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RESOURCE CONSERVATION AND RECOVERY ACT FACILITY ASSESSMENT WORK PLAN
REVISION 1 WITH TRANSMITTAL LETTER NAS KEY WEST FL
4/11/2002
TETRA TECH NUS

TETRA TECH NUS, INC.

AIK-02-0113

April 11, 2002

Project Number HK N2870 *via U.S. Mail*

Commander
Department of the Navy
SOUTHDIV NAVFACENGCOM
ATTN: Joel Sanders (Code ES31)
P.O. Box 190010
North Charleston, South Carolina 29419-9010

Reference: CLEAN Contract No. N62467-94-D-0888
Contract Task Order No. 0188

Subject: RCRA Facility Assessment Work Plan, Rev. 1, Naval Air Facility, Key West, Florida

Dear Mr. Sanders:

I have enclosed the PDF file for the final RCRA Facility Assessment Work Plan, Rev. 1, Naval Air Facility, Key West, Florida. A CD is being distributed to the members of the NAF Key West Partnering Team for their convenience and to meet TtNUS's contractual obligation under CTO 0188. I don't expect to receive any comments on this plan.

Please call me at (803) 649-7963, extension 345, if you have any questions regarding the enclosed report.

Sincerely,

C. M. Bryan
Project Manager

CMB:spc

Enclosure

c: Ms. Debbie Wroblewski (Cover Letter Only)
Mr. T. Ballard, EPA
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RCRA Facility Assessment Work Plan

Naval Air Facility
Key West, Florida

Southern Division
Naval Facilities Engineering Command

Contract Number N62467-94-D-0888
Contract Task Order 0188

April 2002

Rev. 1

Rev. 1
AIK-02-0113

RCRA FACILITY ASSESSMENT WORK PLAN

NAVAL AIR FACILITY
KEY WEST, FLORIDA

COMPREHENSIVE LONG-TERM
ENVIRONMENTAL ACTION NAVY (CLEAN) CONTRACT

Submitted to:
Southern Division
Naval Facilities Engineering Command
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North Charleston, South Carolina 29406

Submitted by:
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CONTRACT NUMBER N62467-94-D-0888
CONTRACT TASK ORDER 0188

APRIL 2002

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LIST OF ACRONYMS AND ABBREVIATIONS

AIMD	Aircraft Intermediate Maintenance Department
AOC	area of concern
ARARS/SALS	Applicable or Relevant and Appropriate Requirements/Screening Action Levels
AST	Above-ground Storage Tank
ASTM	American Society of Testing and Materials
bls	below land surface
°C	degrees Celsius
CCI	CH2M HILL Construction, Inc.
CLEAN	Comprehensive Long-Term Environmental Action Navy
CLP	Contract Laboratory Procedure
CompQAP	Comprehensive Quality Assurance Plan
CTO	Contract Task Order
DPT	Direct Push Technology
DQO	Data Quality Objective
EPA	United States Environmental Protection Agency
ERNA	Environmental Restoration, Navy Account
FDEP	Florida Department of Environmental Protection
FID	flame-ionization detector
FOL	Field Operations Leader
ft	feet
GPS	global positioning system
HASP	Health and Safety Plan
HSA	hollow stem auger
HSM	health and safety manager
ID	inner diameter
IDW	investigation-derived waste
IRA	Interim Remedial Action
mL	milliliter
msl	mean sea level
µS/cm	microSiemens per centimeter
NAF	Naval Air Facility
NFESC	Naval Facilities Engineering Service Center
NSF	National Sanitation Foundation
NTU	nephelometric turbidity unit

OD	outside diameter
OVA	organic vapor analyzer
PAH	polynuclear aromatic hydrocarbons
PID	photo-ionization detector
PM	Program Manager
ppm	parts per million
QA	quality assurance
QAPP	Quality Assurance Project Plan
QC	quality control
RAC	Remedial Action Contractor
RCRA	Resource Conservation and Recovery Act
RFA	RCRA Facility Assessment
RFI	RCRA Facility Investigation
RI	Remedial Investigation
RPM	Remedial Project Manager
SAP	Sample and Analysis Plan
SouthDiv	Southern Division, Naval Facilities Engineering Command
SOP	Standard Operating Procedure
SVOC	semivolatile organic compound
SWMU	Solid Waste Management Unit
TAL	Target Analyte List
TOM	Task Order Manager
TPH	total petroleum hydrocarbons
TtNUS	Tetra Tech NUS, Inc.
VOC	volatile organic compound

1.0 INTRODUCTION

1.1 INTRODUCTION

Tetra Tech NUS, Inc. (TtNUS) has been contracted by the Department of the Navy, Southern Division, Naval Facilities Engineering Command (SouthDiv) to complete a Resource Conservation and Recovery Act (RCRA) Facility Assessment (RFA) for the Boca Chica Tar Tank Spill Area and the Former Boca Chica Blast Media Disposal Area at Naval Air Facility (NAF) Key West on Boca Chica Key, Florida. The RFA Work Plan is being conducted under contract number N62467-94-D-0888, Contract Task Order (CTO) Number 0188.

The Work Plan addresses the following elements applied during the investigation process: (1) Data Quality Objectives (DQOs), (2) Sampling and Analysis Plan (SAP), (3) Quality Assurance Project Plan (QAPP), and (4) Health and Safety Plan (HASP). This document is based on the limited background information available.

1.2 PURPOSE AND SCOPE

The RFA will be performed in accordance with RCRA guidelines. The Tar Tank Spill Area and the Former Boca Chica Blast Media Disposal Area will be investigated to identify and gather information on releases of hazardous waste or hazardous constituents that threaten human health or the environment. The scope of the work at Tar Tank Spill Area will include confirming that the Interim Remedial Action (IRA) performed by the Remedial Action Contractor (RAC) has removed all contaminated soils. Confirmation sampling will be performed following excavation of the visually contaminated areas of soil. Investigative activities at the Former Boca Chica Blast Media Disposal Area will include sampling of soil and groundwater to delineate contamination. These activities will also aid in determining the need for additional corrective actions. In addition, monitoring wells will be installed at each site and groundwater samples will be collected to determine whether groundwater contamination is a concern.

During the RFA process, modifications to the scope of work or sample collection procedures may be required to satisfy program objectives. In the event that factors or conditions are revealed that require a modification of the Work Plan, a technical memorandum will be used to document the modification. The modification would be enacted upon gaining consensus between the United States Environmental Protection Agency (EPA), the Florida Department of Environmental Protection (FDEP), Navy reviewers, and the RAC. This group is known collectively as the NAF Key West Partnering Team.

1.3 REPORT ORGANIZATION

This Work Plan consists of five chapters and four appendices. Section 1.0 provides the Introduction, Purpose and Scope of the document, Report Organization Facility Description, and Geology and Hydrogeology. Section 2.0 presents an overview of the environmental setting at Boca Chica Key, NAF Key West, and a characterization of the sites addressed in this Work Plan. Section 3.0 describes the SAP. Section 4.0 describes the management aspects of the project, such as management structure reporting requirements. Appendix A presents the Response to Comments, which will be included in Revision 1 of the Work Plan. The QAPP, which includes the DQOs, is provided in Appendix B. The HASP is provided in Appendix C. Standard Operating Procedures (SOPs), field log forms, and other documentation used during fieldwork are included in Appendix D.

1.4 FACILITY DESCRIPTION

NAF Key West is in southern Monroe County, Florida, and based on Boca Chica Key, approximately 5 miles east of Key West. Key West and Boca Chica Key, the two westernmost major islands of the Florida Keys, are approximately 150 miles southwest of Miami. The Overseas Highway (U.S. Highway 1) connects Key West and Boca Chica Key to the mainland. Figure 1-1 presents a regional map showing the location of Boca Chica Key and Key West within the Florida Keys. Figure 1-2 presents the location of Tar Tank Spill Area and the Former Boca Chica Blast Media Disposal Area.

Several installations in various parts of the lower Florida Keys comprise what is known as the Naval Complex at Key West. Most of these are on Key West and Boca Chica Key. Other parts of the complex include Sigsbee Key (formerly Dredgers Key), Fleming Key, Demolition Key, and Big Coppitt Key. The entire complex encompasses approximately 5,000 acres. Boca Chica Key is approximately 3 miles wide and 3 miles long, while the air station encompasses about 3,250 acres. With the exception of filled areas that underlie U.S. Highway 1, the elevations of Boca Chica Key are less than 5 feet (ft) above mean sea level (msl) (IT, 1994).

1.5 GEOLOGY AND HYDROGEOLOGY

The lower Keys, which are within the southern geomorphic division of Florida, were formed during the Pleistocene era. The Keys are known as the “Oolitic Keys”, a reference to the Oolitic Member of the Miami Limestone. The Oolitic Member consists of variably sandy, fossiliferous limestone composed primarily of ooids. The Oolitic Member is divided into two lithofacies: an ooid calcarenite and an oomolid-recrystalline facies. The Key Largo Limestone underlies the Miami Limestone. The Key Largo Limestone is a light gray to light yellow coralline limestone, comprised of coral heads encased in a matrix of

calcarenite. In the Key West area, the Miami Limestone is approximately 27 ft thick and the Key Largo Limestone is more than 270 ft thick (ABB, 1994).

The surficial aquifer system present in the lower Keys is an unconfined, porous, highly permeable unit with solution cavities. Rainfall recharge seeps quickly into the ocean and saltwater intrusion is common. The water table ranges in depth from less than 1 foot above msl to approximately 2.5 ft below msl and fluctuates diurnally, due to tidal effects.

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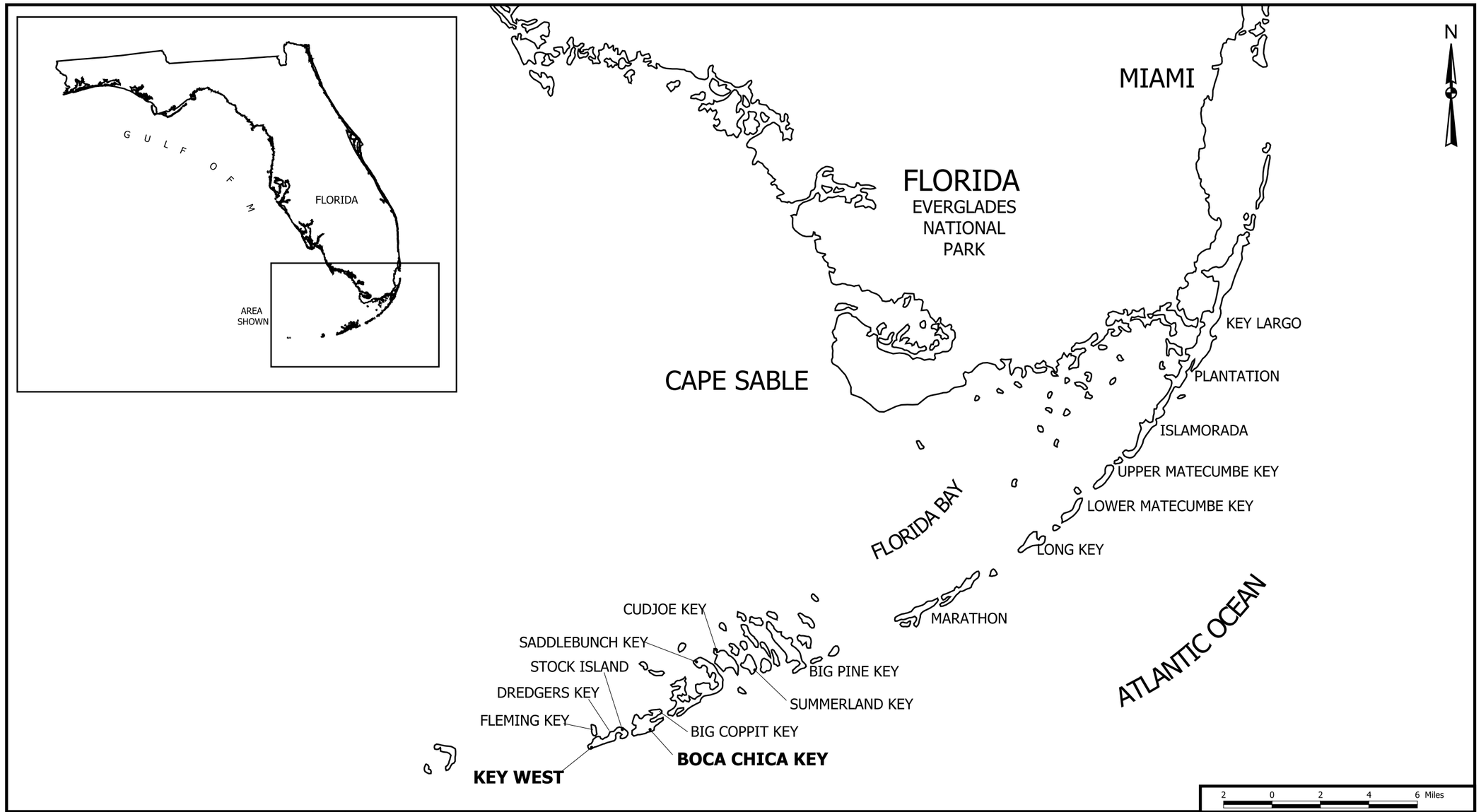

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DRAWN BY CM	DATE 10/13/2000
CHECKED BY SCS	DATE 2/19/01
COST/SCHED-AREA	
SCALE AS NOTED	

RFA Work Plan
FIGURE 1-1
LOCATION MAP
NAVAL AIR STATION
KEY WEST, FLORIDA

CONTRACT NO. 2870	
APPROVED BY CMB	DATE 2/20/01
APPROVED BY	DATE
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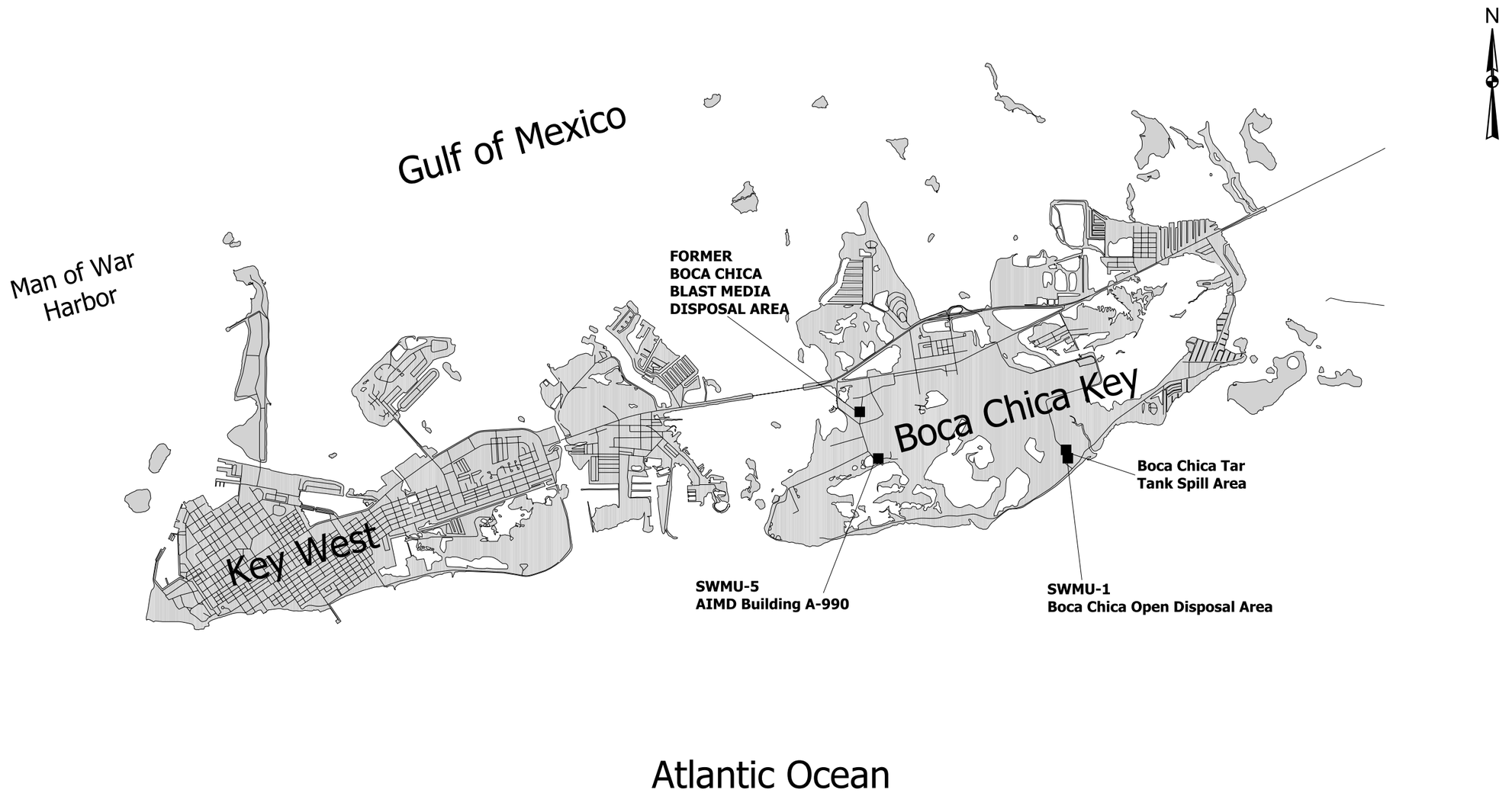
P:/GOVERNMENT/KEYWEST/EGIS/RFA_WORKPLAN.APR LAYOUT: FIG 1-1
DATE: 10/30/2001 BY: CM



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RFA WORK PLAN
FIGURE 1-2
AREA OF CONCERN AND AST SITE
NAVAL AIR STATION
KEY WEST, FLORIDA

CONTRACT NO. 2870	
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P:/GOVERNMENT/KEYWEST/EGIS/RFA_WORKPLAN.APR LAYOUT: FIG 1-2
DATE: 10/30/2001 BY: CM

2.0 SITE BACKGROUND

This chapter describes the site characteristics, site history, and scope and goals of the investigation.

2.1 TAR TANK SPILL AREA

2.1.1 Location, Description, and History

Site Location. The Tar Tank Spill Area is located on the southeastern portion of Boca Chica Key, immediately north of the boundary of Solid Waste Management Unit (SWMU) 1, the Former Boca Chica Open Disposal Area. The site area is shown on Figure 2-1.

Site Description. The Tar Tank Spill Area is the location of the remnants of a 10-foot-diameter above-ground storage tank (AST). The base of the tank still exists and is filled with 2.5 to 3 inches, or approximately 147 gallons, of an unknown tar-like substance. In hot weather, this substance has been observed to ooze from the tank onto the ground surface. Patches of the unknown substance surround the AST and become particularly viscous during hot weather.

Site History. The Tar Tank Spill Area is located directly north of SWMU 1, the Former Boca Chica Open Disposal Area. SWMU 1 received general refuse and waste associated with aircraft maintenance activities. The AST at the Tar Tank Spill Area is thought to have been associated with asphalt mixing activities.

During the RCRA Facility Investigation/Remedial Investigation (RFI/RI) performed by IT Corporation in 1993, one soil sample was collected from the area near the Tar Tank Spill Area. However, past volatile organic compounds (VOCs), pesticides, metals, and polynuclear aromatic hydrocarbon (PAH) sample results do not exceed current industrial soil action levels.

2.2 FORMER BOCA CHICA BLAST MEDIA DISPOSAL AREA

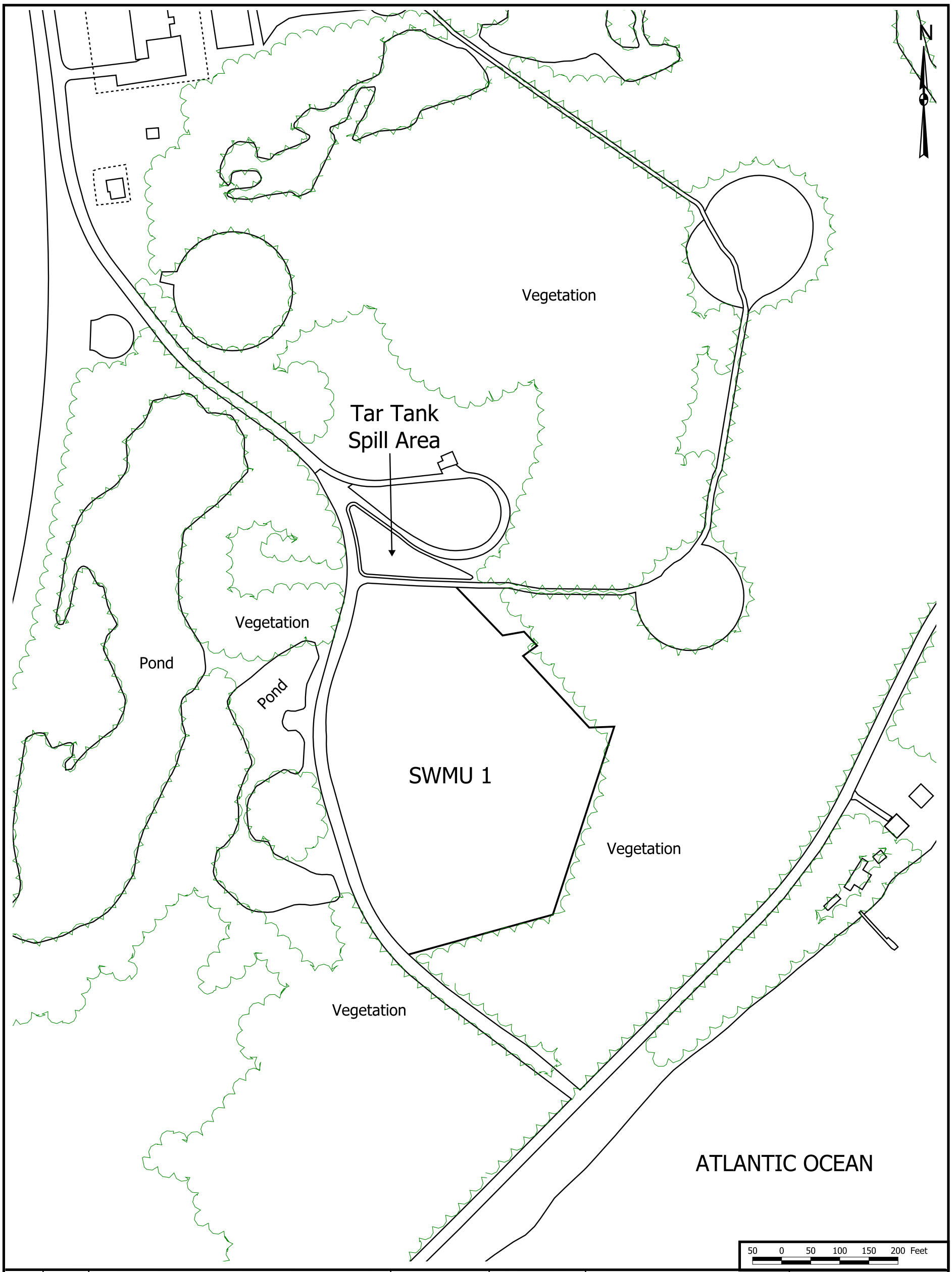
2.2.1 Location, Description, and History

Site Location. The Former Boca Chica Blast Media Disposal Area, an unnumbered area of concern (AOC), is located on the central western portion of Boca Chica Key. The site area is shown in Figure 2-2.

Site Description. The Former Boca Chica Blast Media Disposal Area was used to dispose of sandblasting material produced during the removal of paint from surfaces of ground-handling and ground-support vehicles and equipment, aircraft parts, and other metal objects and pieces of equipment. The sandblasting activities took place at SWMU 5, Boca Chica Aircraft Intermediate Maintenance Department (AIMD) Sand Blasting Building A-990, located at the western end of the airfield on Boca Chica Key. A mound of concrete and metal debris is present at the site. In addition to pine straw, the mound is also covered by Australian pine trees.

Black Beauty®, the brand name for a coal slag abrasive used in sand blasting, has been identified predominantly on the southern and western areas of the site. The sand blasting material was identified on the surface of the mound at five different locations during a visual inspection of site.

Site History. Other than visual inspections, no investigative activities have taken place at the Former Boca Chica Blast Media Disposal Area. However, SWMU 5 was used as a sand blasting area from the early 1970s until 1995. A conservative assumption is that the sand blasting material was disposed at the site during this entire time period. Therefore, the site would probably contain the same contaminants as were found at SWMU 5. Supplemental RFI/RI activity (BRE, 1998) and a Corrective Measures Study (TtNUS, 1999a) at SWMU 5 revealed metals in the soil and groundwater in excess of the most restrictive Applicable or Relevant and Appropriate Requirements/Screening Action Levels (ARARs/SALs).



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RFA WORK PLAN
FIGURE 2-1
TAR TANK SPILL AREA
SITE LOCATION MAP
NAVAL AIR STATION
KEY WEST, FLORIDA

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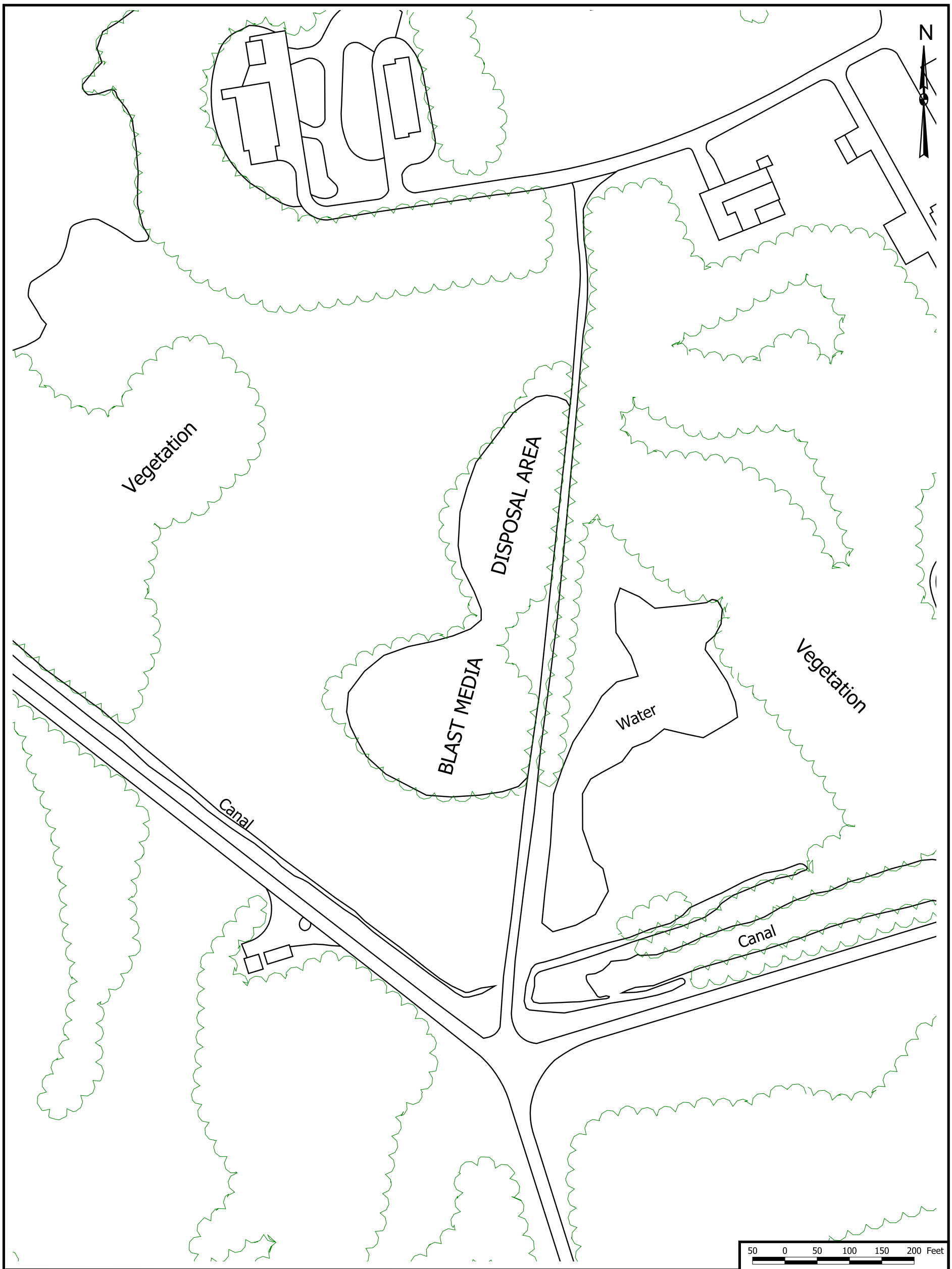

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DRAWN BY CM	DATE 10/30/2001
CHECKED BY SCS	DATE 10/30/2001
COST/SCHED-AREA	
SCALE AS NOTED	

RFA WORK PLAN
FIGURE 2-2
SITE LOCATION MAP
BLAST MEDIA DISPOSAL AREA
NAVAL AIR STATION
KEY WEST, FLORIDA

CONTRACT NO. 2870	
APPROVED BY DSF	DATE 10/30/2001
APPROVED BY _____	DATE ___
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P:/GOVERNMENT/KEYWEST/EGIS/RFA_WORKPLAN.APR LAYOUT: FIG 2-1
DATE: 10/30/2001 BY: CM

3.0 SAMPLING AND ANALYSIS PLAN

This chapter describes the SAP: sampling objectives, quality assurance (QA) objectives; sampling techniques and equipment; sampling handling and analysis; surveying; investigation-derived waste (IDW) management; decontamination; and QA reports and performance system audits.

Following approval of this Work Plan, TtNUS will procure the required subcontractors and begin mobilization activities. Activities to be performed will require at least two separate mobilizations and demobilizations. The first mobilization (Phase I) will require TtNUS personnel to oversee IRA excavation efforts and soil confirmation sample collection at the Tar Tank Spill Area, as well as temporary well installation and soil, sediment, and groundwater grab sample collection at the Former Boca Chica Blast Media Disposal Area. The second mobilization (Phase II) will include permanent well installation at both sites, soil and groundwater sampling, and land surveying.

All field team members will review the Work Plan, the SAP, the QAPP and the HASP. Mobilization will include attendance at a site-specific health and safety meeting during the initiation of onsite activities. This meeting will also include field team orientation in order to familiarize all personnel with the scope of field activities.

3.1 SAMPLING OBJECTIVES

The nature and extent of potential contaminants are not fully characterized at the Tar Tank Spill Area and the Former Boca Chica Blast Media Disposal Area. The primary objectives of this Work Plan are:

- to ensure that the IRA at the Tar Tank Spill Area removes all soil contamination from the spill on the surrounding ground and the tar-filled AST and surrounding area and
- to determine what corrective action is necessary at the Former Boca Chica Blast Media Disposal Area.

The following processes will be utilized:

- Confirmation sampling following soil removal at the Tar Tank Spill Area
- Preliminary assessment sampling of soil and surface soil to delineate contamination at the Former Boca Chica Blast Media Disposal Area
- Installation of permanent groundwater monitoring wells at both sites.

3.1.1 Tar Tank Spill Area

During Phase I, CH2M HILL Construction, Inc. (CCI) will perform an IRA to remove contaminated soil at the Tar Tank Spill Area. This will entail 1) removing and containing the tar material, 2) removing the AST structure, 3) cleaning tar from the concrete AST supports, and 4) removing surface soil containing visible tar from around the AST. The limits of the excavation will be based on visual and organic vapor analyzer (OVA) confirmation. Once the excavation is completed by CCI, confirmation samples will be collected by TtNUS from the sidewalls and floor of the excavation to confirm that all contaminated soils were removed.

Twelve confirmation soil samples (10 sidewall and 2 floor) will be collected from the excavation. The proposed area of excavation and locations at which the samples will be collected are shown on Figure 3-1. The samples will be collected from evenly dispersed sample locations within the limits of the excavation. Samples will be collected in accordance with Section 3.3.1.1. The sample aliquots will then be transferred to laboratory-supplied sample containers immediately following collection. Samples will be placed in coolers, chilled with ice, and sent by overnight express mail under chain-of-custody protocol to the offsite laboratory for analysis. Samples will be analyzed at a contracted laboratory for Appendix IX VOCs, semivolatile organic compounds (SVOCs), and Target Analyte List (TAL) metals (Table 3-1).

An additional soil sample aliquot will be collected at each location and analyzed for total petroleum hydrocarbons (TPH) using Hach® colorimeter/immunoassay field test kits (Section 3.3.1.1). The Hach® Soil TPH field test kit has a detection range between 10 and 200 parts per million (ppm). Use of these test kits will produce immediate results to verify that all contaminated soils have been removed before demobilization of equipment. If the Hach® results for a sample location indicate that contaminated soil remains, Hach® testing will be repeated at least twice at that specific sample location. If additional Hach® testing results indicate contamination still remaining, the TtNUS Field Operations Leader (FOL) and CCI FOL will contact the TtNUS Task Order Manager (TOM) and the CCI Project Manager to determine the appropriate action, which might be further excavation or contacting the SouthDiv Remedial Program Manager. Following appropriate resolution of newly addressed concerns, the excavated area will then be backfilled to grade by the RAC with an equivalent volume of clean fill material. The parameter groups and media of interest are shown in Table 3-2. A summary of field activity is detailed in Table 3-3.

Groundwater grab/screening samples will not be collected because TtNUS and the Navy do not expect to find VOC or SVOC contaminants in groundwater at this site.

During Phase II, four permanent 10- to 12-foot groundwater monitoring wells will be installed via hollow stem auger (HSA) and sampled at the Tar Tank Spill Area. During each monitoring well installation, two soil samples will be collected using a split-spoon sampler (Section 3.3.1.1). Split-spoon samples will be

collected at 0-2 and 2-4 ft below land surface (bls). One groundwater sample will be collected from each well following purging (Section 3.3.1.3.2). A total 12 environmental samples (4 groundwater and 8 soil) will be collected. The proposed permanent well locations are shown on Figure 3-1. The parameter groups and media of interest to be collected are shown in Table 3-2. A summary of field activity is detailed in Table 3-2.

3.1.2 Former Boca Chica Blast Media Disposal Area

A total of 29 environmental samples are expected to be collected at the Former Boca Chica Blast Media Disposal Area during Phase I, based on the limited visual inspection conducted by TtNUS personnel. Twelve temporary wells will be installed utilizing Direct Push Technology (DPT), eight wells along the perimeter of the site and four wells on the mound. Temporary well installation is detailed in Section 3.3.1.3.1. One soil sample will be collected from 0-4 ft bls during the installation of each of temporary well. Following installation, one groundwater grab/screening sample will be collected from each temporary well. Samples will be placed in coolers, chilled on ice, and sent by overnight express mail under chain-of-custody protocol to the offsite laboratory for analysis. All samples will be analyzed for TAL metals at the fixed-base laboratory. The methodology for groundwater screening sample collection is detailed in Section 3.3.1.3.1. All pertinent data will be recorded on the Bore Log shown in Appendix D. The parameter groups and media of interest to be collected are shown in Table 3-2. A summary of field activity is detailed in Table 3-3.

Groundwater screening samples will be collected for the purpose of obtaining samples in the areas most likely to contain contamination. Because the FDEP does not accept conclusions based on data from temporary well points, data from the groundwater screening samples will be used as a tool in the placement of permanent monitoring wells. The Partnering Team will review the groundwater screening sample results and use this data to determine locations for permanent monitoring wells at the site. Five surface sediment samples will be collected from the area according to EPA Region IV SOPs. Figure 3-2 displays proposed temporary monitoring well and sampling locations.

Five surface soil samples will be collected at depths from 0-6 inches along the outermost edges of the suspected mound. Note that, during actual sample collection, the sample area could be either wet or dry, dependent on recent weather conditions. The samples will be collected in accordance with Section 3.3.1.3.

TtNUS Biologists did not observe any threatened or endangered species during a limited visual inspection. As a precaution and prior to any machinery being taken into the area, a TtNUS Biologist will survey the area for endangered or threatened species, and will remain in constant contact with the Natural Resources Manager of the Base.

During Phase II, three permanent groundwater monitoring wells will be installed to depths of 10-12 ft bls, utilizing HSA at the Former Boca Chica Blast Media Disposal Area. Two soil samples will be collected during the installation of each monitoring well, using a split-spoon sampler (Section 3.3.1.1). The intervals at which split-spoon samples will be collected are from 0-2 and 2-4 ft bls. One groundwater sample will be collected are from each well following purging (Section 3.3.1.3.2). A total of nine environmental samples (six soil and three groundwater) are estimated to be collected from these wells. The parameter groups and media of interest to be collected are shown in Table 3-2. A summary of field activity is detailed in Table 3-3

3.2 QUALITY ASSURANCE OBJECTIVES

This SAP describes measures that will be undertaken by TtNUS and its subcontractors to (1) perform quality work to accomplish the stated objectives and (2) be responsive to QA requirements of the EPA and FDEP. The EPA and FDEP QA requirements focus on the acquisition of environmental data of acceptable quality.

3.2.1 Prevention of Cross-Contamination

Before being moved to a site, all sampling equipment will be cleaned to remove foreign material and prevent the introduction of contamination to the site. All drilling equipment that will be in contact with the soil will be decontaminated before use. All monitoring well screens and blank casings in contact with groundwater will be decontaminated, unless they are packaged from the factory. Sampling equipment will be decontaminated before use at each sample location. Procedures for decontamination of drilling and sampling equipment are provided in Section 5.0 of the QAPP. Disposal of decontamination byproducts is discussed in Section 3.7 of this document.

3.2.2 Sample Turnaround Time

For preliminary assessment and permanent groundwater well installation sampling for VOCs, SVOCs, and TAL metals the fixed-base laboratory will provide a turnaround time of approximately 28 days. The Tar Tank Spill Area confirmation samples analyzed in the field with TPH test kits will produce immediate results. This timeframe will meet the project schedule and objectives.

3.2.3 Field Documentation and Data Management

An integral part of the SAP field activities will be maintaining the site logbook and associated sample logsheets, as cited in Section 5.0 of the QAPP.

3.2.4 Sample Bottle Preparation and Preservation

All sample bottles used by TtNUS will be shipped to NAF Key West by the laboratory in sealed containers and will be EPA-certified clean, as cited in Section 5.0 of the QAPP. Table 3-1 presents the types and volumes of sample bottles that may be used for collection of environmental samples during field activities, as well as the sample preservative required for each analytical method.

3.2.5 Quality Control of Field Data

Field data generated in accordance with this Work Plan will consist primarily of soil classification, soil boring advancement data, and monitoring well installation and development data (i.e., field temperature, pH, turbidity, and specific conductance data), which is discussed in greater detail in Section 9.1 of the QAPP. These data will be validated by review of the project documentation to check that all forms specified in the field sampling plan have been completely and correctly filled out and that documentation exists for the required instrument calibration. This documentation will be considered sufficient to ensure that procedures have been followed properly during the field investigation.

3.2.6 Field Equipment Calibration

The calibration or standardization of monitoring, measuring, or test equipment is necessary to ensure proper operation and response of the equipment. In addition, it is necessary to determine the accuracy, precision, or sensitivity of the measurement and determine if correction should be applied. Field calibration procedures and frequencies are summarized in Table 3-4. Field equipment calibration is discussed in Section 7.1 of the QAPP. A copy of the TtNUS Calibration Form is included in Appendix D of this document.

3.2.7 Preventive Maintenance

Periodic preventive maintenance is required for equipment whose performance can impact results. Preventive maintenance for field equipment is discussed in Section 12.1 of the QAPP.

3.2.8 Ambient Air Monitoring

Air monitoring will be performed with a flame-ionization detector (FID) or photo-ionization detector (PID). The FID or PID will be used to monitor the presence of VOCs in media during drilling and sampling activities. The actions to be taken by personnel for results fall above background levels are addressed in the HASP (Appendix C).

Ambient air samples will be collected at the source of the activity (e.g., the borehole or well annules) and in the “breathing zone” of the personnel present (e.g., the area where personnel are taking in air to breath). All air monitoring results will be recorded in the field logbooks and/or boring logs to document the presence or absence of VOCs.

3.3 SAMPLING TECHNIQUES AND EQUIPMENT

Any sample obtained during a field sampling event should be representative of the sample location and free of contaminants from sources other than the sampling point. The equipment and techniques that will be employed to obtain representative samples will be in accordance with the approved sampling procedures described below.

When possible, samples from a given media will be collected from the least contaminated to the most contaminated locations at a site. At any sampling location, sample bottles should be filled in the following order, where applicable: VOCs, extractable organics, total metals, and other inorganics.

Media-specific sampling requirements are discussed below. Several general sampling precautions will be used to enhance sample integrity:

- Samples will be collected in order from least to most contaminated, when this information is known. Anticipated or known direction of groundwater flow will be used to determine sampling order when no chemical data are available. Areas upgradient from contaminated source areas will be sampled first and sampling will then proceed from areas farthest downgradient, working toward the source areas.
- Prior to sampling monitoring wells will be purged to ensure representative sampling of groundwater in the saturated zone.
- Medical-grade or Nitrile gloves will always be worn during, and changed between, each sample collection. Sample handling will be kept to a minimum.
- Sample preservatives and containers will be handled carefully to minimize exposure time and the potential for evaporative loss and/or airborne contamination.
- Upon completion of a round of sampling at a site, all stainless steel sampling equipment will be decontaminated pursuant to Section 5.0 of the QAPP (Appendix B).
- Samples will be delivered to the analyzing laboratory as soon as possible following sample collection, typically via overnight express mail service.

3.3.1 Soil Sampling Techniques

Some confirmation soil samples collected at the Tar Tank Spill Area will utilize a decontaminated stainless steel bowl and spoon. VOC soil samples will be collected with an En Core® Sampler, details are presented in Section 3.3.1.3. Soil will be collected from each sample location with a decontaminated spoon. That soil will then be mixed in a decontaminated stainless steel bowl. An aliquot of the soil will be placed in a laboratory-supplied container and placed on ice in a cooler. The sample will be sent by overnight express mail to an offsite laboratory.

3.3.1.1 HACH® TPH Soil Test Kit

Some confirmation soil samples collected at the Tar Tank Spill Area will be analyzed in the field, utilizing the Hach® TPH Soil Test Kit. Hach® immunoassay tests use antigen/antibody reactions to test for TPH in soil. Antibodies specific for TPH are attached to the walls of plastic cuvettes. They selectively bind and remove TPH from complex sample matrices. Ten grams of soil will be collected from each sample location and prepared in accordance with the TPH Test Kit Instruction Manual. A prepared soil sample and reagent, containing enzyme-conjugate molecules (analyte molecules attached to molecules of an enzyme), are added to the antibody cuvettes. During incubation, enzyme-conjugate molecules and TPH compete for binding sites on the antibodies. Samples with higher levels of analyte will have more antibody sites occupied by TPH and fewer antibody sites occupied by the enzyme-conjugate molecules.

After incubation, the sample and unbound enzyme conjugate are washed from the cuvette and a color-development reagent is added. The enzyme in the conjugate catalyzes the development of color. Thus, there is an inverse relationship between color intensity and the amount of TPH in the sample: the lighter the color, the higher the TPH concentration. The resulting color is then compared with a TPH calibrator to determine whether the TPH concentration in the sample is greater or less than threshold levels.

3.3.1.2 DPT

Soil samples will be collected at the Former Boca Chica Blast Media Disposal Area during the installation by DPT of temporary wells. The DPT system consists of a truck or van equipped with a hydraulic ram. The hydraulic ram drives a threaded, 1-inch-outside-diameter (OD), hollow-steel rod assembly attached to an interchangeable stainless steel sleeve that is driven to the desired sample collection depth of 0-4 ft bls. An acetate sleeve is placed inside the stainless steel sleeve. At the soil sample collection depth, the tip of the direct-push sampler is retracted from a rigid leading position and whole hydraulic pressure is applied to advance the sample collection sleeve. As hydraulic pressure is applied to the tip, the sample retracts upward within the sleeve and sample material enters the acetate collection sleeve. Upon retrieval, the acetate sleeve will be cut longitudinally and the entire sample will be screened with an FID.

The sample will then be placed in appropriate sample containers. The FID screening results and a description of the soil sample will be entered on a boring log, soil sample sheet, and in the field logbook. In order to obtain an appropriate amount of sample for the full suite of chemical analyses, it may be necessary to collect several sample sleeves of soil from the same location. When this is necessary, samples will be collected from a discrete interval and the sample will be composited prior to collection. This involves mixing the soil in a stainless steel bowl in order to obtain a homogenous medium. The sample aliquot will then be transferred to the laboratory-supplied sample containers immediately after sample collection. Samples will be placed in coolers, chilled with ice, and sent by overnight express mail service under chain-of-custody protocol to the offsite laboratory for analysis.

3.3.1.3 HSA

Soil samples will be collected from both sites during the installation of permanent groundwater wells, via split-spoon samples. Split-spoon samples will be collected continuously from the ground surface to the termination depth of the borings, in accordance with American Society of Testing and Materials (ASTM) Standard Method D 1586-84 and TtNUS SOP SA-1.3. The split-spoon sampler consists of a heavy carbon steel or stainless steel sampling tube that can be split into two equal halves to reveal the soil sample. The split-spoon sampler will be attached to a drill rod and driven to the required depth by means of a drill-rig-mounted hammer, weighing 140 pounds and falling 30 inches for each blow. The split-spoon samplers will have a minimum inside diameter (ID) of 2 inches and a length of 2 ft to fulfill sample volume requirements for chemical analysis. The split-spoon sampler will be opened to reveal the soil sample. The soil sample will then be field screened with an FID. The soil core will be carefully separated with a decontaminated stainless steel knife or trowel at approximately 6-inch intervals, while scanning the center of the core for elevated readings. Stained soil, soil lenses, and anomalies will also be scanned if any are present. All readings will be recorded.

VOC and lithological samples will be collected simultaneously. VOC samples will be collected from the center of the core (this area represents the least disturbed area with minimal atmospheric contact), utilizing the En Core® Sampler. Once the En Core® Sampler is assembled per packaging instructions, the Sampler will be pushed into the soil until the coring body is completely filled. The coring body will then be capped removed from the Sampler assembly. An En Core® Sampler label will be completed, placed on the cap of the coring body, and sealed in the provided zipper bag. Samples will then be placed in coolers, chilled with ice, and sent by overnight express mail service under chain-of-custody protocol to the offsite laboratory for analysis. Eight-ounce lithologic sample jars will also be filled. Lithologic samples will provide information relevant to contaminant fate and transport modeling. Lithologic sample jars will be labeled as described in the Section 3.4.1.1 and retained onsite until completion of the investigation, at which time all lithologic samples will be properly disposed.

Split-spoon samples will be divided and placed in sample containers. The same trowel that was utilized during VOC collection will be used to remove the sample material from the split-spoon sampler (except for the small portion of disturbed soil usually found at the top of the core sample). The sample material will be placed in a decontaminated stainless steel mixing bowl and thoroughly mixed, prior to filling the remaining sample containers. Sample containers will be labeled and placed on ice.

3.3.2 Surface Soil Sampling Technique

Five surface soil samples will be collected from depths of 0-6 inches from the perimeter of the Former Boca Chica Blast Media Disposal Area (Figure 3-2). Samples will be collected according to EPA Region IV SOPs (EPA, 1996). The sampling equipment will consist of a decontaminated stainless steel bowl and spoon used to extract surface soil at the sample location. The sample aliquot will be transferred to the laboratory-supplied sample containers immediately after sample collection. Samples will then be placed in coolers, chilled with ice, and sent by overnight express mail service under chain-of-custody protocol to the offsite laboratory for analysis.

3.3.3 Groundwater Monitoring Well Installation and Sampling

Standard activities involved in groundwater sampling include: monitoring well installation (using DPT for temporary and HSA for permanent); monitoring well drilling, construction and development; monitoring well elevation survey; water level measurements; removal of standing water in wells (i.e., well evacuation or purging); and retrieval of groundwater samples. Groundwater monitoring will comply with the FDEP SOP 62-522 (Appendix D).

Boreholes will be logged as the drilling proceeds. Boring logs will be generated to document subsurface conditions on the Visual Classification of Soils Form, based on ASTM's D2488 Standard Practice for description identification of soils and the Unified. Soil Classification System. The lithologic borehole descriptions submitted to EPA, as part of the RFA Report, will include the following:

- Detailed lithologic description of each unit
- Split-spoon blow counts and percent recovery
- Soil classification used
- Depth to first water encountered
- Termination depth of borehole.

The drilling contractor will be responsible for securing boring or well drilling permits required by state and/or local authorities and for complying with state and local regulations with regard to the submission of

driller's well logs, etc. TtNUS will be responsible for complying with regulations regarding boring/well drilling safety, as described in the HASP (Appendix C). Field activity logs will be completed daily to document drilling activities, such as footage drilled and materials used. Well installation will follow all commonly accepted professional drilling procedures.

3.3.3.1 Temporary Groundwater Monitoring Well Installation

Groundwater screening samples will be collected via DPT, in accordance to TtNUS SOP SA-2.5. To locate the water-bearing zone, a hydraulic ram of the DPT drives a threaded, hollow-steel rod assembly (attached to an interchangeable stainless steel) sleeve to the desired selected groundwater screening locations. It is anticipated that water will be encountered at 4 to 8 ft bls. A detachable drive tip, attached to a 24-28-inch screen encased in a lead probe tube, will be advanced into the water-bearing zone. The probe will be withdrawn 24 to 60 inches, allowing the retractable screen to open to the formation. Screening sample collection will adhere to the development, water level measurement, purging, and sampling techniques outlined in Sections 3.3.1.3.3 through 3.3.1.3.5.

3.3.3.2 Permanent Groundwater Monitoring Well Installation

All permanent monitoring well installations during this field effort will be performed in accordance with TtNUS SOPs GH-1.3, and GH –2.8 and FDEP SOP 62-532 (Appendix D) and ASTM Method D 5784-95. The drilling method consists of rotating a HSA into the ground. The HSA is advanced by a power-operated drilling machine having sufficient torque and ram range to rotate and force the augers to the desired depth. All wells will be 2-inch outside diameter, installed to a depth of 10-12 ft bls and constructed with National Sanitation Foundation (NSF) material. The well screen will intersect the top of the seasonal water table.

The Monitoring Well Installation Log Sheet (illustrated in Appendix D) will be completed in its entirety. The letter designation "NA" for "not applicable" or "NK" for "not known" will be used in all blank spaces, when the question asked is not applicable or the answer is unknown. If some steps or procedures were not performed as described, the reason will be stated as completely as is practicable on the appropriate form or submitted as an attachment thereto. Actual materials utilized in well construction will be documented on the well-specific forms.

Wells will be developed with a centrifugal pump to remove drilling fires. All water generated during well development will be collected in 55-gallon drums. It is assumed that this material is non-hazardous in nature, and it will be disposed onsite at a later date. However, if contaminant levels in aqueous IDW are above set limits, disposal of the IDW will be documented.

Well Development Records and Monitoring Well Sampling Sheets will be maintained on well development forms (provided in Appendix D).

3.3.3.3 Water Level Measurements

Synoptic rounds of water level measurements of the proposed permanent monitoring wells at both sites will be collected during groundwater sample collection. Water level measurements will be used to indicate tide levels during sampling.

All water level measurements in each monitoring well will be made from a measurement point located at the top of the well casing (positioned on the north side of the well casing) and will be conspicuously marked for each well. Groundwater Level Measurement Sheets are located in Appendix D. Water level measurements will be made using an electronic probe, as discussed in Section 5.0 of the QAPP.

3.3.3.4 Well Purging

All wells will be purged, using a peristaltic pump with precleaned Teflon® tubing interfacing with silicon tubing at the pump head. All purged water will be collected and containerized, pending results of the laboratory analyses and determination of disposal options. General reference information concerning groundwater well purging is provided in Appendix D, TtNUS SOP SA 1-1.

3.3.3.4.1 Volume Determination

Prior to purging a well, it will be necessary to determine the volume of water being held in the well casing. Well volume will be calculated as follows:

- Measure the ID of well casing
- Measure the static water level
- Determine the total depth of the well from the measuring point
- Calculate the number of linear feet of static water (total depth of well minus the static water level)
- Calculate the volume of water in 1-inch-and 2-inch-ID well casings using the following equations:

1-inch-ID	$V = 0.0408h$
2-inch-ID	$V = 0.1632h$

Where,

V	=	Volume of water (gallons)
0.1632	=	Conversion factor constant for 2-inch-diameter well
h	=	Height of water in well (ft)

3.3.3.4.2 Placement of Intake Hosing

Monitoring wells will be purged from the middle of the well screen.

3.3.3.4.3 Pumping Rate

The pumping rate used for monitoring well purging will be kept to a minimum. While purging, the pumping rate shall be 200 milliliters (mL) per minute or less to allow the well to stabilize and maintain a low turbidity. The flow rate of the pump may be measured by using a graduated plastic bucket, graduated cylinder, or a totalizing flow meter. A water level of less than 0.3 ft drawdown should be maintained.

3.3.3.4.4 Volume Purged

Three to five casing volumes will be removed from the monitoring well prior to sample collection. If field parameters have stabilized (see Section 3.3.1.3.4.5) after three casing volumes, the well will be sampled; otherwise, up to five volumes will be purged prior to sampling. If the monitoring well goes dry during purging, it will be allowed to recover and it will be then sampled directly without additional purging.

3.3.3.4.5 Well Stabilization

In addition to keeping track of the volume of water pumped from a monitoring well, the 1) pH, 2) specific conductivity, and 3) temperature of discharge water will be monitored approximately every 10 minutes. A monitoring well will be considered sufficiently purged when these three parameters meet the stabilization criteria stated below, provided that a minimum of three casing volumes have been purged. When three consecutive pH readings are within +/- 0.2 standard pH units, pH will be considered stabilized. Conductivity will be considered stabilized when each of three conductivity values are within +/- 10 micor Siemens per centimeter (µS/cm) of each other. Temperature will be considered stabilized when three consecutive temperature readings are within +/- 0.2 degrees Celsius (°C) of one another. Turbidity, which is not considered an integral factor in determining stabilization, will be considered stabilized when the reading is less than 10 nephelometric turbidity units (NTUs) for three consecutive readings. Temperature, pH, turbidity, and conductivity values obtained during well purging will be recorded in field logbooks. It should be noted that, after five well volumes have been purged, the well will be considered stabilized regardless of fluctuations in the above parameters.

3.3.3.5 Sample Collection

Immediately after a monitoring well has been properly purged, it will be sampled, unless the well has a very slow recharge rate. In that case, the monitoring well will be sampled within three hours. For all parameters, except VOCs, wells will be sampled using a peristaltic pump and precleaned Teflon® tubing interfaced with silicon tubing at the pump head. Metals and SVOC samples will be collected first with the standard peristaltic pump setup, with the sample running through both the Teflon® tubing and silicon tubing in the pump head. Following this, VOC samples will be drawn into the Teflon® tubing by pump suction, the tubing will be crimped and disconnected from the pump, and VOC samples will be collected by gravity-flow induced by uncrimping the tubing. All information will be recorded on a sample collection log form. An example of a Sample (Groundwater, or Soil and Sediment) Log Sheet form used by TtNUS for recording well purging and sample collection data during groundwater sample collection is contained in Appendix D.

Water sample collection for VOCs, SVOCs, and TAL metals will be performed in accordance with the procedures outlined in the following sections.

3.3.3.5.1 Volatile Organic Compounds

- Three screw-cap vials with Teflon®-lined silicone rubber septa (EPA-approved vials) will be filled to overflowing and sealed without any entrapped air bubbles. These vials will be 40 ml or larger.
- Each vial will be placed in a secure cooler.
- The samples will not be composited.
- A sample collection log, a chain-of-custody form, a laboratory request-for-analysis form, and a sample label will be filled out in the field. These forms, except for the sample collection log, will accompany the samples to the laboratory.
- The sample vials will be placed in a cooler with bubble wrap packing to prevent breakage during shipment.
- Sample storage prior to shipment and packing is discussed in Section 3.4.1.4.

3.3.3.5.2 Semivolatile Organic Compounds

- One-liter amber-glass bottles complete with Teflon®-lined caps, will be filled to 90 percent capacity and sealed, allowing 10 percent headspace to compensate for any pressure and/or temperature changes.

- The sample bottles will be placed in a cooler with sufficient packing to prevent breakage during shipment.
- A sample collection log, a chain-of-custody form, a request-for-analysis form, and a sample label will be filled out in the field. These forms, except for the sample collection log, will accompany the samples to the laboratory.
- Sample storage prior to shipment and packing is discussed in Section 3.4.1.4.

3.3.3.5.3 Metals

- Samples will be placed in 1-liter polyethylene or glass bottles that have been pre-preserved with HNO_3.
- Bottles will be filled to within 10 mls of capacity.
- Sample storage prior to shipment and packing is discussed in Section 3.4.1.4.

3.4 SAMPLE HANDLING AND ANALYSIS

All samples will be labeled, tracked, shipped, and analyzed according to the following requirements.

3.4.1 Sample Custody

To support the integrity of the field data, it is necessary to document the locations of samples collected and demonstrate that samples reached the laboratory without being altered prior to analyses. To accomplish this, evidence of the collection, shipment, laboratory receipt, and custody of samples until disposal must be documented, pursuant to Section 6.0 of the QAPP.

3.4.1.1 Sample Identification and Labeling

All sample labels will be marked with a unique identifier (including location and sample type), analysis to be performed, date and time of collection, preservative, and initials of sampler. A unique sample number will be used to tie a particular sample to a specific physical location. This sample number will be referenced in field logbooks, sample collection logs, and chain-of-custody forms. The sample designation will be constructed as described below:

- Location identifier: two or more letters and possibly one or more digits (TTSA = Tar Tank Spill Area or BCBM = Boca Chica Blast Media)

- Media type:

  SO = soil
  SD = sediment
  TW = groundwater (groundwater screening sample from temporary monitoring well)
  MW = groundwater (groundwater sample from permanent monitoring well)

- Individual sample identifier: 01, 02, 03, etc.

- Sample depth (where applicable): 0-2 ft = 02, 2-4 ft = 24, or 0-4 ft = 04

Example: TTSA-SO-01-02 = Tar Tank Spill Area, soil sample number 01, soil sample depth 02

Example: BCBM-MW-01 = Boca Chica Blast Media Disposal Area, permanent monitoring well, groundwater sample number 01

3.4.1.2 Laboratory Analysis Request and Chain-of-Custody Form

The laboratory analysis request will be accomplished by completion of the chain-of-custody form. The chain-of-custody form includes the sampling location, sample type and amount, date and time of collection, name(s) of persons responsible for sample collection, the number(s) and type(s) of laboratory analyses, dates and times of all custody transfers, signature of the person relinquishing or accepting sample custody, and an explanation field. An example of this form is found in Appendix D. A copy of the completed chain-of-custody form will be maintained in the field file.

3.4.1.3 Sample Logsheet

A sample logsheet will be prepared for each collected sample to record information pertaining to the location, condition, and collection of a sample. The sample logsheets will be prepared either in the field or from field logbook notes in the office following field activities. The information to be recorded includes the following:

- Project name and number
- Date and time of collection
- Field personnel responsible for sample collection
- Sample identification and type (e.g., soil, water, sediment, etc.)
- Any field testing results (e.g., FID/PID readings, pH, temperature, conductivity, etc.)

- Sketch of sample location
- Weather conditions
- General field observations
- Depth of sample.

3.4.1.4 Sample Packing and Shipment

3.4.1.4.1 Sample Storage

All samples will be collected and properly labeled, placed in individual zip-lock-type plastic bags, and placed in field coolers packed with ice. The field coolers will be sturdy and have the drain plug (if present) duct-taped. Samples will be transferred from the field coolers to a refrigerator or repacked for shipment. The refrigerator will be monitored daily to verify acceptable storage conditions and the temperature will be taken and recorded daily in a logbook. Clean field coolers will be received from the laboratory, and the coolers will be cleaned as needed during the sample collection, storage, and shipment process to ensure that no samples are packed in contaminated shipping containers.

3.4.1.4.2 Sample Packing

The packing and shipment of samples is detailed in Section 5.0 of the QAPP.

3.4.1.5 Laboratory Receipt

A controlled offsite laboratory will perform analytical work associated with this Work Plan. The offsite laboratory will be responsible for the following:

- Delivery of appropriate sample containers with preservatives
- Sample receipt and check-in
- Storage of samples
- Initiation of testing program
- Sample disposal
- Issuance of certificate of analysis.

3.4.2 Sample Analysis

Analytical procedures were selected for the RFA according to site history and existing data generated during the NAF Key West BRAC Supplemental Site Inspection (TtNUS, 1999c). Quality control (QC) samples will be collected and analyzed by the same procedures to ensure that the data are adequate and representative. Analytical procedures and QC samples are addressed in more detail in Sections 8.0 and 9.0 of the QAPP.

3.4.2.1 Analytical Procedures

Standard analytical methods have been selected to characterize the parameter groups of interest at the RFA sites. Based on existing data and site history, sets of analytical parameters were defined for each subzone. The methods and parameters selected for inclusion under each method are described below:

- TAL metals by SW-846 Method 6010B
- Appendix IX VOCs by SW-846 Method 8260b
- Appendix IX SVOCs by SW-846 Method 8270c
- TPH by Hach® Test Kit for Soil, utilizing a colorimeter/immunoassay.

3.4.2.2 Sample Quality Control

QC procedures are designed to ensure the consistency and continuity of data. The frequency of QC checks is based on the type of analysis. Standard QC samples may include, but are not limited to, duplicate samples, equipment rinsate blanks, trip blanks, matrix spike and matrix spike duplicate samples, and field blanks. The offsite laboratory performing analyses at DQO Level III will analyze all QC samples. QC samples will be analyzed for the same parameters as the environmental samples collected during the site-specific event, except for trip blanks, which will be analyzed for Appendix IX VOCs only. Quantities and types of QC samples are provided in Table 3-5. QC sample collection frequencies are provided in Table 3-6.

Other internal QC activities are undertaken during work performance of to ensure that the service, design, and documents produced meet currently accepted professional standards. QC in this assignment will entail periodic discussions among the technical staff, Project Manager, and Program Manager. An internal audit will be performed, as described in Section 3.8.2.

3.5 SURVEYING

A certified land surveyor will survey all permanent monitoring well locations. Global positioning system (GPS) or direct measurements will be used to locate all sample locations. An X-Y-Z coordinate system will be used to identify locations. Each location will be measured from a reference point to the state plane system, where the X coordinate describes the east-west axis location (Easting) and the Y coordinate describes the north-south axis location (Northing). The vertical coordinate (Z coordinates) of each well will be surveyed in reference to the National Geodetic Vertical Datum.

All surveyed locations will be reported using the Florida State Plane Coordinate System-Eastern Zone. Existing installation benchmarks will serve as the horizontal and vertical data for the survey. Elevations and horizontal locations will be measured to the nearest hundredth of a foot. The elevations of all monitoring wells will be surveyed to the water level measuring notch on the riser pipe and on the undisturbed ground surface adjacent to the pad, as well as on the pad itself.

3.6 INVESTIGATION-DERIVED WASTE MANAGEMENT

All IDW accumulated during soil sampling, well installation, and decontamination activities will be collected, containerized, and stored in DOT-approved (Specification 17-C/H) 55-gallon drums at the site. The drums will be labeled as soon as possible after they are filled and will be kept onsite, pending the results of soil and groundwater analyses.

Upon receipt of the analytical results (approximately 35 days after completion of sampling), a determination will be made as to whether offsite disposal or treatment is required. TtNUS will provide information required by NAF Key West Public Works for proper removal and disposal of drummed waste. NAF Key West will be responsible for the final disposition of IDW.

3.7 DECONTAMINATION

The field team personal protective equipment will be disposed as required. These items, such as disposable latex gloves and paper towels, will be temporarily stored in plastic bags and transferred to dumpsters at the end of each workday. Personnel will also perform the decontamination procedures required by the HASP before departing from the site. Additional decontamination procedures are discussed in Section 5.0 of the QAPP.

3.8 QUALITY ASSURANCE

3.8.1 Reports to Management

QA reports to management will be provided in three primary formats during the course of the NAF Key West RFA Work Plan sampling program. Data review letter reports will be prepared on an SDG-specific basis and will summarize QA issues related to the subcontract laboratory data. In addition, written weekly reports will be provided by the FOL, summarizing accomplishments and QA/QC issues during the field investigation. Finally, monthly progress reports are provided by the TOM. In addition, a summary of data review qualifiers and a completeness assessment for all project samples will be included in the report. QA reports to Management pursuant to Section 15.0 of the QAPP.

3.8.2 Performance System Audits and Frequency

Audits are performed to confirm that work being completed within the RFA program complies with QA program goals. Internal audits of laboratory subcontractors are routinely conducted, and subcontracted laboratories must be both Contract Laboratory Program (CLP)-and SW-846-qualified and Naval Facilities Engineering Service Center (NFESC)-approved. The laboratory must also be certified by the Florida Department of Health-Division of Laboratory Services and have an FDEP-approved Comprehensive Quality Assurance Plan (CompQAP) (TtNUS, 1999).

Technical reviews and internal audits will be performed in accordance with the QA elements in the Work Plan and Section 11.0 of the QAPP. All primary documents will receive internal technical reviews. A minimum of one internal audit will be scheduled for the RFA program by the QA Manager in coordination with the FOL during the RFA sampling activities. All audit records (including audit plans, reports, written responses, and corrective action forms) will be maintained with the project files.

TABLE 3-1

TYPES AND VOLUMES OF SAMPLE BOTTLES FOR ENVIRONMENTAL SAMPLE ANALYSES
RFA WORK PLAN
NAVAL AIR FACILITY
KEY WEST, FLORIDA

Matrix	Bottleware	Volume Referenced for Analysis[1]	Preservative[1]	Holding Times[1]
Appendix IX Volatiles by SW-846 Method 8260B; Fixed-Base Laboratory				
Aqueous	3 clear glass vials with Teflon® septa	40 mL	Cool to 4°C, HCL to pH < 2	14 days from VTSR[2]
Solid	2 En Core® containers	5 gram	Cool to 4°C	14 days from VTSR[2]
Appendix IX Semivolatiles by SW-846 Method 8270C; Fixed-Base Laboratory				
Aqueous	1 amber-glass bottle with Teflon®-lined cap	1,000 mL	Cool to 4°C	7 days from VTSR[2] to extraction, 40 days after extraction
Solid	1 widemouth glass jar with Teflon®-lined cap	8 oz	Cool to 4°C	14 days from VTSR[2] to extraction, 40 days after extraction
TAL Metals SW-846 Method 6010B; Fixed-Base Laboratory				
Aqueous	1 polyethylene bottle with plastic cap	1,000 mL	Cool to 4°C, HNO_3 to pH < 2	28 days from VTSR[2,3]
Solid	1 widemouth glass jar with Teflon®-lined cap	8 oz	Cool to 4°C	28 days from VTSR[2,3]

TAL = Target Analyte List
1 40 CFR Part 136.
2 VTSR – Validated time of sample receipt.
3 The short holding time is due to the inclusion of mercury analysis. Without mercury analysis, the holding time for inorganics is 180 days from VTSR.

TABLE 3-2

**PARAMETER GROUPS AND MEDIA OF INTEREST
RFA WORK PLAN
NAVAL AIR FACILITY
KEY WEST, FLORIDA**

Area	Medium	Number of Samples	Parameter Groups			
			VOCS	SVOCs	Metals	TPH*
Phase I						
Tar Tank Spill Area excavation sidewalls	SO	10	X	X	X	X
	SO	2	X	X	X	X
Former Boca Chica Blast Media Disposal Area	SO	12			X	
	SD	5			X	
	GS	12			X	
Phase II						
Tar Tank Spill Area	GW	4	X	X	X	
	SO	8	X	X	X	
Former Boca Chica Blast Media Disposal Area	GW	3			X	
	SO	6			X	

GS = Groundwater screening sample
GW = Groundwater sample
SD = Sediment
SO = Soil
TPH = total petroleum hydrocarbon
* = Hach® TPH Test Kit for soil

TABLE 3-3

**SUMMARY OF FIELD ACTIVITY
RFA WORK PLAN
NAVAL AIR FACILITY
KEY WEST, FLORIDA**

Location	Activity	Number of Samples
Phase I		
Tar Tank Spill Area	Confirmation soil samples (10 sidewall, 2 floor)	12
Former Boca Chica Blast Media Disposal Area	Surface sediment samples	5
	Temporary well installation/DPT (10-12 ft bls)	12
	Groundwater grab/screening samples	12
	Soil samples (0-4 ft bls)	12
Phase II		
Tar Tank Spill Area	Permanent well installation/HSA (10-12 ft bls)	4
	Soil samples (0-2 ft bls)	4
	Soil samples (2-4 ft bls)	4
Former Boca Chica Blast Media Disposal Area	Permanent well installation/HSA (10-12 ft bls)	3
	Soil samples (0-2 ft bls)	3
	Soil samples (2-4 ft bls)	3

bls = below land surface
DPT = Direct Push Technology
ft = feet
HAS = hollow-stem auger

TABLE 3-4

**FIELD CALIBRATION PROCEDURES AND FREQUENCIES
RFA WORK PLAN
NAVAL AIR FACILITY
KEY WEST, FLORIDA**

Instrument	Calibration Standards Used	Acceptance Limits	Corrective Action	Documentation
Horiba U-10 water quality checker	Daily: calibration solution	Auto 1-point calibration; repeatability requirements: pH ± 0.05 pH units Conductivity ± 1% Turbidity ± 3% DO ± 0.1 mg/l Temperature ± 0.1°C	Recalibrate to standards, clean or replace electrode, service unit	Logbook and calibration forms
Sensodyne Flame-ionization Detector	Daily: known gas standards, methane at 100 ppm	± 10 %	Recalibrate to standards or replace, if faulty	Logbook and calibration forms
Photo-ionization Detector	Daily: known gas standards, isobutylene at 100 ppm	± 10 %	Recalibrate to standards or replace, if faulty	Logbook and calibration forms

TABLE 3-5

SAMPLE ANALYSIS, MATRIX, AND EXPECTED NUMBER OF QUALITY CONTROL SAMPLES
RFA WORK PLAN
NAVAL AIR FACILITY
KEY WEST, FLORIDA

Matrix	Number of Samples	Laboratory QC Samples[1]	Field QC Samples[2]
Phase I			
Solid	24 Soil, 5 Sediment	2 MS/2 MSD	3 Dups, 3 RB, 4 TB
Aqueous	12 Groundwater	1 MS/1 MSD	1 Dup, 1 RB, 3 TB
Phase II			
Solid	14 Soil	1 MS/1 MSD	1 RB, 1 TB
Aqueous	7 Groundwater	----	1 Dup (Tar Tank Spill Area), 1 TB

1 Laboratory QC samples (matrix spike [MS] and matrix spike duplicates [MSD]) will be collected at a rate of one per every 20 samples (or 5% of total number of samples). When calculating the quantity of laboratory QC samples, all samples, blanks, and duplicates were considered.

2 One trip blank (TB) will be analyzed per cooler of samples submitted for volatile organic compounds analysis (VOC). It is estimated that 12 VOC samples will fit in a single cooler. Rinsate blanks (RB) will be collected from one of every 20 pieces of sampling equipment cleaned. The number may vary, depending on the quantity of equipment used. One duplicate (Dup) sample will be collected for every 10 environmental samples collected.

TABLE 3-6

FREQUENCY OF FIELD QUALITY CONTROL SAMPLES
RFA WORK PLAN
NAVAL AIR FACILITY
KEY WEST, FLORIDA

Types of Sample	Frequency
Rinsate Blank	1 per media per sample event for non-dedicated equipment
Trip Blank (VOCs only)	1 per sample shipment
Duplicate	1 per 10 samples/matrix
Matrix spike/matrix spike duplicate (MS/MSD)	1 per 20 samples/matrix

4.0 MANAGEMENT PLAN

This section identifies key roles in the project and program organization and specifies the proposed project schedule.

4.1 KEY PROJECT PERSONNEL

The following sections highlight individuals in the TtNUS CLEAN program and this RFA. Project organization is depicted on Figure 4-1.

4.1.1 SouthDiv Remedial Project Manager

The SouthDiv Remedial Project Manager, Mr. Joel Sanders, is responsible for the technical and financial management of RFA activities at NAF Key West. Mr. Sanders is the primary project contact. He prepares the project statement of work, manages the project scope, schedule, and budget, and provides technical review and approval of all deliverables. Mr. Sanders will be responsible for approving changes in the scope of work identified during Project Manager's Meetings.

4.1.2 ERNA Partnering Team

The Partnering Team is a structured approach for SouthDiv, NAF Key West Public Works, the SouthDiv contractor, FDEP, and EPA Region IV to work together in the interest of the project. For the Environmental Restoration, Navy Account (ERNA) RFA, the Partnering Team will meet to determine the DQOs for the project. The role of the Partnering Team is to agree on pertinent decisions for the project, prior to execution of the investigation. The Partnering Team will continue to review decisions for the project until the final report is completed.

4.1.3 Task Order Manager

The TOM for the RFA is responsible for evaluating the appropriateness and adequacy of the technical and engineering services provided. He/she is responsible for financial and schedule management and for ensuring that the project fulfills, and remains within, the contracted scope of work. He/she is also responsible for identifying necessary changes in the scope of work during Project Manager's Meetings. The TOM is responsible for the daily conduct of work, including integration of input from supporting disciplines and subcontractors, and will serve as the primary Project Manager.

4.1.4 ERNA Planning Team

The ERNA Planning Team is a subgroup of the ERNA Partnering Team and is made up primarily of the Navy and its contractors. The Planning Team is often tasked with the Partnering Team's action items related to the DQO issues of the investigation.

4.1.5 QA Manager

The TOM and FOL are supported by a QA Manager, who will report to the Program Manager (PM). The QA Manager will oversee implementation of appropriate Naval Facilities Engineering Service Center (NFESC) and EPA protocols. The QA Manager will also work with the TOM to establish QC procedures.

4.1.6 Health and Safety

The TOM and FOL are supported by the Health and Safety Manager (HSM) who will report to the Project Manager. The HSM will oversee implementation of the appropriate corporate health and safety requirements and the CLEAN Program HASP.

TtNUS staff will adhere to the approved HASP (Appendix C). The plan addresses possible contaminants that could be encountered at Tar Tank Spill Area and the Former Boca Chica Blast Media Disposal Area.

4.1.6.1 Field Staff

- Emily McRee TtNUS Aiken, Field Operations Leader
- Nathan Reel TtNUS Aiken, Environmental Technician
- Shonda Sumpter TtNUS Aiken, Environmental Scientist
- John Webster TtNUS Stone Mountain, Geologist
- Rebecca Dohn TtNUS Aiken, Environmental Scientist
- Mike Whitten TtNUS Aiken, Environmental Biologist

4.2 REPORTING

Before analytical results are included in a report, they will be reviewed and discussed by the NAF Key West Partnering Team. The results will be then reported in two reports: the Tar Tank Spill Area Confirmation Sampling Report and the Former Boca Chica Blast Media Disposal Area RFA Report. All collected field screening and laboratory data will be evaluated and presented in the Confirmation Sampling Report. The RFA Report will present the current potentiometric flow map of the shallow

groundwater system, current is isoconcentration maps for TAL metals detected in excess of ARARs, and recommendations for remediation of the site.

4.3 NAVY SUPPORT

The CLEAN Remedial Project Manager (RPM) is Joel Sanders

The NAF Key West Point of Contact is Bob Courtright

Throughout sampling activities, various support functions will be provided by NAF Key West personnel, as described below:

- Take custody of any purge fluids requiring disposal according to applicable state or federal regulations
- If necessary, provide access to the Former Boca Chica Blast Media Disposal Area
- Provide potable water source for field equipment and personnel cleaning.

4.4 CONTINGENCY PLAN

In the event of problems that may be encountered during site activities, the TtNUS Project Manager will immediately notify the NAF Key West Point of Contact and RPM. The Project Manager will determine a course of action that does not interfere with the schedule or budget. All contingency plans will be approved through the NAF Key West Point of Contact and the RPM before being initiated.

4.4.1 Field Operations Leader

The FOL is responsible for the field support staff and subcontractors executing the RFA SAP in the field. The FOL will be field liaison between SouthDiv and the NAF Key West Point of Contact and will also act as the Site Safety Officer for this project.

4.4.1.1 Site Safety Officer

The Site Safety Officer is responsible for field staff and subcontractor compliance with corporate health and safety requirements and the CLEAN Program HASP. Conformance with safety protocols will be assessed through periodic site visits and daily supervision by the FOL.

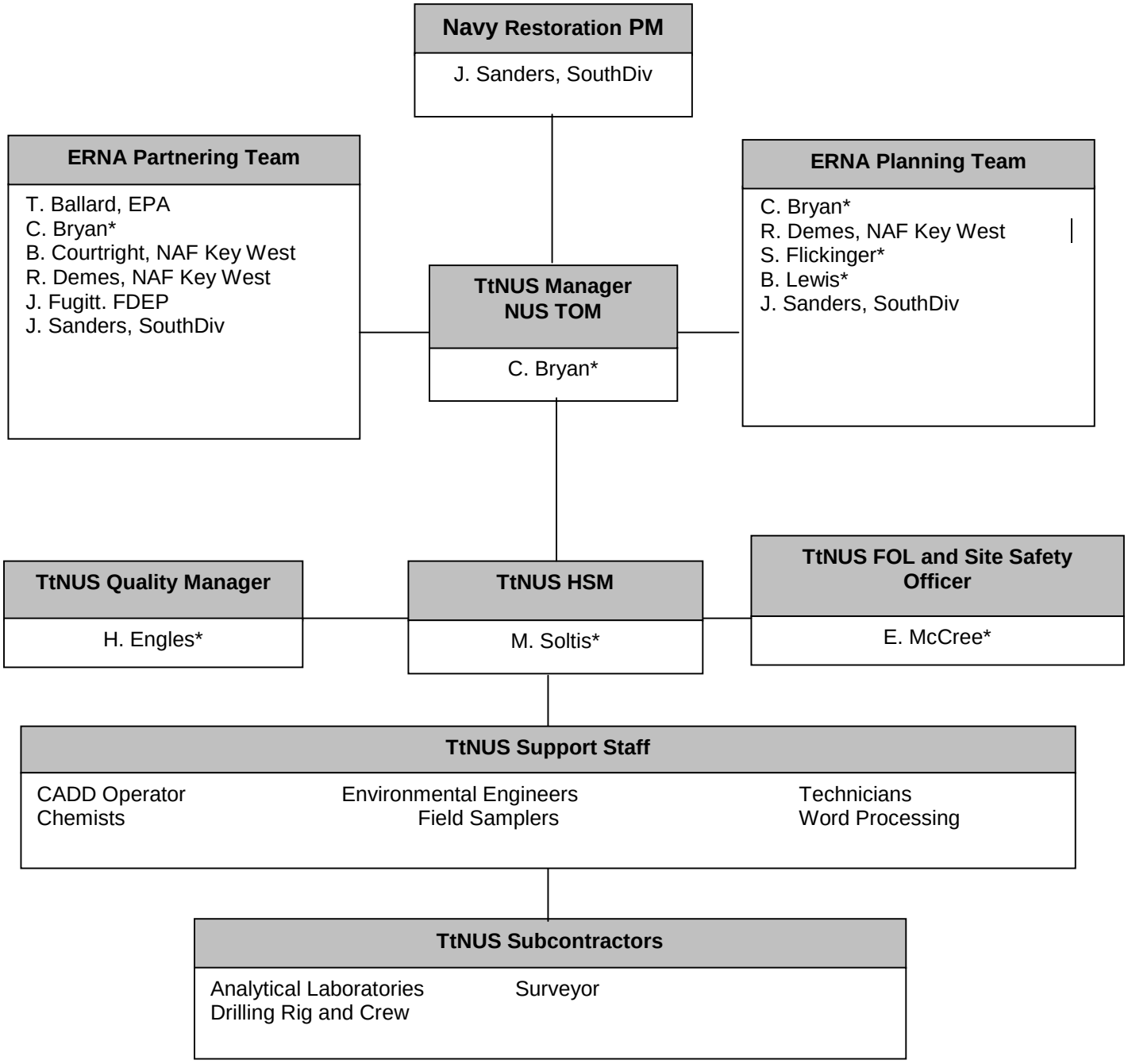
4.4.2 Bottleware Requirements

Bottleware, preservation, and holding time requirements for sample analyses proposed for this investigation are provided in Table 3-1. The laboratory subcontractor will supply pre-preserved, certified-clean bottleware.

4.4.3 Data Reduction, Validation, and Reporting

All sample data will be validated (using the most recent EPA Functional Guidelines for data validation) in a manner similar to data review performed during the Supplemental RFI/RI (B&RE, 1997 and 1998). This will ensure that data is of sufficient quality to meet performance monitoring objectives, as discussed in Section 10.0 of the QAPP.

Figure 4-1. Project Organization Chart



* Personnel employed by TtNUS
ERNA Environmental Restoration, Navy Account
FOL Field Operations Leader
HSM Health and Safety Manager
PM Program Manager
TOM Task Order Manager

REFERENCES

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APPENDIX A

RESPONSE TO COMMENTS

APPENDIX A. RESPONSE TO COMMENTS

Comment 1:

Change NAS to NAF throughout-I think the logo changed also.

Response to Comment 1:

Concur.

Comment 2:

Remove all AST work throughout document including appendices.

Response to Comment 2:

Concur.

Comment 3:

Why do we remove 3 well volumes if parameters have stabilized?

Response to Comment 3:

Section 4.2.5.5.e of the FDEP SOPs (September 1992) which were in effect when the RFA Workplan was written, states that purging is complete after removal of three well volumes and subsequent stabilization of field parameters. If parameters do not stabilize, 5 well volumes must be removed.

Comment 4:

QAPP - section 3.1.1 1st sentence. Check to see if "and" is necessary.

Response to Comment 4:

The sentence should read ."Precision is a measure of the amount of variability <u>and bias</u> inherent in a data set." The word "bias" was mistakenly omitted and will be included in Rev. 1 of the document.

APPENDIX B

QUALITY ASSURANCE PROJECT PLAN

Quality Assurance Project Plan

Naval Air Facility
Key West, Florida

Southern Division
Naval Facilities Engineering Command

Contract Number N62467-94-D-0888
Contract Task Order 0188

April 2002

Rev. 1

QUALITY ASSURANCE PROJECT PLAN

NAVAL AIR FACILITY
KEY WEST, FLORIDA

COMPREHENSIVE LONG-TERM
ENVIRONMENTAL ACTION NAVY (CLEAN) CONTRACT

Submitted to:
Southern Division
Naval Facilities Engineering Command
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North Charleston, South Carolina 29406

Submitted by:
Tetra Tech NUS, Inc.
661 Andersen Drive
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CONTRACT NUMBER N62467-94-D-0888
CONTRACT TASK ORDER 0188

APRIL 2002

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ACRONYMS/ABBREVIATIONS

AOC	area of concern
AIMD	Aircraft Intermediate Maintenance Department
AST	above-ground storage tank
BFB	bromofluorobenzene
BTAG	Biochemical Assistance Group
°C	degrees Celsius
CIH	Certified Industrial Hygienist
CLEAN	Comprehensive Long-Term Environmental Action, Navy
COC	Chain of Custody
CompQAP	Tetra Tech NUS, Inc. Comprehensive Quality Assurance Plan
CTO	Contract Task Order
CVAA	cold vapor atomic absorption
DFTPP	decafluorotriphenyl phosphine
DO	Dissolved Oxygen
DQO	Data Quality Objective
EDB	1,2-dibromoethane
EPA	U.S. Environmental Protection Agency
FDEP	Florida Department of Environmental Protection
FOL	Field Operations Leader
FTMR	Field Task Modification Request
GC	gas chromatograph
GC/MS	gas chromatograph/mass spectrometer
HASP	Health and Safety Plan
HPLC	high-performance liquid chromatography
HSM	Health and Safety Manager
ICP	Inductively Coupled Plasma
IR	Installation Restoration
IRA	Interim Remedial Action
LCS	Laboratory Control Sample
MCL	Maximum Contaminant Level
MDL	Method Detection Limit
µg/kg	micrograms per kilogram
µg/L	micrograms per liter
mg/L	milligrams per liter

mL	milliliter
µS/cm	microsiemens per centimeter
MS/MSD	Matrix Spike/Matrix Spike Duplicate
NAF	Naval Air Facility
NFESC	Naval Facilities Engineering Service Center
NIST	National Institute of Standards and Technology
NTU	Nephelometric turbidity unit
OME	Ontario Ministry of the Environment
PAH	polynuclear aromatic hydrocarbon
PARCC	precision, accuracy, representativeness, comparability, completeness
ppb	parts per billion
ppm	parts per million
QA/QC	Quality Assurance/Quality Control
QAM	Quality Assurance Manager
QAO	Quality Assurance Officer
QAPP	Quality Assurance Project Plan
RAG	Risk Assessment Guidelines
RBC	risk-based concentration
RCRA	Resource Conservation and Recovery Act
RDL	Required Detection Limit
RFA	RCRA Facility Assessment
RFI/RI	RCRA Facility Investigation/Remedial Investigation
RL	Reporting Limit
RPD	Relative Percent Difference
RPM	Remedial Project Manager
RQL	Required Quantitation Limits
SC	specific conductivity
SCTL	Soil Clean-up Target Level
SDG	Sample Delivery Group
SOP	Standard Operating Procedure
SouthDiv	U.S. Naval Facilities Engineering Command, Southern Division
SQB	Sediment Quality Benchmark
SQC	Sediment Quality Criteria
SVOC	semivolatile organic compound
SWMU	Solid Waste Management Unit
TAL	Target Analyte List
TOM	Task Order Manager

TPH	total petroleum hydrocarbon
TtNUS	Tetra Tech NUS, Inc.
VOC	volatile organic compound
%R	Percent Recovery

1.0 PROJECT DESCRIPTION

1.1 INTRODUCTION

This Quality Assurance Project Plan (QAPP) has been prepared by Tetra Tech NUS, Inc. (TtNUS) on behalf of the United States Navy Naval Facilities Engineering Command Southern Division (SouthDiv) and the Naval Air Facility (NAF) Key West, Key West, Florida, under the Comprehensive Long-Term Environmental Action Navy (CLEAN III) Contract Number N62467-94-D-0888, Contract Task Order (CTO) 0188. The QAPP and other associated documents, including the TtNUS Florida Department of Environmental Protection (FDEP)-approved Comprehensive Quality Assurance Plan (CompQAP) No. 980038 (TtNUS, 1999a) and the Health and Safety Plan (HASP) prepared in April 2000 (TtNUS, 2000), constitute the project planning documents for the Resource Conservation and Recovery Act (RCRA) Facility Assessment (RFA). Two sites, the Tar Tank Spill Area and the Former Boca Chica Blast Media Disposal Area, both located on Boca Chica Key at NAF Key West, are covered under this QAPP.

This QAPP presents the organization, objectives, planned activities, and specific quality assurance/quality control (QA/QC) procedures associated with this project. Specific protocols for sampling, sample handling and storage, chain of custody (COC), and laboratory and field analyses are described in the document. All QA/QC procedures are structured in accordance with applicable technical standards, the Naval Facilities Engineering Service Center (NFESC) guidance document, “Navy Installation Restoration Chemical Data Quality Manual” (NFESC, 1999), and United States Environmental Protection Agency (EPA) Region IV and FDEP requirements, regulations, guidances, and technical standards.

1.2 FACILITY DESCRIPTION

The Boca Chica Tar Tank Spill Area is located on the southeastern portion of Boca Chica Key, immediately north of the boundary of Solid Waste Management Unit (SWMU) 1, the Former Boca Chica Open Disposal Area. The site area is shown on Figure 1-2 of the RFA Work Plan. The Tar Tank Spill Area has remnants of a 10-foot-diameter aboveground storage tank (AST). The base of the tank still exists and is filled with 2.5 to 3 inches of an unknown tar-like substance. From visual inspection, the base of the tank is estimated to contain approximately 147 gallons of the tar-like substance. In hot weather, the unknown tar-like substance has been observed to ooze from the tank onto the ground surface. Patches of the unknown tar-like substance surround the AST and become particularly glutinous during hot weather.

The Former Boca Chica Blast Media Disposal Area, an unnumbered area of concern (AOC), is in the west-central portion of Boca Chica Key. The Former Boca Chica Blast Media Disposal Area was used to dispose of sandblasting material produced during the removal of paint from surfaces of ground-handling and ground-support vehicles and equipment, aircraft parts, and other metal objects and pieces of equipment. The sandblasting activities took place at SWMU 5, Boca Chica Aircraft Intermediate Maintenance Department (AIMD) Sand Blasting Building A-990, at the western end of the airfield on Boca Chica Key. A mound at the site consists of concrete and metal debris. Significant vegetation is established on the mound, in the form of Australian pine trees, and the ground is covered with pine straw.

Black Beauty®, the brand name for a coal slag abrasive used in sand blasting, has been identified predominantly on the southern and western areas of the site. The sand blasting material was identified on the surface of the mound at five different locations during a visual inspection of the site. Delineation of soil, sediment, and groundwater contamination at this site will center around known areas of Black Beauty® disposal.

1.3 SITE HISTORY

The Tar Tank Spill Area is located directly north of SWMU 1, the Former Boca Chica Open Disposal Area. SWMU 1 received general refuse and waste associated with aircraft maintenance activities. The AST at the Tar Tank Spill Area is thought to have been associated with asphalt mixing activities. During the RCRA Facility Investigation/Remedial Investigation (RFI/RI) performed by IT Corporation (1994), one soil sample was collected from the area near the Old Tar Tank. However, sample results did not exceed the current industrial soil clean-up target levels (SCTLs), indicating that the tar-like substance had not spread onto the ground significantly until after that investigation.

Other than visual inspections, no investigative activities have taken place at the Former Boca Chica Blast Media Disposal Area. Because SWMU 5 was used as a sand blasting area from the early 1970s until 1995, a conservative assumption has been made that the sand blasting material was disposed at the site during this time period. However, no records exist of the amount of Black Beauty® that was disposed at the Former Boca Chica Blast Media Disposal Area.

1.4 PROJECT OBJECTIVES

This section discusses overall project objectives, anticipated target parameters, and intended data uses for both field and laboratory analytical data.

1.4.1 Overall Project Objectives

Under the authority of RCRA, TtNUS will conduct sampling activities at the Tar Tank Spill Area and the Former Boca Chica Blast Media Disposal Area. The overall objective of the work is to determine concentrations of volatile organic compounds (VOCs), semivolatile organic compounds (SVOCs), and total petroleum hydrocarbon (TPH) at the Tar Tank Spill Area and Target Analyte List (TAL) metals only at the Former Boca Chica Blast Media Disposal Area through sampling and analyses. Soil confirmation sampling and analyses will be conducted at the Boca Chica Tar Tank Spill Area to ensure that contaminated soil has been removed through excavation. Investigative soil, sediment, and groundwater sampling will be conducted at the Former Boca Chica Blast Media Disposal Area to determine the nature and extent of contamination. Monitoring wells will be installed at both sites, following confirmation and investigative sampling, to monitor any leaching of contamination that may have occurred. Groundwater samples will be collected at both sites immediately following installation and development of the monitoring wells. Solid samples at the Tar Tank Spill Area will be analyzed for VOCs, SVOCs, and TPH. Aqueous samples at the Tar Tank Spill Area will be analyzed for VOCs and SVOCs. Solid and aqueous samples at the Former Boca Chica Blast Media Disposal Area will be analyzed for TAL metals.

1.4.2 Project Target Parameters and Intended Data Uses

This section discusses the field and laboratory analytical information to be generated during the course of the investigation. Field parameters and intended data uses are discussed in Section 1.4.2.1. Laboratory parameters and intended data uses are discussed in Section 1.4.2.2.

1.4.2.1 Field Parameters

Field parameters will include those parameters associated with groundwater and soil sampling and analysis. All field measurements will be obtained by using simple field instrumentation.

Field parameters, measured in all groundwater samples, will include specific conductivity (SC), pH, turbidity, temperature, dissolved oxygen (DO), and salinity. All field parameters will be measured with field water-quality meters and used to assure field personnel that groundwater samples being collected are representative of site groundwater.

The Hach® colorimeter/immunoassay field test kits for TPH will be utilized to analyze soil confirmation samples from the Tar Tank Spill Area. The soil test kits detect TPH at a range between 10 and 200 parts per million (ppm). Soil confirmation samples will be tested for TPH in the field (to obtain immediate results) to determine that the excavation based on visual observation did, in fact, remove contaminated s

oils, before equipment is demobilized. Soil sample analytical results for VOCs and SVOCs will be used to help determine the locations for permanent monitoring wells at the site.

Data collected from soil, sediment, and groundwater samples at the Former Boca Chica Media Disposal Area will be used as a tool in the placement of permanent groundwater wells.

1.4.2.2 Laboratory Parameters

The analytical methods to be used for analysis of the NAF Key West samples are based on the histories of the sites. The required analyses for the Tar Tank Spill Area include Appendix IX VOCs and SVOCs and TAL metals. The required analysis for the Former Boca Chica Blast Media Disposal Area includes TAL metals. Tables B-1-1 through B-1-3 provide the Required Quantitation Limits (RQLs) for chemicals in these groups. The RQLs listed in Tables B-1-1 through B-1-3 are equivalent to or less than the Florida Drinking Water Maximum Contaminant Levels (MCLs). Analytical methods are further discussed in Section 8.0 of this QAPP.

Data obtained from laboratory analyses will be used to determine the presence or absence of constituents of concern for the Tar Tank Spill Area and the Former Boca Chica Blast Media Disposal Area. This data will eventually be used to justify closure of each site. Decision rules, Data Quality Objectives (DQOs), and the sampling design rationale are discussed in Section 4.0.

1.5 SAMPLE NETWORK DESIGN AND RATIONALE

The sample network design and rationale are discussed in detail in Section 3.0 of the RFA Work Plan, Figures 3-1 and 3-2 of the Work Plan provide proposed sampling locations. Sampling will be conducted in general accordance with FDEP Standard Operating Procedures (SOPs), unless otherwise specified in this document. An FDEP-approved laboratory will be subcontracted by TtNUS to perform the fixed-base laboratory chemical analyses for soil, sediment, and groundwater samples collected at the RFA sites.

1.6 PROJECT SCHEDULE

The actual start date of the project schedule has yet to be determined.

TABLE B-1-1

SW-846 8260B ANALYTICAL QUANTITATION LIMITS
APPENDIX IX[1] VOCS
NAVAL AIR FACILITY
KEY WEST, FLORIDA
PAGE 1 OF 2

Parameter	RQL[2] Solid Sample (µg/kg)	RQL[2] Groundwater Samples (µg/L)
Volatile Organic Compounds		
Acetone	50	5
Acrolein	40	1
Acrylonitrile	100	1
Benzene	10	1
Bromodichloromethane	10	1
Bromoform	10	1
Bromomethane	10	1
2-Butanone	50	5
Carbon disulfide	10	1
Carbon tetrachloride	10	1
Chlorobenzene	10	1
Chloroethane	10	1
2-Chloroethylvinyl ether	10	1
Chloroform	10	1
Chloromethane	10	1
Chloroprene	10	1
3-Chloroprene	10	1
Dibromochloromethane	10	1
1,2-Dibromo-3-chloropropane	10	1
Dibromomethane	10	1
1,2-Dibromoethane[3]	10	1
1,2-Dichlorobenzene	10	1
1,3-Dichlorobenzene	10	1
1,4-Dichlorobenzene	10	1
trans-1,4-Dichloro-2-butene	10	1
Dichlorodifluoromethane	10	1
1,1-Dichloroethane	10	1
1,2-Dichloroethane	10	1
1,1-Dichloroethene	10	1
1,2-Dichloroethene (total)	10	NA
cis-1,2-Dichloroethene	10	1
trans-1,2-Dichloroethene	10	1
1,2-Dichloropropane	10	1
cis-1,3-Dichloropropene	10	1
trans-1,3-Dichloropropene	10	1
Ethylbenzene	10	1
Ethyl methacrylate	10	1
2-Hexanone	50	5
Iodomethane	10	1
Methacrylonitrile	10	1
Methylene chloride	50	2
Methyl methacrylate	10	1

TABLE B-1-1

SW-846 8260B ANALYTICAL QUANTITATION LIMITS
APPENDIX IX[1] VOCS
NAVAL AIR FACILITY
KEY WEST, FLORIDA
PAGE 2 OF 2

Parameter	RQL[2] Solid Sample (µg/kg)	RQL[2] Groundwater Samples (µg/L)
Volatile Organic Compounds		
4-Methyl-2-pentanone	50	5
Pentachloroethane	10	1
Styrene	10	1
1,1,1,2-Tetrachloroethane	10	1
1,1,2,2-Tetrachloroethane	10	1
Tetrachloroethene	10	1
1,1,1-Trichloroethane	10	1
1,1,2-Trichloroethane	10	1
Trichloroethene	10	1
Trichlorofluoromethane	10	5
1,2,3-Trichloropropane	10	1
Toluene	10	1
Vinyl acetate	20	1
Vinyl chloride	10	1
Xylenes (total)	10	1

NA = Not analyzed.
1 Appendix IX: 40 Code of Federal Regulations Part 264, Appendix IX Groundwater Monitoring List.
2 RQL: Required Maximum Quantitation Limit.
3 Analyzed using EPA Method 504.1.

TABLE B-1-2

SW-846 8270C ANALYTICAL QUANTITATION LIMITS
APPENDIX IX[1] SVOCS
NAVAL AIR FACILITY
KEY WEST, FLORIDA
PAGE 1 OF 3

Parameter	RQL[2] Solid Samples (µg/kg)	RQL[2] Groundwater Samples (µg/L)
Semivolatile Organic Compounds		
Acenaphthene	330	10
Acenaphthylene	330	10
Acetophenone	330	10
2-Acetylaminofluorene	330	10
4-Aminobiphenyl	330	10
Aniline	330	10
Anthracene	330	10
Aramite	330	10
7,12-Dimethylbenz(a)axobenzene	330	10
p-(Dimethylamino)azobenzene	330	10
Benzo(a)anthracene	330	0.2
Benzo(a)pyrene	100	0.2
Benzo(b)fluoranthene	330	0.2
Benzo(g,h,i)perylene	330	0.2
Benzo(k)fluoranthene	330	0.2
Benzyl alcohol	330	10
Bis(2-chloroethoxy)methane	330	10
Bis(2-chloroethyl)ether	300	10
Bis(2-ethylhexyl)phthalate	330	5.0
4-Bromophenyl-phenylether	330	10
Butylbenzylphthalate	330	10
Carbazole	330	10
4-Chloroaniline	330	10
4-Chloro-3-methylphenol	330	10
2-Chloronaphthalene	330	10
2-Chlorophenol	330	10
4-Chlorophenyl-phenylether	330	10
Chrysene	330	5.0
Dibenz(a,h)anthracene	330	0.2
Dibenzofuran	330	10
Di-n-butylphthalate	330	10
3,3'-Dichlorobenzidine	330	10
1,2-Dichlorobenzene	330	10
1,3-Dichlorobenzene	330	10
1,4-Dichlorobenzene	330	10
2,4-Dichlorophenol	330	1.0
1,3-Dinitrobenzene	330	10
2,6-Dichlorophenol	330	10
Diethylphthalate	330	10
3,3'-Dimethylbenzidine	330	10
2,4-Dimethylphenol	330	10
Dimethylphthalate	330	10
4,6-Dinitro-2-methylphenol	830	25
2,4-Dinitrophenol	830	25
2,4-Dinitrotoluene	330	1.0
2,6-Dinitrotoluene	330	10
Di-n-octylphthalate	330	10
Diphenylamine	330	10
Hexachlorobenzene	330	10
Hexachlorobutadiene	330	10
Hexachlorocyclopentadiene	330	10
Hexachloroethane	330	10

TABLE B-1-2

SW-846 8270C ANALYTICAL QUANTITATION LIMITS
APPENDIX IX[1] SVOCS
NAVAL AIR FACILITY
KEY WEST, FLORIDA
PAGE 2 OF 3

Parameter	RQL[2]	
	Solid Samples (µg/kg)	Groundwater Samples (µg/L)
Hexachloropropene	330	10
Isophorone	330	10
2-Methylnaphthalene	330	10
2-Methylphenol	330	10
4-Methylphenol	330	10
Naphthalene	330	10
1,4-Napthoquinone	330	10
1-Napthylamine	330	10
2-Nitroaniline	330	25
3-Nitroaniline	830	25
4-Nitroaniline	830	25
Nitrobenzene	830	10
2-Nitrophenol	330	10
4-Nitrophenol	830	25
n-Nitrosodimethylamine	330	4.0
n-Nitroso-di-n-propylamine	330	10
n-nitrosodiphenylamine	330	10
2,2'-OxyBis(1-chloropropane)	330	10
Pentachlorophenol	830	25
Phenanthrene	330	10
Phenol	330	10
2-Picoline	330	10
Pronamide	330	10
Pyrene	330	10
1,2,4-Trichlorobenzene	330	10
2,4,5-Trichlorophenol	830	25

TABLE B-1-2

SW-846 8270C ANALYTICAL QUANTITATION LIMITS
APPENDIX IX SVOCS
NAVAL AIR FACILITY
KEY WEST, FLORIDA
PAGE 3 OF 3

Parameter	RQL[1]	
	Solid Samples (µg/kg)	Groundwater Samples (µg/L)
Semivolatile Organic Compounds		
Ethyl methanesulfonate	330	10
Hexachlorophene	330	10
Methapyrilene	330	10
3-Methylcholanthrene	330	10
Methyl methanesulfonate	330	10
3-and-4-Methylphenol	330	10
2-Naphthylamine	330	10
5-Nitro-o-toluidine	330	10
4-Nitroquinoline-1-oxide	330	10
n-Nitrosodiethylamine	330	10
n-Nitrosomethylethylamine	330	10
n-Nitroso-di-n-butylamine	330	10
n-Nitrosomorpholine	330	10
n-Nitrosopyrrolidine	330	10
Pentachlorobenzene	330	10
Pentachloronitrobenzene	330	10
Phenacetin	330	10
p-Phenylenediamine	330	10
Pyridine	330	10
Safrole	330	10
Sulfotepp	330	10
1,2,4,5-Tetrrachlorobenzene	330	10
2,3,4,6-Tetrrachlorophenol	330	10
Thionazin (Zinphos)	330	10
o-Toluidine	330	10
2,4,6-Trichlorophenol	330	10
1,3,5-Trinitrobenzene	330	10

Shaded compounds will be analyzed using Method SW-846 8310.

1 Appendix IX: 40 Code of Federal Regulations Part 264, Appendix IX Groundwater Monitoring List.

2 RQL: Required Maximum Quantitation Limit.

TABLE B-1-3

SW-846 6010B, 9010B, 7000A ANALYTICAL DETECTION LIMITS
TARGET ANALYTE LIST (TAL)[1] METALS
NAVAL AIR FACILITY
KEY WEST, FLORIDA

Parameter	RDL[2] Groundwater Samples (µg/L)
TAL Metals	
Aluminum	200
Antimony	60
Arsenic	10
Barium	200
Beryllium	5
Cadmium	5
Calcium	5000
Chromium (total)	10
Cobalt	50
Copper	25
Iron	25
Lead	3
Magnesium	5000
Manganese	15
Mercury	0.2
Nickel	40
Potassium	5000
Selenium	5
Silver	10
Sodium	5000
Thallium	10
Tin	10
Vanadium	50

1 TAL = Target Analyte List.
2 RDL = Required Detection Limit expressed as Instrument Detection Limit obtained in pure water. Detection Limit for soil adjusted for the amount of sample analyzed and percent moisture.

2.0 PROJECT ORGANIZATION

The various quality assurance and management responsibilities of key project personnel are defined in the following paragraphs. A project organization chart is shown in Figure 5.1 of the Work Plan.

Partnering Team - The Partnering Team is responsible for overall technical guidance and is the decision-making body for the groundwater monitoring program. The Partnering Team is comprised of the Navy (SouthDiv) Remedial Project Manager (RPM), the NAF Key West Installation Restoration (IR) Program Manager, the EPA Region IV Project Manager, the FDEP Project Manager, and the TtNUS Task Order Manager (TOM).

SouthDiv Remedial Project Manager - The SouthDiv RPM is responsible for managing funding for the groundwater monitoring program, project management, and oversight of the TtNUS contract. The RPM for the RFA is Mr. Joel Sanders.

Installation Restoration Program Manager - The IR Program Manager, Mr. Robert Courtright, oversees the IR program at NAF Key West.

CLEAN Program Manager - The TtNUS CLEAN Program Manager is responsible for the execution of all contractual obligations. The TtNUS CLEAN Program Manager is Ms. Debbie Wroblewski. She serves as the primary point of contact for the client and provides an interface between the Navy and the project staff.

CLEAN Task Order Manager - The TtNUS CLEAN TOM is responsible for project management, including technical performance, adherence to budget and schedule, and for ensuring the availability of necessary personnel, equipment, subcontractors, and services. The TtNUS TOM for CTO No. 0188 is Mr. Charles Bryan. He will direct development of the field program, evaluation of findings, determination of conclusions and recommendations, and preparation of technical reports.

Field Operations Leader/Sampling Coordinator - Ms. Emily McRee will act as the TtNUS Field Operations Leader (FOL), responsible for providing onsite supervision of day-to-day field activities on the project. The FOL serves as the primary onsite contact with the client and subcontractors. She is also responsible for all field QA/QC and safety-related issues, as defined in the HASP. In addition, the FOL will coordinate the schedule of field sampling activities with the schedule and capacity requirements of the selected analytical laboratories. All environmental sampling will be coordinated to assure that it is conducted in a

manner that complies with all QA/QC requirements and with holding time and analytical procedure requirements.

Health and Safety Manager - The Program Health and Safety Manager (HSM) will review and internally approve the HASP that has been tailored to the specific needs of the investigation. The TtNUS HSM is Mr. Matthew Soltis, Certified Industrial Hygienist (CIH). In consultation with the TOM/FOL, Mr. Soltis will ensure that an adequate level of personal protection exists for all field personnel for anticipated potential hazards. As the HSM does not report to either the Program Manager or TOM, his/her actions are not dictated by program or project constraints (such as budget and schedule), other than assuring appropriate safeguards while conducting investigation activities.

Site Safety Officer - The Site Safety Officer ensures that the HASP is followed during field activities. The Site Safety Officer operates independently of the FOL and ensures that all Health and Safety procedures are followed during field activities. The Site Safety Office reports to the HSM.

Quality Assurance Officer - The Quality Assurance Officer (QAO) operates independently of the TOM and is responsible for all project quality assurance issues and development of the QAPP. The TtNUS QAO for this study is Mr. Howard Engle. Specific responsibilities of the QAO include reviewing laboratory reports to ensure that all QA/QC requirements have been met, and inspecting work activities and project deliverables to make sure that QC activities are not compromised. The QAO will communicate issues of non-compliance directly to the TOM and the TtNUS Quality Assurance Manager (QAM).

Quality Assurance Manager - The QAM operates independently of the TOM and the Program Manager and is responsible for all Program-wide quality assurance issues and the development of the TtNUS SOUTHDIV CLEAN Program's Quality Assurance Program.

Project Laboratory - An FDEP-approved laboratory will be subcontracted by TtNUS to perform routine chemical analyses for the environmental samples collected during the RFA. The laboratory is responsible for checking its QA/QC procedures against the requirements of this QAPP and the laboratory CompQAP before laboratory reports are transferred to TtNUS.

3.0 QUALITY ASSURANCE OBJECTIVES FOR MEASUREMENT DATA

The overall QA objective for this project is to develop and implement procedures for field sampling, COC, laboratory analysis, and reporting that will provide results to support the attainment of project objectives. Intended data uses are described in Section 1.4.2 of this QAPP. Specific procedures for sampling, COC, laboratory instrument calibration, laboratory analysis, reporting of data, internal quality control, audits, preventive maintenance of field and laboratory equipment, and corrective action are described in other sections of this QAPP.

The precision, accuracy, representativeness, comparability, and completeness (PARCC) parameters are qualitative and/or quantitative statements regarding the quality characteristics of the data used to support project objectives and, ultimately, environmental decisions. These parameters are discussed in the remainder of this section. Specific routine procedures used to assess the quantitative data parameters (accuracy, precision, and completeness) are provided in Section 13.0.

3.1 PRECISION

3.1.1 Definition

Precision is a measure of the amount of variability and bias inherent in a data set. Precision describes the reproducibility of measurements of the same parameter for multiple samples collected and analyzed under similar conditions. The equation for determining precision is provided in Section 13.2.

3.1.2 Field Precision Objectives

Duplicate field measurements for aqueous matrix samples will not be required. In lieu of taking duplicate measurements and using independent QC check standards, more frequent continuing calibrations will be performed. Field precision is further discussed in Section 5 and Subsection 7.5.1.5 of the TtNUS CompQAP. Field duplicate precision establishes the consistency with which environmental samples were obtained and analyzed and is a measure of short-range spatial variability of analyte concentrations. Field duplicate results for solid matrix samples are considered to be precise if the Relative Percent Difference (RPD) is less than or equal to 50 percent. Field duplicate results for aqueous matrix samples are considered to be precise of the RPD is less than or equal to 30 percent. Field precision is assessed through the collection and measurement of field duplicates at a rate of 1 duplicate per 10 environmental samples. If RPD goals are not met, the laboratory and validation procedures will be revisited after which it will be determined whether to invalidate the sample results and re-sample.

3.1.3 Laboratory Precision Objectives

Laboratory precision QC samples are analyzed at a frequency of 5 percent (i.e., one QC sample per 20 environmental samples). Laboratory precision is measured via comparison of calculated RPD values and Precision Control Limits specified in the analytical method or by the laboratory's QA/QC program. Precision for inorganic analyses will be measure via RPDs for laboratory duplicates. Internal laboratory control limits for precision, which are typically set at three times the standard deviation of a series of RPDs, will be used by the laboratory for evaluation of precision. The laboratory-derived RPDs must meet the RPDs listed in Table B-3-1. If RPD goals are not met, the laboratory and validation procedures will be revisited after which it will be determined whether to invalidate the sample results and re-sample.

Precision for VOC analyses will be measured via the RPDs for matrix spike/matrix spike duplicate (MS/MSD) samples. The analytical method for low-concentration volatiles analysis does not require a specific QC sample to monitor precision, although calibration requirements of the method (i.e., specific limits of precision for the calibration standards) do ensure that a sufficient level of precision is achieved. Calibration is further discussed in Section 7.0. Table B-3-2 presents the precision control limits for MS/MSD RPDs for volatile and semivolatile organics that are representative of the target analytes. Internal laboratory control limits for precision, which are typically set at three times the standard deviation of a series of RPDs, will be used to evaluate precision for these parameters.

3.2 ACCURACY

3.2.1 Definition

Accuracy is the degree of agreement between the observed value and an accepted reference value. The equation for determining accuracy is provided in Section 13.1.

3.2.2 Field Accuracy Objectives

The determination of accuracy in the field is not required. In lieu of using matrix spikes in the field and independent QC check standards, more frequent continuing calibrations will be performed. Once the field meter has been calibrated, these checks will take place at intervals of no more than four hours and at the end of each sampling day. If a field meter fails a continuing calibration, a complete initial calibration must be performed. Field precision is further discussed in Section 5 and Subsection 7.5.1.5, of the TtNUS CompQAP.

3.2.3 Laboratory Accuracy Objectives

Accuracy in the laboratory is measured through comparison of a spiked sample result against a known or accepted value and is expressed as a percent recovery (%R). Percent recoveries are derived from the analysis of known amounts of compounds spiked into analyte-free water (i.e., laboratory control sample [LCS] analysis) or into actual samples (MS analysis). LCS analyses measure the accuracy of laboratory operations without effects from matrix interferences. MS analyses also measure the accuracy of laboratory operations, but as they are affected by the sample matrix. LCS and MS analyses are performed with a frequency of 1 per 20 associated samples of like matrix. Laboratory accuracy is assessed via comparison of calculated %Rs with accuracy control limits specified in the laboratory's QA/QC program.

Accuracy for inorganic analyses will be measured via the %Rs for matrix spikes and laboratory control samples. Internal laboratory control limits for accuracy, which are typically set at three times the standard deviation of a series of %R values, will be used by the laboratory for evaluation of accuracy. Tables B-3-3 and B-3-4 presents the accuracy control limits for MS and LCS %Rs for TAL metals, respectively.

Accuracy for volatile organics analyses will be measured via the %Rs for surrogate spikes and MS/MSDs. Table B-3-5 presents control limits for LCS spike recoveries for low-concentration representative VOCS and SVOCS. Tables B-3-6 and B-3-7 present control limits for MS/MSD and surrogate spike recoveries, respectively for representative VOCs and SVOCs. Accuracy for the remaining parameters will typically be measured via %Rs for MSs and/or LCSs. Internal laboratory control limits for accuracy, which are typically set at three times the standard deviation of a series of %R values, will be used to evaluate accuracy for these parameters.

3.3 COMPLETENESS

Completeness is a measure of the amount of usable and valid analytical data obtained, compared to the amount expected. Completeness is typically expressed as a percentage. The equation for completeness is presented in Section 13.3.

The ideal objective for completeness is 100 percent (i.e., every sample planned for collection is collected; every sample submitted for analysis yields valid data). However, samples can be rendered unusable during shipping or preparation (e.g., bottles broken or extracts accidentally destroyed), errors can be introduced during analysis (e.g., loss of instrument sensitivity, introduction of ambient laboratory contamination), or sample heterogeneity can become apparent (e.g., extremely high field duplicate RPDs).

These instances may result in data that do not meet QC criteria. Based on these considerations, 95 percent is considered an acceptable target for the data completeness objective. If critical data points are lost, re-sampling and/or re-analysis might be required. In instances where errors are introduced during analysis or in the case of high RPDs, the Partnering Team will determine whether re-sampling or re-analysis is required.

As further discussed in Section 10.2.2, 100 percent of the laboratory data for the RFA program will undergo a limited review (refer to Section 10.2 of this QAPP for data validation procedure). Data rejected as a result of the review process will be treated as unusable data, unless additional review shows that the data are usable. Factors considered during limited review include sample holding times, method blank analyses, initial and continuing calibration standards, data completeness, reported detection limits, and duplicate sample analyses. Criteria to be applied to the data to gauge data quality are described in Section 10.2.2.

3.4 REPRESENTATIVENESS

3.4.1 Definition

Representativeness is an expression of the degree to which data accurately and precisely depict the actual characteristics of a population or environmental condition existing at an individual sampling point.

Adherence to this QAPP and attendant Work Plan and use of standardized sampling, handling, analytical, and reporting procedures will ensure that the final data accurately represent actual site conditions.

3.4.2 Measures to Ensure Representativeness of Field Data

Representativeness depends on proper design of the sampling program. It will be satisfied by ensuring that the QAPP is followed and that proper sampling techniques are used. The sampling network for the RFA program was designed to provide data representative of site conditions. The rationale of the sampling network is discussed in detail in Section 4.0 of the Work Plan.

3.4.3 Measures to Ensure Representativeness of Laboratory Data

Representativeness in laboratory data is ensured by using proper analytical procedures, meeting sample holding times, and (except for low-level VOC analysis) analyzing and assessing duplicate sample results.

3.5 COMPARABILITY

3.5.1 Definition

Comparability is defined as the confidence with which one data set can be compared to another (e.g., between sampling points; between sampling events). Comparability is achieved by using standardized sampling and analysis methods and data reporting formats (including using consistent units of measure). Additionally, consideration is given to seasonal conditions and other environmental variations that could influence data results.

3.5.2 Measures to Ensure Comparability of Field Data

Comparability depends on proper design of the sampling program and will be satisfied in part by ensuring that the QAPP and SOPs are followed. It also depends on accurately recording field measurements in the correct units. Field measurement units are further discussed in Section 10.1.1.

3.5.3 Measures to Ensure Comparability of Laboratory Data

Planned analytical data will be comparable when similar sampling and analytical methods are used and documented. Results will be reported in units that ensure comparability with previous data and with current state and Federal standards and guidelines. Laboratory measurement units are further discussed in Section 10.1.2.

3.6 LEVEL OF QUALITY CONTROL EFFORT

Trip blank, rinsate blank, method blank, field and laboratory duplicates, laboratory control samples, and MS samples will be analyzed to assess the quality of data resulting from the field sampling and analytical programs.

External QC measures (i.e., field QC samples) consist of field duplicates, trip blanks, and equipment rinsate blanks. Information gained from these analyses further characterizes the level of data quality obtained to support project goals. Each field QC sample undergoes the same preservation, analysis, and reporting procedures as its related environmental sample. The types of field QC samples are discussed below.

A field duplicate is collected at a single sampling location at the same time as an environmental sample. Both will be analyzed by the laboratory for the same constituents, in order to measure the precision of the

sampling and analytical methods employed. The level of the QC effort will be one field duplicate for every 5 to 9 samples, and then 10 percent of the number of additional investigative samples.

Trip blanks, consisting of analyte-free water, will be submitted to the laboratory to provide the means to assess the quality of data resulting from the field sampling program. Trip blanks are only used with samples collected for VOC analysis to assess the potential for contamination of samples (to be analyzed for VOCs) by contaminant migration into sample containers during sample shipment and storage. Trip blanks are prepared by the laboratory prior to the sampling event, shipped to the site with the sample containers, and kept with the investigative samples throughout the sampling event. They are then packaged for shipment only with the VOC samples and sent for analysis. There will be one trip blank included in each sample shipping cooler that contains samples for VOC analysis. At no time after preparation will the sample containers having trip blanks be opened before they reach the laboratory. Trip blanks are further discussed in Section 5 and Subsection 9.1.1.1.a.2 of the TtNUS CompQAP.

Equipment or rinsate blanks are obtained under representative field conditions by collecting the rinse water generated by running analyte-free water through sample collection equipment after decontamination and prior to use. At least one equipment blank will be collected per day for each sample matrix. If pre-cleaned, dedicated, or disposable sampling equipment is used, one rinsate blank per type of equipment used must be collected as a "batch blank." Rinsate blanks are analyzed for the same chemical constituents as the associated environmental samples. Equipment blanks are further discussed in Section 5 and Subsection 9.1.1.1.a.1, of the TtNUS CompQAP.

Method blank samples are generated within the laboratory and are used to assess contamination resulting from laboratory procedures. Environmental samples with positive results that correspond to positive results in the method blank will be designated with a qualifier by the laboratory. Method blanks are further discussed in Section 9.2 of this QAPP.

MS/MSD samples are investigative samples spiked with known quantities of target analytes. MS/MSDs provide information about the effect of the sample matrix on the measurement methodology. One MS/MSD sample will be collected/designated for every 20 or fewer investigative samples per sample matrix.

The level of QC effort for analytical testing will conform to the analytical methods listed in Table B-8-1 of this QAPP.

TABLE B-3-1

PRECISION CONTROL LIMITS (RPD)[1]
LABORATORY DUPLICATE SAMPLES
TAL METALS ANALYSIS[2]
NAVAL AIR FACILITY
KEY WEST, FLORIDA

Chemical	Aqueous Samples µg/L	Solid Samples µg/kg
TAL Metals		
Aluminum	20	35
Antimony	20	35
Arsenic	20	35
Barium	20	35
Beryllium	20	35
Cadmium	20	35
Calcium	20	35
Chromium (total)	20	35
Cobalt	20	35
Copper	20	35
Iron	20	35
Lead	20	35
Magnesium	20	35
Manganese	20	35
Mercury	20	35
Nickel	20	35
Potassium	20	35
Selenium	20	35
Silver	20	35
Sodium	20	35
Thallium	20	35
Tin	20	35
Vanadium	20	35
Zinc	20	35

Shaded chemicals will be analyzed by SW-846 Method 7470A or 7471A.
1 RPD: Relative Percent Difference, as described in Section 13.0.
2 EPA Method SW-846 6010B.

TABLE B-3-2

PRECISION CONTROL LIMITS (RPD)[1]
MATRIX SPIKE/MATRIX SPIKE DUPLICATE SAMPLES
VOLATILE AND SEMIVOLATILE ORGANIC ANALYSIS[2]
NAVAL AIR FACILITY
KEY WEST, FLORIDA

Chemical	Aqueous Samples µg/L	Solid Samples µg/kg
Volatile Organic Compounds		
Benzene	21	21
Chlorobenzene	21	21
1,1-Dichloroethene	22	22
Toluene	21	21
Trichloroethene	24	24
Semivolatile Organic Compounds		
Acenaphthene	31	19
2-Chlorophenol	40	50
4-Chloro-3-methylphenol	42	33
1,4-Dichlorobenzene	28	27
2,4-Dinitrotoluene	38	47
4-Nitrophenol	50	50
n-Nitroso-di-n-propylamine	38	38
Pentachlorophenol	50	47
Phenol	42	35
Pyrene	31	36
1,2,4-Trichlorobenzene	28	23

1 RPD: Relative Percent Difference, as described in Section 13.0.
2 EPA Methods SW-846 8260B and 8270C.

TABLE B-3-3

ACCURACY CONTROL LIMITS (%R)[1]
MATRIX SPIKE SAMPLES
TAL[2] METALS ANALYSIS[3]
NAVAL AIR FACILITY
KEY WEST, FLORIDA

Chemical	Aqueous Samples µg/L	Solid Samples µg/kg
TAL Metals		
Aluminum	75-125	NS
Antimony	75-125	75-125
Arsenic	75-125	75-125
Barium	75-125	75-125
Beryllium	75-125	75-125
Cadmium	75-125	75-125
Calcium	NS	NS
Chromium (total)	75-125	75-125
Cobalt	75-125	75-125
Copper	75-125	75-125
Iron	75-125	NS
Lead	75-125	75-125
Magnesium	NS	NS
Manganese	75-125	75-125
Mercury	75-125	75-125
Nickel	75-125	75-125
Potassium	NS	NS
Selenium	75-125	75-125
Silver	75-125	75-125
Sodium	NS	NS
Thallium	75-125	75-125
Tin	75-125	75-125
Vanadium	75-125	75-125
Zinc	75-125	75-125

Shaded chemicals will be analyzed by SW-846 7470A or 7471A.
1 %R: Percent Recovery, as described in Section 13.0.
2 TAL = Target Analyte List
3 EPA Method 6010B.
NS Not Spiked.

TABLE B-3-4

ACCURACY CONTROL LIMITS (%R)[1]
LABORATORY CONTROL SAMPLES
TAL[2] METALS ANALYSIS[3]
NAVAL AIR FACILITY
KEY WEST, FLORIDA

Chemical	Aqueous Samples µg/L	Solid Samples µg/kg
Aluminum	80-120	75 – 125
Antimony	80-120[3]	75 – 125
Arsenic	80-120	75 – 125
Barium	80-120	75 – 125
Beryllium	80-120	75 – 125
Cadmium	80-120	75 – 125
Calcium	80-120	75 – 125
Chromium	80-120	75 – 125
Cobalt	80-120	75 – 125
Copper	80-120	75 – 125
Iron	80-120	75 – 125
Lead	80-120	75 – 125
Magnesium	80-120	75 – 125
Manganese	80-120	75 – 125
Mercury	NA	75 – 125
Nickel	80-120	75 – 125
Potassium	80-120	75 – 125
Selenium	80-120	75 – 125
Silver	80-120[4]	75 – 125
Sodium	80-120	75 – 125
Thallium	80-120	75 – 125
Tin	80-120	75 – 125
Vanadium	80-120	75 – 125
Zinc	80-120	75 – 125

Shaded chemicals will be analyzed by SW-846 7470A or 7471A.
1 %R: Percent Recovery, as described in Section 13.0.
2 TAL = Target Analyte List
3 EPA Method 6010B.
4 Advisory Limits.

TABLE B-3-5

ACCURACY CONTROL LIMITS (%R)[1]
LABORATORY CONTROL SAMPLES AND SURROGATE SPIKES
VOLATILE AND SEMIVOLATILE ORGANICS[2]
NAVAL AIR FACILITY
KEY WEST, FLORIDA

Chemical	Aqueous Samples µg/L	Solid Samples µg/kg
Volatile Organic Compounds		
Benzene	70 - 130	60 – 140
Chlorobenzene	70 - 130	60 – 140
1,1-Dichloroethene	70 - 130	60 – 140
Toluene	70 - 130	60 – 140
Trichloroethene	70 - 130	60 – 140
Semivolatile Organic Compounds		
Acenaphthene	46-118	31-137
4-Chloro-3-methylphenol	23-97	26-103
2-Chlorophenol	27-123	25-102
1,4-Dichlorobenzene	36-97	28-104
2,4-Dinitrotoluene	24-96	28-89
4-Nitrophenol	10-80	11-114
n-Nitroso-di-n-propylamine	41-116	41.126
Pentachlorophenol	9-103	17-109
Phenol	12-110	26-90
Pyrene	26-127	35-142
1,2,4-Trichlorobenzene	39-98	38-107

1 %R: Percent Recovery, as described in Section 13.0.
2 EPA Method 8260B.

TABLE B-3-6

ACCURACY CONTROL LIMITS (%R)[1]
MATRIX SPIKE/MATRIX SPIKE DUPLICATE SAMPLES
VOLATILE AND SEMIVOLATILE ORGANIC ANALYSIS[2]
NAVAL AIR FACILITY
KEY WEST, FLORIDA

Chemical	Aqueous Samples µg/L	Solid Samples µg/kg
Volatile Organic Compounds		
Benzene	70 - 130	66-142
Chlorobenzene	70 – 130	60-133
1,1-Dichloroethene	70 - 130	59-172
Toluene	70 - 130	59-139
Trichloroethene	70 - 130	62-137
Semivolatile Organic Compounds		
Acenaphthene	46-118	31-137
2-Chlorophenol	27-123	25-102
4-Chloro-3-methylphenol	23-97	26-103
1,4-Dichlorobenzene	36-97	28-104
2,4-Dinitrotoluene	24-96	28-89
4-Nitrophenol	10-80	11-114
n-Nitroso-di-n-propylamine	41-116	41.126
Pentachlorophenol	9-103	17-109
Phenol	12-110	26-90
Pyrene	26-127	35-142
1,2,4-Trichlorobenzene	39-98	38-107

1 %R: Percent Recovery, as described in Section 13.0.
2 EPA Methods SW-846 8260B and 8270C.

TABLE B-3-7

ACCURACY CONTROL LIMITS (%R)[1]
SURROGATE SPIKES
VOLATILE AND SEMIVOLATILE ORGANIC ANALYSIS[2]
NAVAL AIR FACILITY
KEY WEST, FLORIDA

Chemical	Aqueous Samples µg/L	Solid Samples µg/kg
Volatile Organic Compounds		
Bromofluorobenzene	59-113	59-113
1,2-Dichloroethane-d4	70-121	70-121
Toluene-d8	84-138	84-138
Semivolatile Organic Compounds		
2-Chlorophenol-d4	20-130[3]	33-110[3]
1,2-Dichlorobenzene-d4	20-130[3]	16-110[3]
2-Fluorobiphenyl	30-115	43-116
2-Fluorophenol	24-121	21-110
Nitrobenzene-d5	23-120	35-114
Phenol-d5	24-113	10-110
Terphenyl-d14	18-137	33-141
2,4,6-Tribromophenol	19-122	10-123

1 %R: Percent Recovery, as described in Section 13.0.
2 EPA Methods SW-846 Method 8260B and 8270C.
3 Advisory Limits only.

4.0 DATA QUALITY OBJECTIVES PROCESS

The DQO process (EPA, 2000a) was used as a tool when developing the RFA Work Plan to determine the type, quantity, and quality of data needed to determine the corrective action needed at the Tar Tank Spill Area and the Former Boca Chica Blast Media Disposal Area. As a systematic planning tool based on the scientific method, the seven-step DQO process is used to establish criteria for defensible decision-making at the onset of a study and to develop specifications for a data-collection design based on these criteria. The DQO steps require the specification of such information as the goal of the investigation, the inputs needed to reach the goal and make a decision, the temporal and areal boundaries of the investigation, the statistical level of confidence required to support a decision (when applicable), and finally, a sampling design that is adequate to support the decision-making.

This DQO process addresses two separate sites, the Tar Tank Spill Area and the Former Boca Chica Blast Media Disposal Area. Each of the seven steps of the DQO process addresses both sites.

4.1 DATA QUALITY OBJECTIVES PROCESS

4.1.1 Step 1 - State the Problem

The first step in the DQO process is to generate a problem statement. This step addresses development of a Planning Team that will define the problem and implement subsequent steps of the process. It also calls for the identification of decision-makers who will lead the Planning Team members and make final resolutions during the DQO process.

Planning Team Members

- Chuck Bryan - TOM, TtNUS
- Bob Courtright - IR Program Manager, NAF Key West
- Scott Flickinger - Staff Chemist, TtNUS
- Joel Sanders - RPM, SouthDiv

Decision-makers - NAF Key West Tier I Partnering Team

- Turpin Ballard - USEPA Region IV
- Chuck Bryan - TtNUS
- Tracie Vaught - FDEP

- Bob Courtright - NAF Key West
- Ron Demes - NAF Key West
- Joel Sanders - SouthDiv

4.2 PROBLEM STATEMENT

(1) The Tar Tank Spill Area consists of an AST base containing approximately 147 gallons of a tar-like substance. This substance has been observed dripping from the tank base in hot weather and has also been observed on the ground around the AST. An interim remedial action (IRA) has been planned to remove the tank base and contaminated soil. Therefore, confirmation that contamination has been removed is necessary at the Tar Tank Spill Area.

(2) The Former Boca Chica Blast Media Disposal Area was used to dispose of sand-blasting material for an unknown period of time. This material has been observed on the ground surface in several areas of the site. For this reason, investigative sampling will take place to determine whether there is a risk to human health and the environment and, if so, whether corrective action is necessary to eliminate such risk.

Available Resources and Deadlines

Budget:	$215,410
Deadline:	08/08/02
Personnel:	Listed above as Planning Team and Decision-makers
Guidance:	DQO Process (EPA QA/G-4), Data Quality Assessment (EPA QA/G-9)
Site Knowledge:	(1) RI Report (IT, 1991), RFI/RI Report (IT, 1994) (2) None
Experience:	Prior Work Plan review and preparation experience on the part of the Planning Team and Decision-makers

4.2.1 Step 2 - Identify the Decision

The second step in the DQO process establishes the principal study question for each of the sites and presents the various alternative actions that could result from resolving the question.

Principal study question

(1) Has contamination been sufficiently remediated at the Tar Tank Spill Area?

(2) Is corrective action required at the Former Boca Chica Blast Media Disposal Area?

Alternative actions that could result from resolution of the principal study question

The Tar Tank Spill Area

- Additional corrective action will be necessary.
- No additional corrective action will be necessary.

Boca Chica Former Media Blast Media Disposal Area

- Corrective action will be necessary.
- Corrective action will not be necessary.

Decision statement

The Tar Tank Spill Area

- Determine whether the IRA successfully remediated the site. The effectiveness of the IRA will be based on whether soil confirmation and groundwater contaminant concentrations have been reduced to less than action levels.

Former Boca Chica Blast Media Disposal Area

- Determine whether corrective action is necessary at the site. This determination will be based on whether soil, sediment, and groundwater contaminant concentrations are less than action levels.

4.2.2. Step 3 - Identify Inputs to the Decision

In this step, the Planning Team will identify the different types of information needed to resolve the decision statement.

Information that will be required to resolve the decision statement

The Tar Tank Spill Area

- Historical information about the site
- New soil confirmation and groundwater analytical data

Former Boca Chica Blast Media Disposal Area

- Historical information about the site
- New soil, surface soil, and groundwater analytical data

Sources of the information needed to resolve the decision

The Tar Tank Spill Area

- Historical information about the site:
  - Existing documents (reports, drawings, maps, etc.)
    - IT Corporation: RI Report, Final Draft, 1991.
    - IT Corporation: RFI/RI, Final Report. 1994.
  - Site Visits (reports, drawings, maps, etc.)
    - TtNUS. TtNUS/Navy site visit 2001.
    - Current/ongoing activities
- Existing soil data
- New soil confirmation and groundwater data
  - Through the following analytical methods, the Planning Team needs to obtain measurements of Appendix IX VOCs, Appendix IX SVOCs, and TPH in soil and groundwater to determine whether the IRA reduced contaminant concentrations to less than action levels:
    - VOCs - SW-846 Method 8260b
    - SVOCs - SW 846 Method 8270c
    - TPH (field test kit) - colorimeter/immunoassay

Former Boca Chica Blast Media Disposal Area

- Historical information about the site:
  - Existing documents (reports, drawings, maps, etc.)
    - None
  - Site Visits (reports, drawings, maps, etc.)
  - TtNUS. TtNUS/Navy site visit 2001
- New soil, sediment, and groundwater data
  - Through the following analytical method, the Planning Team needs to obtain measurements of TAL metals in soil, surface soil, and groundwater to determine whether contaminant concentrations are less than action levels:
    - TAL Metals - SW-846 Method 6010B/7000A series

<u>Information necessary for establishing action levels</u>

- Legal action levels
  - MCL - EPA, Drinking Water Regulations and Health Advisories, 1996
  - FL MCL - FDEP, Drinking Water Standards, Monitoring and Reporting, 1995
  - FDEP Industrial Goals - FDEP, Applicability of Soil Clean-up Goals for Florida, 1996
  - FDEP Industrial Goals - FDEP, Soil Clean-up Goals for Florida, 1995
  - FDEP Residential Goals - FDEP, Applicability of Soil Clean-up Goals for Florida, 1996
  - FDEP Residential Goals - FDEP, Soil Clean-up Goals for Florida, 1995
- Guidance action levels
  - Tap Water Risk-Based Concentrations (RBCs) - EPA, Risk-Based Concentration Table, 1997
  - Residential Soil RBCs - EPA, RBC Table, 1997
  - FDEP Criteria - FDEP, Approach to the Assessment of Sediment Quality in Florida Coastal Waters: Volume 1 - Development and Evaluation of Sediment Quality Assessment Guidelines, 1994
  - EPA Sediment Quality Criteria (SQC) Fresh - EPA, ECO Update, 1996
  - EPA SQC Marine - EPA, ECO Update, 1996
  - EPA Sediment Quality Benchmark (SQB) - EPA, ECO Update 1996
  - REG III Biochemical Assistance Group (BTAGS) - EPA, EPA Region III BTAG Screening Levels, 1995
  - Ontario Guidelines - Ontario Ministry of the Environment (OME), Guidelines for the Protection and Management of Aquatic Sediment Quality in Ontario, 1992

- ER-M - Long, E. R., D. D. MacDonald, S. L. Smith, and F. D. Calder, Incidence of Adverse Biological Effects within Ranges of Chemical Concentrations in marine and Estuarine Sediment, 1995
- Chem and Tox - Baudo, R., J. Geisy, and H. Muntau (eds.), Sediments: Chemistry and Toxicity of In-Place Pollutants, 1990
- EPA Region IV - EPA, Supplemental Guidance to Risk Assessment Guidelines (RAGs): Region 4 Bulletins - Ecological Risk Assessment, 1995
- Tox. Benchmarks - Hull, R. N., and G. W. Suter, Toxicological Benchmarks to Screening Contaminants of Potential Concern for Effects on Sediment-associated Biota

- Background concentrations
  - A subset of applicable background data has been extracted from the Comprehensive Background Report for NAF Key West (Appendix F of the Supplemental RFI/ RI for Eight Sites, 1998b)

Measurement Methods for Analytical Data

The appropriate measurement methods have been selected, as stated above. In order to adequately resolve the decision, required detection limits (RDLs) and reporting limits (RLs) should be less than action levels, as discussed in Section 8.0. This will be ensured by supplying the selected action levels along with the laboratory Statement of Work.

4.2.3 Step 4 - Define the Study Boundaries

The purpose of this step is to define the spatial and temporal boundaries of the investigation.

Spatially, the decision applies to soil and groundwater within the boundary of the Tar Tank Spill Area and soil, sediment, and groundwater within the boundary of the Former Boca Chica Blast Media Disposal Area.

Temporally, it is assumed that any analytical data obtained to facilitate the decision-making process are representative of site conditions at the time of sampling.

Characteristics that define the population of interest

The Tar Tank Spill Area

The population of interest is the soil and groundwater at the Tar Tank Spill Area that may have been contaminated by tar from the remnants of the AST at the site. Because the tar-like substance is very thick

and can be easily seen, contamination is assumed to be limited to the area immediately surrounding the AST (where the substance is visible on the ground surface. Groundwater at the site is assumed to be a homogeneous body of water beneath the land surface). Following excavation and soil confirmation sampling, monitoring wells will be installed to determine the extent to which the leaking tar has contaminated groundwater. The locations of the wells will be based on soil confirmation sampling results.

Former Boca Chica Blast Media Disposal Area

The population of interest includes soil, surface soil, and groundwater at the Former Boca Chica Blast Media Disposal Area that may have been contaminated by the used sandblasting material disposed at the site. The groundwater is assumed to be a homogeneous body of water found beneath the land surface. Following initial soil, surface soil, and groundwater screening sampling, monitoring wells will be installed at the site to determine the extent of groundwater contamination. The locations of the wells will be based on soil investigative sampling results.

<u>Spatial boundary of the decision statement</u>

- Define the geographic area to which the decision statement applies
  (1) Decisions apply to soil and groundwater within the boundary of the Tar Tank Spill Area (see Figure 2-1 in the RFA Work Plan).
  (2) Decisions apply to the soil, sediment, and groundwater within the boundary of the Former Boca Chica Blast Media Disposal Area (see Figure 2-2 in the RFA Work Plan).
- When appropriate, divide the population into strata that have relatively homogeneous characteristics
  (1) Stratification is not necessary in this case because both soil and groundwater at the Tar Tank Spill Area are assumed to be homogeneous.
  (2) Stratification is not necessary in this case because soil, sediment, and groundwater at the Former Boca Chica Blast Media Disposal Area are assumed to be homogeneous.

<u>Temporal boundary of the decision statement</u>

- Determine the timeframe to which the decision applies
  (1) It will be assumed that sample data represent current concentrations of chemicals in soil and groundwater at the Tar Tank Spill Area.
  (2) It will be assumed that sample data represent current concentrations of chemicals in soil, sediment, and groundwater at the Former Boca Chica Blast Media Disposal Area.
- Determine when to collect sample data
  – Samples will be collected during daylight hours at both sites.

Define the scale of decision-making

The scale of decision making will be at the site level.

Physical constraints on data collection

Weather conditions (heavy rains or thunderstorms) could possibly interfere with sampling activities, lengthening the time period that will be required for sampling. Sampling equipment is not waterproof and TtNUS personnel are required to stop work when lightning is visible, in accordance with the HASP (Appendix C of the RFA Work Plan). A hurricane could also cause cancellation of a sampling event, substantially delaying sample collection. Sampling immediately following a hurricane can also flush contamination, causing contaminant concentrations to temporarily fall significantly below previously measured levels, as seen in 1998 with Hurricane Georges at SWMU 9. Contaminant levels at SWMU 9 did rebound in subsequent sampling events (TtNUS, 1999b). In the event of a hurricane, sampling may be delayed at least one month, so that samples collected will be representative of normal site conditions.

4.2.4 Step 5 - Develop a Decision Rule

This step states the decision rule and addresses elements that contributed to decision rule development.

The statistical parameter that characterizes the population (the parameter of interest)

The Tar Tank Spill Area

The Planning Team is interested in discrete concentrations of TAL metals, Appendix IX VOCs, SVOCs, and TPHs in soil and groundwater samples. The measured contaminant concentrations in soil and groundwater will be compared directly to action levels. No attempt will be made to incorporate statistical treatment of data variability, in accordance with the FDEP directive (July 1997 Partnering Team meeting).

If soil confirmation samples detect contaminant concentrations at greater than action levels, the IRA will be deemed unsuccessful and further excavation of contaminated soil and additional confirmation sampling will take place, until all sample results are below action levels. If groundwater sample results are above action levels, the NAF Key West Partnering Team will determine if additional corrective action is warranted.

Former Boca Chica Blast Media Disposal Area

The Planning Team is interested in discrete concentrations of TAL metals in soil, sediment, and groundwater samples. The measured contaminant concentrations in soil, sediment, and groundwater will be compared directly to action levels. No attempt will be made to incorporate statistical treatment of data variability, in accordance with the directive FDEP (July 1997 Partnering Team meeting).

If any perimeter samples associated with a contaminant source exhibit measured analyte concentrations greater than their applicable action levels (Tables B-4-1 through B-4-6), sampling will continue in an outward direction until all analytes in all perimeter samples exhibit concentrations that are less than the action levels, or until two sampling and analysis rounds have been executed. If all perimeter samples after two rounds of sampling and analysis exhibit all analyte concentrations at less than action levels, sampling will cease and the contamination will be declared to be bounded. If, after two rounds of sampling, the contamination is not completely bounded as described above, the Navy will discuss with regulators an appropriate course of action.

Action levels for the study

Various sources of information were used in defining the appropriate action level for arsenic. The Partnering Team has decided to adopt the most conservative legal requirement as the action level. In the event that no legal action level has been established, the most conservative guidance level will be employed. For inorganics commonly detected in background in the vicinity of NAF Key West, twice the mean background concentration will be used as the action level, unless the most conservative legal requirement (or guidance value, in the event a legal action level has not been established) is higher. In the event that no legal, guidance, or background concentrations are available for the parameter, the Planning Team will agree on a reasonable basis for action. Based on the criteria discussed here, action levels have been selected for each parameter that will be evaluated at the Tar Tank Spill Area and the Former Boca Chica Blast Media Disposal Area. Parameters that may require attention of the Planning Team are identified in specific Tables B-4-1 through B-4-6 with the notation 'NA'.

4.2.5 Step 6 - Specify Tolerable Limits on Decision

The purpose of this step is to specify the decision-makers' (NAF Key West Partnering Team's) tolerable limits on decision errors, which are used to establish performance goals for the data collection design. In this case, a statistical approach was disallowed by the FDEP (July 1997 NAF Key West Partnering Team meeting). Therefore, no statistical treatment of decision-error tolerance was conducted.

4.2.6 Step 7 - Optimize the Design

Review the DQO outputs and existing environmental data

DQO outputs were assimilated into the decision rule in Step 5. No statistical decision-error tolerance approach was used. However, certain factors that govern the temporal spacing of samples are addressed here, as are the spatial sampling design considerations.

Develop general data collection design alternatives

Because a likely area of contamination exists and that is the area being targeted for evaluating concentration changes, a biased approach to sample design will be required.

For each data collection design alternative, select the optimal sample size that satisfies the DQOs

No statistical analysis of data will be performed; therefore, the number of samples to be collected was not determined statistically.

Select the most resource-effective data collection design that satisfies the DQOs

A biased approach to sampling will be used because historical data indicate a likely area of contamination.

Document in the sampling and analysis plan the operational details and theoretical sampling assumptions of the selected design

Soil confirmation sampling will take place at the Tar Tank Spill Area to ensure that the excavation was successful in remediating soil contamination.

Soil, sediment, and groundwater sampling will take place at the Former Boca Chica Blast Media Disposal Area to delineate metals contamination at the site.

Four monitoring wells at the Tar Tank Spill Area and three monitoring wells at the Former Boca Chica Blast Media Disposal Area will be sampled within the probable areas of contamination to delineate such contamination.

TABLE B-4-1

**SOIL ACTION LEVELS
NAVAL AIR FACILITY
KEY WEST, FLORIDA
PAGE 1 OF 4**

Parameter	Selected Action Level	Source of Selected Action Level
Volatile Organic Compounds (µg/kg)		
Acenaphthylene	5,600,000	FDEP Industrial Goals
Acetone	1,800,000	FDEP Industrial Goals
Anthracene	3E+08	FDEP Industrial Goals
Benzene	2,000	FDEP Industrial Goals
Benzo(a)anthracene	4,900	FDEP Industrial Goals
Benzo(a)pyrene	500	FDEP Industrial Goals
Benzo(b)fluoranthene	5,000	FDEP Industrial Goals
Benzo(g,h,i)perylene	50,000	FDEP Industrial Goals
Benzo(k)fluoranthene	48,000	FDEP Industrial Goals
Bis(2-chloroethoxy)methane	3,000,000	FDEP Industrial Goals
Bis(2-chloroethyl)ether	900	FDEP Industrial Goals
Bis(2-chloroisopropyl)ether	9,100	Residential Soil RBCs
Bis(2-ethylhexyl)phthalate	110,000	FDEP Industrial Goals
Bromodichloromethane	1,000	FDEP Industrial Goals
Bromoform	130,000	FDEP Industrial Goals
Bromomethane	110,000	Residential Soil RBCs
2-Butanone	15,000,000	FDEP Industrial Goals
Butyl benzyl phthalate	3.1E+08	FDEP Industrial Goals
Carbazole	120,000	FDEP Industrial Goals
Carbon disulfide	34,000	FDEP Industrial Goals
Carbon tetrachloride	800	FDEP Industrial Goals
Chlorobenzene	300,000	FDEP Industrial Goals
Chloroethane	31,000,000	Residential Soil RBCs
Chloroform	800	FDEP Industrial Goals
Chloromethane	300	FDEP Industrial Goals
Chrysene	500,000	FDEP Industrial Goals
Dibenzo(a,h)anthracene	500	FDEP Industrial Goals
Dibenzofuran	3,500,000	FDEP Industrial Goals
Dibromochloromethane	1,700	FDEP Industrial Goals
1,1-Dichloroethane	2,100,000	FDEP Industrial Goals
cis-1,2-Dichloroethene	180,000	FDEP Industrial Goals
1,1-Dichloroethene	100	FDEP Industrial Goals
trans-1,2-Dichloroethene	430,000	FDEP Industrial Goals
1,2-Dichloropropane	1,200	FDEP Industrial Goals
trans-1,3-Dichloropropene	400	FDEP Industrial Goals
cis-1,3-Dichloropropene	400	FDEP Industrial Goals
Diethyl phthalate	9.7E+08	FDEP Industrial Goals
Dimethyl phthalate	1E+09	FDEP Industrial Goals
Di-n-butyl phthalate	1.4E+08	FDEP Industrial Goals
Di-n-octyl phthalate	32,000,000	FDEP Industrial Goals

TABLE B-4-1

**SOIL ACTION LEVELS
NAVAL AIR FACILITY
KEY WEST, FLORIDA
PAGE 2 OF 4**

Parameter	Selected Action Level	Source of Selected Action Level
Volatile Organic Compounds (µg/kg)		
Ethylbenzene	10,000,000	FDEP Industrial Goals
Fluoranthene	48,000,000	FDEP Industrial Goals
Fluorene	30,000,000	FDEP Industrial Goals
Hexachlorobenzene	1,600	FDEP Industrial Goals
Hexachlorobutadiene	4,900	FDEP Industrial Goals
Hexachlorocyclopentadiene	550,000	Residential Soil RBCs
Hexachloroethane	120,000	FDEP Industrial Goals
2-Hexanone	14.55	2x Avg Background
Indeno(1,2,3-cd)pyrene	5,000	FDEP Industrial Goals
Isophorone	670,000	Residential Soil RBCs
Methylene chloride	23,000	FDEP Industrial Goals
4-Methyl-2-pentanone	3,700,000	FDEP Industrial Goals
Naphthalene	12,000,000	FDEP Industrial Goals
Nitrobenzene	250,000	FDEP Industrial Goals
n-Nitroso-di-n-propylamine	1E-08	NA (Discuss Value)
n-Nitrosodiphenylamine	130,000	FDEP Industrial Goals
Pentachlorophenol	12,000	FDEP Industrial Goals
Phenanthrene	21,000,000	FDEP Industrial Goals
Phenol	4.4E+08	FDEP Industrial Goals
Pyrene	41,000,000	FDEP Industrial Goals
Styrene	34,000,000	FDEP Industrial Goals
1,1,2,2-Tetrachloroethane	1,400	FDEP Industrial Goals
Tetrachloroethene	28,000	FDEP Industrial Goals
Toluene	3,500,000	FDEP Industrial Goals
Trichloroethene	9,300	FDEP Industrial Goals
1,1,1-Trichloroethane	4,300,000	FDEP Industrial Goals
1,1,2-Trichloroethane	3,000	FDEP Industrial Goals
Vinyl chloride	7	FDEP Industrial Goals
Semivolatile Organic Compounds (µg/kg)		
4-Bromophenyl phenyl ether	4,500,000	Residential Soil RBCs
4-Chloroaniline	3,300,000	FDEP Industrial Goals
4-Chloro-3-methylphenol	1E+09	FDEP Industrial Goals
2-Chloronaphthalene	4,000,000	FDEP Industrial Goals
2-Chlorophenol	3,700,000	FDEP Industrial Goals
4-Chlorophenyl phenyl ether	1E-08	NA (Discuss Value)
1,2-Dichlorobenzene	6,000,000	FDEP Industrial Goals
1,3-Dichlorobenzene	13,000,000	FDEP Industrial Goals
1,4-Dichlorobenzene	1,100	FDEP Industrial Goals

TABLE B-4-1

**SOIL ACTION LEVELS
NAVAL AIR FACILITY
KEY WEST, FLORIDA
PAGE 3 OF 4**

Parameter	Selected Action Level	Source of Selected Action Level
Semivolatile Organic Compounds (µg/kg)		
3,3'-Dichlorobenzidine	1,400	Residential Soil RBCs
2,4-Dichlorophenol	4,000,000	FDEP Industrial Goals
2,4-Dimethylphenol	16,000,000	FDEP Industrial Goals
2,4-Dinitrophenol	160,000	Residential Soil RBCs
2,4-Dinitrotoluene	2,000,000	FDEP Industrial Goals
2,6-Dinitrotoluene	1,300,000	FDEP Industrial Goals
2-Methyl-4,6-dinitrophenol	1E-08	NA (Discuss Value)
2-Methylnaphthalene	8,800,000	FDEP Industrial Goals
2-Methylphenol	32,000,000	FDEP Industrial Goals
3,4-Methylphenol	5,500,000	FDEP Industrial Goals
3-Nitroaniline	230,000	Residential Soil RBCs
4-Nitroaniline	4,700,000	FDEP Industrial Goals
4-Nitrophenol	4,800,000	Residential Soil RBCs
1,2,4-Trichlorobenzene	780,000	Residential Soil RBCs
2,4,5-Trichlorophenol	1.3E+08	FDEP Industrial Goals
2,4,6-Trichlorophenol	280,000	FDEP Industrial Goals
2-Nitroaniline	73,000	FDEP Industrial Goals
2-Nitrophenol	1E-08	NA (Discuss Value)
Acenaphthene	30,000,000	FDEP Industrial Goals
Metals (mg/kg)		
Aluminum	1,000,000	FDEP Industrial Goals
Antimony	220	FDEP Industrial Goals
Arsenic	3.7	FDEP Industrial Goals
Barium	84,000	FDEP Industrial Goals
Beryllium	1	FDEP Industrial Goals
Cadmium	600	FDEP Industrial Goals
Calcium	1E-08	NA (Discuss Value)
Chromium	430	FDEP Industrial Goals
Cobalt	110,000	FDEP Industrial Goals
Copper	3,100	Residential Soil RBCs
Iron	23,000	Residential Soil RBCs
Lead	1,000	FDEP Industrial Goals
Magnesium	1E-08	NA (Discuss Value)
Manganese	5,500	FDEP Industrial Goals
Mercury	480	FDEP Industrial Goals
Nickel	26,000	FDEP Industrial Goals
Potassium	1E-08	NA (Discuss Value)
Selenium	9,900	FDEP Industrial Goals
Silver	9,000	FDEP Industrial Goals
Sodium	1E-08	NA (Discuss Value)
Thallium	1.59	2x Avg Background

TABLE B-4-1

**SOIL ACTION LEVELS
NAVAL AIR FACILITY
KEY WEST, FLORIDA
PAGE 4 OF 4**

Parameter	Selected Action Level	Source of Selected Action Level
Metals (mg/kg)		
Tin	670,000	FDEP Industrial Goals
Vanadium	4,800	FDEP Industrial Goals
Zinc	560,000	FDEP Industrial Goals

BTAGS Biochemical Assistance Groups
FDEP Florida Department of Environmental Protection
MCL Maximum Contaminant Level
NA May require the attention of the Planning Team
RBC risk-based concentration
SQB Sediment Quality Benchmark

TABLE B-4-2

**SEDIMENT ACTION LEVELS
NAVAL AIR FACILITY
KEY WEST, FLORIDA
PAGE 1 OF 4**

Parameter	Selected Action Level	Source of Selected Action Level
Volatile Organic Compounds (µg/kg)		
Acetone	64	Ontario Guidelines
2-Butanone	1E-08	NA (Discuss Value)
Benzene	57	USEPA SQB
Bis(2-chloroisopropyl)ether	1E-08	NA (Discuss Value)
Bromodichloromethane	1E-08	NA (Discuss Value)
Bromoform	1E-08	NA (Discuss Value)
Bromomethane	1E-08	NA (Discuss Value)
Carbon disulfide	13	Ontario Guidelines
Carbon tetrachloride	1E-08	NA (Discuss Value)
Chlorobenzene	820	USEPA SQB
Chloroethane	1E-08	NA (Discuss Value)
Chloroform	1E-08	NA (Discuss Value)
Chloromethane	1E-08	NA (Discuss Value)
Dibromochloromethane	1E-08	NA (Discuss Value)
cis-1,2-Dichloroethene	23	Tox. Benchmarks
trans-1,2-Dichloroethene	1E-08	NA (Discuss Value)
cis-1,3-Dichloropropene	1E-08	NA (Discuss Value)
trans-1,3-Dichloropropene	1E-08	NA (Discuss Value)
1,1-Dichloroethane	1E-08	NA (Discuss Value)
1,2-Dichloroethane	1E-08	NA (Discuss Value)
1,1-Dichloroethene	1E-08	NA (Discuss Value)
1,2-Dichloropropane	1E-08	NA (Discuss Value)
Ethylbenzene	10	REG III BTAGs
2-Hexanone	1E-08	NA (Discuss Value)
Methylene chloride	427	Ontario Guidelines
4-Methyl-2-pentanone	1E-08	NA (Discuss Value)
Styrene	1E-08	NA (Discuss Value)
1,1,2,2-Tetrachloroethane	940	USEPA SQB
Tetrachloroethene	57	REG III BTAGs
Toluene	670	USEPA SQB
1,1,1-Trichloroethane	31	REG III BTAGs
1,1,2-Trichloroethane	31	REG III BTAGs
Trichloroethene	1,600	USEPA SQB
Vinyl chloride	1E-08	NA (Discuss Value)
Xylenes, total	25	USEPA SQB
Semivolatile Organic Compounds (µg/kg)		
Acenaphthene	6.71	FDEP Criteria
Acenaphthylene	5.87	FDEP Criteria
Anthracene	46.9	FDEP Criteria
Benzo(a)anthracene	74.8	FDEP Criteria
Benzo(a)pyrene	88.8	FDEP Criteria
Benzo(b)fluoranthene	3,200	REG III BTAGs

TABLE B-4-2

**SEDIMENT ACTION LEVELS
NAVAL AIR FACILITY
KEY WEST, FLORIDA
PAGE 2 OF 4**

Parameter	Selected Action Level	Source of Selected Action Level
Semivolatile Organic Compounds (µg/kg)		
Benzo(g,h,i)perylene	670	REG III BTAGs
Benzo(k)fluoranthene	1E-08	NA (Discuss Value)
Bis(2-chloroethoxy)methane	1E-08	NA (Discuss Value)
Bis(2-chloroethyl)ether	1E-08	NA (Discuss Value)
Bis(2-ethylhexyl)phthalate	182	FDEP Criteria
4-Bromophenyl phenyl ether	1,300	USEPA SQB
Butyl benzyl phthalate	63	REG III BTAGs
Carbazole	1E-08	NA (Discuss Value)
4-Chloro-3-methylphenol	1E-08	NA (Discuss Value)
4-Chloroaniline	1E-08	NA (Discuss Value)
2-Chloronaphthalene	1E-08	NA (Discuss Value)
2-Chlorophenol	1E-08	NA (Discuss Value)
4-Chlorophenyl phenyl ether	1E-08	NA (Discuss Value)
Chrysene	108	FDEP Criteria
Dibenzo(a,h)anthracene	6.22	FDEP Criteria
Dibenzofuran	540	REG III BTAGs
1,2-Dichlorobenzene	35	REG III BTAGs
1,3-Dichlorobenzene	1,700	USEPA SQB
1,4-Dichlorobenzene	110	REG III BTAGs
3,3'-Dichlorobenzidine	1E-08	NA (Discuss Value)
2,4-Dichlorophenol	1E-08	NA (Discuss Value)
Diethyl phthalate	200	REG III BTAGs
Dimethyl phthalate	71	REG III BTAGs
2,4-Dimethylphenol	29	REG III BTAGs
Di-n-butyl phthalate	1,400	REG III BTAGs
2,4-Dinitrophenol	1E-08	NA (Discuss Value)
2,4-Dinitrotoluene	1E-08	NA (Discuss Value)
2,6-Dinitrotoluene	1E-08	NA (Discuss Value)
Di-n-octyl phthalate	6,200	REG III BTAGs
Fluoranthene	113	FDEP Criteria
Fluorene	19	ER-L
Hexachlorobenzene	22	REG III BTAGs
Hexachlorobutadiene	11	REG III BTAGs
Hexachlorocyclopentadiene	1E-08	NA (Discuss Value)
Hexachloroethane	1,000	USEPA SQB
Indeno(1,2,3-cd)pyrene	600	REG III BTAGs
Isophorone	1E-08	NA (Discuss Value)
2-Methyl-4,6-dinitrophenol	1E-08	NA (Discuss Value)
2-Methylnaphthalene	20.2	FDEP Criteria
2-Methylphenol	63	REG III BTAGs
3,4-Methylphenol	1E-08	NA (Discuss Value)
Naphthalene	34.6	FDEP Criteria

TABLE B-4-2

**SEDIMENT ACTION LEVELS
NAVAL AIR FACILITY
KEY WEST, FLORIDA
PAGE 3 OF 4**

Parameter	Selected Action Level	Source of Selected Action Level
Semivolatile Organic Compounds (µg/kg)		
2-Nitroaniline	1E-08	NA (Discuss Value)
3-Nitroaniline	1E-08	NA (Discuss Value)
4-Nitroaniline	1E-08	NA (Discuss Value)
Nitrobenzene	1E-08	NA (Discuss Value)
2-Nitrophenol	1E-08	NA (Discuss Value)
4-Nitrophenol	1E-08	NA (Discuss Value)
n-Nitrosodiphenylamine	28	REG III BTAGs
n-Nitroso-di-n-propylamine	1E-08	NA (Discuss Value)
Pentachlorophenol	360	REG III BTAGs
Phenanthrene	86.7	FDEP Criteria
Phenol	420	REG III BTAGs
Pyrene	153	FDEP Criteria
1,2,4-Trichlorobenzene	9,200	USEPA SQB
2,4,5-Trichlorophenol	1E-08	NA (Discuss Value)
2,4,6-Trichlorophenol	1E-08	NA (Discuss Value)
Metals (mg/kg)		
Aluminum	2,663.78	2x Avg Background
Antimony	12	EPA Region IV
Arsenic	7.24	FDEP Criteria
Barium	40	Chem and Tox
Beryllium	0.1	2x Avg Background
Cadmium	0.676	FDEP Criteria
Calcium	1E-8	NA (Discuss Value)
Chromium	52.3	FDEP Criteria
Cobalt	0.48	2x Avg Background
Copper	18.7	FDEP Criteria
Iron	2,398	2x Avg Background
Lead	34.18	2x Avg Background
Magnesium	1E-08	NA (Discuss Value)
Manganese	460	Tox. Benchmarks
Mercury	0.13	FDEP Criteria
Nickel	15.9	FDEP Criteria
Potassium	1E-08	NA (Discuss Value)
Selenium	1.42	2x Avg Background
Silver	0.733	FDEP Criteria
Sodium	1E-08	NA (Discuss Value)

TABLE B-4-2

**SEDIMENT ACTION LEVELS
NAVAL AIR FACILITY
KEY WEST, FLORIDA
PAGE 4 OF 4**

Parameter	Selected Action Level	Source of Selected Action Level
Metals (mg/kg)		
Thallium	1E-08	NA (Discuss Value)
Tin	1.98	2x Avg Background
Vanadium	10.44	2x Avg Background
Zinc	124	FDEP Criteria

BTAGS Biochemical Assistance Groups
FDEP Florida Department of Environmental Protection
MCL Maximum Contaminant Level
NA may require the attention of the Planning Team
RBC risk-based concentration
SQB Sediment Quality Benchmark

TABLE B-4-3

**GROUNDWATER ACTION LEVELS
NAVAL AIR FACILITY
KEY WEST, FLORIDA
PAGE 1 OF 4**

Parameter	Selected Action Level	Source of Selected Action Level
Volatile Organic Compounds (µg/L)		
Acetone	3,700	Tap Water RBCs
Benzene	1	Fl MCL
Bis(2-chloroisopropyl)ether	0.26	Tap Water RBCs
Bromodichloromethane	100	MCL
Bromoform	100	MCL
Bromomethane	8.7	Tap Water RBCs
2-Butanone	1,900	Tap Water RBCs
Dibromochloromethane	100	MCL
1,1-Dichloroethane	810	Tap Water RBCs
1,1-Dichloroethene	7	MCL
1,2-Dichloroethane	3	Fl MCL
1,2-Dichloropropane	5	MCL
Carbon disulfide	1,000	Tap Water RBCs
Carbon tetrachloride	3	Fl MCL
Chlorobenzene	100	MCL
Chloroethane	8,600	Tap Water RBCs
Chloroform	100	MCL
Chloromethane	1.4	Tap Water RBCs
cis-1,2-Dichloroethene	70	MCL
trans-1,2-Dichloroethene	100	MCL
cis-1,3-Dichloropropene	0.077	Tap Water RBCs
trans-1,3-Dichloropropene	0.077	Tap Water RBCs
Ethylbenzene	700	MCL
2-Hexanone	428,000	EPA 1995 (fresh water)
Methylene chloride	5	Fl MCL
4-Methyl-2-pentanone	2,900	Tap Water RBCs
Styrene	100	MCL
1,1,2,2-Tetrachloroethane	0.052	Tap Water RBCs
Tetrachloroethene	3	Fl MCL
Toluene	1,000	MCL
1,1,1-Trichloroethane	200	MCL
1,1,2-Trichloroethane	5	MCL
Trichloroethene	3	Fl MCL
Vinyl chloride	1	Fl MCL
Xylenes, total	10,000	MCL
Semivolatile Organic Compounds (µg/L)		
Acenaphthene	2,200	Tap Water RBCs
Acenaphthylene	1E-08	NA (Discuss Value)
Anthracene	11,000	Tap Water RBCs
Benzo(a)anthracene	0.092	Tap Water RBCs

TABLE B-4-3

**GROUNDWATER ACTION LEVELS
NAVAL AIR FACILITY
KEY WEST, FLORIDA
PAGE 2 OF 4**

Parameter	Selected Action Level	Source of Selected Action Level
Semivolatile Organic Compounds (µg/L)		
Benzo(b)fluoranthene	0.092	Tap Water RBCs
Benzo(k)fluoranthene	0.92	Tap Water RBCs
Benzo(g,h,i)perylene	1E-08	NA (Discuss Value)
Benzo(a)pyrene	0.2	MCL
Bis(2-chloroethyl)ether	0.0092	Tap Water RBCs
Bis(2-chloroethoxy)methane	1E-08	NA (Discuss Value)
Bis(2-ethylhexyl)phthalate	6	MCL
4-Bromophenyl phenyl ether	2,100	Tap Water RBCs
Butyl benzyl phthalate	7,300	Tap Water RBCs
Carbazole	3.4	Tap Water RBCs
4-Chloroaniline	150	Tap Water RBCs
4-Chloro-3-methylphenol	1E-08	NA (Discuss Value)
2-Chloronaphthalene	1E-08	NA (Discuss Value)
3-Chlorophenol	180	Tap Water RBCs
4-Chlorophenyl phenyl ether	1E-08	NA (Discuss Value)
Chrysene	9.2	Tap Water RBCs
Dibenzo(a,h)anthracene	0.0092	Tap Water RBCs
Dibenzofuran	150	Tap Water RBCs
1,2-Dichlorobenzene	600	MCL
1,3-Dichlorobenzene	540	Tap Water RBCs
1,4-Dichlorobenzene	75	MCL
3,3'-Dichlorobenzidine	0.15	Tap Water RBCs
2,4-Dichlorophenol	110	Tap Water RBCs
Diethyl phthalate	29,000	Tap Water RBCs
2,4-Dimethylphenol	730	Tap Water RBCs
Dimethyl phthalate	370,000	Tap Water RBCs
2,4-Dinitrophenol	73	Tap Water RBCs
2,4-Dinitrotoluene	73	Tap Water RBCs
2,6-Dinitrotoluene	37	Tap Water RBCs
Di-n-butyl phthalate	3,700	Tap Water RBCs
Di-n-octyl phthalate	730	Tap Water RBCs
Fluoranthene	1,500	Tap Water RBCs
Fluorene	1,500	Tap Water RBCs
Hexachlorobenzene	1	MCL
Hexachlorobutadiene	0.14	Tap Water RBCs
Hexachlorocyclopentadiene	50	MCL
Hexachloroethane	0.75	Tap Water RBCs
Indeno(1,2,3-cd)pyrene	0.092	Tap Water RBCs
Isophorone	71	Tap Water RBCs
2-Methyl-4,6-dinitrophenol	1E-08	NA (Discuss Value)
2-Methylnaphthalene	1E-08	NA (Discuss Value)

TABLE B-4-3

**GROUNDWATER ACTION LEVELS
NAVAL AIR FACILITY
KEY WEST, FLORIDA
PAGE 3 OF 4**

Parameter	Selected Action Level	Source of Selected Action Level
Semivolatile Organic Compounds (µg/L)		
2-Methylphenol	1,800	Tap Water RBCs
3,4-Methylphenol	1,800	Tap Water RBCs
Naphthalene	1,500	Tap Water RBCs
2-Nitroaniline	2.2	Tap Water RBCs
3-Nitroaniline	110	Tap Water RBCs
4-Nitroaniline	110	Tap Water RBCs
Nitrobenzene	3.4	Tap Water RBCs
2-Nitrophenol	1E-08	NA (Discuss Value)
4-Nitrophenol	2,300	Tap Water RBCs
n-Nitrosodiphenylamine	14	Tap Water RBCs
n-Nitroso-di-n-propylamine	1E-08	NA (Discuss Value)
Pentachlorophenol	1	MCL
Phenanthrene	8.3	EPA 1996 (marine water)
Phenol	22,000	Tap Water RBCs
Pyrene	1,100	Tap Water RBCs
1,2,4-Trichlorobenzene	70	MCL
2,4,5-Trichlorophenol	3,700	Tap Water RBCs
2,4,6-Trichlorophenol	6.1	Tap Water RBCs
Metals (µg/L)		
Aluminum	37,000	Tap Water RBCs
Antimony	6	MCL
Arsenic	50	MCL
Barium	2,000	MCL
Beryllium	4	MCL
Cadmium	5	MCL
Calcium	1E-08	NA (Discuss Value)
Chromium	100	MCL
Cobalt	2,200	Tap Water RBCs
Copper	1,500	Tap Water RBCs
Iron	11,000	Tap Water RBCs
Lead	15	MCL
Magnesium	1E-08	NA (Discuss Value)
Manganese	840	Tap Water RBCs
Mercury	2	MCL

TABLE B-4-3

**GROUNDWATER ACTION LEVELS
NAVAL AIR FACILITY
KEY WEST, FLORIDA
PAGE 4 OF 4**

Parameter	Selected Action Level	Source of Selected Action Level
Metals (µg/L)		
Nickel	100	MCL
Potassium	1E-08	NA (Discuss Value)
Selenium	50	MCL
Silver	180	Tap Water RBCs
Sodium	160,000	Fl MCL
Thallium	4.62	2x Avg Background
Tin	22,000	Tap Water RBCs
Vanadium	260	Tap Water RBCs
Zinc	11,000	Tap Water RBCs

BTAGS Biochemical Assistance Groups
FDEP Florida Department of Environmental Protection
MCL Maximum Contaminant Level
NA may require the attention of the Planning Team
RBC risk-based concentration
SQB Sediment Quality Benchmark

TABLE B-4-4

SELECTION OF SEDIMENT ACTION LEVELS FOR POTENTIAL FUTURE INDUSTRIAL SITES
NAVAL AIR FACILITY
KEY WEST, FLORIDA
PAGE 1 OF 4

Parameter	FDEP Criteria[1]	EPA Reg IV[2]	EPA SQC Fresh[3]	EPA SQC Marine[4]	ER-L[5]	ER-M[6]	EPA SQB[7]	OTHER	Reg III BTAG Levels[12]	2x Average BG[14]	Industrial Soil Action Level	Selected Action Level	Source of Selected Action Level
Volatile Organic Compounds (µg/kg)													
Acetone	NA	NA	NA	NA	NA	NA	NA	64[(9)]	NA	NA	1,800,000	64	Ontario Guidelines
Benzene	NA	NA	NA	NA	NA	NA	57	NA	NA	NA	2,000	57	USEPA SQB
Bis(2-chloroisopropyl)ether	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	9,100	9,100	Residential Soil RBCs
Bromodichloromethane	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	1,000	1,000	FDEP Industrial Goals
Bromoform	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	130,000	130,000	FDEP Industrial Goals
Bromomethane	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	110,000	110,000	Residential Soil RBCs
2-Butanone	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	15,000,000	1.5E7	FDEP Industrial Goals
Carbon disulfide	NA	NA	NA	NA	NA	NA	NA	13[(9)]	NA	NA	34,000	13	Ontario Guidelines
Carbon tetrachloride	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	800	800	FDEP Industrial Goals
Chlorobenzene	NA	NA	NA	NA	NA	NA	820	NA	NA	NA	300,000	820	USEPA SQB
Chloroethane	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	31,000,000	31,000,000	Residential Soil RBCs
Chloroform	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	800	800	FDEP Industrial Goals
Chloromethane	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	300	300	FDEP Industrial Goals
Dibromochloromethane	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	1,700	1,700	FDEP Industrial Goals
1,1-Dichloroethane	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	2,100,000	2,100,000	FDEP Industrial Goals
1,2-Dichloroethane	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	1,000	1,000	FDEP Industrial Goals
1,1-Dichloroethene	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	100	100	FDEP Industrial Goals
cis-1,2-Dichloroethene	NA	NA	NA	NA	NA	NA	NA	23[(10)]	NA	NA	180,000	23	Tox. Benchmarks
trans-1,2-Dichloroethene	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	430,000	430,000	FDEP Industrial Goals
1,2-Dichloropropane	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	1,200	1,200	FDEP Industrial Goals
cis-1,3-Dichloropropene	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	400	400	FDEP Industrial Goals
trans-1,3-Dichloropropene	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	400	400	FDEP Industrial Goals
Ethylbenzene	NA	NA	NA	NA	NA	NA	3,600	NA	10	NA	10,000,000	10	REG III BTAGs
2-Hexanone	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
4-Methyl-2-pentanone	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	3,700,000	3,700,000	FDEP Industrial Goals
Methylene chloride	NA	NA	NA	NA	NA	NA	NA	427[(9)]	NA	NA	23,000	427	Ontario Guidelines
Styrene	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	34,000,000	34,000,000	FDEP Industrial Goals
1,1,2,2-Tetrachloroethane	NA	NA	NA	NA	NA	NA	940	NA	NA	NA	1,400	940	USEPA SQB
Tetrachloroethene	NA	NA	NA	NA	NA	NA	530	NA	57	NA	28,000	57	REG III BTAGs
Toluene	NA	NA	NA	NA	NA	NA	670	NA	NA	NA	3,500,000	670	USEPA SQB
1,1,1-Trichloroethane	NA	NA	NA	NA	NA	NA	170	NA	31	NA	4,300,000	31	REG III BTAGs
1,1,2-Trichloroethane	NA	NA	NA	NA	NA	NA	NA	NA	31	NA	3,000	31	REG III BTAGs
Trichloroethene	NA	NA	NA	NA	NA	NA	1,600	NA	NA	NA	9,300	1,600	USEPA SQB
Vinyl chloride	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	7	7	FDEP Industrial Goals
Xylenes, total	NA	NA	NA	NA	NA	NA	25	NA	40	NA	92,000,000	25	USEPA SQB

TABLE B-4-4

SELECTION OF SEDIMENT ACTION LEVELS FOR POTENTIAL FUTURE INDUSTRIAL SITES
NAVAL AIR FACILITY
KEY WEST, FLORIDA
PAGE 2 OF 4

Parameter	FDEP Criteria[1]	EPA Reg IV[2]	EPA SQC Fresh[3]	EPA SQC Marine[4]	ER-L[5]	ER-M[6]	EPA SQB[7]	OTHER	Reg III BTAG Levels[12]	2x Average BG[14]	Industrial Soil Action Level	Selected Action Level	Source of Selected Action Level
Semivolatile Organics (µg/kg)													
Acenaphthene	6.71	330	620	1,100	16	500	NA	NA	16	NA	30,000,000	6.71	FDEP Criteria
Acenaphthylene	5.87	330	NA	NA	44	640	NA	NA	44	NA	5,600,000	5.87	FDEP Criteria
Anthracene	46.9	330	NA	NA	85.3	1,100	NA	NA	85.3	NA	300,000,000	46.9	FDEP Criteria
Semivolatile Organic Compounds (µg/kg)													
Benzo(a)anthracene	74.8	330	NA	NA	261	1,600	NA	NA	261	NA	4,900	74.8	FDEP Criteria
Benzo(a)pyrene	88.8	330	NA	NA	430	1,600	NA	NA	430	NA	500	88.8	FDEP Criteria
Benzo(b)fluoranthene	NA	NA	NA	NA	NA	NA	NA	NA	3,200	NA	5,000	3,200	REG III BTAGs
Benzo(g,h,i)perylene	NA	NA	NA	NA	NA	NA	NA	NA	670	NA	50,000	670	REG III BTAGs
Benzo(k)fluoranthene	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	48,000	48,000	FDEP Industrial Goals
Bis(2-chloroethoxy)Methane	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	3,000,000	3,000,000	FDEP Industrial Goals
Bis(2-chloroethyl)Ether	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	900	900	FDEP Industrial Goals
Bis(2-ethylhexyl)Phthalate	182	182	NA	NA	NA	NA	NA	890,000,000[(9)]	1,300	NA	110,000	182	FDEP Criteria
4-Bromophenyl phenyl ether	NA	NA	NA	NA	NA	NA	1,300	NA	NA	NA	4,500,000	1,300	USEPA SQB
Butyl benzyl phthalate	NA	NA	NA	NA	NA	NA	11,000	NA	63	NA	310,000,000	63	REG III BTAGs
Carbazole	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	120,000	120,000	FDEP Industrial Goals
4-Chloroaniline	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	3,300,000	3,300,000	FDEP Industrial Goals
4-Chloro-3-methylphenol	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	1,000,000,000	1E+09	FDEP Industrial Goals
2-Chloronaphthalene	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	4,000,000	4,000,000	FDEP Industrial Goals
2-Chlorophenol	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	3,700,000	3,700,000	FDEP Industrial Goals
4-Chlorophenyl phenyl ether	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Chrysene	108	330	NA	NA	384	2,800	NA	NA	384	NA	500,000	108	FDEP Criteria
Dibenzo(a,h)anthracene	6.22	330	NA	NA	63.4	260	NA	NA	63.4	NA	500	6.22	FDEP Criteria
Dibenzofuran	NA	NA	NA	NA	NA	NA	2,000	NA	540	NA	3,500,000	540	REG III BTAGs
Di-n-butyl phthalate	NA	NA	NA	NA	NA	NA	11,000	NA	1,400	NA	140,000,000	1,400	REG III BTAGs
1,2-Dichlorobenzene	NA	NA	NA	NA	NA	NA	340	NA	35	NA	6,000,000	35	REG III BTAGs
1,3-Dichlorobenzene	NA	NA	NA	NA	NA	NA	1,700	NA	NA	NA	13,000,000	1,700	USEPA SQB
1,4-Dichlorobenzene	NA	NA	NA	NA	NA	NA	350	NA	110	NA	1,100	110	REG III BTAGs
3,3'-Dichlorobenzidine	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	1,400	1,400	Residential Soil RBCs
2,4-Dichlorophenol	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	4,000,000	4,000,000	FDEP Industrial Goals
Diethyl phthalate	NA	NA	NA	NA	NA	NA	630	NA	200	NA	970,000,000	200	REG III BTAGs
2,4-Dimethylphenol	NA	NA	NA	NA	NA	NA	NA	NA	29	NA	16,000,000	29	REG III BTAGs
2,4-Dinitrophenol	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	160,000	160,000	Residential Soil RBCs
2,4-Dinitrotoluene	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	2,000,000	2,000,000	FDEP Industrial Goals
2,6-Dinitrotoluene	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	1,300,000	1,300,000	FDEP Industrial Goals
Dimethyl phthalate	NA	NA	NA	NA	NA	NA	NA	NA	71	NA	1E9	71	REG III BTAGs
Di-n-octyl phthalate	NA	NA	NA	NA	NA	NA	NA	NA	6,200	NA	32,000,000	6,200	REG III BTAGs
Dioxin (ng/kg)	NA	2.5	NA	NA	NA	NA	NA	NA	NA	NA	NA	2.5	EPA REG IV

TABLE B-4-4

SELECTION OF SEDIMENT ACTION LEVELS FOR POTENTIAL FUTURE INDUSTRIAL SITES
NAVAL AIR FACILITY
KEY WEST, FLORIDA
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Parameter	FDEP Criteria[1]	EPA Reg IV[2]	EPA SQC Fresh[3]	EPA SQC Marine[4]	ER-L[5]	ER-M[6]	EPA SQB[7]	OTHER	Reg III BTAG Levels[12]	2x Average BG[14]	Industrial Soil Action Level	Selected Action Level	Source of Selected Action Level
Fluoranthene	113	330	2,900	1,400	600	5,100	NA	NA	600	NA	48,000,000	113	FDEP Criteria
Fluorene	21.2	330	NA	NA	19	540	540	NA	19	NA	30,000,000	19	ER-L
Hexachlorobenzene	NA	NA	NA	NA	NA	NA	NA	NA	22	NA	1,600	22	REG III BTAGs
Hexachlorobutadiene	NA	NA	NA	NA	NA	NA	NA	NA	11	NA	4,900	11	REG III BTAGs
Hexachlorocyclopentadiene	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	550,000	550,000	Residential Soil RBCs
Hexachloroethane	NA	NA	NA	NA	NA	NA	1,000	NA	NA	NA	120,000	1,000	USEPA SQB
Indeno(1,2,3-cd)pyrene	NA	NA	NA	NA	NA	NA	NA	NA	600	NA	5,000	600	REG III BTAGs
Isophorone	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	670,000	670,000	Residential Soil RBCs
2-Methyl-4,6-dinitrophenol	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
2-Methylnaphthalene	20.2	330	NA	NA	70	670	NA	NA	70	NA	8,800,000	20.2	FDEP Criteria
2-Methylphenol	NA	NA	NA	NA	NA	NA	NA	NA	63	NA	32,000,000	63	REG III BTAGs
Semivolatile Organic Compounds (µg/kg)													
3 & 4-Methylphenol	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	5,500,000	5,500,000	FDEP Industrial Goals
Naphthalene	34.6	330	NA	NA	160	2,100	480	NA	160	NA	12,000,000	34.6	FDEP Criteria
2-Nitroaniline	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	73,000	73,000	FDEP Industrial Goals
3-Nitroaniline	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	230,000	230,000	Residential Soil RBCs
4-Nitroaniline	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	4,700,000	4,700,000	FDEP Industrial Goals
Nitrobenzene	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	250,000	250,000	FDEP Industrial Goals
2-Nitrophenol	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
4-Nitrophenol	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	4,800,000	4,800,000	Residential Soil RBCs
n-Nitrosodiphenylamine	NA	NA	NA	NA	NA	NA	NA	NA	28	NA	130,000	28	REG III BTAGs
Pentachlorophenol	NA	NA	NA	NA	NA	NA	NA	NA	360	NA	12,000	360	REG III BTAGs
Phenanthrene	86.7	330	850	1,100	240	1,500	NA	NA	240	NA	21,000,000	86.7	FDEP Criteria
Phenol	NA	NA	NA	NA	NA	NA	NA	NA	420	NA	440,000,000	420	REG III BTAGs
Pyrene	153	330	NA	NA	665	2,600	NA	NA	665	NA	41,000,000	153	FDEP Criteria
1,2,4-Trichlorobenzene	NA	NA	NA	NA	NA	NA	9,200	NA	NA	NA	780,000	9,200	USEPA SQB
2,4,5-Trichlorophenol	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	130,000,000	1.3E+08	FDEP Industrial Goals
2,4,6-Trichlorophenol	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	280,000	280,000	FDEP Industrial Goals
Metals (mg/kg)													
Aluminum	NA	NA	NA	NA	NA	NA	NA	NA	NA	2663.78	1,000,000	2,664	2x Avg Background
Antimony	NA	12	NA	NA	NA	NA	NA	NA	150	NA	220	12	EPA Region IV
Arsenic	7.24	7.24	NA	NA	8.2	70	NA	NA	8.2	5.44	3.7	7.24	FDEP Criteria
Barium	NA	NA	NA	NA	NA	NA	NA	40[8]	NA	19.06	84,000	40	Chem and Tox
Beryllium	NA	NA	NA	NA	NA	NA	NA	NA	NA	0.1	1	0.1	2x Avg Background
Cadmium	0.676	1	NA	NA	1.2	9.6	NA	NA	1.2	0.34	600	0.676	FDEP Criteria
Calcium	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Chromium	52.3	52.3	NA	NA	81	370	NA	NA	81	9.22	430	52.3	FDEP Criteria
Cobalt	NA	NA	NA	NA	NA	NA	NA	NA	NA	0.48	110,000	0.48	2x Avg Background
Copper	18.7	18.7	NA	NA	34	270	NA	NA	34	18.42	3,100	18.7	FDEP Criteria

TABLE B-4-4

SELECTION OF SEDIMENT ACTION LEVELS FOR POTENTIAL FUTURE INDUSTRIAL SITES
NAVAL AIR FACILITY
KEY WEST, FLORIDA
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Parameter	FDEP Criteria[1]	EPA Reg IV[2]	EPA SQC Fresh[3]	EPA SQC Marine[4]	ER-L[5]	ER-M[6]	EPA SQB[7]	OTHER	Reg III BTAG Levels[12]	2x Average BG[14]	Industrial Soil Action Level	Selected Action Level	Source of Selected Action Level
Iron	NA	NA	NA	NA	NA	NA	NA	NA	NA	2,398	23,000	2,398	2x Avg Background
Lead	30.2	30.2	NA	NA	46.7	218	NA	NA	46.7	34.18	1,000	34.18	2x Avg Background
Magnesium	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Manganese	NA	NA	NA	NA	NA	NA	NA	460[10]	NA	30.78	5,500	460	Tox. Benchmarks
Mercury	0.13	0.13	NA	NA	0.15	0.71	NA	NA	0.15	0.1	480	0.13	FDEP Criteria
Nickel	15.9	15.9	NA	NA	20.9	51.6	NA	NA	20.9	4.14	26,000	15.9	FDEP Criteria
Potassium	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Metals (mg/kg)													
Selenium	NA	NA	NA	NA	NA	NA	NA	NA	NA	1.42	9,900	1.42	2x Avg Background
Silver	0.733	2	NA	NA	1	3.7	NA	NA	1	0.44	9,000	0.733	FDEP Criteria
Sodium	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Thallium	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Tin	NA	NA	NA	NA	NA	NA	NA	NA	NA	1.98	670,000	1.98	2x Avg Background
Vanadium	NA	NA	NA	NA	NA	NA	NA	NA	NA	10.44	4,800	10.44	2x Avg Background
Zinc	124	124	NA	NA	150	410	NA	NA	150	46.66	560,000	124	FDEP Criteria

1 Florida Sediment Quality Assessment Guidelines (FDEP, 1994a).
2 EPA Region IV Sediment Quality Screening Values (EPA, 1995b), revised August 11, 1999 [Dioxin Screening Value added].
3 EPA Freshwater Sediment Quality Criteria (EPA, 1996b).
4 EPA Saltwater Sediment Quality Criteria (EPA, 1996b).
5 Effects Range-Low Guidelines (Long et al., 1995).
6 Effects Range-Medium Guidelines (Long et al., 1995).
7 EPA Sediment Quality Benchmarks (EPA, 1996b).
8 From *Sediments: Chemistry and Toxicity of In-Place Pollutants* (Baudo et al., 1990).
9 Guidelines for Protection and Management of Sediment Quality in Ontario (OME, 1992).
10 Toxicological Benchmarks for Screening Contaminants of Potential Concern for Effects on Sediment (Hull and Suter, 1994).
11 40 CFR Part 264 Proposed RCRA Action Levels.
12 EPA Region III BioTechnical Assistance Group Screening Levels for Sediment(EPA, 1995a).
13 Residential Soil Risk-Based Screening Concentrations (EPA, 1997).
14 As agreed by the NAS Key West Partnering Team, 2x average background values are presented here for inorganics, while average background values are presented here for pesticides. This data is based on a subset of data from Appendix F of the Supplemental RFI/RI for Eight Sites as NAS Key West.

TABLE B-4-5

SELECTION OF SEDIMENT ACTION LEVELS FOR POTENTIAL FUTURE RESIDENTIAL SITES
NAVAL AIR FACILITY
KEY WEST, FLORIDA
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Parameter	FDEP Criteria[1]	EPA Reg IV[2]	EPA SQC Fresh[3]	EPA SQC Marine[4]	ER-L[5]	ER-M[6]	EPA SQB[7]	OTHER	Reg III BTAG Levels[12]	2x Average BG[14]	Residential Soil RBCs	Selected Action Level	Source of Action Level
Volatile Organic Compounds (µg/kg)													
Acetone	NA	NA	NA	NA	NA	NA	NA	64[(9)]	NA	NA	260,000	64	Ontario Guidelines
Benzene	NA	NA	NA	NA	NA	NA	57	NA	NA	NA	1,400	57	USEPA SQB
Bis(2-chloroisopropyl)ether	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	9,100	9,100	Residential Soil RBCs
Bromodichloromethane	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	700	700	Residential Soil RBCs
Bromoform	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	65,000	65,000	Residential Soil RBCs
Bromomethane	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	110,000	110,000	Residential Soil RBCs
2-Butanone	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	2,200,000	2,200,000	Residential Soil RBCs
Carbon disulfide	NA	NA	NA	NA	NA	NA	NA	13[(9)]	NA	NA	5,200	13	Ontario Guidelines
Carbon tetrachloride	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	600	600	Residential Soil RBCs
Chlorobenzene	NA	NA	NA	NA	NA	NA	820	NA	NA	NA	44,000	820	USEPA SQB
Chloroethane	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	31,000,000	31,000,000	Residential Soil RBCs
Chloroform	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	600	600	Residential Soil RBCs
Chloromethane	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	200	200	Residential Soil RBCs
Dibromochloromethane	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	1200	1,200	Residential Soil RBCs
1,1-Dichloroethane	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	310,000	310,000	Residential Soil RBCs
1,2-Dichloroethane	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	700	700	Residential Soil RBCs
1,1-Dichloroethene	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	100	100	Residential Soil RBCs
cis-1,2-Dichloroethene	NA	NA	NA	NA	NA	NA	NA	23[(10)]	NA	NA	26,000	23	Tox. Benchmarks
trans-1,2-Dichloroethene	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	62,000	62,000	Residential Soil RBCs
1,2-Dichloropropane	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	800	800	Residential Soil RBCs
cis-1,3-Dichloropropene	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	300	300	Residential Soil RBCs
trans-1,3-Dichloropropene	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	300	300	Residential Soil RBCs
Ethylbenzene	NA	NA	NA	NA	NA	NA	3,600	NA	10	NA	1,400,000	10	REG III BTAGs
2-Hexanone	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Methylene chloride	NA	NA	NA	NA	NA	NA	NA	427[(9)]	NA	NA	16,000	427	Ontario Guidelines
4-Methyl-2-pentanone	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	520,000	520,000	Residential Soil RBCs
Styrene	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	4,100,000	4,100,000	Residential Soil RBCs
1,1,2,2-Tetrachloroethane	NA	NA	NA	NA	NA	NA	940	NA	NA	NA	900	940	USEPA SQB
Tetrachloroethene	NA	NA	NA	NA	NA	NA	530	NA	57	NA	12,000	57	REG III BTAGs
1,1,2-Trichloroethane	NA	NA	NA	NA	NA	NA	NA	NA	31	NA	2,000	31	REG III BTAGs
Trichloroethene	NA	NA	NA	NA	NA	NA	1,600	NA	NA	NA	6,500	1,600	USEPA SQB
1,1,1-Trichloroethane	NA	NA	NA	NA	NA	NA	170	NA	31	NA	610,000	31	REG III BTAGs
Toluene	NA	NA	NA	NA	NA	NA	670	NA	NA	NA	520,000	670	USEPA SQB
Vinyl chloride	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	5	5	Residential Soil RBCs
Xylenes, total	NA	NA	NA	NA	NA	NA	25	NA	40	NA	13,000,000	25	USEPA SQB
Semivolatile Organic Compounds (µg/kg)													
Acenaphthene	6.71	330	620	1,100	16	500	NA	NA	16	NA	2,800,000	6.71	FDEP Criteria
Acenaphthylene	5.87	330	NA	NA	44	640	NA	NA	44	NA	670,000	5.87	FDEP Criteria

TABLE B-4-5

SELECTION OF SEDIMENT ACTION LEVELS FOR POTENTIAL FUTURE RESIDENTIAL SITES
NAVAL AIR FACILITY
KEY WEST, FLORIDA
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Parameter	FDEP Criteria[1]	EPA Reg IV[2]	EPA SQC Fresh[3]	EPA SQC Marine[4]	ER-L[5]	ER-M[6]	EPA SQB[7]	OTHER	Reg III BTAG Levels[12]	2x Average BG[14]	Residential Soil RBCs	Selected Action Level	Source of Action Level
Anthracene	46.9	330	NA	NA	85.3	1,100	NA	NA	85.3	NA	20,000,000	46.9	FDEP Criteria
Benzo(a)anthracene	74.8	330	NA	NA	261	1,600	NA	NA	261	NA	1,400	74.8	FDEP Criteria
Benzo(g,h,i)perylene	NA	NA	NA	NA	NA	NA	NA	NA	670	NA	14,000	670	REG III BTAGs
Benzo(a)pyrene	88.8	330	NA	NA	430	1,600	NA	NA	430	NA	100	88.8	FDEP Criteria
Benzo(b)fluoranthene	NA	NA	NA	NA	NA	NA	NA	NA	3,200	NA	1,400	3,200	REG III BTAGs
Semivolatile Organic Compounds (µg/kg)													
Benzo(k)fluoranthene	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	14,000	14,000	Residential Soil RBCs
Bis(2-chloroethoxy)methane	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	170,000	170,000	Residential Soil RBCs
Bis(2-chloroethyl)ether	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	500	500	Residential Soil RBCs
Bis(2-ethylhexyl)phthalate	182	182	NA	NA	NA	NA	NA	890,000,000[(9)]	1,300	NA	48,000	182	FDEP Criteria
4-Bromophenyl phenyl ether	NA	NA	NA	NA	NA	NA	1,300	NA	NA	NA	4,500,000	1,300	USEPA SQB
Butyl benzyl phthalate	NA	NA	NA	NA	NA	NA	11,000	NA	63	NA	15,000,000	63	REG III BTAGs
Carbazole	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	42,000	42,000	Residential Soil RBCs
4-Chloroaniline	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	240,000	240,000	Residential Soil RBCs
4-Chloro-3-methylphenol	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	1.4E+08	140,000,000	Residential Soil RBCs
2-Chloronaphthalene	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	560,000	560,000	Residential Soil RBCs
2-Chlorophenol	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	280,000	280,000	Residential Soil RBCs
4-Chlorophenyl phenyl ether	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Chrysene	108	330	NA	NA	384	2,800	NA	NA	384	NA	140,000	108	FDEP Criteria
Dibenzo(a,h)anthracene	6.22	330	NA	NA	63.4	260	NA	NA	63.4	NA	100	6.22	FDEP Criteria
Dibenzofuran	NA	NA	NA	NA	NA	NA	2,000	NA	540	NA	240,000	540	REG III BTAGs
Di-n-butyl phthalate	NA	NA	NA	NA	NA	NA	11,000	NA	1,400	NA	7,300,000	1,400	REG III BTAGs
1,4-Dichlorobenzene	NA	NA	NA	NA	NA	NA	350	NA	110	NA	7,500	110	REG III BTAGs
1,2-Dichlorobenzene	NA	NA	NA	NA	NA	NA	340	NA	35	NA	820,000	35	REG III BTAGs
1,3-Dichlorobenzene	NA	NA	NA	NA	NA	NA	1,700	NA	NA	NA	1,700,000	1,700	USEPA SQB
3,3'-Dichlorobenzidine	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	1,400	1,400	Residential Soil RBCs
2,4-Dichlorophenol	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	220,000	220,000	Residential Soil RBCs
Diethyl phthalate	NA	NA	NA	NA	NA	NA	630	NA	200	NA	56,000,000	200	REG III BTAGs
2,4-Dimethylphenol	NA	NA	NA	NA	NA	NA	NA	NA	29	NA	1,200,000	29	REG III BTAGs
Dimethyl phthalate	NA	NA	NA	NA	NA	NA	NA	NA	71	NA	6.3E+08	71	REG III BTAGs
2,4-Dinitrophenol	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	160,000	160,000	Residential Soil RBCs
2,4-Dinitrotoluene	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	130,000	130,000	Residential Soil RBCs
2,6-Dinitrotoluene	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	71,000	71,000	Residential Soil RBCs
Di-n-octyl phthalate	NA	NA	NA	NA	NA	NA	NA	NA	6,200	NA	1,500,000	6,200	REG III BTAGs
Fluoranthene	113	330	2,900	1,400	600	5,100	NA	NA	600	NA	2,900,000	113	FDEP Criteria
Fluorene	21.2	330	NA	NA	19	540	540	NA	19	NA	2,400,000	19	ER-L
Hexachlorobenzene	NA	NA	NA	NA	NA	NA	NA	NA	22	NA	600	22	REG III BTAGs
Hexachlorobutadiene	NA	NA	NA	NA	NA	NA	NA	NA	11	NA	3,100	11	REG III BTAGs
Hexachlorocyclopentadiene	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	550,000	550,000	Residential Soil RBCs
Hexachloroethane	NA	NA	NA	NA	NA	NA	1,000	NA	NA	NA	27,000	1,000	USEPA SQB

TABLE B-4-5

SELECTION OF SEDIMENT ACTION LEVELS FOR POTENTIAL FUTURE RESIDENTIAL SITES
NAVAL AIR FACILITY
KEY WEST, FLORIDA
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Parameter	FDEP Criteria[1]	EPA Reg IV[2]	EPA SQC Fresh[3]	EPA SQC Marine[4]	ER-L[5]	ER-M[6]	EPA SQB[7]	OTHER	Reg III BTAG Levels[12]	2x Average BG[14]	Residential Soil RBCs	Selected Action Level	Source of Action Level
Indeno(1,2,3-cd)pyrene	NA	NA	NA	NA	NA	NA	NA	NA	600	NA	1,400	600	REG III BTAGs
Isophorone	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	670,000	670,000	Residential Soil RBCs
2-Methyl-4,6-dinitrophenol	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
2-Methylnaphthalene	20.2	330	NA	NA	70	670	NA	NA	70	NA	960,000	20.2	FDEP Criteria
2-Methylphenol	NA	NA	NA	NA	NA	NA	NA	NA	63	NA	2,600,000	63	REG III BTAGs
3- & 4-Methylphenol	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	340,000	340,000	Residential Soil RBCs
Naphthalene	34.6	330	NA	NA	160	2,100	480	NA	160	NA	1,300,000	34.6	FDEP Criteria
2-Nitroaniline	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	4,000	4,000	Residential Soil RBCs
3-Nitroaniline	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	230,000	230,000	Residential Soil RBCs
4-Nitroaniline	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	230,000	230,000	Residential Soil RBCs
Semivolatile Organic Compounds (µg/kg)													
Nitrobenzene	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	22,000	22,000	Residential Soil RBCs
2-Nitrophenol	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
4-Nitrophenol	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	4,800,000	4,800,000	Residential Soil RBCs
n-Nitrosodiphenylamine	NA	NA	NA	NA	NA	NA	NA	NA	28	NA	73,000	28	REG III BTAGs
Pentachlorophenol	NA	NA	NA	NA	NA	NA	NA	NA	360	NA	5,400	360	REG III BTAGs
Phenanthrene	86.7	330	850	1,100	240	1,500	NA	NA	240	NA	1,700,000	86.7	FDEP Criteria
Phenol	NA	NA	NA	NA	NA	NA	NA	NA	420	NA	34,000,000	420	REG III BTAGs
Pyrene	153	330	NA	NA	665	2,600	NA	NA	665	NA	2,200,000	153	FDEP Criteria
1,2,4-Trichlorobenzene	NA	NA	NA	NA	NA	NA	9,200	NA	NA	NA	780,000	9,200	USEPA SQB
2,4,5-Trichlorophenol	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	7,100,000	7,100,000	Residential Soil RBCs
2,4,6-Trichlorophenol	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	87,000	87,000	Residential Soil RBCs
Metals (mg/kg)													
Aluminum	NA	NA	NA	NA	NA	NA	NA	NA	NA	2663.78	75,000	2,664	2x Average BG
Antimony	NA	12	NA	NA	NA	NA	NA	NA	150	NA	26	12	EPA Region IV
Arsenic	7.24	7.24	NA	NA	8.2	70	NA	NA	8.2	5.44	2.66	7.24	FDEP Criteria
Barium	NA	NA	NA	NA	NA	NA	NA	40[8]	NA	19.06	5,200	40	Chem and Tox
Beryllium	NA	NA	NA	NA	NA	NA	NA	NA	NA	0.1	0.2	0.1	2x Average BG
Cadmium	0.676	1	NA	NA	1.2	9.6	NA	NA	1.2	0.34	37	0.676	FDEP Criteria
Calcium	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Chromium	52.3	52.3	NA	NA	81	370	NA	NA	81	9.22	290	52.3	FDEP Criteria
Cobalt	NA	NA	NA	NA	NA	NA	NA	NA	NA	0.48	4,700	0.48	2x Average BG
Copper	18.7	18.7	NA	NA	34	270	NA	NA	34	18.42	3,100	18.7	FDEP Criteria
Iron	NA	NA	NA	NA	NA	NA	NA	NA	NA	2,398	23,000	2,398	2x Average BG
Lead	30.2	30.2	NA	NA	46.7	218	NA	NA	46.7	34.18	500	34.18	2x Average BG
Magnesium	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Manganese	NA	NA	NA	NA	NA	NA	NA	460[10]	NA	30.78	370	460	Tox. Benchmarks
Mercury	0.13	0.13	NA	NA	0.15	0.71	NA	NA	0.15	0.1	23	0.13	FDEP Criteria
Nickel	15.9	15.9	NA	NA	20.9	51.6	NA	NA	20.9	4.14	1,500	15.9	FDEP Criteria
Potassium	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA

TABLE B-4-5

SELECTION OF SEDIMENT ACTION LEVELS FOR POTENTIAL FUTURE RESIDENTIAL SITES
NAVAL AIR FACILITY
KEY WEST, FLORIDA
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Parameter	FDEP Criteria[1]	EPA Reg IV[2]	EPA SQC Fresh[3]	EPA SQC Marine[4]	ER-L[5]	ER-M[6]	EPA SQB[7]	OTHER	Reg III BTAG Levels[12]	2x Average BG[14]	Residential Soil RBCs	Selected Action Level	Source of Action Level
Metals (mg/kg)													
Selenium	NA	NA	NA	NA	NA	NA	NA	NA	NA	1.42	390	1.42	2x Average BG
Silver	0.733	2	NA	NA	1	3.7	NA	NA	1	0.44	390	0.733	FDEP Criteria
Sodium	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Thallium	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Tin	NA	NA	NA	NA	NA	NA	NA	NA	NA	1.98	44,000	1.98	2x Average BG
Vanadium	NA	NA	NA	NA	NA	NA	NA	NA	NA	10.44	490	10.44	2x Average BG
Zinc	124	124	NA	NA	150	410	NA	NA	150	46.66	23,000	124	FDEP Criteria

1 Florida Sediment Quality Assessment Guidelines (FDEP, 1994a).
2 EPA Region IV Sediment Quality Screening Values (EPA, 1995b), revised August 11, 1999 [Dioxin Screening Value added].
3 EPA Freshwater Sediment Quality Criteria (EPA, 1996b).
4 EPA Saltwater Sediment Quality Criteria (EPA, 1996b).
5 Effects Range-Low Guidelines (Long et al., 1995).
6 Effects Range-Medium Guidelines (Long et al., 1995).
7 EPA Sediment Quality Benchmarks (EPA, 1996b).
8 From *Sediments: Chemistry and Toxicity of In-Place Pollutants* (Baudo et al., 1990).
9 Guidelines for Protection and Management of Sediment Quality in Ontario (OME, 1992).
10 Toxicological Benchmarks for Screening Contaminants of Potential Concern for Effects on Sediment (Hull and Suter, 1994).
11 40 CFR Part 264 Proposed RCRA Action Levels.
12 EPA Region III BioTechnical Assistance Group Screening Levels for Sediment(EPA, 1995a).
13 Residential Soil Risk-Based Screening Concentrations (EPA, 1997).
14 As agreed by the NAS Key West Partnering Team, 2x average background values are presented here for inorganics, while average background values are presented here for pesticides. This data is based on a subset of data from Appendix F of the Supplemental RFI/RI for Eight Sites as NAS Key West.
µg/kg = micrograms per kilogram
mg/kg = milligrams per kilogram

TABLE B-4-6

**SELECTION OF GROUNDWATER ACTION LEVELS
NAVAL AIR FACILITY
KEY WEST, FLORIDA
PAGE 1 OF 4**

Parameter	MCL[1]	Florida MCL[2]	Tap Water RBCs[3]	2x Average BG[4]	Selected Level Action	Source of Selected Action Level
Volatile Organic Compounds (µg/L)						
Acetone	NA	NA	3,700	NA	3,700	Tap Water RBCs
Benzene	5	1	0.36	NA	1	Fl MCL
Bis(2-chloroisopropyl)ether	NA	NA	0.26	NA	0.26	Tap Water RBCs
Bromodichloromethane	100	NA	0.17	NA	100	MCL
Bromoform	100	NA	2.4	NA	100	MCL
Bromomethane	NA	NA	8.7	NA	8.7	Tap Water RBCs
2-Butanone	NA	NA	1,900	NA	1,900	Tap Water RBCs
Carbon disulfide	NA	NA	1,000	NA	1,000	Tap Water RBCs
Carbon tetrachloride	5	3	0.16	NA	3	Fl MCL
Chlorobenzene	100	100	39	NA	100	MCL
Chloroethane	NA	NA	8,600	NA	8,600	Tap Water RBCs
Chloroform	100	NA	0.15	NA	100	MCL
Chloromethane	NA	NA	1.4	NA	1.4	Tap Water RBCs
Dibromochloromethane	100	NA	0.13	NA	100	MCL
1,1-Dichloroethane	NA	NA	810	NA	810	Tap Water RBCs
1,2-Dichloroethane	5	3	0.12	NA	3	Fl MCL
1,1-Dichloroethene	7	7	0.044	NA	7	MCL
cis-1,2-Dichloroethene	70	70	61	NA	70	MCL
trans-1,2-Dichloroethene	100	100	120	NA	100	MCL
1,2-Dichloropropane	5	5	0.16	NA	5	MCL
cis-1,3-Dichloropropene	NA	NA	0.077	NA	0.077	Tap Water RBCs
trans-1,3-Dichloropropene	NA	NA	0.077	NA	0.077	Tap Water RBCs
Ethylbenzene	700	700	1,300	NA	700	MCL
2-Hexanone	NA	NA	NA	NA	428,000	Reg III BTAG
4-Methyl-2-pentanone	NA	NA	2,900	NA	2,900	Tap Water RBCs
Methylene chloride	NA	5	4.1	NA	5	Fl MCL
Styrene	100	100	1,600	NA	100	MCL
Tetrachloroethene	5	3	1.1	NA	3	Fl MCL
1,1,2,2-Tetrachloroethane	NA	NA	0.052	NA	0.052	Tap Water RBCs
Toluene	1,000	1,000	750	NA	1,000	MCL
1,1,1-Trichloroethane	200	200	790	NA	200	MCL
1,1,2-Trichloroethane	5	5	0.19	NA	5	MCL
Trichloroethene	5	3	1.6	NA	3	Fl MCL
Vinyl chloride	2	1	0.019	NA	1	Fl MCL
Xylenes, total	10,000	10,000	12,000	NA	10,000	MCL
Semivolatile Organic Compounds (µg/L)						
Acenaphthene	NA	NA	2,200	NA	2,200	Tap Water RBCs
Acenaphthylene	NA	NA	NA	NA	NA	NA

TABLE B-4-6

**SELECTION OF GROUNDWATER ACTION LEVELS
NAVAL AIR FACILITY
KEY WEST, FLORIDA
PAGE 2 OF 4**

Parameter	MCL[1]	Florida MCL[2]	Tap Water RBCs[3]	2x Average BG[4]	Selected Level Action	Source of Selected Action Level
Semivolatile Organic Compounds (µg/L)						
Anthracene	NA	NA	11,000	NA	11,000	Tap Water RBCs
Benzo(a)anthracene	NA	NA	0.092	NA	0.092	Tap Water RBCs
Benzo(a)pyrene	0.2	0.2	0.0092	NA	0.2	MCL
Benzo(b)fluoranthene	NA	NA	0.092	NA	0.092	Tap Water RBCs
Benzo(g,h,i)perylene	NA	NA	NA	NA	NA	NA
Benzo(k)fluoranthene	NA	NA	0.92	NA	0.92	Tap Water RBCs
Bis(2-chloroethoxy)methane	NA	NA	NA	NA	NA	NA
Bis(2-chloroethyl)ether	NA	NA	0.0092	NA	0.0092	Tap Water RBCs
Bis(2-Ethylhexyl)phthalate	6	6	4.8	NA	6	MCL
4-Bromophenyl phenyl ether	NA	NA	2,100	NA	2,100	Tap Water RBCs
Butyl benzyl phthalate	NA	NA	7,300	NA	7,300	Tap Water RBCs
Carbazole	NA	NA	3.4	NA	3.4	Tap Water RBCs
4-Chloro-3-methylphenol	NA	NA	NA	NA	NA	NA
4-Chloroaniline	NA	NA	150	NA	150	Tap Water RBCs
2-Chloronaphthalene	NA	NA	NA	NA	NA	NA
2-Chlorophenol	NA	NA	180	NA	180	Tap Water RBCs
4-Chlorophenyl phenyl ether	NA	NA	NA	NA	NA	NA
Chrysene	NA	NA	9.2	NA	9.2	Tap Water RBCs
Dibenzo(a,h)anthracene	NA	NA	0.0092	NA	0.0092	Tap Water RBCs
Dibenzofuran	NA	NA	150	NA	150	Tap Water RBCs
1,3-Dichlorobenzene	NA	NA	540	NA	540	Tap Water RBCs
1,4-Dichlorobenzene	75	75	0.44	NA	75	MCL
3,3'-Dichlorobenzidine	NA	NA	0.15	NA	0.15	Tap Water RBCs
2,4-Dichlorophenol	NA	NA	110	NA	110	Tap Water RBCs
Diethyl phthalate	NA	NA	29,000	NA	29,000	Tap Water RBCs
2,4-Dimethylphenol	NA	NA	730	NA	730	Tap Water RBCs
Dimethyl phthalate	NA	NA	370,000	NA	370,000	Tap Water RBCs
Di-n-butyl phthalate	NA	NA	3,700	NA	3,700	Tap Water RBCs
2,4-Dinitrophenol	NA	NA	73	NA	73	Tap Water RBCs
2,4-Dinitrotoluene	NA	NA	73	NA	73	Tap Water RBCs
2,6-Dinitrotoluene	NA	NA	37	NA	37	Tap Water RBCs
Di-n-octyl phthalate	NA	NA	730	NA	730	Tap Water RBCs
Fluoranthene	NA	NA	1,500	NA	1,500	Tap Water RBCs
Fluorene	NA	NA	1,500	NA	1,500	Tap Water RBCs
Hexachlorobenzene	1	1	0.0066	NA	1	MCL
Hexachlorobutadiene	NA	NA	0.14	NA	0.14	Tap Water RBCs
Hexachlorocyclopentadiene	50	50	0.15	NA	50	MCL
Hexachloroethane	NA	NA	0.75	NA	0.75	Tap Water RBCs
Indeno(1,2,3-cd)pyrene	NA	NA	0.092	NA	0.092	Tap Water RBCs

TABLE B-4-6

**SELECTION OF GROUNDWATER ACTION LEVELS
NAVAL AIR FACILITY
KEY WEST, FLORIDA
PAGE 3 OF 4**

Parameter	MCL[1]	Florida MCL[2]	Tap Water RBCs[3]	2x Average BG[4]	Selected Level Action	Source of Selected Action Level
Semivolatile Organic Compounds (µg/L)						
Isophorone	NA	NA	71	NA	71	Tap Water RBCs
2-Methyl-4,6-dinitrophenol	NA	NA	NA	NA	NA	NA
2-Methylnaphthalene	NA	NA	NA	NA	NA	NA
2-Methylphenol	NA	NA	1,800	NA	1,800	Tap Water RBCs
3 and 4-Methylphenol	NA	NA	1,800	NA	1,800	Tap Water RBCs
Naphthalene	NA	NA	1,500	NA	1,500	Tap Water RBCs
2-Nitroaniline	NA	NA	2.2	NA	2.2	Tap Water RBCs
3-Nitroaniline	NA	NA	110	NA	110	Tap Water RBCs
4-Nitroaniline	NA	NA	110	NA	110	Tap Water RBCs
Nitrobenzene	NA	NA	3.4	NA	3.4	Tap Water RBCs
2-Nitrophenol	NA	NA	NA	NA	NA	NA
4-Nitrophenol	NA	NA	2,300	NA	2,300	Tap Water RBCs
n-Nitro-di-n-propylamine	NA	NA	NA	NA	NA	NA
n-Nitrosodiphenylamine	NA	NA	14	NA	14	Tap Water RBCs
Pentachlorophenol	1	1	0.56	NA	1	MCL
Phenanthrene	NA	NA	NA	NA	8.3	EPA 1996
Phenol	NA	NA	22,000	NA	22,000	Tap Water RBCs
Pyrene	NA	NA	1,100	NA	1,100	Tap Water RBCs
2,4,5-Trichlorophenol	NA	NA	3,700	NA	3,700	Tap Water RBCs
2,4,6-Trichlorophenol	NA	NA	6.1	NA	6.1	Tap Water RBCs
Metals (µg/L)						
Aluminum	NA	NA	37,000	NA	37,000	Tap Water RBCs
Antimony	6	6	15	NA	6	MCL
Arsenic	50	50	0.045	9.9	50	MCL
Barium	2,000	2,000	2,600	19.16	2,000	MCL
Beryllium	4	4	0.016	NA	4	MCL
Cadmium	5	5	18	NA	5	MCL
Calcium	NA	NA	NA	NA	NA	NA
Chromium	100	100	180	1.92	100	MCL
Cobalt	NA	NA	2,200	NA	2,200	Tap Water RBCs
Copper	NA	NA	1,500	3.36	1,500	Tap Water RBCs
Cyanide	200	200	730	2.94	200	MCL
Iron	NA	NA	11,000	83.44	11,000	Tap Water RBCs
Lead	15	15	NA	NA	15	MCL
Magnesium	NA	NA	NA	NA	NA	NA

TABLE B-4-6

**SELECTION OF GROUNDWATER ACTION LEVELS
NAVAL AIR FACILITY
KEY WEST, FLORIDA
PAGE 4 OF 4**

Parameter	MCL[1]	Florida MCL[2]	Tap Water RBCs[3]	2x Average BG[4]	Selected Level Action	Source of Selected Action Level
Metals (µg/L)						
Manganese	NA	NA	840	7.56	840	Tap Water RBCs
Mercury	2	2	11	0.2	2	MCL
Nickel	100	100	730	NA	100	MCL
Potassium	NA	NA	NA	NA	NA	NA
Selenium	50	50	180	4.3	50	MCL
Silver	NA	NA	180	2.06	180	Tap Water RBCs
Sodium	NA	160,000	NA	NA	160,000	Fl MCL
Thallium	2	2	NA	4.62	4.62	2x Average BG
Tin	NA	NA	22,000	NA	22,000	Tap Water RBCs
Vanadium	NA	NA	260	3.8	260	Tap Water RBCs
Zinc	NA	NA	11,000	2.34	11,000	Tap Water RBCs

µg/L = micrograms per liter.
1 Safe Drinking Water Act Maximum Contaminant Levels MCLs (EPA, 1996a).
2 Florida MCLs (FDEP, 1995a).
3 Tap Water Risk-Based Concentrations (RBCs) (EPA, 1997).
4 Twice the average background concentration based on a subset of data from Appendix F of the Supplemental RFI/RI Report for Eight Sites as NAF Key West.
5 EPA Region IV Saltwater Surface Water Screening Values (EPA, 1995b).
6 EPA Region III Biotechnical Assistance Group Marine Surface Water Screening Levels (EPA, 1995a).

5.0 SAMPLING PROCEDURES

The specific types of field sampling for the RFA Work Plan program will follow the FDEP-approved TtNUS CompQAP, No. 980038 (August 25, 1999). In addition, the TtNUS CompQAP and the QAPP address the following field investigation tasks:

- Groundwater level measurements - Section 5 and Subsection 4.2.5.4 TtNUS CompQAP
- Monitoring well purging - Section 5 and Subsection 4.2.5.5 TtNUS CompQAP
- Sample containers, preservatives, and volume requirements - Appendix A (TtNUS SOP SA-6.1)
- Field measurements - Section 7.5 TtNUS CompQAP
- Decontamination procedures - Section 5 and Subsection 4.1 TtNUS CompQAP
- Investigation-derived waste - Section 4.6 Work Plan
- Sample identification system - Section 3.4.1.1 Work Plan
- Sample packaging and shipping procedures - Section 5 and Subsection 4.4.3.2 TtNUS CompQAP
- Field QC samples - Section 5 and Subsection 9.1.1 TtNUS CompQAP
- Recordkeeping - Appendix A (TtNUS SOP SA-6.3)

6.0 CUSTODY PROCEDURES

Maintenance of sample custody is one of several factors needed for the admissibility of environmental data as evidence in a court of law. Custody procedures help satisfy the two major requirements for admissibility: relevance and authenticity. Sample custody is addressed in three parts: field sample collection, laboratory analysis, and final evidence files. Final evidence files, including all originals of laboratory reports and purge files, are maintained under document control in a secure area. A sample or evidence file is under custody if:

- the item is in the actual physical possession of an authorized person, or
- the item is in view of the person after being in his or her possession, or
- the item was placed in a secure area to prevent tampering, or
- the item is in a designated and identified secure area with access restricted to authorized personnel only.

The COC report is a multi-part, standardized form used to summarize and document pertinent information for each sample, such as sample identification and type, matrix, date and time of collection, preservation, and requested analyses. Further, through the sequential signatures of various sample custodians (e.g., sampler, airbill number, laboratory sample custodian), the COC report documents sample custody and tracking. “Cradle-to-Grave” sample tracking will be employed during this project. Custody procedures apply to all environmental and associated field QC samples obtained as part of the data collection system.

6.1 FIELD CUSTODY PROCEDURES

The FOL (or designee) is responsible for the care and custody of collected samples until they are relinquished to the analyzing laboratory or entrusted to a commercial overnight courier. COC reports are completed for each sample in a shipment. The reports are filled out in a legible manner, using waterproof ink, and are signed and dated by the sampler. Pertinent notes (such as whether the sample is suspected to be high in contaminant concentration) are also indicated in the COC report. Information similar to that contained in the COC report is also provided on each sample label, which is securely attached to each sample bottle. COC report forms and sample labels will be supplied by the laboratory subcontractor. In accordance with NFESC guidelines, samples for chemical constituent analysis must be sent (for next-day receipt) to the laboratory within 24 hours of collection.

Full details regarding sample COCs (including use of custody seals and sample shipment protocols) are contained in TtNUS Corporate SOP SA-6.1, which is provided as Appendix A of this document. TtNUS Corporate SOP SA-6.3, provided as Appendix A, discusses maintenance of site logbooks, site notebooks, and other field records. Additionally, each of the various sampling SOPs incorporated into this QAPP contains a section that addresses relevant sample documentation (i.e., completion of sample logsheets, etc.). All sample records are eventually docketed into the TtNUS project central file.

6.2 LABORATORY CUSTODY PROCEDURES

When samples are received by the laboratory subcontractor, the laboratory's sample custodian examines each cooler's custody seals to verify that they are intact and that the integrity of the samples has been maintained. The sample custodian then signs the COC report, opens the cooler, and measures its internal temperature. The temperature reading is noted on the accompanying COC report. The sample custodian then examines the contents of the cooler. Sample container breakages or discrepancies between the COC report and sample label documentation are recorded. With the exception of samples for volatiles analysis, the pH of chemically preserved samples is checked (using pH paper) and recorded. All problems or discrepancies noted during this process are to be promptly reported to the TtNUS TOM (or designee). Inter-laboratory COC procedures and specific procedures for sample handling, storage, disbursement for analysis, and remnant disposal will be followed according to the subcontract laboratory's SOPs and/or its QA plan.

The laboratory will maintain in a secure area a hardcopy file of all analytical data associated with this project. Access to the data will be limited to laboratory, TtNUS, and Navy personnel. The hardcopy files will be maintained by the laboratory for a minimum of seven years.

6.3 FINAL EVIDENCE FILES

The TtNUS project central file will be the repository for all documents that constitute evidence relevant to sampling and analysis activities described in this QAPP. TtNUS is the custodian of the evidence file and maintains its contents, including all relevant records, reports, logs, field notebooks, photographs, subcontractor reports, and data reviews in a secure, limited-access location and under custody of the TtNUS facility manager. The central file will include, at a minimum:

- field logbooks
- field data and data deliverables
- photographs
- drawings

- soil boring logs
- laboratory data deliverables
- data validation reports
- data assessment reports
- progress reports, QA reports, interim project reports, etc., and
- all custody documentation (COC forms, airbills, etc.).

Upon completion of the contract, all pertinent files will be relinquished to the custody of the U.S. Navy.

7.0 CALIBRATION PROCEDURES AND FREQUENCY

All instruments used to perform chemical measurements must be properly calibrated prior to use, in order to obtain and ensure valid and usable results. The requirement to properly calibrate instruments prior to use applies equally to field instruments and fixed laboratory instruments. Field instrument calibration is discussed in Section 7.1 and laboratory instrument calibration is discussed in Section 7.2.

7.1 FIELD INSTRUMENT CALIBRATION

Field instrument calibration will be conducted according to Section 3.0 of the Work Plan and Subsection 7.5 of the TtNUS CompQAP. Field calibration will occur daily, with calibration checks being performed at intervals of no more than four hours and at the end of the sampling day.

7.2 LABORATORY INSTRUMENT CALIBRATION

Calibration procedures for a specific laboratory instrument will consist of initial calibration (typically 3 to 5 calibration points) and continuing calibration verification. In all cases, the initial calibration will be verified, using an independently prepared calibration verification solution. The frequency of calibration will be performed according to the requirements of the specific analytical method.

All standards used to calibrate analytical instruments must be obtained from the National Institute of Standards and Technology (NIST) or through a reliable commercial supplier with a proven record for quality standards. All commercially supplied standards must be traceable to NIST reference standards where possible, and appropriate documentation must be obtained from the supplier. In cases where documentation is not available, the laboratory will analyze the standard and compare the results to an EPA-supplied known or previous NIST-traceable standard.

The calibration procedures and frequencies used by the subcontract laboratory will comply with the applicable analytical method. Brief descriptions of calibration procedures for applicable major instrument types follow.

7.2.1 Volatile Organic Compounds Analysis

For VOCs, with the exception of 1,2-dibromoethane (EDB), the gas chromatograph/mass spectrometer (GC/MS) system will be tuned and calibrated in accordance with SW-846 Method 8260a/8260b. A bromofluorobenzene (BFB) instrument performance check (tuning check) must be run prior to the initial

calibration and each continuing calibration, and must meet all method-specified criteria before analysis may continue. Initial calibration is required before any samples are analyzed and must include a blank and a minimum of five different concentrations, as specified in the method. A BFB tuning check and a continuing calibration check, including the mid-range standard and a blank, must be performed at the beginning of each 12-hour period during which analyses are performed.

To obtain the VOC RQLs, the laboratory must analyze the samples using a 25 milliliter (mL) purge-and-trap method. The purge-and-trap method used will be in accordance with the SW-846 Methods 5030 and 5035 guidelines.

For EDB analyses, the gas chromatograph (GC) system will be calibrated in accordance with EPA Method 504.1. At least three calibration standards are needed. One should contain EDB at a concentration near, but above, the detection limit. The remaining standards should correspond to the expected range of concentrations found in environmental samples or the working range of the GC. A calibration standard must also be injected at intervals of not less than every 20 samples.

7.2.2 Semivolatile Organic Compounds Analysis

For SVOCs, except polynuclear aromatic hydrocarbons (PAHs), the GC/MS will be tuned and calibrated in accordance with the SW-846 Method 8270b/8270c. A decafluorotriphenyl phosphine (DFTPP) instrument performance check (tuning check) must be run prior to the initial and each continuing calibration and must meet all method-specified criteria before analyses may continue. Initial calibration is required before any samples are analyzed and must include a blank plus five different concentrations, as specified in the method. A DFTPP tuning back check and a continuing calibration check, including the mid-range standard as a blank, must be performed at the beginning of each 12-hour shift during which analyses are performed.

SW-846 Method 8310 will be used to determine the concentration of PAHs. Method 8310 provides high-performance liquid chromatographic (HPLC) conditions for the detection of parts per billion (ppb) levels of certain PAHs. The chromatographic system may be calibrated by using either the internal or external standard calibration techniques described in SW-846 Method 8000. Regardless of whether external or internal standard calibration is used, the calibration standard must be introduced into the instrument using the same technique that will be used to introduce the actual samples into the GC, 10-100 microliters injections for HPLC methods. Initial calibration is required before any samples are analyzed and must include a blank plus five different concentrations, as specified in the method. The initial calibration must be verified at the beginning of each 12-hour shift during which samples are analyzed.

7.2.3 Metals Analysis

7.2.3.1 Inductively Coupled Argon Plasma Analysis

Inductively coupled plasma (ICP) spectrometry systems will be calibrated for the analysis of TAL metals in accordance with the SW-846 Method 6010B. For all analytes and determinations, the laboratory must analyze a check standard and calibration blank immediately following the daily calibration, after every 10th sample, and at the end of the sample run. The calibration verification must be analyzed immediately following the daily calibration. Analysis of the check standard, calibration verification, and calibration blank must verify that the instrument is within 10 percent of calibration, with a relative standard deviation of less than 3 percent from replicate (more than two) integrations.

7.2.3.2 Atomic Absorption Analyses

Cold vapor atomic absorption (CVAA) analyses will be calibrated in accordance with the appropriate SW-846 methods. Calibration curves are always required. A blank and at least three calibration standards in graduated amounts in the appropriate range of the linear portion of the curves should be prepared. A mid-range check standard must be run after every 10 samples.

8.0 ANALYTICAL AND MEASUREMENT PROCEDURES

Samples will be subject to field and laboratory parameter measurements as needed, based on the sample location under investigation. The analytical program for environmental samples collected at each anticipated location is provided in Section 3.0 of the RFA Work Plan.

Chemical/physical parameters to be measured with field instruments include temperature, SC, pH, turbidity, DO, and salinity, using a field water quality meter. Measurement of field parameters and calibration of field instruments are discussed in Section 3.0 of the Work Plan and Subsection 7.5, of the TtNUS CompQAP.

The analytical laboratory responsible for chemical analyses is NFESC-approved, certified by the Florida Department of Health, Division of Laboratory Certification, for all analyses that are requested by TtNUS, and has a current FDEP-approved CompQAP. Documentation of the certifications has been provided to TtNUS, as described in the TtNUS analytical Statement of Work for the contracted laboratory.

All groundwater samples for low-concentration volatile organic analysis will be analyzed in accordance with current SW-846 methods.

A complete list of the target compounds/analytes and their RQLs is provided in Section 1.4.2.2 of this QAPP. Data generated through use of the SW-846 method protocols will be reported at the RDL for nondetected compounds from metals analysis. All environmental data generated through use of non-SW-846 methods will be reported to the laboratory's RL. An analyte's RL is an expression of the method detection limit (MDL), with adjustments made to ensure that the precision and accuracy requirements of the method are attainable at the RL. The RLs are not provided in the tables in Section 1.4.2.2 because these values vary by laboratory.

Quantitation and detection limits will also be adjusted as needed, based on dilutions and sample volume.

TABLE B-8-1

SUMMARY OF ORGANIC ANALYTICAL PROCEDURES[1]
SOLID AND AQUEOUS MATRICES
NAVAL AIR FACILITY
KEY WEST, FLORIDA

Analytical Parameter	Analytical Method
Appendix IX* Volatile Organics	SW-846 8260B (25mL or 5g purge)
Appendix IX* Semivolatile Organics	SW-846 8270C
TAL Metals	SW-846 Method 6010B, and 7470A or 7471A for mercury

1 EPA, 1997. Update and revisions to Test Methods for Evaluating Solid Wastes, Physical/Chemical Methods. SW-846, 3rd ed.
* Appendix IX – 40 Code of Federal Regulations, Part 264, Subpart EE, Appendix IX Groundwater Monitoring List.

9.0 INTERNAL QUALITY CONTROL CHECKS

Field-related QC checks were discussed in Section 3.0 of this QAPP and in Section 5 and Subsection 9.1.1 of the TtNUS CompQAP. This section provides additional information regarding internal QC checks for the field and the laboratory.

9.1 FIELD QUALITY CONTROL CHECKS

QC procedures for field measurements will include calibrating the instruments, as discussed in Section 5 and Subsection 7.5 of the TtNUS CompQAP. Assessment of field sampling precision and bias will be made by collection of field duplicates and rinsate blanks for laboratory analysis, as discussed in Section 3.6 of this QAPP.

9.2 LABORATORY QUALITY CONTROL CHECKS

The subcontract laboratory will have a QC program to ensure the reliability and validity of analyses performed at the laboratory. Internal QC procedures for analyses will comply with the applicable analytical method requirements.

Several internal laboratory QC checks are briefly discussed in the remainder of this section.

Laboratory method blanks are prepared and analyzed in accordance with the analytical method employed, to indicate whether contaminants originating from laboratory sources have been introduced and may have affected environmental sample analytical results. A method blank consists of an aliquot of analyte-free water that is subjected to the same preparation and analysis procedures as the environmental samples undergoing analysis. Method blanks must not contain levels of target analytes greater than the reported detection limits. Under no circumstances are laboratory method blank contaminant values subtracted from environmental sample analysis results.

Matrix spike analysis for inorganic fraction analyses is performed as a measure of how the sample matrix affects analytical accuracy. As discussed in Section 3.0 of this QAPP, control limits for MS and laboratory duplicate analyses are listed in Tables B-3-2, B-3-3, and B-3-6.

Laboratory control samples serve to monitor the overall performance of each step during the analysis, including sample preparation. LCS analysis will be performed for low-concentration volatiles and as required by the applicable analytical method. Aqueous LCS results must fall within the control limits

specified in the analytical method, where applicable, or those established by the laboratory. Aqueous LCSs shall be analyzed by utilizing the same sample preparations, analytical methods, and QA/QC procedures that are used for the environmental samples. As discussed in Section 3.0 of this QAPP, control limits for LCSs are listed in Tables B-3-4 and B-3-5.

Duplicate samples and MSDs serve to monitor the overall precision of the inorganic and organic analyses, respectively. The precision of overall analysis can be determined from the comparison of duplicate sample results and the environmental sample results. The precision control limits for duplicate sample analyses are listed in Tables B-3-1 and B-3-2. The equation for determining precision is presented in Section 13.2.

10.0 DATA REDUCTION, VALIDATION, AND REPORTING

This section describes the procedures to be used for data reduction, review, and reporting for the NAF Key West RFA Work Plan sampling program. All data generated during the course of the investigation will be maintained in hardcopy format by TtNUS in the Naval Facilities Engineering Command Southern Division designated central files, located in the TtNUS Pittsburgh, Pennsylvania, office.

In addition to the central files, photocopies of all hardcopy data (as well as electronic data) will be maintained in the Chemistry/Toxicology/Risk Assessment Department database records files located in the TtNUS, Pittsburgh, Pennsylvania, office. Upon completion of the contract, all files will be relinquished to the Navy.

10.1 DATA REDUCTION

Data reduction will be completed for laboratory-generated analytical data.

10.1.1 Field Data Reduction

Field data will be generated through onsite water quality testing for the general indicator parameters pH, SC, turbidity, temperature, DO, and salinity. Field test kits for TPH will also be utilized for soil confirmation samples at the Former Boca Chica Blast Media Disposal Area.

Field parameters will be recorded in the site logbook or on sample logsheets immediately after the measurements are taken, and will be later encoded in the NAF Key West database for presentation in the report. If an error is made in the logbook, the error will be legibly crossed out (single-line strikeout), initialed and dated by the field member, and corrected in a space adjacent to the original (erroneous) entry. No calculations will be necessary to reduce these data for inclusion in the report. Field data will be entered into the electronic database manually, and the entries will be verified by an independent reviewer to make sure that no "transcription" errors occurred.

Field measurements will be recorded and reported in the following units:

- Hydronium ion concentration (standard pH units)
- Temperature in degrees Celsius (°C)
- Specific conductivity [microSiemens per centimeter (µS/cm)]
- Turbidity (Nephelometric turbidity units [NTU])

- TPH (ppm)
- DO (milligrams per liter [mg/L])
- Salinity (%)

Standard pH units, as specified above, are the negative logarithm (base 10) of the hydronium ion concentration in moles/liter.

10.1.2 Laboratory Data Reduction

Laboratory analytical data will be reported using standard concentration units, to ensure comparability with regulatory standards/guidelines and previous analytical results. Reporting units for solid and aqueous matrices for the classes of chemicals under consideration are as follows:

- Groundwater samples
  - Appendix IX VOCs and SVOCs – micrograms per liter (µg/L)
  - TAL metals - µg/L
- Soil samples
  - Appendix IX VOCs and SVOCs – micrograms per kilogram (µg/kg)
  - TAL metals - µg/kg

Field QC sample results will be included in the database for the NAF Key West RFA Work Plan sampling program. Specifically, analytical results for rinsate blanks will be provided. The results for field QC samples will be considered during the course of data review (in concert with laboratory method blanks) to eliminate false positive results, according to the 5- and 10-times rules specified in the National Functional Guidelines for Inorganic Review (EPA, 1994). The results for laboratory QC samples, such as method blanks, will not be presented in the report database.

10.2 DATA VALIDATION

Validation of field measurements and laboratory analytical data are discussed in this section. Validation of field data will be limited to real-time checks. Laboratory analytical data will be reviewed against the data validation rules described below. Review of field measurement data is discussed in Section 10.2.1. Review of laboratory analytical data is discussed in Section 10.2.2.

10.2.1 Field Measurement Data Validation

Field measurements will not be subject to a formal data validation process. However, field technicians will ensure that the equipment used for field measurements is performing accurately via calibration, as discussed in Section 5 and Subsection 7.5 of the TtNUS CompQAP. The FOL will ensure that the field meters are used in accordance with the instrument manufacturer's instructions. Results of field measurements will be recorded in field logbooks or on sample logsheets. This information will be reviewed by the FOL to verify that the information was recorded properly (i.e., no transcription errors) and that the correct field measurements were recorded. As described in Section 10.1.1, all field data entered into the electronic database will be independently reviewed for transcription errors. A comparison will be made of samples collected, relative to samples planned for collection, to ensure that all intended samples have been collected.

10.2.2 Laboratory Data Review

One hundred percent of the laboratory data will undergo a limited review. A limited review evaluates the following items: sample holding times, method blank analyses, initial and continuing calibration standards, data completeness, reported detection limits, and duplicate sample analyses. Review of analytical data will be completed by the TtNUS Chemistry Department, located in the TtNUS Pittsburgh, Pennsylvania, office. Final review and approval of reviewed deliverables will be completed by the Department's Data Validation Manager. The TOM will maintain contact with the Data Validation Manager to ensure that management of the acquired data proceeds in an organized and expeditious manner.

Organic data analytical results will be reviewed against the applicable analytical method. Data will be accepted, rejected, or qualified based on the results of the limited review items. Guidelines established in the EPA National Functional Guidelines for Organic Data Review (1999), the EPA Contract Laboratory Program National Functional Guidelines for Inorganic Data Review (1994), and the NFESC guidelines, "Navy Installation Restoration Chemical Data Quality Manual" (1999), will be used as guidances to define criteria for the limited review items.

10.3 DATA REPORTING

10.3.1 Field Measurement Data Reporting

Field data will be reported in the units discussed in Section 10.1.1. The report will include a comprehensive database, including all field measurements. Field measurements will be transferred manually from the site logbook or sample logsheets to the electronic database and will be reviewed for

accuracy by an independent reviewer. Transfer of field measurements to the electronic database will be completed shortly after completion of the field investigation and prior to receipt of laboratory analytical data.

All records regarding field measurements (i.e., field logbooks, sampling logbooks, and sample logsheets) will be placed in TtNUS' Southern Division central files upon completion of the field effort. Entry of these results in the database will require removal of the results from the files. Outcards will be used to document the removal of any such documentation from the files (date, person, subject matter). Field measurement data will be reported in an appendix to the report (at a minimum) and may also be reported in summary fashion, if they are indicative of the presence of contamination (e.g., high SC readings).

10.3.2 Laboratory Data Reporting

Data reported by the laboratory will be in accordance with the reporting format described in TtNUS' analytical Statement of Work for the contracted laboratory. Case narratives and a certificate of analysis will be provided for each Sample Delivery Group (SDG).

All environmental and field QC sample results (rinsate blanks) will be included in the report as an appendix. The database will include pertinent sampling information, such as sample number, sampling date, general location, depth, and survey coordinates (if applicable). Sample-specific detection limits will be reported for nondetected analytes. Units will be clearly summarized in the database and will conform to those identified in Section 10.1.2. The analytical data may also be reported in summary fashion within the body of the report text in tabular and graphic fashion.

Data will be handled electronically, pursuant to the electronic deliverable requirements specified in TtNUS' Basic Ordering Agreement with analytical laboratories. This agreement requires the analytical laboratories to provide data in both hardcopy and electronic forms. The laboratory will provide a 14-calendar-day turnaround time for delivery of the SDG in both hardcopy and electronic formats. The original electronic diskettes and the original hardcopy analytical data will be maintained in the TtNUS Southern Division central files, as they are received.

Data review will be completed using the hardcopy data. Upon completion of the SDG review and review by the Data Validation Manager, review qualifiers will be entered in the electronic database and will be subjected to an independent review for accuracy. During this review process, the electronic data-base printout will also be compared with the hardcopy data to ensure that the hardcopy data and electronic data are consistent.

In addition, a summary of the data qualifiers for all project samples will be prepared. This summary will include a list of the chemicals identified as laboratory and/or field QC blank contaminants, holding time exceedances, and samples exhibiting field duplicate/replicate imprecision, as well as affected chemicals, rejected results and associated specific causes, and general reasons for estimated results. This summary will facilitate preparation of a summary of the data review results and completeness assessment for inclusion in the report.

11.0 PERFORMANCE AND SYSTEM AUDITS

Performance and system audits will be conducted periodically, to ensure that work is being implemented in accordance with the approved project plans and in an overall satisfactory manner. Such audits will be performed by various personnel and will include evaluation of field, laboratory, data review, and data reporting processes. Examples of pertinent audits are as follows:

- The FOL will supervise and check daily that field measurements are made accurately, equipment is thoroughly decontaminated, samples are collected and handled properly, and field work is documented accurately and neatly.

- Performance and system audits of the laboratory will be performed regularly by a Navy Contractor (internal), in accordance with the laboratory QA plan (internal).

- Data reviewers will evaluate (on a timely basis) the chemical analytical data packages submitted by the laboratory. The data reviewers will check that data were obtained through use of an approved methodology, that the appropriate level of QC effort and reporting was conducted, and whether or not the results are in conformance with QC criteria. Based on these factors, the data reviewer will generate a report describing data limitations, which will be reviewed internally by the Data Validation Manager prior to submittal to the TOM.

A formal audit of field sampling procedures may be conducted by the TtNUS QAM (or designee), in addition to the auditing that is an inherent part of daily project activities. The purpose of this audit is to ensure that sample collection, handling, and shipping protocols, as well as equipment decontamination and field documentation procedures, are being performed in accordance with the approved project plans and SOPs. An audit will be performed if the TtNUS TOM, QAM, QAO, Navy RPM, EPA regulator, or FDEP Project Manager develops concerns with regard to the field sampling effort.

12.0 PREVENTIVE MAINTENANCE PROCEDURES

Measuring equipment used in environmental monitoring or analysis for the NAF Key West RFA Work Plan sampling program will be maintained in accordance with the manufacturers' operation and maintenance manuals. Equipment and instruments will be calibrated in accordance with the procedures, and at the frequency, discussed in Section 7.0. Preventive maintenance for field and laboratory equipment is discussed in the remainder of this section.

12.1 FIELD EQUIPMENT PREVENTIVE MAINTENANCE

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

- The TtNUS Equipment Manager keeps an inventory of the equipment in terms of items (models and serial numbers), quantities, and conditions. Each item of equipment is signed out when in use, and its operating condition and cleanliness are checked upon return.

- The TtNUS Equipment Manager conducts routine checks on the status of equipment and is responsible for the stocking of spare parts and equipment readiness. The Equipment Manager also maintains the equipment manual library.

- The FOL is responsible for working with the Equipment Manager to ensure that all equipment is tested, cleaned, charged, and calibrated in accordance with the manufacturer's instructions and Section 5 and Subsection 7.5 of the TtNUS CompQAP, before being taken to the job site and used during field activities.

- During calibration, an appropriate maintenance check is performed on each piece of equipment. Any problems encountered while operating the instrument will be recorded in the field logbook, including a description of the symptoms and corrective actions taken.

- If a problem with the equipment is detected or service is required, the equipment should be logged, tagged, and segregated from equipment in proper working order. Use of an instrument will not be resumed until the problem is resolved.

12.2 LABORATORY INSTRUMENT PREVENTIVE MAINTENANCE

Proper maintenance of laboratory instruments and equipment is essential to ensuring their readiness when needed. Depending on manufacturer's recommendations, maintenance intervals are established for each instrument. Each major instrument must be labeled with its model and serial numbers, and a maintenance logbook must be maintained for each major instrument. Personnel must always be alert to the maintenance status of the equipment they are using.

12.2.1 Major Instruments

Table B-12-1 provides a summary of preventive maintenance procedures for key analytical instruments. The analytical laboratory will perform the appropriate maintenance for the analyses to be performed. Maintenance of key instruments is sometimes covered under service contracts with external firms. These contracts provide for periodic routine maintenance to help guard against unexpected instrument downtime. The contracts also provide for quick response to unscheduled service calls when malfunctions are observed by the operator.

The use of manufacturer-recommended grades (or better) of supporting supplies and reagents is also a form of preventive maintenance. For example, gases used in the ICP should be of sufficient grade to minimize fouling of the instrument. The routine use of septa, ferrules, AA furnace tubes, and other supporting supplies from reputable manufacturers will assist in averting unnecessary periods of instrument downtime.

TABLE B-12-1

**TYPICAL PREVENTIVE MAINTENANCE FOR KEY ANALYTICAL INSTRUMENTS
NAVAL AIR FACILITY
KEY WEST, FLORIDA**

Instrument	Preventive Maintenance	Maintenance Frequency
GC/MS	VOCs: Bake oven, replace septum, and check carrier gas.	As required.
	SVOCs: Replace the septum, clean injection port, replace liner, bake oven, check carrier gas, and clean the source.	As required.
	Replace solvent washes and clean syringe.	Daily.
GC	Replace solvent washes and clean syringe.	Daily.
	Clip column, clean injection port, replace liner, and bake oven.	As required.
ICP	Change sample introduction tubing, clean nebulizer, clean spray chamber, clean torch, manual profile, and automatic profile optics.	As required.
CVAA	Change sample introduction tubing, change drying cell, rezero detector.	As required.

CVAA cold vapor atomic absorption
GC gas chromatograph
GC/MS gas chromatograph/mass spectrometer
ICP inductively coupled plasma

13.0 SPECIFIC ROUTINE PROCEDURES USED TO ASSESS DATA ACCURACY, PRECISION, COMPLETENESS, AND FIELD DUPLICATES

Compliance with the QA/QC objectives outlined in Section 3.0 will be monitored via two separate mechanisms. Precision and accuracy will be assessed through data quality measures, while compliance with the completeness objectives for field and laboratory data and measurements will be calculated by hand (field measurements) and electronically, via a database subroutine (laboratory data). Information necessary to complete precision and accuracy calculations will be provided in electronic and hardcopy forms by the subcontract laboratory. Equations to be used for the precision, accuracy, and completeness assessments are outlined in the remainder of this section.

13.1 ACCURACY ASSESSMENT

To assure the accuracy of analytical procedures, a minimum of 1 of every 20 samples is spiked with a known amount of the analyte or analytes to be evaluated. The spiked sample is then analyzed. The increased concentration of the analyte observed in the spiked sample (because of the addition of a known quantity of the analyte) compared to the reported value of the same analyte in the unspiked sample, determines the %R. Control charts are plotted for each commonly analyzed compound and are kept on matrix-specific and analyte-specific bases. The %R for a spiked sample is calculated according to the following formula:

$$\%R = \frac{\text{Amount in spiked sample} - \text{amount in sample}}{\text{Known amount added}} \text{ X } 100\,\%$$

13.2 PRECISION ASSESSMENT

Duplicate and MS/MSD samples are prepared and analyzed at a minimum frequency of 1 per every 20 environmental samples. Duplicate samples are produced by the field crew. MS/MSD samples are prepared by spiking each of the aliquots with a known amount of analyte.

Laboratory duplicate samples are handled just like the other environmental samples included in the analytical sample set. The RPD between the environmental sample (or MS) and the duplicate sample (or MSD) is calculated and plotted. The RPD is calculated according to the following formula:

$$\text{RPD} = \frac{|\text{Amount in sample - amount in duplicate}|}{0.5\,(\text{amount in sample} + \text{amount in duplicate})} \text{ X } 100\,\%$$

13.3 COMPLETENESS ASSESSMENT

Completeness is the ratio of the number of valid sample results to the total number of sample results expected to be obtained for the project as a whole. Following completion of analytical testing and data validation, the percent completeness will be calculated by the following equation:

$$\text{Completeness} = \frac{(\text{number of valid measurements})}{(\text{number of measurements planned})} \text{ X } 100\,\%$$

Results of the data validation process and the completeness assessment will be summarized in the report, using the summary format discussed in Section 10.3.2 and an electronic database subroutine.

14.0 CORRECTIVE ACTION

Under TtNUS' QA/QC program, it is required that any and all personnel who note conditions adverse to quality report these conditions immediately to the TOM and QAO. These parties, in turn, are charged with performing root-cause analyses and implementing appropriate corrective actions in a timely manner. It is ultimately the responsibility of the QAO to document all findings and corrective actions taken and to monitor the effectiveness of the corrective measures performed.

14.1 FIELD CORRECTIVE ACTION

Field nonconformances or conditions adverse to quality must be identified and corrected as quickly as possible, so that work integrity or quality of product is not compromised. The need for corrective action may arise because of deviations from project plans and procedures, adverse field conditions, or other unforeseen circumstances. Corrective action needs may become apparent during the performance of daily work tasks or as a consequence of internal or external field audits.

Corrective action may include resampling and could involve amending previously approved field procedures. If warranted by the severity of the problem (e.g., if a change is required in the approved project plan documents or SOPs), the Navy will be notified in writing via a Field Task Modification Request (FTMR), and Navy (in conjunction with EPA Region IV and FDEP) approvals will be obtained. The FOL is responsible for initiating FTMRs; an FTMR will be initiated for all deviations from the project plan documents, as applicable. An example of an FTMR is provided as Figure B-14-1. Copies of all FTMRs will be maintained with the onsite project planning documents and will be placed in the final evidence file.

Minor modifications to field activities, such as a slight offset of a boring location, will be initiated at the discretion of the FOL, subject to onsite approval by NAF Key West personnel. Approval for major modifications (e.g., elimination of a sampling point) must be obtained via an FTMR.

14.2 LABORATORY CORRECTIVE ACTION

In general, laboratory corrective actions are warranted whenever an out-of-control event or potential out-of-control event is noted. The specific corrective action taken depends on the specific analysis and the nature of the event. Generally, the following occurrences alert laboratory personnel that corrective action may be necessary:

- QC data are outside established warning or control limits
- Method blank analyses yield concentrations of target analytes above acceptable levels
- Undesirable trends are detected in spike recoveries or in duplicate RPDs
- There is an unexplained change in compound detection capability
- Inquiries concerning data quality are received, or
- Deficiencies are detected by laboratory QA staff audits or from performance evaluation sample test results.

Corrective actions are typically documented on a corrective action form for out-of-control situations. Using a corrective action form, any employee may notify the QA/QC Officer of a problem. The QA/QC Officer generally initiates corrective action by relaying the problem to the appropriate Laboratory Manager and/or Internal Coordinator, who then investigates or assigns responsibility for investigating the problem and its cause. When an appropriate corrective action is determined, it is approved by the QA/QC Officer. Its implementation is verified and documented on the corrective action form and is further documented through audits.

14.3 CORRECTIVE ACTION DURING DATA REVIEW AND DATA ASSESSMENT

The need for corrective action may become apparent during data review, interpretation, or presentation activities, or problems may be identified as a result of oversight findings. Performing rework, instituting a change in work procedures, or providing additional/refresher training are possible corrective actions relevant to data evaluation activities. The TOM will be responsible for approving the implementation of corrective actions.

FIGURE B-14-1

TETRA TECH NUS, INC.
FIELD TASK MODIFICATION REQUEST FORM

_____ _____ _____
Client Identification Project Number FTMR Number

To_____Location_____Date_____

Description:

_____
_____
_____

Reason for Change:

_____
_____
_____

Recommended Disposition:

_____
_____
_____

_____
Field Operations Leader (Signature, if applicable) Date

Disposition:

_____
_____
_____
_____

_____
Task Order Manager (Signature, if required) Date

_____
Distribution:
Program Manager
Quality Assurance Manager
Quality Assurance Officer
Task Order Manager
Field Operations Leader

Others as required_____
_____
_____
_____

15.0 QUALITY ASSURANCE REPORTS TO MANAGEMENT

QA reports to management will be provided in three primary formats during the course of the NAF Key West RFA Work Plan sampling program. Data review letter reports will be prepared on an SDG-specific basis and will summarize QA issues related to the subcontract laboratory data. In addition, written weekly reports provided by the FOL will summarize accomplishments and QA/QC issues during the field investigation. Finally, monthly progress reports are provided by the TOM. In addition, a summary of data review qualifiers and a completeness assessment for all project samples will be included in the reports.

15.1 CONTENTS OF PROJECT QUALITY ASSURANCE REPORTS

The contents of specific QA reports are as follows. Data review reports address major and minor laboratory noncompliances, as well as noted sample matrix effects. In the event that major problems occur with the analytical laboratory (e.g., holding time exceedances, calibration noncompliances, etc.), the Data Validation Manager will notify the TOM, the Technical Program Manager, and the Laboratory Services Coordinator. Such notifications (when necessary) are typically provided via internal memoranda and are placed in the project file. Data review reports contain a summary of the noncompliance, a synopsis of the impact on individual projects, and recommendations regarding corrective action(s) and compensational adjustments. Corrective actions are initiated at the program level.

The FOL will provide the TOM with weekly reports regarding accomplishments, deviations from the QAPP, upcoming activities, and a QA summary. In addition, monthly project review meetings are held for all active Navy CLEAN III projects. Issues discussed at project review meetings include all aspects of budget and schedule compliance and QA/QC problems. The TOM provides a monthly progress report to the Navy that addresses the project budget, schedule, accomplishments, planned activities, required revisions of the QAPP, QA/QC issues, and intended corrective actions.

15.2 INDIVIDUALS RECEIVING/REVIEWING QUALITY ASSURANCE REPORTS

Data review QA reports are provided to the TOM for inclusion in the project files. In the event that major problems are observed for a given laboratory, the Program Manager, Deputy Program Manager, QAM, QAO, TOM, and Laboratory Services Coordinator are provided with copies of the QA report. Weekly field progress reports are provided to the TOM. Monthly progress reports are provided to the Navy CLEAN III Program Manager and the Navy CLEAN III Contracting Officers Technical Representative.

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APPENDIX A

TTNUS CORPORATE SOPS SA-6.1 AND SA-6.3

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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 14C.

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 – Salinity is a unitless property of industrial and natural waters. It is the measurement of dissolved slats 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 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.

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 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 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) shall be placed near the bottom of the screened section, and approximately one casing volume of water shall be pumped from the well at a 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.,

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), engineer's rule, 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 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.
- 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.

- There is minimal outgassing of volatile organics while the sample is in the bailer.
- Bailers are relatively easy to decontaminate.

Limitations on the use of bailers include the following:

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

Suction Pumps

There are many different types of inexpensive suction pumps including centrifugal, diaphragm, 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)
- Certain Dissolved Constituents Using Specific Ion Elements
- 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.

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 hydrion 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 meter equipped with an in-line sample chamber (e.g., YSI 610).
- 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, slowly stirring the probe until the pH stabilizes. Stabilization may take several seconds to minutes. If the pH continues to drift, the sample temperature may not be stable, a 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.

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.

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 meter equipped with an in-line sample chamber (e.g., YSI 610).
- 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):

- 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. Attachment B provides guidance in this regard.
- Rinse the cell with one or more portions of the sample to be tested or with deionized water.
- Immerse the electrode in the sample and measure the conductivity. Adjust the temperature setting to the sample temperature (if applicable).
- 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 or dial-type thermometers. In addition, various meters such as specific conductance or dissolved oxygen meters, which have

temperature measurement capabilities, may also be used. Using such instrumentation along with suitable probes and cables, in-situ measurements of temperature at great depths can be performed.

5.5.3.3 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.

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 meter equipped with an in-line sample chamber (e.g., YSI 610).
- Sufficient cable to allow the probe to contact the sample.
- Manufacturer's operation manual.

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. Dissolved oxygen values for air-saturated water can be determined by consulting a table listing oxygen solubilities as a function of temperature and salinity (see Attachment C).
- 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. Be sure to record whether the liquid was analyzed in-situ, or if a sample was taken.

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

5.5.5 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 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:

- Portable pH meter or equivalent, with a millivolt scale.
- Platinum electrode to fit above pH meter.
- Reference electrode such as a calomel, silver-silver chloride, or equivalent.
- 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 calibrated and have its batteries checked before going to the field.

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

- Thoroughly rinse the electrode with deionized water.

- Verify the sensitivity of the electrodes by noting the change in millivolt reading when the pH of the test solution is altered. The ORP will increase when the pH of the test solution decreases, and the ORP

will decrease if the test solution pH is increased. Place the sample in a clean 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. If the ORP does not respond as above when the caustic is added, the electrodes shall be cleaned and the above procedure repeated.

- After the assembly has been checked for sensitivity, wash the electrodes with three changes of water or by means of a flowing stream of deionized water from a wash bottle. Place the sample in a clean container and insert the electrodes. Set temperature compensator throughout the measurement period. Read the millivolt potential of the solution, allowing sufficient time for the system to stabilize and reach temperature equilibrium. Measure successive portions of the sample until readings on two successive portions differ by no more than 10 mV. A system that is very slow to stabilize properly will not yield a meaningful ORP. Record all results in a field logbook or sample logsheet, including ORP (to nearest 10 mV), sample temperature and pH at the time of measurement.

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 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 turbidmeter. 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:

- Stand alone portable turbidity meter, or combination meter (e.g., Horiba U-10), or combination meter equipped with an in-line sample chamber (e.g., YSI 61).

- 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 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 cell with one or more portions of the sample to be tested or with deionized water.
- Immerse the probe in the sample and measure the turbidity. 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 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 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 610).
- 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 probes 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).
- 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 SOP SA-6.3); 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 and stopwatch are most commonly used; other techniques include use of pipe trajectory methods, weir boxes or flow meters.

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.

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 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 2 inches 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 5 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.
- Tubing - Teflon, Teflon-lined polyethylene, polyethylene, PVC, Tygon, 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).
- Flow measurement supplies.
- Interface probe, if needed.

- 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 and dissolved oxygen, flow-through cell is required. Standards to perform field calibration of instruments.
- Decontamination supplies.
- Logbook(s), and other forms (e.g., well purging forms).
- 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.
- Field Sampling Plan.
- PID or FID instrument for measuring VOCs (volatile organic compounds).

5.7.3 Purging and Sampling Procedure

Use a submersible pump to purge and sample monitoring wells which have a 2.0 inch or greater well casing diameter.

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

Lower pump, safety cable, tubing and electrical lines 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.

When starting the pump, slowly increase the pump speed until a discharge occurs. Check water level. Adjust pump speed to maintain little or no water level drawdown. The target drawdown should be less than 0.3 feet and it should stabilize. If the target of less than 0.3 feet cannot be achieved or maintained, the sampling is acceptable if remaining criteria in the procedure are met. Subsequent sampling rounds will probably have intake settings and extraction rates that are comparable to those used in the initial sampling rounds.

Monitor water level and pumping rate every five to ten minutes (or as appropriate) during purging. Record pumping rate adjustments and depths to water. Pumping rates should, as needed, be reduced to the minimum capabilities of the pump (e.g., 0.1-0.2 l/min) to ensure stabilization of indicator parameters. Adjustments are best made in the first fifteen minutes of pumping in order to help minimize purging time. During initial pump start-up, drawdown may exceed the 0.3 feet target and then recover as pump flow adjustments are made (minimum purge volume calculations should utilize stabilized drawdown values, not the initial drawdown). If the recharge rate of the well is less than minimum capability of the pump do not

allow the water level to fall to the intake level (if the static water level is above the screen, avoid lowering the water level into the screen). Shut off the pump if either of the above is about to occur and allow the water level to recover. Repeat the process until field indicator parameters stabilize and the minimum purge volume is removed. The minimum purge volume with negligible drawdown (0.3 feet or less) is two saturated screen length volumes. In situations where the drawdown is greater than 0.3 feet and has stabilized, the minimum purge volume is two times the saturated screen volume plus the stabilized drawdown volume. After the minimum purge volume is attained (and field parameters have stabilized) begin sampling. For low yields wells, commence sampling as soon as the well has recovered sufficiently to collect the appropriate volume for all anticipated samples.

During well purging, monitor field indicator parameters (turbidity, temperature, specific conductance, pH, etc.) every five to ten minutes (or as appropriate). Purging is complete and sampling may begin when all field indicator parameters have stabilized (variations in values are within ten percent of each other, pH +/- 0.2 units, for three consecutive readings taken at five to ten minute intervals). If the parameters have stabilized, but turbidity remains above 5 NTU goal, decrease pump flow rate, and continue measurement of parameters every five to ten minutes. If pumping rate cannot be decreased any further and stabilized turbidity values remain above 5 NTU goal record this information. Measurements of field parameters should be obtained (as per Section 5.5) and recorded.

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			
	Water Level >25 feet				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

ATTACHMENT A

PURGING EQUIPMENT SELECTION

PAGE 2

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.

ATTACHMENT A

PURGING EQUIPMENT SELECTION

PAGE 3

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.

ATTACHMENT B

SPECIFIC CONDUCTANCE OF 1 MOLAR KCl AT VARIOUS TEMPERATURES[1]

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

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

ATTACHMENT C

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

Temperature (°C)	Dissolved Oxygen (mg/L)					
	Chloride Concentration in Water					Difference/ 100 mg Chloride
	0	5,000	10,000	15,000	20,000	
0	14.6	13.8	13.0	12.1	11.3	0.017
1	14.2	13.4	12.6	11.8	11.0	0.016
2	13.8	13.1	12.3	11.5	10.8	0.015
3	13.5	12.7	12.0	11.2	10.5	0.015
4	13.1	12.4	11.7	11.0	10.3	0.014
5	12.8	12.1	11.4	10.7	10.0	0.014
6	12.5	11.8	11.1	10.5	9.8	0.014
7	12.2	11.5	10.9	10.2	9.6	0.013
8	11.9	11.2	10.6	10.0	9.4	0.013
9	11.6	11.0	10.4	9.8	9.2	0.012
10	11.3	10.7	10.1	9.6	9.0	0.012
11	11.1	10.5	9.9	9.4	8.8	0.011
12	10.8	10.3	9.7	9.2	8.6	0.011
13	10.6	10.1	9.5	9.0	8.5	0.011
14	10.4	9.9	9.3	8.8	8.3	0.010
15	10.2	9.7	9.1	8.6	8.1	0.010
16	10.0	9.5	9.0	8.5	8.0	0.010
17	9.7	9.3	8.8	8.3	7.8	0.010
18	9.5	9.1	8.6	8.2	7.7	0.009
19	9.4	8.9	8.5	8.0	7.6	0.009
20	9.2	8.7	8.3	7.9	7.4	0.009
21	9.0	8.6	8.1	7.7	7.3	0.009
22	8.8	8.4	8.0	7.6	7.1	0.008
23	8.7	8.3	7.9	7.4	7.0	0.008
24	8.5	8.1	7.7	7.3	6.9	0.008
25	8.4	8.0	7.6	7.2	6.7	0.008

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

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

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

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1.0 PURPOSE

The purpose of this Standard Operating Procedure (SOP) is to identify and designate the field data record forms, logs and reports generally initiated and maintained for documenting Tetra Tech NUS field activities.

2.0 SCOPE

Documents presented within this procedure (or equivalents) shall be used for all Tetra Tech NUS field activities, as applicable. Other or additional documents may be required by specific client contracts or project planning documents.

3.0 GLOSSARY

None

4.0 RESPONSIBILITIES

Project Manager (PM) - The Project Manager is responsible for obtaining hardbound, controlled-distribution logbooks (from the appropriate source), as needed. In addition, the Project Manager is responsible for placing all field documentation used in site activities (i.e., records, field reports, sample data sheets, field notebooks, and the site logbook) in the project's central file upon the completion of field work.

Field Operations Leader (FOL) - The Field Operations Leader is responsible for ensuring that the site logbook, notebooks, and all appropriate and current forms and field reports illustrated in this guideline (and any additional forms required by the contract) are correctly used, accurately filled out, and completed in the required time-frame.

5.0 PROCEDURES

5.1 Site Logbook

5.1.1 General

The site logbook is a hard-bound, paginated, controlled-distribution record book in which all major onsite activities are documented. At a minimum, the following activities/events shall be recorded or referenced (daily) in the site logbook:

- All field personnel present
- Arrival/departure of site visitors
- Arrival/departure of equipment
- Start and/or completion of borehole, trench, monitoring well installation, etc.
- Daily onsite activities performed each day
- Sample pickup information
- Health and Safety issues (level of protection observed, etc.)
- Weather conditions

A site logbook shall be maintained for each project. The site logbook shall be initiated at the start of the first onsite activity (e.g., site visit or initial reconnaissance survey). Entries are to be made for every day that onsite activities take place which involve Tetra Tech NUS or subcontractor personnel. Upon completion of the fieldwork, the site logbook must become part of the project's central file.

The following information must be recorded on the cover of each site logbook:

- Project name
- Tetra Tech NUS project number
- Sequential book number
- Start date
- End date

Information recorded daily in the site logbook need not be duplicated in other field notebooks (see Section 5.2), but must summarize the contents of these other notebooks and refer to specific page locations in these notebooks for detailed information (where applicable). An example of a typical site logbook entry is shown in Attachment A.

If measurements are made at any location, the measurements and equipment used must either be recorded in the site logbook or reference must be made to the field notebook in which the measurements are recorded (see Attachment A).

All logbook, notebook, and log sheet entries shall be made in indelible ink (black pen is preferred). No erasures are permitted. If an incorrect entry is made, the data shall be crossed out with a single strike mark, and initialed and dated. At the completion of entries by any individual, the logbook pages used must be signed and dated. The site logbook must also be signed by the Field Operations Leader at the end of each day.

5.1.2 Photographs

When movies, slides, or photographs are taken of a site or any monitoring location, they must be numbered sequentially to correspond to logbook/notebook entries. The name of the photographer, date, time, site location, site description, and weather conditions must be entered in the logbook/notebook as the photographs are taken. A series entry may be used for rapid-sequence photographs. The photographer is not required to record the aperture settings and shutter speeds for photographs taken within the normal automatic exposure range. However, special lenses, films, filters, and other image-enhancement techniques must be noted in the logbook/notebook. If possible, such techniques shall be avoided, since they can adversely affect the accuracy of photographs. Chain-of-custody procedures depend upon the subject matter, type of film, and the processing it requires. Film used for aerial photography, confidential information, or criminal investigation require chain-of-custody procedures. Once processed, the slides of photographic prints shall be consecutively numbered and labeled according to the logbook/notebook descriptions. The site photographs and associated negatives must be docketed into the project's central file.

5.2 Field Notebooks

Key field team personnel may maintain a separate dedicated field notebook to document the pertinent field activities conducted directly under their supervision. For example, on large projects with multiple investigative sites and varying operating conditions, the Health and Safety Officer may elect to maintain a separate field notebook. Where several drill rigs are in operation simultaneously, each site geologist assigned to oversee a rig must maintain a field notebook.

5.3 Sample Forms

A summary of the forms illustrated in this procedure is shown as the listing of Attachments in the Table of Contents for this SOP. Forms may be altered or revised for project-specific needs contingent upon client

approval. Care must be taken to ensure that all essential information can be documented. Guidelines for completing these forms can be found in the related sampling SOP.

5.3.1 Sample Collection, Labeling, Shipment, Request for Analysis, and Field Test Results

5.3.1.1 Sample Log Sheet

Sample Log Sheets are used to record specified types of data while sampling. Attachments B-1 to B-4 are examples of Sample Log Sheets. The data recorded on these sheets are useful in describing the waste source and sample as well as pointing out any problems, difficulties, or irregularities encountered during sampling. A log sheet must be completed for each sample obtained, including field quality control (QC) samples.

5.3.1.2 Sample Label

A typical sample label is illustrated in Attachment B-5. Adhesive labels must be completed and applied to every sample container. Sample labels can usually be obtained from the appropriate Program source electronically generated in-house, or are supplied from the laboratory subcontractor.

5.3.1.3 Chain-of-Custody Record Form

The Chain-of-Custody (COC) Record is a multi-part form that is initiated as samples are acquired and accompanies a sample (or group of samples) as they are transferred from person to person. This form must be used for any samples collected for chemical or geotechnical analysis whether the analyses are performed on site or off site. One carbonless copy of the completed COC form is retained by the field crew, one copy is sent to the Project Manager, while the original is sent to the laboratory. The original (top, signed copy) of the COC form shall be placed inside a large Ziploc-type bag and taped inside the lid of the shipping cooler. If multiple coolers are sent but are included on one COC form, the COC form should be sent with the first cooler. The COC form should then state how many coolers are included with that shipment. An example of a Chain-of-Custody Record form is provided as Attachment B-6. Once the samples are received at the laboratory, the sample cooler and contents are checked and any problems are noted on the enclosed COC form (any discrepancies between the sample labels and COC form and any other problems that are noted are resolved through communication between the laboratory point-of-contact and the Tetra Tech NUS Project Manager). The COC form is signed and copied. The laboratory will retain the copy while the original becomes part of the samples' corresponding analytical data package.

5.3.1.4 Chain-of-Custody Seal

Attachment B-7 is an example of a custody seal. The Custody seal is an adhesive-backed label. It is part of a chain-of-custody process and is used to prevent tampering with samples after they have been collected in the field and sealed in coolers for transport to the laboratory. The COC seals are signed and dated by the samplers and affixed across the opening edges of each cooler containing environmental samples. COC seals may be available from the laboratory; these seals may also be purchased from a supplier.

5.3.1.5 Field Analytical Log Sheets for Geochemical Parameters

Field Analytical Log Sheets (Attachment B-8) are used to record geochemical and/or natural attenuation field test results. Attachments B-8 (3-page form) should be used when applicable.

5.3.2 Hydrogeological and Geotechnical Forms

5.3.2.1 Groundwater Level Measurement Sheet

A groundwater level measurement sheet, shown in Attachment C-1 must be filled out for each round of water level measurements made at a site.

5.3.2.2 Data Sheet for Pumping Test

During the performance of a pumping test (or an in-situ hydraulic conductivity test), a large amount of data must be recorded, often within a short time period. The pumping test data sheet (Attachment C-2) facilitates this task by standardizing the data collection format, and allowing the time interval for collection to be laid out in advance.

5.3.2.3 Packer Test Report Form

A packer test report form shown in Attachment C-3 must be completed for each well upon which a packer test is conducted.

5.3.2.4 Summary Log of Boring

During the progress of each boring, a log of the materials encountered, operation and driving of casing, and location of samples must be kept. The Summary Log of Boring, or Boring Log, (Attachment C-4) is used for this purpose and must be completed for each soil boring performed. In addition, if volatile organics are monitored on cores, samples, cuttings from the borehole, or breathing zone, (using a PID or FID), these results must be entered on the boring log at the appropriate depth. The "Remarks" column can be used to subsequently enter the laboratory sample number, the concentration of key analytical results, or other pertinent information. This feature allows direct comparison of contaminant concentrations with soil characteristics.

5.3.2.5 Monitoring Well Construction Details Form

A Monitoring Well Construction Details Form must be completed for every monitoring well, piezometer, or temporary well point installed. This form contains specific information on length and type of well riser pipe and screen, backfill, filter pack, annular seal and grout characteristics, and surface seal characteristics. This information is important in evaluating the performance of the monitoring well, particularly in areas where water levels show temporal variation, or where there are multiple (immiscible) phases of contaminants. Depending on the type of monitoring well (in overburden or bedrock), different forms are used (see Attachments C-5 through C-9). Similar forms are used for flush-mount well completions.

5.3.2.6 Test Pit Log

When a test pit or trench is constructed for investigative or sampling purposes, a Test Pit Log (Attachment C-10) must be filled out by the responsible field geologist or sampling technician.

5.3.2.7 Miscellaneous Monitoring Well Forms

Monitoring Well Materials Certificate of Conformance (Attachment C-11) should be used as the project directs to document all materials utilized during each monitoring well installation.

The Monitoring Well Development Record (Attachment C-12) should be used as the project directs to document all well development activities.

5.3.3 Equipment Calibration and Maintenance Form

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

Each instrument requiring calibration has its own Equipment Calibration Log (Attachment D) which documents that the manufacturer's instructions were followed for calibration of the equipment, including frequency and type of standard or calibration device. An Equipment Calibration Log must be maintained for each electronic measuring device used in the field; entries must be made for each day the equipment is used.

5.4 Field Reports

The primary means of recording onsite activities is the site logbook. Other field notebooks may also be maintained. These logbooks and notebooks (and supporting forms) contain detailed information required for data interpretation or documentation, but are not easily useful for tracking and reporting of progress. Furthermore, the field logbook/notebooks remain onsite for extended periods of time and are thus not accessible for timely review by project management.

5.4.1 Daily Activities Report

To provide timely oversight of onsite contractors, Daily Activities Reports are completed and submitted as described below.

5.4.1.1 Description

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

5.4.1.2 Responsibilities

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

5.4.1.3 Submittal and Approval

At the end of the shift, the rig geologist must submit the Daily Activities Report to the Field Operations Leader (FOL) for review and filing. The Daily Activities Report is not a formal report and thus requires no further approval. The DAR reports are retained by the FOL for use in preparing the site logbook and in preparing weekly status reports for submission to the Project Manager.

5.4.2 Weekly Status Reports

To facilitate timely review by project management, photocopies of logbook/notebook entries may be made for internal use.

It should be noted that in addition to the summaries described herein, other summary reports may also be contractually required. Attachment F is an example of a Field Trip Summary Report form.

6.0 ATTACHMENTS

Attachment A	TYPICAL SITE LOGBOOK ENTRY
Attachment B-1	EXAMPLE GROUNDWATER SAMPLE LOG SHEET
Attachment B-2	EXAMPLE SURFACE WATER SAMPLE LOG SHEET
Attachment B-3	EXAMPLE SOIL/SEDIMENT SAMPLE LOG SHEET
Attachment B-4	CONTAINER SAMPLE LOG SHEET FORM
Attachment B-5	SAMPLE LABEL
Attachment B-6	CHAIN-OF-CUSTODY RECORD FORM
Attachment B-7	CHAIN-OF-CUSTODY SEAL
Attachment B-8	FIELD ANALYTICAL LOG SHEET
Attachment C-1	EXAMPLE GROUNDWATER LEVEL MEASUREMENT SHEET
Attachment C-2	EXAMPLE PUMPING TEST DATA SHEET
Attachment C-3	PACKER TEST REPORT FORM
Attachment C-4	EXAMPLE BORING LOG
Attachment C-5	EXAMPLE OVERBURDEN MONITORING WELL SHEET
Attachment C-5A	EXAMPLE OVERBURDEN MONITORING WELL SHEET (FLUSHMOUNT)
Attachment C-6	EXAMPLE CONFINING LAYER MONITORING WELL SHEET
Attachment C-7	EXAMPLE BEDROCK MONITORING WELL SHEET - OPEN HOLE WELL
Attachment C-8	EXAMPLE BEDROCK MONITORING WELL SHEET - WELL INSTALLED IN BEDROCK
Attachment C-9	EXAMPLE BEDROCK MONITORING WELL SHEET - WELL INSTALLED IN BEDROCK (FLUSHMOUNT)
Attachment C-10	EXAMPLE TEST PIT LOG
Attachment C-11	MONITORING WELL MATERIALS CERTIFICATE OF CONFORMANCE
Attachment C-12	MONITORING WELL DEVELOPMENT RECORD
Attachment D	EXAMPLE EQUIPMENT CALIBRATION LOG
Attachment E	EXAMPLE DAILY ACTIVITIES RECORD
Attachment F	FIELD TRIP SUMMARY REPORT

ATTACHMENT A
TYPICAL SITE LOGBOOK ENTRY

START TIME: _____ DATE: _____

SITE LEADER: _____

PERSONNEL:

TtNUS	DRILLER	SITE VISITORS
_____	_____	_____
_____	_____	_____
_____	_____	_____

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

ACTIVITIES:

1. Steam jenney and fire hoses were set up.
2. Drilling activities at well ____ resumes. Rig geologist was _____. See Geologist's Notebook, No. 1, page 29-30, for details of drilling activity. Sample No. 123-21-S4 collected; see sample logbook, page 42. Drilling activities completed at 11:50 and a 4-inch stainless steel well installed. See Geologist's Notebook, No. 1, page 31, and well construction details for well _____.
3. Drilling rig No. 2 steam-cleaned at decontamination pit. Then set up at location of well _____.
4. Well _____ drilled. Rig geologist was _____. See Geologist's Notebook, No. 2, page ____ for details of drilling activities. Sample numbers 123-22-S1, 123-22-S2, and 123-22-S3 collected; see sample logbook, pages 43, 44, and 45.
5. Well _____ was developed. Seven 55-gallon drums were filled in the flushing stage. The well was then pumped using the pitcher pump for 1 hour. At the end of the hour, water pumped from well was "sand free."
6. EPA remedial project manger arrives on site at 14:25 hours.
7. Large dump truck arrives at 14:45 and is steam-cleaned. Backhoe and dump truck set up over test pit _____.
8. Test pit _____ dug with cuttings placed in dump truck. Rig geologist was _____. See Geologist's Notebook, No. 1, page 32, for details of test pit activities. Test pit subsequently filled. No samples taken for chemical analysis. Due to shallow groundwater table, filling in of test pit ___ resulted in a very soft and wet area. A mound was developed and the area roped off.
9. Express carrier picked up samples (see Sample Logbook, pages 42 through 45) at 17:50 hours. Site activities terminated at 18:22 hours. All personnel off site, gate locked.

_____

Field Operations Leader

ATTACHMENT B-1

Tetra Tech NUS, Inc.

GROUNDWATER SAMPLE LOG SHEET

Page___ of ___

Project Site Name: _____
Project No.: _____

[] Domestic Well Data
[] Monitoring Well Data
[] Other Well Type: _____
[] QA Sample Type: _____

Sample ID No.: _____
Sample Location: _____
Sampled By: _____
C.O.C. No.: _____
Type of Sample:
[] Low Concentration
[] High Concentration

SAMPLING DATA:

Date:	Color	pH	S.C.	Temp.	Turbidity	DO	Salinity	Other
Time:	(Visual)	(S.U.)	(mS/cm)	(^{0}C)	(NTU)	(mg/l)	(%)	
Method:								

PURGE DATA:

Date:	Volume	pH	S.C.	Temp.	Turbidity	DO	Salinity	Other
Method:								
Monitor Reading (ppm):								
Well Casing Diameter & Material								
Type:								
Total Well Depth (TD):								
Static Water Level (WL):								
One Casing Volume(gal/L):								
Start Purge (hrs):								
End Purge (hrs):								
Total Purge Time (min):								
Total Vol. Purged (gal/L):								

SAMPLE COLLECTION INFORMATION:

Analysis	Preservative	Container Requirements	Collected

OBSERVATIONS / NOTES:

Circle if Applicable:		Signature(s):
MS/MSD	Duplicate ID No.:	

ATTACHMENT B-2

Tetra Tech NUS, Inc.

SURFACE WATER SAMPLE LOG SHEET

Page___ of ___

Project Site Name: _____
Project No.: _____

[] Stream
[] Spring
[] Pond
[] Lake
[] Other: _____
[] QA Sample Type: _____

Sample ID No.: _____
Sample Location: _____
Sampled By: _____
C.O.C. No.: _____

Type of Sample:
[] Low Concentration
[] High Concentration

SAMPLING DATA:

	Color (Visual)	pH (S.U.)	S.C. (mS/cm)	Temp. (°C)	Turbidity (NTU)	DO (mg/l)	Salinity (%)	Other
Date:								
Time:								
Depth:								
Method:								

SAMPLE COLLECTION INFORMATION:

Analysis	Preservative	Container Requirements	Collected

OBSERVATIONS / NOTES:

MAP:

Circle if Applicable:

MS/MSD	Duplicate ID No.:

Signature(s):

ATTACHMENT B-3

Tetra Tech NUS, Inc.

SOIL & SEDIMENT SAMPLE LOG SHEET

Page___ of ___

Project Site Name: _____
Project No.: _____

[] Surface Soil
[] Subsurface Soil
[] Sediment
[] Other: _____
[] QA Sample Type: _____

Sample ID No.: _____
Sample Location: _____
Sampled By: _____
C.O.C. No.: _____

Type of Sample:
[] Low Concentration
[] High Concentration

GRAB SAMPLE DATA:

Date:	Depth Interval	Color	Description (Sand, Silt, Clay, Moisture, etc.)
Time:			
Method:			
Monitor Reading (ppm):			

COMPOSITE SAMPLE DATA:

Date:	Time	Depth Interval	Color	Description (Sand, Silt, Clay, Moisture, etc.)
Method:				
Monitor Readings (Range in ppm):				

SAMPLE COLLECTION INFORMATION:

Analysis	Container Requirements	Collected	Other

OBSERVATIONS / NOTES:

MAP:

Circle if Applicable:

MS/MSD	Duplicate ID No.:

Signature(s):

ATTACHMENT B-4

Tetra Tech NUS, Inc.

CONTAINER SAMPLE & INSPECTION SHEET

Page_____ of _____

Project Site Name: _____
Project Number: _____
Site Identification: _____
Container Number(s): _____
Sample Type: 0 Grab
0 Composite

Sample ID No. _____
Sampled By: _____
C.O.C. No. _____
Concentration: 0 High
0 Medium
0 Low

CONTAINER SOURCE	CONTAINER DESCRIPTION
DRUM: 0 Bung Top 0 Lever Lock 0 Bolted Ring 0 Other _____	**COLOR:** _____ **CONDITION:** _____
TANK: 0 Plastic 0 Metal 0 Other _____	**MARKINGS:** _____ **VOL. OF CONTENTS:** _____
OTHER: _____	**OTHER:** _____

CONTAINER DISPOSITION	CONTENTS DESCRIPTION
SAMPLED: _____ **OPENED BUT NOT SAMPLED:** Reason _____ _____ **NOT OPENED:** Reason _____ _____	**SINGLE PHASED:** _____ _____ **MULTIPHASE :** Layer 1 / Layer 2 / Layer 3 Phase (Sol. or Liq.) _____ _____ _____ Color _____ _____ _____ Viscosity L, M or H L, M or H L, M orH % of Total Volume _____ _____ _____
MONITOR READING:	**SAMPLE and /or INSPECTION DATE & TIME:** _____HRS. **METHOD:**_____
SAMPLER(S) and / or INSPECTOR(S) SIGNATURE:	**ANALYSIS:**

ATTACHMENT B-5

Tetra Tech NUS, Inc. 661 Andersen Drive Pittsburgh, 15220 (412)921-7090	**Project:** **Site:** **Location:**	
Sample No:		**Matrix:**
Date:	**Time:**	**Preserve:**
Analysis:		
Sampled by:	**Laboratory:**	

ATTACHMENT B-6

TETRA TECH NUS, INC. CHAIN OF CUSTODY | NUMBER | PAGE ____ OF _____

PROJECT NO:	SITE NAME:	PROJECT MANAGER AND PHONE NUMBER	LABORATORY NAME AND CONTACT:
SAMPLERS (SIGNATURE)		FIELD OPERATIONS LEADER AND PHONE NUMBER	ADDRESS
		CARRIER/WAYBILL NUMBER	CITY, STATE

STANDARD TAT ☐
RUSH TAT ☐
☐ 24 hr. ☐ 48 hr. ☐ 72 hr. ☐ 7 day ☐ 14 day

CONTAINER TYPE PLASTIC (P) or GLASS (G)
PRESERVATIVE USED

DATE YEAR	TIME	SAMPLE ID	MATRIX	GRAB (G) COMP (C)	No. OF CONTAINERS	TYPE OF ANALYSIS								COMMENTS

1. RELINQUISHED BY	DATE	TIME	1. RECEIVED BY	DATE	TIME
2. RELINQUISHED BY	DATE	TIME	2. RECEIVED BY	DATE	TIME
3. RELINQUISHED BY	DATE	TIME	3. RECEIVED BY	DATE	TIME

COMMENTS

DISTRIBUTION: WHITE (ACCOMPANIES SAMPLE) YELLOW (FIELD COPY) PINK (FILE COPY)

3/99
FORM NO. TtNUS-001

ATTACHMENT B-7

CHAIN-OF-CUSTODY SEAL

CUSTODY SEAL	**CUSTODY SEAL**
Date	**Date**
Signature	**Signature**

ATTACHMENT B-8

Tetra Tech NUS, Inc.

FIELD ANALYTICAL LOG SHEET
GEOCHEMICAL PARAMETERS

Page __ of __

Project Site Name: _____ Sample ID No.: _____

Project No.: _____ Sample Location: _____

Sampled By: _____ Duplicate: ☐

Field Analyst: _____ Blank: ☐

Field Form Checked as per QA/QC Checklist (initials): ☐

SAMPLING DATA:

	Color (Visual)	pH (S.U.)	S.C. (mS/cm)	Temp. (°C)	Turbidity (NTU)	DO (mg/l)	Salinity (%)	Other
Date: / Time:								
Method:								

SAMPLE COLLECTION/ANALYSIS INFORMATION:

ORP (Eh) (+/- mv):_____ Electrode Make & Model:_____

Reference Electrode (circle one): Silver-Silver Chloride / Calomel / Hydrogen

Dissolved Oxygen:

Equipment: HACH Digital Titrator OX-DT CHEMetrics (Range: _____mg/L) Analysis Time: _____

Range Used:	Range	Sample Vol.	Cartridge	Multiplier
☐	1-5 mg/L	200 ml	0.200 N	0.01
☐	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

CHEMetrics: _____mg/L

Notes:

Alkalinity: Analysis Time: _____

Equipment: HACH Digital Titrator AL-DT CHEMetrics (Range: _____mg/L) Filtered: ☐

Range Used:	Range	Sample Vol.	Cartridge	Multiplier	Titration Count	Multiplier		Concentration
☐	10-40 mg/L	100 ml	0.1600 N	0.1	_____ & _____	x 0.1	=	mg/L
☐	40-160 mg/L	25 ml	0.1600 N	0.4	_____ & _____	x 0.4	=	mg/L
☐	100-400 mg/L	100 ml	1.600 N	1.0	_____ & _____	x 1.0	=	mg/L
☐	200-800 mg/L	50 ml	1.600 N	2.0	_____ & _____	x 2.0	=	mg/L
☐	500-2000 mg/L	20 ml	1.600 N	5.0	_____ & _____	x 5.0	=	mg/L
☐	1000-4000 mg/L	10 ml	1.600 N	10.0	_____ & _____	x 10.0	=	mg/L

Parameter:	Hydroxide	Carbonate	Bicarbonate
Relationship:			

CHEMetrics: _____mg/L

Notes:

Standard Additions: ☐ Titrant Molarity:_____ Digits Required: 1st.:_____ 2nd.:_____ 3rd.:_____

Carbon Dioxide:

Equipment: HACH Digital Titrator CA-DT CHEMetrics (Range: _____mg/L) Analysis Time: _____

Range Used:	Range	Sample Vol.	Cartridge	Multiplier
☐	10-50 mg/L	200 ml	0.3636 N	0.1
☐	20-100 mg/L	100 ml	0.3636 N	0.2
☐	100-400 mg/L	200 ml	3.636 N	1.0
☐	200-1000 mg/L	100 ml	3.636 N	2.0

Titration Count			Concentration
_____	x 0.1	=	mg/L
_____	x 0.2	=	mg/L
_____	x 1.0	=	mg/L
_____	x 2.0	=	mg/L

CHEMetrics: _____mg/L

Notes:

Standard Additions: ☐ Titrant Molarity:_____ Digits Required: 1st.:_____ 2nd.:_____ 3rd.:_____

ATTACHMENT B-8 (Continued)

Tetra Tech NUS, Inc.

FIELD ANALYTICAL LOG SHEET
GEOCHEMICAL PARAMETERS

Page __ of __

Project Site Name: _____ Sample ID No.: _____

Project No.: _____ Sample Location: _____

Sampled By: _____ Duplicate: ☐

Field Analyst: _____ Blank: ☐

Field Form Checked as per QA/QC Checklist (initials): ☐

SAMPLE COLLECTION/ANALYSIS INFORMATION:

Sulfide (S^{2-}):

Equipment: DR-700 DR-8 _ _ HS-WR Color Wheel Other: _____ Analysis Time: _____

Program/Module: 610nm 93

Concentration: _____ mg/L Filtered: ☐

Notes: _____

Sulfate (SO_4^{2-}):

Equipment: DR-700 DR-8 _ _ Other: _____ Analysis Time: _____

Program/Module: 91

Concentration: _____ mg/L Filtered: ☐

Standard Solution: ☐ Results: _____

Standard Additions: ☐ Digits Required: 0.1ml:_____ 0.2ml:_____ 0.3ml:_____

Notes: _____

Nitrite (NO_2^--N):

Analysis Time: _____

Equipment: DR-700 DR-8 _ _ Other: _____ Filtered: ☐

Program/Module: 60

Concentration: _____ mg/L Reagent Blank Correction: ☐

Standard Solution: ☐ Results: ☐

Notes: _____

Nitrate (NO_3^--N):

Analysis Time: _____

Equipment: DR-700 DR-8 _ _ Other: _____ Filtered: ☐

Program/Module: 55

Concentration: _____ mg/L

Nitrite Interference Treatment: ☐

Standard Solution: ☐ Results: _____ Reagent Blank Correction: ☐

Standard Additions: ☐ Digits Required: 0.1ml:_____ 0.2ml:_____ 0.3ml:_____

Notes: _____

ATTACHMENT B-8 (Continued)

Tetra Tech NUS, Inc.

FIELD ANALYTICAL LOG SHEET
GEOCHEMICAL PARAMETERS

Page __ of __

Project Site Name: _____ Sample ID No.: _____

Project No.: _____ Sample Location: _____

Sampled By: _____ Duplicate: ☐

Field Analyst: _____ Blank: ☐

Field Form Checked as per QA/QC Checklist (initials): ☐

SAMPLE COLLECTION/ANALYSIS INFORMATION:

Manganese (Mn^{2+}):

Equipment: DR-700 DR-8 _ _ HACH MN-5 Other: _____ Analysis Time: _____

Program/Module: 525nm 41

Concentration: _____ mg/L Filtered: ☐

Digestion: ☐

Standard Solution: ☐ Results: _____ Reagent Blank Correction: ☐

Standard Additions: ☐ Digits Required: 0.1ml:_____ 0.2ml:_____ 0.3ml:_____

Notes: _____

Ferrous Iron (Fe^{2+}):

Equipment: DR-700 DR-8 _ _ IR-18C Color Wheel Other: _____ Analysis Time: _____

Program/Module: 500nm 33

Concentration: _____ mg/L Filtered: ☐

Notes: _____

Hydrogen Sulfide (H_2S):

Equipment: HS-C Other: _____ Analysis Time: _____

Concentration: _____ mg/L Exceeded 5.0 mg/L range on color chart: ☐

Notes: _____

QA/QC Checklist:

All data fields have been completed as necessary: ☐

Correct measurement units are cited in the SAMPLING DATA block: ☐

Values cited in the SAMPLING DATA block are consistent with the Groundwater Sample Log Sheet: ☐

Mulitplication is correct for each *Multiplier* table: ☐

Final calulated concentration is within the appropriate *Range Used* block: ☐

Alkalinity *Relationship* is determined appropriatly as per manufacturer (HACH) instructions: ☐

QA/QC sample (e.g., Std. Additions, etc.) frequency is appropriate as per the project planning documents: ☐

Nitrite Interference treatment was used for Nitrate test if Nitrite was detected: ☐

Title block on each page of form is initialized by person who performed this QA/QC Checklist: ☐

ATTACHMENT C-1
EXAMPLE GROUNDWATER LEVEL MEASUREMENT SHEET

Tetra Tech NUS, Inc.

GROUNDWATER LEVEL MEASUREMENT SHEET

Project Name: _____ **Project No.:** _____
Location: _____ **Personnel:** _____
Weather Conditions: _____ **Measuring Device:** _____
Tidally Influenced: Yes ___ No ___ **Remarks:** _____

Well or Piezometer Number	Date	Time	Elevation of Reference Point (feet)*	Total Well Depth (feet)*	Water Level Indicator Reading (feet)*	Thickness of Free Product (feet)*	Groundwater Elevation (feet)*	Comments

* All measurements to the nearest 0.01 foot

Page ____ of ____

ATTACHMENT C-2
EXAMPLE PUMPING TEST DATA SHEET

Tetra Tech NUS, Inc.

PUMPING TEST DATA SHEET

PROJECT NAME: _____ PUMPING WELL NUMBER: _____
PROJECT NUMBER: _____ MEASURED WELL NUMBER: _____

[ ] PUMPING TEST [ ] STEP DRAW DOWN TEST

DATE(s): MONITORING POINT:
MEASUREMENT METHOD: DEPTH CORRECTION (ft):
TEST NUMBER: PUMP SETTING (Ft. below monitoring point):
STATIC WATER LEVEL (ft): DISTANCE FROM PUMPING WELL (ft):
PERSONNEL:
REMARKS:

MILITARY TIME	ELAPSED TIME SINCE PUMP START OR STOP (Min.)	WATER LEVEL (Ft.)	CORRECTION (Ft.)	DRAW DOWN OR RECOVERY (Ft.)	PUMPING RATE (GPM)	FLOW METER READING (Gals.)	REMARKS

NOTE: All measurements to nearest 0.01 foot measured from top of well riser pipe unless otherwise noted.

ATTACHMENT C-3

ATTACHMENT C-3

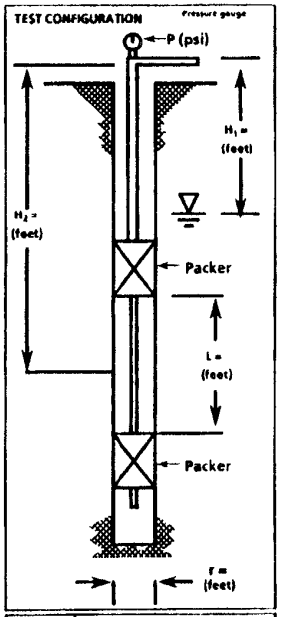
PACKER TEST REPORT FORM

PROJECT: _____ **PROJECT NO.:** _____ **TEST NO:** _____ **PAGE** ____ **OF** ____

BORING NO.: _____ **CASING DEPTH:** _____ **CONTRACTOR:** _____ **STATIC WATER LEVEL** _____

TEST INTERVAL: _____ **BY:** _____ **CHECKED:** _____ **PACKER PRESSURE** _____

Flow Test					Calculated Results							
Pressure, p (psi)	Elapsed Time (min)	Flow Reading	Δ Flow, ΔQ (ft^3)	Δ Flow, ΔQ (gal)	Flow Rate Q (gal/min)	H_1* (ft)	Hp(Ft) = 2.31·(psi)	H_2* (ft)	H = Hp + (H1 or H2)	Cp	K (ft/yr) = Cp·Q/H	K (cm/sec) = 9.67 x 10^{-7} K (ft/yr)



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

CP = (1/(2 π L)) ln(L/r) (70,315 5)
7.48 Gallons = 1 Ft^3
1 psi = 2.31 ft head

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

Remarks: _____

ATTACHMENT C-4

Tetra Tech NUS, Inc.

BORING LOG

Page ___ of ___

PROJECT NAME: _____ BORING No.: _____
PROJECT NUMBER: _____ DATE: _____
DRILLING COMPANY: _____ GEOLOGIST: _____
DRILLING RIG: _____ DRILLER: _____

Sample No. and Type or RQD	Depth (Ft.) or Run No.	Blows / 6" or RQD (%)	Sample Recovery / Sample Length	Lithology Change (Depth/Ft.) or Screened Interval	MATERIAL DESCRIPTION: Soil Density/ Consistency or Rock Hardness	Color	Material Classification	USCS *	Remarks	PID/FID Reading (ppm): Sample	Sampler BZ	Borehole**	Driller BZ**

* When rock coring, enter rock brokeness.

** Include monitor reading in 6 foot intervals @ borehole. Increase reading frequency if elevated reponse read.

Drilling Area Background (ppm): _____

Remarks: _____

Converted to Well: Yes _____ No _____ Well I.D. #: _____

ATTACHMENT C4 (Continued)

LEGEND

SOIL TERMS

UNIFIED SOIL CLASSIFICATION (USCS)

COARSE-GRAINED SOILS — More Than Half of Material is LARGER Than No. 200 Sieve Size

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

FINE-GRAINED SOILS — More Than Half of Material is SMALLER Than No. 200 Sieve Size

FIELD IDENTIFICATION PROCEDURES (Excluding Particles Larger Than 3 Inches and Basing Fractions on Estimated Weights)	Identification Procedures on Fraction Smaller than No. 40 Sieve Size: DAY STRENGTH (Crushing Characteristics)	DILATANCY (Reaction to Shaking)	TOUGHNESS (Consistency Near Plastic Limit)	GROUP SYMBOL	TYPICAL NAMES
SILTS AND CLAYS Liquid Limit <50	None to Slight	Quick to Slow	None	ML	Inorganic silts and very fine sands, rock flour, silty or clayey fine sands with slight plasticity.
	Medium to High	None to Very Slow	Medium	CL	Inorganic clays of low to medium plasticity, gravelly clays, sandy clays, silty clays, lean clays.
	Slight to Medium	Slow	Slight	OL	Organic silts and organic silt-clays of low plasticity.
SILTS AND CLAYS Liquid Limit >50	Slight to Medium	Slow to None	Slight to Medium	MH	Inorganic silts, micaceous or diatomaceous fine sandy or silty soils, elastic silts.
	High to Very High	None	High	CH	Inorganic clays of high plasticity, fat clays.
	Medium to High	None to Very Slow	Slight to Medium	OH	Organic clays of medium to high plasticity.
HIGHLY ORGANIC SOILS	Readily identified by color, odor, spongy feel and frequently by fibrous texture.			Pt	Peat and other organic soils

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

DENSITY OF GRANULAR SOILS	
DESIGNATION	STANDARD PENETRATION RESISTANCE-BLOWS/FOOT
Very Loose	0-4
Loose	5-10
Medium Loose	11-30
Dense	31-50
Very Dense	Over 50

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

ROCK TERMS

ROCK HARDNESS (FROM CORE SAMPLES)			ROCK BROKENESS		
Descriptive Terms	Screwdriver or Knife Effects	Hammer Effects	Descriptive Terms	Abbreviation	Spacing
Soft	Easily Gouged	Crushes when pressed with hammer	Very Broken	(V. Br.)	0-2"
Medium Soft	Can be Gouged	Breaks (one blow); crumbly edges	Broken	(Br.)	2"-1'
Medium Hard	Can be scratched	Breaks (one blow); sharp edges	Blocky	(Bl.)	1'-3"
Hard	Cannot be scratched	Breaks conchoidally (several blows); sharp edges	Massive	(M.)	3'-10'

LEGEND:

SOIL SAMPLES - TYPES

5-2" Split-Barrel Sample

ST-3" O.D. Undisturbed Sample
O - Other Samples, Specify in Remarks

ROCK SAMPLES - TYPES

X-NX (Conventional) Core (~2-1/8" O.D.)

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

WATER LEVELS

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

12/18

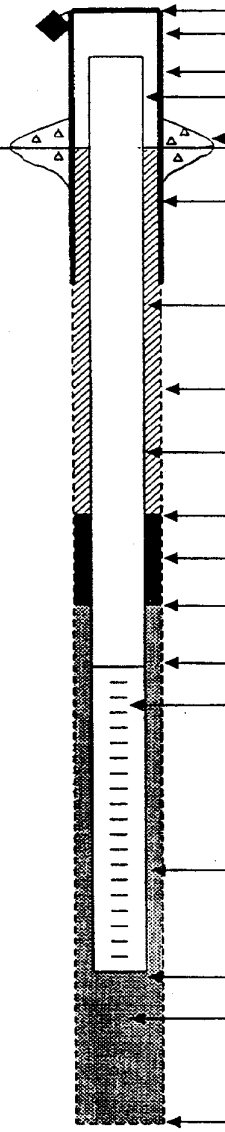
ATTACHMENT C-5
EXAMPLE OVERBURDEN MONITORING WELL SHEET

BORING NO.: _____

OVERBURDEN
MONITORING WELL SHEET

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

DRILLER _____
DRILLING METHOD _____
DEVELOPMENT METHOD _____



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

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

TYPE OF SURFACE SEAL: _____

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

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

BOREHOLE DIAMETER: _____

TYPE OF BACKFILL: _____

ELEVATION / DEPTH TOP OF SEAL: _____ / _____

TYPE OF SEAL: _____

DEPTH TOP OF SAND PACK: _____

ELEVATION / DEPTH TOP OF SCREEN: _____ / _____

TYPE OF SCREEN: _____

SLOT SIZE x LENGTH: _____

I.D. OF SCREEN: _____

TYPE OF SAND PACK: _____

ELEVATION / DEPTH BOTTOM OF SCREEN: _____ / _____

ELEVATION / DEPTH BOTTOM OF SAND PACK: _____ / _____

TYPE OF BACKFILL BELOW OBSERVATION WELL: _____

ELEVATION / DEPTH OF HOLE: _____ / _____

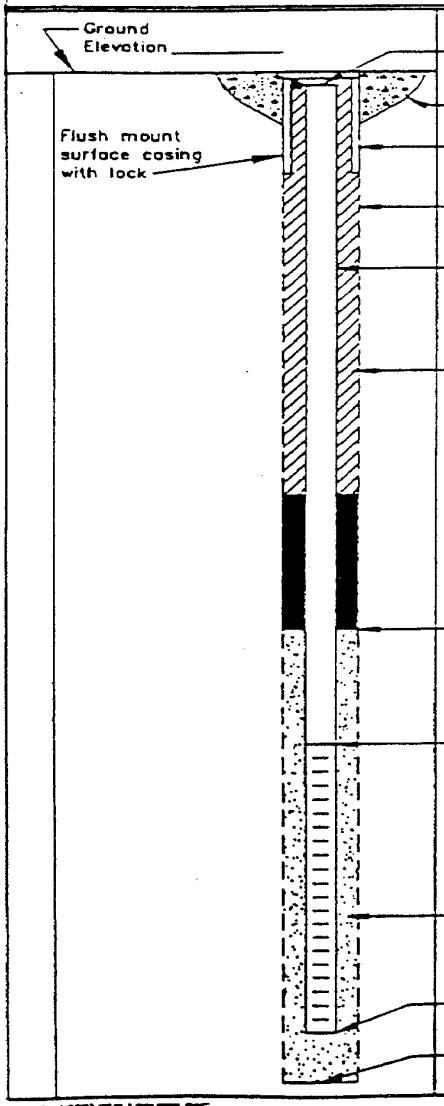
ATTACHMENT C-5A
EXAMPLE OVERBURDEN MONITORING WELL SHEET (FLUSHMOUNT)

BORING NO.: _____

MONITORING WELL SHEET

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

DRILLER _____
DRILLING METHOD _____
DEVELOPMENT METHOD _____



ELEVATION TOP OF RISER: _____

TYPE OF SURFACE SEAL: _____

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

DIAMETER OF HOLE: _____

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

TYPE OF BACKFILL/SEAL: _____
_____

DEPTH/ELEVATION TOP OF SAND: _____/_____

DEPTH/ELEVATION TOP OF SCREEN: _____/_____
TYPE OF SCREEN: _____
SLOT SIZE x LENGTH: _____

TYPE OF SAND PACK: _____

DIAMETER OF HOLE IN BEDROCK: _____

DEPTH/ELEVATION BOTTOM OF SCREEN: _____/_____
DEPTH/ELEVATION BOTTOM OF SAND: _____/_____
DEPTH/ELEVATION BOTTOM OF HOLE: _____/_____
BACKFILL MATERIAL BELOW SAND: _____

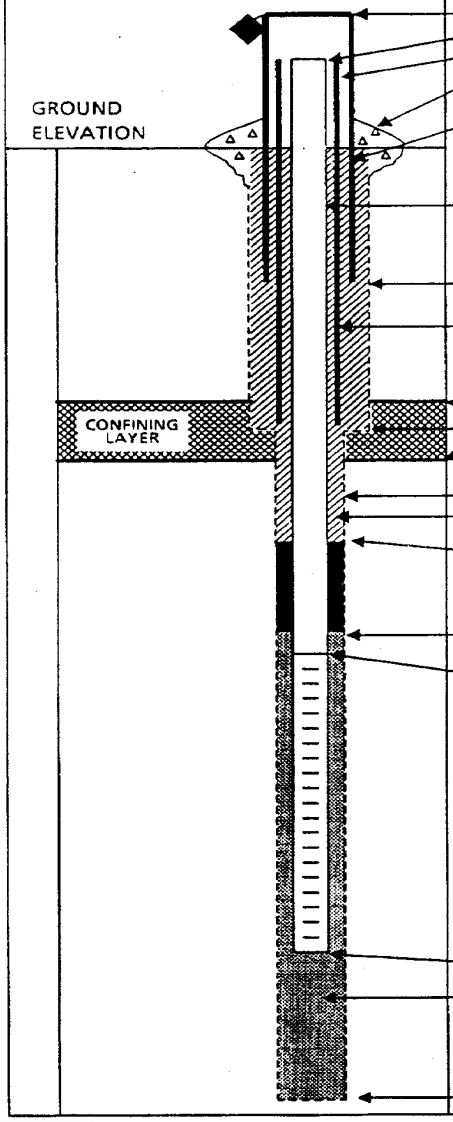
ATTACHMENT C-6
EXAMPLE CONFINING LAYER MONITORING WELL SHEET

BORING NO.: _____

CONFINING LAYER
MONITORING WELL SHEET

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

DRILLER _____
DRILLING METHOD _____
DEVELOPMENT METHOD _____



ELEVATION OF TOP OF SURFACE CASING : _____
ELEVATION OF TOP OF RISER PIPE: _____
ELEVATION TOP OF PERM. CASING: _____
TYPE OF SURFACE SEAL: _____

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

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

BOREHOLE DIAMETER: _____

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

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

BOREHOLE DIA. BELOW CASING: _____
TYPE OF BACKFILL: _____

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

DEPTH TOP OF SAND PACK: _____

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

TYPE OF SAND PACK: _____

ELEVATION / DEPTH BOTTOM OF SCREEN: _____

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

ELEVATION / DEPTH OF HOLE: _____

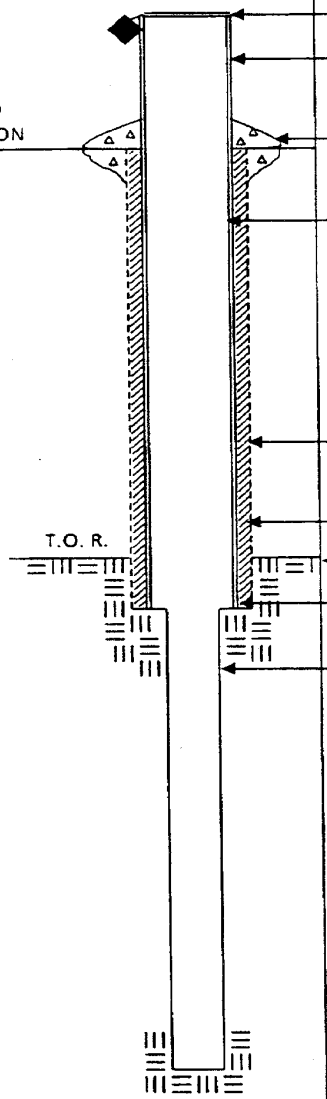
ATTACHMENT C-7
EXAMPLE BEDROCK MONITORING WELL SHEET - OPEN HOLE WELL

BORING NO.: _____

BEDROCK
MONITORING WELL SHEET
OPEN HOLE WELL

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

DRILLER _____
DRILLING METHOD _____
DEVELOPMENT METHOD _____



ELEVATION OF TOP OF CASING: _____

STICK UP OF CASING ABOVE GROUND SURFACE: _____

TYPE OF SURFACE SEAL: _____

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

TEMP. / PERM.: _____

DIAMETER OF HOLE: _____

TYPE OF CASING SEAL: _____

DEPTH TO TOP OF ROCK: _____

DEPTH TO BOTTOM CASING: _____

DIAMETER OF HOLE IN BEDROCK: _____

DESCRIBE IF CORE / REAMED WITH BIT:

_____
_____
_____

DESCRIBE JOINTS IN BEDROCK AND DEPTH:

_____
_____
_____

ELEVATION / DEPTH OF HOLE: _____ / _____

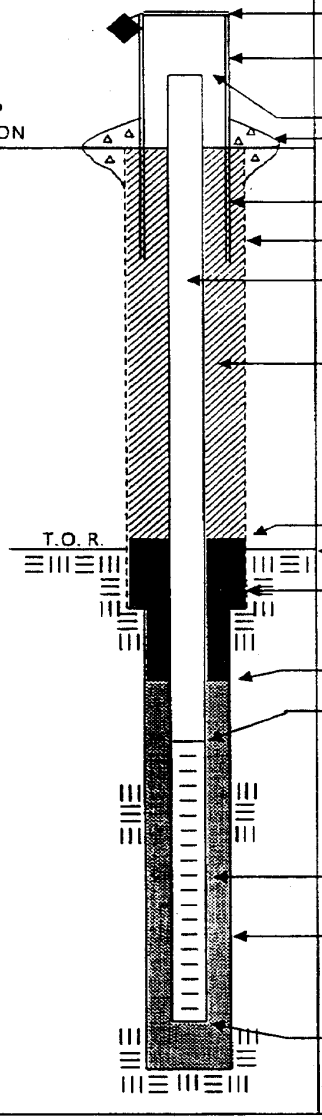
ATTACHMENT C-8
EXAMPLE BEDROCK MONITORING WELL SHEET - WELL INSTALLED IN BEDROCK

BORING NO.: _____

BEDROCK
MONITORING WELL SHEET
WELL INSTALLED IN BEDROCK

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

DRILLER _____
DRILLING METHOD _____
DEVELOPMENT METHOD _____



ELEVATION OF TOP OF SURFACE CASING: _____

STICK UP OF CASING ABOVE GROUND SURFACE: _____

ELEVATION TOP OF RISER: _____

TYPE OF SURFACE SEAL: _____

I.D. OF SURFACE CASING: _____

DIAMETER OF HOLE: _____

RISER PIPE I.D.: _____

TYPE OF RISER PIPE: _____

TYPE OF BACKFILL: _____

ELEVATION / DEPTH TOP OF SEAL: ____/____

ELEVATION / DEPTH TOP OF BEDROCK: ____/____

TYPE OF SEAL: _____

ELEVATION / DEPTH TOP OF SAND: ____/____

ELEVATION / DEPTH TOP OF SCREEN: ____/____

TYPE OF SCREEN: _____

SLOT SIZE x LENGTH: _____

I.D. SCREEN: _____

TYPE OF SAND PACK: _____

DIAMETER OF HOLE IN BEDROCK:

CORE / REAM: _____

ELEVATION / DEPTH BOTTOM SCREEN: ____/____

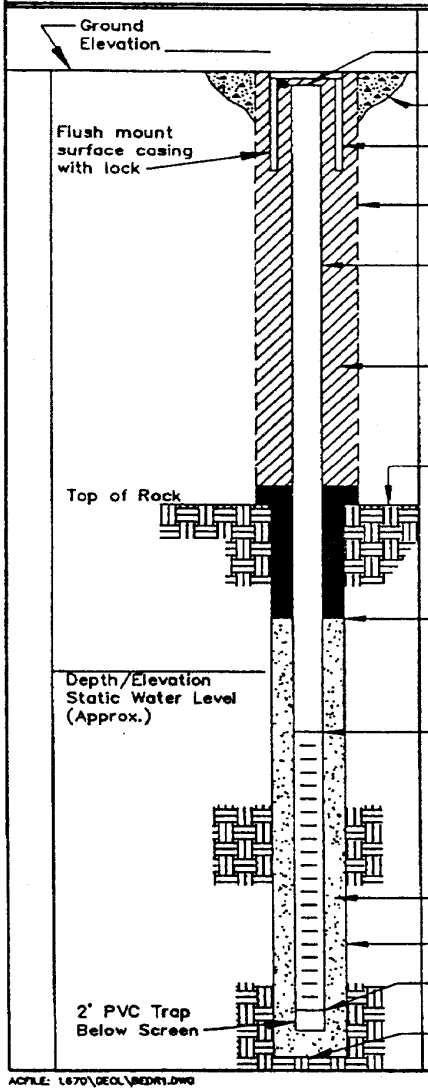
ELEVATION / DEPTH BOTTOM OF HOLE: ____/____

ATTACHMENT C-9
EXAMPLE BEDROCK MONITORING WELL SHEET
WELL INSTALLED IN BEDROCK (FLUSHMOUNT)

BORING NO.: _____

BEDROCK
MONITORING WELL SHEET
WELL INSTALLED IN BEDROCK

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



ELEVATION TOP OF RISER: _____
TYPE OF SURFACE SEAL: _____
TYPE OF PROTECTIVE CASING: _____
I.D. OF PROTECTIVE CASING: _____
DIAMETER OF HOLE: _____
TYPE OF RISER PIPE: _____
RISER PIPE I.D.: _____
TYPE OF BACKFILL/SEAL: _____
_____
DEPTH/ELEVATION TOP OF BEDROCK: _____/_____
DEPTH/ELEVATION TOP OF SAND: _____/_____
DEPTH/ELEVATION TOP OF SCREEN: _____/_____
TYPE OF SCREEN: _____
SLOT SIZE x LENGTH: _____
TYPE OF SAND PACK: _____
DIAMETER OF HOLE IN BEDROCK: _____
DEPTH/ELEVATION BOTTOM OF SCREEN: _____/_____
DEPTH/ELEVATION BOTTOM OF SAND: _____/_____
DEPTH/ELEVATION BOTTOM OF HOLE: _____/_____
BACKFILL MATERIAL BELOW SAND: _____

ACFILE: L670\GEOL\BEDR1.DWG

ATTACHMENT C-10
EXAMPLE TEST PIT LOG

TEST PIT LOG

Tetra Tech NUS, Inc.

PROJECT: _____ TEST PIT NO.:

PROJECT NO _____ DATE: _____

LOCATION: _____

FIELD GEOLOGIST: _____

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

Test Pit Cross Section and / or Plan View

REMARKS _____

PHOTO LOG _____ TEST PIT _____

PAGE ____ OF ____

ATTACHMENT C-11
EXAMPLE CERTIFICATE OF CONFORMANCE

MONITORING WELL MATERIALS
CERTIFICATE OF CONFORMANCE

Well Designation: _____ Site Geologist: _____
Site Name: _____ Drilling Company: _____
Date Installed: _____ Driller: _____
Project Name: _____ Project Number: _____

Material	Brand/Description	Source/Supplier	Sample Collected ?
Well Casing			
Well Screen			
End Cap			
Drilling Fluid			
Drilling Fluid Additives			
Backfill Material			
Annular Filter Pack			
Bentonite Seal			
Annular Grout			
Surface Cement			
Protective Casing			
Paint			
Rod Lubricant			
Compressor Oil			

To the best of my knowledge, I certify that the above described materials were used during installation of this monitoring well.

Signature of Site Geologist: _____

ATTACHMENT C-12
EXAMPLE MONITORING WELL DEVELOPMENT RECORD

Tetra Tech NUS, Inc.

MONITORING WELL DEVELOPMENT RECORD

Page ___ of _____

Site: _____ Depth to Bottom (ft.): _____ Project Name: _____
Well: _____ Static Water Level Before (ft.): _____ Project Number: _____
Date Installed: _____ Static Water Level After (ft.): _____ Site Geologist: _____
Date Developed: _____ Screen Length (ft.): _____ Drilling Co.: _____
Dev. Method: _____ Specific Capacity: _____
Pump Type: _____ Casing ID (in.): _____

Time	Estimated Sediment Thickness (Ft.)	Cumulative Water Volume (Gal.)	Water Level Readings (Ft. below TOC)	Temperature (Degrees C)	pH	Specific Conductance (Units _____)	Turbidity (NTU)	Remarks (odor, color, etc.)

ATTACHMENT D
EXAMPLE EQUIPMENT CALIBRATION LOG

Tetra Tech NUS, Inc.

EQUIPMENT CALIBRATION LOG

PROJECT NAME : _____

SITE NAME: _____

PROJECT No.: _____

INSTRUMENT NAME/MODEL: _____

MANUFACTURER: _____

SERIAL NUMBER: _____

Date of Calibration	Instrument I.D. Number	Person Performing Calibration	Instrument Settings		Instrument Readings		Calibration Standard (Lot No.)	Remarks and Comments
			Pre-calibration	Post-calibration	Pre-calibration	Post-calibration		

ATTACHMENT E

Tetra Tech NUS, Inc.

DAILY ACTIVITIES RECORD

PROJECT NAME: _____ **PROJECT NUMBER:** _____

CLIENT: _____ **LOCATION:** _____

DATE: _____ **ARRIVAL TIME:** _____

Tt NUS PERSONNEL: _____ **DEPARTURE TIME:** _____

CONTRACTOR: _____ **DRILLER:** _____

ITEM	QUANTITY ESTIMATE	QUANTITY TODAY	PREVIOUS TOTAL QUANTITY	CUMULATIVE QUANTITY TO DATE

COMMENTS: _____

APPROVED BY:

_____ _____

Tt NUS REPRESENTATIVE DRILLER

DATE: _____

ATTACHMENT F
FIELD TRIP SUMMARY REPORT
PAGE 1 OF 2

SUNDAY

Date: _____ Personnel: _____
Weather: _____ Onsite: _____

Site Activities: _____
_____
_____
_____

MONDAY

Date: _____ Personnel: _____
Weather: _____ Onsite: _____

Site Activities: _____
_____
_____
_____

TUESDAY

Date: _____ Personnel: _____
Weather: _____ Onsite: _____

Site Activities: _____
_____
_____
_____

WEDNESDAY

Date: _____ Personnel: _____
Weather: _____ Onsite: _____

Site Activities: _____
_____
_____
_____

ATTACHMENT F
PAGE 2 OF 2
FIELD TRIP SUMMARY REPORT

THURSDAY

Date: _____ Personnel: _____

Weather: _____ Onsite: _____

Site Activities: _____

_____

_____

_____

FRIDAY

Date: _____ Personnel: _____

Weather: _____ Onsite: _____

Site Activities: _____

_____

_____

_____

SATURDAY

Date: _____ Personnel: _____

Weather: _____ Onsite: _____

Site Activities: _____

_____

_____

_____

APPENDIX B

EPA REGION IV RECOMMENDED CONTAINERS, HOLDING TIMES, AND PRESERVATION

APPENDIX B
USEPA REGION IV RECOMMENDED CONTAINERS, HOLDING TIMES, & PRESERVATION

ANALYTICAL GROUP	Soil/Sediment			Water/Wastewater[1]			Waste		
	Cont	Pres	Hold	Cont	Pres	Hold	Cont	Pres	Hold
BIOLOGICAL									
Bacteriological*	--	--	--	B	I	6hr	--	--	--
Toxicity, Acute	--	--	--	CU	I	2	--	--	--
Toxicity, Chronic	--	--	--	CU	I	2	--	--	--
INORGANICS									
pH*	8G	NA	--	--	--	--	8G	NA	N
Dermal Corrosion	--	--	--	--	--	--	8G	NA	N
Flashpoint	--	--	--	--	--	--	8G	NA	N
BTU Content	--	--	--	--	--	--	8G	NA	N
Ash Content	--	--	--	--	--	--	8G	NA	N
Residual Chlorine*	--	--	--	SM	NA	I	--	--	--
Turbidity	--	--	--	SM	I	2	--	--	--
Conductivity	--	--	--	SM	I	28[11]	--	--	--
Temperature*	--	--	--	SM	NA	I	--	--	--
BOD5	--	--	--	HP[2]	I	2	--	--	--
Solids Series	--	--	--	HP	I	7	--	--	--
Settleable Solids	--	--	--	HP	I	2	--	--	--
Nutrients (N,P)	8G	I	NS	HP	S/I	28	--	--	--
Chloride	--	--	--	LP	NA	28	--	--	--
Ortho-P	8G	I	NS	LP	I[4]	2	--	--	--
Dissolved P	--	--	--	LP	S[4]/I	28	--	--	--
COD	8G	I	NS	LP	S/I	28	--	--	--
Alkalinity	--	--	--	LP	I	14	--	--	--
Color	--	--	--	GP	I	2	--	--	--
Oil & Grease*	--	--	--	LG	S/I	28	--	--	--
Metals	8G	I	180	LP	N	180	8G	NA	180

ANALYTICAL GROUP	Soil/Sediment			Water/Wastewater[1]			Waste		
	Cont	Pres	Hold	Cont	Pres	Hold	Cont	Pres	Hold
Mercury	8G	I	180	LP	N	28	8G	NA	180
Metals - TCLP	8G	I	360[12]	LP	I	360[12]	8G	NA	360[12]
Metals - EP	8G	I	360[12]	LP	I	360[12]	8G	NA	360[12]
Cromium VI	--	--	--	LP	I	1	--	--	--
Cyanide	--	--	--	LP	A[5]/C[6]/I	14	8G	NA	14
Sulfides	--	--	--	LP	Z/C[7]/I	7	--	--	--
Sulfates	--	--	--	LP	I	28	--	--	--
Nitrite	--	--	--	LP	I	2	--	--	--
Nitrate	--	--	--	HP	I	2	--	--	--
Hardness	--	--	--	LP	N	180	--	--	--
Fluoride	--	--	--	LP	NA	28	--	--	--
ORGANICS									
VOCs*	2G	I	14	V	H or B[8]/I	14/7[16]	8G	NA	14
VOCs - TCLP*	2G	I	28[13]	V	I	28[13]	8G	NA	28[13]
Extractables[19]	8G	I	54[18]	GG	I[9]	47[17]	8G	NA	54[18]
Extractables - TCLP	8G	I	61[14]	GG	I	61[14]	8G	NA	61[14]
Dioxins[20]	8G	I	75[15]	LA[3]	I[10]	75[15]	8G	I	75[19]
Percent Alcohol	8G	I	NS	GG	I	NS	8G	NA	NS
Phenols	--	--	--	LA	F/S/I	28	--	--	--
Org Halide (TOX)	8G	I	28	LA	S/I	28	--	--	--

General Footnotes:

Cont - Container
Pres - Preservation
Hold - Holding Time (days)
* - Grab sample only, unless indicated a grab or composite is acceptable.
1 - Consult 40 CFR Part 136 Table II. - Required Containers, Preservation Techniques, and Holding Times for latest requirements.
19 - Including pesticides, herbicides and PCBs
20 - Consult local laboratory for most recent dioxin container and preservation requirements.

Containers:

B - Bateriological container
CU - Cubitainer: one gallon or 2 gallon
8G - 8 oz. widemouth glass (Teflon lid)
2G - 2 oz. widemouth glass (Teflon septum lid)
LP - One liter polyethylene
GG - One gallon amber glass (Teflon lid)
V - 40 ml glass (Teflon septum lid)
SM - Stormore 500 ml polyethylene
LG - One liter widemouth glass (Teflon lid)
GP - Gallon polyethylene
HP - Half-gallon polyethylene
LA - One liter amber glass (Teflon lid)
A - 500 ml widemouth amber glass (Teflon lid)
2 - Use GP for BOD with multiple parameters
3 - Collect 2 sample containers (LA) per sample plus 4 at one location for matrix spike

Preservatives:

A - Ascorbic acid
B - Sodium bisulfite
C - NaOH
H - HCl 50%
I - Ice (4^oC)
N - 50% HNO_3 (pH < 2.0 S.U.)
NA - Not applicable
S - 50% H_2SO_4 (pH < 2.0 S.U.)
Z - Zinc acetate
F - Ferrous Salt
4 - Filter on-site
5 - Only with residual CL_2
6 - To pH > 12.0 S.U.
7 - To pH > 9.0 S.U.
8 - With residual CL_2 mix sample in 8 oz. glass container with 8 drops 25% ascorbic acid
9 - With residual CL_2 mix sample with 0.008% sodium thiosulfate
10 - With residual CL_2 mix sample with 80 mg of sodium thiosulfate per liter

Holding Times: in days unless noted otherwise:

NS - Not Specified
N - Indefinate
I - Immediate (within 15 minutes: 40 CFR 136 Table II)
11 - Determine on-site if possible
12 - 360 days: 180 days to extraction plus 180 days to analysis
13 - 28 days: 14 days to TCLP extraction plus 14 days to analysis (7 days if not preserved following extraction)
14 - 61 days: 14 days to TCLP extraction, 7 days to solvent extraction, 40 days to analysis
15 - Method 8290 specifies 30 days to extraction plus 45 days to analysis
16 - 14 days with either acid preservative, 7 days if not preserved
17 - 47 days: 7 days to extraction, 40 days to analysis
18 - 54 days: 14 days to extraction, 40 days to analysis

Shipping Note:

When samples are to be shipped by common carrier or sent through the United States mail, it must comply with the Department of Transportation Hazardous Materials Regulations (49 CFR 172). The person offering such material for transportation is responsible for ensuring such compliance. For the preservation requirements of 40 CFR, Part 136, Table II, the Office of Hazardous Materials, Materials Transportation Bureau, Department of Transportation has determined that the Hazardous Materials Regulations do not apply to the following materials: Hydrochloric Acid (HCL) in water solutions at concentrations of 0.04% by weight or less (pH about 1.96 or greater); Nitric acid ($HN0_3$) in water solutions at concentrations of 0.15% by weight or less (pH about 1.62 or greater); Sulfuric acid (H_2SO_4) in water solutions at concentrations of 0.35% by weight or less (pH about 1.15 or greater); and Sodium Hydroxide (NaOH) in water solutions at concentrations of 0.08% by weight or less (pH about 12.30 or less). This footnote is wholly reproduced from 40 CFR 136.3, which is definitive.

APPENDIX C

HEALTH AND SAFETY PLAN

Health and Safety Plan

For

RCRA Facility Assessment Work Plan

Naval Air Facility Key West

Key West, Florida

Southern Division
Naval Facilities Engineering Command

Contract No. N62467-94-D-0888
Contract Task Order 0188

April 2002

HEALTH AND SAFETY PLAN

FOR

RCRA FACILITY ASSESSMENT WORK PLAN

NAVAL AIR FACILITY KEY WEST
KEY WEST, FLORIDA

COMPREHENSIVE LONG-TERM
ENVIRONMENTAL ACTION NAVY CONTRACT

SUBMITTED TO:

SOUTHERN DIVISION
NAVAL FACILITIES ENGINEERING COMMAND
2155 EAGLE DRIVE
NORTH CHARLESTON, SOUTH CAROLINA 29406

SUBMITTED BY:

TETRA TECH NUS
661 ANDERSEN DRIVE
FOSTER PLAZA 7
PITTSBURGH, PENNSYLVANIA 15220

CONTRACT NO. N62467-94-D-0888
CONTRACT TASK ORDER 0188

April 2002

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1.0 INTRODUCTION

This Health and Safety Plan (HASP) has been developed to provide practices and procedures for Tetra Tech NUS, Inc. (TtNUS) and subcontractor personnel engaged in Tar Tank Spill Area and the Former Boca Chica Blast Media Disposal Area at the Naval Air Facility (NAF) Key West, located on Boca Chica Key, Florida.. This HASP is part of an overall effort conducted under Comprehensive Long-Term Environmental Action Navy (CLEAN III) administered through the U.S. Navy Southern Division Naval Facilities Engineering Command (NAVFAC), as defined under Contract Number N62467-94-D-0888. In addition to the HASP, a copy of the Tetra Tech NUS, Inc. (TtNUS) Environmental Health and Safety Guidance Manual must be present at the site during the performance of site activities. The Guidance Manual provides detailed information pertaining to the HASP, as well as TtNUS Standard Operating Procedures (SOP's). Both documents must be present at the site to comply with the requirements stipulated in the Occupational Safety and Health Administration (OSHA) standard 29 CFR 1910.120.

This HASP has been developed using the latest available information regarding known or suspected chemical contaminants and potential physical hazards associated with the proposed work and site. The HASP will be modified if new information becomes available. All changes to the HASP will be made by the Project Health & Safety Officer (PHSO) and approved by the TtNUS Health and Safety Manager (HSM) and the Task Order Manager (TOM). The TOM will notify affected personnel of all changes.

The elements of this HASP are in compliance with the requirements established by OSHA 29 CFR 1910.120, "Hazardous Waste Operations and Emergency Response" (HAZWOPER), and sections of 29 CFR 1926, "Safety and Health Regulations for Construction". The information contained in this plan, as well as policies on conducting onsite operations, have been obtained from the TtNUS Health and Safety Program.

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1.1 KEY PROJECT PERSONNEL AND ORGANIZATION

This section defines responsibility for site safety and health for TtNUS and subcontractor employees engaged in onsite activities. engaged in onsite activities. Personnel assigned to these positions will exercise the primary responsibility for all onsite health and safety. These persons will be the primary points of contact for any questions regarding the safety and health procedures and the selected control measures that are to be implemented for onsite activities. that are to be implemented for onsite activities.

- The TtNUS TOM is responsible for the overall direction project. of health and safety for this project.

- The PHSO is responsible for developing this HASP in accordance with applicable OSHA regulations. Specific responsibilities include:

  i. Providing information regarding site contaminants and physical hazards associated with the site.
  ii. Establishing air monitoring and decontamination procedures.
  iii. Assigning personal protective equipment based on task and potential hazards.
  iv. Determining emergency response procedures and emergency contacts.
  v. Stipulating training requirements and reviewing appropriate training and medical surveillance certificates.
  vi. Providing standard work practices to minimize potential injuries and exposures associated with hazardous waste work.
  vii. Modify this HASP, as it becomes necessary.

- The TtNUS Field Operations Leader (FOL) is responsible for implementation of the HASP with the assistance of an appointed SSO. The FOL manages field activities, executes the work plan, and enforces safety procedures as applicable to the work plan.

- The SSO supports site activities by advising the FOL on all aspects of health and safety on-site. These duties may include:

  i. Coordinates all health and safety activities with the FOL.
  ii. Selects, applies, inspects, and maintains personal protective equipment.
  iii. Establishes work zones and control points in areas of operation.
  iv. Implements air monitoring program for onsite activities.
  v. Verifies training and medical clearance of onsite personnel status in relation to site activities.
  vi. Implements Hazard Communication, Respiratory Protection Programs, and other associated health and safety programs as they may apply to site activities.
  vii. Coordinates emergency services.
  viii. Provides site-specific training for all onsite personnel.
  ix. Investigates all accidents and injuries (see Attachment I - Illness/Injury Procedure and Report Form)
  x. Provides input to the PHSO regarding the need to modify, this HASP, or applicable health and safety associated documents as per site-specific requirements.

- Compliance with the requirements stipulated in this HASP is monitored by the SSO and coordinated through the TtNUS CLEAN HSM.

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

1.2 SITE INFORMATION AND PERSONNEL ASSIGNMENTS

Site Name: Naval Air Facility (NAF) Key West **Address:** Key West, Florida

Site Point of Contact: Mr. Robert Courtright **Phone Number:** (305) 293-2881

Purpose of Site Visit: TtNUS will conduct media sampling and field activities to support RFA activities (permanent and temporary well installations and soil, surface soil, and groundwater sampling) at NAF Key West. See Sections 3.0 and 4.0 for details concerning the site background and scope of work.

Proposed Dates of Work: September 2002 – December 2002

Project Team:

Tetra Tech NUS Personnel:	**Discipline/Tasks Assigned:**
Chuck Bryan	Task Order Manager (TOM)
Emily McRee	Field Operations Leader (FOL)
Matthew M. Soltis, CIH, CSP	Health and Safety Manager (HSM)
Clyde Snyder	Project Health and Safety Officer (PHSO)
Nate Reel / Shonda Sumpter / Rebecca Dohn / Mike Whitten	Samplers
Emily McRee	Site Safety Officer (SSO)
John Webster	Geologist

Subcontractor Personnel:	**Discipline/Tasks Assigned:**
TBD	Drilling Subcontractor
TBD	Direct Push Technology Subcontractor
CH2M Hill Constructors, Inc.	Remedial Action Contractor (RAC)
TBD	Analytical Laboratory
TBD	Surveyor

Hazard Assessment (for purposes of 29 CFR 1910.132) for HASP preparation has been conducted by:

Prepared by: Clyde J. Snyder

2.0 EMERGENCY ACTION PLAN

2.1 INTRODUCTION

This section has been developed as part of a preplanning effort to direct and guide field personnel in the event of an emergency. However, given the nature of the work planned, significant emergencies are not anticipated. Also, because a majority of potential emergency situations will require assistance from outside emergency responders, TtNUS personnel will not provide emergency response support for emergency events beyond the capabilities of onsite personnel. In the event of emergencies that cannot be handled by personnel, an evacuation will be initiated. In an evacuation, site personnel will move to a safe place of refuge and the appropriate emergency response agencies will be notified. The emergency response agencies listed in this plan are capable of providing the most effective response and, as such, will be designated as the primary responders. These agencies are located within a reasonable distance from the area of operations, which ensures adequate emergency response time. This emergency action plan conforms to the requirements of OSHA Standard 29 CFR 1910.38(a), as allowed in OSHA 29 CFR 1910.120(l)(1)(ii).

TtNUS personnel will, through the necessary actions, provide incidental response measures for incidents such as:

- Incipient fire and spill prevention and response
- Removal of personnel from emergency situations
- Provision of initial medical support for injuries/illnesses requiring only first-aid level support
- Provision of site control and security measures, as necessary.

2.2 PRE-EMERGENCY PLANNING

Through the initial hazard/risk assessment effort, there is very minor potential for injuries or illnesses resulting from exposure to chemical, physical, or other hazards and, subsequently, little likelihood of emergency situations. To further minimize or eliminate potential emergency situations, pre-emergency planning activities associated with this project shall be implemented. The FOL is responsible for:

- Coordinating response actions with NAF Key West Emergency Services personnel to ensure that TtNUS emergency action activities are compatible with existing facility emergency response procedures.

- Establishing and maintaining information at the project staging area (support zone) for easy access in the event of an emergency. This information will include the following:
  - Chemical Inventory (of chemicals used onsite), with Material Safety Data Sheets.
  - Onsite personnel medical records (Medical Data Sheets).
  - A log book identifying personnel onsite each day.
  - Hospital route maps with directions (these should also be placed in each site vehicle).
  - Emergency Notification - phone numbers.

The TtNUS FOL will be responsible for the following tasks:

- Identifying a chain of command for emergency action.
- Educating site workers to the hazards and control measures associated with planned activities at the site, and providing early recognition and prevention, where possible.
- Periodically performing practice drills to ensure site workers are familiar with incidental response measures.
- Providing the necessary equipment to safely accomplish identified tasks.

2.3 EMERGENCY RECOGNITION AND PREVENTION

2.3.1 Recognition

Emergency situations that may be encountered during site activities will generally be recognized by visual observation. Visual observation is primarily relevant for physical hazards that may be associated with the proposed scope of work. Visual observation will also play a role in detecting some chemical hazards. To adequately recognize chemical exposures, site personnel must have a clear knowledge of signs and symptoms of exposure associated with site contaminants. This information is provided in Table 6-1. Tasks to be performed at the site, potential hazards associated with those tasks and the recommended control methods are discussed in detail in Sections 5.0 and 6.0. Additionally, early recognition of hazards will be supported by daily site surveys to eliminate any situation predisposed to an emergency. The FOL and/or the SSO will be responsible for performing surveys of work areas prior to initiating site operations and periodically while operations are being conducted. Survey findings will be documented by the FOL and/or the SSO in the Site Health and Safety logbook, however, all site personnel will be responsible for reporting hazardous situations. Where potential hazards exist, TtNUS will initiate control measures to prevent adverse effects to human health and the environment.

The above actions will provide early recognition for potential emergency situations, and allow TtNUS to instigate necessary control measures. However, if the FOL and the SSO determine that control measures are not sufficient to eliminate the hazard, TtNUS will withdraw from the site and notify the appropriate response agencies listed in Table 2-1.

2.3.2 Prevention

TtNUS and subcontractor personnel will minimize the potential for emergencies by ensuring compliance with the HASP, the Health and Safety Guidance Manual, applicable OSHA regulations. Daily site surveys of work areas, prior to the commencement of that day's activities, by the FOL and/or the SSO will also assist in prevention of illness/injuries when hazards are recognized early and control measures initiated.

2.4 SAFE DISTANCES AND PLACES OF REFUGE

In the event that the site must be evacuated, all personnel will immediately stop activities and report to a pre-determined safe place of refuge. The safe place of refuge may also serve as the telephone communication point, as communication with emergency response agencies may be necessary. Telephone communication points and safe places of refuge will be determined prior to the commencement of site activities and will be conveyed to personnel as part of pre-site training. Upon reporting to the refuge location, personnel will remain there until directed otherwise by the TtNUS FOL or the On-Scene Incident Commander. The FOL will take a head count at this location to confirm the presence of all site personnel. Emergency response agencies will be notified of any unaccounted-for personnel.

2.5 EVACUATION ROUTES AND PROCEDURES

Once an evacuation is initiated, personnel will terminate site activities and proceed immediately to the designated place of refuge, unless doing so would further jeopardize the welfare of workers. In such an event, personnel will proceed to a designated alternate location and remain there until further notification from the FOL. The use of these locations as assembly points provides communication and a direction point for emergency services, should they be needed.

2.5.1 Decontamination Procedures/Emergency Medical Treatment

During any site evacuation, decontamination procedures will be performed only if doing so does not further jeopardize the welfare of site workers. Decontamination will be postponed if the incident warrants immediate evacuation. However, the likelihood that an evacuation would occur which would require workers to evacuate the site without first performing the necessary decontamination procedures is limited.

TtNUS personnel will perform rescue operations from emergency situations and may provide initial medical support for injury/illnesses requiring only "Basic First-Aid" level support, and only within the limits of training obtained by site personnel. Basic First-Aid is considered treatment that can be rendered by a trained first aid provider at the injury location and not requiring follow-up treatment or examination by a physician (for example; minor cuts, bruises, stings, scrapes, and burns). Medical attention above First-Aid level support will require assistance from the designated emergency response agencies. Attachment I provides the procedure to follow when reporting an injury/illness, and the form to be used for this purpose. **If the emergency involves personnel exposures to chemicals, follow the steps provided in Figure 2-1.**

2.6 EMERGENCY CONTACTS

Prior to initiating field activities, all personnel will be thoroughly briefed on the emergency procedures to be followed in the event of an accident. Table 2-1 provides a list of emergency contacts and their telephone numbers. This table must be posted where it is readily available to all site personnel. Facility maps should also be posted showing potential evacuation routes and designated meeting areas.

As soon as possible, Navy contact Dave Kruzicki must be informed of any incident or accident that requires medical attention. Any pertinent information regarding allergies to medications or other special conditions will be provided to medical services personnel. This information is listed on Medical Data Sheets filed onsite. If an exposure to hazardous materials has occurred, provide hazard information from Table 6-1 to medical service personnel**.**

2.7 EMERGENCY ALERTING AND ACTION/RESPONSE PROCEDURES

Because TtNUS personnel will be working in close proximity to each other, voice commands will comprise the mechanisms to alert site personnel of an emergency. If an incident occurs, site personnel will initiate the following procedures:

- Initiate incident alerting procedures (if needed) verbally.
- Describe to the FOL (who will serve as the Incident Coordinator) what has occurred and provide as many details as possible.
- If the FOL determines that the situation is beyond the capabilities of site personnel, emergency services will be contacted using the emergency reference information listed in Table 2-1. When the situation has been explained, the appropriate emergency services will be dispatched. The person making the call will stay on the phone and follow the instructions of the emergency contact.

TABLE 2-1

EMERGENCY REFERENCE

NAF KEY WEST

KEY WEST, FLORIDA

AGENCY	TELEPHONE
Key West Police/Rescue Services	911 or (305) 293-2971
NAF Key West Point of Contact Robert Courtright	(305) 293-2881
Base Police	(305) 293-2114
Base Fire Department Boca Chica	(305) 293-3333
Hospital: Lower Florida Keys Health System	(305) 294-5531
Base Officer of the Day (OOD)	(305) 293-2971
Sunshine State One-Call (utility clearance)	**1-800-432-4770**
Chemtrec National Response Center	(800) 424-9300 (800) 424-8802
TtNUS, Aiken Office	(803) 649-7963
Task Order Manager Chuck Bryan	(803) 649-7963 x345
Field Operations Leader Emily McRee	(305) 293-2043
TtNUS, Pittsburgh Office	(800) 245-2730
Health and Safety Manager Matthew M. Soltis, CIH, CSP	(412) 921-8912
Project Health and Safety Officer Clyde J. Snyder	(412) 921-8904

FIGURE 2-1
Emergency Response Protocol

The purpose of this protocol is to provide guidance for the medical management of exposure situations. In the event of a personnel exposure to a hazardous substance or agent:

- Rescue, when necessary, employing proper equipment and methods.
- Give attention to emergency health problems -- breathing, cardiac function, bleeding, and shock.
- Transfer the victim to the medical facility designated in this HASP by suitable and appropriate conveyance (i.e., ambulance for serious events)
- Obtain as much exposure history as possible (a Potential Exposure report is attached).
- If the exposed person is a TtNUS employee, call the medical facility and advise that the patient(s) is/are being sent and that they can anticipate a call from the WorkCare physician. WorkCare will contact the medical facility and request specific testing that may be appropriate. The care of the victim will be monitored by WorkCare physicians. Site officers and personnel should not attempt to get this information, as this activity leads to confusion and misunderstanding.
- Call WorkCare at 1-800-455-6155 (enter Ext. 109), or follow the voice prompt for after-hours and weekend notification, and be prepared to provide:
  - Any known information about the nature of the exposure.
  - As much of the exposure history as was feasible to determine in the time allowed.
  - Name and phone number of the medical facility to which the victim(s) has/have been taken.
  - Name(s) of the exposed TtNUS employee(s).
  - Name and phone number of an informed site officer who will be responsible for further investigations.
  - Fax appropriate information [e.g., Material Safety and Data Sheet (MSDS)] to WorkCare at (714) 456-2154.
- Contact Corporate Health and Safety Department (Matt Soltis) at 1-800-245-2730.

As environmental data is gathered and the exposure scenario becomes more clearly defined, this information should be forwarded to WorkCare.

WorkCare will compile the results of all data and provide a summary report of the incident. A copy of this report will be placed in each victim's medical file, in addition to being distributed to appropriately designated company officials.

Each involved worker will receive a letter describing the incident, but deleting any personal or individual comments. This generalized summary will be accompanied by a personal letter describing the individual's findings/results. A copy of the personal letter will be filed in the continuing medical file maintained by WorkCare.

FIGURE 2-1 (continued)
POTENTIAL EXPOSURE REPORT

Name: _____ Date of Exposure: _____

Social Security No.: _____ Age: _____ Sex: _____

Client Contact: _____ Phone No.: _____

Company Name: _____

I. Exposing Agent

Name of Product or Chemicals (if known):_____

_____

Characteristics (if the name is not known)

Solid Liquid Gas Fume Mist Vapor

II. Dose Determinants

What was individual doing?_____

How long did individual work in area before signs/symptoms developed? _____

Was protective gear being used? If yes, what was the PPE? _____

Was there skin contact?_____

Was the exposing agent inhaled?_____

Were other persons exposed? If yes, did they experience symptoms? _____

III. Signs and Symptoms (check off appropriate symptoms)

Immediately With Exposure:

Burning of eyes, nose, or throat
Tearing
Headache
Cough
Shortness of Breath
Chest Tightness / Pressure
Nausea / Vomiting
Dizziness
Weakness

Delayed Symptoms:

Weakness
Nausea / Vomiting
Shortness of Breath
Cough
Loss of Appetite
Abdominal Pain
Headache
Numbness / Tingling

IV. Present Status of Symptoms (check off appropriate symptoms)

Burning of eyes, nose, or throat
Tearing
Headache
Cough
Shortness of Breath
Chest Tightness / Pressure
Cyanosis
Nausea / Vomiting
Dizziness
Weakness
Loss of Appetite
Abdominal Pain
Numbness / Tingling

Have symptoms: (please check off appropriate response and give duration of symptoms)

Improved: _____ Worsened: _____ Remained Unchanged: _____

V. Treatment of Symptoms (check off appropriate response)

None: ___ Self-Medicated: _____ Physician Treated: _____

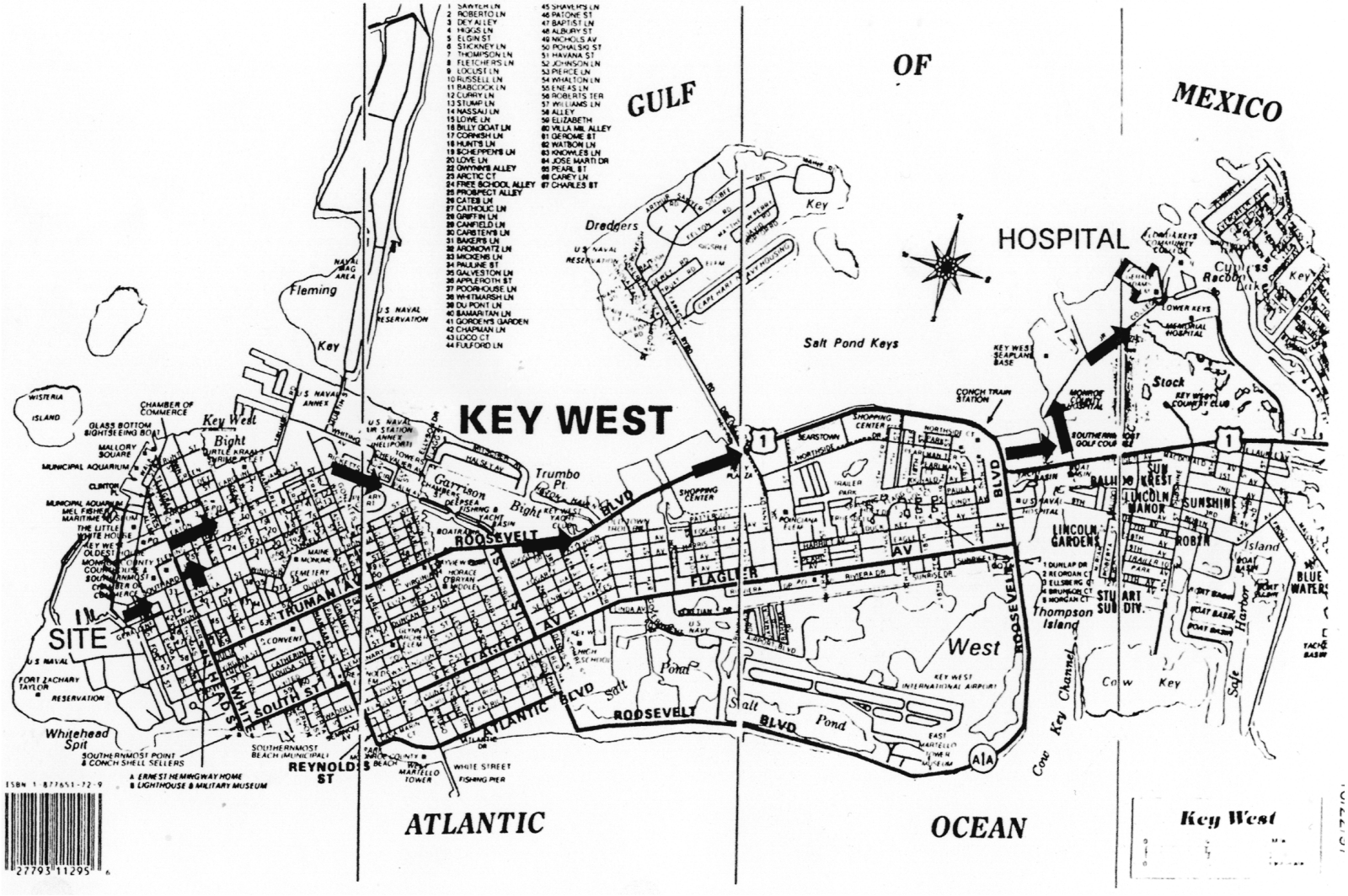

Figure 2-2. Lower Florida Keys Health System Hospital.

3.0 SITE BACKGROUND

NAF Key West is in southern Monroe County, Florida. The U.S. Navy manages 6,323 acres of land, divided into 20 separate tracts in the lower Florida Keys, and concentrated around Key West and Boca Chica Key. The Naval Facility at Key West was disestablished in 1974, resulting in the relocation of several units. At present, NAF Key West is proceeding with realignment of aviation operations, a research laboratory, communications intelligence, counternarcotics air surveillance operations, a weather service, and several other activities on Key West. In addition to the Naval activities and units, other U.S. Department of Defense (DOD) and Federal agencies at NAF Key West include the U.S. Air Force, U.S. Army, and U.S. Coast Guard.

Several installations in various parts of the lower Florida Keys comprise the Naval Complex at Key West. Most of these are on Key West or Boca Chica Key. Key West, one of the two westernmost major islands of the Florida Keys, is approximately 150 miles southwest of Miami and 90 miles north of Havana, Cuba. Key West is connected to the mainland by the Overseas Highway (U.S. Highway No. 1). The topography at the NAF Key West is generally flat.

3.1 TAR TANK SPILL AREA

The Tar Tank Spill Area is located on the southeastern portion of Boca Chica Key, immediately north of the boundary of Solid Waste Management Unit (SWMU) 1, the Former Boca Chica Open Disposal Area. SWMU 1 received general refuse and waste associated with aircraft maintenance activities.
The Tar Tank Spill Area contains remnants of a 10-foot-diameter aboveground storage tank (AST). The AST at the Tar Tank Spill Area is thought to have been associated with asphalt mixing activities. The base of the tank still exists and is filled with 2.5 to 3 inches, or approximately 147 gallons, of an unknown tar-like substance. In hot weather, this substance has been observed to ooze from the tank onto the ground surface. Patches of the unknown substance surround the AST and become particularly viscous during hot weather.

3.2 FORMER BOCA CHICA BLAST MEDIA DISPOSAL AREA

The Former Boca Chica Blast Media Disposal Area, an unnumbered area of concern (AOC), is located in the west-central portion of Boca Chica Key.

The Former Boca Chica Blast Media Disposal Area was used to dispose of sandblasting material produced during the removal of paint from surfaces of ground-handling and ground-support vehicles and equipment, aircraft parts, and other metal objects and pieces of equipment. The sandblasting activities

took place at SWMU 5, Boca Chica Aircraft Intermediate Maintenance Department (AIMD) Sand Blasting Building A-990, at the western end of the airfield on Boca Chica Key. A mound of concrete and metal debris at the site is covered with pine straw and Australian pine trees.

Black Beauty®, the brand name for a coal slag abrasive used in sand blasting, has been identified, predominantly on the southern and western areas of the site. This material was identified at five different locations on the surface of the mound during a visual inspection of the site.

4.0 SCOPE OF WORK

This section of the HASP addresses all proposed site activities to be conducted while performing the RFA at NAF Key West. If tasks other than those identified are to be performed at this site, the HASP will be modified accordingly.

- Multi media sampling
  - Surface soil
  - Soil
  - Groundwater
- Temporary Well Installation by Direct Push Technology (DPT) at one of the RFA sites (Former Boca Chica Blast Media Disposal Area)
- Permanent Monitoring Well Installation by hollow stem auger (HSA) at both sites
- Decontamination of sampling equipment
- Surveying
- Investigation-derived Waste (IDW) management

The activities will be performed to identify the nature and extent of actual or potential site contamination. Any tasks to be conducted outside of the elements listed here will be considered a change in scope, requiring modification of this document. All requested modifications to this document will be submitted to the HSM by the TOM or a designated representative.

5.0 TASKS/HAZARDS/ASSOCIATED CONTROL MEASURES SUMMARIZATION

Table 5-1 of this section serves as the primary portion of the site-specific HASP that identifies tasks that are to be performed as part of the scope of work. This table will be modified and incorporated into this document as new or additional tasks are performed at the site. The anticipated hazards, recommended control measures, air monitoring recommendations, required Personal Protective Equipment (PPE), and decontamination measures for each site task are discussed in detail. This table and the associated control measures will be changed if the scope of work, contaminants of concern, or other conditions change.

Through using the table, site personnel can determine which hazards are associated with each task at each site, and what associated control measures are necessary to minimize potential exposure or injuries related to those hazards. The table also assists field team members in determining which PPE and decontamination procedures to use, based on proper air monitoring techniques and site-specific conditions.

As discussed earlier, a Health and Safety Guidance Manual accompanies this table and HASP. The manual is designed to further explain supporting programs and elements for other site-specific aspects, as required by 29 CFR 1910.120. The Guidance Manual should be referenced for additional information regarding air monitoring instrumentation, decontamination activities, emergency response, hazard assessments, hazard communication and hearing conservation programs, medical surveillance, PPE, respiratory protection, site control measures, standard work practices, and training requirements. Many Tetra Tech NUS SOPs are also provided in this Guidance Manual.

Safe Work Permits issued for all activities (See Attachment III) will use elements defined in Table 5-1 as their primary reference. The FOL and/or the SSO completing the Safe Work Permit will add additional site-specific information. In situations where the Safe Work Permit is more conservative than the direction provided in Table 5-1, due to the incorporation of site-specific elements, the Safe Work Permit will be followed.

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TABLE 5-1

TASKS/HAZARDS/CONTROL MEASURES COMPENDIUM FOR NAVAL AIR FACILITY KEY WEST, KEY WEST, FLORIDA
PAGE 1 OF 6

Tasks/Operation/ Locations	Anticipated Hazards	Recommended Control Measures	Hazard Monitoring	Personal Protective Equipment *Italicize text represents optional equipment to be worn when conditions require.*	Decontamination Procedures
Soil borings and installation of monitoring wells. Soil borings and monitoring installations will be performed using both Dirtect Push Technolgy (DPT) and Hollow Stem Augers (HSA). Temporary monitoring wells will be installed at the Former Boca Chica Blast Media Disposal Area Boca Chica using DPT.	***Chemical Hazards:*** 1) Air/particulate/water borne contaminants including the following: SWMU 1 (Tar Tank Spill Area) - Various SVOCs (particularly Poly Aromatic Hydrocarbons (PAHs) which were previously detected in soils. Additionally a few pesticides (4,4 – DDE and 4,4 – DDT) and VOCs (primarily benzene and vinyl chloride) were previously detected in groundwater but all were at concentrations that are not sufficient to present an inhalation exposure hazard to site personnel. SWMU 5 (Former Boca Chica Blast Media Disposal Area) – Various metals (lead, chromium, cadmium, arsenic, berylium, etc.). However, given the previously detected concentrations of metals in soils and sediments, it is unlikley that any of these will present a significant exposure hazard to site personnel. Addiutionally, site activities are not likely to produce significant dusts which would be the most efficient method of exposure. Adequate decontamination and personal hygiene methods will be used to prevent potential exposure via other routes (i.e., ingestion). Further information on these contaminants is presented in Table 6-1. 2) Transfer of contamination into clean areas or onto persons ***Physical hazards*:** 3) Pinch/compression points 4) Noise 5) Energized systems 6) Lifting 7) Natural Hazards (Insect/animal bites and stings) 8) Inclement weather	1) For VOCs, use real-time monitoring instrumentation, action levels, and identified PPE to control exposures to potentially contaminated media (air, water, soils, etc.). Generation of dusts should be minimized to the greatest extent possible to avoid exposure to non-VOCs present as particulates or bound to particulates. If airborne dusts are observed, area wetting methods will be used to reduce the generation of dusts created during Drilling activities. If area wetting methods are not feasible termination of activities will be used to minimize exposure to observed airbonre dusts. 2) Decontaminate all equipment and supplies between boreholes and prior to leaving the site. 3) All equipment to be used will be - Inspected in accordance with Federal safety and transportation guidelines, OSHA (1926.600,.601,.602), and manufacturers design and documented as such using the Equipment Inspection Sheet (See Attachment II of this HASP or Section 10.0 of the TtNUS Health and Safety Guidance Manual). - Operated by qualified operators, and knowledgeable ground crew. - Used within establish safe zones and routes of approach - Only manufacturer approved equipment may be used in conjunction with equipment repair procedures (i.e. pins, etc.). In addition, to equipment considerations the following safe operating procedures will be incorporated: - All personnel not directly supporting this operation will remain at least 25 feet from the point of operation. - Hydraulic masts or other projecting devices shall be at least 20 feet from overhead power sources and a minimum of 3 feet from underground utilities unless the exact location of the underground utility is known. - Hand signals will be established prior to the commencement of the operation. - Only manufacturer approved equipment may be used in conjunction with equipment repair procedures (i.e., flight connectors etc.). - Work areas will be kept clear of clutter. - Secure all loose articles to avoid possible entanglement. - All equipment shall be equipped with movement warning systems. - All personnel working in high equipment traffic areas are required to wear reflective vests for high visibility, and to establish unimpeded work areas around the operation. This activity may require areas of the building to be coordined off during this operation. - All personnel will be instructed in the location and operations of the emergency shut off device(s). This device will be tested initially (and then periodically) to insure its operational status. - Areas will be inspected prior to the movement of Drill Rig and support vehicles to eliminate any physical hazards. This will be the responsibility of the FOL and/or SSO. - The Drill Rig and support vehicles will be moved no closer than 3 feet to floor openings, sidewalls, and excavations. 4) Hearing protection will be used during all subsurface activities. 5) All utility clearances shall be obtained prior to subsurface activities. Prior to any subsurface investigations, the locations of all underground utilities will be identified and marked. Obtain written permit clearance prior to all subsurface investigations. See Attachment IV Utility Locating And Excavation Clearance of this HASP. 6) Use machinery or multiple personnel for heavy lifts. Use proper lifting techniques. 7) Avoid nesting areas, use commerically available repellents. Report potential hazards to the SSO. 8) Suspend or terminate operations until directed otherwise by SSO	**It is anticipated that potential contaminant concentrations at outdoor locations will be dispersed via natural wind currents and dilution prior to reaching worker breathing zones.** Photoionization Detector w/ 10.06 eV UV lamp source, or a Flame Ionization Detector, will be used to detect VOCs as follows: Source (borehole and sampling locations) monitoring will be conducted at regular intervals determined by the SSO. The SSO will also monitor the breathing zone of all potentially affected employees, with the following guidance: - Any sustained reading above background in the BZ requires evacuation to a safe area until BZ reading return to background levels. Many of the contaminants of concern are solids, and are non-detectable using PID/FID direct reading instruments. Also, other site contaminants may adhere to or be part of airborne dusts or particulates generated during site activities. Generation of dusts should be minimized to the greatest extent possible to avoid inhalation of contaminated dusts or particulates. Evaluation of dust concentrations will be qualitative by observing work conditions for visible dust clouds or accumulations. Potential exposure to contaminants attached to dust particles will be controlled by using water to suppress dusts, by avoiding dust plumes, or by upgrading the level of protection. Where the utility clearance cannot be obtained in a reasonable period, or not located, intrusive activities shall proceed with extreme caution using a magnetometer for periodic downhole surveys every 2 feet to a depth of at least 6 feet. See Attachment IV Utility Locating And Excavation Clearance of this HASP.	All subsurface operations are to be initiated in Level D protection. Level D protection constitutes the following minimum protection - Standard field attire (Sleeved shirt; long pants) - Tyvek coveralls and disposable boot covers if surface contamination is present or if the potential exists for soiling work attire. - Nitrile gloves or leather gloves with surgical style inner gloves - Steel toe safety shoes - Safety glasses - Hardhat - Hearing protection for high noise areas, as directed by the SSO. - *Reflective vest for high traffic areas* **Note:** The Safe Work Permit(s) for this task (see Attachment III) will be issued at the beginning of each day to address the tasks planned for that day. As part of this task, additional PPE may be assigned to reflect site-specific conditions or special considerations or conditions associated with any identified task.	**Personnel Decontamination** will consist of a soap/water wash and rinse for outer protective equipment (boots, gloves, PVC splash suits, etc.). This function will take place at an area adjacent to the site activities. This procedure will consist of: - Equipment drop - Soap/water wash and rinse of outer boots and gloves - Soap/water wash and rinse of the outer splash suit, as applicable - Outer suit, boot covers, outer glove removal - Wash hands and face, leave contamination reduction zone **Equipment Decontamination** - All heavy equipment decontamination will take place at a centralized decontamination pad utilizing steam or pressure washers. Heavy equipment such as Drill Rig, will have the wheels and tires cleaned along with any loose debris removed, prior to transporting to the central decontamination area. All site vehicles will be restricted access to exclusion zones, or also have their wheels/tires sprayed off as not to track mud onto the roadways servicing this installation. Roadways shall be cleared of any debris resulting from the onsite activity. All equipment used in the exclusion zone will require a complete decontamination between locations and prior to removal from the site. The FOL or the SSO will be responsible for evaluating equipment arriving onsite and that which is to leave the site. No equipment will be authorized access or exit without this authorization. Evaluation will consist of - Visual inspection - Scanning equipment with monitoring instruments

TABLE 5-1

TASKS/HAZARDS/CONTROL MEASURES COMPENDIUM FOR NAVAL AIR FACILITY KEY WEST, KEY WEST, FLORIDA
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Tasks/Operation/ Locations	Anticipated Hazards	Recommended Control Measures	Hazard Monitoring	Personal Protective Equipment *Italicize text represents optional equipment to be worn when conditions require.*	Decontamination Procedures
Multi Media Sampling including groundwater, surface soils, sediment and IDW.	***Chemical Hazards:*** 1) Air/particulate/water borne contaminants including the following: SWMU 1 (Tar Tank Spill Area) - Various SVOCs (particularly Poly Aromatic Hydrocarbons (PAHs) which were previously detected in soils. Additionally a few pesticides (4,4 – DDE and 4,4 – DDT) and VOCs (primarily benzene and vinyl chloride) were previously detected in groundwater but all were at concentrations that are not sufficient to present an inhalation exposure hazard to site personnel. SWMU 5 (Former Boca Chica Blast Media Disposal Area) – Various metals (lead, chromium, cadmium, arsenic, berylium, etc.). However, given the previously detected concentrations of metals in soils and sediments, it is unlikley that any of these will present a significant exposure hazard to site personnel. Addiutionally, site activities are not likely to produce significant dusts which would be the most efficient method of exposure. Adequate decontamination and personal hygiene methods will be used to prevent potential exposure via other routes (i.e., ingestion). Further information on these contaminants is presented in Table 6-1. 2) Transfer of contamination into clean areas ***Physical hazards:*** 3) Noise 4) Lifting (muscle strains and pulls) 5) Pinches and compressions 6) Slip, trips, and falls 7) Natural hazards (Insect/animal bites and stings) 8) Inclement weather	1) For VOCs, use real-time monitoring instrumentation, action levels, and identified PPE to control exposures to potentially contaminated media (air, water, soils, etc.). Generation of dusts should be minimized to the greatest extent possible. If airborne dusts are observed, area wetting methods will be used to reduce the generation of dusts created during Drill Rig activities. If area wetting methods are not feasible, upgraded levels of protection or termination of activities will be used to minimize exposure to observed airbonre dusts. 2) Decontaminate all equipment and supplies between sampling locations and prior to leaving the site. 3) When sampling at the Drill Rig rig use hearing protection. The use of hearing protection to protect against excessive noise outside of 25 feet from the point of operations should be incorporated under the following condition: Hearing protection during sample acquisition outside of the boring sample will be determine on a case by case scenario. As a general rule of thumb, if you have to raise your voice to talk to someone who is within 2 feet of your location, noise levels may becoming excessive. 4) Use machinery or multiple personnel for heavy lifts. Use proper lifting techniques. 5) Use pinch bars or other equipment to remove hands from the point of operation. 6) Preview work locations for unstable/uneven terrain. Barricade all excavations and other associated drop off points at least 3 feet from the edge. 7) Avoid nesting areas, use commerically available repellents. Report potential hazards to the SSO. 8) Suspend or terminate operations until directed otherwise by SSO	**It is anticipated that potential contaminant concentrations at outdoor locations will be dispersed via natural wind currents and dilution prior to reaching worker breathing zones.** Photoionization Detector w/ 10.06 eV UV lamp source, or a Flame Ionization Detector, will be used to detect VOCs as follows: Source (borehole and sample location) monitoring will be conducted at regular intervals determined by the SSO. The SSO will also monitor the breathing zone of all potentially affected employees, with the following guidance: - Any sustained reading above background in the BZ requires evacuation to a safe area. Many of the contaminants of concern are solids, and are non-detectable using PID/FID direct reading instruments. Also, other site contaminants may adhere to or be part of airborne dusts or particulates generated during site activities. Generation of dusts should be minimized to the greatest extent possible to avoid inhalation of contaminated dusts or particulates. Evaluation of dust concentrations will be qualitative by observing work conditions for visible dust clouds or accumulations. Potential exposure to contaminants attached to dust particles will be controlled by using water to suppress dusts, by avoiding dust plumes, or by upgrading the level of protection. Where the utility clearance cannot be obtained in a reasonable period, or not located, intrusive activities shall proceed with extreme caution using a magnetometer for periodic downhole surveys every 2 feet to a depth of at least 6 feet. See Attachment IV Utility Locating And Excavation Clearance of this HASP.	Level D protection will be utilized for the initiation of all sampling activities. Level D - (Minimum Requirements) - Standard field attire (sleeved shirt; long pants) - Tyvek coveralls and disposable boot covers if surface contamination is present or if the potential for soiling work attire exists. - Nitrile gloves with surgical style inner gloves for soil and groundwater sampling - Steel toe safety shoes - Safety glasses - *Hardhat (when overhead hazards exists, or identified as a operation requirement)* - *Reflective vest for high traffic areas* - *Hearing protection for high noise areas, or as required based on the noise level at each operation.* **Note:** The Safe Work Permit(s) for this task (see Attachment III) will be issued at the beginning of each day to address the tasks planned for that day. As part of this task, additional PPE may be assigned to reflect site-specific conditions or special considerations or conditions associated with any identified task.	**Personnel Decontamination** will consist of a soap/water wash and rinse for outer protective equipment (e.g. boots, gloves, PVC splash suits, etc.). This function will take place at a satellite location. Disposable PPE will be bagged between sampling events. This procedure will consist of - Sample acquisition - Clean (Deionized water spray) the outside of the sample containers/label/bag This decontamination procedure for Level D protection will consist of - Equipment drop - Soap/water wash and rinse of outer boots and outer gloves, as applicable - Soap/water wash and rinse of the outer splash suit, as applicable - Wash hands and face, leave contamination reduction zone .

TABLE 5-1

TASKS/HAZARDS/CONTROL MEASURES COMPENDIUM FOR NAVAL AIR FACILITY KEY WEST, KEY WEST, FLORIDA
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Tasks/Operation/ Locations	Anticipated Hazards	Recommended Control Measures	Hazard Monitoring	Personal Protective Equipment *Italicize text represents optional equipment to be worn when conditions require.*	Decontamination Procedures
Mobilization/ Demobilization	***Physical Hazards:*** 1) Lifting (muscle strains and pulls) 2) Pinches and compressions 3) Slip, trips, and falls 4) Moving machinery 5) Natural hazards (Insect/animal bites and stings) 6) Vehicular and foot traffic	1) Use machinery or multiple personnel for heavy lifts. Use proper lifting techniques. 2) Use pinch bars or other equipment if caught in the machine point of operation. 3) Preview work locations for unstable/uneven terrain. Barricade all excavations from access closer than two feet from the edge. 4) All equipment will be - Inspected in accordance with OSHA, and manufacturers design. (See Attachment II of this HASP or Section 10.0 of the TtNUS Health and Safety Guidance Manual). - Operated by qualified operators, and knowledgeable ground crew. 5) Avoid nesting areas, use comerically available repellents. Report potential hazards to the SSO. 6) Traffic and equipment considerations are to include the following: - Establish safe zones of approach (i.e. Boom + 3 feet). - Secure all loose articles to avoid possible entanglement. - All equipment shall be equipped with movement warning systems. - Employ safety belts and follow the site traffic rules. Traffic patterns will be required supporting onsite activities. However, regulated patterns in and about the work zones and support thereof will be established to safely control moving equipment, vehicles, and pedestrians around the area of operation.	Not required	Level D - (Minimum Requirements) - Standard field attire (Sleeved shirt; long pants) - Steel toe safety shoes - *Safety glasses* - *Hardhat (when overhead hazards exists, or identified as a operation requirement)* - *Reflective vest for high traffic areas* - *Hearing protection for high noise areas, or as required based on the noise level at each operation.* **Note:** The Safe Work Permit(s) for this task (see Attachment III) will be issued at the beginning of each day to address the tasks planned for that day. As part of this task, additional PPE may be assigned to reflect site-specific conditions or special considerations or conditions associated with any identified task.	Not required

TABLE 5-1

TASKS/HAZARDS/CONTROL MEASURES COMPENDIUM FOR NAVAL AIR FACILITY KEY WEST, KEY WEST, FLORIDA
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Tasks/Operation/ Locations	Anticipated Hazards	Recommended Control Measures	Hazard Monitoring	Personal Protective Equipment *Italicize text represents optional equipment to be worn when conditions require.*	Decontamination Procedures
Decontamination of Sampling and Heavy Equipment	***Chemical Hazards:*** 1) Air/particulate/water borne contaminants including the following: SWMU 1 (Tar Tank Spill Area) - Various SVOCs (particularly Poly Aromatic Hydrocarbons (PAHs) which were previously detected in soils. Additionally a few pesticides (4,4 – DDE and 4,4 – DDT) and VOCs (primarily benzene and vinyl chloride) were previously detected in groundwater but all were at concentrations that are not sufficient to present an inhalation exposure hazard to site personnel. SWMU 5 (Former Boca Chica Blast Media Disposal Area) – Various metals (lead, chromium, cadmium, arsenic, berylium, etc.). However, given the previously detected concentrations of metals in soils and sediments, it is unlikley that any of these will present a significant exposure hazard to site personnel. Addiutionally, site activities are not likely to produce significant dusts which would be the most efficient method of exposure. Adequate decontamination and personal hygiene methods will be used to prevent potential exposure via other routes (i.e., ingestion). Further information on these contaminants is presented in Table 6-1. 2) Decontamination fluids - Liquinox (detergent), acetone or methanol, and hexane ***Physical Hazards:*** 3) Lifting (muscle strains and pulls) 4) Pinches and compressions 5) Inclement weather	1) and 2) Use protective equipment to minimize contact with site contaminants and hazardous decontamination fluids. Obtain manufacturer's MSDS for any decontamination solvents used onsite. Use appropriate PPE as identified on MSDS. 3) Use multiple persons where necessary for lifting and handling sampling equipment for decontamination purposes. 4) Provide stacking racks for air drying of decontaminated equipment to prevent unstable drying stacks of equipment from collapsing. 5) Suspend or terminate operations until directed otherwise by SSO	Use visual observation, and real-time monitoring instrumentation to ensure all equipment has been properly cleaned of contamination and dried.	*For Heavy Equipment* This applies to high pressure soap/water, steam cleaning wash and rinse procedures. Level D Minimum requirements - - Standard field attire (Sleeved shirt; long pants) - Safety shoes (Steel toe/shank) - Chemical resistant boot covers - Nitrile outer gloves, cotton liners - PVC Rainsuits or PE or PVC coated Tyvek - Safety glasses underneath a splash shield Respiratory protection is not anticipated for this activity. For sampling equipment, the following PPE is required Level D Minimum requirements - - Standard field attire (Sleeved shirt; long pants) - Steel toe safety shoes - Nitrile outer gloves, cotton liners - Safety glasses underneath a splash shield In the event of overspray of chemical decontamination fluids use PVC Rainsuits or PE or PVC coated Tyvek as necessary. **Note:** The Safe Work Permit(s) for this task (see Attachment III) will be issued at the beginning of each day to address the tasks planned for that day. As part of this task, additional PPE may be assigned to reflect site-specific conditions or special considerations or conditions associated with any identified task.	**Personnel Decontamination:** This decontamination procedure for Level D protection will consist of: - Soap/water wash and rinse of outer gloves - Soap/water wash and rinse of the outer splash suit, as applicable - Wash hands and face, leave contamination reduction zone **Equipment Decontamination** - All heavy equipment decontamination will take place at a centralized decontamination pad utilizing steam or pressure washers. Heavy equipment will have the wheels and tires cleaned along with any loose debris removed, prior to transporting to the central decontamination area. All site vehicles will be restricted access to exclusion zones, or also have their wheels/tires sprayed off as not to track mud onto the roadways servicing this installation. Roadways shall be cleared of any debris resulting from the onsite activity. All equipment used in the exclusion zone will require a complete decontamination between locations and prior to removal from the site. Evaluation will consist of - Visual inspection - Scanning equipment with monitoring instruments Sampling equipment will be decontaminated as per the requirements in the Sampling and Analysis Plan and/or Work Plan. MSDS for any decon solutions (Alconox, methanol, isopropanol, hexane, etc.) will be obtained and used to determine proper handling / disposal methods and protective measures (PPE, first-aid, etc.). The FOL or the SSO will be responsible for evaluating equipment arriving onsite and that which is to leave the site. No equipment will be authorized access or exit without this evaluation

TABLE 5-1

TASKS/HAZARDS/CONTROL MEASURES COMPENDIUM FOR NAVAL AIR FACILITY KEY WEST, KEY WEST, FLORIDA
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Tasks/Operation/ Locations	Anticipated Hazards	Recommended Control Measures	Hazard Monitoring	Personal Protective Equipment *Italicize text represents optional equipment to be worn when conditions require.*	Decontamination Procedures
Monitoring well development, purging and IDW handling activities.	***Chemical Hazards:*** 1) Air/particulate/water borne contaminants including the following: SWMU 1 (Tar Tank Spill Area) - Various SVOCs (particularly Poly Aromatic Hydrocarbons (PAHs) which were previously detected in soils. Additionally a few pesticides (4,4 – DDE and 4,4 – DDT) and VOCs (primarily benzene and vinyl chloride) were previously detected in groundwater but all were at concentrations that are not sufficient to present an inhalation exposure hazard to site personnel. SWMU 5 (Former Boca Chica Blast Media Disposal Area) – Various metals (lead, chromium, cadmium, arsenic, berylium, etc.). However, given the previously detected concentrations of metals in soils and sediments, it is unlikley that any of these will present a significant exposure hazard to site personnel. Addiutionally, site activities are not likely to produce significant dusts which would be the most efficient method of exposure. Adequate decontamination and personal hygiene methods will be used to prevent potential exposure via other routes (i.e., ingestion). Further information on these contaminants is presented in Table 6-1. 2) Transfer of contamination into clean areas or onto persons ***Physical hazards:*** 3) Pinch/compression points 4) Noise 5) Energized systems	1) For VOCs, use real-time monitoring instrumentation, action levels, and identified PPE to control exposures to potentially contaminated media (air, water, soils, etc.). Generation of dusts should be minimized to the greatest extent possible. If airborne dusts are observed, area wetting methods will be used to reduce the generation of dusts created during Drill Rig activities. If area wetting methods are not feasible, upgraded levels of protection or termination of activities will be used to minimize exposure to observed airborne dusts. 2) Decontaminate all equipment and supplies between boreholes and prior to leaving the site. 3) All equipment to be used will be - Inspected in accordance with Federal safety and transportation guidelines, OSHA (1926.600,.601,.602), and manufacturers design. (See Attachment II of this HASP or Section10.0 of the TtNUS Health and Safety Guidance Manual). - Operated by qualified operators, and knowledgeable ground crew. - Used within establish safe zones and routes of approach - Only manufacturer approved equipment may be used in conjunction with equipment repair procedures (i.e. pins, etc.). In addition, to equipment considerations the following safe operating procedures will be incorporated: - All personnel not directly supporting this operation will remain at least 25 feet from the point of operation. - Hydraulic masts or other projecting devices shall be at least 20 feet from overhead power sources and a minimum of 3 feet from underground utilities unless the exact location of the underground utility is known. - Hand signals will be established prior to the commencement of the operation. - Only manufacturer approved equipment may be used in conjunction with equipment repair procedures (i.e., flight connectors etc.). - Work areas will be kept clear of clutter. - Secure all loose articles to avoid possible entanglement. - All equipment shall be equipped with movement warning systems. - All personnel working in high equipment traffic areas are required to wear reflective vests for high visibility, and to establish unimpeded work areas around the operation. This activity may require areas of the building to be coordined off during this operation. - All personnel will be instructed in the location and operations of the emergency shut off device(s). This device will be tested initially (and then periodically) to insure its operational status. - Areas will be inspected prior to the movement of Drill Rig and support vehicles to eliminate any physical hazards. This will be the responsibility of the FOL and/or SSO. - The Drill Rig and support vehicles will be moved no closer than 3 feet to floor openings, sidewalls, and excavations. 4) Hearing protection will be used during all subsurface activities until the SSO can quantify associated noise levels. 5) All utility clearances shall be obtained prior to subsurface activities. Prior to any subsurface investigations, the locations of all underground utilities will be identified and marked. Obtain written permit clearance prior to all subsurface investigations.	**It is anticipated that potential contaminant concentrations at outdoor locations will be dispersed via natural wind currents and dilution prior to reaching worker breathing zones.** Photoionization Detector w/ 10.06 eV UV lamp source, or a Flame Ionization Detector, will be used to detect VOCs as follows: Source (borehole and sample location) monitoring will be conducted at regular intervals determined by the SSO. The SSO will also monitor the breathing zones of all potentially affected employees, with the following guidance: - Any sustained reading above background in the BZ requires evacuation to a safe area. Many contaminants of concern are solids, and are non-detectable using PID/FID direct reading instruments. Also, other site contaminants may adhere to or be part of airborne dusts or particulates generated during site activities. Generation of dusts should be minimized to the greatest extent possible to avoid inhalation of contaminated dusts or particulates. Evaluation of dust concentrations will be qualitative by observing work conditions for visible dust clouds or accumulations. Potential exposure to contaminants attached to dust particles will be controlled by using water to suppress dusts, by avoiding dust plumes, or by upgrading the level of protection. Where the utility clearance cannot be obtained in a reasonable period, or not located, intrusive activities shall proceed with extreme caution using a magnetometer for periodic downhole surveys every two feet to a depth of at least six feet. See Attachment IV Utility Locating And Excavation Clearance of this HASP.	Level D protection will be utilized for the initiation of all sampling activities. Level D - (Minimum Requirements) - Standard field attire (long sleeve shirt; long pants) - Tyvek coveralls and disposable boot covers, if surface contamination is present or if the potential for soiling work attire exists - Nitrile gloves with surgical style inner gloves for soil and groundwater sampling - Steel-toe safety shoes - Safety glasses - Hardhat (when overhead hazards exists, or when identified as a operation requirement) - Reflective vest for high traffic areas - Hearing protection for high noise areas, or as required, based on the noise level at each operation. **Note:** The Safe Work Permit(s) for this task (see Attachment III) will be issued at the beginning of each day to address the tasks planned for that day. As part of this task, additional PPE may be assigned to reflect site-specific conditions or special considerations or conditions associated with any identified task.	**Personnel Decontamination** will consist of a soap/water wash and rinse for outer protective equipment (boots, gloves, PVC splash suits, etc.). This function will take place at an area adjacent to the site activities. This procedure will consist of: - Equipment drop - Soap/water wash and rinse of outer boots and gloves - Soap/water wash and rinse of the outer splash suit, as applicable - Outer suit, boot covers, outer glove removal - Wash hands and face, leave contamination reduction zone

TABLE 5-1

TASKS/HAZARDS/CONTROL MEASURES
NAVAL AIR FACILITY KEY WEST, FLORIDA
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Tasks/Operation/ Locations	Anticipated Hazards	Recommended Control Measures	Hazard Monitoring/Type and Action Levels	Personal Protective Equipment *Italicize text represents optional equipment to be worn when conditions require.*	Decontamination Procedures
Geographical surveying activities	***Chemical hazards:*** **Exposure to potential site contaminants during surveying activities is unlikely given the nature of surveying work and the limited contact with potentially contaminated media (soils, sediments, surface water, etc.). To further reduce the potential for exposure, site personnel performing surveying activities will minimize contact with potentially contaminated media and will avoid areas where chemical hazards may exist.** Refer to Section 6.0 for a list of potential and representative site contaminants. See individual Safe Work Permits contained in Attachment III for specific contaminants of concern associated with particular sites and site activities. ***Physical hazards:*** 1) Slip, trips, and falls 2) Natural hazards (Insect/animal bites and stings, poisonous plants) 3) Inclement weather	1) Preview work locations and site lines for uneven and unstable terrain. Clear necessary vegetation and establish temporary means for traversing hazardous terrain (e.g. rope ladders). 2) Avoid potential nesting areas of biting/stinging insects and animals. Use commercially available insect repellents. Avoid contact with poisonous vegetation. Wear appropriate clothing. Tape ankle and wrists areas to prevent ticks, chiggers, etc. from attaching themselves to your skin. Wear light-colored clothing so that ticks and other biting insects can be easily visible and be removed. If working in areas where snakes are a threat, wear snake chaps to protect against bites. Follow directions as specified in section 6.3 concerning natural hazards. 3) All operations will be temporarily suspended during electrical storms.	No air monitoring is needed given that volatile contaminants are not likely to be present during surveying activities. The potential for exposure to site contaminants during this activity is considered minimal. .	Surveying activities shall be performed in Level D protection Level D Protection consists of the following: - Standard field dress including sleeved shirt and long pants - Steel-toe work boots or shoes - *Safety glasses, hard hats (if working near machinery)* - *Tyvek coveralls may be worn to provide additional protection against poisonous plants and insects, particularly ticks.* - *Work gloves may be worn if desired.* - *Snake chaps for heavily wooded area where encounters are likely.* **Note:** The Safe Work Permit(s) for this task (see Attachment III) will be issued at the beginning of each day to address the tasks planned for that day. As part of this task, additional PPE may be assigned to reflect site-specific conditions or special considerations or conditions associated with any identified task.	Personnel Decontamination - A structured decontamination is not required, as the likelihood of encountering contaminated media is considered remote. However, survey parties should inspect themselves and one another for the presence of ticks when exiting wooded areas, grassy fields, etc. This action will be used to stop the transfer of these insects into vehicles, homes, and offices.

6.0 HAZARD ASSESSMENT AND CONTROLS

This section provides reference information regarding the chemical and physical hazards that may associated with activities to be conducted as part of the scope of work. Table 6-1 provides specific information related to various chemical hazards that may be present at the planned project areas within NAF Key West. Specifically, toxicological information, exposure limits, warning property ratings, symptoms of exposure, physical properties, and air monitoring and sampling data are discussed in the table.

6.1 CHEMICAL HAZARDS

Information provided regarding previous site activities and potential sources of contamination dictates the following primary contaminants of concern:

- VOCs
- Semi-volatile organic compounds (SVOCs)
- Total petroleum hydrocarbons (TPH)
- Metals

Exposure to chemical hazards while performing the elements identified within the scope of work is considered to be minimal, even though the activity is intrusive. This assessment is based on the number of locations to be investigated, the method(s) of extraction, and the contaminant concentrations identified during prior sampling programs and visual inspection of the two RFA sites.

6.2 PHYSICAL HAZARDS

In addition to the chemical hazards discussed above, the following physical hazards may be present during the performance of the site activities.

- Heavy equipment hazards
- Cuts and Lacerations
- Slips, trips, and falls
- Energized systems (contact with underground or overhead utilities)
- Lifting (strain/muscle pulls)
- Noise in excess of 85 decibels (dBA)

TABLE 6-1

CHEMICAL, PHYSICAL AND TOXICOLOGICAL DATA FOR NAVAL AIR FACILITY KEY WEST KEY WEST, FLORIDA

Substance	CAS No.	Air Monitoring/Sampling Information		Exposure Limits	Warning Property Rating	Physical Properties	Health Hazard Information
Benzene	71-43-2	PID: I.P 9.24 eV, 100% response with PID and 10.2 eV lamp. FID: 150% relative response ratio with FID.	Air sample using charcoal tube; carbon disulfide desorption; Sampling and analytical protocol in accordance with OSHA 07 or NIOSH Method #1500.	OSHA: 1 ppm ACGIH: 10 ppm NIOSH: 0.1 ppm IDLH: 500 ppm	Inadequate - Odor threshold 34-199 ppm. OSHA accepts the use of air-purifying respirators with organic vapor cartridge up to 10 ppm despite the inadequate warning properties providing cartridges are changed at the beginning of each shift. **Recommended gloves:** Butyl/neoprene blend - >8.00 hrs; Silver shield as a liner - >8.00 hrs; Viton - >8.00 hrs	**Boiling Pt:** 176°F; 80°C **Melting Pt:** 42°F; 5.5°C **Solubility:** 0.07% **Flash Pt:** 12°F; -11°C **LEL/LFL:** 1.3% **UEL/UFL:** 7.9% **Vapor Density:** 2.77 **Vapor Pressure:** 75 mmHg **Specific Gravity:** 0.88 **Incompatibilities:** Strong oxidizers, fluorides, perchlorates, and acids **Appearance and Odor:** Colorless to a light yellow liquid with an aromatic odor	Overexposure may result in irritation to the eyes, nose, throat, and respiratory system. CNS effects include giddiness, lightheadedness, headaches, staggered gait, fatigue, and lassitude and depression. Additional effects may include nausea. Long duration exposures may result in respiratory collapse. Regulated as an OSHA carcinogen. May cause damage to the blood forming organs and may cause a form of cancer called leukemia.
Vinyl chloride	75-01-4	PID: I.P. 9.99 eV, High response with PID and 10.2 eV lamp. FID: 40% response with FID.	Air sample using charcoal or ANAForb CMS sorbent tube; carbon disulfide desorption; gas chromatography-flame ionization detection; Sampling and analytical protocol shall proceed in accordance with NIOSH Method #1007, or OSHA Method #75.	OSHA: 1.0 ppm PEL 5.0 ppm (Ceiling) ACGIH: 5 ppm NIOSH: Lowest Feasible Concentration	Inadequate - Odor threshold 10-20 ppm. Gas Mask with a vinyl chloride Type N canister may be employed for concentrations up to 25 ppm. Canisters employed must have a minimum service life of 4-hrs. Exceedances over 25 ppm, must use a positive pressure demand, open-circuit, self-contained breathing apparatus, pressure demand type, with full facepiece. Refer to 29 CFR 1910.1017(g) for specific requirements based on atmospheric concentrations of vinyl chloride. **Recommended gloves:** Silver shield >6.00 hrs; Nitrile 5.70 hrs; or Viton 4.4 hrs	**Boiling Pt:** 7°F; -13.9°C **Melting Pt:** -256°F; -160°C **Solubility:** 0.1% @ 77°F; 25 °C **Flash Pt:** 18°F; -8°C **LEL/LFL:** 3.6% **UEL/UFL:** 33% **Vapor Density:** 2.21 **Vapor Pressure:** 3.3 atm **Specific Gravity:** N.A. **Incompatibilities:** Oxidizers, copper, aluminum, peroxides, iron, steel, **Appearance and Odor:** Colorless gas or liquid (below 7°F) with a pleasant odor at high concentrations.	A severe skin, eye, and mucous membrane irritant(Liquid: frostbite). Narcotic effect causing weakness, abdominal pains, GI bleeding, and pallor skin or cyanosis. Chronic exposure has been linked to the formation of malignant tumors originating from blood lymphatic vessels in the liver (associated enlargement of the liver), and kidneys (angiosarcoma and nephroblastoma). Listed as a carcinogen by NTP, IARC and ACGIH.

TABLE 6-1

CHEMICAL, PHYSICAL AND TOXICOLOGICAL DATA FOR NAVAL AIR FACILITY KEY WEST KEY WEST, FLORIDA

Substance	CAS No.	Air Monitoring/Sampling Information		Exposure Limits	Warning Property Rating	Physical Properties	Health Hazard Information
Arsenic	7440-38-2	Particulate form - This substance is unable to be detected by PID/FID.	Air sample using a particulate filter; acid desorption; AAS detection. Sampling and analytical protocol shall proceed in accordance with NIOSH Method #7900.	OSHA: Organic compounds 0.5 mg/m^3 Inorganic compounds 0.01 mg/m^3 NIOSH: (Ceiling) 0.002 mg/m^3 ACGIH: 0.2 mg/m^3 IDLH: 5 mg/m^3 as arsenic	No identifiable warning properties to indicate presence and thereby detection. **Recommended APR Cartridge:** Suitable for dust and fume. Organic vapor acid gases with HEPA filter. This substance may be presented as a pesticide, therefore a cartridge suitable for pesticides (MSA-GMP). **Recommended Gloves:** This is in the particulate form. Therefore any glove suitable to prevent skin contact (Nitrile has been the one most widely used for the other substances).	**Boiling Pt:** sublimation @ 1134°F; 612°C **Melting Pt:** 1497°F; 814°C @ 36 atm **Solubility:** Insoluble in water;soluble in nitric acid **Flash Pt:** Nonflammable, however, airborne in the form of a dust this substance will support combustion **LEL/LFL:** Nonflammable **UEL/UFL:** Nonflammable **Vapor Density:** Not available **Vapor Pressure:** 1 mmHg @ 372°C (sublimes) **Specific Gravity:** 5.73 **Incompatibilities:** Oxidizers, halogens,zinc, lithium, azides, and acetylides **Appearance and odor:** Gray to black, brittle, crystalline, amorphous, odorless.	Overexposure to this substance through inhalation or ingestion may result in ulceration of the NAFal septum, GI disturbances resulting in violent purging and vomiting, hoarse voice, sore throat, excessive salivation, peripheral neuropathy (numbness and burning sensations beginning at the extremities followed by motor weakness), respiratory irritation leading to possible pulmonary edema. Skin or eye contact may result in irritation, conjunctiva, dermatitis, and hyperpigmentation (darkening of the areas exposed) of the skin. This substance has been judged to be a Human carcinogen by NTP, and IARC.
Beryllium	7440-41-7 as Be	Particulate form - This substance is unable to be detected by PID/FID.	Air sample using a particulate filter; acid desorption; AAS/GF detection. Sampling and analytical protocol shall proceed in accordance with NIOSH Method #7102.	OSHA: 0.002 mg/m^3, (ceiling) 0.005 mg/m^3 NIOSH: 0.0005 mg/m^3 ACGIH: 0.002 mg/m^3	No identifiable warning properties to indicate presence and thereby detection. **Recommended APR Cartridge:** Suitable for dust and fume. Organic vapor acid gases with HEPA filter. **Recommended gloves:** This is in the particulate form. Therefore any glove suitable to prevent skin contact (Nitrile has been the one most widely used for the other substances).	**Boiling Pt:** 5378°F; 2970°C **Melting Pt:** 2332°F; 1278°C **Solubility:** Insoluble **Flash Pt:** Not available (Airborne dust may burn or explode when exposed to heat, flame, or incompatible chemicals) **LEL/LFL:** Not available **UEL/UFL:** Not available **Vapor Density:** Not available **Vapor Pressure:** 0 mmHg **Specific Gravity:** 1.85 **Incompatibilities:** Halocarbons, strong oxidizers, acids and caustics **Appearance and odor:** gray to white hard light metal, brittle	Overexposure to this substance may result in respiratory symptoms including difficulty in breathing, coughing, rales, chest pain, possibly pulmonary edema, weakness, fatigue, headache, weight loss. Direct contact may result in irritant action on the skin (dermatitis), eyes (conjunctivae), and mucous membranes. This substance has been identified as a potential human carcinogen.

TABLE 6-1

CHEMICAL, PHYSICAL AND TOXICOLOGICAL DATA FOR NAVAL AIR FACILITY KEY WEST KEY WEST, FLORIDA

Substance	CAS No.	Air Monitoring/Sampling Information		Exposure Limits	Warning Property Rating	Physical Properties	Health Hazard Information
Cadmium	7440-43-9	Particulate Form - Unable to be easily detected by PID or FID.	Air sample using a mixed cellulose-ester filter / acid desorption and analysis by atomic absorption-flame. Sampling and analytical protocol shall proceed in accordance with NIOSH Method #7300 or #7048.	OSHA: 2 $\mu g/m^3$ (0.002 mg/m^3) ACGIH: 0.01 mg/m^3 (total particulate) 0.002 mg/m^3 (respirable particulate) IDLH: 9 mg/m3 (as cd)	The use of an air purifying, full face-piece respirator with a high efficiency particulate air filter for concentrations up to 0.25 mg/m^3. **Recommended Gloves:** This is in particulate form. Therefore any glove suitable to prevent skin contact.	**Boiling Pt:** 1412°F; 767°C **Melting Pt:** 610°F; 321°C **Solubility:** Insoluble **Flash Pt:** Not applicable (Airborne dust may burn or explode when exposed to heat, flame, or incompatible chemicals) **LEL/LFL:** Not applicable **UEL/UFL:** Not applicable **Vapor Density:** Not available **Vapor Pressure:** 1 mmHg @ 741°F; 394 °C **Specific Gravity:** 8.65 @ 90°F; 32°C **Incompatibilities:** Strong oxidizers, elemental sulfur, selenium, tellurium, zinc, nitric acid, and hydrazoic acid **Appearance and Odor:** Metal: Silver-white, blue-tinged lustrous, odorless solid. Fume: yellow-brown, finely divided particulate dispersed in air.	Overexposure to this substance may result in irritation to the respiratory tract, dyspnea, tightness in the chest, coughing, possibly pulmonary edema. Overexposure to fumes causes symptoms characteristic of the flu (headaches, chills, muscle aches, nausea, vomiting, diarrhea). Chronic exposure may result in damage to the lungs, kidneys and liver. This substance has been identified as a confirmed animal; potential human carcinogen by IARC and NTP.
Chromium Compounds	7440-47-3 (Element)	Not detectable by PID. Not detectable by FID.	Air sample using mixed cellulose - ester filter; acid desorption and analysis by atomic absorption. Sampling and analytical protocol shall proceed in accordance with NIOSH Method #7024.	OSHA & NIOSH: (Chromium II, III) 0.5 mg/m^3 (Chromium VI) 0.1 mg/m^3 (Ceiling) ACGIH: 0.5 mg/m^3 (Chromium II, III compounds), 0.05 mg/m^3 (Chromium VI compounds) IDLH: 30 mg/m^3 (Chromium VI compounds)	The use of a air purifying, full face-piece respirator with a high efficiency particulate filter for concentrations up to 0.1 mg/m^3. **Recommended Gloves:** This is in particulate form. Therefore any glove suitable to prevent skin contact.	**Boiling Pt:** 4788°F; 2642°C **Melting Pt:** 3452°F; 1900°C **Solubility:** Insoluble **Flash Pt:** Not applicable (Airborne dust may burn or explode when exposed to heat, flame, or incompatible chemicals) **LEL/LFL:** Not applicable **UEL/UFL:** Not applicable **Vapor Density:** Not available **Vapor Pressure:** 0 mmHg **Specific Gravity:** 7.14 **Incompatibilities:** Strong oxidizers, peroxides, and alkalis **Appearance and Odor:** Appearance and odor vary depending upon the specific compound.	Health hazards are characterized normally through chronic exposure manifesting as histologic fibrosis of the lungs and ulceration of the NAFal septum and skin. IARC, NTP and ACGIH list various chromium compounds as possessing carcinogenic properties.

TABLE 6-1

CHEMICAL, PHYSICAL AND TOXICOLOGICAL DATA FOR NAVAL AIR FACILITY KEY WEST KEY WEST, FLORIDA

Substance	CAS No.	Air Monitoring/Sampling Information		Exposure Limits	Warning Property Rating	Physical Properties	Health Hazard Information
Lead	7439-92-1	Particulate form - Unable to be detected by either PID or FID.	Air sample using a mixed cellulose ester filter; or HNO_3 or H_2O_2 desorption; or Atomic absorption detection. NIOSH Method #7082 or #7300.	OSHA: 0.05 mg/m^3 ACGIH: 0.15 mg/m^3 NIOSH: 0.10 mg/m^3 IDLH: 100 mg/m^3 as lead	The use of a air purifying, full-face respirator with high efficiency particulate air filter for up to 2.5 mg/m^3. **Recommended gloves:** This is in the particulate form. Therefore any glove suitable to prevent skin contact (Nitrile has been the one most widely used for the other substances).	**Boiling Pt:** 3164°F; 1740°C **Melting Pt:** 621°F; 327°C **Solubility:** Insoluble **Flash Pt:** Not applicable (Airborne dust may burn or explode when exposed to heat, flame, or incompatible chemicals) **LEL/LFL:** Not applicable **UEL/UFL:** Not applicable **Vapor Density:** Not available **Vapor Pressure:** 0 mmHg **Specific Gravity:** 11.34 **Incompatibilities:** Strong oxidizers, peroxides, sodium acetylide, zirconium, and acids **Appearance and Odor:** Metal: A heavy ductile, soft gray solid.	Overexposure to this substance via ingestion or inhalation may result in metallic taste in the mouth, dry throat, thirst, Gastrointestinal disorders (burning stomach pain, nausea, vomiting, possible diarrhea sometimes bloody or black, accompanied by severe bouts of colic), CNS effects (muscular weakness, pain, cramps, headaches, insomnia, depression, partial paralysis possibly coma and death. Extended exposure may result in damage to the kidneys, gingival lead line, brain, and anemia.
Mercury	7439-97-6	Jerome Mercury Vapor Analyzer This substance is unable to be detected by PID/FID.	Air sample using Hydrar® sorbent tube; acid desorption; AA cold detection. Sampling and analytical protocol shall proceed in accordance with NIOSH Method #6009.	OSHA; NIOSH; ACGIH: as alkyl compounds 0.01 mg/m^3; STEL 0.03 mg/m^3 IDLH: 10 mg/m^3	No identifiable warning properties to indicate presence and thereby detection. **Recommended APR Cartridge:** Suitable for Metallic mercury with HEPA filter. Preferably, with an end-of-service life indicator. **Recommended gloves:** Rubber gloves	**Boiling Pt:** 674°F; 356.9°C **Melting Pt:** -38°F; -38.89°C **Solubility:** Insoluble **Flash Pt:** Not available **LEL/LFL:** Not available **UEL/UFL:** Not available **Vapor Density:** Not available **Vapor Pressure:** 0.0012 mmHg @ 77°F; 25°C **Specific Gravity:** 13.6 **Incompatibilities:** Acetylene, ammonia, chlorine dioxide, azides, calcium, sodium carbide, lithium, rubidium, and copper **Appearance and odor:** Silvery-white heavy mobile liquid, odorless	This substance is corrosive to all points of contact. Systemic symptoms include irritability, wakefulness, muscle weakness and tremors, increased reflexes, gingivitis, anorexia, headache, tinnitus, hypermobility, GI disturbances (nausea, vomiting), diarrhea (sometimes bloody), liver changes, dermatitis, and fever. Symptoms experienced via inhalation include to those above coughing, chest pain, dyspnea, bronchial pneumonitis, and excessive salivation.

TABLE 6-1

CHEMICAL, PHYSICAL AND TOXICOLOGICAL DATA FOR NAVAL AIR FACILITY KEY WEST KEY WEST, FLORIDA

Substance	CAS No.	Air Monitoring/Sampling Information		Exposure Limits	Warning Property Rating	Physical Properties	Health Hazard Information
DDT and the major metabolites; DDD and DDE.	50-29-3 72-54-8 72-55-9	Substance is not volatile, I.P. is unknown, detection by PID is unknown. Substance non-combustible, therefore a FID is anticipated to have reduced response to DDT.	Air sample using a binder free, glass fiber filter; isoctane desorption; gas chromatography-electron capture detector. Sampling and analytical protocol will proceed in accordance with NIOSH Method #3(S274).	OSHA; ACGIH: 1 mg/m^3 NIOSH: 0.5 mg/m^3	Adequate - Can use air purifying respirator with high efficiency particulate air filter (HEPA). **Recommended glove:** Nitrile acceptable for incidental contact.	**Boiling Pt:** 230°F; 110°C **Melting Pt:** 226°F; 108°C **Solubility:** Insoluble **Flash Pt:** 162-171°F; 72-77°C **LEL/LFL:** Not available **UEL/UFL:** Not available **Vapor Density:** Not available **Vapor Pressure:** Low **Specific Gravity:** 0.99 **Incompatibilities:** Strong oxidizers and alkalis **Appearance and Odor:** Colorless crystals or off-white powder with a slight aromatic odor	Large doses are followed by vomiting due to gastric irritation, diarrhea may follow. Numbness and parethesias of the lips tongue and face associated with malaise, headache, sorethroat, fatigue and weakness. Coarse tremors (usually first of the neck, head, and eyelids). This may be accompanied by confusion, apprehension, and depression. Convulsions may result and death may occur from respiratory failure. DDT is absorbed and retained in the fat of humans. Chronic exposure may result in damage to the liver, kidneys and Peripheral Nervous System. DDT is recognized as possessing carcinogenic properties by IARC and NTP.
Benzo(a)pyrene	50-32-8	Particulate form - This substance is not detectable using a PID or FID.	Air sample using a glass fiber or silver membrane filter; analysis by gas chromatography/infrared or other spectrophotometric method or colorimeter. Sampling and analytical protocol shall proceed in accordance with NIOSH Method #1(186).	OSHA: 0.2 mg/m^3 NIOSH: 0.1 mg/m^3	Adequate - use a full-face air-purifying respirator with dust/mist cartridge up to 10 mg/m^3. **Recommended glove:** Nitrile	**Boiling Pt:** 594°F; 312°C **Melting Pt:** 354°F; 179°C **Solubility:** Insoluble **Flash Pt:** Not available **LEL/LFL:** Not available **UEL/UFL:** Not available **Vapor Density:** Not available **Vapor Pressure:** 10 mmHg @ 594°F; 312°C **Specific Gravity:** Not available **Incompatibilities:** Not available **Appearance and Odor:** Yellow odorless crystals.	Regulated primarily as a result of potential carcinogenic properties. Listed by NTP, IARC, and ACGIH as carcinogenic.

TABLE 6-1

CHEMICAL, PHYSICAL AND TOXICOLOGICAL DATA FOR NAVAL AIR FACILITY KEY WEST KEY WEST, FLORIDA

Substance	CAS No.	Air Monitoring/Sampling Information		Exposure Limits	Warning Property Rating	Physical Properties	Health Hazard Information
Bis(2-ethylhexyl) phthalate	117-81-7	No information found This is a combustible liquid therefore the FID should detect it however the relative response ratio is unknown.	Particulate filter; carbon disulfide desorption; GC/FID detection. Sampling and analytical protocol shall proceed in accordance with NIOSH Method #5020.	NIOSH; ACGIH: 5 mg/m^3, STEL 10 mg/m^3 OSHA: 6 mg/m^3 IDLH: 5000 mg/m^3	Irritating, tingling sensation. **Recommended APR Cartridge:** Organic vapor acid gases with HEPA filter. **Recommended gloves:** Nitrile >6.00 hrs has been the one most widely used for the other substances and is acceptable for this substance. Other options include butyl rubber >8.00 hrs or neoprene >6.00 hrs	**Boiling Pt:** 680°F; 386°C **Melting Pt:** freezes 6.8°F; -14°C **Solubility:** Insoluble **Flash Pt:** 419°F; 215°C **LEL/LFL:** 0.3% @ 473°F; 245°C **UEL/UFL:** Not available **Vapor Density:** Not available **Vapor Pressure:** <0.01 mm **Specific Gravity:** 0.99 **Incompatibilities:** Nitrates, strong oxidizers, acids, and caustics. **Appearance and odor:** Colorless, oily liquid, odorless	This substance is a mild skin, eye, mucous membrane irritant, and mild gastric disturbance. In test animals liver damage and teratogenic effects have been noted.
Creosote / cresol (Fluoranthene, pyrene)	8001-58-9 1319-77-3 (206-44-0)	PID: I.P. of 8.97 eV, relative response ratio unknown. FID: Response factor unknown but given the substances flammability, detection by FID can be anticipated.	Air sampling for cresol (a major constituent of creosote) by silica gel or xad-7 sorbent tube; Acetone desorption and analysis by gas chromatography - flame ionization detector or high-pressure liquid chromatography. Sampling and analytical protocol shall be in accordance with NIOSH Method #2001, or OSHA Method #32	OSHA; ACGIH: 5 ppm NIOSH: 2.3 ppm IDLH: 80 mg/m^3	Adequate - use a full-face air-purifying respirator with organic vapor / dust/mist cartridge up to 250 ppm. Odor Threshold of creosol is 0.00005-0.0079 ppm. **Recommended gloves:** Viton >96.00 hrs; butyl rubber >90.00 hrs; neoprene >4.50 hrs	**Boiling Pt:** 376-397°F; 191-203°C **Melting Pt:** 52-96°F; 10.9-35.5°C **Solubility:** Insoluble **Flash Pt:** 178°F; 81°C **LEL/LFL:** Not available **UEL/UFL:** Not available **Vapor Density:** 3.72 **Vapor Pressure:** 1 mmHg @ 100-127°F; 38-53°C **Specific Gravity:** 1.030-1.038 **Incompatibilities:** Nitric acid, oleum, chlorosulfonic acid, oxidizers **Appearance and Odor:** Yellowish or colorless, flammable, oily liquid (often brownish because of impurities or oxidation)	Regulated based on effects on central nervous system, and respiratory system. Acute exposures may result in difficulty breathing, respiratory failure and skin and eye burns. Chronic exposure may damage the liver, kidneys, lungs and skin.

- Flying projectiles
- Pinches and compressions
- Vehicular and foot traffic

These physical hazards are discussed in Table 5-1 as applicable to each site task. Further, many of these hazards are discussed in detail in Section 4.0 of the Health and Safety Guidance Manual. Specific discussions on some of these hazards are presented below.

6.2.1 Heavy Equipment Hazards

Often the hazards associated with drilling operations such as pinch/compression points, rotating equipment, etc. are the most dangerous to be encountered during site activities. The SSO will discuss safe drilling procedures as part of site-specific training and/or during daily safety meetings using Safe Work Permits (Figure 9-1) presented in this HASP. The following rules will apply to all drilling operations:

- Site personnel will be aware of the location and operation of this equipment.
- Each drill rig must be equipped with emergency stop devices which will be tested daily to ensure that they are operational.
- Long handled shovels or equivalent shall be used to clear cuttings from the borehole and rotating equipment.

Additional requirements during drilling activities are discussed in Table 5-1. The SSO will thoroughly discuss safe drilling procedures during the pre-activities training session. All site personnel will sign the form in Figure 8-2 documenting that they received the training and understand the procedures.

6.2.2 Cuts

A number of accidents have been reported in last few years when field personnel accidentally cut themselves while extracting soil samples from acetate sample tubes. The tubes are normally inserted in the Macro Core® Samplers or the dual tube samplers. Removing the soil sample requires cutting the tube and spooning the sample into a sample jar.

However, this activity has resulted in numerous cuts to the hands and legs. These injuries have occurred when field personnel open plastic liners improperly. To minimize this hazard, it is recommended that a liner cutter kit of some type be used. The Geoprobe® Corporation markets a liner cutter kit that can be

used. This liner cutter makes two simultaneous longitudinal cuts 1-3/8 in. wide the entire length of Macro Core® liners. The kit includes cutting tool, cutter holder, and hooked stationary blades. The liner cutter holder is 48-in. long and slips onto a flat surface. Also has center mount for securing in a vise. In addition, the following safe work practices will assist in the minimization of this hazard. These items have been engineered to allow sample acquisition without placing the sampler at risk.

- Always cut away from yourself and others, then, if a knife slips, you will not impale yourself or others.
- Do not place items to be cut in your hand or on your knee.
- Change out blades as necessary to maintain a sharp cutting edge. Many accidents result from struggling with dull cutting attachments.

6.2.3 Contact with Underground or Overhead Utilities

Underground utilities such as pressurized lines, water lines, telephone lines, buried utility lines, and high voltage power lines may be present throughout the facility. **Therefore, all subsurface activities must be conducted following the requirements of the Tetra Tech NUS SOP for "Utility Locating and Excavation Clearance (HS-1.0)"**. A copy of this SOP is provided as Attachment II. Clearance of underground and overhead utilities for each sample location will be coordinated with NAS Cecil Field personnel. Dave Kruzicki is the point-of-contact for NAS Cecil Field and can be reached at (904) 778-5620 Ext. 114. Additionally, drilling operations will be conducted at a safe distance from overhead power lines as discussed in Attachment II. In certain cases, NAS Cecil Field personnel may need to de-energize electrical cables using facility lockout/tagout procedures to insure electrical hazards are eliminated.

6.3 NATURAL HAZARDS

Insect/animal bites and stings, poisonous plants, and inclement weather are natural hazards that may be present given the location of activities to be conducted. In general, avoidance of areas of known infestation or growth will be the preferred exposure control for insects/animals and poisonous plants. Specific discussion on principle hazards of concern follows:

6.3.1 Insect/Animal Bites and Stings

Fire Ants

Various insects and animals may be present and should be considered. For example, fire ants present a unique situation when working outdoors in Florida. Their aggressive behavior and their ability to sting

repeatedly can pose a unique health threat. The sting injects venom (formic acid) that causes an extreme burning sensation. Pustules form which can become infected if scratched. Allergic reactions of people sensitive to the venom include dizziness, swelling, shock and in extreme cases unconsciousness and death. People exhibiting such symptoms should see a physician. Fire ants can be identified by their habitat. They build mounds in open sunny areas sometimes supported by a wall or shrub. The mound has no external opening. The size of the mound can range from a few inches across to some which are in excess of two feet or more in height and diameter. When disturbed they defend it by swarming out and over the mound, even running up grass blades and sticks.

Also, areas to be investigated could be prime nesting and/or hiding locations for snakes and other insects. Personnel should avoid reaching into areas that are not visibly clear of snakes or insects. Snake chaps will be worn in areas of known or anticipated snake infestation. All site personnel who are allergic to stinging insects such as bees, wasps, and hornets must be particularly careful since severe illness and death may result from allergic reactions. As with any medical condition or allergy, information regarding the condition must be listed on the Medical Data Sheet and the FOL and SSO notified.

Alligators

Alligators live in all Florida counties but are most common in the major river drainage basins and large lakes in the central and southern portions of the state. They also can be found in marshes, swamps, ponds, drainage canals, phosphate-mine settling ponds, and ditches. Alligators are tolerant of poor water-quality and occasionally inhabit brackish marshes along the coast. A few even venture into salt water.

Mature alligators seek open water areas during the April-to-May courtship and breeding season. After mating, the females move into marsh areas to nest in June and early July where they remain until the following spring. Males generally prefer open and deeper water year-round. Alligators less than four feet long typically inhabit the marshy areas of lakes and rivers. Dense vegetation in these habitats provides protective cover and many of the preferred foods of young alligators.

- Most human attacks associated with alligators occur when they have been fed by humans or when defending their nests.

- Under no circumstances should you approach an alligator closely. They are quite agile, even on land. As with any wild animal, alligators merit a measure of respect.

- Alligators are classified as a threatened species and thus enjoy the protection of state and federal law. Only representatives of the Florida Game and Fresh Water Fish Commission are empowered to handle nuisance alligators.

- It is illegal to feed, tease, harass, molest, capture or kill alligators.

- If a serious problem does exist, contact the Florida Game and Fresh Water Fish Commission.

Ticks

There are various areas throughout the U.S. where Lyme Disease is endemic. Fortunately, Florida is not one of these areas. Nonetheless, personnel should be aware of the hazards of tick bites and Lyme Disease. The longer a disease carrying tick remains attached to the body, the greater the potential for contracting the disease. Wearing long sleeved shirts and long pants (tucked into boots). As well as performing frequent body checks will prevent long term attachment. Site first aid kits should be equipped with medical forceps and rubbing alcohol to assist in tick removal. For information regarding tick removal procedures, and symptoms of exposure consult Section 4.0 of the Health and Safety Guidance Manual.

6.3.2 Inclement Weather

Project tasks under this Scope of Work will be performed outdoors and near water. As a result, inclement weather may be encountered. In the event that adverse weather conditions arise (electrical storms, hurricanes, etc.), the FOL and/or the SSO will be responsible for temporarily suspending or terminating activities until hazardous conditions no longer exist.

Tropical Storms and Hurricanes

As Florida is a tropical storm, hurricane prone area, the following information is supplied to explain the potential severity of these natural hazards. The decision to curtail operations and evacuate the area should be made by the FOL, PM, and the HSM.

During the early summer to late fall months, typically from the first of June through the end of November, disturbances migrating off the West Coast of Africa move into the Atlantic Ocean and develop into tropical cyclones known as tropical storms and hurricanes. Many of these cyclones become strong enough to threaten life and property along the Eastern Seaboard and Gulf Coast. There are three main threats associated with tropical storms and hurricanes:

- High winds
- Excessive rainfall
- Storm surge

The impacts of high winds and excessive rainfall occur hours, maybe days, before the tropical storm or hurricane makes landfall. However, the storm surge accompanies the storm or hurricane at the time that landfall occurs.

High Winds

Sustained winds vary greatly from storm to storm, but can range from 39 to 73 miles per hour (wind speeds associated with a tropical storm) to greater than 74 miles per hour (minimal wind speed for a Category 1 hurricane). Table 6-2 compares the type of storm or hurricane and the corresponding wind speed.

TABLE 6-2

TROPICAL STORM/HURRICANE RATING SCALE

TYPE	CATEGORY*	WINDS (MPH)
Tropical Depression	NA	>35-38
Tropical Storm	NA	39 – 73
Hurricane	1	74 – 95
Hurricane	2	96 – 110
Hurricane	3	111 – 130
Hurricane	4	131 – 155
Hurricane	5	>155

Based on the Saffir-Simpson scale

NA – Not Applicable

In addition to strong winds, there is the threat of debris (i.e. building material, trees, etc.) becoming airborne projectiles as they are carried by the high winds. Thunderstorms and tornadoes embedded within the tropical storm or hurricane can further increase the wind speeds on a localized level.

Excessive Rainfall

Heavy rains associated with tropical storms and hurricanes also vary greatly from storm to storm. On average, an inch of rainfall an hour is not uncommon with major hurricanes, somewhat lesser amounts

with tropical storms. However, the primary threat is not the intensity of rain, but the duration of rainfall. Since many tropical storms and hurricanes are slow-movers, they are capable of producing sustained heavy rainfall over a long period of time. It is not uncommon for an area to receive nearly 20 inches of rain in 24 hours. Under these conditions, street; stream and creek flooding is inevitable only to be exacerbated by locally heavier rains from thunderstorms.

Storm Surge

The storm surge is an abnormal rise in sea level accompanying a hurricane or tropical storm. The height of the storm surge (usually measured in feet) is the difference in sea level from the observed level (during the storm) and the level that would have occurred in the absence of the storm or hurricane. The more intense the storm or hurricane the higher the storm surge. Storm surges become even higher if they occur during periods of high tide. Table 6-3 defines some of the terminology and possible calls to action regarding tropical cyclones:

TABLE 6-3
TROPICAL STORM/HURRICANE
WATCH AND WARNING

STORM DESCRIPTION	DEFINITION	CALL TO ACTION
Tropical Storm Watch	Tropical storm conditions are possible in the specified area of the watch, usually within 36 hours	Weather conditions should be monitored for further advisories. Prepare for possible evacuation by local officials
Tropical Storm Warning	Tropical storm conditions are expected in the specified area of the warning, usually within 24 hours.	Work should be suspended in areas where lightning, high winds and rainfall could pose a threat to life. Mandatory evacuations may be enforced by local officials.
Hurricane Watch	Hurricane conditions are possible in the specified area of the watch, usually within 36 hours.	Weather conditions should be monitored for further advisories. Prepare for possible evacuation by local officials
Hurricane Warning	Hurricane conditions are expected in the specified area of the warning, usually within 24 hours.	Mandatory evacuations will most likely be enforced by local officials.

A NOAA Weather Radio is the best means to receive watches and warnings from the National Weather Service. The National Weather Service continuously broadcasts updated hurricane advisories that can be received by widely available NOAA Weather Radios.

6.3.3 Heat Stress

Given the geographic location of the site and the project schedule, overexposure to high ambient temperatures (heat stress) may exist during performance of this work depending on the project schedule. (extremely cold temperatures are not expected to be encountered due to project location). Work performed when ambient temperatures exceed 70 ^{o}F may result in varying levels of heat stress (heat rash, heat cramps, heat exhaustion, and/or heat stroke) depending on variables such as wind speed, humidity, and percent sunshine, as well as physiological factors such as metabolic rate and skin moisture content. Additionally, work load and level of protective equipment will affect the degree of exposure. Site personnel will be encouraged to drink plenty of fluids to replace those lost through perspiration. Additional information such as Work-Rest Regimens and personnel monitoring may be found in Section 4.0 of the Health & Safety Guidance Manual.

Many of these physical hazards are discussed in detail in Section 4.0 of the Health and Safety Guidance Manual. Additional information regarding physical hazards associated with the site is provided in Table 5-1 of this HASP.

The following is a list of physical hazards that may be encountered at the site or may be present during the performance of site activities associated with the scope of work:

- Slip, trip, and fall hazards
- Strain/muscle pulls from manual lifting
- Noise in excess of 85 decibel (dBA)
- Exposure to pinch or compression points
- Entanglement or contact with moving or rotating equipment/machinery
- Contact with energized sources (aboveground and underground)
- Ambient temperature extremes
- Inclement weather
- Natural Hazards (ticks, snakes, plants, etc.).

Many of these physical hazards are discussed in detail in Section 4.0 of the Health and Safety Guidance Manual. Additional information regarding physical hazards associated with the site is provided in Table 5-1 of this HASP.

7.0 AIR MONITORING

Direct reading instruments will be used at the site to detect and evaluate the presence of contaminants and other potentially hazardous conditions. As a result, specific air monitoring measures and requirements are established in Table 5-1, as they pertain to the specific hazards and tasks of an identified operation. Additionally, the Health and Safety Guidance Manual, Section 1.0, contains detailed information regarding direct reading instrumentation, as well as general calibration procedures for various instruments.

7.1 INSTRUMENTS AND USE

Instruments will be used primarily to monitor source points and worker breathing zone areas, while observing instrument action levels. Action levels are discussed in Table 5-1, as they may apply to a specific task or location.

7.1.1 Photo Ionization Detector or Flame Ionization Detector

In order to accurately monitor for any substances that may present an exposure potential to site personnel, a Photo Ionization Detector (PID) using a lamp energy of 10.6 eV or higher will be used. This instrument will be used to monitor potential source areas and to screen the breathing zones of employees during site activities. The PID has been selected because it is capable of detecting the organic vapors of concern (Note**:** A Flame Ionization Detector [FID] may be used as an alternative to the PID).

Prior to the commencement of any field activities, background levels of the site must be determined and noted. Daily background readings will be taken away from any areas of potential contamination. These readings, any influencing conditions (i.e., weather, temperature, humidity) and site location must be documented in the field operations logbook or other site documentation (e.g., sample log sheet).

7.1.2 Hazard Monitoring Frequency

Table 5-1 presents the frequencies at which hazard monitoring will be performed, as well as the action levels which will initiate the use of elevated levels of protection. The SSO may decide to increases these frequencies based on instrument responses and site observations. The frequency at which monitoring is performed will not be reduced without the prior consent of the PHSO or HSM.

7.2 INSTRUMENT MAINTENANCE AND CALIBRATION

Hazard monitoring instruments will be maintained and pre-field calibrated by the TtNUS Equipment Manager. Operational checks and field calibration will be performed on all instruments each day prior to their use. Field calibration will be performed on instruments according to manufacturers' recommendations (e.g., the PID must be field-calibrated daily and an additional field calibration must be performed at the end of each day to determine any significant instrument drift). These operational checks and calibration efforts will be performed in a manner that complies with the employees health and safety training, the manufacturers' recommendations, and with the applicable manufacturer standard operating procedure (copies of which can be found in the Health and Safety Guidance Manual, which will be maintained on site for reference). All calibration efforts must be documented. Figure 7-1 is provided for documenting these calibration efforts. This information may instead be recorded in a field operations logbook, provided that all information specified in Figure 7-1 is recorded. This required information includes the following:

- Date calibration was performed
- Individual calibrating the instrument
- Instrument name, model, and serial number
- Any relevant instrument settings and resultant readings (before and after) calibration
- Identification of the calibration standard (lot number, source concentration, supplier)
- Any relevant comments or remarks.

FIGURE 7-1
DOCUMENTATION OF FIELD CALIBRATION

SITE NAME: _____ **PROJECT NO.:**_____

Date of Calibration	Instrument Name and Model	Instrument I.D. Number	Person Performing Calibration	Instrument Settings		Instrument Readings		Calibration Standard (Lot Number)	Remarks/ Comments
				Pre-Calibration	Post-Calibration	Pre-Calibration	Post-Calibration		

8.0 TRAINING/MEDICAL SURVEILLANCE REQUIREMENTS

8.1 INTRODUCTORY/REFRESHER/SUPERVISORY TRAINING

This section is included to specify health and safety training and medical surveillance requirements for TtNUS personnel participating in onsite activities.

8.1.1 Requirements for TtNUS Personnel

All TtNUS personnel must complete 40 hours of introductory hazardous waste site training prior to performing work at NAF Key West. TtNUS personnel who have had introductory training more than 12 months prior to site work must have completed 8 hours of refresher training within the past 12 months before being cleared for site work. In addition, 8-hour supervisory training in accordance with 29 CFR 1910.120(e)(4) will be required for site supervisory personnel.

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

8.1.2 Requirements for Subcontractors

Identified TtNUS subcontractor personnel must have completed introductory hazardous waste site training or equivalent work experience as defined in OSHA Standard 29 CFR 1910.120(e), and 8 hours of refresher training meeting the requirements of 29 CFR 1910.120(e)(8) prior to performing field work at NAF Key West. TtNUS subcontractors must certify that each employee has had such training by sending TtNUS a letter, on company letterhead, containing the information shown in the example letter in Figure 8-1. This letter will be accompanied by training certificates or some other form of official documentation for all subcontractor personnel participating in site activities.

8.2 SITE-SPECIFIC TRAINING

TtNUS will provide site-specific training to all TtNUS personnel who will perform work on this project. Site-specific training will include:

- Names of designated personnel and alternates responsible for site safety and health
- Safety, health, and other hazards present on site
- Use of PPE

- Work practices to minimize risks from hazards
- Medical surveillance requirements
- Contents of the HASP
- Signs and symptoms of overexposure to site contaminants
- Emergency response procedures (evacuation and assembly points)
- Spill response procedures
- Review of the contents of relevant Material Safety Data Sheets(MSDS)
- Emergency response procedures (evacuation and assembly points)
- Associated hazards and restricted areas within NAF Key West.

Site-specific training will be documented as shown in Figure 8-2.

8.3 MEDICAL SURVEILLANCE

All TtNUS personnel participating in project field activities will have had a physical examination that met the requirements of TtNUS' medical surveillance program. Documentation for medical clearances will be maintained in the TtNUS Pittsburgh, office and made available, as necessary.

8.3.1 Medical Surveillance Requirements for Subcontractors

Identified subcontractors are required to obtain certificates of their ability to perform hazardous waste site work and to wear respiratory protection. The "Subcontractor Medical Approval Form" provided in Figure 8-3 will be used to satisfy this requirement, providing it is properly completed and signed by a licensed physician.

Subcontractors who have a company medical surveillance program meeting the requirements of paragraph (f) of OSHA 29 CFR 1910.120 can substitute "Subcontractor Medical Approval Form" with a letter, on company letterhead, containing all of the information in the example letter presented in Figure 8-4 of this HASP.

8.3.2 Requirements for All Field Personnel

Each field team member, including subcontractors and visitors, entering the exclusion zone(s) will be required to complete and submit a copy of the Medical Data Sheet found in the TtNUS Health and Safety Guidance Manual. This shall be provided to the SSO, prior to participating in site activities. The purpose of this document is to provide site personnel and emergency responders with additional information that may be needed in order to administer medical attention.

8.4 SUBCONTRACTOR EXCEPTIONS

The use of the subcontractor exception is strictly limited to the authority of the CLEAN Health and Safety Manager.

In situations in which the exclusion zone is not entered or when there is no potential for exposure to site contaminants, subcontractor personnel may be exempt from some of the training and medical surveillance requirements. All subcontractors and visiting personnel are required to receive site-specific training (as discussed in Section 8.2) regarding information provided in this HASP. Examples of subcontractors who may be exempt from training and medical surveillance requirements may include surveyors who perform surveying activities at the site perimeters or in areas where there is no potential for exposure to site contaminants.

FIGURE 8-1. EXAMPLE TRAINING LETTER

The following statements must be typed on company letterhead and signed by an officer of the company and accompanied by copies of personnel training certificates:

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

Month, day, year

Mr. Chuck Bryan
Task Order Manager
Tetra Tech NUS
900 Trail Ridge Road
Aiken, South Carolina 29803

Subject: HAZWOPER Training for Naval Air Station Key West (NAS Key West), Key West, Florida

Dear Mr. Bryan:

As an officer of XYZ Corporation, I hereby state that I am aware of the potential hazardous nature of the subject project. I also understand that it is our responsibility to comply with all applicable occupational safety and health regulations, including those stipulated in Title 29 of the Code of Federal Regulations (CFR), Parts 1900 through 1910 and Part 1926.

I also understand that Title 29 CFR 1910.120, entitled "Hazardous Waste Operations and Emergency Response," requires an appropriate level of training for certain employees engaged in hazardous waste operations. In this regard, I hereby state that the following employees have had 40 hours of introductory hazardous waste site training or equivalent work experience as required by 29 CFR 1910.120(e) and have had 8 hours of refresher training as required by 29 CFR 1910.120(e)(8) and site supervisory personnel have had training in accordance with 29 CFR 1910.120(e)(4).

LIST FULL NAMES OF EMPLOYEES AND THEIR SOCIAL SECURITY NUMBERS HERE.

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

Sincerely,

(Name and Title of Company Officer)

Enclosed - Copies of Training Certificates

FIGURE 8-2
SITE-SPECIFIC TRAINING DOCUMENTATION

My signature below indicates that I am aware of the potential hazardous nature of performing remedial investigation activities at NAS Cecil Field, Jacksonville, Florida and that I have received site-specific training which included the elements presented below:

- Names of designated personnel and alternates responsible for site safety and health
- Safety, health, and other hazards present at the sites
- Use of personal protective equipment
- Safe use of engineering controls and equipment
- Medical surveillance requirements
- Signs and symptoms of overexposure
- Contents of the Health and Safety Plan
- Emergency response procedures (evacuation and assembly points)
- Initial response procedures
- Review of the contents of relevant Material Safety Data Sheets
- Review of the use of Safe Work Permits

I state that I have been given the opportunity to ask questions and that all of my questions have been answered to my satisfaction. I further state, by presence of my signature below, that the date of my training (introductory, refresher, and supervisory, as applicable) and my medical surveillance requirements are accurate and correct to the best of my knowledge.

Name (Printed and Signature)	Site-Specific Training Date	40-Hour Training (Date)	8-Hour Refresher Training (Date)	8-Hour Supervisory Training (Date)	Medical Exam

FIGURE 8-3. SUBCONTRACTOR MEDICAL APPROVAL FORM

For employees of _____
Company Name

Participant Name: _____ Date of Exam: _____

Part A

The above-named individual has:

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

   ( ) qualified to perform work at the Naval Air Station Key West; Key West, Florida

   ( ) not qualified to perform work at the Naval Air Station Key West; Key West, Florida

   and,

2. Undergone a physical examination in accordance with OSHA 29 CFR 1910.134(b)(10) and was found to be medically -

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

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

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

Part B

I, _____, have examined _____
Physician's Name (print) Participant's Name (print)

and have determined the following information:

FIGURE 8-3. SUBCONTRACTOR MEDICAL APPROVAL FORM

PAGE TWO

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

_____

_____

_____

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

_____

_____

_____

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

_____

_____

_____

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

Based on the information provided to me, and in view of the activities and hazard potentials involved at the Naval Air Station Key West; Key West, Florida, this participant

( ) may
( ) may not

perform his/her assigned task.

Physician's Signature _____

Address _____

Phone Number _____

NOTE: Copies of test results are maintained and available at:

_____

Address

FIGURE 8-4.
EXAMPLE MEDICAL SURVEILLANCE LETTER

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

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

Month, day, year

Mr. Chuck Bryan
Task Order Manager
Tetra Tech NUS
900 Trail Ridge Road
Aiken, South Carolina 29803

Subject: Medical Surveillance forNaval Air Station Key West (NAS Key West), Key West, Florida

Dear Mr. Bryan:

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

LIST FULL NAMES OF EMPLOYEES AND THEIR SOCIAL SECURITY NUMBERS HERE.

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

Sincerely,

(Name and Title of Company Officer)

9.0 SITE CONTROL

This section outlines the means by which TtNUS will delineate work zones and use these work zones in conjunction with decontamination procedures to prevent the spread of contaminants into previously unaffected areas of the site. It is anticipated that a fractured three-zone approach will be used during work at this site. This three-zone approach will utilize an exclusion zone, a contamination reduction zone, and a support zone. It is also anticipated that this control measure will be used to control access to site work areas. Use of such controls will restrict the general public, minimize the potential for the spread of contaminants, and protect individuals who are not cleared to enter work areas.

9.1 EXCLUSION ZONE

The exclusion zone will be considered those areas of active operations plus an established safety zone, depending on the task. The following represent the exclusion zone boundaries for the identified tasks:

- Soil Borings and Monitoring Well Installation – The boundary perimeter will be established by determining the height of the mast, plus 5 feet. Therefore, a 35-foot mast plus 5 feet equals a 40-foot boundary surrounding the point of operation.

- Well Development – 10 feet surrounding the well head and discharge point.

- Groundwater sampling – 10 feet surrounding the well head.

- Subsurface soils – 5 feet surrounding the sample collection point or point of excavation.

- Decontamination (heavy equipment – steam/pressure washers) – 35 feet surrounding the point of operation. This opeation will take place at a centralized location.

Where appropriate and necessary to direct facility personnel, this area will be delineated using barrier tape, cones and/or drive poles, and postings.

9.1.1 <u>Exclusion Zone Clearance</u>

A pre-startup site visit will be conducted by members of the field team in an effort to identify proposed subsurface investigation locations, conduct utility clearances, and provide up-front notices concerning scheduled activities within the facility. In all cases, no subsurface activities will proceed without utility clearance. Subsurface activities must be conducted following the requirements of the Tetra Tech NUS SOP

for “Utility Locating and Excavation Clearance (HS-1.0)”. In the event that a utility is struck during a subsurface investigative activity, the appropriate site contact identified in Table 2-1 will be notified. When base personnel are working within the proximity of this investigation, they will be moved or their operation temporarily discontinued to protect them from potential hazards associated with this operation.

9.2 CONTAMINATION REDUCTION ZONE

The contamination reduction zone (CRZ) will be a buffer area between the exclusion zone and any area of the site where contamination is not suspected. This area will also serve as a focal point in supporting exclusion zone activities. This area will be delineated with barrier tape, cones, and postings to inform and direct facility personnel. Decontamination will be conducted at a central location. All potentially contaminated equipment will be bagged and taken to that location for decontamination. Given this consideration, equipment required to complete this operation may include stainless steel bowls and spatulas for each location.

9.3 SUPPORT ZONE

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

9.4 SAFE WORK PERMITS

All Exclusion Zone work conducted in support of this project will be performed using Safe Work Permits to guide and direct field crews on a task by task basis. An example of the Safe Work Permit to be used is illustrated in Figure 9-1. Partially completed Permits for the work to be performed are included in Attachment IV. The daily meetings conducted at the site will further support these work permits. This effort will ensure all site-specific considerations and changing conditions are incorporated into the planning effort. All permits will require the signature of the FOL and/or the SSO. Use of these permits will provide the communication line for reviewing protective measures and hazards associated with each operation. This HASP will be used as the primary reference for selecting levels of protection and control measures. The work permit will take precedence over the HASP when more conservative measures are required based on specific site conditions. All permits will be turned into the FOL and/or the SSO upon reaching their termination period or upon completion of the task for which the permit was issued.

FIGURE 9-1
SAFE WORK PERMIT

Permit No. _____ Date: _____ Time: From _____ to _____

SECTION I: General Job Scope (To be filled in by person performing work)

I. Work limited to the following (description, area, equipment used): _____

II. Names: _____

III. Onsite Inspection conducted ☐ Yes ☐ No Initials of Inspector _____ _____
TtNUS

SECTION II: General Safety Requirements (To be filled in by permit issuer)

IV. Protective equipment required
Level D ☐ Level B ☐
Level C ☐ Level A ☐
Detailed on Reverse

Respiratory equipment required
Full face APR ☐ Escape Pack ☐
Half face APR ☐ SCBA ☐
SKA-PAC SAR ☐ Bottle Trailer ☐
Skid Rig ☐ None ☐

Modifications/Exceptions: _____

V. Chemicals of Concern | Action Level(s) | Response Measures
_____ _____ _____
_____ _____ _____

VI. Additional Safety Equipment/Procedures

Hardhat	☐ Yes	☐ No	Hearing Protection (Plugs/Muffs)	☐ Yes	☐ No
Safety Glasses	☐ Yes	☐ No	Safety belt/harness	☐ Yes	☐ No
Chemical/splash goggles	☐ Yes	☐ No	Radio	☐ Yes	☐ No
Splash Shield	☐ Yes	☐ No	Barricades	☐ Yes	☐ No
Splash suits/coveralls	☐ Yes	☐ No	Gloves (Type)	☐ Yes	☐ No
Steel toe/shank Workboots	☐ Yes	☐ No	Work/rest regimen	☐ Yes	☐ No

Modifications/Exceptions: _____

VII. Procedure review with permit acceptors

	Yes	NA		Yes	NA
Safety shower/eyewash (Location & Use)	☐	☐	Emergency alarms	☐	☐
Procedure for safe job completion	☐	☐	Evacuation routes	☐	☐
Contractor tools/equipment inspected	☐	☐	Assembly points	☐	☐

IX. Site Preparation

	Yes	No	NA
Utility Locating and Excavation Clearance completed	☐	☐	☐
Vehicle and Foot Traffic Routes Cleared and Established	☐	☐	☐
Physical Hazards Barricaded and Isolated	☐	☐	☐
Emergency Equipment Staged	☐	☐	☐

IX. Additional Permits required (Hot work, confined space entry, excavation etc.). ☐ Yes ☐ No
If yes, fill out appropriate section(s) on safety work permit addendum

X. Special instructions, precautions: _____

Permit Issued by: _____ Permit Accepted by: _____
Job Completed by: _____ Date: _____

9.5 SITE VISITORS

Site visitors, for the purpose of this document, are identified as representing the following groups of individuals:

- Personnel invited by TtNUS to observe or participate in operations
- Regulatory personnel (i.e., DOD, U.S. Environmental Protection Agency [EPA], OSHA)
- Southern Division Navy personnel
- Other authorized visitors.

All non-DOD personnel working on this project are required to gain initial access to the Base by coordinating with the TtNUS FOL or designee and following established Base access procedures.

Once access to the base is obtained, all personnel who require site access into areas of ongoing operations will be required to obtain permission from the FOL and the Base Contact. Upon gaining access to the site, all site visitors wishing to observe operations in progress will be escorted by a TtNUS representative and be required to meet the minimum requirements discussed below:

- All site visitors will be routed to the FOL, who will sign them into the field logbook. Information to be recorded in the logbook will include the individual's name (proper identification required), the entity represented, and the purpose of the visit.

- All site visitors will be required to produce the necessary information supporting clearance to the site. This shall include information attesting to applicable training and medical surveillance, as stipulated in Section 8.0 of this document. In addition, to enter site operational zones during planned activities, all visitors will be required to first go through site-specific training, covering the topics stipulated in Section 8.2 of this HASP.

Once site visitors have completed the above items, they will be permitted to enter the operational zone. All visitors are required to observe the protective equipment and site restrictions in effect at the site at the time of their visit. All visitors entering the exclusion zones during ongoing operations will be accompanied by a TtNUS representative. Any and all visitors not meeting the requirements stipulated in this plan for site clearance will not be permitted to enter the site operational zones during planned activities. Any incidence of unauthorized site visitation will cause termination of all onsite activities until the unauthorized visitor is removed from the premises. Removal of unauthorized visitors will be accomplished with support from the Base Contact, who will be notified of any unauthorized visitors.

9.6 SITE SECURITY

Site security will be maintained by TtNUS field personnel. TtNUS will retain complete control over active operational areas. Because these activities take place at a Navy facility open to public access, the first line of security will be exclusion zone barriers, site work permits, and any existing barriers at the sites to restrict the general public. The second line of security, at the work site, will refer interested parties to the Base Contact. The Base Contact will serve as a focal point for Base personnel, interested parties, and serve as the final line of security and the primary enforcement contact.

9.7 SITE MAP

Once the areas of contamination, access routes, topography, and dispersion routes are determined, a site map will be generated and adjusted as site conditions change. These maps will be posted to illustrate up-to-date collection of contaminants and adjustment of zones and access points.

9.8 BUDDY SYSTEM

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

9.9 MSDS REQUIREMENTS

TtNUS and subcontractor personnel will provide MSDSs for all chemicals brought onsite. The contents of these documents will be reviewed by the SSO with the user(s) of the chemical substances prior to any actual onsite use or application of the substances. A chemical inventory of all chemicals used on site will be developed using the Health and Safety Guidance Manual. The MSDSs will then be maintained in a central location (i.e., temporary office) and will be available for anyone to review upon request.

9.10 COMMUNICATION

As personnel will be working in proximity to one another during field activities, a supported means of communication between field crew members will not be necessary.

External communication will be accomplished by using the telephones at predetermined and approved locations. External communication will primarily be used for the purpose of resource and emergency resource communications. Prior to the commencement of activities at NAF Key West, the FOL will arrange for appropriate telephone communications.

10.0 SPILL CONTAINMENT PROGRAM

10.1 SCOPE AND APPLICATION

It is anticipated that bulk quantities of potentially hazardous materials (greater than 55 gallons) will not be handled during site activities. However, it is possible that, as the job progresses, disposable PPE and other non-reusable items may be generated. As needed, 55-gallon drums will be used to contain unwanted items generated during sampling activities. The drum(s) will be labeled with the site name and address, the type of contents, and the date the container was filled, as well as an identified contact person. As warranted, samples will be collected and analyzed to characterize the material and determine appropriate disposal measures. Once characterized the drum(s) will be removed from the staging area and disposed in accordance with Federal, State and local regulations. Given the likely solid nature of drum contents, a comprehensive Spill Containment Program is not necessary. The following discussion is provided as contingency information only.

10.2 POTENTIAL SPILL AREAS

Should drums contain liquid wastes, potential spill areas will be monitored in an ongoing attempt to prevent and control potential further contamination of the environment. Areas designated for handling, loading, and unloading of potentially contaminated water and debris present limited potential for leaks or spills.

10.2.1 Site Drums/Containers

All drums/containers used for containing liquids will be sealed, labeled, and staged within a centralized area to await shipment or disposal.

10.3 LEAK AND SPILL DETECTION

To establish early detection of potential spills or leaks, periodic inspections by the SSO will be conducted during working hours to visually determine that containers are not leaking. If a leak is detected, the first approach will be to transfer the container contents (using a hand pump) into a new container. Other provisions for the transfer of container contents will be made and appropriate emergency contacts will be notified. In most instances, leaks will be collected and contained by using absorbents such as Oil-dry, vermiculite, and/or sand, which may be stored at the staging area in a conspicuously marked drum. This material will also be containerized for disposal, pending analyses. All inspections will be documented in the Project Logbook.

10.4 PERSONNEL TRAINING AND SPILL PREVENTION

All personnel will be instructed on the procedures for spill prevention, containment, and collection of hazardous materials in the site-specific training. The FOL and/or the SSO will serve as the Spill Response Coordinator for this operation, should the need arise.

10.5 SPILL PREVENTION AND CONTAINMENT EQUIPMENT

The following types of equipment may be maintained at the staging area for the purpose of supporting this Spill Containment Program (depending on the likelihood that drums and/or liquid wastes are generated):

- Sand, clean fill, vermiculite, or other noncombustible absorbent (oil-dry);
- Drums (55-gallon U.S. Department of Transportation [DOT] 17-E or 17-H)
- Shovels, rakes, and brooms
- Labels.

10.6 SPILL CONTROL PLAN

This section describes the procedures the TtNUS field crew members will employ upon the detection of a spill or leak.

1. Notify the SSO or FOL immediately upon detection of a leak or spill. Activate emergency alerting procedures for that area to remove all non-essential personnel.

2. Employ the personal protective equipment stored at the staging area. Take immediate actions to stop the leak or spill by plugging or patching the container or raising the leak to the highest point in the vessel. Spread the absorbent material in the area of the spill, covering it completely.

3. Transfer the material to a new vessel; collect and containerize the absorbent material. Label the new container appropriately. Await analyses for treatment and disposal options.

4. Recontainerize spills, including 2-inch of top cover impacted by the spill. Await test results for treatment or disposal options.

It is not anticipated that a spill will occur that the field crew cannot handle. Should this occur, notification of the appropriate Emergency Response agencies will be carried out by the FOL or SSO in accordance with the procedures discussed in Section 2.0 of this HASP.

11.0 CONFINED-SPACE ENTRY

It is not anticipated, under the proposed scope of work, that confined space and permit-required confined space activities will be conducted. Therefore, personnel under the provisions of this HASP are not allowed, under any circumstances, to enter confined spaces. A confined space is defined as an area which has one or more of the following characteristics:

- Is large enough and so configured that an employee can bodily enter and perform assigned work.
- Has limited or restricted means for entry or exit (for example, tanks, vessels, silos, storage bins, hoppers, vaults, and pits are spaces that may have limited means of entry)
- Is not designed for continuous employee occupancy.

A Permit-Required Confined Space is one that:

- Contains or has a potential to contain a hazardous atmosphere
- Contains a material that has the potential to engulf an entrant
- Has an internal configuration such that an entrant could be trapped or asphyxiated by inwardly converging walls or by a floor which slopes downward and tapers to a smaller cross-section
- Contains any other recognized, serious, safety, or health hazard.

For further information on confined space, consult the Health and Safety Guidance Manual or call the PHSO. If confined space operations are to be performed as part of the scope of work, detailed procedures and training requirements will have to be addressed.

12.0 MATERIALS AND DOCUMENTATION

The TtNUS FOL shall ensure that the following materials/documents are taken to the project site and used when required:

- A complete copy of this HASP
- Health and Safety Guidance Manual
- Incident Reports
- Medical Data Sheets
- MSDS for all chemicals brought onsite, including decontamination solutions, fuels, lime, sample preservatives, calibration gases, etc.
- A full-size OSHA Job Safety and Health Poster (posted in the site trailers)
- Training/Medical Surveillance Documentation Form (Blank)
- Emergency Reference Information (Section 2.0, extra copy for posting)

12.1 MATERIALS TO BE POSTED OR MAINTAINED AT THE SITE

The following documentation is to be posted or maintained at the site for quick reference purposes. In situations where posting these documents is not feasible, (such as no office trailer), these documents should be separated and immediately accessible.

Chemical Inventory Listing (posted) - This list represents all chemicals brought onsite, including decontamination solutions, sample preservations, fuel, etc.. This list should be posted in a central area.

MSDS (maintained) - The MSDSs should also be in a central area, accessible to all site personnel. These documents should match all items on the chemical inventory list for all substances employed onsite. It is acceptable to have these documents in a central folder with the chemical inventory as the table of contents.

The OSHA Job Safety and Health Protection Poster (posted) - This poster, as directed by 29 CFR 1903.2 (a)(1), should be conspicuously posted in places where notices to employees are normally posted. Each FOL shall ensure that this poster is not deface, altered, or covered by other material.

Site Clearance (maintained) - This list is within the training section of the HASP (See Figure 8-2 and identifies all site personnel, dates of training (including site-specific training), and medical surveillance. The list indicates not only clearance, but also status. If personnel do not meet these requirements, they do not enter the site while personnel are engaged in site activities.

Emergency Phone Numbers and Directions to the Hospital(s) (posted) - This list of numbers and directions will be maintained at all phone communication points and in each site vehicle.

Medical Data Sheets/Cards (maintained) - Medical Data Sheets will be filled out by onsite personnel and filed in a central location. The Medical Data Sheet will accompany any injury or illness requiring medical attention to the medical facility. A copy of this sheet or a wallet card will be given to all personnel to be carried on his/her person.

Hearing Conservation Standard (29 CFR 1910.95) (posted) - This standard will be posted any time hearing protection or other noise abatement procedures are employed.

Personnel Monitoring (maintained) - All results generated through personnel sampling (levels of airborne toxins, noise levels, etc.) will be posted to inform individuals of the results of that effort.

Placards and Labels (maintained) - Where chemical inventories have been separated because of quantities and incompatibilities, these areas will be conspicuously marked, using DOT placards and acceptable (Hazard Communication 29 CFR 1910.1200(f)) labels.

The purpose of maintaining or posting this information, as stated above, is to allow site personnel quick access. Variations concerning locations and methods of presentation are acceptable, provided that the objection is accomplished.

13.0 GLOSSARY

LIST OF ACRONYMS AND ABBREVIATIONS

AIMD	Aircraft Intermediate Maintenance Department
AOC	area of concern
ARAR	Applicable or Relevant and Appropriate Requirement
AST	Aboveground Storage Tank
BRE	Brown & Root Environmental
CFR	Code of Federal Regulations
CIH	Certified Industrial Hygienist
CLEAN	Comprehensive Long Term Environmental Action Navy
CRZ	Contamination Reduction Zone
CSP	Certified Safety Professional
CTO	Contract Task Order
dBA	Decibel
DOD	U.S. Department of Defense
DOT	Department of Transportation
DPT	Direct Push Technology
EPA	Environmental Protection Agency
FID	Flame Ionization Detector
FOL	Field Operations Leader
HASP	Health and Safety Plan
HAZWOPER	Hazardous Waste Operations and Emergency Response
HSA	Hollow stem auger
HSM	Health and Safety Manager
IDW	Investigation-derived Waste
MSDS	Material Safety Data Sheet
NAF	Naval Air Facility
OOD	Officer of the Day
OSHA	Occupational Safety and Health Administration (U.S. Department of Labor)
PAH	Polynuclear Aromatic Hydrocarbon
PID	Photo Ionization Detector
PHSO	Project Health and Safety Officer
PPE	Personal Protective Equipment
RAC	Remedial Action Contractor

RCRA	Resource Conservation & Recovery Act
RFA	RCRA Facility Assesssment
RFI	RCRA Facility Investigation
RI	Remedial Investigation
SAL	Screening Action Levels
SMWU	Solid Waste Management Unit
SOP	Standard Operating Procedures
SSO	Site Safety Officer
SVOCs	Semi-Volatile Organic Compounds
TBD	To be determined
TOM	Task Order Manager
TPH	total petroleum hydrocarbons
TtNUS	Tetra Tech NUS
VOCs	Volatile Organic Compounds

ATTACHMENT I

INJURY/ILLNESS PROCEDURE AND REPORT FORM

CASE NO. _____

TETRA TECH NUS, INC.

INJURY/ILLNESS PROCEDURE
WORKER'S COMPENSATION PROGRAM

WHAT YOU SHOULD DO IF YOU ARE INJURED OR DEVELOP AN ILLNESS AS A RESULT OF YOUR EMPLOYMENT:

- If injury is minor, obtain appropriate first aid treatment.
- If injury or illness is severe or life threatening, obtain professional medical treatment at the nearest hospital emergency room.
- If incident involves a chemical exposure on a project work site, follow instructions in the Health & Safety Plan.
- Immediately report any injury or illness to your supervisor or office manager. In addition, you must contact your Human Resources representative, Marilyn Diethorn at (412) 921-8475, and the Corporate Health and Safety Manager, Matt Soltis at (412) 921-8912 within 24 hours. You will be required to complete an Injury/Illness Report (attached). You may also be required to participate in a more detailed investigation from the Health Sciences Department.
- If further medical treatment is needed, The Hartford Network Referral Unit will furnish a list of network providers customized to the location of the injured employee. These providers are to be used for treatment of Worker's Compensation injuries subject to the laws of the state in which you work. Please call Marilyn Diethorn at (412) 921-8475 for the number of the Referral Unit.

ADDITIONAL QUESTIONS REGARDING WORKER'S COMPENSATION:

Contact your local human resources representative, corporate health and safety coordinator, or Corporate Administration in Pasadena, California, at (626) 351-4664.

Worker's compensation is a state-mandated program that provides medical and disability benefits to employees who become disabled due to job related injury or illness. Tetra Tech, Inc. and its subsidiaries (Tetra Tech or Company) pay premiums on behalf of their employees. The type of injuries or illnesses covered and the amount of benefits paid are regulated by the state worker's compensation boards and vary from state to state. Corporate Administration in Pasadena is responsible for administering the Company's worker's compensation program. The following is a general explanation of worker's compensation provided in the event that you become injured or develop an illness as a result of your employment with Tetra Tech or any of its subsidiaries. Please be aware that the term used for worker's compensation varies from state to state.

WHO IS COVERED:

All employees of Tetra Tech, whether they are on a full-time, part-time or temporary status, working in an office or in the field, are entitled to worker's compensation benefits. All employees must follow the above injury/illness reporting procedures. Consultants, independent contractors, and employees of subcontractors are not covered by Tetra Tech's Worker's Compensation plan.

WHAT IS COVERED:

If you are injured or develop an illness caused by your employment, worker's compensation benefits are available to you subject to the laws of the state you work in. Injuries do not have to be serious; even injuries treated by first aid practices are covered and must be reported. Please note that if you are working out-of-state and away from your home office, you are still eligible for worker's compensation benefits.

CASE NO. _____

TETRA TECH NUS, INC.
INJURY/ILLNESS PROCEDURE
WORKER'S COMPENSATION PROGRAM

To: Corporate Health and Safety Manager
Human Resource Administrator

Prepared by: _____

Position: _____

Project Name: _____

Office: _____

Project No. _____

Telephone: _____

Information Regarding Injured or Ill Employee:

Name: _____

Office: _____

Home address: _____

_____

Gender: M ☐ F ☐ No. of dependents: _____

Marital status: _____

Home telephone: _____

Date of birth: _____

Occupation (regular job title): _____

Social Security No.: _____

Department: _____

Date of Accident: _____

Time of Accident: _____

Location of Accident Was place of accident or exposure on employer's premises Yes ☐ No ☐

Street address: _____

City, state, and zip code: _____

County: _____

Narrative Description of How Accident Occurred: (Be specific. Explain what the employee was doing and how the accident occurred.)

TETRA TECH, INC.
INJURY/ILLNESS REPORT

Did employee die? Yes ☐ No ☐
Was employee performing regular job duties? Yes ☐ No ☐
Was safety equipment provided? Yes ☐ No ☐
Was safety equipment used? Yes ☐ No ☐
Note: Attach any police reports or related diagrams to this accident report.

Witness(es):

Name:

Address:

Telephone:

Describe the Illness or Injury and Part of Body Affected:

Name the Object or Substance which Directly Injured the Employee:

Medical Treatment Required:

☐ No ☐ Yes ☐ First Aid Only

Physician's Name: _____

Address: _____

Hospital or Office Name: _____

Address: _____

_____

Telephone No.: _____

Lost Work Days:

☐ No. of Lost Work Days _____

Last Date Worked _____

Time Employee Left Work _____

Date Employee Returned to Work _____

☐ No. of Restricted Work Days_____

☐ None

Corrective Action(s) Taken by Unit Reporting the Accident:

Corrective Action Still to be Taken (by whom and when):

Name of Tetra Tech employee the injury or illness was first reported to: _____

Date of Report: _____ Time of Report: _____

	Printed Name	Signature	Telephone No.	Date
Project or Office Manager				
Site Safety Coordinator				
Injured Employee				

To be completed by Human Resources:

Date of hire: Hire date in current job:

Wage information: $_____ per _____ (hour, day, week, or month)

Position at time of hire:

Shift hours:

State in which employee was hired:

Status: ☐ Full-time ☐ Part-time Hours per week: _____ Days per week: _____

Temporary job end date:

To be completed during report to workers' compensation insurance carrier:

Date reported: Reported by:

TeleClaim phone number:

TeleClaim account number:

Location code:

Confirmation number:

Name of contact:

Field office of claims adjuster:

ATTACHMENT II

EQUIPMENT INSPECTION CHECKLIST

EQUIPMENT INSPECTION

COMPANY:_____ **UNIT NO.**_____
FREQUENCY: Inspect daily, document prior to use and as repairs are needed.

Inspection Date: ____/____/____ Time: _____ Equipment Type:_____
(e.g., bulldozer)

	Good	Need Repair	N/A
Tires or tracks	❒	❒	❒
Hoses and belts	❒	❒	❒
Cab, mirrors, safety glass	❒	❒	❒
- Turn signals, lights, brake lights, etc. (front/rear) for equipment approved for highway use?	❒	❒	❒
- Is the equipment equipped with audible back-up alarms and back-up lights?	❒	❒	❒
Horn and gauges	❒	❒	❒
Brake condition (dynamic, park, etc.)	❒	❒	❒
Fire extinguisher (Type/Rating -_____)	❒	❒	❒
Fluid Levels:			
- Engine oil	❒	❒	❒
- Transmission fluid	❒	❒	❒
- Brake fluid	❒	❒	❒
- Cooling system fluid	❒	❒	❒
- Windshield wipers	❒	❒	❒
- Hydraulic oil	❒	❒	❒
Oil leak/lube	❒	❒	❒
Coupling devices and connectors	❒	❒	❒
Exhaust system	❒	❒	❒
Blade/boom/ripper condition	❒	❒	❒
Accessways: Frame, hand holds, ladders, walkways (non-slip surfaces), guardrails?	❒	❒	❒
Power cable and/or hoist cable	❒	❒	❒
Steering (standard and emergency)	❒	❒	❒

Safety Guards:	**Yes**	**No**
– Around rotating apparatus (belts, pulleys, sprockets, spindles, drums, flywheels, chains) all points of operations protected from accidental contact?_____	❒	❒
– Hot pipes and surfaces exposed to accidental contact?_____	❒	❒
– All emergency shut offs have been identified and communicated to the field crew?_____	❒	❒
– Have emergency shutoffs been field tested? _____	❒	❒
– Results?_____	❒	❒
– Are any structural members bent, rusted, or otherwise show signs of damage?_____	❒	❒

- Are fueling cans used with this equipment approved type safety cans?_____ ❒ ❒
- Have the attachments designed for use (as per manufacturer's recommendation) with this equipment been inspected and are considered suitable for use?_____ ❒ ❒

Portable Power Tools:

- Tools and Equipment in Safe Condition?_____ ❒ ❒
- Saw blades, grinding wheels free from recognizable defects (grinding wheels have been sounded)?_____ ❒ ❒
- Portable electric tools properly grounded?_____ ❒ ❒
- Damage to electrical power cords?_____ ❒ ❒
- Blade guards in place?_____ ❒ ❒
- Components adjusted as per manufacturers recommendation?_____ ❒ ❒

Cleanliness:

- Overall condition (is the decontamination performed prior to arrival on-site considered acceptable)?_____
- Where was this equipment used prior to its arrival on site?_____
- Site Contaminants of concern at the previous site?_____
- Inside debris (coffee cups, soda cans, tools and equipment) blocking free access to foot controls?_____

Operator Qualifications (as applicable for all heavy equipment):

- Does the operator have proper licensing where applicable, (e.g., CDL)?_____
- Does the operator, understand the equipments operating instructions?_____
- Is the operator experienced with this equipment? _____
- Does the operator have emotional and/or physical limitations which would prevent him/her from performing this task in a safe manner?_____
- Is the operator 21 years of age or more?_____

Identification:

- Is a tagging system available, for positive identification, for tools removed from service?___

Additional Inspection Required Prior to Use On-Site

	Yes	No
– Does equipment emit noise levels above 90 decibels?	❒	❒
– If so, has an 8-hour noise dosimetry test been performed?	❒	❒

- Results of noise dosimetry:_____
- Defects and repairs needed:_____
- General Safety Condition: _____
- Operator or mechanic signature:_____

Approved for Use: ❒ Yes ❒ No

_____
Site Safety Officer Signature

ATTACHMENT III

SAFE WORK PERMITS

SAFE WORK PERMIT
DECONTAMINATION ACTIVITIES
CTO 0188

Permit No. _____ Date: _____ Time: From _____ to _____

SECTION I: General Job Scope

I. Work limited to the following (description, area, equipment used): Decontamination of sampling equipment and machinery (i.e., DPT and HSA rigs). Brushes and spray bottles will be used to decon small sampling equipment. Pressure washers or steam cleaning units will be used to decon the drilling equipment.

II. Required Monitoring Instrument(s): PID with 10.06 eV or higher lamp source (used to screen equipment)

III. Field Crew: _____

IV. On-site Inspection conducted ☒ Yes ☐ No Initials of Inspector _____ _____
TtNUS

SECTION II: General Safety Requirements (To be filled in by permit issuer)

IV. Protective equipment required

Level D	☒	Level B	☐		
Level C	☐	Level A	☐		
Detailed on Reverse					

Respiratory equipment required

Full face APR	☐	Escape Pack	☐
Half face APR	☐	SCBA	☐
SAR	☐	Bottle Trailer	☐
Skid Rig	☐	None	☒

Modifications/Exceptions: Minimum requirement include sleeved shirt and long pants, safety glasses, safety footwear, and nitrile gloves. When using pressure washers, steam cleaners field crews will wear hearing protection, and face shields.

V.

Chemicals of Concern	Action Level(s)	Response Measures
VOC's, PAHs, and metals	Any sustained readings above background in worker breathing zones.	Suspend site activities and report to an unaffected area.

VI. Additional Safety Equipment/Procedures

Hard-hat	☒ Yes	☐ No	Hearing Protection (Plugs/Muffs)	☒ Yes	☐ No
Safety Glasses	☒ Yes	☐ No	Safety belt/harness	☐ Yes	☒ No
Chemical/splash goggles	☐ Yes	☒ No	Radio	☐ Yes	☒ No
Splash Shield	☒ Yes	☐ No	Barricades	☐ Yes	☒ No
Splash suits/coveralls	☒ Yes	☐ No	Gloves (Type - Nitrile)	☒ Yes	☐ No
Steel toe Work shoes or boots	☒ Yes	☐ No	Work/rest regimen	☐ Yes	☒ No

Modifications/Exceptions: PVC rain suits or PE or PVC coated Tyvek for protection against splashes and overspray. Chemical resistant boot covers if excessive liquids are generated or to protected footwear.

VII. Procedure review with permit acceptors

	Yes	NA		Yes	NA
Safety shower/eyewash (Location & Use)	☒	☐	Emergency alarms	☒	☐
Procedure for safe job completion	☐	☒	Evacuation routes	☒	☐
Contractor tools/equipment/PPE inspected	☐	☒	Assembly points	☒	☐

VIII. Site Preparation

	Yes	No	NA
Utility Locating and Excavation Clearance completed	☐	☐	☒
Vehicle and Foot Traffic Routes Cleared and Established	☐	☐	☒
Physical Hazards Barricaded and Isolated	☐	☐	☒
Emergency Equipment Staged	☐	☐	☒

IX. Additional Permits required (Hot work, confined space entry, excavation etc.). ☐ Yes ☒ No
If yes, complete permit required or contact Health Sciences, Pittsburgh Office

X. Special instructions, precautions: Chemical hazards when performing decontamination due to use of fluids such as isopropyl alcohol, methanol, etc. To minimize the potential for exposure, site personnel will use PPE and prevent contact with potentially contaminated equipment. Refer to the manufacturer's MSDS regarding PPE, handling, storage, and first-aid measures related to decontamination fluids.

Permit Issued by:_____ Permit Accepted by:_____

SAFE WORK PERMIT FOR
SOIL BORINGS
CTO 0188

Permit No. _____ Date: _____ Time: From _____ to _____

SECTION I: General Job Scope

I. Work limited to the following (description, area, equipment used): Soil borings using Direct Push Technology and hand-augering techniques. This task includes monitoring well installation, development, purging and soil analysis.

II. Required Monitoring Instruments: PID with 10.06 eV (or higher) probe strength

III. Field Crew: _____

IV. On-site Inspection conducted ☐ Yes ☐ No Initials of Inspector _____ _____
TtNUS

SECTION II: General Safety Requirements (To be filled in by permit issuer)

IV. Protective equipment required

Level D ☒	Level B ☐	Full face APR ☐	Escape Pack ☐
Level C ☐	Level A ☐	Half face APR ☐	SCBA ☐
Detailed on Reverse		SAR ☐	Bottle Trailer ☐
		Skid Rig ☐	None ☒

Respiratory equipment required

Modifications/Exceptions: Minimum requirement include sleeved shirt and long pants, safety shoes, safety glasses, nitrile gloves, hearing protection, and hardhat.

V.

Chemicals of Concern	Action Level(s)	Response Measures
VOC's, PAHs, and metals	Any sustained readings above background in worker breathing zones*.	Suspend site activities and report to an unaffected area.

VI. Additional Safety Equipment/Procedures

Hard-hat	☒ Yes	☐ No	Hearing Protection (Plugs/Muffs)	☒ Yes	☐ No
Safety Glasses	☒ Yes	☐ No	Safety belt/harness	☐ Yes	☒ No
Chemical/splash goggles	☐ Yes	☒ No	Radio	☐ Yes	☒ No
Splash Shield	☐ Yes	☒ No	Barricades	☐ Yes	☒ No
Splash suits/coveralls	☐ Yes	☐ No	Gloves (Type - Nitrile)	☒ Yes	☐ No
Steel toe Work shoes or boots	☒ Yes	☐ No	Work/rest regimen	☐ Yes	☒ No

Modifications/Exceptions: Reflective vests for high traffic areas. Tyvek coverall and impermeable boots if there is a potential for soiling work clothes. Hard hat, hearing protection, and safety glasses not required when hand augering. Leather gloves over surgeon's gloves are acceptable alternative to nitrile gloves.

VII. Procedure review with permit acceptors

	Yes	NA		Yes	NA
Safety shower/eyewash (Location & Use)	☒	☐	Emergency alarms	☒	☐
Procedure for safe job completion	☒	☐	Evacuation routes	☒	☐
Contractor tools/equipment/PPE inspected	☒	☐	Assembly points	☒	☐

IX. Site Preparation

	Yes	No	NA
Utility Locating and Excavation Clearance completed	☒	☐	☐
Vehicle and Foot Traffic Routes Cleared and Established	☒	☐	☐
Physical Hazards Barricaded and Isolated	☐	☐	☐
Emergency Equipment Staged	☒	☐	☐

IX. Additional Permits required (Hot work, confined space entry, excavation etc.). ☒ Yes ☐ No

If yes, complete permit required or contact Health Sciences, Pittsburgh Office

X. Special instructions, precautions: Follow TtNUS SOP "Utility Locating and Excavation Clearance" (Attachment II of the HASP).

Permit Issued by: _____ Permit Accepted by: _____

SAFE WORK PERMIT FOR
MULTI-MEDIA SAMPLING
CTO 0188

Permit No. _____ Date: _____ Time: From _____ to _____

SECTION I: General Job Scope

I. Work limited to the following (description, area, equipment used): Multi-media sampling including, surface and subsurface soils and groundwater. IDW sampling is also included in this task

II. Required Monitoring Instrument(s): FID or PID with10.06 eV lamp (or higher) lamp source; Combination Meter with LEL/O2/CO

III. Field Crew: _____

IV. On-site Inspection conducted ☒ Yes ☐ No Initials of Inspector _____ _____
TtNUS

SECTION II: General Safety Requirements (To be filled in by permit issuer)

IV. Protective equipment required

Level D ☒ Level B ☐
Level C ☐ Level A ☐
Detailed on Reverse

Respiratory equipment required

Full face APR	☐	Escape Pack	☐
Half face APR	☐	SCBA	☐
SAR	☐	Bottle Trailer	☐
Skid Rig	☐	None	☒

Modifications/Exceptions: Minimum requirement include sleeved shirt and long pants, safety shoes, surgical style gloves, and safety glasses. Hard hats and hearing protection will be worn when working near operating equipment or when required by the SSO.

V. Chemicals of Concern	Action Level(s)	Response Measures
VOC's, PAHs, and metals	Any sustained readings above background in worker breathing zones*.	Suspend site activities and report to an unaffected area.

VI. Additional Safety Equipment/Procedures

Hard-hat	☐ Yes	☒ No	Hearing Protection (Plugs/Muffs)	☐ Yes	☒ No
Safety Glasses	☒ Yes	☐ No	Safety belt/harness	☐ Yes	☒ No
Chemical/splash goggles	☐ Yes	☒ No	Radio	☐ Yes	☒ No
Splash Shield	☐ Yes	☒ No	Barricades	☐ Yes	☒ No
Splash suits/coveralls	☐ Yes	☒ No	Gloves (Type – Surgical Style)	☒ Yes	☐ No
Steel toe Work shoes or boots	☒ Yes	☐ No	Work/rest regimen	☐ Yes	☒ No

Modifications/Exceptions: Reflective vests for high traffic areas. Tyvek coverall if there is a potential for soiling work clothes.

VII. Procedure review with permit acceptors

	Yes	NA		Yes	NA
Safety shower/eyewash (Location & Use)	☒	☐	Emergency alarms	☒	☐
Procedure for safe job completion	☒	☐	Evacuation routes	☒	☐
Contractor tools/equipment/PPE inspected	☐	☒	Assembly points	☒	☐

VIII. Site Preparation

	Yes	No	NA
Utility Locating and Excavation Clearance completed	☐	☐	☒
Vehicle and Foot Traffic Routes Cleared and Established	☒	☐	☐
Physical Hazards Barricaded and Isolated	☒	☐	☐
Emergency Equipment Staged	☒	☐	☐

IX. Additional Permits required (Hot work, confined space entry, excavation etc.). ☐ Yes ☒ No
If yes, complete permit required or contact Health Sciences, Pittsburgh Office

X. Special instructions, precautions _____

Permit Issued by: _____ Permit Accepted by: _____

ATTACHMENT IV

STANDARD OPERATING PROCEDURE FOR UTILITY LOCATING AND EXCAVATION CLEARANCE

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1.0 PURPOSE

Utilities such as electric service lines, natural or propane gas lines, water and sewage lines, telecommunications, and steam lines are very often in the immediate vicinity of work locations. Contact with underground or overhead utilities can have serious consequences including employee injury/fatality, property and equipment damage, substantial financial impacts, and loss of utility service to users.

The purpose of this procedure is to provide minimum requirements and technical guidelines regarding the appropriate procedures to be followed when performing subsurface and overhead utility locating services. It is the policy of Tetra Tech NUS, Inc. (TtNUS) to provide a safe and healthful work environment for the protection of our employees. The purpose of this Standard Operating Procedure (SOP) is to aid in achieving the objectives of the TtNUS Utility Locating and Clearance Policy. The TtNUS Utility Locating and Clearance Policy must be reviewed by anyone potentially involved with underground or overhead utility services.

2.0 SCOPE

This procedure applies to all TtNUS field activities where there may be potential contact with underground or overhead utilities. This procedure provides a description of the principles of operation, instrumentation, applicability, and implementability of typical methods used to determine the presence or absence of utility services. This procedure is intended to assist with work planning and scheduling, resource planning, field implementation, and subcontractor procurement. Utility locating and excavation clearance requires site-specific information prior to the development of detailed operating procedures. This guidance is not intended to provide a detailed description of methodology and instrument operation. Specialized expertise during both planning and execution of several of the geophysical methods may also be required.

3.0 GLOSSARY

Electromagnetic Induction (EMI) Survey - A geophysical exploration method whereby electromagnetic fields are induced in the ground and the resultant secondary electromagnetic fields are detected as a measure of ground conductivity.

Magnetometer – A device used for precise and sensitive measurements of magnetic fields.

Magnetic Survey – A geophysical survey method that depends on detection of magnetic anomalies caused by the presence of buried ferromagnetic objects.

Metal Detection – A geophysical survey method that is based on electromagnetic coupling caused by underground conductive objects.

Vertical Gradiometer – A magnetometer equipped with two sensors that are vertically separated by a fixed distance. It is best suited to map near surface features and is less susceptible to deep geologic features.

Ground Penetrating Radar – Ground Penetrating Radar (GPR) involves specialized radar equipment whereby a signal is sent into the ground via a transmitter. Some portion of the signal will be reflected from the subsurface material, which is then recorded with a receiver and electronically converted into a graphic picture.

4.0 RESPONSIBILITIES

Project Manager (PM)/Task Order Manager (TOM) - Responsible for ensuring that all field activities are conducted in accordance with this procedure and the TtNUS Utility Locating and Clearance Policy.

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).

Site Health & Safety Officer (SHSO) – Responsible to provide technical assistance and verify full compliance with this SOP and the TtNUS Utility Locating and Clearance Policy. The SHSO is also responsible for reporting any deficiencies to the Corporate Health and Safety Manager (HSM) and to the PM/TOM.

Health & Safety Manager (HSM) – Responsible for preparing, implementing, and modifying corporate health and safety policy.

Site Personnel – Responsible for understanding and implementing this SOP and the TtNUS Utility Locating and Clearance Policy.

5.0 PROCEDURES

This procedure addresses the requirements and technical procedures that must be performed to minimize the potential for contact with underground and overhead utility services. These procedures are addressed individually from a buried and overhead standpoint.

5.1 Buried Utilities

Buried utilities present a heightened concern because their location is not typically obvious by visual observation, and it is common that their presence and/or location is unknown or incorrectly known on client properties. The following procedure must be followed prior to beginning any excavation that might potentially be in the vicinity of underground utility services. In addition, the Utility Clearance Form (Attachment 3) must be completed for every location or cluster of locations where intrusive activities will occur.

Where the positive identification and de-energizing of underground utilities cannot be obtained and confirmed using the following steps, the PM/TOM is responsible for arranging for the procurement of a qualified, experienced, utility locating subcontractor who will accomplish the utility location and demarcation duties specified herein.

1. A comprehensive review must be made of any available property maps, blue lines, or as-builts prior to site activities. Interviews with local personnel familiar with the area should be performed to provide additional information concerning the location of potential underground utilities. Information regarding utility locations shall be added to project maps upon completion of this exercise.

2., A visual site inspection must be performed to compare the site plan information to actual field conditions. Any findings must be documented and the site plan/maps revised. The area(s) of proposed excavation or other subsurface activities must be marked at the site in white paint or pin flags to identify those locations of the proposed intrusive activities. The site inspection should focus on locating surface indications of potential underground utilities. Items of interest include the presence of nearby area lights, telephone service, drainage grates, fire hydrants, electrical service vaults/panels, asphalt/concrete scares and patches, and topographical depressions. Note the location of any emergency shut off switches. Any additional information regarding utility locations shall be added to project maps upon completion of this exercise and returned to the PM/TOM.

3. If the planned work is to be conducted on private property (e.g., military installations, manufacturing facilities, etc.) the FOL must identify and contact appropriate facility personnel (e.g., public works or facility engineering) before any intrusive work begins to inquire about (and comply with) property owner requirements. It is important to note that private property owners may require several days to several weeks advance notice prior to locating utilities.

4. If the work location is on public property, the state agency that performs utility clearances must be notified (see Attachment 1). State “one-call” services must be notified prior to commencing fieldwork per their requirements. Most one-call services require, by law, 48- to 72-hour advance notice prior to beginning any excavation. Such services typically assign a "ticket" number to the particular site. This ticket number must be recorded for future reference and is valid for a specific period of time, but may be extended by contacting the service again. The utility service will notify utility representatives who then mark their respective lines within the specified time frame. It should be noted that most military installations own their own utilities but may lease service and maintenance from area providers. Given this situation, “one call” systems may still be required to provide location services on military installations.

5. Utilities must be identified and their locations plainly marked using pin flags, spray paint, or other accepted means. The location of all utilities must be noted on a field sketch for future inclusion on project maps. Utility locations are to be identified using the following industry-standard color code scheme, unless the property owner or utility locator service uses a different color code:

white	excavation/subsurface investigation location
red	electrical
yellow	gas, oil, steam
orange	telephone, communications
blue	water, irrigation, slurry
green	sewer, drain

6. Where utility locations are not confirmed with a high degree of confidence through drawings, schematics, location services, etc., the work area must be thoroughly investigated prior to beginning the excavation. In these situations, utilities must be identified using such methods as passive and intrusive surveys, physical probing, or hand augering. Each method has advantages and disadvantages including complexity, applicability, and price. It also should be noted that in many states, initial excavation is required by hand to a specified depth.

7. At each location where trenching or excavating will occur using a backhoe or other heavy equipment, and where utility identifications and locations cannot be confirmed prior to groundbreaking, the soil must be probed with a hand auger or pole (tile probe) made of non-conductive material. If these efforts are not successful in clearing the excavation area of suspect utilities, hand shoveling must be performed for the perimeter of the intended excavation.

8. All utilities uncovered or undermined during excavation must be structurally supported to prevent potential damage. Unless necessary as an emergency corrective measure, TtNUS shall not make any repairs or modifications to existing utility lines without prior permission of the utility owner, property owner, and Corporate HSM. All repairs require that the line be locked-out/tagged-out prior to work.

5.2 Overhead Power Lines

If it is necessary to work within the minimum clearance distance of an overhead power line, the overhead line must be de-energized and grounded, or re-routed by the utility company or a registered electrician. If protective measures such as guarding, isolating, or insulating are provided, these precautions must be

adequate to prevent employees from contacting such lines directly with any part of their body or indirectly though conductive materials, tools, or equipment.

The following table provides the required minimum clearances for working in proximity to overhead power lines.

Nominal Voltage	Minimum Clearance
0 -50 kV	10 feet, or one mast length; whichever is greater
50+ kV	10 feet plus 4 inches for every 10 kV over 50 kV or 1.5 mast lengths; whichever is greater

6.0 UNDERGROUND LOCATING TECHNIQUES

6.1 Geophysical Methods

Geophysical methods include electromagnetic induction, magnetics, and ground penetrating radar. Additional details concerning the design and implementation of electromagnetic induction, magnetics, and ground penetrating radar surveys can be found in one or more of the TtNUS SOPs included in the References (Section 8.0).

Electromagnetic Induction

Electromagnetic Induction (EMI) line locators operate either by locating a background signal or by locating a signal introduced into the utility line using a transmitter. A utility line acts like a radio antenna, producing electrons, which can be picked up with a radiofrequency receiver. Electrical current carrying conductors have a 60HZ signal associated with them. This signal occurs in all power lines regardless of voltage. Utilities in close proximity to power lines or used as grounds may also have a 60HZ signal, which can be picked up with an EM receiver. A typical example of this type of geophysical equipment is an EM-61.

EMI locators specifically designed for utility locating use a special signal that is either indirectly induced onto a utility line by placing the transmitter above the line or directly induced using an induction clamp. The clamp induces a signal on the specific utility and is the preferred method of tracing since there is little chance of the resulting signals being interfered with. A good example of this type of equipment is the Schonstedt® MAC-51B locator. The MAC-51B performs inductively traced surveys, simple magnetic locating, and traced nonmetallic surveys.

When access can be gained inside a conduit to be traced, a flexible insulated trace wire can be used. This is very useful for non-metallic conduits but is limited by the availability of gaining access inside the pipe.

Magnetics

Magnetic locators operate by detecting the relative amounts of buried ferrous metal. They are incapable of locating or identifying nonferrous utility lines but can be very useful for locating underground storage tanks (UST's), steel utility lines, and buried electrical lines. A typical example of this type of equipment is the Schonstedt® GA-52Cx locator. The GA-52Cx is capable of locating 4-inch steel pipe up to 8 feet deep.

Non-ferrous lines are often located by using a typical plumbing tool (snake) fed through the line. A signal is then introduced to the snake that is then traced.

Ground Penetrating Radar

Ground Penetrating Radar (GPR) involves specialized radar equipment whereby a signal is sent into the ground via a transmitter. Some portion of the signal will be reflected from the subsurface material, which is then recorded with a receiver and electronically converted into a graphic picture. In general, an object which is harder than the surrounding soil will reflect a stronger signal. Utilities, tunnels, UST's, and footings will reflect a stronger signal than the surrounding soil. Although this surface detection method may determine the location of a utility, this method does not specifically identify utilities (i.e., water vs. gas, electrical vs. telephone); hence, verification may be necessary using other methods. This method is somewhat limited when used in areas with clay soil types or with a high water table.

6.2 Passive Detection Surveys

Acoustic Surveys

Acoustic location methods are generally most applicable to waterlines or gas lines. A highly sensitive Acoustic Receiver listens for background sounds of water flowing (at joints, leaks, etc.) or to sounds introduced into the water main using a transducer. Acoustics may also be applicable to determine the location of plastic gas lines.

Thermal Imaging

Thermal (i.e., infrared) imaging is a passive method for detecting the heat emitted by an object. Electronics in the infrared camera convert subtle heat differentials into a visual image on the viewfinder or a monitor. The operator does not look for an exact temperature; rather they look for heat anomalies (either elevated or suppressed temperatures) characteristic of a potential utility line.

The thermal fingerprint of underground utilities results from differences in temperature between the atmosphere and the fluid present in a pipe or the heat generated by electrical resistance. In addition, infrared scanners may be capable of detecting differences in the compaction, temperature and moisture content of underground utility trenches. High-performance thermal imagery can detect temperature differences to hundredths of a degree.

6.3 Intrusive Detection Surveys

Vacuum Excavation

Vacuum excavation is used to physically expose utility services. The process involves removing the surface material over approximately a 1' x 1' area at the site location. The air-vacuum process proceeds with the simultaneous action of compressed air-jets to loosen soil and vacuum extraction of the resulting debris. This process ensures the integrity of the utility line during the excavation process, as no hammers, blades, or heavy mechanical equipment comes into contact with the utility line, eliminating the risk of damage to utilities. The process continues until the utility is uncovered. Vacuum excavation can be used at the proposed site location to excavate below the "utility window" which is usually 8 feet.

Hand-auger Surveys

When the identification and location of underground utilities cannot be positively confirmed through document reviews and/or other methods, borings must be hand-augered for all locations where there is a potential to impact buried utilities. The minimum hand-auger depth that must be reached is to be determined considering the geographical location of the work site. This approach recognizes that the

placement of buried utilities is influenced by frost line depths that vary by geographical region. Attachment 2 presents frost line depths for the regions of the contiguous United States. At a minimum, hand-auger depths must be at least to the frost line depth plus two (2) feet, but never less than 4 feet below ground surface (bgs). For augering, the hole must be reamed by hand to at least the diameter of the drill rig auger or bit prior to drilling. For soil gas surveys, the survey probe shall be placed as close as possible to the cleared hand-auger. It is important to note that a post-hole digger must not be used in place of a hand-auger.

Tile Probe Surveys

For some soil types, site conditions, and excavation requirements, tile probes may be used instead of or in addition to hand-augers. Tile probes must be performed to the same depth requirements as hand-augers. Depending upon the site conditions and intended probe usage, tile probes should be made of non-conductive material such as fiberglass.

7.0 INTRUSIVE ACTIVITIES SUMMARY

The following list summarizes the activities that must be performed prior to beginning subsurface activities:

1. Map and mark all subsurface locations and excavation boundaries using white paint or markers specified by the client or property owner.

2. Notify the property owner and/or client that the locations are marked. At this point, drawings of locations or excavation boundaries shall be provided to the property owner and/or client so they may initiate (if applicable) utility clearance.

   Note: Drawings with confirmed locations should be provided to the property owner and/or client as soon as possible to reduce potential time delays.

3. Notify “One Call” service. If possible, arrange for an appointment to show the One Call representative the subsurface locations or excavation boundaries in person. This will provide a better location designation to the utilities they represent. You should have additional drawings should you need to provide plot plans to the One Call service.

4. Complete Attachment 3, Utility Clearance Form. This form should be completed for each excavation location. In situations where multiple subsurface locations exist within the close proximity of one another, one form may be used for multiple locations provided those locations are noted on the Utility Clearance Form. Upon completion, the Utility Clearance Form and revised/annotated utility location map becomes part of the project file.

8.0 REFERENCES

TtNUS Utility Locating and Clearance Policy
TtNUS SOP GH-3.1; Resistivity and Electromagnetic Induction
TtNUS SOP GH-3.2; Magnetic and Metal Detection Surveys
TtNUS SOP GH-3.4; Ground-penetrating Radar Surveys

ATTACHMENT 1
LISTING OF UNDERGROUND UTILITY CLEARANCE RESOURCES

ALABAMA
Alabama Line Location (800) 292-8525

Tucson Blue Stake Center (800) 782-5348

Alaska
Locate Call Center of Alaska Inc. (800) 478-3121

Arizona
Arizona Blue Stake Inc. (800) 782-5348

Arkansas
Arkansas One Call System Inc. (800) 482-8998

California
Underground Service Alert North (800) 227-2600

Underground Service Alert South (800) 227-2600

Colorado
Utility Notification Center of Colorado
(800) 922-1987

Connecticut
Call Before You Dig (800) 922-4455

Delaware
Miss Utility of Delmarva
(800) 282-8555

District of Columbia
Miss Utility (800) 257-7777

Florida
Call Sunshine (800) 432-4770

Georgia
Utilities Protection Center Inc.
(800) 282-7411

Idaho
Palouse Empire Underground Coordinating Council
(800) 882-1974

Utilities Underground Location Center
(800) 424-5555

Kootenai Country Utility Coordinating Council
(800) 428-4950

Shoshone County One Call (800) 398-3285

Dig Line (800) 342-1585

One Call Concepts (800) 626-4950

Illinois
Julie Inc. (800) 892-0123

Digger (Chicago Utility Alert Network)
(312) 744-7000

Indiana
Indiana Underground Plant Protection Services
(800) 382-5544

Iowa
Underground Plant Location Service Inc.
(800) 292-8989

Kansas
Kansas One-Call Center (800) 344-7233

Kentucky
Kentucky Underground Protection Inc.
(800) 752-6007

Louisiana
Louisiana One Call (800) 272-3020

Maine
Dig Safe – Maine (800) 225-4977

Maryland
Miss Utility (800) 257-777

Miss Utility of Delmarva (800) 282-8555

Massachusetts
Dig Safe – Massachusetts (800) 322-4844

Michigan
Miss Dig System (800) 482-7171

Minnesota
Gopher State One Call (800) 252-1166

Mississippi
Mississippi One-Call System Inc. (800) 227-6477

Missouri
Missouri One Call System Inc. (800) 344-7483

Montana
Utilities Underground Location Center
(800) 424-5555

Montana One Call Center (800) 551-8344

Nebraska
Diggers Hotline of Nebraska (800) 331-5666

Nevada
Underground Service Alert North (800) 227-2600

New Hampshire
Dig Safe – New Hampshire (800) 225-4977

New Jersey
New Jersey One Call (800) 272-1000

New Mexico
New Mexico One Call System Inc.
(800) 321-ALERT

Las Cruces-Dona Utility Council (505) 526-0400

New York
Underground Facilities Protection Organization
(800) 962-7962

New York City: Long Island One Call Center
(800) 272-4480

North Carolina
The North Carolina One-Call Center Inc.
(800) 632-4949

North Dakota
Utilities Underground Location Center
(800) 795-0555

Ohio
Ohio Utilities Protection Service
(800) 362-2764

Oil & Gas Producers Underground Protection Service
(800) 925-0988

Oklahoma
Call Okie (800) 522-6543

Oregon
Utilities Underground Location Center
(800) 424-5555

Douglas Utilities Coordinating Council
(503) 673-6676

Josephine Utilities Coordinating Council
(503) 476-6676

Rogue Basin Utility Coordinating Council
(503) 779-6676

Utilities Notification Center
(800) 332-2344

Pennsylvania
Pennsylvania One Call System Inc.
(800) 242-1776

Rhode Island
Dig Safe – Rhode Island (800) 225-4977

South Carolina
Palmetto Utility Protection Service Inc.
(800) 922-0983

South Dakota
South Dakota One Call (800) 781-7474

Tennessee
Tennessee One-Call System (800) 351-1111

Texas
Texas One Call System (800) 245-4545

Texas Excavation Safety System (800) 344-8377

Lone Star Notification Center (800) 669-8344

Utah
Blue Stakes Location Center (800) 662-4111

Vermont
Dig Safe – Vermont (800) 225-4977

Virginia
Miss Utility of Virginia (800) 552-7001

Miss Utility (800) 257-7777

Miss Utility of Delmarva (800) 441-8355

Washington
Utilities Underground Location Center
(800) 424-5555

Grays Harbor & Pacific County
Utility Coordinating Council
(206) 535-3550

Utilities County of Cowlitz County
(360) 425-2506

Chelan-Douglas Utilities Coordinating Council
(509) 663-6111

Upper Yakima County
Underground Utilities Council
(800) 553-4344

Inland Empire Utility Coordinating Council
(509) 456-8000

Palouse Empire Utilities Coordinating Council
(800) 822-1974

Utilities Notification Center (800) 332-2344

West Virginia
Miss Utility of West Virginia Inc. (800) 245-4848

Wisconsin
Diggers Hotline Inc. (800) 242-8511

Wyoming
West Park Utility Coordinating Council
(307) 587-4800

Call-In Dig-In Safety Council (800) 300-9811

Fremont County Utility Coordinating Council
(800) 489-8023

Central Wyoming Utilities Coordinating Council
(800) 759-8035

Southwest Wyoming One Call (307) 362-8888

Carbon County Utility
Utility Coordinating Council (307) 324-6666

Albany County Utility Coordinating Council
(307) 742-3615

Southeast Wyoming Utilities Coordinating Council
(307) 638-6666

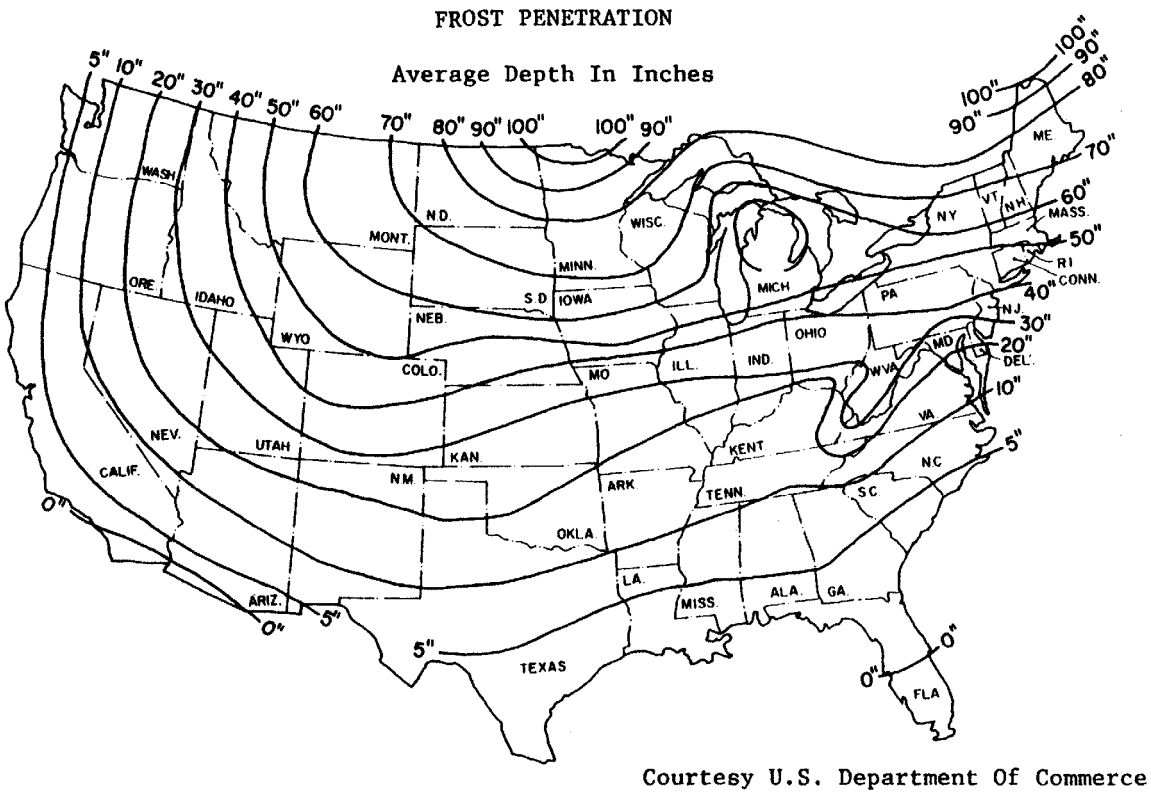
Wyoming One-Call
(800) 348-1030

Utilities Underground Location Center
(800) 454-5555

Converse County Utility Coordination Council
(800) 562-5561

ATTACHMENT 2

FROST LINE PENETRATION DEPTHS BY GEOGRAPHIC LOCATION



ATTACHMENT 3
UTILITY CLEARANCE FORM

Client: _____ Project Name: _____

Project No.: _____ Completed By: _____

Location Name: _____ Work Date: _____

Excavation Method/Overhead Equipment:_____

1. Underground Utilities — Circle One

a)	Review of existing maps?	yes no N/A
b)	Interview local personnel?	yes no N/A
c)	Site visit and inspection?	yes no N/A
d)	Excavation areas marked in the field?	yes no N/A
e)	Utilities located in the field?	yes no N/A
f)	Located utilities marked/added to site maps?	yes no N/A
g)	Client contact notified Name _____ Telephone:_____ Date: _____	yes no N/A
g)	State One-Call agency called? Caller: _____ Ticket Number: _____ Date: _____	yes no N/A
h)	Geophysical survey performed? Survey performed by:_____ Method: _____ Date: _____	yes no N/A
i)	Hand augering performed? Augering completed by:_____ Total depth:_____feet Date: _____	yes no N/A
j)	Trench/excavation probed? Probing completed by:_____ Depth/frequency: _____ Date: _____	yes no N/A

2. Overhead Utilities — Present Absent

a)	Determination of nominal voltage	yes no N/A
b)	Marked on site maps	yes no N/A
c)	Necessary to lockout/insulate/re-route	yes no N/A
d)	Document procedures used to lockout/insulate/re-route	yes no N/A
e)	Minimum acceptable clearance (SOP Section 5.2): _____	

3. Notes:

_____

_____

_____

Approval:

_____ _____

Site Manager/Field Operations Leader Date

c: PM/Project File
Program File

ATTACHMENT V

MEDICAL DATA SHEET

MEDICAL DATA SHEET

This Medical Data Sheet must be completed by all on-site personnel and kept in the command post during the conduct of site operations. This data sheet will accompany any personnel when medical assistance is needed or if transport to hospital facilities is required.

Project _____

Name _____ Home Telephone _____

Address _____

Age _____ Height _____ Weight _____

Name of Next Kin _____

Drug or other Allergies _____

Particular Sensitivities _____

Do You Wear Contacts? _____

Provide a Checklist of Previous Illnesses or Exposure to Hazardous Chemicals _____

_____

_____

What medications are you presently using? _____

_____

_____

Do you have any medical restrictions? _____

_____

_____

Name, Address, and Phone Number of personal physician: _____

_____

_____

_____

I am the individual described above. I have read and understand this HASP.

_____ _____

Signature Date

ATTACHMENT VI

OSHA POSTER

You Have a Right to a Safe and Healthful Workplace.

IT'S THE LAW!

- You have the right to notify your employer or OSHA about workplace hazards. You may ask OSHA to keep your name confidential.
- You have the right to request an OSHA inspection if you believe that there are unsafe and unhealthful conditions in your workplace. You or your representative may participate in the inspection.
- You can file a complaint with OSHA within 30 days of discrimination by your employer for making safety and health complaints or for exercising your rights under the *OSH Act*.
- You have a right to see OSHA citations issued to your employer. Your employer must post the citations at or near the place of the alleged violation.
- Your employer must correct workplace hazards by the date indicated on the citation and must certify that these hazards have been reduced or eliminated.
- You have the right to copies of your medical records or records of your exposure to toxic and harmful substances or conditions.
- Your employer must post this notice in your workplace.

The *Occupational Safety and Health Act of 1970 (OSH Act)*, P.L. 91-596, assures safe and healthful working conditions for working men and women throughout the Nation. The Occupational Safety and Health Administration, in the U.S. Department of Labor, has the primary responsibility for administering the *OSH Act*. The rights listed here may vary depending on the particular circumstances. To file a complaint, report an emergency, or seek OSHA advice, assistance, or products, call 1-800-321-OSHA or your nearest OSHA office: • Atlanta (404) 562-2300 • Boston (617) 565-9860 • Chicago (312) 353-2220 • Dallas (214) 767-4731 • Denver (303) 844-1600 • Kansas City (816) 426-5861 • New York (212) 337-2378 • Philadelphia (215) 861-4900 • San Francisco (415) 975-4310 • Seattle (206) 553-5930. Teletypewriter (TTY) number is 1-877-889-5627. To file a complaint online or obtain more information on OSHA federal and state programs, visit OSHA's website at **www.osha.gov**. If your workplace is in a state operating under an OSHA-approved plan, your employer must post the required state equivalent of this poster.

1-800-321-OSHA
www.osha.gov

U.S. Department of Labor • Occupational Safety and Health Administration • OSHA 3165

APPENDIX D

STANDARD OPERATING PROCEDURES,

RECORDS, AND FORMS

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1.0 PURPOSE

The purpose of this procedure is to describe the methods and equipment necessary to perform soil and rock borings and identify the equipment, sequence of events, and appropriate methods necessary to obtain soil, both surface and subsurface, and rock samples during field sampling activities.

2.0 SCOPE

This guideline addresses most of the accepted and standard drilling techniques, their benefits, and drawbacks. It should be used generally to determine what type of drilling techniques would be most successful depending on site-specific geologic conditions and the type of sampling required.

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

3.0 GLOSSARY

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

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

4.0 RESPONSIBILITIES

Project Manager - In consultation with the project geologist, the Project Manager is responsible for evaluating the drilling requirements for the site and specifying drilling techniques that will be successful given the study objectives and the known or suspected geologic conditions at the site. The Project Manager also determines the disposal methods for products generated by drilling, such as drill cuttings and well development water, as well as any specialized supplies or logistical support required for the drilling operations.

Field Operations Leader (FOL) - The FOL is responsible for the overall supervision and scheduling of drilling activities, and is strongly supported by the project geologist.

Project Geologist - The project geologist is responsible for ensuring that standard and approved drilling procedures are followed. The geologist will generate a detailed boring log for each test hole. This log shall include a description of materials, samples, method of sampling, blow counts, and other pertinent drilling and testing information that may be obtained during drilling (see SOPs SA-6.3 and GH-1.5). Often this position for inspecting the drilling operations may be filled by other geotechnical personnel, such as soils and foundation engineers, civil engineers, etc.

Determination of the exact location for borings is the responsibility of the site geologist. The final location for drilling must be properly documented on the boring log. The general area in which the borings are to be located will be shown on a site map included in the Work Plan and/or Sampling and Analysis Plan.

Drilling Subcontractor - Operates under the supervision of the FOL. Responsible for obtaining all drilling permits and clearances, and supplying all services (including labor), equipment and material required to perform the drilling, testing, and well installation program, as well as maintenance and quality control of such required equipment except as stated in signed and approved subcontracts.

The driller must report any major technical or analytical problems encountered in the field to the FOL within 24 hours of determination, and must provide advance written notification of any changes in field procedures, describing and justifying such changes. No such changes shall be made unless requested and authorized in writing by the FOL (with the concurrence of the Project Manager). Depending on the subcontract, the Project Manager may need to obtain written authorization from appropriate administrative personnel before approving any changes.

The drilling subcontractor is responsible for following decontamination procedures specified in the project plan documents. Upon completion of the work, the driller is responsible for demobilizing all equipment, cleaning up any materials deposited on site during drilling operations, and properly backfilling any open borings.

5.0 PROCEDURES

5.1 General

The purpose of drilling boreholes is:

- To determine the type, thickness, and certain physical and chemical properties of the soil, water and rock strata which underlie the site.
- To install monitoring wells or piezometers.

All drilling and sampling equipment will be cleaned between samples and borings using appropriate decontamination procedures as outlined in SOP SA-7.1. Unless otherwise specified, it is generally advisable to drill borings at "clean" locations first, and at the most contaminated locations last, to reduce the risk of spreading contamination between locations. All borings must be logged by the site geologist as they proceed (see SOPs SA-6.3 and GH-1.5). Situations where logging would not be required would include installation of multiple well points within a small area, or a "second attempt" boring adjacent to a boring that could not be continued through resistant material. In the latter case, the boring log can be resumed 5 feet above the depth at which the initial boring was abandoned, although the site geologist should still confirm that the stratigraphy at the redrilled location conforms essentially with that encountered at the original location. If significant differences are seen, each hole should be logged separately.

5.2 Drilling Methods

The selected drilling methods described below apply to drilling in subsurface materials, including, but not limited to, sand, gravel, clay, silt, cobbles, boulders, rock and man-made fill. Drilling methods should be selected after studying the site geology and terrain, the waste conditions at the site, and reviewing the purpose of drilling and the overall subsurface investigation program proposed for the site. The full range of different drilling methods applicable to the proposed program should be identified with final selection based on relative cost, availability, time constraints, and how well each method meets the sampling and testing requirements of the individual drilling program.

5.2.1 Continuous-Flight Hollow-Stem Auger Drilling

This method of drilling consists of rotating augers with a hollow stem into the ground. Cuttings are brought to the surface by the rotating action of the auger. This method is relatively quick and inexpensive. Advantages of this type of drilling include:

- Samples can be obtained without pulling the augers out of the hole. However, this is a poor method for obtaining grab samples from thin, discrete formations because of mixing of soils which occurs as the material is brought to the surface. Sampling of such formations requires the use of split-barrel or thin-wall tube samplers advanced through the hollow core of the auger.
- No drilling fluids are required.
- A well can be installed inside the auger stem and backfilled as the augers are withdrawn.

Disadvantages and limitations of this method of drilling include:

- Augering can only be done in unconsolidated materials.

- The inside diameter of hollow stem augers used for well installation should be at least 4 inches greater than the well casing. Use of such large-diameter hollow-stem augers is more expensive than the use of small-diameter augers in boreholes not used for well installation. Furthermore, the density of unconsolidated materials and depths become more of a limiting factor. More friction is produced with the larger diameter auger and subsequently greater torque is needed to advance the boring.

- The maximum effective depth for drilling is 150 feet or less, depending on site conditions and the size of augers used.

- In augering through clean sand formations below the water table, the sand will tend to flow into the hollow stem when the plug is removed for soil sampling or well installation. If the condition of "running" or "flowing" sands is persistent at a site, an alternative method of drilling is recommended, in particular for wells or boreholes deeper than 25 feet.

Hollow-stem auger drilling is the preferred method of drilling. Most alternative methods require the introduction of water or mud downhole (air rotary is the exception) to maintain the open borehole. With these other methods, great care must be taken to ensure that the method does not interfere with the collection of a representative sample (which may be the prime objective of the borehole construction). With this in mind, the preferred order of choice of drilling method after hollow-stem augering (HSA) is:

- Cable tool
- Casing drive (air)
- Air rotary
- Mud rotary
- Rotosonic
- Drive and wash
- Jetting

However, the use of any method will also depend on efficiency and cost-effectiveness. In many cases, mud rotary is the only feasible alternative to hollow-stem augering. Thus, mud rotary drilling is generally acceptable as a first substitute for HSA.

The procedures for sampling soils through holes drilled by hollow-stem auger shall conform with the applicable ASTM Standards: D1587-83 and D1586-84. The guidelines established in SOP SA-1.3 shall

also be followed. The hollow-stem auger may be advanced by any power-operated drilling machine having sufficient torque and ram range to rotate and force the auger to the desired depth. The machine must, however, be equipped with the accessory equipment needed to perform required sampling, or rock coring.

The hollow-stem auger may be used without the plug when boring for geotechnical examination or for well installation. However, when drilling below the water table, specially designed plugs which allow passage of formation water but not solid material shall be used (see Reference 1 of this guideline). This drilling configuration method also prevents blow back and plugging of the auger when the plug is removed for sampling.

Alternately, it may be necessary to keep the hollow stem full of water, at least to the level of the water table, to prevent blowback and plugging of the auger. If water is added to the hole, it must be sampled and analyzed to determine if it is free from contaminants prior to use. In addition, the amount of water introduced, the amount recovered upon attainment of depth, and the amount of water extracted during well development must be carefully logged in order to ensure that a representative sample of the formation water can be obtained. Well development should occur as soon after well completion as practicable (see SOP GH-2.8 for well development procedures). If gravelly or hard material is encountered which prevents advancing the auger to the desired depth, augering should be halted and either driven casing or hydraulic rotary methods should be attempted. If the depth to the bedrock/soil interface and bedrock lithology must be determined, then a 5-foot confirmatory core run should be conducted (see Section 5.2.9).

At the option of the Field Operations Leader (in communication with the Project Manager), when resistant materials prevent the advancement of the auger, a new boring can be attempted. The original boring must be properly backfilled and the new boring started a short distance away at a location determined by the site geologist. If multiple water bearing strata were encountered, the original boring must be grouted. In some formations, it may be prudent to also grout borings which penetrate only the water table aquifer, since loose soil backfill in the boring may still provide a preferred pathway for surface liquids to reach the water table. Backfilling requirements may also be driven by state or local regulations.

5.2.2 Continuous-Flight Solid-Stem Auger Drilling

This drilling method is similar to hollow-stem augering. Practical application of this method is severely restricted compared to use of hollow-stem augers. Split-barrel (split-spoon) sampling cannot be performed without pulling the augers out, which may allow the hole to collapse. The continuous-flight solid-stem auger drilling method is therefore very time consuming and is not cost effective. Also, augers would have to be withdrawn before installing a monitoring well, which again, may allow the hole to collapse. Furthermore, geologic logging by examining the soils brought to the surface is unreliable, and depth to water may be difficult to determine while drilling.

There would be very few situations where use of a solid-stem auger would be preferable to other drilling methods. The only practical applications of this method would be to drill boreholes for well installation where no lithologic information is desired and the soils are such that the borehole can be expected to remain open after the augers are withdrawn. Alternatively, this technique can be used to find depth to bedrock in an area when no other information is required from drilling.

5.2.3 Rotary Drilling

Direct rotary drilling includes air-rotary and fluid-rotary drilling. For air or fluid-rotary drilling, the rotary drill may be advanced to the desired depth by any power-operated drilling machine having sufficient torque

and ram range to rotate and force the bit to the desired depth. The drilling machine must, however, be equipped with any accessory equipment needed to perform required sampling, or coring. Prior to sampling, any settled drill cuttings in the borehole must be removed.

Air-rotary drilling is a method of drilling where the drill rig simultaneously turns and exerts a downward pressure on the drilling rods and bit while circulating compressed air down the inside of the drill rods, around the bit, and out the annulus of the borehole. Air circulation serves to both cool the bit and remove the cuttings from the borehole. Advantages of this method include:

- The drilling rate is high (even in rock).
- The cost per foot of drilling is relatively low.
- Air-rotary rigs are common in most areas.
- No drilling fluid is required (except when water is injected to keep down dust).
- The borehole diameter is large, to allow room for proper well installation procedures.

Disadvantages to using this method include:

- Formations must be logged from the cuttings that are blown to the surface and thus the depths of materials logged are approximate.
- Air blown into the formation during drilling may "bind" the formation and impede well development and natural groundwater flow.
- In-situ samples cannot be taken, unless the hole is cased.
- Casing must generally be used in unconsolidated materials.
- Air-rotary drill rigs are large and heavy.
- Large amounts of Investigation Derived Waste (IDW) may be generated which may require containerization, sampling, and off-site disposal.

A variation of the typical air-rotary drill bit is a down hole hammer which hammers the drill bit down as it drills. This makes drilling in hard rock faster. Air-rotary drills can also be adapted to use for rock coring although they are generally slower than other types of core drills. A major application of the air-rotary drilling method would be to drill holes in rock for well installation.

Fluid-Rotary drilling operates in a similar manner to air-rotary drilling except that a drilling fluid ("mud") or clean water is used in place of air to cool the drill bit and remove cuttings. There are a variety of fluids that can be used with this drilling method, including bentonite slurry and synthetic slurries. If a drilling fluid other than water/cuttings is used, it must be a natural clay (i.e., bentonite) and a "background" sample of the fluid should be taken for analysis of possible organic or inorganic contaminants.

Advantages to the fluid-rotary drilling method include:

- The ability to drill in many types of formations.
- Relatively quick and inexpensive.
- Split-barrel (split-spoon) or thin-wall (Shelby) tube samples can be obtained without removing drill rods if the appropriate size drill rods and bits (i.e., fish-tail or drag bit) are used.

- In some borings temporary casing may not be needed as the drilling fluids may keep the borehole open.
- Drill rigs are readily available in most areas.

Disadvantages to this method include:

- Formation logging is not as accurate as with hollow-stem auger method if split-barrel (split-spoon) samples are not taken (i.e., the depths of materials logged from cuttings delivered to the surface are approximate).
- Drilling fluids reduce permeability of the formation adjacent to the boring to some degree, and require more extensive well development than "dry" techniques (augering, air-rotary).
- No information on depth to water is obtainable while drilling.
- Fluids are needed for drilling, and there is some question about the effects of the drilling fluids on subsequent water samples obtained. For this reason as well, extensive well development may be required.
- In very porous materials (i.e., rubble fill, boulders, coarse gravel) drilling fluids may be continuously lost into the formation. This requires either constant replenishment of the drilling fluid, or the use of casing through this formation.
- Drill rigs are large and heavy, and must be supported with supplied water.
- Groundwater samples can be potentially diluted with drilling fluid.

The procedures for performing direct rotary soil investigations and sampling shall conform with the applicable ASTM standards: D2113-83, D1587-83, and D1586-84.

Soil samples shall be taken as specified by project plan documents, or more frequently, if requested by the project geologist. Any required sampling shall be performed by rotation, pressing, or driving in accordance with the standard or approved method governing use of the particular sampling tool.

When field conditions prevent the advancement of the hole to the desired depth, a new boring may be drilled at the request of the Field Operations Leader. The original boring shall be backfilled using methods and materials appropriate for the given site and a new boring started a short distance away at a location determined by the project geologist.

5.2.4 Rotosonic Drilling

The Rotosonic drilling method employs a high frequency vibrational and low speed rotational motion coupled with down pressure to advance the cutting edge of a drill string. This produces a uniform borehole while providing a continuous, undisturbed core sample of both unconsolidated and most bedrock formations. Rotosonic drilling advances a 4-inch diameter to 12-inch diameter core barrel for sampling and can advance up to a 12-inch diameter outer casing for the construction of standard and telescoped monitoring wells. During drilling, the core barrel is advanced ahead of the outer barrel in increments as determined by the site geologist and depending upon type of material, degree of subsurface contamination and sampling objectives.

The outer casing can be advanced at the same time as the inner drill string and core barrel, or advanced down over the inner drill rods and core barrel, or after the core barrel has moved ahead to collect the undisturbed sample and has been pulled out of the borehole. The outer casing can be advanced dry in most cases, or can be advanced with water or air depending upon the formations being drilled, the depth and diameter of the hole, or requirements of the project.

Advantages of this method include:

- Sampling and well installation are faster as compared to other drilling methods.
- Continuous sampling, with larger sample volume as compared to split-spoon sampling.
- The ability to drill through difficult formations such as cobbles or boulders, hard till and bedrock.
- Reduction of IDW by an average of 70 to 80 percent.
- Well installations are quick and controlled by elimination of potential bridging of annular materials during well installation, due to the ability to vibrate the outer casing during removal.

Disadvantages include:

- The cost for Rotosonic drilling as compared to other methods are generally higher. However, the net result can be a significant savings considering reduced IDW and shortened project duration.
- Rotosonic drill rigs are large and need ample room to drill, however, Rotosonic units can be placed on the ground or placed on an ATV.
- There are a limited number of Rotosonic drilling contractors at the present time.

5.2.5 Reverse Circulation Rotary Drilling

The common reverse-circulation rig is a water or mud-rotary rig with a large-diameter drill pipe which circulates the drilling water down the annulus and up the inside of the drill pipe (reverse flow direction from direct mud-rotary). This type of rig is used for the construction of large-capacity production water wells and is not suited for small, water quality sampling wells because of the use of drilling muds and the large-diameter hole which is created. A few special reverse-circulation rotary rigs are made with double-wall drill pipe. The drilling water or air is circulated down the annulus between the drill pipes and up inside the inner pipe.

Advantages of the latter method include:

- The formation water is not contaminated by the drilling water.
- Formation samples can be obtained, from known depths.
- When drilling with air, immediate information is available regarding the water-bearing properties of formations penetrated.
- Collapsing of the hole in unconsolidated formations is not as great a problem as when drilling with the normal air-rotary rig.

Disadvantages include:

- Double-wall, reverse-circulation drill rigs are rare and expensive to operate.
- Placing cement grout around the outside of the well casing above a well screen often is difficult, especially when the screen and casing are placed down through the inner drill pipe before the drill pipe is pulled out.

5.2.6 Drill-through Casing Driver

The driven-casing method consists of alternately driving casing (fitted with a sharp, hardened casing shoe) into the ground using a hammer lifted and dropped by the drill rig (or an air-hammer) and cleaning out the casing using a rotary chopping bit and air or water to flush out the materials. The casing is driven down in stages (usually 5 feet per stage); a continuous record is kept of the blows per foot in driving the casing (see SOP GH-1.5). The casing is normally advanced by a 300-pound hammer falling freely through a height of 30 inches. Simultaneous washing and driving of the casing is not recommended. If this procedure is used, the elevations within which wash water is used and in which the casing is driven must be clearly recorded.

The driven casing method is used in unconsolidated formations only. When the boring is to be used for later well installation, the driven casing used should be at least 4 inches larger in diameter than the well casing to be installed. Advantages to this method of drilling include:

- Split-barrel (split-spoon) sampling can be conducted while drilling.
- Well installation is easily accomplished.
- Drill rigs used are relatively small and mobile.
- The use of casing minimizes flow into the hole from upper water-bearing layers; therefore, multiple aquifers can be penetrated and sampled for rough field determinations of some water quality parameters.

Some of the disadvantages include:

- This method can only be used in unconsolidated formations.
- The method is slower than other methods (average drilling progress is 30 to 50 feet per day).
- Maximum depth of the borehole varies with the size of the drill rig and casing diameter used, and the nature of the formations drilled.
- The cost per hour or per foot of drilling may be substantially higher than other drilling methods.
- It is difficult and time consuming to pull back the casing if it has been driven very deep (deeper than 50 feet in many formations).

5.2.7 Cable Tool Drilling

A cable tool rig uses a heavy, solid-steel, chisel-type drill bit ("tool") suspended on a steel cable, which when raised and dropped, chisels or pounds a hole through the soils and rock. Drilling progress may be

expedited by the use of "slip-jars" which serve as a cable-activated down hole percussion device to hammer the bit ahead.

When drilling through the unsaturated zone, some water must be added to the hole. The cuttings are suspended in the water and then bailed out periodically. Below the water table, after sufficient ground water enters the borehole to replace the water removed by bailing, no further water needs to be added. When soft caving formations are encountered, it is usually necessary to drive casing as the hole is advanced to prevent collapse of the hole. Often the drilling can be only a few feet below the bottom of the casing. Because the drill bit is lowered through the casing, the hole created by the bit is smaller than the casing. Therefore, the casing (with a sharp, hardened casing shoe on the bottom) must be driven into the hole (see Section 5.2.5 of this guideline).

Advantages of the cable-tool method include the following:

- Information regarding water-bearing zones is readily available during the drilling. Even relative permeabilities and rough water quality data from different zones penetrated can be obtained by skilled operators.
- The cable-tool rig can operate satisfactorily in all formations, but is best suited for caving, boulder, cobble or coarse gravel type formations (e.g., glacial till) or formations with large cavities above the water table (such as limestones).
- When casing is used, the casing seals formation water out of the hole, preventing down hole contamination and allowing sampling of deeper aquifers for field-measurable water quality parameters.
- Split-barrel (split-spoon) or thin-wall (Shelby) tube samples can be collected through the casing.

Disadvantages include:

- Drilling is slow compared with rotary rigs.
- The necessity of driving the casing in unconsolidated formations requires that the casing be pulled back if exposure of selected water-bearing zones is desired. This process complicates the well completion process and often increases costs. There is also a chance that the casing may become stuck in the hole.
- The relatively large diameters required (minimum of 4-inch casing) plus the cost of steel casing result in higher costs compared to rotary drilling methods where casing is not required (e.g., such use of a hollow-stem auger).
- Cable-tool rigs have largely been replaced by rotary rigs. In some parts of the U.S., availability may be difficult.

5.2.8 Jet Drilling (Washing)

Jet drilling, which should be used only for piezometer or vadose zone sampler installation, consists of pumping water or drilling mud down through a small diameter (1/2- to 2-inch) standard pipe (steel or PVC). The pipe may be fitted with a chisel bit or a special jetting screen. Formation materials dislodged by the bit and jetting action of the water are brought to the surface through the annulus around the pipe. As the pipe is jetted deeper, additional lengths of pipe may be added at the surface.

Jet percussion is a variation of the jetting method, in which the casing is driven with a drive weight. Normally, this method is used to place 2-inch-diameter casing in shallow, unconsolidated sand formations, but this method has also been used to install 3- to 4-inch-diameter casings to a depth of 200 feet.

Jetting is acceptable in very soft formations, usually for shallow sampling, and when introduction of drilling water to the formation is acceptable. Such conditions would occur during rough stratigraphic investigation or installation of piezometers for water level measurement. Advantages of this method include:

- Jetting is fast and inexpensive.
- Because of the small amount of equipment required, jetting can be accomplished in locations where access by a normal drilling rig would be very difficult. For example, it would be possible to jet down a well point in the center of a lagoon at a fraction of the cost of using a drill rig.
- Jetting numerous well points just into a shallow water table is an inexpensive method for determining the water table contours, hence flow direction.

Disadvantages include the following:

- A large amount of foreign water or drilling mud is introduced above and into the formation to be sampled.
- Jetting is usually done in very soft formations which are subject to caving. Because of this caving, it is often not possible to place a grout seal above the screen to assure that water in the well is only from the screened interval.
- The diameter of the casing is usually limited to 2 inches.
- Jetting is only possible in very soft formations that do not contain boulders or coarse gravel, and the depth limitation is shallow (about 30 feet without jet percussion equipment).
- Large quantities of water are often needed.

5.2.9 Drilling with a Hand Auger

This method is applicable wherever the formation, total depth of sampling, and the site and groundwater conditions are such as to allow hand auger drilling. Hand augering can also be considered at locations where drill rig access is not possible. All hand auger borings will be performed according to ASTM D1452-80.

Samples should be taken continuously unless otherwise specified by the project plan documents. Any required sampling is performed by rotation, pressing, or driving in accordance with the standard or approved method governing use of the particular sampling tool. Typical equipment used for sampling and advancing shallow "hand auger" holes are Iwan samplers (which are rotated) or post hole diggers (which are operated like tongs). These techniques are slow but effective where larger pieces of equipment do not have access, and where very shallow holes are desired (less than 15 feet). Surficial soils must be composed of relatively soft and non-cemented formations to allow penetration by the auger.

5.2.10 Rock Drilling and Coring

When soil borings cannot be continued using augers or rotary methods due to the hardness of the soil or when rock or large boulders are encountered, drilling and sampling can be performed using a diamond bit corer in accordance with ASTM D2113.

Drilling is done by rotating and applying downward pressure to the drill rods and drill bit. The drill bit is a circular, hollow, diamond-studded bit attached to the outer core barrel in a double-tube core barrel. The use of single-tube core barrels is not recommended, as the rotation of the barrel erodes the sample and limits its use for detailed geological evaluation. Water or air is circulated down through the drill rods and annular space between the core barrel tubes to cool the bit and remove the cuttings. The bit cuts a core out of the rock which rises into an inner barrel mounted inside the outer barrel. The inner core barrel and rock core are removed by lowering a wire line with a coupling into the drill rods, latching onto the inner barrel and withdrawing the inner barrel. A less efficient variation of this method utilizes a core barrel that cannot be removed without pulling all of the drill rods. This variation is practical only if less than 50 feet of core is required.

Core borings are made through the casing used for the soil borings. The casing must be driven and sealed into the rock formation to prevent seepage from the overburden into the hole to be cored (see Section 5.3 of this guideline). A double-tube core barrel with a diamond bit and reaming shell or equivalent should be used to recover rock cores of a size specified in the project plans. The most common core barrel diameters are listed in Attachment A.

Soft or decomposed rock should be sampled with a driven split-barrel whenever possible or cored with a Denison or Pitcher sampler.

When coring rock, including shale and claystone, the speed of the drill and the drilling pressure, amount and pressure of water, and length of run can be varied to give the maximum recovery from the rock being drilled. Should any rock formation be so soft or broken that the pieces continually fall into the hole causing unsatisfactory coring, the hole should be reamed and a flush-joint casing installed to a point below the broken formation. The size of the flush-joint casing must permit securing the core size specified. When soft or broken rock is anticipated, the length of core runs should be reduced to less than 5 feet to avoid core loss and minimize core disturbance.

Advantages of core drilling include:

- Undisturbed rock cores can be recovered for examination and/or testing.
- In formations in which the cored hole will remain open without casing, water from the rock fractures may be recovered from the well without the installation of a well screen and gravel pack.
- Formation logging is extremely accurate.
- Drill rigs are relatively small and mobile.

Disadvantages include:

- Water or air is needed for drilling.
- Coring is slower than rotary drilling (and more expensive).
- Depth to water cannot accurately be determined if water is used for drilling.
- The size of the borehole is limited.

This drilling method is useful if accurate determinations of rock lithology are desired or if open wells are to be installed into bedrock. To install larger diameter wells in coreholes, the hole must be reamed out to the proper size after boring, using air or mud rotary drilling methods.

5.2.11 Drilling & Support Vehicles

In addition to the drilling method required to accomplish the objectives of the field program, the type of vehicle carrying the drill rig and/or support equipment and its suitability for the site terrain, will often be an additional deciding factor in planning the drilling program. The types of vehicles available are extensive, and depend upon the particular drilling subcontractor's fleet. Most large drilling subcontractors will have a wide variety of vehicle and drill types suited for most drilling assignments in their particular region, while smaller drilling subcontractors will usually have a fleet of much more limited diversity. The weight, size, and means of locomotion (tires, tracks, etc.) of the drill rig must be selected to be compatible with the site terrain to assure adequate mobility between borehole locations. Such considerations also apply to necessary support vehicles used to transport water and/or drilling materials to the drill rigs at the borehole locations. When the drill rigs or support vehicles do not have adequate mobility to easily traverse the site, provisions must be made for assisting equipment, such as bulldozers, winches, timber planking, etc., to maintain adequate progress during the drilling program.

Some of the typical vehicles which are usually available for drill rigs and support equipment are:

- Totally portable drilling/sampling equipment, where all necessary components (tripods, samplers, hammers, catheads, etc.) may be hand carried to the borehole site. Drilling/sampling methods used with such equipment include:

  - Hand augers and lightweight motorized augers.
  - Retractable plug samplers--driven by hand (hammer).
  - Motorized cathead - a lightweight aluminum tripod with a small gas-engine cathead mounted on one leg, used to install small-diameter cased borings. This rig is sometimes called a "monkey on a stick."

- Skid-mounted drilling equipment containing a rotary drill or engine-driven cathead (to lift hammers and drill string), a pump, and a dismounted tripod. The skid is pushed, dragged, or winched (using the cathead drum) between boring locations.

- Small truck-mounted drilling equipment using a Jeep, stake body or other light truck (4 to 6 wheels), upon which are mounted the drill and/or a cathead, a pump, and a tripod or small drilling derrick. On some rigs, the drill and/or a cathead are driven by a power take-off from the truck, instead of by a separate engine.

- Track-mounted drilling equipment is similar to truck-mounted rigs, except that the vehicle used has wide bulldozer tracks for traversing soft ground. Sometimes a continuous-track "all terrain vehicle" is also modified for this purpose. Some types of tracked drill rigs are called "bombardier" or "weasel" rigs.

- Heavy truck-mounted drilling equipment is mounted on tandem or dual tandem trucks to transport the drill, derrick, winches, and pumps or compressors. The drill may be provided with a separate engine or may use a power take-off from the truck engine. Large augers, hydraulic rotary and reverse circulation rotary drilling equipment are usually mounted on such heavy duty trucks. For soft-ground sites, the drilling equipment is sometimes mounted on vehicles having low pressure, very wide diameter tires and capable of floating; these vehicles are called "swamp buggy" rigs.

- Marine drilling equipment is mounted on various floating equipment for drilling borings in lakes, estuaries and other bodies of water. The floating equipment varies, and is often manufactured or customized by the drilling subcontractor to suit specific drilling requirements. Typically, the range of flotation vehicles include:

  - Barrel-float rigs - a drill rig mounted on a timber platform buoyed by empty 55-gallon drums or similar flotation units.

  - Barge-mounted drill rigs.

  - Jack-up platforms - drilling equipment mounted on a floating platform having retractable legs to support the unit on the sea or lake bed when the platform is jacked up out of the water.

  - Drill ships - for deep ocean drilling.

In addition to the mobility for the drilling equipment, similar consideration must be given for equipment to support the drilling operations. Such vehicles or floating equipment are needed to transport drill water, drilling supplies and equipment, samples, drilling personnel, etc. to and/or from various boring locations.

5.2.12 Equipment Sizes

In planning subsurface exploration programs, care must be taken in specifying the various drilling components, so that they will fit properly in the boring or well.

For drilling open boreholes using rotary drilling equipment, tri-cone drill bits are employed with air, water or drilling mud to remove cuttings and cool the bit. Tri-cone bits are slightly smaller than the holes they drill (i.e., 5-7/8-inch or 7-7/8-inch bits will nominally drill 6-inch and 8-inch holes, respectively).

For obtaining split-barrel samples of a formation, samplers are commonly manufactured in sizes ranging from 2 inches to 3-1/2 inches in outside diameter. However, the most commonly used size is the 2-inch O.D., 1-3/8-inch I.D. split-barrel sampler. When this sampler is used and driven by a 140-pound (± 2-pound) hammer dropping 30 inches (± 1 inch), the procedure is called a Standard Penetration Test, and the blows per foot required to advance the sampler into the formation can be correlated to the formation's density or strength.

In planning the drilling of boreholes using hollow-stem augers or casing, in which thin-wall tube samples or diamond core drilling will be performed, refer to the various sizes and clearances provided in Attachment A of this guideline. Sizes selected must be stated in the project plan documents.

5.2.13 Estimated Drilling Progress

To estimate the anticipated rates of drilling progress for a site, the following must be considered:

- The speed of the drilling method employed.

- Applicable site conditions (e.g., terrain, mobility between borings, difficult drilling conditions in bouldery soils, rubble fill or broken rock, etc.).

- Project-imposed restrictions (e.g., drilling while wearing personal protective equipment, decontamination of drilling equipment, etc.).

Based on recent experience in drilling average soil conditions (no boulders) and taking samples at 5-foot intervals, for moderate depth (30 feet to 50 feet) boreholes (not including installation or development of wells), the following daily rates of total drilling progress may be anticipated for the following drilling methods:

Drilling Method	Average Daily Progress (linear feet)
Hollow-stem augers	75'
Solid-stem augers	50'
Mud-Rotary Drilling	100' (cuttings samples)
Rotosonic Drilling	100'-160' (continuous core)
Reverse-Circulation Rotary	100' (cuttings samples)
Skid-Rig with driven casing	30'
Rotary with driven casing	50'
Cable Tool	30'
Hand Auger	Varies
Continuous Rock Coring	50'

5.3 Prevention of Cross-Contamination

A telescoping or multiple casing technique minimizes the potential for the migration of contaminated groundwater to lower strata below a confining layer. The telescoping technique consists of drilling to a confining layer utilizing a spun casing method with a diamond cutting or augering shoe (a method similar to the rock coring method described in Section 5.2.10, except that larger casing is used) or by using a driven-casing method (see Section 5.2.6 of this guideline) and installing a specified diameter steel well casing. The operation consists of three separate steps. Initially, a drilling casing (usually of 8-inch diameter) is installed followed by installation of the well casing (6-inch-diameter is common for 2-inch wells). This well casing is driven into the confining layer to ensure a tight seal at the bottom of the hole. The well casing is sealed at the bottom with a bentonite-cement slurry. The remaining depth of the boring is drilled utilizing a narrower diameter spun or driven casing technique within the outer well casing. A smaller diameter well casing with an appropriate length of slotted screen on the lower end, is installed to the surface.

Clean sand is placed in the annulus around and to a point of about 2 feet above the screen prior to withdrawal of the drilling casing. The annular space above the screen and to a point 2 feet above the bottom of the outer well casing is sealed with a tremied cement-bentonite slurry which is pressure-grouted or displacement-grouted into the hole. The remaining casing annulus is backfilled with clean material and grouted at the surface, or it is grouted all the way to the surface.

5.4 Cleanout of Casing Prior to Sampling

The boring hole must be completely cleaned of disturbed soil, segregated coarse material and clay adhering to the inside walls of the casing. The cleaning must extend to the bottom edge of the casing and, if possible, a short distance further (1 or 2 inches) to bypass disturbed soil resulting from the advancement of the casing. Loss of wash water during cleaning should be recorded.

For disturbed samples both above and below the water table and where introduction of relatively large volumes of wash water is permissible, the cleaning operation is usually performed by washing the material out of the casing with water; however, the cleaning should never be accomplished with a strong, downward-directed jet which will disturb the underlying soil. When clean out has reached the bottom of the casing or slightly below (as specified above), the string of tools should be lifted one foot off the bottom with the water still flowing, until the wash water coming out of the casing is clear of granular soil particles. In formations where the cuttings contain gravel and other larger particles, it is often useful to repeatedly raise and lower the drill rods and wash bit while washing out the hole, to surge these large particles upward out of the hole. As a time saver, the drilling contractor may be permitted to use a split-barrel (split-spoon) sampler with the ball check valve removed as the clean-out tool, provided the material below the spoon is not disturbed and the shoe of the spoon is not damaged. However, because the ball check valve has been removed, in some formations it may be necessary to install a flap valve or spring sample retainer in the split-spoon bit, to prevent the sample from falling out as the sampler is withdrawn from the hole. The use of jet-type chopping bits is discouraged except where large boulders and cobbles or hard-cemented soils are encountered. If water markedly softens the soils above the water table, clean out should be performed dry with an auger.

For undisturbed samples below the water table, or where wash water must be minimized, clean out is usually accomplished with an appropriate diameter clean out auger. This auger has cutting blades at the bottom to carry loose material up into the auger, and up-turned water jets just above the cutting blades to carry the removed soil to the surface. In this manner, there is a minimum of disturbance at the top of the material to be sampled. If any gravel material washes down into the casing and cannot be removed by the clean out auger, a split-barrel sample can be taken to remove it; bailers and sandpumps should not be used. For undisturbed samples above the groundwater table, all operations must be performed in a dry manner.

If all of the cuttings created by drilling through the overlying formations are not cleaned from the borehole prior to sampling, some of the problems which may be encountered during sampling include:

- When sampling is attempted through the cuttings remaining in the borehole, all or part of the sampler may become filled with the cuttings. This limits the amount of sample from the underlying formation which can enter and be retained in the sampler, and also raises questions as to the validity of the sample.

- If the cuttings remaining in the borehole contain coarse gravel and/or other large particles, these may block the bit of the sampler and prevent any materials from the underlying formation from entering the sampler when the sampler is advanced.

- In cased borings, should sampling be attempted through cuttings which remain in the lower portion of the casing, these cuttings could cause the sampler to become bound into the casing, such that it becomes very difficult to either advance or retract the sampler.

- When sampler blow counts are used to estimate the density or strength of the formation being sampled, the presence of cuttings in the borehole will usually give erroneously high sample blow counts.

To confirm that all cuttings have been removed from the borehole prior to attempting sampling, it is important that the site geologist measure the "stickup" of the drill string. This is accomplished by measuring the assembled length of all drill rods and bits or samplers (the drill string) as they are lowered to the bottom of the hole, below some convenient reference point of the drill string, then measuring the height of this reference point above the ground surface. The difference of these measurements is the

depth of the drill string (lower end of the bit or sampler) below the ground surface, which must then be compared with the depth of sampling required (installed depth of casing or depth of borehole drilled). If the length of drill string below grade is more than the drilled or casing depth, the borehole has been cleaned too deeply, and this deeper depth of sampling must be recorded on the log. If the length of drill string below grade is less than the drilled or casing depth, the difference represents the thickness of cuttings which remain in the borehole. In most cases, an inch or two of cuttings may be left in the borehole with little or no problem. However, if more than a few inches of cuttings are encountered, the borehole must be recleaned prior to attempting sampling.

5.5 Materials of Construction

The effects of monitoring well construction materials on specific chemical analytical parameters are described and/or referenced in SOP GH-2.8. However, there are several materials used during drilling, particularly drilling fluids and lubricants, which must be used with care to avoid compromising the representativeness of soil and ground water samples.

The use of synthetic or organic polymer slurries is not permitted at any location where soil samples for chemical analysis are to be collected. These slurry materials could be used for installation of long-term monitoring wells, but the early time data in time series collection of ground water data may then be suspect. If synthetic or organic polymer muds are proposed for use at a given site, a complete written justification including methods and procedures for their use must be provided by the site geologist and approved by the Project Manager. The specific slurry composition and the concentration of suspected contaminants for each site must be known.

For many drilling operations, potable water is an adequate lubricant for drill stem and drilling tool connections. However, there are instances, such as drilling in tight clayey formations or in loose gravels, when threaded couplings must be lubricated to avoid binding. In these instances, to be determined in the field by the judgment of the site geologist and noted in the site logbook, and only after approval by the Project Manager, a vegetable oil or silicone-based lubricant should be used. Petroleum based greases, etc. will not be permitted. Samples of lubricants used must be provided and analyzed for chemical parameters appropriate to the given site.

5.6 Subsurface Soil Samples

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

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

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

Surface protocols for various soil sampling techniques are discussed in SOP SA-1.3. Continuous-core soil sampling and rock coring are discussed below. The procedures described here are representative of

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

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

5.7 Rock Sampling (Coring) (ASTM D2113-83)

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

Borehole diameter can be drilled to various sizes, depending on the information needed. Standard sizes of core barrels (showing core diameter) and casing are shown in Figure 1.

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

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

FIGURE 1

STANDARD SIZES OF CORE BARRELS AND CASING

Coring Bit Size	Nominal*		Set Size*	
	O.D.	I.D.	O.D.	I.D.
RWT	1 5/32	3/4	1.160	0.735
EWT	1 1/2	29/32	1.470	0.905
EX, EXL, EWG, EWM	1 1/2	13/16	1.470	0.845
AWT	1 7/8	1 9/32	1.875	1.281
AX, AXL, AWG, AWM	1 7/8	1 3/16	1.875	1.185
BWT	2 3/8	1 3/4	2.345	1.750
BX, BXL, BWG, BWM	2 3/8	1 5/8	2.345	1.655
NWT	3	2 5/16	2.965	2.313
NX, NXL, NWG, NWM	3	2 1/8	2.965	2.155
HWT	3 29/32	3 3/16	3.889	3.187
HWG	3 29/32	3	3.889	3.000
2 3/4 x 3 7/8	3 7/8	2 3/4	3.840	2.690
4 x 5 1/2	5 1/2	4	5.435	3.970
6 x 7 3/4	7 3/4	6	7.655	5.970
AX Wire line ___|___/	1 7/8	1	1.875	1.000
BX Wire line ___|___/	2 3/8	1 7/16	2.345	1.437
NX Wire line ___|___/	3	1 15/16	2.965	1.937

* All dimensions are in inches; to convert to millimeters, multiply by 25.4.

___|___/ Wire line dimensions and designations may vary according to manufacturer.

FIGURE 1
STANDARD SIZES OF CORE BARRELS AND CASING
PAGE TWO

Size Designations		Casing O.D., Inches	Casing Coupling		Casing bit O.D., Inches	Core barrel bit O.D., Inches*	Drill rod O.D., Inches	Approximate Core Diameter	
Casing; Casing coupling; Casing bits; Core barrel bits	Rod; rod couplings		O.D., Inches	I.D., Inches				Normal, Inches	Thinwall, Inches
RX	RW	1.437	1.437	1.188	1.485	1.160	1.094	---	0.735
EX	E	1.812	1.812	1.500	1.875	1.470	1.313	0.845	0.905
AX	A	2.250	2.250	1.906	2.345	1.875	1.625	1.185	1.281
BX	B	2.875	2.875	2.375	2.965	2.345	1.906	1.655	1.750
NX	N	3.500	3.500	3.000	3.615	2.965	2.375	2.155	2.313
HX	HW	4.500	4.500	3.938	4.625	3.890	3.500	3.000	3.187
RW	RW	1.437	Flush Joint	No Coupling	1.485	1.160	1.094	---	0.735
EW	EW	1.812			1.875	1.470	1.375	0.845	0.905
AW	AW	2.250			2.345	1.875	1.750	1.185	1.281
BW	BW	2.875			2.965	2.345	2.125	1.655	1.750
NW	NW	3.500			3.615	2.965	2.625	2.155	2.313
HW	HW	4.500			4.625	3.890	3.500	3.000	3.187
PW	---	5.500			5.650	---	---	---	---
SW	---	6.625			6.790	---	---	---	---
UW	---	7.625			7.800	---	---	---	---
ZW	---	8.625			8.810	---	---	---	---
---	AX __|__\	---	---	---	---	1.875	1.750	1.000	---
---	BX __|__\	---	---	---	---	2.345	2.250	1.437	---
---	NX __|__\	---	---	---	---	2.965	2.813	1.937	---

* All dimensions are in inches; to convert to millimeters, multiply by 25.4.

___|___/ Wire line dimensions and designations may vary according to manufacturer.

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

5.7.1 Diamond Core Drilling

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

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

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

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

- When soft materials are encountered that produce less than 50 percent recovery, stop the core drilling. If soil samples are desired, secure such samples in accordance with the procedures described in ASTM Method D 1586 (Split-barrel Sampling) or in Method D 1587 (Thin-Walled Tube Sampling); sample soils per SOP SA-1.3. Resume diamond core drilling when refusal materials are again encountered.

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

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

5.7.2 Rock Sample Preparation and Documentation

Once the rock coring has been completed and the core recovered, the rock core shall be carefully removed from the barrel, placed in a core tray (previously labeled "top" and "bottom" to avoid confusion), classified, and measured for percentage of recovery as well as the rock quality designation (RQD). Each core shall be described, classified, and logged using a uniform system as presented in SOP GH-1.5. If moisture content will be determined or if it is desirable to prevent drying (e.g., to prevent shrinkage of clay formations) or oxidation of the core, the core shall be wrapped in plastic sleeves immediately after logging. Each plastic sleeve shall be labeled with indelible ink. The boring number, run number, and the footage represented in each sleeve shall be included, as well as designating the top and bottom of the core run.

After sampling, rock cores shall be placed in the sequence of recovery in well-constructed wooden boxes provided by the drilling contractor. Rock cores from two different borings shall not be placed in the same core box unless accepted by the Project Geologist. The core boxes shall be constructed to accommodate at least 20 linear feet of core in rows of approximately 5 feet each and shall be constructed with hinged tops secured with screws, and a latch (usually a hook and eye) to keep the top securely fastened down. Wood partitions shall be placed at the end of each core run and between rows.

The depth from the surface of the boring to the top and bottom of the drill run and run number shall be marked on the wooden partitions with indelible ink. A wooden partition (wooden block) shall be placed at the end of each run with the depth of the bottom of the run written on the block. These blocks will serve to separate successive core runs and indicate depth intervals for each run. The order of placing cores shall be the same in all core boxes. Rock core shall be placed in the box so that, when the box is open, with the inside of the lid facing the observer, the top of the cored interval contained within the box is in the upper left corner of the box, and the bottom of the cored interval is in the lower right corner of the box. The top and bottom of each core obtained and its true depth shall be clearly and permanently marked on each box. The width of each row must be compatible with the core diameter to prevent lateral movement of the core in the box. Similarly, an empty space in a row shall be filled with an appropriate filler material or spacers to prevent longitudinal movement of the core in the box.

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

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

For easy retrieval when core boxes are stacked, the sides and ends of the box shall also be labeled and include project number, boring number, top and bottom depths of core and box number.

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

6.0 REFERENCES

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ATTACHMENT A

DRILLING EQUIPMENT SIZES

Drilling Component	Designation or Hole Size (Inches)	O.D. (Inches)	I.D. (Inches)	Coupling I.D. (Inches)
Hollow-stem augers (Ref. 7)	6 1/4	5	2 1/4	
	6 3/4	5 3/4	2 3/4	---
	7 1/4	6 1/4	3 1/4	---
	13 1/4	12	6	---
Thin Wall Tube Samplers (Ref. 7)	---	2	1 7/8	---
	---	2 1/2	2 3/8	---
	---	3	2 7/8	---
	---	3 1/2	3 3/8	---
	---	4 1/2	4 3/8	---
	---	5	4 3/4	---
Drill Rods (Ref. 7)	RW	1 3/32	23/32	13/32
	EW	1 3/8	15/16	7/16
	AW	1 3/4	1 1/4	5/8
	BW	2 1/8	1 3/4	3/4
	NW	2 5/8	2 1/4	1 3/8
	HW	3 1/2	3 1/16	2 3/8
	E	1 5/16	7/8	7/16
	A	1 5/8	1 1/8	9/16
	B	1 7/8	1 1/4	5/8
	N	2 3/8	2	1
				Wall Thickness (Inches)
Driven External Coupled Extra Strong Steel* Casing (Ref. 8)	2 1/2	2.875	2.323	0.276
	3	3.5	2.9	0.300
	3 1/2	4.0	3.364	0.318
	4	4.5	3.826	0.337
	5	5.63	4.813	0.375
	6	6.625	5.761	0.432
	8	8.625	7.625	0.500
	10	10.750	9.750	0.500
	12	12.750	11.750	0.500

* Add twice the casing wall thickness to casing O.D. to obtain the approximate O.D. of the external pipe couplings.

ATTACHMENT A
DRILLING EQUIPMENT SIZES
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Drilling Component	Designation or Hole Size (Inches)	O.D. (Inches)	I.D. (Inches)	Coupling I.D. (Inches)
Flush Coupled Casing (Ref. 7)	RX	1 7/16	1 3/16	1 3/16
	EX	1 13/16	1 5/8	1 1/2
	AX	2 1/4	2	1 29/32
	BX	2 7/8	2 9/16	2 3/8
	NX	3 1/2	3 3/16	3
	HX	4 1/2	4 1/8	3 15/16
Flush Joint Casing (Ref. 7)	RW	1 7/16	1 3/16	
	EW	1 13/16	1 1/2	
	AW	2 1/4	1 29/32	
	BW	2 7/8	2 3/8	
	NW	3 1/2	3	
	HW	4 1/2	4	
	PW	5 1/2	5	
	SW	6 5/8	6	
	UW	7 5/8	7	
	ZW	8 5/8	8	
Diamond Core Barrels (Ref. 7)	EWM	1 1/2	7/8**	
	AWM	1 7/8	1 1/8**	
	BWM	2 3/8	1 5/8**	
	NWM	3	2 1/8	
	HWG	3 7/8	3	
	2 3/4 x 3 7/8	3 7/8	2 11/16	
	4 x 5 1/2	5 1/2	3 15/16	
	6 x 7 3/4	7 3/4	5 15/16	
	AQ (wireline)	1 57/64	1 1/16**	
	BQ (wireline)	2 23/64	1 7/16**	
	NQ (wireline)	2 63/64	1 7/8	
	HQ (wireline)	3 25/32	2 1/2	

** Because of the fragile nature of the core and the difficulty to identify rock details, use of small-diameter core (1 3/8") is not recommended.

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1.0 PURPOSE

This procedure provides general guidance and information pertaining to proper monitoring well design, installation, and development.

2.0 SCOPE

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

3.0 GLOSSARY

Monitoring Well - A well which is screened, cased, and sealed which is capable of providing a groundwater level and groundwater sample representative of the zone being monitored. Some monitoring wells may be constructed as open boreholes.

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

Potentiometric Surface - The surface representative of the level to which water will rise in a well cased to the screened aquifer.

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

4.0 RESPONSIBILITIES

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

Field Geologist - The field geologist supervises and documents well installation and construction performed by the driller, and insures that well construction is adequate to provide representative groundwater data from the monitored interval. Geotechnical engineers, field technicians, or other suitable trained personnel may also serve in this capacity.

5.0 PROCEDURES

5.1 Equipment/Items Needed

Below is a list of items that may be needed when installing a monitoring well or piezometer:

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

5.2 Well Design

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

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

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

5.2.1 Well Depth, Diameter, and Monitored Interval

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

The decision concerning the monitored interval and well depth is based on the following (and possibly other) information:

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

In most situations where groundwater flow lines are horizontal, depending on the purpose of the well and the site conditions, monitored intervals are 20 feet or less. Shorter screen lengths (5 feet or less) are usually required where flow lines are not horizontal, (i.e., if the wells are to be used for accurate measurement of the potentiometric head at a specific point).

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

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

Standard monitoring well diameters are 2, 4, 6, or 8 inches. Drive points are typically 1-1/4 or 2 inches in diameter. For monitoring programs which require screened monitoring wells, either a 2-inch or 4-inch-diameter well is preferred. Typically, well diameters greater than 4 inches are used in monitoring programs in which open-hole bedrock monitoring wells are used. With smaller diameter wells, the volume of stagnant water in the well is minimized, and well construction costs are reduced; however, the sampling devices that can be used are limited.

In specifying well diameter, sampling requirements must be considered (up to a total of 4 gallons of water may be required for a single sample to account for full organic and inorganic analyses, and split samples), particularly if the monitored formation is known to be a low-yielding formation. The unit volume of water contained within a monitoring well is dependent on the well diameter as follows:

Casing Inside Diameter (Inch)	Standing Water Length to Obtain 1 Gallon Water (Feet)
2	6.13
4	1.53
6	0.68

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

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

5.2.2 Riser Pipe and Screen Materials

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

The selection of well screen and riser materials depends on the method of drilling, the type of subsurface materials the well penetrates, the type of contamination expected, and natural water quality and depth. Cost and the level of accuracy required are also important. The materials generally available are Teflon, stainless steel, PVC galvanized steel, and carbon steel. Each has advantages and limitations (see Attachment A of this guideline for an extensive presentation on this topic). The two most commonly used materials are PVC and stainless steel. Properties of these two materials are compared in Attachment B. Stainless steel is a good choice where trace metals or organic sampling is required; however, costs are high. Teflon materials are extremely expensive, but are relatively inert and provide the least opportunity for water contamination due to well materials. PVC has many advantages, including low cost, excellent availability, light weight, ease of manipulation, and widespread acceptance. The crushing strength of PVC may limit the depth of installation, but the use of Schedule 80 materials may overcome some of the problems associated with depth. However, the smaller inside diameter of Schedule 80 pipe may be an important factor when considering the size of bailers or pumps required for sampling or testing. Due to this problem, the minimum well pipe size recommended for Schedule 80 wells is 4-inch I.D.

Screens and risers may have to be decontaminated before use because oil-based preservatives and oil used during thread cutting and screen manufacturing may contaminate samples. Metal pipe may corrode and release metal ions or chemically react with organic constituents, but this is considered a minor issue. Galvanized steel is not recommended where samples may be collected for metals analyses, as zinc and cadmium levels in groundwater samples may become elevated from leaching of the zinc coating.

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

When the water-bearing zone is in consolidated bedrock, such as limestone or fractured granite, a well screen is often not necessary (the well is simply an open hole in bedrock). Unconsolidated materials, such as sands, clay, and silts require a screen. A screen slot size of 0.010 or 0.020 inch is generally used when a screen is necessary, and the annular borehole space around the screened interval is artificially packed with an appropriately sized sand, selected based on formation grain size. The slot size controls the quantity of water entering the well and prevents entry of natural materials or sand pack. The screen shall pass no more than 10 percent of the pack material, or in-situ aquifer material. The site geologist

shall specify the combination of screen slot size and sand pack which will be compatible with the water-bearing zone, to maximize groundwater inflow and minimize head losses and movement of fines into the wells. For example, as a standard procedure, a Morie No. 1 or No. 10 to No. 20 U.S. Standard Sieve size filter pack is typically appropriate for a 0.020-inch slot screen; however, a No. 20 to No. 40 U.S. Standard Sieve size filter pack is typically appropriate for a 0.010-inch slot screen.

5.2.3 Annular Materials

Materials placed in the annular space between the borehole and riser pipe and screen include a sand pack when necessary, a bentonite seal, and cement-bentonite grout. The sand pack is usually a medium- to coarse-grained poorly graded, silica sand and should relate to the grain size of the aquifer sediments. The quantity of sand placed in the annular space is dependent upon the length of the screened interval, but should always extend at least 1 foot above the top of the screen. At least 1 to 3 feet of bentonite pellets or equivalent shall be placed above the sand pack. Cement-bentonite grout (or equivalent) is then placed to extent from the top of the bentonite pellets to the ground surface.

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

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

Grout is a general term which has several different connotations. For all practical purposes within the monitoring well installation industry, grout refers to the solidified material which is installed and occupies the annular space above the bentonite pellet seal. Grout, most of the time, is made up of one or two assemblages of material, (e.g., cement and/or bentonite). A cement-bentonite grout, which is the most common type of grout used in monitoring well completions, normally is a mixture of cement, bentonite, and water at a ratio of one 90-pound bag of Portland Type I cement, plus 3 to 5 pounds of granular or flake-type bentonite, and 6-7 gallons of water. A neat cement consists of one ninety-pound bag of Portland Type I cement and 6-7 gallons of water. A bentonite slurry (bentonite and water mixed to a thick but pumpable mixture) is sometimes used instead of grout for deep well installations where placement of bentonite pellets is difficult. Bentonite chips are also occasionally used for annular backfill in place of grout.

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

5.2.4 Protective Casing

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

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

5.3 Monitoring Well Installation

Pertinent data regarding monitoring well installation shall be recorded on log sheets as depicted and discussed in SOP SA-6.3. Attachments to this referenced SOP illustrate terms and physical construction of various types of monitoring wells.

5.3.1 Monitoring Wells in Unconsolidated Sediments

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

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

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

After the sand pack is installed to the desired depth (at least 1 foot above the top of the screen), then the bentonite pellet seal (or equivalent), can be installed in the same manner as the sand pack. At least 1 to 3 feet of bentonite pellets should be installed above the sand pack. Pellets should be added slowly and their fall monitored closely to ensure that bridging does not occur.

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

5.3.2 Confining Layer Monitoring Wells

When drilling and installing a well in a confined aquifer, proper well installation techniques must be applied to avoid cross contamination between aquifers. Under most conditions, this can be accomplished by installing double-cased wells. This is accomplished by drilling a large-diameter boring through the upper aquifer, 1 to 5 feet into the underlying confining layer, and setting and pressure grouting or tremie grouting a large-diameter casing into the confining layer. The grout material must fill the space between the native material and the outer casing. A smaller diameter boring is then continued through the confining layer for installation of the monitoring well as detailed for overburden monitoring wells. Sufficient time (determined by the field geologist), must be allowed for setting of the grout prior to drilling through the confined layer.

5.3.3 Bedrock Monitoring Wells

When installing bedrock monitoring wells, a large diameter boring is drilled through the overburden and approximately 5 –10 feet into bedrock. A casing (typically steel) is installed and either pressure grouted or tremie grouted in place. After the grout has cured, a smaller diameter boring is continued into bedrock to the desired depth. If the boring does not collapse, the well can be left open, and a screen is not necessary. If the boring collapses, then a screen is required and can be installed as detailed for overburden monitoring wells. If a screen is to be used, then the casing which is installed through the overburden and into the bedrock does not require grouting and can be removed when the final well installation is completed.

5.3.4 Drive Points

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

Direct push sampling/monitoring point installation methods, using a direct push rig or drilling rig, are described in SOP SA-2.5.

5.3.5 Innovative Monitoring Well Installation Techniques

Certain innovative sampling devices have proven advantageous. These devices are essentially screened samplers installed in a borehole with only small-diameter tubes extending to the surface. This reduces drilling costs, decreases the volume of stagnant water, and provides a sampling system that minimizes cross-contamination from sampling equipment. Four manufacturers of these samplers include Timco Manufacturing Company, Inc., of Prairie du Sac, Wisconsin, BARCAD Systems, Inc., of Concord, Massachusetts, Westbay Instruments Ltd. of Vancouver, British Columbia, Canada and the University of Waterloo at Waterloo, Ontario, Canada.. Each manufacturer offers various construction materials.

5.4 Well Development Methods

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

5.4.1 Overpumping and Backwashing

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

5.4.2 Surging with a Surge Plunger

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

5.4.3 Compressed Air

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

5.4.4 High Velocity Jetting

In the high velocity jetting method, water is forced at high velocities from a plunger-type device and through the well screen to loosen fine particles from the sand pack and surrounding formation. The jetting tool is slowly rotated and raised and lowered along the length of the well screen to develop the entire

screened area. Jetting using a hose lowered into the well may also be effective. The fines washed into the screen during this process can then be bailed or pumped from the well.

6.0 RECORDS

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

A Monitoring Well Sheet (see Attachments to SOP SA-6.3) shall be completed, ensuring the uniform recording of data for each installation and rapid identification of missing information. Well depth, length, materials of construction, length and openings of screen, length and type of riser, and depth and type of all backfill materials shall be recorded. Additional information shall include location, installation date, problems encountered, water levels before and after well installation, cross-reference to the geologic boring log, and methods used during the installation and development process. Documentation is very important to prevent problems involving questionable sample validity. Somewhat different information will need to be recorded, depending on whether the well is completed in overburden (single- or double-cased), as a cased well in bedrock, or as an open hole in bedrock.

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

7.0 REFERENCES

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ATTACHMENT A

RELATIVE COMPATIBILITY OF RIGID WELL CASING MATERIAL (PERCENT)

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

Preliminary Ranking of Rigid Materials:

1 Teflon®
2 Stainless Steel 316
3. Stainless Steel 304
4 PVC 1
5 Lo-Carbon Steel
6 Galvanized Steel
7 Carbon Steel

* Trademark of DuPont

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

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

Preliminary Ranking of Semi-Rigid or Elastomeric Materials:

1 Teflon®
2 Polypropylene (PP)
3. PVC Flexible/PE Linear
4 Viton®
5 PE Conventional
6 Plexiglas/Lucite (PMM)
7 Silicone/Neoprene

* Trademark of DuPont

Source: Barcelona et al., 1983

ATTACHMENT B

COMPARISON OF STAINLESS STEEL AND PVC FOR MONITORING WELL CONSTRUCTION

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

* See also Attachment A.

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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 14C.

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 – Salinity is a unitless property of industrial and natural waters. It is the measurement of dissolved slats 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 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.

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 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 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) shall be placed near the bottom of the screened section, and approximately one casing volume of water shall be pumped from the well at a 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.,

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), engineer's rule, 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 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.
- 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.

- There is minimal outgassing of volatile organics while the sample is in the bailer.
- Bailers are relatively easy to decontaminate.

Limitations on the use of bailers include the following:

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

Suction Pumps

There are many different types of inexpensive suction pumps including centrifugal, diaphragm, 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)
- Certain Dissolved Constituents Using Specific Ion Elements
- 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.

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 hydrion 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 meter equipped with an in-line sample chamber (e.g., YSI 610).
- 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, slowly stirring the probe until the pH stabilizes. Stabilization may take several seconds to minutes. If the pH continues to drift, the sample temperature may not be stable, a 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.

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.

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.

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 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 2 inches 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 5 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.
- Tubing - Teflon, Teflon-lined polyethylene, polyethylene, PVC, Tygon, 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).
- Flow measurement supplies.
- Interface probe, if needed.

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.

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 meter equipped with an in-line sample chamber (e.g., YSI 610).
- Sufficient cable to allow the probe to contact the sample.
- Manufacturer's operation manual.

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. Dissolved oxygen values for air-saturated water can be determined by consulting a table listing oxygen solubilities as a function of temperature and salinity (see Attachment C).
- 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. Be sure to record whether the liquid was analyzed in-situ, or if a sample was taken.

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

5.5.5 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 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:

- Portable pH meter or equivalent, with a millivolt scale.
- Platinum electrode to fit above pH meter.
- Reference electrode such as a calomel, silver-silver chloride, or equivalent.
- 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 calibrated and have its batteries checked before going to the field.

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

- Thoroughly rinse the electrode with deionized water.

- Verify the sensitivity of the electrodes by noting the change in millivolt reading when the pH of the test solution is altered. The ORP will increase when the pH of the test solution decreases, and the ORP

will decrease if the test solution pH is increased. Place the sample in a clean 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. If the ORP does not respond as above when the caustic is added, the electrodes shall be cleaned and the above procedure repeated.

- After the assembly has been checked for sensitivity, wash the electrodes with three changes of water or by means of a flowing stream of deionized water from a wash bottle. Place the sample in a clean container and insert the electrodes. Set temperature compensator throughout the measurement period. Read the millivolt potential of the solution, allowing sufficient time for the system to stabilize and reach temperature equilibrium. Measure successive portions of the sample until readings on two successive portions differ by no more than 10 mV. A system that is very slow to stabilize properly will not yield a meaningful ORP. Record all results in a field logbook or sample logsheet, including ORP (to nearest 10 mV), sample temperature and pH at the time of measurement.

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 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 turbidmeter. 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:

- Stand alone portable turbidity meter, or combination meter (e.g., Horiba U-10), or combination meter equipped with an in-line sample chamber (e.g., YSI 61).

- 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 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 cell with one or more portions of the sample to be tested or with deionized water.
- Immerse the probe in the sample and measure the turbidity. 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 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 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 610).
- 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 probes 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).
- 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 SOP SA-6.3); 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 and stopwatch are most commonly used; other techniques include use of pipe trajectory methods, weir boxes or flow meters.

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.

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 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 2 inches 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 5 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.
- Tubing - Teflon, Teflon-lined polyethylene, polyethylene, PVC, Tygon, 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).
- Flow measurement supplies.
- Interface probe, if needed.

- 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 and dissolved oxygen, flow-through cell is required. Standards to perform field calibration of instruments.

- Decontamination supplies.

- Logbook(s), and other forms (e.g., well purging forms).

- 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.

- Field Sampling Plan.

- PID or FID instrument for measuring VOCs (volatile organic compounds).

5.7.3 Purging and Sampling Procedure

Use a submersible pump to purge and sample monitoring wells which have a 2.0 inch or greater well casing diameter.

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

Lower pump, safety cable, tubing and electrical lines 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.

When starting the pump, slowly increase the pump speed until a discharge occurs. Check water level. Adjust pump speed to maintain little or no water level drawdown. The target drawdown should be less than 0.3 feet and it should stabilize. If the target of less than 0.3 feet cannot be achieved or maintained, the sampling is acceptable if remaining criteria in the procedure are met. Subsequent sampling rounds will probably have intake settings and extraction rates that are comparable to those used in the initial sampling rounds.

Monitor water level and pumping rate every five to ten minutes (or as appropriate) during purging. Record pumping rate adjustments and depths to water. Pumping rates should, as needed, be reduced to the minimum capabilities of the pump (e.g., 0.1-0.2 l/min) to ensure stabilization of indicator parameters. Adjustments are best made in the first fifteen minutes of pumping in order to help minimize purging time. During initial pump start-up, drawdown may exceed the 0.3 feet target and then recover as pump flow adjustments are made (minimum purge volume calculations should utilize stabilized drawdown values, not the initial drawdown). If the recharge rate of the well is less than minimum capability of the pump do not

allow the water level to fall to the intake level (if the static water level is above the screen, avoid lowering the water level into the screen). Shut off the pump if either of the above is about to occur and allow the water level to recover. Repeat the process until field indicator parameters stabilize and the minimum purge volume is removed. The minimum purge volume with negligible drawdown (0.3 feet or less) is two saturated screen length volumes. In situations where the drawdown is greater than 0.3 feet and has stabilized, the minimum purge volume is two times the saturated screen volume plus the stabilized drawdown volume. After the minimum purge volume is attained (and field parameters have stabilized) begin sampling. For low yields wells, commence sampling as soon as the well has recovered sufficiently to collect the appropriate volume for all anticipated samples.

During well purging, monitor field indicator parameters (turbidity, temperature, specific conductance, pH, etc.) every five to ten minutes (or as appropriate). Purging is complete and sampling may begin when all field indicator parameters have stabilized (variations in values are within ten percent of each other, pH +/- 0.2 units, for three consecutive readings taken at five to ten minute intervals). If the parameters have stabilized, but turbidity remains above 5 NTU goal, decrease pump flow rate, and continue measurement of parameters every five to ten minutes. If pumping rate cannot be decreased any further and stabilized turbidity values remain above 5 NTU goal record this information. Measurements of field parameters should be obtained (as per Section 5.5) and recorded.

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.

6.0 REFERENCES

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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			
	Water Level >25 feet				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

ATTACHMENT A

PURGING EQUIPMENT SELECTION

PAGE 2

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.

ATTACHMENT A

PURGING EQUIPMENT SELECTION

PAGE 3

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.

ATTACHMENT B

SPECIFIC CONDUCTANCE OF 1 MOLAR KCl AT VARIOUS TEMPERATURES[1]

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

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

ATTACHMENT C

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

Temperature (°C)	Dissolved Oxygen (mg/L)					
	Chloride Concentration in Water					Difference/ 100 mg Chloride
	0	5,000	10,000	15,000	20,000	
0	14.6	13.8	13.0	12.1	11.3	0.017
1	14.2	13.4	12.6	11.8	11.0	0.016
2	13.8	13.1	12.3	11.5	10.8	0.015
3	13.5	12.7	12.0	11.2	10.5	0.015
4	13.1	12.4	11.7	11.0	10.3	0.014
5	12.8	12.1	11.4	10.7	10.0	0.014
6	12.5	11.8	11.1	10.5	9.8	0.014
7	12.2	11.5	10.9	10.2	9.6	0.013
8	11.9	11.2	10.6	10.0	9.4	0.013
9	11.6	11.0	10.4	9.8	9.2	0.012
10	11.3	10.7	10.1	9.6	9.0	0.012
11	11.1	10.5	9.9	9.4	8.8	0.011
12	10.8	10.3	9.7	9.2	8.6	0.011
13	10.6	10.1	9.5	9.0	8.5	0.011
14	10.4	9.9	9.3	8.8	8.3	0.010
15	10.2	9.7	9.1	8.6	8.1	0.010
16	10.0	9.5	9.0	8.5	8.0	0.010
17	9.7	9.3	8.8	8.3	7.8	0.010
18	9.5	9.1	8.6	8.2	7.7	0.009
19	9.4	8.9	8.5	8.0	7.6	0.009
20	9.2	8.7	8.3	7.9	7.4	0.009
21	9.0	8.6	8.1	7.7	7.3	0.009
22	8.8	8.4	8.0	7.6	7.1	0.008
23	8.7	8.3	7.9	7.4	7.0	0.008
24	8.5	8.1	7.7	7.3	6.9	0.008
25	8.4	8.0	7.6	7.2	6.7	0.008

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

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

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

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1.0 PURPOSE

The purpose of this procedure is to provide general reference information on Direct Push Technology (DPT). DPT is designed to collect soil, groundwater, and soil gas samples without using conventional drilling techniques. The advantage of using DPT over conventional drilling includes the generation of little or no drill cuttings, sampling in locations with difficult accessibility, reduced overhead clearance requirements, no fluid introduction during probing, and typical lower costs per sample than with conventional techniques. Disadvantages include a maximum penetration depth of approximately 15 to 40 feet in dense soils (although it may be as much as 60 to 80 feet in certain types of geological environments), reduced capability of obtaining accurate water-level measurements, and the inability to install permanent groundwater monitoring wells. The methods and equipment described herein are for collection of surface and subsurface soil samples and groundwater samples. Soil gas sampling is discussed in SOP SA-2.4.

2.0 SCOPE

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

3.0 GLOSSARY

Direct Push Technology (DPT) - DPT refers to sampling tools and sensors that are driven directly into the ground without the use of conventional drilling equipment. DPT typically utilizes hydraulic pressure and/or percussion hammers to advance the sampling tools. A primary advantage of DPT over conventional drilling techniques is that DPT results in the generation of little or no investigation derived waste.

Geoprobe® - Geoprobe® is a manufacturer of a hydraulically-powered, percussion/probing machines utilizing DPT to collect subsurface environmental samples. Geoprobe® relies on a relatively small amount of static weight (vehicle) combined with percussion as the energy for advancement of a tool string. The Geoprobe® equipment can be mounted in a multitude of vehicles for access to all types of environmental sites.

HydroPunch™ - HydroPunch™ is a manufacturer of stainless steel and Teflon® sampling tools that are capable of collecting representative groundwater and/or soil samples without requiring the installation of a groundwater monitoring well or conventional soil boring. HydroPunch™ is an example of DPT sampling equipment.

Flame Ionization Detector (FID) - A portable instrument for the measurement of many combustible organic compounds and a few inorganic compounds in air at parts-per million levels. The basis for the detection is the ionization of gaseous species utilizing a flame as the energizing source.

Photo Ionization Detector (PID) - A portable instrument for the measurement of many combustible organic compounds and a few inorganic compounds in air at parts-per million levels. The basis for the detection is the ionization of gaseous species utilizing ultraviolet radiation as the energizing source.

4.0 RESPONSIBILITIES

Project Manager - The Project Manager is responsible for selecting and/or reviewing the appropriate DPT drilling procedure required to support the project objectives.

Field Operations Leader (FOL)- The FOL is primarily responsible for performing the DPT in accordance with the project-specific plan.

5.0 SOIL SAMPLING PROCEDURES

5.1 General

The common methodology for the investigation of the vadose zone is soil boring drilling and soil sampling. However, drilling soil borings can be very expensive. Generally the advantage of DPT for subsurface soil sampling is the reduced cost of disposal of drilling cuttings and shorter sampling times.

5.2 Sampling Equipment

Equipment needed for conducting DPT drilling for subsurface soil sampling includes, but is not limited to, the following:

- Geoprobe® Sampling Kit
- Cut-resistant gloves
- 4-foot x 1.5-inch diameter macrocore sampler
- Probe sampling adapters
- Roto-hammer with 1.5-inch bit
- Disposable acetate liners for soil macrocore sampler
- Cast aluminum or steel drive points
- Geoprobe® AT-660 Series Large Bore Soil Sampler, or equivalent
- Standard decontamination equipment and solutions

For health and safety equipment and procedures, follow the direction provided in the Safe Work Permit in Attachment 1, or the more detailed directions provided in the project's Health and Safety Plan.

5.3 DPT Sampling Methodology

There are several methods for the collection of soil samples using DPT drilling. The most common method is discussed in the following section. Variations of the following method may be conducted upon approval of the Project Manager in accordance with the project-specific plan.

- Macrocore samplers fitted with detachable aluminum or steel drive points are driven into the ground using hydraulic pressure. If there is concrete or pavement over a sampling location, a Roto-hammer is used to drill a minimum 1.5-inch diameter hole through the surface material. A Roto-hammer may also be used if very dense soils are encountered.

- The sampler is advanced continuously in 4-foot intervals or less if desired. No soil cuttings are generated because the soil which is not collected in the sampler is displaced within the formation.

- The sampler is retracted from the hole, and the 4-foot continuous sample is removed from the outer coring tube. The sample is contained within an inner acetate liner.

- Attach the metal trough from the Geoprobe® Sampling Kit firmly to the tail gate of a vehicle. If a vehicle with a tail gate is not available, secure the trough on another suitable surface.

- Place the acetate liner containing the soils in the trough.

- While wearing cut-resistant gloves (constructed of leather or other suitable material), but the acetate liner through its entire length using the double-bladed knife that accompanies the Geoprobe® Sampling Kit. Then remove the strip of acetate from the trough to gain access to the collected soils. Do not attempt to cut the acetate liner while holding it in your hand.

- Field screen the sample with an FID or PID, and observe/examine the sample (according to SOP GH-1.3). If appropriate, transfer the sample to sample bottles for laboratory analysis. If additional volume is required, push an additional boring adjacent to the first and composite/mix the same interval. Field compositing is usually not acceptable for sample requiring volatile organics analysis.

- Once sampling has been completed, the hole is backfilled with bentonite chips or bentonite cement grout, depending upon project requirements. Asphalt or concrete patch is used to cap holes through paved or concrete areas. All holes should be finished smooth to existing grade.

- In the event the direct push van/truck cannot be driven to a remote location or a sampling location with difficult accessibility, sampling probes may be advanced and sampled manually or with battery/electric operated equipment (e.g., jack hammer).

- Sampling equipment is decontaminated prior to collecting the next sample.

6.0 GROUNDWATER SAMPLING PROCEDURES

6.1 General

The most common methodology for the investigation of groundwater is the installation and sampling of permanent monitoring wells. If only groundwater screening is required, the installation and sampling of temporary well points may be performed. The advantage of temporary well point installation using DPT is reduced cost due to no or minimal disposal of drilling cuttings and well construction materials, and shorter installation/times sampling.

Two disadvantages of DPT drilling for well point installation are:

- In aquifers with low yields, well points may have to be sampled without purging or development.
- If volume requirements are high, this method can be time consuming for low yield aquifers.

6.2 Sampling Equipment

Equipment needed for temporary well installation and sampling using DPT includes, but is not limited, to the following:

- 2-foot x 1-inch diameter mill-slotted (0.005 to 0.02-inch) well point
- Connecting rods
- Roto-hammer with 1.5-inch bit
- Mechanical jack
- 1/4-inch OD polyethylene tubing
- 3/8-inch OD polyethylene tubing
- Peristaltic pump
- Standard decontamination equipment and solutions

6.3 DPT Temporary Well Point Installation and Sampling Methodology

There are several methods for the installation and sampling of temporary well points using DPT. The most common methodology is discussed below. Variations of the following method may be conducted upon approval of the Project Manager in accordance with the project specific plan.

- A 2-foot x 1-inch diameter mill-slotted (0.005 to 0.02-inch) well point attached to connecting rods is driven into the ground to the desired depth using a rotary electric hammer or other direct push drill rig. If there is concrete or pavement over a sampling location, a Roto-hammer or electric coring machine is used to drill a hole through the surface material.

- The well point will be allowed to equilibrate for at least 15 minutes, after which a measurement of the static water level will be taken. The initial measurement of the water level will be used to assess the amount of water which is present in the well point and to determine the amount of silt and sand infiltration that may have occurred.

- The well point will be developed using a peristaltic pump and polyethylene tubing to remove silt and sand which may have entered the well point. The well point is developed by inserting polyethylene tubing to the bottom of the well point and lifting and lowering the tubing slightly while the pump is operating. The pump will be operated at a maximum rate of approximately 2 liters per minute. After removal of sediment from the bottom of the well point, the well point will be vigorously pumped at maximum capacity until discharge water is visibly clear and no further sediments are being generated. Measurements of pH, specific conductance, temperature, and turbidity shall be recorded every 5 minutes during the purging process. After two consistent readings of pH, specific conductance, temperature and turbidity ($\pm$10 percent), the well may be sampled.

- A sample will be collected using the peristaltic pump set at the same or reduced speed as during well development. Samples (with the exception of the samples to be analyzed for volatile organic compounds, VOCs) will be collected directly from the pump discharge. Sample containers for VOCs will be filled by (first shutting off the pump) crimping the discharge end of the sample tubing when filled, removing the inlet end of the sample tubing from the well, suspending the inlet tubing above the vial, and allowing water to fill each vial by gravity flow.

- Once the groundwater sample has been collected, the connecting rods and well point will be removed from the hole with the direct push rig hydraulics. The hole will be backfilled with bentonite chips or bentonite cement grout, depending upon project requirements. Asphalt or concrete patch will be used to cap holes through paved or concrete areas. All holes will be finished smooth to existing grade.

- In the event the direct push van/truck cannot be driven to a remote location or sampling location with difficult accessibility, sampling probes may be advanced and sampled manually or with battery/electric-operated equipment (e.g., jack hammer).

- Decontaminate the equipment before moving to the next location.

7.0 RECORDS

A record of all field procedures, tests, and observations must be recorded in the field logbook, boring logs, and sample log sheets, as needed. Entries should include all pertinent data regarding the investigation. The use of sketches and field landmarks will help to supplement the investigation and evaluation.

ATTACHMENT 1
SAFE WORK PERMIT FOR DPT OPERATIONS

Permit No. _____ Date: _____ Time: From _____ to _____

SECTION I: General Job Scope

I. Work limited to the following (description, area, equipment used): **Monitoring well drilling and installation through direct push technology**

II. Required Monitoring Instruments: _____

III. Field Crew: _____

IV. On-site Inspection conducted ☐ Yes ☐ No Initials of Inspector _____ _____
TtNUS

SECTION II: General Safety Requirements (To be filled in by permit issuer)

V. Protective equipment required

Level D ☒ Level B ☐
Level C ☐ Level A ☐
Detailed on Reverse

Respiratory equipment required

Full face APR ☐ Escape Pack ☐
Half face APR ☐ SCBA ☐
SKA-PAC SAR ☐ Bottle Trailer ☐
Skid Rig ☐ None ☒

Level D Minimum Requirements: Sleeved shirt and long pants, safety footwear, and work gloves. Safety glasses, hard hats, and hearing protection will be worn when working near or sampling in the vicinity of the DPT rig.

Modifications/Exceptions.

VI. Chemicals of Concern | Action Level(s) | Response Measures

VII. Additional Safety Equipment/Procedures

Hard-hat	☒ Yes	☐ No	Hearing Protection (Plugs/Muffs)	☒ Yes	☐ No
Safety Glasses	☒ Yes	☐ No	Safety belt/harness	☐ Yes	☒ No
Chemical/splash goggles	☐ Yes	☒ No	Radio	☐ Yes	☒ No
Splash Shield	☐ Yes	☒ No	Barricades	☒ Yes	☐ No
Splash suits/coveralls	☐ Yes	☐ No	Gloves (Type - _____)	☐ Yes	☐ No
Steel toe Work shoes or boots	☒ Yes	☐ No	Work/warming regimen	☐ Yes	☐ No

Modifications/Exceptions: Reflective vests for high traffic areas.

VIII. Procedure review with permit acceptors

	Yes	NA		Yes	NA
Safety shower/eyewash (Location & Use)	☐	☒	Emergency alarms	☐	☐
Daily tail gate meetings	☒	☐	Evacuation routes	☐	☐
Contractor tools/equipment/PPE inspected	☐	☐	Assembly points	☐	☐

IX. Site Preparation

Utility Clearances obtained for areas of subsurface investigation	☐ Yes	☐ No
Physical hazards removed or blockaded	☐ Yes	☐ No
Site control boundaries demarcated/signage	☐ Yes	☐ No

X. Equipment Preparation

	Yes	NA
Equipment drained/depressurized	☐	☒
Equipment purged/cleaned	☐	☒
Isolation checklist completed	☐	☒
Electrical lockout required/field switch tested	☐	☒
Blinds/misalignments/blocks & bleeds in place	☐	☒
Hazardous materials on walls/behind liners considered	☐	☒

XI. Additional Permits required (Hot work, confined space entry). ☐ Yes ☐ No
If yes, complete permit required or contact Health Sciences, Pittsburgh Office

XII. Special instructions, precautions:

_____

Permit Issued by: _____ Permit Accepted by: _____

CHAPTER 62-522
GROUND WATER PERMITTING AND MONITORING REQUIREMENTS

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62-522.100 Intent of Ground Water Permitting and Monitoring. (Repealed)
Specific Authority 403.061, FS.
Law Implemented 403.021, 403.061, 403.087, 403.088, 403.182, FS.
History -- New 9-8-92, Amended 4-14-94, Formerly 17-522.100, Repealed 12-9-96.

62-522.200 Definitions for Ground Water Permitting and Monitoring.

(1) For the purposes of Chapters 62-520 and 62-522, F.A.C., "Existing Installation" means any installation which had filed a complete application for a water discharge permit on or before January 1, 1983, or which submitted a ground water monitoring plan no later than six months after the date required for that type of installation as listed in Rule 17-4.245, F.A.C., (1983) and a plan was subsequently approved by the Department, or which was in fact an installation reasonably expected to release contaminants into the ground water on or before July 1, 1982, and operated consistently with statutes and rules relating to ground water discharge in effect at the time of the operation.

(2) For other terms in this Chapter, the definitions contained in Chapter 62-520, F.A.C., shall prevail over any inconsistent definitions established elsewhere by Department rule.

Specific Authority 403.061, FS.
Law Implemented 403.021, 403.061, 403.087, 403.088, FS.
History -- New 9-8-92, Amended 4-14-94, Formerly 17-522.200.

62-522.300 General Provisions for Ground Water Permitting and Monitoring.

(1) Unless exempted by Rule 62-520.500, 62-520.510, or 62-520.520, F.A.C., no installation shall directly or indirectly discharge into ground water any contaminant that causes a violation in the water quality standards and criteria for the receiving ground water as established in Chapter 62-520, F.A.C., except within a zone of discharge established by permit or rule pursuant to this chapter.

(2) Zones of discharge shall be allowed for projects that allow direct contact with ground water as provided below:

(a) Projects or facilities listed in 1. and 2. below, which provide beneficial discharges through wells to ground water, are allowed a zone of discharge as described in the cited rules.

1. projects designed to recharge aquifers with surface water of comparable quality, or projects designed to transfer water across or between aquifers of comparable quality for the purpose of storage or conservation; and

2. facilities permitted under Rule 62-610.466 for aquifer storage and recovery of reclaimed water, 62-610.560(3) for ground water recharge by injection of reclaimed

water, or 62-610.562(4) for creation of salinity barrier systems by injection of reclaimed water.

(3) Other discharges through wells or sinkholes that allow direct contact with Class G-I, Class F-I, or Class G-II ground water shall not be allowed a zone of discharge.

(4) Discharges that may cause an imminent hazard to the public or the environment through contamination of underground supplies of drinking water or surface water affected by the ground water.

(5) Installations operated to render water fit for human consumption and which dispose non-hazardous concentrates from membrane separation technologies, such as reverse osmosis, membrane softening, ultra-filtration, and electrodialysis, through land application operations are exempt from obtaining a zone of discharge in order to discharge to ground water, provided the applicant demonstrates that the receiving unconfined aquifer exhibits a natural background total dissolved solids concentration exceeding 1500 mg/L. Installations discharging to such aquifers shall not cause a violation of primary or secondary drinking water standards at any private or public water supply well outside of the installation's property boundary.

(6) It is the intent of the Department whenever possible to incorporate ground water discharge considerations into other Department permits as appropriate, and not to require a separate permit for discharges to ground water. However, any published notice of proposed agency action on an application for a permit shall contain notice, when appropriate, that ground water considerations are being incorporated into such permits.

(7) The purpose of monitoring is to ensure that the permitting of zones of discharge, or exemptions therefrom, will not cause a violation of ground water standards. Ground water monitoring is intended to allow predictions to be made of the movement and composition of the discharge plume and compliance with applicable state ground water standards at the boundary of the zone of discharge. Efforts shall be made to minimize the number and cost of monitoring wells, consistent with the ability to obtain useful and reliable information.

(8) Existing installations discharging to Class G-II ground water are exempt from compliance with secondary standards outside of a zone of discharge obtained by Department permit or rule except where compliance is required under Rule 62-520.520, F.A.C.

Specific Authority 403.061, FS.
Law Implemented 403.021, 403.061, 403.087, 403.088, FS.
History -- New 9-8-92, Amended 4-14-94, Formerly 17-522.300, Amended 12-9-96, Amended 8-21-00.

62-522.400 Dimensions of Zones of Discharge for Class G-I Ground Water.

(1) No zone of discharge shall be allowed into Class G-I ground water, except that domestic effluent or reclaimed water and stormwater discharge sites authorized by Department permit or rule shall have zones of discharge extending no more than 100 feet

from the site boundary or to the installation's property boundary, whichever is less, unless a smaller zone of discharge is necessary to protect the designated use of adjacent waters outside the zone of discharge.

(2) Other discharge sites shall be granted zones of discharge of the same size as those in (1) above if the discharges meet the criteria for domestic effluent or reclaimed water in chemical, physical, and microbiological quality and are treated to the degree required in Rule 62-600.530, F.A.C.

(3) Installations authorized to discharge to ground water at the time of its reclassification to Class G-I by the Commission shall meet the same requirements as existing installations in G-II ground water as described in Rule 62-522.410, F.A.C. However, should such existing installations wish to increase the volume of discharge or change the composition of the waste stream above permitted levels as of the date of G-I classification, the new waste stream shall be distinctly separate from the existing stream and shall meet all provisions applicable to new installations discharging to G-I ground water as described in (1) or (2) above.

Specific Authority 403.061, FS.

Law Implemented 403.021, 403.061, 403.087, 403.088, FS.

History -- New 9-8-92, Amended 4-14-94, Formerly 17-522.400.

62-522.410 Dimensions of Zones of Discharge for Class G-II Ground Water. Upon affirmative demonstration by an applicant or installation owner that a ground water discharge will not impair the designated uses of contiguous waters outside a zone of discharge, the Department shall establish a zone of discharge for Class G-II ground water in one of the following ways:

(1) Existing installations shall have the zone of discharge specified in the permit or extending to the owner's property line if no zone of discharge is defined in the permit, until such time as the permit is renewed or modified as provided in Rule 62-522.500, F.A.C.

(2) A zone of discharge for any installation that is not an existing installation as defined herein shall be established in accordance with (a) or (b) below, and (c) if applicable, at the permit applicant's option, but the zone of discharge shall not extend beyond the applicant's property boundary:

(a) Any applicant seeking a zone of discharge and not electing to use the procedure below shall have a zone of discharge established by the Department. The boundary of the zone of discharge shall be 100 feet from the site boundary or to the installation's property boundary, whichever is less, unless a smaller zone of discharge is necessary to protect the designated use of contiguous waters.

(b) The Department shall establish a zone of discharge larger than that provided in (a) above upon an affirmative demonstration by the applicant that:

1. The size and shape of the requested zone of discharge will not cause violations of applicable ground water standards in present and future potable water supplies; and

2. The size and shape of the requested zone of discharge will not interfere with existing or designated uses of contiguous waters, or cause a violation of applicable surface water quality criteria of contiguous waters outside a permitted mixing zone; and

3. The economic and social benefits of a zone of discharge of larger dimensions than those in 1. above outweigh the economic, environmental, and social costs resulting from the larger zone of discharge.

(c) Where multiple sites occur within close proximity, a single zone of discharge for the sites may be established in the same manner as either (a) or (b) above.

(3) Unless otherwise required by Department rule, the following installations shall not be required to obtain a permit establishing a zone of discharge. These installations shall have a zone of discharge of 100 feet from the site or to the installation's property boundary, whichever is less, unless a different zone is specified in any appropriate Department permit. If the discharge from the installation threatens to violate ground water standards at the boundary of the zone of discharge, violates minimum criteria, or otherwise threatens to impair the designated use of contiguous waters, the Department shall require the installation owner to obtain a permit which addresses the ground water discharge if he has none, define an appropriate zone of discharge or modify it if a permit exists, and institute appropriate monitoring plans pursuant to Rule 62-522.600, F.A.C.

(a) Agricultural fields, ditches and canals;

(b) Waste management systems for animal feeding operations exempted from permitting under Chapter 62-670, F.A.C.; and

(c) Stormwater facilities.

Specific Authority 403.061, FS.
Law Implemented 403.021, 403.061, 403.087, 403.088, FS.
History-- New 9-8-92, Amended 4-14-94, Formerly 17-522.410.

62-522.500 Permit Renewal and Modification Procedures for Installations Discharging to Ground Water.

(1) At any time, including the time of permit renewal, the Department may order or a permittee may petition for modification of the zone of discharge or monitoring requirements for any of the following reasons or reasons contained in Rule 62-4.080, F.A.C.:

(a) Monitoring data indicate that the discharge plume has resulted or may in the foreseeable future result in a violation of applicable water quality standards beyond the boundary of the existing zone of discharge;

(b) Continuation of the existing zone of discharge will impair the designated use of underground sources of drinking water or the surface waters immediately affected by the ground water;

(c) Continuation of the existing zone of discharge will result in an imminent threat to public health or the environment;

(d) A zone of discharge smaller than the existing zone will afford necessary protection to the water resources at a cost that is commensurate with the benefits to the public of such protection;

(e) The monitoring data provided by the installation owner are inadequate to allow a determination of compliance with applicable zone of discharge limitations and the owner fails to provide reasonable additional data requested by the Department; or

(f) A change in the chemical, physical, or microbiological composition, or the volume or the location of the discharge, requires a change in the zone of discharge or the monitoring scheme to assure compliance.

(2) Unless modified pursuant to (1) above, a permit holder shall continue to have the same zone of discharge in the new permit. If no zone of discharge is specified in the existing permit, the new permit shall specify the boundary of the zone of discharge.

(3) If a modification is requested pursuant to (1) above, a zone of discharge shall be established as follows:

(a) The zone of discharge modification described in (1) above shall be based upon a showing that one of the conditions in (1)(a) through (f) above has occurred.

(b) Once the party seeking the modification has established that one of the conditions in (1)(a) through (f) above has occurred, the Department shall modify the zone of discharge or monitoring requirements to assure that none of the conditions in (1)(a) through (c) above will occur, based upon the monitoring data received from the monitoring program implemented pursuant to Rule 62-520.600, F.A.C.

(c) No zone of discharge shall be modified to allow it to extend beyond the limits of the installation owner's property boundary line except as provided in (d) below.

(d) An owner of an existing installation may petition the Department in writing for a permit modification to extend its zone of discharge for certain specified water quality parameters, and the Department shall modify the installation's permit to include such extension if the owner affirmatively demonstrates that conditions 1 through 4 below are met. The permit modification procedures for an extension of a zone of discharge, including those of newspaper notice publication, shall be the same as any other permit modification procedure except that condition 5 below shall also apply.

1. The discharge shall not significantly impair any designated use of the receiving ground water, or surface water;

2. The discharge shall not in the foreseeable future result in a violation of applicable ground water standards in a currently used source of drinking water outside the zone of discharge; and

3. The discharge shall not prevent persons within the proposed zone of discharge from enjoying the reasonable and beneficial use of their property; and

4. The economic and social benefits of a zone of discharge extending beyond the property boundary outweigh the economic, environmental, and social costs resulting

from the extended zone of discharge, taking into account the feasibility of preventative measures or corrective actions.

5. The Department shall provide written notice to the property owners of the property underlain by the proposed extended zone of discharge.

(e) If the permit modification request in (d) above is granted, it shall be recorded in the property records of the affected parcels by the recipient of the zone of discharge permit modification.

Specific Authority 403.061, FS.
Law Implemented 403.021, 403.061, 403.087, 403.088, FS.
History -- New 9-8-92, Amended 4-14-94, Formerly 17-522.500.

62-522.600 Ground Water Monitoring Requirements and Exemptions.

(1) Unless otherwise exempted by the Department, any installation discharging into ground water shall establish a monitoring program as described in (3) below and shall meet the quality assurance requirements in category 2c described in Rule 62-160.300(7), F.A.C., and the Department's reference, "Standard Operating Procedures for Laboratory Operations and Sample Collection Activities," DER-QA-001/92, September 30, 1992, hereby incorporated and adopted as a reference. Copies of the reference are available from the Department's Quality Assurance Section, 2600 Blair Stone Road, Tallahassee, Florida 32399-2400. However, a monitoring program instituted under some other state, federal, or local governmental regulation or permit shall be substituted for this program if it is in substantial compliance with (3) below.

(2) Plan Submission and Timetable.

(a) New installations shall submit to the Department monitoring plans in conjunction with construction permit applications.

(b) Existing installations shall submit to the Department an acceptable monitoring plan on or before March 1984.

(c) Installations exempt from obtaining permits to discharge to ground water shall develop a monitoring plan only upon Department order that the installation owner obtain a permit defining ground water discharge.

(3) Monitoring Plan Contents. Using part or all of the information listed from (a) through (m) below, the installation owner shall provide the Department with a plan containing findings and recommendations for ground water monitoring derived from site-specific information. Pursuant to Chapters 492 and 471, F.S., the ground water monitoring plan shall be signed and sealed by the professional geologist or professional engineer who prepared or approved it. The plan shall show the locations of the proposed background and downgradient monitor wells, construction details of the monitor wells, and a water sampling and chemical analysis protocol. The plan shall indicate how to determine background or natural background (where available) quality of the ground water in the vicinity of the site and any deviations in the quality of the receiving ground water in the downgradient monitor wells. The Department shall evaluate the adequacy of the plan upon

submittal; however, the applicant should arrange a preapplication meeting with the Department to resolve the needed information at an early stage. The following information is generally required for detailed assessment of the most complex plans unless otherwise specified in other Department rules. Less complex cases will need less information:

(a) Hydrogeological, physical and chemical data for the site, such as:

1. Direction and rate of ground water flow, background ground water quality (all field verified), and natural background ground water quality where available;

2. Porosity, horizontal and vertical permeability for the aquifer(s);

3. The depth to, and lithology of, the first confining bed(s);

4. Vertical permeability, thickness, and extent of any confining beds;

5. Topography, soil information and surface water drainage systems surrounding the site;

6. Fracture trace analysis;

7. Geophysical methods such as ground penetrating radar surveys;

(b) Waste disposal rate and frequency, chemical composition, method of discharge, pond volume, spray-field dimension, or other applicable site specific information;

(c) Toxicity of waste;

(d) Present and anticipated discharge volume and seepage rate to the receiving ground water; and physical, chemical, and microbiological characteristics of the leachate;

(e) Disposal system water balance;

(f) Present and reasonably expected future pollution sources located within one mile radius of the site;

(g) Inventory depth, construction details, and cones of depression of water supply wells or wellfields and monitor wells located within one mile radius of the site or potentially affected by the discharge;

(h) Site specific economic and feasibility considerations;

(i) Chronological information on water levels in the monitor wells and water quality data on water supplies collected from the water supply and monitor wells;

(j) Type and number of waste disposal facilities within the installation;

(k) Chronological information on surface water flows and water quality upstream and downstream from the site;

(l) Construction and operation details of disposal facilities;

(m) History of construction and land development in the vicinity of the site.

(4) Plan Approval. Within 90 days of the date of the Department's receipt of a completed monitoring plan from existing installations described in (2)(b) above, or at the time of permit issuance or denial, whichever is appropriate, the Department shall either approve or deny the monitoring plan.

(5) Implementation of Monitoring Program. The installation owner shall begin the monitoring program based upon the plan within 90 days of the date an appropriate permit is issued. In the case of an existing installation, the owner shall begin within 90 days after

submission and Department approval pursuant to the timetable in (2)(b) above. If the Department determines from the monitoring plan that the discharge will not impair the designated use of the underlying ground water, the Department may exempt the installation owner from implementing a monitoring program.

(6) Location of Monitoring Wells to Detect Migration of Contaminants. Unless the installation owner can demonstrate that detection can be obtained by a methodology other than the use of monitoring wells, wells shall be located as follows:

(a) One upgradient well located as close as possible to the site, without being affected by that site's discharge, to determine the background or natural background quality where available, of the ground water (background well);

(b) One well at the edge of the zone of discharge downgradient from the site (compliance well);

(c) One well downgradient from the site and within the zone of discharge designed to detect the chemical, physical, and microbiological (if applicable) characteristics of the discharge plume (intermediate well); and;

(d) Such other wells as are dictated by the complexity of the hydrogeology of the site, the magnitude and direction of the plume or the likelihood of threat to the public health, to ensure adequate and reliable monitoring data in generally accepted engineering or hydrogeological practice.

(7) Special Monitoring Requirements for Class G-III Ground Water. Discharges to Class G-III ground water shall be monitored to assure compliance with the standards in Rule 62-520.400, F.A.C.; alternatively, the permittee may institute a ground water monitoring program which shall demonstrate that the criteria in Rule 62-520.400, F.A.C., are not violated.

(8) Special Monitoring Requirements for Class G-IV Ground Water. The Department shall specify applicable monitoring criteria on a case-by-case basis for installations which discharge to Class G-IV waters in confined aquifers.

(9) Monitoring Exemptions. The Department shall exempt the following installations which discharge to ground water from ground water monitoring requirements:

(a) Domestic sewage treatment installations with less than 100,000 gpd design capacity except those described in (10) below; stormwater facilities; agricultural fields, ditches and canals; and waste management systems for animal feeding operations exempted from permitting under Chapter 62-670, F.A.C.; as long as the discharges present no potential hazard to human health or the environment, or do not endanger a source of drinking water; and as long as the facilities do not discharge directly to ground water.

(b) Wastewater impoundments containing effluent or reclaimed water, cooling water, or other discharge waters meeting the minimum criteria of Rule 62-520.400, F.A.C., and the applicable standards for the receiving ground water and contiguous surface waters; provided, however, that if necessary to ensure that the water quality criteria and standards are being met, the Department shall require the installation owner to determine

the background, or natural background where available, water quality of the receiving ground water and regularly sample the quality of the discharge prior to contact with ground water.

(10) New domestic wastewater facilities which discharge to ground water with less than 100,000 gpd design capacity (excluding on-site sewage disposal systems) which have filed a complete permit application after July 1, 1994, shall install and analyze samples (as described below) from one downgradient monitor well designed to evaluate the impact of such facilities on the ground water quality. One ground water sample from within the upper 20 feet of the zone of saturation shall be collected and analyzed semiannually for the ground water monitor parameters listed in Chapter 62-601, F.A.C.

(11) Reporting Requirements. Installations required to monitor shall submit the following reports:

(a) Within 90 days after the permittee has implemented the plan approved by the Department, the permittee shall submit a report stating the volume and chemical, physical, and microbiological composition of the discharge.

(b) On a quarterly basis thereafter, or such other frequency specified in the permit, the permittee shall submit reports on all monitoring wells indicating the type, number and concentration of discharge constituents or parameters indicated by the report in (a) above that have been approved by the Department as appropriate criteria to monitor in the monitoring program based upon their potential to exceed the minimum criteria contained in Rule 62-520.400, F.A.C., and the appropriate standards for the particular class of water adjacent to the zone of discharge as described in Rules 62-520.420 through 62-520.460, F.A.C. The report shall also state what is the current nature of the discharge plume relative to the previous report with regard to its size, direction, and rate of movement.

(c) When there is a change in the permitted volume, location, or chemical, physical, and microbiological composition of the discharge plume, the permittee shall notify the Department and, if requested by the Department, submit a new report containing the information required in (a) above.

Specific Authority 403.061, FS.
Law Implemented 403.021, 403.061, 403.087, 403.0877, 403.088, FS.
History -- New 9-8-92, Amended 4-14-94, Formerly 17-522.600.

62-522.700 Ground Water Corrective Action.

Whether or not an installation is operating under a currently valid Department permit, the Department may order the installation owner to take corrective action under the following circumstances:

(1) Where the installation is discharging into the ground water in a manner which represents an imminent hazard to public health, the Department shall require the installation owner to take immediate action to remove or reduce the hazard in such a way as to prevent any threat to the public health and the environment. Such action may include

but not be limited to clean up of the aquifer, halting the discharge, or confinement or containment of the waste plume.

(2) Where no imminent hazard exists, but the plume has extended beyond the zone of discharge or otherwise threatens or is likely to threaten in the foreseeable future to impair the designated use of an underground source of drinking water or surface water immediately affected by the ground water, the Department shall require the installation owner to take appropriate action to clean up, increase the degree of treatment prior to discharge, contain or otherwise correct the violation of water quality standards. The type of corrective action shall be based upon the following factors:

(a) Direction of the plume movement in relationship to existing and potential sources of drinking water;

(b) Plume size both in the areal and vertical dimensions;

(c) Rate of migration of the plume;

(d) Level of toxicity of the plume;

(e) Rate at which the plume is being diluted;

(f) The costs of clean up or other corrective action in comparison with the benefits to the public of such corrective action; and

(g) Current and projected future use of adjacent ground and surface waters affected by the plume.

Specific Authority 403.061, FS.
Law Implemented 403.021, 403.061, 403.087, 403.088, 403.121, 403.141, 403.161, FS.
History -- New 9-8-92, Formerly 17-522.700.

62-522.900 Ground Water Forms.

The forms used by the Department for ground water permitting and monitoring are adopted and incorporated by reference in this section. The form is listed by rule number, which is also the form number, and with the subject, title, and effective date. Copies of forms may be obtained by writing to the Department of Environmental Protection, Information Center, 2600 Blair Stone Road, Tallahassee, Florida 32399-2400.

(1) Application for Monitoring Plan Approval, April 14, 1994.

(2) Ground Water Monitoring Report, April 14, 1994.

(3) Monitor Well Completion Report, April 14, 1994.

Specific Authority 120.53(1), 403.061, FS.
Law Implemented 120.53(1), 403.0875, 403.0877, FS.
History -- New 11-30-82, Amended 1-1-83, Formerly 17-1.216, Amended 9-8-92, Amended 4-14-94, Formerly 17-522.900.

CHAPTER 62-532
WATER WELL PERMITTING AND CONSTRUCTION REQUIREMENTS

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62-532.100 Intent of Water Well Permitting And Construction. (Repealed)

Specific Authority 373.309, FS.
Law Implemented 373.016, 373.026, 373.043, 373.103, 373.113, 373.306, 373.308, 373.309, FS.
History -- New 8-17-74, Formerly 17-21.01, 17-21.001, Amended 7-30-89, 3-11-92, Formerly 17-532.100, Repealed 12-9-96.

62-532.200 Definitions for Water Well Permitting and Construction.

The following words and phrases, when used in this Chapter, shall have the following meaning, except where the context clearly indicates a different meaning:

(1) "Abandoned well" means a well the use of which has been permanently discontinued or which is in such a state of disrepair that it cannot be used for its intended purpose or for observation purposes.

(2) "Annulus" or "Annular Space" means any artificially created void existing between a well casing or liner pipe and a bore hole wall or between two casings or between tubing and casing or liner pipe.

(3) "Aquifer" means a geologic formation, group of formations, or part of a formation capable of yielding a significant amount of ground water to wells, springs or surface water.

(4) "Construction of Water Wells" means all parts and acts necessary to obtain ground water by wells, including the location and excavation of the wells, but excluding the installation of pumps and pumping equipment.

(5) "Department" means the Department of Environmental Protection.

(6) "Dewatering" means the use of wells or other such equipment to temporarily lower a water level as may be necessary during construction activities.

(7) "District" means a water management district created pursuant to Chapter 373, F.S.

(8) "Drive Shoe" means any device specifically designed, fabricated, and installed to protect the bottom end of a water well casing or liner pipe from collapse or other damage while the casing or liner pipe is being driven into place in a water well.

(9) "Driving Casing" means casing that has been installed by driving where the bore hole is equal to or smaller in diameter than the nominal outside diameter of the casing.

(10) "Liner" means a metallic or nonmetallic pipe which is installed either within the outer casing to improve, repair, or protect the outer casing or below the outer casing to seal off caving material which may be encountered in the open hole of the well.

(11) "Neat Cement Grout" means a mixture consisting of water and Portland cement (American Concrete Institute Type I or American Concrete Institute Type III), or other approved types of cement and acceptable amounts of those additives approved for use in cement grouts by the permitting authority.

(12) "Permitting Authority" means the Department or any district, or political subdivision that has been delegated the authority to issue permits under Chapter 373, Part III, F.S.

(13) "Repair" means any action which involves the physical alteration or replacement of any part of a well, but does not include the alteration or replacement of any portion of a well which is above ground surface.

(14) "Telescoping Casing" means an interior casing extending below and sealed within an exterior casing.

(15) "Water Well" or "Well" means any excavation that is drilled, cored, bored, washed, driven, dug, jetted, or otherwise constructed when the intended use of such excavation is for the location, acquisition, development, or artificial recharge of ground water, but such term does not include any well for the purpose of obtaining or prospecting for oil, natural gas, minerals, or products of mining or quarrying; for inserting media to dispose of oil brines or to repressure oil-bearing or natural gas-bearing formation; for storing petroleum, natural gas, or other products; or for temporary dewatering of subsurface formation for mining, quarrying, or construction purposes.

(16) "Water Well Contractor" means an individual who is responsible for the construction, repair, or abandonment of a water well and who is licensed under Chapter 62-531, F.A.C., to engage in the business of construction, repair, or abandonment of wells.

(17) "Well Seal" means an approved arrangement or device to prevent contaminants from entering the well at the upper terminal.

Specific Authority 373.309, FS.
Law Implemented 373.019, 373.303, FS.
History -- New 8-17-74, Amended 7-16-81, Formerly 17-21.02, 17-21.020, Amended 7-30-89, 3-11-92, Formerly 17-532.200.

62-532.300 General Provisions for Water Well Permitting and Construction. (Repealed)

Specific Authority 373.309, FS.
Law Implemented 373.043, 373.106, 373.303, 373.306, 373.309, 373.313, 373.316, FS.
History -- New 8-17-74, Formerly 17-21.03, 17-21.030, Amended 7-30-89, 3-11-92, Formerly 17-532.300, Repealed 12-9-96.

62-532.400 Permit for Water Well Construction or Repair.

(1) After the effective date upon which a district implements a permit system pursuant to Chapter 373, Part III, F.S., a permit shall be required before beginning construction or repair of any water well within such area. The permit shall be obtained from the permitting authority by making written application on appropriate forms. The application shall be made and submitted to the permitting authority by the owner or by the water well contractor on behalf of the owner and shall contain: the well location, description, use, and such other pertinent information as the permitting authority shall require. Any required fee shall be submitted with the permit applications.

(2) Permit issuance shall require that:

(a) The application is in the proper form and contains the required information; provided that the proposed construction or repair will not violate applicable laws, rules, or orders of the permitting authority.

(b) Additional information shall be required by the permitting authority if needed to assess site specific conditions. Such information includes, but shall not be limited to: geophysical logs, geologic samples and logs, and well pumping tests.

(3) Receipt of the permit shall constitute permission to begin well construction or repair.

(4) The permit shall be available for inspection at the site of the well during construction or repair of the well.

(5) Any permittee who desires to change the location of a well before construction or repair is completed shall apply to the permitting authority for an amendment of his permit. Where a permit fee was required to obtain the original permit no charge shall be made to amend the permit. As a condition to approving an amended permit, the permitting authority shall require the sealing or plugging of the uncompleted well.

(6) Each permit shall be valid for a period of one year. In the event construction or repair is not completed within that time, the permitting authority shall extend the time limit upon written request by the permittee or require the applicant to obtain a new permit before continuing construction or repair of a water well.

(7) Water wells shall be placed to comply with set back distances established in Chapters 62-555, 62-610, 62-640, 62-670, 62-701, 62-761, 10D-4, and 10D-6, F.A.C.

Specific Authority 373.309, FS.
Law Implemented 373.306, 373.308, 373.309, 373.316, 403.862, FS.
History New 8-17-74, Amended 9-10-78, Formerly 17-21.04, 17-21.040, Amended 7-30-89, 3-11-92, Formerly 17-532.400.

62-532.410 Water Well Completion Report.

Within 30 days after completion of the construction or repair of any water well, a written report shall be filed on the appropriate forms.
Specific Authority 373.309, FS.
Law Implemented 373.309, FS.
History -- New 8-17-74, Formerly 17-21.05, 17-21.050 Amended 7-30-89, Formerly 17-532.410.

62-532.420 Emergency Water Well Permits.

(1) Permission to begin construction or repair of any well may be applied for by telephone when emergency conditions exist which would justify such a request. The permitting authority may grant an emergency permit to avert an imminent and substantial danger to the public health, safety, or welfare.

(2) The applicant for an emergency permit shall reduce his application to writing in accordance with the provisions of Rule 62-532.400, F.A.C., and submit it within ten days. All other provisions of this Chapter shall remain applicable.
Specific Authority 373.309, FS.
Law Implemented 373.306, 373.309, 373.313, 373.326, FS.
History -- New 8-17-74, Formerly 17-21.06, 17-21.060, Amended 7-30-89, Formerly 17-532.420.

62-532.430 Intent to Deny a Water Well Construction Permit.

(1) The permitting authority shall issue an intent to deny whenever it determines that an application for a permit under Rule 62-532.400, F.A.C., fails to meet the requirements of Chapter 373, F.S., or any rule, order, or standard adopted pursuant thereto, or that the proposed well will be harmful to the water resources of the State.

(2) The intent to deny shall:

(a) state the grounds for denial, and

(b) be served in writing upon the owner and user by registered or certified mail.

(3) Any person receiving an intent to deny may petition for a hearing by filing a written petition with the permitting authority within 30 days of the receipt of the intent. The hearing shall be conducted pursuant to Chapter 120, F.S.
Specific Authority 373.309 FS.
Law Implemented 373.333, 373.306, 373.309, 373.313, 373.342 FS.
History -- New 8-17-74, Formerly 17-21.07,17-21.070, Amended 7-30-89, Formerly 17-532.430.

62-532.440 Abandonment of Water Wells.

A district shall establish a permit system regulating the abandonment of water wells, where it determines such system is reasonably necessary to protect the ground water resources. All abandoned wells shall be filled and sealed in accordance with Rule 62-532.500(4), F.A.C., or with the rules of the permitting authority.
Specific Authority 373.309 FS.
Law Implemented 373.333, 373.306, 373.309, 373.313, 373.316, FS.
History -- New 8-17-74, Formerly 17-21.09, 17-21.090 Amended 7-30-89, Formerly 17-532.440.

62-532.500 Water Well Construction Standards.

The following minimum standards shall apply to the construction and repair of water wells in the State unless exempted by district rule with the concurrence of the Department.

(1) Casing and Liner Pipe Requirements.

(a) Well casing and liner pipe shall be new or shall be pipe or casing in like new condition which has been salvaged from a water well test hole or dry hole. Such casing or pipe shall not be used unless free of breaks, corrosion and dents, is straight and true, and not out of round. Welded or seamless black or galvanized steel pipe or casing, or stainless steel pipe or casing; or approved types of nonmetalic pipe shall be used for well casing or liner pipe. All well casing shall conform to one of the following standards: American Society for Testing and Materials (ASTM) A53-89a, A120-84, A135-89a, A252-89, A589-89a, or American Petroleum Institute (API) 5L-6/91. Well casing
that conforms to any of the aforementioned ASTM or API standards shall also conform to the American National Standard for Welded and Seamless Wrought Steel Pipe (ANSI/ASME B36.10M-1985). All well casing shall be stenciled with the applicable standard no later than January 1, 1994.

(b) Black or galvanized steel casing installed by driving shall not have less than the dimensions and weights specified below.

Nominal Size (in.)	Outside Diameter (in.)	Wall Thickness (in.)	Plain End Weight (lbs/ft)
1.25	1.660	.140	2.27
1.5	1.900	.145	2.72
2	2.375	.154	3.65
3	3.5	.216	7.58
3.5	4.000	.226	9.11

4	4.5	.237	10.79
5	5.563	.258	14.62
6	6.625	.280	18.97
8	8.625	.277	24.70
10	10.750	.307	34.24
12	12.750	.330	43.77
14-30		.375	
>30		.500	

Note: A 4 inch nominal size casing with a wall thickness of .188 and a plain end weight of 8.66 may be used if it conforms to standard API 5L-6/91, Grade B, 60 KSI tensile strength. Other casing that meets these minimum tensile strength standards shall be acceptable. For example, A53-89a, Grade B, may also be substituted.

(c) Black or galvanized steel casing or liner pipe set into place without driving shall not have less than the dimensions and weights specified below.

Nominal Size (in.)	Outside Diameter (in.)	Wall Thickness (in.)	Plain End Weight (lbs./ft)
1.25	1.660	.140	2.27
1.5	1.900	.145	2.72
2	2.375	.154	3.65
2.5	2.875	.203	5.79
3	3.500	.18	6.65
3.5	4.00	.188	7.65
4	4.500	.188	8.66
5	5.500	.188	10.79
6	6.625	.188	12.92
8	8.625	.188	16.94
10-16		.250	
>16		.375	

(d) Stainless steel pipe used for casing or liner pipe shall be Schedule 10S of the American National Standards Institute (ANSI/ASME B36.19M-1985), or stronger classification.

(e) Polyvinyl Chloride (PVC) pipe may be used for well casing or liner pipe. Any PVC pipe used to construct a water well shall have been marked by the manufacturer, under a method specified in ANSI/NSF Standard 14-1990, National Sanitation Foundation, Post Office Box 1468, Ann Arbor, Michigan 48106, as suitable for use in potable water systems. Any PVC pipe used for well construction or repair

shall at a minimum meet the specifications for Schedule 40 or Standard Dimension Ratio (SDR) 21. The appropriate water management district shall require the use of stronger PVC casing if necessary to protect the integrity of the well.

(f) The Department shall approve a well casing or liner pipe not otherwise specified in Rule 62-532.500(1)(a) through (e), F.A.C., if the applicant makes a showing, certified by a professional engineer, to justify that such use would provide an equivalent material strength and durability. The following material has been approved pursuant to this procedure: DNS Well-Cor, Allied Tube and Conduit, A Division of Grinnel Corporation, 1440 Massaro Boulevard, Tampa, Florida, 33619.

Nominal Size (in.)	Outside Diameter (in.)	Wall Thickness (in.)
1.25	1.638	.085
2	2.360	.095
4	4.466	.150

(g) Well casing or liner pipe for potable water use placed into service on or after January 1, 1994, shall conform to NSF Standard 61-1991, National Sanitation Foundation, Post Office Box 1468, Ann Arbor, Michigan 48106, as certified by an entity approved by the American National Standards Institute (ANSI).

(h) Steel well casing and liner pipe shall be joined in a watertight manner by threaded couplings, electrical welding methods, or other methods approved by the appropriate water management district which provide equivalent protection. PVC pipe shall be joined by solvent bonded couplings threaded couplings, heat welding, or other methods approved by the appropriate water management district which provide equivalent protection.

(i) Nonmetalic and stainless steel well casing or liner pipe shall not be installed by driving unless prior approval is obtained from the appropriate water management district based on a demonstration that the integrity of the well casing or liner pipe will be maintained. For well casing or liner pipe installed by driving, the casing or pipe shall not butt together inside threaded couplings unless the joint is electrically welded so as to be completely watertight. A drive shoe is required for use on casing or pipe installed by driving unless prior approval is obtained from the appropriate water management district based on a demonstration that a drive shoe is not necessary to maintain the integrity of the casing or pipe.

(2) Well Construction Criteria.

(a) For wells obtaining water from unconsolidated earth materials, casing shall extend from the upper terminus of the well to the well screen. The well screen shall be attached to the casing with a watertight seal.

(b) For wells obtaining water from consolidated earth materials, a continuous casing shall extend from the upper terminus of the well to the top of the uppermost consolidated unit. Wells constructed of telescoping casings shall be considered as a continuous casing provided the grout requirements are satisfied. The bottom end of the well casing shall extend to or below the water level of the aquifer intended to supply water to the well. In addition, all caving zones below the uppermost consolidated unit shall be cased.

(c) Prevention of Interchange of Water and Loss of Artesian Pressure. All water wells shall be properly designed and constructed to prevent an interchange of water between water bearing zones which may result in deterioration of the quality of water in one or more water bearing zones, or will result in a loss of artesian pressure. If a well cannot be properly completed to prevent such an unauthorized interchange of water between water bearing zones or to prevent a loss of artesian pressure, the well shall be abandoned and plugged in accordance with this Chapter or other directions from the permitting authority, which are appropriate for the geological conditions encountered.

(d) Grouting and Sealing.

1. Casing for wells which obtain their water from a rock layer or other such consolidated formation shall, as a minimum, be seated, or sealed with neat cement grout, into that rock layer or other consolidated formation.

2. For wells with driven casing in a bore hole equal to or smaller in diameter than the outside diameter of the casing, an attempt to cement grout the entire length of the casing need not be made.

3. For any part of a well casing with an outside diameter of four inches or larger intended to be installed in a bore hole which is larger in diameter than the outside diameter of the casing, the annular space shall be filled from bottom to top with not less than a nominal two inch thickness of neat cement grout. For those well casings with an outside diameter of less than four inches the minimum grout thickness shall be a nominal one inch. The casing shall be centered in the bore hole prior to grouting. In those cases where, during grouting operations, circulation of the grout is lost so that the annular space being grouted cannot be filled in one continuous operation, a tremie pipe shall be installed in the annular space to a point immediately above the zone of lost circulation and the annulus shall be bridged at that point by sand or other approved material introduced through the pipe. Grouting of the annular space shall be completed using the tremie pipe or other equivalent method approved by the permitting authority.

4. Any district may grant individual exceptions or, with the concurrence of the Department, may exempt any areas of that district from the requirements of cement grouting the annular space between the well casing and bore hole wall of that part of a well which penetrates an unconsolidated formation upon demonstration that:

a. The unconsolidated formation material is of such a caving nature that upon stopping the circulation of drilling fluid through the well the aquifer material will immediately cave into and fill up the annular space between the well casing and bore hole wall.

b. A flow space is not created by such construction that will allow any movement of waters along the outside of the well casing which did not naturally occur prior to construction of the well.

5. Except as provided in 4. above, grouting and sealing of water wells shall be accomplished by the practices and methods recommended by Sections 7 and 13 of AWWA A100-84, AWWA Standard for Water Wells, American Water Works Association, Inc.

6. Alternate grouting methods providing equivalent protection shall be approved in writing by the permitting authority.

(3) Top of the Well.

(a) Well Covers.

1. Whenever there is an interruption in work on the well, such as overnight shutdown, the well opening shall be sealed with a tamper resistant cover.

2. Except for those areas of a district designated by the Department with the concurrence of the permitting authority, any well in which pumping equipment is installed seasonally or periodically shall, whenever pumping equipment is not installed, be capped with steel or reinforced concrete cover, or valve.

3. Any cased well equipped with permanently installed pumping equipment shall have that pumping equipment and any necessary piping installed through a well seal.

4. Any unused well shall be capped in a watertight manner with a threaded, welded, or bolted cover or valve. Any well vent shall extend at least two 2 feet above land surface.

(b) Flowing Wells.

If the well flows at land surface, control shall be provided by valved pipe connections, watertight pump connections, or receiving reservoirs set at an altitude corresponding to the artesian head.

(4) Plugging. All abandoned wells shall be plugged by filling them from bottom to top with neat cement grout. An alternate method providing equivalent protection shall be approved in writing by the Department or the permitting authority.

Specific Authority 373.309, FS.
Law Implemented 373.309, 373.313, 373.316, FS.
History -- New 8-17-74, Formerly 17-21.10, 17-21.100, Amended 7-30-89, 3-11-92, Formerly 17-532.500.

62-532.510 Water Well Inspections.

(1) During the construction, repair or abandonment of any well, the Department or the permitting authority may conduct inspections as is necessary to ensure conformity with applicable standards. Duly authorized representatives of the Department or the permitting authority shall be given access, at reasonable times, to any premises for the purpose of such inspection.

(2) If during construction, repair, or abandonment, the Department or the permitting authority finds the work does not meet the requirements of rules and standards adopted pursuant to Chapter 373, F.S., the Department or the permitting authority shall give the owner and water well contractor written notice pursuant to the requirements in Section 120.60, F.S.

Specific Authority 373.309, FS.
Law Implemented 120.60, 373.316, 373.319, 373.323, 373.333, FS.
History -- New 8-17-74, Formerly 17-21.11, 17-21.110, Amended 7-30-89, Formerly 17-532.510.

62-532.600 Enforcement of Water Well Permitting and Construction Requirements.

Enforcement shall be as provided by Section 373.333, F.S.

Specific Authority 373.309, FS.
Law Implemented 373.129, 373.333, FS.
History -- New 8-17-74, Formerly 17-21.12, 17-21.120, Amended 7-30-89, Formerly 17-532.600.

62-532.610 Penalties for Violation of Water Well Permitting and Construction Requirements.

Penalties shall be as provided by Section 373.336, F.S.

Specific Authority 373.309 FS.
Law Implemented 373.336, FS.
History -- New 8-17-74, Formerly 17-21.13, Formerly 17-532.610.