801. Responsibility for performing the checks is assigned within the laboratory section where the units are located. The QA Department is responsible for ascertaining that checks have been performed and that necessary corrective actions have been instituted when needed. The QA Department is responsible for maintaining all historical temperature logsheets.

5.2.2 Solvent Lot Checks

Solvents are checked for trace contaminants on a lot-by-lot basis. When a new lot is opened, the chromatogram for the blank associated with the first samples extracted using this new lot is checked for any contamination. All information relevant to the check is recorded and maintained in a Solvent Check File. Responsibility for performing the checks and maintaining the records is assigned to the Extractions Laboratory Group Supervisor.

5.3 Glassware

All glassware used in the laboratory is maintained in good condition, cleaned, properly stored, and separated according to its specific laboratory application. Cracked, excessively chipped or otherwise defective glassware is either discarded or repaired. PACE NE's analytical laboratory purchases the majority of glassware from recognized commercial laboratory glassware suppliers such as Fisher Scientific and Baxter. All volumetric glassware utilized is class "A" certified.

Each laboratory maintains its own set of glassware, completely independent from the other laboratories. Cleaning of glassware is performed in each preparation laboratory to ensure that the glassware remains within each laboratory.

5.4 Glassware Cleaning

Laboratory glassware is scrupulously cleaned prior to use. Different cleaning procedures exist for different types of analyses and glassware. Refer to PACE NE SOP QA-802 (inorganics), QA-805 (metals preparation), and QA-804 (general organics).

5.5 Sample Preservation and Storage

Samples are preserved according to the EPA's recommendations (refer to Table 6.1) unless otherwise instructed, and stored to minimize sample contamination. To keep samples of differing levels of contamination separate, samples are segregated when high levels of contamination are known to be present. The laboratory must rely upon information supplied by the sampling team to document any known hazards. If there are samples that are suspected of having contaminants at high levels, they are unpacked in a hood. For Log-In procedures and supporting documentation, see Section 6 and PACE NE SOPs QA-400 and QA-401.

A holding blank comprised of DI water is placed into the volatiles storage refrigerators in the sample Receiving Area to monitor the potential of cross contamination. The holding blank is created daily for volatiles and analyzed whenever the associated jobs are analyzed.

5.6 Instruments

Laboratory instrumentation used shall be as specified in the protocol for the analytical method. Table 5-1 is a listing of major analytical instrumentation present in this laboratory.

Preventive maintenance is performed for each instrument by analysts and technicians on an ongoing basis and the activities documented in a bound instrument maintenance logbook or in the analysts runlogs.

Corrective maintenance shall be provided as required for all instruments and equipment and documented in appropriate logbooks. Factory replacement parts, trained service technicians and first quality materials shall be used whenever available. It is PACE NE's policy to conduct repairs at the lowest level of complexity necessary and to obtain parts directly from primary manufacturers whenever possible. The purpose of this policy is to maintain efficiency, economy and reliability of quality maintenance.

TABLE 5-1

ANALYTICAL INSTRUMENTATION

ITEM	QTY.	DESCRIPTION
GC/MS & GC SYSTEMS:		
GC/MS/DS	2	HP 5970 on RTE A900 HP-1000
GC/MS/DS	2	HP 5970 on RTE A900 HP-1000
GC/MS/DS	2	HP 5970 on RTE 600 HP-1000
GC/MS/DS	1	Extrel, ELQ 400 on Digital PDP-11
GC/(2ECD)	2	HP 5890
GC(2ECD)	1	HP 5880
GC(FID, FPD)	1	HP 5890
GC(NPD, ECD)	1	HP 5890
GC(FID, ECD)	2	HP 5840, HP 5890
GC(FID, TCD)	1	HP 5880 dual channel
GC(PID, HECD)	1	Tracor 540
GC(HECD,ELCD)	2	HP 5890
GC(FID)	1	HP 5890
GC(NPD-FID)	1	Waters Dimension 1
GC(Hall-PID)	1	Waters Dimension 1
Auto Sampler	9	HP 7673A
Auto Sampler	1	Tekmar ALS 2016
Auto Sampler	5	Tekmar ALS
Purge & Trap	2	Tekmar LSC 2000
Purge & Trap	5	Tekmar LSC 2
Dynamic Headspace Concentrator	1	Tekmar 4000/4200
Thermal Desorber	1	Century ATD
Auto Sampler	2	HP 7672A
Auto Sampler	1	Varian 8050
Auto Sampler	2	Dynatech PTA-30
HPLC SYSTEMS:		
LC System-Auto Sampler	6	Waters Assoc. 48 position 712 WISP
LC System-Chromatography Pumps	5	Waters Assoc. 510
LC System-Conductivity Detector	1	Waters Assoc. 431
LC System-Fluorescence Detector	1	Waters Assoc. 420
LC System-Pump Controller	3	Waters Assoc. 680
LC System-RI Detector	1	Waters Assoc. 410
LC System-UV Spectrophotometer	2	Waters Assoc. 490E
LC System-UV Spectrophotometer	1	Waters Assoc. 441
LC System-Chromatography Pump	1	Waters Assoc. 590

TABLE 5-1 - CONTINUED

ANALYTICAL INSTRUMENTATION

ITEM	QTY.	DESCRIPTION
HPLC SYSTEMS - CONTINUED:		
LC System-Fraction Collector	1	ISCO - "Foxy"
LC System-Fraction Collector	1	Waters Assoc.
Post Column Derivatization System	1	Waters Assoc.
LC System-WAVS	1	Waters Assoc. Auto. Valve Station
Ion Chromatograph	1	Dionex 2000i
LC System-UV Detector	1	LDC Spectromonitor II
LC System-Scanning Fluorescence Detector	2	Waters Assoc. 470
LC System-Tunable Absorbance Detector	2	Waters Assoc. 484
LC System Controller & Pump	1	Waters Assoc. 600E
LC System Temperature Control Module	1	Waters Assoc. TCM
METALS INSTRUMENTATION:		
ICP	1	Thermo Jarrell Ash ICAP 61
ICP	1	Leeman Labs Plasma Spectrophotometer
AA Spectrophotometer	1	Hitachi Z9000 Zeeman (4 channel)
AA Spectrophotometer	1	Varian Spectra AA 20AA
AA Spectrophotometer	1	Perkin-Elmer 5100 Zeeman Furnace
AA Spectrophotometer	1	Perkin-Elmer 3100
Vapor Generation Accessory	1	Varian VGA-76
Auto Sampler	1	Varian PS-56
Auto Sampler	1	Perkin-Elmer AS90
Auto Sampler	1	Perkin-Elmer AS60/70
Furnace Atomizer	1	Perkin Elmer HGA 600
Mercury/Hydride System	1	Perkin-Elmer FIAS 200
DATA MANAGEMENT EQUIPMENT:		
Lab Automation System (LAS)	1	HP 3350 on RTE A900 HP-1000
Lab Information System (LABSAM)	1	HP on RTE A900 HP-1000
Tape Backup System (LABSAM, LAS)	1	HP 35401
Tape Data Archival (GC/MS)	2	HP 7970B
Tape Data Archival (GC/MS)	2	HP 7974
LAS/LABSAM Terminals	22	HP B&W/Color/150 Terminals
Personal Computers	85	NEC, CompuAdd & Compaq
Organic CLP Software	-	Finnigan Formaster
Inorganic CLP Software	-	Telecations

TABLE 5-1 - CONTINUED

ANALYTICAL INSTRUMENTATION

ITEM	QTY.	DESCRIPTION
OTHER INSTRUMENTATION:		
Autoanalyzer	1	Lachat QuickChem AE
IR Spectrophotometer	1	Perkin Elmer 1420
Total Organic Carbon Analyzer	1	Astro 2001
Total Organic Halide Analyzer	1	Dohrman
Liquid Scintillation Counter	1	LKB Wallac 1214 Rackbeta
UV-Vis Spectrophotometer	1	Bausch & Lomb Spectronic 601
Visable Spectrophotometer	2	Milton Roy 301
Analytical Balance	2	Mettler AE200
Analytical Balance	1	Mettler H31AR
Analytical Balance	1	American Sci. Prod. SP182
Top-loading Balance	1	American Sci. Prod. Z3000
Top-loading Balance	1	American Sci. Prod. Z410
Top-Loading Balance	1	Mettler PJ400
Top-Loading Balance	1	AND EK-1200A
pH Meter	1	Beckman 43
pH Meter	1	Beckman 11
pH Meter	1	Jenco Electronics 6071
Conductivity Meter	1	YSI Scientific Model 32
Rotary Extractors	4	Associated Design Model 3740-12-BRE

6.0 SAMPLE CUSTODY

Chain-of-Custody encompasses three major elements: field sampling, laboratory analysis and final data file. A Chain-of-Custody (COC) document may be the means in some types of legal proceedings by which evidence of custody of samples from time of receipt to completion of analysis is proved in the courts. PACE NE has implemented standard operating procedures to ensure that sample custody objectives of traceability and responsibility are achieved for every project. This section covers quality related activities from the receipt of samples at the laboratory through the issuance of final analytical data and the storage of data in its final data file.

6.1 Chain-of-Custody

The National Enforcement Investigations Center (NEIC) of EPA defines evidence of custody in the following manner:

1. It is in your actual possession, or

2. It is in your view, after being in your physical possession, or

3. It was in your possession and then you locked or sealed it up to prevent tampering, or

4. It is in a secure area.

Samples may be physical evidence and should be handled according to certain procedural safeguards. Field personnel or Client representatives complete a Chain-of-Custody Form for all samples. Samples are received by the laboratory accompanied by these forms.

The sampler should provide the following information:

- Client project name
- Project location
- Field sample number/identification
- Date and time sampled
- Sample type

- Preservative
- Analysis requested
- Sampler signature
- Signature of person relinquishing samples
- Date and time relinquished
- Sampler remarks
- Custody Seal Number

The record is filled out completely and legibly. Errors are corrected by drawing a single line through and initialing and dating the error. The error is also "error coded" to explain the reason for the correction (refer to Table 9-1). The correct information is then recorded with indelible ink. All transfers of samples except to and from commercial couriers must be recorded on the Chain-of-Custody via the "relinquished" and "received by" sections. All information except signatures may be printed.

When samples are received into the laboratory (refer to Section 6.3), Sample Management Personnel sign the Chain-of-Custody, verify their integrity as they are unpacked and explicitly state in the receipt records whether the Chain-of-Custody seal is intact, whether the sample is received intact or broken, and whether the sample is appropriately identified. This information is documented on the Sample Receipt Condition Report (SRCR) and the client is contacted if any discrepencies or problems are found. If the integrity requirements are met or when any discrepancies are resolved, the sample is assigned a laboratory identification number, the sample is stored in the appropriate refrigerator and the pertinent information is entered into the Laboratory Information Management System (LIMS). Once samples are in the laboratory, an Internal Custody Record is generated to track the transport and status of each sample within the laboratory. After sample log-in, a project file is started by the Sample Management Group Supervisor which includes the Chain-of-Custody record and all sample receipt documentation. Further detail on internal laboratory custody procedures is provided in subsequent subsections.

6.2 Sampling Kits

In general, sampling kits comprise the following:

- Sampling containers
- Preservatives (upon request) and appropriate MSDSs
- Chain-of-Custody forms
- Custody Seals (upon request)
- Sample labels
- Packing Material
- Shipping containers
- Ice Packs

Sample kit requests are received by the laboratory personnel (generally the Sample Manager) from a Project Manager or sampling team members via telephone request, memo, or facsimile.

Based upon the specific request, the Sample Manager or Project Manager determines the appropriate containers, preservatives and the necessary volume/quantity to specify for the analysis. This information is outlined in Tables 6-1. Refer to PACE NE SOP QA-402, Bottle Orders and QA-403.

6.2.1 Sample Containers

VOA vials (40 mL) are purchased pre-cleaned from Industrial Glassware.

Sample bottles for all analyses other than VOA are purchased from Fisher Scientific. All glass and plasticware is purchased in lots of about 15-50 cases per size and type of bottle.

An internal lot number is assigned to each batch of bottles purchased so that each batch may be tracked and tested for cleanliness. One or two bottles per batch per type of analysis is taken at random and tested. PACE NE tests its glassware for cyanide, 23 metals, acid/base/neutrals, pesticides, PCBs, and volatile organics as follows:

Table 6-1
Sampling and Preservation Requirements

Parameter	Method	Required Volume & Containers [3]	Preservation [7]	Holding Time (in days)
Organics:				
Drinking water GC/MS VOA	EPA 524.1/524.2	3 x 40 ml Glass vial	HCl; 4°C [2]; No headspace	14
Wastewater GC/MS VOA	EPA 624/SW846 8240	2 x 40 ml Glass vial	HCl; 4°C [2]; No headspace	14
Purgeable Halocarbons	EPA 601/SW846 8010	2 x 40 ml Glass vial	HCl: 4°C [2]; No headspace	14
Aromatics	EPA 602/SW846 8020	2 x 40 ml Glass vial	HCl; 4°C [2]; No headspace	14
Acrolein, Acrylonitrile	EPA 603/SW846 8030	2 x 40 ml Glass vial	pH 4-5;4°C [2]; No headspace	14
TOX (Total Organic Halides)	subcontracted	250 ml Glass,amber	H_2SO_4; 4°C; No headspace	7
Acids/Base Neutrals	EPA 625/SW846 8270	1000 ml/30 g Glass,amber	4°C [2]	7(14)/40
Pesticides/PCB's	EPA 608/SW846 8080	1000 ml/30 g Glass	NaOH,H_2SO_4,pH 5-9;4°C [2]	7(14)/40
Carbamate Pesticides	EPA 531.1	120 ml Glass	3.6 ml Monochloroacetic acid buffer pH 3; Freeze	28
Herbicides (SDWA)	SM 509A/SW846 8150	1000 ml/30 g Glass	4°C [2]	7(14)/40
Petroleum Hydrocarbons-GC/FID	ASTM D-3328-78	1000 ml/30 g Glass	H_2SO_4; 4°C	7(14)/40 [6]
Petroleum Hydrocarbons-IR	EPA 418.1	1000 ml/30 g Glass	H_2SO_4; 4°C	28
Polynuclear Aromatics	EPA 610/SW846 8100	1000 ml/30 g Glass,amber	4°C [2]	7(14)/40
Oil & Grease - Gravimetry	EPA 413.1	1000 ml/30 g Glass	1+1 HCl; 4°C	28
Oil & Grease - IR	EPA 413.2	1000 ml/30 g Glass	1+1 HCl; 4°C	28
NM2P	EPA 625/SW846 8270	1000 ml/30 g Glass	4°C	7(14)/40
Total Phenolics	EPA 420.3	200 ml/30 g Glass,amber	H_2SO_4; 4°C	28
Dioxins	subcontracted	1000 ml/100 g Glass	4°C [2]	7(14)/40
Metals:				
Mercury	245.1/7470 (7471)	50 ml/10 g	HNO_3	28
Arsenic & Selenium	EPA 200/7000 Series	50 ml/10 g	HNO_3	180
Lead, Thallium, Antimony	EPA 200/7000 Series	50 ml/10 g	HNO_3	180
All other metals (ICP metals)	EPA 200.7/SW 6010	50 ml/10 g	HNO_3	180
plus Hardness	SM 314A/EPA 200.7	(Included)	HNO_3	180

The following elements can be analyzed by ICP: Al, Ag, B, Ba, Be, Ca, Cd, Co, Cr, Cu, Fe, K, Mg, Mo, Mn, Si, Sr, Sn, Na, Ni, Pb, Ti, V and Zn in water, wastewater, and digested solids. As, Pb (water), Se, Tl and other metals normally analyzed by furnace may be determined by ICP but only with reduced sensitivity and therefore higher detection limits. Hg is analyzed by cold vapor.

NOTE: If duplicates and spikes are required, triple the sample volume for water samples.

EPTOX	SW846 1310	250 grams	N/A	N/A
TCLP	Fed.Reg.Vol. 55 Nov. 24, 1992 Rules and Reg.	250 grams (2 X 250 g containers if VOAs are required)	4°C	See Below

TCLP PARAMETER	FROM COLLECTION TO TCLP EXTRACTION	FROM TCLP EXTRACTION TO PREPARATIVE EXT'N	FROM PREP EXT'N TO ANALYSIS
VOLATILES	14	N/A	14
SEMIVOLATILES	14	7	40
MERCURY	28	N/A	28
METALS EXCEPT MERCURY	180	N/A	180
PESTs/HERBs	14	7	40

Table 6-1, continued

Sampling and Preservation Requirements

Parameter	Method	Required Volume & Containers [3]	Preservation [7]	Holding Time (in days)
Inorganics:				
Acidity	EPA 305.1	125 ml/ 2 g	4°C	14
Alkalinity	EPA 310.1	125 ml/ 2 g	4°C	14
Asbestos	subcontracted	1000 ml Glass	4°C	
Bromide	EPA 300.0	10 ml/20 g	4°C	28
BOD	EPA 405.1	250 ml	4°C	2
BTU	ASTM D 240	5 ml/ 2 g	4°C	N/A
Chloride	EPA 300.0 or 325.1	10 ml/20 g	4°C	28
Chlorine upon Combustion (oil)	ASTM D 129-64/300.0	20 g	4°C	N/A
Chlorine, Residual	APHA 4500-CLG	200 ml		Field Test
COD	EPA 410.4	50 ml/ 5 g	H_2SO_4; 4°C	28
Coliform Bacteria	subcontracted	125 ml sterile	4°C [2]	24(6) Hours [5]
Color	EPA 110.2	100 ml	4°C	2
Conductance	EPA 120.1	100 ml	4°C	28
Cyanide, Total	EPA 335.2/SW 9010	1000 ml/25 g	NaOH; 4°C [1]	14
Cyanide, Ammenable	EPA 335.1/SW 9010	1000 ml/25 g	NaOH; 4°C [1]	14
Flashpoint	ASTM D 93-77	80 ml/80 g	4°C	N/A
Fluoride	EPA 340.1/340.2	100 ml (NPDES=500ml) Plastic	4°C	28
Formaldehyde	NIOSH 3500 mod	20 ml/20 g	4°C	N/A
Grain size (dry sieving)	EPA/CE-81-1	100 g		N/A
Hexavalent Chromium	SW846 7196	125 ml/20 g	4°C	1
Ignitability	SW846 1010	50 ml/25 g	4°C	N/A
MBAS (Surfactants)	EPA 425.1	150 ml	4°C	2
Nitrogen - Ammonia	EPA 350.1 or .3	200 ml/ 5 g	H_2SO_4; 4°C	28
" - Nitrate	EPA 300.0 or 353.2	25 ml/20 g	4°C	2
" - Nitrite	EPA 300.0 or 354.1	25 ml/20 g	4°C	2
Nitrogen - Nitrate+nitrite	EPA 353.2	25 ml/20 g	H_2SO_4; 4°C	28
" - TKN	EPA 351.3	200 ml/ 5 g	H_2SO_4; 4°C	28
" - TON (NH_4 & TKN)	EPA 350.3/351.3	250 ml/ 5 g	H_2SO_4; 4°C	28
Ortho Phosphate-P	EPA 365.1 or .3	100 ml	4°C	2
Particle size (wet digestion)	EPA/CE-81-1	100 g	4°C	N/A
pH	EPA 150.1	25 ml		Field Test
Phosphorus, Total	EPA 365.3 or .4	100 ml/ 5 g	H_2SO_4; 4°C	28
Radiology - R, U, Alpha,Beta,Gamma	subcontracted	3000 ml	HNO_3; 4°C	180
Radon	subcontracted	2 x 40 ml Glass	4°C	2
Reactivity- Sulfide Spot Test	SM 427.3C	10 ml/10 g	4°C	N/A
Reactivity- Cyanide Spot Test	SM 412J	10 ml/10 g	4°C	N/A
Reactivity- Releasable Cyanide	SW 846,Sec.7.3.3.2	10 g	No Headspace, 4°C	N/A
Reactivity- Releasable Sulfide	SW 846,Sec.7.3.4.1	10 g	No Headspace, 4°C	N/A
Silicate, Reactive	EPA 370.1	100 ml/ 2 g Plastic	4°C	28
Solids, Settleable	EPA 160.5	1000 ml	4°C	2
Solids, Total (TS)	EPA 160.3	100 ml [4]	4°C	7
Solids, Total Suspended (TSS)	EPA 160.2	100 ml [4]	4°C	7
Solids, Total Dissolved (TDS)	EPA 160.1	100 ml [4]	4°C	7
Solids, Total Volatile (TVS)	EPA 160.4	100 ml [4]	4°C	7
Solids, Total Suspended Volatile	EPA 160.4 or .2	100 ml [4]	4°C	7
% Solids (% moisture)	APHA 2540G	30 g	4°C	N/A
Specific Gravity	EPA/CE 1981	30 ml	4°C	N/A
Sulfate	EPA 300.0 or 375.2	10 ml/20 g	4°C	28
Sulfide	EPA 376.2	250 ml	ZnAc;NAOH,pH>9; 4°C	7
Sulfite	EPA 377.1	100 ml		Field Test
Tannins and Lignins	APHA 5550B	100 ml	4°C	N/A

Table 6-1, continued
Sampling and Preservation Requirements

Parameter	Method	Required Volume & Containers[3]	Preservation[7]	Holding Time (in days)
Inorganics:				
TIC (Total Inorganic Carbon)	EPA 415.1 mod	60 ml/ 2 g	4°C	28
TOC	EPA 415.1	60 ml/ 2 g	No Headspace H_2SO_4; 4°C	28
Turbidity	EPA 180.1	100 ml	4°C	2
Viscosity	ASTM D-445	300 ml	4°C	N/A

References:

EPA = 40 CFR 136
SW846 = Test Methods for Evaluating Solid Waste Physical/Chemical Methods, US EPA SW846, 3rd edition, 1986
SM = Standard Methods For The Examination of Water and Wastewater, 16th ed., 1985
APHA = Standard Methods For The Examination of Water and Wastewater, 17th ed., 1989
ASTM = American Society for Testing and Materials

[1] .006% ascorbic acid if residual chlorine is present.
[2] .008% sodium thiosulfate if residual chlorine is present.
[3] Plastic or glass jars are suitable unless otherwise indicated.
[4] TSS, TDS and TSVS are performed on the same 100 ml sample. TS & TVS are performed on the same 100 ml sample.
[5] "Holding time is not to exceed six hours if the data is to be used in litigation."
[6] No holding time is published - these times are suggested/borrowed from the ABN hold time.
[7] Acid preservations (H_2SO_4, HNO_3, HCl) are adjusted to pH < 2, base preservations (NaOH) are adjusted to pH > 12 unless otherwise noted.

Cyanide: Fill a one liter plastic bottle with DI water and preserve with NaOH. Analyze the water according to normal laboratory procedures.

Metals: Fill a 500 mL poly bottle with 100 mL of 2% nitric acid solution from the metals instrumentation room. Shake. Analyze for metals.

ABNs, Pesticides, PCBs: Submit an empty 1 L glass jar to the Organics Extractions Laboratory for testing with instructions for special extraction procedures to be employed as follows - Add 60 mL $MeCL_2$, shake for 2 minutes, KD to appropriate test volume and analyze under normal laboratory procedures.

VOA: Submit an empty 120 mL jar to the volatiles laboratory with instructions to fill the jar with VOA-free DI water. Let stand for 24 hours and analyze under normal laboratory procedures.

If any analyses indicate contamination, the affected lot is washed according to one of the following protocols and a random sample is retested.

Cleaning Procedure 1 (Extractable Organics)

- wash glass bottles, teflon* liner and caps in hot tap water with laboratory grade non-phosphate detergent
- rinse with tap water
- rinse with 10% HCl (metals-grade HCl in ASTM deionized water)
- rinse three times with ASTM type 1 deionized water
- rinse with hexane
- rinse with pesticide grade methylene chloride
- air dry or oven dry at 125°C
- place liners in lids and cap containers

Procedure 1 is used for amber and clear glass wide mouth jars, amber and clear glass Boston round, and amber and clear glass jugs.

Cleaning Procedure 2 (Purgeable Volatile Organics)

- bake opened jars and lids in a 125°C oven for 30 minutes
- cool
- cap

Procedure 2 is used for 40 ml glass vials, amber and clear, open and closed top, and 8 oz. amber Boston round with septa top.

Cleaning Procedure 3 (Metals, Cyanide)

- wash polyethylene bottles and caps in hot tap water with laboratory grade non-phosphate detergent
- rinse with tap water
- rinse with 10% HNO_3 (metals-grade HNO_3 in ASTM deionized water)
- rinse with deionized water
- invert and air dry in contaminant-free environment
- cap bottle

Procedure 3 is used for HDPE modern round bottles and cubitainers.

6.2.2 Assembling Kits

All glass containers are to be surrounded with packing material to prevent damage.

All preservatives are stored in 10 - 20 ml plastic squeeze bottles, contained within 250 ml plastic wide mouth jars which are appropriately labelled.

The appropriate number of labels and COC's are affixed to the ziplock plastic bag that the sample is stored in.

All the above contents are to be placed inside a cooler with ice packs (if requested) and secured for shipment using styrofoam (packing peanuts or other appropriate packing materials).

Sample kits are delivered to the sampling team via Federal Express, UPS, courier, or personally picked up by the sampling team.

6.3 Sample Receipt and Log-In

Refer to PACE NE SOP QA-400, Sample Receiving and Identification.

Typically, samples are received by the laboratory during normal business hours (8:00 am to 6:00 pm), Monday through Friday and 8:00 am to noon on Saturday.

Shipments for after hours and Sunday delivery are prearranged with laboratory personnel to ensure that personnel will be available to sign the airbill, record the date and time of sample receipt and to place the cooler in the sample management area under refrigeration until the next business day.

Upon sample receipt, the coolers are inspected for the general condition of the Custody Seal, if present. The coolers are then opened and each sample is inspected for damage. The sample containers are removed from the packing material and identities are verified against the Chain-of-Custody. All information regarding sample condition upon receipt is documented on the Sample Receipt Condition Report (SRCR). The report documents:

- Name of person if hand delivered
- Presence/Absence of COC forms and custody seals
- Condition of the custody seals, if present
- Discrepancies noted
- Holding times and preservatives
- Proper sample containers
- Appropriate sample volume

The Sample Receipt Condition Report is completed by signing and recording the date and time. If there are any discrepancies or problems with the samples or documentation, the sample custodian immediately notifies the client or the appropriate PACE NE project manager.

The samples are logged into the laboratory system. Each sample group is assigned a unique five digit laboratory number. This number is preprinted on the SRCR sheets. A unique number is assigned to each sample in the group during the receiving process. This Laboratory Number consists of the PACE NE Laboratory Number followed by a numerical suffix serialized to account for the number of samples in a sample group. This laboratory ID is also recorded on the Chain-of-Custody form.

All of this paper work is then used to log the samples into the PACE NE Laboratory Information Management System (LIMS), a computerized management and tracking system. The LIMS generates laboratory worklists of all samples in the system.

6.4 Initiation of Testing Program

Once samples are received and logged into the laboratory system, the Chain-of-Custody, Sample Receipt Condition Report, and any memo or other documentation is placed into a project file created by sample management. If a sample group is a priority or if samples have a short holding time, sample management will immediately provide notification to the appropriate laboratory personnel that samples have arrived and are ready for processing or will deliver the samples directly to the lab. Otherwise, the LIMS automatically produces a daily worklist for each laboratory section listing all samples in the system which need to be processed, the type of quality control samples required, the priority status, holding time and test(s) required.

There is a system for tracking the status and internal chain-of-custody of samples within the laboratory once sample processing begins. The system documents the movement of samples from sample receiving to sample preparation and back and also the movement of processed sample extracts from sample preparation through analysis. The Internal Custody Record is used by sample preparation personnel to locate samples in the sample management storage areas. The transfer from storage to preparation is documented on this sheet. It also serves to document:

- Who removed the sample from storage
- When

- Which samples are associated with a Lab Number
- If the entire sample was entirely consumed
- When and by whom the remainder of sample was returned to storage

The original Internal Custody Record is maintained by Sample Management until the sample disposal date is recorded on it. After sample disposal, the Internal Custody Record is forwarded to the QA department for archiving.

The second system for tracking samples is the LIMS generated worklist. The worklist is generated every night and lists the status for each sample batch/project and for each analytical section. The worklist is distributed to each laboratory section. When the section personnel completes the particular task, they log into the LIMS and complete the information for that batch of samples.

6.5 Sample Disposal

After completion of sample analysis and submission of the analytical report, unused portions of samples are retained by the laboratory for a minimum of 2 weeks. After 2 weeks, samples will be disposed of according to the nature of the samples. The Hazardous Waste Manager receives a copy of the data report and uses that information to select the appropriate waste steam for the samples. The samples are considered hazardous waste and are handled by state and federally licensed hazardous waste disposal firms.

Upon disposal of samples, a computer spreadsheet is maintained by the Hazardous Waste Manager listing the sample number, inherent waste stream and date disposed. This data file is updated on a weekly basis and is kept on file by the Hazardous Waste Manager and Sample Management.

6.6 Subcontracting Analytical Services

Every effort is made to perform chemical analyses for PACE NE clients within the PACE NE laboratory. There are, however, instances where subcontracting of analytical services is necessary. Currently, the following analyses are subcontracted:

- Bacteriological
- Asbestos
- Dioxins
- Radiological
- Total Organic Halides
- NPDES Tin (furnace method 282.1 and 282.2)

When subcontracting becomes necessary, a preliminary verbal communication with an appropriate laboratory is undertaken. Work involving NEESA samples may be subcontracted only to NEESA approved laboratories. Approval must be obtained from the prime contractor before work may be sent out. The contact and preliminary arrangements and terms of agreement are made between the PACE NE Project Manager and the appropriate subcontract laboratory personnel (i.e., laboratory manager, customer services contact, or the appropriate laboratory section manager). The specific terms of the subcontract laboratory agreement should include (when applicable):

- Method (EPA or otherwise) of analysis
- Number and type of samples expected
- Project specific QA/QC requirements
- Deliverables required
- Applicable laboratory certification status
- Price per analysis
- Turn around time requirements

Chain-of-Custody forms must be generated for samples which require subcontracting to other laboratories. The sample management personnel repackage the samples for shipment, create a transfer chain-of-custody form and record the following information:

- PACE NE Laboratory Number
- Matrix
- Requested analysis
- Special instructions (quick turn around, required detection limits, anything unusual known about the samples or analytical procedure).

- Signature in "Relinquished By"

All subcontracted sample data reports are sent to the PACE NE Project Manager. The Project Manager sends the report to the appropriate PACE NE laboratory manager for review.

Any PACE NE work sent to other labs within the PACE, Inc. network is handled as subcontracted work. All of the conditions and considerations noted in Section 6.6 above apply.

7.0 CALIBRATION PROCEDURES AND FREQUENCY

All instruments and equipment used in the laboratory must follow a well defined calibration routine. Calibration may be accomplished by laboratory personnel using certified reference materials traceable to NIST or EPA certified materials or by external calibration agencies or equipment manufacturers. The discussion presented here is general in nature because the requirements for calibration are instrument (or equipment) and method specific. Details of calibrations can be found in PACE NE Standard Operating Procedures, analytical methods; and operations manuals.

7.1 Standards and Traceability

Analytical standards are prepared from pure compounds or are purchased prepared from reputable vendors. They are used to prepare serial dilutions that are used as calibration and spiking standards. Each laboratory section is responsible for the preparation, storage and disposal of its standards. The preparation information is recorded into section specific Standards Notebooks. The notebooks are where the preparer records all information needed to maintain proper traceability.

Each standard is given an internal identification number. In some instances, particularly with pre-mixed organic standards, the identification number is the solution lot number followed by an PACE NE assigned letter. The preparation of all stock standards shall be documented in a Standards Notebook which is used to record the date of preparation, the analyst, the source of the reference material, amounts used, final volume, etc. and the serial reference number of that stock solution. All standards shall be labelled with the standard serial reference number (small glass ampules), and with the name, concentration, date of preparation and expiration date of the stock standards. All diluted working standards not consumed during an analytical session shall be labelled fully, including the serial reference number of any stock standard used in its preparation.

If no expiration date has been assigned by the manufacturer, then an expiration date of one year from the date of preparation (or the date first opened in the case of sealed ampules) is reported unless degradation prior to this date is observed. To help determine if a standard has degraded, one must note inconsistencies. For instance, very poor recoveries from newly prepared quality control spikes or abnormally low instrument response to a specific standard are indications of possible standard degradation. However, for some standards, degradation is more easily noted. For instance, DDT breaks down to form DDD and DDE. Here one can visually note, on a chromatogram, the degradation of DDT by the increased concentrations of DDD and DDE. If

degradation is observed before the default expiration date, it should be noted in the Standard Notebook for that standard and the standard removed from service. Standards can be held past assigned expiration dates only if it can be demonstrated, by using NIST procedures and a standard from a separate source, that there has been no degradation.

Before any set of non-CRADA standards can be utilized in a calibration curve they must be verified by a secondary means:

- Analysis of an EPA QC Check Sample, or
- Analysis of an independently prepared check standard.

7.2 General Calibration Procedures

Calibration standards for each parameter are chosen to bracket the expected concentrations of those parameters in the sample, and to operate within the linear response range of the instrument. Samples that fall outside of the calibration range are diluted until bracketed by the calibration standards. Calibration standards are prepared typically at a minimum of three concentration levels, usually chosen at two times, three to five times, and five to ten times the estimated method detection limit plus a calibration blank, with the exception of most organic analyses which do not require a calibration blank. Either an internal standard or external standard quantification technique can be utilized.

Calibration standards are prepared from materials of the highest available purity. To establish instrument calibration, working standards are prepared from more concentrated working stock solutions. All organic standards are refrigerated or frozen. Inorganic standards are refrigerated as necessary. Data regarding their preparation is recorded in the each laboratory sections' Standards Notebook.

Instrumental responses to calibration standards for each parameter are subjected to an appropriate statistical test of fitness (least squares linear regression, quadratic equation, or relative standard deviation of response factors) or as required by the method or QAPP. The calibration must reflect an acceptable correlation of data points or linearity to be acceptable. In cases where the calibration data are outside of these criteria, the analyst must rerun the calibration standards (meeting the same criteria), changing instrumental conditions as necessary.

For analyses which are performed frequently and for which substantial calibration data is available, a complete recalibration is not required each time an analysis is performed providing that the following criterion is met: one calibration standard is analyzed at the

beginning of the analysis which may vary from the expected response (based on the initial, most recent calibration curve) by no more than ±25% or as specified by the method, SOP or QAPP. If this criterion is not met, a complete recalibration is necessary.

During the course of analysis, calibration standards are routinely analyzed to ensure that the instrumental response has not changed. Again the criterion stipulated in each method, or SOP for expected response is used by the analyst to determine whether the instrument must be recalibrated or the instrument conditions further optimized.

The accuracy of prepared standards is periodically checked by comparison with a standard from an independent source.

Certain pieces of equipment such as balances, pH meters, and turbidity meters are normally calibrated with NIST traceable standard reference material.

7.2.1 Analytical Balances

Every six months, calibration of the entire analytical range shall be checked by a qualified service technician. The calibration of each balance is checked each day of use using weights traceable to the National Institute of Standards and Technology (NIST). Calibration weights are Class S or better and are recertified every two years. If balances are calibrated by an external agency, verification of their weights shall be provided. All information pertaining to balance maintenance and calibration is found in the individual balance logbook.

7.2.2 Thermometer

Certified, or reference, thermometers are maintained for checking calibration of working thermometers. Reference thermometers are provided with NIST traceability for initial calibration and are recertified every year with equipment directly traceable to the NIST.

Working thermometers are compared with the reference thermometers every 12 months. Each thermometer is tagged and individually numbered. In addition, working thermometers are visually inspected by laboratory personnel prior to use.

Calibration temperatures and acceptance criteria are based upon the working range of the thermometer and the accuracy required for its use. Laboratory thermometer inventory and calibration data is found in the thermometer logbook.

7.2.3 pH/Electrometer

The meter is calibrated before use each day, and once after each four hours of use using buffer solutions as required by PACE NE SOP QA-800, Use, Calibration, and Maintenance of Equipment - Inorganics Lab.

7.2.4 Spectrophotometer

During use, spectrophotometer performance is checked against CCVs and ICVs. The instrument operating capability is also evaluated every six months by an outside service (QC Services).

7.2.5 Titrimetric Methods

Reagents are standardized when newly prepared and every six months following. If the stability of a solution is known to be less than six months it is checked more frequently. Check standards are run with each batch of samples to demonstrate the integrity of the reagents and that the technique employed has not been comprimised over time.

7.2.6 Oven Calibration

Oven temperature is monitored prior to use and daily once in use by calibrated thermometers.

7.2.7 Refrigerator Calibration

Refrigerator temperature is monitored two times on a daily basis by calibrated thermometers.

7.3 GC/MS Calibration Procedures

All volatile and semivolatile analyses by GC/MS performed in support of NEESA shall follow current CLP methodologies (EPA CLP SOW OLM01.8). The following operations should be performed routinely in the laboratory:

- Documentation of GC/MS mass calibration and abundance pattern
- Documentation of GC/MS response factor stability
- Internal standard response and retention time

Prior to initiating data collection, it is necessary to establish that a given GC/MS meets the standard mass spectral abundance criteria. This is accomplished through the analysis of decafluorotriphenylphosphine (DFTPP) for base/neutral and acid (BNA) compounds or p-bromofluorobenzene (BFB) for volatile compounds. The ion abundance criteria for each calibration compound should be met before any samples, blanks, or standards can be analyzed.

Each GC/MS system used for the analysis of semivolatile organic compounds by EPA methods must be tuned to meet method specific abundance criteria for a 50 nanogram (ng) injection of DFTPP. This criteria must be demonstrated every twelve (12) hours. Documentation of the calibration must be provided in the form of a bar graph plot and as a mass listing.

Each GC/MS system used for the analysis of volatile organic compounds by EPA methods must be tuned to meet method specific abundance criteria, typically for a 50 ng injection of BFB. The criteria must be demonstrated every twelve (12) hours. Documentation of the calibration should be provided in the form of a bar graph and a mass listing.

Prior to the analysis of samples and after tuning criteria have been met, the GC/MS system must be initially calibrated with a minimum of five concentrations of each compound being analyzed to determine the linearity of response. USEPA criteria specify both the concentration levels for initial calibration and the specific internal standard to be used on a compound-by-compound basis for quantification. The response factor (RF) for each compound at each concentration level is calculated using the following Equation 7.1:

$$RF = \frac{A_x}{A_{is}} * \frac{C_{is}}{C_x} \qquad (7.1)$$

where:

A_x = area of the characteristic ion for the compound to be measured.

A_{is} = area of the characteristic ion for the specific internal standards.

C_{is} = concentration of the internal standard (ng/ul).

C_x = concentration of the compound to be measured (ng/ul)

Using the RF from the initial calibration, the percent relative standard deviation (%RSD) for compounds identified as Calibration Check Compounds is calculated using Equation 7.2:

$$\%RSD = \frac{s}{\bar{x}} \times 100 \qquad (7.2)$$

where:

RSD = relative standard deviation
s = standard deviation of initial five response factors (per compound).
$\bar{x}$ = mean of initial five response factors (per compound).

The %RSD for each individual CCC should be <u>less</u> than 25 % or as specified by the method. This criteria must be met for the initial calibration to be valid.

A calibration standard containing all compounds of interest as well as all required surrogates, is performed each day of analysis. The RF data from the standards is compared each day against the average RF from the initial calibration for a specific instrument. If the response to a calibration check standard differs from the initial calibration by more than ±25% or as specified by the method, then investigation and corrective action must be performed, including a complete recalibration if necessary.

7.4 Gas Chromatography Calibration Procedures

Calibration of a gas chromatograph (GC) for volatiles analyses is similar to GC/MS calibration procedures. Initially, a five point calibration curve, consisting of all compounds of interest at five different concentrations plus a calibration blank, is established to define the linear range of the instrument. The curve is determined to be linear if the correlation coefficient is ≥ 0.99. Linearity may also be determined using response factors. Response factors are calculated for each compound at each concentration level. These RF will be averaged to generate the mean daily RF for each compound over the range of the standard curve. The mean response factor will be used to calculate the sample concentration of the compound of interest. When sample responses exceed the range of the standard curve, the sample will be diluted to fall within the range of the standard curve and be reanalyzed. The results of the daily GC standardization will be tabulated and filed with the corresponding sample analyses. Daily full calibration is not necessary if a calibration check standard validates the initial

calibration curve. If the response to a calibration check standard differs from the initial calibration by more than ±15% for any analyte being quantitated or as specified by the method, then investigation and corrective action will be performed, including complete recalibration, if necessary.

Initial Calibration of a GC for semivolatile compound analyses (pesticides/herbicides) typically involves a five point calibration curve, consisting of all compounds of interest at five different concentrations to define the working range. Using analyte peak height or peak area, a quadratic curve is applied and extrapolated through the origin. A correlation coefficient of the calibration data should be 0.99 or better for the calibration to be used for quantitation. Continuing Calibration is checked every ten samples or 24 hours, whichever comes first after the initial calibration by analyzing mid-point calibration standards. Each analyte of interest in the continuing calibration must be within 15% of the peak height observed in the initial calibration. For certain multi-peak compounds, the average result for 5 peak heights must be within 15% of the average of the same 5 peak heights observed in the initial calibration.

7.5 Calibration of Inductively Coupled Argon Plasma Spectrophotometer (ICP) and Atomic Absorption Spectrophotometer (AAS)

The ICP and AAS are standardized for the metal of interest by the analysis of a set of calibration standards prepared by diluting a stock solution of known concentration. Working standards are prepared by dilution of the stock standard. For the AAS, the concentration of the calibration standards is chosen so as to cover the working range of the instrument. For ICP, a standard is analyzed as a sample to determine the upper limit of the calibration. Subsequently, all sample measurements are made within this working range. Once the working standards are prepared, they are analyzed on the ICP or AAS and the instrument response is calibrated to provide a direct readout in concentration.

The calibration is accomplished by entering the metal concentration equivalent to the readout in absorbance units (or emission intensity) during analysis of the working standards.

Once the instrument has been initially calibrated, the analysis of the working standards is repeated during sample analysis to standardize instrument response during analysis and to confirm the calibration settings. A typical analysis sequence is presented below.

- Working standards are prepared by dilution of a stock standard solution of the metal of interest.

- A calibration curve within the working range of the instrument is established by analysis of three to five working standards.

- An independent standard is analyzed to confirm the calibration settings. If the calibration settings are not confirmed, the instrument is recalibrated.

- The samples are analyzed for the metal of interest.

- During sample analysis, a check standard is analyzed to monitor instrument stability. If the analysis indicates that instrument calibration has changed by more than $\pm 10\%$ for ICP or more than $\pm 20\%$ for AAS, the instrument is recalibrated and the analysis is repeated.

- Following completion of the sample analyses, the check standard is reanalyzed to confirm calibration settings. If calibration settings are confirmed, the analysis is completed. However, if the calibration settings are not confirmed, the problem is corrected, and the analyses are repeated.

Written records of all calibrations shall be kept in the appropriate instrument logbook.

8.0 ANALYTICAL PROCEDURES

PACE NE Laboratories are capable of analyzing the full range of environmental samples from all media, including surface and groundwater, soil, sediment, tissue, and waste. Refer to Table 8-2 for a listing of specific PACE NE analytical capabilities. The methodologies generally employed constitute the most recent guidance from agencies such as EPA, ASTM, USGS, NIOSH and in certain instances, state regulatory agencies. In some situations, PACE NE develops and validates methodologies which are more applicable to a specific problem or objective.

Analytical procedures are detailed descriptions of any and all processing, preparation and analysis of samples in the laboratory. In some instances, data format, presentation and delivery are also described. All analytical procedures shall be conducted in strict adherence with written Standard Operating Procedures manuals which have been reviewed and approved by the Laboratory Manager(s)/Technical Director(s), the PACE NE QA Officer and the PACE NE Regional Director. Documents from which SOPs are developed include the references listed in Table 8-1. Additional SOPs may be adapted from other sources or generated in-house as project needs require.

8.1 Analytical Methods

Numerous sources of information are available to offer guidance in analytical methods. Selection of the appropriate method is dependent upon data usage and the regulatory requirements during the analysis. Table 8-1 describes the analytical references routinely used by PACE NE Laboratories. PACE NE may modify existing methods based on the following considerations: 1) in order to meet project specific objectives; 2) in order to incorporate modifications or improvements in analytical technology; 3) in order to comply with changing regulations and requirements; 4) in order to address unusual matrices not covered in available methods.

PACE NE will make every effort to disclose to its clients any instances in which modified methods are being used in the analysis of samples and shall obtain permission from the appropriate prime contractor prior to using any modified methods for NEESA-related work.

8.2 Method Validation

When an established method is first used by the laboratory or when the laboratory develops a method, the laboratory establishes the validity of the method prior to applying it to client samples. Method validity is established by meeting certain criteria for precision and accuracy.

The design of the validation study will vary with the nature of the matrix, parameters and requirements of the client. However, in all cases, the laboratory demonstrates that adequate and reproducible recoveries are attainable. The precision of the test method is measured as the relative standard deviation for a minimum of four (4) replicate analyses of the lowest concentration recovery sample.

Accuracy of the test method is established as the relative standard deviation of the average measurement of each recovery sample (at a specific concentration). Design of validation studies incorporates several recovery samples at each concentration level. Thus, it is feasible to determine the test method accuracy at each concentration level, if significant variances occur with concentration.

8.3 Method Detection Limits (MDLs)

When an analytical procedure does not detect a parameter of interest, it is important to know what the lower limit of detection is for that particular method and sample matrix. The laboratory endeavors to prevent matrix interferences from substantially reducing analytical sensitivity, thereby raising the analytical detection limit. When matrix interferences are present, various clean-up techniques may be employed to reduce or eliminate them.

Method detection limit studies are performed for each method in use at least annually and after any procedural or configurational change.

Method detection limits may be determined using replicate spiked laboratory water samples. A minimum of seven aliquots of a sample spiked for the purpose are processed through the entire analytical method. The concentration of the detection limit sample should be between 2 and 5 times the anticipated detection limit.

The laboratory calculates the detection limit as 3.143 times the standard deviation of replicate measurements of the spiked samples. The reader is referred to 40 CFR Part 136, Appendix B for further discussion.

IT IS IMPERATIVE TO NOTE THAT METHOD DETECTION LIMITS LISTED IN THE CITED METHODS ARE FOR GUIDANCE AND MAY NOT ALWAYS BE ACHIEVABLE.

PACE NE may report results of analyses based on Reporting Limits which are the method detection limits adjusted for practical limitations such as sample size, matrix interferences and dilutions. Reporting Limits may never be lower than the statistically determined MDL.

8.4 Compliance

8.4.1 Definition - Compliance is the proper execution of recognized, documented procedures which are either approved or required. Adherence to these procedures is required in order to provide data products acceptable to a regulatory body of competent jurisdiction in a specific regulatory context. Compliance is separate from, but not inconsistent with, technical scientific quality. PACE NE accepts compliance as part of the PACE corporate definition of quality: "Quality is the *fulfillment of expectations and needs* in all activities, demonstrated by the satisfaction of those we serve." PACE NE understands that the expectations of our clients commonly include the assumption that data and reports will satisfy a regulatory purpose and will be found acceptable *and compliant* with regulatory requirements for the performance of tests and generation of data.

8.4.2 Understanding the Regulatory Framework - Compliance is not likely to be achieved in the absence of an understanding of the regulatory framework. PACE NE will attempt to ascertain, prior to beginning a project, what regulatory jurisdiction (USEPA, NJDEPE, etc.) pertains to a project; within the regulatory jurisdiction, what body of regulation is meant to be satisfied (RCRA, SDWA, ECRA, 21E, etc.); and finally, within this context, what protocols are required/expected (CLP, AFCEE, NEESA, ASP, etc.). PACE NE will work with its clients to come to a mutual understanding of all requirements.

8.4.3 Commitment - Clients may, but often do not, fully understand their compliance needs. Clients may sometimes fail to communicate their compliance requirements to PACE NE. Nevertheless, PACE NE, Inc., in defining quality as in 8.4.1 above, has accepted much responsibility for compliance.

PACE NE makes the following commitments to its clients:

1) PACE NE will proactively attempt to identify and understand the regulatory context of clients' needs.

2) PACE NE will strive to be expert in understanding and executing the regulatory requirements for compliance.

3) PACE NE will identify and disclose to clients instances of non-compliance in a forthright fashion.

8.4.4 Resolving Compliance Cantradictions and Hierarchies - It is a common occurrence that multiple regulatory juristictions overlap in a specific case. This causes uncertainty or even contradictions to arise in a work plan. PACE NE will make every effort to detect such inconsistencies, and will communicate them to clients so that an informed decision can be made by the client regarding execution of the project. Similarly, methods and protocols will often be prescribed in a scope of work or QAPP which either will not achieve stated or implied DQOs or which are in conflict with the regulatory requirements. PACE NE will attempt to detect these inconsistencies, and upon detection, disclose same to our client. PACE NE voluntarily accepts a responsibility to provide advice to clients, however, **the primary responsibility for this issue remains with the client.**

8.4.5 Disclosure of Noncompliance - As stated previously, it is PACE NE policy to disclose in a forthright manner any detected noncompliance that may effect the usability of data produced by PACE NE. It is not within our expertise to predict the manner in which a specific regulator or regulatory body will interpret the rules governing analysis; PACE NE is unable to guarantee compliance. It is PACE NE policy that our responsibility begins with a bona fide and competent attempt to evaluate potential compliance issues and ends with disclosure of any findings that may be useful to our client in their making the final judgement.

TABLE 8-1

ANALYTICAL PROTOCOLS

- "Guidelines Establishing Test Procedures for the Analysis of Pollutants Under the Clean Water Act." Federal Register, 40 CFR Part 136, October 26, 1984.
- "Test Methods for Evaluating Solid Wastes: Physical/Chemical Methods." SW-846. 3rd edition, 1986, and Update I, Office of Solid Waste and Emergency Response, U.S. EPA.
- "Methods for Chemical Analysis of Water and Wastes", EPA 600/4-79-020, 1979 Revised 1983, U.S. EPA.
- U.S. EPA Contract Laboratory Program Statement of Work for Organic Analysis, SOW OLM01.8, 8/91.
- U.S. EPA Contract Laboratory Program Statement of Work for Inorganic Analysis, SOW ILM03.0.
- "Standard Methods for the Examination of Water and Wastewater", 15th, 16th and 17th editions, 1980, 1985, 1989. APHA-AWWA-WPCF.
- "Annual Book of ASTM Standards", Section 4: Construction, Volume 04.04: Soil and Rock; Building Stones, American Society for Testing and Materials, 1987.
- "Annual Book of ASTM Standards", Section 11: Water and Environmental Technology, American Society for Testing and Materials, 1987.
- "NIOSH Manual of Analytical Methods", Third Edition, 1984, U.S. Department of Health and Human Services, National Institute for Occupational Safety and Health.
- "Methods for the Determination of Organic Compounds in Finished Drinking Water and Raw Source Water", U.S. EPA, Environmental Monitoring and Support Laboratory - Cincinnati (September 1986).
- New York State Department of Environmental Conservation. Analytical Services Protocol, September, 1989.

TABLE 8-2

PACE NE ANALYTICAL CAPABILITIES
ORGANIC ANALYSES

Analyte	EPA Methods	
Volatile Organic Compounds		
GC/MS	624	8240
GC/MS + 15 Peaks*	624	8240
CLP Volatiles Analysis and Deliverables	3/91 SOW	3/91 SOW
GC/MS Low Detection Limits	624	8240
GC/MS Drinking Water Volatiles	524.1	NA
GC/MS Drinking Water VOA (Extended List)	524.2	NA
GC Drinking Water Halogenated Compounds	502.1	NA
GC Drinking Water Aromatic Compounds	503.1	NA
GC Drinking Water VOA(Combined 502.1 & 503.1)	502.2	NA
Purgeable Halocarbons	601	8010
Purgeable Aromatics	602	8020
Combined Purgeables	601 & 602	8010 & 8020
Acrolein, Acrylonitrile	603	8030
Non-halogenated Volatiles (Partial List)	8015	8015
Base Neutral/Acid Extractables (HSL)	625	8270
Base Neutral/Acid Extractables + 25 Peaks*	625	8270
Acid Extractables Only (HSL)	625	8270
Acid Extractables Only + 10 Peaks*	625	8270
Base Neutral Extractables Only (HSL)	625	8270
Base Neutral Extractables Only + 15 Peaks*	625	8270
CLP Semivolatiles Analysis and Deliverables	3/91 SOW	3/91 SOW
Polynuclear Aromatics (PNA) GC/MS	625	8270
Polynuclear Aromatics (PNA) GC	610	8100

* Tentative identification via computer search of specified number of non-target peaks.

TABLE 8-2, continued

ORGANIC ANALYSES (continued)

Analyte	EPA Methods	
Organochlorine Pesticides & PCBs	608	8080
CLP Organochlorine Pesticides & PCBs	3/91 SOW	3/91 SOW
Organochlorine Pesticides & PCBs (Tissue)	608	8080
Organophosphorus Pesticides	614	8140
Chlorinated Phenoxy Herbicides	8150	
PCBs in oils	ASTM	
PCBs wipes/filters	ASTM	
Petroleum Hydrocarbons, Extractables (water/soil, tissues)	Capillary GC/FID	
Petroleum Hydrocarbons, Purgeables	Modified 8015	
Gasoline Hydrocarbons BTEX(+MTBE)	602	8020
Compositing		

TABLE 8-2, continued

WASTE CHARACTERIZATION

Analyte		EPA Methods
EP Toxicity	Extraction	1310/1330
	Metals in Extract	
	Arsenic	6010
	Barium	6010
	Cadmium	6010
	Chromium	6010
	Lead	6010
	Mercury	7470
	Selenium	6010
	Silver	6010
	Pesticides in Extract	8080
	Endrin	
	Lindane	
	Methoxychlor	
	Toxaphene	
	Herbicides in Extract	8150
	2,4-D	
	2,4,5-TP	
Corrosivity	pH	9040/9045
Reactivity	Releasable Cyanide	SW 846 7.3.3.2
	Releasable Sulfide	SW 846 7.3.4.1
	Releasable Cyanide & Sulfide	
	Water Reactivity	N/A
Ignitability		1010

TABLE 8-2, continued

TCLP ANALYSES

Quality Assurance section of the method requires that a matrix spike be performed for each sample type. A determination as to whether a spike is needed must be made prior to submitting the sample. Matrix spikes are made at five times the method detection limit or at the regulatory limit unless other levels are specified in advance.

Matrix spike for pesticides requires that single component pesticides be analyzed separately from multicomponent pesticides (toxaphene). Therefore, two matrix spikes are required and are reflected in the matrix spike analysis.

Samples containing free liquid that is not miscible with the TCLP extract require that both the free liquid and the extract be analyzed separately and that the results be combined mathematically. An additional charge is required for the analysis of the free liquid or of multiple phases. If a matrix spike is required, only the TCLP extract is spiked.

Analyte		EPA Methods
Extraction for Volatiles (ZHE)		1311
Extraction for Metals, Semivolatiles, Pesticides & Herbicides		1311
Volatiles	benzene	8240
	carbon tetrachloride	
	chlorobenzene	
	chloroform	
	1,2-dichloroethane	
	1,1-dichloroethylene	
	methyl ethyl ketone	
	tetrachloroethylene	
	trichloroethylene	
	vinyl chloride	

TABLE 8-2, continued

TCLP ANALYSES (continued)

Analyte		EPA Methods
Semi-Volatiles	*pyridine*	8270
	m-cresol (3-methyl phenol)	
	o-cresol (2-methyl phenol)	
	p-cresol (4-methyl phenol)	
	1,4-dichlorobenzene	
	2,4-dinitrotoluene	
	hexachloro-1,3-butadiene	
	hexachlorobenzene	
	hexachloroethane	
	nitrobenzene	
	pentachlorophenol	
	2,4,5-trichlorophenol	
	2,4,6-trichlorophenol	
Pesticides	chlordane	8080
	endrin	
	heptachlor	
	heptachlor epoxide	
	lindane	
	methoxychlor	
	toxaphene	
Herbicides	2,4-dichlorophenoxyacetic acid	8150
	2,4-5-trichlorophenoxypropionic acid	
Metals	As, Ba, Cd, Cr, Pb, Se, Ag	6010
	Hg	7470

TABLE 8-2, continued
METALS ANALYSES

Analyte	Required Digest	EPA Methods
Aluminum	3010/3050	200.7 or 6010
Antimony	3010/3050	200.7 or 6010
Antimony (furnace)	3010/3050	204.2 or 7041
Arsenic (furnace)	7060/3050	206.2 or 7060
Barium	3010/3050	200.7 or 6010
Beryllium	3010/3050	200.7 or 6010
Boron	3010/3050	200.7 or 6010
Cadmium	3010/3050	200.7 or 6010
Cadmium (furnace)	3020/3050	213.2 or 7131
Calcium	3010/3050	200.7 or 6010
Chromium	3010/3050	200.7 or 6010
Chromium (furnace)	3020/3050	218.2 or 7191
Cobalt	3010/3050	200.7 or 6010
Copper	3010/3050	200.7 or 6010
Iron	3010/3050	200.7 or 6010
Lead	3010/3050	200.7 or 6010
Lead (furnace)	3020/3050	239.2 or 7421
Magnesium	3010/3050	200.7 or 6010
Manganese	3010/3050	200.7 or 6010
Mercury (cold vapor)	7470/7471	245.1 or 7470/7471
Molybdenum	3010/3050	200.7 or 6010
Nickel	3010/3050	200.7 or 6010
Potassium	3010/3050	200.7 or 6010
Selenium (furnace)	7740/3050	270.2 or 7740
Silver	3010/3050	200.7 or 6010
Sodium	3010/3050	200.7 or 6010
Strontium	3010/3050	200.7 or 6010
Thallium (furnace)	3020/3050	279.1 or 7841
Tin	3010/3050	200.7 or 6010
Titanium	3010/3050	200.7 or 6010
Vanadium	3010/3050	200.7 or 6010
Zinc	3010/3050	200.7 or 6010

Packages Available

CLP Deliverables-23 Metals
13 Priority Pollutant Metals
8 Safe Drinking Water Act Metals
23 HSL Metals-Commercial Deliverables

Digestions

Water	3010,3020,7060,7740
Soil/ICP	3050
Soil/GFAA	3050
Tissues/ICP	3050 Modified
Tissues/GFAA	3050 Modified
Mercury-water/soil	7470/7471

Dissolution (Oils) 3040

TABLE 8-2, continued

INORGANIC ANALYSES

Analyte	Methods
Acidity	EPA 305.1
Alkalinity	EPA 310.1
Bromide	EPA 300.0
Biochemical Oxygen Demand	EPA 405.1
Bicarbonate	APHA 2320
Carbonate	APHA 2320
Bicarbonate & Carbonate	APHA 2320
Carbon - Total Inorganic (water)	EPA 415.1
- Total Organic (water)	EPA 415.1
- Total (soil)	
- Total Organic (soil)	
Cation Exchange Capacity (soil)	EPA 9080
Chemical Oxygen Demand	
Detection limit of 20 mg/L	EPA 410.4
Detection limit of 5 mg/L	EPA 410.4/410.2
Chloride	EPA 300.0 or 325.1
Chlorine, Total Residual	APHA 4500-CLG.
Coliform Bacteria - Total	APHA 9222B
- Fecal	APHA 9222D
Color	EPA 110.2
Chromium - Hexavalent	SW846 7196
Cyanide - Total	EPA 335.2
Cyanide - Total & Ammenable	EPA 335.1
Cyanide, WAD	APHA 4500-CNI.
Density	
Fluoride EPA 340.2	
Formaldehyde	NIOSH 3500
Hardness (Ca, Mg by calculation)	EPA 200.7 and SM 314 B
Calculation only	
Halides, Total Organic (TOX) - Water	9020
- Solids/Oils	
Lime Equivalence	AOAC 1.004-6
Nitrogen - Ammonia	EPA 350.1 or 350.3
- Nitrate plus Nitrite Nitrogen (combined)	EPA 353.2
- Nitrate	EPA 300.0 or 353.2
- Nitrite	EPA 300.0 or 353.2
- Total Kjeldahl	EPA 351.2 or 353.3
- Total Organic-Calculation Fee (requires analysis of TKN & NH3)	

TABLE 8-2, continued

INORGANIC ANALYSES (continued)

Analyte	Methods
Oil & Grease (Gravimetric or IR)	EPA 413.1/413.2
Oxidation Reduction Potential	
Free Liquid Content (Paint Filter Test)	EPA 9095
Total Petroleum Hydrocarbon IR	EPA 418.1
pH	EPA 150.1
Phenols - Total	EPA 420.3
Phosphorus - Total	EPA 365.3 or 365.4
- Ortho	EPA 365.1 or 365.3
Silicate - Reactive	EPA 370.1
Solids - Total	EPA 160.3
- Suspended	EPA 160.2
- Dissolved	EPA 160.1
- Volatile	EPA 160.4
- Suspended Volatile	EPA 160.2 or 160.4
- Settleable	EPA 160.5
Specific Conductance	EPA 120.1
Specific Gravity	EPA/COE 1981
Sulfate	EPA 300.0 or 375.2
Sulfide	EPA 376.2
Sulfite	EPA 377.1
Surfactants - MBAS	EPA 425.1
Tannins and Lignins (as tannic acid)	APHA 5550B
Turbidity	EPA 180.1
Sample Prep:	
Compositing	
Filtration	APHA 3030B

TABLE 8-2, continued

APPENDIX NINE ANALYSES

Appendix IX is derived from Appendix VIII Hazardous Constituents. These parameter lists are intended to apply to groundwater monitoring at hazardous waste storage and disposal sites and are applied to uncontrolled site investigations and remediations.

Analyte	EPA Methods
Volatile Organics (extended list 19 Compounds)	8240
Acrolein and Acrylonitrile	8030
Acid and Base Neutrals (extended list 48 Compounds)	3550/8270
Dioxins/2378 TCDDD	8280
Pesticides and PCB's	3540/8080
Herbicides	8150
Total Cyanide	9010
Hydrogen Sulfide	376.1
pH	150.1
17 Metals	
Arsenic	7060
Antimony	6010
Barium	6010
Beryllium	6010
Cadmium	6010
Cobalt	6010
Chromium	6010
Copper	6010
Mercury	7470
Nickel	6010
Lead	7421
Selenium	7740
Silver	6010
Tin	6010
Thallium	7841
Vanadium	6010
Zinc	6010
Metals Digest	3010,3020,7060,7470

TABLE 8-2, continued

FORM 2C ANALYSES FOR NPDES PERMITS

Analyte	Methods
Part A	
Biochemical Oxygen Demand	EPA 405.1
Chemical Oxygen Demand	EPA 410.4
Total Organic Carbon	EPA 415.1
Total Suspended Solids	EPA 160.1
Ammonia as Nitrogen	EPA 350.2/350.3 or 350.2/350.1
pH	EPA 150.1
Part B	
Total Residual Chlorine	EPA 330.5
Color	EAP 110.2
Fecal Coliform	APHA 9222D
Fluoride	EAP 340.1/340.2
Nitrate	EPA 353.2 or 300.0
Nitrite	EPA 353.2 or 300.0
Total Organic Nitrogen	350.2/350.3/351.3 or 350.2/350.1/351.2
Oil and Grease	EPA 413.1 or 413.2
Total Phosphorus	EPA 365.1 or 365.4
Alpha	
Beta	
Radium	
Sulfate	EPA 300.0
Sulfide	EPA 376.1
Sulfite	EPA 377.1
Surfactants	EPA 425.1
Aluminum	EPA 200.7
Barium	EPA 200.7
Boron	EPA 200.7
Cobalt	EPA 200.7
Iron	EPA 200.7
Magnesium	EPA 200.7
Molybdenum	EPA 200.7
Manganese	EPA 200.7
Tin	EPA 200.7
Titanium	EPA 200.7
Metals Digestion	(3010)

TABLE 8-2, continued

FORM 2C ANALYSES FOR NPDES PERMITS (continued)

Analyte	Methods
Part C	
Antimony	EPA 200.7
Arsenic	EPA 206.2
Beryllium	EPA 200.7
Cadmium	EPA 200.7
Chromium	EPA 200.7
Copper	EPA 200.7
Lead	EPA 239.2
Mercury	EPA 245.1
Nickel	EPA 200.7
Selenium	EPA 270.2
Silver	EPA 200.7
Thallium	EPA 279.1
Zinc	EPA 200.7
Total Cyanide	EPA 335.2 or 335.3
Total Phenols	EPA 420.3
Dioxin	EPA 8280
Volatile Organic Compounds	EPA 624
Acid and Base Neutral Compounds	EPA 625
Pesticides and PCB's	EPA 608
Metals Digestions	(3010,3020,7060)

TABLE 8-2, continued

NON-ROUTINE ANALYSES

PACE New England has the capability to perform the following analyses upon request. Turnaround time is subject to instrument availability and prices are quoted based on analyst and instrument time required and quantity of samples submitted.

Analysis	Methods
BTU	ASTM D 240
Chlorine (%)	ASTM D 129-64
Sulfur (%)	ASTM D 129-64
HalogenS	ASTM D 808
Viscosity	ASTM D 445
Flash point	ASTM D 93-77
API Gravity	ASTM D 287
Ash Content	ASTM D 482-87
pH	SW846 9045
Free Liquids	(Paint Filter)
% Moisture	APHA 2540G
% Sand, Silt, Clay	EPA/CE-81-1
Sieve Analysis (6 fractions >8mm to <2mm)	EPA/CE-81-1
Particle Size (19 fractions >8mm to .02mm)	EPA/CE-81-1
Diquat, Paraquat by HPLC	EPA 549
Carbamate Pesticides by HPLC	EPA 531
PNA by HPLC	EPA 8310
Ethylene Glycol by HPLC	
Nitrogen-Phosphorus Pesticides by GC	EPA 507
EDB & DBCP by GC	EPA 504
GC Direct Inject for Alcohols	
Volatile Air Analysis in Tedlar Bags by GC or GC/MS	
Calibrated Volatile Non-target Compounds by GC/MS	
Method Development for any Organic Compounds by HPLC, GC/MS, or GC	
Non-routine Furnace or ICP Metals	
Bromide by Ion Chromatagraph	EPA 300.0
Formaldehyde by HPLC	EPA 8315
Nitroaromatic Explosives by HPLC	EPA 8330

APPENDIX B

Representative Method Detection Limits
For Parameters and Methods Performed by PACE NE

PACE, INC.

Metals Instrumentation Laboratory Method Detection Limits 3-93

ICP-3010 ELEMENT	REP.1	REP.2	REP.3	REP.4	REP.5	REP.6	REP.7	MEAN	S.D.	DETECT. LIMIT	TRUE VALUE	ANALYSIS DATE
ALUMINUM	135	130	130	134	136	140	151	136.6	6.72	21.1	100	01/11/93
ANTIMONY	33	27	22	29	32	30	29	28.9	3.36	10.5	40	01/18/93
ARSENIC	193	174	195	185	177	177	174	182.1	8.25	25.9	200	01/11/93
BARIUM	2	1	1	3	1	1	1	1.4	0.73	2.3	1	01/18/93
BERYLLIUM	0.7	0.8	0.6	0.6	0.8	0.7	0.8	0.71	0.08	0.3	1	01/18/93
BORON	49	18	13	19	14	26	81	31.43	23.22	72.9	21	01/11/93
CADMIUM	9	9	10	9	11	11	10	9.86	0.83	2.6	10	01/11/93
CALCIUM	126	128	136	209	139	174	138	150	28.2	88.7	51	01/11/93
CHROMIUM	25	24	25	26	26	24	23	24.7	1.03	3.2	21	01/11/93
COBALT	9	0	10	10	10	10	9	8.29	3.41	10.7	10	01/11/93
COPPER	10	10	10	9	10	10	10	9.9	0.35	1.1	10	01/11/93
IRON	289	231	244	229	259	229	237	245.4	20.37	64.0	200	03/19/93
LEAD	106	94	101	99	102	106	105	101.9	4.05	12.7	100	01/11/93
MAGNESIUM	97	96	106	99	109	101	109	102.4	5.12	16.1	101	01/11/93
MANGANESE	4	5	5	5	5	5	5	4.9	0.35	1.1	5	01/11/93
NICKEL	50	52	55	57	50	53	48	52.1	2.90	9.1	51	01/11/93
POTASSIUM	1540	1640	1560	1620	1760	1640	1550	1616	70.9	222.7	1500	01/11/93
SELENIUM	196	190	209	192	191	167	180	189.3	12.12	38.1	201	01/11/93
SILVER	1	1	2	1	1	1	2	1.3	0.45	1.4	4	01/18/93
SODIUM	100	68	80	81	93	110	224	108.0	49.1	154.2	52	01/11/93
THALLIUM	149	201	186	175	170	173	166	174.3	15.0	47.2	199	01/11/93
TIN	64	57	62	57	60	58	60	59.7	2.43	7.6	50	01/11/93
VANADIUM	2	2	3	2	3	1	4	2.4	0.90	2.8	2	01/18/93
ZINC	29	29	34	37	34	34	30	32.4	2.87	9.0	21	01/11/93
MOLYBDENUM	87	101	113	104	114	102	101	103.1	8.34	26.2	100	03/23/93
STRONTIUM	98	95	99	94	99	90	97	96.0	3.02	9.5	100	03/23/93
TITANIUM	95	95	99	92	99	91	98	95.6	3.02	9.5	100	03/23/93
GFAA-7060												
ARSENIC	5.28	5.64	4.94	5.2	5.15	5.4	5.24	5.3	0.20	0.63	5	01/08/93
SELENIUM	4.2	4.3	4.2	4.3	4.3	4.1	4	4.2	0.11	0.3	5	01/18/93
GFAA-3020												
LEAD	4.95	4.55	4.95	4.95	4.8	4.75	4.45	4.8	0.19	0.6	5	02/02/93
THALLIUM	4.33	2.68	4.99	4.4	3.94	3.58	3.73	4.0	0.68	2.1	5	01/15/93
CVAA-7470												
MERCURY	0.61	0.63	0.58	0.61	0.61	0.64	0.53	0.60	0.034	0.11	0.5	01/08/93

All values are in ug/L (ppb).

PACE NEW ENGLAND, INC.
METHOD DETECTION LIMIT VERIFICATION STUDY
INORGANICS WET LAB PARAMETERS
JAN. 93

TEST	METHOD	CONC. mg/L	CONC. mg/L	CONC. mg/L	CONC. mg/L	CONC. mg/L	CONC. mg/L	CONC. mg/L	STD DEV	MDL mg/L	MEAN	SPIKE LEVEL
TOTAL CYANIDE	335.3	0.0435	0.0460	0.0435	0.0430	0.0415	0.0425	0.0440	0.0014	0.004	0.043	0.04
TOTAL ORGANIC CARBON	415.1	5.00	5.06	5.10	4.90	5.29	5.34	5.00	0.1609	0.51	5.10	5.0
CHEMICAL OXYGEN DEMAND HIGH	410.1	75.76	78.28	75.76	73.23	73.23	75.76	78.28	2.0617	6.47	75.76	75
CHEMICAL OXYGEN DEMAND LOW	410.1	10.10	9.40	9.90	9.50	9.70	6.80	9.30	1.1133	3.50	9.24	10
SULFATE	300.0	2.04	1.77	1.96	1.60	1.63	1.76	1.79	0.1604	0.50	1.79	1
BROMIDE	300.0	1.97	1.78	1.88	1.67	1.79	1.80	1.88	0.0957	0.30	1.82	1
FORMALDEHYDE	P&CAM 125	0.54	0.52	0.53	0.51	0.52	0.51	0.54	0.0127	0.04	0.52	0.5
ORTHO PHOSPHATE	365.2	0.045	0.046	0.046	0.047	0.047	0.046	0.047	0.0008	0.002	0.05	0.05
ALKALINITY	310.0	4.4	4.9	5.3	4.3	4.6	4.5	4.7	0.3402	1.07	4.67	5.58
SPECIFIC CONDUCTANCE	120.1	5.08	4.97	4.52	4.46	4.37	4.35	4.29	0.3165	0.99	4.58	1.68
SILICA	370.1	0.54	0.49	0.47	0.47	0.49	0.49	0.47	0.0248	0.08	0.49	0.5
AMMONIA	350.1	0.103	0.105	0.103	0.106	0.105	0.099	0.101	0.0025	0.008	0.103	0.1
NITRITE + NITRATE	353.2	0.270	0.250	0.259	0.259	0.253	0.257	0.263	0.0066	0.021	0.259	0.20
NITRATE	353.2	0.126	0.098	0.116	0.115	0.106	0.112	0.114	0.0087	0.027	0.112	0.10
NITRITE	353.2	0.144	0.152	0.144	0.144	0.147	0.145	0.149	0.0031	0.010	0.146	0.10
HEXAVALENT CHROMIUM	7196	0.0532	0.0532	0.0546	0.0546	0.0546	0.0532	0.0532	0.0007	0.0023	0.0538	0.05
TURBIDITY	180.1	0.44	0.43	0.42	0.43	0.42	0.43	0.42	0.0076	0.02	0.43	0.4
SULFITE	377.1	4.00	3.90	3.75	3.90	3.85	3.75	3.50	0.1618	0.51	3.81	10
TOTAL PHOSPHORUS	365.2	0.052	0.046	0.048	0.047	0.048	0.047	0.050	0.0021	0.006	0.048	0.05
CHLORIDE	325.1	4.370	5.052	4.918	5.124	4.664	4.710	4.708	0.2588	0.813	4.792	5.0
TOTAL KJELDAHL NITROGEN	351.3	1.11	1.08	1.09	1.15	1.05	1.08	1.09	0.0309	0.10	1.09	1.0
SULFIDE	376.1	4.18	3.35	3.05	4.00	4.04	3.53	3.31	0.4348	1.37	3.64	3.55
TOTAL DISSOLVED SOLIDS	160.1	40.2	38.5	35.2	34.7	37.1	39.2	36.1	2.0860	6.55	37.29	32.96
TOTAL SUSPENDED SOLIDS	160.2	20.8	21.3	18.4	18.8	18.4	16.8	20.8	1.6640	5.23	19.33	27.9
TOTAL SOLIDS	160.3	66.0	65.3	59.2	56.2	54.2	64.6	59.8	4.6547	14.62	60.76	56.8
TOTAL ORGANIC CARBON(%)	WALKLEY BLACK	0.039	0.042	0.040	0.042	0.039	0.040	0.039	0.0013	0.004	0.040	0.04
BOD	405.1	1.5	0.94	1.8	1.5	1.4	1.5	1.5	0.2566	0.81	1.45	2.0
TANNINS-LIGNINS	SM513	0.995	1.00	1.00	1.02	1.04	1.02	1.02	0.0160	0.05	1.01	1.0
FLUORIDE	340.2	0.043	0.045	0.038	0.044	0.036	0.043	0.039	0.0034	0.01	0.04	0.05
WADCN	412H	0.0365	0.0395	0.0375	0.0375	0.0345	0.0350	0.0380	0.0017	0.01	0.04	0.04

PACE, INC.

METHOD DETECTION LIMIT VERIFICATION STUDY
VOLATILE ORGANIC COMPOUNDS
METHOD 524.2 DMS WATERS
8/93

COMPOUND (1 ppb, exceptions noted)	>D6760 CONC. ug/L	>D6765 CONC. ug/L	>D6764 CONC. ug/L	>D6763 CONC. ug/L	>D6755 CONC. ug/L	>D6759 CONC. ug/L	>D6756 CONC. ug/L	STD DEV	X 3.14 MDL ug/L	MEAN
CHLOROMETHANE	0.76	0.8	0.9	0.95	1.03	0.87	0.76	0.1016	0.32	0.87
BROMOMETHANE	1.01	0.97	1.11	1.12	1.02	1.15	0.88	0.0959	0.30	1.04
DICHLORODIFLUOROMETHANE	1.04	1.08	1.37	1.25	1.12	1.24	0.99	0.1353	0.42	1.16
CHLOROETHANE	0.98	1.23	1.27	1.08	1.18	1.35	1.07	0.1292	0.41	1.17
VINYL CHLORIDE	1.19	1.3	1.41	1.35	1.26	1.26	1.05	0.1163	0.37	1.26
METHYLENE CHLORIDE	0.77	0.62	0.45	0.59	0.76	0.59	0.98	0.1719	0.54	0.68
ACETONE (5 PPB)	7.07	7.39	6.26	7.31	7.59	7.29	5.86	0.6487	2.04	6.97
CARBON DISULFIDE	1.00	1	1.1	1.03	0.96	1.01	0.99	0.0439	0.14	1.01
TRICHLOROFLUOROMETHANE	0.95	1.05	0.44	1.02	1.08	1.01	0.99	0.2219	0.70	0.93
1,1-DICHLOROETHENE	1.04	1.11	1.2	1.09	1.08	1.09	1.12	0.0493	0.15	1.10
BROMOCHLOROMETHANE	0.97	1.09	1.06	1.01	1.43	1.05	1.01	0.1556	0.49	1.09
1,1-DICHLOROETHANE	0.98	1.02	0.97	1	1.02	1.04	1.1	0.0434	0.14	1.02
1,2-DICHLOROETHENE (CIS)	1.04	1.02	0.95	0.94	0.99	0.95	1.09	0.0559	0.18	1.00
1,2-DICHLOROETHENE(TRANS)	0.94	1.02	1.06	1	1.02	0.99	1.02	0.0368	0.12	1.01
CHLOROFORM	1.01	1.01	0.98	0.96	0.96	1.01	1.04	0.0299	0.09	1.00
2-BUTANONE	5.33	5.66	5.46	5.45	6.73	5.79	6.78	0.6127	1.92	5.89
BENZENE	1.00	1.02	1.04	1.01	1.01	1.02	1.06	0.0206	0.06	1.02
TOLUENE	1.07	1.03	0.97	0.99	0.94	1.06	1.09	0.0561	0.18	1.02
DIBROMOMETHANE	1.08	1.02	1	0.92	1.08	1.03	1.1	0.0618	0.19	1.03
1,2-DICHLOROETHANE	0.98	1.03	0.93	1.01	1.12	1.05	1.11	0.0680	0.21	1.03
2,2-DICHLOROPROPANE	1.04	1.07	1.08	1.07	1.09	1.09	1.11	0.0219	0.07	1.08
1,1,1-TRICHLOROETHANE	0.98	1.01	0.99	0.98	1.03	1.03	1.07	0.0330	0.10	1.01
CARBON TETRACHLORIDE	0.94	1.03	1.03	0.98	1.13	1	1.04	0.0593	0.19	1.02
BROMODICHLOROMETHANE	1.02	1	0.97	0.98	1.07	1.04	1.1	0.0476	0.15	1.03
1,2-DICHLOROPROPANE	1.07	1.03	1	1.02	1.03	1.1	1.15	0.0528	0.17	1.06
1,1-DICHLOROPROPENE	0.92	1.01	1.01	0.97	1.05	1	1.03	0.0426	0.13	1.00
CIS-1,3-DICHLOROPROPENE (.5 ppb)	0.98	0.94	0.96	0.91	0.98	1	0.99	0.0315	0.10	0.97
TRICHLOROETHENE	1.00	1.01	1.04	0.99	1.04	0.96	1.07	0.0369	0.12	1.02
1,1,2-TRICHLOROETHANE	0.95	0.96	0.96	0.93	0.97	0.97	1	0.0214	0.07	0.96
1,3-DICHLOROPROPANE	0.96	0.97	0.92	0.96	0.99	0.91	1.08	0.0560	0.18	0.97
TRANS-1,3-DICHLOROPROPENE (.6 ppb)	1.03	1.01	0.98	1.02	1.08	1.08	1.12	0.0489	0.15	1.05
4-METHYL-2-PENTANONE (5 PPB)	4.46	4.45	4.35	4.47	4.89	4.66	5.65	0.4538	1.42	4.70
2-HEXANONE (5 PPB)	4.86	4.75	4.56	4.43	5.22	4.95	6.02	0.5300	1.66	4.97
TETRACHLOROETHENE	0.99	0.91	0.91	0.87	0.91	0.91	0.99	0.0454	0.14	0.93
CHLOROBENZENE	1.04	1.05	1.09	1.07	1	1.03	1.07	0.0300	0.09	1.05
ETHYLBENZENE	1.13	1.04	1.09	1.03	1	1.11	1.08	0.0467	0.15	1.07
BROMOBENZENE	1.03	1.03	1.07	1.02	1.02	1.05	1.03	0.0181	0.06	1.04
ISOPROPYLBENZENE	1.06	1.06	1.08	1.05	1.03	1.08	1.06	0.0173	0.05	1.06
O-XYLENE	1.01	1.02	1.07	1.03	1.02	1.06	1.08	0.0279	0.09	1.04
M,P-XYLENES (2 PPB)	2.13	2.17	2.2	2.08	2.06	2.14	2.11	0.0489	0.15	2.13
STYRENE	1.00	1.02	1.04	1.04	1.01	1.02	1.03	0.0150	0.05	1.02
N-PROPYLBENZENE	1.06	1.05	1.14	1.09	1.03	1.08	1.09	0.0355	0.11	1.08
TERT-BUTYLBENZENE	1.02	1.01	1.09	1.07	1.04	1.04	1.04	0.0276	0.09	1.04
2-CHLOROTOLUENE	1.05	1.12	1.17	1.19	0.99	1.11	1.08	0.0689	0.22	1.10
4-CHLOROTOLUENE	1.11	0.97	1.05	0.98	1.07	1	1.09	0.0555	0.17	1.04
SEC-BUTYLBENZENE	1.08	1.09	1.15	1.13	1.04	1.12	1.09	0.0365	0.11	1.10
DIBROMOCHLOROMETHANE	1.07	1.02	0.99	1.03	1.04	1.03	1.14	0.0479	0.15	1.05
1,2-DIBROMOETHANE	1.13	1.01	1.08	1.1	1.13	1.15	1.14	0.0486	0.15	1.11
1,3-DICHLOROBENZENE	1.07	1.02	1.04	1.05	0.98	1.06	1.07	0.0324	0.10	1.04
1,2-DICHLOROBENZENE	1.08	1	1.01	1.05	1.01	1.06	1.07	0.0327	0.10	1.04

PACE, INC.

(continued)

METHOD DETECTION LIMIT VERIFICATION STUDY
VOLATILE ORGANIC COMPOUNDS
METHOD 524.2 DMS WATERS
8/93

COMPOUND (1 ppb, exceptions noted)	>D6760 CONC. ug/L	>D6765 CONC. ug/L	>D6764 CONC. ug/L	>D6763 CONC. ug/L	>D6755 CONC. ug/L	>D6759 CONC. ug/L	>D6756 CONC. ug/L	STD DEV	X 3.14 MDL ug/L	MEAN
1,4-DICHLOROBENZENE	1.05	1.01	1.05	1.11	0.99	1.08	1.09	0.0431	0.14	1.05
P-ISOPROPYLTOLUENE	1.07	1.05	1.15	1.12	1.01	1.05	1.08	0.0469	0.15	1.08
1,3,5-TRIMETHYLBENZENE	1.05	1.01	1.14	1.06	0.96	1.01	1.05	0.0560	0.18	1.04
BROMOFORM	1.04	1.01	0.98	1.05	0.96	1.06	1.07	0.0420	0.13	1.02
1,1,1,2-TETRACHLOROETHANE	1.00	1.01	1.02	0.98	1.02	1.07	1.1	0.0418	0.13	1.03
1,1,2,2-TETRACHLOROETHANE	1.15	1.07	1.02	1.06	1.13	1.12	1.17	0.0541	0.17	1.10
1,2,3-TRICHLOROPROPANE	1.14	0.95	1.05	1	1.16	0.73	1.13	0.1507	0.47	1.02
N-BUTYLBENZENE	1.08	1.06	1.16	1.11	0.99	1.03	1.03	0.0568	0.18	1.07
1,2,4-TRIMETHYLBENZENE	1.03	1.06	1.12	1.05	0.94	1.02	1.05	0.0540	0.17	1.04
1,2,4-TRICHLOROBENZENE	1.02	1.01	1.16	1.11	0.93	1.02	1.13	0.0814	0.26	1.05
1,2,3-TRICHLOROBENZENE	1.12	1.03	1.14	1.1	1.07	1.06	1.07	0.0378	0.12	1.08
NAPHTHALENE	1.08	0.89	1.11	1.1	0.95	1.03	1.12	0.0887	0.28	1.04
1,2-DIBROMO-3-CHLOROPROPANE	0.68	0.83	0.92	0.87	1.27	1.24	0.69	0.2400	0.75	0.93
HEXACHLOROBUTADIENE	1.14	1.06	1.19	1.12	1.04	1.12	1.13	0.0503	0.16	1.11

PACE, INC.

METHOD DETECTION LIMIT VERIFICATION STUDY
VOLATILE ORGANIC COMPOUNDS
METHOD 524.2 GMS WATERS
4/93

COMPOUND (1 ppb, exceptions noted)	>G5034 CONC. ug/L	>G5035 CONC. ug/L	>G5036 CONC. ug/L	>G5037 CONC. ug/L	>G5038 CONC. ug/L	>G5042 CONC. ug/L	>G5043 CONC. ug/L	STD DEV	X 3.14 MDL ug/L	MEAN
HLOROMETHANE	0.97	1.24	0.97	1.04	1.05	1.10	1.10	0.0930	0.29	1.07
BROMOMETHANE	1.14	1.54	1.39	1.31	1.45	1.30	1.42	0.1287	0.40	1.36
ICHLORODIFLUOROMETHANE	1.01	1.19	1.07	0.98	0.97	0.93	0.98	0.0869	0.27	1.02
HLOROETHANE	0.59	0.64	0.67	0.62	0.62	0.60	0.54	0.0410	0.13	0.61
VINYL CHLORIDE	0.97	1.01	0.94	1.08	1.04	1.02	1.00	0.0456	0.14	1.01
METHYLENE CHLORIDE	0.98	1.09	1.04	1.02	1.11	1.16	1.09	0.0606	0.19	1.07
CETONE (5 PPB)	4.78	5.57	4.80	5.52	4.93	5.03	5.58	0.3689	1.16	5.17
ARBON DISULFIDE	0.99	0.97	0.97	1.03	0.89	1.78	0.94	0.3110	0.98	1.08
TRICHLOROFLUOROMETHANE	0.95	1.08	1.07	1.02	0.98	1.01	1.03	0.0462	0.15	1.02
,1-DICHLOROETHENE	0.91	1.07	1.01	0.94	1.04	1.00	0.92	0.0619	0.19	0.98
ROMOCHLOROMETHANE	0.89	1.16	0.96	0.93	1.02	1.04	0.95	0.0898	0.28	0.99
1,1-DICHLOROETHANE	0.94	1.12	1.04	0.85	0.99	0.99	0.97	0.0834	0.26	0.99
1,2-DICHLOROETHENE (cis)	1.01	1.09	1.03	0.95	1.07	1.05	0.99	0.0482	0.15	1.03
,2-DICHLOROETHENE(trans)	1.03	1.09	1.04	0.98	1.12	1.09	1.06	0.0467	0.15	1.06
HLOROFORM	0.91	1.02	1.04	0.96	1.05	1.02	0.99	0.0495	0.16	1.00
2-BUTANONE (5 PPB)	6.21	7.01	5.54	4.79	5.74	4.67	4.00	1.0202	3.20	5.42
ENZENE	0.97	1.02	0.93	0.98	0.99	0.98	0.94	0.0304	0.10	0.97
OLUENE	0.94	0.98	1.02	0.89	0.99	1.00	0.97	0.0432	0.14	0.97
DIBROMOMETHANE	1.01	1.13	1.15	1.23	1.19	1.24	1.14	0.0774	0.24	1.16
,2-DICHLOROETHANE	1.00	1.09	1.11	1.03	1.10	1.05	1.06	0.0399	0.13	1.06
,2-DICHLOROPROPANE	1.01	1.06	0.98	0.91	0.98	0.92	0.89	0.0608	0.19	0.96
1,1,1-TRICHLOROETHANE	0.99	1.07	0.96	0.97	0.98	1.02	0.96	0.0399	0.13	0.99
CARBON TETRACHLORIDE	0.96	1.00	1.01	0.94	1.05	0.93	1.02	0.0446	0.14	0.99
ROMODICHLOROMETHANE	0.95	1.00	1.02	0.96	0.98	1.00	0.93	0.0320	0.10	0.98
,2-DICHLOROPROPANE	0.91	1.22	0.96	0.97	1.07	0.95	0.99	0.1047	0.33	1.01
1,1-DICHLOROPROPENE	0.92	1.09	0.94	0.89	0.94	0.90	0.94	0.0668	0.21	0.95
IS-1,3-DICHLOROPROPENE	0.87	0.94	0.98	0.92	0.93	0.85	0.93	0.0439	0.14	0.92
RICHLOROETHENE	0.91	0.92	1.01	0.96	1.01	0.93	0.95	0.0408	0.13	0.96
1,1,2-TRICHLOROETHANE	0.73	1.05	0.88	0.86	0.87	0.91	0.92	0.0948	0.30	0.89
,3-DICHLOROPROPANE	0.93	1.14	1.01	1.00	0.97	1.05	0.85	0.0914	0.29	0.99
RANS-1,3-DICHLOROPROPENE	0.91	1.10	0.88	0.92	1.01	0.95	0.95	0.0739	0.23	0.96
4-METHYL-2-PENTANONE (5 PPB)	4.67	4.51	4.46	4.50	4.94	4.35	4.55	0.1899	0.60	4.57
2-HEXANONE (5 PPB)	4.85	5.45	5.37	5.08	4.56	4.66	4.74	0.3495	1.10	4.96
ETRACHLOROETHENE	0.95	1.23	1.06	0.97	1.02	1.04	0.99	0.0934	0.29	1.04
HLOROBENZENE	0.99	1.02	1.00	0.95	1.06	0.99	1.04	0.0364	0.11	1.01
ETHYLBENZENE	0.98	0.93	1.04	0.97	0.97	0.98	0.99	0.0327	0.10	0.98
ROMOBENZENE	0.99	1.03	0.95	1.02	1.07	0.97	1.03	0.0410	0.13	1.01
SOPROPYLBENZENE	0.94	0.91	0.96	0.95	0.95	0.97	1.01	0.0305	0.10	0.96
o-XYLENE	0.88	0.94	0.98	0.83	0.92	0.98	0.97	0.0567	0.18	0.93
m,p-XYLENES (2 PPB)	2.12	2.27	2.21	2.04	2.05	2.20	2.32	0.1070	0.34	2.17
TYRENE	0.86	0.85	0.88	0.85	0.91	0.83	0.93	0.0359	0.11	0.87
n-PROPYLBENZENE	1.00	0.93	0.98	0.98	0.99	0.99	1.02	0.0276	0.09	0.98
tert-BUTYLBENZENE	1.00	0.90	0.95	0.97	0.97	1.01	1.04	0.0454	0.14	0.98
-CHLOROTOLUENE	0.86	0.88	0.86	0.85	0.86	1.01	1.00	0.0704	0.22	0.90
-CHLOROTOLUENE	0.93	0.90	0.99	0.97	0.72	0.84	0.96	0.0944	0.30	0.90
sec-BUTYLBENZENE	1.05	0.94	1.02	1.00	1.04	1.02	1.11	0.0516	0.16	1.03
IBROMOCHLOROMETHANE	1.10	1.13	1.02	0.93	1.13	1.02	1.07	0.0725	0.23	1.06
,2-DIBROMOETHANE	1.09	1.16	1.17	1.03	1.05	1.09	1.02	0.0596	0.19	1.09
1,3-DICHLOROBENZENE	0.96	0.99	0.99	0.94	0.98	0.94	0.98	0.0219	0.07	0.97
1,2-DICHLOROBENZENE	1.00	1.08	0.98	1.05	1.02	0.98	1.05	0.0386	0.12	1.02
,4-DICHLOROBENZENE	0.96	0.99	0.95	0.94	0.98	0.94	0.98	0.0206	0.06	0.96

PACE, INC.

(continued)
VOLATILE ORGANIC COMPOUNDS
METHOD 524.2 GMS WATERS
4/93

COMPOUND (1 ppb, exceptions noted)	>G5034 CONC. ug/L	>G5035 CONC. ug/L	>G5036 CONC. ug/L	>G5037 CONC. ug/L	>G5038 CONC. ug/L	>G5042 CONC. ug/L	>G5043 CONC. ug/L	STD DEV	X 3.14 MDL ug/L	MEAN
p-ISOPROPYLTOLUENE	0.94	0.91	1.02	0.96	0.99	1.01	1.10	0.0622	0.20	0.99
1,3,5-TRIMETHYLBENZENE	1.08	0.97	1.03	1.02	0.97	1.02	1.08	0.0450	0.14	1.02
BROMOFORM	0.85	1.23	0.96	1.05	0.97	1.01	0.91	0.1215	0.38	1.00
1,1,1,2-TETRACHLOROETHANE	1.06	1.13	1.04	1.06	1.12	1.10	1.09	0.0336	0.11	1.09
1,1,2,2-TETRACHLOROETHANE	1.04	1.20	1.19	1.03	0.97	1.11	1.13	0.0860	0.27	1.10
1,2,3-TRICHLOROPROPANE	1.12	1.74	1.04	1.32	1.46	1.40	1.04	0.2573	0.81	1.30
n-BUTYLBENZENE	0.98	0.93	0.99	1.00	0.97	1.02	1.03	0.0334	0.10	0.99
1,2,4-TRIMETHYLBENZENE	1.00	0.93	1.03	1.01	0.97	0.89	1.08	0.0634	0.20	0.99
1,2,4-TRICHLOROBENZENE	1.01	1.03	1.05	1.07	1.06	1.03	1.15	0.0457	0.14	1.06
1,2,3-TRICHLOROBENZENE	0.99	0.93	0.98	0.97	1.07	0.94	1.05	0.0526	0.17	0.99
NAPHTHALENE	0.94	1.05	0.99	0.99	1.00	0.94	0.96	0.0389	0.12	0.98
1,2,-DIBROMO-3-CHLOROPROPANE	0.68	1.09	0.60	0.81	0.85	0.73	0.99	0.1727	0.54	0.82
HEXACHLOROBUTADIENE	0.96	0.87	0.93	0.91	0.93	0.96	1.02	0.0469	0.15	0.94

PACE, INC.

METHOD DETECTION LIMIT VERIFICATION STUDY
VOLATILE ORGANIC COMPOUNDS
METHOD 624 DMS WATERS – megabore column
3/93

COMPOUND (5 ppb, exceptions noted)	>D4719 CONC. ug/L	>D4726 CONC. ug/L	>D4724 CONC. ug/L	>D4725 CONC. ug/L	>D4727 CONC. ug/L	>D4728 CONC. ug/L	>D4730 CONC. ug/L	STD DEV	X 3.14 MDL ug/L	MEAN
CHLOROMETHANE	7.63	6.83	6.23	6.24	6.68	5.33	5.75	0.7524	2.36	6.38
BROMOMETHANE	4.82	4.42	4.12	4.21	4.30	4.18	4.13	0.2475	0.78	4.31
VINYL CHLORIDE	4.22	4.01	3.97	4.36	3.60	4.03	4.44	0.2819	0.89	4.09
CHLOROETHANE	5.23	4.36	4.74	4.65	5.05	4.74	5.33	0.3454	1.08	4.87
METHYLENE CHLORIDE	4.63	4.78	4.56	4.79	4.54	4.25	4.34	0.2045	0.64	4.56
ACETONE	4.04	3.71	4.28	3.88	4.68	4.74	4.85	0.4532	1.42	4.31
CARBON DISULFIDE	4.41	4.48	4.07	3.78	4.43	4.42	4.45	0.2649	0.83	4.29
TRICHLOROFLUOROMETHANE	5.05	5.25	4.82	5.05	4.15	4.66	5.35	0.4075	1.28	4.90
1,1-DICHLOROETHENE	4.85	4.71	4.12	4.67	4.60	3.86	4.13	0.3767	1.18	4.42
TETRAHYDROFURAN	4.85	2.13	4.44	4.24	5.16	3.85	2.06	1.2498	3.92	3.82
1,1-DICHLOROETHANE	5.11	4.50	4.31	4.41	4.50	4.16	4.60	0.3002	0.94	4.51
1,2-DICHLOROETHENE(cis)	4.39	4.20	3.84	3.84	4.15	3.59	3.92	0.2707	0.85	3.99
1,2-DICHLOROETHENE(trans)	5.91	5.93	5.50	4.88	5.91	5.17	6.17	0.4706	1.48	5.64
CHLOROFORM	3.62	3.47	3.22	3.33	3.31	3.24	3.33	0.1402	0.44	3.36
2-BUTANONE	3.75	3.37	3.29	3.39	3.38	3.53	3.12	0.1963	0.62	3.40
1,2-DICHLOROETHANE	5.04	4.74	4.37	4.60	4.79	4.49	4.72	0.2181	0.68	4.68
DIOXANE	5.68	5.03	4.54	4.33	5.20	4.62	4.89	0.4561	1.43	4.90
1,1,1-TRICHLOROETHANE	4.79	4.69	4.86	4.71	4.71	4.76	4.66	0.0683	0.21	4.74
CARBON TETRACHLORIDE	5.13	5.19	5.12	5.02	4.84	5.30	5.23	0.1516	0.48	5.12
VINYL ACETATE	4.27	4.00	4.04	4.27	3.80	3.94	3.91	0.1787	0.56	4.03
BROMODICHLOROMETHANE	5.08	4.98	4.95	5.05	5.07	5.03	4.93	0.0596	0.19	5.01
1,2-DICHLOROPROPANE	5.14	4.65	4.73	4.95	4.92	4.91	4.56	0.2000	0.63	4.84
CIS-1,3-DICHLOROPROPENE	4.87	4.43	4.18	4.44	4.33	4.43	4.19	0.2313	0.73	4.41
TRICHLOROETHENE	4.86	4.67	4.61	4.57	4.75	4.90	4.42	0.1685	0.53	4.68
DIBROMOCHLOROMETHANE	4.89	5.01	4.79	5.43	4.94	5.44	5.06	0.2573	0.81	5.08
1,1,2-TRICHLOROETHANE	5.27	4.97	4.79	4.91	4.89	5.14	4.87	0.1688	0.53	4.98
BENZENE	4.99	4.67	4.73	4.69	4.54	4.73	4.48	0.1634	0.51	4.69
TRANS-1,3-DICHLOROPROPENE	5.27	4.72	4.50	4.76	4.62	4.77	4.15	0.3369	1.06	4.68
2-CHLOROETHYLVINYLETHER	5.15	4.59	4.93	4.93	4.67	4.88	4.51	0.2263	0.71	4.81
BROMOFORM	4.83	5.28	5.16	5.10	5.34	5.17	4.98	0.1742	0.55	5.12
4-METHYL-2-PENTANONE	5.09	4.38	4.50	4.63	4.66	4.40	4.35	0.2583	0.81	4.57
2-HEXANONE	4.43	4.05	4.21	4.26	4.46	4.11	3.87	0.2096	0.66	4.20
TETRACHLOROETHENE	5.28	5.08	4.90	5.25	5.59	5.20	5.13	0.2122	0.67	5.20
1,1,2,2-TETRACHLOROETHANE	4.94	4.75	4.66	4.65	4.70	4.72	4.34	0.1786	0.56	4.68
TOLUENE	4.88	4.61	4.44	4.69	4.88	4.68	4.50	0.1703	0.53	4.67
CHLOROBENZENE	4.90	5.04	4.60	5.04	5.07	4.87	4.69	0.1835	0.58	4.89
ETHYLBENZENE	4.85	4.30	4.49	4.67	4.69	4.66	4.13	0.2510	0.79	4.54
STYRENE	4.59	4.38	4.28	4.53	4.46	4.50	4.13	0.1600	0.50	4.41
XYLENE(O)	4.43	4.37	4.38	4.35	4.54	4.52	4.22	0.1088	0.34	4.40
XYLENE (total) (10 ppb)	9.51	9.41	8.98	9.38	9.67	9.62	8.70	0.3559	1.12	9.32

PACE New England, Inc.
MATRIX DETECTION LIMIT VERIFICATION STUDY
VOLATILE ORGANIC COMPOUNDS
METHOD 624 DMS WATERS - packed column
1/93

COMPOUND (10 ppb, exceptions noted	>D384 CONC ug/L	>D384 CONC ug/L	>D385 CONC ug/L	>D385 CONC ug/L	>D385 CONC ug/L	>D385 CONC ug/L	>D3854 CONC ug/L	STD DEV	X 3.14 MDL ug/L	MEAN
								====	===	=====
CHLOROMETHANE	8.40	10.18	10.98	10.89	10.00	11.56	10.84	1.0266	3.22	10.41
BROMOMETHANE	9.15	9.67	10.92	10.37	9.96	11.07	10.46	0.6840	2.15	10.23
VINYL CHLORIDE	9.87	11.08	11.44	11.01	10.94	11.48	11.68	0.5969	1.87	11.07
CHLOROETHANE	9.97	10.79	11.59	11.63	10.66	11.61	11.46	0.6426	2.02	11.10
METHYLENE CHLORIDE	10.70	10.44	11.35	11.93	10.58	11.27	11.48	0.5463	1.72	11.11
ACETONE	9.48	9.12	8.86	10.72	12.93	9.13	8.41	1.5531	4.88	9.81
CARBON DISULFIDE	10.95	10.52	11.98	11.39	11.14	12.09	11.16	0.5580	1.75	11.32
TRICHLOROFLUOROMETHANE	10.01	10.59	11.60	10.50	10.71	11.58	11.01	0.5825	1.83	10.86
1,1-DICHLOROETHENE	11.18	10.81	11.05	10.31	10.40	11.27	10.20	0.4411	1.39	10.75
TETRAHYDROFURAN	5.79	4.25	5.01	4.53	7.10	4.61	6.29	1.0554	3.31	5.37
1,1-DICHLOROETHANE	9.77	10.31	11.29	10.50	10.30	10.39	10.10	0.4663	1.46	10.38
1,2-DICHLOROETHENE(total) (20 pp	20.27	20.75	22.10	21.25	20.58	22.01	21.22	0.6969	2.19	21.17
CHLOROFORM	9.79	10.17	11.26	10.66	10.16	11.10	10.95	0.5545	1.74	10.58
2-BUTANONE	10.45	7.87	9.83	9.64	7.47	9.53	8.99	1.0811	3.39	9.11
1,2-DICHLOROETHANE	9.02	10.05	10.93	10.39	10.34	10.88	10.76	0.6640	2.08	10.34
MTBE	9.76	10.24	10.92	10.12	9.88	11.06	10.91	0.5399	1.70	10.41
1,1,1-TRICHLOROETHANE	9.59	10.20	10.37	9.66	9.55	10.26	9.53	0.3766	1.18	9.88
CARBON TETRACHLORIDE	9.68	10.63	10.42	9.91	9.72	10.65	9.61	0.4622	1.45	10.09
VINYL ACETATE	9.70	10.23	11.14	9.75	10.50	11.97	10.87	0.8083	2.54	10.59
BROMODICHLOROMETHANE	9.79	10.26	10.12	10.15	9.90	10.90	9.81	0.3832	1.20	10.13
1,2-DICHLOROPROPANE	9.14	9.95	10.25	9.74	9.78	10.44	9.50	0.4394	1.38	9.83
CIS-1,3-DICHLOROPROPENE (9.6 pp	8.70	9.51	9.83	9.48	9.45	10.17	9.47	0.4472	1.40	9.52
TRICHLOROETHENE	10.35	10.33	10.52	10.18	9.17	10.75	9.90	0.5148	1.62	10.17
DIBROMOCHLOROMETHANE	9.43	10.25	10.37	9.89	10.05	10.93	10.37	0.4660	1.46	10.18
1,1,2-TRICHLOROETHANE	9.29	10.03	10.86	10.00	9.37	10.23	9.63	0.5449	1.71	9.92
BENZENE	10.11	10.10	10.57	10.19	10.02	10.73	10.00	0.2869	0.90	10.25
TRANS-1,3-DICHLOROPROPENE (1	9.82	10.42	10.67	10.36	9.84	10.82	10.30	0.3797	1.19	10.32
2-CHLOROETHYLVINYLETHER	8.02	8.97	10.07	9.50	8.40	10.25	8.98	0.8243	2.59	9.17
BROMOFORM	9.73	10.39	10.50	9.17	10.10	10.75	9.76	0.5433	1.71	10.06
4-METHYL-2-PENTANONE	10.46	9.98	10.61	9.98	11.42	11.00	9.81	0.5942	1.87	10.47
2-HEXANONE	10.15	8.55	8.19	9.65	8.47	8.75	8.56	0.7158	2.25	8.90
TETRACHLOROETHENE	9.43	9.37	10.46	9.92	9.16	10.42	9.76	0.5110	1.60	9.79
1,1,2,2-TETRACHLOROETHANE	10.03	10.27	10.96	9.95	10.31	10.72	10.29	0.3610	1.13	10.36
TOLUENE	9.53	9.73	10.27	9.98	9.78	10.54	9.94	0.3423	1.07	9.97
CHLOROBENZENE	9.26	10.01	10.33	9.95	9.48	10.27	9.60	0.4061	1.28	9.84
ETHYLBENZENE	9.30	9.91	10.48	9.89	9.71	10.34	9.64	0.4070	1.28	9.90
STYRENE	8.95	9.51	10.38	9.59	9.64	9.80	9.79	0.4256	1.34	9.67
XYLENE	9.26	10.22	10.14	10.13	9.64	10.13	10.15	0.3619	1.14	9.95
XYLENE (total)	18.53	19.32	21.23	19.64	19.94	21.47	19.55	1.0503	3.30	19.95

PACE New England, Inc.
METHOD DETECTION LIMIT VERIFICATION STUDY
VOLATILE ORGANIC COMPOUNDS
METHOD 624 EMS WATERS
9/93

MPOUND (10 ppb, exceptions noted)	>E4570 CONC. ug/L	>E4572 CONC. ug/L	>E4578 CONC. ug/L	>E4575 CONC. ug/L	>E4576 CONC. ug/L	>E4577 CONC. ug/L	>E4579 CONC. ug/L	STD DEV	X 3.14 MDL ug/L	MEAN
CHLOROMETHANE	10.29	10.65	11.31	9.36	9.66	10.46	9.68	0.6804	2.14	10.20
OMOMETHANE	10.82	11.36	11.32	9.58	10.23	10.30	10.81	0.6389	2.01	10.63
NYL CHLORIDE	10.16	10.05	10.18	9.60	9.53	10.57	10.50	0.4014	1.26	10.08
CHLOROETHANE	9.02	9.09	8.66	8.29	8.49	9.43	8.80	0.3874	1.22	8.83
METHYLENE CHLORIDE	9.46	9.48	11.53	10.15	10.75	10.71	11.85	0.9317	2.93	10.56
ETONE	7.16	3.44	6.93	6.79	6.70	8.92	6.12	1.6363	5.14	6.58
CARBON DISULFIDE	10.28	10.72	10.98	10.06	9.94	10.15	10.35	0.3721	1.17	10.35
TRICHLOROFLUOROMETHANE	8.72	9.07	9.15	8.80	8.65	9.04	8.93	0.1899	0.60	8.91
1-DICHLOROETHENE	8.70	9.54	8.81	7.28	8.38	8.21	7.90	0.7186	2.26	8.40
BE	10.52	9.89	10.23	9.17	9.34	10.65	10.25	0.5693	1.79	10.01
1,1-DICHLOROETHANE	9.18	9.59	10.39	9.16	9.62	10.05	9.55	0.4441	1.39	9.65
2-DICHLOROETHENE(cis)	8.52	8.47	9.5	8.15	8.90	9.10	8.52	0.4565	1.43	8.74
2-DICHLOROETHENE(trans)	9.06	9.16	9.55	8.55	9.48	9.30	8.90	0.3468	1.09	9.14
CHLOROFORM	9.17	9.34	10.17	8.79	8.84	9.85	9.26	0.5061	1.59	9.35
2-BUTANONE	9.69	8.75	10.82	5.75	7.71	7.22	10.20	1.8036	5.66	8.59
2-DICHLOROETHANE	9.47	9.40	10.18	9.31	9.54	10.69	10.19	0.5261	1.65	9.83
1,1,1-TRICHLOROETHANE	9.91	9.20	9.77	9.13	9.46	10.02	10.01	0.3780	1.19	9.64
CARBON TETRACHLORIDE	9.03	9.70	10.48	9.64	9.31	10.37	9.93	0.5276	1.66	9.78
NYL ACETATE	10.19	6.71	5.05	6.53	6.14	5.68	7.93	1.7101	5.37	6.89
OMODICHLOROMETHANE	8.75	9.48	9.84	9.10	9.36	10.02	9.76	0.4455	1.40	9.47
1,2-DICHLOROPROPANE	9.34	9.70	9.43	8.41	9.69	9.06	10.12	0.5466	1.72	9.39
CIS-1,3-DICHLOROPROPENE	9.75	9.99	10.18	9.78	10.09	10.85	9.72	0.3945	1.24	10.05
ICHLOROETHENE	9.41	9.78	10.25	8.82	9.11	9.99	9.31	0.5059	1.59	9.52
DIBROMOCHLOROMETHANE	9.62	9.17	9.17	8.91	8.90	9.67	9.64	0.3417	1.07	9.30
1,1,2-TRICHLOROETHANE	9.39	10.66	9.76	10.25	8.63	10.84	10.41	0.7829	2.46	9.99
NZENE	10.00	9.51	10.58	9.47	9.99	9.69	10.33	0.4155	1.30	9.94
ANS-1,3-DICHLOROPROPENE	9.75	9.99	10.18	9.78	10.09	10.85	9.72	0.3945	1.24	10.05
2-CHLOROETHYLVINYLETHER	10.60	8.84	9.9	8.83	9.46	9.18	9.39	0.6269	1.97	9.46
OMOFORM	10.30	9.58	9.08	8.11	8.49	9.52	9.44	0.7325	2.30	9.22
METHYL-2-PENTANONE	10.45	10.84	11.26	9.36	10.55	11.97	11.07	0.8075	2.54	10.79
2-HEXANONE	10.65	8.06	12.77	11.94	5.06	11.09	8.99	2.6438	8.30	9.79
TETRACHLOROETHENE	8.33	9.82	9.18	8.62	9.73	8.88	8.35	0.6146	1.93	8.99
1,2,2-TETRACHLOROETHANE	9.75	11.54	11.71	8.47	9.07	9.86	13.18	1.6766	5.26	10.51
TOLUENE	8.60	9.31	10.08	8.84	9.60	9.72	9.75	0.5303	1.67	9.41
CHLOROBENZENE	9.44	9.80	10.34	8.83	9.49	9.05	9.40	0.4929	1.55	9.48
HYLBENZENE	9.19	9.67	9.51	9.33	8.96	8.58	9.64	0.3951	1.24	9.27
YRENE	9.87	10.88	10.53	10.22	10.66	10.47	10.94	0.3742	1.17	10.51
XYLENE (o)	8.90	10.07	10.53	9.30	9.11	9.29	10.49	0.6782	2.13	9.67
LENE (m,p) (20 PPB)	18.16	21.37	21.5	18.66	18.41	20.84	20.57	1.4624	4.59	19.93

PACE New England, Inc.
METHOD DETECTION LIMIT VERIFICATION STUDY
VOLATILE ORGANIC COMPOUNDS
METHOD 624 EMS WATERS
4/93

COMPOUND (5 ppb, exceptions noted)	>E3859 CONC. ug/L	>E3860 CONC. ug/L	>E3861 CONC. ug/L	>E3867 CONC. ug/L	>E3863 CONC. ug/L	>E3868 CONC. ug/L	>E3865 CONC. ug/L	STD DEV	X 3.14 MDL ug/L	MEAN
CHLOROMETHANE	4.85	4.51	4.72	3.95	3.59	4.60	4.73	0.4693	1.47	4.42
BROMOMETHANE	4.79	4.85	4.83	4.81	4.98	4.69	4.54	0.1378	0.43	4.78
VINYL CHLORIDE	4.50	4.37	4.74	4.68	4.90	4.10	4.36	0.2718	0.85	4.52
CHLOROETHANE	3.27	5.43	5.25	4.25	5.28	4.38	4.98	0.7745	2.43	4.69
METHYLENE CHLORIDE	4.58	4.61	4.62	5.96	5.36	5.85	5.69	0.6224	1.95	5.24
ACETONE	3.58	3.04	4.52	3.26	4.20	3.74	4.83	0.6601	2.07	3.88
CARBON DISULFIDE	3.93	4.73	4.31	4.89	4.27	3.81	4.04	0.4034	1.27	4.28
TRICHLOROFLUOROMETHANE	4.86	4.88	4.65	4.88	4.83	4.80	4.65	0.1016	0.32	4.79
1,1-DICHLOROETHENE	4.37	4.35	4.40	4.17	4.68	4.42	3.76	0.2841	0.89	4.31
1,1-DICHLOROETHANE	4.40	4.46	4.40	4.43	4.32	4.34	4.14	0.1067	0.34	4.36
1,2-DICHLOROETHENE(cis)	4.75	4.81	4.68	4.55	4.53	4.12	4.11	0.2859	0.90	4.51
1,2-DICHLOROETHENE(trans)	4.85	4.47	4.47	4.37	4.51	4.32	4.46	0.1708	0.54	4.49
CHLOROFORM	5.04	4.67	4.56	4.67	4.82	4.74	4.31	0.2251	0.71	4.69
2-BUTANONE	8.72	7.09	7.27	4.29	7.87	4.32	3.48	2.0672	6.49	6.15
1,2-DICHLOROETHANE	5.11	5.22	5.65	5.35	5.74	5.28	5.43	0.2282	0.72	5.40
1,1,1-TRICHLOROETHANE	4.70	5.07	4.91	5.02	5.41	5.44	5.38	0.2846	0.89	5.13
CARBON TETRACHLORIDE	4.67	4.70	5.02	5.01	4.99	5.59	5.27	0.3193	1.00	5.04
VINYL ACETATE	4.54	5.31	5.97	4.71	6.83	5.98	6.64	0.8934	2.81	5.71
BROMODICHLOROMETHANE	5.21	5.10	5.23	5.13	5.51	5.34	5.59	0.1878	0.59	5.30
1,2-DICHLOROPROPANE	4.60	4.84	4.74	4.74	5.02	5.24	5.06	0.2236	0.70	4.89
CIS-1,3-DICHLOROPROPENE (4.48 ppb)	4.65	4.47	4.65	4.81	5.32	4.81	4.82	0.2659	0.83	4.79
TRICHLOROETHENE	4.74	4.72	4.93	5.19	4.98	5.19	4.85	0.1928	0.61	4.94
DIBROMOCHLOROMETHANE	5.18	5.19	5.81	5.48	6.43	5.59	6.15	0.4722	1.48	5.69
1,1,2-TRICHLOROETHANE	4.68	5.00	5.33	5.02	5.96	5.76	6.09	0.5396	1.69	5.41
BENZENE	4.96	5.11	5.01	4.82	5.17	4.97	4.74	0.1509	0.47	4.97
TRANS-1,3-DICHLOROPROPENE (5.52 ppb)	5.74	5.50	5.73	5.93	6.55	5.93	5.94	0.3267	1.03	5.90
BROMOFORM	5.48	5.54	6.30	5.57	7.42	6.68	7.00	0.7821	2.46	6.28
4-METHYL-2-PENTANONE	5.57	6.48	9.82	5.88	10.85	6.31	9.65	2.2146	6.95	7.79
2-HEXANONE	7.87	8.37	10.87	6.74	7.08	10.87	12.72	2.2719	7.13	9.22
TETRACHLOROETHENE	4.87	5.19	4.82	4.97	5.12	5.04	4.70	0.1733	0.54	4.96
1,1,2,2-TETRACHLOROETHANE	5.72	5.82	6.31	5.40	7.05	5.91	7.52	0.7703	2.42	6.25
TOLUENE	4.84	5.05	5.22	5.07	5.24	4.74	5.09	0.1852	0.58	5.04
CHLOROBENZENE	4.93	4.80	5.09	4.92	5.19	4.75	4.91	0.1539	0.48	4.94
ETHYLBENZENE	5.00	5.33	5.25	5.26	4.94	5.02	5.13	0.1507	0.47	5.13
STYRENE	4.96	5.47	5.23	5.24	5.57	5.28	4.96	0.2310	0.73	5.24
XYLENE (o)	4.83	5.28	5.10	4.81	4.91	4.86	4.77	0.1854	0.58	4.94
XYLENE (m,p) (10.0 ppb)	9.84	9.28	10.00	9.45	10.25	9.19	9.62	0.3888	1.22	9.66

PACE New England, Inc.
METHOD DETECTION LIMIT VERIFICATION STUDY
VOLATILE ORGANIC COMPOUNDS
METHOD 624 GMS WATERS
1/93

:O POUND (5 ppb, exceptions noted)	>G370 CONC ug/L	>G370 CONC ug/L	>G370 CONC ug/L	>G370 CONC ug/L	>G370 CONC ug/L	>G370 CONC ug/L	>G3709 CONC ug/L	STD DEV	X 3.14 MDL ug/L	MEAN
								====	===	=====
:HLOROMETHANE	3.58	3.73	3.66	3.41	3.39	3.93	3.59	0.1866	0.59	3.61
:R MOMETHANE	3.36	3.14	3.15	3.17	3.40	3.30	3.39	0.1166	0.37	3.27
'IN. .L CHLORIDE	3.40	4.15	3.80	3.45	3.16	3.84	3.52	0.3318	1.04	3.62
:HLOROETHANE	3.04	3.42	2.91	3.23	3.21	3.43	3.10	0.1921	0.60	3.19
ME HYLENE CHLORIDE	3.50	3.22	3.08	3.81	3.90	3.46	3.78	0.3114	0.98	3.54
\C_TONE	3.91	2.57	3.72	4.85	3.75	3.86	3.87	0.6639	2.08	3.79
:ARBON DISULFIDE	3.82	3.56	3.47	3.78	3.43	3.64	3.53	0.1498	0.47	3.60
'R :HLOROFLUOROMETHANE	3.49	3.33	3.32	3.32	3.34	3.53	3.37	0.0873	0.27	3.39
,1· ICHLOROETHENE	3.51	3.55	3.37	3.52	3.59	3.35	3.56	0.0946	0.30	3.49
:ETRAHYDROFURAN	3.79	3.39	3.62	4.59	3.77	3.51	3.57	0.3967	1.25	3.75
,1· ICHLOROETHANE	3.44	3.48	3.31	3.47	3.51	3.68	3.48	0.1092	0.34	3.48
,2· ICHLOROETHENE(cis)	3.38	3.29	3.22	3.19	3.39	3.33	3.24	0.0786	0.25	3.29
,2-DICHLOROETHENE(trans)	3.39	3.27	3.28	3.54	3.42	3.26	3.35	0.1012	0.32	3.36
:H :OROFORM	3.58	3.58	3.50	3.64	3.44	3.49	3.72	0.0962	0.30	3.56
:-B TANONE	3.77	3.63	3.89	4.54	4.35	4.22	4.22	0.3311	1.04	4.09
MTBE	3.72	3.67	3.56	3.87	3.79	3.56	3.60	0.1191	0.37	3.68
,2- ICHLOROETHANE	3.65	3.41	3.42	3.37	3.37	3.43	3.34	0.1034	0.32	3.43
,1, TRICHLOROETHANE	3.06	3.46	3.29	3.25	3.36	3.27	3.25	0.1219	0.38	3.28
:ARBON TETRACHLORIDE	3.44	3.74	3.45	3.51	3.53	3.72	3.38	0.1397	0.44	3.54
VIN YL ACETATE	3.43	3.58	3.66	3.37	3.50	3.27	3.33	0.1397	0.44	3.45
3R MODICHLOROMETHANE	3.44	3.43	3.50	3.53	3.61	3.44	3.46	0.0652	0.20	3.49
,2-DICHLOROPROPANE	3.59	3.49	3.71	3.48	3.46	3.32	3.58	0.1229	0.39	3.52
:IS ,3-DICHLOROPROPENE (4.7 PP	3.19	3.53	3.60	3.15	3.33	3.16	3.10	0.1991	0.63	3.29
TR :HLOROETHENE	3.28	3.56	3.67	3.55	3.45	3.60	3.46	0.1270	0.40	3.51
DIBROMOCHLOROMETHANE	3.44	3.57	3.52	3.57	3.77	3.54	3.61	0.1015	0.32	3.57
1,1 ?-TRICHLOROETHANE	3.44	3.57	3.33	3.71	3.68	3.48	3.67	0.1429	0.45	3.55
BE ZENE	3.15	3.43	3.34	3.32	3.42	3.41	3.40	0.0986	0.31	3.35
TRANS-1,3-DICHLOROPROPENE (5.	3.43	3.54	3.47	3.45	3.53	3.40	3.28	0.0879	0.28	3.44
2-CHLOROETHYLVINYLETHER	2.86	1.45	2.95	3.89	1.46	2.71	3.85	0.9930	3.12	2.74
BF :MOFORM	3.32	3.60	3.53	3.51	3.68	3.47	3.61	0.1168	0.37	3.53
4-METHYL-2-PENTANONE	3.50	2.96	3.40	3.76	3.06	3.12	3.65	0.3088	0.97	3.35
2-HEXANONE	3.52	3.74	3.76	4.25	3.65	3.63	4.01	0.2521	0.79	3.79
TE RACHLOROETHENE	3.38	3.54	3.53	3.67	3.55	3.63	3.47	0.0963	0.30	3.54
1,1,2,2-TETRACHLOROETHANE	3.27	3.72	3.45	3.43	3.42	3.20	3.33	0.1673	0.53	3.40
TOLUENE	3.39	3.23	3.18	3.69	3.58	3.44	3.47	0.1806	0.57	3.43
CH .OROBENZENE	3.48	3.43	3.73	3.42	3.58	3.73	3.73	0.1446	0.45	3.59
ET YLBENZENE	3.57	3.62	3.58	3.53	3.76	3.67	3.49	0.0905	0.28	3.60
STYRENE	3.20	3.31	3.48	3.47	3.33	3.44	3.31	0.1036	0.33	3.36
X ENE (O)	3.56	3.61	3.51	3.69	3.40	3.86	3.36	0.1717	0.54	3.57
X ENE (total) (10 PPB)	6.67	7.08	6.57	7.43	7.20	7.09	6.85	0.3039	0.95	6.98

PACE New England, Inc.
METHOD DETECTION LIMIT VERIFICATION STUDY
VOLATILE ORGANIC COMPOUNDS
METHOD 8240 CMS LOW SOIL
1/93

COMPOUND (5 ppb, exceptions noted)	>C548 CONC ug/Kg	>C548 CONC ug/Kg	>C548 CONC ug/Kg	>C548 CONC ug/Kg	>C548 CONC ug/Kg	>C548 CONC ug/Kg	>C5490 CONC ug/Kg	STD DEV	X 3.14 MDL ug/L	MEAN
								====	===	=====
CHLOROMETHANE	4.20	4.74	4.15	4.45	4.38	4.93	5.21	0.3940	1.24	4.58
BROMOMETHANE	3.93	4.96	4.97	4.85	5.06	5.26	5.27	0.4553	1.43	4.90
VINYL CHLORIDE	4.05	4.99	4.64	4.54	5.12	4.96	5.05	0.3815	1.20	4.76
CHLOROETHANE	4.28	5.24	5.18	4.57	5.49	5.48	5.53	0.4933	1.55	5.11
METHYLENE CHLORIDE	4.21	5.15	5.14	5.26	5.09	5.73	5.21	0.4527	1.42	5.11
ACETONE	3.18	4.36	2.87	3.20	5.20	4.15	5.27	0.9821	3.08	4.03
CARBON DISULFIDE	4.57	3.43	4.74	3.72	3.46	3.73	4.05	0.5212	1.64	3.96
TRICHLOROFLUOROMETHANE	5.17	4.54	5.43	3.75	6.51	4.83	6.76	1.0668	3.35	5.28
1,1-DICHLOROETHENE	4.94	5.31	5.55	5.13	5.87	5.70	5.67	0.3365	1.06	5.45
TETRAHYDROFURAN	3.55	3.91	5.17	4.97	4.68	4.37	3.79	0.6209	1.95	4.35
1,1-DICHLOROETHANE	4.00	5.26	5.23	5.14	5.62	5.66	5.85	0.6110	1.92	5.25
1,2-DICHLOROETHENE(total) (10 PP	8.36	10.25	10.40	10.02	10.29	10.72	11.13	0.8752	2.75	10.17
CHLOROFORM	3.69	5.09	5.01	5.00	5.11	5.53	5.34	0.5952	1.87	4.97
2-BUTANONE	3.53	3.89	5.36	5.03	4.52	4.19	3.90	0.6612	2.08	4.35
1,2-DICHLOROETHANE	3.49	5.28	5.04	4.93	5.07	6.04	5.35	0.7712	2.42	5.03
MTBE	3.83	5.08	4.93	5.07	4.64	5.72	5.19	0.5813	1.83	4.92
1,1,1-TRICHLOROETHANE	4.00	5.03	4.34	4.73	5.24	5.32	5.35	0.5247	1.65	4.86
CARBON TETRACHLORIDE	4.03	4.95	4.39	4.29	4.72	5.02	4.94	0.3854	1.21	4.62
VINYL ACETATE	5.04	5.15	5.55	5.33	5.12	3.73	5.13	0.5887	1.85	5.01
BROMODICHLOROMETHANE	3.92	5.31	5.27	4.89	5.01	5.64	5.23	0.5477	1.72	5.04
1,2-DICHLOROPROPANE	3.77	5.20	5.35	5.01	4.99	5.68	5.15	0.5996	1.88	5.02
CIS-1,3-DICHLOROPROPENE (4.7 PP	4.10	5.11	5.26	4.96	5.08	5.59	5.20	0.4606	1.45	5.04
TRICHLOROETHENE	4.27	4.98	4.75	4.38	4.70	5.49	4.87	0.4041	1.27	4.78
DIBROMOCHLOROMETHANE	4.40	5.24	5.17	4.85	4.72	5.47	5.05	0.3581	1.12	4.99
1,1,2-TRICHLOROETHANE	4.51	5.71	5.52	5.48	5.51	6.09	5.62	0.4808	1.51	5.49
BENZENE	4.03	5.09	4.97	4.90	5.02	5.46	5.28	0.4549	1.43	4.96
TRANS-1,3-DICHLOROPROPENE (5.	4.01	5.61	5.73	5.32	5.40	6.03	5.47	0.6437	2.02	5.37
2-CHLOROETHYLVINYLETHER	3.91	5.21	5.27	4.95	4.65	5.73	4.90	0.5704	1.79	4.95
BROMOFORM	5.47	5.29	5.13	4.96	4.70	5.25	4.77	0.2836	0.89	5.08
4-METHYL-2-PENTANONE	4.23	4.99	5.44	5.21	4.95	5.59	4.26	0.5344	1.68	4.95
2-HEXANONE	4.87	4.16	5.29	5.05	4.91	5.50	3.80	0.6082	1.91	4.80
TETRACHLOROETHENE	4.02	4.79	4.34	4.31	4.51	4.63	4.64	0.2592	0.81	4.46
1,1,2,2-TETRACHLOROETHANE	6.11	4.93	5.24	4.92	4.77	4.92	4.69	0.4845	1.52	5.08
TOLUENE	4.09	5.22	4.99	4.86	4.83	5.20	5.16	0.3938	1.24	4.91
CHLOROBENZENE	3.99	5.22	5.04	4.80	4.76	5.24	5.02	0.4286	1.35	4.87
ETHYLBENZENE	3.84	5.21	4.88	4.91	5.06	5.37	5.19	0.5078	1.59	4.92
STYRENE	3.99	5.14	5.16	4.65	5.03	5.50	5.27	0.5003	1.57	4.96
XYLENE	3.91	5.31	5.04	5.22	5.20	5.55	5.42	0.5466	1.72	5.09
XYLENE (total) (10 PPB)	7.94	10.83	10.31	10.23	10.36	11.01	11.12	1.0819	3.40	10.26

PACE New England, Inc.
METHOD DETECTION LIMIT VERIFICATION STUDY
VOLATILE ORGANIC COMPOUNDS
METHOD 8240 DMS LOW SOIL - packed column
1/93

OMPOUND (10 ppb, exceptions noted	>D387 CONC ug/Kg	>D387 CONC ug/Kg	>D387 CONC ug/Kg	>D387 CONC ug/Kg	>D387 CONC ug/Kg	>D387 CONC ug/Kg	>D3876 CONC ug/Kg	STD DEV ====	X 3.14 MDL ug/L ===	MEAN =====
HLOROMETHANE	8.62	9.19	8.27	8.50	8.48	8.53	8.26	0.3122	0.98	8.55
ROMOMETHANE	9.08	8.65	8.39	8.55	8.34	8.12	8.56	0.3005	0.94	8.53
VINYL CHLORIDE	9.09	9.04	8.89	8.18	8.30	8.43	8.13	0.4146	1.30	8.58
HLOROETHANE	8.14	7.84	7.89	8.12	7.07	7.87	7.81	0.3566	1.12	7.82
ETHYLENE CHLORIDE	8.66	8.54	8.27	8.42	8.23	7.86	8.39	0.2578	0.81	8.34
ACETONE	6.63	5.05	6.18	6.29	5.73	6.59	5.41	0.6032	1.89	5.98
ARBON DISULFIDE	8.45	8.99	7.67	8.17	8.55	8.16	8.50	0.4108	1.29	8.36
RICHLOROFLUOROMETHANE	9.25	9.53	7.97	8.36	8.68	8.93	8.94	0.5273	1.66	8.81
1,1-DICHLOROETHENE	9.97	10.58	9.49	9.72	9.06	9.47	9.46	0.4845	1.52	9.68
ETRAHYDROFURAN	9.57	9.19	9.02	5.21	4.60	8.60	8.49	2.0255	6.36	7.81
1-DICHLOROETHANE	9.09	9.09	8.36	8.47	8.22	8.43	8.56	0.3487	1.09	8.60
1,2-DICHLOROETHENE(total) (20 PP	17.71	17.62	15.69	16.33	15.63	15.85	16.38	0.8742	2.74	16.46
HLOROFORM	9.25	9.40	9.17	9.07	8.93	8.83	8.80	0.2240	0.70	9.06
BUTANONE	9.84	8.33	6.97	7.67	6.61	8.30	6.07	1.2724	4.00	7.68
1,2-DICHLOROETHANE	9.71	9.76	9.34	9.30	9.54	9.10	9.00	0.2911	0.91	9.39
MTBE	9.30	9.95	9.56	9.42	9.41	9.20	9.35	0.2447	0.77	9.46
1,1-TRICHLOROETHANE	9.70	10.25	9.62	10.11	9.09	8.97	9.23	0.4965	1.56	9.57
CARBON TETRACHLORIDE	9.82	9.95	9.41	10.17	9.27	8.88	9.53	0.4397	1.38	9.58
VINYL ACETATE	10.22	11.25	9.73	9.65	9.32	9.75	9.26	0.6810	2.14	9.88
ROMODICHLOROMETHANE	10.21	10.39	10.02	10.29	9.56	9.51	9.55	0.3841	1.21	9.93
1,2-DICHLOROPROPANE	10.29	10.56	10.34	10.85	9.64	9.63	10.17	0.4506	1.41	10.21
CIS-1,3-DICHLOROPROPENE (9.6 PP	9.49	9.65	8.97	9.78	8.84	8.80	8.56	0.4763	1.50	9.16
RICHLOROETHENE	9.43	9.39	9.13	10.06	8.91	8.52	9.10	0.4808	1.51	9.22
DIBROMOCHLOROMETHANE	10.22	10.90	10.71	10.67	10.31	9.42	9.76	0.5379	1.69	10.28
1,1,2-TRICHLOROETHANE	10.16	11.14	10.39	10.88	9.90	9.81	10.03	0.5060	1.59	10.33
ENZENE	9.97	10.38	9.86	10.15	9.38	9.23	9.86	0.4059	1.27	9.83
TRANS-1,3-DICHLOROPROPENE (1	10.80	10.86	10.36	10.98	10.42	10.00	10.00	0.4031	1.27	10.49
2-CHLOROETHYLVINYLETHER	10.57	11.35	7.44	10.78	10.59	10.62	10.81	1.2930	4.06	10.31
ROMOFORM	10.80	11.61	10.60	10.55	10.09	9.73	10.70	0.5899	1.85	10.58
METHYL-2-PENTANONE	12.84	11.61	10.56	10.15	9.75	11.29	9.46	1.1857	3.72	10.81
2-HEXANONE	11.69	10.40	8.42	9.29	7.77	10.47	7.86	1.4938	4.69	9.41
ETRACHLOROETHENE	10.15	10.24	9.90	10.11	9.42	9.71	9.77	0.2903	0.91	9.90
1,2,2-TETRACHLOROETHANE	12.30	11.87	11.42	10.81	10.30	10.96	9.97	0.8322	2.61	11.09
TOLUENE	10.06	10.21	10.04	10.08	9.93	9.63	10.07	0.1836	0.58	10.00
HLOROBENZENE	10.86	10.68	10.35	10.36	9.98	10.15	9.99	0.3353	1.05	10.34
THYLBENZENE	10.73	10.47	10.67	10.56	9.91	9.44	10.12	0.4720	1.48	10.27
STYRENE	10.58	11.14	10.51	10.50	10.17	9.92	10.23	0.3885	1.22	10.44
YLENE	10.18	10.20	10.37	9.92	9.81	9.32	9.40	0.4047	1.27	9.89
YLENE (total) (20 PPB)	20.40	21.28	19.81	20.93	20.03	19.23	19.62	0.7299	2.29	20.19

PACE NEW ENGLAND, INC
METHOD DETECTION LIMIT VERIFICATION STUDY
VOLATILE ORGANIC COMPOUNDS
METHOD 8240 DMS MEGABORE LOW SOIL
3/93

COMPOUND (5 ppb, exceptions noted)	>D4708 CONC. ug/Kg	>D4707 CONC. ug/Kg	>D4702 CONC. ug/Kg	>D4705 CONC. ug/Kg	>D4703 CONC. ug/Kg	>D4713 CONC. ug/Kg	>D4714 CONC. ug/Kg	STD DEV	X 3.14 MDL ug/L	MEAN
CHLOROMETHANE	3.95	3.7	5.31	3.95	4.73	3.47	3.58	0.6749	2.12	4.10
BROMOMETHANE	2.14	3.62	5.29	5.45	4.65	3.15	4.55	1.2052	3.78	4.12
VINYL CHLORIDE	3.67	2.57	4.45	2.15	3.9	3.54	4.07	0.8269	2.60	3.48
CHLOROETHANE	5.61	5.33	6.58	4.64	3.23	4.32	5.12	1.0577	3.32	4.98
METHYLENE CHLORIDE	7.06	6.98	5.52	5.52	5.33	7.06	7.49	0.9207	2.89	6.42
ACETONE	7.16	6.19	5.88	5.11	5.31	6.85	6.44	0.7587	2.38	6.13
CARBON DISULFIDE	8.88	6.69	5.35	5.25	3.87	6.04	7.09	1.5962	5.01	6.17
TRICHLOROFLUOROMETHANE	3.75	3.87	5.23	4.08	5.02	4.28	3.9	0.5887	1.85	4.30
1,1-DICHLOROETHENE	4.84	4.56	5.58	5.34	4.82	4.53	5.32	0.4137	1.30	5.00
TETRAHYDROFURAN	14.35	11.07	17.11	11.23	10.22	12.15	6.11	3.4286	10.77	11.75
1,1-DICHLOROETHANE	4.72	4.66	5.14	4.89	4.94	4.6	4.49	0.2243	0.70	4.78
1,2-DICHLOROETHENE(cis)	4.94	4.61	5.16	5.01	4.93	4.8	5	0.1747	0.55	4.92
1,2-DICHLOROETHENE(trans)	4.72	4.52	4.32	5.6	5.24	5.49	5.62	0.5441	1.71	5.07
CHLOROFORM	4.85	4.88	5.08	5.2	5.09	4.72	4.65	0.2050	0.64	4.92
2-BUTANONE	6.74	5.87	4.81	4.14	4.19	5.82	5.15	0.9564	3.00	5.25
1,2-DICHLOROETHANE	4.95	5.13	5.02	4.93	4.86	4.58	4.78	0.1774	0.56	4.89
MTBE	5.82	5.43	4.97	5.26	5.06	5.4	5.47	0.2830	0.89	5.34
1,1,1-TRICHLOROETHANE	4.67	4.73	4.86	4.73	4.87	4.9	4.94	0.1028	0.32	4.81
CARBON TETRACHLORIDE	4.89	4.92	4.84	4.76	4.96	4.82	5.17	0.1330	0.42	4.91
VINYL ACETATE	5.17	4.96	4.45	4.38	4.25	4.79	3.39	0.5851	1.84	4.48
BROMODICHLOROMETHANE	4.96	4.91	4.91	5.08	4.92	5	4.89	0.0673	0.21	4.95
1,2-DICHLOROPROPANE	4.88	5.16	4.96	4.87	4.94	5.27	4.58	0.2217	0.70	4.95
CIS-1,3-DICHLOROPROPENE (4.7 ppb)	4.75	5.03	4.81	5.21	5.07	4.66	4.38	0.2825	0.89	4.84
TRICHLOROETHENE	4.61	4.79	4.62	4.62	4.67	4.83	4.59	0.0955	0.30	4.68
DIBROMOCHLOROMETHANE	5.06	5.35	4.86	5.2	5	5.16	4.89	0.1755	0.55	5.07
1,1,2-TRICHLOROETHANE	5.08	5.44	5.09	4.83	5.23	4.99	5.08	0.1907	0.60	5.11
BENZENE	4.96	4.94	4.75	4.92	4.85	4.7	5	0.1125	0.35	4.87
TRANS-1,3-DICHLOROPROPENE (5.3 ppb)	4.75	4.84	5.03	4.85	4.85	4.64	4.66	0.1336	0.42	4.80
2-CHLOROETHYLVINYLETHER	5.96	5.19	4.81	4.89	4.92	4.31	4.92	0.4991	1.57	5.00
BROMOFORM	5.59	5.82	4.54	5	4.93	5.51	4.87	0.4632	1.45	5.18
4-METHYL-2-PENTANONE	6.4	5.97	4.59	4.27	4.44	5.69	5.36	0.8265	2.60	5.25
2-HEXANONE	6.9	5.8	3.95	3.34	4.1	4.99	5.08	1.2127	3.81	4.88
TETRACHLOROETHENE	4.63	5.05	4.84	4.82	4.89	4.72	5.7	0.3560	1.12	4.95
1,1,2,2-TETRACHLOROETHANE	5.86	5.38	4.44	4.41	4.56	4.98	5.18	0.5427	1.70	4.97
TOLUENE	4.96	4.84	4.85	5.01	5.26	4.76	5.2	0.1884	0.59	4.98
CHLOROBENZENE	4.97	5.09	4.98	5.1	5.03	4.7	5.31	0.1834	0.58	5.03
ETHYLBENZENE	5.15	4.65	5.54	5.1	4.99	4.52	4.99	0.3358	1.05	4.99
STYRENE	4.7	4.57	4.8	4.72	4.79	4.27	4.73	0.1855	0.58	4.65
XYLENE(O)	5.09	4.86	5.05	4.88	4.6	4.8	4.93	0.1635	0.51	4.89
XYLENE (total) (10 ppb)	10.2	9.73	10.2	9.99	10.44	9.27	10.33	0.4051	1.27	10.02

PACE New England, Inc.
METHOD DETECTION LIMIT VERIFICATION STUDY
VOLATILE ORGANIC COMPOUNDS
METHOD 8240 GMS LOW SOIL
1/93

COMPOUND (5 ppb, exceptions noted)	>G372 CONC ug/Kg	>G372 CONC ug/Kg	>G373 CONC ug/Kg	>G373 CONC ug/Kg	>G373 CONC ug/Kg	>G373 CONC ug/Kg	>G3735 CONC ug/Kg	STD DEV
								====
CHLOROMETHANE	4.80	4.14	3.87	4.28	4.40	5.04	5.07	
BROMOMETHANE	4.15	4.52	4.14	4.21	4.07	4.23	4.58	
VINYL CHLORIDE	4.32	3.50	3.92	3.98	3.76	4.51	4.97	
CHLOROETHANE	5.00	4.52	4.31	4.07	3.62	4.28	4.15	
METHYLENE CHLORIDE	5.06	5.51	5.72	5.21	5.55	5.42	5.37	
ACETONE	6.56	5.42	9.01	6.71	8.23	4.99	4.19	
CARBON DISULFIDE	4.25	3.83	4.25	4.52	4.40	4.44	4.67	
TRICHLOROFLUOROMETHANE	4.59	4.17	4.39	4.19	4.05	4.45	4.41	
1,1-DICHLOROETHENE	4.21	3.99	4.26	3.76	3.91	4.13	4.21	
TETRAHYDROFURAN	5.66	6.24	5.88	4.29	5.53	5.73	4.89	
,1-DICHLOROETHANE	4.74	4.43	4.35	4.39	4.54	4.58	4.75	
1,2-DICHLOROETHENE(cis)	4.56	4.44	4.40	4.42	4.24	4.44	4.47	
,2-DICHLOROETHENE(trans)	4.64	4.55	4.83	4.27	4.76	4.90	4.45	
CHLOROFORM	4.33	4.31	4.63	4.28	4.35	4.17	4.27	
2-BUTANONE	4.56	5.94	5.41	5.29	5.38	4.82	4.62	
MTBE	4.53	4.95	4.80	4.77	4.66	4.40	4.37	
,2-DICHLOROETHANE	4.33	4.46	4.54	4.55	4.43	4.20	4.38	
1,1,1-TRICHLOROETHANE	4.60	4.23	4.26	4.43	4.24	4.07	4.04	
CARBON TETRACHLORIDE	4.45	4.19	4.27	4.10	4.33	4.26	4.39	
VINYL ACETATE	4.06	4.66	5.11	4.77	4.35	4.52	4.49	
BROMODICHLOROMETHANE	4.98	4.64	4.65	4.50	4.24	4.36	4.40	
,2-DICHLOROPROPANE	5.11	5.83	4.84	4.65	4.72	4.52	4.82	
CIS-1,3-DICHLOROPROPENE (4.3 ppb	4.08	4.25	3.98	3.79	4.04	3.81	3.81	
TRICHLOROETHENE	4.34	4.12	4.33	4.26	3.83	3.98	4.45	
DIBROMOCHLOROMETHANE	4.54	4.45	4.53	4.37	4.30	4.35	4.25	
,1,2-TRICHLOROETHANE	4.65	4.85	5.28	4.84	4.48	4.19	4.44	
BENZENE	4.60	4.55	4.53	4.26	4.35	4.13	4.47	
TRANS-1,3-DICHLOROPROPENE (5.	4.91	4.67	4.97	4.65	4.77	4.44	4.37	
-CHLOROETHYLVINYLETHER	5.07	4.81	4.71	4.26	5.72	3.05	3.33	
BROMOFORM	4.33	4.77	4.57	4.33	4.44	3.89	3.99	
TOLUENE-d8	5.05	4.82	4.93	4.75	4.93	4.96	4.89	
-METHYL-2-PENTANONE	4.52	5.01	5.27	4.62	4.89	4.03	3.98	
2-HEXANONE	4.79	5.79	5.52	4.53	5.16	4.11	4.22	
TETRACHLOROETHENE	4.52	4.02	4.51	4.09	4.25	4.23	4.07	
,1,2,2-TETRACHLOROETHANE	4.87	5.00	5.34	4.51	4.86	4.42	4.41	
TOLUENE	4.72	4.50	4.83	4.43	4.71	4.63	4.71	
CHLOROBENZENE	4.75	4.30	4.24	4.12	4.26	4.25	4.07	
ETHYLBENZENE	4.69	4.41	4.47	4.27	4.05	4.22	4.03	
STYRENE	4.51	4.26	4.15	4.02	4.07	4.16	4.29	
XYLENE (O)	4.75	4.17	4.51	4.04	4.31	4.25	4.17	
XYLENE (total) (10 ppb)	8.80	8.31	8.52	7.30	8.24	8.24	8.14	

PACE New England, Inc.
METHOD DETECTION LIMIT VERIFICATION STUDY
VOLATILE ORGANIC COMPOUNDS
METHOD 8260 DMS LOW WATERS
1/93

COMPOUND (5 ppb, exceptions noted)	>D6909 CONC. ug/L	>D6910 CONC. ug/L	>D6911 CONC. ug/L	>D6912 CONC. ug/L	>D6913 CONC. ug/L	>D6914 CONC. ug/L	>D6916 CONC. ug/L	STD DEV	X 3.14 MDL ug/L	MEAN
CHLOROMETHANE	5.30	4.69	5.05	4.66	5.29	5.50	5.41	0.3393	1.07	5.13
BROMOMETHANE	5.13	5.06	4.90	4.60	5.14	5.29	5.09	0.2221	0.70	5.03
VINYL CHLORIDE	5.05	4.91	4.74	4.54	5.09	5.34	5.13	0.2660	0.84	4.97
CHLOROETHANE	5.15	4.82	5.19	4.72	5.35	5.26	5.32	0.2477	0.78	5.12
METHYLENE CHLORIDE	5.22	5.23	5.28	4.96	5.47	5.63	5.61	0.2410	0.76	5.34
ACETONE	4.68	6.25	5.05	5.81	4.40	4.76	4.90	0.6643	2.09	5.12
CARBON DISULFIDE	5.08	4.99	5.07	4.70	5.44	5.39	5.42	0.2750	0.86	5.16
TRICHLOROFLUOROMETHANE	5.21	4.84	5.22	4.48	4.94	5.51	5.10	0.3290	1.03	5.04
1,1-DICHLOROETHENE	5.04	5.05	4.97	4.81	5.19	5.23	5.17	0.1465	0.46	5.07
TETRAHYDROFURAN	6.02	6.54	6.51	6.36	6.61	5.73	5.03	0.5739	1.80	6.11
1,1-DICHLOROETHANE	5.11	5.01	5.02	4.84	5.34	5.34	5.31	0.1963	0.62	5.14
1,2-DICHLOROETHENE(cis)	5.12	5.01	5.02	4.81	5.22	5.24	5.09	0.1460	0.46	5.07
1,2-DICHLOROETHENE(trans)	5.07	4.88	4.94	4.74	5.30	5.38	5.21	0.2347	0.74	5.07
CHLOROFORM	5.20	5.18	5.02	4.85	5.40	5.45	5.31	0.2121	0.67	5.20
2-BUTANONE	5.13	5.68	4.99	5.46	5.21	5.00	4.41	0.4026	1.26	5.13
1,2-DICHLOROETHANE	5.22	5.51	5.08	5.27	5.43	5.42	5.19	0.1545	0.48	5.30
MTBE	5.11	5.46	5.01	5.12	5.20	5.11	4.84	0.1883	0.59	5.12
1,1,1-TRICHLOROETHANE	4.98	5.04	5.14	4.99	5.08	5.20	5.18	0.0888	0.28	5.09
CARBON TETRACHLORIDE	4.96	5.01	5.06	4.83	5.08	5.15	5.10	0.1064	0.33	5.03
VINYL ACETATE	4.98	5.75	5.45	5.93	5.58	5.61	4.90	0.3843	1.21	5.46
BROMODICHLOROMETHANE	5.10	5.34	5.27	5.51	5.27	5.39	5.10	0.1492	0.47	5.28
1,2-DICHLOROPROPANE	5.04	5.33	5.22	5.37	5.24	5.45	5.19	0.1344	0.42	5.26
CIS-1,3-DICHLOROPROPENE	5.05	5.23	5.10	5.29	5.16	5.16	4.92	0.1217	0.38	5.13
TRICHLOROETHENE	4.83	4.91	4.92	4.77	5.00	4.89	4.89	0.0723	0.23	4.89
DIBROMOCHLOROMETHANE	5.02	5.48	5.11	5.69	5.13	5.29	4.81	0.2949	0.93	5.22
1,1,2-TRICHLOROETHANE	4.98	5.5	5.10	5.60	5.18	5.14	4.86	0.2670	0.84	5.19
BENZENE	4.97	5.08	5.07	5.05	5.21	5.29	5.09	0.1068	0.34	5.11
TRANS-1,3-DICHLOROPROPENE	5.10	5.44	5.26	5.61	5.18	5.19	4.80	0.2566	0.81	5.23
2-CHLOROETHYLVINYLETHER	4.88	5.37	4.85	5.59	4.97	4.66	4.39	0.4079	1.28	4.96
BROMOFORM	4.85	5.57	5.16	5.83	4.93	5.04	4.73	0.4011	1.26	5.16
4-METHYL-2-PENTANONE	4.78	5.52	4.91	5.75	4.96	4.82	4.48	0.4448	1.40	5.03
2-HEXANONE	4.50	5.43	5.04	5.58	4.94	4.57	4.30	0.4818	1.51	4.91
TETRACHLOROETHENE	4.85	4.74	4.88	4.69	4.91	4.83	4.93	0.0885	0.28	4.83
1,1,2,2-TETRACHLOROETHANE	4.78	5.46	5.00	5.53	4.94	4.96	4.58	0.3449	1.08	5.04
TOLUENE	4.74	4.77	4.88	4.77	4.98	5.02	5.05	0.1303	0.41	4.89
CHLOROBENZENE	4.59	4.82	4.68	4.82	4.89	4.91	4.83	0.1154	0.36	4.79
ETHYLBENZENE	4.84	4.86	4.88	4.83	5.03	5.08	5.03	0.1063	0.33	4.94
STYRENE	4.75	5.02	4.89	5.00	5.00	4.85	4.82	0.1047	0.33	4.90
XYLENE(O)	4.74	4.75	4.74	4.77	4.91	5.00	4.85	0.1013	0.32	4.82
XYLENE (total)	9.68	9.73	9.75	9.66	10.07	10.16	10.05	0.2124	0.67	9.87

PACE New England, Inc.
METHOD DETECTION LIMIT VERIFICATION STUDY
VOLATILE ORGANIC COMPOUNDS
METHOD 8260 GMS LOW WATERS
1/93

COMPOUND (5 ppb, exceptions noted)	>G388 CONC ug/L	>G388 CONC ug/L	>G388 CONC ug/L	>G388 CONC ug/L	>G388 CONC ug/L	>G388 CONC ug/L	>G3886 CONC ug/L	STD DEV	X 3.14 MDL ug/L	MEAN
								====	===	=====
HLOROMETHANE	4.82	4.53	4.57	4.49	4.74	4.50	4.75	0.1370	0.43	4.63
ROMOMETHANE	5.05	4.95	4.58	4.84	4.73	4.72	4.92	0.1610	0.51	4.83
VINYL CHLORIDE	5.09	5.02	4.79	5.00	5.08	4.92	5.08	0.1093	0.34	5.00
HLOROETHANE	4.99	4.60	4.71	4.90	4.89	4.63	4.99	0.1661	0.52	4.82
ETHYLENE CHLORIDE	4.96	5.05	4.59	4.98	4.97	4.91	4.49	0.2176	0.68	4.85
ACETONE	5.95	5.13	5.20	7.41	6.07	6.05	5.31	0.7917	2.49	5.87
ARBON DISULFIDE	4.82	4.47	4.49	4.61	4.72	4.45	4.67	0.1409	0.44	4.60
RICHLOROFLUOROMETHANE	5.03	4.81	4.56	4.77	4.83	4.66	4.81	0.1470	0.46	4.78
1,1-DICHLOROETHENE	5.25	4.94	4.88	5.06	5.27	5.15	5.05	0.1475	0.46	5.09
ETRAHYDROFURAN	5.13	5.05	3.96	6.34	4.91	4.53	5.06	0.7222	2.27	5.00
1-DICHLOROETHANE	5.17	4.88	4.86	4.94	4.93	4.81	5.03	0.1209	0.38	4.95
1,2-DICHLOROETHENE(cis)	4.85	4.76	4.65	4.91	4.85	4.89	4.95	0.1018	0.32	4.84
2-DICHLOROETHENE(trans)	5.08	4.70	4.88	4.73	4.98	4.87	5.01	0.1419	0.45	4.89
HLOROFORM	5.17	4.87	4.77	5.03	5.16	4.96	4.90	0.1494	0.47	4.98
2-BUTANONE	5.81	6.59	5.61	7.19	6.79	6.67	5.81	0.6041	1.90	6.35
TBE	4.90	4.75	4.78	4.92	5.36	4.94	4.78	0.2092	0.66	4.92
-DICHLOROETHANE	5.08	4.85	4.79	5.06	5.05	4.85	4.77	0.1362	0.43	4.92
1,1,1-TRICHLOROETHANE	5.01	4.93	4.68	4.81	4.94	4.95	4.86	0.1104	0.35	4.88
ARBON TETRACHLORIDE	5.01	4.84	4.55	4.83	4.94	4.75	4.82	0.1465	0.46	4.82
NYL ACETATE	4.85	4.81	4.46	5.03	4.90	4.52	4.84	0.2065	0.65	4.77
BROMODICHLOROMETHANE	5.15	4.81	4.74	4.84	5.04	4.82	4.89	0.1448	0.45	4.90
2-DICHLOROPROPANE	4.87	4.96	4.79	4.92	4.98	5.20	5.12	0.1415	0.44	4.98
S-1,3-DICHLOROPROPENE (4.5 PP	4.39	4.25	4.13	4.24	4.35	4.37	4.34	0.0931	0.29	4.30
TRICHLOROETHENE	4.98	4.78	4.83	4.92	5.09	4.93	5.07	0.1148	0.36	4.94
DIBROMOCHLOROMETHANE	5.13	4.94	4.77	5.18	5.18	5.27	5.14	0.1720	0.54	5.09
,2-TRICHLOROETHANE	4.98	4.79	4.79	5.43	5.22	5.44	5.38	0.2911	0.91	5.15
BENZENE	4.84	4.86	4.79	4.97	5.05	4.99	4.88	0.0934	0.29	4.91
TRANS-1,3-DICHLOROPROPENE (5.	5.44	5.30	4.99	5.26	5.52	5.26	5.20	0.1707	0.54	5.28
CHLOROETHYLVINYLETHER	4.25	4.07	3.94	3.40	3.51	4.20	4.05	0.3331	1.05	3.92
BROMOFORM	5.21	4.85	4.90	5.22	5.73	5.31	5.09	0.2935	0.92	5.19
CHLOROBENZENE-d5	10.00	10.00	10.00	10.00	10.00	10.00	10.00	0.0000	0.00	10.00
OLUENE-d8	24.91	24.50	25.24	23.92	24.97	24.41	23.80	0.5419	1.70	24.54
-METHYL-2-PENTANONE	4.89	4.67	4.30	4.40	4.56	4.72	4.27	0.2317	0.73	4.54
2-HEXANONE	4.38	4.42	4.45	4.27	4.83	4.47	4.55	0.1761	0.55	4.48
ETRACHLOROETHENE	5.11	4.94	5.24	4.98	5.30	5.26	5.25	0.1456	0.46	5.15
,2,2-TETRACHLOROETHANE	4.71	4.79	4.77	5.00	4.42	4.99	4.92	0.2017	0.63	4.80
TOLUENE	4.94	4.67	4.96	4.80	4.75	4.90	4.87	0.1061	0.33	4.84
HLOROBENZENE	4.89	4.57	4.76	4.66	4.88	4.93	4.75	0.1319	0.41	4.78
THYLBENZENE	5.16	4.80	5.00	4.92	5.27	5.16	4.92	0.1680	0.53	5.03
STYRENE	4.95	4.79	4.97	4.78	4.93	4.85	4.88	0.0758	0.24	4.88
YLENE (O)	4.99	4.76	5.05	4.92	5.08	5.06	4.95	0.1110	0.35	4.97
YLENE (total) (10 PPB)	9.31	9.16	9.08	9.04	9.44	9.35	9.60	0.2024	0.64	9.28

PACE, INC.

METHOD 601
DETECTION LIMIT STUDY
ON THE WATERS GC
DEC 17 1992 LMH

COMPOUND	AVG	SD	DET LIM	CONCENTRATION (PPB)						
DICHLORODIFLUOROMETHANE	6.17	0.78	2.45	5.65	7.57	7.09	5.26	6.04	5.86	5.69
CHLOROMETHANE	5.98	0.52	1.65	6.19	6.27	6.96	5.42	5.86	5.92	5.27
VINYL CHLORIDE	5.70	0.32	1.02	5.87	5.80	6.16	5.04	5.86	5.65	5.55
BROMOMETHANE	5.42	0.48	1.50	5.24	5.68	5.75	4.33	5.63	5.79	5.55
CHLOROETHANE	5.75	0.52	1.64	6.75	5.31	6.24	5.19	5.79	5.56	5.39
TRICHLOROFLUOROMETHANE	5.53	0.34	1.08	5.63	5.31	5.90	4.82	5.86	5.52	5.65
1,1-DICHLOROETHENE	5.31	0.31	0.98	5.24	4.95	5.46	4.87	5.73	5.24	5.70
METHYLENE CHLORIDE	8.38	0.80	2.50	8.85	7.17	9.36	8.72	8.98	9.15	9.96
TRANS-1,2-DICHLOROETHENE	5.57	0.30	0.95	5.31	5.03	5.49	5.66	5.82	5.69	6.01
1,1-DICHLOROETHANE	5.43	0.24	0.76	5.51	5.15	5.18	5.54	5.81	5.78	5.41
CHLOROFORM	5.56	0.21	0.67	5.85	5.44	5.28	5.78	5.29	5.69	5.59
1,1,1-TRICHLOROETHANE	8.44	0.25	0.79	8.52	8.12	8.52	8.88	8.18	8.63	8.26
CARBON TETRACHLORIDE	6.12	0.39	1.23	6.63	5.72	6.07	6.68	6.29	5.76	5.70
1,2-DICHLOROETHANE	6.22	0.18	0.58	6.19	6.09	6.31	6.35	6.47	5.86	6.25
TRICHLOROETHENE	5.53	0.31	0.98	5.38	5.42	5.60	5.88	5.95	4.94	5.52
1,2-DICHLOROPROPANE	5.65	0.24	0.75	5.78	5.50	5.77	5.60	5.99	5.18	5.72
BROMODICHLOROMETHANE	5.67	0.37	1.16	5.64	5.61	5.91	5.73	5.98	4.83	5.97
2-CHLOROETHYLVINYLETHER	9.49	0.87	2.72	9.01	8.67	9.94	9.55	11.00	8.24	10.04
CIS-1,3-DICHLOROPROPENE	5.99	0.44	1.37	6.42	5.37	6.33	5.84	6.35	5.35	6.27
TRANS-1,3-DICHLOROPROPENE	5.79	0.34	1.08	6.13	5.71	6.13	5.55	6.14	5.15	5.75
1,1,2-TRICHLOROETHANE	5.42	0.37	1.15	5.51	5.14	5.53	5.21	5.89	4.81	5.87
TETRACHLOROETHANE	4.97	0.45	1.41	5.29	4.26	5.22	4.76	5.67	4.52	5.08
DIBROMOCHLOROMETHANE	4.89	0.32	1.01	5.03	4.71	5.04	4.33	5.00	4.68	5.42
CHLOROBENZENE	4.90	0.47	1.48	4.59	4.72	4.60	4.68	5.87	4.52	5.34
BROMOFORM	4.40	0.31	0.97	4.20	4.39	4.44	4.32	5.12	4.17	4.19
1,1,2,2-TETRACHLOROETHANE	5.77	0.24	0.77	6.10	5.53	5.83	5.69	5.46	5.67	6.14
1,3-DICHLOROBENZENE	4.92	0.32	0.99	5.44	4.42	5.12	5.02	5.00	4.57	4.87
1,4-DICHLOROBENZENE	4.69	0.23	0.72	5.05	4.40	4.99	4.63	4.59	4.47	4.67
1,2-DICHLOROBENZENE	4.94	0.17	0.53	5.00	4.79	4.99	4.89	5.00	4.67	5.24

PACE, INC.

METHOD 602

DETECTION LIMIT STUDY ON THE TRACOR GC

STABILWAX COLUMN

FEBRUARY 10 1993 LMH 5PPB STANDARD

COMPOUND	Concentration (ppb)							AVG	SD	DET LIM
MTBE	2.25	2.22	2.34	2.04	2.39	2.45	2.40	2.30	0.13	0.41
BENZENE	2.38	2.42	2.45	2.35	2.46	2.51	2.39	2.42	0.05	0.16
LUENE	2.12	2.06	2.17	2.10	2.11	2.21	2.28	2.15	0.07	0.22
-BENZENE	2.12	2.16	2.11	2.07	2.20	1.98	2.10	2.11	0.06	0.20
P-XYLENE	2.43	2.47	2.38	2.37	2.52	2.22	2.36	2.39	0.09	0.23
XYLENE	2.36	2.49	2.34	2.30	2.49	2.28	2.37	2.38	0.08	0.24
XYLENE	2.16	2.17	2.13	2.06	2.28	2.02	2.26	2.15	0.09	0.28

PACE NEW ENGLAND, INC.
METHOD DETECTION LIMIT VERIFICATION STUDY
SEMIVOLATILE ORGANIC COMPOUNDS
HMS 3/93 method 625 LMA 3/31/93

OMPOUND (20 PPB)	>H9650 (UG/L)	>H9651 (UG/L)	>H9652 (UG/L)	>H9653 (UG/L)	>H9654 (UG/L)	>H9655 (UG/L)	>H9656 (UG/L)	STD DEV	X 3.14 MDL UG/L	MEAN
,4-DICHLOROBENZENE-d4	40.00	40.00	40.00	40.00	40.00	40.00	40.00	0.0000	0.00	40.00
-NITROSODIMETHYLAMINE	20.00	21.20	20.92	20.05	20.73	20.73	20.06	0.4853	1.52	20.53
-FLUOROPHENOL	16.65	17.53	17.81	17.42	17.35	18.12	17.52	0.4531	1.42	17.49
HENOL-d5	17.40	17.95	18.58	17.39	17.94	18.29	17.86	0.4337	1.36	17.92
-CHLOROPHENOL-d4	17.48	18.16	18.50	17.99	18.04	18.81	18.44	0.4300	1.35	18.20
,2-DICHLOROBENZENE-d4	17.40	18.13	18.09	17.40	17.53	18.77	18.10	0.5034	1.58	17.92
HENOL	17.07	17.32	18.11	17.45	17.79	18.11	17.96	0.4112	1.29	17.69
NILINE	17.50	17.86	19.02	18.27	18.12	18.13	18.32	0.4662	1.46	18.17
IS(2-CHLOROETHYL)ETHER	16.55	17.31	17.37	17.09	17.31	17.61	17.58	0.3594	1.13	17.26
-CHLOROPHENOL	17.42	18.04	18.32	17.91	17.98	18.22	18.20	0.2989	0.94	18.01
,3-DICHLOROBENZENE	16.62	17.52	17.47	17.08	17.32	18.16	17.40	0.4666	1.47	17.37
,4-DICHLOROBENZENE	16.49	17.76	17.61	17.35	17.42	18.40	18.05	0.6046	1.90	17.58
ENZYL ALCOHOL	22.97	22.72	23.74	23.51	22.69	21.61	21.53	0.8530	2.68	22.68
,2-DICHLOROBENZENE	16.71	17.54	17.44	17.08	17.35	17.77	17.69	0.3688	1.16	17.37
-METHYLPHENOL	17.72	18.62	19.19	17.96	18.07	18.12	18.53	0.4972	1.56	18.32
IS(2-CHLOROISOPROPYL)ETH	18.34	19.37	19.70	19.09	19.04	19.22	19.30	0.4183	1.31	19.15
-METHYLPHENOL	17.35	17.85	18.22	17.82	18.01	18.22	17.77	0.3013	0.95	17.89
-NITROSO-DI-N-PROPYLAMIN	16.04	16.67	16.99	16.30	16.12	15.95	16.58	0.3809	1.20	16.38
EXACHLOROETHANE	13.12	14.21	14.00	14.12	14.51	15.33	15.11	0.7384	2.32	14.34
APHTHALENE-d8	40.00	40.00	40.00	40.00	40.00	40.00	40.00	0.0000	0.00	40.00
ITROBENZENE	17.45	17.78	18.72	17.74	18.51	18.15	18.24	0.4523	1.42	18.08
SOPHORONE	18.32	18.58	19.53	18.69	18.72	18.51	18.50	0.3924	1.23	18.69
ITROBENZENE-d5	17.43	17.79	18.47	17.87	18.13	18.13	17.57	0.3588	1.13	17.91
-NITROPHENOL	19.06	19.34	20.20	19.34	19.80	19.81	18.92	0.4577	1.44	19.50
,4-DIMETHYLPHENOL	14.99	16.14	17.09	15.92	16.09	16.83	15.08	0.7932	2.49	16.02
ENZOIC ACID	2.27	1.53	2.56	2.22	2.24	3.25	2.01	0.5257	1.65	2.30
IS(2-CHLOROETHOXY)METHAN	17.51	17.71	18.56	18.20	18.52	18.14	18.03	0.3883	1.22	18.10
,4-DICHLOROPHENOL	19.06	19.76	20.61	19.57	19.85	20.20	19.20	0.5421	1.70	19.75
,2,4-TRICHLOROBENZENE	17.98	18.67	19.04	19.08	19.06	19.39	18.68	0.4551	1.43	18.84
APHTHALENE	18.28	18.58	19.24	19.02	19.14	19.14	18.95	0.3498	1.10	18.91
-CHLOROANILINE	18.84	19.05	19.94	19.36	20.08	18.84	19.37	0.4986	1.57	19.35
EXACHLOROBUTADIENE	17.84	18.61	19.02	18.82	19.03	19.13	18.55	0.4434	1.39	18.71
-CHLORO-3-METHYLPHENOL	19.72	19.89	20.63	20.60	20.77	20.43	19.81	0.4420	1.39	20.26
-METHYLNAPHTHALENE	18.90	19.03	20.61	19.42	20.34	20.10	19.66	0.6536	2.05	19.72
ACENAPHTHENE-d10	40.00	40.00	40.00	40.00	40.00	40.00	40.00	0.0000	0.00	40.00
2,4,6-TRIBROMOPHENOL	23.41	24.01	24.16	24.45	24.54	24.61	23.46	0.4955	1.56	24.09
2-FLUOROBIPHENYL	19.85	20.54	20.95	20.79	21.30	20.67	20.59	0.4445	1.40	20.67
HEXACHLOROCYCLOPENTADIENE	4.54	5.89	6.55	6.87	6.14	7.69	7.59	1.0862	3.41	6.47
2,4,6-TRICHLOROPHENOL	20.83	21.61	21.29	20.98	22.17	21.08	20.30	0.5950	1.87	21.18
2,4,5-TRICHLOROPHENOL	20.21	20.69	19.74	20.19	21.39	20.65	20.22	0.5264	1.65	20.44
2-CHLORONAPHTHALENE	19.87	20.49	20.84	20.04	20.91	21.37	20.44	0.5200	1.63	20.57
2-NITROANILINE	19.45	19.53	20.38	19.95	20.51	19.96	20.20	0.4025	1.26	20.00
DIMETHYLPHTHALATE	19.78	20.32	20.60	20.16	20.91	21.00	20.76	0.4401	1.38	20.50
ACENAPHTHYLENE	20.01	20.64	21.38	20.57	21.49	21.05	20.20	0.5669	1.78	20.76
3-NITROANILINE	19.54	19.91	20.63	19.80	20.96	20.65	19.75	0.5543	1.74	20.18
ACENAPHTHENE	19.19	19.54	20.51	19.78	20.55	20.20	19.67	0.5136	1.61	19.92
2,4-DINITROPHENOL	8.00	8.34	8.95	10.14	10.53	8.97	9.50	0.9163	2.88	9.20
4-NITROPHENOL	17.56	17.90	17.98	17.88	16.97	17.75	17.49	0.3489	1.10	17.65
DIBENZOFURAN	18.76	19.33	19.81	18.84	19.58	19.70	19.19	0.4109	1.29	19.32
2,6-DINITROTOLUENE	20.79	22.17	21.87	22.05	21.44	21.15	20.96	0.5492	1.72	21.49
2,4-DINITROTOLUENE	19.62	19.56	19.89	20.02	20.31	19.97	19.90	0.2521	0.79	19.90

SEMI-VOLATILE ORGANIC COMPOUNDS - HMS 3-93
METHOD 625 - continued

ETHYLPHTHALATE	18.98	19.20	19.68	18.98	19.93	19.65	19.30	0.3705	1.16	19.39
-CHLOROPHENYL-PHENYLETHE	19.22	19.73	20.34	20.18	20.56	20.10	20.11	0.4391	1.38	20.03
U ENE	19.36	19.88	20.14	19.75	20.95	20.21	19.31	0.5636	1.77	19.94
N..ROANILINE	20.42	20.48	21.03	19.63	20.68	20.37	20.61	0.4272	1.34	20.46
ENANTHRENE-d10	40.00	40.00	40.00	40.00	40.00	40.00	40.00	0.0000	0.00	40.00
6 DINITRO-2-METHYLPHENO	12.42	13.37	14.08	15.17	14.93	13.89	14.98	1.0004	3.14	14.12
-N ROSODIPHENYLAMINE	20.63	21.21	22.06	21.27	21.95	22.04	21.50	0.5320	1.67	21.52
CBENZENE	22.56	22.99	22.85	22.69	23.64	23.12	22.84	0.3531	1.11	22.96
-BROMOPHENYL-PHENYLETHER	22.48	22.50	22.81	23.12	23.32	24.19	22.74	0.5991	1.88	23.02
EX HLOROBENZENE	21.95	21.59	23.20	22.60	22.94	23.01	22.40	0.5901	1.85	22.53
ENTACHLOROPHENOL	22.33	22.38	22.58	23.31	22.09	21.51	21.83	0.5765	1.81	22.29
HENANTHRENE	19.87	20.58	20.87	20.56	21.15	21.03	20.58	0.4219	1.32	20.66
NT ACENE	19.47	20.10	20.62	20.73	20.88	20.65	20.48	0.4846	1.52	20.42
I- BUTYLPHTHALATE	20.45	20.55	21.40	20.65	21.49	21.42	21.00	0.4479	1.41	20.99
LUORANTHENE	20.58	20.33	21.00	21.14	21.15	21.12	20.91	0.3176	1.00	20.89
EN DINE	27.22	13.21	38.79	23.90	25.33	20.32	25.90	7.7256	24.26	24.95
HR ENE-d12	40.00	40.00	40.00	40.00	40.00	40.00	40.00	0.0000	0.00	40.00
ERPHENYL-d14	21.87	23.00	22.75	23.26	22.95	23.39	23.50	0.5478	1.72	22.96
YRENE	20.39	21.12	21.48	21.67	21.39	21.29	21.99	0.5011	1.57	21.33
UT BENZYLPHTHALATE	20.85	22.24	22.33	22.49	22.19	22.41	22.34	0.5695	1.79	22.12
,3 -DICHLOROBENZIDINE	25.53	26.45	27.46	27.46	26.78	27.88	27.37	0.8006	2.51	26.99
ENZO(A)ANTHRACENE	20.32	21.67	21.61	22.03	21.91	21.66	22.00	0.5899	1.85	21.60
IS 2-ETHYLHEXYL)PHTHALAT	20.07	20.93	20.84	21.06	20.93	21.04	20.97	0.3450	1.08	20.83
HF SENE	19.58	20.54	20.84	20.59	20.86	21.21	21.32	0.5747	1.80	20.71
ERYLENE-d12	40.00	40.00	40.00	40.00	40.00	40.00	40.00	0.0000	0.00	40.00
DI- OCTYLPHTHALATE	21.58	21.57	21.78	22.08	22.22	22.16	21.98	0.2689	0.84	21.91
EN O(B)FLUORANTHENE	21.24	19.27	18.31	19.57	22.04	21.35	19.06	1.4070	4.42	20.12
ENZO(K)FLUORANTHENE	19.00	21.57	24.56	22.93	20.85	21.27	23.09	1.8060	5.67	21.90
ENZO(A)PYRENE	19.92	19.44	20.19	20.31	20.33	20.36	20.38	0.3444	1.08	20.13
NI O(1,2,3-CD)PYRENE	19.49	19.40	19.61	19.50	19.71	19.15	19.13	0.2193	0.69	19.43
DIBENZ(A,H)ANTHRACENE	20.30	19.94	20.10	20.12	20.33	20.10	19.73	0.2061	0.65	20.09
ENZO(G,H,I)PERYLENE	18.40	17.93	18.49	18.23	18.36	17.86	17.75	0.2947	0.93	18.15

PACE, INC.

PACE NEW ENGLAND, INC.
METHOD DETECTION LIMIT VERIFICATION STUDY
EDB/DBCP METHOD 504
1/93

DATA FILES:
(1) G1L09065
(2) G1L09066
(3) G1L09067
(4) G1L09068
(5) G1L09069
(6) G1L09070
(7) G1L09071

COMPOUND	(1) CONC. ug/L	(2) CONC. ug/L	(3) CONC. ug/L	(4) CONC. ug/L	(5) CONC. ug/L	(6) CONC. ug/L	(7) CONC. ug/L	STD DEV	X 3.14 MDL ug/L	MEAN
EDB	0.0456	0.0497	0.0402	0.0504	0.0474	0.0414	0.0470	0.0039	0.0122	0.0460
DBCP	0.0455	0.0539	0.0411	0.0502	0.0460	0.0391	0.0453	0.0050	0.0158	0.0459

PPEDB.

PACE NEW ENGLAND, INC.
METHOD DETECTION LIMIT VERIFICATION STUDY
HERBICIDES DRINKING WATER METHOD 515
4/93

DATA FILES:
(1) G19G03728
(2) G19G03729
(3) G19G03730
(4) G19G03731
(5) G19G03732
(6) G19G03733
(7) G19G03734

OMPOUND	(1) CONC. ug/L	(2) CONC. ug/L	(3) CONC. ug/L	(4) CONC. ug/L	(5) CONC. ug/L	(6) CONC. ug/L	(7) CONC. ug/L	STD DEV	X 3.14 MDL ug/L	MEAN
ALAPON	17.5508	17.9803	18.2884	16.7459	17.7101	16.5626	18.7284	0.7845	2.4634	17.652
ICAMBA	1.7808	1.8749	1.7673	1.6548	1.8381	1.6053	1.9399	0.1185	0.3722	1.780
ICHLOROPROP	6.0012	5.7705	5.5396	5.2617	5.2633	4.8595	6.0395	0.4344	1.3640	5.534
2,4-D	3.7465	3.5679	3.4506	3.3916	3.4014	3.1470	3.7603	0.2166	0.6801	3.495
ENTACHLOROPHENOL	1.9613	1.9323	1.8461	1.7117	1.6745	1.5690	2.8515	0.4282	1.3446	1.935
ILVEX	1.8515	1.8300	1.7402	1.6985	1.7467	1.5767	1.8882	0.1062	0.3334	1.762
2,4,5-T	2.1140	1.9021	2.0930	1.8860	1.9280	1.9112	2.1726	0.1205	0.3783	2.001
INOSEB	2.1146	2.2287	2.3386	1.9298	2.1952	1.9165	2.3982	0.1866	0.5860	2.160
,4'-DB	14.5637	13.3385	13.0567	11.0684	9.1685	9.1924	14.5307	2.3285	7.3116	12.131
BENTOZON	3.8099	3.8792	3.3789	3.1300	3.1672	3.2863	3.5825	0.3013	0.9459	3.462
PICLORAM	1.8877	2.0006	1.9292	1.7277	1.9509	1.7889	2.1868	0.1493	0.4689	1.925

PACE NEW ENGLAND, INC.
METHOD DETECTION LIMIT VERIFICATION STUDY
PESTICIDES/PCBS METHOD 608
1/93

DATA FILES:

PACE NEW ENGLAND, INC.
METHOD DETECTION LIMIT VERIFICATION STUDY
PESTICIDES/PCBS METHOD 608
1/93

DATA FILES:
* GC11
(1) G1L09755
(2) G1L09756
(3) G1L09757
(4) G1L09759
(5) G1L09760
(6) G1L09761
(7) G1L09762

COMPOUND	(1) CONC. ug/L	(2) CONC. ug/L	(3) CONC. ug/L	(4) CONC. ug/L	(5) CONC. ug/L	(6) CONC. ug/L	(7) CONC. ug/L	STD DEV	X 3.14 MDL ug/L	MEAN
ALPHA-BHC	0.0442	0.0461	0.0467	0.0453	0.0431	0.0486	0.0436	0.0019	0.0061	0.0454
GAMMA-BHC	0.0467	0.0482	0.0507	0.0485	0.0461	0.0513	0.0467	0.0020	0.0064	0.0483
BETA-BHC	0.0494	0.0529	0.0525	0.0512	0.0501	0.0541	0.0499	0.0018	0.0055	0.0514
HEPTACHLOR	0.0501	0.0526	0.0527	0.0528	0.0507	0.0555	0.0497	0.0020	0.0063	0.0520
DELTA-BHC	0.0400	0.0417	0.0600	0.0419	0.0391	0.0433	0.0403	0.0073	0.0229	0.0438
ALDRIN	0.0489	0.0515	0.0508	0.0511	0.0496	0.0543	0.0496	0.0018	0.0056	0.0508
HEPTACHLOR EPOXIDE	0.0521	0.0560	0.0554	0.0559	0.0535	0.0580	0.0530	0.0021	0.0065	0.0548
GAMMA-CHLORDANE	0.0508	0.0522	0.0563	0.0551	0.0519	0.0573	0.0509	0.0027	0.0084	0.0535
4,4'-DDE	0.1111	0.1182	0.1119	0.1187	0.1112	0.1205	0.1123	0.0041	0.0129	0.1148
DIELDRIN	0.1027	0.1102	0.1061	0.1110	0.1037	0.1131	0.1054	0.0040	0.0125	0.1075
ENDRIN	0.0998	0.1050	0.0937	0.0986	0.0882	0.0981	0.1010	0.0054	0.0170	0.0978
4,4'-DDD	0.0865	0.0917	0.1032	0.0901	0.0847	0.0890	0.0840	0.0065	0.0204	0.0899
ENDOSULFAN II	0.1031	0.1110	0.1124	0.1113	0.1043	0.1123	0.1058	0.0040	0.0127	0.1086
4,4'-DDT	0.0872	0.0919	0.1162	0.0921	0.0825	0.0913	0.0861	0.0111	0.0347	0.0925
ENDRIN ALDEHYDE	0.0997	0.1122	0.1177	0.1102	0.1058	0.1174	0.1086	0.0064	0.0200	0.1102
ENDOSULFAN SULFATE	0.0914	0.0967	0.1382	0.0961	0.0895	0.0971	0.0898	0.0172	0.0541	0.0998
METHOXYCHLOR	0.5046	0.5444	0.6096	0.5422	0.4932	0.5314	0.5101	0.0387	0.1216	0.5336
ENDRIN KETONE	0.0960	0.1063	0.1256	0.1102	0.1066	0.1110	0.0996	0.0095	0.0299	0.1079
ENDOSULFAN I *	0.0473	0.0494	0.0497	0.0491	0.0464	0.0510	0.0468	0.0017	0.0054	0.0485
ALPHA-CHLORDANE *	0.0481	0.0513	0.0526	0.0512	0.0482	0.0527	0.0489	0.0020	0.0063	0.0504

PPGC01A

PACE NEW ENGLAND, INC.
METHOD DETECTION LIMIT VERIFICATION STUDY
PESTICIDES/PCBS METHOD 608
1/93

DATA FILES:
(1) G1608011
(2) G1608012
(3) G1608013
(4) G1608014
(5) G1608016
(6) G1608017
(7) G1608018

COMPOUND	(1) CONC. ug/L	(2) CONC. ug/L	(3) CONC. ug/L	(4) CONC. ug/L	(5) CONC. ug/L	(6) CONC. ug/L	(7) CONC. ug/L	STD DEV	X 3.14 MDL ug/L	MEAN
CHLORDANE	1.130	1.140	1.020	1.090	1.020	1.090	0.986	0.0596	0.1872	1.0680
TOXAPHENE	1.080	1.100	0.942	0.825	0.965	0.985	0.918	0.0946	0.2970	0.9736

PPGC16A.WQ1

PACE NEW ENGLAND, INC.
METHOD DETECTION LIMIT VERIFICATION STUDY
PCB'S - METHOD 608
1/93

ATA FILES:

A	B	C	D	E
1) G19M03378	(1) G19M03353	(1) G19M03367	(1) G19M03344	(1) G19M03333
2) G19M03379	(2) G19M03354	(2) G19M03368	(2) G19M03345	(2) G19M03334
3) G19M03380	(3) G19M03355	(3) G19M03369	(3) G19M03346	(3) G19M03335
4) G19M03381	(4) G19M03356	(4) G19M03370	(4) G19M03347	(4) G19M03336
5) G19M03383	(5) G19M03357	(5) G19M03372	(5) G19M03348	(5) G19M03337
6) G19M03384	(6) G19M03358	(6) G19M03373	(6) G19M03349	(6) G19M03339
7) G19M03385	(7) G19M03359	(7) G19M03374	(7) G19M03350	(7) G19M03340

OMPOUND	CONC. ug/L	CONC. ug/L	CONC. ug/L	CONC. ug/L	CONC. ug/L	CONC. ug/L	CONC. ug/L	STD DEV	X 3.14 MDL ug/L	MEAN
A =	(1)	(2)	(3)	(4)	(5)	(6)	(7)			
ROCLOR 1016	1.160	1.140	1.210	1.250	1.180	1.240	1.140	0.0456	0.1432	1.1886
ROCLOR 1260	1.090	1.050	1.090	1.130	1.090	1.090	1.050	0.0276	0.0867	1.0843
B =	(1)	(2)	(3)	(4)	(5)	(6)	(7)			
ROCLOR 1232	1.220	0.980	1.240	0.820	1.010	0.780	1.200	0.1908	0.5990	1.0357
C =	(1)	(2)	(3)	(4)	(5)	(6)	(7)			
ROCLOR 1242	1.058	1.047	1.068	1.014	1.056	1.047	0.952	0.0400	0.1255	1.0344
D =	(1)	(2)	(3)	(4)	(5)	(6)	(7)			
ROCLOR 1248	1.100	1.100	1.160	1.090	1.110	1.160	1.210	0.0446	0.1401	1.1329
E =	(1)	(2)	(3)	(4)	(5)	(6)	(7)			
ROCLOR 1221	1.290	1.120	1.070	1.240	1.340	1.320	1.560	0.1607	0.5046	1.2771
ROCLOR 1254	0.890	0.890	0.830	0.970	1.080	1.140	1.290	0.1648	0.5175	1.0129

PCBG19A WQ1

PACE NEW ENGLAND, INC.
METHOD DETECTION LIMIT VERIFICATION STUDY
AROCLOR 1232
6/93
METHOD 608

MPOUND	SP2765 CONC. ug/L	SP2766 CONC. ug/L	SP2767 CONC. ug/L	SP2768 CONC. ug/L	SP2769 CONC. ug/L	SP2770 CONC. ug/L	SP2771 CONC. ug/L	STD DEV	X 3.14 MDL ug/L	MEAN
AROCLOR 1232	1.28	1.18	1.53	1.42	1.28	1.16	1.28	0.13	0.41	1.30

PACE NEW ENGLAND, INC.
METHOD DETECTION LIMIT VERIFICATION STUDY
AROCLOR 1254 IN SOIL
MEDIUM SOLID EXTRACTION
4/93

DATA FILES:
(1) G10M09278
(2) G10M09279
(3) G10M09280
(4) G10M09281
(5) G10M09282
(6) G10M09283
(7) G10M09284

COMPOUND	(1) CONC. ug/g	(2) CONC. ug/g	(3) CONC. ug/g	(4) CONC. ug/g	(5) CONC. ug/g	(6) CONC. ug/g	(7) CONC. ug/g	STD DEV	X 3.14 MDL ug/g	MEAN
ARCLOR 1254	1.97	1.99	1.95	1.99	2.02	1.99	1.92	0.0326	0.1023	1.9757

PACE NEW ENGLAND, INC.
METHOD DETECTION LIMIT VERIFICATION STUDY
AROCLOR 1254 IN OIL
4/93

DATA FILES:
) G6M13337
) G6M13338
(3) G6M13339
(4) G6M13340
) G6M13341
(6) G6M13342
(7) G6M13344

COMPOUND	(1) CONC. ug/g	(2) CONC. ug/g	(3) CONC. ug/g	(4) CONC. ug/g	(5) CONC. ug/g	(6) CONC. ug/g	(7) CONC. ug/g	STD DEV	X 3.14 MDL ug/g	MEAN
CLOR 1254	8.43	8.24	9.24	8.21	8.78	9.26	8.99	0.4493	1.4109	8.7357

PACE NEW ENGLAND, INC.
METHOD DETECTION LIMIT VERIFICATION STUDY
PESTICIDES/PCBS METHOD 8140
1/93

DATA FILES:
(1) G9G13004
(2) G9G13005
(3) G9G13006
(4) G9G13007
(5) G9G13008
(6) G9G13009
(7) G9G13010

COMPOUND	(1) CONC. ug/L	(2) CONC. ug/L	(3) CONC. ug/L	(4) CONC. ug/L	(5) CONC. ug/L	(6) CONC. ug/L	(7) CONC. ug/L	STD DEV	X 3.14 MDL ug/L	MEAN
DICHLORVOS	6.0347	4.7354	5.1758	4.7671	4.9145	4.2948	4.8825	0.5383	1.6903	4.9721
MEVINPHOS	2.6326	2.0288	2.3125	2.1218	2.3538	1.9704	2.1659	0.2265	0.7112	2.2265
ETHOPROP	3.1840	2.5656	2.7250	2.5710	2.7339	2.4029	2.5847	0.2483	0.7795	2.6810
NALED/PHORATE	1.3494	0.8469	1.7460	1.8062	1.4885	0.3882	1.0601	0.5104	1.6025	1.2408
DIAZINON/DEMETON	2.9056	2.3340	2.4283	2.1035	2.4510	2.0723	2.1813	0.2862	0.8987	2.3537
DISULFOTON	0.0818	0.0424	0.7947	1.0371	0.2464	0.0397	0.0554	0.4137	1.2990	0.3282
RONNEL	2.8964	2.4158	2.4236	2.3013	2.4035	2.1624	2.2469	0.2368	0.7436	2.4071
CHLORPYRIFOS/MERPHOS	5.8751	4.7718	4.9066	4.5194	4.6372	4.2605	4.5424	0.5211	1.6364	4.7876
METHYL PARATHION	2.8997	2.3657	2.3988	2.2600	2.3037	2.1135	2.2136	0.2543	0.7985	2.3650
TRICHLORONATE	2.9725	2.4194	2.4812	2.2494	2.3366	2.1568	2.3134	0.2664	0.8364	2.4185
FENTHION	1.3654	0.7726	1.9272	1.9540	1.5344	0.0645	1.1046	0.6712	2.1075	1.2461
TOKUTHION	2.7336	2.1692	2.2445	2.2262	2.2025	1.9579	2.0855	0.2426	0.7618	2.2313
STIROPHOS	2.9153	2.3701	2.4395	2.2319	2.3832	2.1048	2.2728	0.2578	0.8096	2.3882
BOLSTAR	1.2552	0.7169	1.8870	1.9283	1.5098	0.1015	0.9913	0.6564	2.0610	1.1986
FENSULFOTHION	2.9933	2.4949	2.3760	2.1600	2.4053	2.1341	2.2741	0.2903	0.9115	2.4054
AZINPHOSMETHYL	2.7963	2.2596	2.3083	2.1705	2.3095	2.0364	2.1009	0.2490	0.7818	2.2831
COUMAPHOS	2.9304	2.4110	2.4313	2.2163	0.0726	2.0463	2.1998	0.9139	2.8695	2.0440

PACE NEW ENGLAND, INC.
METHOD DETECTION LIMIT VERIFICATION STUDY
HERBICIDES METHOD 8150
3/93

DA . FILES:
(1 G19G03707
(2) G19G03708
(3 G19G03709
(4 G19G03710
(5) G19G03711
(6) G19G03712
(7 G19G03713

COMPOUND	(1) CONC. ug/L	(2) CONC. ug/L	(3) CONC. ug/L	(4) CONC. ug/L	(5) CONC. ug/L	(6) CONC. ug/L	(7) CONC. ug/L	STD DEV	X 3.14 MDL ug/L	MEAN
DA PON	1.847	1.635	1.596	1.740	1.492	1.910	2.362	0.2879	0.9041	1.797
DICAMBA	2.174	2.032	2.196	2.282	2.285	2.132	2.107	0.0921	0.2892	2.172
MCPA	72.900	89.100	93.800	92.100	93.700	89.900	80.100	7.9101	24.8376	87.371
DI LOROPROP/MCPP	195.132	186.224	191.310	192.531	200.517	173.562	177.919	9.5924	30.1203	188.171
2,4 D	1.973	1.838	1.964	2.053	2.057	1.900	1.840	0.0911	0.2862	1.947
SILVEX	1.936	1.757	1.894	1.975	1.965	1.856	1.813	0.0811	0.2546	1.885
2, 5-T	2.274	2.087	2.481	2.480	2.640	2.239	2.345	0.1845	0.5792	2.363
DI SEB	1.422	0.909	0.846	1.057	1.327	1.017	0.820	0.2348	0.7372	1.057
2,4'-DB	2.021	1.932	1.969	2.063	2.025	1.824	2.035	0.0819	0.2570	1.981

PACE NEW ENGLAND, INC.
METHOD DETECTION LIMIT VERIFICATION STUDY
VOL ORGANICS WET LAB PARAMETERS
MARCH 1993

TEST	METHOD	CONC. mg/L	CONC. mg/L	CONC. mg/L	CONC. mg/L	CONC. mg/L	CONC. mg/L	CONC. mg/L	STD DEV	MDL ug/L	MEAN	SPIKE LEVEL
									=====	====	====	====
OIL AND GREASE WATER	GRAV	7.3	7.900	7.4	7.300	8.9	8.4	8.9	0.7221	2.267	8.014	
OIL AND GREASE WATER	IR	2.36	2.46	2.55	2.34	2.11	2.50	2.50	0.1502	0.47	2.40	
PHC WATER	IR	2.34	2.16	2.36	2.19	2.28	2.29	2.40	0.0880	0.28	2.29	
PHENOL WATERS	SPEC	10.40	7.53	7.18	6.82	7.18	7.53	5.39	1.5000	4.71	7.43	

JDC 5/24/93

PACE, INC.

METHOD 531.1
CARBAMATE PESTICIDES
DETECTION LIMIT STUDY

STRUMENT: LC5
L MN: NOVAPAK C18

(ALL CONCENTRATIONS ARE IN UG/L)

M JUND	REP1	REP2	REP3	REP4	REP5	REP6	REP7	s	D.L.	AVG	TRUE CONC	RPD
D ULFOX	3.02	2.76	3.26	2.84	3.17	3.42	3.66	0.32	1.00	3.16	3.0	5.33
D ULFAN	2.94	2.78	2.96	2.68	2.90	3.24	3.54	0.29	0.92	3.01	3.0	0.19
AMYL	2.75	2.64	3.25	2.81	3.13	3.12	3.20	0.24	0.77	2.98	3.0	-0.48
TH MYL	2.85	2.61	3.08	2.74	3.02	3.16	3.31	0.24	0.77	2.97	3.0	-0.93
H DROXYC	3.04	2.53	3.14	2.63	3.19	3.09	3.63	0.37	1.15	3.04	3.0	1.19
D ARB	2.86	2.45	3.00	2.42	2.97	3.07	4.27	0.62	1.93	3.00	3.0	-0.19
YGON	3.01	2.55	3.22	2.68	2.98	2.98	3.65	0.36	1.13	3.01	3.0	0.33
R FURAN	2.55	1.99	2.69	2.51	2.62	3.02	3.32	0.42	1.32	2.71	3.0	-9.52
R RYL	4.13	3.45	3.06	2.84	3.17	3.15	3.55	0.42	1.33	3.34	3.0	11.19
THIODARB	2.84	2.62	2.83	2.39	3.14	2.90	3.78	0.44	1.39	2.93	3.0	-2.38
MP	2.62	3.98	2.91	2.19	3.31	3.12	3.97	0.64	2.02	3.14	3.0	4.76

MP E	DATE	FILE
M 2306	5/21/93	L5001652
M 307	5/21/93	L5010653
M 308	5/21/93	L5010654
M 2309	5/21/93	L5001655
M 2310	5/21/93	L5001656
M 311	5/21/93	L5001657
M 2313	5/21/93	L5001660

9.0 DATA REDUCTION, VALIDATION AND REPORTING

All analytical data generated within the PACE NE Laboratories undergo a well-defined, well-documented multi-tier review process before being reported to the client.

9.1 Data Reduction

When primary analytical data, otherwise known as "raw data", are manually generated, the data are recorded either in bound Logbooks with prenumbered pages or on preprinted forms. Entries are made in black ink and are initialled and dated by the individual who makes the entry. It is acceptable to initial and date once for an entire page. Errors are corrected by drawing a single line through the entry; this change is initialled and dated by the individual who makes the change. The reason for the change is indicated either by description or by error code (see Figure 9-1). Raw data may not be obscured in any way. The use of white-out is prohibited on all raw data, including instrumental hardcopy.

The analyst who completes the analysis assembles all relevant raw data and results together with chromatograms, strip chart recordings, instrument settings and other information essential to data interpretation. For data which are reduced by manual calculations, the calculations are documented in a laboratory notebook or on an analyst's worksheet. The results are transferred to a standard laboratory reporting form which has been approved by the Group Supervisor and Lab Manager. Reporting forms include at a minimum the sample identification number, the date analyzed, the result expressed per unit volume, the method reference and the analyst's initials.

9.2 Data Validation

The analyst initiates the data validation process by reviewing and accepting the data. The completed data package is then sent to the Group Supervisor. The Group Supervisor provides a technical assessment of the data package and technical review for accuracy according to methods employed and laboratory protocols. Group Supervisors also review analyst generated calculations.

For data which are reduced via computer, calculations are checked by the analyst (or designee) assigned to this task at a frequency designed to assure that the data manipulations are valid. This data validation step is documented by the analysts' initials on the hardcopy of the raw data. The results are either manually transferred to a standard reporting form or reported via computer generation of forms.

The Group Supervisor submits the validated data package, including the reporting forms and the appropriate laboratory control sheets, to the Laboratory Manager who reviews the package for QC requirements and completeness. If any errors are discovered, the entire package shall be returned to the Group Supervisor for full reworking.

When accepted, the Laboratory Manager assembles the data with other data from the sample set, drafts any narrative comments if required by the Quality Assurance Project Plan, and forwards the report and the data package to the Reporting Department.

The Reporting Department assembles and types the final report, checks for transcription errors, and provides the final report to the Laboratory Manager/Technical Director for final signature.

The Laboratory Manger/Technical Director examines the report for method appropriateness, detection limits and whether or not QC criteria were satisfied. Any deviations from the referenced methods are checked for documentation and validity, and QC corrective actions are reviewed for successful resolution. The Laboratory Manager/Technical Director signs the completed reports prior to their release.

The Laboratory Manager/Technical Director may delegate the final review and signing of reports to the Regional Director, as necessary.

9.3 Data Report

All data segments pertaining to a particular PACE NE Laboratory Number are channeled to the Reporting Department for assembly into the final report format and generation of the analytical narrative. All points mentioned during technical and QC review are included in the narrative if it is deemed to impact the quality of the data.

The final report is given to the Laboratory Manager/Technical Director for final review and release. After verifying the report's completeness and accuracy, the Technical Director signs the cover letter indicating acceptance of the report.

The standard commercial report to the client consists of the following sections:

1) the narrative
2) sample results
3) Chain-of-Custody forms

The narrative briefly describes the condition of the samples upon receipt, sample holding time performance, instrument calibration information, and the quality control results. Any discrepancies discovered and matrix problems are also addressed in this section.

The sample results are tabulated. PACE NE number, client identification, and data analyzed are presented along with the observed concentrations for each parameter analyzed and detection limits.

9.4 Data Archive

Each data report which supports the analytical process for all samples received by the laboratory is thoroughly reviewed for completeness and accuracy. After the technical review it is routed to the Reporting Department for assembling the final report for submission to the client. The report is approved, signed, and submitted.

One copy of the report remains with all the raw data which is stored in the data archives under the control of the QA Department.

The Data Archivist has oversight responsibility for the data archive ensuring the continued integrity of all documentation generated in support of laboratory analyses.

The archive room is a secure storage area with limited access to non-authorized personnel. Sign-out procedures are in place where every document removed from the archive room must be electronically signed out by a member of the QA Department.

A copy of the report is forwarded to the Hazardous Waste Manager for use in characterizing the samples for ultimate disposal.

TABLE 9-1.

Error Codes

1 (or E1)	Misspelled
2 (or E2)	Mathematical Error
3 (or E3)	Wrong Entry
4 (or E4)	Transposition or Sequencing Error
5 (or E5)	Transcription Change (copy error)
6 (or E6)	Procedural Change
7 (or E7)	Wrong Conclusion
8 (or E8)	Illegible Entry
9 (or E9)	Unnecessary Entry
10 (or E10)	Footnoted Explanation
11 (or E11)	Additional Comment
12 (or E12)	Instrumentation Error/Failure

10.0 RECORDS MANAGEMENT

Records are the means by which an organization documents its operations and activities. They are an integral part of the Quality Assurance program since they provide documented evidence for program functionality and necessary information for performance evaluation and quality assurance audits.

10.1 Standard Operating Procedures

Standard Operating Procedures (SOPs) are written for specific procedures or operations. Complex tasks of inspection, testing, calibration, monitoring, maintenance, data handling, and quality control as well as methods utilized in the laboratory are specified and documented by SOPs.

As a minimum requirement, each SOP must include a title, the purpose or applicability, list of materials or references, and detailed procedures. SOPs are updated when necessary. Each has an PACE NE reference number and revision data at the upper right corner of each page. More detailed information regarding SOPs can be found in Section 12.

All personnel are required to follow these documents when a specific operation or method is being utilized. It is the responsibility of the supervisor to make sure that employees are aware of and follow the SOPs. Any suggestions for additional SOPs or changes to existing SOPs can be directed to the QA Department.

10.2 Sample Tracking

Samples are tracked from the time they are received, through storage, preparation, analysis, and final disposition.

Proper sample identification must be established during sample collection. This information must be clearly and permanently written on a label and attached to the sample. In addition, a Chain-of-Custody must be initiated with the appropriate information recorded. Samples should also be properly preserved and stored.

Sample Management Personnel verifies the samples' integrity as they are unpacked. The PACE NE Project Manager and/or the Client are notified of samples that are broken or have not been properly stored or preserved. The sample identification label must also be checked against Chain-of-Custody identification. Any discrepancies must be verified

by the Client or sampler. All these checks and any discrepancies or changes must be documented on the Sample Receiving documentation.

The Sample Management Personnel assign each sample a sequential laboratory identification number, which is written on the sample container and recorded onto the Chain-of-Custody. Samples are properly stored in their respective storage refrigerators.

Upon receipt the Sample Management Personnel also initiates an Internal Custody Record for the sample set. This sheet is used to document sample removal from and return to sample storage. The final disposition of a sample is documented on the hazardous waste disposal spreadsheet and on the internal sample custody record.

10.2.1 Chain-of-Custody

The Chain-of-Custody Form traces the possession of a sample from the time the sample is obtained in the field through analysis in the laboratory. To initiate a Chain-of-Custody, the field sampler must fill in the appropriate information: Client or Project Name, Signature of Sampler, Sample Identification, Date and Time Sampled, Type of Sample, and Analysis Requested. After the sample is brought into the laboratory, sample breakage, preservation, and identification are checked. Any inconsistencies are noted in the sample management documentation. For samples accepted into the laboratory, the Sample Management Personnel record the assigned lab sample number for each sample onto the Chain-of-Custody form, signs in the space marked "Received for Laboratory" and records the date and time received.

10.2.2 Internal Sample Custody Record

The Internal Custody Record is created at the time of sample receipt and is a mechanism for tracking samples from sample management to sample preparation and back. When laboratory personnel remove samples from sample storage, it is recorded on the Internal Custody Record. Upon returning any remaining sample, the individual records the date in the "Returned By" box for the appropriate sample. The original Internal Custody Record is archived by the QA department.

10.3 Standards

Standards preparation is documented at PACE NE in a Standards Logbook maintained by each laboratory. These logbooks are where the preparer records all information

needed to maintain proper traceability. More complete information regarding standards is provided in Section 7.1.

10.4 Maintenance Logbooks

Maintenance Logbooks are kept for each instrument. Each logbook is unique to its instrument. In the logbook, an analyst records initial instrument setup, routine preventive maintenance, and instrumental malfunctions, dates taken in and out of service, and resolutions. Instrument logs not only describe the instrument's history, but can be helpful when troubleshooting.

10.5 Data Report/Raw Data Package

A Data Report contains the results of analyses as presented to the Client. There is a narrative describing the general condition of the samples and an overview of the analyses. For more information see Section 9.3.

The Raw Data Package contains information needed to reconstruct how the analysis of a batch of samples including QA/QC results data were derived. Information such as inorganic or organic preparation, chromatograms or strip chart recording, and regression analysis data are usually included.

11.0 QUALITY CONTROL

A quality control program is a systematic process that controls the validity of analytical results by measuring the accuracy and precision of each method and matrix, developing expected control limits, using these limits to detect errors or out-of-control events, and requiring corrective action techniques to prevent or minimize the recurrence of these events. When laboratory established control limits are less stringent than method control limits, the method control limits are used to detect errors or out-of-control events.

11.1 Accuracy and Precision Measurements

The results of quality control samples created in the laboratory represent estimates of accuracy and precision for the preparation and analysis steps of sample handling. This section describes the quality control information provided by each of these analytical measurements. Information on the procedures to follow in preparation of the samples or spiking solutions is described for each method and matrix in the respective method Standard Operating Procedure.

Method Blank

A method blank is a volume of deionized, distilled laboratory water for water samples, or a purified solid matrix for soil/sediment samples, carried through the entire analytical procedure. The volume or weight of the blank must be approximately equal to the sample volume or weight processed. A method blank is performed with each batch of samples or one with every 20 field samples whichever is more frequent. Analysis of the blank verifies that method interferences caused by contaminants in solvents, reagents, glassware, and other sample processing hardware are known and minimized. Optimally, a method blank should contain no greater than five times (5X) the method detection limit for common laboratory solvents and phthalate esters; less than the detection limit for all other parameters unless otherwise specified in the method or project QA plan. Results of method blank analyses are maintained with other QC data in the respective laboratories. If requested by the client, this data will be included in the report.

Accuracy Measurements

Laboratory Control Samples (LCS), consist of aliquots of ideal matrices (water, sand, etc.) spiked with analytes of interest. LCS's for methods with extensive lists of analytes that may interfere with one another may include a limited number of

analytes, but the analytes included must be representative of as many analytes as is practical. In the case of metals analysis, all analytes of interest must be included. Laboratory pure water is used to prepare most LCS's for methods for analysis of water. Highly characterized solids, where available, are used for LCS's for methods for analysis of solids. Where no such solid LCS is available, spiked laboratory pure water or spiked reagent blanks may be substituted. LCS's provide an estimate of bias based on recovery of the compounds from a clean, control matrix. They provide evidence that the laboratory is performing the method within accepted guidelines without potential non-matrix interferences. They are prepared in duplicate at a rate of one set per twenty samples or one set per 14 days whichever is more frequent.

For tests that are performed infrequently, an LCS and its duplicate shall be analyzed at least monthly if the number of samples is less than 20. This monthly requirement shall NOT apply to low-volume tests for which state certification is not sought, or for tests expected to be performed solely as part of a special project, or for tests involving study specific matrices other than water, soil, sludges and oils.

Matrix Spikes/Matrix Spike Duplicates are similar to the Laboratory Control Sample except the analytes used for spiking are added to a second and third separate aliquot from the same container of a selected few client samples in a batch of analyses. When prepared and analyzed, MS/MSD's can also provide a measure of overall precision. They incorporate sample matrix effects and field conditions. MS/MSD's are routinely prepared at a frequency of 10% when adequate sample volume is provided.

Surrogates provide an estimate of bias based on recovery of similar compounds, but not the compounds analyzed, for each sample, incorporating sample matrix effects and field conditions. Surrogates are added to all samples analyzed by GC/MS and certain GC analyses prior to sample preparation.

An **Internal standard** is an analyte that has the same characteristics as the surrogate, but is added to each sample in a batch, just prior to analysis and is used for quantitation. It corrects for bias or change in instrument performance from sample to sample, incorporating matrix effects associated with the analysis process only.

Precision Measurements

A **Laboratory duplicate** is a laboratory control sample that has been homogenized and split into two equal portions before the method sample preparation process. It measures method precision associated with the preparation through analysis and is

prepared and analyzed at a rate of one per batch or one per twenty samples whichever is greater.

A **Sample duplicate** is a sample that has been homogenized and split into two equal portions before the method sample preparation process. It measures sample precision associated with the preparation through analysis and is prepared and analyzed at a rate of one per batch or one per twenty samples whichever is greater in the inorganic laboratories. For organic analyses the MS/MSD fills this function.

11.2 Control Charts

Control charts are quality control tools which graphically display the QC parameters over time. Accuracy (Figure 11-1) control charts are maintained for each method and matrix. Each chart can be broken into three parts: sample identification, sample response/calculation, and graphic representation (the plot).

11.2.1 Accuracy

For certain analytical programs (NEESA, AFCEE), accuracy charts are maintained for Surrogate and Laboratory Control Sample recovery. Each sample is identified by its PACE NE sample number. The true value (three-significant-figure expected value based on the amount spiked) is denoted as SR. This amount is fixed for each method and matrix to be approximately five to ten times the MDL. The experimental value (three-significant-figure observed value) is denoted by SA and varies for each sample based on the recovery of the amount spiked. From these two values the percent recovery (%R) is calculated as:

$$\%R = (SR / SA) * 100$$

except for the matrix spike sample where the concentration present in the original sample aliquot must also be factored in. For matrix spike samples, the percent recovery is calculated as:

$$(SSR-SR)/SA \times 100$$

where: **SSR** is the spiked sample recovery
SR is the original sample recovery
SA is the amount of spike added

The percent recovery is plotted onto the graph where:

- the x-axis is the number of data points per page; and
- the y-axis is the range of percent recoveries.

11.2.2 Limits

Both upper and lower warning limits and upper and lower control limits are established to aid in interpreting a suspicious or an out-of-control event. Warning limits express a narrower confidence interval and are used to warn the analyst or supervisor of possible system inconsistencies or failures, before an out-of-control event occurs. Control limits express the outer limits of accepted method variability. Control limits and warning limits are updated at least yearly.

Warning Limits

When not mandated by the method, PACE NE adopts warning limits to be the mean ± 2 standard deviations or a 95% confidence interval.

Control Limits

Unless otherwise specified by the analytical method in use or by the project QA plan, PACE NE uses the 99% confidence interval as the control limits, which is defined as the mean ± 3 standard deviations. Where interlaboratory expected ranges have been determined, PACE NE's goal is for their control limits to fall within these multi-laboratory expected ranges for that method. When this does not happen, the method multi-laboratory expected ranges are used.

Both warning and control limits are determined and published at the end of each year for each method and matrix based on the cumulative historic performance. However, a running mean and standard deviation may be calculated with each addition of 20 new data points to demonstrate short term variability and is available to those interested.

Suspicious/Out-of-Control Events

Plotting and connecting successive data points on control charts enables the laboratory to detect many types of suspicious and out-of-control situations. An event is considered suspicious if it falls within the control limits but is statistically out-of-control. Suspicious and out-of-control events can be caught by monitoring the following: outliers (suspicious and out-of-control), runs (suspicious), trends (suspicious), and periodicity (suspicious). Both suspicious and out-of-control events require investigation and corrective action by the laboratory.

Outliers

There are two types of outliers: any particular point that falls outside the control limits or three consecutive points that fall outside the warning limits. A point that falls outside the control limits is classified as an out-of-control event; three points that falls outside the warning limits is classified as a suspicious event.

Runs

A run is defined as a series of points that line up on one side of the central line (the mean). Any run that has a length of eight points is indicative of a potential abnormality in the process, a suspicious event. A run can suggest several potential problems such as a leak in the system, elevated contamination, or incorrect dilutions of standards. When a run is detected investigation and corrective action will be initiated.

Trends

A trend is defined as a series of points that are marked by an unbroken rise or fall. Any trend with a length of five points is classified as a suspicious event. A trend may indicate a change in instrument sensitivity due to a dirty source or injection port or standard degradation, to name a few.

Periodicity

Periodicity is a term used to describe a recurring pattern of change over equal intervals. This occurrence may be of any length or amplitude; thus, careful observation of the control chart is necessary.

11.3 Corrective Action

Procedural changes, insufficient analyst training, an improperly prepared stock solution, or a new standard supplier are some of the things that may lead to a trend being observed. Investigation will be initiated immediately when a trend is observed. A record of the investigation and return to control will be documented on a corrective action report. The reason behind a trend may not be readily discernable and investigation may continue over a period of time. If the quality control data falls with in the 99% confidence limits, data may be reported while investigation continues. If data falls outside the 99% confidence interval, analysis must stop until the system is brought back into control.

11.4 Utilization of Quality Control Data

The purpose for preparing and analyzing quality control samples is to demonstrate, through the known entities, how accurate and precise the investigative sample data are. Tables 11-1 and 11-2 summarize the quality control assessment criteria by matrix for the most commonly used methods by this laboratory. Different criteria may be dictated by different methods or by project QA plans.

TABLE 11-1
TYPICAL QUALITY CONTROL CRITERIA FOR ORGANIC ANALYSES

Parameter	Type	Frequency	Compounds	Performance Criteria	
WATER					
Volatiles (OLMO1.8)	Method blank	1/20 or 1/batch	---	± D.L.	
	System Monitoring Compounds	every sample	$D_4$1,2-dichloroethane	76 to 114%	
			BFB	86 to 115%	
			D_8-toluene	88 to 110%	
				Recovery	RPD
	Matrix Spike/ Matrix Spike Duplicate Sample	1/20 or 1/batch	Benzene	76 to 127%	11
			1,1-dichloroethene	61 to 145%	14
			Trichloroethene	71 to 120%	14
			Chlorobenzene	75 to 130%	13
			Toluene	76 to 125%	13
	Calibration check	every 12 hours		≤ 25% difference from min. RRFs for the majority of target analytes	
Base/neutral Acid compounds (OLMO1.8)	Method blank	1/20 or 1/batch	---	± D.L.	
	Surrogate spike	every sample	D_5 -phenol	10 to 110%	
			2-fluorophenol	21 to 110%	
			2,4,6-tribromophenol	10 to 123%	
			D_5-nitrobenzene	35 to 114%	
			2-fluorobiphenyl	43 to 116%	
			D_{14}-terphenyl	33 to 141%	
			2-chlorophenol-d4 (advisory)	33 to 110%	
			1,2-dichlorobenzene-d4 (")	16 to 110%	
				Recovery	RPD
	Matrix Spike Matrix Spike Duplicate	1/20 or 1/batch	Phenol	12 to 110%	42
			2-chlorophenol	27 to 123%	40
			1,4-dichlorobenzene	36 to 97%	28
			N-nitrosodipropylamine	41 to 116%	38
			1,2,4-trichlorobenzene	39 to 98%	28
			4-chloro-3-methylphenol	23 to 97%	42
			Acenaphthene	46 to 118%	31
			2,4-dinitrotoluene	24 to 96%	38
			4-nitrophenol	10 to 80%	50
			Pentachlorophenol	9 to 103%	50
			Pyrene	26 to 127%	31
	Calibration check	every 12 hours		≤25% difference from min. RRFs for majority of target analytes	

TABLE 11-1 (Continued)

Parameter	Type	Frequency	Compounds	Performance Criteria	
Pesticides & Aroclors (OLM01.8)	Method blank	1/20 or 1/batch	---	± D.L.	
	Instrument Blank	every 12 hours			
	Surrogate spike	every sample	TCX (advisory)	60 to 150%	
			DCB (advisory)	60 to 150%	
				Recovery	RPD
	Matrix Spike	1/20 or 1/batch	Lindane	56 to 123%	15
	Matrix Spike Duplicate		Heptachlor	40 to 131%	20
	LCS		Aldrin	40 to 120%	22
			Dieldrin	52 to 126%	18
			Endrin	56 to 121%	21
			4,4-DDT	38 to 127%	27
			Arochlor 1254	27 to 122%	
	Calibration check	every 12 hours		PEMs - ≤25 %D ≤20% breakdown	
Pesticides & Aroclors (method 8080)	Method blank	1/20 or 1/batch	---	± D.L.	
	Surrogate spike	every sample	Dibutyl chlorendate	24 to 154%	
				Recovery	RPD
	Laboratory Control Sample, MS/MSD	1/20 or 1/batch	Lindane	56 to 123%	15
			Heptachlor	40 to 131%	20
			Aldrin	40 to 120%	22
			Dieldrin	52 to 126%	18
			Endrin	56 to 121%	21
			4,4-DDT	38 to 127%	27
	Calibration check	every 10 samples		≤ 15% difference	
SOIL					
Volatiles (OLM01.8)	Method blank	1/20 or 1/batch	---	± D.L.	
	System monitoring compound spike recovery	every sample	$D_4$1,2-dichloroethane	70 to 121%	
			BFB	59 to 113%	
			D_8-toluene	84 to 138%	
				Recovery	RPD
	Matrix Spike				
	Matrix spike duplicate Sample	1/20 or 1/batch	Benzene	66 to 142%	21
			1,1-dichloroethene	59 to 172%	22
			Trichloroethene	62 to 137%	24
			Chlorobenzene	60 to 133%	21
			Toluene	59 to 139%	21
	Calibration check	every 12 hours		≤ 25% difference from min. RRFs for the majority of target analytes	

TABLE 11-1 (Continued)

Parameter	Type	Frequency	Compounds	Performance Criteria	
Base/Neutral Acid compounds (OLMO1.8)	Method blank	1/20 or 1/batch	—	± D.L.	
	Surrogate spike	every sample	D_5 -phenol	24 to 113%	
			2-fluorophenol	25 to 121%	
			2,4,6-tribromophenol	19 to 122%	
			D_5-nitrobenzene	23 to 120%	
			2-fluorobiphenyl	30 to 115%	
			D_{14}-terphenyl	18 to 137%	
			2-chlorophenol-d4 (advisory)	20 to 130%	
			1,2-dichlorobenzene (*)	20 to 130%	
				Recovery	RPD
	Matrix Spike Matrix Spike Duplicate Sample	1/20 or 1/batch	Phenol	26 to 90%	35
			2-chlorophenol	25 to 102%	50
			1,4-dichlorobenzene	28 to 104%	27
			N-nitrosodipropylamine	41 to 126%	38
			1,2,4-trichlorobenzene	38 to 107%	23
			4-chloro-3-methylphenol	26 to 103%	33
			Acenaphthene	31 to 137%	19
			2,4-dinitrotoluene	28 to 89%	47
			4-nitrophenol	11 to 114%	50
			Pentachlorophenol	17 to 109%	47
			Pyrene	35 to 142%	36
	Calibration check	every 12 hours		≤25% difference from min. RRFs for the majority of target analytes	
Pesticides & Aroclors (OLMO1.8)	Method blank	1/20 or 1/batch	—	± D.L.	
	Instrument Blank	every 12 hours			
	Surrogate spike	every sample	TCX (advisory)	60 to 150%	18 to 150%
			DCB (advisory)	60 to 150 %	
				Recovery	RPD
	Matrix Spike Matrix Spike Duplicate LCS	1/20 or 1/batch	Lindane	46 to 127%	50
			Heptachlor	35 to 130%	31
			Aldrin	34 to 132%	43
			Dieldrin	31 to 134%	38
			Endrin	42 to 139%	45
			4,4-DDT	23 to 134%	50
			Arochlor 1254	21 to 128%	
	Calibration check	every 12 hours	INDs - ≤25 %D	PEMs - ≤25 %D; ≤20% breakdown	
Pesticides & PCBs (method 8080)	Method blank	1/20 or 1/batch	—	± D.L.	
	Surrogate spike	every sample	Dibutyl chlorendate	18 to 150%	
				Recovery	RPD
	Laboratory Control Sample, MS/MSD	1/20 or 1/batch	Lindane	46 to 127%	50
			Heptachlor	35 to 130%	31
			Aldrin	34 to 132%	43
			Dieldrin	31 to 134%	38
			Endrin	42 to 139%	45
			4,4-DDT	23 to 134%	50
	Calibration check	every 10 samples		≤ 15% difference	

TABLE 11-2
TYPICAL QUALITY CONTROL CRITERIA FOR INORGANICS ANALYSES

Soil and Water

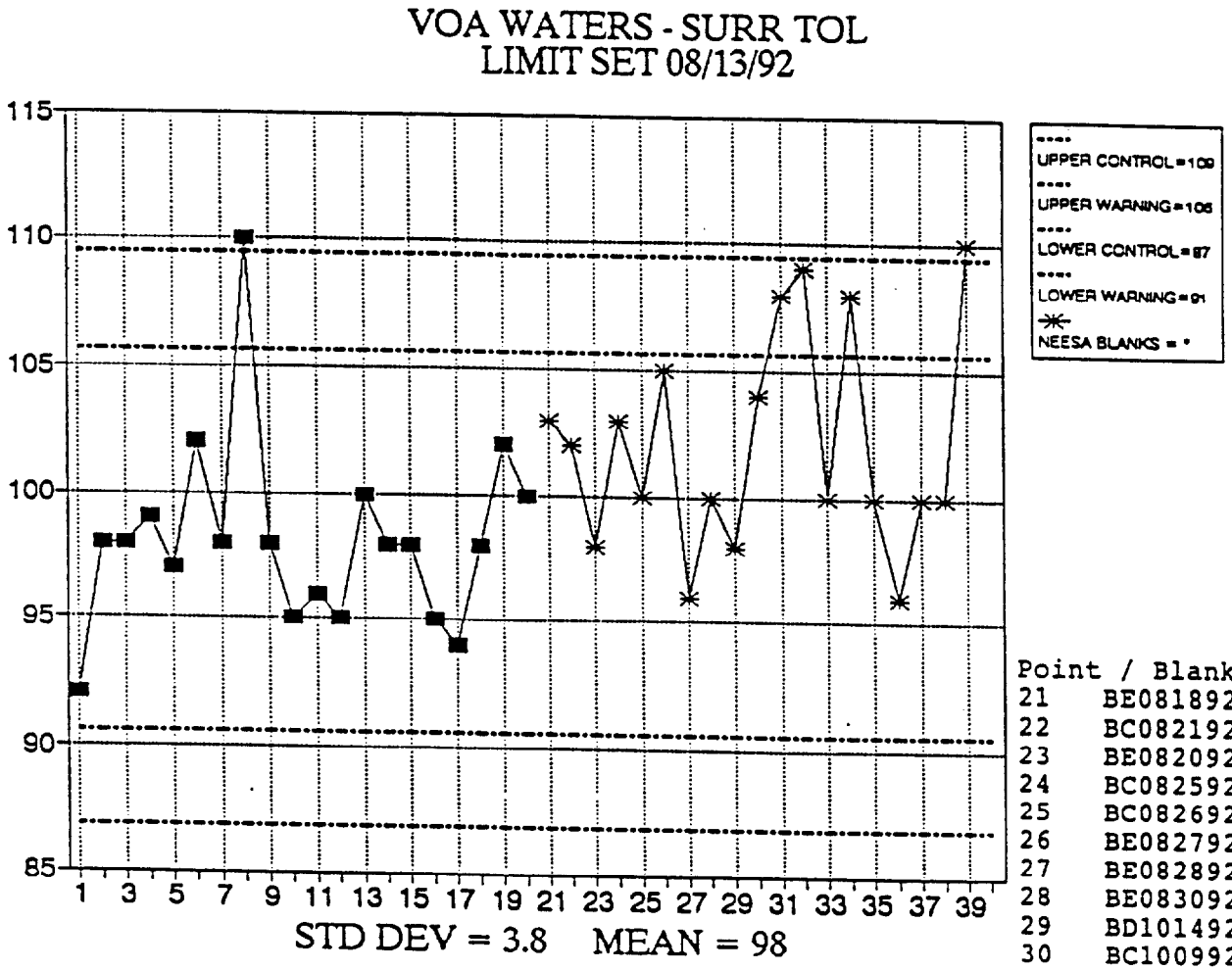
Parameter	Type	Frequency	Performance Criteria
Metals by ICP (Method 6010)	Calibration Blank	every calibration	± D.L.
	Calibration verification	every calibration	90 to 110%
	Continuing calibration	1/10 samples	90 to 110%
	Method blank	1/20 or 1/batch	± D.L.
	Laboratory Control Sample/LSC dup	1/20 or 1/batch	80 to 120%
	Sample duplicate	1/20 or 1/batch	± D.L. or 20% RPD
	Matrix Spike	1/20 or 1/batch	75 to 125%
Metals by Furnace AA (7000 series methods)	Calibration blank	every calibration	± D.L.
	Calibration verification	every calibration	90 to 110%
	Continuing calibration	1/10 samples	90 to 110%
	Method blank	1/20 or 1/batch	± D.L.
	Laboratory Control Sample/LCS dup	1/20 or 1/batch	80 to 120%
	Sample duplicate	1/20 or 1/batch	± D.L. or 20% RPD
	Matrix Spike	1/20 or 1/batch	75 to 125%
	Duplicate injections	every sample and standard	± 20% RPD
Cold Vapor AA (Mercury)	Calibration blank	every calibration	± D.L.
	Calibration verification	every calibration	80 to 120%
	Continuing calibration	1/10 samples	80 to 120%
	Method blank	1/20 or 1/batch	± D.L.
	Lab control sample/LCS Dup	1/20 or 1/batch	80 to 120%
	Sample duplicate	1/20 or 1/batch	± D.L. or 20% RPD
	Matrix Spike	1/20 or 1/batch	75 to 125%
Total Petroleum Hydrocarbons	Calibration blank	every calibration	± D.L.
	Calibration verification	every calibration	85 to 115%
	Continuing calibration	1/10 samples	85 to 115%
	Method blank	1/20 or 1/batch	± D.L.
	Lab control sample	1/20 or 1/batch	75 to 125%
	Sample duplicate	1/20 or 1/batch	± 30% RPD
Total Cyanide	Calibration blank	every calibration	± D.L.
	Calibration verification	every calibration	85 to 115%
	Continuing calibration	1/10 samples	85 to 115%
	Method blank	1/20 or 1/batch	± D.L.
	Laboratory Control Sample/LCS dup	1/20 or 1/batch	80 to 120%
	Sample duplicate	1/20 or 1/batch	± 30% RPD
	Matrix Spike	1/20 or 1/batch	75 to 125%
General Wet Chemistries	Calibration blank	every calibration	± D.L.
	Calibration verification	every calibration	85 to 115%
	Continuing calibration	1/10 samples	85 to 115%
	Method blank	1/20 or 1/batch	± D.L.
	Laboratory Control Sample/LCS dup	1/20 or 1/batch	80 to 120%
	Sample duplicate	1/20 or 1/batch	± 30% RPD
	Matrix Spike	1/20 ro 1/batch	75 to 125%

TABLE 11-2 (cont.)
TYPICAL QUALITY CONTROL CRITERIA FOR INORGANICS ANALYSES

Soil and Water

Parameter	Type	Frequency	Performance Criteria
Metals by ICP (ILMO3.0)	Calibration Blank	1/10 samples	< CRDL
	Calibration verification	every calibration	90 to 110%
	Continuing calibration	1/10 samples	90 to 110%
	Method blank	1/20 or 1/batch	< CRDL
	Laboratory Control Sample/LSC dup	1/20 or 1/batch	80 to 120%
	Sample duplicate	1/20 or 1/batch	± D.L. or 20% RPD
	Matrix Spike	1/20 or 1/batch	75 to 125%
Metals by Furnace AA (ILMO3.0)	Calibration blank	1/10 samples	< CRDL
	Calibration verification	every calibration	90 to 110%
	Continuing calibration	1/10 samples	90 to 110%
	Method blank	1/20 or 1/batch	< CRDL
	Laboratory Control Sample/LCS dup	1/20 or 1/batch	80 to 120%
	Sample duplicate	1/20 or 1/batch	± D.L. or 20% RPD
	Matrix Spike	1/20 or 1/batch	75 to 125%
	Duplicate injections	every sample and standard	± 20% RPD
Cold Vapor AA (Mercury ILMO3.0)	Calibration blank	1/10 samples	< CRDL
	Calibration verification	every calibration	80 to 120%
	Continuing calibration	1/10 samples	80 to 120%
	Method blank	1/20 or 1/batch	< CRDL
	Lab control sample/LCS Dup	1/20 or 1/batch	80 to 120%
	Sample duplicate	1/20 or 1/batch	± D.L. or 20% RPD
	Matrix Spike	1/20 or 1/batch	75 to 125%
Total Cyanide (ILMO3.0)	Calibration blank	every calibration	± D.L.
	Calibration verification	every calibration	85 to 115%
	Continuing calibration	1/10 samples	85 to 115%
	Method blank	1/20 or 1/batch	± D.L.
	Laboratory Control Sample/LCS dup	1/20 or 1/batch	80 to 120%
	Sample duplicate	1/20 or 1/batch	± 20% RPD
	Matrix Spike	1/20 or 1/batch	75 to 125%

Figure 11-1
Examples of Accuracy Control Chart



Point	/ Blank
21	BE081892A
22	BC082192A
23	BE082092A
24	BC082592A
25	BC082692A
26	BE082792A
27	BE082892B
28	BE083092A
29	BD101492A
30	BC100992A
31	BC110692A
32	BC111992A
33	BE112092A
34	BC112392A
35	BG113092B
36	BG120192A
37	BC122292A
38	BG013093B
39	BC012193A

12.0 STANDARD OPERATING PROCEDURES

12.1 Purpose and General Provisions

Standard Operating Procedures (SOPs) are formal, revision-controlled documents that:

1) define, to PACE NE's clients and to regulatory agencies, the methods used by PACE NE in the performance of tasks having an effect on the quality of data, findings or conclusions;

2) establish the basis for similar training of personnel and set a standard for assessment;

3) provide standard methods for execution and documentation of work, to maximize consistency, uniformity and reliability of products; and

4) facilitate coordination among individuals performing separate, but interdependent tasks.

SOPs describe standard methodologies that may at times be inappropriate for a specific project. In such cases, exceptions to the SOPs are stated in an SOP Deviation Form, with rationale. The SOP Deviation form is kept as part of the data package archived at PACE NE.

12.2 Responsibilities

The Laboratory Section Managers are responsible for determining, through consultation with the Quality Assurance Officer and PACE NE Management, the activities that require SOPs, and for working with the appropriate technical personnel to develop the SOPs.

The Quality Assurance Department is responsible for obtaining technical review and approval of SOPs, for maintaining control of new SOPs and revisions, and for maintaining an up-to-date distribution list for SOPs.

PACE NE personnel are responsible for performing tasks in accordance with applicable SOPs, except as explicitly directed by the relevant Quality Assurance Project Plan, contract, or Health and Safety policy. PACE NE personnel are also responsible for assisting in designing accurate and practical SOPs and in keeping the SOPs up-to-date.

Technical reviewers of SOPs are responsible for providing review of drafts sent to them within the schedule indicated in the request.

12.3 Minimum Contents of SOPs

Each Standard Operating Procedure shall contain at a minimum, the following information:

Title - The name of the concerned task

SOP Number - The internal document control number assigned and tracked by the QA Department

Acceptance - The signature of the originator(s), Quality Assurance Officer and appropriate operations management authority to officially adopt the procedure

Date - date of issue of most recent revision

Section 1.0 - Purpose and Applicability - An explanation of the objectives of the procedure, typical applications and limitations

Section 2.0 - Definitions - A listing of any terms, expressions, or acronyms found in the procedure

Section 3.0 - Applicable Documents/References - A listing of pertinent, supporting procedure or reference documents such as methods, manuals and/or SOPs

Section 4.0 - Apparatus and Materials - A complete list of the equipment, apparatus, reagents, etc. needed for the procedure

Section 5.0 - Method/Procedure - A clear description of the task on a step-by-step basis. The method description should be written clearly enough, and in sufficient detail, to ensure that any two persons performing the procedure will achieve equivalent results, and to provide clients and reviewing agencies with a thorough understanding of the procedure. Acceptable and equivalent alternatives should be addressed whenever possible, and described in the same detail

Section 6.0 - Quality Control Requirements and Acceptance Criteria - An outline of quality control requirements, including procedures frequency requirements and acceptance criteria. Acceptance criteria may take the form of an illustration such as a

chart of acceptable results with tolerances, or other appropriate forms

Section 7.0 - Calculations, Data Management and Reporting of Results - A summary of the automated and manual calculations performed as well as reporting requirements, including data flow charts as appropriate

Section 8.0 Corrective Actions - A description of what must be done, when and by whom in instances when the QC requirements are not met

Section 9.0 Responsibilities - Identification of the individuals (by title or organizational position) who are responsible for performing and facilitating the tasks governed by the SOP

Section 10.0 Health and Safety Considerations - A discussion of specific Health and Safety issues that must be considered prior to and during the performance of the procedure described.

12.4 SOP Development and Approval

Laboratory SOPs are developed by the laboratory's technical staff, working with the QA Department (PACE NE SOP QA-553 Preparation of SOP's). The QA Department will also assist by assigning SOP numbers and by coordinating word processing, review and approval. Laboratory SOPs must be reviewed and approved by the management of the laboratory operations to which the SOPs apply. Thus, the following people must review and approve each laboratory SOP:

- the Supervisor of the specific operation to which the SOP pertains if applicable) or the Laboratory Manager - This signature indicates that the written SOP reflects the current practice in the laboratory.
- the Laboratory Technical Director - This signature indicates that the SOP is technically adequate to handle the analysis of environmental samples expected to be received at PACE NE and technically compliant within the framework given in Section 8.0 and with any known exceptions noted.
- the Quality Assurance Officer - This signature indicates that the SOP has been reviewed for compliance with the referenced methods and that desrepencies between the method and practice have been resolved.
- the PACE NE Regional Director - This signature signifies a management review and approval of the practices detailed in the SOP.

12.5 Numbering

Each SOP is assigned a unique PACE NE number from the Inventory of PACE NE SOPs, maintained by the QA Department. Each laboratory section has been assigned a block of numbers.

12.6 Revisions

SOP revisions may be necessitated by regulatory requirements, technological advancements or other causes, but not by the requirements of a single project alone. Contradictions between standard procedures and the requirements of a specific project are resolved in the quality assurance plan for that project and are controlled internally through the generation of an SOP Deviation Form (Figure 12-1).

Revisions may be proposed initially by the Quality Assurance Department or they may be recommended by users. Recommendations for revisions must be sent to the Quality Assurance Department.

Technical changes to an SOP need to be made immediately, but revisions must not be made by an individual to only his/her personal copy. If there are changes to an SOP, they need the approval of the Group Supervisor, Lab Manager and QA and must be made manually to ALL copies of that SOP in use in the lab. A formal revision should be initiated ASAP. Recommendations for minor revisions will be accumulated by QA until sufficient to warrant a document revision.

Revisions are accomplished by the preparation of a new typed draft with the changes incorporated and listed on the cover page. (The cover page is a permanent document and stays with the SOP despite revisions.) Approval of the revisions is signified by dated acceptance signatures adjacent to the listed revisions in the lower section of the cover page. The QA Officer is authorized to approve minor revisions. Revisions which effect the technical approach or content will also require review and approval of a technical or section manager. Once formally accepted, the revised document replaces the previous version and is distributed to controlled copy holders with instructions as to what document(s) it replaces.

Occasionally, revisions are significant enough to warrant a complete rewrite. In such cases, the changes are not listed on the cover page. Instead the words "complete rewrite" are entered and the new document must undergo review and approval as for a new SOP. The judgement as to whether a complete rewrite is required shall be made by the Quality Assurance Officer.

Technical revisions and complete rewrites will necessitate training recertification for all personnel involved. The laboratory or section manager is responsible for ensuring that training is accomplished and documented. Required training documentation and instructions will be distributed with the SOPs by the QA Department.

12.7 Distribution

The QA Department distributes SOPs to technical staff and maintains distribution lists to ensure that revisions and new SOPs are distributed to all responsible individuals. The QA Department maintains a complete set of up-to-date SOPs and distributes them as required. An SOP archive is maintained by QA Department and SOPs are distributed from that archive.

12.8 SOP Archive

An archive of all PACE NE SOPs, in the form of both hard-copy and electronic masters of current revisions, are maintained by the Quality Assurance Department. The hard-copy archive also contains a hard-copy master of all obsolete versions of each revised SOP.

Access to originals is obtained through QA personnel.

Figure 12-1
SOP Deviation Form
(Revision 1, 1/93)

SOP Number and Title:_____

Date and Signature_____

Lab Number/Job/or Client deviation applies to:

_____
_____
_____

Describe deviation in detail, including normal procedure and reason for deviation:

_____
_____
_____
_____
_____
_____
_____
_____
_____
_____

Approval/Date

_____Date_____
Technical Director

_____Date_____
Quality Assurance Officer

_____Date_____
Regional Director

13.0 PERFORMANCE AND SYSTEM AUDITS

PACE NE's Analytical Chemistry Laboratory participates in a variety of interlaboratory tests and intralaboratory and performance checks to provide periodic assessment of the effectiveness of the overall quality control program.

13.1 Interlaboratory Performance Surveys

Performance surveys conducted by the EPA and the New Hampshire Department of Environmental Services constitute the bulk of interlaboratory comparisons.

- EPA Performance Evaluations - Water Supply - Semiannual (April and September)

  - Trace Metals
  - Nitrate/Nitrite/Fluoride
  - Insecticides
  - Herbicides
  - PAH's
  - Adipate/Phthalates
  - Trihalomethanes (THMs)
  - Volatile Organic Compounds
  - Residual Free Chlorine
  - Turbidity
  - Total Filterable Residue
  - Calcium (as $CaCO_3$)
  - pH
  - Alkalinity
  - Corrosivity
  - Sodium
  - Sulfate
  - Total Cyanide

- EPA Performance Evaluations - Water Pollution - Semiannual (February and August)

  - Trace Metals
  - Minerals
  - Nutrients

- Demand
- PCB's
- PCB's in Oil
- Pesticides
- Volatile Halocarbons
- Volatile Aromatics
- Total Cyanide
- Non-Filterable Residue
- Oil and Grease
- Total Phenolics

PACE NE's performance is evaluated by the respective agency after each round of testing, and reported to the Laboratory Technical Director. The Laboratory Technical Director forwards the results to the QA Auditor in charge of certifications. The QA Auditor distributes copies of the results to section managers and the QA Officer.

In addition to the EPA WP/WS performance evaluation studies, PACE NE participates in a number of different state, federal and commercial studies such as the State of New York, US Navy NEESA, US Army COE, USEPA CLP Quarterly Blind samples, US EPA DMR PE studies, and Chemical Waste Management round robin studies.

13.2 Periodic Internal Audits

Internal auditing is conducted by the QA Auditors. These audits occur at least every month, and typically focus on either performance relative to an SOP or a specific project. Internal audits take two forms - performance audits and systems audits. Performance audits involve submittal of blind spikes to the laboratory by the Quality Assurance Department for assessment of analytical accuracy. Systems audits consist of a thorough review of procedures and documentation to confirm that work was performed in accordance with this Manual, SOPs, and/or project QA Plan and that adequate documentation exists to satisfy the project requirements.

13.2.1 Performance Audits

<u>Audit Standards</u>

As required on specific projects, the Quality Assurance Department provides spikes for analysis as independent check samples (audit standards). The QA Department prepares any audit standards that can be prepared readily from relatively non-hazardous, pure materials or certified concentrated standards. In

some cases, preparation of reliable audit standards requires special facilities and equipment due to the hazardous nature of the materials and/or the requirement for precise measurement of minute quantities. In such cases, audit standards are obtained from the USEPA, Environmental Monitoring and Support Laboratory (EMSL), Cincinnati, Ohio, or from an equivalent source. The nature of the audit standards and the frequency of performance audits are specified in the Quality Assurance Plan of each project for which performance auditing is required. When practical, audit standards are provided in matrices resembling real project sample matrices, and undergo the full sample preparation and analysis procedure. However in many cases this is impractical, and it is necessary to submit audit samples as extracts, for analysis only. All measurable constituents in the audit standards should be within the expected range of concentrations to be encountered in the real samples (or in the extracts).

13.2.2 Systems Audits

There are two different types of laboratory systems audits. Systems audits of laboratory operations are performed at a minimum frequency of once every month. Systems audits address general laboratory operations and conformance to the Laboratory Quality Assurance Manual. Some project quality assurance plans require project-specific laboratory systems audits (Project Audits).

Systems Audit Procedures

The systems audits are performed by the Quality Assurance Auditors. Audit checklists are used to ensure that all salient points are addressed and documented. The checklists are filled out legibly and reproduceably, in ink, by the auditor, and are signed and dated by the auditor when completed. The audit checklist is based on EPA laboratory evaluation criteria, the provisions of the Laboratory Quality Assurance Manual and PACE NE SOPs. Project audit checklists are drawn from the applicable QAPPs, as well as relevant provisions of the QA Manual.

Audit checklists will cover at least the following areas:

- Systems Audit
  - Personnel qualifications and training records
  - Adequacy of laboratory facilities, including work space, lighting, ventilation, and supplies
  - Maintenance and calibration recordkeeping for analytical

equipment
- Safety (facility configuration and practices)
- General operations, including glassware cleaning, inventory and checking of reagents and standards, and storage procedures
- Recordkeeping, including sample log-in and tracking, traceability of standards, control charts, and raw data recording and tracking.

- Project Audit

  - Sample log-in and chain-of-custody records
  - Sample storage procedures and records
  - Sample preparation and analysis procedures
  - Method validation (where applicable)
  - Conformance to QAPP
  - Control charts
  - Precision and accuracy assessment
  - Method blanks, reagent blanks, duplicates, check samples, fortifications, surrogates, etc.
  - Calibration
  - Data packages
  - Analyst qualifications
  - Data validation and reporting

13.3 QA Reporting and Corrective Action

Each systems audit is immediately followed by a debriefing, in which the auditor discusses his/her findings with the laboratory representatives. The debriefing serves a two-fold purpose. First, laboratory management is afforded an early summary of findings, which allows them to begin formulating corrective strategies, and second, the auditor has a chance to test preliminary conclusions and to correct any misconceptions before drafting his report.

The systems audit report (which may or may not contain performance audit findings) is issued to the Laboratory Manager and appropriate supervisors and personnel for corrective action. These responses are forwarded, in writing, to the auditor. The auditor then circulates the report to the QA Officer, laboratory management and to company management.

Results of interlaboratory performance surveys and in-house audits, along with unresolved corrective action items are summarized in a monthly report from the Quality Assurance Officer to the PACE NE Regional Director.

14.0 PREVENTIVE MAINTENANCE

To minimize downtime and interruption of analytical work, preventive maintenance is routinely performed on each analytical instrument. Designated laboratory personnel are trained in routine maintenance procedures for all major instrumentation. When repairs are necessary, they are performed by either trained staff or instrument manufacturer service personnel.

SOPs are written for each instrument that cover basic operation and maintenance procedures (QA-800, Use, Calibration, and Maintenance of Equipment - Inorganics Lab, QA-801, Use, Calibration, and Maintenance of Equipment - Organics Lab). Detailed logbooks documenting preventive maintenance, non-routine maintenance and repairs are also maintained for each instrument. The following are brief summaries of maintenance for each major instrument.

14.1 Preventive Maintenance - GC/MS

Regularly performed maintenance includes, but is not limited to the following for GC/MS instrumentation:

- hard tune with calibration gas (PFTBA)
- removal of 2-3 inches from the injection end of the capillary columns
- replacement of 2-3 inches of column packing from the injection end of packed columns
- injection port liner replacement
- replace injection port septum
- clean ion source as needed
- check vacuum pump oil level
- check carrier gas tanks
- replace or recondition vent traps

14.2 Preventive Maintenance - GC

Regularly performed maintenance includes, but is not limited to the following for GC instrumentation:

- replacement of 2-3 inches from the injection end of the capillary columns
- removal of 2-3 inches of column packing from the injection end of packed columns
- injection port liner replacement
- replace septum
- check carrier and support gases
- NRC wipe test ECD

14.3 Preventive Maintenance - ICP

- check liquid argon tank level
- change pump tubing
- clean nebulizer and spray chamber as needed
- replace and realign plasma torch when required
- check cooling system water level
- empty waste reservoir when full

14.4 Preventive Maintenance - AA Graphite Furnace

- check and align source lamps
- clean and inspect graphite tube, replacing when surface appears excessively burnt or cracked
- clean and inspect contact ring, replacing when excessively worn

- clean mirrors for optical sensor and sample compartment windows
- check autosampler injector alignment and deposition

14.5 Preventive Maintenance - Mercury Analyzer

- Check and align source lamp
- remove and clean sample cell and connecting tubes
- check sparger for proper operation
- clean sample compartment windows

14.6 Preventive Maintenance - General Laboratory Areas

- clean and calibrate balances biannually
- check balance calibration each day of use
- clean balance pan prior to each use
- calibrate class "S" weights every two years
- calibrate automatic pipets and burets monthly
- calibrate thermometers yearly against an NBS traceable thermometer
- record refrigerator, freezer, and oven temperatures each weekday
- clean, check, calibrate to manufacturers specifications all pH, DO, conductivity and, turbidity meters, and spectrophotometers biannually
- general housekeeping: keep counter tops, hoods, and floors clean
- check airflow in hoods once a week

15.0 CORRECTIVE ACTION

When errors, deficiencies, unusual occurrences, or out-of control situations exist, the QA program provides systematic procedures, called "corrective actions", to resolve problems and restore proper functioning to the analytical system. Within PACE NE, a distinction is made between "out-of-control events" and "unusual occurrences" for the purposes of requiring corrective actions.

An out-of-control event is any event which is beyond the acceptance limits established for laboratory operation by PACE NE SOP's, EPA methods, or client specific contracts or protocols. This can be due to data which are outside of the accepted bounds for accuracy and/or precision, method contamination, improper instrument calibration or maintenance, or deviations from the contract or SOP detected by a QA audit.

An unusual occurrence is a situation in which the analytical system is, strictly speaking, compliant with the protocol or SOP and therefore in control but an atypical or undesirable incident has occurred which warrants further investigation. Such an occurrence could be a holding blank which is contaminated or differences in the pattern of non-spiked target compounds between a spiked and unspiked aliquot of a sample used as the matrix spike.

Both out-of-control events and unusual occurrences are noted on a PACE NE Corrective Action Report (Figure 15-1). A corrective action report must be generated whenever either type of event is noted.

15.1 Out-of Control Events

Out-of-control events associated with the statistical analysis and review of data are straight forward to identify. The analyst generating the data is responsible for checking the results against the established limits. Any deviations are immediately addressed. If data are outside accepted limits, the analyst immediately notifies the responsible section supervisor. If the situation is not corrected so that an out-of-control condition occurs, or is expected to, the section supervisor shall notify the Laboratory Manager and the Quality Assurance Officer. The Laboratory Manager and Section Supervisors are responsible for identifying the source of the problem and initiating corrective action. Completion of corrective action should be evidenced by the return of data to prescribed acceptable limits.

Events which do not readily cause an immediate obvious effect on data quality are more difficult to identify. Such events could be samples stored at an incorrect temperature or held beyond prescribed holding times, or improper maintenance of records. Everyone in the laboratory is

responsible for reporting "system" problems. Analysts should report out-of-control events to their supervisor, the Section Supervisors, who should in turn **report** to the Laboratory Manager. Corrective action is again the responsibility of the Laboratory Manager and the Section Supervisors. They shall review and approve the action taken.

If an out-of-control event does occur during analysis, for instance an LCS recovery falls outside the expected range, the analyst must describe on the corrective action report the event, the investigative and corrective actions taken, the cause of the event, and notify the QA Officer. In some cases, investigation of an out-of-control event will reveal no problems. In such cases, only the event and the investigative action is recorded.

The investigative action taken is somewhat dependent on the analysis and the event. However, listed below is a progression of steps which may be taken to find the cause of an out-of-control event:

- Check calculations to ensure there are no errors
- Check standard and spiking solutions for degradation or contamination
- Check instrument performance

If the problem is with the standards or instrument performance, the analyst must recalibrate or retune the instrument before reanalyzing the sample extracts affected. If the out-of-control condition is still not remediated, the samples may require reextraction and reanalysis or data qualification.

It is occasionally necessary to qualify data when the accompanying quality control data are not within established performance criteria. The qualifying of data alert the data end user to the fact that the analysis was, to some degree, flawed and that the precision and accuracy of the data produced may not fulfill the data quality objectives (DQOs) for that particular project. Based on the project DQOs, analytical data with qualifiers may not be appropriate for the intended use.

15.1.1 Volatile Organic Analyses

Method Blanks

If target compounds are detected in the method blank above the detection limit (above 5 times the detection limit for methylene chloride, acetone, toluene, and 2-butanone) the corrective action consists of checking the calculations, reanalyzing the blank, qualifying the associated sample data, and investigating the source of the problem to implement corrective action for the future. When target list compounds are detected in a method blank, the following condition applies:

- When any target compound is detected in a method blank above the action levels listed earlier, but not in associated samples, then no qualifier is applied.

Surrogates

The % recovery of the surrogates is calculated for each sample, blank, and LCS. Corrective action is taken whenever one (or more) surrogate recovery is outside the acceptance criteria. The following corrective actions are taken when required as stated above:

- Check calculations to assure there are no errors;
- Check internal standard and surrogate solutions for degradation, contamination, etc., and check instrument performance;
- If instrument failure is indicated, reanalyze the sample;
- If a method blank surrogate is outside of acceptance criteria, then the problem must be corrected before proceeding with sample analysis. This may include reanalysis, reextraction or recalibration;
- If the surrogate could not be measured because the sample required a dilution, no corrective action is required. The recovery of the surrogate is recorded with the note "surrogate diluted out".
- If all QC associated with the sample is within acceptance limits (the method blank surrogate recovery and LCS spike recovery), the problem may be attributed to a matrix effect. Samples exhibiting a matrix effect will be qualified and discussed in the report narrative.

Laboratory Control Sample/Laboratory Control Sample Duplicates

The % recovery of the Laboratory Control Samples (LCS) and the relative percent difference (RPD) for LCS Duplicates are calculated. Corrective action is taken whenever one (or more) recovery or RPD is outside the established acceptance criteria. The following corrective actions are taken when required as stated above:

- Check calculations to assure there are no errors;

- Check internal standard and spiking standard solutions for degradation, contamination, etc., and check instrument performance;
- Reanalyze samples associated with a failed LCS, if available;
- If that does not correct the problem, then the data is reported and a qualifying statement included in the report narrative.

For Matrix Spike and Matrix Spike Duplicates, if all QC associated with a sample is within acceptance limits (the method blank and LCS/LCS dup spike recovery), the problem may be attributed to a matrix effect. Samples exhibiting a matrix effect will be qualified and discussed in the report narrative.

Calibration

For an initial 5 point calibration curve to be valid, the % relative standard deviation of the individual relative response factors (RRF) for the Calibration Check Compounds (CCC) shall be less than or equal to 25%. If this criteria is not met, then the calibration curve shall be reanalyzed.

For continuing calibration checks to be valid, the relative response factor for each of the System Performance Check Compounds (SPCC) should be at least 0.300 (0.250 for Bromoform) and the RRF for each of the CCC should be $\leq$25% different from the average RRF from the initial calibration. If these criteria are not met, then the following corrective actions should be taken:

- Check internal standard and standard solutions for degradation, contamination, etc.,
- Check instrument for contamination at the injection port inlet and front end of the column;
- If no source of the problem is identified, then a complete 5 point initial calibration must be performed.

The SPCC and CCC for Volatiles are:

SPCC	CCC
Chloromethane	Vinyl Chloride
1,1-Dichloroethane	1,1-Dichloroethene
Bromoform	Chloroform

1,1,2,2-Tetrachloroethane	1,2-Dichloropropane
Chlorobenzene	Toluene
	Ethylbenzene

15.1.2 Semivolatile Organic Compounds

Method Blanks

If target compounds are detected in the method blank above the detection limit (above 5 times the detection limit for phthalate esters) the corrective action consists of the following:

- checking the calculations;
- reanalyzing the blank;
- flagging the associated sample data;
- investigating the source of the problem to implement corrective action for the future.

When target list compounds are detected in a method blank, the following data condition applies:

- when any target compound is detected in a method blank above the action levels listed earlier but not in associated samples, then no flag is applied.

Surrogates

The % recovery of the surrogates is calculated for each sample, blank, and standard. Corrective action is taken whenever one (or more) surrogate recovery from either the base/neutral or acid fraction is outside the acceptance criteria. The following corrective actions are taken when required as stated above:

- Check calculations to assure there are no errors;
- Check internal standard and surrogate solutions for degradation, contamination, etc., and check instrument performance;
- If instrument failure is indicated, reanalyze the sample;

- If more than one method blank surrogate is outside of acceptance criteria or if one surrogate yields less than 10% recovery, then the problem must be corrected before proceeding with sample analysis. This may include reanalysis, reextraction or recalibration;

- If the surrogate could not be measured because the sample required a dilution, no corrective action is required. The recovery of the surrogate is recorded with the note "surrogate diluted out";

- If all QC associated with the sample is within acceptance limits (the method blank surrogate recovery and LCS spike recovery), the problem may be attributed to a matrix effect. Samples exhibiting a matrix effect will be qualified and discussed in the report narrative.

Laboratory Control Sample/Laboratory Control Sample Duplicates

The % recovery of the Laboratory Control Samples and the relative percent difference (RPD) for LCS Duplicates are calculated. Corrective action is taken whenever one (or more) recovery or RPD is outside the acceptance criteria. The following corrective action is taken when required as stated above:

- Check calculations to assure there are no errors;

- Check internal standard and spiking standards solutions for degradation, contamination, etc., and check instrument performance;

- Reanalyze all associated samples, if available;

- If that does not correct the problem, then the data is reported and a qualifying statement regarding the laboratory control sample is included in the report narrative.

For Matrix Spike and Matrix Spike Duplicates, if all QC associated with a sample is within acceptance limits (the method blank and LCS/LCS dup spike recovery), the problem may be attributed to a matrix effect. Samples exhibiting a matrix effect will be qualified and discussed in the report narrative.

Calibration

For an initial 5 point calibration curve to be valid, the % relative standard

deviation of the individual relative response factors (RRF) for the Calibration Check Compounds (CCC) should be less than or equal to 40%. If this criteria is not met, then the calibration curve should be reanalyzed.

For continuing calibration checks to be valid, the relative response factor for each of the System Performance Check Compounds (SPCC) should be at least 0.050 and the RRF for each of the CCC should be $\leq$ 40% different from the average RRF from the initial calibration. If these criteria are not met, then the following corrective actions should be taken:

- Check internal standard and standard solutions for degradation, contamination, etc.,
- Check instrument for contamination at the injection port inlet and front end of the column;
- If no source of the problem is identified, then a complete 5 point initial calibration must be performed.

The SPCC and CCC for Semivolatiles are:

<u>SPCC</u>

N-Nitroso-di-n-propylamine
Hexachlorocyclopentadiene
2,4-Dinitrophenol
4-Nitrophenol

<u>CCC</u>

Acenaphthene	4-Chloro-3-Methylphenol
1,4-Dichlorobenzene	2,4-Dichlorophenol
Hexachlorobutadiene	2-Nitrophenol
N-Nitroso-di-phenylamine	Phenol
Di-n-octylphthalate	Pentachlorophenol
Fluoranthene	2,4,6-Trichlorophenol
Benzo(a)pyrene	

15.1.3 Gas Chromatography

Method Blanks

If target compounds are detected in the method blank above the detection limit the corrective action consists of the following:

- checking the calculations;
- reanalyzing the blank;
- flagging the associated sample data;
- Investigating the source of the problem to implement corrective action for the future.

When target compounds are detected in a method blank, the following conditions apply:

- when any target compound is detected in a method blank above the action levels listed earlier, but not in associated samples, then no flag is applied.

Surrogates

The % recovery of the surrogates is calculated for each sample, blank, and standard. Corrective action is taken whenever one (or more) surrogate recovery is outside the acceptance criteria. The following corrective action is taken when required as stated above:

- Check calculations to assure there are no errors;
- Check standard and surrogate solutions for degradation, contamination, etc., and check instrument performance;
- If instrument failure is indicated, reanalyze the sample;
- If the surrogate could not be measured because the sample required a dilution, no corrective action is required. The recovery of the surrogate is recorded with the note "surrogate diluted out";
- If all QC associated with the sample is within acceptance limits (the method blank surrogate recovery and LCS spike recovery), the problem

may be attributed to a matrix effect. Samples exhibiting a matrix effect will be qualified and discussed in the report narrative.

Laboratory Control Sample/Laboratory Control Sample Duplicates

The % recovery of the Laboratory Control Samples and the relative percent difference (RPD) for LCS Duplicates are calculated for each set of spiked samples. Corrective action is taken whenever one (or more) recovery or RPD is outside the acceptance criteria. The following corrective action is taken when required as stated above:

- Check calculations to assure there are no errors;
- Check standard and spiking standard solutions for degradation, contamination, etc., and check instrument performance;
- If that does not correct the problem, then the data is reported and a qualifying statement regarding the laboratory control sample is included in the report narrative.

Calibration

For an initial 5 point calibration curve to be valid, the responses for each compound should be linear over the calibration range. If this criteria is not met, then the calibration curve should be reanalyzed.

For continuing calibration checks to be valid, the % difference in the calibration factor for each compound in calibration should not exceed 15% from the initial calibration. If these criteria are not met, then the following corrective actions should be taken:

- Check standard solutions for degradation, contamination, etc.,
- Check instrument for contamination at the injection port inlet and front end of the column;
- If no source of the problem is identified, then a complete 5 point initial calibration must be performed.

15.1.4 Metals Analyses

Method Blanks

If target analytes are detected in the method blank above the reporting limit the corrective action consists of the following:

- checking the calculations;
- reanalyzing the blank;
- investigating the source if the problem to implement corrective action for the future;
- redigesting and reanalyzing the associated samples if the analyte concentration in the samples is less than 5 times the blank concentration and greater than the reporting limit.
- Data that cannot be regenerated acceptably is flagged as non-compliant.

When target analytes are detected in a method blank, the following data condition applies:

- when any target analyte is detected in a method blank above the action levels listed earlier but not in associated samples, then no flag is applied.

Laboratory Control Sample/Laboratory Control Sample Duplicates

The % recovery of the Laboratory Control Samples and the relative percent difference (RPD) for LCS Duplicates are calculated for each set of spiked samples. Corrective action is taken whenever one (or more) recovery or RPD is outside the acceptance criteria. The following corrective action is taken when required as stated above:

- Check calculations to assure there are no errors;
- Check standard and spiking standard solutions for degradation, contamination, etc., check instrument performance;
- Redigest and reanalyze samples if there is no indication of failure in any of the above;

- If that does not correct the problem, then the data is reported and a qualifying statement regarding the laboratory control sample is included in the report narrative.

An exception to this criteria is allowed for matrix spike samples when the sample concentration exceeds the spike concentration by a factor or 4 or more. In that instance, the data is reported unqualified.

For Matrix Spike, Matrix Spike Duplicates and Sample Duplicates, if all QC associated with a sample is within acceptance limits (the method blank and LCS/LCS dup spike recovery), the problem may be attributed to a matrix effect. Samples exhibiting a matrix effect will be qualified and discussed in the report narrative.

Calibration

For an initial and continuing instrument calibration to be valid, the responses for each analyte must be linear over the calibration range and the accuracy of calibration, as determined by analysis of an independent check standard, must be within $\pm 10\%$ of the true value for ICP/AA analyses and within $\pm 20\%$ for cold vapor AA analyses. If these criteria are not met, then the following corrective actions taken:

- Check standard solutions for degradation, contamination, etc.,
- Check instrument for contamination, incorrect operating conditions, etc.;
- If no source of the problem is identified, then a complete instrument calibration must be performed.

15.1.5 Classical Wet Chemistry Techniques

Method Blanks

If target analytes are detected in the method blank above the detected limit the corrective action consists of the following:

- checking the calculations;
- reanalyzing the blank;

- investigating the source if the problem to implement corrective action for the future;

- redigesting and reanalyzing the associated samples if the analyte concentration in the samples is less than 5 times the blank concentration.

When target analytes are detected in a method blank, the following data condition applies:

- when any target analyte is detected in a method blank above the action levels listed earlier but not in associated samples, then no flag is applied.

Laboratory Control Sample/Laboratory Control Sample Duplicates

The % recovery of the Laboratory Control Samples and the relative percent difference (RPD) for LCS Duplicates are calculated for each set of spiked samples. Corrective action is taken whenever one (or more) recovery or RPD is outside the acceptance criteria. The following corrective action is taken when required as stated above:

- Check calculations to assure there are no errors;

- Check standard and spiking standard solutions for degradation, contamination, etc., and check instrument performance;

- Reanalyze the sample if no problems are indicated by checking the items above;

- If that does not correct the problem, then the data is reported and a qualifying statement regarding the laboratory control sample is included in the report narrative.

An exception to this criteria is allowed for matrix spike samples when the sample concentration exceeds the spike concentration by a factor or 4 or more. In that instance, the data is reported unqualified.

For Matrix Spike, Matrix Spike Duplicates and Sample Duplicates, if all QC associated with a sample is within acceptance limits (the method blank and

LCS/LCS dup spike recovery), the problem may be attributed to a matrix effect. Samples exhibiting a matrix effect will be qualified and discussed in the report narrative.

Calibration

For an initial and continuing instrument calibration to be valid, the responses for each analyte must be linear over the calibration range and the accuracy of calibration, as determined by analysis of an independent check standard, must be within $\pm 10\%$ of the true value. If these criteria are not met, then the following corrective actions taken:

- Check standard solutions for degradation, contamination, etc.,
- Check instrument for contamination, incorrect operating conditions, etc.;
- If no source of the problem is identified, then a complete instrument calibration must be performed.

15.2 Unusual Occurrences

Whereas out-of-control events involve occurrences outside of pre-established acceptance windows, unusual occurrences are more subjective and involve incidents which may be compliant with the assessment criteria but still warrant investigation. Many of these investigations will be the result of the professional judgement of the analyst, auditor or data reviewer that the analysis was not typical or reasonable. Another example of this type of investigation is an inquiry or questioning of data received from a client or from the results of performance evaluation samples.

FIGURE 15-1

PACE NE CORRECTIVE ACTION REPORT

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Protocol_____

Date:_____ Reported By:_____

Sample ID Number(s) Involved and QC batch #:_____

Type of Event: ☐ Out-of Control Event ☐ Unusual Occurrence

Description of Event:_____

Discussion of Known or Suspected Cause:_____

Corrective Action(s) Taken (include date, person and action):_____

Signed_____

Signed_____
Group Supervisor

Signed_____
Technical Director

Follow Up:_____

Quality Assurance Review

_____ Date _____

Management Review

_____ Date _____

16.0 QUALITY ASSURANCE REPORTS TO MANAGEMENT

The Quality Assurance Officer and Quality Assurance Auditors are responsible for preparing reports to management indicating effectiveness of the laboratory Quality Assurance Program.

16.1 Quality Assurance Auditors

Results of audits performed by the QA staff are detailed in formal, written audit reports. These reports are distributed to the audited personnel, section supervisor, Laboratory director, QA officer, and Regional Director for review and appropriate action. These and other QA-related reports are distributed as produced, with no set schedule.

Auditor reports will include, but not be limited to:

- Results of internal laboratory review activities
- Results of internal data review activities
- Results of Proficiency Evaluation studies
- Results of state certification applications
- Summary of holding time exceedence and data qualification
- Method detection limit study status

To demonstrate management review, the audit report will contain a page which will be signed and dated by the QA Officer and Regional Director acknowledging that they have received the report and have reviewed its contents, and taken the necessary action dictated by their position.

16.2 Quality Assurance Officer

The Quality Assurance Officer will issue a report of QA activities and findings on a monthly basis to the Regional Director. The monthly status report will include:

- Results of internal systems or performance audits
- Corrective Action recommendations
- Discussion of QA issues raised by laboratory users
- Results of third party or external audits
- Status of laboratory certifications
- Other significant events
- Performance Evaluation Sample Results

16.3 Management Review of the Quality Assurance Program

Review of the appropriateness and adequacy of the Quality Assurance Program is ongoing. At anytime, any laboratory employee, through the Laboratory Manager may present recommended changes to the Quality Assurance Officer.

During system audits, the Quality Assurance Program should be discussed. The audit report will document recommendations made by either the Laboratory Manager or the auditor for revision.