

**Work Plan
for
Groundwater Investigation Activities
at
Site 2 – Fire Training Area
Naval Weapons Industrial Reserve Plant
Calverton, New York**



**Naval Facilities Engineering Command
Mid-Atlantic**

**CONTRACT NUMBER N62467-04-D-0055
Contract Task Order 450**

November 2007

**WORK PLAN
FOR
GROUNDWATER INVESTIGATION ACTIVITIES
AT
SITE 2 – FIRE TRAINING AREA
NAVAL WEAPONS INDUSTRIAL RESERVE PLANT
CALVERTON, NEW YORK**

**Submitted to:
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9742 Maryland Avenue
Norfolk, Virginia 23511-3095**

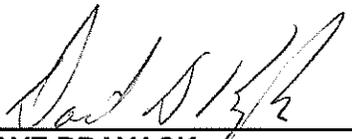
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In Support Of:

**CONTRACT NUMBER N62467-04-D-0055
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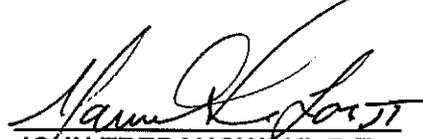
November 2007

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ACRONYMS

AS/SVE	Air sparging/soil vapor extraction
AST	above ground storage tank
bgs	Below ground surface
CHSO	Company Health and Safety Officer
CLEAN	Comprehensive Long-Term Environmental Action Navy
CN	Cyanide
CTO	Contract Task Order
DRO	Diesel range organics
EE/CA	Engineering evaluation/cost analysis
FOL	Field Operations Leader
FTMR	Field Task Modification Request
ft/day	feet per day
GOCO	Government owned contractor operated
GRO	Gasoline range organics
HASP	Health and Safety Plan
HSM	Health and Safety Manager
IAS	Initial Assessment Study
IDW	Investigation-derived waste
IR	Installation Restoration
MCL	maximum contaminant level
MEE	Methane, ethane, and ethane
MPC	Marine Pollution Control
msl	Mean Sea Level
MS/MSD	matrix spike/matrix spike duplicate
NFEC	Naval Facilities Engineering Command
NGC	Northrop Grumman Corporation
NWIRP	Naval Weapons Industrial Reserve Plant
NYCRR	New York Code of Rules and Regulations
NYSDEC	New York State Department of Environmental Conservation
NYSDOH	New York State Department of Health
PAH	Polynuclear aromatic hydrocarbon
PCB	Polychlorinated biphenyl
PPE	Personal protective equipment
PRG	Preliminary remediation goals
QA	Quality Assurance

ACRONYMS (Continued)

QAM	Quality Assurance Manager
QAO	Quality Assurance Officer
QAPP	Quality Assurance Project Plan
QC	Quality control
RCRA	Resource Conservation and Recovery Act
RFI	RCRA Facility Investigation
RPM	Remedial Project Manager
SI	Site Investigation
SOP	Standard Operating Procedure
SSO	Site Safety Officer
SVOC	Semi volatile organic compound
TAGM	Technical and Administrative Guidance Memorandum
TAL	Target Analyte List
TCL	Target Compound List
TICS	Tentatively Identified Compounds
TPH	Total petroleum hydrocarbons
TtNUS	Tetra Tech NUS, Inc.
USDOl	United States Department of Interior
USEPA	United States Environmental Protection Agency
VOC	Volatile organic compound
µg/kg	Microgram per kilogram
µg/L	Microgram per liter

1.0 INTRODUCTION

This Work Plan has been prepared for the Mid-Atlantic Division of the Naval Facilities Engineering Command (NFEC) under Contract Task Order (CTO) 450 issued by the Mid-Atlantic Division of the Naval Facilities Engineering Command under the Comprehensive Long-Term Environmental Action Navy (CLEAN) III contract number N62467-04-D-0055, dated June 19, 2007. The Work Plan addresses a Groundwater Investigation to be conducted at the Naval Weapons Industrial Reserve Plant (NWIRP) located in Calverton, New York (Figures 1-1 and 1-2). This investigation is being conducted in accordance with the NAVY Installation Restoration (IR) Program and New York State Department of Environmental Conservation (NYSDEC) Resource Conservation and Recovery Act (RCRA) permit number 1-4730-00013/00001-0.

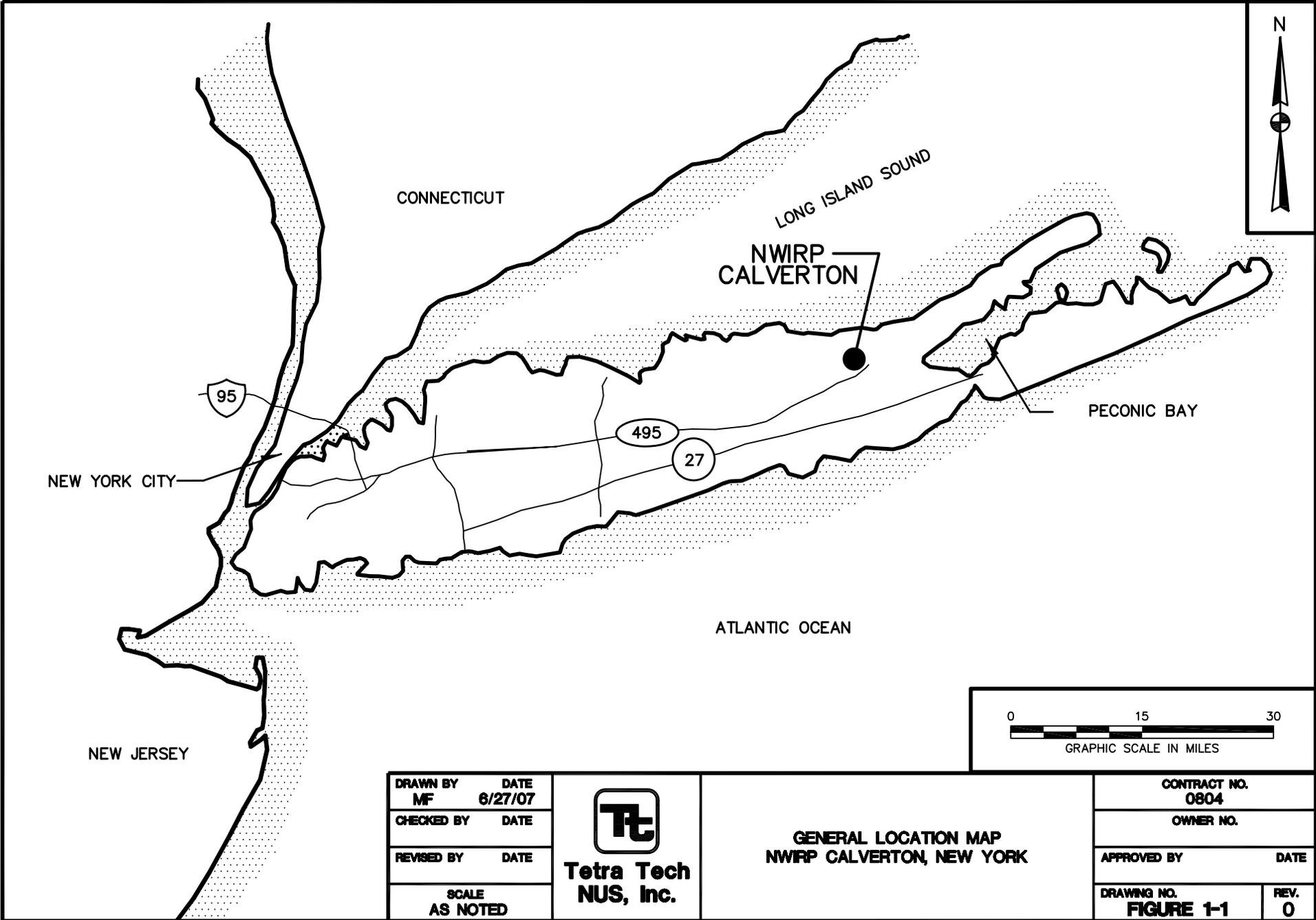
1.1 SCOPE AND OBJECTIVES

This document details the planned Groundwater Investigation activities to be conducted at the NWIRP Calverton Site 2-Fire Training Area. The primary objective of the Groundwater Investigation is to perform an investigation of the site to develop an understanding of the current site characteristics, and presence of contamination, to identify potential exposure pathways and receptors, and natural degradation of site contaminants.

1.2 PLAN ORGANIZATION

This Work Plan provides general program implementation information and the approach to be used in conducting the Groundwater Investigation activities. The plan consists of five sections. Section 1.0 provides this introduction and the scope and general objectives of the Groundwater Investigation. Section 2.0 provides a summary of the facility background and environmental setting. Section 3.0 details the field investigation activities to be conducted at Site 2. Section 4.0 presents the analytical data and evaluation methodology to be applied during the project. Section 5.0 briefly describes the reporting requirements.

1-2

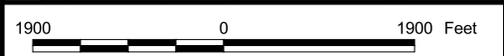


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**GENERAL LOCATION MAP
NWIRP CALVERTON, NEW YORK**

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2.0 SITE BACKGROUND

2.1 SITE DESCRIPTION

2.1.1 Site Location and Layout

The Navy's Calverton facility is located in Suffolk County on Long Island, approximately 70 miles east of New York City (Figures 1-1 and 1-2). Formerly engaged in the manufacture of aircraft parts and subassemblies, the property known as NWIRP Calverton, New York was a Government-Owned Contractor-Operated (GOCO) installation leased by the Navy to the Northrop Grumman Corporation (NGC) until 1996. Since that time, all the property contained within the perimeter fence, with the exception of three noncontiguous parcels of land totaling approximately 209 acres that are being retained by the Navy to continue IR program activities, have been conveyed to the Town of Riverhead (Figure 2-1). There are currently no operational activities being conducted on the Navy's 209 acres. There are no longer any process-type operations being conducted at the Calverton facility that could generate hazardous waste nor are there any requirements for storage of hazardous materials on the Navy's property. Similarly, there will be no hazardous materials brought onto the Calverton property to be used as part of any process-type operations. In addition, the Navy will not be operating a hazardous waste storage area that would require permitting pursuant to 6 New York Code of Rules and Regulations (NYCRR) Part 373. Rather, all wastes generated as a result of continuation of the Navy's IR program will be managed at each parcel location for which a corrective action is taking place. As such, these parcels should be considered as less than 90-day storage areas that are exempt from 6 NYCRR Part 373 permit requirements.

Site 2- Fire Training Area is located on the eastern side of a 9-acre clearing in the south central area of the NWIRP Calverton facility (see Figure 2-1). A circular, concrete pit built in 1983, in the southeast corner of the clearing was used to contain liquids for the fire training exercises. The pit is approximately 80 feet in diameter and is located about 500 feet north and 800 feet west of the facility south gate. A 1,000-gallon, steel, above-ground, fuel storage tank, located approximately 75 feet north of the training pit was used to store fuels. This tank was removed in 1996. A 6,000 gallon fuel storage tank was located north of the training area prior to 1982. Little information is available on the 6,000-gallon storage tank, other than it was likely an aboveground tank located north of the concrete pit and is no longer present at this site (TtNUS, 2005a).

2.1.2 Site History

The Fire Training Area was used by Northrup Grumman and Navy crash rescue crews as a training area since 1955, and possibly as early as 1952. According to the 1986 Initial Assessment Study (IAS), soil disturbances in the area were continuously evident in historical photographs. Before the concrete pit was built, in 1982, activities at the site consisted of clearing an area up to 100 feet or more in diameter and enclosing it with an earthen berm. A layer of water was then placed within the bermed area. Waste fuels, oils, and waste solvents were floated on the water and ignited. The IAS reports that up to 450 gallons of waste solvent were mixed with up to 2,100 gallons of waste fuel per year for use in the training exercises. Aircraft sections were sometimes placed in the area to simulate actual crash conditions. After 1975, waste solvents were reportedly no longer mixed with the waste fuels and oils to be ignited.

Fire fighting materials used in the training exercises included aqueous fire fighting foam, gaseous Halon 1301, water, and dry chemical extinguishers (NEESA, 1986).

The 6,000-gallon storage tank formerly located north of the fire-training ring was used for an unknown period of time prior to 1982 to store waste fuels and solvents at the site. An unknown quantity of liquid was released from the tank in August 1982. The concrete pit was constructed after the spill cleanup to prevent further soil contamination by waste fuels. The 1,000-gallon above ground storage tank (AST) was installed to replace the 6,000-gallon storage tank (NEESA, 1986). A second spill of approximately 300 gallons of waste No. 2 fuel oil occurred in 1983. The spill emanated from a leak in the piping associated with the 1,000 gallon AST.

2.1.3 Environmental Investigation History

In 1982 and 1983, two spills of waste oil were reported at the Fire Rescue Training Area. As a result of the 1982 spill, the entire Fire Rescue Training Area was upgraded. Concrete berms were installed to contain the oil and water used in the training exercises. Piping in the area was modified to prevent spills (NEESA, 1986).

Marine Pollution Control (MPC) of Calverton, New York removed 327 cubic yards (cy) of contaminated soil in 1982 because of the spill that occurred in August 1982 from the 6,000-gallon storage tank. In addition, four groundwater monitoring wells were installed in the spill area. Following the second spill of approximately 300 gallons in 1983, seven additional monitoring wells were installed by MPC to monitor potential contamination resulting from the spills (TtNUS, 2005a).

A groundwater recovery well and oil-water separation system was installed at the Fire Training Area in December 1987. The system used a pumping well, an oil recovery well, and an oil/water separation tank (Haliburton NUS, 1992). This system consisted both of an active and a passive free product recovery system. The active recovery system included a groundwater pumping well, an oil recovery well, and an oil/water separator tank. The passive recovery system consisted of hydrophobic filters located in shallow wells. The active recovery system was shut down in 1993. Passive free product recovery continued until 1996. By December 1996, approximately 325 gallons of petroleum product had been removed from this site (TtNUS, 2005a).

In 1987, Sampling activities at the Fire Training Area consisted of collecting 15 soil samples at 5 soil boring locations, 6 samples of groundwater, and samples of free product layers found in two of the monitoring wells. Each of the samples was analyzed for volatile organic compounds (VOCs), semi volatile organic compounds (SVOCs), metals, cyanide (CN), polychlorinated biphenyls (PCBs), and pesticides.

Results of the soil boring samples indicated significant contamination by VOCs and SVOCs, PCBs, and pesticides. Contamination by inorganic parameters was limited. Volatile and semi volatile organic tentatively identified compounds (TICS) were identified in all soil-boring samples

Groundwater monitoring results from the six monitoring wells indicated the presence of significant contamination by VOCs, SVOCs, and inorganic compounds.

The results of the chemical analysis of the free product layer found in two of the monitoring wells indicated that significant concentrations of chlorinated VOCs were present. A limited number of significant TICS were identified.

In 1994 and 1995, a RCRA investigation was conducted (Haliburton NUS, 1995). Two rounds of groundwater samples were collected and analyzed for Target Compound List (TCL) VOCs, SVOCs, pesticide/PCB organic compounds, Target Analyte List (TAL) metals/CN, and hexavalent chromium.

VOCs were detected at relatively high concentrations in Site 2 soil. The fire-training pit was the most likely primary source area. VOCs detected in soil included solvents and fuel-related contaminants. Solvents detected included 2-butanone (5,900 micrograms per kilogram [$\mu\text{g}/\text{kg}$]), chloroethane (330 $\mu\text{g}/\text{kg}$), dichlorobenzene (900 $\mu\text{g}/\text{kg}$), tetrachloroethene (470 $\mu\text{g}/\text{kg}$), and 1, 1, 1-trichloroethane (9,900 $\mu\text{g}/\text{kg}$). Fuel-related contaminants detected include ethylbenzene (3,700 $\mu\text{g}/\text{kg}$), toluene (6,100 $\mu\text{g}/\text{kg}$), and xylenes (85,000 $\mu\text{g}/\text{kg}$).

Groundwater testing results during the RCRA Facility Investigation (RFI) exhibited VOCs at concentrations above federal Maximum Contaminant Levels (MCLs) or New York groundwater quality standards: chloroethane (1,100 micrograms per liter [$\mu\text{g/L}$]), 1,1-dichloroethane (1,200 $\mu\text{g/L}$), toluene (320 $\mu\text{g/L}$), 1,1,1-trichloroethane (140 $\mu\text{g/L}$), and xylenes (230 $\mu\text{g/L}$).

The area of these detections was addressed by the pilot-scale air sparging/soil vapor extraction (AS/SVE) system that started operation in 1995. By June 1997, the maximum detected chlorinated VOC concentration was 78 $\mu\text{g/L}$ (1,2-dichloroethene) and the maximum detected fuel-related concentration for xylenes was 91 $\mu\text{g/L}$. The state groundwater standard for most VOCs is 5 $\mu\text{g/L}$. PCBs (18 $\mu\text{g/L}$), Polynuclear aromatic hydrocarbons (PAHs) (3 $\mu\text{g/L}$), and lead (30.8 $\mu\text{g/L}$) were detected at concentrations above federal MCLs or state groundwater quality standards. Phthalates and pesticides were detected at concentrations below these standards in several monitoring well samples. Based on the similarity between chemicals found in Site 2 soil and groundwater, it is likely that soil contaminants have affected groundwater.

By 2000, approximately 80 pounds of target VOCs had been removed. In addition, an estimated 30,000 pounds of organics had been destroyed through biodegradation. VOC concentrations in soil and groundwater had been reduced by approximately 70 to 95 percent.

In 1997, a Phase 2 RI was conducted (TtNUS, 2001). Four on-site and four off-site temporary monitoring wells were installed. Groundwater samples were collected from various depths at each location and analyzed for VOCs. In addition, one shallow depth and one intermediate depth permanent monitoring well were installed. Two rounds of groundwater samples were collected from permanent monitoring wells and analyzed for VOCs. The results of the sampling indicated that the nature and extent of groundwater contamination had been defined, and there were no remaining data gaps.

The Navy conducted an Engineering Evaluation/Cost Analysis (EE/CA) in 1998 for several sites at NWIRP Calverton, including Site 2 (TtNUS, 1998). The analysis recommended that free product recovery be restarted at Site 2. Groundwater extraction tests were conducted in 1999 in anticipation of a new free product recovery system (vapor-assisted oil skimming). However, based on subsequent field-testing, several interferences were noted that impacted the ability to successfully extract and treat the groundwater. An alternate recommendation was made to recover product using passive techniques (i.e. absorbent pillows).

In May 2005, three surface water samples were collected from water located within the concrete pit. The samples were submitted for laboratory analysis. The purpose of the sampling was to determine if draining the water from the concrete pit and onto the site was acceptable. Results from the sampling indicated that no contamination was present in the water (TtNUS, 2005b).

In 2005, five surface soil locations were sampled and analyzed for total petroleum hydrocarbons (TPH) - diesel range organics (DRO), TPH- gasoline range organics (GRO), PAHs, pesticides, PCBs, and inorganics. There were 11 exceedances of seven PAHs [benzo(a)anthracene, benzo(a)pyrene; benzo(b)fluoranthene, benzo(k)fluoranthene, chrysene, dibenzo(a,h)anthracene, and indeno(1,2,3-cd)pyrene], one PCB (Aroclor-1248) exceedance, and five exceedances of four metals (beryllium, calcium, manganese, and sodium) compared to screening levels.

In addition, thirty-eight soil borings were drilled during the field investigation. A total of 29 samples were collected from 20 borings from depths ranging from 2 to 16 feet below ground surface (bgs) and submitted for laboratory analysis of VOCs, PAHs, PCBs, pesticides, metals, and TPH -DRO and GRO. Of the 29 soil boring samples, there were 13 screening level exceedances of TPH-DRO. In addition, there were 13 exceedances of four PAHs [benzo(a)anthracene, benzo(a)pyrene, chrysene, and dibenzo(a,h)anthracene] in seven soil boring samples. There were no Technical and Administrative Guidance Memorandum (TAGM) 4046 exceedances of VOCs or PCBs in the 29 soil boring samples. Excluding essential nutrients such as calcium, magnesium, potassium, and sodium, there were three exceedances of beryllium (TtNUS, 2005b). Most of the samples had detectable concentrations of metals, PAHs, and pesticides, but not at concentrations greater than TAGM 4046. Some samples had detections of VOCs, but not at concentrations greater than TAGM 4046 (TtNUS, 2005a).

2.2 ENVIRONMENTAL SETTING

2.2.1 Topography and Drainage

NWIRP Calverton is located in an area underlain by permeable glacial material and characterized by limited surface water drainage features. Normal precipitation at the facility is expected to infiltrate rapidly into the soil. Wetland areas and glacially formed lakes and ponds are located south and southwest of the facility. NWIRP Calverton occupies a relatively flat, intermorainal area. The topographic relief at NWIRP Calverton is 54 feet and elevations range from 30 to 84 feet above mean sea level (msl) (TtNUS, 2005a).

2.2.2 Geology and Soils

NWIRP Calverton lies within the Atlantic Coastal Plain Physiographic Province. Generally, this region can be characterized as an area of relatively undissected low-lying plains. The Atlantic Coastal Plain is underlain by a thick sequence of unconsolidated deposits. The surface topography has been created or modified by Pleistocene glaciation (Isbister, 1966). The facility is underlain by approximately 1,300 feet of unconsolidated sediments that consist of four distinct geologic units. These units, in descending order,

are the Upper Glacial Formation, the Magothy Formation, the Raritan Clay Member of the Raritan Formation, and the Lloyd Sand Member of the Raritan Formation (McClymonds and Franke, 1972).

Soil boring and sampling activities previously completed at NWIRP Calverton reveal that the sites are predominantly underlain by fine to coarse sediments of probable glaciofluvial origin. Three distinct lithofacies were encountered. The upper lithofacies represent a mixture of soil, fill, and glacial deposits and consist predominantly of silty, fine-grained sand with varying amounts of peat and clay. Fill material, where present, is always associated with the upper lithofacies. The middle lithofacies consist of predominantly fine-grained sand with varying amounts of medium- to coarse-grained sand and pebbles, and are probably representative of undisturbed glacial deposits. The lower lithofacies consist of micaceous, silty clay and may represent the Magothy Formation.

2.2.3 Surface Water and Hydrogeology

The majority of the facility is located within the Peconic River drainage basin. The eastward-flowing Peconic River is located approximately 1,300 feet south of the facility at its closest point. The Peconic River discharges to Peconic Bay located 8.5 stream miles from the facility. Major surface water features near the facility include McKay Lake and Northeast Pond. McKay Lake is a man-made groundwater recharge basin located north of River Road, midway along the southern site border. Northeast Pond is located at the northeast corner of the facility. Several small drainage basins exist near the Fuel Calibration Area (Runway Ponds). All of these surface water features are land locked, with the exception of McKay Lake, which has an intermittent discharge to Swan Pond, located 1,500 feet to the south of NWIRP Calverton. Overhead flow from the drainage basins to the Peconic River may also occur periodically.

A number of small wetlands exist on the Calverton facility. The U.S. Department of the Interior (USDOI), Fish and Wildlife Department classifies the western half of the 2-acre Northeast Pond as palustrine, forested/scrub/shrub/emergent wetland. The drainage basins are classified as palustrine, scrub/shrub/emergent wetland (USDOI, 1980).

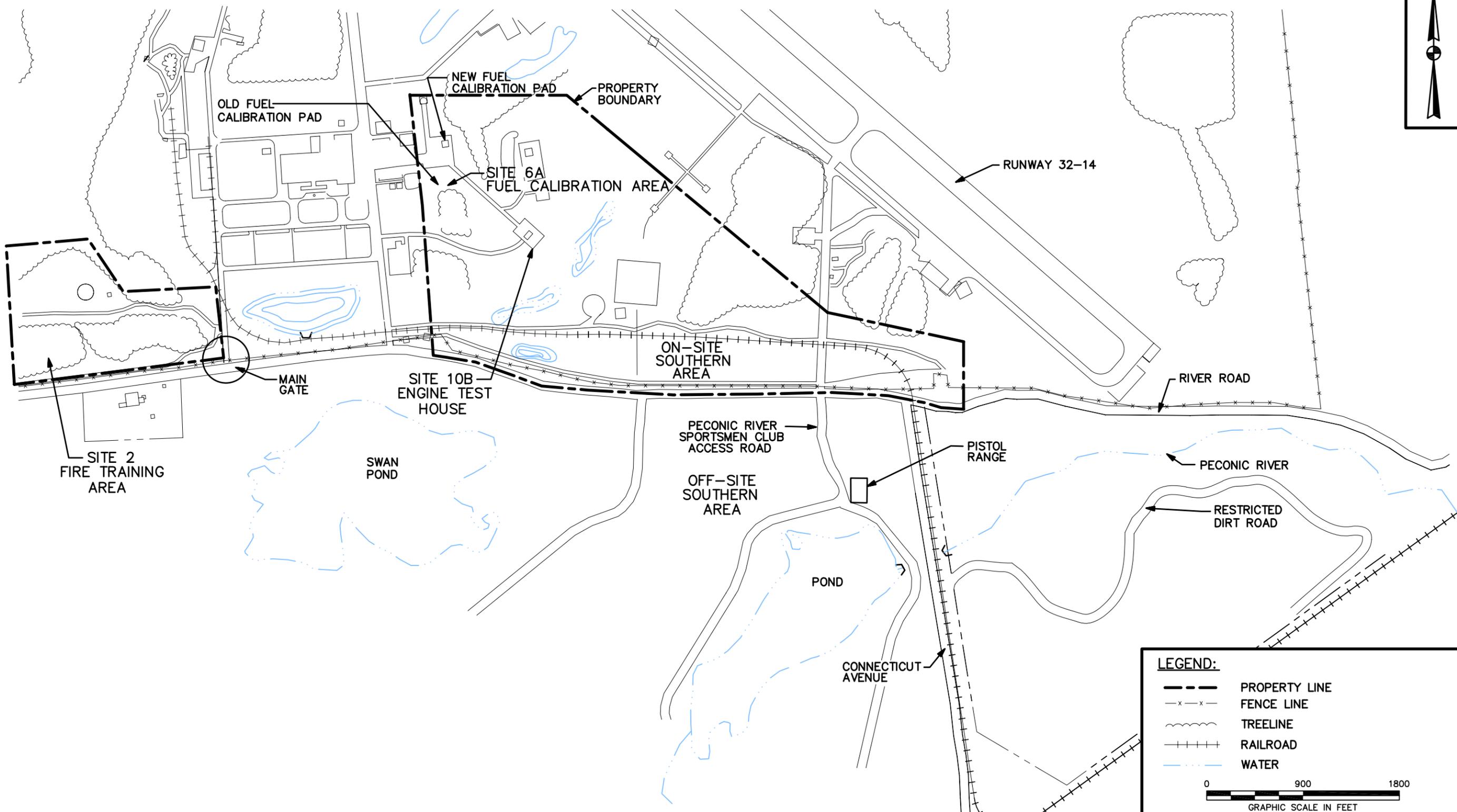
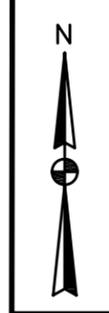
The unconsolidated sediments that underlie NWIRP Calverton are generally coarse-grained with high porosities and permeabilities. These factors create aquifers with high yields and transmissivities. The Upper Glacial Formation, the Magothy Formation, and the Lloyd Sand are the major regional aquifers. The Upper Glacial and Magothy aquifers are of principle importance in Suffolk County because of their proximity to the ground surface. The Raritan Clay of the Raritan Formation has a very low permeability and acts as a regional confining layer that is believed to minimize the local risk of contamination to the underlying Lloyd Sand aquifer (McClymonds and Franke, 1972). The Lloyd Sand has not been

extensively developed due to its depth and the abundant water available in the overlying aquifers. The Upper Glacial aquifer is widely used as a source of groundwater in Suffolk County. The water table beneath the NWIRP Calverton lies within this aquifer. Porosities in excess of 30 percent have been calculated for the Upper Glacial aquifer in adjoining Nassau County. Hydraulic conductivity is estimated at 270 feet per day (ft/day).

The Magothy aquifer is widely used as a source of groundwater in Suffolk County. The most productive units are coarser sand and gravel. The permeability of the Magothy is high and hydraulic conductivity has been calculated in excess of 70 ft/day.

The Upper Glacial and Magothy aquifers are believed to be hydraulically interconnected and to function as a single unconfined aquifer. Logs from on-site monitoring wells, previous hydrogeologic investigations, and geologic mapping indicate that although clay lenses that may create locally confining and/or perched conditions are present in both aquifers, these lenses are not widespread and do not function as regional aquitards (McClymonds and Franke, 1972; Fetter, 1976).

NWIRP Calverton straddles a regional groundwater divide, with groundwater beneath the northern half of the facility flowing to the northeast, with the Long Island Sound as the probable discharge point for groundwater in the shallow aquifer zones. Groundwater beneath the southern half of the facility flows to the southeast and the Peconic River basin is the likely discharge point. Groundwater on the divide, the location of which can fluctuate, flows to the east.

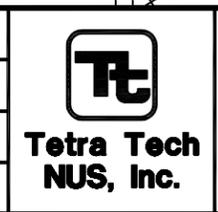


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- x-x- FENCE LINE
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- ++++ RAILROAD
- WATER

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SITE LAYOUT
SITE 2, SITE 6A, SITE 10B,
AND SOUTHERN AREA
NWRP CALVERTON
CALVERTON, NEW YORK

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3.0 PLANNED INVESTIGATION

3.1 FIELD INVESTIGATION

A groundwater investigation is planned for Site 2 to evaluate groundwater quality in support of monitored natural attenuation. There are no surface water bodies within Site 2.

The following subsections identify the sampling locations and type of samples to be collected at each sampling location. The number of samples and the approximate locations are provided in Table 3-1 and Figure 3-1. Sampling locations are pre-determined due to existing groundwater monitoring wells.

3.1.1 Groundwater Sampling

Groundwater investigation activities will be conducted to characterize groundwater at Site 2 and to determine if site-related contamination remain. Sixteen groundwater monitoring wells will be sampled during the groundwater investigation. In addition, water level measurements will be recorded from each of the 16 monitoring wells onto water level measurement sheets. The monitoring well locations are described below and are presented on Figure 3-1.

Groundwater samples will be collected from the 16 monitoring wells using United States Environmental Protection Agency (USEPA) Region 3 low-flow (low-stress) purging and sampling techniques (see Section 3.3). Sampling will occur after water levels stabilize. Field parameters including turbidity, dissolved oxygen, pH, specific conductance, and temperature will be recorded during low-flow purging and sampling activities. All groundwater samples will be analyzed for VOCs, and methane, ethane, and ethene (MEE).

Quality Assurance/Quality Control (QA/QC) samples to be collected include matrix spike/matrix spike duplicates (MS/MSD), field duplicates, and trip blanks. If decontaminated equipment is to be used (e.g., submersible sampling pump), field blanks and rinsate blanks will be collected.

3.2 GENERAL FIELD OPERATIONS

This section describes general field activities and operations to be conducted during the groundwater investigation. Pertinent standard operating procedures (SOPs) are included in Appendix A. Several variations from these SOPs are outlined in this section (e.g., optional use of Alconox for decontamination as opposed to use of other solvents listed in specific SOP). In all cases, the text in this section supersedes the procedures in the SOPs. Sample preservation, packaging and shipping, chain-of-custody

documentation, and other analytical quality procedures are described in the Quality Assurance Project Plan (QAPP) submitted under separate cover. Specific field activities (e.g. groundwater sampling) are described in Section 3.3. The general activities described in this section are listed below.

- Site management and field team responsibilities
- Mobilization/demobilization
- Equipment decontamination
- Field changes and corrective action
- Investigation-derived waste (IDW) management

3.2.1 Site Management and Field Team Responsibilities

The Navy Remedial Project Manager (RPM) is the point-of-contact for all activities related to Site 2. While performing the field activities described in this Work Plan, Tetra Tech NUS, Inc (TtNUS) will be in constant contact with the Navy RPM.

TtNUS will maintain site security by conducting their activities from a secure vehicle. All sampling equipment and other field supplies will be maintained in the vehicle, and the field team will collect all supplies and equipment in the vehicle or designated storage area prior to each departure from the site. Additionally, the field team will conduct the work such that all samples from a sampling point are collected during a single day in the field.

TtNUS will be responsible for the overall management and conduct of the groundwater investigation described in this Work Plan. Navy personnel will be actively involved in coordination among regulatory agencies and TtNUS. Key personnel planned for the Groundwater Investigation are listed in the following organization chart.

**KEY PROJECT PERSONNEL
SITE 2-FIRE TRAINING AREA
NWIRP CALVERTON, NEW YORK**

NAME	ADDRESS/PHONE	RESPONSIBILITY
Susan Clarke	Naval Facilities Engineering Command Mid-Atlantic 9742 Maryland Avenue Norfolk, VA 23511	Navy Remedial Project Manager (RPM)
Al Taormina	NWIRP Bethpage 999 South Oyster Bay Road Bethpage, New York 11714	Facility Manager (TtNUS)
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Vincent Shickora	Tetra Tech NUS 234 Mall Boulevard, Suite 260 King of Prussia, PA 19406 610-491-9688	Field Operations Leader (FOL) (TtNUS)
Kelly Carper	Tetra Tech NUS 661 Andersen Drive, Foster Plaza 7 Pittsburgh, PA 15220 412-921-7273	Quality Assurance Manager (QAM) (TtNUS)
Matthew Soltis, CIH, CSP	Tetra Tech NUS 661 Andersen Drive, Foster Plaza 7 Pittsburgh, PA 15220 412-921-8912	Health and Safety Manager (HSM) (TtNUS)

In some cases, one person may be designated responsibilities for more than one position. For example, the FOL may also be responsible for Site Safety Officer (SSO) duties. This action will be performed only as credentials, experience, and availability permits.

TtNUS Project Manager. The Project Manager serves as the TtNUS point of contact and has primary responsibility for the management and conduct of the work. He is responsible for the coordination of all on-site personnel and for providing technical assistance for all activities directly related to the implementation of this Work Plan.

Field Operations Leader. The FOL is responsible for all day-to-day aspects of the fieldwork. The FOL will have overall responsibility and authority for the various field activities. The FOL will be responsible for coordinating and managing the field sampling team and subcontractors. A field team consisting of at least two people will be used during Site Investigation (SI) field activities. The team will coordinate directly with the FOL and Project Manager. The FOL will report directly to the Project Manager. Specific responsibilities of the FOL include the following:

- Assuring that all field team members are familiar with this document.
- Ultimate responsibility for field operations, QC, and documentation.
- Providing team members with daily assignments.
- Assuring that all field team members have completed health and safety training.
- Reporting to the Project Manager on a regular basis regarding the status of all fieldwork and any problems encountered.
- Completing site logbooks, field logs, and other required documentation on a daily basis (refer to the QAPP for more detail).
- Completing Field Task Modification Request (FTMR) forms, as necessary, for approval by the Project Manager.
- Directing and monitoring on-site subcontractor activities.
- Assuring that team members comply with the procedures outlined in this Work Plan.
- Ensuring that sample documentation and shipping requirements are met.
- Coordinating with Navy personnel to assure access to the site.
- Ensuring that mobilization and demobilization are completed, especially the collection, containment, and labeling of IDW.
- Identifying an FOL designee in his absence.

Site Safety Officer. The SSO will be responsible for training and monitoring site conditions. The SSO reports to the Company Health and Safety Officer (CHSO) and indirectly to the FOL and TtNUS Project Manager. Details of the SSO's responsibilities are presented in the Health and Safety Plan (HASP) provided under a separate cover and include the following:

- Controlling specific health and safety-related field operations such as personnel decontamination, monitoring of worker heat or cold stress, and distribution of safety equipment.
- Conducting and documenting a daily health and safety briefing each day while on site.
- Assuring that field personnel comply with all procedures established in the HASP.
- Identifying an assistant SSO in his absence.
- Terminating work when an imminent safety hazard, emergency situation, or other potentially dangerous situation is encountered.

- Assuring the availability and condition of health and safety monitoring equipment.
- Coordinating with the FOL for the Groundwater Investigation and Project Manager to institute and document any necessary HASP modifications.
- Ensuring that Navy personnel and subcontractors are adequately advised and kept clear of potentially contaminated materials.

Project Quality Assurance Officer. The Project QAO will be responsible for ensuring that all fieldwork performed by the TtNUS team or their subcontractors is being conducted in accordance with this plan. The Project QAO will be responsible for conducting on-site and laboratory audits, as necessary, and reporting deficiencies. The Project QAO will report directly to the Project Manager. Specific details regarding the responsibilities of the Project QAO are outlined in Section 2.1 of the QAPP.

3.2.2 Mobilization/Demobilization

Mobilization/demobilization activities include equipment procurement and transport, subcontractor procurement and coordination, utility awareness and clearance, location and setup of areas for decontamination and waste storage, acquisition of vehicles, and establishment of an on-site staging area.

Equipment requirements will be finalized by the FOL following the acceptance of the Work Plan. The FOL will review the scope of work and assemble equipment (e.g., vehicles and sampling, personal protection, and decontamination equipment) to implement and complete the field investigations.

This equipment list will be reviewed by the project team and by the Project Manager. The FOL will be responsible for packaging and loading equipment, and ensuring that all equipment is operable and calibrated.

The FOL will be responsible for tracking equipment used in the field. The analytical laboratory services will be subcontracted. Following the procurement of these services, the FOL will be responsible for coordinating activities related to these services. The QAO will be responsible for and delivery of sample containers to the site.

Prior to conducting any subsurface intrusive investigations, NWIRP personnel will be contacted and a review of utility and operational subsurface features will be conducted. The proposed areas of intrusive activities will be noted on a facility map and field located for clearance by NWIRP personnel. Work permits, if required by the facility, will be obtained prior to conducting field activities.

Company vehicles are to be used for storage of equipment, containers, and other related equipment and/or sampling supplies. The vehicles will be parked in a secured location when the field team is off site. The doors will be locked at all times when TtNUS personnel are not present. The FOL will be responsible for making arrangements with Navy personnel.

During mobilization, the FOL will review the roles and responsibilities of each member, and review the requirements of the various field activities. A series of meetings will be conducted to review the sampling and analytical requirements. Upon mobilization, an on-site meeting will be conducted to review health and safety requirements. The SSO will be responsible for reviewing the HASP with the field team members and subcontractors.

3.2.3 Decontamination

All reusable sampling equipment (e.g., pumps, water level meters, etc.) will be decontaminated prior to sampling and between samples according to the sequence established in SOP SA-7.1 (Appendix A). Based on prior sampling results and the risk of cross-contamination, strong solvents (i.e., acetone and hexane) will not be used for normal decontamination of sampling equipment. Strong solvents would only be used if visible contamination (e.g., adsorbed substances) were present.

Decontamination will generally consist of a tap water rinse to remove gross contamination, followed by a non-phosphate detergent (e.g., Alconox) water rinse, a tap water rinse, and finally a deionized water rinse. If equipment is to be stored or transported, it should be wrapped in aluminum foil after air drying. Disposable sampling equipment will be used where practical to minimize the need for decontamination.

Water generated during decontamination of sampling equipment will be handled as described in Section 3.2.5. If materials require containerization, they will be placed in 55-gallon drums. The Navy will identify a staging area for decontamination of equipment that will be covered and will have an impervious base. The drums will be handled in accordance with the IDW procedures described in Section 3.2.5.

3.2.4 Field Changes and Corrective Action

If changes to the Groundwater Investigation become necessary due to field conditions (e.g., weather problems, obstructions at sampling locations, etc.) or other unanticipated conditions, the planned change(s) will be communicated by the FOL to the Project Manager, and then to the Navy and the regulatory agency NYSDEC. Upon agreement of the best corrective action, the method will be implemented and the change will be documented on a FTMR form, with the FTMR placed in the project

file and documented in the Data Summary Report. An example FTMR is included in Section 13 of the QAPP.

3.2.5 Investigation-Derived Waste Management

Waste materials generated during the groundwater investigation must be disposed in such a manner as to not contribute to further environmental contamination or pose a threat to public health or safety. Waste materials expected to be generated during the groundwater investigation include the following:

- Decontamination fluid
- Used personal protective equipment (PPE)
- Used sampling equipment
- Well purge water

These wastes will be handled in the following manner:

- Visibly clear phosphate-free detergent wash water and rinse water decontamination fluids from sampling equipment will be released to the ground, in the immediate vicinity of its point of generation.
- Used PPE such as sampling gloves, Tyvek coveralls, paper towels, or other materials will be bagged and sealed prior to disposal as general refuse.
- Used sampling equipment, which generally has minor contamination, will be disposed with the PPE as general refuse.
- All purge water will be contained and disposed of properly after the analytical results of the groundwater have been evaluated.

The Navy will sign any manifests and shipping papers.

3.3 FIELD INVESTIGATION STANDARD OPERATING PROCEDURES

This section describes the procedures and requirements associated with groundwater investigation field activities.

3.3.1 Groundwater Sampling

Groundwater samples will be collected according to TtNUS SOP SA-1.1 and in accordance with USEPA Region 3 low-flow sampling guidelines and protocols (see Appendix A). Groundwater samples will be obtained via low-flow sampling techniques, and field parameters including pH, conductivity, temperature,

dissolved oxygen, turbidity, salinity, and oxidation reduction potential will be measured and recorded at each well. The wells will be purged until field parameters stabilize in accordance with SOP SA-1.1 (Appendix A). The groundwater samples will be collected directly into laboratory-provided clean glassware and will be analyzed for VOCs and MEE.

Water level measurements for the monitoring wells will be measured according to TtNUS SOP GH 1.2 (see Appendix A). All data will be recorded on a Groundwater Level Measurement Sheet.

3.4 ANALYTICAL METHODS

Parameters, anticipated containers, preservation, analytical methods, and holding times are presented in Table 3-2.

**TABLE 3-1
 PROPOSED SAMPLING AND ANALYSIS SUMMARY
 SITE 2 – FIRE TRAINING AREA
 NWIRP GROUNDWATER INVESTIGATION WORK PLAN
 CALVERTON, NEW YORK
 PAGE 1 OF 1**

LOCATION	SAMPLE NUMBER	MEDIUM	SAMPLE DEPTH	ANALYTICAL PARAMETERS	SAMPLING METHOD
GROUNDWATER					
FT-MW-01I	FT-MW-01I-2007MMDD	Groundwater	68-78 feet	VOCs and M, E, E.	USEPA Region 3 low-flow (low-stress) sampling methods.
FT-MW-01S	FT-MW-01S-2007MMDD		18.5-28.5 feet		
FT-MW-02I	FT-MW-02I-2007MMDD		70-80 feet		
FT-MW-02S	FT-MW-02S-2007MMDD		10.5-20.5 feet		
FT-MW-03	FT-MW-03-2007MMDD		21.5-31.5 feet		
FT-MW-04	FT-MW-04-2007MMDD		17-27 feet		
FT-MW-05S	FT-MW-05S-2007MMDD		8-18 feet		
FT-MW-05I	FT-MW-05I-2007MMDD		70-80 feet		
FT-MW-06S	FT-MW-06S-2007MMDD		17.5-27.5 feet		
FT-MW-06I	FT-MW-06I-2007MMDD		65.5-75.5 feet		
FT-MW-07	FT-MW-07-2007MMDD		25.5-35.5 feet		
FT-MW-08S	FT-MW-08S-2007MMDD		4-14 feet		
FT-MW-08I	FT-MW-08I-2007MMDD		23-33 feet		
FT-PZT1	FT-PZT1-2007MMDD		Water table		
FT-PZT2	FT-PZT2-2007MMDD		Water table		
FT-PZT3	FT-PZT3-2007MMDD		Water table		

VOCs-Volatile organic compounds.

M, E, E-Methane, ethane, and ethene.

MW-Monitoring well.

FT-Fire Training Area.

PZT-Piezometer

USEPA-United States Environmental Protection Agency

**TABLE 3-2
SAMPLE CONTAINERS, PRESERVATION, METHODS AND HOLDING TIMES
NWIRP GROUNDWATER INVESTIGATION WORK PLAN
SITE 2 – FIRE TRAINING AREA
CALVERTON, NEW YORK
PAGE 1 OF 1**

PARAMETER	CONTAINER	PRESERVATION	METHOD	HOLDING TIME FROM TIME OF SAMPLE COLLECTION
GROUNDWATER				
VOCs	3 40 mL volatiles vials	HCl to pH<2; Cool 4°C	SW-846 8260B	Analysis within 14 days of collection
Methane, Ethane, and Ethene	3 40 mL volatile vials	HCl to pH <2; Cool 4°C	RSK SOP 175	Analysis within 14 days of collection

VOCs – Volatile organic compounds.

°C- degrees Centigrade.

oz-ounce.

HCl – hydrochloric acid.

mL-milliliter.

SW-846 - Test Methods for Evaluating Solid Waste, Physical/Chemical Methods (Third Edition) with updates online at <http://www.epa.gov/epaoswer/hazwaste/test/sw846.htm> (USEPA, 2006e).

RSK (Robert S. Kerr) SOP (Standard Operating Procedure) 175- Sample Preparation and Calculations for Dissolved Gas Analysis in Water Samples Using a GC Headspace Equilibration Technique online at <http://epa.gov/ne/info/testmethods/pdfs/RSKsop175v2.pdf>

REV.	0
DRAWING NO. FIGURE 3-1	
APPROVED BY	DATE
OWNER NO.	DATE
CONTRACT NO.	DATE
0902	11/21/07

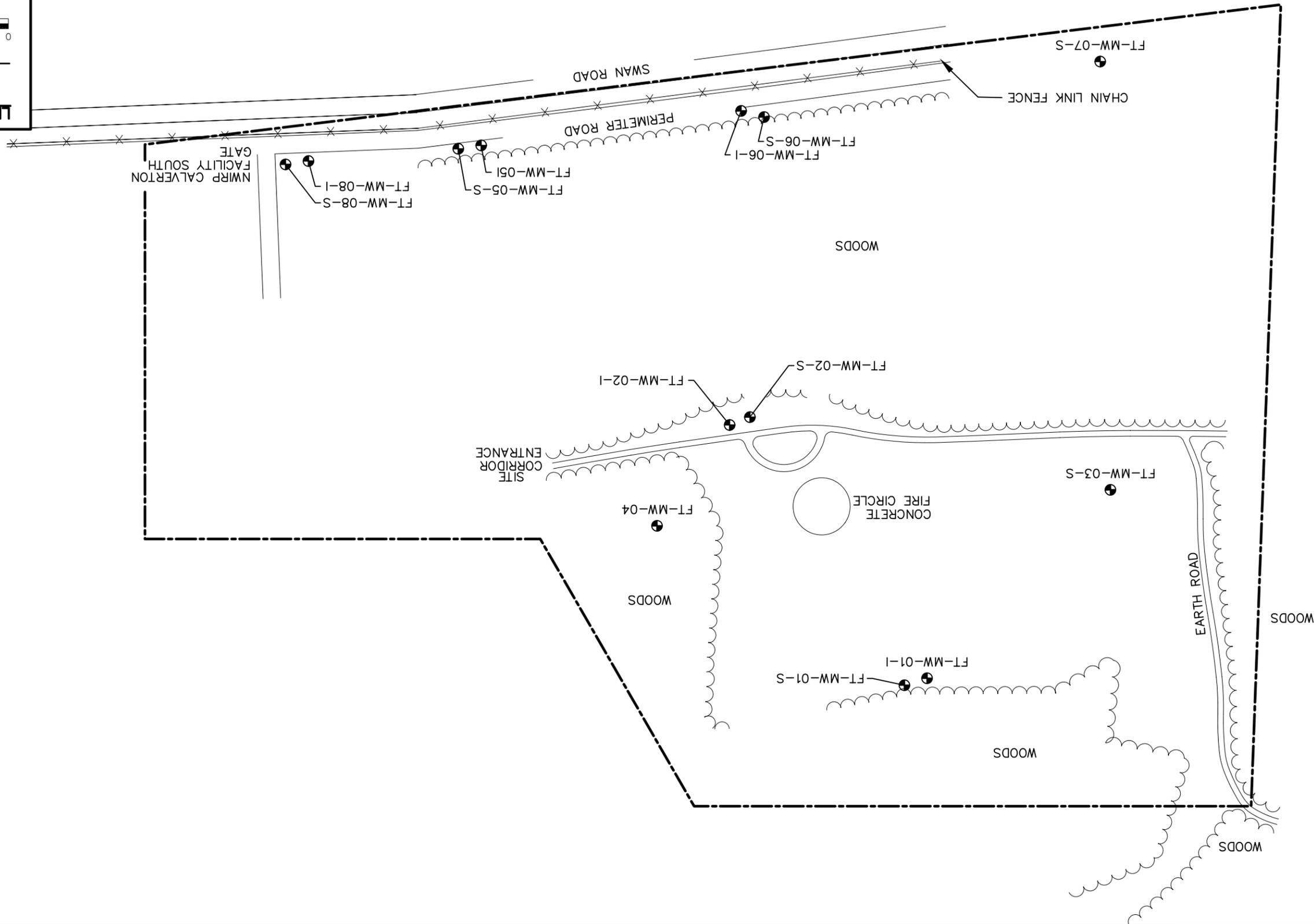
MONITORING WELL LOCATION MAP
SITE 2 - FIRE TRAINING AREA
NWRP, CALVERTON, NEW YORK



DRAWN BY	DATE
MF	11/21/07
CHECKED BY	DATE
DATE	DATE
REVISID BY	DATE
SCALE	AS NOTED



LEGEND:
 MONITORING WELL
 PROPERTY LINE



4.0 DATA EVALUATION

Section 4.0 describes the methodologies that will be used to evaluate and apply the analytical data collected during the groundwater sampling.

4.1 DATA EVALUATION

Groundwater data will be compared to Federal MCLs, NYSDEC groundwater quality standards, and New York State Department of Health (NYSDOH) MCLs (Table 4-1). For reference, detection limits are also presented. Groundwater at the site is classified as GA, indicating its use as a potable water supply.

TABLE 4-1

**ANALYTICAL DETECTION LIMITS FOR GROUNDWATER
SITE 2-FIRE TRAINING AREA
NWIRP CALVERTON, NEW YORK
PAGE 1 OF 2**

Chemical	CAS No.	Federal MCLs (¹) (µg/l)	NYSDOH MCLs (²) (µg/l)	Aqueous Detection Limits (³) (µg/l)
TCL Volatile Organic Compounds				
1,1,1-Trichloroethane	71-55-6	200	5	10
1,1,2,2-Tetrachloroethane	79-34-5		5	10
1,1,2-Trichloroethane	79-00-5	5	5	10
1,1-Dichloroethane	75-34-3		5	10
1,1-Dichloroethene	75-35-4	7	5	10
1,2-Dibromomethane	106-93-4	0.05	50	10
1,2-Dibromo-3-Chloropropane	96-12-8	0.2	5	10
1,2-Dichlorobenzene	95-50-1		5	10
1,2-Dichloroethane	107-06-2	5	5	10
1,2-Dichloroethane-D4	17060-07-0		5	10
1,2-Dichloroethene (total)	540-59-0		5	10
1,2-Dichloropropane	78-87-5	5	5	10
1,2,4-Trichlorobenzene	120-82-1	70	5	10
1,3-Dichlorobenzene	541-73-1		5	10
1,4-Dichlorobenzene	106-46-7		5	10
2-Butanone	78-93-3		50	10
2-Hexanone	591-78-6		50	10
4-Methyl - 2 pentanone	108-10-1		50	10
Acetone	67-64-1		50	10
Benzene	71-43-2	5	5	10
Bromodichloromethane	75-27-4	80	5	10
Bromoform	75-25-2	80	50	10
Bromomethane	74-83-9		5	10
Carbon disulfide	75-15-0		50	10
Carbon tetrachloride	56-23-5	5	5	10
Chlorobenzene	108-90-7	100	5	10
Chloroethane	75-00-3		5	10
Chloromethane	74-87-3		5	10
Chloroform	67-66-3	80	5	10
cis-1,3-Dichloropropene	10061-01-5		5	10
cis-1,2-Dichloroethene	156-59-2	70	5	10
Cyclohexane	1735-17-7		50	10
Dibromochloromethane	124-48-1	80	5	10
Dibromofluoromethane	1868-53-7		5	10
Dichlorodifluoromethane	75-71-8		5	10
Ethylbenzene	100-41-4	700	5	10
Freon-113	76-13-1		5	10
Isopropylbenzene	98-82-8		50	10
Methyl Acetate	79-20-9		50	10

TABLE 4-1

**ANALYTICAL DETECTION LIMITS FOR GROUNDWATER
SITE 2-FIRE TRAINING AREA
NWIRP CALVERTON, NEW YORK
PAGE 2 OF 2**

Chemical	CAS No.	Federal MCLs (1)	NYSDOH MCLs (2)	Aqueous Detection Limits (3)
		(µg/l)	(µg/l)	(µg/l)
Methylene chloride	75-09-2	5	5	10
Methylcyclohexane	108-87-2		50	10
Methyl tert-butyl ether	1634-04-4		50	10
p-Bromoflourobenzene	460-00-4		5	10
Styrene	100-42-5	100	5	10
Tetrachloroethene	127-18-4	5	5	10
Toluene	108-88-3	1000	5	10
trans-1,2-Dichloroethene	156-60-5	100	5	10
trans-1,3-Dichloropropene	10061-02-6		5	10
Trichloroethene	79-01-6	5	5	10
Trichlorofluormethane	75-69-4		5	10
Vinyl chloride	75-01-4	2	2	10
m+p-xylenes	1330-20-7		50	10
o-Xylene	95-47-6		50	10
Xylenes (total)	1330-20-7	10,000	50	10

CAS-Chemical Abstracts Service

MCL- Maximum contaminat level

GW- Groundwater

TCL-Target Compound List

TAL-Target Analyte List

NYSDEC- New York State Department of Environmental Conservation

µg/L-Micrograms per liter

Blank cells - No Criteria

1- (USEPA, 2007) Drinking Water Contaminants National Primary Drinking Water Regulations, from the USEPA website at <http://www.epa.gov/safewater/contaminants/index.html#primary>

2- (NYSDOH, 2004) New York Public Supply Regulations, 10 NYCRR Part 5, Subpart 5-1 Public Water Systems, Table 3-Organic Chemicals Maximum Contaminant Level Determination and Table 9D - Organic Chemicals - Principal Organic Contaminants, from the NYSDOH website at <http://www.health.state.ny.us/environmental/water/drinking/part5/subpart5.hm>

3-The reporting limits presented are those that are typically acheivable for the cited methods by most environmental testing laboratories.

5.0 SITE INVESTIGATION REPORTING

This section presents the reporting requirements for the planned groundwater investigation. A draft and final version of the Data Summary Report will be prepared and submitted to NYSDEC for review and concurrence. The purpose of the Data Summary Report will be to present the findings of the investigation and to support a decision regarding the need for additional IR Program and RCRA studies or action at Site 2.

5.1 REPORT

The field sampling data generated during this investigation will be presented in a Data Summary Report. The report will summarize the site history, present a description of field activities performed, present and discuss the analytical results and risk evaluation, and include recommendations regarding the need for additional studies or actions. Analytical data will be presented in tables and figures that will be used to support the evaluation and recommendations. Laboratory analytical validation reports will be presented in an appendix. The report will be submitted in draft form for review. Comments received on the draft will be responded to in writing, and a revised report will be issued after resolution of these comments.

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APPENDIX A

TtNUS SOPs

Bulletin No. QAD023 Recommended Procedure for Low-Flow Purging and Sampling of Groundwater Monitoring Wells

CT-04 Sample Nomenclature

SA 1.1 Groundwater Sample Acquisition and Onsite Water Quality Testing

SA 1.6 Natural Attenuation Parameter Collection

SA 7.1 Decontamination of Field Equipment

GH 1.2 Evaluation of Existing Monitoring Wells and Water Level Measurement

RECOMMENDED PROCEDURE FOR LOW-FLOW PURGING AND SAMPLING OF GROUNDWATER MONITORING WELLS

1.0 OBJECTIVE AND APPLICATION

This directive provides a procedure for collection of ground-water samples in small-diameter wells with short-screened intervals using low-flow purging and sampling. While these procedures pertain to the Superfund program in Region III, they were based on recommendations presented in the EPA Ground Water Issue paper entitled "Low-Flow (Minimal Drawdown) Ground-Water Sampling Procedures". The low-flow purging and sampling method is not appropriate for use in all hydrogeologic regimes, and particular groundwater monitoring well designs may make the method unsuitable (e.g. open hole and long screen monitoring wells in bedrock and stratified sand and clay where the water bearing zones have not been characterized). Therefore, please confer with a Region III hydrogeologist or geologist before using these procedures at a site.

2.0 BACKGROUND

Past scientific research (Barcelona et al., 1983; Nielson and Yeates, 1985) and EPA guidance have discussed sampling devices in terms of their compatibility with contaminants being sampled, and well construction, depth, and diameter. Although some sampling devices have been used in order to provide more representative groundwater samples in certain situations, most of these incorporate high-volume withdrawal techniques (i.e., in excess of the "natural" recharge rate of groundwater flow through the well screen) for both purging and sampling.

Research conducted by Puls et al. (1992), Puls and Powell (1992), and Powell and Puls (1993) has shown that high-volume purging and sampling cause significant turbidity and suspended particulate artifacts that can result in biased-high metals results. Additionally, purging can cause pressure changes and bailing can cause aeration that can strip VOCs from the sample (Pennino, 1988). The use of low-flow pumping devices (preferably dedicated) for purging and sampling minimizes both the disturbance of water in well casing and the potential for mobilization of colloidal material (Barcelona et al., 1994). Low-flow purging with maintenance of water level in the well and stabilization of indicator parameters (especially turbidity) allows collection of groundwater samples that are more representative of conditions without filtering (U.S. EPA, 1993; Backhus et al., 1993). In many cases, use of a low-flow pump to purge and sample monitoring wells decreases sampling time, reduces the need to handle large volumes of purge water and lowers the cost associated with its disposal, and allows collection of samples for inorganic analyses without filtering. This procedure is designed to be used in conjunction with groundwater sampling and analyses for the most common types of groundwater contaminants (volatile and semi-volatile organic compounds, pesticides, PCBs and inorganic compounds).

3.0 EQUIPMENT

- Adjustable rate, positive displacement pumps (e.g. low flow-rate submersible centrifugal or bladder pumps constructed of stainless steel or Teflon). Low flow-rate electrical submersible pumps are recommended because (1) they are not subject to cyclical flow/arrest and consequent potential for mobilizing fine-grained material, and (2) they may be less prone to operator error, thereby reducing potential error resulting from application by different personnel. The pump should be easily adjustable and capable of operating reliably at low flow rates. Peristaltic pumps may be used only

for inorganic sample collection. Bailers are inappropriate for use in this procedure.

- **Tubing:** Tubing used in purging and sampling each well must be dedicated to the individual well. Once properly located, moving the pump in the well should be avoided. Consequently, the same tubing should be used for purging and sampling. Teflon or Teflon-lined polyethylene tubing must be used to collect samples for organic analysis. For samples collected for inorganic analysis, Teflon or Teflon lined polyethylene, PVC, Tygon or polyethylene tubing may be used. The tubing wall thickness should be maximized (3/8 to 1/2 inch) and the tubing length should be minimized (i.e. do not have excess tubing outside of the well).
- Polyethylene sheeting and sampling gloves.
- Water level measuring device, 0.01 feet accuracy, (electronic preferred for tracking water level drawdown during all pumping operations).
- Flow measurement supplies (e.g. graduated cylinder and stop watch).
- Interface probe, if needed.
- Power source (e.g. generator, located downwind; nitrogen tank, etc). The generator should not be oversized for the pump.
- In-line flow-through cell containing purge criteria parameter monitoring instruments for pH, turbidity, specific conductance, temperature, Eh and dissolved oxygen (DO). The in-line device should be bypassed or disconnected during sample collection.
- Photoionization detector (PID), or equivalent.
- Nylon stay-ties.
- Decontamination supplies.
- Logbook(s).
- Sample Bottles. It is recommended that preservatives are added to sample bottles prior to field activities to reduce potential error or introduction of contaminants.
- Sample preservation supplies (as required by the analytical method; see previous bullet).
- Sample tags or labels, chain of custody.
- Well construction data, location map, field data from last sampling event.
- Approved Field Sampling Plan/QA Project Plan.

4.0 PRELIMINARY SITE ACTIVITIES

1) Check the condition of the monitoring well for damage and evidence of tampering, and record pertinent observations.

2) In order to maintain a clean work area, lay out a sheet of polyethylene to place sampling and monitoring equipment.

3) Remove well cap and measure VOCs at the rim of the well with a PID or FID instrument and record the reading in the field logbook.

4) If the well casing does not have a reference point (usually a V-cut or indelible mark in the well casing) make one.

5) Measure and record the depth to water (to 0.01 feet) in all wells to be sampled before any purging begins. Care should be taken to minimize disturbance to the water column and to any particulate attached to the sides or at the bottom of the well. Consequently, in order to avoid disturbing any accumulated sediment and to prevent mixing of stagnant water with water in the screened interval, the total depth of a well should be measured well in advance (one to two weeks) of purging and sampling or after sampling is completed. Obtain depth to bottom of well information from the well construction log and calculate standing water volume as: depth of water column times cross-sectional area of the well.

6) For wells where an Light Non-aqueous Phase Liquid (LNAPL) has been detected, a stilling tube should be inserted into the well prior to purging. Refer to Section 7.2.4 of EPA (1992) for the procedure to follow. If the wells are constructed so that DNAPLs could accumulate, their detection and /or sampling should occur, at a minimum, a week before groundwater purging and sampling. Measurement and sampling of potential DNAPL should be conducted as a separate event to minimize disturbance of any sediments which have accumulated in the bottom of the well. A double check valve, bottom loading bailer is recommended for sampling. Light non-aqueous phase liquid (LNAPL) measurement may be conducted (with an interface probe), with care to avoid disturbance of the water column within the well.

5.0 PURGING AND SAMPLING PROCEDURES

The following describes the procedure for the low-flow purging and sampling method. Equipment calibration, logbook documentation, sample bottle filling and preservation, and shipping will be conducted in accordance with the site-specific Quality Assurance Project Plan (QAPjP). Personal protective equipment will be donned in accordance with the requirements of the site-specific Health and Safety Plan. Wells should be sampled in the order of least contaminated to most contaminated.

1) Attach and secure the polyethylene tubing to the low-flow pump. As the pump is slowly lowered into the well, secure the safety drop cable, tubing, and electrical lines to each other using nylon stay-ties.

2) Pump, safety cable, tubing and electrical lines should be lowered slowly into the well to a depth corresponding to the center of the saturated screen section of the well, or at a location determined to either be a preferential flow path or zone where contamination is present. The pump intake should be kept above the bottom of the well to prevent mobilization of any sediment or DNAPL present in the bottom of the well. It is recommended that the pump be placed in the well 12 to (preferably) 48 hours prior to purging/sampling to minimize the effects of turbidity and mixing in the well from introducing the pump.

3) Measure the water level again with the pump in the well before starting the pump. Start the pump at the lowest rate possible (100 mL/min) while measuring the drawdown continuously. The pumping can only be increased as long as there is no drawdown. Avoid surging. Observe air bubbles displaced from discharge tube to assess progress of steady pumping until water arrives at the surface. The pumping rate should cause little or no water level drawdown in the well (less than 0.2 ft) and the water level should stabilize. Water level measurements should be made continuously. Precautions should be taken to avoid pump suction loss

or air entrainment. Pumping rates should, if needed, be reduced to the minimum capabilities of the pump to avoid pumping the well dry and ensure stabilization of indicator parameters. If the recharge rate of the well is very low, purging should be interrupted so as not to cause the drawdown within the well to advance below the pump intake but the operator should attempt to maintain a steady flow rate with the pump to the extent practicable. In these low-yielding wells, where 100 mL/min exceeds the entrance rate of groundwater into the well, it is important to avoid dewatering the well screen interval. In these cases, the pump should remain in place and the water level should be allowed to recover repeatedly until there is sufficient volume in the well to permit collection of samples. An alternative means of sample collection may be necessary under these conditions.

4) While purging the well, monitoring of in-line water quality indicator parameters should include turbidity, specific conductance, pH, dissolved oxygen (DO), temperature and redox potential (Eh) which must be collected every three to five minutes until all of the parameters have stabilized. Stabilization is achieved when three successive readings are within ± 0.1 for pH, $\pm 3\%$ for conductivity and temperature, ± 10 mv for redox potential (Eh), and $\pm 10\%$ for turbidity and DO. A minimum subset of these parameters that can be used to determine stabilization during purging in this procedure are pH, specific conductivity and turbidity or DO. Turbidity and DO are typically the last parameters to stabilize. If the parameters have stabilized, but the turbidity is not in the range of 5-10 NTU, then follow step 6.

5) Once stabilization has been documented, VOC and gas sensitive (e.g. Fe^{+2} , CH_4 , $\text{H}_2\text{S/HS}$) parameter samples should be immediately collected first and directly into pre-preserved sample containers. All sample containers should be filled by allowing the pump discharge to flow gently down the inside of the container with minimal turbulence.

Samples requiring pH adjustment should have their pH checked to assure that the proper pH has been obtained. For VOC samples, this will require that a test sample be collected to determine the amount of preservative required to be added to the sample containers prior to sampling.

6) If the turbidity measurements do not approach the range of that of natural groundwater (10 NTU), both filtered and unfiltered samples should be collected for metals analysis. Filtered metal samples are to be collected with an in-line filter. A high capacity, in-line 0.45 micron particulate filter must be pre-rinsed according to the manufacturer's recommendations, or with approximately 1 liter of groundwater following purging and prior to sampling. After the sample is filtered it must be preserved immediately.

7) As each sample is collected, the sample should be labeled as defined in the QAPjP. All samples should be placed into a cooler with proper temperature control as outlined in the QAPjP.

After collection of the samples, the tubing from the pump should be properly discarded or dedicated to the well for re-sampling (by hanging the tubing inside the well).

8) Measure and record well total depth.

9) Secure the well (close and lock it up).

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TETRA TECH NUS, INC.

STANDARD OPERATING PROCEDURES

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Applicability	Tetra Tech NUS, Inc.		
Prepared	Risk Assessment Department		
Approved	D. Senovich <i>ds</i>		

Subject
SAMPLE NOMENCLATURE

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1.0 PURPOSE

The purpose of this document is to specify a consistent sample nomenclature system that will facilitate subsequent data management in a cost-effective manner. The sample nomenclature system has been devised such that the following objectives can be attained:

- Sorting of data by matrix.
- Sorting of data by depth.
- Maintenance of consistency (field, laboratory, and data base sample numbers).
- Accommodation of all project-specific requirements.
- Accommodation of laboratory sample number length constraints (maximum of 20 characters).

2.0 SCOPE

The methods described in this procedure shall be used consistently for all projects requiring electronic data.

3.0 GLOSSARY

None.

4.0 RESPONSIBILITIES

Program Manager - It shall be the responsibility of the Program Manager (or designee) to inform contract-specific Project Managers of the existence and requirements of this Standard Operating Procedure.

Project Manager - It shall be the responsibility of the Project Manager to determine the applicability of this Standard Operating Procedure based on: (1) program-specific requirements, and (2) project size and objectives. It shall be the responsibility of the Project Manager (or designee) to ensure that the sample nomenclature is thoroughly specified in the relevant project planning document (e.g., sampling and analysis plan) and is consistent with this Standard Operating Procedure if relevant. It shall be the responsibility of the project manager to ensure that the Field Operations Leader is familiar with the sample nomenclature system.

Field Operations Leader - It shall be the responsibility of the Field Operations Leader to ensure that all field technicians or sampling personnel are thoroughly familiar with this Standard Operating Procedure and the project-specific sample nomenclature system. It shall be the responsibility of the Field Operations Leader to ensure that the sample nomenclature system is used during all project-specific sampling efforts.

5.0 PROCEDURES

5.1 Introduction

The sample identification (ID) system can consist of as few as 8 but not more than 20 distinct alphanumeric characters. The sample ID will be provided to the laboratory on the sample labels and chain-of-custody forms. The basic sample ID provided to the lab has three segments and shall be as follows where "A" indicates "alpha," and "N" indicates "numeric":

A or N 3- or 4-Characters	AAA 2- or 3-Characters	A or N 3- to 6-Characters
Site Identifier	Sample Type	Sample Location

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Additional segments may be added as needed. For example:

(1) Soil and Sediment Sample ID

A or N 3- or 4-Characters	AAA 2- or 3-Characters	A or N 3- to 6-Characters	NNNN 4-Characters
Site Identifier	Sample Type	Sample Location	Sample Depth

(2) Aqueous (groundwater or surface water) Sample ID

A or N 3- or 4-Characters	AAA 2- or 3-Characters	A or N 3- to 6-Characters	NN 2-Characters	-A
Site Identifier	Sample type	Sample Location	Round Number	Filtered Sample only

(3) Biota Sample ID

A or N 3- or 4-Characters	AAA 2- or 3-Characters	A or N 3- to 6-Characters	AA 2-Characters	NNN 3-Characters
Site Identifier	Sample Type	Sample Location	Species Identifier	Sample Group Number

5.2 Sample Identification Field Requirements

The various fields in the sample ID will include but are not limited to the following:

- Site Identifier
- Sample Type
- Sample Location
- Sample Depth
- Sampling Round Number
- Filtered
- Species Identifier
- Sample Group Number

The site identifier must be a three- or four-character field (numeric characters, alpha characters, or a mixture of alpha and numeric characters may be used). A site number is necessary since many facilities/sites have multiple individual sites, SWMUs, operable units, etc. Several examples are presented in Section 5.3 of this SOP.

The sample type must be a two- or three-character alpha field. Suggested codes are provided in Section 5.3 of this SOP.

The sample location must be at least a three-character field but may have up to six-characters (alpha, numeric, or a mixture). The six-characters may be useful in identifying a monitoring well to be sampled or describing a grid location.

The sample depth field is used to note the depth below ground surface (bgs) at which a soil or sediment sample is collected. The first two numbers of the four-number code specify the top interval, and the third and fourth specify the bottom interval in feet bgs of the sample. If the sample depth is equal to or greater than 100, then only the top interval would be represented and the sampling depth would be truncated to

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three-characters. The depths will be noted in whole numbers only; further detail, if needed, will be recorded on the sample log sheet, boring log, logbook, etc.

A two-digit round number will be used to track the number of aqueous samples taken from a particular aqueous sample location. The first sample collected from a location will be assigned the round identifier 01, the second 02, etc. This applies to both existing and proposed monitoring wells and surface water locations.

Aqueous samples that are field filtered (dissolved analysis) will be identified with an "-F" in the last field segment. No entry in this segment signifies an unfiltered (total) sample.

The species identifier must be a two-character alpha field. Several suggested codes are provided in Section 5.3 of this SOP.

The three digit sample group number will be used to track the number of biota sample groups (a particular group size may be determined by sample technique, media type, the number of individual caught, weight issues, time, etc.) by species and location. The first sample group of a particular species collected from a given location will be assigned the sample group number 001 and the second sample group of the same species collected from the same location will be assigned the sample group number 002.

5.3 Example Sample Field Designations

Examples of each of the fields are as follows:

Site Identifier - Examples of site numbers/designations are as follows:

- A01 - Area of Concern Number 1
- 125 - Solid Waste Management Unit Number 125
- 000 - Base or Facility Wide Sample (e.g., upgradient well)
- BBG - Base Background

The examples cited are only suggestions. Each Project Manager (or designee) must designate appropriate (and consistent) site designations for their individual project.

Sample Type - Examples of sample types are as follows:

- AH - Ash Sample
- AS - Air Sample
- BM - Building Material Sample
- BSB - Biota Sample Full Body
- BSF - Biota Sample Fillet
- CP - Composite Sample
- CS - Chip Sample
- DS - Drum Sample
- DU - Dust Sample
- FP - Free Product
- IDW - Investigation Derived Waste Sample
- LT - Leachate Sample
- MW - Monitoring Well Groundwater Sample
- OF - Outfall Sample
- RW - Residential Well Sample
- SB - Soil Boring Sample
- SD - Sediment Sample
- SC - Scrape Sample

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- SG - Soil Gas Sample
- SL - Sludge Sample
- SP - Seep Sample
- SS - Surface Soil Sample
- ST - Storm Sewer Water Sample
- SW - Surface Water Sample
- TP - Test Pit Sample
- TW - Temporary Well Sample
- WC - Well Construction Material Sample
- WP - Wipe Sample
- WS - Waste/Solid Sample
- WW - Wastewater Sample

Sample Location - Examples of the location field are as follows:

- 001 - Monitoring Well 1
- N32E92 - Grid location 32 North and 92 East
- D096 - Investigation derived waste drum number 96

Species Identifier - Examples of species identifier are as follows:

- BC - Blue Crab
- GB - Blue Gill
- CO - Corn
- SB - Soybean

5.4 Examples of Sample Nomenclature

The first round monitoring well groundwater sample collected from existing monitoring well 001 at SWMU 16 for a filtered sample would be designated as 016MW00101-F.

The second round monitoring well groundwater sample collected from existing monitoring well C20P2 at Site 23 for an unfiltered sample would be designated as 023MWC20P202.

The second surface water sample collected from point 01 at SWMU 130 for an unfiltered sample would be designated as 130SW00102.

A surface soil sample collected from grid location 32 North and 92 East at Site 32 at the 0- to 2-foot interval would be designated as 032SSN32E920002.

A subsurface soil sample from soil boring 03 at SWMU 32 at an interval of 4 to 5 feet bgs would be designated as 032SB0030405.

A sediment sample collected at SWMU 19 from 0 to 6 inches at location 14 would be designated as 019SD0140001. The sample data sheet would reflect the precise depth at which this sample was collected.

During biota sampling for full body analysis the first time a minnow trap was checked at grid location A25 of SWMU 1415 three small blue gills were captured, collected and designated with the sample ID of 1415BSBA25BG001. The second time blue gill were collected at the same location (grid location A25 at SWMU 1415) the sample ID designation given was 1415BSBA25BG002.

Note: No dash (-) or spacing is used between the segments with the exception of the filtered segment. The "F" used for a filtered aqueous sample is preceded by a dash "-F".

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5.5 Field Quality Assurance/Quality Control (QA/QC) Sample Nomenclature

Field QA/QC will be designated using a different coding system. The QC code will consist of a three- to four-segment alpha-numeric code that identifies the sample QC type, the date the sample was collected, and the number of this type of QC sample collected on that date.

AA	NNNNNN	NN	-F
QC Type	Date	Sequence Number (per day)	Filtered (aqueous only, if needed)

The QC types are identified as:

TB = Trip Blank
 RB = Rinsate Blank (Equipment Blank)
 FD = Field Duplicate
 AB = Ambient Conditions Blank
 WB = Source Water Blank

The sampling time recorded on the Chain-of-Custody Form, labels, and tags for duplicate samples will be 0000 so that the samples are "blind" to the laboratory. Notes detailing the sample number, time, date, and type will be recorded on the routine sample log sheets and will document the location of the duplicate sample (sample log sheets are not provided to the laboratory). Documentation for all other QC types (TB, RB, AB, and WB) will be recorded on the QC Sample Log sheet (see SOP on Field Documentation).

5.6 Examples of Field QA/QC Sample Nomenclature

The first duplicate of the day for a filtered ground water sample collected on June 3, 2000 would be designated as FD06030001-F.

The third duplicate of the day taken of a subsurface soil sample collected on November 17, 2003 would be designated as FD11170303.

The first trip blank associated with samples collected on October 12, 2000 would be designated as TB10120001.

The only rinsate blank collected on November 17, 2001 would be designated as RB11170101.

6.0 **DEVIATIONS**

Any deviation from this SOP must be addressed in detail in the site specific planning documents.



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Effective Date	09/03	Revision	5
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Prepared	Earth Sciences Department		
Approved	D. Senovich <i>[Signature]</i>		

Subject
GROUNDWATER SAMPLE ACQUISITION AND
ONSITE WATER QUALITY TESTING

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1.0 PURPOSE

The purpose of this procedure is to provide general reference information regarding the sampling of groundwater wells.

2.0 SCOPE

This procedure provides information on proper sampling equipment, onsite water quality testing, 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 modifications to methodology.

3.0 GLOSSARY

Conductivity – Conductivity is a numerical expression of the ability of an aqueous solution to carry an electric current. This ability depends on the presence of ions, their total concentration, mobility, valence, and relative concentrations, and on temperature of measure. Conductivity is highly dependent on temperature and should be reported at a particular temperature, i.e., 20.2 mS/cm at 14°C.

Dissolved Oxygen (DO) – DO levels in natural and wastewater depend on the physical, chemical, and biochemical activities in the water sample.

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

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

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

Salinity – The measurement of dissolved salts in a given mass of solution. Note: most field meters determined salinity automatically from conductivity and temperature. The displayed value will be displayed in either parts per thousand (ppt) or % (e.g., 35 ppt will equal 3.5%).

Turbidity – Turbidity in water is caused by suspended matter, such as clay, silt, fine organic and inorganic matter. Turbidity is an expression of the optical property that causes light to be scattered and absorbed rather than transmitted in a straight line through the sample.

4.0 RESPONSIBILITIES

Project Hydrogeologist - Responsible for selecting and detailing the specific groundwater sampling techniques, onsite water quality testing (type, frequency, and location), and equipment to be used, and providing detailed input in this regard to the project plan documents. The project hydrogeologist is also responsible for properly briefing and overseeing the performance of the site sampling personnel.

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Project Geologist/Field Sample Technician - is primarily responsible for the proper acquisition of the groundwater samples. He/she is also responsible for the actual analyses of onsite water quality samples, as well as instrument calibration, care, and maintenance. When appropriate, such responsibilities may be performed by other qualified personnel (e.g., field technicians).

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 analysis 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 prior to sampling. In a high-yielding groundwater formation and where there is no stagnant water in the well above the screened section, extensive evacuation prior to sample withdrawal is not as critical.
2. For wells that can be purged dry, the well shall be evacuated and allowed to recover to 75% full capacity prior to sample acquisition. If the recovery rate is fairly rapid, evacuation of more than one volume of water is required.
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 or the 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 drops. 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 or other approved device may be used to collect the sample for analysis.
 - The intake line of the sampling pump (or the submersible pump itself) unless otherwise directed shall be placed near the center of the screened section, and approximately one casing volume of water shall be pumped from the well at a low purge rate, equal to the well's recovery rate (low flow sampling).

Stratification of contaminants may exist in the aquifer. Concentration gradients as a result of mixing and dispersion processes, layers of variable permeability, and the presence of separate-phase product (i.e.,

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floating hydrocarbons) may cause stratification. Excessive pumping or improper sampling methods can dilute or increase the contaminant concentrations in the recovered sample compared to what is representative of the integrated water column as it naturally occurs at that point, thus the result is the collection of a non-representative sample.

5.2 Sampling, Monitoring, and Evacuation Equipment

Sample containers shall conform with the guidelines expressed in SOP SA-6.1.

The following equipment shall be on hand when sampling groundwater wells (reference SOPs SA-6.1 and SA-7.1):

- Sample packaging and shipping equipment - Coolers for sample shipping and cooling, chemical preservatives, appropriate sampling containers and filler, ice, labels and chain-of-custody documents.
- Field tools and instrumentation - Multi-parameters water quality meter capable of measuring ORP, pH, temperature, DO, specific conductance, turbidity and salinity or individual meters (as applicable), pH paper, camera and film (if appropriate), appropriate keys (for locked wells), water level indicator.
- Pumps
 - Shallow-well pumps: Centrifugal, bladder, 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 bladder pumps where applicable.
- Other sampling equipment - Bailers and inert line with tripod-pulley assembly (if necessary).
- Pails - Plastic, graduated.
- Decontamination solutions - Deionized water, potable water, laboratory detergents, 10% nitric acid solution (as required), and analytical-grade solvent (e.g., pesticide-grade isopropanol), as required.

Ideally, sample withdrawal equipment shall be completely inert, economical, easily cleaned, cleaned prior to use, reusable, able to operate at remote sites in the absence of power sources, and capable of delivering variable rates for well purging 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 site logbook or field notebook or on a sample log sheet form (see SOP SA-6.3):

- Obtain all available information on well construction (location, casing, screens, etc.).
- Determine well or inner casing diameter.
- Measure and record static water level (depth below ground level or top of casing reference point).
- Determine depth of well by sounding using a clean, decontaminated, weighted tape measure.

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- 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 $V = (0.163)(T)(r^2)1$

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.

- Per evacuation volumes discussed above, determine the minimum amount to be evacuated before sampling.

5.4 **Evacuation of Static Water (Purging)**

5.4.1 **General**

The amount of purging 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, specific conductance, pH, and turbidity (as applicable), have stabilized. Onsite measurements of these parameters shall be recorded in the site logbook, field notebook, or on standardized data sheets.

5.4.2 **Evacuation Devices**

The following discussion is limited to those devices commonly used at hazardous waste sites. Attachment A provides guidance on the proper evacuation device to use for given sampling situations. Note that all of these techniques involve equipment which is portable and readily available.

Bailers

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

Advantages of bailers include:

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

Limitations on the use of bailers include the following:

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

Suction Pumps

There are many different types of inexpensive suction pumps including centrifugal, diaphragm, and peristaltic pumps. Centrifugal and diaphragm pumps can be used for well evacuation at a fast pumping rate and for sampling at a low pumping rate. The peristaltic pump is a low volume pump that uses rollers to squeeze a flexible tubing, thereby creating suction. This tubing can be dedicated to a well to prevent cross contamination.

These pumps are all portable, inexpensive and readily available. However, because they are based on suction, their use is restricted to areas with water levels within 20 to 25 feet of the ground surface. A significant limitation is that the vacuum created by these pumps can cause significant loss of dissolved gases and volatile organics.

Air-Lift Samplers

This group of pump samplers uses gas pressure either in the annulus of the well or in a venturi to force the water up a sampling tube. These pumps are also relatively inexpensive. Air (or gas)-lift samplers are more suitable for well development than for sampling because the samples may be aerated, leading to pH changes and subsequent trace metal precipitation, or loss of volatile organics.

Submersible Pumps

Submersible pumps take in water and push the sample up a sample tube to the surface. The power sources for these samplers may be compressed gas or electricity. The operation principles vary and the displacement of the sample can be by an inflatable bladder, sliding piston, gas bubble, or impeller. Pumps are available for 2-inch-diameter wells and larger. These pumps can lift water from considerable depths (several hundred feet).

Limitations of this class of pumps include:

- They may have low delivery rates.
- Many models of these pumps are expensive.
- Compressed gas or electric power is needed.
- Sediment in water may cause clogging of the valves or eroding the impellers with some of these pumps.
- Decontamination of internal components can be difficult and time-consuming.

5.5 Onsite Water Quality Testing

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

- pH
- Specific Conductance
- Temperature
- Dissolved Oxygen (DO)
- Oxidation-Reduction Potential (ORP)

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- Turbidity
- Salinity

This section is applicable for use in an onsite groundwater quality monitoring program to be conducted at a hazardous or nonhazardous site. The procedures and equipment described are applicable to groundwater samples and are not, in general, subject to solution interferences from color, turbidity, and colloidal material or suspended matter.

This section provides general information for measuring the parameters listed above with instruments and techniques in common use. Since instruments from different manufacturers may vary, review of the manufacturer's literature pertaining to the use of a specific instrument is required before use. Most meters used to measure field parameters require calibration on a daily basis. Refer to SOP 6.3 for example equipment calibration log.

5.5.1 Measurement of pH

5.5.1.1 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.

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.

5.5.1.2 Principles of Equipment Operation

Use of pH papers for pH measurement relies on a chemical reaction caused by the acidity or alkalinity of the solution created by the addition of the water sample reacting with the indicator compound on the paper. Various types of pH papers are available, including litmus (for general acidity or alkalinity determination) and specific pH range hydron paper.

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 (in this instance, 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 the ion concentration is generated and measured.

5.5.1.3 Equipment

The following equipment is needed for taking pH measurements:

- Stand-alone portable pH meter, or combination meter (e.g., Horiba U-10), or combination meters equipped with an in-line sample chamber (e.g., YSI 600 series and Horiba U-22).

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- 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).
- Buffer solutions, as specified by the manufacturer.
- pH indicator paper, to cover the pH range 2 through 12.
- Manufacturer's operation manual.

5.5.1.4 Measurement Techniques for Field Determination of pH

pH Meter

The following procedure is used for measuring pH with a pH meter (meter standardization is according to manufacturer's instructions):

- Inspect the instrument and batteries prior to initiation of the field effort.
- Check the integrity of the buffer solutions used for field calibration. Buffer solutions need to be changed often as a result of degradation upon exposure to the atmosphere.
- If applicable, 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).
- Calibrate on a daily use basis (or as recommended by manufacturer) following manufacturer's instructions. Record calibration data on an equipment calibration log sheet.
- Immerse the electrode(s) in the sample. Stabilization may take several seconds to minutes. If the pH continues to drift, the sample temperature may not be stable, a physical 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.
- Read and record the pH of the sample. pH shall be recorded to the nearest 0.01 pH unit. Also record the sample temperature.
- Rinse the electrode(s) with deionized water.
- Store the electrode(s) in an appropriate manner when not in use.

Any visual observation of conditions which may interfere with pH measurement, such as oily materials, or turbidity, shall be noted.

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 and proceed with successively narrower range paper until the sample pH is adequately determined.

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5.5.2 Measurement of Specific Conductance

5.5.2.1 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. Most conductivity meters in use today display specific conductance (SC); units of milliSiemens per centimeter, which is the conductivity normalized to temperature @ 25°C. This format (SC) is the required units recorded on the groundwater sample log field form (Attachment B).

5.5.2.2 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 dissociate 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.

5.5.2.3 Equipment

The following equipment is needed for taking specific conductance (SC) measurements:

- Stand alone portable conductivity meter, or combination meter (e.g., Horiba U-10), or combination meters equipped with an in-line sample chamber (e.g., YSI 600 series and Horiba U-22).
- Calibration solution, as specified by the manufacturer.
- Manufacturer's operation manual.

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

5.5.2.4 Measurement Techniques for Specific Conductance

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

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- Check batteries and calibrate instrument before going into the field.
- Calibrate on a daily use basis (or as recommended by manufacturer), according to the manufacturer's instructions and record all pertinent information on an equipment calibration log sheet. Potassium chloride solutions with a SC closest to the values expected in the field shall be used for calibration.
- 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.
- Read and record the results in a field logbook or sample log sheet.
- Rinse the electrode with deionized water.

If the specific conductance measurements become erratic, recalibrate the instrument and see the manufacturer's instructions for details.

5.5.3 Measurement of Temperature

5.5.3.1 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.

5.5.3.2 Equipment

Temperature measurements may be taken with alcohol-toluene, mercury filled, dial-type thermometers or combination meters equipped with an in-line sample chamber (e.g., YSI 600 series and Horiba U-22).. 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.

5.5.3.3 Measurement Techniques for Water Temperature

If a thermometer is used to determine the temperature for a water sample:

- Immerse the thermometer in the sample until temperature equilibrium is obtained (1-3 minutes). To avoid the possibility of cross-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 used, the instrument shall be calibrated according to manufacturer's recommendations.

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5.5.4 Measurement of Dissolved Oxygen

5.5.4.1 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 monitoring method 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 is not susceptible to interference caused by color, turbidity, colloidal material or suspended matter.

5.5.4.2 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, while leaving the surface of the solution undisturbed.

Dissolved oxygen probes are relatively unaffected by 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 a 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.

5.5.4.3 Equipment

The following equipment is needed to measure dissolved oxygen concentration:

- Stand alone portable dissolved oxygen meter, or combination meter (e.g., Horiba U-10), or combination meters equipped with an in-line sample chamber (e.g., YSI 600 series and Horiba U-22).
- Sufficient cable to allow the probe to contact the sample.
- Manufacturer's operation manual.

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5.5.4.4 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 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 according to manufacturer's recommendations or in a freshly air-saturated water sample of known temperature.
- Record all pertinent information on an equipment calibration sheet.
- Rinse the probe with deionized water.
- Immerse the probe in the sample. Be sure to provide for sufficient flow past the membrane by stirring the sample. 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.
- Rinse the probe with deionized water.
- 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.

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

5.5.5 **Measurement of Oxidation-Reduction Potential**

5.5.5.1 General

The oxidation-reduction potential (ORP) provides a measure of the tendency of organic or inorganic compounds to exist in an oxidized state. The ORP parameter 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.

5.5.5.2 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 is 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

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measurements, such as dissolved oxygen, may be correlated with ORP to provide a knowledge of the quality of the solution, water, or wastewater.

5.5.5.3 Equipment

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

- Combination meters with an in-line sample chamber (e.g., YSI 600 series and Horiba U-22).
- Reference solution as specified by the manufacturer.
- Manufacturer's operation manual.

5.5.5.4 Measurement Techniques for Oxidation-Reduction Potential

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

- The equipment shall be checked using the manufacturer's recommended reference solution and have its batteries checked before going to the field.
- Thoroughly rinse the electrode with deionized water.
- If the probe does not respond properly to the recommended reference solution, then verify the sensitivity of the electrodes by noting the change in millivolt reading when the pH of a test solution is altered. The ORP will increase when the pH of a test solution decreases, and the ORP will decrease if the test solution pH is increased. Place the sample in a clean container and agitate the sample. Insert the electrodes and note the ORP drops sharply when the caustic is added (i.e., pH is raised) thus indicating 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 or the probe should be replaced.
- Record all pertinent information on an equipment calibration log sheet.

5.5.6 **Measurement of Turbidity**

5.5.6.1 General

Turbidity is an expression of the optical property that causes light to be scattered and absorbed rather than transmitted in a straight line through the sample. Turbidity in water is caused by suspended matter, such as clay, silt, finely divided organic and inorganic matter, soluble colored organic compounds, and microscopic organisms, including plankton.

It is important to obtain a turbidity reading immediately after taking a sample, since irreversible changes in turbidity may occur if the sample is stored too long.

5.5.6.2 Principles of Equipment Operation

Turbidity is measured by the Nephelometric Method. This method is based on a comparison of the intensity of light scattered by the sample under defined conditions with the intensity of light scattered by a standard reference suspension under the same conditions. The higher the scattered light intensity, the higher the turbidity.

Formazin polymer is used as the reference turbidity standard suspension because of its ease of preparation combined with a higher reproducibility of its light-scattering properties than clay or turbid

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natural water. The turbidity of a specified concentration of formazin suspension is defined as 40 nephelometric units. This same suspension has an approximate turbidity of 40 Jackson units when measured on the candle turbidimeter. Therefore, nephelometric turbidity units (NTU) based on the formazin preparation will approximate units derived from the candle turbidimeter but will not be identical to them.

5.5.6.3 Equipment

The following equipment is needed for turbidity measurement:

- Light meter (e.g., LaMotte 2020) which calibrates easily using test cells with standards of 0.0 NTUs, and 10 NTUs, or combination meter (e.g., Horiba U-10), or combination meter equipped with an in-line sample chamber (e.g., YSI 600 series and Horiba U-22).
- Calibration solution, as specified by the manufacturer.
- Manufacturer's operation manual.

5.5.6.4 Measurement Techniques for Turbidity

The steps involved in taking turbidity measurements utilizing an electrode (e) or light meter (l) are listed below (standardization is according to manufacturer's instructions):

- Check batteries and calibrate instrument before going into the field.
- Check the expiration date (etc.) of the solutions used for field calibration.
- Calibrate on a daily use basis, according to the manufacturer's instructions and record all pertinent information on an equipment calibration log sheet.
- Rinse the electrode with one or more portions of the sample to be tested or with deionized water (applies to "e").
- Fill the light meters glass test cell with ~5 ml of sample, screw on cap, wipe off glass, place test cell in light meter and close the lid (applies to "l").
- Immerse the electrode in the sample and measure the turbidity (applies to "e").
- The reading must be taken immediately as suspended solids will settle over time resulting in a lower, inaccurate turbidity reading.
- Read and record the results in a field logbook or sample log sheet. Include a physical description of the sample, including color, qualitative estimate of turbidity, etc.
- Rinse the electrode or test cell with deionized water.

5.5.7 **Measurement of Salinity**

5.5.7.1 General

Salinity is a unitless property of industrial and natural waters. It is the measurement of dissolved salts in a given mass of solution. Note: Most field meters determined salinity automatically from conductivity and

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temperature. The displayed value will be displayed in either parts per thousand (ppt) or % (e.g., 35 ppt will equal 3.5%).

5.5.7.2 Principles of Equipment Operation

Salinity is determined automatically from the meter's conductivity and temperature readings according to algorithms (found in *Standard methods for the Examination of Water and Wastewater*). Depending on the meter, the results are displayed in either ppt or %. The salinity measurements are carried out in reference to the conductivity of standard seawater (*corrected to S = 35*).

5.5.7.3 Equipment

The following equipment is needed for Salinity measurements:

- Multi-parameter water quality meter capable of measuring conductive, temperature and converting them to salinity (e.g., Horiba U-10 or YSI 600 series).
- Calibration Solution, as specified by the manufacturer.
- Manufacturer's operation manual.

5.5.7.4 Measurement Techniques for Salinity

The steps involved in taking Salinity measurements are listed below (standardization is according to manufacturer's instructions):

- Check batteries and calibrate before going into the field.
- Check the expiration date (etc.) of the solutions used for field calibration.
- Calibrate on a daily use basis, according to the manufacturer's instructions and record all pertinent information on an equipment calibration log sheet.
- Rinse the cell with the sample to be tested.
- Immerse the multi-probe in the sample and measure the salinity. Read and record the results in a field logbook or sample log sheet.
- Rinse the probes with deionized water.

5.6 Sampling

5.6.1 Sampling Plan

The sampling approach consisting of the following, shall be developed as part of the project plan documents which are approved prior to beginning work in the field:

- Background and objectives of sampling.
- Brief description of area and waste characterization.
- Identification of sampling locations, with map or sketch, and applicable well construction data (well size, depth, screened interval, reference elevation).

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- Intended number, sequence volumes, and types of samples. If the relative degrees of contamination between wells is unknown or insignificant, a sampling sequence which facilitates sampling logistics may be followed. Where some wells are known or strongly suspected of being highly contaminated, these shall be sampled last to reduce the risk of cross-contamination between wells as a result of the sampling procedures.
- Sample preservation requirements.
- Work schedule.
- List of team members.
- List of observers and contacts.
- Other information, such as the necessity for a warrant or permission of entry, requirement for split samples, access problems, location of keys, etc.

5.6.2 Sampling Methods

The collection of a groundwater sample consists of the following steps:

1. The site Health & Safety Officer (or designee) will first open the well cap and use volatile organic detection equipment (PID or FID) on the escaping gases at the well head to determine the need for respiratory protection.
2. When proper respiratory protection has been donned, sound the well for total depth and water level (using clean equipment) and record these data on a groundwater sampling log sheet (see Attachment B); then calculate the fluid volume in the well pipe (as previously described in this SOP).
3. Calculate well volume to be removed as stated in Section 5.3.
4. Select the appropriate purging equipment (see Attachment A). If an electric submersible pump with packer is chosen, go to Step 10.
5. Lower the purging equipment or intake into the well to a short distance below the water level and begin water removal. Collect the purged water and dispose of it in an acceptable manner (as applicable). Lower the purging device, as required, to maintain submergence.
6. Measure the rate of discharge frequently. A graduated bucket or cylinder and stopwatch are most commonly used.
7. Observe the peristaltic pump intake for degassing "bubbles." If bubbles are abundant and the intake is fully submerged, this pump is not suitable for collecting samples for volatile organics.
8. Purge a minimum of three to five casing volumes before sampling. In low-permeability strata (i.e., if the well is pumped to dryness), one volume will suffice. Purged water shall be collected in a designated container and disposed in an acceptable manner.
9. If sampling using a pump, lower the pump intake to midscreen (or the middle of the open section in uncased wells) and collect the sample. If sampling with a bailer, lower the bailer to just below the water surface.

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10. (For pump and packer assembly only). Lower the assembly into the well so that the packer is positioned just above the screen or open section. Inflate the packer. Purge a volume equal to at least twice the screened interval (or unscreened open section volume below the packer) before sampling. Packers shall always be tested in a casing section above ground to determine proper inflation pressures for good sealing.
11. In the event that recovery time of the well is very slow (e.g., 24 hours or greater), sample collection can be delayed until the following day. If the well has been purged early in the morning, sufficient water may be standing in the well by the day's end to permit sample collection. If the well is incapable of producing a sufficient volume of sample at any time, take the largest quantity available and record this occurrence in the site logbook.
12. Fill sample containers (preserve and label as described in SOP SA-6.1).
13. Replace the well cap and lock as appropriate. Make sure the well is readily identifiable as the source of the samples.
14. Process sample containers as described in SOP SA-6.1.
15. Decontaminate equipment as described in SOP SA-7.1.

5.7 Low Flow Purging and Sampling

5.7.1 **Scope & Application**

Low flow purging and sampling techniques are sometimes required for groundwater sampling activities. The purpose of low flow purging and sampling is to collect groundwater samples that contain "representative" amounts of mobile organic and inorganic constituents in the vicinity of the selected open well interval, at or near natural flow conditions. The minimum stress procedure emphasizes negligible water level drawdown and low pumping rates in order to collect samples with minimal alterations in water chemistry. This procedure is designed primarily to be used in wells with a casing diameter of 1 inch or more and a saturated screen, or open interval, length of ten feet or less. Samples obtained are suitable for analyses of common types of groundwater contaminants (volatile and semi-volatile organic compounds, pesticides, PCBs, metals and other inorganic ions [cyanide, chloride, sulfate, etc.]). This procedure is not designed to collect non-aqueous phase liquids samples from wells containing light or dense non-aqueous phase liquids (LNAPLs or DNAPLs), using the low flow pumps.

The procedure is flexible for various well construction types and groundwater yields. The goal of the procedure is to obtain a turbidity level of less than 10 NTU and to achieve a water level drawdown of less than 0.3 feet during purging and sampling. If these goals cannot be achieved, sample collection can take place provided the remaining criteria in this procedure are met.

5.7.2 **Equipment**

The following equipment is required (as applicable) for low flow purging and sampling:

- Adjustable rate, submersible pump (e.g., centrifugal or bladder pump constructed of stainless steel or Teflon).
- Disposable clear plastic bottom filling bailers may be used to check for and obtain samples of LNAPLs or DNAPLs.

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- Tubing - Teflon, Teflon-lined polyethylene, polyethylene, PVC, Tygon, or stainless steel tubing can be used to collect samples for analysis, depending on the analyses to be performed and regulatory requirements.
- Water level measuring device, 0.01 foot accuracy, (electronic devices are preferred for tracking water level drawdown during all pumping operations).
- Interface probe, if needed.
- Flow measurement supplies.
- Power source (generator, nitrogen tank, etc.). If a gasoline generator is used, it must be located downwind and at a safe distance from the well so that the exhaust fumes do not contaminate the samples.
- Indicator parameter monitoring instruments - pH, turbidity, specific conductance, and temperature. Use of a flow-through cell is recommended. Optional Indicators - ORP, salinity, and dissolved oxygen, flow-through cell is required. Standards to perform field calibration of instruments.
- Decontamination supplies.
- Logbook(s), and other forms (see Attachments B and C).
- Sample Bottles.
- Sample preservation supplies (as required by the analytical methods).
- Sample tags and/or labels.
- Well construction data, location map, field data from last sampling event (if available).
- Field Sampling Plan.
- PID or FID instrument for measuring VOCs (volatile organic compounds).

5.7.3 Purging and Sampling Procedure

Open monitoring well, measure head space gases using PID/FID. If there is an indication of off gassing when opening the well, wait 3-5 minutes to permit water level an opportunity to reach equilibrium.

Measure and record the water level immediately prior to placing the pump in the well.

Lower pump or tubing slowly into the well so that the pump intake is located at the center of the saturated screen length of the well. If possible keep the pump intake at least two feet above the bottom of the well, to minimize mobilization of sediment that may be present in the bottom of the well. Collection of turbidity-free water samples may be difficult if there is three feet or less of standing water in the well.

Start with the initial pump rate set at approximately 0.1 liters/minute. Use a graduated cylinder and stopwatch to measure the pumping rate. Adjust pumping rates as necessary to prevent drawdown from exceeding 0.3 feet during purging. If no drawdown is noted, the pump rate may be increased (to a max of 0.4 liters/minute) to expedite the purging and sampling event. The pump rate will be reduced if turbidity is greater than 10 NTUs after all other field parameters have stabilized. If groundwater is drawn down below

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the top of the well screen, purging will cease or the well will be pumped to dryness and the well will be allowed to recover before purging continues. Slow recovering wells will be identified and purged at the beginning of the workday. If possible, samples will be collected from these wells within the same workday and no later than 24 hours after the start of purging.

Measure the well water level using the water level meter every 5 to 10 minutes. Record the well water level on the Low-Flow Purge Data Form (Attachment C).

Record on the Low-Flow Purge Data Form every 5 to 10 minutes the water quality parameters (pH, specific conductance, temperature, turbidity, oxidation-reduction potential, dissolved oxygen and salinity or as specified by the approved site specific work plan) measured by the water quality meter and turbidity meter. If the cell needs to be cleaned during purging operations, continue pumping (allow the pump to discharge into a container) and disconnect the cell. Rinse the cell with distilled/deionized water. After cleaning is completed, reconnect the flow-through cell and continue purging. Document the cell cleaning on the Low-Flow Purge Data Form.

Measure the flow rate using a graduated cylinder. Remeasure the flow rate any time the pump rate is adjusted.

During purging, check for the presence of bubbles in the flow-through cell. The presence of bubbles is an indication that connections are not tight. If bubbles are observed, check for loose connections.

After stabilization is achieved, sampling can begin when a minimum of two saturated screen volumes have been removed and three consecutive readings, taken at 5 to 10 minute intervals, are within the following limits:

- pH ± 0.2 standard units
- Specific conductance $\pm 10\%$
- Temperature $\pm 10\%$
- Turbidity less than 10 NTUs
- Dissolved oxygen $\pm 10\%$

If the above conditions have still not been met after the well has been purged for 4 hours, purging will be considered complete and sampling can begin. Record the final well stabilization parameters from the Low-Flow Purge Data Form onto the Groundwater Sample Log Form.

VOC samples are preferably collected first, directly into pre-preserved sample containers. Fill all sample containers by allowing the pump discharge to flow gently down the inside of the container with minimal turbulence.

If the water column in the pump tubing collapses (water does not completely fill the tubing) before exiting the tubing, use one of the following procedures to collect VOC samples: (1) Collect the non-VOCs samples first, then increase the flow rate incrementally until the water column completely fills the tubing, collect the sample and record the new flow rate; (2) reduce the diameter of the existing tubing until the water column fills the tubing either by adding a connector (Teflon or stainless steel), or clamp which should reduce the flow rate by constricting the end of the tubing; (3) insert a narrow diameter Teflon tube into the pump's tubing so that the end of the tubing is in the water column and the other end of the tubing protrudes beyond the pump's tubing, collect sample from the narrow diameter tubing.

Prepare samples for shipping as per SOP SA-6.1.

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ATTACHMENT A

PURGING EQUIPMENT SELECTION

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

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Manufacturer	Model Name/Number	Principle of Operation	Maximum Outside Diameter/Length (Inches)	Construction Materials (w/Lines and Tubing)	Lift Range (ft)	Delivery Rates or Volumes	1982 Price (Dollars)	Comments
BarCad Systems, Inc.	BarCad Sampler	Dedicated; gas drive (positive displacement)	1.5/16	PE, brass, nylon, aluminum oxide	0-150 with std. tubing	1 liter for each 10-15 feet of submergence	\$220-350	Requires compressed gas; custom sizes and materials available; acts as piezometer.
Cole-Parmer Inst. Co.	Master Flex 7570 Portable Sampling Pump	Portable; peristaltic (suction)	<1.0/NA	(not submersible) Tygon®, silicone Viton®	0-30	670 mL/min with 7015-20 pump head	\$500-600	AC/DC; variable speed control available; other models may have different flow rates.
ECO Pump Corp.	SAMPLifier	Portable; venturi	<1.5 or <2.0/NA	PP, PE, PVC, SS, Teflon®, Tefzel®	0-100	0-500 mL/min depending on lift	\$400-700	AC, DC, or gasoline-driven motors available; must be primed.
Geltek Corp.	Bailer 219-4	Portable; grab (positive displacement)	1.66/38	Teflon®	No limit	1,075 mL	\$120-135	Other sizes available.
GeoEngineering, Inc.	GEO-MONITOR	Dedicated; gas drive (positive displacement)	1.5/16	PE, PP, PVC, Viton®	Probably 0-150	Approximately 1 liter for each 10 feet of submergence	\$185	Acts as piezometer, requires compressed gas.
Industrial and Environmental Analysts, Inc. (IEA)	Aquarius	Portable; bladder (positive displacement)	1.75/43	SS, Teflon®, Viton®	0-250	0-2,800 mL/min	\$1,500-3,000	Requires compressed gas; other models available; AC, DC, manual operation possible.
IEA	Syringe Sampler	Portable; grab (positive displacement)	1.75/43	SS, Teflon®	No limit	850 mL sample volume	\$1,100	Requires vacuum and/or pressure from hand pump.
Instrument Specialties Co. (ISCO)	Model 2600 Well Sampler	Portable; bladder (positive displacement)	1.75/50	PC, silicone, Teflon®, PP, PE, Detrin®, acetal	0-150	0-7,500 mL/min	\$990	Requires compressed gas (40 psi minimum).
Keck Geophysical Instruments, Inc.	SP-81 Submersible Sampling Pump	Portable; helical rotor (positive displacement)	1.75/25	SS, Teflon®, PP, EPDM, Viton®	0-160	0-4,500 mL/min	\$3,500	DC operated.
Leonard Mold and Die Works, Inc.	GeoFilter. Small Diameter Well Pump (#0500)	Portable; bladder (positive displacement)	1.75/38	SS, Teflon®, PC, Neoprene®	0-400	0-3,500 mL/min	\$1,400-1,500	Requires compressed gas (55 psi minimum); pneumatic or AC/DC control module.
Oil Recovery Systems, Inc.	Surface Sampler	Portable; grab (positive displacement)	1.75/12	acrylic, Detrin®	No limit	Approximately 250 mL	\$125-160	Other materials and models available; for measuring thickness of "floating" contaminants.
Q.E.D. Environmental Systems, Inc.	Well Wizard® Monitoring System (P-100)	Dedicated; bladder (positive displacement)	1.66/36	PVC	0-230	0-2,000 mL/min	\$300-400	Requires compressed gas; piezometric level indicator; other materials available.

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Manufacturer	Model Name/Number	Principle of Operation	Maximum Outside Diameter/Length (Inches)	Construction Materials (w/Lines and Tubing)	Lift Range (ft)	Delivery Rates or Volumes	1982 Price (Dollars)	Comments
Randolph Austin Co.	Model 500 Vari-Flow Pump	Portable; peristaltic (suction)	<0.5/NA	(Not submersible) Rubber, Tygon®, or Neoprene®	0-30	See comments	\$1,200-1,300	Flow rate dependent on motor and tubing selected; AC operated; other models available.
Robert Bennett Co.	Model 180	Portable; piston (positive displacement)	1.8/22	SS, Teflon®, Delrin® PP, Viton®, acrylic, PE	0-500	0-1,800 mL/min	\$2,600-2,700	Requires compressed gas; water level indicator and flow meter; custom models available.
Slope Indicator Co. (SINCO)	Model 514124 Pneumatic Water Sampler	Portable; gas drive (positive displacement)	1.9/18	PVC, nylon	0-1,100	250 mL/flushing cycle	\$250-350	Requires compressed gas; SS available; piezometer model available; dedicated model available.
Solinst Canada Ltd.	5W Water Sampler	Portable; grab (positive displacement)	1.9/27	PVC, brass, nylon, Neoprene®	0-330	500 mL	\$1,300-1,800	Requires compressed gas; custom models available.
TIMCO Mfg. Co., Inc.	Std. Bailer	Portable; grab (positive displacement)	1.66/Custom	PVC, PP	No limit	250 mL/ft of bailer	\$20-60	Other sizes, materials, models available; optional bottom-emptying device available; no solvents used.
TIMCO	Air or Gas Lift Sampler	Portable; gas drive (positive displacement)	1.66/30	PVC, Tygon®, Teflon®	0-150	350 mL/flushing cycle	\$100-200	Requires compressed gas; other sizes, materials, models available; no solvents used.
Tole Devices Co.	Sampling Pump	Portable; bladder (positive displacement)	1.38/48	SS, silicone, Delrin®, Tygon®	0-125	0-4,000 mL/min	\$800-1,000	Compressed gas required; DC control module; custom built.

Construction Material Abbreviations:

PE Polyethylene
 PP Polypropylene
 PVC Polyvinyl chloride
 SS Stainless steel
 PC Polycarbonate
 EPDM Ethylene-propylene diene (synthetic rubber)

Other Abbreviations:

NA Not applicable
 AC Alternating current
 DC Direct current

NOTE: Other manufacturers market pumping devices which could be used for groundwater sampling, though not expressly designed for this purpose. The list is not meant to be all-inclusive and listing does not constitute endorsement for use. Information in the table is from sales literature and/or personal communication. No skimmer, scavenger-type, or high-capacity pumps are included.

Source: Barcelona et al., 1983.

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TETRA TECH NUS, INC.

STANDARD OPERATING PROCEDURES

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Applicability	Tetra Tech NUS, Inc.		
Prepared	Earth Sciences Department		
Approved	D. Senovich <i>ds</i>		

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NATURAL ATTENUATION PARAMETER COLLECTION

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1.0 PURPOSE

The purpose of this document is to provide general reference information regarding natural attenuation parameter and methodology selection, sample collection, and a general understanding of the sample results.

2.0 SCOPE

This document provides information on selection of appropriate groundwater natural attenuation parameters, selection of sampling methods for these parameters, techniques for onsite field analysis of select parameters, and some basic understanding of the field sample results. Review of the information contained herein will facilitate planning of the field sampling effort by describing standard sampling practices and techniques. To a limited extent, it shall also facilitate the understanding and interpretation of the sampling results. It addresses field procedures for collection of data at sites with organic groundwater contaminants (e.g., chlorinated and petroleum hydrocarbons) to the extent practical. The focus of this document is on natural attenuation, not enhanced bioremediation.

The techniques described shall be followed whenever applicable, noting that site-specific conditions, project-specific objectives, local, state, and federal guidelines may be used as a basis for modification of the procedures noted herein. The intent of this document is to supplement the local, state, and federal guidance documents and manufacturer's analytical methods referenced in Section 6.0. It is not intended for this document to supersede this guidance or information. Please note that natural attenuation is a relatively dynamic science with ongoing research in the science and engineering community. It is important that data collectors and interpreters use the most recent regulatory guidance, which may be updated on a periodic basis from that noted in Section 6.

3.0 GLOSSARY

Aerobe: Bacteria that use oxygen as an electron acceptor.

Anaerobe: Organisms that can use electron acceptors other than molecular oxygen to support their metabolism.

Anoxic groundwater: Groundwater that contains oxygen in concentrations less than about 0.5 mg/L. This term is synonymous with the term anaerobic.

Anthropogenic: Man-made.

Cometabolism: The process in which a compound is fortuitously degraded by an enzyme or cofactor produced during microbial metabolism of another compound.

Daughter product: A compound that results directly from the biotic or abiotic degradation of another. For example, *cis*-1,2-dichloroethene (*cis*-1,2-DCE) is a common daughter product of trichloroethene (TCE).

Diffusion: The process whereby molecules move from a region of higher concentration to a region of lower concentration as a result of Brownian motion.

Dispersion: The tendency for a solute to spread from the path that it would be expected to follow under advective transport.

Electron acceptor: A compound capable of accepting electrons during oxidation-reduction reactions. Microorganisms obtain energy by transferring electrons from an electron donor such as an organic compound (or sometimes a reduced inorganic compound such as sulfide) to an electron acceptor. Electron acceptors are compounds that are relatively oxidized and include oxygen, nitrate, iron(III), manganese(IV), sulfate, carbon dioxide, or in some cases chlorinated aliphatic hydrocarbons such as tetrachloroethene (PCE), TCE, DCE and vinyl chloride (VC).

Electron donor: A compound capable of supplying (giving up) electrons during oxidation-reduction reactions. Microorganisms obtain energy by transferring electrons from an electron donor such as an organic compound (or sometimes a reduced inorganic compound such as sulfide) to an

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electron acceptor. Electron donors are compounds that are relatively reduced and include fuel hydrocarbons and native organic carbon.

Metabolic byproduct: A product of the reaction between an electron donor and an electron acceptor. Metabolic byproducts include volatile fatty acids, daughter products of chlorinated aliphatic hydrocarbons, methane, and chloride.

Oxic groundwater: Groundwater that contains oxygen in concentrations greater than about 0.5 mg/L.

Oxidation/reduction reaction: A chemical or biological reaction wherein an electron is transferred from an electron donor (donor is oxidized) to an electron acceptor (acceptor is reduced).

Predominant terminal electron-accepting process: The electron-accepting process (oxygen reduction, nitrate reduction, iron(III) reduction, etc.) that sequesters the majority of the electron flow in a given system.

Reductive dechlorination: Reduction of a chlorine-containing organic compound via the replacement of chlorine with hydrogen.

Respiration: The process of coupling the oxidation of organic compounds with the reduction of inorganic compounds such as oxygen, nitrate, iron(III), manganese(IV), and sulfate.

Seepage velocity: The average velocity of groundwater in a porous medium.

Substrate: A compound used by microorganisms to obtain energy for growth. The term can refer to either an electron acceptor or an electron donor.

4.0 RESPONSIBILITIES

Project Manager (PM) / Task Order Manager (TOM) - Responsible for ensuring that all field activities are conducted in accordance with this standard operating procedure (SOP).

Project Hydrogeologist or Geochemist - Responsible for selecting and detailing the specific groundwater sampling techniques, onsite water quality testing (type, frequency, and location), and equipment to be used, and providing detailed input in this regard to the project plan documents. The project hydrogeologist or geochemist is also responsible for properly briefing and overseeing the performance of the site sampling personnel.

Site Manager (SM) / Field Operations Leader (FOL) - Responsible for the onsite verification that all field activities are performed in compliance with approved SOPs or as otherwise directed by the approved project plan(s).

Project Geologist - is primarily responsible for the proper acquisition of the groundwater samples. He/she is also responsible for the actual analyses of onsite water quality samples, as well as instrument calibration, care, and maintenance. When appropriate, such responsibilities may be performed by other qualified personnel (e.g., field sampling technicians or site personnel).

5.0 PROCEDURES

5.1 General

Natural attenuation includes physical, chemical, and biochemical processes affecting the concentrations of dissolved contaminants in groundwater. These processes may include advection, dispersion, volatilization, dilution, sorption to aquifer solids, and/or precipitation or mineralization of compounds. Of greatest importance are those processes that lead to a reduction in contaminant mass (by degrading or destroying contaminants) such as biodegradation. These biochemical processes remove organic contaminants from the aquifer by destruction. Depending on the type of contaminant, particularly the organic contaminant (e.g., petroleum hydrocarbons or chlorinated organic solvents), the biochemical environment in the aquifer will vary. The biochemical environment within the aquifer influences and is influenced by the activities of aquifer microbiota. Specific types of microbiota, working singly or in complex consortia, may use organic contaminants as part of their normal cell functions. Natural

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attenuation monitoring is designed to measure indicators of the biochemical environment within the aquifer and, with direct and indirect lines of evidence and associated chemical concentration data, evaluate the likely fate (i.e., transformation, destruction, dilution, attenuation, etc.) of organic contaminants.

5.2 Planning for Natural Attenuation Sampling

The first step in preparing a natural attenuation investigation is to develop a site-specific conceptual model. The first step in development of this model is the analysis and review of available site-specific characterization data. The development and refinement of this model should be supplemented with additional data as needed. The data should include but is not limited to:

- Geologic and hydrogeologic information in three dimensions
- Nature, extent, and magnitude of contamination
- Location and presence of potential receptors to contamination

Lines of Evidence

Several lines of evidence are used to determine whether natural attenuation is working. The most compelling, primary evidence is decreasing groundwater contaminant concentrations over time. Decreasing concentration trends can be demonstrated in several ways including:

- Isoconcentration maps of the dissolved plume over time wherein the extent of the plume is either stable or decreasing.
- Time series plots of contaminant concentrations within a well illustrating a clear downward trend.
- Contaminant concentration profiles in a series of monitoring wells along a groundwater flow path illustrating decreasing concentrations beyond that attributable to dilution and dispersion.

Secondary, or supporting, lines of evidence include:

- Analytical data showing production and subsequent destruction of primary contaminant breakdown products.
- Geochemical data indicating that the biochemical environment is favorable for the appropriate microbiota.
- Geochemical data that indicate the aquifer microbiota are active.

Monitoring Well Location and Sampling Frequency

The number and locations of wells required to monitor natural attenuation will depend on the physical setting at each location. One possible array of monitoring wells is illustrated in Attachment A. In this scenario, one well is used to monitor conditions upgradient of the source, one well is located in the source area, and several wells are used to define and monitor the downgradient and lateral extent of the dissolved plume. At a minimum, there should be at least one upgradient well (ideally with no contamination present), one well in the source area, one well downgradient from the source area in the dissolved plume, and one downgradient well where contaminant concentrations are below regulatory criteria. Note that the number and locations of monitoring wells will vary depending on the site complexity and site objectives.

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Sampling frequency will be dictated by the ultimate use of the data and site-specific characteristics. Contaminant concentrations may be used to define statistically meaningful trends in contaminant concentrations. The sampling frequency may be defined by the hydrogeologic and/or geochemical conditions as well as the proposed statistical method for data analysis. For example, groundwater flow and contaminant characteristics (e.g., seepage velocity and contaminant loading) may dictate the sample frequency. Regardless of the factors, sampling frequency and duration will need to establish the range of natural chemical variability within the aquifer. After a sufficient amount of data has been collected and the geochemical conditions are understood, the frequency of sampling may be reduced. See Section 5.4 for additional information on sample collection and frequency.

5.3 Selection of Natural Attenuation Parameters

Natural attenuation via biodegradation depends on the nature of the organic contaminants and the oxidation-reduction (redox) environment within the aquifer. Simply stated, if the contaminants are fuels, biodegradation will be most effective if the redox conditions are aerobic or oxidizing. If the contaminants are chlorinated solvents, the biodegradation will be most effective (in the source and near source areas) if redox conditions in the aquifer are anaerobic or reducing.

Several parameters are needed to evaluate whether natural attenuation is taking place and, if so, the rate at which it may be occurring. The primary parameter providing direct evidence of natural attenuation is the aqueous concentrations of parent and daughter volatile organic compounds. More specifically, a decrease in parent products, an increase in daughter products, evidence that the plume is stable or shrinking in size, and overall decline in contaminant concentrations is direct evidence of natural attenuation. Natural attenuation or geochemical parameters that provide information about the redox conditions in the aquifer include:

- Dissolved oxygen
- Nitrate/nitrite
- Dissolved manganese
- Iron
- Sulfate/sulfide
- Methane
- Oxidation-reduction potential (ORP)

Secondary parameters that indicate biological activity in the aquifer and thereby support the natural attenuation evaluation include:

- Dissolved hydrogen
- Alkalinity
- Dissolved carbon dioxide

The concentrations of natural attenuation parameters are used to define the aquifer redox conditions. It is important to record and document the presence or absence (i.e., measurable or not measurable concentration) of certain natural attenuation parameters. The presence or absence of a certain substance may be sufficient to indicate the redox condition within the aquifer. By reference to Attachment B, which illustrates the typical sequence of biologically mediated redox reactions in natural systems, it is apparent that, for example, sulfate reduction (producing dissolved sulfide in groundwater) does not operate in an aerobic environment. Therefore, measurable sulfide should not be present if there is also dissolved oxygen at concentrations indicating an aerobic environment. Attachment B also illustrates the redox potential (measured in millivolts) associated with the redox reactions. ORP readings, also in millivolts, measured during well purging, may be compared with the range of values in Attachment B but with caution. Redox potentials measured with a platinum electrode in natural water samples may be misleading, especially when biologically mediated reactions are important, because many of the critical

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reactions in Attachment B do not generate a response in the electrode. Dissolved hydrogen concentration ranges associated with important redox reactions are also indicated in Attachment B. Because dissolved hydrogen is actually used by microbiota during redox reactions, its concentration may provide an additional indicator of the overall redox condition in the aquifer.

Attachments C and D tabulate the natural attenuation parameters for chlorinated volatile organic compound and petroleum hydrocarbon plumes, respectively. The parameters listed in these tables are organized in order of importance. Parameters selected for analysis shall be determined based on site conditions, project-specific plans, and/or other criteria established for the project. Based on these criteria, it is possible that all of the parameters may be selected.

5.4 Selection of Natural Attenuation Analytical Methods and Procedures

There are many analytical methods available to measure concentrations of the natural attenuation parameters discussed in the previous sections. Attachment E summarizes the sample methodologies, sampling equipment needed, sample volume, container, preservation, and holding time requirements. This table also summarizes the detection limits and the detection ranges for each method. A number of factors should be considered when selecting the appropriate sample analytical methodology including the required parameters, appropriate detection ranges for each compound, cost, and ease of use in the field. For example, when determining the correct methodology for measuring concentrations of total sulfide, the metabolic byproduct of sulfate reducing conditions, it is important to analyze for each of the forms of sulfide (H_2S , S^{2-} , and HS^-). Also, when the detection limit of the selected method is exceeded, another method may be considered, or the sampler may be able to dilute the sample (per manufacturer's instructions) to quantify it within the detected range. In terms of cost, some parameters are very time consuming when performed in the field. Without sacrificing sample integrity it may be more appropriate to select a methodology performed in a fixed-base laboratory. Finally, in terms of ease of use, certain field methods are generally easier compared to other methods. Using simpler methods may result in better quality sample results and increased sample repeatability without sacrificing sample integrity. For example, in some cases CHEMetrics Titret® Titration Ampule kits may be a good alternative to other hand digital titration methods.

The sample technicians should be aware that based on geochemical conditions recorded in the field, certain geochemical parameters may not have positive detections. For example, if dissolved oxygen concentrations indicate aerobic conditions then it is unlikely that dissolved hydrogen is present (see Section 5.10 for additional information). Another example is alkalinity. If the pH of the groundwater sample is less than 4.5, then it is unlikely that alkalinity will be measurable. Despite the potential for non-detect results, in cases such as those described above, all parameters should be collected in the field based upon project plans. The value in collecting the parameters in the future shall be determined by the project hydrogeologist and/or geochemist in accordance with the projects planning documents data quality objectives (DQO) and the items discussed in Section 5.2.

5.5 Procedures for Sample Collection

Groundwater sample collection for natural attenuation sampling should be performed using low flow purging and sampling techniques. These techniques are described in detail in SOP SA-1.1. Low flow purging and sampling procedures should be used to ensure the collection of a sample that is "representative" of the water present in the aquifer formation. Minimizing stress on the aquifer formation during low flow purging and sample collection ensures that there are minimal alternations to the water chemistry of the sample. The criteria used in the purging process should include minimization of drawdown in the well, stabilization of applicable indicator parameters, and evacuation of a sufficient amount of purge volume in accordance with SOP SA-1.1, project plans, and/or applicable regulatory guidance.

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Groundwater purging and sampling for natural attenuation should be performed using submersible pumps (e.g., bladder pumps) in accordance with SOP SA-1.1. However, in accordance with project plans and applicable regulatory guidance, peristaltic pumps may also be used for this purpose. Limitations of and factors associated with using these devices should be considered (see SOP SA-1.1 for more information). As a result of difficulties in collecting "representative" groundwater samples, bailers should not be used for the collection of natural attenuation samples.

It is critical that disturbance and aeration of samples monitored and collected at the well head are minimized. As a result, a flow-through sampling cell and a direct reading meter shall be used for the measurement of well stabilization indicator parameters (e.g., pH, conductivity, temperature, dissolved oxygen, turbidity, and ORP) at the well head. The pump effluent tubing should be placed at the bottom of the flow-through cell allowing effluent water from the cell to discharge at the top of the meter (above the detector probes) to minimize the agitation of water in the cell.

Documentation of the purging process shall be recorded during and at the completion of purging as discussed in Section 5.8. Immediately following the purging process and before sampling, all applicable indicator parameters must be measured and recorded on the appropriate sample log sheets as discussed in Section 5.8.

After all of the purging requirements have been met, groundwater sampling and natural attenuation data collection can begin. Monitoring wells will be sampled using the same pump and tubing used during well purging.

5.6 Procedures for Field Sample Analysis

Each of the field and fixed-base laboratory sample parameters requires different sampling procedures and holding times. Attachment E presents parameter-specific requirements for sampling, analysis, and storage of all of the parameters and methods sampled as part of natural attenuation analysis.

Due to parameter procedure and holding times, it is important to consider the sequence of sample collection and analysis. Generally speaking, with the exception of volatile organic compounds, field parameters shall be analyzed first followed by fixed-base laboratory sample collection. All samples will be collected in a sequence and manner that minimizes volatilization, oxidation, and/or chemical transformation of compounds. As a result, the following sample and analysis order should be followed:

- | | |
|---|------------------------------------|
| 1. Volatile organic compounds | 8. Nitrate / Nitrite |
| 2. Dissolved oxygen | 9. Dissolved manganese |
| 3. Alkalinity | 10. Semivolatile organic compounds |
| 4. Dissolved carbon dioxide | 11. Other dissolved metals |
| 5. Dissolved ferrous iron | 12. Total metals |
| 6. Dissolved sulfide (hydrogen sulfide and sulfide) | 13. All other constituents |
| 7. Dissolved hydrogen, methane, ethene, and ethane | |

Field-analyzed parameters should be collected and immediately analyzed directly from the pump effluent per the requirements on Attachment E and manufacturer's recommendations. Care should be taken to minimize any unnecessary disturbance, aeration, or agitation of the sample prior to analysis. It is not acceptable to collect and store samples that are to be analyzed immediately at the well head in a temporary holding container (e.g., open topped pitcher) to be analyzed at a later time.

The manufacturer's procedure manual for each of the field-based analyses shall be maintained in the field during the entire sampling program. The procedures give a detailed explanation of how to perform each particular method and include information on sampling, storage, accuracy checks, interferences, reagents, and apparatus needed to perform each analysis.

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5.7 Procedures for Quality Assurance and Quality Control Field Sample Analysis

Accuracy and precision checks shall be performed to check the performance of the reagents, apparatus, and field analytical procedures per the manufacturer's recommendations. The accuracy checks should include the use of standard solutions (i.e., standard addition), as appropriate. The manufacturer's field test kit manual provides details on how to perform each of the accuracy checks for each parameter where applicable. Refer to Section 6.0 for manufacturer contact information.

Precision checks must include the performance of duplicate analysis. When using a colorimeter, precision checks may also include reagent blank corrections and standard curve adjustments as recommended by the manufacturer. Field duplicate results shall be performed and evaluated for relative percent difference (RPD) at a rate of 1 per 10 samples or as determined by the project plans. The RPD can be calculated as follows:

$$RPD = \left| \frac{\text{First result} - \text{Second result}}{\text{Mean arithmetic (average) of first and second result}} \right| \times 100$$

If the RPD exceeds 50 percent, it is required that the test be performed again to verify the result. The duplicate results shall be documented in the 'Notes' section for that specific parameter on the appropriate sample logsheet (see Section 5.8).

If a colorimeter (e.g., HACH DR-890 or equivalent) is used for parameter analysis, an instrument performance verification test using absorbance standards may also be performed to ensure the meter is providing accurate measurements.

The following table lists examples of the types and frequencies of accuracy checks required for each parameter. Refer to the manufacturer's instructions for information regarding other analyses.

Parameter	Method	Standard Solution	Field Duplicate	Reagent Blank Correction
Alkalinity	CHEMetrics K-9810, -15, -20	None	1 per 10	None
Carbon dioxide	CHEMetrics K-1910, -20, -25	None	1 per 10	None
Dissolved oxygen	CHEMetrics K-7501, -12	None	1 per 10	None
Ferrous iron	HACH DR-890	None	1 per 10	None
Nitrite	HACH DR-890	1 per round	1 per 10	1 per lot
Nitrate	HACH DR-890	1 per round	1 per 10	1 per lot
Sulfide	HACH DR-890	None	1 per 10	None
Hydrogen sulfide	HACH HS-C	None	1 per 10	None

Prior to analysis, the expiration dates of reagents shall be checked. If the reagents have exceeded their expiration date or shelf life, the reagents shall be replaced. If deviations from the applicable analytical procedure are identified, the deviations shall be corrected and the associated samples re-analyzed. If problems are identified with the reagents, apparatus, or procedures, data interferences may be present. Interferences may also be due to other factors (e.g., pH, presence or concentration of other ions, turbidity, temperature, etc.) that may interfere with the sample result. The manufacturer's procedures (e.g., Hach, 1999) should be reviewed prior to analysis to avoid or minimize such interferences. Associated problems

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or suspected interferences shall be documented in the 'Notes' section of the sample logsheet. Often, interferences cannot be avoided. In these cases, the sampler should be aware of these potential interferences and document them properly.

5.8 Documentation Procedures for Field Sample Analysis

Field results shall be properly documented in the field as noted in SOP SA-6.3. The sample log sheet titled "Field Analytical Log Sheet, Geochemical Parameters" shall be prepared for each sample collected and analyzed in the field. A copy of this form can be found as Attachment F of this SOP. Other field log sheets (e.g., low flow purge log sheet, groundwater sample logsheet, etc.) shall also be completed in accordance with SOP SA-6.3.

Specific information shall also be recorded in the project logbook. This information shall include, but is not limited to, the test kit name and model number, lot number and expiration date of the test kit and reagents used, serial number of the instrument (e.g., colorimeter) used for the analysis, and results of the quality assurance and quality control field sample analysis. Because environmental conditions and changes in those conditions may affect the field analytical results, it is important to document the site conditions (weather, temperature, etc.) at the time of sampling in the logbook in accordance with SOP SA-6.3.

5.9 Waste Handling and Disposal

Several of the test kits listed in Attachment E require the use of chemicals and materials that must be properly handled and disposed of in a proper and responsible manner. Refer to specific manufacturer's guidance for handling and disposal practices. See also Section 6.0 for more detailed and complete information. Handling and disposal of these items should be conducted in accordance with all local, state, and federal guidelines.

5.10 Understanding Field Sample Analytical Results

Natural attenuation data interpretation is complicated by the complex inter-relationships of various parameters. The complexity reflects the myriad of biochemical processes. Real-time evaluation of field analytical data can be misleading because a full interpretation often requires combining the field analytical results with fixed-base laboratory results. Regardless, some simple observations and data interpretations in the field may provide insights about the monitoring system or early warnings about sample collection and handling problems.

Data collected from the designated upgradient monitoring well is the baseline from which other interpretations are made. Field analytical data will indicate that the upgradient environment is either oxidizing or reducing. The redox condition within the upgradient area of the aquifer may be natural or impacted by other contaminant source areas (see Section 5.2 for upgradient well selection). Regardless, the redox condition of the upgradient groundwater will influence the source area. Changes in field analytical results from the upgradient well to the source area well will be reflected in samples from monitoring wells further downgradient.

The general characteristics of the two redox environments are summarized in the following table.

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Aerobic/Oxidizing	Anaerobic/Reducing
<ul style="list-style-type: none"> • Measurable dissolved oxygen (>1 to 2 ppm) • Measurable nitrate • No measurable dissolved manganese • No measurable dissolved ferrous iron • Measurable dissolved sulfate • No measurable dissolved sulfide • No measurable dissolved methane • No measurable dissolved hydrogen 	<ul style="list-style-type: none"> • No measurable dissolved oxygen (<1 ppm) • No measurable nitrate • Measurable dissolved manganese • Measurable dissolved ferrous iron • No measurable dissolved sulfate • Measurable dissolved sulfide • Measurable dissolved methane • Measurable dissolved hydrogen

Transitional environments between these two extremes may have intermediate characteristics and are actually quite common. Because reactions are mediated by biological systems, equilibrium (the basis for the figure in Attachment B) conditions within the aquifer should not be expected. For example, sulfate reduction environments may occur in close proximity to methanogenic environments, and this natural attenuation data may be difficult to interpret. Carefully collected and analyzed field measurements and sample collections for fixed-base laboratory analyses are designed to characterize the aquifer environment along the continuum between strongly aerobic and strongly anaerobic. Because the land surface environment is generally more oxidizing than any groundwater environment, sample handling at the point of collection and analysis is extremely important in preserving the chemical integrity of the groundwater sample.

6.0 REFERENCES

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Chemetrics, 2002, <http://www.chemetrics.com>.

Department of the Navy, 1998. Technical Guidelines for Evaluating Monitored Natural Attenuation of Petroleum Hydrocarbons and Chlorinated Solvents in Ground Water at Naval and Marine Corps Facilities, Department of the Navy, September. Prepared by T. H. Weidemeier and F. H. Chappelle.

USEPA (United States Environmental Protection Agency), 1998. Technical Protocol for Evaluating Natural Attenuation of Chlorinated Solvents in Ground Water, EPA/600/R-98/128, Office of Research and Development, Washington, D.C.

Hach Company, 1999. DR-890 Colorimeter Procedures Manual, Product Number 48470-22, Loveland Colorado.

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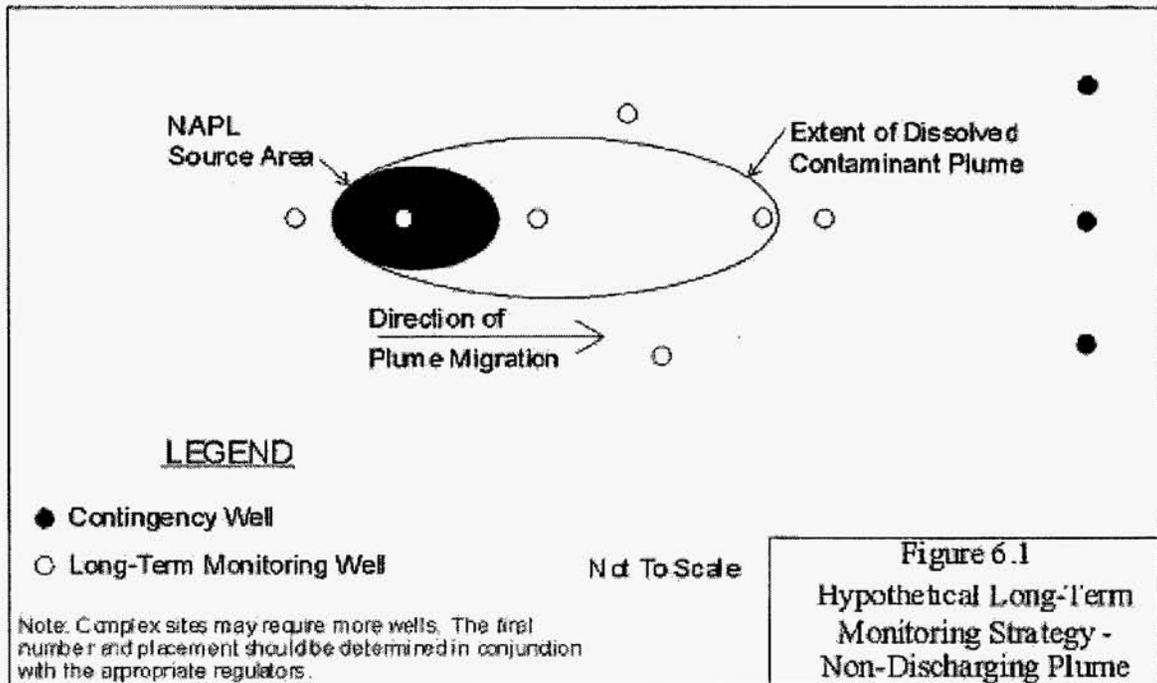
USEPA, 1997. Draft EPA Region 4 Suggested Practices for Evaluation of a Site for Natural Attenuation (Biological Degradation) of Chlorinated Solvents; Version 3.0. November.

USEPA, 1999. Use of Monitored Natural Attenuation at Superfund, RCRA Corrective Action, and Underground Storage Tank Sites, USEPA OSWER Directive 9200.4-17P, April 21, 1999

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ATTACHMENT A

HYPOTHETICAL LONG-TERM MONITORING STRATEGY



Taken from: Department of the Navy, 1998, Technical Guidelines for Evaluating Monitored Natural Attenuation of Petroleum Hydrocarbons and Chlorinated Solvents in Ground Water at Naval and Marine Corps Facilities, Prepared by Todd Weidemeier and Francis Chappelle.

ATTACHMENT B

REDOX POTENTIALS FOR VARIOUS ELECTRON ACCEPTORS

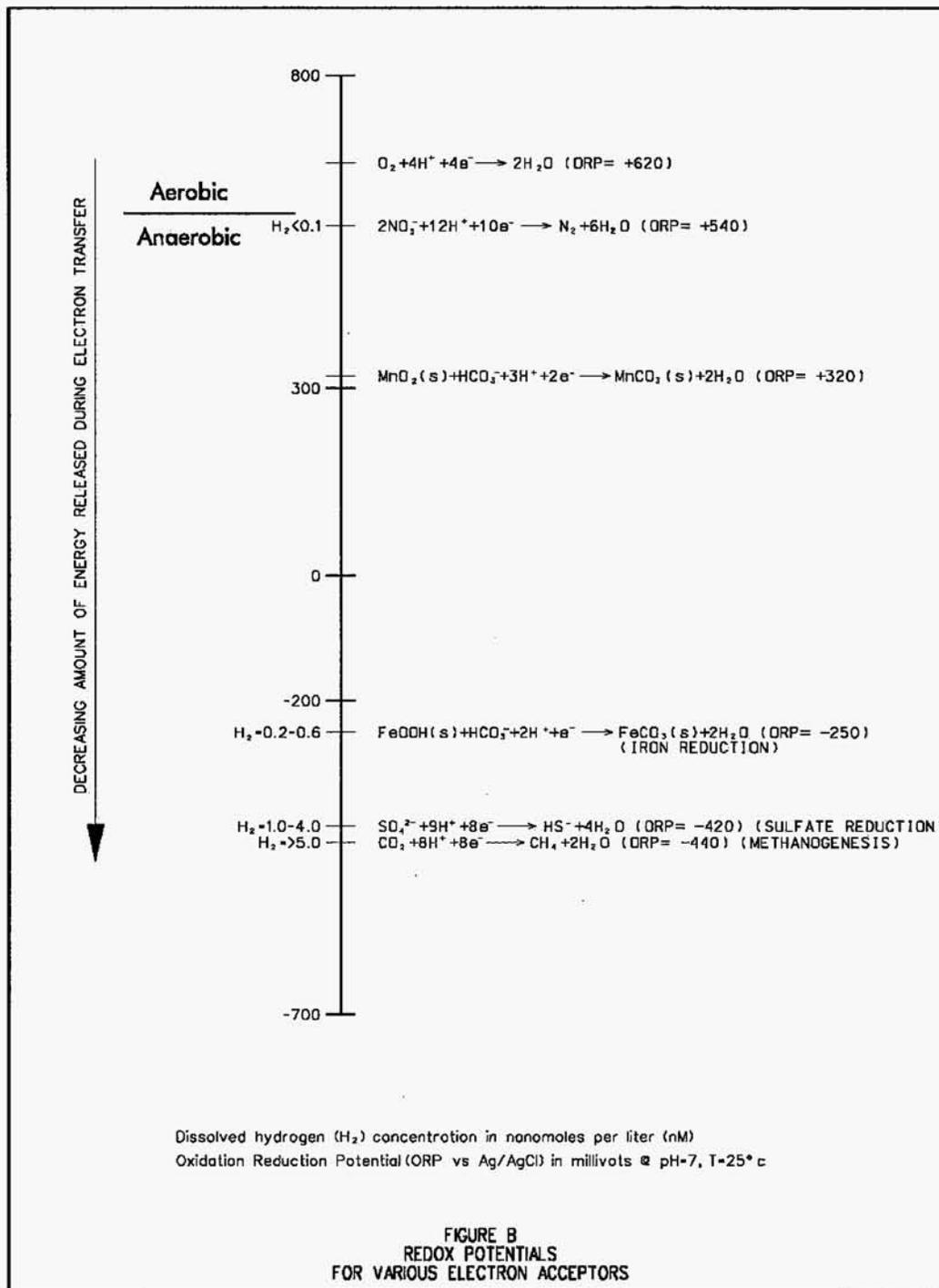


FIGURE B
REDOX POTENTIALS
FOR VARIOUS ELECTRON ACCEPTORS

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ATTACHMENT C

NATURAL ATTENUATION PARAMETERS FOR CHLORINATED VOLATILE ORGANIC COMPOUND PLUMES SCREENING PROCESS SUMMARY FOR REDUCTIVE (ANAEROBIC) DECHLORINATION

Potential Electron Donors	Electron Acceptors:	Reduced Species:	Related Dechlorination Pathway:
Native total organic carbon (TOC) Anthropogenic carbon (e.g., leachate) Fuel hydrocarbons (e.g., BTEX) Lightly chlorinated solvents (DCE/VC)	Dissolved Oxygen	⇒ Carbon Dioxide (CO ₂)	~ DCE → VC → CO ₂
	Manganese (Mn ⁴⁺)	⇒ Manganese (Mn ²⁺)	~ DCE → VC
	Nitrate (NO ₃)	⇒ Nitrite (NO ₂)	~ DCE → VC
	Ferric Iron (Fe ³⁺)	⇒ Ferrous Iron (Fe ²⁺)	~ DCE → VC → CO ₂
	Sulfate (SO ₄)	⇒ Sulfide (S ²⁻ , HS ⁻ , H ₂ S)	~ TCE → DCE → VC → Ethene
	Carbon Dioxide (CO ₂)	⇒ Methane (CH ₄)	~ PCE → TCE → DCE → VC → Ethene

Geochemical Parameter List:

Parameter	Field or Lab	Rationale	Importance
Volatile organic compounds	L	Source products; daughter products; electron donors (e.g., benzene, toluene, ethylbenzene, and xylene; BTEX)	1
Dissolved oxygen	F	Primary electron acceptor (respiration); an/aerobic indicator	1
Nitrate (and nitrite), dissolved	F or L	Anaerobic electron acceptor (product of nitrate reduction)	1
Manganese, dissolved	F or L	Anaerobic electron acceptor	1
Ferrous Iron (Fe ²⁺)	F	Product of iron reduction	1
Sulfate [and sulfide (S ²⁻)]	F or L	Common anaerobic electron acceptor (product of sulfate reduction)	1
Sulfide (H ₂ S)	F	Common product of sulfate reduction	1
Methane, ethane, ethene	L	Product of methanogenesis; daughter products of reductive dechlorination	1
Chloride	L	Ultimate daughter product of reductive dechlorination	1
TOC - upgradient groundwater	L	Electron donor	1
ORP, pH, specific conductance, temperature, turbidity	F	General water quality determination	1
Carbon dioxide (CO ₂)	F	Anaerobic electron acceptor (methanogenesis); biotic respiration indicator	2
Alkalinity/DIC	F	Buffering capacity; biotic respiration indicator	2
Hydrogen, dissolved	L	Fingerprint for characterizing electron acceptor pathway - indicator of what redox is occurring	2
TOC - upgradient soil	L	Input to analytical NA models; quantifies soil-water distribution coefficient and retardation factor	2
Volatile fatty acids	L	Determination of anthropogenic carbon used as an electron donor	3

Importance: 1=Most important; 3=Least important (depending on DQOs, all may be recommended). See Attachment E for details regarding analytical methods.

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ATTACHMENT D

**NATURAL ATTENUATION PARAMETERS FOR
PETROLEUM HYDROCARBON PLUMES
SCREENING PROCESS SUMMARY FOR OXIDATIVE (AEROBIC) DEGRADATION**

Parameter	Field or Lab	Rationale	Importance
Volatile organic compounds	L	Source products; daughter products; electron donors (BTEX)	1
Dissolved oxygen	F	Primary electron acceptor (respiration); an/aerobic indicator	1
Nitrate (and nitrite), dissolved	F or L	Anaerobic electron acceptor (and product of nitrate reduction)	1
Manganese, dissolved	F or L	Anaerobic electron acceptor	1
Ferrous Iron (Fe ²⁺)	F	Product of iron reduction	1
Sulfate [and Sulfide (S ⁻²)]	F or L	Common anaerobic electron acceptor (product of sulfate reduction)	1
Sulfide (H ₂ S)	F	Common product of sulfate reduction	1
TOC - upgradient groundwater	L	Electron donor	1
ORP, pH, specific conductance temperature, turbidity	F	General water quality determination	1
Dissolved methane (CH ₄)	L	Product of methanogenesis	1
Anions: chloride (Cl), nitrate (NO ₃), nitrite (NO ₂), phosphate (PO ₄), sulfate (SO ₄)	L		1
TOC - Upgradient soil	L	Input to analytical NA models; quantifies soil-water distribution coefficient and retardation factor	2
Biological oxygen demand (BOD)	L	Understanding of aquifer oxygen demand	3
Chemical oxygen demand (COD)	L	Understanding of aquifer oxygen demand	3

Importance: 1=Most important; 3=Least important (depending on DQOs, all may be recommended).

See Attachment E for details regarding analytical methods.

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**ATTACHMENT E
 GEOCHEMICAL SAMPLING PARAMETERS - METHODS, EQUIPMENT, VOLUMES, CONTAINERS,
 PRESERVATION, HOLDING TIMES, AND DETECTION RANGES
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Parameter	Method / Reference	Equipment / Method Chemistry	Sample Volume, Container, Preservation, & Holding Time	Range (mg/L)	Precision (mg/L)	Estimated Detection Limit (mg/L)
Alkalinity	CHEMetrics K-9810, K-9815, K-9820 -ASTM D 1067-92 -EPA 310.1	Titret® Titration Ampules / Hydrochloric Acid, Phenolphthalein	Field. Follow test kit instructions. Avoid agitation and analyze at well head to determine total alkalinity. Filter if turbid (>10 NTU).	10-100 (K-9810) 50-500 (K-9815) 100-1000 (K-9820)	N/A	10 50 100-
Alkalinity	Fixed-base lab -EPA 310.1	N/A	100 to 250 mL in glass or plastic container. Cool to 4°C. Analyze within 14 days. Filter if turbid.	N/A	N/A	N/A
Alkalinity / Dissolved Inorganic Carbon	HACH AL-DT -HACH 8203 -SM 2320 / SM 403	Digital Titration / Hydrochloric Acid, Phenolphthalein (P) and Total (M)	Field. Follow test kit instructions. Avoid agitation and analyze at well head to determine carbonate, bicarbonate, and hydroxide ions. Filter if turbid as recommended by manufacture. May use a pH meter for colored samples.	10-4000	N/A	10
Arsenic	Fixed-base lab -SW-6010 B	N/A	1 liter glass or polyethylene container, HNO ₃ to pH ≤ 2, 6 months.	N/A	N/A	N/A
Biochemical Oxygen Demand	Fixed-base lab -EPA 410.1	N/A	2 liter HDPE. Cool to 4°C. Analyze within 48 hours.	N/A	N/A	N/A
Carbon Dioxide, dissolved	CHEMetrics K-1910, K-1920, K-1925 -ASTM D 513.82 -SM 4500-CO ₂ -C	Titret® Titration Ampules / Sodium Hydroxide, Phenolphthalein	Field. Follow test kit instructions. Avoid agitation and analyze at well head.	10-100 (K-1910) 100-1000 (K-1920) 250-2500 (K-1925)	N/A	10 100 250
Carbon Dioxide, dissolved	Fixed-base lab -VOA water sample (Vaportech)	GC-ECD/RGD/FID Detector	40 mL in VOA vial. 2 to 3 vials by (Vaportech).	N/A	N/A	N/A
Carbon Dioxide, dissolved	Fixed-base lab -Microseeps gas stripping cell	GC-ECD/RGD/FID Detector	Field bubble-strip sampling required. Ship in glass septum vial (Microseeps only).	N/A	N/A	N/A
Carbon Dioxide, dissolved	HACH CA-DT -HACH 8205 -Mod. SM 406	Digital Titration / Sodium Hydroxide, Phenolphthalein	Field. Follow test kit instructions. Do not aerate or agitate. Analyze at well head.	10-1000	N/A	10
Chemical Oxygen Demand	Fixed-base lab -EPA 410.1	N/A	125 mL HDPE. H ₂ SO ₄ to pH <2.0. Cool to 4°C. Analyze within 28 days.	N/A	N/A	N/A
Chloride (Cl)	Fixed-base lab -EPA 300	N/A	100 to 250 mL in glass or plastic container. Cool to 4°C. Analyze within 28 days.	N/A	N/A	N/A
Chlorine - Total (Cl ₂)	HACH DR-850 -HACH 8167 -SM 4500-Cl	Colorimeter / DPD Method	Field. Follow test kit instructions.	0.02-2.00	+ 0.01 mg/L with a 1.00 mg/L chlorine solution.	1
Conductance, Specific	Field Meter -SW-8050 A	Direct Reading Meter	100 to 250 mL in glass or plastic container. Analyze immediately.	N/A	N/A	N/A
Ethane, dissolved	Fixed-base lab -VOA water sample, Vaportech -RSK SOP-147 & 175	GC-ECD/RGD/FID Detector	40 mL in VOA vial. 2 to 3 vials by (Vaportech).	N/A	N/A	N/A
Ethane, dissolved	Fixed-base lab -Microseeps gas stripping cell -RSK SOP-147 & 175	GC-ECD/RGD/FID Detector	Field bubble-strip sampling required. Ship in glass septum vial (Microseeps only).	N/A	N/A	N/A

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ATTACHMENT E

**GEOCHEMICAL SAMPLING PARAMETERS - METHODS, EQUIPMENT, VOLUME, CONTAINER,
 PRESERVATION, HOLDING TIME, AND DETECTION RANGES
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Parameter	Method / Reference	Equipment / Method Chemistry	Sample Volume, Container, Preservation, & Holding Time	Range (mg/L)	Precision (mg/L)	Estimated Detection Limit (mg/L)
Ethene, dissolved	Fixed-base lab -VOA water sample, Vaportech -RSK SOP-147 & 175	GC-ECD/RGD/FID Detector	40 mL in VOA vial. 2 to 3 vials by (Vaportech).	N/A	N/A	N/A
Ethene, dissolved	Fixed-base lab -Microseeps gas stripping cell -RSK SOP-147 & 175	GC-ECD/RGD/FID Detector	Field bubble-strip sampling required. Ship in glass septum vial (Microseeps only).	N/A	N/A	N/A
Fraction Organic Carbon (foc)-Soil Upgradient Saturated Soil	Fixed-base lab -Walk-Black -SW-846 9060	N/A	200 gram glass jar. Cool to 4°C. Analyze within 14 days.	N/A	N/A	N/A
Hydrogen, dissolved	Fixed-base lab -Microseeps or Vapor Tech gas stripping cell -RSK SOP-147 & 175	GC-ECD/RGD/FID Detector	Field bubble-strip sampling required. Ship in glass septum vial.	N/A	N/A	N/A
Iron, ferrous (Fe ²⁺)	HACH DR-850 -HACH 8146 -Mod. SM 315 B	Colorimeter 1, 10 Phenanthroline	Field. Follow test kit instructions. Analyze immediately at well head. Filter if turbid (>10 NTU) as recommended by the manufacture.	0-3.00	±0.017 mg/L with a 2.00 mg/L Fe ²⁺ solution.	0.03
Iron, ferrous (Fe ²⁺)	HACH IR-18C -Mod. SM 315 B	Color Disc 1, 10 Phenanthroline	Field. Follow test kit instructions. Analyze immediately at well head. Filter if turbid (>10 NTU) as recommended by the manufacture.	0-10	N/A	0.2
Iron, total dissolved (Filtered)	Fixed-base lab -SW-846 6010B	N/A	250 mL in plastic container. Field filter to 0.45 µ. HCl to pH <2. Cool to 4°C. Analyze within 6 months.	N/A	N/A	N/A
Manganese (Mn ²⁺)	HACH DR-850 -HACH 8034 -CFR 44(116) 34193	Colorimeter / Cold Periodate Oxidation	Field. Follow test kit instructions. Avoid agitation and analyze at well head. Filter if turbid as recommended by the manufacture.	0-20.0	+ 0.18 mg/L with a 10.00 mg/L Mn solution.	0.12
Manganese (Mn ²⁺)	HACH MN-5 -Mod. SM 319 B -CFR 44(116) 34193	Color Disc / Cold Periodate Oxidation	Field. Follow test kit instructions. Avoid agitation and analyze at well head. Filter if turbid as recommended by the manufacture.	0-3	N/A	0.1
Manganese, total dissolved (Filtered)	Fixed-base lab -SW-846 6010B	N/A	250 mL in plastic container. Field filter to 0.45 µ. HCl to pH <2. Cool to 4°C. Analyze within 6 months.	N/A	N/A	N/A
Methane, dissolved	Fixed-base lab -VOA water sample, Vaportech -RSK SOP-147 & 175	GC-ECD/RGD/FID Detector	40 mL in VOA vial. 2 to 3 vials by (Vaportech).	N/A	N/A	N/A
Methane, dissolved	Fixed-base lab -Microseeps gas stripping cell -RSK SOP-147 & 175	GC-ECD/RGD/FID Detector	Field bubble-strip sampling required. Ship in glass septum vial (Microseeps only).	N/A	N/A	N/A
Nitrate (NO ₃)	Fixed-base lab -EPA 300	N/A	250 mL plastic container. Cool to 4°C. Analyze within 48 hours.	N/A	N/A	N/A
Nitrate (NO ₃)	HACH DR-850 -HACH 8192 -Mod. EPA 353.2	Colorimeter / Cadmium Reduction	Field. Follow test kit instructions. Avoid agitation and analyze at well head. Pretreatment required if nitrite is present.	0-0.50	+ 0.03 mg/L with a 0.25 mg/L of nitrate nitrogen (NO ₃ ⁻ N) solution.	0.01
Nitrite (NO ₂)	Fixed-base lab -EPA 300	N/A	250 mL plastic container. Cool to 4°C. Analyze within 48 hours. Filter if turbid as recommended by the manufacture.	N/A	N/A	N/A

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ATTACHMENT E

**GEOCHEMICAL SAMPLING PARAMETERS - METHODS, EQUIPMENT, VOLUME, CONTAINER,
 PRESERVATION, HOLDING TIME, AND DETECTION RANGES
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Parameter	Method / Reference	Equipment / Method Chemistry	Sample Volume, Container, Preservation, & Holding Time	Range (mg/L)	Precision (mg/L)	Estimated Detection Limit (mg/L)
Nitrite (NO ₂ ⁻)	HACH DR-850 -HACH 8507 -Mod. EPA 354.1 -Mod. SM 419 -CFR 44(85) 25595	Colorimeter / Diazotization	Field. Follow test kit instructions. Avoid agitation and analyze at well head. Filter if turbid as recommended by the manufacture.	0-0.350	± 0.001 mg/L with a 0.250 mg/L nitrite nitrogen solution.	0.005
Nitrogen, dissolved	Fixed-base lab -Microseeps gas stripping cell -Vaportech VOA water sample	GC-ECD/RGD/FID Detector	Field bubble-strip sampling required for Microseeps. Ship in glass septum vial (Microseeps) or VOA vial (Vaportech).	N/A	N/A	N/A
Nitrogen, Total Kjeldahl	Fixed-base lab -EPA 351.2	N/A	500 mL plastic/glass container. Cool to 4°C. H ₂ SO ₄ to pH ≤ 2. Analyze within 28 days.	N/A	N/A	N/A
Oxidation Reduction Potential	Field Meter - ASTM D-1498	Direct Reading Meter	Field. Do not aerate. Gently agitate probe using flow over or flow-through method. Analyze immediately at well head.	N/A	N/A	N/A
Oxygen, dissolved	CHEMetrics K-7501, K-7512 -ASTM D 5543-94 -ASTM D 887-92	CHEMetrics® Vacuum Vials / Rhodazine D and Indigo Carmine	Field. Follow test kit instructions. Avoid agitation and analyze immediately at well head.	0-1 (K-7501) 1-12 (K-7512)	N/A	0.025 1
Oxygen, dissolved	Fixed-base lab -VOA water sample, Vaportech -RSK SOP-147 & 175	GC-ECD/RGD/FID Detector	40 mL in VOA vial. 2 to 3 vials by (Vaportech).	N/A	N/A	N/A
Oxygen, dissolved	Fixed-base lab -Microseeps gas stripping cell -RSK SOP-147 & 175	GC-ECD/RGD/FID Detector	Field bubble-strip sampling required. Ship in glass septum vial (Microseeps only).	N/A	N/A	N/A
Oxygen, dissolved	HACH OX-DT -HACH 8215 -SM 4500-O-G	Digital Titration / Azide Modification of Winkler Digital Titration Method	Field. Follow test kit instructions. Avoid agitation and analyze immediately at well head.	1-10	N/A	1
Oxygen, dissolved	HACH DR-850 (AccuVac Ampules) LR HRDO Method	-Indigo Carmine Method -Rhodazine D Method	Field. Follow test kit instructions. Avoid agitation and analyze immediately at well head.	0-0.8 ppm 0-10 ppm	0.01 ppm 0.1 ppm	N/A
Oxygen, dissolved	Field Meter	Direct Reading Meter	Analyze immediately at well head. Avoid agitation and analyze immediately at well head. Used for well stabilization measurement parameter only.	N/A	N/A	N/A
pH	Field Meter -SW 9040B	Direct Reading Meter	Analyze immediately at well head.	N/A	N/A	N/A
Phosphate (ortho)	Fixed-base lab -EPA 300	Ion Chromatography	250 mL plastic container. Cool to 4°C. Analyze within 48 hours. Filter if turbid as recommended by the manufacture.	N/A	N/A	N/A
Phosphate, potassium	Fixed-base lab -SW-846 6010B	Inductively Coupled Plasma	250 mL plastic container. Cool to 4°C. Analyze within 48 hours. Filter if turbid as recommended by the manufacture.	N/A	N/A	N/A
Salinity	Field Meter	Direct Reading Meter	Analyze immediately.	N/A	N/A	N/A
Sulfate (SO ₄ ²⁻)	Fixed-base lab N/A	N/A	250 mL plastic container. Cool to 4°C. Analyze within 48 hours. Filter if turbid as recommended by the manufacture.	N/A	N/A	N/A
Sulfate (SO ₄ ²⁻)	HACH DR-850 -HACH 8051 -EPA 375.4	Colorimeter / Turbimetric SulfaVer 4	Field. Follow test kit instructions. Filter if turbid as recommended by the manufacture.	0-70	± 0.5 mg/L with a 50 mg/L sulfate solution.	4.9
Sulfide (Hydrogen Sulfide, H ₂ S)	HACH HS-C -HACH Proprietary -Mod. SM 426 C	Color Chart / Effervescence of H ₂ S through sulfide reactive paper.	Field. Follow test kit instructions. Avoid agitation and analyze immediately at well head.	0-5	N/A	0.1
Sulfide (S ²⁻)	CHEMetrics K-9510 -SM 4500-S ²	CHEMetrics® Vacuum Vials / Methylene Blue	Field. Follow test kit instructions. Avoid agitation and analyze immediately at well head.	0-1 1-10	N/A	0.1 1

Subject
**NATURAL ATTENUATION
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 1

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 Effective Date
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ATTACHMENT E

**GEOCHEMICAL SAMPLING PARAMETERS - METHODS, EQUIPMENT, VOLUME, CONTAINER,
 PRESERVATION, HOLDING TIME, AND DETECTION RANGES
 PAGE 4 OF 4**

Parameter	Method / Reference	Equipment / Method Chemistry	Sample Volume, Container, Preservation, & Holding Time	Range (mg/L)	Precision (mg/L)	Estimated Detection Limit (mg/L)
Sulfide (S ²⁻)	Fixed-base lab -EPA 376.1/376.2	N/A	1 liter in plastic container, no headspace. NaOH to pH >9. Cool to 4°C. Avoid agitation and analyze within 7 days.	N/A	N/A	N/A
Sulfide (S ²⁻)	HACH DR-850 -HACH 8131 -SM 4500-S ²	Colorimeter / Methylene Blue	Field. Follow test kit instructions. Avoid agitation and analyze immediately at well head. Pretreatment required for turbid samples as recommended by the manufacture.	0-0.70	± 0.02 mg/L with a 0.73 mg/L sulfide solution.	0.01
Sulfide (S ²⁻)	HACH HS-WR -SM 4500-S ²	Color Disc / Methylene Blue	Field. Follow test kit instructions. Avoid agitation and analyze immediately at well head. Pretreatment required for turbid samples as recommended by the manufacture.	0-11.25	N/A	0.1-2.5
Temperature	Field Meter / Thermometer - E 170.1	Direct Reading Meter / Thermometer	Analyze immediately.	N/A	N/A	N/A
Total Organic Carbon (TOC)-Groundwater	Fixed-base lab - E 415.1	N/A	125 mL HDPE. H ₂ SO ₄ to pH < 2.0. Cool to 4°C. Analyze within 28 days.	N/A	N/A	N/A
Turbidity	Field Meter - E 180.1	Direct Reading Meter	Analyze immediately.	N/A	N/A	N/A

N/A = Not applicable.

ATTACHMENT F

FIELD ANALYTICAL LOG SHEET, GEOCHEMICAL PARAMETERS PAGE 1 OF 3

Note: Analyte, method, and/or equipment may be deleted from form if not being performed.



FIELD ANALYTICAL LOG SHEET GEOCHEMICAL PARAMETERS

Tetra Tech NUS, Inc.

Page of

Project Site Name: _____				Sample ID No.: _____																																											
Project No.: _____				Sample Location: _____																																											
Sampled By: _____				Duplicate: <input type="checkbox"/>																																											
Field Analyst: _____				Blank: <input type="checkbox"/>																																											
Field Form Checked as per QA/QC Checklist (initials): _____																																															
SAMPLING DATA:																																															
Date: _____	Color (Visual)	pH (S.U.)	S.C. (mS/cm)	Temp. (°C)	Turbidity (NTU)	DO (mg/l)	Salinity (%)	ORP (Eh) (+/- mv)																																							
Time: _____																																															
Method: _____																																															
SAMPLE COLLECTION/ANALYSIS INFORMATION:																																															
ORP (Eh) (+/- mv)				Electrode Make & Model: _____																																											
Reference Electrode (circle one): Silver-Silver Chloride / Calomel / Hydrogen																																															
Dissolved Oxygen:																																															
Equipment: Chemetrics Test Kit				Concentration: _____ ppm																																											
<table border="1" style="width:100%; border-collapse: collapse;"> <tr> <th>Range Used:</th> <th>Range</th> <th>Method</th> <th>Concentration ppm</th> </tr> <tr> <td><input type="checkbox"/></td> <td>0 to 1 ppm</td> <td>K-7510</td> <td></td> </tr> <tr> <td><input type="checkbox"/></td> <td>1 to 12 ppm</td> <td>K-7512</td> <td></td> </tr> </table>				Range Used:	Range	Method	Concentration ppm	<input type="checkbox"/>	0 to 1 ppm	K-7510		<input type="checkbox"/>	1 to 12 ppm	K-7512		Analysis Time: _____																															
Range Used:	Range	Method	Concentration ppm																																												
<input type="checkbox"/>	0 to 1 ppm	K-7510																																													
<input type="checkbox"/>	1 to 12 ppm	K-7512																																													
Equipment: HACH Digital Titrator OX-DT				Analysis Time: _____																																											
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Range Used:	Range	Sample Vol.	Cartridge	Multiplier																																											
<input type="checkbox"/>	1-5 mg/L	200 ml	0.200 N	0.01																																											
<input type="checkbox"/>	2-10 mg/L	100 ml	0.200 N	0.02																																											
Titration Count	Multiplier	Concentration																																													
_____	x 0.01	= _____ mg/L																																													
_____	x 0.02	= _____ mg/L																																													
Notes: _____																																															
Carbon Dioxide:																																															
Equipment: Chemetrics Test Kit				Concentration: _____ ppm																																											
<table border="1" style="width:100%; border-collapse: collapse;"> <tr> <th>Range Used:</th> <th>Range</th> <th>Method</th> <th>Concentration ppm</th> </tr> <tr> <td><input type="checkbox"/></td> <td>10 to 100 ppm</td> <td>K-1910</td> <td></td> </tr> <tr> <td><input type="checkbox"/></td> <td>100 to 1000 ppm</td> <td>K-1920</td> <td></td> </tr> <tr> <td><input type="checkbox"/></td> <td>250 to 2500 ppm</td> <td>K-1925</td> <td></td> </tr> </table>				Range Used:	Range	Method	Concentration ppm	<input type="checkbox"/>	10 to 100 ppm	K-1910		<input type="checkbox"/>	100 to 1000 ppm	K-1920		<input type="checkbox"/>	250 to 2500 ppm	K-1925		Analysis Time: _____																											
Range Used:	Range	Method	Concentration ppm																																												
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<input type="checkbox"/>	100 to 1000 ppm	K-1920																																													
<input type="checkbox"/>	250 to 2500 ppm	K-1925																																													
Equipment: HACH Digital Titrator CA-DT																																															
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Range Used:	Range	Sample Vol.	Cartridge	Multiplier																																											
<input type="checkbox"/>	10-50 mg/L	200 ml	0.3636 N	0.1																																											
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_____	x 0.1	= _____ mg/L																																													
_____	x 0.2	= _____ mg/L																																													
_____	x 1.0	= _____ mg/L																																													
_____	x 2.0	= _____ mg/L																																													
Standard Additions: <input type="checkbox"/> Titrant Molarity: _____ Digits Required: 1st: _____ 2nd: _____ 3rd: _____																																															
Notes: _____																																															
Hydrogen, dissolved																																															
Equipment: Bubble strip sampling field method																																															
Start stripper at _____ (time)																																															
End stripper at _____ (time)																																															
Total stripper time _____																																															
Pump rate _____ milliliters/minute																																															

ATTACHMENT F

**FIELD ANALYTICAL LOG SHEET, GEOCHEMICAL PARAMETERS
PAGE 2 OF 3**

Note: Analyte, method, and/or equipment may be deleted from form if not being performed.



**FIELD ANALYTICAL LOG SHEET
GEOCHEMICAL PARAMETERS**

Tetra Tech NUS, Inc.

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Project Site Name: _____				Sample ID No.: _____			
Project No.: _____				Sample Location: _____			
Sampled By: _____				Duplicate: <input type="checkbox"/>			
Field Analyst: _____				Blank: <input type="checkbox"/>			
Alkalinity:							
Equipment: Chemetrics Test Kit				Concentration: _____ ppm			
Range Used:	Range	Method	Concentration ppm	Analysis Time: _____			
<input type="checkbox"/>	10 to 100 ppm	K-9810		Filtered: <input type="checkbox"/>			
<input type="checkbox"/>	50 to 500 ppm	K-9815					
<input type="checkbox"/>	100 to 1000 ppm	K-9820					
Equipment: HACH Digital Titrator AL-DT							
Range Used:	Range	Sample Vol.	Cartridge	Multiplier	Titration Count	Multiplier	Concentration
<input type="checkbox"/>	10-40 mg/L	100 ml	0.1600 N	0.1	&	x 0.1	= mg/L
<input type="checkbox"/>	40-160 mg/L	25 ml	0.1600 N	0.4	&	x 0.4	= mg/L
<input type="checkbox"/>	100-400 mg/L	100 ml	1.600 N	1.0	&	x 1.0	= mg/L
<input type="checkbox"/>	200-800 mg/L	50 ml	1.600 N	2.0	&	x 2.0	= mg/L
<input type="checkbox"/>	500-2000 mg/L	20 ml	1.600 N	5.0	&	x 5.0	= mg/L
<input type="checkbox"/>	1000-4000 mg/L	10 ml	1.600 N	10.0	&	x 10.0	= mg/L
Parameter:		Hydroxide	Carbonate	Bicarbonate			
Relationship:							
Standard Additions: <input type="checkbox"/> Titrant Molarity: _____ Digits Required: 1st: _____ 2nd: _____ 3rd: _____							
Notes:							
Ferrous Iron (Fe²⁺):							
Equipment: DR-850		DR-8 __	Range: 0 - 3.00 mg/L		Concentration: _____ ppm		
Program/Module: 500nm		33			Analysis Time: _____		
Equipment: IR-18C Color Wheel		Range: 0 - 10 mg/L		Filtered: <input type="checkbox"/>			
Notes:							
Hydrogen Sulfide (H₂S):							
Equipment: HS-C		Other: _____		Range: 0 - 5 mg/L		Concentration: _____ ppm	
Exceeded 5.0 mg/L range on color chart: <input type="checkbox"/>						Analysis Time: _____	
Notes:							
Sulfide (S²⁻):							
Equipment: Chemetrics Test Kit		Range: 0 - 10 mg/L		Concentration: _____ ppm			
Range Used:	Range	Method	Concentration ppm	Analysis Time: _____			
<input type="checkbox"/>	0 to 1 ppm	K-9510		Filtered: <input type="checkbox"/>			
<input type="checkbox"/>	1 to 10 ppm	K-9510					
Equipment: DR-850		DR-8 __	Range: 0 - 0.70 mg/L				
Program/Module: 610nm		93					
Notes:							

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**FIELD ANALYTICAL LOG SHEET, GEOCHEMICAL PARAMETERS
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Note: Analyte, method, and/or equipment may be deleted from form if not being performed.



**FIELD ANALYTICAL LOG SHEET
GEOCHEMICAL PARAMETERS**

Tetra Tech NUS, Inc.

Page of

Project Site Name: _____		Sample ID No.: _____	
Project No.: _____		Sample Location: _____	
Sampled By: _____		Duplicate: <input type="checkbox"/>	
Field Analyst: _____		Blank: <input type="checkbox"/>	
Sulfate (SO₄²⁻):			
Equipment	DR-850	DR-8 __	Range: 0 - 70 mg/L
Concentration:	_____ ppm		
Program/Module:	91	Analysis Time:	_____
Standard Solution:	<input type="checkbox"/>	Results: _____	Filtered: <input type="checkbox"/>
Standard Additions:	<input type="checkbox"/>	Digits Required: 0.1ml: _____ 0.2ml: _____ 0.3ml: _____	
Notes: _____			
Nitrate (NO₃⁻-N):			
Equipment	DR-850	DR-8 __	Range: 0 - 0.50 mg/L ⁽¹⁾
Concentration:	_____ ppm		
Program/Module:	55	Analysis Time:	_____
Standard Solution:	<input type="checkbox"/>	Results: _____	Filtered: <input type="checkbox"/>
Standard Additions:	<input type="checkbox"/>	Digits Required: 0.1ml: _____ 0.2ml: _____ 0.3ml: _____	
Alternate forms:	NO ₂ _____ NaNO ₂ _____ mg/L		
Notes (1): If results are over limit use dilution method at step 3, 5ml sample 10ml DI result X3, range upto 1.5mg/L			
Notes: _____			
Nitrite (NO₂⁻-N):			
Equipment	DR-850	DR-8 __	Range: 0 - 0.350 mg/L
Concentration:	_____ ppm		
Program/Module:	62	Analysis Time:	_____
Standard Solution:	<input type="checkbox"/>	Results: _____	Filtered: <input type="checkbox"/>
Standard Additions:	<input type="checkbox"/>	Digits Required: 0.1ml: _____ 0.2ml: _____ 0.3ml: _____	
		Reagent Blank Correction:	<input type="checkbox"/>
Notes: _____			
Manganese (Mn²⁺):			
Equipment	DR-850	DR-8 __	Range: 0 - 20.0 mg/L
Concentration:	_____ ppm		
Program/Module:	525nm	Analysis Time:	_____
Standard Solution:	<input type="checkbox"/>	Results: _____	Filtered: <input type="checkbox"/>
Standard Additions:	<input type="checkbox"/>	Digits Required: 0.1ml: _____ 0.2ml: _____ 0.3ml: _____	
		Digestion:	<input type="checkbox"/>
		Reagent Blank Correction:	<input type="checkbox"/>
Equipment	HACH MN-5	Range:	0 - 3 mg/L
Notes: _____			
QA/QC Checklist:			
All data fields have been completed as necessary: <input type="checkbox"/>			
Correct measurement units are cited in the SAMPLING DATA block: <input type="checkbox"/>			
Values cited in the SAMPLING DATA block are consistent with the Groundwater Sample Log Sheet: <input type="checkbox"/>			
Multiplication is correct for each Multiplier table: <input type="checkbox"/>			
Final calculated concentration is within the appropriate Range Used block: <input type="checkbox"/>			
Alkalinity Relationship is determined appropriately as per manufacturer (HACH) instructions: <input type="checkbox"/>			
QA/QC sample (e.g., Std. Additions, etc.) frequency is appropriate as per the project planning documents: <input type="checkbox"/>			
Nitrite interference treatment was used for Nitrate test if Nitrite was detected: <input type="checkbox"/>			
Title block on each page of form is initialized by person who performed this QA/QC Checklist: <input type="checkbox"/>			



TETRA TECH NUS, INC.

STANDARD OPERATING PROCEDURES

Number	SA-7.1	Page	1 of 8
Effective Date	09/03	Revision	3
Applicability	Tetra Tech NUS, Inc.		
Prepared	Earth Sciences Department		
Approved	D. Senovich <i>[Signature]</i>		

Subject DECONTAMINATION OF FIELD EQUIPMENT

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3.0 GLOSSARY	2
4.0 RESPONSIBILITIES.....	3
5.0 PROCEDURES.....	3
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1.0 PURPOSE

Decontamination is the process of removing and/or neutralizing site contaminants that have contacted and/or accumulated on equipment. The objective/purpose of this SOP is intended to protect site personnel, general public, and the sample integrity through the prevention of cross contamination onto unaffected persons or areas. It is further intended through this procedure to provide guidelines regarding the appropriate procedures to be followed when decontaminating drilling equipment, monitoring well materials, chemical sampling equipment and field analytical equipment.

2.0 SCOPE

This procedure applies to all equipment including drilling equipment, heavy equipment, monitoring well materials, as well as chemical sampling and field analytical equipment decontamination that may be used to provide access/acquire environmental samples. Where technologically and economically feasible, single use sealed disposable equipment will be employed to minimize the potential for cross contamination. This procedure also provides general reference information on the control of contaminated materials.

3.0 GLOSSARY

Acid - For decontamination of equipment when sampling for trace levels of inorganics, a 10% solution of nitric acid in deionized water should be used. Due to the leaching ability of nitric acid, it should not be used on stainless steel.

Alconox/Liquinox - A brand of phosphate-free laboratory-grade detergent.

Decontamination Solution - Is a solution selected/identified within the Health and Safety Plan or Project-Specific Quality Assurance Plan. The solution is selected and employed as directed by the project chemist/health and safety professional.

Deionized Water (DI) - Deionized water is tap water that has been treated by passing through a standard deionizing resin column. This water may also pass through additional filtering media to attain various levels of analyte-free status. The DI water should meet CAP and NCCLS specifications for reagent grade, Type I water.

Potable Water - Tap water used from any municipal water treatment system. Use of an untreated potable water supply is not an acceptable substitute for tap water.

Pressure Washing - Employs high pressure pumps and nozzle configuration to create a high pressure spray of potable water. High pressure spray is employed to remove solids.

Solvent - The solvent of choice is pesticide-grade Isopropanol. Use of other solvents (methanol, acetone, pesticide-grade hexane, or petroleum ether) may be required for particular projects or for a particular purpose (e.g. for the removal of concentrated waste) and must be justified in the project planning documents. As an example, it may be necessary to use hexane when analyzing for trace levels of pesticides, PCBs, or fuels. In addition, because many of these solvents are not miscible in water, the equipment should be air dried prior to use. Solvents should not be used on PVC equipment or well construction materials.

Steam Pressure Washing - This method employs a high pressure spray of heated potable water. This method through the application of heat provides for the removal of various organic/inorganic compounds.

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4.0 RESPONSIBILITIES

Project Manager - Responsible for ensuring that all field activities are conducted in accordance with approved project plan(s) requirements.

Field Operations Leader (FOL) - Responsible for the onsite verification that all field activities are performed in compliance with approved Standards Operating Procedures or as otherwise dictated by the approved project plan(s).

Site Health and Safety Officer (SHSO) - The SHSO exercises shared responsibility with the FOL concerning decontamination effectiveness. All equipment arriving on-site (as part of the equipment inspection), leaving the site, moving between locations are required to go through a decontamination evaluation. This is accomplished through visual examination and/or instrument screening to determine the effectiveness of the decontamination process. Failure to meet these objectives are sufficient to restrict equipment from entering the site/exiting the site/ or moving to a new location on the site until the objectives are successfully completed.

5.0 PROCEDURES

The process of decontamination is accomplished through the removal of contaminants, neutralization of contaminants, or the isolation of contaminants. In order to accomplish this activity a level of preparation is required. This includes site preparation, equipment selection, and evaluation of the process. Site contaminant types, concentrations, media types, are primary drivers in the selection of the types of decontamination as well as where it will be conducted. For purposes of this SOP discussion will be provided concerning general environmental investigation procedures.

The decontamination processes are typically employed at:

- Temporary Decontamination Pads/Facilities
- Sample Locations
- Centralized Decontamination Pad/Facilities
- Combination of some or all of the above

The following discussion represents recommended site preparation in support of the decontamination process.

5.1 Decontamination Design/Constructions Considerations

5.1.1 Temporary Decontamination Pads

Temporary decontamination pads are constructed at satellite locations in support of temporary work sites. These structures are generally constructed to support the decontamination of heavy equipment such as drill rigs and earth moving equipment but can be employed for smaller articles.

The purpose of the decontamination pad is to contain wash waters and potentially contaminated soils generated during decontamination procedures. Therefore, construction of these pads should take into account the following considerations

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- Site Location – The site selected should be within a reasonable distance from the work site but should avoid:
 - Pedestrian/Vehicle thoroughfares
 - Areas where control/custody cannot be maintained
 - Areas where a potential releases may be compounded through access to storm water transport systems, streams or other potentially sensitive areas.
 - Areas potentially contaminated.

- Pad – The pad should be constructed to provide the following characteristics
 - Size – The size of the pad should be sufficient to accept the equipment to be decontaminated as well as permitting free movement around the equipment by the personnel conducting the decontamination.
 - Slope – An adequate slope will be constructed to permit the collection of the water and potentially contaminated soils within a trough or sump constructed at one end. The collection point for wash waters should be of adequate distance that the decontamination workers do not have to walk through the wash waters while completing their tasks.
 - Sidewalls – The sidewalls should be a minimum of 6-inches in height to provide adequate containment for wash waters and soils. If splash represents a potential problem, splash guards should be constructed to control overspray. Sidewalls maybe constructed of wood, inflatables, sand bags, etc. to permit containment.
 - Liner – Depending on the types of equipment and the decontamination method the liner should be of sufficient thickness to provide a puncture resistant barrier between the decontamination operation and the unprotected environment. Care should be taken to examine the surface area prior to placing the liner to remove sharp articles (sticks, stones, debris) that could puncture the liner. Liners are intended to form an impermeable barrier. The thickness may vary from a minimum recommended thickness of 10 mil to 30 mil. Achieving the desired thickness maybe achieved through layering lighter constructed materials. It should be noted that various materials (rubber, polyethylene sheeting) become slippery when wet. To minimize this potential hazard associated with a sloped liner a light coating of sand maybe applied to provide traction as necessary.
 - Wash/drying Racks – Auger flights, drill/drive rods require racks positioned off of the ground to permit these articles to be washed, drained, and dried while secured from falling during this process. A minimum ground clearance of 2-feet is recommended.
 - Maintenance – The work area should be periodically cleared of standing water, soils, and debris. This action will aid in eliminating slip, trip, and fall hazards. In addition, these articles will reduce potential backsplash and cross contamination. Hoses should be gathered when not in use to eliminate potential tripping hazards.

5.1.2 Decontamination Activities at Drill Rigs/DPT Units

During subsurface sampling activities including drilling and direct push activities decontamination of drive rods, Macro Core Samplers, split spoons, etc. are typically conducted at an area adjacent to the operation. Decontamination is generally accomplished using a soap/water wash and rinse utilizing buckets and brushes. This area requires sufficient preparation to accomplish the decontamination objectives.

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Buckets shall be placed within mortar tubs or similar secondary containment tubs to prevent splash and spills from reaching unprotected media. Drying racks will be employed as directed for temporary pads to permit parts to dry and be evaluated prior to use/re-use.

5.1.3 Decontamination Activities at Remote Sample Locations

When sampling at remote locations sampling devices such as trowels, pumps/tubing should be evacuated of potentially contaminated media to the extent possible. This equipment should be wrapped in plastic for transport to the temporary/centralized decontamination location for final cleaning and disposition.

5.2 Equipment Decontamination Procedures

The following represents procedures to be employed for the decontamination of equipment that may have contacted and/or accumulated contamination through site investigation activities.

5.2.1 Monitoring Well Sampling Equipment

5.2.1.1 Groundwater sampling pumps – This includes pumps inserted into the monitoring well such as Bladder pumps, Whale pumps, Redi-Flo, reusable bailers, etc.

- 1) Evacuate to the extent possible, any purge water within the pump.
- 2) Scrub using soap and water and/or steam clean the outside of the pump and tubing, where applicable.
- 3) Insert the pump and tubing into a clean container of soapy water. Pump a sufficient amount of soapy water through the pump to flush any residual purge water. Once flushed, circulate soapy water through the pump to ensure the internal components are thoroughly flushed.
- 4) Remove the pump and tubing from the container, rinse external components using tap water. Insert the pump and tubing into a clean container of tap water. Pump a sufficient amount of tap water through the pump to evacuate all of the soapy water (until clear).
- 5) Rinse equipment with pesticide grade isopropanol
- 6) Repeat item #4 using deionized water through the hose to flush out the tap water and solvent residue as applicable .
- 7) Drain residual deionized water to the extent possible, allow components to air dry.
- 8) Wrap pump in aluminum foil or a clear clean plastic bag for storage.

5.2.1.2 Electronic Water Level Indicators/Sounders/Tapes

During water level measurements, rinsing with the extracted tape and probe with deionized water and wiping the surface of the extracted tape is acceptable. However, periodic full decontamination should be conducted as indicated below.

* - The solvent should be employed when samples contain oil, grease, PAHs, PCBs, and other hard to remove materials. If these are not of primary concern, the solvent step may be omitted. In addition, do not rinse PE, PVC, and associated tubing with solvents.

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- 1) Wash with soap and water
- 2) Rinse with tap water
- 3) Rinse with deionized water

Note: In situations where oil, grease, free product, other hard to remove materials are encountered probes and exposed tapes should be washed in hot soapy water.

5.2.1.3 Miscellaneous Equipment

Miscellaneous equipment including analytical equipment (water quality testing equipment) should be cleaned per manufacturer's instructions. This generally includes wiping down the sensor housing and rinsing with tap and deionized water.

Coolers/Shipping Containers employed to ship samples are received from the lab in a variety of conditions from marginal to extremely poor. Coolers should be evaluated prior to use for

- Structural integrity – Coolers missing handles or having breaks within the outer housing should be removed and not used. Notify the laboratory that the risk of shipping samples will not be attempted and request a replacement unit.
- Cleanliness – As per protocol only volatile organic samples are accompanied by a trip blank. If a cooler's cleanliness is in question (visibly dirty/stained) or associated with noticeable odors it should be decontaminated prior to use.

- 1) Wash with soap and water
- 2) Rinse with tap water
- 3) Dry

If these measures fail to clean the cooler to an acceptable level, remove the unit from use as a shipping container and notify the laboratory to provide a replacement unit.

5.2.2 **Down-Hole Drilling Equipment**

This includes any portion of the drill rig that is over the borehole including auger flights, drill stems, rods, and associated tooling that would extend over the borehole. This procedure is to be employed prior to initiating the drilling/sampling activity, then between locations.

- 1) Remove all soils to the extent possible using shovels, scrapers, etc. to remove loose soils.
- 2) Through a combination of scrubbing using soap and water and/or steam cleaning remove visible dirt/soils.
- 3) Rinse with tap water.
- 4) Rinse equipment with pesticide grade isopropanol
- 5) To the extent possible allow components to air dry.
- 6) Wrap or cover equipment in clear plastic until it is time to be used.

5.2.3 **Soil/Sediment Sampling Equipment**

This consists of soil sampling equipment including but not limited to hand augers, stainless steel trowels/spoons, bowls, dredges, scoops, split spoons, Macro Core samplers, etc.

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- 1) Remove all soils to the extent possible.
- 2) Through a combination of scrubbing using soap and water and/or steam cleaning remove visible dirt/soils.
- 3) Rinse with tap water.
- 4) Rinse equipment with pesticide grade isopropanol
- 5) Rinse with deionized water
- 6) To the extent possible allow components to air dry.
- 7) If the device is to be used immediately, screen with a PID/FID to insure all solvents (if they were used) and trace contaminants have been adequately removed.
- 8) Once these devices have been dried wrap in aluminum foil for storage until it is time to be used.

5.3 Contact Waste/Materials

During the course of field investigations disposable/single use equipment becomes contaminated. These items include tubing, trowels, PPE (gloves, overboots, splash suits, etc.) broken sample containers.

With the exception of the broken glass, single use articles should be cleaned (washed and rinsed) of visible materials and disposed of as normal refuse. The exception to this rule is that extremely soiled materials that cannot be cleaned should be containerized for disposal in accordance with applicable federal state and local regulations.

5.3.1 Decontamination Solutions

All waste decontamination solutions and rinses must be assumed to contain the hazardous chemicals associated with the site unless there are analytical or other data to the contrary. The waste solution volumes could vary from a few gallons to several hundred gallons in cases where large equipment required cleaning.

Containerized waste rinse solutions are best stored in 55-gallon drums (or equivalent containers) that can be sealed until ultimate disposal at an approved facility. These containers must be appropriately labeled.

5.4 Decontamination Evaluation

Determining the effectiveness of the decontamination process will be accomplished in the following manner

- Visual Evaluation – A visual evaluation will be conducted to insure the removal of particulate matter. This will be done to insure that the washing/rinsing process is working as intended.
- Instrument Screening – A PID and/or an FID should be used to evaluate the presence of the contaminants or solvents used in the cleaning process. The air intake of the instrument should be passed over the article to be evaluated. A positive detection requires a repeat the decontamination process. It should be noted that the instrument scan is only viable if the contaminants are detectable within the instruments capabilities.

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- Rinsate Blanks – It is recommended that Rinsate samples be collected to
 - Evaluate the decontamination procedure representing different equipment applications (pumps versus drilling equipment) and different decontamination applications.
 - Single use disposable equipment – The number of samples should represent different types of equipment as well as different Lot Numbers of single use articles.

The collection and the frequency of collection of rinsate samples are as follows:

- Per decontamination method
- Per disposable article/Batch number of disposable articles

It is recommended that an initial rinsate sample be collected early in the project to ensure that the decontamination process is functioning properly and in an effort to avoid using a contaminated batch of single use articles. It is recommended that a follow up sample be collected during the execution of the project to insure those conditions do not change. Lastly, rinsate samples collection may be driven by types of and/or contaminant levels. Hard to remove contaminants, oils/greases, some PAHs/PCBs, etc. may also support the collection of additional rinsates due to the obvious challenges to the decontamination process. This is a field consideration to be determined by the FOL.



TETRA TECH NUS, INC.

STANDARD OPERATING PROCEDURES

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Applicability Tetra Tech NUS, Inc.	
Prepared Earth Sciences Department	
Approved D. Senovich <i>[Signature]</i>	

Subject EVALUATION OF EXISTING MONITORING WELLS AND WATER LEVEL MEASUREMENT

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1.0 PURPOSE

The purpose of this procedure is to provide reference information regarding the proper methods for evaluating the physical condition and project utility of existing monitoring wells and determining water levels.

2.0 SCOPE

The procedures described herein are applicable to all existing monitoring wells and, for the most part, are independent of construction materials and methods.

3.0 GLOSSARY

Hydraulic Head - The height to which water will rise in a well.

Water Table - A surface in an unconfined aquifer where groundwater pressure is equal to atmospheric pressure (i.e., the pressure head is zero).

4.0 RESPONSIBILITIES

Site Geologist/Hydrogeologist - Has overall responsibility for the evaluation of existing wells, obtaining water level measurements and developing groundwater contour maps. The site geologist/hydrogeologist (in concurrence with the Project Manager) shall specify the reference point from which water levels are measured (usually a specific point on the upper edge of the inner well casing), the number and location of data points which shall be used for constructing a contour map, and how many complete sets of water levels are required to adequately define groundwater flow directions (e.g., if there are seasonal variations).

Field Personnel - Must have a basic familiarity with the equipment and procedures involved in obtaining water levels and must be aware of any project-specific requirements or objectives.

5.0 PROCEDURES

Accurate, valid and useful groundwater monitoring requires that four important conditions be met:

- Proper characterization of site hydrogeology.
- Proper design of the groundwater monitoring program, including adequate numbers of wells installed at appropriate locations and depths.
- Satisfactory methods of groundwater sampling and analysis to meet the project data quality objectives (DQOs).
- The assurance that specific monitoring well samples are representative of water quality conditions in the monitored interval.

To insure that these conditions are met, adequate descriptions of subsurface geology, well construction methods and well testing results must be available. The following steps will help to insure that the required data are available to permit an evaluation of the utility of existing monitoring wells for collecting additional samples.

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5.1 Preliminary Evaluation

A necessary first step in evaluating existing monitoring well data is the study and review of the original work plan for monitoring well installation (if available). This helps to familiarize the site geologist/hydrogeologist with site-specific condition, and will promote an understanding of the original purpose of the monitoring wells.

The next step of the evaluation should involve a review of all available information concerning borehole drilling and well construction. This will allow interpretation of groundwater flow conditions and area geology, and will help to establish consistency between hydraulic properties of the well and physical features of the well or formation. The physical features which should be identified and detailed, if available, include:

- The well identification number, permit number and location by referenced coordinates, the distance from prominent site features, or the location of the well on a map.
- The installation dates, drilling methods, well development methods, past sampling dates, and drilling contractors.
- The depth to bedrock -- where rock cores were not taken, auger refusal, drive casing refusal or penetration test results (blow counts for split-barrel sampling) may be used to estimate bedrock interface.
- The soil profile and stratigraphy.
- The borehole depth and diameter.
- The elevation of the top of the protective casing, the top of the well riser, and the ground surface.
- The total depth of the well.
- The type of well materials, screen type, slot size, and length, and the elevation/depths of the screen, interval, and/or monitored interval.
- The elevation/depths of the tops and bottom of the filter pack and well seals and the type and size.

5.2 Field Inspection

During the onsite inspection of existing monitoring wells, features to be noted include:

- The condition of the protective casing, cap and lock.
- The condition of the cement seal surrounding the protective casing.
- The presence of depressions or standing water around the casing.
- The presence of and condition of dedicated sampling equipment.
- The presence of a survey mark on the inner well casing.

If the protective casing, cap and lock have been damaged or the cement collar appears deteriorated, or if there are any depressions around the well casing capable of holding water, surface water may have infiltrated into the well. This may invalidate previous sampling results unless the time when leakage started can be precisely determined.

The routine physical inspection must be followed by a more detailed investigation to identify other potential routes of contamination or sampling equipment malfunction. Any of these occurrences may invalidate

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previously-collected water quality data. If the monitoring well is to be used in the future, considerations shown in the steps described above should be rectified to rehabilitate the well.

After disconnecting any wires, cables or electrical sources, remove the lock and open the cap. Check for the presence of organic vapors with a photoionization detector (PID) or flame-ionization detector (FID) to determine the appropriate worker safety level. The following information should be noted:

- Cap function.
- Physical characteristics and composition of the inner casing or riser, including inner diameter and annular space.
- Presence of grout between the riser and outer protective casing and the existence of drain holes in the protective casing.
- Presence of a riser cap, method of attachment to casing, and venting of the riser.
- Presence of dedicated sampling equipment; if possible, remove such equipment and inspect size, materials of construction and condition.

The final step of the field inspection is to confirm previous hydraulic or physical property data and to obtain data not previously available. This includes the determination of static water levels, total well depth and well obstruction. This may be accomplished using a weighted tape measure which can also be used to check for sediment (the weight will advance slowly if sediment is present, and the presence of sediment on the weight upon removal should be noted). If sediment is present and/or the well has not been sampled in 12 or more months, it should be redeveloped before sampling.

Lastly, as a final step, the location, condition and expected water quality of the wells should be reviewed in light of their usefulness for the intended purpose of the investigation.

See Attachment A, Monitoring Well Inspection Sheet.

5.3 Water Level (Hydraulic Head) Measurements

5.3.1 **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 purging or sampling.

All groundwater level measurements shall be made to the nearest 0.01 foot, and recorded in the site geologist/hydrogeologist's field notebook or on the Groundwater Level Measurement Sheet (Attachment B), 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 barometric 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. 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.

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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 geologist/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 to weather changes.

5.3.2 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 site geologist/hydrogeologist.

In most instances, preparation of accurate potentiometric surface maps require that static water level measurements be obtained to a precision of 0.01 feet. To obtain such measurements in individual accessible wells, electrical water level indicator methods have been found to be best, and thus should be utilized. Other, less precise methods, such as the popper or bell sound, or bailer line methods, should be avoided. 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 a pressure transducer.

5.3.3 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. Never remove an air-tight lock (such as a J-plug) with your face over the well. Pressure changes within the well may explosively force the cap off once loosened.
2. Record all information specified below in the geologist/hydrogeologist's field notebook or on the Groundwater Level Measurement Sheet (Attachment B):
 - Well number.
 - Water level (to the nearest 0.01 foot). Water levels shall be taken from the surveyed reference mark on the top edge of the inner well casing. If the J-plug was on the well very tightly, it may take several minutes for the water level to stabilize.
 - Time and day of the measurement.
 - Thickness of free product if present.

Water level measuring devices with permanently marked intervals shall be used. The devices shall be free of kinks or folds which will affect the ability of the equipment to hang straight in the well pipe.

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5.3.4 Water Level Measuring Devices

Electric Water Level Indicators

These are the most commonly used devices and 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 adjacent to the survey mark on the inner well casing. The electric tape is read (to the nearest 0.01 ft.) at the measuring point and recorded where contact with the water surface was indicated.

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 "popping" or "plopping" 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.

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.

5.3.5 Data Recording

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

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5.3.6 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. Manufacturer's instructions for cleaning the device shall be strictly followed. Some devices used to measure groundwater levels may need to be calibrated. These devices shall be calibrated to 0.01 foot accuracy and any adjustments/corrections shall be recorded in the field logbook/notebook. After the corrections/adjustments are made to the measuring device and entered in the field logbook/notebook, the corrected readings shall be entered onto the Groundwater Level Measurement Sheet (Attachment B). Elevations will be entered on the sheet when they become available.

5.4 Equipment Decontamination

Equipment used for water level measurements provide a mechanism for potentially cross contaminating wells. Therefore, all portions of a device which project down the well casing must be decontaminated prior to advancing to the next well. Decontamination procedures vary based on the project objectives but must be defined prior to conducting any field activities including the collection of water level data. Consult the project planning documents and SA-7.1 Decontamination of Field Equipment.

5.5 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 or FID shall be performed to determine required levels of protection. Under certain conditions, air-tight well caps may explosively fly off the well when the pressure is relieved. Never stand directly over a well when uncapping it.

6.0 RECORDS

A record of all field procedures, tests and observations must be recorded in the site logbook or designated field notebook. Entries in the log/notebook should include the individuals participating in the field effort, and the date and time. The use of annotated sketches may help to supplement the evaluation.

